



Public Input No. 207-NFPA 70-2019 [Global Input]

"no less than"
change to
"not less than"

Statement of Problem and Substantiation for Public Input

The term "no less than" is used approximately 6 times in the NEC.
The term "not less than" is used approximately 881 times in the NEC.

Reason for the global change is for consistency, and to comply with the style manual. The "no less than's" can be found in:

Definitions, Overcurrent Protective Device, Branch-Circuit.
240.21(B)(4)(9)
430.109(F)
600.32(A)(4) [appears twice in this section]
691.1

Submitter Information Verification

Submitter Full Name: Nick Sasso

Organization: Clark County Building and Fire

Street Address:

City:

State:

Zip:

Submittal Date: Thu Dec 26 19:34:36 EST 2019

Committee: NEC-P01

Copyright Assignment

I, Nick Sasso, 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 Nick Sasso, 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. 259-NFPA 70-2020 [Global Input]

**"unless permitted by..." or "unless permitted by Article..."
change to
"unless permitted in..."**

Statement of Problem and Substantiation for Public Input

Basically this is just clean up language, and to be in accordance with section 4.1.2 of the style manual. Let's pick one or the other. I believe that the correct language should be "unless permitted in..."

The unless permitted by's are located in:

300.13(A)

348.20(A)

356.20(A)

411.5(B)

625.46

626.26

725.136(A)

760.136(A)

The unless permitted in's are located in

225.30

230.2

348.20

356.20

411.5(B)

625.46

626.26

725.136(A)

760.136(A)

Submitter Information Verification

Submitter Full Name: Nick Sasso

Organization: Clark County Building and Fire

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jan 08 14:31:09 EST 2020

Committee: NEC-P01

Copyright Assignment

I, Nick Sasso, 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 Nick Sasso, 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. 276-NFPA 70-2020 [Global Input]

(capable of being) locked in the open position
to
(capable of being) lockable open

Statement of Problem and Substantiation for Public Input

There are approximately 21 references to, "capable of being locked in the open position..."
and
there are approximately 26 references to, "capable of being lockable open..."

Let's pick one. Reason for change is consistency throughout NEC

Submitter Information Verification

Submitter Full Name: Nick Sasso

Organization: Clark County Building and Fire

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jan 11 17:27:37 EST 2020

Committee: NEC-P01

Copyright Assignment

I, Nick Sasso, 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 Nick Sasso, 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. 277-NFPA 70-2020 [Global Input]

(capable of being) lockable open
change to
(capable of being) locked in the open position

Statement of Problem and Substantiation for Public Input

There are approximately 26 references to, "capable of being lockable open..."

and

there are approximately 21 references to, "capable of being locked in the open position..."

Let's pick one. Reason for change is consistency throughout NEC. Personally, I prefer "capable of being locked in the open position."

Submitter Information Verification

Submitter Full Name: Nick Sasso

Organization: Clark County Building and Fire

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jan 11 17:33:21 EST 2020

Committee: NEC-P01

Copyright Assignment

I, Nick Sasso, 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 Nick Sasso, 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. 368-NFPA 70-2020 [Global Input]

Please provide page headers with the appropriate identifiers to make use of the code less confusing.

Example 1: Chapter 1 Article 100 - Definitions - PART III - Haz Locs

Example 2: 110.31 Article 110 - Reqs for Electrical Installations -Part III - OVER 1000 VOLTS nom

Example 3: Annex C- Tables Informative Annex C - Table C-3 (FMC) cont.

Statement of Problem and Substantiation for Public Input

Earlier versions of the document included shorthand page headers that greatly improved user ease of finding the correct code sections. As written now the document is confusing with important distinctions hard to ferret out. For example the sections that are limited in application to certain voltages or locations may run for pages but the transition to that distinction is hard to find, and any page after the initial distinguishing information is not notated in any way to indicate that a limitation of scope applies.. Identifiers such as Part III Over 1000 volts is not prominently distinguished in the body of the text and is not reflected in the page heading on latter pages, leading to much confusion when using the document in the field. (Earlier versions also had the PART III or similar transitions prominently bold to make finding them easier.) Please accept my apology if this is submitted in the incorrect format or to the incorrect panel or group. This would appear to be a style request more than a code request but I did not find any public input option for style or page headers.

Submitter Information Verification

Submitter Full Name: Joe Kunkel

Organization: NU Electric Co

Street Address:

City:

State:

Zip:

Submittal Date: Sun Jan 26 12:24:46 EST 2020

Committee: NEC-P01

Copyright Assignment

I, Joe Kunkel, 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 Joe Kunkel, 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. 454-NFPA 70-2020 [Global Input]

Type your content here: I would like to see one of the two things I have listed happen; either put all definitions in article 100 no matter how many times the term is used throughout the NEC or keep the NEC at the current format limiting article 100 for definitions of terms used more than twice in the NEC and using xxx.2 for definitions that are only used in that particular article. Do not use xxx.2 for anything besides definitions. Currently if an article does not contain any definitions, xxx.2 is used for anything. Example; 90.2 SCOPE, 110.2 APPROVAL, 200.2 GENERAL, plus many other articles, although this change would not in essence save lives, it would add consistencey to the NEC, ...

Statement of Problem and Substantiation for Public Input

This would add consistency to the NEC,

Submitter Information Verification

Submitter Full Name: Ray Pritchett

Organization: NJATC

Affiliation: Evansville Electrical Training Center IBEW Local 16

Street Address:

City:

State:

Zip:

Submission Date: Sun Feb 09 22:55:07 EST 2020

Committee: NEC-P01

Copyright Assignment

I, Ray Pritchett, 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 Ray Pritchett, 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. 2989-NFPA 70-2020 [Global Input]

Regarding the division of NEC Articles into "Parts";

Where "Parts" are used to sub-divide NEC Articles by topic, it is proposed to amend the Part description text with a set of brackets that enclose the span of paragraph numbers that is encompassed by the respective Part category.

For example, NEC Chapter 2, Article 210, Part III.

This "Part" text string is represented as;

Part III. Over 1000 Volts

The proposal is to revise this "Part" text string to;

Part III. Over 1000 Volts (210.50-.70)

And, to do the same for all "Parts" of all NEC Articles.

Statement of Problem and Substantiation for Public Input

BASIS FOR CODE REVISION: to facilitate quicker more efficient code searches by providing a context clue via association of the paragraphs that are correlated to the "Part" sub-category. Page-by-page code searches that miss seeing the keyword "Part" somewhere on the page, could now be less prone to such erroneous mis-associations

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 03 19:32:38 EDT 2020

Committee: NEC-P01

Copyright Assignment

I, John Blissett, 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 John Blissett, 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. 3013-NFPA 70-2020 [Global Input]

Move all definitions in the code to Article 100, arrange them in alphabetical order and without any subdivisions.

Statement of Problem and Substantiation for Public Input

The National Electrical Code has definitions in multiple parts in Article 100 and many definitions scattered through out the code many of them in the .2 section of the articles.

Most of the other standards under NFPA have their definitions in one location and this will allow the NEC the same requirement. The Revisions to the NEC Style require all the definitions to be moved to Article 100.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 03 21:41:22 EDT 2020

Committee: NEC-P01

Copyright Assignment

I, David Williams, 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 David Williams, 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. 3141-NFPA 70-2020 [Global Input]

Move all definitions in current (2020) NEC text to Article 100. Insert those definitions in alphabetical order. For definitions that apply in only one article, the article number in parentheses shall follow the definition. The CMP responsible for the definition shall be identified in parentheses at the end of the definition following any extract or article information.

Type your content here ...

Statement of Problem and Substantiation for Public Input

This revision provides a more usable code by providing a uniform process to find definitions. Users are currently required to look in multiple locations to determine if a term is defined. Other NFPA codes and standards utilize a single location for all definitions.

Submitter Information Verification

Submitter Full Name: Donald Cook

Organization: Shelby County Department of De

Affiliation: Self

Street Address:

City:

State:

Zip:

Submission Date: Sat Sep 05 15:11:40 EDT 2020

Committee: NEC-P01

Copyright Assignment

I, Donald Cook, 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 Donald Cook, 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. 3327-NFPA 70-2020 [Global Input]

Review the revisions to the new NEC Style Manual and make changes to comply with the Style Manual.

Statement of Problem and Substantiation for Public Input

The NEC Style Manual has been revised and every code making panel needs to review the manual and make changes to their code articles to comply with the Style Manual revisions.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 07:31:11 EDT 2020

Committee: NEC-P01



Public Input No. 3328-NFPA 70-2020 [Global Input]

Review the Articles with multiple parts to comply with the revisions made to the NEC Style Manual. Make changes based on the Style Manual revisions.

Statement of Problem and Substantiation for Public Input

Section 2.1.4 was revised by adding the last two sentences. Where an article contains multiple parts and includes general installation requirements, such requirements shall be located in the first part titled "Part I. General". Part titles shall be descriptive and as concise as possible.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 07:34:42 EDT 2020

Committee: NEC-P01



Public Input No. 3329-NFPA 70-2020 [Global Input]

Revise the Definition Title Structure to comply with the NEC Style Manual.

Statement of Problem and Substantiation for Public Input

Review the Style Manual Revisions in 2.2.2.3 Definition Title Structure. Definitions that have sub-parts shall be listed alphabetically by the base term, with a comma and then the modifying descriptor.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 07:36:42 EDT 2020

Committee: NEC-P01



Public Input No. 3330-NFPA 70-2020 [Global Input]

Verify that all exceptions are written in completed sentences.

Statement of Problem and Substantiation for Public Input

The NEC Style Manual requires that all exceptions are written as complete sentences in accordance with 3.1.4.1.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 07:40:56 EDT 2020

Committee: NEC-P01



Public Input No. 3331-NFPA 70-2020 [Global Input]

Revise the definitions in Article 100 to include an acronym, as desired, for subsequent use in the NEC without having to state the term.

Statement of Problem and Substantiation for Public Input

The permitted use of acronyms in the NEC has changed with the Style Manual revisions in 3.2.3. When a term is defined in Article 100 and includes an acronym, that acronym is permitted to be used elsewhere through out the code.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 07:43:12 EDT 2020

Committee: NEC-P01



Public Input No. 3332-NFPA 70-2020 [Global Input]

Review the structure of all Informational Notes to comply with the revised NEC Style Manual.

Statement of Problem and Substantiation for Public Input

Sections 3.1.3.1 and 4.1.3 of the revised NEC Style Manual includes designed structure for references in Informational Notes.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 07:48:58 EDT 2020

Committee: NEC-P01



Public Input No. 3333-NFPA 70-2020 [Global Input]

Review all references to articles or parts of articles to comply with the Style Manual.

Statement of Problem and Substantiation for Public Input

Section 4.1.4 References to a Part Within an Article. Except for Article 100, references shall not be made to an entire article. References to parts within articles shall be permitted.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 07:50:17 EDT 2020

Committee: NEC-P01



Public Input No. 3335-NFPA 70-2020 [Global Input]

Review the use of Parts within an article and the section number for parts of an article.

Statement of Problem and Substantiation for Public Input

The code panels need to review the sections under their purview to comply with the revisions made to the NEC Style Manual. 2.4.2.1 Parts. If an article is subdivided into parts, it is recommended that the section numbering within each part start with the next decade as a minimum to allow for future growth. New or significantly reorganized articles shall follow this numbering convention. Where an article has multiple parts, Part I. shall be titled "General".

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 08:02:00 EDT 2020

Committee: NEC-P01



Public Input No. 3336-NFPA 70-2020 [Global Input]

More than one informational note in a section or subdivision shall be consecutively numbered.

Statement of Problem and Substantiation for Public Input

The numbering of informational notes need to comply with the changes made to the revised Style Manual.

2.4.3. Numbering Informational Notes. If there are two or more informational notes in a definition, section or subdivision, consecutive numbering of the informational notes shall only occur in that definition, section or subdivision.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 08:10:27 EDT 2020

Committee: NEC-P01



Public Input No. 3490-NFPA 70-2020 [Global Input]

100 Definitions

Defined terminology associated with Manufacture and Construction activities.

1. The term “Construction” shall be defined as the process of deploying product or installation of a device, material, or item of equipment in accordance to its designated purpose. An owner or owner’s agent (e.g. contractor) implements construction at a specific worksite location for either a permanent installation, or a temporary application as permitted by code. Installation shall comply with manufacturer terms and ratings unless permitted otherwise in this code. All code delegated responsibilities for testing, marking, labeling, identification, documentation, etc., which are not the clear accomplished responsibility of the manufacture production process, shall be the due diligence responsibility of those involved with the construction process, unless approved otherwise by the authority having jurisdiction.

Informational Note: construction applications include, but are not limited to, activities associated with activities involved with: install, field installed, field applied, field tested, field assembled, field evaluation, field wiring, field marking, field conversion, and field labeled.

2. The term “Fabricated” shall be defined to apply to equipment or an assembly that is neither necessarily listed nor mass-produced. For example, custom equipment, a custom assembly, or equipment that is altered from its original listing. Fabrication may occur in whole or part onsite or offsite. Component parts and materials may be listed, or may be required to be listed by this code or by the authority having jurisdiction. Generally, where fabricated products are permitted by this code, code compliant product qualification shall be by a Field Evaluation Body, where duties typically include: product testing, marking, labeling, identification, standards compliance, product documentation and instructions sufficient for the safe operation appropriate per the application criteria. Fabricated applications also include reconditioned equipment and retrofit equipment, as permitted by this code, wherever equipment is functionally restored to other than conformance to the original manufacturer’s equipment ratings and life cycle projections. Fabricated equipment and systems that encompass, in part or whole, any associated construction activities and elements, shall absorb the associated due diligence responsibilities involved, except as approved otherwise by the authority having jurisdiction.

Informational Note: fabrication applications generally include, but are not limited to, activities associated with pre-fabricated equipment and systems: electrical system assemblies, mechanical system assemblies, and modular building assemblies. Where the assembly is listed as a unit, then the manufacture application responsibilities apply.

3. The term “Pre-fabricated” shall be defined to apply to those fabricated equipment assembly activities that occur at a site other than the permanent installation location.
4. The term “Manufacture” shall be defined as the factory assembly of a product, characteristically mass produced and distributed. Examples include: equipment, wire, devices, material, and compounds. The manufacture process includes production activities including: factory testing, marking, labeling, identification; NRTL Listing where applicable; standards compliance, product document publication for sales and designer specifications including those used for: shipping, install, field

testing, owner use, and maintenance. By definition, final assembly or other in-field activities of a product at its permanently installed location will not constitute an aspect of manufacture, unless performed by the manufacturer.

Informational Note 1: applications where a product's permanent or temporary installation occurs at a point-of-use location under direct supervision of the manufacturer, the requirement duties of both the manufacture process(es) and associated construction process shall be the responsibility of the manufacturer, except as approved otherwise by the authority having jurisdiction.

Informational Note 2: manufacture applications shall include modular equipment, where an assemblage of different products has been hybridized into a singular unit, when the unitized equipment is listed. Where the unitized equipment is not listed as a unit, then the fabricated application responsibilities apply.

Statement of Problem and Substantiation for Public Input

BASIS FOR CODE REVISION:

The term "construction" is used throughout NEC in reference to code requirements that are aimed at typically different segments of industry, which only occasionally overlap each other's general task sets. Product construction during manufacture is one application, versus product install during site construction. The code text describes both contexts as construction. Where practicable, it would improve functional clarity in code text requirements to employ distinct construction-like terms wherever reasonable and appropriate. The terms and definitions proposed are suggestions; to serve as a basis to move this discussion and consensus forward.

Where code requirements clearly intend compliance fulfillment to be about the product's activities prior to leaving the factory, distinct terminology can communicate this with added clarity. Similarly, where code compliance fulfillment clearly applies to the implementation of a product, as regards its permanent installation, a distinctly defined term for 'construction' will yield improved comprehension as to intended context. A third distinct category can also be established by definition that encompasses fabrication, to serve to encompass custom fabrication assemblies, reconditioned equipment, and retrofits.

Applications where the code responsibility can fall into gray areas for accountability between the three, can be attended to by a default assignment of responsibility. This explicit clarity helps ensure that enforceable code compliance responsibilities are clearly stated. Allowance for an exception, per AHJ acceptance, provides a mechanism to formally transfer an obligation of responsibility.

Where the code speaks to putting an identifying mark, or information, or color onto a cable or item of equipment, it more often refers to those which would intend to be understood as the responsibility of the manufacturer. The following two sets of code citations illustrate where the manufacturer is to provide a mark or color (first set) versus where the installer is to provide a mark or color. The third set of code citations is where it is intuitively apparent that either the manufacturer or installer could either be involved (or both involved) in providing a mark or color on the electrical equipment.

Example requirements for manufacturer marks or color include but are not necessarily limited to;

110.14(D), 110.28, 200.4(B), 200.6, 200.7, 200.9, 200.10(B), 200.10(D), 215.12(A), 215.12(B), 225.30(A)(7), 230.46, 230.66(A), 230.70(B), 230.77, 240.50(C), 240.81, 240.82, 240.83(A&B), 240.83(D), 240.85, 250.28(B), 250.110 Ex3, 250.119, 250.119(A), 250.119(B), 250.119(C), 250.126, 250.28(B), 250.112, 250.114, 250.119, 250.126, 300.11(B)(1), 300.11(B)(2), 310.3(D), Table 310.4(A), 310.6(ABC), 310.8(C)&(D), 310.10(C), 310.10(D), 311.14, 311.16(A), 311.16(B)(1&2)), 311.16(B4&C), 311.32, 314.16(C)(2), 322.56(B), 322.120(C), 336.120, 338.120, 368.12(E), 386.70, 388.70, 406.3(D), 406.3(E), 406.10(B), 406.13 (A-D), 409.110, 430.52(C)(5), 500.8, 501.5, 501.17, 501.105(B)(1), 501.130(A)(1), 502.6, 502.130(B)(1), 502.130(B)(2), 503.130(A), 504.80(C), 505.8, 505.20(B&C), 505.22, 505.26, 506.9(C)(1), 506.9(C)(2), 506.9(D), 517.18(A), 517.19(A), 517.61(C)(2), 530.21(B), 530.22(B), 545.22(A), 551.77(A), 552.10(B)(3), 552.10(E)(2), 555.8, 555.33(B)(2), 600.23(F), 600.33(A)(3), 600.33(A)(4), 690.12(C), 690.51, 694.22(A), 700.10(A), 705.12(D), 705.20, 706.15(C), 708.10(A)(2), 712.37, 725.3(P), 725.179, 760.3(O), 760.30, 760.176(G), 760.179(G)(1), 770.179, 800.182, 805.179, 820.179, 830.90(A)(2), 830.179(C&D), 840.170(B), and 840.170(E).

Example requirements for the installer to do the marks or color indications include but are not necessarily limited to; 200.4(B), 200.6, 210.5(C)(1), 210.5(C)(2), 210.12, 215.12(A), 215.12(C)(1), 215.12(C)(2), 225.30(B), 225.38(C), 225.52(D&E), 230.72(A), 300.5(D)(3), Table 300.50, 310.6(ABC), 311.14, 406.3(E),

406.10(B), 408.3(E)(2), 408.3(F)(1), 408.3(F)(2), 408.3(F)(3), 408.3(F)(4), 408.3(F)(5), 517.18(A), 517.19(A), 517.160(A)(5), 530.21(B), 530.22(B), 547.9(A)(10), 550.33(A), 552.43(C), 620.53, 620.55, 647.4(C), 647.7(A)(4), 668.21(C), 690.54, 690.55, 700.10(A), 712.25, 712.55, 725.124, 760.30, and 770.179(F).

Example requirements for either the manufacturer and/or the installer to do the marks or color indications include but are not necessarily limited to; 230.56, 250.21(C), 250.167(C), 408.3(E)(1), 409.102(B), 430.97(B), 430.109(A)(6), 430.109(E), 517.31(C)(1), 517.31(E), 517.42(E), 520.44(C)(3), 520.54(C), 520.54(J)(1), 520.54(K), 530.21(B), 530.22(B), 550.10(I), 690.1, 690.31(B)(1), 690.31(D)(2), 770.179(G), 805.90(A)(2), and 805.170(A).

As regards reconditioned equipment and retrofit equipment, the code is in its developing infancy as regards code requirements for marks, as they are few, yet likely to grow in upcoming code cycles. Having distinct groups for manufacture, installation, and fabrication also serves to help make obvious, the places in code that similar code requirements between them may be missing but warranted.

Similar to the topic above for equipment marks between manufacture, installation, and fabrication, are topics for labels and signage which are beyond marks.

In NEC Chapter 3, 4 and 7 the term “manufacture specifications” can substituted for “construction specifications”. And in NEC Chapter 5 and 6, where specifications have other terminology variations based on product qualities, “manufacture specifications” can be used with such term descriptors for NEC consistency to augment transparency when a code specification is intended to apply to manufacture apart from installation criterion.

Another example benefit from having a distinction between manufacture, installation, and fabrication are for the code required documentation and whom is to provide it. Such as; instructions for shipping, install, or maintenance, versus installer instructions for operation sequence, equipment ratings guidance or site-specific diagnostic protocols.

Where an entity assumes multiple roles of manufacture, installation, and/or fabrication, they are intended to assume the respective responsibilities. And, what those responsibilities are will have improved certainty, when there are improvements to distinctions of terminology and nomenclature. Inspections and commissioning processes will similarly be improved for the same basis of improved enforceable clarity.

SIDEBAR: a supplemental suggestion, in the earnest of minimizing code text where practicable, is to utilize a letter or symbol icon, for use in NEC margins, that correlates to each of the three definitions for, manufacture, versus fabricated, versus construction. For example, a symbol icon for manufacturer (e.g. Hex Note enclosing an 'M'), versus those affiliated with the product install construction process (e.g. Hex Note with 'C'), versus the symbol for the fabrication process (e.g. Hex Note with 'F'). One example of benefit of deploying a symbolic nomenclature is the topic of labels, signage, and markings; which are often able to be grouped by: manufacturer, fabricated, or installer. Each instance in code for label, mark, or sign can include one or more of these three symbols in the margin alongside the code text without adding pages to the code. A raised bar of label and signage compliance is likely the result, plus an improved ease and capacity for enforcement by way of inspection or commissioning.

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submission Date: Tue Sep 08 17:16:57 EDT 2020

Committee: NEC-P01

Copyright Assignment

I, John Blissett, 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 John Blissett, 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. 4390-NFPA 70-2020 [Global Input]

When an Article has Parts the revised Style Manual requires the following in 2.1.4.

Part titles shall be descriptive and as concise as possible.

Example:

Part I. General

Part II. Installation

Part III. Construction

Statement of Problem and Substantiation for Public Input

The revised Style Manual requires Article Part titles to be descriptive and concise as possible and provides examples for the code panels to use.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 11:45:05 EDT 2020

Committee: NEC-P01

Copyright Assignment

I, David Williams, 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 David Williams, 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. 4707-NFPA 70-2020 [Global Input]

Globally revise the use of term "Listed", and revise use of the term "Labeled"

To distinguish the NRTL (testing lab) context for the term "labeled" and "listed" from other NEC context uses of these words in all their forms; label, labels, labeling and labeled, it recommended to apply capitalization to the word "Labeled" and "Listed" when intended for this particular context of a testing organization. Capitalization as proper nouns will make this context more readily recognizable.

For additional distinctive clarity for this context of these terms 'listed' and "labeled", apply them with their "NRTL" modifier; and deploy "NRTL Listed" and "NRTL Labeled" throughout the Code text. Of course, all variants formed for grammatical correctness would also be amended and capitalized, such as "NRTL Listing" and "NRTL Label" etc.

In the definitions, it is appropriate to associate NRTL to "Nationally Recognized Testing Laboratory", which is generally the type of testing agency. Any other testing agency, where approved by an AHJ, is allowed. It is also appropriate to include a reference to the industry standard organization that acknowledged to govern this industry acceptance standard for each NRTL, the Occupational Safety and Health Administration (OSHA). With OSHA acknowledged as the official agency, it becomes a Code-legitimized reference, able to facilitate any follow-up enquiries regarding code compliance. To help facilitate back-checks has never been more suitable than in this age of ever-increasing pirating of product and other pretenders to suitability.

Wherever the term 'Labeled' is used as part of 'NRTL Listed and Labeled', it shall refer to the equipment mounted labeling that is pertinent to all of the equipment item's application-specific Listing(s) and shall include the equipment ratings.

Wherever the term 'Marked' is used as part of 'NRTL Listed and Marked' or 'NRTL Listed and Labeled and Marked', 'marked' shall refer to the marking or labeling that is associated with the Listing and shall include the specific qualification of use mentioned in code. E.g. listed and labeled and marked as being suitable for use as service equipment.

Statement of Problem and Substantiation for Public Input

BASIS FOR CODE REVISION:

The term 'Listing' and 'Listed' will be capitalized and treated as a proper noun; short for 'NRTL Listing' and 'NRTL Listed'. The term 'Labeled' will also be capitalized as a proper noun when used to indicate 'NRTL Labeled' or 'Manufacturer Labeled' as regards the manufacturer's terms of use for the equipment. NFPA codes does not capitalize these three terms generally so they are indistinguishable from the other contexts for a list or label. Manufacturer terms of use regarding labeling can include ratings, Listing types, or other declarations of compliance to particular industry standards.

There Code text of NEC 110.3, Part (C) may have intended for equipment generally to be Listed, but technically it is not ever stated. All that is stated is the terms for who will do the testing and evaluation as regards a Listing.

The Occupational Safety and Health Administration (OSHA) is the official agency that recognizes qualified testing laboratories, of which there are 23 approved labs to date. OSHA confirms that NEC's "electrical" sub-distinction of labs in NEC 110.3, Part (C) doesn't formally exist as an industry recognized group. The 'electrical' testing laboratory distinction is an obscure reference used in two other places in the NEC [90.7,

490.48(A)], but not in the NEC's other (14) references of a testing laboratory. Underwriter Laboratories (UL) is the only distinct NRTL lab whose standards are cited in the NEC and there are hundreds of UL citations (see. NEC Informative Annex A). One relevant ATS example is cited in NEC; UL1008 for transfer switches up to 600V. And one relevant ATS example is not cited in NEC; UL1008A for 750V-46kV ATSs. Whether another NRTL lab other than UL may qualify NEC's intent as an "electrical lab" is unknown. The NEC requirements are functional without the "electrical" sub-distinction, and so this likely warrants deletion of "electrical" in an upcoming NEC code revision.

Though these code articles infer an expectation that an ATS shall be used, an ATS is not overtly mandated as required. Only when an ATS is used, then definitive code requirements apply, like a Listing for emergency use.

NEC Article 705 applies to Interconnected Power Production Sources that parallel with the normal source, which is typically the utility supplied power source. There is an incongruence of code due to what NEC 705 allows. That is whenever the 705 code language is interpreted as an absolute permission due to the omission of disallowances of use as an essential-class power system. The code requirement variance compared to similar applications is a risk, because it then grants an emergency power distribution topology absolution because the code language allows it. NEC Article 705 has no requirements for equipment to be Listed for any aspect.

NEC 705 applies to distribution gear that interconnects normal power (e.g. utility) with an alternate source of power (e.g. generator). The 705 distribution gear may serve in place of an automatic transfer switch because the code does not disallow that use. Yet code does not require it be listed for emergency use, nor does it even require the automated switching mechanisms to be electrically operated and mechanically held. The NEC 705 gear has latitude to have more than two sources and more than one load. The function of NEC 705 gear may be no less critical but it is more susceptible to dysfunction than an ATS. It is arguably more important even than any single automatic transfer switch as it can perform the duty of multiple transfer switches or be the power source to many ATSs. It is like using a string to support a chain. This example illustrates how language of one NEC article (705) can permit use of a power distribution topology that is inconsistent to all other instances of code text regarding transfer switching of emergency power, which would otherwise be fairly consistent.

Application Specific Code Requirements

A summary of code findings on power source selection for emergency applications is as follows;

1. FOR ALL CODIFIED POWER SYSTEM TYPES OTHER THAN NORMAL: An ATS shall be NRTL Listed for Emergency Use (and also identified for Standby Use). Exceptions are:

- A. Optional Standby Power System (NEC 702; other Listing requirements may apply)
- B. Fire Pump (NEC 695; other Listing applies)
- C. Interconnected Power Production Sources (NEC 705)
- D. Medium Voltage (see caveats below)

2. MEDIUM VOLTAGE CAVEATS:

A. NFPA 99 indicates an ATS <600V must be Listed for the purpose. No mention of requirements for other voltages >600V. Allowance for ATS >600V to not be Listed is one logical inference.

B. NFPA 110 states MV transfer of central plant or mechanical equipment is allowed using electrically interlocked medium voltage circuit breakers; but the equipment branch MV transfer switch is not to include life safety (LS), emergency (RE), or critical branch (CR) loads. By mention of critical branch this code regards healthcare but is not correlated by any healthcare code; neither by NFPA 99 nor by NEC 517. Allowance by Listing omission may be logically inferred for power system types not mentioned; SEPSS (NFPA 111), RSPSS (NEC 701), EQ (NEC 517), FPPSS (NEC 695), FCPSS (NEC 692), and EPSS (NFPA 110). Note that an MV transfer equipment is not disallowed for LS, RE, or CR if the MV switch is separated from mechanical loads. Also, there is no disallowance to separate loads if the MV ATS is Listed.

C. NFPA 70 (NEC) does not mandate a Listing requirement specific to distribution gear generally, including medium voltage (MV) equipment. NEC makes no mention of MV ATSs, nor provides any specific exemption for an MV ATS. That paralleling gear has no Listing requirement at all would apparently extend to MV types of paralleling gear.

3. FOR FIRE PUMP APPLICATIONS: A fire pump's local ATS and/or controller shall be NRTL Listed for electric motor-driven fire pump service. Other transfer equipment upstream of a fire pump ATS does not qualify it as a fire pump ATS also; so only the lower level ATS must meet these 'Fire Pump ATS' requirements.

4. GENERAL REQUIREMENTS: NRTL Listing types compound for each condition of use that applies; 'emergency', 'wet location', etc; whenever the NRTL Listed Use is an available product offering. An ATS must be NRTL Listed for all of the load types to be served. Field labeling by a Field Evaluation Body is an alternate compliance path for a Listing requirement generally, except where a Listing is overtly stated as the only compliance path such as for an ATS and select other NEC applications.

5. OPTIONAL STANDBY APPLICATIONS: Transfer equipment shall be NRTL 'Listed as Transfer Equipment' wherever supplemental circuit protection devices (CPD) are integral to the transfer equipment. No other Listing requirements apply for Optional Standby transfer equipment.

6. INTERCONNECTED POWER PRODUCTION SOURCES are a recognized transfer switch application apart from an ATS. NEC 705 scope only applies to multiple sources if the normal source (e.g. utility) is one of the sources. Where field labeling is provided, the NEC does not mandate any requirement for a Listing of any kind. Even if it is Listed, NEC doesn't require the gear to be NRTL 'Listed as Transfer Equipment' (as CPD optional standby transfer equipment must do), nor 'Listed for Emergency Use' (as all other emergency power transfer equipment must do). Where NEC 705 is applied to critical grade topologies, NEC suffers a glaring omission for any code-required NRTL type validation for a failsafe style of integrity, suitable for essential-class loads.

7. PARALLELING GEAR for automatic transfer switching of multiple sources (apart from an Article 705 type system) has no code article that governs its performance requirements. Only if the paralleling gear is connected to a normal (utility) source must it then comply with NEC 705. But even then the 705 requirements are not up to the usual code standards for critical or emergency gear and so it does not impose any failsafe standard for integrity including associated Listings.

Ironically, NEC 110.3(B) does state (by omission) that only the Listed or Labeled equipment needs to be used in accordance with the equipment manufacturer's instructions. Because the NEC makes no similar requirement of equipment that is not Listed nor Labeled, this equipment category escapes the stipulation to comply with the manufacturer's terms of use. This however is recognizable as nonsense, and an intonation of NEC intent must be interpolated.

NEC 110.3, Part (C) fails to identify that multiple Listings may be required for a product, and that one Listing may not be adequate. An individual separate Listing for each specific category of use is required whenever such Listing categories apply to the conditions of the equipment use.

NEC 110.3, Part (C) also fails to identify NEC's own exemptions for its general requirement that everything be Listed, and whether there are terms for when these exceptions are permitted or disallowed. One category is custom fabricated equipment, of which certain field assemblies may qualify as hybrid sub-category. One other category is equipment that has been reconditioned, refurbished or remanufactured. One final category is non-Listed equipment where NEC has outlined the specific terms of permitted use based on application. The problems arising from potential distinctions of allowances for non-Listed equipment is much more pronounced when the inconsistencies of Listing requirements by specific application are attempted to be put into a proper context (more on this in Chapter 8).

A best practice default for equipment selection is to choose a Listed product whenever one is available, and include each Listing application type that applies. Only when a Listed product cannot meet the design requirement should an alternative be considered; such as a custom fabricated product. Even then, such non-Listed applications shall be responsibly managed to best show coherence to all other code intent toward trustworthy integrity of; the components, the assembly work, and the resultant functionality. And where NEC outlines terms for use specific to "non-Listed" equipment (as done in Chapter 8), it shall be considered an acceptable form of compliance.

The NEC variations of terminology for Listed and for Labeled is diverse but the reason for this inconsistency is not always evident. The numeral in parenthesis is the number of occurrences found for each term in the NEC.

SIDEBAR: As the deadline for 2020 Public Comment is impending, the values and citations from here forward were not back-checked to 2020 NEC from the v2017 they were derived from .

1. Listed (1715), Listing (247), List (9)
2. Approved (473), Approving (2), Approval (44)
3. Labeled (65), Labeling (30), Labels (57), Label (55), Field Labeled (3), clearly Labeled (1)
4. Identified (2), Identifying (35), Identify (41)
5. Marked (647), Marking (555), Mark (31), Marks (3)
6. " Listed for" (332)
7. "Listed and Labeled" (21)
8. "Listed and Labeled for" (2)
9. "Listed or Labeled" (6)
10. "Listed, Labeled, and identified" (18)
11. "Listed, Labeled, or identified" (1)
12. "Prominently Labeled" (2)
13. "Listed, Labeled, and marked" (1)
14. "Listed and Labeled or field identified" (1)

Situation specific NEC requirements for equipment to be "Listed" vary case-by-case, whether by code article, or by site application type, or by equipment category. The way the requirements varied indicate that either code intent is not always consistent, or that the manner in which NEC requirements are written are a mixed bag of inconsistencies. In actuality, it is both.

The code citations below are selected to indicate general requirements and the requirements specific to switch transfer of emergency power sources. Other unrelated code citations are included to illustrate how the code may show consistency and how it shows inconsistency.

1. Listing Requirements by NEC Article

Every material item used for Trailer Parks (NEC 552), RVs (NEC 551), and mobile homes (NEC 550) must be Listed. But not a thing is mandated as needing to be Listed for hospitals (NEC 517), floating buildings (NEC 553), and certain other applications in NEC such as; Cablebus (370), Multioutlet Assemblies (380), Underfloor Raceways (390), Concealed Knob and Tube Wiring (394), Open Wiring on Insulators (398), Outdoor Overhead Conductors Over 1000V (399), Flexible Cords and Flexible Cables (400; though only nearly nil), Fixture Wires (402), Industrial Control Panels (409), Fixed Industrial Heating Equipment (455), Capacitors (460), Resistors and Reactors (470), Equipment Over 1000V (490), Integrated Electrical Systems (685), Interconnected Power Production Sources (705; aka paralleling gear), Circuits and Equipment Under 50V (720), and Energy Management Systems (750).

2. Listing Requirements by Equipment Category

For other NEC articles, the requirements for Listed equipment amounts to an honorable mention of oddities in bits and pieces; not because those bits are especially significant, or associated with criticality. NEC will

mention a Listing requirement for the parenthetically consequential 1% and miss the more essential 99%. Switchgear (408) requires that insulated conductors are Listed, but NEC invokes no other requirements of anything else to do with switchgear to be Listed. There are times that NEC chapters or paragraphs only apply technically for any equipment which is Unlisted.

Most all raceways and cabling, but one, are required to be Listed from the 300 series articles of NEC. But at many points amongst the other code articles, only the fittings are indicated as needing to be Listed. The singular 300-series article for cablebus that was inadvertently skipped, is likely an oversight.

3. Listing Requirements by Application Type

Some aspects of Listings are meant to apply categorically, like a Wet Location Listing for any equipment in wet locations; but NEC consistency is sporadic and omissions prolific where they should apply. This inconsistency is similar to the requirements mentioned for sun exposure considerations.

At some points of code there are common applications with common importance factors but they are treated with uncommon requirements.

4. Observations of Inconsistent and Irrelevant Text

The terminologies for similar types of Listings has aspects of inconsistency, such as the five different terms used for an ATS to be Listed for Emergency Use. The verbiage variations could infer that these refined differences in text vary for good reason (with potentially varying requirements), but under scrutiny they do not.

There are code sentences that are superfluous because the Listing requirement for a subcomponent item being mentioned was already imposed generally at some other NEC article prior. Such as for particular conduit fittings to be Listed. To make matters worse, the requirements at one location in code doesn't always match the other location.

Other code text is a waste of language as the statement is redundant unto itself. Such as stating that use of equipment is okay if the Listing says it's okay. Or employing a double-negative to state that equipment is not to be used in a way that the Listing doesn't say is okay. As a side issue, such statements infer that there are "Listing Instructions" to follow for each Listing type. That such instructions exist and are published respective to Listing types is not affirmed to be an industry accepted understanding. How is it proposed that such reference materials are to be captured with consistent integrity by electrical system designers?

At times one or two specifications or features of the Listing itself, are mentioned with the NEC code text. But the exclusion of the other Listing features beckons follow-up questions as to why a partial redundant mention is relevant for some features of the Listing but not the others.

Some NEC text has inferences that a Listing requirement exists without an actual requirement of a Listing ever being stated overtly, only as an inference that the requirement already exists. Conditional statements employing logical grouping sometimes miss clear meaning due to commas missing at relevant points of the sentence.

The benefit that the above comments hope to achieve is in universal applications of Listing requirements as a categorical default wherever practicable, with caveats to follow as to exceptions or specialty additions, such that taken together, the Code edits would amount to less text and simpler forms of clarity. It would be an aide, perhaps suited to Chapter 9 indexes if nowhere else, to have a running list of all potential types of Listings that may be suited to electrical applications governed by NEC. Of course, such a reference list would be subject to on-going updates, but to see them all is perhaps the opportune way to know them.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
<u>Public Input No. 4586-NFPA 70-2020 [Definition: Labeled.]</u>	similar topic
<u>Public Input No. 4591-NFPA 70-2020 [Definition: Listed.]</u>	similar topic

[Public Input No. 4619-NFPA 70-2020 \[Section No. 110.3\(B\)\]](#)

[similar topic](#)

[Public Input No. 4624-NFPA 70-2020 \[Section No. 110.3\(C\)\]](#)

[similar topic](#)

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 18:05:35 EDT 2020

Committee: NEC-P01

Copyright Assignment

I, John Blissett, 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 John Blissett, 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. 233-NFPA 70-2020 [Part I.]

Part I. General

Add definition

Emergency disconnect- a disconnecting means that has a Red Lever handle and will disconnect all grounded and ungrounded conductors . This disconnect will meet all lockout standards in NFPA 70e

Statement of Problem and Substantiation for Public Input

This will allow all first responders to properly lock out and isolate all energy in system for the team.

Submitter Information Verification

Submitter Full Name: Joseph Bednarik

Organization: IBEW 223

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jan 01 18:27:19 EST 2020

Committee: NEC-P01

Copyright Assignment

I, Joseph Bednarik, 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. Except to the extent that I may lack authority to make an assignment of content identified above, 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 Joseph Bednarik, 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. 1091-NFPA 70-2020 [New Part after II.]

TITLE OF NEW CONTENT

Type your content here .. Retrofit Trip Units for Power Circuit Breakers. _ Retrofit trip units shall be listed for use with the specific circuit breaker with which it is installed.

Statement of Problem and Substantiation for Public Input

To apply to power circuit breakers used in assemblies covered by Section 408.

Submitter Information Verification

Submitter Full Name: David Bredhold

Organization: DB Technical Services

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 16 09:39:07 EDT 2020

Committee: NEC-P09

Copyright Assignment

I, David Bredhold, 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 David Bredhold, 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. 1882-NFPA 70-2020 [New Definition after Definition: Conductor, Insulated.]

Conductor, System

Circuit conductors that are on the supply side of the main disconnect or transfer switch in systems where the supply source is not considered a service.

Statement of Problem and Substantiation for Public Input

The term "System Conductor" is used 12 times in the 2020 NEC and the usage is confined to Articles 100 and 250. In each instance of usage, it is describing a grounded conductor and in 11 of the 12 instances it is part of the term "Grounded System Conductor". The term "Circuit Conductor" is used 81 times throughout the 2020 NEC. The term "Grounded Circuit Conductor" is used 43 times throughout the 2020 NEC and 10 times in Article 250.

In Articles 100 and 250, it is not clear that there is a difference between a "Grounded System Conductor" and a "Grounded Circuit Conductor", these terms appear to be used interchangeably.

If it is not the intent that these terms be used interchangeably:

- Definitions should be provided as proposed in PIs 1881-NFPA 70-2020 and 1882-NFPA 70-2020 to delineate the unique features of a "System Conductor" versus those of a "Circuit Conductor"
- PIs 1883-NFPA 70-2020 , 1906-NFPA 70-2020 , 1892-NFPA 70-2020 , 1893-NFPA 70-2020 , 1904-NFPA 70-2020 , and 1905-NFPA 70-2020 should be disregarded

If it is the intent that the two terms are to be used interchangeably:

- All instances of "System Conductor" should be changed to "Circuit Conductor"
- PIs 1883-NFPA 70-2020 , 1906-NFPA 70-2020 , 1892-NFPA 70-2020 , 1893-NFPA 70-2020 , 1904-NFPA 70-2020 , and 1905-NFPA 70-2020 should be accepted to change instances of "system conductor" to "circuit conductor"
- PI 1881-NFPA 70-2020 may be helpful in this scenario to clarify the meaning of the term "Circuit Conductor"
- Replacing all instances of "Circuit Conductor" with "System Conductor" and defining the term "System Conductor" would accomplish the same goal. "Circuit Conductor" is presently more used throughout the NEC, so the proposal above requires a smaller number of revisions.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 1881-NFPA 70-2020 [New Definition after Definition: Conductor, Bare.]	
Public Input No. 1906-NFPA 70-2020 [Section No. 250.36(B)]	
Public Input No. 1893-NFPA 70-2020 [Section No. 250.84]	
Public Input No. 1904-NFPA 70-2020 [Section No. 250.187(C)]	
Public Input No. 1905-NFPA 70-2020 [Section No. 250.34(C)]	
Public Input No. 1883-NFPA 70-2020 [Definition: Grounded Conductor.]	

Public Input No. 1892-NFPA 70-2020 [Section No. 250.80]

Submitter Information Verification

Submitter Full Name: John Cowans

Organization: Siemens

Street Address:

City:

State:

Zip:

Submission Date: Mon Jul 13 15:41:04 EDT 2020

Committee: NEC-P04

Copyright Assignment

I, John Cowans, 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 John Cowans, 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. 4337-NFPA 70-2020 [Global Input]**

Many diverse undefined terminologies are used to invoke some manner of required approval from an AHJ. It may benefit the clarity of intent to either consolidate the use of terminologies or to define their distinctions in respect to each other, or to do some combination of both.

Statement of Problem and Substantiation for Public Input**BASIS FOR CODE REVISION**

Here are examples of the diverse types of AHJ approval requirements in code;

1. Approved means; 215.12(C)(1), 215.12(C)(2), 230.24, 230.30(A&B), 230.40, 230.50(B), 230.51, 230.53, 240.5(B)(1), 240.21(B)(2&3), 240.67(A), 250.6(B) 250.68(C)(2), 250.70 (4), 250.94 exception (3), 300.4(H), 300.5, 300.5(F), 300.5(K), 300.6(A)(2), 300.6(A)(2), 300.6(A)(3), 300.6(C)(1), 300.6(C)(2), 300.11(C), 300.15, 300.19(B&C), 300.21, 300.25, 300.50(C).
2. Acceptable to AHJ; 500.8(A), 505.9, 506.9(A).
3. Made available if requested by AHJ; 110.31(A)(3), 110.70, 215.5, 225.56(A) 399.30(A), 399.30(B), 691.6, 691.7, 691.8, 691.9.
4. Made available to AHJ; 110.41, 230.95(C), 240.67(C), 240.87(C) 490.48(A), 517.17(D), 590.6(B)(2), 645.27.
5. Given to AHJ prior to energization; 225.56(B).
6. If Adopted by Local AHJ; 220.12(B), 225.22, 225.36.
7. Preventative Maintenance Plan Required by AHJ; 708.6 (A-E)
8. Initial/Periodic Witness Test by AHJ; 700.3(A), 700.3(D), 708.6 (A-E).

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 10:37:56 EDT 2020

Committee: NEC-P01

Copyright Assignment

I, John Blissett, 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 John Blissett, 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. 3202-NFPA 70-2020 [New Article after 100]****TITLE OF NEW CONTENT**

Type your content here ... [Voltage Stabilizing Ground Reference \(VSGR\) System](#) – an engineered assembly of interconnected passive inductive devices that utilize mutual counter electro-magnetic inductance to stabilize phase voltages of a connected supply system with respect to each other and to ground.

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Code_Input.docx	Changes proposed for OVERVOLTAGE protection	

Statement of Problem and Substantiation for Public Input

In the 2020 NEC cycle, ARTICLES 280 and 285 were combined to make ARTICLE 242. This was a positive change that began to address the issue of OVERVOLTAGE as a technical subject apart from particular product methods (SPDs and Surge Arresters). There are other technologies and products to address the issue of OVERVOLTAGE. This input attempts to add one such technology as well as correlate the other code references to the subject of OVERVOLTAGE, surge protective devices, and surge arresters to be consistent. This is important to allow for other technologies to be utilized without prejudice to certain products promoted by manufacturers.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
<u>Public Input No. 3200-NFPA 70-2020 [Section No. 242.1]</u>	

Submitter Information Verification

Submitter Full Name: Karl Cunningham
Organization: Self Employed
Street Address:
City:
State:
Zip:
Submittal Date: Sun Sep 06 18:04:16 EDT 2020
Committee: NEC-P10

Substantiation for Changes: In the 2020 NEC cycle, ARTICLES 280 and 285 were combined to make ARTICLE 242. This was a positive change that began to address the issue of **OVERVOLTAGE** as a technical subject apart from particular product methods (SPDs and Surge Arresters). There are other technologies and products to address the issue of **OVERVOLTAGE**. This input attempts to add one such technology as well as correlate the other code references to the subject of **OVERVOLTAGE**, surge protective devices, and surge arresters to be consistent. This is important to allow for other technologies to be utilized without prejudice to certain products promoted by manufacturers.

ARTICLE 100 - DEFINITIONS

Voltage Stabilizing Ground Reference (VSGR) System – an engineered assembly of interconnected passive inductive devices that utilize mutual counter electro-magnetic inductance to stabilize phase voltages of a connected supply system with respect to each other and to ground.

ARTICLE 242 Overvoltage Protection

Part I. General

242.1 Scope.

This article provides the general requirements, installation requirements, and connection requirements for overvoltage protection and overvoltage protective devices. Part II covers surge-protective devices (SPDs) permanently installed on premises wiring systems of not more than 1000 volts, nominal, while Part III covers surge arresters permanently installed on premises wiring systems over 1000 volts, nominal. Part IV covers Voltage Stabilizing Ground Reference (VSGR) systems permanently installed on premises wiring systems for any voltage.

Informational Note: Article [242](#) combines and replaces Articles 280 and 285 in *NFPA 70-2017*.

242.3 Other Articles.

Equipment shall be protected against overvoltage in accordance with the article in this *Code* that covers the type of equipment or location specified in [Table 242.3](#).

Table 242.3 Other Articles

Equipment	Article
Class I locations	501
Class II locations	502
Community antenna television and radio distribution systems	820
Critical operations power systems	708

Table 242.3 Other Articles

Equipment	Article
Elevators, dumbwaiters, escalators, moving walks, platform lifts, and stairway chairlifts	620
Emergency systems	700
Equipment over 1000 volts, nominal	490
Fire pumps	695
Industrial machinery	670
Information technology equipment	645
Modular data centers	646
Outdoor overhead conductors over 1000 volts	399
Radio and television equipment	810
Receptacles, cord connectors, and attachment plugs (caps)	406
Wind electric systems	694

Part II. Surge-Protective Devices (SPDs), 1000 Volts or Less

Informational Note: Surge arresters 1000 volts or less are also known as Type 1 SPDs.

242.6 Uses Not Permitted.

An SPD device shall not be installed in the following:

1. (1)

Circuits over 1000 volts

2. (2)

On ungrounded systems, impedance grounded systems, or corner grounded delta systems unless listed specifically for use on these systems

3. (3)

Where the rating of the SPD is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application

242.8 Listing.

An SPD shall be a listed device.

242.10 Short-Circuit Current Rating.

The SPD shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating. This marking requirement shall not apply to receptacles.

242.12 Type 1 SPDs.

Type 1 SPDs shall be installed in accordance with [242.12\(A\)](#) and (B).

242.12(A) Installation.

Type 1 SPDs shall be permitted to be connected in accordance with one of the following:

1. (1)

To the supply side of the service disconnect as permitted in [230.82](#)(4)

2. (2)

As specified in [242.14](#)

242.12(B) At the Service.

When installed at services, Type 1 SPDs shall be connected to one of the following:

1. (1)

Grounded service conductor

2. (2)

Grounding electrode conductor

3. (3)

Grounding electrode for the service

4. (4)

Equipment grounding terminal in the service equipment

242.14 Type 2 SPDs.

Type 2 SPDs shall be installed in accordance with [242.14\(A\)](#) through (C).

242.14(A) Service-Supplied Building or Structure.

Type 2 SPDs shall be connected anywhere on the load side of a service disconnect overcurrent device required in [230.91](#) unless installed in accordance with [230.82](#)(8).

242.14(B) Feeder-Supplied Building or Structure.

Type 2 SPDs shall be connected at the building or structure anywhere on the load side of the first overcurrent device at the building or structure.

242.14(C) Separately Derived System.

The SPD shall be connected on the load side of the first overcurrent device in a separately derived system.

242.16 Type 3 SPDs.

Type 3 SPDs shall be permitted to be installed on the load side of branch-circuit overcurrent protection up to the equipment served. If included in the manufacturer's instructions, the Type 3 SPD connection shall be a minimum 10 m (30 ft) of conductor distance from the service or separately derived system disconnect.

242.18 Type 4 and Other Component Type SPDs.

Type 4 component assemblies and other component type SPDs shall only be installed by the equipment manufacturer.

242.20 Number Required.

Where used at a point on a circuit, the SPD shall be connected to each ungrounded conductor.

242.22 Location.

SPDs shall be permitted to be located indoors or outdoors and shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.24 Routing of Connections.

The conductors used to connect the SPD to the line or bus and to ground shall not be any longer than necessary and shall avoid unnecessary bends.

242.26 Connection.

Where an SPD device is installed, it shall comply with [242.12](#), [242.14](#), [242.16](#), [242.28](#), and [242.30](#).

242.28 Conductor Size.

Line and grounding conductors shall not be smaller than 14 AWG copper or 12 AWG aluminum.

242.30 Connection Between Conductors.

An SPD shall be permitted to be connected between any two conductors — ungrounded conductor(s), grounded conductor, equipment grounding conductor, or grounding electrode conductor. The grounded conductor and the equipment grounding conductor shall be interconnected only by the normal operation of the SPD during a surge.

242.32 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, SPD grounding connections shall be made as specified in Article [250](#), Part III. Grounding electrode conductors installed in metal enclosures shall comply with [250.64\(E\)](#).

Part III. Surge Arresters, Over 1000 Volts**242.40 Uses Not Permitted.**

A surge arrester shall not be installed where the rating of the surge arrester is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application.

242.42 Surge Arrester Selection.

The surge arresters shall comply with [242.42\(A\)](#) and (B).

242.42(A) Rating.

The rating of a surge arrester shall be equal to or greater than the maximum continuous operating voltage available at the point of application.

242.42(A)(1) Solidly Grounded Systems.

The maximum continuous operating voltage shall be the phase-to-ground voltage of the system.

242.42(A)(2) Impedance or Ungrounded System.

The maximum continuous operating voltage shall be the phase-to-phase voltage of the system.

242.42(B) Silicon Carbide Types.

The rating of a silicon carbide-type surge arrester shall be not less than 125 percent of the rating specified in [242.42\(A\)](#).

Informational Note No. 1: For further information on surge arresters, see IEEE C62.11-2012, *Standard for Metal-Oxide Surge Arresters for Alternating-Current Power Circuits (>1 kV)*, and IEEE C62.22-2009, *Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems*.

Informational Note No. 2: The selection of a properly rated metal oxide arrester is based on considerations of maximum continuous operating voltage and the magnitude and duration of overvoltages at the arrester location as affected by phase-to-ground faults, system grounding techniques, switching surges, and other causes. See the manufacturer's application rules for selection of the specific arrester to be used at a particular location.

242.44 Number Required.

Where used at a point on a circuit, a surge arrester shall be connected to each ungrounded conductor. A single installation of such surge arresters shall be permitted to protect a number of interconnected circuits if no circuit is exposed to surges while disconnected from the surge arresters.

242.46 Location.

Surge arresters shall be permitted to be located indoors or outdoors. Surge arresters shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.48 Routing of Surge Arrester Equipment Grounding Conductors.

The conductor used to connect the surge arrester to line, bus, or equipment and to an equipment grounding conductor or grounding electrode connection point as provided in [242.50](#) shall not be any longer than necessary and shall avoid unnecessary bends.

242.50 Connection.

The arrester shall be connected to one of the following:

1. (1)
Grounded service conductor
2. (2)
Grounding electrode conductor
3. (3)
Grounding electrode for the service
4. (4)
Equipment grounding terminal in the service equipment

242.52 Surge-Arrester Conductors.

The conductor between the surge arrester and the line, and the surge arrester and the grounding connection, shall not be smaller than 6 AWG copper or aluminum.

242.54 Interconnections.

The surge arrester protecting a transformer that supplies a secondary distribution system shall be interconnected as specified in [242.54\(A\)](#), (B), or (C).

242.54(A) Metal Interconnections.

A metal interconnection shall be made to the secondary grounded circuit conductor or the secondary circuit grounding electrode conductor, if, in addition to the direct grounding connection at the surge arrester, the connection complies with [242.54\(A\)\(1\)](#) or (A)(2).

242.54(A)(1) Additional Grounding Connection.

The grounded conductor of the secondary has a grounding connection elsewhere to a continuous metal underground water piping system. In urban water-pipe areas where there are at least four water-pipe connections on the neutral conductor and not fewer than four such connections in each mile of neutral conductor, the metal interconnection shall be permitted to be made to the secondary neutral conductor with omission of the direct grounding connection at the surge arrester.

242.54(A)(2) Multigrounded Neutral System Connection.

The grounded conductor of the secondary system is part of a multigrounded neutral system or static wire of which the primary neutral conductor or static wire has at least four grounding connections in each 1.6 km (1 mile) of line in addition to a grounding connection at each service.

242.54(B) Through Spark Gap or Device.

Where the surge arrester grounding electrode conductor is not connected as in [242.54\(A\)](#), or where the secondary is not grounded as in [242.54\(A\)](#) but is otherwise grounded as in [250.52](#), an interconnection shall be made through a spark gap or listed device as required by [242.54\(B\)\(1\)](#) or (B)(2).

242.54(B)(1) Ungrounded or Ungrounded Primary System.

For ungrounded or ungrounded primary systems, the spark gap for a listed device shall have a 60-Hz breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge-arrester grounding electrode.

242.54(B)(2) Multigrounded Neutral Primary System.

For multigrounded neutral primary systems, the spark gap or listed device shall have a 60-Hz breakdown of not more than 3 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge-arrester grounding electrode.

242.54(C) By Special Permission.

An interconnection of the surge-arrester ground and the secondary neutral conductor, other than as provided in [242.54\(A\)](#) or (B), shall be permitted to be made only by special permission.

242.56 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, surge-arrester grounding electrode conductor connections shall be made as specified in Article [250](#), Parts III and X. Grounding electrode conductors installed in metal enclosures shall comply with [250.64\(E\)](#).

Part IV. Voltage Stabilizing Ground Reference (VSGR) systems.**242.68 Listing.**

A VSGR shall be a listed device or system composed of listed components.

242.70 Short-Circuit Current Rating.

The VSGR shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating.

242.71 Voltage Rating.

The rating of the VSGR shall be equal to or greater than the maximum system continuous operating voltage at the point of application.

242.72 Installation.

VSGRs shall be installed in accordance with 242.72(A) through (C).

242.72(A) Service-Supplied Building or Structure.

VSGR shall be connected anywhere on the load side of a service disconnect overcurrent device required in 230.91 unless installed in accordance with 230.82(8).

242.72(B) Feeder-Supplied Building or Structure.

VSGR shall be connected at the building or structure anywhere on the load side of the first overcurrent device at the building or structure.

242.72(C) Separately Derived System.

VSGR shall be connected on the load side of the first overcurrent device in a separately derived system.

242.82 Location.

VSGRs shall be permitted to be located indoors or outdoors and shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.84 Conductor Size.

Line and grounding conductors shall not be smaller than 14 AWG copper or 12 AWG aluminum.

242.90 Connection Between Conductors.

VSGR connections shall follow the manufacturer's instructions for the system connections.

242.92 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, VSGR grounding connections shall be made as specified in Article 250, Part III. Grounding electrode conductors installed in metal enclosures shall comply with 250.64(E).

501.35 Overvoltage Surge Protection.**501.35(A) Class I, Division 1.**

Overvoltage protection devices, surge arresters, surge-protective devices, and capacitors shall be installed in enclosures identified for Class I, Division 1 locations. Surge-protective capacitors shall be of a type designed for specific duty.

501.35(B) Class I, Division 2.

Overvoltage protection devices, surge arresters and surge-protective devices shall be nonarcing, such as metal-oxide varistor (MOV) sealed type, and surge-protective capacitors shall be of a type designed for specific duty. Enclosures shall be permitted to be of the general-purpose type. Overvoltage Surge protection of types other than described in this paragraph shall be installed in enclosures identified for Class I, Division 1 locations.

502.35 Overvoltage Surge Protection — Class II, Divisions 1 and 2.

Overvoltage protection devices, surge arresters and surge-protective devices installed in a Class II, Division 1 location shall be in suitable enclosures. Surge-protective capacitors shall be of a type designed for specific duty.

551.72(E) Connected Devices.

The use of autotransformers shall not be permitted. The use of listed overvoltage and surge protective devices shall be permitted.

Table 490.24 Minimum Clearance of Live Parts

Note: The values given are the minimum clearance for rigid parts and bare conductors under favorable service conditions. They shall be increased for conductor movement or under unfavorable service conditions or wherever space limitations permit. The selection of the associated impulse withstand voltage for a particular system voltage is determined by the characteristics of the [overvoltage surge](#) protective equipment.

490.48(A) Design and Documentation.

(12) [Overvoltage Surge](#) arresters

620.51(E) [Overvoltage Surge](#) Protection.

[Overvoltage protection shall be provided](#) where any of the disconnecting means in [620.51](#) has been designated as supplying an emergency system load, a legally required system load, or a critical operation power system load, ~~listed surge protection shall be provided.~~

645.18 [Overvoltage Surge](#) Protection for Critical Operations Data Systems.

[Overvoltage Listed surge](#) protection shall be provided for critical operations data systems.

670.6 Surge Protection.

Industrial machinery with safety interlock ~~control devices not effectively protected from voltage surges on the incoming supply circuit~~ shall have [overvoltage surge](#) protection installed.

694.7(D) [Overvoltage Protection Surge Protective Devices \(SPD\)](#).

[Overvoltage protection A surge protective device](#) shall be installed between a wind electric system and any loads served by the premises electrical system. The [surge](#) protective device shall be permitted to be a [VSGR](#), or a Type 3 SPD on the circuit serving a wind electric system, or a Type 2 SPD located anywhere on the load side of the service disconnect. [Overvoltage Surge](#) protective devices shall be installed in accordance with Part II of Article [242](#).

695.15 [Overvoltage Surge](#) Protection.

[Overvoltage A listed surge](#) protection ~~device~~ shall be [provided for installed in or on](#) the fire pump controller.

700.8 [Overvoltage Surge](#) Protection.

[Overvoltage protection A listed SPD](#) shall be [provided installed in or on for](#) all emergency systems switchboards and panelboards.

708.20(D) Overvoltage Surge Protection Devices.

Surge protection devices shall be provided at all facility distribution voltage levels

**Public Input No. 4269-NFPA 70-2020 [New Article after 100]****TITLE OF NEW CONTENT**

Short Circuit. An abnormal connection (including an arc) of relatively low impedance, whether made accidentally or intentionally, between two points of different potential.

Informational Note: The term fault or short-circuit fault is used to describe a short circuit. (IEEE 100-1992, The New IEEE Standard Dictionary of Electrical and Electronic Terms, 5th Edition)

Statement of Problem and Substantiation for Public Input

The phrase "Short Circuit" appears in several locations throughout the NEC. It would seem prudent that a definition of this term be found in the NEC. This definition would be best suited to be located in Part I of Article 100. It was not my intent for this definition to be located after definitions located in Part 3. If acted upon favorably by the code making panel, this definition should be found in alphabetical order in Part 1 of the Article 100 Definitions.

It seems the definition is needed so that the user of the Code understands from the NEC definitions what a short circuit is and is not. Currently the user of the Code must rely on other industry manuals and documents to determine the definition of this term.

Below are some of the locations that this phrase is used in the NEC: (partial list and not an all-inclusive list)

- 90.8(B)
- Definition of fault current
- Informational Note of Fault Current, Available
- Informational Note Figure 100.1 Available Fault Current
- Definition of Overcurrent
- Definition of Overload
- 110.7
- 110.10
- 110.36

Submitter Information Verification

Submitter Full Name: Joseph Wages

Organization: Self

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 08:52:47 EDT 2020

Committee: NEC-P10

**Public Input No. 4506-NFPA 70-2020 [Definition: Adjustable (as applied to circuit breakers).]****Circuit Breaker, Adjustable- (as applied to circuit breakers ,_(Adjustable Circuit Breaker).**

A qualifying term indicating that the circuit breaker can be set to trip at various values of current, time, or both, within a predetermined range. (CMP-10)

Statement of Problem and Substantiation for Public Input

This revision is to account for the revised NEC Style Manual.
The defined term is separated by a comma and then the modifying descriptor.
For electronic searching the term is listed in parentheses.
The Code Panel designation was also added.

Submitter Information Verification

Submitter Full Name: David Williams
Organization: Delta Charter Township
Street Address:
City:
State:
Zip:
Submittal Date: Thu Sep 10 14:24:46 EDT 2020
Committee: NEC-P10

**Public Input No. 3501-NFPA 70-2020 [Definition: Circuit Breaker.]****Circuit Breaker.**

~~A switching device capable of making, carrying, and interrupting currents under normal circuit conditions, and also of making, carrying for a specified time, and interrupting currents under specified abnormal circuit conditions, such as those of short circuit.~~

Statement of Problem and Substantiation for Public Input

Delete this definition for Switching Device, Circuit Breaker. It is not used or necessary. The current term Circuit Breaker includes over 1,000 volts as well. When searching the NEC for those terms used together, there are no matches?

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 18:04:58 EDT 2020

Committee: NEC-P10



Public Input No. 159-NFPA 70-2019 [Definition: Electronically Actuated Fuse.]

Fuse. An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it. (CMP-10)

Fuse. ~~Electronically Actuated Fuse~~ .

An overcurrent protective device that generally consists of a control module that provides current-sensing, electronically derived time–current characteristics, energy to initiate tripping, and an interrupting module that interrupts current when an overcurrent occurs. Such fuses may or may not operate in a current-limiting fashion, depending on the type of control selected. (CMP-10)

Statement of Problem and Substantiation for Public Input

Editorially relocate the definition of fuse from Part II to Part I of Article 100. Also, editorially revise the way Electronically Actuated Fuse appears moving "Fuse," to appear first. Also, place this in alphabetical order in Part I. The definition of fuse is not unique to over 1,000 volts. Its placement in Part I would have this definition apply "wherever the term is used throughout this Code per the Article 100 scope. The definition of fuse only applies to over 1,000 volts due to its present placement in Part II of Article 100.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 158-NFPA 70-2019 [Definition: Fuse.]	Correlate relocation.
Public Input No. 157-NFPA 70-2019 [Definition: Fuse.]	

Submitter Information Verification

Submitter Full Name: Palmer Hickman
Organization: Electrical Training Alliance
Street Address:
City:
State:
Zip:
Submission Date: Wed Nov 27 14:33:58 EST 2019
Committee: NEC-P10



Public Input No. 4687-NFPA 70-2020 [Definition: Electronically Actuated Fuse.]

Electronically Actuated Fuse.

An overcurrent protective device that generally consists of a control module that provides current sensing, electronically derived time-current characteristics, energy to initiate tripping, and an interrupting module that interrupts current when an overcurrent occurs. Electronically actuated fuses may or may not operate in a current-limiting fashion, depending on the type of control selected. (CMP-10)

([Delete this Definition](#))

Statement of Problem and Substantiation for Public Input

The term Electronically Actuated Fuse is defined by CMP-10 in Part I and Part II of Article 100.

Delete this term in Part II of Article 100.

The NEC Style Manual revisions in Section 2.2.2 and its subdivisions requires multiple changes to the definitions in Article 100 and all Articles in the NEC including the use of acronyms in Section 3.2.3. Every panel should review all definitions under their purview and make the necessary changes to comply with the style manual revisions. Section 2.2.2.4 Terms with Multiple Definitions. Where two or more definitions exist for a term, a task group shall be formed to work on the development of a single acceptable definition. When this cannot be accomplished, another term shall be selected or the term shall be identified in the context of the specific application.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 16:47:29 EDT 2020

Committee: NEC-P10



Public Input No. 4691-NFPA 70-2020 [Definition: Electronically Actuated Fuse.]

Electronically Actuated Fuse.

An overcurrent protective device that generally consists of a control module that provides current-sensing, electronically derived time–current characteristics, energy to initiate tripping, and an interrupting module that interrupts current when an overcurrent occurs. ~~Such Electronically actuated~~ fuses may or may not operate in a current-limiting fashion, depending on the type of control selected. (CMP-10)

Statement of Problem and Substantiation for Public Input

"The term Electronically Actuated Fuse is defined by CMP-10 in Part I and Part II of Article 100. This definition was modified for clarity and submitted another Public Input to delete this term in Part II of Article 100. The NEC Style Manual revisions in Section 2.2.2 and its subdivisions requires multiple changes to the definitions in Article 100 and all Articles in the NEC including the use of acronyms in Section 3.2.3. Every panel should review all definitions under their purview and make the necessary changes to comply with the style manual revisions. Section 2.2.2.4 Terms with Multiple Definitions. Where two or more definitions exist for a term, a task group shall be formed to work on the development of a single acceptable definition. When this cannot be accomplished, another term shall be selected or the term shall be identified in the context of the specific application."

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 16:52:56 EDT 2020

Committee: NEC-P10

**Public Input No. 3140-NFPA 70-2020 [Definition: Feeder.]****Feeder.**

All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source other than a PV system inverter output and the final branch-circuit overcurrent device. (CMP-10)

Statement of Problem and Substantiation for Public Input

PV inverter output conductors are not considered feeders and do not follow any feed conductor rules. The way the section is written it would include this type of power supply source which would contradict and cause confusion of the issue.

Submitter Information Verification

Submitter Full Name: Alfio Torrisi

Organization: Master electrician

Street Address:

City:

State:

Zip:

Submittal Date: Sat Sep 05 12:08:02 EDT 2020

Committee: NEC-P10

**Public Input No. 157-NFPA 70-2019 [Definition: Fuse.]****Fuse.**

An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it. (CMP-10)

Informational Note: _

A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Controlled Vented Power Fuse.

A fuse with provision for controlling discharge circuit interruption such that no solid material may be exhausted into the surrounding atmosphere.

Informational Note: The fuse is designed so that discharged gases will not ignite or damage insulation in the path of the discharge or propagate a flashover to or between grounded members or conduction members in the path of the discharge where the distance between the vent and such insulation or conduction members conforms to manufacturer's recommendations.

Expulsion Fuse Unit (Expulsion Fuse).

A vented fuse unit in which the expulsion effect of gases produced by the arc and lining of the fuseholder, either alone or aided by a spring, extinguishes the arc.

Nonvented Power Fuse.

A fuse without intentional provision for the escape of arc gases, liquids, or solid particles to the atmosphere during circuit interruption.

Power Fuse Unit.

A vented, nonvented, or controlled vented fuse unit in which the arc is extinguished by being drawn through solid material, granular material, or liquid, either alone or aided by a spring.

Vented Power Fuse.

A fuse with provision for the escape of arc gases, liquids, or solid particles to the surrounding atmosphere during circuit interruption.

Statement of Problem and Substantiation for Public Input

Relocate the definition of "fuse" from Part II to Part I of Article 100. The term "fuse" is not presently defined in Part I and the definition of a fuse is not unique to its use for over 1,000 volts as it is because of it being located in Part II.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 159-NFPA 70-2019 [Definition: Electronically Actuated Fuse.]	Correlate relocation.
Public Input No. 158-NFPA 70-2019 [Definition: Fuse.]	

Submitter Information Verification

Submitter Full Name: Palmer Hickman
Organization: Electrical Training Alliance
Street Address:
City:
State:
Zip:
Submittal Date: Wed Nov 27 11:33:28 EST 2019
Committee: NEC-P10



Public Input No. 158-NFPA 70-2019 [Definition: Fuse.]

Fuse.

An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it. (CMP-10)

Informational Note: _ _

A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Fuse, Controlled Vented Power- Fuse .

A fuse with provision for controlling discharge circuit interruption such that no solid material may be exhausted into the surrounding atmosphere.

Informational Note: The fuse is designed so that discharged gases will not ignite or damage insulation in the path of the discharge or propagate a flashover to or between grounded members or conduction members in the path of the discharge where the distance between the vent and such insulation or conduction members conforms to manufacturer's recommendations.

Fuse, Expulsion Fuse Unit (Expulsion Fuse).

A vented fuse unit in which the expulsion effect of gases produced by the arc and lining of the fuseholder, either alone or aided by a spring, extinguishes the arc.

Fuse, Nonvented Power- Fuse .

A fuse without intentional provision for the escape of arc gases, liquids, or solid particles to the atmosphere during circuit interruption.

Fuse, Power Fuse Unit.

A vented, nonvented, or controlled vented fuse unit in which the arc is extinguished by being drawn through solid material, granular material, or liquid, either alone or aided by a spring.

Fuse, Vented Power- Fuse .

A fuse with provision for the escape of arc gases, liquids, or solid particles to the surrounding atmosphere during circuit interruption.

Statement of Problem and Substantiation for Public Input

The subcategories of fuses are editorially revised by placing "fuse," first and making the balance of the defined term appear next so that they remain in Part II and in alphabetical order as a type of fuse unique to Part II.

Related Public Inputs for This Document

Related Input

Public Input No. 157-NFPA 70-2019
[Definition: Fuse.]

Public Input No. 159-NFPA 70-2019
[Definition: Electronically Actuated Fuse.]

Relationship

To correlate the relocation of the definition of "fuse" to Part I. This is additionally related to Public Input No. 159-NFPA 70-2019.

Submitter Information Verification

Submitter Full Name: Palmer Hickman

Organization: Electrical Training Alliance

Street Address:

City:

State:

Zip:

Submittal Date: Wed Nov 27 13:18:03 EST 2019

Committee: NEC-P10



Public Input No. 4532-NFPA 70-2020 [Definition: Instantaneous Trip (as applied to circuit break...]

Circuit Breaker, Instantaneous Trip (as applied to circuit breakers Instantaneous Trip Circuit Breaker).

A qualifying term indicating that no delay is purposely introduced in the tripping action of the circuit breaker.
(CMP-10)

Statement of Problem and Substantiation for Public Input

"This revision is to account for the revised NEC Style Manual.
The defined term is separated by a comma and then the modifying descriptor.
For electronic searching the term is listed in parentheses.
The Code Panel designation was also added."

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 14:47:34 EDT 2020

Committee: NEC-P10

**Public Input No. 4537-NFPA 70-2020 [Definition: Inverse Time (as applied to circuit breakers).]****Circuit Breaker, Inverse Time (as applied to circuit breakers Inverse Time Circuit Breaker).**

A qualifying term indicating that there is purposely introduced a delay in the tripping action of the circuit breaker, which delay decreases as the magnitude of the current increases. (CMP-10)

Statement of Problem and Substantiation for Public Input

"This revision is to account for the revised NEC Style Manual.
The defined term is separated by a comma and then the modifying descriptor.
For electronic searching the term is listed in parentheses.
The Code Panel designation was also added."

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 14:50:27 EDT 2020

Committee: NEC-P10



Public Input No. 4542-NFPA 70-2020 [Definition: Nonadjustable (as applied to circuit breakers).]

Circuit Breaker, Nonadjustable (as applied to circuit breakers Nonadjustable Circuit Breaker).

A qualifying term indicating that the circuit breaker does not have any adjustment to alter the value of the current at which it will trip or the time required for its operation. (CMP-10)

Statement of Problem and Substantiation for Public Input

"This revision is to account for the revised NEC Style Manual.
The defined term is separated by a comma and then the modifying descriptor.
For electronic searching the term is listed in parentheses.
The Code Panel designation was also added."

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 14:53:24 EDT 2020

Committee: NEC-P10



Public Input No. 2007-NFPA 70-2020 [Definition: Overcurrent Protective Device, Branch-Circuit.]

Overcurrent Protective Device, ~~Branch-Circuit~~ .

A device capable of providing protection for service, feeder, and branch circuits and equipment over the full range of overcurrents between its rated current and its interrupting rating. Such devices are provided with interrupting ratings appropriate for the intended use but no less than 5000 amperes. (CMP-10)

Statement of Problem and Substantiation for Public Input

The words "branch circuit" do not belong in the term as it applies to the protection of service conductors, feeder conductors as well as branch circuit conductors.

Submitter Information Verification

Submitter Full Name: Don Ganiere

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 25 14:30:31 EDT 2020

Committee: NEC-P10



Public Input No. 4559-NFPA 70-2020 [Definition: Overcurrent Protective Device, Supplementary.]

Overcurrent Protective Device, Supplementary. (Supplementary Overcurrent Protective Device)

A device intended to provide limited overcurrent protection for specific applications and utilization equipment such as luminaires and appliances. This limited protection is in addition to the protection provided in the required branch circuit by the branch-circuit overcurrent protective device. (CMP-10)

Statement of Problem and Substantiation for Public Input

This revision is to account for the revised NEC Style Manual.
For electronic searching the term is listed in parentheses.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 15:09:12 EDT 2020

Committee: NEC-P10

**Public Input No. 358-NFPA 70-2020 [Definition: Overcurrent.]****Overcurrent.**

Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload condition , short circuit condition , or ground fault condition . (CMP-10)

Informational Note: A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore, the rules for overcurrent protection are specific for particular situations.

Statement of Problem and Substantiation for Public Input

This change is clearer and better aligns with the changes to the 2020 NEC resulting from the PIs submitted by the Fault Current Working Group under the Correlating Committee

Submitter Information Verification

Submitter Full Name: Timothy Crnko

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jan 23 13:48:47 EST 2020

Committee: NEC-P10

**Public Input No. 359-NFPA 70-2020 [Definition: Overload.]****Overload Condition (Overload) .**

Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of its ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. ~~A fault, such as a short circuit. A short-circuit condition~~ or ground fault ~~, is condition is~~ not an overload condition . (CMP-10)

Statement of Problem and Substantiation for Public Input

This change is clearer and better aligns with the changes to the 2020 NEC resulting from the PIs submitted by the Fault Current Working Group under the Correlating Committee.

Submitter Information Verification

Submitter Full Name: Timothy Crnko

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Thu Jan 23 14:04:49 EST 2020

Committee: NEC-P10



Public Input No. 1790-NFPA 70-2020 [Definition: Reconditioned.]

Reconditioned.

Electromechanical systems, equipment, ~~apparatus components~~ , or ~~components that materials that~~ are restored to operating conditions and to suitability for the specific purpose, function, use, environment, application, and so forth . This process differs from ~~normal routine servicing, maintenance or repair of systems, equipment, or materials that remains remain installed~~ within a facility, or replacement of ~~listed equipment~~ on a one-to-one basis of ~~listed equipment or components thereof~~ . This process excludes salvaging without restoration of ~~systems, equipment, components or materials that have been previously installed at another facility.~~ (CMP-10)

Informational Note: The term *reconditioned* ~~is~~ is frequently referred to as *rebuilt*, *refurbished*, or *remanufactured*.

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Public_Input_No._1790-NFPA_70-2020_Definition_Reconditioned_.docx	Clean MSWord DOCX copy of this Public Input No. 1790 WITHOUT TerraView alteration of the Submitter's intent	

Statement of Problem and Substantiation for Public Input

The existing definition for "Reconditioned" blurs clear responsibility for compliance to Code and listing requirements following such restoration and further complicates enforcement. It also fails to differentiate between legitimate reconditioning versus mere salvaging without any restoration or any assurance of the same completeness and suitability for purpose, use or application as originally produced and listed. Consequently, an added final sentence clarifies what reconditioning is not (i.e., salvaging that typically omits parts discarded as not required for a particular prior installation).

"Materials" are added explicitly to set clearer boundaries as well for where materials (rather than equipment, apparatus, et cetera) are specified in requirements of Chapters 3, 4, 8, et alibi.

Reconditioning not only entails restoration to operating conditions but also, from the definition for "Identified", to "suitability for the specific purpose, function, use, environment, application, and so forth".

"Normal" in "normal servicing" is an unenforceable qualifier whereas "routine" implies a servicing schedule. Furthermore, maintenance and possible repairs by the owner are possibly part of that routine.

The verb "remains" is pluralized and changed to "remain INSTALLED" to differentiate equipment and materials that have been previously installed versus unreconditioned equipment and materials salvaged from another facility (foisted as "reconditioned") versus obsolete or otherwise UNTRACEABLE equipment and materials that have never been installed and merely stored (again, foisted as "reconditioned").

Replacement "on a one-to-one basis" is expanded from solely listed equipment to that plus legitimate replacement of OEM components within listed equipment.

"Apparatus" is deleted because that term is already included within the definition of "Equipment".

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 1809-NFPA 70-2020 [Section No. 110.3(A)]	Correlated revisions
Public Input No. 1810-NFPA 70-2020 [Section No. 110.21(A)(2)]	Correlated revisions
Public Input No. 1940-NFPA 70-2020 [Section No. 110.21(A)(1)]	Affiliated revision
Public Input No. 1941-NFPA 70-2020 [Section No. 90.7]	Affiliated revisions
Public Input No. 1942-NFPA 70-2020 [New Definition after Definition: Luminaire.]	Affiliated addition of new definition "Manufacturer"
Public Input No. 1809-NFPA 70-2020 [Section No. 110.3(A)]	
Public Input No. 1810-NFPA 70-2020 [Section No. 110.21(A)(2)]	
Public Input No. 1940-NFPA 70-2020 [Section No. 110.21(A)(1)]	
Public Input No. 1941-NFPA 70-2020 [Section No. 90.7]	

Public Input No. 1942-NFPA 70-2020 [New Definition after Definition:
Luminaire.]

Submitter Information Verification

Submitter Full Name: Brian Rock

Organization: Hubbell Incorporated

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 04 19:38:44 EDT 2020

Committee: NEC-P10

NFPA Public Input Form

NOTE: All Public Input must be received by 5:00 pm EST/EDST on the published Public Input Closing Date.

For further information on the standards-making process, please contact the Codes and Standards Administration at 617-984-7249 or visit www.nfpa.org/codes.

For technical assistance, please call NFPA at 1-800-344-3555

FOR OFFICE USE ONLY

Log #: _____

Date Rec'd: _____

Date 2020-July-04 Name Brian E. Rock Tel. No.

Company Hubbell Incorporated Email

Street Address 40 Waterview Drive City Shelton State CT Zip 06484

Please indicate organization represented (if any) Hubbell Incorporated

1. (a) Title of NFPA Standard National Electrical Code® NFPA No. & Year 70 - 2020

(b) Section/Paragraph Definition: Reconditioned

2. Public Input Recommends (check one): ☐ new text ☒ revised text ☐ deleted text

3. Proposed Text of Public Input (include proposed new or revised wording, or identification of wording to be deleted):

[Note: Proposed text should be in legislative format; i.e., use underscore to denote wording to be inserted (inserted wording) and strike-through to denote wording to be deleted (~~deleted wording~~).]

Reconditioned.

Electromechanical systems, equipment, ~~apparatus, or components, or materials~~ that are restored to operating conditions and to suitability for the specific purpose, function, use, environment, application, and so forth. This process differs from normal routine servicing, maintenance or repair of ~~systems, equipment, or materials~~ that remains installed within a facility, or replacement of listed equipment on a one-to-one basis of ~~listed equipment or components thereof~~. This process excludes salvaging without such restoration of systems, equipment, components or materials previously installed at another facility. (CMP-10)

Informational Note: The term "reconditioned" is frequently referred to as "rebuilt", "refurbished", or "remanufactured".

4. Statement of Problem and Substantiation for Public Input: (Note: State the problem that would be resolved by your recommendation; give the specific reason for your Public Input, including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

The existing definition for "Reconditioned" blurs clear responsibility for compliance to Code and listing requirements following such restoration and further complicates enforcement. It also fails to differentiate between legitimate reconditioning versus mere salvaging without any restoration or any assurance of the same completeness and suitability for purpose, use or application as originally produced and listed. Consequently, an added final sentence clarifies what reconditioning is not (i.e., salvaging that typically omits parts discarded as not required for a particular prior installation).

"Materials" are added explicitly to set clearer boundaries as well for where materials (rather than equipment, apparatus, et cetera) are specified in requirements of Chapters 3, 4, 8, et alibi.

Reconditioning not only entails restoration to operating conditions but also, from the definition for "Identified", to "suitability for the specific purpose, function, use, environment, application, and so forth".

"Normal" in "normal servicing" is an unenforceable qualifier whereas "routine" implies a servicing schedule. Furthermore, maintenance and possible repairs by the owner are possibly part of that routine.

The verb "remains" is pluralized and changed to "remain INSTALLED" to differentiate equipment and materials that have been previously installed versus unreconditioned equipment and materials salvaged from another facility (foisted as "reconditioned") versus obsolete or otherwise UNTRACEABLE equipment and materials that have never been installed and merely stored (again foisted as "reconditioned").

Replacement "on a one-to-one basis" is expanded from solely listed equipment to that plus legitimate replacement of OEM components within listed equipment.

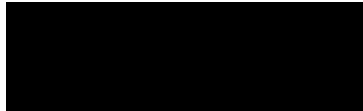
"Apparatus" is omitted because the term is included within the definition of equipment.

5. Copyright Assignment

- (a) ☒ I am the author of the text or other material (such as illustrations, graphs) proposed in the Public Input.
- (b) ☐ Some or all of the text or other material proposed in this Public Input was not authored by me. Its source is as follows: (please identify which material and provide complete information on its source)

I hereby grant and assign to the NFPA all and full rights in copyright in this Public Input (including both the Proposed Text and the Statement of Problem and Substantiation). I understand that I acquire no rights in any publication of NFPA in which this Public Input in this or another similar or analogous form is used. Except to the extent that I do not have authority to make an assignment in materials that I have identified in (b) above, I hereby warrant that I am the author of this Public Input and that I have full power and authority to enter into this assignment.

Signature (Required)



PLEASE USE SEPARATE FORM FOR EACH PUBLIC INPUT

To: Secretary, Standards Council National Fire Protection Association
1 Batterymarch Park · Quincy, MA 02169-7471 OR
Fax to: (617) 770-3500 OR Email to: proposals_comments@nfpa.org

9/16/2020



Public Input No. 3152-NFPA 70-2020 [Definition: Reconditioned.]

Reconditioned.

Electromechanical systems, equipment, apparatus, or components that are restored - Restored to operating conditions. This process differs from normal servicing of equipment that remains within a facility, or - does not include replacement of listed equipment on a one - to - one basis and differs from servicing and electrical preventive maintenance of equipment . (CMP-10)

Informational Note No. 1 : The term *reconditioned* is frequently referred to as *rebuilt*, *refurbished*, or *remanufactured*, even though these are sometimes different processes .

Informational Note No. 2 Used equipment that is in safe operating condition is not considered to be reconditioned.

Informational Note No. 3 Electrical Preventive Maintenance (EPM) is a program of inspecting, testing, analyzing and servicing electrical systems and equipment with the purpose of maintaining safe operations and production by reducing or eliminating system interruptions and equipment breakdowns. Servicing may be part of an EPM or may be part of a breakdown repair. See Recommended Practice for Electrical Equipment Maintenance, NFPA 70B

Statement of Problem and Substantiation for Public Input

This public input is submitted on behalf of the task group formed in accordance with the direction of the NFPA Standards Council in Decision D#19-11. This task group was appointed to identify potential proposed changes to the 2020 edition of the NEC in the form of proposed Tentative Interim Amendments (TIAs) or to the 2023 edition of the NEC in the form of Public Inputs (PIs) that are within the Task Group's scope of activity as specified by the Standards Council.

These proposed Public Inputs relate to requirements covering the use of reconditioned electrical equipment throughout the NEC as a coordinated set of new or revised requirements. These Public Inputs should not be misconstrued by the CMPs as precluding equal consideration of other Public Inputs, with supporting information, submitted now or in the future by individuals.

The task group members are: G. Scott Harding (Chair), Tom Bishop, Casey Blevins, John Catlett, Dave Dagenais, James Dollard, Robert Fahey, Paul Grein, Howard Herndon, David Hittinger, Christel Hunter, Bob Jordan, David Kendall, Dave King, Jack Lyons, Ryan McClarnon, Robert Osborne, Chris Paxton, David Rosenfield, Michael Savage, Bill Schofield and Ron Widup. This task group of balanced interests provided the expertise to develop these public inputs. Multiple sub task groups were set up during the process with the results of the sub task group work shared with and voted on by the full task group.

Public Inputs are being submitted as follows:

- Revised to Article 100 definition of Reconditioned
- Revisions to Sections 110.21(A)(2), 240.88 and 210.15(3)
- New requirements/Sections 110.17, 110.20, 430.3 and 445.3

A summary of the proposed changes to the definition of Reconditioned is noted below:

1. The definition is formatted to address the use of the term as it applies to equipment.
2. As written in the 2020 NEC, the first sentence attempts to identify the equipment that is covered by the definition. The use of the terms "electromechanical systems, apparatus, and components" has created confusion; therefore, this sentence is modified to only specify "equipment," as this is a defined term in Article 100, and its definition is sufficiently broad to meet the intent of this sentence.
3. The reference to "operating conditions" is retained. This clarifies that equipment (for example, used equipment) that is in operating condition is not reconditioned. Additionally, the reference to "operating condition" is proposed as new text in Article 110 (reference Public Inputs for new Sections 110.17 and 110.20) in order to clarify the requirements that support bringing equipment back to an operational state.
4. The second sentence clarifies that "replacement of listed equipment on a one-to-one basis" is not reconditioning. This concept is part of the existing definition, and is relocated for improved readability.
5. The reference to equipment that remains within a facility is deleted to eliminate confusion, and additional text is added to clarify that reconditioning differs from servicing of equipment and electrical preventive maintenance of equipment. With proper differentiation between "reconditioning" and "servicing" and "electrical preventive maintenance", location is not considered to be a critical aspect of the process. These processes are quantified with the Public Inputs submitted for new Sections 110.17 and 110.20.
6. The existing informational note is modified for clarity and identified as Informational Note No. 1, as two new informational notes are included. Clarity is provided with text to explain that the term reconditioned is frequently referred to as rebuilt, refurbished, or remanufactured, even though these are sometimes different processes.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3159-NFPA 70-2020 [New Section after 110.18]	Requirements to tie into proposed new definition of Reconditioned
Public Input No. 3354-NFPA 70-2020 [New Section after 110.16]	Requirements to tie into proposed new definition of Reconditioned
Public Input No. 3159-NFPA 70-2020 [New Section after 110.18]	
Public Input No. 3354-NFPA 70-2020 [New Section after 110.16]	

Submitter Information Verification

Submitter Full Name:	G. Scott Harding
Organization:	F. B. Harding, Inc.
Affiliation:	Independent Electrical Contractors
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sat Sep 05 19:17:42 EDT 2020
Committee:	NEC-P10



Public Input No. 602-NFPA 70-2020 [Definition: Reconditioned.]

Reconditioned.

Electromechanical systems, equipment, apparatus, or components that are have been removed from normal use and have been restored to operating conditions for reinstallation in the field at another location by a party other than the original manufacturer . This process differs from normal servicing of equipment that remains within a facility, or replacement of listed equipment on a one-to-one basis. (CMP-10)

Informational Note No. 1 : The term *reconditioned* is frequently referred to as *rebuilt*, *refurbished*, or *remanufactured*.

Informational Note No. 2: Electromechanical systems, equipment, apparatus, or components that can be restored to operating conditions by the original manufacturer while maintaining the original equipment listing differs from the equipment reconditioning process.

Statement of Problem and Substantiation for Public Input

The term "reconditioned" needs to be redefined for additional clarity. Equipment reconditioning is the removal of installed equipment from one location that is then restored to "like new" operating conditions for installation as "new equipment" at another location in the field by a party other than the original equipment manufacturer. The proposed informational note provides clarity that equipment could be repaired by the original manufacturer while still maintaining the equipment listing.

As an example, a generator enclosure that is damaged in the shipping process is returned to the manufacturer for repair prior to installation. After the repair has been performed, the generator can be installed as new equipment in the field and maintains its listing.

Submitter Information Verification

Submitter Full Name: Brian Baughman

Organization:

Affiliation: myself

Street Address:

City:

State:

Zip:

Submittal Date: Wed Mar 04 15:36:40 EST 2020

Committee: NEC-P10



Public Input No. 4583-NFPA 70-2020 [Definition: Service Conductors, Overhead.]

Service Conductors, Overhead. (Overhead Service Conductors)

The overhead conductors between the service point and the first point of connection to the service-entrance conductors at the building or other structure. (CMP-10)

Statement of Problem and Substantiation for Public Input

"This revision is to account for the revised NEC Style Manual.
For electronic searching the term is listed in parentheses."

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 15:25:01 EDT 2020

Committee: NEC-P10



Public Input No. 4592-NFPA 70-2020 [Definition: Service Conductors, Underground.]

Service Conductors, Underground. (Underground Service Conductors)

The underground conductors between the service point and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure, inside or outside the building wall. (CMP-10)

Informational Note: Where there is no terminal box, meter, or other enclosure, the point of connection is considered to be the point of entrance of the service conductors into the building.

Statement of Problem and Substantiation for Public Input

"This revision is to account for the revised NEC Style Manual.
For electronic searching the term is listed in parentheses."

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 15:32:17 EDT 2020

Committee: NEC-P10

**Public Input No. 2008-NFPA 70-2020 [Definition: Service Equipment.]****Service Equipment.**

The necessary equipment, consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, ~~connected to the serving utility and intended to constitute the main control and disconnect of the premises wiring system from the~~ serving utility system . (CMP-10)

Statement of Problem and Substantiation for Public Input

This edit is for clarity and to make the definition easier to understand and apply. It is not a technical change.

Submitter Information Verification

Submitter Full Name: Don Ganiere

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 25 14:35:22 EDT 2020

Committee: NEC-P10



Public Input No. 2416-NFPA 70-2020 [Definition: Service.]

Service.

The conductors and equipment ~~connecting the~~ for delivering electric energy from the serving utility to the ~~wiring system~~ service equipment of the premises served. (CMP-10)

Statement of Problem and Substantiation for Public Input

The change to the definition of service in the 2020 NEC has created confusion throughout the electrical industry as the definition is not clear and unambiguous.

The permitted supply-side connection of a nonseparately derived interconnected power production source does not make the entire Article 705 system part of the electrical service, as the associated equipment for the interconnection does not physically connect the serving utility to the premises being served at the service point. Power source output circuits conductors are not defined as service conductors in Article 705, and the inverters where these conductor originate from are not listed as being suitable for use as service equipment. Article 230.82(6) requires the disconnecting means for these systems to be listed as suitable for use as service equipment where they interconnect on the supply-side of an existing service disconnecting means. The revised definition of service would include these supply side disconnects and the wiring to the line side of the disconnect as part of the service.

Submitter Information Verification

Submitter Full Name: Brian Baughman

Organization:

Affiliation: myself

Street Address:

City:

State:

Zip:

Submittal Date: Thu Aug 20 09:17:32 EDT 2020

Committee: NEC-P10

**Public Input No. 4553-NFPA 70-2020 [Definition: Setting (of circuit breakers).]****Setting (of circuit breakers) Circuit Breaker, Setting .**

The value of current, time, or both, at which an adjustable circuit breaker is set to trip. (CMP-10)

Statement of Problem and Substantiation for Public Input

"This revision is to account for the revised NEC Style Manual.
The defined term is separated by a comma and then the modifying descriptor.
For electronic searching the term is listed in parentheses.
The Code Panel designation was also added."

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 15:02:16 EDT 2020

Committee: NEC-P10



Public Input No. 4388-NFPA 70-2020 [Definition: Surge-Protective Device (SPD).]

Surge-Protective Device (SPD).

A protective device for limiting transient voltages by diverting or limiting surge current; it also prevents continued flow of follow current while remaining capable of repeating these functions and is designated as follows:

Type 1: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device, as well as the load side, including watt-hour meter socket enclosures and Molded Case SPDs intended to be installed without an external overcurrent protective device.

Type 2: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.

Type 3: Point of utilization SPDs.

Type 4: Component SPDs, including discrete components, as well as assemblies. (CMP-10)

Informational Note: For further information on Type 1, Type 2, Type 3, and Type 4 SPDs, see UL 1449, *Standard for Surge Protective Devices*.

Statement of Problem and Substantiation for Public Input

Surge Protective Devices (SPDs) are listed to UL 1449. Under UL 1449, a Type 1 SPD is suitable for installation on the load side of the service equipment overcurrent device. This public input aligns the NFPA definition with the UL 1449 definition for Type 1 SPD.

Submitter Information Verification

Submitter Full Name: Frank Tse

Organization: Leviton Manufacturing Company,

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 11:39:23 EDT 2020

Committee: NEC-P10

**Public Input No. 4671-NFPA 70-2020 [Definition: Surge-Protective Device (SPD).]****Surge-Protective Device (SPD).**

A protective device for limiting transient voltages by diverting or limiting surge current; it also prevents continued flow of follow current while remaining capable of repeating these functions and is designated as follows:

Type 1: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

Type 2: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.

Type 3: Point of utilization SPDs.

Type 4: Component SPDs, including discrete components, as well as assemblies. (CMP-10)

Informational Note: - For further See UL 1449, *Standard for Surge Protective Devices*, for information on Type 1, Type 2, Type 3, and Type 4 SPDs, see UL 1449, *Standard for Surge Protective Devices*.

Statement of Problem and Substantiation for Public Input

This revision is to account for the revised NEC Style Manual.

The reference structure should include the word "See" followed by the reference and an explanation of the reference.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 16:38:31 EDT 2020

Committee: NEC-P10



Public Input No. 1881-NFPA 70-2020 [New Definition after Definition: Conductor, Bare.]

Conductor, Circuit

Conductors that are intended to carry current during normal operation. This is inclusive of service conductors, feeders and branch circuit conductors, but does not include equipment grounding conductors or accessories that provide a path to ground.

Statement of Problem and Substantiation for Public Input

The term "System Conductor" is used 12 times in the 2020 NEC and the usage is confined to Articles 100 and 250. In each instance of usage, it is describing a grounded conductor and in 11 of the 12 instances it is part of the term "Grounded System Conductor". The term "Circuit Conductor" is used 81 times throughout the 2020 NEC. The term "Grounded Circuit Conductor" is used 43 times throughout the 2020 NEC and 10 times in Article 250.

In Articles 100 and 250, it is not clear that there is a difference between a "Grounded System Conductor" and a "Grounded Circuit Conductor", these terms appear to be used interchangeably.

If it is not the intent that these terms be used interchangeably:

- Definitions should be provided as proposed in PIs 1881-NFPA 70-2020 and 1882-NFPA 70-2020 to delineate the unique features of a "System Conductor" versus those of a "Circuit Conductor"

- PIs 1883-NFPA 70-2020 , 1906-NFPA 70-2020 , 1892-NFPA 70-2020 , 1893-NFPA 70-2020 , 1904-NFPA 70-2020 , and 1905-NFPA 70-2020 should be disregarded

If it is the intent that the two terms are to be used interchangeably:

- All instances of "System Conductor" should be changed to "Circuit Conductor"

- PIs 1883-NFPA 70-2020 , 1906-NFPA 70-2020 , 1892-NFPA 70-2020 , 1893-NFPA 70-2020 , 1904-NFPA 70-2020 , and 1905-NFPA 70-2020 should be accepted to change instances of "system conductor" to "circuit conductor"

- PI 1881-NFPA 70-2020 may be helpful in this scenario to clarify the meaning of the term "Circuit Conductor"

- Replacing all instances of "Circuit Conductor" with "System Conductor" and defining the term "System Conductor" would accomplish the same goal, "Circuit Conductor" is presently more used throughout the NEC and this proposal requires a smaller number of revisions

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 1882-NFPA 70-2020 [New Definition after Definition: Conductor, Insulated.]	
Public Input No. 1893-NFPA 70-2020 [Section No. 250.84]	
Public Input No. 1904-NFPA 70-2020 [Section No. 250.187(C)]	
Public Input No. 1905-NFPA 70-2020 [Section No. 250.34(C)]	
Public Input No. 1906-NFPA 70-2020 [Section No. 250.36(B)]	
Public Input No. 1883-NFPA 70-2020 [Definition: Grounded Conductor.]	
Public Input No. 1892-NFPA 70-2020 [Section No. 250.80]	
Public Input No. 1882-NFPA 70-2020 [New Definition after Definition: Conductor, Insulated.]	
Public Input No. 1883-NFPA 70-2020 [Definition: Grounded Conductor.]	
Public Input No. 1892-NFPA 70-2020 [Section No. 250.80]	
Public Input No. 1893-NFPA 70-2020 [Section No. 250.84]	
Public Input No. 1904-NFPA 70-2020 [Section No. 250.187(C)]	
Public Input No. 1905-NFPA 70-2020 [Section No. 250.34(C)]	
Public Input No. 1906-NFPA 70-2020 [Section No. 250.36(B)]	

Submitter Information Verification

Submitter Full Name: John Cowans
Organization: Siemens
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 13 14:41:19 EDT 2020
Committee: NEC-P10



Public Input No. 927-NFPA 70-2020 [New Definition after Definition: Fuel Cell System.]

TITLE OF NEW CONTENT The definition of Fuse

Fuse. An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it.

Statement of Problem and Substantiation for Public Input

Fuse is defined in the NEC; however, it is in Part II of Article 100 which is for Over 1000 Volts Nominal. The term is used elsewhere in the NEC in parts that are not over 1000 volts, i.e. Articles 240 and 430. The definition proposed is the same as the definition in Part II of Article 100 and also in Article 100 of NFPA 70E.

Submitter Information Verification

Submitter Full Name: Roger Zieg

Organization: R.Zieg, LLC

Street Address:

City:

State:

Zip:

Submittal Date: Fri May 01 15:59:31 EDT 2020

Committee: NEC-P10



Public Input No. 2964-NFPA 70-2020 [New Definition after Definition: Overload.]

Article 100 - Overvoltage

Any voltage in excess of the rated voltage of a circuit, device, equipment or system.

Informational Note No.1: An overvoltage condition may be a result of atmospheric overvoltage, power frequency overvoltage or resonant overvoltage and may be a temporary, short-term duration, long-term duration, or transient overvoltage event. For further information on transient overvoltage, see 1159-2019 - IEEE Recommended Practice for Monitoring Electric Power Quality.

Informational Note No. 2: A transient overvoltage is impulsive or oscillatory in nature, may be caused by switching, lighting, or function of a device and commonly referred to as a surge, impulse, or spike.

Overvoltage Protection. A process, device, or equipment capable of either regulating the voltage or limiting the transient voltage of a circuit, device, equipment, or system.

Informational Note No. 1: Overvoltage protection may include but is not limited to voltage regulators, voltage monitors, voltage relays, surge arresters, surge-protective devices (SPDs) and surge protectors.

Informational Note No. 2: For further information on surge arresters, see IEEE C62.11-2012, Standard for Metal-Oxide Surge Arresters for Alternating-Current Power Circuits (>1 kV). For further information on surge-protective devices (SPDs) UL 1449, Standard for Surge Protective Devices. For further information on surge protectors, see UL 497, Standard for Protectors for Paired-Conductor Communications Circuits, UL 497(A), Standard for Secondary Protectors for Communications Circuits, and UL 497(B), Standard for Protectors for Data Communications and Fire-Alarm Circuits.

Statement of Problem and Substantiation for Public Input

The intent of this public input is to provide a definition and guidance information for a new definition of "overvoltage" and "overvoltage protection". The definition of "overvoltage" is closely aligned with the NEC definition of "overcurrent" in Article 100. Informational Note No. 1 describes several conditions that may result in an overvoltage condition and a pointer to IEEE 1159 is provided for guidance to the user. Information Note No. 2 provides common terms used in the electrical industry to describe a transient overvoltage and a basic description.

The definition of "overvoltage protection" indicates the regulation or limiting of overvoltage conditions can be provided by processes, devices, or equipment intended to serve that purpose. Information Note No. 1 describes several types of devices and equipment that may be used to protect against overvoltage conditions. Informational Note No. 2 provides a pointer to the applicable product standards for surge arresters, SPDs, and surge protectors which are the three primary methods the NEC currently has overvoltage protection requirements for.

This public input is aligned with and harmonized with eleven correlating public inputs covering Sections 230.67, 501.35, 502.35, 620.51(E), 645.18, 670.6, 694.7(D), 695.15, 700.8, 708.20(D), and Informative Annex G.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 03 14:43:43 EDT 2020

Committee: NEC-P10



Public Input No. 3349-NFPA 70-2020 [New Definition after Definition: Service Point.]

TITLE OF NEW CONTENT

Short Circuit. An abnormal connection (including an arc) of relatively low impedance, whether made accidentally or intentionally, between two points of different potential.

-

Informational Note: The term fault or short-circuit fault is used to describe a short circuit. (IEEE 100-1992, The New IEEE Standard Dictionary of Electrical and Electronic Terms, 5th Edition)

Statement of Problem and Substantiation for Public Input

The phrase "Short Circuit" appears in several locations throughout the NEC. It would seem prudent that a definition of this term be found in the NEC. This definition would be best suited to be located in Part I of Article 100. It seems the definition is needed so

that the user of the Code understands from the NEC definitions what a short circuit is and is not. Currently the user of the Code must rely on other industry manuals and documents to determine the definition of this term.

Below are some of the locations that this phrase is used in the NEC: (partial list and not an all-inclusive list)

- 90.8(B)
- Definition of fault current
- Informational Note of Fault Current, Available
- Informational Note Figure 100.1 Available Fault Current
- Definition of Overcurrent
- Definition of Overload
- 110.7
- 110.10
- 110.36

Submitter Information Verification

Submitter Full Name: L. Keith Lofland

Organization: IAEI

Affiliation: None

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 08:59:30 EDT 2020

Committee: NEC-P10



Public Input No. 3356-NFPA 70-2020 [New Definition after Definition: Service Point.]

TITLE OF NEW CONTENT

Short Circuit. An abnormal connection (including an arc) of relatively low impedance, whether made accidentally or intentionally, between two points of different potential.

-

Informational Note: The term fault or short-circuit fault is used to describe a short circuit. (IEEE 100-1992, The New IEEE Standard Dictionary of Electrical and Electronic Terms, 5th Edition)

Statement of Problem and Substantiation for Public Input

The phrase "Short Circuit" appears in several locations throughout the NEC. It would seem prudent that a definition of this term be found in the NEC. This definition would be best suited to be located in Part I of Article 100. It seems the definition is needed so

that the user of the Code understands from the NEC definitions what a short circuit is and is not. Currently the user of the Code must rely on other industry manuals and documents to determine the definition of this term.

Below are some of the locations that this phrase is used in the NEC: (partial list and not an all-inclusive list)

- 90.8(B)
- Definition of fault current
- Informational Note of Fault Current, Available
- Informational Note Figure 100.1 Available Fault Current
- Definition of Overcurrent
- Definition of Overload
- 110.7
- 110.10
- 110.36

Submitter Information Verification

Submitter Full Name: Rudolph Garza

Organization: IAEI

Affiliation: IAEI

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 10:23:03 EDT 2020

Committee: NEC-P10



Public Input No. 2018-NFPA 70-2020 [Section No. 215.2(A)(1)]

(1) General.

Feeder conductors shall have an ampacity not less than the larger of 215.2(A)(1)(a) or (A)(1)(b) and shall comply with 110.14(C).

(a) Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum feeder conductor size shall have an ampacity as shown in the applicable ampacity table, of not less than the noncontinuous load plus 125 percent of the continuous load.

Exception No. 1: If the assembly, including the overcurrent devices protecting the feeder(s), is listed for operation at 100 percent of its rating, the ampacity of the feeder conductors shall be permitted to be not less than the sum of the continuous load plus the noncontinuous load.

Exception No. 2: Where a portion of a feeder is connected at both its supply and load ends to separately installed pressure connections as covered in 110.14(C)(2), it shall be permitted to have an ampacity not less than the sum of the continuous load plus the noncontinuous load. No portion of a feeder installed under this exception shall extend into an enclosure containing either the feeder supply or the feeder load terminations, as covered in 110.14(C)(1).

Exception No. 3: Grounded conductors that are not connected to an overcurrent device shall be permitted to be sized at 100 percent of the continuous and noncontinuous load.

(b) The minimum feeder conductor size shall have an ampacity not less than the maximum load to be served after the application of any adjustment or correction factors in accordance with 310.14.

Informational Note No. 1: See Examples D1 through D11 in Informative Annex D.

Informational Note No. 2: Conductors for feeders, as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation.

Informational Note No. 3: See 210.19(A), Informational Note No. 4, for voltage drop for branch circuits.

Statement of Problem and Substantiation for Public Input

The term "ampacity" is a defined term in Article 100 and anytime that term is used, it automatically includes any required ampacity adjustment and/or ampacity correction. This PI is attempting to make it clear that the ampacity used in 210.19(A)(1)(a) is the value taken directly from the table. The use of just the term "ampacity" requires the application of the adjustment and/or correction factors per the definition. Defined terms must be used in the manner that they have been defined.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2013-NFPA 70-2020 [Section No. 210.19(A)(1)]	
Public Input No. 2013-NFPA 70-2020 [Section No. 210.19(A)(1)]	

Submitter Information Verification

Submitter Full Name: Don Ganiere

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 25 16:43:41 EDT 2020

Committee: NEC-P10

**Public Input No. 250-NFPA 70-2020 [Section No. 215.2(A)(1)]****(1) General.**

Feeder conductors shall have an ampacity not less than the larger of 215.2(A)(1)(a) or (A)(1)(b) and shall comply with 110.14(C).

(a) Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum feeder conductor size shall have an ampacity not less than the noncontinuous load plus 125 percent of the continuous load.

Exception No. 1: If the assembly, including the overcurrent devices protecting the feeder(s), is listed for operation at 100 percent of its rating, the ampacity of the feeder conductors shall be permitted to be not less than the sum of the continuous load plus the noncontinuous load.

Exception No. 2: Where a portion of a feeder is connected at both its supply and load ends to separately installed pressure connections as covered in 110.14(C)(2), it shall be permitted to have an ampacity not less than the sum of the continuous load plus the noncontinuous load. No portion of a feeder installed under this exception shall extend into an enclosure containing either the feeder supply or the feeder load terminations, as covered in 110.14(C)(1).

Exception No. 3: Grounded conductors that are not connected to an overcurrent device shall be permitted to be sized at 100 percent of the continuous and noncontinuous load.

(b) The minimum feeder conductor size shall have an ampacity not less than the maximum load to be served after the application of any adjustment or correction factors in accordance with 310.14.

Informational Note No. 1: See Examples D1 through D11 in Informative Annex D.

Informational Note No. 2: Conductors for feeders, as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation.

Informational Note No. 3: See 210.19(A), Informational Note No. 4 3, for voltage drop for branch circuits.

Statement of Problem and Substantiation for Public Input

Two informational notes in 210.19 were consolidated, leaving this reference inaccurate.

Submitter Information Verification

Submitter Full Name: Ryan Jackson

Organization: Ryan Jackson

Street Address:

City:

State:

Zip:

Submittal Date: Sun Jan 05 19:57:56 EST 2020

Committee: NEC-P10

**Public Input No. 91-NFPA 70-2019 [Section No. 215.2(A)(1)]****(1) General.**

Feeder conductors shall have an ampacity not less than the larger of 215.2(A)(1)(a) or (A)(1)(b) and shall comply with 110.14(C).

(a) Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum feeder conductor size shall have an ampacity from Tables 310.16 through 310.21 not less than the noncontinuous load plus 125 percent of the continuous load.

Exception No. 1: If the assembly, including the overcurrent devices protecting the feeder(s), is listed for operation at 100 percent of its rating, the ampacity of the feeder conductors shall be permitted to be not less than the sum of the continuous load plus the noncontinuous load.

Exception No. 2: Where a portion of a feeder is connected at both its supply and load ends to separately installed pressure connections as covered in 110.14(C)(2), it shall be permitted to have an ampacity not less than the sum of the continuous load plus the noncontinuous load. No portion of a feeder installed under this exception shall extend into an enclosure containing either the feeder supply or the feeder load terminations, as covered in 110.14(C)(1).

Exception No. 3: Grounded conductors that are not connected to an overcurrent device shall be permitted to be sized at 100 percent of the continuous and noncontinuous load.

(b) The minimum feeder conductor size shall have an ampacity not less than the maximum load to be served after the application of any adjustment or correction factors in accordance with 310.14.

Informational Note No. 1: See Examples D1 through D11 in Informative Annex D.

Informational Note No. 2: Conductors for feeders, as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation.

Informational Note No. 3: See 210.19(A), Informational Note No. 4, for voltage drop for branch circuits.

Statement of Problem and Substantiation for Public Input

Per the article 100 definition, the "ampacity" of a conductor is a value that reflects its condition of use, meaning that adjustment and correction factors have already been applied. So if the part (a) requirement is to apply to values before the application of adjustment and correction factors, as it has historically, then a change in language is required.

My suggestion is to directly reference the tabular values, but many other options are available. For example, the phrase "before the application of adjustment and correction factors" could be restored.

Submitter Information Verification

Submitter Full Name: Wayne Whitney

Organization: None

Affiliation: None

Street Address:

City:

State:

Zip:

Submission Date: Mon Nov 11 11:57:18 EST 2019

Committee: NEC-P10

**Public Input No. 581-NFPA 70-2020 [Section No. 215.2(A)(2)]****(2) Grounded Conductor.**

The size of the feeder circuit grounded conductor shall not be smaller than ~~that~~ the equipment grounding conductor size required by 250.122, except that 250.122(F) shall not apply where grounded conductors are run in parallel.

Additional minimum sizes shall be as specified in 215.2(A)(3) under the conditions stipulated.

Statement of Problem and Substantiation for Public Input

There is no technical change here. This revision is simply meant to clarify that the feeder grounded (neutral) conductor cannot be smaller than the equipment grounding conductor size required by 250.122. Without this additional wording it can be confusing for users trying to figure out what is really required by these 2 Sections. I believe this proposed wording makes it easier to understand the requirements.

Submitter Information Verification

Submitter Full Name: Russ Leblanc

Organization: Leblanc Consulting Services

Street Address:

City:

State:

Zip:

Submittal Date: Mon Mar 02 15:16:15 EST 2020

Committee: NEC-P10



Public Input No. 275-NFPA 70-2020 [Section No. 215.5]

215.5 Diagrams of Feeders.

If required by the authority having jurisdiction, a diagram showing feeder details shall be provided prior to the installation of the feeders. Such a diagram shall ~~show the~~ show the applicable NEC Code cycle to which the feeder diagram was drawn, the location of the main electrical service disconnect for the premises being served, the area in square feet of the building or other structure supplied by each feeder, the total calculated load before applying demand factors, the demand factors used, the calculated load after applying demand factors, and the size and type of conductors to be used.

Statement of Problem and Substantiation for Public Input

For an inspector walking in to a jobsite, it is necessary to understand where the main electrical service is located. Not all feeders may originate at the main service disconnect. Sometimes the feeder diagram that we receive doesn't indicate all of this information, and it's left up to the inspector to figure it all out when he/she gets to the jobsite. For larger buildings, this can be quite a task. Requiring this information on the feeder diagram makes sense, and would save the inspector valuable time.

Stating the applicable edition of the NEC on the plans (or diagram) is also necessary. This will aid with the plan review process. Sometimes between code cycles and between code adoptions, it isn't readily apparent to someone what code the plans were drawn to.

This will help not only with the electrical plans examination process, but also assist with recordkeeping and research. Here in Clark County, NV, all of our plans are scanned into a server with which we can pull them up when we need to. Sometimes it is necessary to research plans from 8 or 10 years ago, (or longer). Indicating the applicable edition of the NEC on the diagram of feeders-document will help in many aspects of building department administration and enforcement. NEC "enforcement" isn't always in the present tense.

It is also just commonsensical to include the NEC code year on the diagram. You would not believe the pushback that we get sometimes, when we simply ask that the code cycle be indicated.

The reason for the added language is to help aid the AHJs with electrical plan review, NEC enforcement, and recordkeeping.

Submitter Information Verification

Submitter Full Name: Nick Sasso

Organization: Clark County Building and Fire

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jan 11 16:05:50 EST 2020

Committee: NEC-P10

**Public Input No. 3611-NFPA 70-2020 [New Section after 215.7]****215.8 Reconditioned Equipment.**

Reconditioned equipment shall be listed as "reconditioned" and the original listing mark removed. The following equipment shall not be reconditioned:

- (1) Equipment that provides ground-fault circuit-interrupter protection for personnel
- (2) Components of equipment that provide ground-fault protection of equipment (GFPE) unless the component is identified as serviceable or maintainable by the original equipment manufacturer's instructions.

Statement of Problem and Substantiation for Public Input

This public input correlates Public Input No. 3416-NFPA 70-2020 [Section 210.15] that came from the task group formed in accordance with the direction of the NFPA Standards Council in Decision D#19-11. Time constraints required the task group to limit the focus to branch circuits; however, the requirements should be expanded to apply to feeders as well.

Many different types of equipment are used in feeder circuit equipment to provide ground fault protection of equipment and ground-fault circuit-interrupter protection for personnel. Equipment that is suitable for reconditioning as allowed in other sections of the NEC may contain components that provide the function of ground fault protection of equipment (GFPE). It is the intention of this proposal to restrict the reconditioning of these GFPE components but still allow the equipment that contains those components to be reconditioned if allowed. The replacement of these components as a one to one replacement would be allowed. This input would prohibit reconditioning ground-fault circuit-interrupter protection for personnel and is consistent with 210.15.

Submitter Information Verification

Submitter Full Name: Barry Rodgers

Organization: Schneider Electric

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 08:58:33 EDT 2020

Committee: NEC-P10

**Public Input No. 2209-NFPA 70-2020 [Section No. 215.9]****215.9** Ground-Fault Circuit-Interrupter Protection for Personnel.

Feeders shall be permitted to be protected by a listed ground-fault circuit interrupter installed in a readily accessible location in lieu of the provisions for such interrupters as specified in 210.8 and 590.6(A).

Statement of Problem and Substantiation for Public Input

I find it a bit ironic that such an important safety device is not required to be tested and certified by an independent lab. GFCI devices are every bit as important, perhaps even more so than the AFCI devices specified in 210.12 which ARE required to be listed.

Using unlisted GFCI devices should not be permitted because these safety devices are simply too important to allow anything less.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2208-NFPA 70-2020 [Section No. 210.8 [Excluding any Sub-Sections]]	Listed GFCI devices
Public Input No. 2210-NFPA 70-2020 [Section No. 555.9]	
Public Input No. 2211-NFPA 70-2020 [Section No. 422.5(A)]	
Public Input No. 2212-NFPA 70-2020 [Section No. 590.6]	
Public Input No. 2213-NFPA 70-2020 [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: Tue Aug 11 07:14:11 EDT 2020
Committee: NEC-P10

**Public Input No. 3556-NFPA 70-2020 [Section No. 215.10]****215.10** Ground-Fault Protection of Equipment.

Each feeder disconnect rated 1000 amperes or more and installed on solidly grounded wye electrical systems of more than 150 volts to ground, but not exceeding ~~600-volts~~ 1000 volts phase-to-phase, shall be provided with ground-fault protection of equipment in accordance with 230.95.

Informational Note: For buildings that contain health care occupancies, see 517.17.

Exception No. 1: This section shall not apply to a disconnecting means for a continuous industrial process where a nonorderly shutdown will introduce additional or increased hazards.

Exception No. 2: This section shall not apply if ground-fault protection of equipment is provided on the supply side of the feeder and on the load side of any transformer supplying the feeder.

Exception No. 3: If temporary feeder conductors are used to connect a generator to a facility for repair, maintenance, or emergencies, ground-fault protection of equipment shall not be required. Temporary feeders without ground-fault protection shall be permitted for the time period necessary but shall not exceed 90 days.

Statement of Problem and Substantiation for Public Input

215.10 references 230.95 for GFPE protection. The 600 volt phase to phase maximum should be changed to 1000 volts phase to phase to match 230.95 requirements.

Submitter Information Verification

Submitter Full Name: William Gross

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 22:13:02 EDT 2020

Committee: NEC-P10

**Public Input No. 4703-NFPA 70-2020 [Section No. 215.10]****215.10** Ground-Fault Protection of Equipment.

Each feeder disconnect rated 1000 amperes or more and installed on solidly grounded wye electrical systems of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase, shall be provided with ground-fault protection of equipment in accordance with 230.95.

Informational Note: - For See 517.17, for buildings that contain health care occupancies, ~~see 517.17.~~

Exception No. 1: This section shall not apply to a disconnecting means for a continuous industrial process where a nonorderly shutdown will introduce additional or increased hazards.

Exception No. 2: This section shall not apply if ground-fault protection of equipment is provided on the supply side of the feeder and on the load side of any transformer supplying the feeder.

Exception No. 3: If temporary feeder conductors are used to connect a generator to a facility for repair, maintenance, or emergencies, ground-fault protection of equipment shall not be required. Temporary feeders without ground-fault protection shall be permitted for the time period necessary but shall not exceed 90 days.

Statement of Problem and Substantiation for Public Input

The Informational Note was revised per the revised Style Manual and for clarity.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 16:58:35 EDT 2020

Committee: NEC-P10



Public Input No. 695-NFPA 70-2020 [Section No. 215.10]

215.10 Ground-Fault Protection of Equipment.

Each feeder disconnect rated 1000 amperes or more and installed on solidly grounded wye electrical systems of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase, shall be provided with ground-fault protection of equipment in accordance with 230.95.

Informational Note: For buildings that contain health care occupancies, see 517.17.

Exception No. 1: This section shall not apply to a disconnecting means for a continuous industrial process where a nonorderly shutdown will introduce additional or increased hazards.

Exception No. 2: This section shall not apply if ground-fault protection of equipment is provided on the supply side of the feeder and on the load side of any transformer supplying the feeder.

Exception No. 3: If temporary feeder conductors are used to connect a generator to a facility for repair, maintenance, or emergencies, ground-fault protection of equipment shall not be required. Temporary feeders without ground-fault protection shall be permitted for the time period necessary but shall not exceed 90 days.

Exception No. 4: For fused disconnects, the ground-fault protection provisions of this section shall not apply if the branch-circuit disconnect complies with Section 240.67, except that 240.67(B)(2) cannot be utilized for this exception.

Exception No. 5: For circuit breakers, the ground-fault protection provisions of this section shall not apply if the branch-circuit circuit breaker complies with Section 240.87, except that 240.87 (B)(3) cannot be utilized for this exception.

Statement of Problem and Substantiation for Public Input

A requirement (230.95) for ground fault protection of equipment (GFPE) was added to the 1971 NEC® because 480/277 volt, solidly grounded wye services, protected by 1000 ampere and larger overcurrent protective devices, were burning down due to arcing faults. 208/120 volt services and those services protected by smaller overcurrent protective devices were not burning down, so they weren't included in the new requirement. Over many Code cycles, GFPE requirements were also added for branch circuits (210.13), feeders (215.10), and equipment (240.13). In all cases, the intent was to limit damage to the switchboard, switchgear, panelboard or equipment, not the downstream conductors or busway. The electrical industry has evolved considerably since those early GFPE requirements were introduced. IEEE 1584 now predicts the magnitude of the arcing current along with the incident energy to which a worker could be exposed while working on energized equipment. It has become clearly evident that the level of protection required to limit arcing fault damage to equipment is nowhere near the level of protection needed to protect employees. Said another way, the level of protection necessary to protect an employee is orders of magnitude greater than that required to protect equipment. With that in mind, this Public Input takes advantage of the arc-energy reduction requirements found in 240.67 and 240.87. It provides an exception for GFPE requirements whenever the 240.67 and 240.87 methods to reduce clearing time are utilized. The methods to reduce clearing time will limit the arcing fault damage to the equipment to a level that is less than currently allowed by the requirements found in 230.95.

The arbitrary value of 1200 amperes found in 230.95(A) is not needed for the exceptions because the arcing current can now be accurately predicted (IEEE 1584).

The arbitrary one second maximum delay (230.95(A)) at 3000 amperes is not necessary for the exceptions because the methods in 240.67 and 240.87 have delays that are much less than one second. (Practically speaking, the methods in 240.67 and 240.87 couldn't protect workers if they were delayed for anywhere close to one second.)

Energy reducing maintenance switches (240.67(B)(2) and 240.87(B)(3)) are excluded from the exceptions because an energy-reducing maintenance switch is typically turned off when a worker is not working on energized equipment, whereas ground fault protection is constantly protecting the equipment, whether or not a worker is working on the energized equipment. If energy reducing maintenance switches are utilized, the requirements of 230.95, 210.13, 215.10, and 240.13 must continue.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 693-NFPA 70-2020 [Section No. 230.95 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: Vincent Saporita
Organization: Saporita Consulting
Affiliation: Saporita Consulting
Street Address:

City:
State:
Zip:
Submittal Date: Wed Mar 18 18:09:35 EDT 2020
Committee: NEC-P10



Public Input No. 2054-NFPA 70-2020 [Section No. 215.11]

215.11 Circuits Derived from Autotransformers.

Feeders shall not be derived from autotransformers unless the system supplied has a grounded conductor that is electrically connected to a grounded conductor of the system supplying the autotransformer.

Exception No. 1: An autotransformer shall be permitted without the connection to a grounded conductor where transforming from a nominal 208 volts to a nominal 240-volt supply or similarly from 240 volts to 208 volts.

Exception No. 2: In industrial occupancies controlled access locations, where conditions of maintenance and supervision ensure that only qualified persons service the installation, autotransformers shall be permitted to supply nominal 600-volt loads from nominal 480-volt systems, and 480-volt loads from nominal 600-volt systems, without line-to-line loads without the connection to a similar grounded conductor.

Statement of Problem and Substantiation for Public Input

This exception shouldn't be limited to industrial locations. It should apply to any location that has controlled access where only trained workers are able to service the installation. The Department of Energy facilities, for example, are not necessarily "industrial" but have extremely strict rules for working on the premises. The contractors must undergo extensive training, work packages must be created, means and methods must all be approved. This is part of a series of proposals to change "industrial locations/premises/occupancies/wiring-systems/..." to "controlled access locations."

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2047-NFPA 70-2020 [Section No. 110.21(A)(2)]	Part of a global proposal to change 'industrial' to 'controlled'
Public Input No. 2048-NFPA 70-2020 [Section No. 110.24(B)]	Part of a global proposal to change 'industrial' to 'controlled'
Public Input No. 2049-NFPA 70-2020 [Section No. 110.70]	Part of a global proposal to change 'industrial' to 'controlled'
Public Input No. 2050-NFPA 70-2020 [Section No. 210.8(B)]	Part of a global proposal to change 'industrial' to 'controlled'
Public Input No. 2051-NFPA 70-2020 [Section No. 210.8(B)]	Part of a global proposal to change 'industrial' to 'controlled'
Public Input No. 2052-NFPA 70-2020 [Section No. 210.9]	Part of a global proposal to change 'industrial' to 'controlled'
Public Input No. 2053-NFPA 70-2020 [Section No. 210.18]	Part of a global proposal to change 'industrial' to 'controlled'
Public Input No. 2087-NFPA 70-2020 [Section No. 225.37]	
Public Input No. 2088-NFPA 70-2020 [Section No. 225.52(A)]	
Public Input No. 2090-NFPA 70-2020 [Section No. 230.205(C)]	
Public Input No. 2091-NFPA 70-2020 [Section No. 240.21(C)(3)]	
Public Input No. 2092-NFPA 70-2020 [Section No. 300.50(A) [Excluding any Sub-Sections]]	
Public Input No. 2093-NFPA 70-2020 [Section No. 336.10]	
Public Input No. 2094-NFPA 70-2020 [Section No. 368.56(B)]	

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date:	Sun Jul 26 19:04:52 EDT 2020
Committee:	NEC-P10

**Public Input No. 3346-NFPA 70-2020 [Section No. 215.11]**

215.11 Circuits Derived from Autotransformers Transformers .

Feeders shall

(A) Barriers. Barriers shall be placed in all equipment supplied directly from transformers such that no uninsulated, ungrounded busbar or terminal is exposed to inadvertant contact by persons or maintenance equipment while servicing load terminations.

(B) Autotransformers. Feeders shall not be derived from autotransformers unless the system supplied has a grounded conductor that is electrically connected to a grounded conductor of the system supplying the autotransformer.

Exception No. 1: An autotransformer shall be permitted without the connection to a grounded conductor where transforming from a nominal 208 volts to a nominal 240-volt supply or similarly from 240 volts to 208 volts.

Exception No. 2: In industrial occupancies, where conditions of maintenance and supervision ensure that only qualified persons service the installation, autotransformers shall be permitted to supply nominal 600-volt loads from nominal 480-volt systems, and 480-volt loads from nominal 600-volt systems, without the connection to a similar grounded conductor.

Statement of Problem and Substantiation for Public Input

This public input seeks to logically expand the requirement for barriers to prevent inadvertent contact to transformer secondary conductors.

Submitter Information Verification

Submitter Full Name: James Dollard

Organization: IBEW Local Union 98

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 08:55:18 EDT 2020

Committee: NEC-P10

**Public Input No. 2878-NFPA 70-2020 [New Section after 215.12]****215.15 Barriers.**

Barriers shall be placed in feeder supplied equipment such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.

Exception: Barriers shall not be required in main lug only panelboards installed in accordance with 408.36.

Statement of Problem and Substantiation for Public Input

The requirements for barriers in 230.62(C) have been incorporated into the industry without creating any issues. The barriers designed for protection from inadvertent contact in service equipment can be installed in feeder supplied equipment with minimal cost. It is practical to require these barriers where they can be installed.

Submitter Information Verification

Submitter Full Name: James Dollard

Organization: IBEW Local Union 98

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 03 07:52:18 EDT 2020

Committee: NEC-P10

**Public Input No. 2372-NFPA 70-2020 [Section No. 215.12]****215.12 Identification for Feeders.**

Informational Note: see 200.6, 210.5, 250.119, 455.6 (B), and 517.160(A) (5) for conductor identification and posting requirements that may apply.

(A) Grounded Conductor.

The grounded conductor of a feeder, if insulated, shall be identified in accordance with 200.6.

(B) Equipment Grounding Conductor.

The equipment grounding conductor shall be identified in accordance with 250.119.

(C) Identification of Ungrounded Conductors.

Ungrounded conductors shall be identified in accordance with 215.12(C)(1) or (C)(2), as applicable.

(1) Feeders Supplied from More Than One Nominal Voltage System.

Where the premises wiring system has feeders supplied from more than one nominal voltage system, each ungrounded conductor of a feeder shall be identified by phase or line and system at all termination, connection, and splice points in compliance with 215.12(C)(1)(a) and (b).

(a) *Means of Identification.* The means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means.

(b) *Posting of Identification Means.* The method utilized for conductors originating within each feeder panelboard or similar feeder distribution equipment shall be documented in a manner that is readily available or shall be permanently posted at each feeder panelboard or similar feeder distribution equipment.

(2) Feeders Supplied from Direct-Current Systems.

Where a feeder is supplied from a dc system operating at more than 60 volts, each ungrounded conductor of 4 AWG or larger shall be identified by polarity at all termination, connection, and splice points by marking tape, tagging, or other approved means; each ungrounded conductor of 6 AWG or smaller shall be identified by polarity at all termination, connection, and splice points in compliance with 215.12(C)(2)(a) and (b). The identification methods utilized for conductors originating within each feeder panelboard or similar feeder distribution equipment shall be documented in a manner that is readily available or shall be permanently posted at each feeder panelboard or similar feeder distribution equipment.

(a) *Positive Polarity, Sizes 6 AWG or Smaller.* Where the positive polarity of a dc system does not serve as the connection for the grounded conductor, each positive ungrounded conductor shall be identified by one of the following means:

- (2) A continuous red outer finish
- (3) A continuous red stripe durably marked along the conductor's entire length on insulation of a color other than green, white, gray, or black
- (4) Imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, gray, or black, and repeated at intervals not exceeding 610 mm (24 in.) in accordance with 310.8(B)
- (5) An approved permanent marking means such as sleeving or shrink-tubing that is suitable for the conductor size, at all termination, connection, and splice points, with imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, gray, or black

(f) *Negative Polarity, Sizes 6 AWG or Smaller.* Where the negative polarity of a dc system does not serve as the connection for the grounded conductor, each negative ungrounded conductor shall be identified by one of the following means:

- (7) A continuous black outer finish
- (8) A continuous black stripe durably marked along the conductor's entire length on insulation of a color other than green, white, gray, or red
- (9) Imprinted minus signs (–) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red, and repeated at intervals not exceeding 610 mm (24 in.) in accordance with 310.8(B)
- (10) An approved permanent marking means such as sleeving or shrink-tubing that is suitable for the conductor size, at all termination, connection, and splice points, with imprinted minus signs (–) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red

Statement of Problem and Substantiation for Public Input

The code has other conductor identification and posting requirements on the topic of facility-wide consistency of conductor marking by voltage system and by phase. A portion of these other codes likely always apply to this application of 215.12. And, each of the separate code requirements on this topic should correlate each other to facilitate consistency across a facility; 200.6 [grounded phase conductors], 210.5 [branch conductors], 215.12 [feeder conductors], 250.119 [equipment grounding conductors], 455.6(B) for conductors of manufactured phases, and 517.160(A)(5) [Isolated Power Systems].

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2368-NFPA 70-2020 [Section No. 455.6(B)]	similar need and edit
Public Input No. 2370-NFPA 70-2020 [Section No. 200.6]	similar need and edit
Public Input No. 2371-NFPA 70-2020 [Section No. 210.5]	similar need and edit
Public Input No. 2374-NFPA 70-2020 [Section No. 517.160(A)(5)]	similar issue and edit
Public Input No. 2373-NFPA 70-2020 [Section No. 250.119]	similar issue and edit
Public Input No. 2368-NFPA 70-2020 [Section No. 455.6(B)]	
Public Input No. 2370-NFPA 70-2020 [Section No. 200.6]	
Public Input No. 2371-NFPA 70-2020 [Section No. 210.5]	
Public Input No. 2373-NFPA 70-2020 [Section No. 250.119]	
Public Input No. 2374-NFPA 70-2020 [Section No. 517.160(A)(5)]	

Submitter Information Verification

Submitter Full Name: John Blissett
Organization: Bernhard TME
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 18 11:11:06 EDT 2020
Committee: NEC-P10



Public Input No. 1834-NFPA 70-2020 [Section No. 215.12(C)]

(C) Identification of Ungrounded Conductors.

Ungrounded conductors shall be identified in accordance with 215.12(C)(1) ~~or~~ (C)(2), or (C)(3), as applicable.

(1) Feeder Supplied from One Nominal Voltage System.

Where the premises wiring system has feeder circuits supplied from one nominal voltage system, each ungrounded conductor of a feeder shall be identified in accordance with 310.6(C).

(2) Feeders Supplied from More Than One Nominal Voltage System.

Where the premises wiring system has feeders supplied from more than one nominal voltage system, each ungrounded conductor of a feeder shall be identified by phase or line and system at all termination, connection, and splice points in compliance with 215.12(C)(1)(a) and (b).

(a) *Means of Identification.* The means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means.

(b) *Posting of Identification Means.* The method utilized for conductors originating within each feeder panelboard or similar feeder distribution equipment shall be documented in a manner that is readily available or shall be permanently posted at each feeder panelboard or similar feeder distribution equipment.

(2.3) Feeders Supplied from Direct-Current Systems.

Where a feeder is supplied from a dc system operating at more than 60 volts, each ungrounded conductor of 4 AWG or larger shall be identified by polarity at all termination, connection, and splice points by marking tape, tagging, or other approved means; each ungrounded conductor of 6 AWG or smaller shall be identified by polarity at all termination, connection, and splice points in compliance with 215.12(C)(2)(a) and (b). The identification methods utilized for conductors originating within each feeder panelboard or similar feeder distribution equipment shall be documented in a manner that is readily available or shall be permanently posted at each feeder panelboard or similar feeder distribution equipment.

(a) *Positive Polarity, Sizes 6 AWG or Smaller.* Where the positive polarity of a dc system does not serve as the connection for the grounded conductor, each positive ungrounded conductor shall be identified by one of the following means:

- (2) A continuous red outer finish
- (3) A continuous red stripe durably marked along the conductor's entire length on insulation of a color other than green, white, gray, or black
- (4) Imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, gray, or black, and repeated at intervals not exceeding 610 mm (24 in.) in accordance with 310.8(B)
- (5) An approved permanent marking means such as sleeving or shrink-tubing that is suitable for the conductor size, at all termination, connection, and splice points, with imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, gray, or black

(f) *Negative Polarity, Sizes 6 AWG or Smaller.* Where the negative polarity of a dc system does not serve as the connection for the grounded conductor, each negative ungrounded conductor shall be identified by one of the following means:

- (7) A continuous black outer finish
- (8) A continuous black stripe durably marked along the conductor's entire length on insulation of a color other than green, white, gray, or red
- (9) Imprinted minus signs (–) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red, and repeated at intervals not exceeding 610 mm (24 in.) in accordance with 310.8(B)
- (10) An approved permanent marking means such as sleeving or shrink-tubing that is suitable for the conductor size, at all termination, connection, and splice points, with imprinted minus signs (–) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red

Statement of Problem and Substantiation for Public Input

I suggest the additional text to help the Code user know how to identify ungrounded conductors supplied by a single source.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 10 12:18:30 EDT 2020

Committee: NEC-P10

**Public Input No. 2277-NFPA 70-2020 [Section No. 215.12(C)(1)]****(1) Feeders Supplied from More Than One Nominal Voltage System.**

Where the premises wiring system has feeders supplied from more than one nominal voltage system, each ungrounded conductor of a feeder shall be identified by its distinct phase or line, and

system at

identified by the distinct voltage system. Applies to all termination, connection, and splice points in compliance with 215.12(C)(1)(a) and (b).

(a) Means of Identification. The means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means.

(b) Posting of Identification Means. The method utilized for conductors originating within each feeder panelboard or similar feeder distribution equipment shall be documented in a manner that is readily available or shall be permanently posted at each feeder panelboard or similar feeder distribution equipment.

Informational Note: see 200.6(D) Grounded Conductors of Different Systems.

Informational Note: see 210.5(C)(1) Branch Circuits Supplied from More Than One Nominal Voltage System.

Statement of Problem and Substantiation for Public Input

- 1) Clarify "identified by ... system" to mean "identified by ... voltage system", as compared to "different power system types", or "different equipment system types", or other potential interpretations for applicable kinds of systems.
- 2) Include an informational note that correlates the requirement for feeder phase conductor distinctions by voltage system to the phase conductor distinctions required for differing voltage systems; 200.6(D).
- 3) Include an informational note that correlates the requirement for feeder phase conductor distinctions by voltage system to the phase conductor distinctions required for differing voltage systems; 210.5(C)(1).

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submittal Date: Thu Aug 13 13:31:08 EDT 2020

Committee: NEC-P10



Public Input No. 1185-NFPA 70-2020 [New Section after 215.12(C)(2)]

215.13 One Building or Other Structure Not to Be Supplied Through Another.

Feeder conductors supplying a building or other structure shall not pass through the interior of another building or other structure.

Statement of Problem and Substantiation for Public Input

There is no way that this would be safe, yet there is nothing in the code to restrict it.

I frequently have issues where services (with disconnects) are located remote from the building, and contractors attempt to pass through one building in order to serve another. The danger is similar or equal to that of Article 230.3. Killing power to a building or unit may not necessarily shut down all the power to that building or unit.

I've also submitted a PI to 230.3. Hopefully one of the code panels will pick it up.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 1184-NFPA 70-2020 [Section No. 230.3]	
Public Input No. 1184-NFPA 70-2020 [Section No. 230.3]	

Submitter Information Verification

Submitter Full Name: Nick Sasso
Organization: Clark County Building and Fire
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 22 19:51:17 EDT 2020
Committee: NEC-P10

**Public Input No. 4032-NFPA 70-2020 [New Section after 225.1]****TITLE OF NEW CONTENT**

Type your content here:

225.2 Definitions

Outside Outside as used in this article shall apply to conductors and equipment outside of the building or structure envelope. Conductors on the outside of a building or structure may be located within an adjacent building or structure.

Outdoors Outdoors as used in this article shall apply to conductors and equipment located outside of the building or structure and exposed to weather or other atmospheric influences.

Statement of Problem and Substantiation for Public Input

The terms outside and outdoors have been used in Article 225 for many years without clear definition. Often outside is construed as being synonymous with outdoors when clearly one can be outside of a given building or structure but not outdoors. The following definitions will provide clear direction when addressing conductors that may pass between buildings but are never in an outdoor environment.

Submitter Information Verification

Submitter Full Name: David Humphrey

Organization: County of Henrico, Virginia

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 18:20:27 EDT 2020

Committee: NEC-P10



Public Input No. 191-NFPA 70-2019 [Section No. 225.3]

225.3 Other Articles.

Application of other articles, including additional requirements to specific cases of equipment and conductors, is shown in Table 225.3.

Table 225.3 Other Articles

<u>Equipment/Conductors</u>	<u>Article</u>
Branch circuits	210
Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits	725
Communications circuits	<u>800 & 805</u>
Community antenna television and radio distribution systems	<u>800 & 820</u>
Conductors for general wiring	310
Electrically driven or controlled irrigation machines	675
Electric signs and outline lighting	600
Feeders	215
Fire alarm systems	760
Fixed outdoor electric deicing and snow-melting equipment	426
Floating buildings	553
Grounding and bonding	250
Hazardous (classified) locations	500
Hazardous (classified) locations — specific	510
Marinas and boatyards	555
Medium-voltage conductors and cable	311
Messenger-supported wiring	396
Mobile homes, manufactured homes, and mobile home parks	550
Open wiring on insulators	398
Over 1000 volts, general	490
Overcurrent protection	240
Radio and television equipment	<u>800 & 810</u>
Services	230
Solar photovoltaic systems	690
Swimming pools, fountains, and similar installations	680
Use and identification of grounded conductors	200
<u>Network-Powered Broadband communications Systems</u>	<u>800 & 830</u>
<u>Premises-Powered Broadband Communications Systems</u>	<u>800 & 840</u>
<u>Data Centers</u>	<u>645</u>
<u>Modular Data Centers</u>	<u>646</u>

Statement of Problem and Substantiation for Public Input

The 2020 NEC introduced Article 800, General Requirements for Communications Systems. This PI corrects apparent omissions by adding references to Article 800 and to Articles 830 & 840 in Chapter 8. In addition it adds references to the data center articles in Chapter 6.

Submitter Information Verification

Submitter Full Name: Stanley Kaufman

Organization: CableSafe, Inc./OFS

Affiliation: PLASTICS Industry Association (PLASTICS)

Street Address:

City:
State:
Zip:
Submittal Date: Fri Dec 20 09:33:26 EST 2019
Committee: NEC-P10



Public Input No. 3786-NFPA 70-2020 [Section No. 225.3]

225.3 Other Articles.

Application of other articles, including additional requirements to specific cases of equipment and conductors, is shown in Table 225.3.

Table 225.3 Other Articles

<u>Equipment/Conductors</u>	<u>Article</u>
Branch circuits	210
Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits	725
Communications circuits	805
Community antenna television and radio distribution systems	820
Conductors for general wiring	310
Electrically driven or controlled irrigation machines	675
Electric signs and outline lighting	600
Feeders	215
Fire alarm systems	760
Fixed outdoor electric deicing and snow-melting equipment	426
<u>Flexible bus systems</u>	<u>371</u>
<u>Floating buildings</u>	<u>553</u>
Grounding and bonding	250
Hazardous (classified) locations	500
Hazardous (classified) locations — specific	510
Marinas and boatyards	555
Medium-voltage conductors and cable	311
Messenger-supported wiring	396
Mobile homes, manufactured homes, and mobile home parks	550
Open wiring on insulators	398
Over 1000 volts, general	490
Overcurrent protection	240
Radio and television equipment	810
Services	230
Solar photovoltaic systems	690
Swimming pools, fountains, and similar installations	680
Use and identification of grounded conductors	200

Statement of Problem and Substantiation for Public Input

This public input is a correlating addition to recognize flexible bus systems as one of the other related articles in 225.3 for outside feeders. A new Article 371 (PI 3616) is being proposed to cover the installation requirements for a new wiring method named “flexible bus systems”. This new wiring method has similarities to busways and cable bus systems, but also has unique characteristics warranting its own Article. This new wiring method is intended for use for service conductors, feeders and branch circuits.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3789-NFPA 70-2020 [Section No. 230.43]	1000V or less wiring method
Public Input No. 3616-NFPA 70-2020 [Global Input]	new article - Flexible Bus Systems
Public Input No. 3616-NFPA 70-2020 [Global Input]	
Public Input No. 3789-NFPA 70-2020 [Section No. 230.43]	

Submitter Information Verification

Submitter Full Name: Ward Judson
Organization: nVent Electric plc
Affiliation: nVent Electric plc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Sep 09 12:42:41 EDT 2020
Committee: NEC-P10

**Public Input No. 755-NFPA 70-2020 [Section No. 225.4]****225.4 Conductor Covering Insulation .**

Where within 3.0 m (10 ft) of any building or structure other than supporting poles or towers, open individual (aerial) overhead conductors shall be insulated for the nominal voltage. The insulation of conductors in cables or raceways, except Type MI cable, shall be of thermoset or thermoplastic type and, in wet locations, shall comply with 310.10(C). The insulation of conductors for festoon lighting shall be of the thermoset or thermoplastic type.

Exception: Equipment grounding conductors and grounded circuit conductors shall be permitted to be bare or covered as specifically permitted elsewhere in this Code.

Statement of Problem and Substantiation for Public Input

The title of this section uses the word "covering" while the requirement addresses "insulation." Replacing "covering" with "insulation" would make the title reflect the content of this section. It would also clarify that this requirement addresses conductor insulation and not conductor covering such as is addressed by the defined term "covered conductor" in Article 100: "Conductor, Covered. A conductor encased within material of composition or thickness that is not recognized by this Code as electrical insulation. (CMP-6)"

Submitter Information Verification

Submitter Full Name: Palmer Hickman

Organization: Electrical Training Alliance

Street Address:

City:

State:

Zip:

Submittal Date: Mon Mar 23 11:28:31 EDT 2020

Committee: NEC-P10



Public Input No. 1902-NFPA 70-2020 [Section No. 225.5]

225.5 Size of Conductors 1000 Volts, Nominal, or Less.

The ampacity of outdoor branch-circuit and feeder conductors shall be in accordance with 310.14 based on loads as determined under 220.10 and Part III of Article 220.

Statement of Problem and Substantiation for Public Input

This is already covered in Articles 210 and 215. There is no reason for it to be here as well.

Submitter Information Verification

Submitter Full Name: Ryan Jackson

Organization: Ryan Jackson

Street Address:

City:

State:

Zip:

Submittal Date: Tue Jul 14 12:59:35 EDT 2020

Committee: NEC-P10

**Public Input No. 1901-NFPA 70-2020 [Section No. 225.7]****~~225.7— Lighting Equipment Installed Outdoors.~~****~~(A)— General.~~**

~~For the supply of lighting equipment installed outdoors, the branch circuits shall comply with Article 210 and 225.7(B) through (D).~~

~~(B)— Common Neutral.~~

~~The ampacity of the neutral conductor shall not be less than the maximum net calculated load current between the neutral conductor and all ungrounded conductors connected to any one phase of the circuit.~~

~~(C)— 277 Volts to Ground.~~

~~Circuits exceeding 120 volts, nominal, between conductors and not exceeding 277 volts, nominal, to ground shall be permitted to supply luminaires for illumination of outdoor areas of industrial establishments, office buildings, schools, stores, and other commercial or public buildings.~~

~~(D)— 1000 Volts Between Conductors.~~

~~Circuits exceeding 277 volts, nominal, to ground and not exceeding 1000 volts, nominal, between conductors shall be permitted to supply the auxiliary equipment of electric-discharge lamps in accordance with 210.6(D) (1).~~

Statement of Problem and Substantiation for Public Input

None of this section is needed. (B) is covered by Articles 210 and 220, (C) contains no requirement (all permissive text), (D) contains no requirement (all permissive text), and after removing (B)-(D), (A) is meaningless.

Submitter Information Verification

Submitter Full Name: Ryan Jackson

Organization: Ryan Jackson

Street Address:

City:

State:

Zip:

Submission Date: Tue Jul 14 12:53:29 EDT 2020

Committee: NEC-P10

**Public Input No. 3752-NFPA 70-2020 [Section No. 225.7(A)]**

(A) General.

For the supply of lighting equipment installed outdoors, the branch circuits shall comply with ~~Article 210.6(D)~~ and 225.7(B) through (D).

Statement of Problem and Substantiation for Public Input

Section 4.1.4 of the 2020 NEC(r) Style Manual prohibits reference to an entire article, other than Article 100. As such, it is proposed to instead point the user to 210.6 since that section includes the voltage limitations for illumination of outside areas.

Submitter Information Verification

Submitter Full Name: Richard Holub

Organization: The DuPont Company, Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 11:50:28 EDT 2020

Committee: NEC-P10

**Public Input No. 4051-NFPA 70-2020 [Section No. 225.11]****225.11 Feeder and Branch-Circuit Conductors Entering, Exiting, or Attached to Buildings or Structures.**

Feeder and branch-circuit conductors entering or exiting buildings or structures shall be installed in accordance ~~with the requirements of~~ with 230.52. Overhead branch circuits and feeders attached to buildings or structures shall be installed in accordance ~~with the requirements of~~ with 230.54.

Statement of Problem and Substantiation for Public Input

Deleting the words "the requirements of" does not change the meaning of the section.
Thanks Terra for messing it up.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 19:11:33 EDT 2020

Committee: NEC-P10

**Public Input No. 999-NFPA 70-2020 [Section No. 225.22]****225.22 Raceways on Exterior Surfaces of Buildings or Other Structures.**

Raceways on exteriors of buildings or other structures shall be arranged to drain and shall be listed or approved for use in wet locations.

One or more weep holes, in the bottom of the exterior or wet location raceways, shall be permissible as a drain method in other than classified locations, in lieu of fittings, enclosures, or routing, etc. that could also serve the purpose. Field created weep holes shall be at least 3mm (1/8") and no greater than 6mm (1/4") diameter. Weep holes shall be created before wiring is installed in accordance with 300.18A.

Statement of Problem and Substantiation for Public Input

Weep holes are now permitted in the bottom of junction boxes 314.15. Preferably, the raceways are routed in a way, use drain fittings, or use junction boxes that would allow the raceway to drain. Weep holes placed in the bottom of a back to back EMT run with the ends upturned would be an example of weep holes being implemented in place of more raceway fittings or boxes.

In an alley, I did see RMC split like a broken water pipe in Colorado. Maybe someone left a service disconnect open and rain filled up the RMC. When winter came the raceway burst from the frozen water.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Thu May 07 18:13:37 EDT 2020

Committee: NEC-P10

**Public Input No. 1455-NFPA 70-2020 [Section No. 225.27]****225.27 Raceway Seal.**

Where a raceway enters a building or structure from outside, it shall be sealed and arranged to drain where necessary . Spare or unused raceways shall also be sealed and arranged to drain where necessary . Sealants shall be identified for use with cable insulation, conductor insulation, bare conductor, shield, or other components.

-

Statement of Problem and Substantiation for Public Input

I have been an inspector for 18 years and can state from my own experience where outside conduits have acted as a funnel (or conduit) for rain water to quickly enter weak spots point of entries (duct seal will only hold for so long) Allowing the AHJ to enforce this new language would be helpful. Asking for any type of drainage is typically met with resistance. I have seen floors heave and IDF rooms flood out in a hospital.

Submitter Information Verification

Submitter Full Name: James Dorsey

Organization: Douglas County Electrical Insp

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jun 05 14:44:13 EDT 2020

Committee: NEC-P10

**Public Input No. 1840-NFPA 70-2020 [Section No. 225.27]****225.27 Raceway Seal.**

Where a raceway enters a building or structure from outside, it shall be sealed or plugged at either or both ends . Spare or unused raceways shall also be sealed. Sealants shall be identified for use with cable insulation, conductor insulation, bare conductor, shield, or other components. An explosionproof seal shall not be required for this purpose.

Statement of Problem and Substantiation for Public Input

Added text from 300.5(G) related to sealed or plugged at both ends.
Add text from 300.7(A) about the seal not required to be explosion proof.

There are four rules related to raceway seals and they all are 'slightly different.' I am submitting a PI so they all are consistent with each other.

225.27 Raceway Seal.

Where a raceway enters a building or structure from outside, it shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with cable insulation, conductor insulation, bare conductor, shield, or other components.

An explosionproof seal shall not be required for this purpose.

230.8 Raceway Seal.

Where a raceway enters a building or structure from the outside, it shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components.

An explosionproof seal shall not be required for this purpose.

300.5 (G) Raceway Seals. Underground raceways entering a building from the outside through which moisture may contact live parts shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components.

An explosionproof seal shall not be required for this purpose.

Informational Note: Presence of hazardous gases or vapors may also necessitate sealing of underground conduits or raceways entering buildings.

300.50 (F) Raceway Seal. Underground raceways enters a building through which moisture may contact live parts shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components. An explosionproof seal shall not be required for this purpose.

Informational Note: Presence of hazardous gases or vapors may also necessitate sealing of underground conduits or raceways entering buildings.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 10 13:28:03 EDT 2020

Committee: NEC-P10

**Public Input No. 2542-NFPA 70-2020 [Section No. 225.30]****225.30** Number of Supplies.

~~A- The supply of a power source circuit from one building or other structure that is served by a branch circuit or feeder on the load side of a service disconnecting means shall be supplied by only one feeder or branch circuit. structure to another building or structure shall be restricted to a single circuit of distribution between them, unless permitted in 225.30(A) through through (F H).~~ For the purpose of this section, a multiwire branch circuit shall be considered a single circuit. ~~Where a branch circuit or feeder originates in these additional buildings or other structures, only one feeder or branch circuit~~

(A) Special Conditions.

Additional feeders or branch circuits shall be permitted to supply power back to the original building or structure, unless permitted in the following:

- (1) Distinctive power source system types
- (2) Redundant Normal power supply system circuit from a separate service.
- (3) Essential Power Supply System circuit in accordance with NFPA 110 .
- (4) Stored Energy Power Supply System circuit in accordance with NFPA 111.
- (5) Fuel cell power supply system circuit , when used as a power source for power system type 225.30(A).

~~through-~~

(1)

(a) (

F

(1)

(a) 1)(E) through 225 .

(1)

(a) 30 (A)

~~– Special Conditions.~~

Additional feeders or branch circuits shall be permitted to supply the following:

- (1) Fire pumps
- (2) Emergency systems
- (3) Legally required standby systems
- (4) Optional standby systems
- (5) Parallel power production systems
- (6)
 - (a) ~~(1)(K)~~ -
 - (b) ~~Essential Electrical System~~ circuits in accordance with Article 517, or any of its sub-system branches;
 - (7) Life Safety Branch
 - (8) Critical Branch
 - (9) Equipment Branch
 - (10) Equipment Branch A
 - (11) Equipment Branch B
 - (c) Fire pump circuit in accordance with Article 695.
 - (d) Emergency system circuit in accordance with Article 700.
 - (e) Legally required standby system circuit in accordance with Article 701.
 - (f) Optional standby system circuit in accordance with Article 702.
 - (g) Critical Operations Power system circuit in accordance with Article 708.
 - (h) Parallel power production system circuit in accordance with Article 705, when used as a power source for power system type 225.30(A)(1)(E) through 225.30(A)(1)(J).
 - (i) Uninterrupted Power Supply (UPS) system circuit. Each of the permitted power system types 225.30(A)(1)(A) through 225.30(A)(1)(K) may have a distinct UPS sub-type.
- (12) ~~Distinctive distribution system~~ - topologies
 - (13) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability
 - (14) Loop feeder systems designed to facilitate a multi-directional source of supply for the purpose of enhanced reliability.
- (15) ~~Distinctive load~~ types and applications
 - (16) Electric vehicle charging systems listed, labeled, and identified for more than a single branch circuit or feeder
 - (17) Docking facilities and piers

~~(B)~~ - Load circuit returned as a source circuit.

~~Where a building or structure has been supplied a power source circuit from another building or structure, that circuit shall not return as power source back to the originating building or structure, unless permitted in 225.30(B)(1) through 225.30(B)(3);~~

- (1) ~~Where the circuit is used as one of multiple sources to derive one of the distinctive power system types described in 225.30(1)(E) through 225.30(1)(K).~~
- (2) ~~Where the circuit is used as one of multiple sources to derive one of the distinctive power system topologies described in 225.30(A)(2).~~
- (3) ~~Where the circuit is used to derive one of the distinctive load-specific power system types described in 225.30(A)(3).~~

(C) - Common Supply Equipment.

Where feeder conductors originate in the same panelboard, switchboard, or other distribution equipment, and each feeder terminates in a single disconnecting means, not more than six feeders shall be permitted. Where more than one feeder is installed in accordance with this section, all feeder disconnects supplying the building or structure shall be grouped in the same location, and the requirements of 225.33 shall not apply. Each disconnect shall be marked to indicate the load served.

(C D) Special Occupancies.

By special permission, additional feeders or branch circuits shall be permitted for either of the following:

- (1) Multiple-occupancy buildings where there is no space available for supply equipment accessible to all occupants
- (2) A single building or other structure sufficiently large to make two or more supplies necessary

(D E) Capacity Requirements.

Additional feeders or branch circuits shall be permitted where the capacity requirements are in excess of 2000 amperes at a supply voltage of 1000 volts or less.

(E F) Different Characteristics.

Additional feeders or branch circuits shall be permitted for different voltages, frequencies, or phases, or for different uses such as control of outside lighting from multiple locations.

(F G) Documented Switching Procedures.

Additional feeders or branch circuits shall be permitted to supply installations under single management where documented safe switching procedures are established and maintained for disconnection.

(H) Sign and label requirements

Where multiple disconnecting means must be operated to remove all power to a building, to a structure or to load equipment, a permanent sign shall be provided on or adjacent to each disconnecting means.

A permanent plaque or directory shall be installed at each source disconnect location, or at an approved readily visible location. The plaque or directory shall denote the location of each power source disconnecting means for the building, structure or load equipment and be grouped with other plaques or directories for other on-site sources. The plaque or directory shall be marked with the wording "CAUTION: MULTIPLE SOURCES OF POWER." Any posted diagrams shall be correctly oriented with respect to the diagram's location. The marking shall comply with 110.21(B) and not handwritten.

Statement of Problem and Substantiation for Public Input

- 1) clarify obscure meaning of 'these additional buildings' and of 'original building or structure.' For example, is 'original building' construed to be that which is upstream in distribution of the service power source, or the building where some other power system type has originated? For example, building #1 is where the service entrance occurs and building #2 is where the required emergency power system is first derived.
- 2) Generally, the sharing of a power source circuit from and to any single pair of buildings or structures is intended to be restricted to a single-layer of distribution between them, with exceptions and caveats described in 225.30(A) through (E). However, by invoking the term "service" in the first paragraph this intent is only constrained to applications where the origin of the power source is a service. However, all other forms of power sources should also be encompassed for consistency of intent, so that the task of removing all power to any one building or structure is not over-complicated.
- 3) Reference label requirements at each source disconnect at each building or structure to facilitate shut down of all power sources at each building or structure, wherever multiple sources are present.
- 4) Clarify the allowance for a bi-directional medium voltage feeder loop that may by design serve multiple buildings or structures yet rely upon on single source, and hence not qualify from item #6. Since #6 is based on increased reliability due to multiple sources, excluding the application of increased reliability from a single source.
- 5) Join item #2 and #3 and rewrite to include all potential categories of code-recognized power systems.
- 6) Clarify that, for any particular source type that is permitted to be shared, it may only be shared to a building or structure from one other building or structure.

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submittal Date:	Mon Aug 24 13:29:03 EDT 2020
Committee:	NEC-P10

**Public Input No. 1858-NFPA 70-2020 [Section No. 225.30(A)]****(A) Special Conditions.**

Additional feeders or branch circuits shall be permitted to supply the following:

- (1) Fire pumps
- (2) Emergency systems
- (3) Legally required standby systems
- (4) Optional standby systems
- (5) Parallel power production systems
- (6) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability
- (7) Electric vehicle ~~charging-~~ power transfer systems listed, labeled, and identified for more than a single branch circuit or feeder
- (8) Docking facilities and piers

Statement of Problem and Substantiation for Public Input

The title for Article 625 was changed to Electric Vehicle Power transfer systems, in the 2020 NEC.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 11 18:08:57 EDT 2020

Committee: NEC-P10

**Public Input No. 2439-NFPA 70-2020 [Section No. 225.30(A)]****(A) Special Conditions.**

Additional feeders or branch circuits shall be permitted to supply the following:

- (1) Fire pumps
- (2) Emergency systems
- (3) Legally required standby systems
- (4) Optional standby systems
- (5) Parallel power production systems
- (6) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability
- (7) Electric vehicle charging systems listed, labeled, and identified for more than a single source of supply; branch circuit(s) or feeder(s)
- (8) Docking facilities and piers

Statement of Problem and Substantiation for Public Input

The intent is not to qualify the electric vehicle charge system by merely whether it has multiple branch circuits or feeders, but whether it has multiple power sources. The distinction being "source" branch circuits or feeders versus "load" branch circuits or feeders.

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submittal Date: Fri Aug 21 13:03:17 EDT 2020

Committee: NEC-P10

**Public Input No. 3580-NFPA 70-2020 [Section No. 225.30(A)]****(A) Special Conditions.**

Additional feeders or branch circuits shall be permitted to supply the following:

- (1) Fire pumps
- (2) Emergency systems
- (3) Legally required standby systems
- (4) Optional standby systems
- (5) Parallel power production systems
- (6) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability
- (7) Electric vehicle charging systems- listed, labeled, and identified for more than a single branch circuit or feeder
- (8) Docking facilities and piers

Statement of Problem and Substantiation for Public Input

Removed redundant text that requires Listed equipment as it is already covered by 625.5. 625.5 Text shown here for reference:

625.5 Listed. All equipment covered by the scope of this article shall be listed.

The PV Industry Forum (PVIF) is a collaborative initiative of several organizations dedicated to continually improving the installation safety of PV systems in the U.S. The organizations are the Solar Energy Industry Association (SEIA), the PV Industry Codes Council (PVICC), Solar Energy International (SEI), the Interstate Renewable Energy Council (IREC), and the Large-Scale Solar Association (LSA). This coalition has come together to organize, convene, support and mentor solar industry professionals through the NEC public input process, which is open to all solar industry participants.

This collaborative effort has resulted in the consensus development of numerous solar-related Public Input proposals for consideration. The list of task group members indicates those individuals who have contributed to the development of various Public Inputs in nine different tasks groups. A consensus process was used to develop each Public Input, therefore this list does not necessarily indicate that each individual or their representative organization participated in or has agreed with every proposed Public Input submitted under the PVIF effort. Each participant has agreed that any original proposal that they submitted and which was subsequently improved by our process is assigned as original and / or improved work to PVIF for submittal and release to NFPA as a proposed Public Input.

Members of the PVIF's effort include the following representatives. Note that those noted below participated in specific task groups and not necessarily all task groups on specific items proposed. Each member is at their discretion to individually comment on PI's as they deem appropriate.

Evelyn Butler, SEIA; Jason Fisher, SEIA; Ward Bower, Ward Bower Innovations LLC/SEIA; Joseph Cain, P.E., SEIA; Bill Brooks, Brooks Engineering/PVICC; Rebekah Hren, Solar Energy International; Brian Mehalic, Solar Energy International; Mark Rodriguez, Sunrun; Paul Joyce, Sunrun; Brian Ewing, Swinerton; Sumana Seshadri, Swinerton; Christian Eder, Fronius USA; Isaac Opalinsky, SunPower; Chris Fox, SunPower; James Cormican, RBI Solar; Dave Compaan, RBI Solar; Shawn Shaw, Natural Power; Cody Oram, Vivint Solar; Greg Elvestad, Vivint Solar; Mike Weimer, Westwood Professional Services; Doug Mutcher, Westwood Professional Services; Jeff Wang, Staubli; Colleen O'Brien, UL; John Doty, UL; Laurie Florence, UL; Tim Zgonena, UL; Gokul Kalyan, FTC Solar; Ali Sedaghat, FTC Solar; K.C. Radford, Radian Generation; Jan Dominguez, LG Electronics; Ben Chamberlain, Olivewood Energy; Klaus Nicolaedis, Unirac Inc.; Leif Cook, Core Development Group; Martin Herzfeld, Herzfeld; Dave Click, esaSolar; Sean White, principal; Kate Collardson, BayWa r.e. Solar Systems; Bryan Holland, NEMA; Jack Lyons, NEMA; Mike Stone, NEMA; Evan Martin, BURNDY; Terry McKinch, Mortenson; Jason Bobruk, SolarEdge Technologies; Reid ; train, Savion; Charlie Dearie, McCalmont Engineering; Sumanth Lokanath, Ray Illuminati LLC; Yann Schwarz, Esdec Inc.; Joseph Armano, PanelClaw, Inc.; Michael Heinrich, PanelClaw, Inc.; Steve Wurmlinger, SMA Solar Technology AG; Thomas Wegener, SMA Solar Technology AG; Chris Flueckiger, Key Renewables; Matt Piantedosi, Ridgeline Energy Analytics; Samantha Doshi, Intertek; Kyle Breuning, Tesla; Charles Picard, Tesla; Steve Connolly, Tesla; Greg Ball, Tesla; Jake West, Tesla; Jamie Daggett, DNV GL; MinWah Leung, DNV GL; Bob White, Fimer SpA; Marvin Hamon, Pure Power Engineering; Milton Nogueira, Roof Tech; Peter Seidel, First Solar; Jason Smolko, Copperweld;

Submitter Information Verification

Submitter Full Name: Evelyn Butler

Organization: Solar Energy Industries Assn

Affiliation: PV Industry Forum (PVIF)

Street Address:

City:
State:
Zip:
Submittal Date: Wed Sep 09 08:16:51 EDT 2020
Committee: NEC-P10

**Public Input No. 3896-NFPA 70-2020 [Section No. 225.30(A)]****(A) Special Conditions.**

Additional feeders or branch circuits shall be permitted to supply the following:

- (1) Fire pumps
- (2) Emergency systems
- (3) Legally required standby systems
- (4) Optional standby systems
- (5) Parallel power production systems
- (6) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability
- (7) ~~Electric vehicle charging systems listed, labeled, and identified for more than a single branch circuit or feeder~~
- (8)
- (9) Docking facilities and piers

Statement of Problem and Substantiation for Public Input

Note: this is another Terror View botch; I only intended to remove (7) and renumber (8) accordingly.

The vehicle charging system allowance went into the NEC at the same time that the definition of structure was changing to its present form, and the two actions have never been correlated. The present allowance is unnecessary because the current definition excludes equipment.

Submitter Information Verification

Submitter Full Name: Frederic Hartwell

Organization: Hartwell Electrical Services, Inc.

Affiliation: self

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 15:01:56 EDT 2020

Committee: NEC-P10

**Public Input No. 2614-NFPA 70-2020 [Section No. 225.30(B)]****(B) Common Supply Equipment.**

Where feeder ~~conductors or branch circuit conductors or combination thereof~~ originate in the same panelboard, switchboard, or other distribution equipment, and each feeder terminates in a single disconnecting means, not more than six feeders shall be permitted. Where more than one feeder is installed in accordance with this section, all feeder disconnects supplying the building or structure shall be grouped in the same location, and the requirements of 225.33 shall not apply. Each disconnect shall be marked to indicate the load served.

Statement of Problem and Substantiation for Public Input

This input is being submitted on behalf of the Minnesota Department of Labor and Industry. The Department's 15 office/field staff, and 65 plus contract electrical inspectors complete over 150,000 electrical inspections annually and are involved in the daily enforcement and interpretation of the National Electrical Code.

Article 225 provides requirements for outdoor feeders and branch circuits. The new language would allow both branch circuits and feeders to be included in the rule. There is no safety reason to limit the allowance of 225.30(B) to only feeder conductors.

Submitter Information Verification

Submitter Full Name: Dean Hunter

Organization: Minnesota Department of Labor

Street Address:

City:

State:

Zip:

Submission Date: Tue Aug 25 20:47:34 EDT 2020

Committee: NEC-P10

**Public Input No. 2534-NFPA 70-2020 [Section No. 225.30(C)]****(C) Special Occupancies.**

By special permission, additional feeders or branch circuits shall be permitted for either of the following:

Multiple multiple -occupancy buildings where there is no space available for supply equipment accessible to all occupants

- ~~A single building or other structure sufficiently large to make two or more supplies necessary~~

7

Statement of Problem and Substantiation for Public Input

The topic regarding provision of an additional building supply based on load capacity is already accommodated by 225.30(D) Capacity Requirements. If any further provision on this topic is intended, such added clarification may best be suited to be encompassed in 225.30(D). Hence this text warrants deletion from 225.30(C) unless some other intent is meant, in which case, a revision of text for clarification is warranted.

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submittal Date: Mon Aug 24 12:15:38 EDT 2020

Committee: NEC-P10

**Public Input No. 3153-NFPA 70-2020 [Section No. 225.30(F)]****(F) Documented Switching Procedures.**

Additional feeders or branch circuits shall be permitted to supply installations under single management where documented safe switching procedures are established and maintained- ~~for disconnection~~ .

Statement of Problem and Substantiation for Public Input

safe switching procedure are not only for disconnection but more importantly re-energizing the system. to say for disconnecting (only) it leaves the more important part out to re-energize. Switching procedures are just that turning the system on and off.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3154-NFPA 70-2020 [Section No. 225.32]	

Submitter Information Verification

Submitter Full Name: Alfio Torrisi
Organization: electrician
Street Address:
City:
State:
Zip:
Submittal Date: Sat Sep 05 19:21:14 EDT 2020
Committee: NEC-P10

**Public Input No. 638-NFPA 70-2020 [Section No. 225.30(F)]**

(F) Documented Switching Procedures.

~~Additional~~ For airports and other large, industrial facilities that permanently employ qualified personnel, additional feeders or branch circuits shall be permitted to supply installations under single management where documented safe switching procedures are established and maintained for disconnection.

Statement of Problem and Substantiation for Public Input

This section is frequently abused. The net result with the current language in 225.30(F) is that it creates a situation whereby 225.30 [parent language] no longer has any "teeth." I've seen store owners, shop owners, strip malls, office buildings, etc., attempt to utilize 225.30(F).

Here in Las Vegas, McCarran Airport has approximately 35-40 licensed electricians on staff (full-time) and actually DOES have documented safe switching procedures. In the event something needs to be shut down, it is all documented and planned out weeks in advance. I believe that this is the true intent behind 225.30(F). The language needs to be more restrictive, IMHO, so it isn't seen as a "way out." Anyone can attempt to invent "documented" procedures, but I believe the true intent is that this section is for larger facilities that have qualified people on staff.

It doesn't always pan out this way in real life, when people contact our bosses, or their lawyers or legislators.

Submitter Information Verification

Submitter Full Name: Nick Sasso

Organization: Clark County Building and Fire

Street Address:

City:

State:

Zip:

Submittal Date: Thu Mar 12 12:08:32 EDT 2020

Committee: NEC-P10

**Public Input No. 2913-NFPA 70-2020 [Section No. 225.31]****225.31 Disconnecting Means.**

(A) Through Building. Means shall be provided for disconnecting all ungrounded conductors that supply or pass through the building or structure.

(B) Emergency Disconnects. For one- and two-family dwelling units, all feeder conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be marked: EMERGENCY DISCONNECT, FEEDER DISCONNECT

Markings shall comply with 110.21(B).

Statement of Problem and Substantiation for Public Input

A new requirement to have an Emergency Disconnect was added for 'services' in 230.85 for one- and two-family dwellings. However, often the service equipment is not placed on the building. In this condition, 'feeder' conductors supply the dwelling unit.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 03 09:18:19 EDT 2020

Committee: NEC-P10

**Public Input No. 2043-NFPA 70-2020 [Sections 225.31, 225.32]****Sections 225.31, 225.32****225.31** Disconnecting Means.

(A) Means shall be provided for disconnecting all ungrounded conductors that supply or pass through the building or structure.

225.32—(B) Location.

The disconnecting means shall be installed either inside or outside of the building or structure served or where the conductors pass through the building or structure. The disconnecting means shall be at a readily accessible location nearest the point of entrance of the conductors. For the purposes of this section, the requirements in 230.6 shall be utilized.

Exception No. 1: For installations under single management, where documented safe switching procedures are established and maintained for disconnection, and where the installation is monitored by qualified individuals, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 2: For buildings or other structures qualifying under Article 685, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 3: For towers or poles used as lighting standards, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 4: For poles or similar structures used only for support of signs installed in accordance with Article 600, the disconnecting means shall be permitted to be located elsewhere on the premises.

Statement of Problem and Substantiation for Public Input

225.32, currently, is titled 'location.' It is meant to be the location of the disconnect described in the section above. It makes sense to move both 225.31 and 225.32 under that same section.

Submitter Information Verification

Submitter Full Name: Eric Stromberg

Organization: Los Alamos National Laboratory

Affiliation: Self

Street Address:

City:

State:

Zip:

Submittal Date: Sun Jul 26 14:27:57 EDT 2020

Committee: NEC-P10

**Public Input No. 24-NFPA 70-2019 [Section No. 225.32]****225.32** Location.

The disconnecting means shall be installed either inside or outside of the building or structure served or where the conductors pass through the building or structure. The disconnecting means shall be at a readily accessible location nearest the point of entrance of the conductors. For the purposes of this section, the requirements in 230.6 shall be utilized.

Exception No. 1: For installations under single management, where documented safe switching procedures are established and maintained for disconnection, and where the installation is monitored by qualified individuals, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 2: For buildings or other structures qualifying under Article 685, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 3: For towers or poles used as lighting standards, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 4: For poles or similar structures used only for support of signs installed in accordance with Article 600, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 5: The disconnecting means shall not be required at the nearest point of entrance for single family dwellings or associated buildings, where a disconnecting means is located within sight from and not more than 30 feet from the exterior wall of the structure it serves. Each set of conductors shall be terminated in a single breaker or set of fuses. 225.34 shall apply at each structure.

Statement of Problem and Substantiation for Public Input

Often the service disconnect location is on a pedestal near the dwelling unit. The requirement now would be to have another disconnect at the nearest point of entrance either inside or outside creating a redundancy. A disconnect within 30 feet and in sight from the outside of the structure would be easily visible to emergency responders and the most likely avenue to disconnect the power if needed. The conductors would have the required overcurrent protection and the disconnects would still be required to be grouped. The 30 foot distance correlates with 550.32 for disconnects of manufactured homes.

Submitter Information Verification

Submitter Full Name: Gary Sonnen

Organization: State of Idaho Division of Building Safety

Street Address:

City:

State:

Zip:

Submission Date: Mon Nov 04 13:35:43 EST 2019

Committee: NEC-P10

**Public Input No. 2758-NFPA 70-2020 [Section No. 225.32]****225.32 Location.**

The disconnecting means shall be installed either inside or outside of the building or structure served or where the conductors pass through the building or structure. The disconnecting means shall be at a readily accessible location nearest the point of entrance of the conductors. For the purposes of this section, the requirements in 230.6 shall be utilized.

Exception No. 1: For installations under single management, where documented safe switching procedures are established and maintained for disconnection, and where the installation is monitored by qualified individuals, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 2: For buildings or other structures qualifying under Article 685, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 3: For towers or poles used as lighting standards, the disconnecting means shall be permitted to be located elsewhere on the premises. Exception No. 4: 3. For poles or similar structures used only for support of signs installed in accordance with Article 600, the disconnecting means shall be permitted to be located elsewhere on the premises.

Statement of Problem and Substantiation for Public Input

With the revised definition of a structure, (Structure: that which is built or constructed, " other than equipment") it is no longer necessary to state the exception for a pole. Prior code cycles included all structures for requiring a disconnecting means, a light pole was exempt. It is a piece of equipment and therefor not required to have a disconnecting means and leaving this in the code only blurs what is a structure

Submitter Information Verification

Submitter Full Name: James Dorsey

Organization: Douglas County Electrical Insp

Street Address:

City:

State:

Zip:

Submittal Date: Mon Aug 31 09:23:30 EDT 2020

Committee: NEC-P10

**Public Input No. 3154-NFPA 70-2020 [Section No. 225.32]****225.32 Location.**

The disconnecting means shall be installed either inside or outside of the building or structure served or where the conductors pass through the building or structure. The disconnecting means shall be at a readily accessible location nearest the point of entrance of the conductors. For the purposes of this section, the requirements in 230.6 shall be utilized.

Exception No. 1: For installations under single management, where documented safe switching procedures are established and maintained- ~~for disconnection~~ , and where the installation is monitored by qualified individuals, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 2: For buildings or other structures qualifying under Article 685, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 3: For towers or poles used as lighting standards, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 4: For poles or similar structures used only for support of signs installed in accordance with Article 600, the disconnecting means shall be permitted to be located elsewhere on the premises.

Statement of Problem and Substantiation for Public Input

same as PI 3153

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3153-NFPA 70-2020 [Section No. 225.30(F)]	

Submitter Information Verification

Submitter Full Name: Alfio Torrisi
Organization: electrician
Street Address:
City:
State:
Zip:
Submittal Date: Sat Sep 05 19:30:37 EDT 2020
Committee: NEC-P10

**Public Input No. 3788-NFPA 70-2020 [Section No. 225.32]****225.32 Location.**

The disconnecting means shall be installed either inside or outside of the building or structure served or where the conductors pass through the building or structure. The disconnecting means shall be at a readily accessible location nearest the point of entrance of the conductors. For the purposes of this section, the requirements in 230.6 shall be utilized.

Exception No. 1: For installations under single management, where documented safe switching procedures are established and maintained for disconnection, and where the installation is monitored by qualified individuals, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 2: For buildings or other structures ~~qualifying under Article 685~~ in accordance with 685.1, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 3: For towers or poles used as lighting standards, the disconnecting means shall be permitted to be located elsewhere on the premises.

Exception No. 4: For poles or similar structures used only for support of signs installed in accordance with ~~Article 600.1~~, the disconnecting means shall be permitted to be located elsewhere on the premises.

Statement of Problem and Substantiation for Public Input

Section 4.1.4 of the 2020 NEC(r) Style Manual prohibits reference to an entire article, other than Article 100. As such, it is proposed to instead reference the scope (or specific part) of the relevant article to address this problem.

Submitter Information Verification

Submitter Full Name: Richard Holub

Organization: The DuPont Company, Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 12:50:13 EDT 2020

Committee: NEC-P10

**Public Input No. 1005-NFPA 70-2020 [Section No. 225.33(A)]****(A) General.**

The disconnecting means for each supply permitted by 225.30 shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard or switchgear. There shall be no more than six disconnects per supply grouped in any one location.

Where one disconnect enclosure is used at a separate structure and this enclosure can accommodate more than 6 disconnecting means, a label suitable for the environment shall be installed and marked with the following:
CAUTION, NO MORE THAN 6 HANDLE THROWS PERMITTED IN THIS ENCLOSURE WITHOUT A MAIN DISCONNECTING MEANS

Exception: For the purposes of this section, disconnecting means used solely for the control circuit of the ground-fault protection system, or the control circuit of the power-operated supply disconnecting means, installed as part of the listed equipment, shall not be considered a supply disconnecting means.

Statement of Problem and Substantiation for Public Input

Maintenance men, homeowners, and other electricians may not know the six switch rule. For example, installing a 12 circuit capacity, main lug only, panel at a separate structure with 4 circuits being used is code compliant. It is easy for this building to have more circuits added and exceed the allowed 6 handles.

Adopting this new code proposal is an easy solution. The building can be prepared for future electrical work if desired. New circuits can be added at a later date without great cost. Cost isn't our safety concern but the described installation is frequently done and poses a threat that my new label proposal could thwart.

The required label reads 'suitable for the environment'. If the label is installed on the exterior of an outdoor enclosure, a placard would be required. If installed inside the panel cover on the dead front of an outside enclosure, a UV rated sticker would suffice.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Fri May 08 15:17:04 EDT 2020

Committee: NEC-P10

**Public Input No. 1007-NFPA 70-2020 [New Section after 225.33(B)]****TITLE OF NEW CONTENT****225.33****(C) Marking**

Type your content here ...

Each of the one through six required disconnecting means, for each given power source, shall be marked: MAIN

Statement of Problem and Substantiation for Public Input

This is similar to 230.70B. It is a requirement to label each of the 1 through 6 service disconnecting means as service disconnect. It should be a requirement for outside branch circuits and feeders, as well. A service disconnect would remain being referred to as a service disconnect. A feeder disconnect would be referred to as 'MAIN'.

The practice would be to mark each of the 1 through 6, grouped, utility feeder disconnects as 'MAIN'. Also, each of the allowed 1 through 6 photovoltaic feeder disconnects as 'MAIN'. Same for generators and so on.

It is important that a user knows what it takes to shut off all power for that separate structure. This proposed code change, along with 225.37 Identification, adds to that assurance.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Fri May 08 15:55:10 EDT 2020

Committee: NEC-P10



Public Input No. 1010-NFPA 70-2020 [New Section after 225.37]

TITLE OF NEW CONTENT

225.37(B) Identification of Remote Branch Circuits and Feeders

Type your content here ...

Where the physical location of a source for a branch circuit or feeder is not evident, while at the load end of a branch circuit or feeder, a permanent label shall be required at the load stating a physical description of where the source is derived. This is the case for buildings, structures, or equipment.

Informational Note: Examples: Motorized gate, premises with multiple outbuildings, signs, or skid mounted equipment, where the source is not evident, would require a permanent label such as 'FED FROM 125 YDS N.W.'

Statement of Problem and Substantiation for Public Input

This new 225.37B code entry is similar to 408.4B but is for loads not distribution points. It also applies to dwellings.

The new 225.37B is a good idea just like 408.4B is a good idea. Once the original electrician leaves the job, service electricians, maintenance personnel and homeowners, may have a hard time locating the source of a circuit at a remote location. It isn't overreaching either because, like 110.22A, if the power source location is evident, the label isn't required.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Fri May 08 16:27:31 EDT 2020

Committee: NEC-P10

**Public Input No. 1009-NFPA 70-2020 [Section No. 225.37]****225.37– 37(A) Multiple Circuits Identification .**

Where a building or structure has any combination of feeders, branch circuits, or services passing through it or supplying it, a permanent plaque or directory shall be installed at each feeder and branch-circuit disconnect location denoting all other services, feeders, or branch circuits supplying that building or structure or passing through that building or structure and the area served by each.

Exception No. 1: A plaque or directory shall not be required for large-capacity multibuilding industrial installations under single management, where it is ensured that disconnection can be accomplished by establishing and maintaining safe switching procedures.

Exception No. 2: This identification shall not be required for branch circuits installed from a dwelling unit to a second building or structure.

Statement of Problem and Substantiation for Public Input

225.37 Identification becomes 225.37(A) Multiple Circuits Identification

The existing 225.37 text remains the same for this new title. This also makes room for new proposal 225.37(B).

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Fri May 08 16:20:41 EDT 2020

Committee: NEC-P10



Public Input No. 2087-NFPA 70-2020 [Section No. 225.37]

225.37 Identification.

Where a building or structure has any combination of feeders, branch circuits, or services passing through it or supplying it, a permanent plaque or directory shall be installed at each feeder and branch-circuit disconnect location denoting all other services, feeders, or branch circuits supplying that building or structure or passing through that building or structure and the area served by each.

Exception No. 1: A plaque or directory shall not be required for large-capacity ~~multibuilding industrial installations~~ multibuilding installations under single management, where conditions of maintenance and supervision ensure that only qualified persons service the installation and where it is ensured that disconnection can be accomplished by establishing and maintaining safe switching procedures.

Exception No. 2: This identification shall not be required for branch circuits installed from a dwelling unit to a second building or structure.

Statement of Problem and Substantiation for Public Input

This exception shouldn't be limited to industrial locations. It should apply to any location that has controlled access where only trained workers are able to service the installation. The Department of Energy facilities, for example, are not necessarily "industrial" but have extremely strict rules for working on the premises. The contractors must undergo extensive training, work packages must be created, means and methods must all be approved. This is part of a series of proposals to change "industrial locations/premises/occupancies/wiring-systems/..." to "controlled access locations."

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2047-NFPA 70-2020 [Section No. 110.21(A)(2)]	part of global proposal to change 'industrial' to 'controlled access'
Public Input No. 2048-NFPA 70-2020 [Section No. 110.24(B)]	part of global proposal to change 'industrial' to 'controlled access'
Public Input No. 2049-NFPA 70-2020 [Section No. 110.70]	part of global proposal to change 'industrial' to 'controlled access'
Public Input No. 2050-NFPA 70-2020 [Section No. 210.8(B)]	part of global proposal to change 'industrial' to 'controlled access'
Public Input No. 2051-NFPA 70-2020 [Section No. 210.8(B)]	part of global proposal to change 'industrial' to 'controlled access'
Public Input No. 2052-NFPA 70-2020 [Section No. 210.9]	part of global proposal to change 'industrial' to 'controlled access'
Public Input No. 2053-NFPA 70-2020 [Section No. 210.18]	part of global proposal to change 'industrial' to 'controlled access'
Public Input No. 2054-NFPA 70-2020 [Section No. 215.11]	part of global proposal to change 'industrial' to 'controlled access'
Public Input No. 2088-NFPA 70-2020 [Section No. 225.52(A)]	
Public Input No. 2090-NFPA 70-2020 [Section No. 230.205(C)]	
Public Input No. 2091-NFPA 70-2020 [Section No. 240.21(C)(3)]	
Public Input No. 2092-NFPA 70-2020 [Section No. 300.50(A) [Excluding any Sub-Sections]]	
Public Input No. 2093-NFPA 70-2020 [Section No. 336.10]	
Public Input No. 2094-NFPA 70-2020 [Section No. 368.56(B)]	

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:

State:

Zip:

Submittal Date: Wed Jul 29 16:44:35 EDT 2020

Committee: NEC-P10

**Public Input No. 1846-NFPA 70-2020 [Section No. 225.39]****225.39 Rating of Disconnect Conductors and Disconnecting Means .**

The feeder or branch-circuit conductors and disconnecting means shall have a rating of not less than the calculated load to be supplied, determined in accordance with Parts I and II of Article 220 for branch circuits, Part III or IV of Article 220 for feeders, or Part V of Article 220 for farm loads. Where the branch circuit or feeder disconnecting means consists of more than one switch or circuit breaker, as permitted by 225.33, combining the ratings of all the switches or circuit breakers for determining the rating of the disconnecting means shall be permitted. In no case shall the rating be lower than specified in 225.39(A), (B), (C), or (D).

(A) One-Circuit Installation.

For installations to supply only limited loads of a single branch circuit, the branch circuit conductors and disconnecting means shall have a rating of not less than 15 amperes.

(B) Two-Circuit Installations.

For installations consisting of not more than two 2-wire branch circuits, the feeder or branch-circuit conductors disconnecting means shall have a rating of not less than 30 amperes.

(C) One-Family Dwelling.

For a one-family dwelling, the feeder conductors and disconnecting means shall have a rating of not less than 100 amperes, 3-wire.

(D) All Others.

For all other installations, the feeder or branch-circuit conductors and disconnecting means shall have a rating of not less than 60 amperes.

Statement of Problem and Substantiation for Public Input

My text is to make it clear that this rule also is intended to ensure that the conductors and disconnect have a rating not less than the calculated load. The way it is currently written, only the disconnect is required to comply with this rule for rating, not the conductor.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 10 13:57:10 EDT 2020

Committee: NEC-P10

**Public Input No. 1197-NFPA 70-2020 [Section No. 225.39(A)]****(A) One-Circuit Installation.**

For installations to supply only limited loads of a single branch circuit, the branch circuit disconnecting means shall have a rating of not less than 15 amperes, conductors shall be a minimum 14 AWG prior to any adjustments and/or corrections . .

Statement of Problem and Substantiation for Public Input

Add language noting the conductors shall be a minimum 14 AWG prior to any adjustments and/or corrections. This change will assist with correlating various other articles such as 110.14 (C) (1), 240.4 (D), 310.15 (A).

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 06:43:50 EDT 2020

Committee: NEC-P10

**Public Input No. 1198-NFPA 70-2020 [Section No. 225.39(B)]****(B) Two-Circuit Installations.**

For installations consisting of not more than two 2-wire branch circuits, the feeder or branch-circuit disconnecting means shall have a rating of not less than 30 amperes, conductors shall be a minimum 10 AWG prior to any adjustments and/or corrections .

Statement of Problem and Substantiation for Public Input

Add language noting the conductors shall be a minimum 10 AWG prior to any adjustments and/or corrections. This change will assist with correlating various other articles such as 110.14 (C) (1), 240.4 (D), 310.15 (A).

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 07:07:00 EDT 2020

Committee: NEC-P10

**Public Input No. 1199-NFPA 70-2020 [Section No. 225.39(C)]****(C) One-Family Dwelling.**

For a one-family dwelling, the feeder disconnecting means shall have a rating of not less than 100 amperes, 3-wire, conductors shall be a minimum 4 AWG prior to any adjustments and/or corrections . .

Statement of Problem and Substantiation for Public Input

Add language noting the conductors shall be a minimum 4 AWG prior to any adjustments and/or corrections. This change will assist with correlating various other articles such as 110.14 (C), 310.12, Table 310.12, 310.15 (A).

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 07:10:10 EDT 2020

Committee: NEC-P10

**Public Input No. 1200-NFPA 70-2020 [Section No. 225.39(D)]**

(D) All Others.

For all other installations, the feeder or branch-circuit disconnecting means shall have a rating of not less than 60 amperes, conductors shall be a minimum 4 AWG prior to any adjustments and/or corrections .

Statement of Problem and Substantiation for Public Input

Add language noting the conductors shall be a minimum 4 AWG prior to any adjustments and/or corrections. This change will assist with correlating various other articles such as 110.14 (C) (1), 240.4 (D), 310.15 (A).

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 07:13:04 EDT 2020

Committee: NEC-P10

**Public Input No. 1201-NFPA 70-2020 [Section No. 225.39(D)]****(D) All Others.**

For all other installations, the feeder or branch-circuit disconnecting means shall have a rating of not less than 60 amperes.

Provide clarifying language noting if the 60 amperes feeder or branch disconnecting means is applicable to single phase and three phase installations. The available power for example in a 120/240 volt application at 60 amps is significantly less than the power available when a 277/480 volt system is used. For three phase applications the requirement to have a 60 amperes rated feeder or branch disconnecting means is disproportionally oversized relative to single phase applications.

Statement of Problem and Substantiation for Public Input

Provide clarifying language noting if the 60 amperes feeder or branch disconnecting means is applicable to single phase and three phase installations. The available power for example in a 120/240 volt application at 60 amps is significantly less than the power available when a 277/480 volt system is used. For three phase applications the requirement to have a 60 amperes rated feeder or branch disconnecting means is disproportionally oversized relative to single phase applications.

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 07:22:45 EDT 2020

Committee: NEC-P10



Public Input No. 2088-NFPA 70-2020 [Section No. 225.52(A)]

(A) Location.

A building or structure disconnecting means shall be located in accordance with 225.32, or, if not readily accessible, it shall be operable by mechanical linkage from a readily accessible point. For ~~multibuilding industrial installations~~ multibuilding installations under single management, where conditions of maintenance and supervision ensure that only qualified persons service the installation, it shall be permitted to be electrically operated by a readily accessible, remote-control device in a separate building or structure.

Statement of Problem and Substantiation for Public Input

This exception shouldn't be limited to industrial locations. It should apply to any location that has controlled access where only trained workers are able to service the installation. The Department of Energy facilities, for example, are not necessarily "industrial" but have extremely strict rules for working on the premises. The contractors must undergo extensive training, work packages must be created, means and methods must all be approved. This is part of a series of proposals to change "industrial locations/premises/occupancies/wiring-systems/..." to "controlled access locations."

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2047-NFPA 70-2020 [Section No. 110.21(A)(2)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2048-NFPA 70-2020 [Section No. 110.24(B)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2049-NFPA 70-2020 [Section No. 110.70]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2050-NFPA 70-2020 [Section No. 210.8(B)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2051-NFPA 70-2020 [Section No. 210.8(B)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2052-NFPA 70-2020 [Section No. 210.9]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2053-NFPA 70-2020 [Section No. 210.18]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2054-NFPA 70-2020 [Section No. 215.11]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2087-NFPA 70-2020 [Section No. 225.37]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2090-NFPA 70-2020 [Section No. 230.205(C)]	
Public Input No. 2091-NFPA 70-2020 [Section No. 240.21(C)(3)]	
Public Input No. 2092-NFPA 70-2020 [Section No. 300.50(A) [Excluding any Sub-Sections]]	
Public Input No. 2093-NFPA 70-2020 [Section No. 336.10]	
Public Input No. 2094-NFPA 70-2020 [Section No. 368.56(B)]	

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:
State:
Zip:

Submittal Date:	Wed Jul 29 16:55:08 EDT 2020
Committee:	NEC-P10



Public Input No. 2068-NFPA 70-2020 [Section No. 225.60]

225.60 Clearances over Roadways, Walkways, Rail, Water, and Open Land.

(A) 22 kV ~~; Nominal; or Less~~ to Ground ~~or Less~~.

The clearances over roadways, walkways, rail, water, and open land for conductors and live parts up to 22 kV ~~; nominal; or less~~ to ground ~~or less~~ shall be not less than the values shown in Table 225.60.

(B) ~~Over~~ More Than 22 kV ~~Nominal~~ to Ground.

Clearances for the categories shown in Table 225.60 shall be increased by 10 mm (0.4 in.) per kV ~~above~~ 22,000 volts ~~, or major fraction thereof, more than 22 kV~~.

(C) Special Cases.

For special cases, such as where crossings will be made over lakes, rivers, or areas using large vehicles such as mining operations, specific designs shall be engineered considering the special circumstances and shall be approved by the authority having jurisdiction.

Informational Note: For additional information, see ANSI/IEEE C2-2017, *National Electrical Safety Code*.

Table 225.60 Clearances over Roadways, Walkways, Rail, Water, and Open Land

<u>Location</u>	<u>Clearance</u>	
	<u>m</u>	<u>ft</u>
Open land subject to vehicles, cultivation, or grazing	5.6	18.5
Roadways, driveways, parking lots, and alleys	5.6	18.5
Walkways	4.1	13.5
Rails	8.1	26.5
Spaces and ways for pedestrians and restricted traffic	4.4	14.5
Water areas not suitable for boating	5.2	17.0

Statement of Problem and Substantiation for Public Input

Useability of the Code.

- What is less than "ground"? "Or less" refers to the value "22 kV", not to the datum "ground". This editorial revision is consistent with the same elsewhere in this Code.
- Given that 225.60(A) address "22 kV OR LESS", it's more appropriate that 225.60(B) address "MORE THAN 22 kV" rather than the LOCATIONAL PREPOSITIONS "OVER" and "ABOVE", particularly if differentiating OVERHEAD clearances.
- Since there are no tolerances associated with 22 kV to enforce, there's no need for "NOMINAL". Furthermore, in 225.60(B), "NOMINAL" confuses at what unstated maximum tolerance beyond 22 kV that one starts to add the 10 mm (0.4 inch) per kV. Is 23 kV encompassed by the 22 kV NOMINAL ratings?
- In accordance with the NEC® Style Manual, Units of Measurement – Code text (p 35), "abbreviate volt (V) [and by extension, kilovolt (kV)] when used with a number to mean a rating".

Submitter Information Verification

Submitter Full Name: Brian Rock

Organization: Hubbell Incorporated

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 27 20:40:53 EDT 2020

Committee: NEC-P10



Public Input No. 2069-NFPA 70-2020 [Section No. 225.61]

225.61 Clearances over Buildings and Other Structures.

(A) 22 kV ~~Nominal or Less~~ to Ground ~~or Less~~.

The clearances over buildings and other structures for conductors and live parts up to 22 kV ~~, nominal, or less~~ to ground ~~or less~~ shall be not less than the values shown in Table 225.61.

(B) ~~Over~~ More Than 22 kV ~~Nominal~~ to Ground.

Clearances for the categories shown in Table 225.61 shall be increased by 10 mm (0.4 in.) per kV ~~above~~ 22,000 volts ~~, or major fraction thereof, more than 22 kV~~.

Informational Note: For additional information, see ANSI/IEEE C2-2017, *National Electrical Safety Code*.

Table 225.61 Clearances over Buildings and Other Structures

<u>Clearance from Conductors or Live Parts from:</u>	<u>Horizontal</u>		:	<u>Vertical</u>	
	<u>m</u>	<u>ft</u>		<u>m</u>	<u>ft</u>
Building walls, projections, and windows	2.3	7.5	-	—	—
Balconies, catwalks, and similar areas accessible to people	2.3	7.5	-	4.1	13.5
Over or under roofs or projections not readily accessible to people	—	—	-	3.8	12.5
Over roofs accessible to vehicles but not trucks	—	—	-	4.1	13.5
Over roofs accessible to trucks	—	—	-	5.6	18.5
Other structures	2.3	7.5	-	—	—

Statement of Problem and Substantiation for Public Input

Useability of the Code.

- What is less than "ground"? "Or less" refers to the value "22 kV", not to the datum "ground". This editorial revision is consistent with the same elsewhere in this Code.
- Given that 225.61(A) address "22 kV OR LESS", it's more appropriate that 225.61(B) address "MORE THAN 22 kV" rather than the LOCATIONAL PREPOSITIONS "OVER" and "ABOVE", particularly if differentiating OVERHEAD clearances.
- Since there are no tolerances associated with 22 kV to enforce, there's no need for "NOMINAL". Furthermore, in 225.61(B), "NOMINAL" confuses at what unstated maximum tolerance beyond 22 kV that one starts to add the 10 mm (0.4 inch) per kV. Is 23 kV encompassed by the 22 kV NOMINAL ratings?
- In accordance with the NEC® Style Manual, Units of Measurement – Code text (p 35), "abbreviate volt (V) [and by extension, kilovolt (kV)] when used with a number to mean a rating".

Submitter Information Verification

Submitter Full Name: Brian Rock

Organization: Hubbell Incorporated

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 27 21:19:11 EDT 2020

Committee: NEC-P10



Public Input No. 2843-NFPA 70-2020 [Section No. 230.2]

230.2—4 Number of Services.

A building or other structure served shall be supplied by only one service unless permitted in 230.2(A) through (D). For the purpose of 230.40, Exception No. 2 only, underground sets of conductors, 1/0 AWG and larger, running to the same location and connected together at their supply end but not connected together at their load end shall be considered to be supplying one service.

(A) Special Conditions.

Additional services shall be permitted to supply the following:

- (1) Fire pumps
- (2) Emergency systems
- (3) Legally required standby systems
- (4) Optional standby systems
- (5) Parallel power production systems
- (6) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability

(B) Special Occupancies.

By special permission, additional services shall be permitted for either of the following:

- (1) Multiple-occupancy buildings where there is no available space for service equipment accessible to all occupants
- (2) A single building or other structure sufficiently large to make two or more services necessary

(C) Capacity Requirements.

Additional services shall be permitted under any of the following:

- (1) Where the capacity requirements are in excess of 2000 amperes at a supply voltage of 1000 volts or less
- (2) Where the load requirements of a single-phase installation are greater than the serving agency normally supplies through one service
- (3) By special permission

(D) Different Characteristics.

Additional services shall be permitted for different voltages, frequencies, or phases, or for different uses, such as for different rate schedules.

(E) Identification.

Where a building or structure is supplied by more than one service, or any combination of branch circuits, feeders, and services, a permanent plaque or directory shall be installed at each service disconnect location denoting all other services, feeders, and branch circuits supplying that building or structure and the area served by each. See 225.37.

Statement of Problem and Substantiation for Public Input

Standard NEC formatting and parallel numbering, according to the NEC Style Manual, leaves XXX.2 for definitions that apply to only one article. 230.2 is not a definition, therefore it should not have the common parallel number format XXX.2. This change is intended to keep formatting consistent throughout the NEC, which in turn helps to keep the NEC easy to navigate. This can also be substantiated by the explanatory material found under the scope of Article 100 in the NEC Handbook.

The next available section number is 230.4, though many other section numbers could also fix the problem. If there are other such examples where section XXX.2 has been assigned to a section that has text other than definitions in the NEC, they should not be used as justification to reject this change proposal, but instead all such examples should be changed as well.

Submitter Information Verification

Submitter Full Name: Darin Mason

Organization: IBEW Local 226, Topeka Electrical JATC

Affiliation:	IBEW and ETA
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Sep 02 13:06:50 EDT 2020
Committee:	NEC-P10

**Public Input No. 3358-NFPA 70-2020 [Section No. 230.2(A)]****(A) Special Conditions.**

Additional services shall be permitted to supply the following:

- (1) Fire pumps
- (2) Emergency systems
- (3) Legally required standby systems
- (4) Optional standby systems
- (5) ~~Parallel power production systems~~ [Interconnected Electric Power Production Sources](#)
- (6) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability

Statement of Problem and Substantiation for Public Input

There is no change in intent of this individual list item. These systems would still be permitted to have an additional service as a Special Condition. However, this change is for clarity in application of 230.2 (A) (5) as it draws the user/enforcer to apply the provisions in Article 705 Interconnected Electric Power Production Sources in this Special Condition. This change also reinforces that Article 705 would apply by replacing the terms Parallel power production systems with the text of the title of Article 705.

Submitter Information Verification

Submitter Full Name: Timothy Croushore

Organization: Timothy M. Croushore, P.E.

Affiliation: I am representing myself.

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 10:30:14 EDT 2020

Committee: NEC-P10

**Public Input No. 3363-NFPA 70-2020 [Section No. 230.2(A)]****(A) Special Conditions.**

Additional services shall be permitted to supply the following:

- (1) Fire pumps
- (2) Emergency systems
- (3) Legally required standby systems
- (4) Optional standby systems
- (5) Parallel power production systems
- (6) ~~Systems~~ By special permission, systems designed for connection to multiple sources of supply for the purpose of enhanced reliability

Statement of Problem and Substantiation for Public Input

The current provision in list item (6) is realistically unenforceable because almost everyone can argue that two services are always more reliable than one service. This public input is to provide the enforcement community the ability to judge when this provision should be applied. Electric reliability provided by an electric utility is regulated by state public utility and public service commissions. Electric reliability is measured by the indices and terms contained in IEEE 1366 - Guide for Electric Power Distribution Reliability Indices. Typically, most public service commissions require CAIDI, SAIDI and SAIFI numbers as a measure of electric reliability. While it is understood that some connections may need enhanced reliability for critical operation, by adding the term "by special permission" to the beginning of list item (6) would require a written consent of all authorities having jurisdiction for electric reliability to allow the additional service. As currently written, it would be difficult for the electrical inspection AHJ to be able to judge the values of these reliability indices without knowing the actual numbers. In addition, knowing the actual numbers and how they compare to baseline numbers would provide an enforceable standard for an additional service for enhanced reliability. By adding the term "by special permission" would require a written justification for the need in list item (6) that would stay for the particular service connection.

Submitter Information Verification

Submitter Full Name: Timothy Croushore

Organization: Timothy M. Croushore, P.E.

Affiliation: Representing myself.

Street Address:

City:

State:

Zip:

Submission Date: Tue Sep 08 10:47:12 EDT 2020

Committee: NEC-P10

**Public Input No. 4393-NFPA 70-2020 [Section No. 230.2(A)]****(A) Special Conditions.**

Additional services shall be permitted to supply the following:

- (1) Fire pumps
- (2) Emergency systems
- (3) Legally required standby systems
- (4) Optional standby systems
- (5) Parallel power production systems
- (6) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability

Informational Note: See IEEE 3006.8 Recommended Practice for Analyzing Reliability Data for Equipment Used in Industrial and Commercial Power Systems

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
IEEE_IAS_Published_Paper_Why_Existing_Utility_Metrics_Do_Not_Work_for_Industrial_Reliability_Analysis_-_Schuerger_Arno_Dowling.pdf	To support analytic power system reliability solutions for the 2023 National Electrical Code NFPA 70	

Statement of Problem and Substantiation for Public Input

This is continuation of an effort to drive reliability perspective in electrical safety solution many of which originated in the legacy IEEE Color Books. Safety concepts in the Color Books have been in the process of being mapped into the IEEE 3000 Collection of best practice literature.

From the project scope:

This recommended practice describes data supporting the reliability evaluation of existing industrial and commercial power systems. It is likely to be of greatest value to the power-oriented engineer with limited experience in the area of reliability. It can also be an aid to all engineers responsible for the electrical design of industrial and commercial power systems.

https://standards.ieee.org/standard/3006_8-2018.html

Note that a supporting paper is attached to this proposal: "Why Existing Utility Metrics Do Not Work for Industrial Reliability Analysis" (Schuerger, Arno, Dowling)

ABSTRACT: Electrical utility reliability indices such as System Average Interruption Frequency Index, System Average Interruption Duration Index, Customer Average Interruption Duration Index, Customer Average Interruption Frequency Index, and Momentary Average Interruption Frequency Index are adequately defined in IEEE Std. 1366-2012, and serve the purpose for which they were developed. However, the explosive growth of the electronics industry moving toward internet of things, along with the data center development necessary to support such explosive growth, has had significant impact on an aging power distribution system. As the utility world evolves toward the notion of smart grid, several new reliability metrics are needed to evaluate the electrical power to the customer's side of the meter.

<https://ieeexplore.ieee.org/document/7448901>

Submitter Information Verification

Submitter Full Name: Michael Anthony

Organization: Standards Michigan + Harris Corporation + MTechnologies

Affiliation: IEEE Education & Healthcare Facilities Committee

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 11:50:17 EDT 2020

Committee: NEC-P10

Why Existing Utility Metrics Do Not Work for Industrial Reliability Analysis

Robert Schuerger PE
Harris Corporation
(robert.j.schuerger@jpl.nasa.gov)

Robert Arno
Harris Corporation
(ramo01@harris.com)

Neal Dowling
MTechnology
(dowling@mtechnology.net)

Abstract -- Electrical utility reliability indices, such as SAIFI, SAIDI, CAIDI, CAIFI, and MAIFI are adequately defined in IEEE Std. 1366-2012 [1] and serve the purpose for which they were developed. However, the explosive growth of the electronics industry moving toward an “internet of things,” along with the data center development necessary to support such explosive growth has had significant impact on an aging power distribution system. As the utility world evolves toward the notion of “smart grid,” several new reliability metrics are needed to evaluate the electrical power to the customer’s side of the meter.

Index Terms -- SAIFI, SAIDI, CAIDI, CAIFI, MAIFI, reliability, availability, failure rate, mean time between failures, mean time to repair

I. INTRODUCTION

For most people, the only time they are consciously aware of electrical power is when there is a problem and it is NOT AVAILABLE to them. The rest of the time they do not pay any attention to it whatsoever. That is actually a very big complement to the electric utility industry as a whole, the original 7x24x365 industry. The electric utility industry is made up of many separate companies across a wide geography with innumerable factors to deal with continually, including working with the other electric utility companies on a continuous basis. There is no intention on the part of the authors to criticize what works in the electrical utility world for reliability metrics. This paper is to point out why the existing electrical utility metrics do not work for industrial and commercial power system reliability analysis. It will also point out an existing gap that will need to be addressed along the road to establishing a workable “smart grid,” which many companies are currently actively working on developing.

There is a Public Utility Commission (PUC) or Public Service Commission (or some other variation of the name) in all 50 states and the District of Columbia. The PUC oversees the local utility companies (electricity, natural gas, sometimes water, etc.) and determines what that utility can charge their customers, since most utilities have a monopoly over a certain area of service. For the electrical power utilities, there is a group of common reliability indices used to measure the company’s performance. These indices are used to compare the company’s performance last year as compared to previous year and also to compare one utility’s performance with another similar company. The yearly result for each of the

common reliability indices of each electrical utility company is publicly available information.

In the next section the common reliability indices used to measure the performance of each electrical utility will be briefly reviewed. However, we are already in a position to present the most significant issue preventing the reliability indices of the electrical utility world from being useful reliability metrics for industrial and commercial power system analysis. The PUC is only interested in evaluating the utility’s performance in areas they could reasonably be expected to control. The utility company obviously cannot control the weather, so the reliability indices are calculated with all of the power disturbances that were weather related REMOVED from data set. When the energy delivery system experienced stresses beyond that normally expected, such as during severe weather, it is considered a Major Event Day and the data is analyzed separately.

The first thing the authors of this paper would like to address is that the idea that the purpose of IEEE Std. 1366 is ONLY to evaluate the performance of the utility companies. We would like it to be useful for BOTH sides of the meter. The new metrics that this paper is proposing are not for the PUC’s use in evaluating the utilities performance. They are for the use of the engineer performing reliability analysis for industrial and commercial power system, such as mission critical facilities. For this type of reliability analysis, the data set that includes ALL power disturbances is required. The weather related failures are often the failures that are the most significant to protect against.

II. ELECTRIC UTILITY RELIABILITY INDICES:

We will start with a review of the existing electric utility reliability indices. To fully understand them, it is important to review a few specific definitions used in their calculation:

Customer: a metered electrical service point for which an active bill account is established at a specific location.

Interruption: the total loss of electric power on one or more normally energized conductors to one or more customers connected to the distribution portion of the system.

Interruption duration: the time period from the initiation of an interruption until service has been restored to the affected customers.

Momentary Interruption: the brief loss of power delivery to one or more customers, caused by the opening and closing operation of an interrupting device.

Outage: the loss of ability of a component to deliver power.

Sustained Interruption: any interruption not classified as part of a momentary event. That is, any interruption that lasts more than five minutes.

It is also important to point out what is not included in ANY of the indices in [1]. The definition of *Interruption* has a second sentence (that has been moved to here for emphasis): This does not include any power quality issues such as: sags, swells, impulse or harmonics.

Another point worth mentioning is that not all PUCs use IEEE Std 1366 definitions of the reliability indices for what they required the local electric utility companies to report. In the definition above, a sustained interruption lasts five minutes or more. Another common the time period used by some PUCs is any interruption one minute or longer.

The electric utility reliability indices defined in [1] that are used as a basis for what this paper proposes as the new reliability metrics needed are as follows.

System Average Interruption Frequency Index (SAIFI) indicates how often the average customer experiences a sustained interruption over a predefined period of time.

$$SAIFI = \frac{\sum \text{Total Number of Customers Interrupted}}{\text{Total Number of Customers Served}}$$

System Average Interruption Duration Index (SAIDI) indicates the total duration of interruptions for the average customer during a predefined period of time. It is commonly measured in minutes or hours of interruption.

$$SAIDI = \frac{\sum \text{Customer Minutes of Interruption}}{\text{Total Number of Customers Served}}$$

Customer Average Interruption Duration Index (CAIDI) represents the average time required to restore service.

$$CAIDI = \frac{\sum \text{Customer Minutes of Interruption}}{\text{Total Number of Customers Interrupted}}$$

Customer Average Interruption Frequency Index (CAIFI) gives the average frequency of sustained interruptions for those customers experiencing sustained interruptions.

$$CAIFI = \frac{\sum \text{Number of Customer Interruptions}}{\text{Number of Distinct Customers Interrupted}}$$

Momentary Average Interruption Frequency Index (MAIFI) indicates the average frequency of momentary interruptions.

$$MAIFI = \frac{\sum \text{Number of Customer Momentary Interruptions}}{\text{Total Number of Customers Served}}$$

III. RELIABILITY TERMINOLOGY AND METRICS:

The next step is a review of the basic definitions of Reliability and the common metrics used for analyzing industrial and commercial power systems. These standard IEEE definitions of Reliability are from [2], [3].

Much of the terminology of Reliability Engineering is common English words and terms borrowed from Statistics. It would probably be more correct to say that Reliability Engineering depends upon the subject of Statistics, since statistics and probability are used extensively for quantification of what is being analyzed.

Reliability (R): the probability that a component or service will perform required functions under stated conditions for a stated period of time or (for discrete missions) a stated number of demands.

Reliability is time dependent; $R(t)$. The longer the time, the lower the reliability, regardless of what the system design is. The better the system design, the higher the probability of successful operation *for a longer period of time*. However, by definition, when a failure does occur $R = 0$.

Reliability is the probability of success. The probability of failure (which is also called *Unreliability*) is $F(t) = 1 - R(t)$.

failure rate (λ): The mean (arithmetic average) number of failures of a component and/or system per unit exposure time. The most common unit in reliability analysis is hours (h) or years (y). Therefore, the failure rate is expressed in failures per hour (f/h) or failures per year (f/y).

For example, select a time interval of 1 year. At the beginning of the interval we turn on 10,000 light bulbs. At the end of the year, 100 light bulbs have failed. The failure rate for those light bulbs would be $100/10,000 = 0.01$ failures/year for that first year.

The Reliability $R(t)$ for this PDF is the remaining area under the curve from t to ∞ : $R(t) = \int_t^{\infty} f(t) dt$

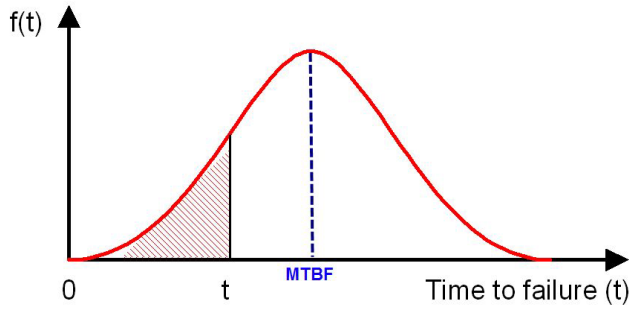


Fig. 1: Probability of failure at t is $F(t) = \int_0^t f(t) dt$

Mean time between failures (MTBF): the arithmetic mean of the times (observed or calculated) between random failures of a component or system.

Mean time to repair (MTTR): the mean time to replace or repair a failed component. Logistics time associated with the repair, such as parts acquisitions, crew mobilizations are not included. It can be estimated by dividing the summation of repair times by the number of repairs and, therefore, is practically the average repair time.

For the case of a constant failure rate, $MTBF = 1/\lambda$ and Reliability as a function of time is:

$$R(t) = e^{-\lambda t}$$

Availability (A): Availability is the long-term average fraction of time that a repairable component or system is in service and satisfactorily performing its intended function.

For example, if the electricity is off for one hour in a year, but the rest of the year the electricity is on, the availability of electrical power for that year is 8759 hours divided by 8760 hours, which is 0.999886.

$$Availability = \frac{operating\ time}{operating\ time + down\ time}$$

There are two common measures of availability, *inherent availability* (A_i) and *operational availability* (A_o). The difference between the two is based on what is included as “down time” or “repair time.” For inherent availability, only the time it takes to fix the equipment is included. Inherent availability assumes that the technician is immediately available to work on the equipment the moment it fails, and that he has all the parts, etc., necessary to complete the repair.

Inherent Availability is mathematically defined as the mean time between failures divided by the mean time between failures plus the mean time to repair:

$$A_i = \frac{MTBF}{MTBF + MTTR}$$

Operational Availability is mathematically defined as the mean time between failures divided by the mean time

between failures plus the mean time to repair plus logistics time:

$$A_o = \frac{MTBF}{MTBF + MTTR + Logistics\ time}$$

For operational availability, all the delays for scheduling, travel time for the technician and/or parts, etc. are included. If it takes 24 hours to fly a part in to repair the equipment, that adds to the “repair time.” With operational availability, the time it takes to actually perform the repair plus the time spent on handling the logistics required to do the repair are all included in the metric A_o . Operational availability reflects how the system performs in real life.

Inherent availability is a more useful tool in analyzing the system design. Since there are wide variations in the maintenance practices from facility to facility, access to parts and qualified personnel, etc., operational availability could vary significantly between two facilities with identical infrastructures. Eliminating all of the logistics and counting only the actual repair time provides a more accurate evaluation of the infrastructure design. It shows the availability that is “inherent” to the design, if the spare parts inventory and repairs are perfect.

Reliability is the “probability of success” for a given period of time. Reliability is a metric directly related to how often (or how fast) the system fails. As shown in Table 1, the system that failed once in a year for 5.26 minutes would have a much better reliability than the system that failed 315 times for one second, but nowhere near as good as the system that failed once in 20 years for 1.77 hours, even though all have the same availability.

TABLE I
THREE OUTAGES WITH THE FIVE 9'S AVAILABILITY

Availability	Number outages per year	Failure rate (failures/hr)	MTBF (hours)	MTBF (years)	Reliability (1 year)
0.99999	315	3.60E-02	27.81	0.0032	0%
0.99999	1	1.14E-04	8,760	1.0	36.78%
0.99999	0.05	5.71E-06	175,200	20	95.12%

The discussion above demonstrates the importance of using both reliability and availability as metrics to determine how dependable the component or system is. This can also be seen in the existing utility metrics. MAIFI shows how reliable the power is in terms of short interruptions. The customer would have to have UPS available to continue operation with no momentary disruption. SAIFI and CAIFI provide an indication of how reliable the utility is to the average customer in terms of sustained outages. The customer would have to have on-site generation to continue to operate beyond the length of time the batteries in the UPS would last. By using SAIDI and CAIDI with SAIFI and CAIFI the availability can be determined.

IV. ISSUES WITH UTILITY RELIABILITY INDICES:

At this point we will discuss why the electric utility reliability indices are not adequate to use in performing reliability analysis of industrial or commercial power distribution systems. In addition to the primary issue of removing the all of weather related power disturbances from the data set already mentioned, there is another specific issue with the indices.

The issue impacts all five of the indices presented earlier, SAIFI, SAIDI, CAIDI, CAIFI and MAIFI. It is the definition of customer: a metered electrical service point for which an active bill account is established at a specific location. Most electric utilities serve MILLIONS of RESIDENTIAL customers. The number of residential customers far outweighs the number of industrial and commercial customers. This factor alone significantly skews the data to the point in which it is not usable for reliability analysis.

V. WHAT IS NEEDED?

By this point it should be obvious that what is needed is another set of reliability indices for industrial and commercial customers. The Scope (section 1.2) of IEEE Std 1366-2012 states “this guide identifies distribution reliability indices and factors that affect their calculation. It includes indices, which are useful today, as well as ones that may be useful in the future.”

Unlike the existing utility metrics, the purpose of the new metrics is NOT to evaluate the performance of the utility company. The purpose of the proposed metrics is to provide the correct and complete failure and repair data for utility power to perform reliability analysis of the power distribution system of the industrial or commercial customer.

Take for example the design of a major data center. In order to achieve “five 9’s” of availability, on-site generation and UPS systems are going to be required. But how many on-site generators will be needed? That depends a great deal on how reliable utility power is at the data center location. Are the generators going to be needed about twice a year for about one hour and twenty minutes, which is the typical “generic utility power” from [2]? Or are they going to be needed much more (or less) frequently? Adding or removing one generator has significant financial impact to the cost of the overall project.

We propose adding the following definitions to IEEE Std. 1366, which would certainly be useful for performing the reliability analysis of Industrial and Commercial Power Systems:

Industrial Customer: a metered electrical service point for which an active bill account is established at a specific industrial or commercial location.

Total Number of Industrial Customers Served: the average number of industrial and commercial customers served during the reporting period.

We propose adding the following reliability indices:

Industrial Customer Average Interruption Duration Index (ICAIDI) is the average time required to restore service for all sustained interruptions to industrial and commercial customers, including Major Event Days and all weather related data.

$$ICAIDI = \frac{\sum \text{Industrial Customer Minutes of Interruption}}{\text{Total No. of Industrial Customers Interrupted}}$$

Industrial Customer Average Interruption Frequency Index (ICAIFI) gives the average frequency of all sustained interruptions to industrial and commercial customers, including Major Event Days and all weather related data. The customer is counted once, regardless of the number of times interrupted for this calculation.

$$ICAIFI = \frac{\sum \text{Number of Industrial Customer Interruptions}}{\text{No. of Distinct Industrial Customers Interrupted}}$$

Industrial Customer Momentary Average Interruption Frequency Index (ICMAIFI) gives the average frequency of all momentary interruptions to industrial and commercial customers, including Major Event Days and all weather related data. The customer is counted once, regardless of the number of times interrupted for this calculation.

$$ICMAIFI = \frac{\sum \text{Industrial Customer Momentary Interruptions}}{\text{Number of Industrial Customers Served}}$$

VI. WHAT THE NEW INDICES WOULD PROVIDE

In comparing section III to section V, it should be obvious what the proposed reliability indices for the electrical power provide; ICAIFI and ICAIDI are the MTBF and MTTR respectively for utility power to the average industrial site within that electric utility’s service area.

MTBF and MTTR data for utility power directly impacts the reliability analysis on whether or not standby generation is needed. Where standby generation is obviously needed, it also provides the means to more accurately evaluate how much redundancy in the standby generation is warranted.

For example, a site that only loses utility power once every five years (MTBF) for 2 hours (MTTR), may decide the N standby generators (the number needed to carry the load) will suffice, if the load being served is not that critical. If the load is critical, N+1 (one redundant) standby generators may be sufficient. However, if utility power is lost every three months for eighteen hours, even the site that is less critical will probably need N+1 standby generators and the critical site would need at least N+2 for the same level of reliability for electrical power to the loads.

The definition of “momentary outage” as “the opening and closing operation of an interrupting device” makes the typical time frame 3 to 5 cycles (50 to 83 milliseconds). Very few of the electronic devices on the market today have

that length of ride-thru capability internally. Therefore some form of energy storage to provide power during the interruption would be needed for any equipment that cannot be allowed to be interrupted and require rebooting.

The proposed index ICMAIFI would provide direct insight for the reliability analysis in this area. For example, a site that experiences two momentary interruptions a year is far more likely to decide that allowing the power interruption to stop operation and reboot the system is acceptable than a site that experiences two momentary interruptions a month.

VII. OTHER FACTORS – WHAT UTILITY RELIABILITY INDICES DO NOT ADDRESS

In section II, under the definition of Interruption we pointed out that the reliability indices do not address Power Quality issues such as sags, swell, transients, etc. There are numerous reasons why this is the case. A primary one is the cost of gathering that level of data and the lack of the necessary monitoring equipment throughout most of the electrical distribution system. With the recent evolution towards “smart grid,” that is changing. However, the sheer size and complexity of the electrical power grid makes smart grid an evolutionary process that will take many years to complete.

In the meantime, there is another side to the issue that can be addressed; the tolerance levels of the equipment the power is being supplied to. When analyzing the problem in terms of at what level of power does the equipment begin to misoperate or fail completely, it is called “susceptibility.”

The two most famous susceptibility curves are the original CBEMA (named after the group that developed it, Computer and Business Equipment Manufacturers Association) and ITIC Curve (named after the same group who had changed their name to Information Technology Industry Council by the time it was developed). Both are badly outdated. The newer of the two, the ITIC Curve was published in IEEE Std 1100 – 1999 (Emerald Book) [4]. Updated susceptibility curves for the various types of electronic equipment would help the design engineers providing power a great deal. Looking at the discussion in section VI on momentary outage, it is readily apparent that increasing the ride-thru of electronic equipment to be greater than 83 milliseconds could eliminate the need for UPS in some applications.

The topic of electronic equipment susceptibility is also addressed from the other side in IEEE Std 1668-2014 [5], which recommends voltage-sag immunity levels as to the equipment manufacturer. It is similar to SEMI F47 developed by the semi-conductor industry so the tools used in making the chips would ride thru voltage sags without damaging the products being manufactured.

With the definition of sustained outage as lasting longer than either one minute (for some PUCs) or five minutes (IEEE Std 1366 definition), a UPS alone will seldom have the required battery storage. In the data center world, battery storage for 5 to 15 minutes is quite common, with an

occasional requirement of 30 minutes. Only in the – 48 VDC world of the telecomm industry, in central offices for example, are batteries sized to carry the load for hours. In the industrial and commercial worlds, some form of standby generation will be required to continue operating during a sustained outage of significant length.

VIII. DATA FOR THE P1366 WORKING GROUP

Though the IEEE does have full time employees working for them, the vast majority of the work of standards development is done by volunteers who willing donate their time and expertise to improving the industry they are a part of. Therefore the less work something requires of the Working Group doing the project, the more likely it is to get done. Since the authors of this paper are not currently a part of the P1366 Working Group, here is the majority of what would need to be added to P1366 for our proposed indices:

Add the following basic factors:

I_r – Restoration Time for each Industrial Customer Sustained Interruption Event

$I_{r_{mi}}$ – Restoration Time for each Industrial Customer Momentary Interruption Event

IN_i – Number of Interrupted Industrial Customers for each Sustained Interruption Event during the reporting period

IN_{mi} – Number of Interrupted Industrial Customers for each Momentary Interruption Event during the reporting period

ICN – Total Number of distinct Industrial Customers who have experienced a Sustained Interruption during the reporting period

ICN_m – Total Number of distinct Industrial Customers who have experienced a Momentary Interruption during the reporting period

Add 4.2.9 ICAIDI: Industrial Customer Average Interruption Duration Index. The Industrial Customer Average Interruption Duration Index (ICAIDI) represents the average time required to restore service for all sustained interruptions to industrial and commercial customers, including Major Event Days. Mathematically it is given by equation (xx): $ICAIDI = \frac{\text{The sum of Industrial Customer Minutes of Interruption}}{\text{Total Number of Industrial Customers Interrupted}}$. To calculate this index, use equation (xx): $ICAIDI = (\sum I_r IN_i) / (\sum IN_i)$

Add 4.2.10 ICAIFI: Industrial Customer Average Interruption Frequency Index. The Industrial Customer Average Interruption Frequency Index (ICAIFI) gives the average

frequency of all sustained interruptions to industrial and commercial customers, including Major Event Days. The customer is counted once, regardless of the number of times interrupted for this calculation. Mathematically it is given by equation (xx): $ICAIFI = (\text{The sum of Total Number of Industrial Customer Interruptions}) / \text{Total Number of Industrial Customers Interrupted}$. To calculate this index, use equation (xx): $ICAIFI = (\sum IN_i)/ICN$

Add 4.2.11 ICMAIFI: Industrial Customer Momentary Average Interruption Frequency Index. The Industrial Customer Momentary Average Interruption Frequency Index (ICMAIFI) gives the average frequency of all momentary interruptions to industrial and commercial customers. The customer is counted once, regardless of the number of times interrupted for this calculation. Mathematically it is given by equation (xx): $ICAIFI = (\text{The sum of Total Number of Industrial Customer Interruptions}) / \text{Total Number of Industrial Customers Interrupted}$. To calculate this index, use equation (xx): $ICAIFI = (\sum IN_{mi})/ICN_m$

IX. SUMMARY

This paper has provided the basic understanding of the existing reliability indices used by the Public Utilities Commissions to measure the performance of the electric utility industry. It has also provided an overview of the metrics used in reliability analysis such as reliability, availability, MTBF and MTTR. It has explained why the electrical power indices used to measure utility performance are not adequate for doing reliability analysis for the customer. Finally the paper proposes three new “industrial customer” reliability indices that would be useful in determining the reliability of power at an industrial or commercial facility. The specific details needed to add these new indices to the next revision of IEEE Std. 1366 have been provide for the Working Group.

REFERENCES

- [1] IEEE Std. 1366 – 2012, *Guide for Electric Power Distribution Reliability Indices*.
- [2] IEEE Std. 493 – 2007, *Recommended Practice for Design of Reliable Industrial and Commercial Power Systems*.
- [3] IEEE Std. 3006.5 – 2013, *Recommended Practice for Use of Probability Methods for Conducting a Reliability Analysis of Industrial and Commercial Power Systems*.
- [4] IEEE Std. 1100- 2005, *Recommended Practice for Powering and Grounding electronic Equipment*.
- [5] IEEE Std 1668-2014 *Trial-Use Recommended Practice for Voltage Sag and Short Interruption Ride-Through Testing for End-Use Electrical Equipment Rated Less than 1000 V*.

**Public Input No. 2982-NFPA 70-2020 [Section No. 230.2(E)]****(E) Identification.**

Where a building or structure is supplied by more than one service, or any combination of branch circuits, feeders, and services, a permanent plaque or directory shall be installed at each service disconnect location, or at an approved readily visible location, denoting all other services, feeders, and branch circuits supplying that building or structure and the area served by each. See 225.37.

Statement of Problem and Substantiation for Public Input

This public input was prepared by the correlating committee task group focused on alternative energy requirements. This task group consisted of the following members: Derrick Atkins (CMP 5), Greg Ball (CMP 13) Ken Boyce (CMP 1), Bill Brooks (CMP 4), Bruce Campbell, Thomas Domitrovich (CMP 2, CMP 10), Jason Fisher (CMP 4), Scott Harding (CMP 5), Pete Jackson (CMP 8), David Kendall (CMP 8, CC), Chad Kennedy (CMP 13), Christine Porter (CMP 5, CC), Timothy Windey (CMP 13).

This public input enters the identified language to align with changes found in new Article 689, Section 689.10. Without this addition a conflict exists between these two sections around the location of the plaque or directory. This accommodates those applications where the service disconnect is not in a readily visible location, located outdoors.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2535-NFPA 70-2020 [Section No. 705.10]	Related section on marking

Submitter Information Verification

Submitter Full Name: Thomas Domitrovich
Organization: Eaton Corporation
Street Address:
City:
State:
Zip:
Submittal Date: Thu Sep 03 18:44:15 EDT 2020
Committee: NEC-P10



Public Input No. 1184-NFPA 70-2020 [Section No. 230.3]

230.3 One Building or Other Structure Not to Be Supplied Through Another.

Service conductors or feeder conductors supplying a building or other structure shall not pass through the interior of another building or other structure.

Statement of Problem and Substantiation for Public Input

The title of this section says it all. I frequently have issues where services (with disconnects) are located remote from the building, and contractors attempt to pass through one building in order to serve another. The danger is similar for feeders, or even exactly the same. Killing power to a building or unit may not necessarily shut down all the power to that building or unit. There is nothing in the code to prohibit this practice.

230.2(E), includes feeders as well as services. I feel that this section should also include feeders, as it is the intent of this very important section not to supply one building by running through the interior of another.

I've also submitted a PI to Article 215. Hopefully one of the code panels will pick it up. Personally, I think the change belongs here in 230. It integrates perfectly with 230.2(E) and 230.3.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 1185-NFPA 70-2020 [New Section after 215.12(C)(2)]	
Public Input No. 1185-NFPA 70-2020 [New Section after 215.12(C)(2)]	

Submitter Information Verification

Submitter Full Name: Nick Sasso
Organization: Clark County Building and Fire
Street Address:
City:
State:
Zip:
Submittal Date: Fri May 22 19:46:31 EDT 2020
Committee: NEC-P10

**Public Input No. 165-NFPA 70-2019 [Section No. 230.6]****230.6 Conductors Considered Outside the Building.**

Conductors shall be considered outside of a building or other structure under any of the following conditions:

- (1) Where installed under not less than 50 mm (2 in.) of concrete beneath a building or other structure
- (2) Where installed within a building or other structure in a raceway that is encased in concrete or brick not less than 50 mm (2 in.) thick
- (3) Where installed in any vault that meets the construction requirements of Article 450, Part III
- (4) Where installed in conduit and under not less than 450 mm (18 in.) of earth beneath a building or other structure
- (5) Where installed within rigid metal conduit (Type RMC) or intermediate metal conduit (Type IMC) used to accommodate the clearance requirements in 230.24 and routed directly through an eave but not a wall of a building
- (6) Where installed in service and fire pump rooms having 2 hour fire rated construction.

Statement of Problem and Substantiation for Public Input

230.70(A)(1) allows a service disconnecting means to be located inside a building, and as the panel member know it is not always possible to install it right at the point where it comes thru the exterior wall, and to run a piece of raceway to the disconnecting means, so this added option will not require to encase that section of raceway in 2" of concrete, and yet provide the necessary safe alternate to minimize damage and/or fire to the building by having a 2-hour fire rated construction of the service and/or fire pump rooms.

Submitter Information Verification

Submitter Full Name: Joel Sandel

Organization: JRS Consulting Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Tue Dec 03 15:07:38 EST 2019

Committee: NEC-P10

**Public Input No. 1261-NFPA 70-2020 [Section No. 230.7]****230.7 Other Conductors in Raceway or Cable .**

Conductors other than service conductors shall not be installed in the same service raceway- ~~or service cable~~
~~, service cable, underground boxes or handhole enclosures~~ in which the service conductors are installed.

Exception No. 1: Grounding electrode conductors or supply side bonding jumpers or conductors shall be permitted within service raceways.

Exception No. 2: Load management control conductors having overcurrent protection shall be permitted within service raceways.

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Vault_Service_Lateral_and_Generator_Feeder_Coingled.jpg	Underground enclosure with feeders and service laterals co-mingled.	

Statement of Problem and Substantiation for Public Input

Service lateral conductors were intercepted at the underground enclosure, rerouted and brought to a generator transfer switch (now the service equipment). Then the feeders from the service equipment (transfer switch) were fed through the same underground enclosure with the utility service lateral conductors (service lateral conductors co-mingled with load side feeder conductors). This installation seems to be even more hazardous than if this installation were in a raceway or cable. Should these feeders ever need to be replaced, examined or inspected, there will be energized utility conductors co-mingled within the same enclosure. Additionally, if there is ever a fault within this underground enclosure, there is a potential for the feeders to become energized from the utility service lateral, bypassing the service disconnect.

Submitter Information Verification

Submitter Full Name: Jeffrey Fecteau

Organization: UL LLC

Affiliation: UL LLC

Street Address:

City:

State:

Zip:

Submission Date: Wed May 27 14:39:19 EDT 2020

Committee: NEC-P10

Jun 20, 2019 at 1:24:07 PM



**Public Input No. 2005-NFPA 70-2020 [Section No. 230.7]****230.7 Other Conductors in Raceway or Cable.**

Conductors other than service conductors shall not be installed in the ~~same~~ meter socket enclosure, service raceway or service cable in which the service conductors are installed.

Exception No. 1: Grounding electrode conductors or supply side bonding jumpers or conductors shall be permitted within service raceways.

Exception No. 2: Load management control conductors having overcurrent protection shall be permitted within service raceways.

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
230.7_meter_with_feeders.png	230.7 Meter with Feeders	

Statement of Problem and Substantiation for Public Input

What is a common practice is to have feeder conductors pass through the meter socket enclosure from a transfer switch. Clearly this is a dangerous practice but it's not a violation of the NEC since 230.7 only addresses raceways and cables.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

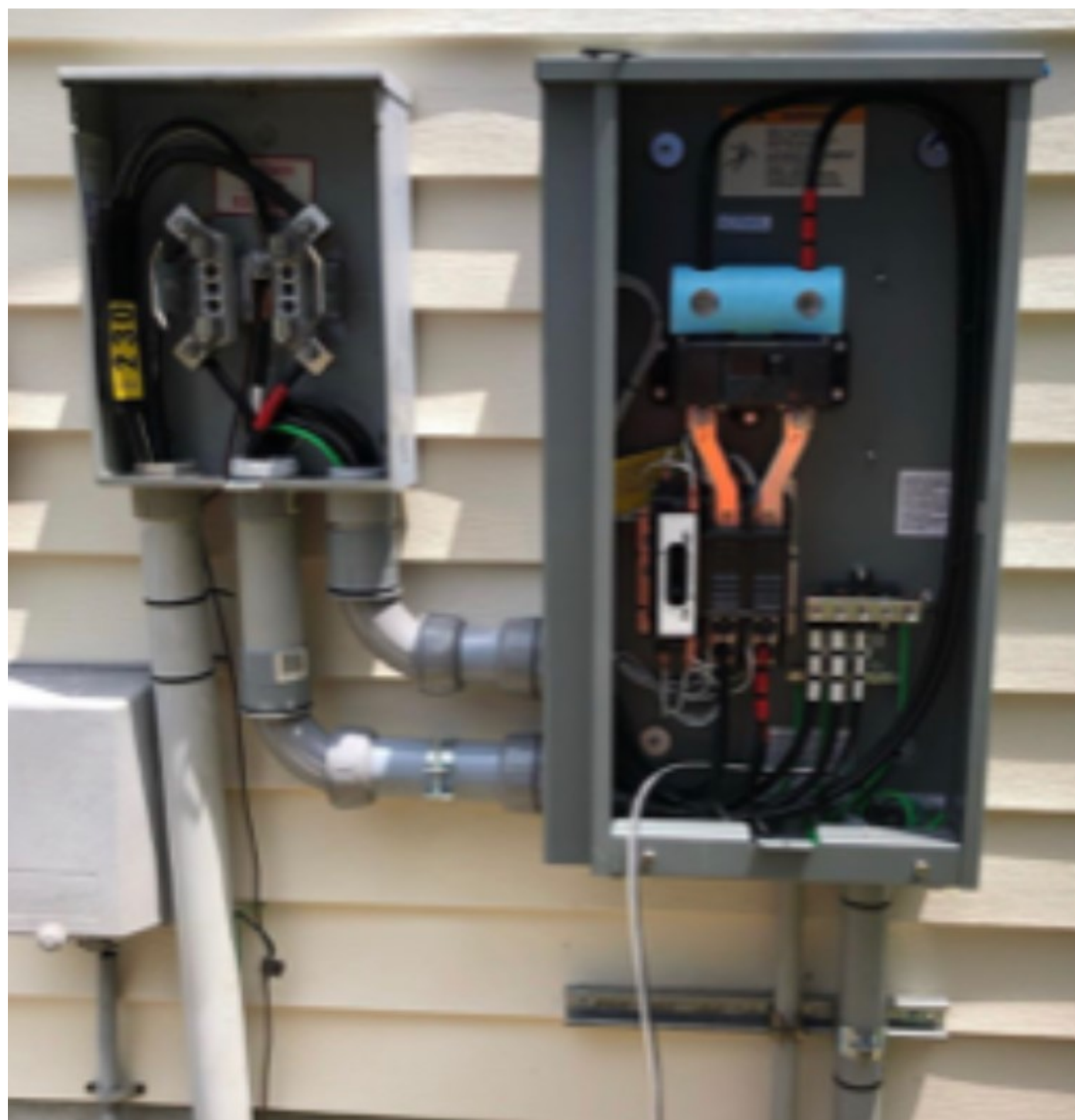
City:

State:

Zip:

Submittal Date: Fri Jul 24 17:01:47 EDT 2020

Committee: NEC-P10





Public Input No. 1841-NFPA 70-2020 [Section No. 230.8]

230.8 Raceway Seal.

Where a ~~service~~ raceway enters a building or structure from ~~an underground distribution system~~ the outside, it shall be sealed in accordance with 300.5(G) - or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components. An explosionproof seal shall not be required for this purpose.

Statement of Problem and Substantiation for Public Input

Added text "the outside, it shall be sealed or plugged at either or both ends" from 300.5(G).

Added text "conductor insulation, bare conductor" so that this rule would be consistent with 225.27.

Add text from 300.7(A) about the seal not required to be explosion proof.

There are four rules related to raceway seals and they all are 'slightly different.' I am submitting a PI so they all are consistent with each other.

225.27 Raceway Seal.

Where a raceway enters a building or structure from outside, it shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with cable insulation, conductor insulation, bare conductor, shield, or other components.

An explosionproof seal shall not be required for this purpose.

230.8 Raceway Seal.

Where a raceway enters a building or structure from the outside, it shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components.

An explosionproof seal shall not be required for this purpose.

300.5 (G) Raceway Seals. Underground raceways entering a building from the outside through which moisture may contact live parts shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components.

An explosionproof seal shall not be required for this purpose.

Informational Note: Presence of hazardous gases or vapors may also necessitate sealing of underground conduits or raceways entering buildings.

300.50 (F) Raceway Seal. Underground raceways enters a building through which moisture may contact live parts shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components. An explosionproof seal shall not be required for this purpose.

Informational Note: Presence of hazardous gases or vapors may also necessitate sealing of underground conduits or raceways entering buildings.

225.27 Raceway Seal.

Where a raceway enters a building or structure from outside, it shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with cable insulation, conductor insulation, bare conductor, shield, or other components.

An explosionproof seal shall not be required for this purpose.

230.8 Raceway Seal.

Where a raceway enters a building or structure from the outside, it shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components.

An explosionproof seal shall not be required for this purpose.

300.5 (G) Raceway Seals. Underground raceways entering a building from the outside through which moisture may contact live parts shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components.

An explosionproof seal shall not be required for this purpose.

Informational Note: Presence of hazardous gases or vapors may also necessitate sealing of underground conduits or raceways entering buildings.

300.50 (F) Raceway Seal. Underground raceways enters a building through which moisture may contact live parts shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components. An explosionproof seal shall

not be required for this purpose.

Informational Note: Presence of hazardous gases or vapors may also necessitate sealing of underground conduits or raceways entering buildings.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 10 13:33:55 EDT 2020

Committee: NEC-P10

**Public Input No. 3791-NFPA 70-2020 [Section No. 230.23(A)]****(A) General.**

Conductors shall have sufficient ampacity to carry the current for the load as calculated ~~in accordance with Article 220~~ - and shall have adequate mechanical strength.

Statement of Problem and Substantiation for Public Input

Section 4.1.4 of the 2020 NEC(r) Style Manual prohibits reference to an entire article, other than Article 100. As such, it is proposed to delete the reference to the entire Article 220 as it is understood per 90.3 that the general articles would apply. Alternatively, the CMP may wish to reference the specific part of Article 220 that applied, though in this case it seems to me that Part II, Part III, Part IV, or Part V could apply so that's why I recommended just deleting the specific reference to the entire article.

Related Public Inputs for This Document**Related Input****Relationship**

Public Input No. 3793-NFPA 70-2020 [Section No. 230.31(A)]

Submitter Information Verification

Submitter Full Name: Richard Holub

Organization: The DuPont Company, Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 12:55:17 EDT 2020

Committee: NEC-P10

**Public Input No. 612-NFPA 70-2020 [Section No. 230.24(A)]****(A)_ Above Roofs.**

Conductors shall have a vertical clearance of not less than ~~than~~ 2.5 m (8 ft) ~~above~~ 7 m (8 ft 6 in) above the roof surface. The vertical clearance above the roof level shall be maintained for a distance of not less than 900 mm (3 ft) in all directions from the edge of the roof.

Exception No. 1: The area above a roof surface subject to pedestrian or vehicular traffic shall have a vertical clearance from the roof surface in accordance with the clearance requirements of 230.24(B).

Exception No. 2: Where the voltage between conductors does not exceed 300 and the roof has a slope of 100 mm in 300 mm (4 in. in 12 in.) or greater, a reduction in clearance to 900 mm (3 ft) shall be permitted.

Exception No. 3: Where the voltage between conductors does not exceed 300, a reduction in clearance above only the overhanging portion of the roof to not less than 450 mm (18 in.) shall be permitted if (1) not more than 1.8 m (6 ft) of overhead service conductors, 1.2 m (4 ft) horizontally, pass above the roof overhang, and (2) they are terminated at a through-the-roof raceway or approved support.

Informational Note: See 230.28 for mast supports.

Exception No. 4: The requirement for maintaining the vertical clearance 900 mm (3 ft) from the edge of the roof shall not apply to the final conductor span where the service drop or overhead service conductors are attached to the side of a building.

Exception No. 5: Where the voltage between conductors does not exceed 300 and the roof area is guarded or isolated, a reduction in clearance to 900 mm (3 ft) shall be permitted.

Statement of Problem and Substantiation for Public Input

Section 230.24 (A) provides a Clearance of 2.5 m (8 ft.) in the 2020 code as well as previous codes. In 225.19 (A) for Outside Branch Circuits and Feeders the Clearance over the same roof is set at 2.7 m (8 ft 6 in). These should be the same height at 2.7 meters to match and not create a possible issue when someone is off by 6 inches. There is another Input for 225.19 (A) that says to match this article.

Submitter Information Verification

Submitter Full Name: David Hittinger

Organization: IEC

Street Address:

City:

State:

Zip:

Submittal Date: Fri Mar 06 14:36:41 EST 2020

Committee: NEC-P10

**Public Input No. 532-NFPA 70-2020 [Section No. 230.24(B)]****(B) Vertical Clearance for Overhead Service Conductors.**

Overhead service conductors, where not in excess of 1000 volts, nominal, shall have the following minimum clearance from final grade:

- (1) 3.0 m (10 ft) — at the electrical service entrance to buildings, also at the lowest point of the drip loop of the building electrical entrance, and above areas or sidewalks accessible only to pedestrians, measured from final grade or other accessible surface only for overhead service conductors supported on and cabled together with a grounded bare messenger where the voltage does not exceed 150 volts to ground
- (2) 3.7 m (12 ft) — over residential property and driveways, and those commercial areas not subject to truck traffic¹, where the voltage does not exceed 300 volts to ground
- (3) 4.5 m (15 ft) — for those areas listed in the 3.7 m (12 ft) classification where the voltage exceeds 300 volts to ground
- (4) 5.5 m (18 ft) — over public streets, alleys, roads, parking areas subject to truck traffic¹, driveways on other than residential property, and other land such as cultivated, grazing, forest, and orchard
- (5) 7.5 m (24½ ft) over tracks of railroads _____ ¹ The term "truck traffic" is defined as any vehicle exceeding xx feet in height.

Statement of Problem and Substantiation for Public Input

The vast majority of wire-strike cases involving vehicle traffic and overhead lines fall under the requirements of the NESC, Table 232-1. This Table includes a footnote which specifically defines the term "truck traffic". The NEC uses the term "truck traffic" and gives clearances for overhead lines in areas which are or are not "subject to truck traffic". However, there is no specific definition given for exactly what constitutes "truck traffic". As an Engineering Professor and Accident Investigator, I have worked on cases in which an NEC specific definition of the term "truck traffic" would have easily cleared the matter up. Based upon my experience investigating wire strikes, clarity and specificity on this is not only much-needed but long overdue.

Submitter Information Verification

Submitter Full Name: Paul Mixon
Organization: Arkansas State University
Affiliation: NA
Street Address:
City:
State:
Zip:
Submittal Date: Tue Feb 25 17:58:43 EST 2020
Committee: NEC-P10

**Public Input No. 610-NFPA 70-2020 [Section No. 230.30(B)]****(B) Wiring Methods.**

Underground service conductors shall be installed in accordance with the applicable requirements of this *Code* covering the type of wiring method used and shall be limited to the following methods:

- (1) Type RMC conduit
- (2) Type IMC conduit
- (3) Type NUCC conduit
- (4) Type HDPE conduit
- (5) Type PVC conduit
- (6) Type RTRC conduit
- (7) Type IGS cable
- (8) Type USE conductors or cables
- (9) Type MV or Type MC cable identified for direct burial applications
- (10) Type MI cable, where suitably protected against physical damage and corrosive conditions
- (11) Type TC-ER cable identified for direct burial applications

Statement of Problem and Substantiation for Public Input

Greetings Code Making Panel Members -

Firstly, I would like to thank you for adding Type TC-ER to the allowances of 230.43(20) and 230.44(6) in the 2017 National Electrical Code development process. However, one additional acceptable use was left out of the including. Since Type TC-ER is permitted, as it should be, for use as Service Entrance Conductors, as referenced in the opening code references, it should also be permitted for use as Underground Service Conductors as well in 230.30(B).

In fact, Type MC cable identified for direct burial applications is listed in 230.30(B) and interesting enough Type TC-ER has to undergo the same testing criteria. When it is marked for direct burial use it is essentially no different than Type MC Cable. The fact the TC-ER has to undergo a crush and impact test in UL 1277 and since it was indeed required to be marked for that use per the ANSI/UL Standards it stands to reason it should be included in this limited list of such products.

Submitter Information Verification

Submitter Full Name: Paul Abernathy

Organization: Electrical Code Academy, Inc. - www.MasterTheNEC.com

Street Address:

City:

State:

Zip:

Submittal Date: Fri Mar 06 12:22:53 EST 2020

Committee: NEC-P10

**Public Input No. 1444-NFPA 70-2020 [Section No. 230.31]****230.31** Size and Ampacity.**(A)** General.

Underground service conductors shall have sufficient ampacity to carry the current for the load as calculated in accordance with Article 220- ~~and shall have adequate mechanical strength .~~

(B) Minimum Size.

The conductors shall not be smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum.

Exception: Conductors supplying only limited loads of a single branch circuit — such as small polyphase power, controlled water heaters, and similar loads — shall not be smaller than 12 AWG copper or 10 AWG aluminum or copper-clad aluminum.

(C) Grounded Conductors.

The grounded conductor shall not be less than the minimum size required by 250.24(C).

Statement of Problem and Substantiation for Public Input

Delete text about underground conductors having “adequate mechanical strength.” I don't know why this would be required for an underground installation or how one is to determine if the conductors have “adequate mechanical strength.”

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 04 18:28:29 EDT 2020

Committee: NEC-P10

**Public Input No. 3793-NFPA 70-2020 [Section No. 230.31(A)]****(A) General.**

Underground service conductors shall have sufficient ampacity to carry the current for the load as calculated in accordance with Article 220 - and shall have adequate mechanical strength.

Statement of Problem and Substantiation for Public Input

Section 4.1.4 of the 2020 NEC(r) Style Manual prohibits reference to an entire article, other than Article 100. As such, it is proposed to delete the reference to the entire Article 220 as it is understood per 90.3 that the general articles would apply. Alternatively, the CMP may wish to reference the specific part of Article 220 that applied, though in this case it seems to me that Part II, Part III, Part IV, or Part V could apply so that's why I recommended just deleting the specific reference to the entire article.

Related Public Inputs for This Document**Related Input****Relationship**

Public Input No. 3791-NFPA 70-2020 [Section No. 230.23(A)]

Submitter Information Verification

Submitter Full Name: Richard Holub

Organization: The DuPont Company, Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 13:00:04 EDT 2020

Committee: NEC-P10

**Public Input No. 598-NFPA 70-2020 [Section No. 230.33]****230.33** Spliced Conductors.

Service conductors shall be permitted to be spliced or tapped in accordance with 110.14, 230.46, 300.5(E), 300.13, and 300.15.

Statement of Problem and Substantiation for Public Input

This would correct what I believe to be an oversight in the 2020 NEC.

Submitter Information Verification

Submitter Full Name: Ryan Jackson

Organization: Ryan Jackson

Street Address:

City:

State:

Zip:

Submittal Date: Wed Mar 04 14:40:37 EST 2020

Committee: NEC-P10

**Public Input No. 3355-NFPA 70-2020 [Section No. 230.40]****230.40** Number of Service-Entrance Conductor Sets.

Each service drop, set of overhead service conductors, set of underground service conductors, or service lateral shall supply only one set of service-entrance conductors.

Exception No. 1: A building with more than one occupancy shall be permitted to have one set of service-entrance conductors for each service, as permitted in 230.2, run to each occupancy or group of occupancies. If the number of service disconnect locations for any given classification of service does not exceed six, the requirements of 230.2(E) shall apply at each location. If the number of service disconnect locations exceeds six for any given supply classification, all the following conditions shall apply:

(1) All service disconnect locations for all supply characteristics, together with any branch circuit or feeder supply sources, if applicable, shall be clearly described using graphics or text, or both, on one or more plaques.

(2) The plaques shall be located in an approved, readily accessible location(s) on the building or structure served and as near as practicable to the point(s) of attachment or entry(ies) for each service drop or service lateral and for each set of overhead or underground service conductors.

Exception No. 2: Where two to six service disconnecting means in separate enclosures are grouped at one location and supply separate loads from one service drop, set of overhead service conductors, set of underground service conductors, or service lateral, one set of service-entrance conductors shall be permitted to supply each or several such service equipment enclosures.

Exception No. 3: A one-family dwelling unit and its accessory structures shall be permitted to have one set of service-entrance conductors run to each from a single service drop, set of overhead service conductors, set of underground service conductors, or service lateral.

Exception No. 4: Two-family dwellings, multifamily dwellings, and multiple occupancy buildings shall be permitted to have one set of service-entrance conductors installed to supply the circuits covered in 210.25.

Exception No. 5: One set of service-entrance conductors connected to the supply side of the normal service disconnecting means shall be permitted to supply each or several systems covered by 230.82(5) or 230.82(6).

Statement of Problem and Substantiation for Public Input

This public input revises the 3rd sentence of Exception No. 1 to Section 230.40 to improve readability. The present version has a single long run-on sentence that is difficult to understand. The proposed revision breaks the requirement into two itemized conditions.

Submitter Information Verification

Submitter Full Name: Danish Zia

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 10:21:46 EDT 2020

Committee: NEC-P10

**Public Input No. 1294-NFPA 70-2020 [Section No. 230.43]****230.43** Wiring Methods for 1000 Volts, Nominal, or Less.

Service-entrance conductors shall be installed in accordance with the applicable requirements of this *Code* covering the type of wiring method used and shall be limited to the following methods:

- (1) Open wiring on insulators
- (2) Type IGS cable
- (3) Rigid metal conduit (RMC)
- (4) Intermediate metal conduit (IMC)
- (5) Electrical metallic tubing (EMT)
- (6) Electrical nonmetallic tubing
- (7) Service-entrance cables
- (8) Wireways
- (9) Busways
- (10) Auxiliary gutters
- (11) Rigid polyvinyl chloride conduit (PVC)
- (12) Cablebus
- (13) Type MC cable
- (14) Mineral-insulated, metal-sheathed cable, Type MI
- (15) Flexible metal conduit (FMC) not over 1.8 m (6 ft) long or liquidtight flexible metal conduit (LFMC) not over 1.8 m (6 ft) long between a raceway, or between a raceway and service equipment, with a supply-side bonding jumper routed with the flexible metal conduit (FMC) or the liquidtight flexible metal conduit (LFMC) according to 250.102(A), (B), (C), and (E)
- (16) Liquidtight flexible nonmetallic conduit (LFNC)
- (17) High density polyethylene conduit (HDPE)
- (18) Nonmetallic underground conduit with conductors (NUCC)
- (19) Reinforced thermosetting resin conduit (RTRC)
- (20) Type TC-ER cable

Exception to (15): Where installed in lengths over 1.8m(6 ft) Flexible metal conduit (FMC) or Liquidtight flexible metal conduit (LFMC) a wire type equipment grounding conductor shall be used.

Statement of Problem and Substantiation for Public Input

Inclusion of a wire type equipment grounding conductor eliminates the use of the flexible raceways as a grounding path and removes the 6 foot length limitation.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Thu May 28 11:49:56 EDT 2020

Committee: NEC-P10



Public Input No. 3789-NFPA 70-2020 [Section No. 230.43]

230.43 Wiring Methods for 1000 Volts, Nominal, or Less.

Service-entrance conductors shall be installed in accordance with the applicable requirements of this *Code* covering the type of wiring method used and shall be limited to the following methods:

- (1) Open wiring on insulators
- (2) Type IGS cable
- (3) Rigid metal conduit (RMC)
- (4) Intermediate metal conduit (IMC)
- (5) Electrical metallic tubing (EMT)
- (6) Electrical nonmetallic tubing
- (7) Service-entrance cables
- (8) Wireways
- (9) Busways
- (10) Auxiliary gutters
- (11) Rigid polyvinyl chloride conduit (PVC)
- (12) Cablebus
- (13) Type MC cable
- (14) Mineral-insulated, metal-sheathed cable, Type MI
- (15) Flexible metal conduit (FMC) not over 1.8 m (6 ft) long or liquidtight flexible metal conduit (LFMC) not over 1.8 m (6 ft) long between a raceway, or between a raceway and service equipment, with a supply-side bonding jumper routed with the flexible metal conduit (FMC) or the liquidtight flexible metal conduit (LFMC) according to 250.102(A), (B), (C), and (E)
- (16) Liquidtight flexible nonmetallic conduit (LFNC)
- (17) High density polyethylene conduit (HDPE)
- (18) Nonmetallic underground conduit with conductors (NUCC)
- (19) Reinforced thermosetting resin conduit (RTRC)
- (20) Type TC-ER cable
- (21) Flexible bus systems

Statement of Problem and Substantiation for Public Input

This public input is a correlating addition to recognize flexible bus systems as one of the available wiring methods in 240.43 for services. A new Article 371 (PI 3616) is being proposed to cover the installation requirements for a new wiring method named "flexible bus systems". This new wiring method has similarities to busways and cable bus systems, but also has unique characteristics warranting its own Article. This new wiring method is intended for use for service conductors, feeders and branch circuits.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3786-NFPA 70-2020 [Section No. 225.3]	outside branch circuits/feeders
Public Input No. 3616-NFPA 70-2020 [Global Input]	new article - Flexible Bus Systems
Public Input No. 3616-NFPA 70-2020 [Global Input]	
Public Input No. 3786-NFPA 70-2020 [Section No. 225.3]	

Submitter Information Verification

Submitter Full Name: Ward Judson

Organization: nVent Electric plc

Affiliation:	nVent Electric plc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Sep 09 12:50:48 EDT 2020
Committee:	NEC-P10



Public Input No. 4325-NFPA 70-2020 [Section No. 230.43]

230.43 Wiring Methods for 1000 Volts, Nominal, or Less.

Service-entrance conductors shall be installed in accordance with the applicable requirements of this *Code* covering the type of wiring method used and shall be limited to the following methods:

- (1) Open wiring on insulators
- (2) Type IGS cable
- (3) Rigid metal conduit (RMC)
- (4) Intermediate metal conduit (IMC)
- (5) Electrical metallic tubing (EMT)
- (6) Electrical nonmetallic tubing
- (7) Service-entrance cables
- (8) Wireways
- (9) Busways
- (10) Auxiliary gutters
- (11) Rigid polyvinyl chloride conduit (PVC)
- (12) Cablebus
- (13) Type MC cable
- (14) Mineral-insulated, metal-sheathed cable, Type MI
- (15) Flexible metal conduit (FMC) not over 1.8 m (6 ft) long or liquidtight flexible metal conduit (LFMC) not over 1.8 m (6 ft) long between a raceway, or between a raceway and service equipment, with a supply-side bonding jumper routed with the flexible metal conduit (FMC) or the liquidtight flexible metal conduit (LFMC) according to 250.102(A), (B), (C), and (E)
- (16) Liquidtight flexible nonmetallic conduit (LFNC)
- (17) High density polyethylene conduit (HDPE)
- (18) Nonmetallic underground conduit with conductors (NUCC)
- (19) Reinforced thermosetting resin conduit (RTRC)
- (20) Type TC-ER cable where identified for such use

Statement of Problem and Substantiation for Public Input

TC-ER was added to the 2020 NEC, 230.43(20) as being suitable for use as service entrance conductors. However, TC-ER has not been evaluated for use as a service entrance.

Since service entrance conductors are not protected by overcurrent devices contained in service equipment, they rely on the protection provided by the utility company. Service entrance cables may be installed in attics or other locations where the cable is pulled through joists. In addition, service entrance cables are typically used outdoors.

In order to indicate that a TC-ER cable is suitable for use as a service entrance, an overload test, similar to that used for other cables that can be used as a service entrance (SE and MC) should be required. A joist pull test and a sunlight resistance test should be part of the evaluation to evaluate the cables for pulling thru joists and use outdoors. Tray cables complying with these requirements should be identifiable to show that they are suitable for use as a service entrance and to differentiate them from TC-ER which has not been evaluated for such conditions.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 4320-NFPA 70-2020 [New Section after 336.10]	
Public Input No. 4320-NFPA 70-2020 [New Section after 336.10]	

Submitter Information Verification

Submitter Full Name: Susan Stene

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 10:10:03 EDT 2020

Committee: NEC-P10

**Public Input No. 326-NFPA 70-2020 [Section No. 230.44]****230.44 Cable Trays.**

Cable tray systems shall be permitted to support service-entrance conductors. Cable trays used to support service-entrance conductors shall contain only service-entrance conductors and shall be limited to the following methods:

- (1) Type SE cable
- (2) Type MC cable
- (3) Type MI cable
- (4) Type IGS cable
- (5) Single conductors 1/0 and larger that are listed for use in cable tray
- (6) Type TC-ER cable

Such cable trays shall be identified with permanently affixed labels with the wording "Service-Entrance Conductors." The labels shall be located so as to be visible after installation with a spacing not to exceed 3 m (10 ft) so that the service-entrance conductors are able to be readily traced through the entire length of the cable tray.

Exception: Conductors, other than service-entrance conductors, shall be permitted to be installed in a cable tray with service-entrance conductors, provided a solid fixed barrier of a material compatible with identified for use with the cable tray is installed to separate the service-entrance conductors from other conductors installed in the cable tray.

Statement of Problem and Substantiation for Public Input

This PI is an attempt to correlate the language in 392.10 with the language in the exception to 230.44. The last sentence of 392.10 states "Cable trays and their associated fittings shall be identified for the intended use." The existing language in the exception to 230.44 references "material compatible with cable tray" which is vague and unenforceable, and conflicts with the language in 392.10.

The NEC Style Manual states:

Paragraph 1.3 Regulatory Adoption

Because the NEC is intended to be suitable for adoption as a regulatory document, it is important that it contain clearly stated mandatory requirements in the Code text.

Paragraph 3.2.1 Unenforceable Terms

The NEC shall not contain references or requirements that are unenforceable or vague.

Submitter Information Verification

Submitter Full Name: Vincent Della Croce

Organization:

Street Address:

City:

State:

Zip:

Submittal Date: Tue Jan 21 11:34:50 EST 2020

Committee: NEC-P10

**Public Input No. 3050-NFPA 70-2020 [Section No. 230.46]****230.46 Spliced and Tapped Conductors.**

Service-entrance conductors shall be permitted to be spliced or tapped in accordance with 110.14, 300.5(E), 300.13, and 300.15. Power distribution blocks, pressure connectors, and devices for splices and taps shall be listed. Power distribution blocks installed on service conductors shall be marked "suitable for use on the line side of the service equipment" or equivalent.

~~Effective January 1, 2023, pressure connectors and devices for splices and taps installed on service conductors shall be marked "suitable for use on the line side of the service equipment" or equivalent.~~

Statement of Problem and Substantiation for Public Input

Recent changes to the NEC (2020) require an additional rating for pressure connectors and devices for splices and taps installed on service conductors. This requirement specifies that, effective January 1, 2023, connectors used to terminate, splice, or tap service conductors shall be marked "suitable for use on the line side of the service equipment". Prior to the publication of the 2020 NEC®, no requirement existed to apply a "line side" marking.

The change was advocated by a video presented to Code Making Panel 10 during their Second Draft meeting, highlighting a potential failure under short circuit conditions.

The video was a demonstration of a hypothetical short circuit event. For this video, the test current ranged from 10k-22k amps, with a test duration of 3 cycles. Utilizing a listed pressure connector, a #6 AWG copper conductor was tapped off the service conductor.

Calculating I^2t for this size conductor and duration would result in annealing the copper for any current exceeding 8928 amps and melting the copper conductor for any current exceeding 16200 amps. Of the failures presented to the Code Making Panel, all tests exceeded the current and duration for the annealing temperature of copper.

As stated in 230.90 Where Required. Each ungrounded service conductor shall have overload protection.

As stated in 240.1 Informational note: Overcurrent protection for conductors and equipment is provided to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation...

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 11:09:25 EDT 2020

Committee: NEC-P10



Public Input No. 1043-NFPA 70-2020 [Section No. 230.50(A)]

(A) Underground Service-Entrance Conductors.

Underground service-entrance conductors shall be protected against physical damage in accordance with 300.5. Trenches containing service conductors shall not contain any pipe, tube, or equal for steam, water, air, gas, drainage, or any system other than electrical.

Statement of Problem and Substantiation for Public Input

This Public Input is specific with regard to underground service conductors only, and not all underground electrical installations. This was also placed in 300.5(D)(3) and is also being placed here, for consideration. This actually may be better suited for Article 230.

The International Fuel Gas code permits gas pipe to be installed at a minimum depth of 12-inches below grade and in some cases, 8-inches below grade. Service conductors are usually required to be installed at greater depths.

Allowing the electrical service conductors in the same trench with other systems creates a potentially deadly conflict with section 300.5(D)(3). Someone who is digging may encounter the [required] warning ribbon and think all is well, when in reality there may be a gas line or some other system near that same depth. They may strike a gas line. Trenches for service conductors should contain no other system, and the warning ribbon should be placed in the trench at the mandated depth. We can (and should) regulate that underground service conductors be installed in their own trench.

In addition, allowing electrical service conductors in the same trench with other systems can create confusion, as the person who encounters the electrical warning tape may believe that the "other system" is actually the electrical installation.

In the event that the proposed language is not accepted by the panel, then more clarification is requested. I will use a gas line in the same trench as the service conductors, for my example.

In the case of underground service conductors buried at 24-inches below grade in the same trench as a gas line buried at 12-inches below grade, where is the electrician supposed to install the required warning ribbon?

Should it be placed above the gas line?

Or should it be placed below the gas line, or to the side of it...and how far away, etc., etc., (you get the point)?

Currently, the NEC creates a defacto relationship with regard to underground service conductors and other systems in the same trench by not having any specific language to prohibit this questionable practice.

The proposed language would fix this.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 1030-NFPA 70-2020 [Section No. 300.5(D)(3)]	
Public Input No. 1030-NFPA 70-2020 [Section No. 300.5(D)(3)]	

Submitter Information Verification

Submitter Full Name: Nick Sasso

Organization: Clark County Building and Fire

Street Address:

City:

State:

Zip:

Submittal Date: Tue May 12 19:50:09 EDT 2020

Committee: NEC-P10

**Public Input No. 1012-NFPA 70-2020 [Section No. 230.53]****230.53 Raceways to Drain.**

Where exposed to the weather, raceways enclosing service-entrance conductors shall be listed or approved for use in wet locations and arranged to drain. Where embedded in masonry, raceways shall be arranged to drain.

One or more field created weep holes, 3mm (1/8") to 6mm (1/4") diameter, shall be permissible in the bottom of raceways exposed to the weather or other wet locations as a drain method in lieu of fittings, enclosures, or routing that could serve the purpose, in other than classified locations. Weep holes shall be created before wiring is installed in accordance with 300.18(A).

Statement of Problem and Substantiation for Public Input

Weep holes are now permitted in the bottom of junction boxes 314.15. Preferably, the raceways are routed in a way, use drain fittings, or use junction boxes that would allow the raceway to drain. Weep holes placed in the bottom of a back to back EMT run with the ends upturned would be an example of weep holes being implemented in place of more raceway fittings or boxes.

In an alley, I did see RMC split like a broken water pipe in Colorado. Maybe someone left a service disconnect open and rain filled up the RMC. When winter came, the raceway burst from the frozen water.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Fri May 08 18:36:26 EDT 2020

Committee: NEC-P10



Public Input No. 118-NFPA 70-2019 [Section No. 230.56]

230.56— Service Conductor with the Higher Voltage to Ground.

~~On a 4-wire, delta-connected service where the midpoint of one phase winding is grounded, the service conductor having the higher phase voltage to ground shall be durably and permanently marked by an outer finish that is orange in color, or by other effective means, at each termination or junction point.~~

Statement of Problem and Substantiation for Public Input

Delete this Section. It is not needed since Section 110.15 already covers high-leg marking.

Submitter Information Verification

Submitter Full Name: Russ Leblanc

Organization: Leblanc Consulting Services

Street Address:

City:

State:

Zip:

Submittal Date: Wed Nov 20 09:06:49 EST 2019

Committee: NEC-P10

**Public Input No. 3621-NFPA 70-2020 [Section No. 230.62(C)]****(C) Barriers.**

Barriers shall be placed in service equipment such that no uninsulated, ungrounded service busbar or service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations associated with the circuits served by the service disconnect .

Statement of Problem and Substantiation for Public Input

This public input provides clarification to 230.62(C) for equipment containing more than one service disconnect, such as switchboards, switchgear or metering centers constructed in accordance with 230.71(B). The current verbiage does not distinguish which load terminations are to be considered when addressing inadvertent contact by maintenance personnel for such equipment. The proposed changes clarify that barriers for inadvertent contact are required per 230.62(C) when servicing load terminations associated with the circuits served by the service disconnect being maintained (which will be de-energized). Load terminations associated with circuits of service disconnects that remain energized would not be serviced until those service disconnects are also de-energized for maintenance.

Submitter Information Verification

Submitter Full Name: Danish Zia

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 09:30:13 EDT 2020

Committee: NEC-P10

**Public Input No. 1410-NFPA 70-2020 [Section No. 230.66(B)]****(B) Meter Sockets.**

(1) Meter sockets shall not be considered service equipment- but .

(2) Meter socket shall be listed and rated for the voltage and ~~current rating of the service~~ calculated load it serves .

Exception: Meter sockets supplied by and under the exclusive control of an electric utility shall not be required to be listed.

Statement of Problem and Substantiation for Public Input

If we have a 1,200A service and there are six 200A service disconnects, the meter socket should not have to be rated 1,200A, but only rated for the calculated load it serves.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Tue Jun 02 12:24:02 EDT 2020

Committee: NEC-P10



Public Input No. 3315-NFPA 70-2020 [Section No. 230.66(B)]

(B) Meter Sockets.

Meter sockets shall not be considered service equipment but shall be listed and rated for the voltage and current rating of the service.

Exception: Meter sockets supplied by and under the exclusive control of an electric utility shall not be required to be listed.

Informational Note: See IEEE 3001.8 Recommended Practice for the Instrumentation and Metering of 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 IEEE Color Books. While much guidance is provided by utilities on metering the line side of the service point; more depth may be found is provided by this title. From its prospectus:

"This recommended practice covers the instrumentation and metering of industrial and commercial power systems. It describes the importance of metering to achieve a successful energy management process, as well as considerations that must be made when applying the latest metering technology."

https://standards.ieee.org/standard/3001_8-2013.html

Submitter Information Verification

Submitter Full Name: Michael Anthony

Organization: Standards Michigan

Affiliation: IEEE Education & Healthcare Facility Electrotechnology Committee

Street Address:

City:

State:

Zip:

Submittal Date: Mon Sep 07 17:10:50 EDT 2020

Committee: NEC-P10



Public Input No. 3612-NFPA 70-2020 [New Section after 230.67]

230.68 Reconditioned Equipment.

Reconditioned equipment shall be listed as "reconditioned" and the original listing mark removed. Components of equipment that provide ground-fault protection of equipment (GFPE) shall not be reconditioned unless the component is identified as serviceable or maintainable by the original equipment manufacturer's instructions.

Statement of Problem and Substantiation for Public Input

This public input correlates Public Input No. 3416-NFPA 70-2020 [Section 210.15] that came from the task group formed in accordance with the direction of the NFPA Standards Council in Decision D#19-11. Time constraints required the task group to limit the focus to branch circuits; however, the requirements should be expanded to apply to services as well.

Many different types of equipment are used in service entrance equipment to provide ground fault protection of equipment. Equipment that is suitable for reconditioning as allowed in other sections of the NEC may contain components that provide the function of ground fault protection of equipment (GFPE). It is the intention of this proposal to restrict the reconditioning of these GFPE components but still allow the equipment that contains those components to be reconditioned if allowed. The replacement of these components as a one to one replacement would be allowed.

Submitter Information Verification

Submitter Full Name: Barry Rodgers

Organization: Schneider Electric

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 09:02:32 EDT 2020

Committee: NEC-P10

**Public Input No. 3722-NFPA 70-2020 [New Section after 230.67]****TITLE OF NEW CONTENT****230.67(E) Ratings**

SPDs shall have a nominal discharge current rating (I_n) of not less than 10kA

Statement of Problem and Substantiation for Public Input

CMP 10 is commended for taking the step to require SPDs be installed on dwelling units. This action will significantly help mitigate the effects of lightning surges and transients damaging system wiring and electrical equipment within the structure.

Purpose

This PI was created with the intention of providing a baseline of protection that SPDs installed at the service entrance should provide.

The present situation provides no lower limit to the nominal surge rating (I_n) of the SPD. It is necessary to provide a lower limit for this rating to ensure that the SPD is suitable for the electrical environment which is expected at the service entrance.

Current requirements

Currently the NEC provides no guidance on the level of robustness that an SPD must have with respect to the anticipated surge levels that can be expected at an installation. The Code only requires that a Type 1 or Type 2 listed device be installed.

SPDs are generally listed to UL 1449. This standard provides the Nominal Discharge Current rating (I_n), to designate what surge rating the SPD has been tested to withstand. I_n is the value selected by the manufacturer which the SPD can be shown to withstand under a test regimen where the device is subjected to 15 impulses at the declared level. UL 1449 allows for Type 1 SPDs to have an I_n of 10 or 20kA and Type 2 SPDs to have an I_n of 3, 5, 10, or 20kA.

Substantiation

Several studies have sought to characterize the surge environment that can be expected at a typical installation. IEEE published a set of documents [1,2,3] which characterize this exposure. IEEE Std C62.41.2 characterizes the service entrance as being typically exposed to surges rated up to 10kA.

NFPA 780 Appendix A [6] provides recommendations that an SPD with minimum I_n rating of 20kA be used at the service entrance and a minimum of 10kA be used at branch panels.

Sources

- 1 - IEEE Std C62.41.1-2000: IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuit
- 2 - IEEE Std C62.41.2-2002: IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC power Circuits
- 3 - IEEE Std C62.71-2016: IEEE Guide for the Application of Surge-Protective Devices for Use on the Load Side of Service Equipment in Low-Voltage (1000 V or Less, 50 Hz or 60 Hz) AC Power Circuits
- 4 - How to Protect Your House and Its Contents from Lightning: IEEE Guide for Surge Protection of Equipment Connected to AC Power and Communication Circuits
- 5 - UL 1449, Standard for Safety: Surge protective Devices
- 6 - NFPA 780: Standard for the Installation of Lightning Protection Systems

Submitter Information Verification

Submitter Full Name: Garret Wernecke

Organization: RAYCAP INC

Street Address:

City:

State:

Zip:

Submission Date: Wed Sep 09 11:22:32 EDT 2020

Committee:	NEC-P10
-------------------	---------

**Public Input No. 1295-NFPA 70-2020 [Section No. 230.67]****230.67 Surge Protection.****(A) Surge-Protective Device.**

All services supplying ~~dwelling units~~ the following occupancies shall be provided with a surge-protective device (SPD).

(1) dwelling units

(2) dormitory units

(3) guest rooms and guest suites of hotels and motels

(4) areas of nursing homes and limited-care facilities used exclusively as patient sleeping rooms

Informational Note: See 517.10(B) (2)

(B) Location.

The SPD shall be an integral part of the service equipment or shall be located immediately adjacent thereto.

Exception: The SPD shall not be required to be located in the service equipment as required in (B) if located at each next level distribution equipment downstream toward the load.

(C) Type.

The SPD shall be a Type 1 or Type 2 SPD.

(D) Replacement.

Where service equipment is replaced, all of the requirements of this section shall apply.

Statement of Problem and Substantiation for Public Input

All service equipment can experience surges that may damage systems designed to save lives. The 2020 NEC introduced the need for surge protection on services of dwelling units. For correlation with Sections 210.12 and 517.10(B)(2), this Public Input is proposing to add the following occupancies: dormitory units, guest rooms and guest suites of hotels and motels, and areas in nursing homes and limited-care facilities used exclusively as patient sleeping rooms. These occupancies are very similar to dwelling units where the same damage can take place.

Electronic life-saving equipment such as fire alarm systems, IDCI's, GFCI's, AFCI's and smoke alarms, may be damaged when a surge occurs due to lightning, internal local switching as well as external utility switching. Egress equipment such as emergency lighting, smoke control systems, occupant evacuation elevator may also be damaged when subjected to surge. In many cases, electronic devices and equipment can be damaged and rendered inoperable by a surge and yet this damage is undetected by the owner. It is practical to require a SPD to provide a general level of protection. In new service installations, as well as service replacements, no consideration is given to providing a general level of protection to the "whole structure" which would include those devices that cannot be afforded a cord connected Type 3 SPD protection. In conjunction with this coverage expansion to 230.67(A), 230.67(D) would require that where these services are replaced, an SPD is to be installed.

Studies by recognized authorities including NEMA, IEEE, and UL, all substantiate the fact that surges can and do cause significant damage. National insurance organizations recognize the need for effective surge protection and have published recommendations that include point-of-use surge protectors and installation of surge protection at service equipment.

The NEC mandates minimum requirements as stated in Section 90.1 of the NEC. It is therefore "practical" to provide this minimum level of protection for electronic life-saving devices already mandated within the NEC.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Thu May 28 11:55:55 EDT 2020

Committee:	NEC-P10
-------------------	---------

**Public Input No. 1740-NFPA 70-2020 [Section No. 230.67]****230.67 Surge Protection.****(A) Surge-Protective Device.**

~~All services supplying~~ Each dwelling units shall be provided with a surge-protective device (SPD).

(B) Location.

~~The SPD shall be an integral part of the service equipment - or shall be located immediately adjacent thereto.~~

~~Exception: The SPD shall not be required to be located in the service equipment as required in (B) if located~~
~~, located immediately adjacent to service equipment, or installed at each next level downstream distribution~~
~~equipment~~

~~downstream toward the load~~

(C) Type.

~~The SPD shall be~~ a Type 1 or Type 2 SPD installed in accordance with Part II of Article 242 .

(D) Replacement.

Where service equipment is replaced for one- or two-family dwelling units , all of the requirements of this section shall apply.

Statement of Problem and Substantiation for Public Input

The way the 2020 NEC reads, a multifamily building needs an SPD at service equipment. This is not a bad idea, but it would be best if the SPD is located for each dwelling unit. Referencing Part II of Article 242 is more appropriate, since we cannot say it can be Type 1 or Type 2, since it might be required to be Type 1 and permitted to be Type 2. Article 242 has all of the information on the Type and installation requirements.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submission Date: Thu Jun 25 17:46:00 EDT 2020

Committee: NEC-P10

**Public Input No. 1949-NFPA 70-2020 [Section No. 230.67]****230.67** Surge- Overvoltage Protection.**(A)** Surge-Protective Device.

All services supplying dwelling units shall be provided with a surge-protective device (SPD).

(B) Location.

The SPD shall be an integral part of the service equipment or shall be located immediately adjacent thereto.

Exception: The SPD shall not be required to be located in the service equipment as required in (B) if located at each next level distribution equipment downstream toward the load.

(C) Type.

The SPD shall be a Type 1 or Type 2 SPD.

(D) Replacement.

Where service equipment is replaced, all of the requirements of this section shall apply.

Statement of Problem and Substantiation for Public Input

This change is proposed to correlate name give to this type of protection in Article 242.

Submitter Information Verification

Submitter Full Name: John Cowans

Organization: Siemens

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 20 14:03:38 EDT 2020

Committee: NEC-P10

**Public Input No. 3051-NFPA 70-2020 [Section No. 230.67]****230.67— Surge Protection 67 Overvoltage Protection .****(A) Surge-Protective Device.**

All services supplying dwelling units shall be provided with a surge-protective device (SPD).

(B) Location.

The SPD shall be an integral part of the service equipment or shall be located immediately adjacent thereto.

Exception: The SPD shall not be required to be located in the service equipment as required in (B) if located at each next level distribution equipment downstream toward the load.

(C) Type.

The SPD shall be a Type 1 or Type 2 SPD.

(D) Replacement.

Where service equipment is replaced, all of the requirements of this section shall apply.

Statement of Problem and Substantiation for Public Input

The purpose of this public input is to correlate and harmonize all of the current sections of the code where “overvoltage protection” is required by:

1. Changing the section titles to “Overvoltage Protection” to properly correlate with Article 242.
 2. Correcting the product description to “listed surge-protective device (SPD)” which is defined in Article 100 and correlates with Article 242.
 3. Adding a pointer to “Part II. of Article 242” to ensure compliance with all of the requirements for SPDs are met when complying with the rule.
- This public input is one of eleven correlating public inputs covering Sections 230.67, 501.35, 502.35, 620.51(E), 645.18, 670.6, 694.7(D), 695.15, 700.8, 708.20(D), and Informative Annex G.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 11:12:32 EDT 2020

Committee: NEC-P10

**Public Input No. 4617-NFPA 70-2020 [Section No. 230.67]****230.67** Surge Protection.**(A)** Surge-Protective Device.

All services supplying dwelling units shall be provided with a surge-protective device (SPD).

(B) Location.

The SPD shall be an integral part of the service equipment or shall be located immediately adjacent thereto.

Exception: The SPD shall not be required to be located in the service equipment as required in (B) if located at each next level distribution equipment downstream toward the load.

(C) Type.

The SPD shall be a Type 1 or Type 2 SPD.

(D) Replacement.

Where service equipment is replaced, all of the requirements of this section shall apply.

(F) The device shall provide not less than 10,000 amperes of nominal discharge current rating (I_n) for every 100 amps of electrical service provided to the building.

Statement of Problem and Substantiation for Public Input

There is no reliability requirement within the current NEC code. A single device with 3,000 amperes of nominal discharge current rating could meet the requirement for a single family dwelling with a 100 ampere service, or a multifamily building with 2,000 amperes of service. A 3kA nominal discharge current rated device will fail earlier on a larger service due to the more frequent electrical transients. A nominal discharge current rating of 10,000 amperes per 100 amperes of service will provide an acceptable minimum life expectancy of the surge protection device.

Submitter Information Verification

Submitter Full Name: Jay Haugen

Organization: Eaton Corporation

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 15:52:46 EDT 2020

Committee: NEC-P10

**Public Input No. 486-NFPA 70-2020 [Section No. 230.67(A)]**

(A) Surge-Protective Device.

All services supplying dwelling units ~~shall~~ may be provided with a surge-protective device (SPD).

Statement of Problem and Substantiation for Public Input

This should be permissive for residences:

single dwelling residences may never be inspected nor serviced after being built. A whole house SPD may not ever be visited. SPD loose their effectiveness over time and thus may give false impression of protection.

The cost of replacing a whole house SPD will make it less likely to happen vs SPDs on power strips which can be replaced by untrained home owners.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 480-NFPA 70-2020 [Section No. 242.14 [Excluding any Sub-Sections]]	same
Public Input No. 479-NFPA 70-2020 [Section No. 242.12 [Excluding any Sub-Sections]]	same
Public Input No. 481-NFPA 70-2020 [Section No. 242.14(A)]	same
Public Input No. 487-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 488-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 489-NFPA 70-2020 [Section No. 230.67(B)]	
Public Input No. 491-NFPA 70-2020 [Section No. 230.67(C)]	
Public Input No. 492-NFPA 70-2020 [Section No. 230.67(D)]	

Submitter Information Verification

Submitter Full Name: saul roe

Organization: HRTM LLC

Street Address:

City:

State:

Zip:

Submittal Date: Wed Feb 19 13:10:04 EST 2020

Committee: NEC-P10

**Public Input No. 487-NFPA 70-2020 [Section No. 230.67(A)]**

(A) Surge-Protective Device.

All services supplying dwelling units ~~shall~~ may be provided with a surge-protective device (SPD).

Statement of Problem and Substantiation for Public Input

SPDs loose their effectiveness over time. In single dwellings, a type 1 or 2 SPD may never be inspected after installation. This may lead to reliance on a none working SPD without the SPD being replaced or serviced. Type 1 or 2 SPDs should be installed and replace by professionals making less likely to occur in single dwelling units.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 479-NFPA 70-2020 [Section No. 242.12 [Excluding any Sub-Sections]]	
Public Input No. 480-NFPA 70-2020 [Section No. 242.14 [Excluding any Sub-Sections]]	
Public Input No. 481-NFPA 70-2020 [Section No. 242.14(A)]	
Public Input No. 486-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 488-NFPA 70-2020 [Section No. 230.67(A)]	

Submitter Information Verification

Submitter Full Name: saul roe
Organization: HRTM LLC
Street Address:
City:
State:
Zip:
Submittal Date: Wed Feb 19 13:17:12 EST 2020
Committee: NEC-P10

**Public Input No. 488-NFPA 70-2020 [Section No. 230.67(A)]**

(A) Surge-Protective Device.

All services supplying dwelling units ~~shall~~ may be provided with a surge-protective device (SPD).

Statement of Problem and Substantiation for Public Input

SPDs loose their effectiveness over time. In single dwellings, a type 1 or 2 SPD may never be inspected after installation. This may lead to reliance on a none working SPD without the SPD being replaced or serviced. Type 1 or 2 SPDs should be installed and replace by professionals making less likely to occur in single dwelling units

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 479-NFPA 70-2020 [Section No. 242.12 [Excluding any Sub-Sections]]	
Public Input No. 480-NFPA 70-2020 [Section No. 242.14 [Excluding any Sub-Sections]]	
Public Input No. 481-NFPA 70-2020 [Section No. 242.14(A)]	
Public Input No. 486-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 487-NFPA 70-2020 [Section No. 230.67(A)]	

Submitter Information Verification

Submitter Full Name: saul roe
Organization: HRTM LLC
Street Address:
City:
State:
Zip:
Submittal Date: Wed Feb 19 13:24:41 EST 2020
Committee: NEC-P10

**Public Input No. 489-NFPA 70-2020 [Section No. 230.67(B)]****(B) Location.**

The SPD ~~shall~~ may be an integral part of the service equipment or shall be located immediately adjacent thereto.

Exception: The SPD shall not may be required to be located in the service equipment as required in (B) if located at each next level distribution equipment downstream toward the load.

Statement of Problem and Substantiation for Public Input

SPDs loose their effectiveness over time. In single dwellings, a type 1 or 2 SPD may never be inspected after installation. This may lead to reliance on a none working SPD without the SPD being replaced or serviced. Type 1 or 2 SPDs should be installed and replace by professionals making less likely to occur in single dwelling units

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 479-NFPA 70-2020 [Section No. 242.12 [Excluding any Sub-Sections]]	
Public Input No. 480-NFPA 70-2020 [Section No. 242.14 [Excluding any Sub-Sections]]	
Public Input No. 481-NFPA 70-2020 [Section No. 242.14(A)]	
Public Input No. 486-NFPA 70-2020 [Section No. 230.67(A)]	

Submitter Information Verification

Submitter Full Name: saul roe
Organization: HRTM LLC
Street Address:
City:
State:
Zip:
Submittal Date: Wed Feb 19 13:27:24 EST 2020
Committee: NEC-P10

**Public Input No. 491-NFPA 70-2020 [Section No. 230.67(C)]**

(C)– Type.

The SPD shall be a Type 1 or Type 2 SPD.

Statement of Problem and Substantiation for Public Input

SPDs lose their effectiveness over time. In single dwellings, a type 1 or 2 SPD may never be inspected after installation. This may lead to reliance on a none working SPD without the SPD being replaced or serviced. Type 1 or 2 SPDs should be installed and replaced by professionals making less likely to occur in single dwelling units

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 479-NFPA 70-2020 [Section No. 242.12 [Excluding any Sub-Sections]]	
Public Input No. 480-NFPA 70-2020 [Section No. 242.14 [Excluding any Sub-Sections]]	
Public Input No. 486-NFPA 70-2020 [Section No. 230.67(A)]	

Submitter Information Verification

Submitter Full Name: saul roe
Organization: HRTM LLC
Street Address:
City:
State:
Zip:
Submittal Date: Wed Feb 19 13:34:23 EST 2020
Committee: NEC-P10

**Public Input No. 492-NFPA 70-2020 [Section No. 230.67(D)]**

(D)– Replacement.

~~Where service equipment is replaced, all of the requirements of this section shall apply.~~

Statement of Problem and Substantiation for Public Input

SPDs lose their effectiveness over time. In single dwellings, a type 1 or 2 SPD may never be inspected after installation. This may lead to reliance on a none working SPD without the SPD being replaced or serviced. Type 1 or 2 SPDs should be installed and replaced by professionals making less likely to occur in single dwelling units

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 479-NFPA 70-2020 [Section No. 242.12 [Excluding any Sub-Sections]]	
Public Input No. 480-NFPA 70-2020 [Section No. 242.14 [Excluding any Sub-Sections]]	
Public Input No. 486-NFPA 70-2020 [Section No. 230.67(A)]	

Submitter Information Verification

Submitter Full Name: saul roe
Organization: HRTM LLC
Street Address:
City:
State:
Zip:
Submittal Date: Wed Feb 19 13:36:36 EST 2020
Committee: NEC-P10

**Public Input No. 1166-NFPA 70-2020 [Section No. 230.70(A)(1)]****(1) Readily Accessible Location.**

The service disconnecting means shall be installed at a readily accessible location either outside of a building or structure or inside ~~nearest~~ as close as practicable to the point of entrance of the service conductors.

Statement of Problem and Substantiation for Public Input

The term "near" or any version of the term such as "nearest" leaves too much gray area to foster consistent application. This term or versions of it are in the list of vague and unenforceable terms in the NEC Style Manual. The revised wording uses a phrase that is more commonly used throughout the NEC and is actually more in line with how this rule is applied in the field. Often it is not possible to install the service disconnect at the point nearest the point where the service conductor raceways or cables enter the structure. But the service disconnect could always be installed as close as practicable to that point.

Submitter Information Verification

Submitter Full Name: Agnieszka Golriz

Organization: NECA

Street Address:

City:

State:

Zip:

Submittal Date: Wed May 20 10:11:47 EDT 2020

Committee: NEC-P10

**Public Input No. 3796-NFPA 70-2020 [Section No. 230.70(C)]****(C) Suitable for Use.**

Each service disconnecting means shall be suitable for the prevailing conditions. Service equipment installed in hazardous (classified) locations shall comply with the hazardous location requirements- of Articles- 500 through 517 .

Statement of Problem and Substantiation for Public Input

Section 4.1.4 of the 2020 NEC(r) Style Manual prohibits reference to an entire article, other than Article 100. As such, it is proposed to delete the reference to Article 500-517 and instead refer to the general "hazardous location articles". It is suggested that this PI also be submitted to CMP14 for information and/or comment.

Submitter Information Verification

Submitter Full Name: Richard Holub

Organization: The DuPont Company, Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 13:02:05 EDT 2020

Committee: NEC-P10

**Public Input No. 1398-NFPA 70-2020 [Section No. 230.71(A)]****(A) General.**

For the purpose of this section, disconnecting means installed as part of listed equipment ~~and used solely for the following- on the supply-side of the service disconnect in accordance with 230.82~~ shall not be considered a service disconnecting means:

- (1) ~~Power monitoring equipment~~
- (2) ~~Surge protective device(s)~~
- (3) ~~Control circuit of the ground-fault protection system~~
- (4) ~~Power operable service disconnecting means~~

.

Statement of Problem and Substantiation for Public Input

The current list of (1) through (4) is not complete and it would be more appropriate to reference 230.82, then to expand that list; such as adding PV or Wind.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submission Date: Tue Jun 02 11:23:58 EDT 2020

Committee: NEC-P10

**Public Input No. 3320-NFPA 70-2020 [New Section after 230.71(B)]****(C) Integral disconnect for electrical maintenance supply**

As part of an approved service disconnect assembly an additional disconnecting means shall be permissible for the sole purpose of supplying power required for electrical maintenance when the service disconnect is open. This OCPD shall be supplied from the same service entrance conductors as the main service but shall be permitted to be configured such that it remains energized while the main disconnect is open, and shall be rated at no more than 10% of the total ampacity of the service disconnecting means. This OCPD shall power a single circuit whose sole purpose is for electrical maintenance including receptacles or lighting outlets around electrical equipment likely to be serviced when the service disconnect is open. When installed the additional circuit shall not be counted as a circuit that would affect the provisions provided for in 310.12(A) or (B).

Statement of Problem and Substantiation for Public Input

The 2020 NEC required external service disconnects for dwelling units, and other recent changes required that line side service terminals be protected from touch potential. Both of these mark great improvements in safety for residential panels. The reduction to a single disconnecting means is an improvement of safety overall, but it also makes it such that there is no longer the ability for a solution where dwelling units can still have some kind of power for maintenance work. Residential panels are likely to have work performed by less qualified persons, who often will leave a panel energized to perform work in it so they have power to perform the work. This represents an unnecessary risk which could easily be solved if manufacturers created a disconnecting means for such services with a separate service disconnect whose sole purpose was to provide enough power for some simple lighting and tool loads. The current code would prohibit such a device from being created or installed.

Ideally this would also permit a combination meter/main with a small panel to be used in this manner as well.

Submitter Information Verification

Submitter Full Name: Chris Rettger

Organization:

Street Address:

City:

State:

Zip:

Submittal Date: Mon Sep 07 22:26:44 EDT 2020

Committee: NEC-P10

**Public Input No. 1971-NFPA 70-2020 [Section No. 230.71(B)]****(B) Two to Six Service Disconnecting Means.**

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

- (1) Separate enclosures with a main service disconnecting means in each enclosure
- (2) Panelboards with a main service disconnecting means in each panelboard enclosure
- (3) Switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section
- (4) Service disconnects in switchgear- ~~or~~ , transfer switches or metering centers where each disconnect is located in a separate compartment

Informational Note No. 1: Metering centers are addressed in UL 67, *Standard for Panelboards*.

Informational Note No. 2: Examples of separate enclosures with a main service disconnecting means in each enclosure include but are not limited to motor control centers, fused disconnects, circuit breaker enclosures, and transfer switches that are suitable for use as service equipment.

Informational Note No. 3: Transfer switches may have one service disconnect or may have multiple service disconnects for multiple services.

Statement of Problem and Substantiation for Public Input

The product standard for transfer switch equipment, ANSI/UL 1008, is being revised to require compartmentalization of all service disconnects in a transfer switch intended for use with multiple services. As written, Information Note No. 2 incorrectly implies that all transfer switches have service disconnects in separate enclosures.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jul 22 14:28:37 EDT 2020

Committee: NEC-P10

**Public Input No. 1972-NFPA 70-2020 [Section No. 230.71(B)]****(B) Two to Six Service Disconnecting Means.**

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

- (1) Separate enclosures with a main service disconnecting means in each enclosure
- (2) Panelboards with a main service disconnecting means in each panelboard enclosure
- (3) Switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section
- (4) Service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment
- (5) Service disconnects in meter centers with barriers installed such that no uninsulated, ungrounded live parts are exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations.

Informational Note No. 1: Metering centers are addressed in UL 67, *Standard for Panelboards*.

Informational Note No. 2: Examples of separate enclosures with a main service disconnecting means in each enclosure include but are not limited to motor control centers, fused disconnects, circuit breaker enclosures, and transfer switches that are suitable for use as service equipment.

Statement of Problem and Substantiation for Public Input

The 2020 NEC introduced compartmentalization requirements that meter centers must adhere to. Modern meter center designs are optimized for safety, efficiency and size and this new requirement has proven impractical to implement.

A review of substantiations for PIs and PCs related to 230.71 of the 2020 NEC showed that the following concerns were expressed:

- Inability to provide Arc-Flash Mitigation on the line-side of the service disconnect (PI 1654; PI 2675)
- Prevent exposure to live parts when the service disconnect is in the OFF position (PI 672)
- Allow establishment of a safe work environment (PI 1654; PI 2675)

A review of the committee statements for 230.71 (FR 8463; SR 7901) showed that the CMP's goal was to improve safety by addressing the following:

- Prevent exposure to live parts when a single service disconnect is switched to the OFF position
- Reduce exposure to energized parts

This PI addresses all of the design issues, safety issues and goals expressed in the committee statements mentioned above. It is the submitter's belief this PI exceeds the goals related to the changes through the following:

- Reducing exposure to live parts, and specifically reducing the chance of an arc-flash incident being generated on the line side by reducing access to live line side components
- Providing for individual access so that only the areas that need to be accessed are exposed
- Improving safety by allowing access to live parts associated with a single service disconnect while allowing for access to live parts associated with other service disconnects to be blocked

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submission Date: Wed Jul 22 14:33:22 EDT 2020

Committee: NEC-P10

**Public Input No. 2262-NFPA 70-2020 [Section No. 230.71(B)]****(B) Two to Six Service Disconnecting Means.**

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

- (1) Separate enclosures with a main service disconnecting means in each enclosure
- (2) Panelboards with a main service disconnecting means in each panelboard enclosure
- (3) Switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section
- (4) Service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment

Informational Note No. 1: Metering centers are addressed in UL 67, *Standard for Panelboards*.

Informational Note No. 2: Examples of separate enclosures with a main service disconnecting means in each enclosure include but are not limited to motor control centers, fused disconnects, circuit breaker enclosures, and transfer switches having a single service disconnect in the transfer switch assembly, that are suitable for use as service equipment.

Informational Note No. 3 Transfer switches having two service disconnects in the same assembly are intended for connection to two separate services. These service disconnects are located in separate compartments within the assembly, and each of these service disconnects shall be counted as one of the allowable service disconnects for their respective service.

Statement of Problem and Substantiation for Public Input**Substantiation:**

Transfer switches suitable for service equipment use may be constructed in one of two ways:

- 1) A transfer switch may be intended for connection to only a single service, with the alternate source terminals connected to supply that is not a service. In this case, the transfer switch has only a single service disconnect switch. The alternate source may be provided with a disconnect switch, but it is not a service disconnect, or
- 2) A transfer switch may be intended for connection to two sources, with both sources being a service. In this case, the transfer switch assembly is provided with two individual service disconnects. Currently, these service disconnects are located within the same transfer switch enclosure, and may or may not be located in separate compartments within the same enclosure. Proposals have been submitted to revise UL 1008, the standard for transfer switch equipment to require separate compartments for each service disconnect when two are provided within the same transfer switch enclosure.

The current informational note No. 2 includes transfer switches in a list of separate enclosures with a main disconnecting means in each enclosure, which is only true when the transfer switch has a single service disconnect. Revising the reference to transfer switches in this informational note and including the proposed Informational Note No. 3 clarifies how transfer switches for service equipment use are constructed, and how the service disconnects should be treated in both of the cases noted.

Submitter Information Verification

Submitter Full Name: Paul Barnhart

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submittal Date: Wed Aug 12 14:35:54 EDT 2020

Committee: NEC-P10

**Public Input No. 2300-NFPA 70-2020 [Section No. 230.71(B)]****(B) Two to Six Service Disconnecting Means.**

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

- (1) Separate enclosures with a main service disconnecting means in each enclosure
- (2) Panelboards with a main service disconnecting means in each panelboard enclosure
- (3) Switchboard(s) where there is only one service disconnect in each separate vertical section- ~~where there are barriers separating each vertical section~~ . Barriers shall be provided between each vertical section to maintain the inadvertent contact protection required in 230.62 based on access from the adjacent section(s).
- (4) Service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment

Informational Note No. 1: Metering centers are addressed in UL 67, *Standard for Panelboards*.

Informational Note No. 2: Examples of separate enclosures with a main service disconnecting means in each enclosure include but are not limited to motor control centers, fused disconnects, circuit breaker enclosures, and transfer switches that are suitable for use as service equipment.

Statement of Problem and Substantiation for Public Input

The section barrier referenced in 230.71(B)(3) does not define the intent which is to prevent inadvertent contact by persons or maintenance equipment while servicing load terminations. This change references 230.62 which defines the intend of a service barrier while maintaining the one service disconnect in each vertical section and the barrier requirement.

Submitter Information Verification

Submitter Full Name: Ronnie Ridgeway

Organization: Siemens Industry, Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Fri Aug 14 08:58:48 EDT 2020

Committee: NEC-P10

**Public Input No. 298-NFPA 70-2020 [Section No. 230.71(B)]****(B) Two to Six Service Disconnecting Means.**

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

- (1) Separate enclosures with a main service disconnecting means in each enclosure
- (2) Panelboards with a main service disconnecting means in each panelboard enclosure
- (3) Switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section
- (4) Service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment

Exception: In existing installations with one enclosure containing two to six disconnecting means the remaining up to six disconnecting means may be installed in the existing single enclosure.

Informational Note No. 1: Metering centers are addressed in UL 67, *Standard for Panelboards*.

Informational Note No. 2: Examples of separate enclosures with a main service disconnecting means in each enclosure include but are not limited to motor control centers, fused disconnects, circuit breaker enclosures, and transfer switches that are suitable for use as service equipment.

Statement of Problem and Substantiation for Public Input

The existing code would require an existing service with one enclosure containing up to six disconnecting means to be reworked when the additional disconnecting means are installed.

Submitter Information Verification

Submitter Full Name: Mason Flanagan

Organization: Sully Electric and Controls Inc

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jan 16 07:49:22 EST 2020

Committee: NEC-P10



Public Input No. 3619-NFPA 70-2020 [Section No. 230.71(B)]

(B) Two to Six Service Disconnecting Means.

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

- (1) Separate enclosures with a main service disconnecting means in each enclosure
- (2) Panelboards with a main service disconnecting means in each panelboard enclosure
- (3) Switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section
- (4) Service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment
- (5) Motor Control Center(s) where there is only one service disconnect in a motor control unit and a maximum of two service disconnects provided in a single motor control center. Barriers shall be provided between units to prevent contact with any live parts in a unit adjacent to a unit being serviced unless the adjacent unit is de-energized by the same service disconnect.

Informational Note No. 1: Metering centers are addressed in UL 67, *Standard for Panelboards*.

Informational Note No. 2: Examples of separate enclosures with a main service disconnecting means in each enclosure include but are not limited to ~~motor control centers~~, fused disconnects, circuit breaker enclosures, and transfer switches that are suitable for use as service equipment.

Statement of Problem and Substantiation for Public Input

This Public Input revises 230.71(B) with respect to motor control centers with more than one service disconnect. The current Exception to 430.95 allows motor control centers to have more than one service disconnect, and there are products on the market utilizing this exception. Motor control centers are not appropriate examples of equipment where a main service disconnecting means is included in each enclosure. Including them in Informational Note 2 to 230.71(B) can be confusing. Motor control centers should be removed from Informational Note 2 of 230.71(B) and instead added as a new item under 230.71(B).

The new item 230.71(B)(5) allows motor control centers to have more than one service disconnect with two limitations:

- a. A maximum of two service disconnects can be provided in a motor control center in accordance with the Exception to Section 430.95.
- b. Each service disconnect is to be installed in a separate motor control unit, and barriers are required between units such that no uninsulated, ungrounded live parts are exposed to inadvertent contact by persons or maintenance equipment while servicing load terminations. This is aligned with changes made by CMP10 for the 2020 Edition of NFPA 70 to improve safety by reducing the likelihood of contact with energized parts on the line side of service equipment with multiple service disconnects. Motor control centers are designed with compartmentalized motor control units, so separation by vertical sections is not necessary.

See related PI for revising Section 430.95.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3615-NFPA 70-2020 [Section No. 430.95]	
Public Input No. 3615-NFPA 70-2020 [Section No. 430.95]	

Submitter Information Verification

Submitter Full Name: Danish Zia

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submittal Date:	Wed Sep 09 09:24:17 EDT 2020
Committee:	NEC-P10

**Public Input No. 4540-NFPA 70-2020 [Section No. 230.71(B)]****(B) Two to Six Service Disconnecting Means.**

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

- (1) Separate enclosures with a main service disconnecting means in each enclosure
- (2) Panelboards with a main service disconnecting means in each panelboard enclosure
- (3) Switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section
- (4) Service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment
- (5) Metering centers with a main service disconnecting means

Informational Note No. 1: Metering centers are addressed in UL 67, *Standard for Panelboards*.

Informational Note No. 2: Examples of separate enclosures with a main service disconnecting means in each enclosure include but are not limited to motor control centers, fused disconnects, circuit breaker enclosures, and transfer switches that are suitable for use as service equipment.

Statement of Problem and Substantiation for Public Input

The products known in the market as Metering centers are addressed in the UL 67, Standard for Panelboards. They are also very commonly referred to as Meter Stacks and Meter Packs in the electrical trade. The pinnacle of design by safety is to provide a main service disconnecting means upstream of the tenant overcurrent protective device (i.e. tenant breaker). The ambiguity of "compartment" in the NEC for Metering centers and not having a defined requirement in UL 67 has created an infeasible situation for installers and inspectors with products they have used frequently that are known as Meter Packs. Adding the requirement to have a main service disconnecting means for Metering centers with eliminate the ambiguity while greatly providing a safer installation.

Submitter Information Verification

Submitter Full Name: Kevin Arnold

Organization: Eaton's Bussmann Business

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 14:52:02 EDT 2020

Committee: NEC-P10

**Public Input No. 4590-NFPA 70-2020 [Section No. 230.71(B)]****(B) Two to Six Service Disconnecting Means.**

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

- (1) Separate enclosures with a main service disconnecting means in each enclosure
- (2) Panelboards with a main service disconnecting means in each panelboard enclosure
- (3) Switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section
- (4) Service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment

Exception to (2), (3) and (4): Existing service equipment, installed in compliance with previous editions of this Code that permitted multiple service disconnecting means in a single enclosure, section or compartment, shall be permitted to contain a maximum of six service disconnecting means provided the installation is in accordance with the equipment listing instructions.

Informational Note No. 1: Metering centers are addressed in UL 67, *Standard for Panelboards*.

Informational Note No. 2: Examples of separate enclosures with a main service disconnecting means in each enclosure include but are not limited to motor control centers, fused disconnects, circuit breaker enclosures, and transfer switches that are suitable for use as service equipment.

Statement of Problem and Substantiation for Public Input

Existing service equipment installed prior to adoption of the 2020 NEC, with provisions to include up to six disconnects was compliant when installed. Many owners selected that equipment with plans for additional load as their needs expand. While it is now recognized that a single disconnect with barriers for supply connections is a needed change and significantly enhances the safety of installation and maintenance of the equipment for workers, it doesn't seem practical to prohibit the continued use of that equipment or require additional work to install a single disconnect on the supply side of the equipment as load is added or an additional tenant occupies a previously unfinished space. While the 2020 NEC text does not specifically mention existing installations, the literal text has no provisions to include an additional service disconnecting means in previously installed service equipment.

Submitter Information Verification

Submitter Full Name: Donald Cook

Organization: Shelby County Department of De

Affiliation: self

Street Address:

City:

State:

Zip:

Submission Date: Thu Sep 10 15:30:55 EDT 2020

Committee: NEC-P10

**Public Input No. 894-NFPA 70-2020 [Section No. 230.71(B)]****(B) Two to Six Service Disconnecting Means.**

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

- (1) Separate enclosures with a main service disconnecting means in each enclosure
- (2) Panelboards with a main service disconnecting means in each panelboard enclosure
- (3) Switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section
- (4) Service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment

Exception to (B): Modifications to service equipment with provisions for not more than six service disconnects in a single enclosure installed in accordance with this code prior to the adoption of the 2020 edition shall be permitted.

Informational Note No. 1: Metering centers are addressed in UL 67, *Standard for Panelboards*.

Informational Note No. 2: Examples of separate enclosures with a main service disconnecting means in each enclosure include but are not limited to motor control centers, fused disconnects, circuit breaker enclosures, and transfer switches that are suitable for use as service equipment.

Statement of Problem and Substantiation for Public Input

The exception is necessary to allow Code enforcers to permit existing compliant services to continue in service when inserting additional disconnects (not exceeding six) in a single enclosure in accordance with previous editions of the NEC.

Submitter Information Verification

Submitter Full Name: Agnieszka Golriz

Organization: NECA

Street Address:

City:

State:

Zip:

Submittal Date: Tue Apr 21 13:03:46 EDT 2020

Committee: NEC-P10

**Public Input No. 1011-NFPA 70-2020 [Section No. 230.72(A)]****(A) General.**

The two to six disconnects, if permitted in 230.71, shall be grouped. Each disconnect shall be marked to indicate the load served.

Where a service enclosure can accommodate more than 6 service disconnecting means, a label shall be installed and marked: NO MORE THAN 6 SERVICE HANDLE THROWS PERMITTED IN THIS ENCLOSURE

Exception: One of the two to six service disconnecting means permitted in 230.71, where used only for a water pump also intended to provide fire protection, shall be permitted to be located remote from the other disconnecting means. If remotely installed in accordance with this exception, a plaque shall be posted at the location of the remaining grouped disconnects denoting its location.

Statement of Problem and Substantiation for Public Input

Maintenance men, homeowners, other electricians may not know the 6 switch rule. Installing a 12 circuit capacity, main lug only, panel for a service with 4 circuits being used, for example, is code compliant provided it is suitable for use as a service. This applies to any service and temporary services I've seen do come to mind.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Fri May 08 17:20:38 EDT 2020

Committee: NEC-P10

**Public Input No. 2975-NFPA 70-2020 [Section No. 230.75]****230.75** Disconnection of Grounded Conductor.

Where the service disconnecting means does not disconnect the grounded conductor from the premises wiring, other means shall be provided for this purpose in the service equipment. A terminal or bus to which all grounded conductors can be attached by means of pressure connectors shall be permitted for this purpose. In a multisection switchboard or switchgear, disconnects for the grounded conductor shall be permitted to be in any section of the switchboard or switchgear, if the switchboard or switchgear section is marked to indicate a grounded conductor disconnect is located within .

Informational Note: In switchgear or multisection switchboards, the disconnecting means provided for the grounded conductor is typically identified as a neutral disconnect link and is typically located in the bus to which the service grounded conductor is connected.

Statement of Problem and Substantiation for Public Input

In the 2017 NEC, the last sentence in 230.75 permitted the neutral disconnect link to be located in any section of a multisection switchboard or switchgear if the switchboard or switchgear section was marked to indicate the neutral disconnect link was located within. This is an important marking for the electrical inspector who often searches through many switchboard sections for the presence of a properly installed and torqued neutral disconnect link. In the 2020 NEC, a proposal was accepted to simply add a new informational note explaining more about the term "neutral disconnect link" but somehow in the process of adding the informational note, the last sentence in 230.75 was deleted. Please bring this important sentence back.

Submitter Information Verification

Submitter Full Name: Mike Miller

Organization: electricallicenser renewal.com

Affiliation: electricallicenser renewal.com

Street Address:

City:

State:

Zip:

Submission Date: Thu Sep 03 16:34:21 EDT 2020

Committee: NEC-P10

**Public Input No. 3469-NFPA 70-2020 [Section No. 230.76]****230.76** Manually or Power Operable.

The service disconnecting means for ungrounded service conductors shall consist of one of the following:

- (1) A manually operable switch or circuit breaker equipped with a handle or other suitable operating means that is accessible external to the enclosure or by means of a simple hinge and clasp cover.
- (2) A power-operated switch or circuit breaker, provided the switch or circuit breaker can be opened by hand in the event of a power supply failure

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Service_Rated_ATS.jpg	Service Rated ATS	
Thumb_Screw.jpg	Thumb Screw	

Statement of Problem and Substantiation for Public Input

First Responders that approach services during an emergency are normally wearing thick fire rated gloves. With service disconnects having handles external to the service enclosure or by means of a simple hinge and clasp type cover, the responder should be able to access the disconnect handle and/or open a cover without the need to stop and remove his/her gloves. Thumb screws such as the ones in the attached images are difficult to manage with heavy gloves on and as can be seen are subject to rusting which then become difficult to unscrew. And as an Inspector I have also seen lost or broken thumb screws replaced with machine screws creating an even greater safety concern.

Submitter Information Verification

Submitter Full Name: Tracy Dolan
Organization: Arkansas Department of Labor & Licensing
Affiliation: Submitting in conjunction with Doug Perry, Inspector/Firefighter, City of Heber Springs, AR
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 08 16:12:04 EDT 2020
Committee: NEC-P10

MAIN DISCONNECT

WARNING
AVERTISSEMENT
ADVERTENCIA

 Electric shock hazard could result in death or serious injury. Disconnect all sources of supply voltage before servicing.

Risque de choc électrique pouvant provoquer des blessures graves, voire la mort. Débranchez toutes les sources de tension électrique avant l'intervention.

Riesgo de descarga eléctrica que podría resultar en muerte o lesiones graves. Desconecte todas las fuentes de energía antes de reparar.

Riesgo de tensión eléctrica antes de la reparación. Desconecte todas las fuentes de energía antes de reparar.

80015810



**Public Input No. 1847-NFPA 70-2020 [Section No. 230.79]****230.79** Rating of Service Conductors and Disconnecting Means.

The service ~~disconnecting- conductor and disconnecting~~ means shall have a rating not less than the calculated load to be carried, determined in accordance with Part III, IV, or V of Article 220, as applicable. In no case shall the rating be lower than specified in 230.79(A), (B), (C), or (D).

(A) One-Circuit Installations.

For installations to supply only limited loads of a single branch circuit, ~~the conductor and~~ service disconnecting means shall have a rating of not less than 15 amperes.

(B) Two-Circuit Installations.

For installations consisting of not more than two 2-wire branch circuits, the ~~service disconnecting-~~ service conductor and disconnecting means shall have a rating of not less than 30 amperes.

(C) One-Family Dwellings.

For a one-family dwelling, the service ~~disconnecting- conductor and disconnecting~~ means shall have a rating of not less than 100 amperes, 3-wire.

(D) All Others.

For all other installations, the service ~~disconnecting- conductor and disconnecting~~ means shall have a rating of not less than 60 amperes.

Statement of Problem and Substantiation for Public Input

My text is to make it clear that this rule also is intended to ensure that the conductors and disconnect have a rating not less than the calculated load. The way it is currently written, only the disconnect is required to comply with this rule for rating, not the conductor.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 10 14:02:05 EDT 2020

Committee: NEC-P10

**Public Input No. 1202-NFPA 70-2020 [Section No. 230.79(A)]****(A) One-Circuit Installations.**

For installations to supply only limited loads of a single branch circuit, the service disconnecting means shall have a rating of not less than 15 amperes, conductors shall be a minimum 14 AWG prior to any adjustments and/or corrections .

Statement of Problem and Substantiation for Public Input

Add language noting the conductors shall be a minimum 14 AWG prior to any adjustments and/or corrections. This change will assist with correlating various other articles such as 110.14 (C) (1), 240.4 (D), 310.15 (A).

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 07:26:20 EDT 2020

Committee: NEC-P10

**Public Input No. 1203-NFPA 70-2020 [Section No. 230.79(B)]****(B) Two-Circuit Installations.**

For installations consisting of not more than two 2-wire branch circuits, the service disconnecting means shall have a rating of not less than 30 amperes, conductors shall be a minimum 10 AWG prior to any adjustments and/or corrections .

Statement of Problem and Substantiation for Public Input

Add language noting the conductors shall be a minimum 10 AWG prior to any adjustments and/or corrections. This change will assist with correlating various other articles such as 110.14 (C) (1), 240.4 (D), 310.15 (A).

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 07:28:14 EDT 2020

Committee: NEC-P10

**Public Input No. 1204-NFPA 70-2020 [Section No. 230.79(C)]****(C) One-Family Dwellings.**

For a one-family dwelling, the service disconnecting means shall have a rating of not less than 100 amperes, 3-wire, conductors shall be a minimum 4 AWG prior to any adjustments and/or corrections . . .

Statement of Problem and Substantiation for Public Input

Add language noting the conductors shall be a minimum 4 AWG prior to any adjustments and/or corrections. This change will assist with correlating various other articles such as 110.14 (C), 310.12, Table 310.12, 310.15 (A).

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 07:31:28 EDT 2020

Committee: NEC-P10

**Public Input No. 1205-NFPA 70-2020 [Section No. 230.79(D)]**

(D) All Others.

For all other installations, the service disconnecting means shall have a rating of not less than 60 amperes, conductors shall be a minimum 4 AWG prior to any adjustments and/or corrections .

Statement of Problem and Substantiation for Public Input

Add language noting the conductors shall be a minimum 4 AWG prior to any adjustments and/or corrections. This change will assist with correlating various other articles such as 110.14 (C) (1), 240.4 (D), 310.15 (A).

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 07:33:37 EDT 2020

Committee: NEC-P10

**Public Input No. 1206-NFPA 70-2020 [Section No. 230.79(D)]**

(D) All Others.

For all other installations, the service disconnecting means shall have a rating of not less than 60 amperes.

Provide clarifying language noting if the 60 amperes service rated disconnecting means is applicable to single phase and three phase installations. The available power for example in a 120/240 volt application at 60 amps is significantly less than the power available when a 277/480 volt system is used. For three phase applications the requirement to have a 60 amperes rated service disconnecting means is disproportionally oversized relative to single phase applications.

Statement of Problem and Substantiation for Public Input

Provide clarifying language noting if the 60 amperes service rated disconnecting means is applicable to single phase and three phase installations. The available power for example in a 120/240 volt application at 60 amps is significantly less than the power available when a 277/480 volt system is used. For three phase applications the requirement to have a 60 amperes rated service disconnecting means is disproportionally oversized relative to single phase applications.

Submitter Information Verification

Submitter Full Name: Gary Hein

Organization: Submission is independent of employer.

Street Address:

City:

State:

Zip:

Submittal Date: Sat May 23 07:35:29 EDT 2020

Committee: NEC-P10



Public Input No. 1020-NFPA 70-2020 [Section No. 230.82]

230.82 Equipment Connected to the Supply Side of Service Disconnect.

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches nominally rated not in excess of 1000 volts ~~that~~ provided they meet all of the following:
 1. They have a short-circuit current rating equal to or greater than the available fault current, if all
 2. They are marked suitable for service equipment.
 3. A main bonding jumper shall connect the grounded conductors to the meter disconnect enclosure.
 4. All metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250. A meter disconnect switch shall be in accordance with Part V of Article 250.
 5. They are capable of interrupting the load served. - A
 6. The meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT

NOT SERVICE EQUIPMENT as follows: METER DISCONNECT NOT SERVICE EQUIPMENT

Informational Note: See 250.24(B)(2) for meter disconnect switch main bonding jumper requirements.

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) Emergency disconnects in accordance with 230.85, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (11) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:
 - (12) Meter-mounted transfer switch
 - (13) Not service equipment

Statement of Problem and Substantiation for Public Input

Mentioned 250.24B2 is a new proposal and will also be submitted.

The meter disconnect switch required provisions are placed in a list for easier reading.

The new #2 on this list is similar to 230.66. Although it is advertised with #6 on this list as 'NOT SERVICE EQUIPMENT', it is line side equipment and subject to the same conditions as equipment regarded as service equipment.

The new main bonding jumper entry (#3) is added following the logic of 250.24C. Whether it's regarded as service equipment or a meter disconnect switch, it is placed line side in the system and is subject to the same conditions as the service equipment. The meter disconnect switch doesn't know it isn't service equipment. If EACH service disconnect switch is required to be bonded, the meter disconnect switch should be, also. Presently, there is no code to enforce it this way. On the other hand, if the code making panel finds the meter enclosure switch should NOT be bonded to the grounded conductors, a code entry should be implemented stating it shall not have the main bonding jumper installed.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Mon May 11 09:50:05 EDT 2020

Committee: NEC-P10



Public Input No. 1690-NFPA 70-2020 [Section No. 230.82]

230.82 Equipment Connected to the Supply Side of Service Disconnect.

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches listed as suitable for use as service equipment, nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current, ~~if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.~~ A meter disconnect switch shall be capable of interrupting the load served. A meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT

NOT SERVICE EQUIPMENT

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) Emergency disconnects in accordance with 230.85, ~~if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250~~ listed as suitable for use as service equipment.
- (11) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:
 - (12) Meter-mounted transfer switch
 - (13) Not service equipment

Statement of Problem and Substantiation for Public Input

I suggest that we add that the disconnect be 'suitable as service equipment and remove any text about grounding and bonding, since we have 250.25 that address the grounding and bonding requirements of 'supply-side' disconnects.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 24 21:35:39 EDT 2020
Committee: NEC-P10



Public Input No. 1817-NFPA 70-2020 [Section No. 230.82]

230.82 Equipment Connected to the Supply Side of Service Disconnect.

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250. A meter disconnect switch shall be capable of interrupting the load served. A meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT

NOT SERVICE EQUIPMENT

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) Emergency disconnects in accordance with 230.85(2) and (3), if all metal housings ~~and service enclosures~~ and enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (11) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:
 - (12) Meter-mounted transfer switch
 - (13) Not service equipment

Statement of Problem and Substantiation for Public Input

Article 230.85(1) permits the service disconnect to be installed on the exterior of the dwelling unit. Article 230.82(10) as currently written technically permits a service rated disconnect used as the Emergency Disconnect in 230.85(1) to supply power to another downstream service rated disconnect with service entrance conductors. This type of installation would be a violation of Article 250.32. Clarity is required in 230.82(10) that only the disconnects permitted in 230.85(2) and (3) are

permitted on the supply-side of the service disconnect.

Submitter Information Verification

Submitter Full Name: Brian Baughman

Organization: Generac Power Systems Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jul 09 09:39:28 EDT 2020

Committee: NEC-P10



Public Input No. 2305-NFPA 70-2020 [Section No. 230.82]

230.82 Equipment Connected to the Supply Side of Service Disconnect.

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250. A meter disconnect switch shall be capable of interrupting the load served. A meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT

NOT SERVICE EQUIPMENT

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) ~~Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.~~
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) Emergency disconnects in accordance with 230.85, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (11) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:
 - (12) Meter-mounted transfer switch
 - (13) Not service equipment

Statement of Problem and Substantiation for Public Input

Item (6) of 230.82 deals with solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources connected on the supply side of the service disconnect. Because of the change in the definition of Service in the 2020 NEC and the proposed change in 705.11, this item is no longer needed. As discussed during the Electrical Section Meeting and the resultant Annual Meeting Floor action, these alternate energy

systems should be connected through a service disconnect meeting all of the requirements in Article 230. This action would significantly reduce the confusion in the industry about how these systems should be interconnected with the electric utility.

Submitter Information Verification

Submitter Full Name: Roland Deike

Organization: CenterPoint Energy, Inc.

Affiliation: Edison Electric Institute/Electric Light & Power Task Force (EEI/EL&P)

Street Address:

City:

State:

Zip:

Submission Date: Fri Aug 14 10:17:41 EDT 2020

Committee: NEC-P10



Public Input No. 2419-NFPA 70-2020 [Section No. 230.82]

230.82 Equipment Connected to the Supply Side of Service Disconnect.

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250. A meter disconnect switch shall be capable of interrupting the load served. A meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT

NOT SERVICE EQUIPMENT

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) Emergency disconnects in accordance with 230.85, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (11) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:
 - (12) Meter-mounted transfer switch
 - (13) Not service equipment
- (14) Listed meter-mounted collar devices for the connection of the interconnected power production sources in (6).

Statement of Problem and Substantiation for Public Input

The 2020 NEC permitted the installation and use of meter-mounted transfer switches in 230.82(11) and the code should also permit the installation and use of other meter mounted equipment. Listed products exist for the supply-side connection

of interconnected electrical power production sources. Where the serving utility approves the use of the equipment, the NEC should have language covering the installation and use.

The PI seeks to add a new (12) to the list in 230.82.

Submitter Information Verification

Submitter Full Name: Brian Baughman

Organization: Generac Power Systems Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Thu Aug 20 10:19:08 EDT 2020

Committee: NEC-P10



Public Input No. 3052-NFPA 70-2020 [Section No. 230.82]

230.82 Equipment Connected to the Supply Side of Service Disconnect.

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250. A meter disconnect switch shall be capable of interrupting the load served. A meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT

NOT SERVICE EQUIPMENT

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) Emergency disconnects in accordance with 230.85, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (11) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:
 - (12) Meter-mounted transfer switch
 - (13) Not service equipment
- (14) Control power circuits for protective relays where installed as part of listed equipment. If suitable overcurrent protection and disconnecting means are provided.

Statement of Problem and Substantiation for Public Input

It is important for control power circuits for protective relays to maintain power and be active when the service disconnect is

open. This is necessary to eliminate the 10 to 100 millisecond start-up delay that the typical protective relay requires to transition from unpowered to active. Should there be a fault upon closing the service disconnect, the protection must act immediately to clear the fault to increase the likelihood of protecting workers. This is common practice for feeder equipment.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 11:15:16 EDT 2020

Committee: NEC-P10



Public Input No. 3108-NFPA 70-2020 [Section No. 230.82]

230.82 Equipment Connected to the Supply Side of Service Disconnect.

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250. A meter disconnect switch shall be capable of interrupting the load served. A meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT

NOT SERVICE EQUIPMENT

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) ~~Emergency disconnects in-~~ Disconnect switches or circuit breakers that serve as emergency disconnects in accordance with 230.85, if all metal (A)(3), if each of the following is satisfied:
 - (11) The disconnect switch or circuit breaker is suitable for use as service equipment
 - (12) Metal housings and service enclosures are bonded and grounded in accordance with Part

VII

- (1) V and

~~bonded in accordance with~~

- (1) Part

V

- (1) VII of Article 250

.

- (1) , respectively

- (2) Is legibly field marked on its exterior in a manner suitable for the environment as follows: NOT SERVICE EQUIPMENT

- (13) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:

(14) [Meter-mounted transfer switch](#)

(15) [Not service equipment](#)

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
230.82_10_clarification.docx	230.82(10) change clarification - edits were not represented accurately in TerraView	

Statement of Problem and Substantiation for Public Input

The change proposed in this PI is an attempt to improve the arrangement of 230.82 and to correlate with proposed changes in 230.85. Item 230.82(10) was added to the NEC in 2020 to accommodate the new section for emergency disconnects 230.85.

The conditions that permit a piece of equipment to be installed on the supply side of the service disconnect are generally specified in 230.82 after “,if.” in each clause. Specifically in 230.82(3, 6, and 11), requirements that the equipment be “suitable for use as service equipment” and be labeled “NOT SERVICE EQUIPMENT” are given. Currently, 230.82(10) delegates these specific requirements to 210.85.

For consistency, this PI moves the “NOT SERVICE EQUIPMENT” and “suitable for use as service equipment” from 230.85 to 230.85(10).

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3109-NFPA 70-2020 [Section No. 230.85]	dependent
Public Input No. 3109-NFPA 70-2020 [Section No. 230.85]	

Submitter Information Verification

Submitter Full Name: Randy Dollar

Organization: Siemens Industry

Affiliation: American Circuit Breaker Manufacturers Association (ACBMA)

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 16:55:30 EDT 2020

Committee: NEC-P10

NFPA Public Input Form

NOTE: All Public Input must be received by 5:00 pm EST/EDST on the published Public Input Closing Date.

For further information on the standards-making process, please contact the Codes and Standards Administration at 617-984-7249 or visit www.nfpa.org/codes.

For technical assistance, please call NFPA at 1-800-344-3555

FOR OFFICE USE ONLY

Log #: _____

Date Rec'd: _____

Date _____ Name _____ Tel. No. _____

Company _____ Email _____

Street Address _____ City _____ State _____ Zip _____

Please indicate organization represented (if any) ACBMA

1. (a) Title of NFPA Standard National Electrical Code NFPA No. & Year 70-2023

(b) Section/Paragraph 230.82(10)

2. Public Input Recommends (check one): ☐ new text ☒ revised text ☐ deleted text

3. Proposed Text of Public Input (include proposed new or revised wording, or identification of wording to be deleted):

[Note: Proposed text should be in legislative format; i.e., use underscore to denote wording to be inserted (inserted wording) and strike-through to denote wording to be deleted (~~deleted wording~~).]

Disconnect switches or circuit breakers that serve as emergency ~~Emergency~~ disconnects in accordance with 230.85(A)(3), if each of the following is satisfied:

- a. The disconnect switch or circuit breaker is suitable for use as service equipment
- b. ~~metal~~ Metal housings and service enclosures are bonded and grounded in accordance with Part VII and bonded in accordance with Part VII of Article 250, respectively
- c. Is legibly field marked on its exterior in a manner suitable for the environment as follows:
NOT SERVICE EQUIPMENT

4. Statement of Problem and Substantiation for Public Input: (Note: State the problem that would be resolved by your recommendation; give the specific reason for your Public Input, including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

The change proposed in this PI is an attempt improve the arrangement of 230.82 and to correlate with proposed changes in 230.85. Item 230.82(10) was added to the NEC in 2020 to accommodate the new section for emergency disconnects 230.85.

The conditions that permit a piece of equipment to be installed on the supply side of the service disconnect are generally specified in 230.82 after "if.." in each clause. Specifically in 230.82(3, 6, and 11), requirements that the equipment be "suitable for use as service equipment" and be labeled "NOT SERVICE EQUIPMENT" are given. Currently, 230.82(10) delegates these specific requirements to 210.85.

For consistency, this PI moves the "NOT SERVICE EQUIPMENT" and "suitable for use as service equipment" from 230.85 to 230.85(10).

5. Copyright Assignment

- (a) ☒ I am the author of the text or other material (such as illustrations, graphs) proposed in the Public Input.
- (b) ☐ Some or all of the text or other material proposed in this Public Input was not authored by me. Its source is as follows: (please identify which material and provide complete information on its source)

I hereby grant and assign to the NFPA all and full rights in copyright in this Public Input (including both the Proposed Text and the Statement of Problem and Substantiation). I understand that I acquire no rights in any publication of NFPA in which this Public Input in this or another similar or analogous form is used. Except to the extent that I do not have authority to make an assignment in materials that I have identified in (b) above, I hereby warrant that I am the author of this Public Input and that I have full power and authority to enter into this assignment.

Signature (Required) _____

PLEASE USE SEPARATE FORM FOR EACH PUBLIC INPUT

To: Secretary, Standards Council National Fire Protection Association
1 Batterymarch Park · Quincy, MA 02169-7471 OR
Fax to: (617) 770-3500 OR Email to: proposals_comments@nfpa.org

9/16/2020

**Public Input No. 3997-NFPA 70-2020 [Section No. 230.82]****230.82 Equipment Connected to the Supply Side of Service Disconnect.**

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250. A meter disconnect switch shall be capable of interrupting the load served. A meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT**NOT SERVICE EQUIPMENT**

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, ~~if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.~~
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) Emergency disconnects in accordance with 230.85, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (11) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:
 - (12) Meter-mounted transfer switch
 - (13) Not service equipment

Statement of Problem and Substantiation for Public Input

This text is not necessary in this location the requirements for this disconnect are more thoroughly covered in 705.20. In addition Chapter 7 would supplement or modify Chapter 2 to these more stringent requirements as described in 90.3

Submitter Information Verification

Submitter Full Name: James Rogers

Organization: Towns of Oak Bluffs, Tisbury,

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 16:57:12 EDT 2020

Committee: NEC-P10

**Public Input No. 4152-NFPA 70-2020 [Section No. 230.82]****230.82 Equipment Connected to the Supply Side of Service Disconnect.**

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250. A meter disconnect switch shall be capable of interrupting the load served. A meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT**NOT SERVICE EQUIPMENT**

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) Emergency disconnects in accordance with 230.85, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (11) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:
 - (12) Meter-mounted transfer switch
 - (13) Not service equipment
- (14) Grounding systems identified by 250.25.

Statement of Problem and Substantiation for Public Input

Propose to add "Grounding Systems identified by 250.25" since there is no provision to permit the the installation on the Supply Side of service.

Submitter Information Verification

Submitter Full Name: Mathher Abbassi

Organization: New York City Department Of Buildings

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 22:27:55 EDT 2020

Committee: NEC-P10



Public Input No. 4690-NFPA 70-2020 [Section No. 230.82]

230.82 Equipment Connected to the Supply Side of Service Disconnect.

Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- (1) Cable limiters.
- (2) Meters and meter sockets nominally rated not in excess of 1000 volts, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (3) Meter disconnect switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250. A meter disconnect switch shall be capable of interrupting the load served. A meter disconnect shall be legibly field marked on its exterior in a manner suitable for the environment as follows:

METER DISCONNECT**NOT SERVICE EQUIPMENT**

- (4) Instrument transformers (current and voltage), impedance shunts, load management devices, surge arresters, and Type 1 surge-protective devices.
- (5) Conductors used to supply load management devices, circuits for standby power systems, fire pump equipment, and fire and sprinkler alarms, if provided with service equipment and installed in accordance with requirements for service-entrance conductors.
- (6) Solar photovoltaic systems, fuel cell systems, wind electric systems, energy storage systems, or interconnected electric power production sources, if provided with a disconnecting means listed as suitable for use as service equipment, and overcurrent protection as specified in Part VII of Article 230.
- (7) Control circuits for power-operable service disconnecting means, if suitable overcurrent protection and disconnecting means are provided.
- (8) Ground-fault protection systems or Type 2 surge-protective devices, where installed as part of listed equipment, if suitable overcurrent protection and disconnecting means are provided.
- (9) Connections used only to supply listed communications equipment under the exclusive control of the serving electric utility, if suitable overcurrent protection and disconnecting means are provided. For installations of equipment by the serving electric utility, a disconnecting means is not required if the supply is installed as part of a meter socket, such that access can only be gained with the meter removed.
- (10) Emergency disconnects in accordance with 230.85, if all metal housings and service enclosures are grounded in accordance with Part VII and bonded in accordance with Part V of Article 250.
- (11) Meter-mounted transfer switches nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. A meter-mounted transfer switch shall be listed and be capable of transferring the load served. A meter-mounted transfer switch shall be marked on its exterior with both of the following:
 - (12) Meter-mounted transfer switch
 - (13) Not service equipment
- (14) Microgrid Interconnect Devices, isolation switches, or other isolation devices nominally rated not in excess of 1000 volts that have a short-circuit current rating equal to or greater than the available fault current. The isolation device shall be listed and shall be capable of interrupting the load served. The isolation device shall be marked on its exterior with both of the following:
 - (15) Isolation Device
 - (16) Not Service Equipment
- (17) Any of the equipment identified in 230.82 (1) - (12) manufactured within the meter socket, within the meter, or within a meter socket adapter. The product shall be listed applicable to its form factor, and shall meet all the requirements identified in the applicable 230.82 section.

Statement of Problem and Substantiation for Public Input

New list item (12) Microgrid Interconnect Devices are commonly used to provide whole home backup. Locating the device on the supply side of the service disconnect is a simple installation method to isolate all loads and power production sources on a premises from the utility supply. Similar equipment, such as meter disconnects and meter-mounted transfer switches, are already allowed within 230.82. The addition of MIDs, isolation switches, and isolation devices ensures that these systems share the same location benefits as other related equipment allowed on the supply side.

New list item (13) - The equipment identified in 230.82, that is allowed on the supply side of the service disconnect, can come in many shapes and sizes. Products already exist on the market that connect allowed equipment on the supply side using each of the aforementioned form factors. The expectation is for more products to be introduced in the future. Though Utility specific rules may dictate equipment requirements, the Code does not need to make a distinction about which hardware form factor is allowed. Meters, meter sockets, and meter socket adapters each have an applicable Standard for which the hardware can be certified to.

Submitter Information Verification

Submitter Full Name: Charles Picard

Organization: Tesla, Inc

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 16:52:32 EDT 2020

Committee: NEC-P10

**Public Input No. 1973-NFPA 70-2020 [New Section after 230.85]****230.86 Emergency Disconnects and Emergency Shutdowns**

For one- and two-family dwelling units having emergency disconnects and/or emergency shutdowns, other than those located adjacent to the emergency disconnect required by 230.85, a plaque or directory identifying the location of all emergency disconnects and/or emergency shutdowns shall be located adjacent to all emergency disconnects and emergency shutdowns.

Statement of Problem and Substantiation for Public Input

First responders may not be aware of the location of other emergency disconnects not co-located with the emergency disconnect at the service.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jul 22 14:39:22 EDT 2020

Committee: NEC-P10

**Public Input No. 2021-NFPA 70-2020 [New Section after 230.85]****Informational Note**

Some overcurrent protective devices have temperature limitations that restrict their use in low temperature applications.

Statement of Problem and Substantiation for Public Input

Some circuit breakers have manufacturer's instructions that prohibit their use below 14°F. In many areas of the country, an emergency disconnect or a service disconnect will be at or below that temperature for a substantial length of time. In addition there is a substantial increase in the trip current for circuit breakers installed in lower temperatures. Based on the data from one manufacture, there is a 25% increase in the trip point where the breaker is in a 50°C ambient. In my area, a 400 amp breaker installed outside, would have a 500 amp or higher trip point for about 5 months of the year as for those months the average high temperature does not exceed 50°F. This informational note is to call these issue to the attention of the installer and inspector.

Submitter Information Verification

Submitter Full Name: Don Ganiere

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 25 17:05:29 EDT 2020

Committee: NEC-P10

**Public Input No. 4416-NFPA 70-2020 [New Section after 230.85]****(B) Replacement.**

Replacement of existing service equipment shall not apply to this section for emergency disconnect where no additional feeders or branch circuits are installed.

Statement of Problem and Substantiation for Public Input

The Code language does not address when an existing dwelling service is changed and if the AHJ is to enforce the replacement requirements of section 230.67(D).

By not addressing existing service equipment changes, this requirement suggests a couple of enforcement options with different risk hazards.

- Enforcement for the AHJ suggests that the Code is silent and there is no hazard in replacing existing service equipment and therefor does not require an exterior emergency disconnect, or
- First responders will incur the same hazard with replacement of existing service equipment as with new construction.

The proposed text is an attempt to provide a limited practical option to maximize protection in modified electrical installations. This addition aligns with many other requirements that directs existing electrical installations such as an elected service change for a remodel or room addition.

Examples

550.33 Feeder. (A) Feeder Conductors Exception:

600.4 Markings. (B) Signs with a Retrofitted Illumination System. (3)

680.22 Lighting, Receptacles, and Equipment. (B) Luminaires, Lighting Outlets, and Ceiling-Suspended (Paddle) Fans. (3) Existing Installations.

Submitter Information Verification

Submitter Full Name: Chris Valtierra

Organization: City of Waco TX

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 12:32:36 EDT 2020

Committee: NEC-P10

**Public Input No. 112-NFPA 70-2019 [Section No. 230.85]****230.85 Emergency Disconnects.**

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

(4) Replacement. Where one- and two- family dwelling units Service Equipment is a new install or replacement or upgrade all of the requirements of this section shall apply.

Statement of Problem and Substantiation for Public Input

In this section it does not advise if this is for new install or a revamp of a service, this will resolve the issue and leave no interpretation issue „if you look at Art. 230.67 for surge protection it is specific in its requirements. Changing this will also

resolve its ambiguity.

Submitter Information Verification

Submitter Full Name: Steven Antonson Sr

Organization: State of Rhode Island /Building Code Commission

Street Address:

City:

State:

Zip:

Submittal Date: Fri Nov 15 13:00:41 EST 2019

Committee: NEC-P10

**Public Input No. 1725-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects Shutdown .**

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT SHUTDOWN ,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT SHUTDOWN ,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT SHUTDOWN ,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

Statement of Problem and Substantiation for Public Input

Changing the rule from an "Emergency Disconnect" to "Emergency Shutdown," will help make it clear that this is a shutdown switch. This coordinates with text in 445.18. It is my opinion that "disconnect" is the correct term where we are opening the connection to the supply source. "Shutdown" is the correct term where we are shutting down equipment such as a generator or a PV system.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 25 15:41:52 EDT 2020

Committee: NEC-P10

**Public Input No. 1818-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects.**

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B). Equipment listed as suitable for use only as service equipment shall not be permitted to be installed in accordance with 230.85(2) and (3).

Statement of Problem and Substantiation for Public Input

Equipment that is listed as suitable for use only as service equipment should not be permitted to be labeled as "not service equipment" in the field. The installation of equipment that is listed as suitable for use only as service equipment, like a meter/main can be installed on the exterior of a dwelling unit and satisfy the requirement in 230.85(1).

Submitter Information Verification

Submitter Full Name: Brian Baughman
Organization: Generac Power Systems Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jul 09 10:14:51 EDT 2020
Committee: NEC-P10

**Public Input No. 2019-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects.**

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location, on or directly adjacent to the dwelling unit . If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

Statement of Problem and Substantiation for Public Input

In some applications the actual service disconnect is remote from the structure and may be difficult for first responders to locate in an emergency. This change requires the emergency disconnect to be readily accessible and installed on the dwelling unit or directly adjacent thereto.

Submitter Information Verification

Submitter Full Name: Don Ganiere

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 25 16:52:54 EDT 2020

Committee: NEC-P10

**Public Input No. 2020-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects.**

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. Where the dwelling unit is supplied by additional power sources such as PV systems, standby generator systems, and energy storage systems, and those disconnecting means are not located adjacent to the emergency disconnect, signage shall be provided at the emergency disconnect indicating the location of the other system disconnects. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

Statement of Problem and Substantiation for Public Input

The first responders need to be able to quickly disconnect all sources of power to the dwelling unit in an emergency. This

requirement will make that disconnection easier to accomplish.

Submitter Information Verification

Submitter Full Name: Don Ganiere

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 25 16:58:53 EDT 2020

Committee: NEC-P10

**Public Input No. 2261-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects.**

~~For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:~~

- ~~• Service disconnects marked as follows:~~

~~EMERGENCY DISCONNECT,~~

~~SERVICE DISCONNECT~~

- ~~• Meter disconnects installed per 230.82 (3) and marked as follows:~~

~~EMERGENCY DISCONNECT,~~

~~METER DISCONNECT,~~

~~NOT SERVICE EQUIPMENT~~

~~Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:~~

~~EMERGENCY DISCONNECT,~~

~~NOT SERVICE EQUIPMENT~~ Markings shall comply with 110.21(B) - ~~shall be outdoors.~~

Statement of Problem and Substantiation for Public Input

The definition of service equipment indicates that it is "the main control and disconnect of the serving utility." If you install a switch on the outside of a house, and that switch is intended to be the main disconnect of the serving utility, it is the service equipment. Putting a sticker on the enclosure stating that it is not the service equipment does not change the definition. If the current options that exist are intended to provide relief from the requirements of 250.24 and 250.142 then those sections should have exceptions in them.

Submitter Information Verification

Submitter Full Name: Ryan Jackson

Organization: Ryan Jackson

Street Address:

City:

State:

Zip:

Submittal Date: Wed Aug 12 14:34:41 EDT 2020

Committee: NEC-P10



Public Input No. 2569-NFPA 70-2020 [Section No. 230.85]

230.85 Emergency Disconnects.

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

Exception (1) to (1), (2), and (3): A building requiring an Emergency Disconnect(s) supplied by a service lateral or by underground service conductors which terminate inside the building shall be permitted to be capable of disconnection from a readily accessible location outside of the dwelling by using a method providing remote control of the service disconnecting means, and marked: REMOTE EMERGENCY ELECTRICAL DISCONNECT and NOT SERVICE EQUIPMENT. The remote control device shall be listed for compatibility with the SERVICE DISCONNECT and be equipped with pilot lights, or other means, to indicate the position of the SERVICE DISCONNECT. The SERVICE DISCONNECT shall be equipped with shunt trip coils, auxiliary contacts as required and wired to terminal strips, accessible to qualified persons, to facilitate electrical interlocking with the REMOTE EMERGENCY ELECTRICAL DISCONNECT.

Markings shall comply with 110.21(B).

This section shall only apply to the following:

- (1) New one- and two-family dwellings, or new buildings of double occupancy, at least one of which is a dwelling unit.
- (2) Two-family dwellings or buildings of double occupancy, at least one of which is a dwelling unit, and newly

created by subdivision of an existing one-family dwelling.

(3) One- and two-family dwellings where the Service Equipment for either or both is(are) entirely replaced.

Statement of Problem and Substantiation for Public Input

Large older cities like Boston have renovated brownstones, row houses, single family residences and created condo complexes adding value and improving neighborhoods. All of which are supplied by laterals from Underground Utility Systems terminating in Utility Owned Terminal Boxes located in the basements. Most of them have stone and granite foundations that were installed not long after the Battle of Bunker Hill. To core through the foundation to install piping and a disconnect outside the building would not only be difficult and impracticable, but the creation of these obstructions on the narrow sidewalks would not be permitted by the city bylaws. Similar existing residential areas, condominium complexes and newer subdivisions in the suburbs have adopted zoning bylaws requiring underground utilities with similar restrictions to unsightly meter banks and to comply with regulations for historical districts. A discretely located and identified shunt trip button recognizable by first responders with clear indication that the SERVICE MAIN has opened is a safe practical solution to create the relief that's needed in these situations and keep the first responders safe.

The inspectional community having lived with 230.85 for eight short months has found confusion as to when to apply this rule. Is it just new construction, or does adding a new breaker to supply a branch circuit, or replacing a meter socket after a storm trigger compliance with the rule? The last section provides practical text for AHJ's and electricians to interpret when to apply the rule and will provide consistency among all jurisdictions.

Submitter Information Verification

Submitter Full Name: Lawrence Forshner

Organization: Bard Rao Athanas Consulting

Affiliation: self

Street Address:

City:

State:

Zip:

Submittal Date: Mon Aug 24 18:28:38 EDT 2020

Committee: NEC-P10

**Public Input No. 2883-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects.**

~~For (A) General.~~ For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

~~(B) Replacement.~~ Where service equipment is replaced, all of the requirements of this section shall apply.

Statement of Problem and Substantiation for Public Input

This PI suggests editorial revisions to clarify that this requirement applies for new and replacement services.

Submitter Information Verification**Submitter Full Name:** James Dollard**Organization:** IBEW Local Union 98**Street Address:****City:****State:****Zip:****Submittal Date:** Thu Sep 03 08:13:42 EDT 2020**Committee:** NEC-P10



Public Input No. 3093-NFPA 70-2020 [Section No. 230.85]

230.85 Emergency Disconnects.

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped.

230.85(A) Disconnect Types

Each disconnect shall be one of the following:

(1) Service disconnects

marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

installed per 230.71 and marked per 230.70(B)

(2) Meter disconnects installed per 230.82 (3)

and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

(3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked

as follows:

EMERGENCY DISCONNECT,

" NOT SERVICE EQUIPMENT

Markings shall comply with 410.21(B)

"

230.85(B) Marking and Labeling Required

Each emergency disconnect shall be marked "Emergency Disconnect" and comply with the following:

(1) The marking or labels shall be located on the outside front of the disconnect enclosure

(2) Have a minimum size of 3-in wide by 2-in height with red background and white text

(3) Minimum font size of 37pt Source Sans Regular or equivalent

(4) The marking or labels shall be permanently affixed to the enclosure and shall not be handwritten

(5) Labels required by this section shall be suitable for the environment where they are installed

Informational Note: UL 969 provides guidelines for marking materials and system based on intended environmental conditions and durability .

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
230.85_5lvde2_Aug.docx	NEMA PI 230.85	

Statement of Problem and Substantiation for Public Input

This proposal separates the marking requirements for the disconnect type from the Emergency Disconnect marking intended to facilitate fire service and emergency response actions. The existing marking for the disconnect types with the NEC have been in place for many cycles and address the electrical function of the disconnect within the system. The Emergency Disconnect marking was new for the 2020 NEC and needs more specification to adequately meet the intended use in the field. NEMA and IAFF worked together to determine the minimum requirements for the Emergency Disconnect marking and the marking location. NEMA published EDM P1-2019 Emergency Disconnect Marking Guide which

summarizes the necessary aspects for labeling equipment for this use.

The key points addressed are the marking location, minimum label size and font size, colors and durability to facilitate fire service locating Emergency Disconnects during night operations. The informational note reference was changed since this marking is separate from equipment hazard markings. The ANSI Z535 standard references UL 969 for marking system requirements for environmental conditions and durability

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 14:55:58 EDT 2020

Committee: NEC-P10

NFPA Public Input Form

NOTE: All Public Input must be received by 5:00 pm EST/EDST on the published Public Input Closing Date.

For further information on the standards-making process, please contact the Codes and Standards Administration at 617-984-7249 or visit www.nfpa.org/codes.

For technical assistance, please call NFPA at 1-800-344-3555

FOR OFFICE USE ONLY

Log #: _____

Date Rec'd: _____

Date _____ Name Megan Hayes Tel. No. _____

Company National Electrical Manufacturers Association (NEMA) Email _____

Street Address 1300 North 17th Street, Suite 900 City Rosslyn State VA Zip 22209

Please indicate organization represented (if any) NEMA

1. (a) Title of NFPA Standard National Electrical Code NFPA No. & Year 70-2023

(b) Section/Paragraph 230.85

2. Public Input Recommends (check one): ☐ new text ☒ revised text ☐ deleted text

3. Proposed Text of Public Input (include proposed new or revised wording, or identification of wording to be deleted):
[Note: Proposed text should be in legislative format; i.e., use underscore to denote wording to be inserted (inserted wording) and strike-through to denote wording to be deleted (~~deleted wording~~).]

230.85 Emergency Disconnects.

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. ~~Each disconnect shall be one of the following:~~

~~(1) Service disconnects marked as follows:~~

~~EMERGENCY-DISCONNECT,
SERVICE-DISCONNECT~~

~~(2) Meter disconnects installed per 230.82(3) and marked as follows:~~

~~EMERGENCY-DISCONNECT,
METER-DISCONNECT,
NOT SERVICE EQUIPMENT~~

~~(3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:~~

~~EMERGENCY-DISCONNECT,
NOT SERVICE EQUIPMENT~~

~~Markings shall comply with 110.21(B).~~

230.85(A) Disconnect Types.

Each disconnect shall be one of the following:

(1) Service disconnects installed per 230.71 and marked per 230.70(B)

(2) Meter disconnects installed per 230.82(3)

(3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked "NOT SERVICE EQUIPMENT".

230.85(B) Marking and Labeling Required

Each emergency disconnect shall be marked "Emergency Disconnect" and comply with the following:

(1) The marking or labels shall be located on the outside front of the disconnect enclosure

(2) Have a minimum size of 3in wide by 2in height with red background and white text

(3) Minimum font size of 37 pt Source Sans Regular or equivalent

(4) The marking or labels shall be permanently affixed to the enclosure and shall not be handwritten

(5) Labels required by this section shall be suitable for the environment where they are installed

Informational Note: UL 969 provides guidelines for marking materials and system based on intended environmental conditions and durability.

4. Statement of Problem and Substantiation for Public Input: (Note: State the problem that would be resolved by your recommendation; give the specific reason for your Public Input, including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

This proposal separates the marking requirements for the disconnect type from the Emergency Disconnect marking intended to facilitate fire service and emergency response actions. The existing marking for the disconnect types with the NEC have been in place for many cycles and address the electrical function of the disconnect within the system. The Emergency Disconnect marking was new for the 2020 NEC and needs more specification to adequately meet the intended use in the field. NEMA and IAFF worked together to determine the minimum requirements for the Emergency Disconnect marking and the marking location. NEMA published EDM P1-2019 Emergency Disconnect Marking Guide which summarizes the necessary aspects for labeling equipment for this use.

The key points addressed are the marking location, minimum label size and font size, colors and durability to facilitate fire service locating Emergency Disconnects during night operations. The informational note reference was changed since this marking is separate from equipment hazard markings. The ANSI Z535 standard references UL 969 for marking system requirements for environmental conditions and durability.

5. Copyright Assignment

- (a) ☒ I am the author of the text or other material (such as illustrations, graphs) proposed in the Public Input.
- (b) ☐ Some or all of the text or other material proposed in this Public Input was not authored by me. Its source is as follows: (please identify which material and provide complete information on its source)

I hereby grant and assign to the NFPA all and full rights in copyright in this Public Input (including both the Proposed Text and the Statement of Problem and Substantiation). I understand that I acquire no rights in any publication of NFPA in which this Public Input in this or another similar or analogous form is used. Except to the extent that I do not have authority to make an assignment in materials that I have identified in (b) above, I hereby warrant that I am the author of this Public Input and that I have full power and authority to enter into this assignment.

Signature (Required) _____

PLEASE USE SEPARATE FORM FOR EACH PUBLIC INPUT

To: Secretary, Standards Council National Fire Protection Association
1 Batterymarch Park · Quincy, MA 02169-7471 OR
Fax to: (617) 770-3500 OR Email to: proposals_comments@nfpa.org

9/21/2020



Public Input No. 3109-NFPA 70-2020 [Section No. 230.85]

230.85 Emergency Disconnects.

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped.

Meter disconnects installed per

230.85(A) Disconnect Types.

Each disconnect shall be one of the following:

- ~~Service disconnects marked as follows:~~

~~EMERGENCY DISCONNECT,~~

~~SERVICE DISCONNECT~~

~~(1) Service disconnects installed in accordance with Part VI of Article 230~~

~~(2) Meter disconnects installed in accordance with 230.82 (3)~~

~~and marked as follows:~~

~~EMERGENCY DISCONNECT,~~

~~METER DISCONNECT,~~

~~NOT SERVICE EQUIPMENT~~

- ~~Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:~~

~~EMERGENCY DISCONNECT,~~

~~NOT SERVICE EQUIPMENT~~

~~Markings shall comply with 110.21(B) :~~

~~(3) Disconnect switches or circuit breakers installed in accordance with 230.82(10).~~

230.85(B) Marking and Labeling Required

Each emergency disconnect shall be marked "Emergency Disconnect" and labeling shall be suitable for the environment where it is installed.

Informational Note 1: UL 969 provides guidelines for marking materials and system based on intended environmental conditions and durability.

Informational Note 2: NEMA EDM P1-2019, Emergency Disconnect Marking Guide provides guidance for labeling equipment for this use.

Statement of Problem and Substantiation for Public Input

This proposal separates the marking requirements for the disconnect type from the Emergency Disconnect marking intended to facilitate fire service and emergency response actions. The existing marking for the disconnect types with the NEC have been in place for many cycles and address the electrical function of the disconnect within the system. The Emergency Disconnect marking was new for the 2020 NEC and needs more specification to adequately meet the intended use in the field. NEMA and IAFF worked together to determine the minimum requirements for the Emergency Disconnect marking and the marking location. NEMA published EDM P1-2019 Emergency Disconnect Marking Guide which summarizes the necessary aspects for labeling equipment for this use.

The key points addressed are the marking location, minimum label size and font size, colors and durability to facilitate fire service locating Emergency Disconnects during night operations. The informational note reference was changed since this

marking is separate from equipment hazard markings. The ANSI Z535 standard references UL 969 for marking system requirements for environmental conditions and durability.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3108-NFPA 70-2020 [Section No. 230.82]	dependent
Public Input No. 3108-NFPA 70-2020 [Section No. 230.82]	

Submitter Information Verification

Submitter Full Name: Randy Dollar
Organization: Siemens Industry
Affiliation: American Circuit Breaker Manufacturers Association (ACBMA)
Street Address:
City:
State:
Zip:
Submittal Date: Fri Sep 04 17:03:57 EDT 2020
Committee: NEC-P10



Public Input No. 3142-NFPA 70-2020 [Section No. 230.85]

230.85 Emergency Disconnects.

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped.

230.85(A) Disconnect Types

Each disconnect shall be one of the following:

- ~~Service disconnects marked as follows:~~

~~EMERGENCY-DISCONNECT,~~

~~SERVICE-DISCONNECT~~

~~(1) Service disconnects installed per 230.71 and marked per 230.70(B)~~

~~(2) Meter disconnects installed per 230.82 (3) - and marked as follows:~~

~~EMERGENCY-DISCONNECT,~~

~~METER-DISCONNECT,~~

~~NOT SERVICE-EQUIPMENT~~

~~(3) Other listed disconnect switches or circuit breakers on breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:~~

~~EMERGENCY-DISCONNECT,~~

~~NOT-SERVICE-EQUIPMENT~~

~~Markings shall comply with 110.21(B) .~~

~~"NOT SERVICE EQUIPMENT".~~

230.85(B) Marking and Labeling Required

Each emergency disconnect shall be marked "Emergency Disconnect" and comply with the following:

~~(1) The marking or labels shall be located on the outside front of the disconnect enclosure~~

~~(2) Have a minimum size of 3in wide by 2in height with red background and white text~~

~~(3) Minimum font size of 37 pt Source Sans Regular or equivalent~~

~~(4) The marking or labels shall be permanently affixed to the enclosure and shall not be handwritten~~

~~(5) Labels required by this section shall be suitable for the environment where they are installed~~

Informational Note: UL 969 provides guidelines for marking materials and system based on intended environmental conditions and durability.

-

Statement of Problem and Substantiation for Public Input

This proposal separates the marking requirements for the disconnect type from the Emergency Disconnect marking intended to facilitate fire service and emergency response actions. The existing marking for the disconnect types with the NEC have been in place for many cycles and address the electrical function of the disconnect within the system. The Emergency Disconnect marking was new for the 2020 NEC and needs more specification to adequately meet the intended use in the field. IAFF and NEMA worked together to determine the minimum requirements for the Emergency Disconnect marking and the marking location. NEMA published EDM P1-2019 Emergency Disconnect Marking Guide which summarizes the necessary aspects for labeling equipment for this use.

The key points addressed are the marking location, minimum label size and font size, colors and durability to facilitate fire service locating Emergency Disconnects during night operations. The informational note reference was changed since the marking is separate from equipment hazard markings. The ANSI Z535 standard references UL 969 for marking system requirements for environmental conditions and durability.

Submitter Information Verification

Submitter Full Name: Anthony Granato

Organization: Manchester Fire Rescue EMS

Affiliation: International Association of Fire Fighters

Street Address:

City:

State:

Zip:

Submittal Date: Sat Sep 05 15:15:11 EDT 2020

Committee: NEC-P10



Public Input No. 3366-NFPA 70-2020 [Section No. 230.85]

230.85 Emergency Disconnects.

For one- and two-family dwelling units, ~~all service conductors shall terminate in a~~ disconnecting means having a short-circuit current rating equal to or greater than the available fault current, shall be installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects, to which the service conductors are terminated, marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects on the supply side of each service disconnect, installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are ~~suitable~~ marked "Suitable for use as service equipment" and additionally marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

Informational Note 1: Conductors between the Emergency Disconnect and the Service Disconnect in 230.85(2) and 230.85(3) are service conductors.

Informational Note 2: Product safety standards allow for two different markings indicating equipment is considered suitable for use as service equipment. These markings includes "Suitable for use as service equipment" and "Suitable only for use as service equipment". These two markings are used to differentiate the construction of the equipment. Equipment marked "Suitable only for use as service equipment" is not appropriate for use as the emergency disconnect in 230.85(3), because it would require the equipment to be modified after leaving the factory, by removing the factory marked "Service Disconnect", and removing the factory installed bonding jumper, which may be non-removable.

The first sentence of 230.85 states that the service conductors must terminate in the device that is serving as the emergency disconnect, but by definition, the service conductors must terminate at the service disconnect, so in 230.85(2) and 230.85(3), the conductors between the emergency disconnect and the service disconnect are still service conductors, and terminate at the service disconnect, which is NOT the emergency disconnect. This revision clarifies the service conductors are required to terminate at the service disconnect, which is different than the emergency disconnect in 230.85(2) and (3). The new Information note 1 clarifies the conductors between the emergency disconnect and the service disconnect are still considered service conductors. The clarification is helpful for the user that may expect the conductors between the emergency disconnect and the service disconnect to be considered feeders. Section 230.85(3) requires the listed disconnect switch or circuit breaker on the supply side of each service disconnect to be suitable for use as service equipment.

Product safety standards distinguish service equipment by one of two markings, depending on whether the “Service Disconnect” labeling and bonding jumper is applied in the factory or the field.

Equipment marked as “Suitable only for use as service equipment” is required to have a factory installed “Service Disconnect” with a factory applied label, and a factory installed bond between the neutral and ground, which may be non-removable. Using this equipment in the scenario described in 230.85(3) would require the equipment to be modified in the field by removing the “Service Disconnect” marking.

Equipment marked as “Suitable for Use as Service Equipment” has the “Service Disconnect” label and the neutral bonding conductor shipped loose with the equipment, so the equipment would not have to be modified to meet the requirement of 230.85(3). The installer would simply not install the “service disconnect” label, and would not install the bonding jumper in the emergency disconnect enclosure. The label and the bonding jumper would be part of the service equipment that is on the load side of the emergency disconnect in 230.85(3).

This Public Input addresses this issue by making certain the equipment used to comply with 230.85(3) is not intended only for service equipment when it leaves the factory. The new informational note 2 describes this distinction, and clarifies that only equipment marked as “Suitable for Use as Service Equipment” is suitable for installation according to 230.85(3).

Submitter Information Verification

Submitter Full Name: Danish Zia

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submission Date: Tue Sep 08 11:06:50 EDT 2020

Committee: NEC-P10



Public Input No. 3455-NFPA 70-2020 [Section No. 230.85]

230.85 Emergency Disconnects.

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location.

If more than one disconnect is provided, they shall be grouped.

(A) New Installations . Each disconnect for new installations shall be one of the following:

(1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

(2) Meter disconnects installed per 230.82 (3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

Other

(3) _

Exception: For existing installations, with special permission, other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

(2) Meter disconnects installed per 230 . 82 (3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

(B) Marking. Markings shall be placed on the outside of the disconnect to identify the purpose of the disconnect. Markings shall comply with 110.21(B) .

(C) Rating. Each disconnecting means shall have a short-circuit current rating equal to or greater than the available fault current.

(D) Grouping. If more than one disconnect is provided, they shall be grouped.

(E) Replacement. Where service equipment is replaced, all of the requirements of this section shall apply.

Statement of Problem and Substantiation for Public Input

This section is proposed to be revised to place separate requirements into separate subdivisions for each rule to increase usability. Per 2.1.5 of the NEC Style Manual.

Previous list item (3) was moved to the exception for list item (1) when special permission is granted. Many users of the Code did not understand what existing List Item (3) intended and why that allowance was included. Proposed Item (B) was amended to include a requirement to state where the marking requirements were to be located along with the existing marking requirement to comply with 110.21(B).

A new Item (E) was added to make it clear that replacements of service equipment would require the installation to comply with all of the requirements of this section similar to existing 230.67 for surge protection.

Submitter Information Verification

Submitter Full Name: Rudolph Garza

Organization: IAEI

Affiliation: IAEI

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 15:28:06 EDT 2020

Committee: NEC-P10

**Public Input No. 4016-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects.**

(A) General. For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

(B) Markings. The information in 230.85(A)(1), (A)(2) or (A)(3) as applicable shall be marked on the outside of the enclosure. The markings shall comply with 110.21(B).

(C) Rating. Each disconnecting means shall have a short-circuit current rating equal to or greater than the available fault current.

(D) Grouping. If more than one disconnecting means is provided, they shall be grouped.

Statement of Problem and Substantiation for Public Input

The section layout was revised by putting the separate requirements into titled subdivisions for usability and to in line with 2.1.5 of the NEC Style Manual. There were no technical changes intended with the PI.

Submitter Information Verification

Submitter Full Name: Mark Hilbert

Organization: MR Hilbert Electrical Inspections & Training

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 17:30:30 EDT 2020

Committee: NEC-P10

**Public Input No. 4562-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects.**

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

Exception: If service equipment panelboard has GFCI protection on all branch circuits, a separate emergency disconnecting means is not required. A field applied label shall be applied on or near the outdoor service equipment stating "ALL BRANCH CIRCUITS ARE GFCI PROTECTED IN LIEU OF AN EXTERNAL EMERGENCY DISCONNECT"

Statement of Problem and Substantiation for Public Input

GFCI is a proven, mature technology. There are many product solutions available in the market that would allow an

installation compliant with the above requirements. If a contractor or specifying engineer chooses to install GFCI on all branch circuits, the goal of removing the hazard of shock or electrocution to first responders has been achieved.

Submitter Information Verification

Submitter Full Name: Jay Haugen

Organization: Eaton Corporation

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 15:10:11 EDT 2020

Committee: NEC-P10

**Public Input No. 4564-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects.**

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

Exception No. 1: If service disconnecting equipment is provided with GFCI or GFPE protection, a separate emergency disconnecting means shall not be required. A field applied label shall be applied on or near the outdoor service equipment stating "SERVICE DISCONNECT IS GFCI PROTECTED IN LIEU OF AN EXTERNAL EMERGENCY DISCONNECT"

Statement of Problem and Substantiation for Public Input

GFCI and GFPE are proven technologies that have been protecting people and equipment for over 50 years.

If the service disconnect has GFCI protection, the goal of removing the hazard of shock or electrocution to first responders has been achieved.

If a service disconnect has GFPE protection, the GFPE is designed to open the circuit when a predetermined amount of current flowing outside the normal path. Paragraph 555.35(A)(1) of the NEC allows 30mA trip threshold GFPE for receptacles providing shore power, so there is precedent for using GFPE to offer personnel protection.

Submitter Information Verification

Submitter Full Name: Jay Haugen

Organization: Eaton Corporation

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 15:13:33 EDT 2020

Committee: NEC-P10

**Public Input No. 4566-NFPA 70-2020 [Section No. 230.85]****230.85 Emergency Disconnects.**

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be one of the following:

- (1) Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- (2) Meter disconnects installed per 230.82(3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- (3) Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

Exception: An outdoor shunt trip installation of the inside main service disconnecting means shall be permitted. The shunt trip operation shall provide outdoor positive indication that the inside main service disconnecting means has been disconnected. The shunt trip controller shall be located in a readily accessible outdoor location.

Shunt trip controllers shall be marked with a field-applied label stating "EMERGENCY SHUTOFF OF SERVICE DISCONNECT"

Statement of Problem and Substantiation for Public Input

A shunt trip with positive indication of operation (such as a light or moving flag that indicates voltage is not present on the service panelboard) accomplishes the goal of removing the hazard of shock or electrocution to first responders, but it does so more elegantly and with less expense than installing a dedicated disconnecting means.

Submitter Information Verification

Submitter Full Name: Jay Haugen

Organization: Eaton Corporation

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 15:14:24 EDT 2020

Committee: NEC-P10



Public Input No. 529-NFPA 70-2020 [Section No. 230.85]

230.85 Emergency Disconnects.

For one- and two-family dwelling units, all service conductors shall terminate in a service disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be

one of the following: Service disconnects marked as follows:

EMERGENCY DISCONNECT,

SERVICE DISCONNECT

- Meter disconnects installed per 230.82 (3) and marked as follows:

EMERGENCY DISCONNECT,

METER DISCONNECT,

NOT SERVICE EQUIPMENT

- Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment and marked as follows:

EMERGENCY DISCONNECT,

NOT SERVICE EQUIPMENT

Markings shall comply with 110.21(B).

Statement of Problem and Substantiation for Public Input

The only way to comply with the present wording is to install a service disconnecting means outside, and then run feeders to the inside panels. Installing only a "meter disconnect switch", or other "emergency disconnect" would not be code compliant since the conductors on the load side of the meter disconnect switch or emergency disconnect are still "service conductors" too by definition in Article 100- Service Conductors. The conductors from the service point to the service disconnecting means. Remember ALL service conductors are presently required to terminate at a disconnect located OUTSIDE of the dwelling! Therefore, the service conductors on the load side of a meter disconnect switch or other emergency disconnect must still terminate in a service disconnect switch located outside in order to comply with the present literal wording in 230.85. Conductors on the load side of a "service disconnect" are no longer service conductors, instead they are feeder conductors and are not required to comply with 230.85. This revision is needed to eliminate the present conflicting and confusing wording.

Submitter Information Verification

Submitter Full Name: Russ Leblanc

Organization:	Leblanc Consulting Services
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Feb 25 10:16:32 EST 2020
Committee:	NEC-P10

**Public Input No. 1745-NFPA 70-2020 [Section No. 230.90]****230.90** Where Required.

Each ungrounded service conductor shall have overload protection.

(A) Ungrounded Conductor.

Such protection shall be provided by an overcurrent device in series with each ungrounded service conductor that has a rating or setting not higher than the ampacity of the conductor. A set of fuses shall be considered all the fuses required to protect all the ungrounded conductors of a circuit. Single-pole circuit breakers, grouped in accordance with 230.71(B), shall be considered as one protective device.

Exception No. 1: For motor-starting currents, ratings that comply with 430.52, 430.62, and 430.63 shall be permitted.

Exception No. 2: Fuses and circuit breakers with a rating or setting that complies with 240.4(B) or (C) and 240.6 shall be permitted.

Exception No. 3: Two to six circuit breakers or sets of fuses shall be permitted as the overcurrent device to provide the overload protection. The sum of the ratings of the circuit breakers or fuses shall be permitted to exceed the ampacity of the service conductors, provided the calculated load does not exceed the ampacity of the service conductors.

Exception No. 4: Overload protection for fire pump supply conductors shall comply with 695.4(B)(2)(a).

Exception No. 5: Overload protection for ~~120/240-volt, 3-wire, single-phase~~ dwelling services shall be permitted in accordance with the requirements of 310.12.

(B) Not in Grounded Conductor.

No overcurrent device shall be inserted in a grounded service conductor except a circuit breaker that simultaneously opens all conductors of the circuit.

Statement of Problem and Substantiation for Public Input

Remove "120/240-volt, 3-wire, single-phase" from Exception No. 5 since 310.12 applies to both 120/240V and 120/208V. Let 310.12 manage the details.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submission Date: Thu Jun 25 19:33:45 EDT 2020

Committee: NEC-P10

**Public Input No. 2983-NFPA 70-2020 [Section No. 230.90(A)]****(A) Ungrounded Conductor.**

Such protection shall be provided by an overcurrent device in series with each ungrounded service conductor that has a rating or setting not higher than the ampacity of the conductor. A set of fuses shall be considered all the fuses required to protect all the ungrounded conductors of a circuit. Single-pole circuit breakers, grouped in accordance with 230.71(B), shall be considered as one protective device.

Exception No. 1: For motor-starting currents, ratings that comply with 430.52, 430.62, and 430.63 shall be permitted.

Exception No. 2: Fuses and circuit breakers with a rating or setting that complies with 240.4(B) or (C) and 240.6 shall be permitted.

Exception No. 3: Two to six circuit breakers or sets of fuses shall be permitted as the overcurrent device to provide the overload protection. The sum of the ratings of the circuit breakers or fuses shall be permitted to exceed the ampacity of the service conductors, provided the calculated load does not exceed the ampacity of the service conductors.

Exception No. 4: Overload protection for fire pump supply conductors shall comply with ~~695~~ 703.4(B)(2)(a).

Exception No. 5: Overload protection for 120/240-volt, 3-wire, single-phase dwelling services shall be permitted in accordance with the requirements of 310.12.

Statement of Problem and Substantiation for Public Input

This public input was prepared by the correlating committee task group focused on alternative energy requirements. This task group consisted of the following members: Derrick Atkins (CMP 5), Greg Ball (CMP 13) Ken Boyce (CMP 1), Bill Brooks (CMP 4), Bruce Campbell, Thomas Domitrovich (CMP 2, CMP 10), Jason Fisher (CMP 4), Scott Harding (CMP 5), Pete Jackson (CMP 8), David Kendall (CMP 8, CC), Chad Kennedy (CMP 13), Christine Porter (CMP 5, CC), Timothy Windey (CMP 13).

This change aligns with an effort to re-organize the alternative energy sources NEC Articles into a series of articles closely located together. This reorganization places all sources alternate sources as follows:

689 On-Site Energy Sources
690 Solar Photovoltaic (PV) Systems
691 Large-Scale Photovoltaic (PV) Systems
692 Fuel Cell Systems
693 Generators
694 Wind Electric Systems
695 Energy Storage Systems
696 Storage Batteries

Submitter Information Verification

Submitter Full Name: Thomas Domitrovich

Organization: Eaton Corporation

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 03 18:48:57 EDT 2020

Committee: NEC-P10



Public Input No. 397-NFPA 70-2020 [Section No. 230.90(A)]

(A) Ungrounded Conductor.

Such protection shall be provided by an overcurrent device in series with each ungrounded service conductor that has a rating or setting not higher than the ampacity of the conductor. A set of fuses shall be considered all the fuses required to protect all the ungrounded conductors of a circuit. Single-pole circuit breakers, grouped in accordance with 230.71(B), shall be considered as one protective device.

Exception No. 1: For motor-starting currents, ratings that comply with 430.52, 430.62, and 430.63 shall be permitted.

Exception No. 2: Fuses and circuit breakers with a rating or setting that complies with 240.4(B) or (C) and 240.6 shall be permitted.

Exception No. 3: Two to six circuit breakers or sets of fuses shall be permitted as the overcurrent device to provide the overload protection. The sum of the ratings of the circuit breakers or fuses shall be permitted to exceed the ampacity of the service conductors, provided the calculated load does not exceed the ampacity of the service conductors.

Exception No. 4: Overload protection for fire pump supply conductors shall comply with 695.4(B)(2)(a).

Exception No. 5: Overload protection for 120/240-volt, 3-wire, single-phase, or 208Y/120-volt, 3-wire, single-phase dwelling services shall be permitted in accordance with the requirements of 310.12.

Statement of Problem and Substantiation for Public Input

Section 310.12 is applicable to 120/240-volt systems AND 208Y/120-volt systems. Why isn't 230.90(A)? This revision will allow the same overload protection sizing for 208Y/120-volt systems as it already does for 120/240-volt systems. Section 230.90(A) needs to correlate with Section 310.12 otherwise it renders 310.12 virtually useless. Section 240.4 also needs to correlate with Section 310.12, and it presently does not. I will be submitting a companion PI for 240.4(G) to help fix this issue.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 398-NFPA 70-2020 [Section No. 240.4(G)]	Overcurrent for service conductors

Submitter Information Verification

Submitter Full Name: Russ Leblanc
Organization: Leblanc Consulting Services
Street Address:
City:
State:
Zip:
Submittal Date: Sun Feb 02 08:00:51 EST 2020
Committee: NEC-P10

**Public Input No. 4054-NFPA 70-2020 [Section No. 230.90(A)]****(A) Ungrounded Conductor.**

Such protection shall be provided by an overcurrent device in series with each ungrounded service conductor that has a rating or setting not higher than the ampacity of the conductor. A set of fuses shall be considered all the fuses required to protect all the ungrounded conductors of a circuit. Single-pole circuit breakers, grouped in accordance with 230.71(B), shall be considered as one protective device.

Exception No. 1: For motor-starting currents, ratings that comply with 430.52, 430.62, and 430.63 shall be permitted.

Exception No. 2: Fuses and circuit breakers with a rating or setting that complies with 240.4(B) or (C) and 240.6 shall be permitted.

Exception No. 3: Two to six circuit breakers or sets of fuses shall be permitted as the overcurrent device to provide the overload protection. The sum of the ratings of the circuit breakers or fuses shall be permitted to exceed the ampacity of the service conductors, provided the calculated load does not exceed the ampacity of the service conductors.

Exception No. 4: Overload protection for fire pump supply conductors shall comply with 695.4(B)(2)(a).

Exception No. 5: Overload protection for 120/240-volt, 3-wire, single-phase dwelling services shall be permitted in accordance with the requirements of with 310.12.

Statement of Problem and Substantiation for Public Input

Deleting the words "the requirements of" does not change the meaning of the section.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submission Date: Wed Sep 09 19:18:25 EDT 2020

Committee: NEC-P10

**Public Input No. 4261-NFPA 70-2020 [Section No. 230.91]****230.91 Location.**

The **(A) General.** The service overcurrent device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto. Where fuses are used as the service overcurrent device, the disconnecting means shall be located ahead of the supply side of the fuses.

(B) Separate Enclosure. Services over 150 volts to ground and not over 1000 volts phase to phase that include fuses rated 1600 A or higher, or circuit breakers where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1600 A or higher, the service disconnecting means and overcurrent device shall be located in a separate enclosure from feeder or branch circuit overcurrent devices. The separation distance between service equipment enclosure(s) and enclosures containing feeder or branch circuit overcurrent devices shall be 3 ft or the arc flash boundary whichever is less.

Exception No.1: The separation distance shall not be required where the service equipment consists of multiple vertical sections and the service disconnect and overcurrent device are located in sections with an arc resistant rating.

Exception No.2: Feeder or branch circuit overcurrent devices shall be permitted in the service disconnect and overcurrent device enclosure where the service equipment has been tested and marked by a qualified testing laboratory to limit line side incident energy exposure to <1.2 cal/cm2 at 18 inches and provides protection from arcing fault propagation from load side to line side of the service disconnect and overcurrent protective device.

Informational Note No.1: NFPA 70E-2018, Standard for Electrical Safety in the Workplace, provides guidance, such as determining severity of potential exposure, planning safe work practices, arc flash labeling, and selecting personal protective equipment.

Informational Note No.2: UL 2986 provides testing and measurement methods to determine the maximum incident energy rating of equipment at a corresponding working distance in accordance with the Standard for Electrical Safety in the Workplace, NFPA 70E.

Statement of Problem and Substantiation for Public Input

For most installations, the line side of the service equipment is the location with the highest incident energy exposure for electrical workers. This public input is submitted to address hazards where justified energized work must be performed in service equipment. In the last NEC cycle, requirements for barriers to prevent inadvertent contact in service equipment were expanded. However, this requirement provides a degree of electric shock protection only and does not address the severity of arc flash hazards in service equipment. According to NFPA 70E, an arc flash hazard exists (1) where exposed energized conductors or circuit parts exist and, (2) or where a person is interacting with the equipment in a manner that increases the likelihood of an arc flash incident. Both of those situations exist when work must be performed within service equipment. The inability to determine the clearing time of a line side fault makes the completion of arc flash risk assessment difficult. The arc-flash hazard due to these energy levels limits the ability to service and maintain the equipment as necessary for continued safe operation. System designers are adapting to address this issue with the implementation of remote mains, arc resistant equipment ratings, and other safety by design approaches that are tested for arcing performance and worker incident energy exposure. This proposal introduces requirements to address installations where the risk typically warrants additional protection methods.

Submitter Information Verification

Submitter Full Name: Chad Kennedy

Organization: Schneider Electric

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 08:44:40 EDT 2020

Committee: NEC-P10

**Public Input No. 3352-NFPA 70-2020 [Section No. 230.95]****230.95 Ground-Fault Protection of Equipment.**

~~Ground-fault protection.~~ Protection of service equipment against arcing faults shall be provided for solidly grounded wye electric services of more than 150 volts to ground but not exceeding 1000 volts phase-to-phase for ~~each service disconnect rated 1000 amperes or more~~ . The grounded conductor for the solidly grounded wye system shall be connected directly to ground through a grounding electrode system, as specified in 250.50, without inserting any resistor or impedance device.

~~The rating of the service disconnect shall be considered to be the rating of the largest fuse that can be installed or the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted.~~

~~Exception: The ground-fault protection provisions of this~~ Exception: This section shall not apply to a service disconnect for a to service equipment for a continuous industrial process where a nonorderly shutdown will introduce additional or increased hazards.

(A)

– Setting.

~~The ground-fault protection system shall operate to cause the service disconnect to open all ungrounded conductors of the faulted circuit. The~~

Protection Method. One of the following means shall be provided.

(1) Ground-fault Protection of Equipment. The maximum setting of the ground-fault protection shall be 1200 amperes, and the maximum time delay shall be

one second

0.07 seconds for ground-fault currents equal to or greater than 3000 amperes.

(

B

2)

–

Fuses.

~~If a switch and fuse combination is used, the fuses employed shall be capable of interrupting any current higher than the interrupting capacity of the switch during a time that the ground-fault protective system will not cause the switch to open.~~

(C) Performance Testing.

~~The ground-fault protection~~

~~– A fuse shall have a clearing time of 0.07 seconds or less at the available arcing current.~~

(3) Other Methods. ~~Any of the following methods shall be permitted to provide protection of equipment when set to operate at less than the available arcing current at the equipment to which protection shall be provided:~~

1. ~~Zone selective interlocking~~

2. ~~Differential relaying~~

3. ~~Energy reducing active arc flash mitigation system~~

4. ~~An instantaneous trip setting that is less than the available arcing current. Temporary adjustment of the instantaneous trip setting to achieve arc energy reduction shall not be permitted.~~

5. ~~An instantaneous override that is less than the available arcing current~~

6. ~~An approved equivalent means~~

~~Informational Note No. 1: An energy reducing active arc flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the circuit breaker or the settings of other devices is required during maintenance when a worker is working within an arc flash boundary as defined in NFPA 70E 2018, Standard for Electrical Safety in the Workplace.~~

~~Informational Note No. 2: An instantaneous trip is a function that causes a circuit breaker to trip with no intentional delay when currents exceed the instantaneous trip setting or current level. If arcing currents are above the instantaneous trip level, the circuit breaker will trip in the minimum possible time.~~

~~Informational Note No. 3: IEEE 1584 2002, IEEE Guide for Performing Arc Flash Hazard Calculations, is one of the available methods that provide guidance in determining arcing current.~~

(B) Performance Testing. The protection system shall be performance tested when first installed on site. This testing shall be conducted by a qualified person(s)

using

.

(1) Ground Fault Protection of Equipment. Testing shall be conducted using a test process of primary current injection, in accordance with instructions that shall be provided with the equipment.

(2) Other Methods. The methods listed in 230.95(A)(3) shall be performance tested by primary current injection testing or another approved method when first installed on site.

(3) Documentation. A written record of the testing in accordance with this testing

section shall be made and shall be available to the authority having jurisdiction.

Informational Note No. 1: Ground-fault protection that functions to open the service disconnect affords no protection from faults on the line side of the protective element. It serves only to limit damage to conductors and equipment on the load side in the event of an arcing ground fault on the load side of the protective element.

Informational Note No. 2: This added protective equipment at the service equipment may make it necessary to review the overall wiring system for proper selective overcurrent protection coordination. Additional installations of ground-fault protective equipment may be needed on feeders and branch circuits where maximum continuity of electric service is necessary.

Informational Note No. 3: Where ground-fault protection is provided for the service disconnect and interconnection is made with another supply system by a transfer device, means or devices may be needed to ensure proper ground-fault sensing by the ground-fault protection equipment.

Informational Note No. 4: See 517.17(A) for information on where an additional step of ground-fault protection is required for hospitals and other buildings with critical areas or life support equipment.

Statement of Problem and Substantiation for Public Input

The terraview software has completely destroyed this PI.

There is new text in proposed (A)(2) and all of (A)(3) that Terra decided to strike through.

The requirements for GFPE protection in 230.95 have existed for many, many years without revision or even a look at new technologies. The reason for this requirement is simple, this exists to protect equipment. The questions that I have been asking myself for years are: (1) why haven't we looked at new technology with respect to GFPE of service equipment, (2) why is this limited to disconnects rated 1000 amps and higher, (3) are smaller 480/277 volt services immune to arc duration?, (4) can the NEC provide other options?

This public input introduces answers to these questions in the form of a revised requirement. We need to look to new technology and embrace it where we can ensure equal or superior protection. We need to delete the requirement for disconnects rated at 1000 amps or more and protect all services that lend themselves well to arc duration. Any service at any ampacity, any disconnect rating, supplied at 480/277 represents significant arc flash hazards, the potential for arc duration and the possible complete destruction of the service equipment. The NEC can and should provide additional options for protection of service equipment supplied at over 150 volts to ground and not over 1000 volts phase to phase.. None of the methods suggested in this PI are new. All of them exist in 240.67 & 240.87 and are proven to protect even better than standard GFPE.

New technology makes it more feasible to protect smaller services

Submitter Information Verification

Submitter Full Name: James Dollard

Organization: IBEW Local Union 98

Street Address:

City:

State:

Zip:

Submission Date: Tue Sep 08 09:31:17 EDT 2020

Committee: NEC-P10

**Public Input No. 2873-NFPA 70-2020 [Section No. 230.95(C)]****(C) Performance Testing Commissioning .**

~~The Commissioning of the ground-fault protection system shall be performance tested when first installed on site. This testing shall be conducted by a qualified person(s) using a test process of primary current injection, in accordance with instructions that shall be provided with the equipment. A written record of this testing shall be made and shall be available to the authority having jurisdiction performed at installation in compliance with 110.17 to verify system operation .~~

Informational Note No. 1: Ground-fault protection that functions to open the service disconnect affords no protection from faults on the line side of the protective element. It serves only to limit damage to conductors and equipment on the load side in the event of an arcing ground fault on the load side of the protective element.

Informational Note No. 2: This added protective equipment at the service equipment may make it necessary to review the overall wiring system for proper selective overcurrent protection coordination. Additional installations of ground-fault protective equipment may be needed on feeders and branch circuits where maximum continuity of electric service is necessary.

Informational Note No. 3: Where ground-fault protection is provided for the service disconnect and interconnection is made with another supply system by a transfer device, means or devices may be needed to ensure proper ground-fault sensing by the ground-fault protection equipment.

Informational Note No. 4: See 517.17(A) for information on where an additional step of ground-fault protection is required for hospitals and other buildings with critical areas or life support equipment.

Statement of Problem and Substantiation for Public Input

Common requirements for device and system commissioning are being proposed to Article 110 in PI 2844 that will help drive consistency in the actions necessary prior to devices and systems being placed into service. This public input is part of a series of revisions proposed throughout the code to include commissioning where the existing requirements only mention testing.

Confirming the installation, setup, and initial performance for devices and equipment necessary for proper system operation and safety extend well beyond a simple testing requirement. Existing requirements for specific tests are not focused on how the device or equipment fits within the overall system. In addition to verifying operational controls and sequence of operation, this revision also adds clarity that overcurrent and protective devices must have settings that have been adjusted and verified when inspected by the AHJ. The requirement to include as-built documentation and a record of the actions taken to correct any shortcomings will enhance the safety of those who will operate, maintain, and service the equipment. The existing requirement to perform ground-fault protection of equipment using only the primary current injection method is appropriate for old iron-frame power circuit breakers but does not reflect the advancements in technology made within overcurrent protection. Many modern circuit breakers employ current sensors that provide an dc output voltage based on the current. These current sensors do not present the same concern as traditional iron core current transformers where the sensing wires could be reversed without detection. Rather, if the wires are reversed on these current sensors the circuit breaker will not remain closed. Similarly, many zero sequence current transformers used within the ground-fault protection for fused switches include a test winding inside the current transformer for testing the system without primary current injection. The use of primary current injection also comes with the risk of equipment damage if additional steps are not taken to protect sensitive electronics. Manufacturers will continue to require the primary current injection method for special designs or complex systems and will include instructions with the equipment when this method is required. This revision would eliminate the single method approach and allow the ground-fault system to be tested in accordance with the instructions provided with the equipment from the manufacturer and performed as part of the system commissioning.

Related Public Inputs for This Document

<u>Related Input</u>
Public Input No. 2844-NFPA 70-2020 [New Section after 110.16]
Public Input No. 2887-NFPA 70-2020 [Definition: Commissioning.]

Relationship**Submitter Information Verification**

Submitter Full Name: Chad Kennedy
Organization: Schneider Electric
Street Address:
City:

State:

Zip:

Submittal Date: Thu Sep 03 07:28:39 EDT 2020

Committee: NEC-P10



Public Input No. 693-NFPA 70-2020 [Section No. 230.95 [Excluding any Sub-Sections]]

Ground-fault protection of equipment shall be provided for solidly grounded wye electric services of more than 150 volts to ground but not exceeding 1000 volts phase-to-phase for each service disconnect rated 1000 amperes or more. The grounded conductor for the solidly grounded wye system shall be connected directly to ground through a grounding electrode system, as specified in 250.50, without inserting any resistor or impedance device.

The rating of the service disconnect shall be considered to be the rating of the largest fuse that can be installed or the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted.

Exception No. 1: The ground-fault protection provisions of this section shall not apply to a service disconnect for a continuous industrial process where a nonorderly shutdown will introduce additional or increased hazards.

Exception No. 2: For fused disconnects, the ground-fault protection provisions of this section shall not apply if the service disconnect complies with Section 240.67, except that 240.67(B)(2) cannot be utilized for this exception.

Exception No. 3: For circuit breakers, the ground-fault protection provisions of this section shall not apply if the service circuit breaker complies with Section 240.87, except that 240.87 (B)(3) cannot be utilized for this exception.

Statement of Problem and Substantiation for Public Input

A requirement (230.95) for ground fault protection of equipment (GFPE) was added to the 1971 NEC® because 480/277 volt, solidly grounded wye services, protected by 1000 ampere and larger overcurrent protective devices, were burning down due to arcing faults. 208/120 volt services and those services protected by smaller overcurrent protective devices were not burning down, so they weren't included in the new requirement. Over many Code cycles, GFPE requirements were also added for branch circuits (210.13), feeders (215.10), and equipment (240.13). In all cases, the intent was to limit damage to the switchboard, switchgear, panelboard or equipment, not the downstream conductors or busway. The electrical industry has evolved considerably since those early GFPE requirements were introduced. IEEE 1584 now predicts the magnitude of the arcing current along with the incident energy to which a worker could be exposed while working on energized equipment. It has become clearly evident that the level of protection required to limit arcing fault damage to equipment is nowhere near the level of protection needed to protect employees. Said another way, the level of protection necessary to protect an employee is orders of magnitude greater than that required to protect equipment. With that in mind, this Public Input takes advantage of the arc-energy reduction requirements found in 240.67 and 240.87. It provides an exception for GFPE requirements whenever the 240.67 and 240.87 methods to reduce clearing time are utilized. The methods to reduce clearing time will limit the arcing fault damage to the equipment to a level that is less than currently allowed by the requirements found in 230.95. The arbitrary value of 1200 amperes found in 230.95(A) is not needed for the exceptions because the arcing current can now be accurately predicted (IEEE 1584). The arbitrary one second maximum delay (230.95(A)) at 3000 amperes is not necessary for the exceptions because the methods in 240.67 and 240.87 have delays that are much less than one second. (Practically speaking, the methods in 240.67 and 240.87 couldn't protect workers if they were delayed for anywhere close to one second.) Energy reducing maintenance switches (240.67(B)(2) and 240.87(B)(3)) are excluded from the exceptions because an energy-reducing maintenance switch is typically turned off when a worker is not working on energized equipment, whereas ground fault protection is constantly protecting the equipment, whether or not a worker is working on the energized equipment. If energy reducing maintenance switches are utilized, the requirements of 230.95, 210.13, 215.10, and 240.13 must continue.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 694-NFPA 70-2020 [Section No. 210.13]	
Public Input No. 695-NFPA 70-2020 [Section No. 215.10]	
Public Input No. 696-NFPA 70-2020 [Section No. 240.13]	

Submitter Information Verification

Submitter Full Name: Vincent Saporita
Organization: Saporita Consulting
Affiliation: Saporita Consulting
Street Address:
City:
State:

Zip:	
Submittal Date:	Wed Mar 18 17:58:27 EDT 2020
Committee:	NEC-P10



Public Input No. 3295-NFPA 70-2020 [Section No. 230.200]

230.200 General.

Service conductors and equipment used on circuits exceeding 1000 volts, nominal, shall comply with all the applicable preceding sections of this article and with the following sections that supplement or modify the preceding sections. In no case shall the provisions of Part VIII apply to equipment on the supply side of the service point.

Informational ~~Note~~ Note 1 : For clearances of conductors of over 1000 volts, nominal, see ANSI/IEEE C2-2017, *National Electrical Safety Code*.

Informational Note 2: For additional information see IEEE 3001.2 *IEEE Recommended Practice for Evaluating the Electrical Service Requirements of Industrial and Commercial Power Systems*

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 301.7 project prospectus:

"Commercial, institutional, and industrial design of electrical services, interconnecting with a utility distribution or transmission system is explored. The electrical system information needed by the designer concerning the utility's system characteristics, and the electrical load information needed by the utility to design a satisfactory electrical interface between the serving utility and the premise electrical distribution system is considered"

https://standards.ieee.org/standard/3001_2-2017.html

Note that this content could just as easily be placed at the head of Article 230; say under Section 230.1 as a second Informational Note..

Submitter Information Verification

Submitter Full Name: Michael Anthony

Organization: Standards Michigan

Affiliation: IEEE Education & Healthcare Facility Electrotechnology Committee

Street Address:

City:

State:

Zip:

Submittal Date: Mon Sep 07 15:43:01 EDT 2020

Committee: NEC-P10



Public Input No. 2090-NFPA 70-2020 [Section No. 230.205(C)]

(C) Remote Control.

For multibuilding, ~~industrial installations~~ installations under single management where the conditions of maintenance and supervision ensure that only qualified persons service the installation, the service disconnecting means shall be permitted to be located at a separate building or structure. In such cases, the service disconnecting means shall be permitted to be electrically operated by a readily accessible, remote-control device.

Statement of Problem and Substantiation for Public Input

This exception shouldn't be limited to industrial locations. It should apply to any location that has controlled access where only trained workers are able to service the installation. The Department of Energy facilities, for example, are not necessarily "industrial" but have extremely strict rules for working on the premises. The contractors must undergo extensive training, work packages must be created, means and methods must all be approved. This is part of a series of proposals to change "industrial locations/premises/occupancies/wiring-systems/..." to "controlled access locations."

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2047-NFPA 70-2020 [Section No. 110.21(A)(2)]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2048-NFPA 70-2020 [Section No. 110.24(B)]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2049-NFPA 70-2020 [Section No. 110.70]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2050-NFPA 70-2020 [Section No. 210.8(B)]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2051-NFPA 70-2020 [Section No. 210.8(B)]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2052-NFPA 70-2020 [Section No. 210.9]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2053-NFPA 70-2020 [Section No. 210.18]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2054-NFPA 70-2020 [Section No. 215.11]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2087-NFPA 70-2020 [Section No. 225.37]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2088-NFPA 70-2020 [Section No. 225.52(A)]	global proposal to change 'industrial location' to 'controlled access location'
Public Input No. 2091-NFPA 70-2020 [Section No. 240.21(C)(3)]	
Public Input No. 2092-NFPA 70-2020 [Section No. 300.50(A) [Excluding any Sub-Sections]]	
Public Input No. 2093-NFPA 70-2020 [Section No. 336.10]	
Public Input No. 2094-NFPA 70-2020 [Section No. 368.56(B)]	

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jul 29 20:17:54 EDT 2020

Committee:

NEC-P10



Public Input No. 3800-NFPA 70-2020 [Section No. 230.209]

230.209 Surge Arresters.

Surge arresters installed in accordance with the requirements of Article 242.1 shall be permitted on each ungrounded overhead service conductor.

Informational Note: Surge arresters may be referred to as lightning arresters in older documents.

Statement of Problem and Substantiation for Public Input

Section 4.1.4 of the 2020 NEC(r) Style Manual prohibits reference to an entire article, other than Article 100. As such, it is proposed to change to point to the scope of the article, or delete the cross reference if not needed.

Submitter Information Verification

Submitter Full Name: Richard Holub

Organization: The DuPont Company, Inc.

Street Address:

City:

State:

Zip:

Submission Date: Wed Sep 09 13:07:32 EDT 2020

Committee: NEC-P10



Public Input No. 4055-NFPA 70-2020 [Section No. 230.209]

230.209 Surge Arresters.

Surge arresters installed in accordance ~~with the requirements~~ with Part III of Article 242 shall be permitted on each ungrounded overhead service conductor.

Informational Note: Surge arresters may be referred to as lightning arresters in older documents.

Statement of Problem and Substantiation for Public Input

Deleting the words "the requirements of" does not change the meaning of the section.

Adding Part III of prior to Article 242 corrects a Style Manual issue 4.1.4 where a section shall not reference a complete article.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 19:20:20 EDT 2020

Committee: NEC-P10

**Public Input No. 1167-NFPA 70-2020 [Section No. 230.210]****230.210** Service Equipment — ~~General Provisions.~~ General

Service equipment, including instrument transformers, shall conform to Article 490, Part I.

Statement of Problem and Substantiation for Public Input

The word "provisions" is unnecessary

Submitter Information Verification

Submitter Full Name: Agnieszka Golriz

Organization: NECA

Street Address:

City:

State:

Zip:

Submittal Date: Wed May 20 10:15:04 EDT 2020

Committee: NEC-P10



Public Input No. 3144-NFPA 70-2020 [Section No. 240.1]

240.1 Scope.

Parts I through VII of this article provide the general requirements for overcurrent protection and overcurrent protective devices not more than 1000 volts, nominal. Part VIII covers overcurrent protection for those portions of supervised industrial installations operating at voltages of not more than 1000 volts, nominal. Part IX covers overcurrent protection over 1000 volts, nominal.

Informational Note 1 : Overcurrent protection for conductors and equipment is provided to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation. See also 110.9 for requirements for interrupting ratings and 110.10 for requirements for protection against fault currents.

Informational Note 2: [Guidance about determining fault current may be found in IEEE 3002.3-2018 Recommended Practice for Conducting Short-Circuit Studies and Analysis of Industrial and Commercial Power Systems](#)

Statement of Problem and Substantiation for Public Input

This is another slice of updated content from the legacy "Red Book" IEEE 141 mapped into the new IEEE 3000 Standards Collection. From the project prospectus:

"Activities related to short-circuit analysis, including design considerations for new systems, analytical studies for existing systems, as well as operational and model validation considerations for industrial and commercial power systems are addressed. Fault current calculation and device duty evaluation is included in short-circuit analysis. Accuracy of calculation results primarily relies on system modeling assumptions and methods used. The use of computer-aided analysis software with a list of desirable capabilities recommended to conduct a modern short-circuit study is emphasized. Examples of system data requirements and result analysis techniques are presented."

https://standards.ieee.org/standard/3002_3-2018.html

This is one of two possible locations where this reference will improve the NEC.

Submitter Information Verification

Submitter Full Name: Michael Anthony

Organization: Standards Michigan

Affiliation: IEEE Education & Healthcare Facilities Committee

Street Address:

City:

State:

Zip:

Submittal Date: Sat Sep 05 15:45:50 EDT 2020

Committee: NEC-P10

**Public Input No. 3350-NFPA 70-2020 [Section No. 240.2]**

(Relocate all definitions in the 240.2 to Article 100, arrange them in alphabetical order and without any subdivisions.)

240.2 Definitions.

The definitions in this section shall apply only within this article.

Current-Limiting Overcurrent Protective Device.

A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Supervised Industrial Installation.

For the purposes of Part VIII, the industrial portions of a facility where all of the following conditions are met:

- (1) Conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system.
- (2) The premises wiring system has 2500 kVA or greater of load used in industrial process(es), manufacturing activities, or both, as calculated in accordance with Article 220.
- (3) The premises has at least one service or feeder that is more than 150 volts to ground and more than 300 volts phase-to-phase.

This definition excludes installations in buildings used by the industrial facility for offices, warehouses, garages, machine shops, and recreational facilities that are not an integral part of the industrial plant, substation, or control center.

Tap Conductor.

A conductor, other than a service conductor, that has overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors that are protected as described elsewhere in 240.4.

Statement of Problem and Substantiation for Public Input

The National Electrical Code has definitions in multiple parts in Article 100 and many definitions scattered through out the code many of them in the .2 section of the articles.

Most of the other standards under NFPA have their definitions in one location and this will allow the NEC the same requirement. The revisions to the NEC Style Manual require all the definitions to be relocated to Article 100.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 09:06:15 EDT 2020

Committee: NEC-P10

**Public Input No. 3523-NFPA 70-2020 [Section No. 240.2]**

Relocate all definitions in the 240.2 to Article 100, arrange them in alphabetical order and without any subdivisions.

240.2 Definitions.

The definitions in this section shall apply only within this article.

Current-Limiting Overcurrent Protective Device.

A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

Supervised Industrial Installation.

For the purposes of Part VIII, the industrial portions of a facility where all of the following conditions are met:

- (1) Conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system.
- (2) The premises wiring system has 2500 kVA or greater of load used in industrial process(es), manufacturing activities, or both, as calculated in accordance with Article 220.
- (3) The premises has at least one service or feeder that is more than 150 volts to ground and more than 300 volts phase-to-phase.

This definition excludes installations in buildings used by the industrial facility for offices, warehouses, garages, machine shops, and recreational facilities that are not an integral part of the industrial plant, substation, or control center.

Tap Conductor.

A conductor, other than a service conductor, that has overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors that are protected as described elsewhere in 240.4.

Statement of Problem and Substantiation for Public Input

The National Electrical Code has definitions in multiple parts in Article 100 and many definitions scattered through out the code many of them in the .2 section of the articles.

Most of the other standards under NFPA have their definitions in one location and this will allow the NEC the same requirement. The revisions to the NEC Style Manual require all the definitions to be relocated to Article 100.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 21:10:29 EDT 2020

Committee: NEC-P10



Public Input No. 4145-NFPA 70-2020 [Definition: Current-Limiting Overcurrent Protective Device.]

(Relocate all definitions in the 240.2 to Article 100, arrange them in alphabetical order and without any subdivisions.)

Current-Limiting Overcurrent Protective Device.

A device that, when interrupting currents in its current-limiting range, reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance. (CMP-10)

Statement of Problem and Substantiation for Public Input

The revisions to the NEC Style Manual require all the definitions to be relocated to Article 100. Moving this definition to Article 100 and adding (CMP-10)

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 21:59:25 EDT 2020

Committee: NEC-P10



Public Input No. 4147-NFPA 70-2020 [Definition: Supervised Industrial Installation.]

Supervised Industrial Installation.

For the purposes of Part VIII of Article 240 , the industrial portions of a facility where all of the following conditions are met:

- (1) Conditions of maintenance and engineering supervision ensure that only qualified persons monitor and service the system.
- (2) The premises wiring system has 2500 kVA or greater of load used in industrial process(es), manufacturing activities, or both, as calculated in accordance with Article 220.
- (3) The premises has at least one service or feeder that is more than 150 volts to ground and more than 300 volts phase-to-phase.

This definition excludes installations in buildings used by the industrial facility for offices, warehouses, garages, machine shops, and recreational facilities that are not an integral part of the industrial plant, substation, or control center. (CMP-10)

Statement of Problem and Substantiation for Public Input

The revisions to the NEC Style Manual require all the definitions to be relocated to Article 100. Move this definition to Article 100, add Article 240 after Part III and add (CMP-10) after the definition.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submission Date: Wed Sep 09 22:05:49 EDT 2020

Committee: NEC-P10

**Public Input No. 4149-NFPA 70-2020 [Definition: Tap Conductor.]**

(Relocate all definitions in the 240.2 to Article 100, arrange them in alphabetical order and without any subdivisions.)

Tap Conductor.

A conductor, other than a service conductor, that has overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors that are protected as described elsewhere in 240.4. (240)
(CMP-10)

Statement of Problem and Substantiation for Public Input

The revisions to the NEC Style Manual require all the definitions to be relocated to Article 100.
Move this definition to Article 100, add (240) and (CMP-10) after the definition.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 22:10:53 EDT 2020

Committee: NEC-P10



Public Input No. 264-NFPA 70-2020 [Section No. 240.3]

240.3 Other Articles.

Equipment shall be protected against overcurrent in accordance with the article in this *Code* that covers the type of equipment specified in Table 240.3.

Table 240.3 Other Articles

<u>Equipment</u>	<u>Article</u>
Air-conditioning and refrigerating equipment	440
Appliances	422
Assembly occupancies	518
Audio signal processing, amplification, and reproduction equipment	640
Branch circuits	210
Busways	368
Capacitors	460
Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits	725
Cranes and hoists	610
Electric signs and outline lighting	600
Electric welders	630
Electrolytic cells	668
Elevators, dumbwaiters, escalators, moving walks, wheelchair lifts, and stairway chairlifts	620
Emergency systems	700
Fire alarm systems	760
Fire pumps	695
Fixed electric heating equipment for pipelines and vessels	427
Fixed electric space-heating equipment	424
Fixed outdoor electric deicing and snow-melting equipment	426
Generators	445
Health care facilities	517
Induction and dielectric heating equipment	665
Industrial machinery	670
Luminaires, lampholders, and lamps	410
Motion picture and television studios and similar locations	530
Motors, motor circuits, and controllers	430
Phase converters	455
Pipe organs	650
Receptacles	406
Services	230
Solar photovoltaic systems	690
Switchboards and panelboards Panelboards	408
Theaters, audience areas of motion picture and television studios, and similar locations	520
Transformers and transformer vaults	450
X-ray equipment	660

Statement of Problem and Substantiation for Public Input

Switchboards do not require overcurrent protection. If the intent of this table is to just refer to the title of the articles and not the actual equipment, it should be updated to reflect switchgear as well.

Submitter Information Verification

Submitter Full Name: Ryan Jackson
Organization: Ryan Jackson
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 09 16:19:35 EST 2020
Committee: NEC-P10



Public Input No. 2986-NFPA 70-2020 [Section No. 240.3]

240.3 Other Articles.

Equipment shall be protected against overcurrent in accordance with the article in this *Code* that covers the type of equipment specified in Table 240.3.

Table 240.3 Other Articles

<u>Equipment</u>	<u>Article</u>
Air-conditioning and refrigerating equipment	440
Appliances	422
Assembly occupancies	518
Audio signal processing, amplification, and reproduction equipment	640
Branch circuits	210
Busways	368
Capacitors	460
Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits	725
Cranes and hoists	610
Electric signs and outline lighting	600
Electric welders	630
Electrolytic cells	668
Elevators, dumbwaiters, escalators, moving walks, wheelchair lifts, and stairway chairlifts	620
Emergency systems	700
Fire alarm systems	760
Fire pumps	695 <u>703</u>
Fixed electric heating equipment for pipelines and vessels	427
Fixed electric space-heating equipment	424
Fixed outdoor electric deicing and snow-melting equipment	426
Generators	445
Health care facilities	517
Induction and dielectric heating equipment	665
Industrial machinery	670
Luminaires, lampholders, and lamps	410
Motion picture and television studios and similar locations	530
Motors, motor circuits, and controllers	430
Phase converters	455
Pipe organs	650
Receptacles	406
Services	230
Solar photovoltaic systems	690
Switchboards and panelboards	408
Theaters, audience areas of motion picture and television studios, and similar locations	520
Transformers and transformer vaults	450
X-ray equipment	660

Statement of Problem and Substantiation for Public Input

This public input was prepared by the correlating committee task group focused on alternative energy requirements. This task group consisted of the following members: Derrick Atkins (CMP 5), Greg Ball (CMP 13) Ken Boyce (CMP 1), Bill Brooks (CMP 4), Bruce Campbell, Thomas Domitrovich (CMP 2, CMP 10), Jason Fisher (CMP 4), Scott Harding (CMP 5), Pete Jackson (CMP 8), David Kendall (CMP 8, CC), Chad Kennedy (CMP 13), Christine Porter (CMP 5, CC), Timothy Windey (CMP 13).

This change aligns with an effort to re-organize the alternative energy sources NEC Articles into a series of articles closely located together. This reorganization places all sources alternate sources as follows:

689 On-Site Energy Sources
690 Solar Photovoltaic (PV) Systems
691 Large-Scale Photovoltaic (PV) Systems
692 Fuel Cell Systems 693 Generators
694 Wind Electric Systems
695 Energy Storage Systems
696 Storage Batteries

This public input recognizes that Article 695 is moved to Article 703 to support this effort. These articles are closely related to each other and this change is in alignment with the direction by the correlating committee to review alternative energy sources for conflicts and usability. This new alignment will create a similar structure as that found for hazardous locations. The new Article 689 is the a combination of Articles 705, 710 and 712 and will act to be the new general requirements for this series of alternative energy sources.

Submitter Information Verification

Submitter Full Name: Thomas Domitrovich

Organization: Eaton Corporation

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 03 19:14:50 EDT 2020

Committee: NEC-P10

**Public Input No. 2023-NFPA 70-2020 [Section No. 240.4(B)]****(B) Overcurrent Devices Rated 800 Amperes or Less.**

The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the following conditions are met:

- (1) The conductors being protected are not part of a branch circuit supplying more than one receptacle for cord-and-plug-connected portable loads.
- (2) The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments).
- (3) The next higher standard rating selected does not exceed 800 amperes.

Where the overcurrent protective device is an adjustable trip device, it shall be permitted to be set to a value that does not exceed the next higher standard value as shown in Table 240.6.

Statement of Problem and Substantiation for Public Input

Not all adjustable trip devices have infinite trip adjustments. This proposed change permits the adjustable trip breakers to be used in the same manner as non-adjustable trip breakers. Without this change, the use of an adjustable trip breaker may, in some cases, require a larger conductor size than a non-adjustable trip breaker used in the same circuit.

Submitter Information Verification

Submitter Full Name: Don Ganiere

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 25 17:26:22 EDT 2020

Committee: NEC-P10

**Public Input No. 807-NFPA 70-2020 [Section No. 240.4(B)]****(B) Overcurrent Devices Rated 800 Amperes or Less.**

~~The~~ Up to the next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the following conditions are met:

- (1) The conductors being protected are not part of a branch circuit supplying more than one receptacle for cord-and-plug-connected portable loads.
- (2) The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments).
- (3) The next higher standard rating selected does not exceed 800 amperes.

Statement of Problem and Substantiation for Public Input

It is clear that 240.4(B) as written allows the Overcurrent device to be increased to the next standard size provided that all the conditions listed therein are met. However, it is not clear that a setting or non-standard size less than the standard size could be permissible. This situation could occur both with a fixed non-standard size device or with a device with adjustable trip settings.

I believe it is implied that this lower value is permissible by noting that it currently states that next standard size "shall be permitted to be used" rather than "must be used". It's allowing, not forcing the jump all the way to the next standard size. So the logic is that if one is allowed to go all the way to the next standard size, it is implied that one is allowed to go less than that (as long as something else isn't being violated). However, this is not abundantly clear and could be up for interpretation.

Consider a scenario where the wire ampacity of a feeder is permissible as 460A. If all the conditions of 240.4(B) are met, then a 500A overcurrent device is acceptable. However, what about a circuit breaker with an adjustable setting at 480A? Or a 480A fuse (if one existed)? A 480A overcurrent device (or setting) would not meet the exact wording of 240.4(B) as is.

There may be other ways of wording this revision that is more consistent with rest of the Code, but adding the words "Up to.." to the beginning of 240.4(B) would clarify this section.

Submitter Information Verification

Submitter Full Name: Ben Watkins

Organization: ARM EnerTech

Street Address:

City:

State:

Zip:

Submission Date: Mon Mar 30 14:12:46 EDT 2020

Committee: NEC-P10



Public Input No. 3238-NFPA 70-2020 [Section No. 240.4(D)]

(D) Small Conductors.

Unless specifically permitted in 240.4(E) or (G), the overcurrent protection shall not exceed that required by (D)(1) through (D)(7 8) after any correction factors for ambient temperature and number of conductors have been applied.

(1) 18 AWG Copper.

7 amperes, provided all the following conditions are met:

- (1) Continuous loads do not exceed 5.6 amperes.
- (2) Overcurrent protection is provided by one of the following:
 - (3) Branch-circuit-rated circuit breakers listed and marked for use with 18 AWG copper wire
 - (4) Branch-circuit-rated fuses listed and marked for use with 18 AWG copper wire
 - (5) Class CC, Class J, or Class T fuses

(2) 16 AWG Copper.

10 amperes, provided all the following conditions are met:

- (1) Continuous loads do not exceed 8 amperes.
- (2) Overcurrent protection is provided by one of the following:
 - (3) Branch-circuit-rated circuit breakers listed and marked for use with 16 AWG copper wire
 - (4) Branch-circuit-rated fuses listed and marked for use with 16 AWG copper wire
 - (5) Class CC, Class J, or Class T fuses

(3) 14 AWG Copper-Clad Aluminum.

10 Amperes

(4) 14 AWG Copper._

15 amperes

(4 5) 12 AWG Aluminum and Copper-Clad Aluminum._

15 amperes

(5 6) 12 AWG Copper._

20 amperes

(6 7) 10 AWG Aluminum and Copper-Clad Aluminum._

25 amperes

(7 8) 10 AWG Copper._

30 amperes

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Proposed_240.4_D_Draft_Fnl.docx	Terra did not correctly display revised text in list. Word document provided for clarity.	
Terminal_and_Conductor_Temperature_Testing_Part_I_Fnl.pdf	Terminal temperature static heating test report as requested by task group.	

Statement of Problem and Substantiation for Public Input

Task Group Statement

This public input is submitted on behalf of the task group formed in accordance with the direction of the NFPA Standards Council in their Decisions D#19-2 and D#19-23. This task group was appointed to identify potential proposed changes to the 2020 edition of the NEC in the form of proposed Tentative Interim Amendments (TIAs) or to the 2023 edition of the NEC

in the form of Public Inputs (PIs) that within the Task Group's scope of activity as specified by the Standards Council.

These proposed PIs relate to new requirements covering the use of copper-clad aluminum conductors throughout the NEC as a coordinated set of new or revised requirements. These Public Inputs should not be misconstrued by the CMPs as precluding consideration of other Public Inputs, with supporting test data, submitted now or in the future, for other potentially eligible conductor materials or sizes.

The task group members are; David Hittinger-Chair, Todd Crisman, Roland Deike, Thomas Domitrovich, Peter Graser, Christel Hunter, Chuck Mello, Ken Riedl, Susan Newman Searce, Susan Stene, George Straniero, Frank Tse and Brian Rock. This task group of balanced interests provided the expertise to develop these public inputs covering the use of copper-clad aluminum conductors.

Public Inputs are being submitted in the following sections: Article 100, definition of "copper-clad aluminum", 210.12, 210.18, 210.21(B)(1), 210.23, 210.24, 210.52(B), 240.4(D), 240.6, 310.3(A), 310.3(B), Table 310.16, Table 310.17, 330.104, 334.104, 336.104, 340.104, 404.14(D), and 406.3(D).

Summary of Changes

This Public Input is part of a coordinated effort to introduce 14 AWG Copper-Clad Aluminum (CCA) into the NEC® for branch-circuit wiring. This is being done by adding an ampacity for 14 AWG CCA to the ampacity tables, and other coordinated changes needed throughout the Code. The change provided in this Public Input is one of those needed to accommodate 14 AWG Copper-Clad Aluminum for branch circuit installations. 14 AWG Copper-Clad Aluminum will have an ampacity of 10 Amps at 60°C in Table 310.16. The revision to this Section is to add a new listing item (3) for 14 AWG Copper-Clad Aluminum and then renumber the succeeding list items. The requirement establishes 14 AWG Copper-Clad Aluminum with a maximum overcurrent protection rating of 10 Amps and aligns with the other small conductors provided in 240.4(D).

Technical Substantiation

The application of energy efficient equipment and the implementation of Energy Codes for modern construction, provides more options for reduced branch circuit loading. The result is that many branch circuits are capable of having a conductor current rating and overcurrent device rating of 10-Amperes. For example, a typical 75-watt equivalent LED lamp has a load rating of 12 watts. At 120 volts this is a load of 0.1 amps per lamp. A continuously loaded 10-ampere branch circuit for fixed lighting would be allowed to have 8 amps of load current, which would equate to 80 of these LED lamps. This is more lamps than found in a typical 2000 square foot home. Other examples are specific limited loads such as fire or burglar alarm panels, kitchen instant hot water dispensers, attic exhaust fans, and others. These specific loads on individual branch circuits only need one or a few amperes and could safely be installed on a 10-Ampere branch circuit. These lighting and specific appliance applications exist in both dwelling unit as well as commercial and industrial installations. There are cases today where equipment is being protected by a 15-Ampere circuit breaker, whereas a 10-Ampere overcurrent device and using 14 AWG Copper-Clad Aluminum conductors would provide a safe level of protection.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2865-NFPA 70-2020 [Section No. 210.12]	Branch circuit AFCI protection
Public Input No. 2864-NFPA 70-2020 [Section No. 210.18]	Branch circuit ratings
Public Input No. 2866-NFPA 70-2020 [Section No. 210.21(B)]	Individual branch circuit receptacle applications and limitations
Public Input No. 3261-NFPA 70-2020 [Section No. 210.23]	Branch circuit applications and limitations
Public Input No. 3940-NFPA 70-2020 [Section No. 210.24]	Summary branch circuit applications and limitations
Public Input No. 3239-NFPA 70-2020 [Section No. 240.6(A)]	Added 10 amperes to standard OCPD ratings
Public Input No. 3241-NFPA 70-2020 [Section No. 310.3(A)]	Branch circuit conductor ratings
Public Input No. 3974-NFPA 70-2020 [Section No. 310.21]	Table 310.16 ampacities for 14 AWG copper-clad aluminum
Public Input No. 3256-NFPA 70-2020 [Section No. 404.14]	Applications and limitations for snap switches
Public Input No. 3259-NFPA 70-2020 [Section No. 406.3]	Applications and limitations for receptacles
Public Input No. 2864-NFPA 70-2020 [Section No. 210.18]	
Public Input No. 2865-NFPA 70-2020 [Section No. 210.12]	
Public Input No. 2866-NFPA 70-2020 [Section No. 210.21(B)]	
Public Input No. 3237-NFPA 70-2020 [Section No. 210.52(B)(1)]	
Public Input No. 3239-NFPA 70-2020 [Section No. 240.6(A)]	
Public Input No. 3241-NFPA 70-2020 [Section No. 310.3(A)]	
Public Input No. 3247-NFPA 70-2020 [Section No. 330.104]	
Public Input No. 3248-NFPA 70-2020 [Section No. 334.104]	

[Public Input No. 3249-NFPA 70-2020 \[Section No. 336.104
\[Excluding any Sub-Sections\]\]](#)

[Public Input No. 3251-NFPA 70-2020 \[Section No. 340.104\]](#)

[Public Input No. 3261-NFPA 70-2020 \[Section No. 210.23\]](#)

[Public Input No. 3940-NFPA 70-2020 \[Section No. 210.24\]](#)

[Public Input No. 3960-NFPA 70-2020 \[Section No. 310.21\]](#)

Submitter Information Verification

Submitter Full Name: David Hittinger

Organization: IEC

Affiliation: NEC Correlating Committee Appointed Task Group

Street Address:

City:

State:

Zip:

Submittal Date: Mon Sep 07 09:48:41 EDT 2020

Committee: NEC-P10

Terminal and Conductor Temperature Testing of 14 AWG Copper-Clad Aluminum and 14 AWG Copper Conductors

Part I – Static Heating and Flexing Tests

For

Bimetallics Task Group

Conducted at

Eaton Laboratories
Menomonee Falls, Wisconsin

Report by

Chuck Mello
on behalf of Bimetallics Task Group

Report Date

August 28, 2020

Table of Contents

1.0	Introduction and Purpose	1
2.0	Testing Arrangement and Setup.....	2
3.0	Materials for Testing	6
4.0	Test Procedures	7
5.0	Test Results	11
6.0	Conclusions.....	16
7.0	Test Equipment and Calibration	17

Appendices

A – Photos.....	A1 – A12
B – Copper-Clad Aluminum Material Verification	B1 – B7
C – Static Heating Test Data	
C1 – Static Heating Test at 100% Rated Current	C1-1 – C1-6
C2 – Static Heating Test at 135% Rated Current	C2-1 – C2-6
C3 – Static Heating Test at 150% Rated Current	C3-1 – C3-6
C4 – Static Heating Test at 200% Rated Current	C4-1 – C4-6
C5 – Static Heating Original 100% and 135% Trip Failure	C5-1
D – Flexing Tests Data.....	D1
E – Certificates of Calibration.....	E1 – E26

1.0 Introduction and Purpose

At the direction of the NFPA Standards Council in their Decisions D#19-2 and D#19-23, a Bimetallics Task Group of balanced interest was appointed. The scope was to review the proposed changes to the 2020 edition of the *NEC*® that relate to copper-clad aluminum conductors and recommend changes through tentative interim amendment(s) and/or to provide public inputs for the next revision cycle.

As the task group conducted the work, it was determined that testing data had been provided substantiating the ampacity of 14 AWG copper-clad aluminum but a number of related questions about 14 AWG copper-clad aluminum applications arose regarding terminal temperatures when applied to circuit breakers, wire splicing devices and device terminals. A testing plan was developed, reviewed over several task group meetings, and accepted by the task group to address the terminal temperature questions. This testing was completed at the Eaton Corporation laboratory facilities in Menomonee Falls, Wisconsin. The helpful assistance of Mr. Tom Domitrovich, Mr. Kevin Arnold, Mr. James Parrett, and Mr. Steve Averbek with Eaton Corporation is greatly appreciated in arranging for and executing the testing.

This test report provides the testing arrangement, testing procedures and results for the static heating and the flexing tests. The Part I testing detailed in this report commenced July 30, 2020 and completed on August 26, 2020. Thermocycling testing is presently being conducted and those test results will be provided in a separate report. The separation of the reports is necessary to meet the NFPA deadline of September 10, 2020 to submit public inputs and any supporting data.

The purpose of this testing is to provide data, as requested by the Bimetallics Task Group, to understand certain installation and operating conditions when considering the application of 14 AWG copper-clad aluminum conductors at the proposed ampacity for branch circuits. The testing being completed also includes 14 AWG copper conductors at its *NEC*® ampacity for comparison and performance. The basis for comparison is at the 60°C ampacity rating for copper (15 amps) and the proposed 60°C ampacity rating for copper-clad aluminum (10 amps). This testing is designed to represent a typical installation to determine the following:

- 1) The temperature (temperature rise) on the terminals and conductor immediately adjacent to a 10 Amp and 15 Amp molded case circuit breaker, under normal and identified abnormal conditions
- 2) The temperature (temperature rise) on wire-splicing devices (e.g., Ideal Wire Nuts® or similar), and conductor immediately adjacent, commonly used for splicing in junction or device boxes or attaching leads from utilization equipment, under normal and abnormal conditions
- 3) The temperature (temperature rise) on wiring devices (single receptacle as representative) and conductor immediately adjacent under normal and abnormal conditions
- 4) Conductor retention on wiring devices after abnormal thermal-cycling
- 5) The flexing durability of 14 AWG copper-clad aluminum when installed and removed from a single-gang device box

Since the various product standards do not presently have requirements, procedures or parameters for 14 AWG copper-clad aluminum, the testing being conducted is based on the 10-ampere branch circuit rating at 60°C and percentage multipliers taken from the applicable standards. Where the standard does not provide a percentage value, then the current for the testing was interpolated from the values for relative copper and/or aluminum conductors from the standard. The values for testing of 14 AWG copper are taken from the applicable product safety standards with an ampacity basis of 15 Amps at 60°C

It is to be understood this testing is only being conducted to provide specific performance data and information as requested by the task group. The testing does not provide performance or data for certification of any of the components used for the testing. If 14 AWG copper-clad aluminum is accepted into the 2023 *NEC*®, then numerous UL standards will need to be revised and testing completed under the requirements established in those standards. This testing for certification could be more extensive and take much more time to complete than what is provided here. The goal again is to provide information for a typical installation specific to terminal temperatures. The changes to UL standards will not begin to occur until 14 AWG copper-clad aluminum is recognized for installation in the *NEC*®.

To provide a basis to consider the test results for 14 AWG copper-clad aluminum, duplicate test set ups were constructed using 14 AWG copper conductors. The only difference in the setup for 14 AWG copper is the circuit breaker was rated 15 Amps and the testing values were based on the 15 Amp ampacity. This additional testing data provides a direct comparison in the same environment at the 60°C ampacity values for these two conductor types and assemblies.

2.0 Testing Arrangement and Setup

The test was conducted in a suitable facility with environmental controls and documented monitoring. The facility was free from extraneous changes in ambient temperature and from having random air flow (drafts) through the testing area. Ambient temperature was maintained between 20°C and 25°C and recorded with thermocouples positioned in the testing area while temperature testing was completed.

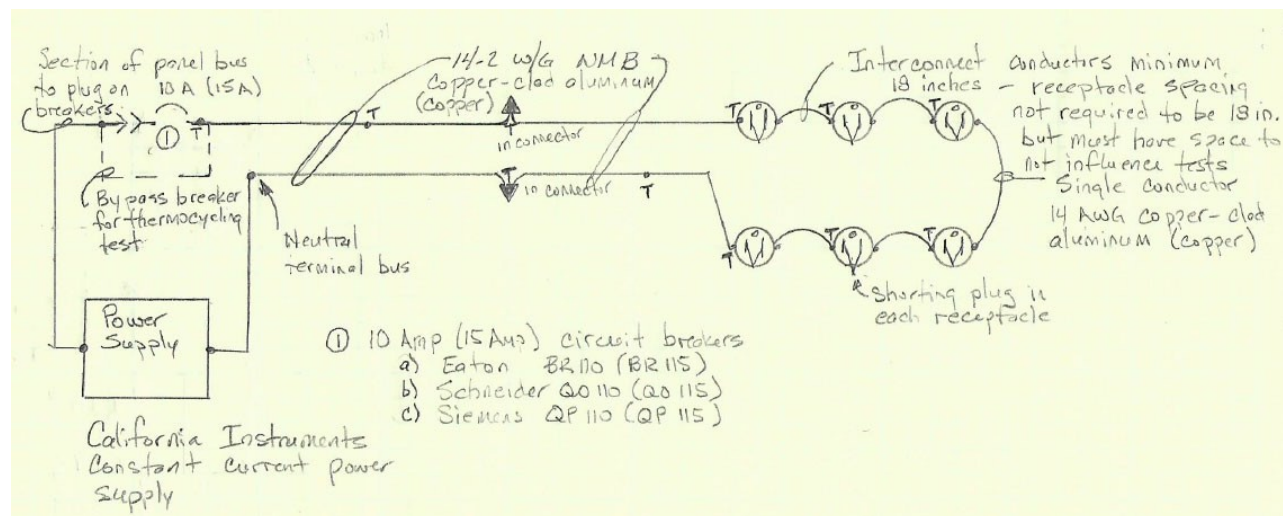


Figure 1 – Typical Test Circuit Diagram

The Eaton facility, being a division within a manufacturing company of wiring devices and circuit breakers, has laboratory technicians that are very familiar with testing of circuit components and equipment to UL standards.

The test circuit diagram shown in figure 1 above provides the basic layout of one (1) testing circuit consisting of one (1) circuit breaker, the conductor (14 AWG copper-clad aluminum or copper NM-B cable) two wire-splicing devices, and six (6) single receptacles. To complete tests 1 through 4 as described below, three (3) of these test circuits were assembled at a time. Photos 1 through 3 in Appendix A show the general test setup for completing the static heating testing. Each of the three (3) circuits have one of the manufacturer's (mfg. 1, mfg. 2, and mfg. 3) circuit breaker, the wire splicing devices on the black and white wire as described below, and three (3) each of receptacles from two of the manufacturers. Photos 4 through 7 show each of the setups with a sign indicating the circuit breaker, conductor material, wire splicing devices, and receptacles in that circuit.

For example, a setup had three (3) circuits with:

- Three different 10-amp circuit breakers (one each mfg. 1, mfg. 2, and mfg. 3)
- 14 AWG copper-clad aluminum NM-B conductors
- Mfg. 4 and mfg.5 wire splicing devices respectively, on the black and white conductors
- Three each of the mfg. 8 and mfg. 9 receptacles, and
- 14 AWG THHN copper-clad aluminum conductors for interconnection of the receptacles

These components were connected together to form a complete circuit. The second setup for 14 AWG copper-clad aluminum were same circuit breakers but with mfg.6 and mfg.7 wire splicing devices and with mfg. 10 and mfg.11 receptacles. The third and fourth setups were the same as 1 and 2 except using 15-amp circuit breakers and 14 AWG copper conductors.

Due to testing of several different circuit breakers, receptacles, and wire-splicing devices, the test arrangement was different than what may be used for certification testing of a single type of device. The test purpose was to approximate an actual installation under laboratory type conditions and not to establish certification type testing for any one device.

For tests 1 through 4 the three power supplies used were programmable constant current power supply sources. Each power supply was connected to one of the circuits and provided the current level specified for the tests being conducted.

For each of the four setups the following description is provided, see circuit diagram in figure 1 and Appendix A photos 1 through 7:

- 1) The three (3) circuits were mounted on an insulating sheet approximately 4 feet high and 8 feet wide. The partition had suitable framing to provide structural support for the partition to be in a vertical orientation to the floor.
- 2) During all testing, suitable barrier tape, safety cones, barriers, or other means was in place in accordance with the laboratory safety procedures to keep unauthorized persons out of the area and away from exposed live parts.
- 3) The individual conductors and devices were arranged horizontally with approximately 12 inches of vertical spacing between each horizontal assembly. Staples, or other fastening devices, such as cable ties, were used to keep the NM-B cable aligned with the respective test assembly.

- 4) For the circuit breaker testing the following was assembled:
- a) For the copper-clad aluminum conductors, three (3) 10-amp plug-on type panelboard circuit breakers were installed on sections of panelboard bus that are mounted onto the insulating board partition.
 - b) For the copper conductors, three (3) 15-amp plug-on type panelboard circuit breakers were installed on sections of panelboard bus that are mounted onto the insulating board partition. The panelboard bus had a terminal for connection of one conductor from the power supply.
- 5) From the circuit breaker approximately 4 feet of 14-2 NM-B cable was installed and supported as provided above. From this center junction another 2 feet of 14-2 NM-B cable (copper-clad aluminum or copper as applicable) was installed. The junction in the middle had approximately 6 inches of exposed conductor and a splice completed with yellow wire-splicing devices as provided for the black, white and equipment grounding conductors. The following was applied to the two setups for the copper-clad aluminum conductors respectfully and repeated for the copper conductor setups.
- a) The black wire for the first circuit set of three used a mfg. 4 yellow wire-splicing devices
 - b) The white wire for the first circuit set of three used an mfg. 5 yellow Wire Nuts®
 - c) The black wire of the second circuit set of three used a mfg. 6 yellow wire-splicing devices
 - d) The white wire of the second circuit set of three used a mfg. 7 yellow wire-splicing devices

The manufacturer and location of the wire-splicing devices used was recorded for each test setup.

- 6) Six (6) receptacles were installed at the end of each horizontal assembly.
- a) The first set of circuits of copper-clad aluminum or of copper had three (3) mfg. 11 receptacles and then three (3) receptacles from mfg. 8 all connected in series.
 - b) The second circuit of copper-clad aluminum or of copper had three (3) receptacles from mfg. 10 and then three (3) receptacles from mfg. 9 all connected in series.

The receptacles were spaced a minimum of six (6) inches apart horizontally and/or vertically and were interconnected with a minimum of eighteen (18) inches of 14 AWG solid THHN copper-clad aluminum or copper conductors respectfully.

The receptacles were mounted to the wall surface with screws, so that the face of the receptacle was approximately 1 1/2 inches from the insulating board partition surface.

For each manufacturer the receptacles were connected to terminals as follows:

- a) One receptacle had the conductors installed at each wire binding screw and the conductors were wrapped counter-clockwise around the screw shank under the screw head, for 2/3 to 3/4 of wire binding screw circumference.

- b) The second receptacle had the conductors installed into one side back terminal (entry hole) of the pressure plate terminal.
- c) The third receptacle had two conductors installed into each back-side pressure plate terminal as follows: one conductor of the test circuit into each side (hot and neutral) of the pressure plate terminal and one additional short conductor of equal diameter and material into the other side (entry hole) of the same pressure plate terminal. The second conductor was to fill the slot only and is not required for any other purpose than to balance the mechanical clamping forces applied.

Each receptacle had a shorting plug installed as follows:

- a) The ungrounded (BLACK) and grounded (WHITE) contacts of each receptacle being tested were connected together by a mated attachment plug having rigidly-attached solid blades.
 - b) The terminals of each attachment plug were short-circuited by the shortest feasible length of 14 AWG stranded copper conductor from type SJ flexible cord.
 - c) The flexible cord shorting conductor was mechanically terminated into the pressure plate terminals and the connection torqued to the manufacturer's specification.
- 7) The conductor from the neutral terminal of the last receptacle in the series was routed back using the white wire in the NM-B cable, through the wire-splicing devices and terminated at a terminal bar mounted to the support board for connection back to the power supply.
- 8) All connections were tightened as follows. Torquing tools were calibrated and calibration documented:
- a) The circuit breaker terminals were torqued as specified on the circuit breaker nameplate.
 - b) The wire-splicing devices were torqued to the manufacturer's specification in the instructions. If there was no specification, then the 14 AWG copper-clad aluminum conductors were torqued to 2.47 lbf-in and the 14 AWG copper conductors were torqued to 4.11 lbf-in [Specification from UL 486C – 9.1.9.4]
 - c) The terminals of the receptacles and of the attachment plugs were torqued to the manufacturer's specification in the installation instructions. If there was no torque specification provided, then the terminals were torqued to 9 lbf-in.
- 9) Thermocouples were connected as shown in the diagram, figure 1 and as shown in Appendix A photos 8 and 11 through 14.
- a) Thermocouples were installed on device terminals so that it did not interfere with the terminal.

For the wire-splicing devices, the thermocouples were attached into the wire bundle within the wire-splicing devices.

- b) The thermocouples that measured center wire temperatures had a flap of the NM-B jacket and the conductor insulation peeled back to expose the conductor. The thermocouple was attached with thermo-cement to the conductor and the conductor insulation and jacket flap folded back to the original position with two wraps of black electrical tape wrapped to hold the flap in place.
 - c) A thermocouple was positioned midway in elevation to the test setup for each circuit and recorded the ambient temperature as testing was completed.
- 10) The power supply was a programable constant current power supply. The current was monitored and recorded by the data logger along with the temperature recordings. The power supply was connected to the lug on the panelboard bus serving the circuit breaker and to the neutral terminal bar where the return white conductor from the NM-B cable was terminated.

3.0 Materials for Testing

The generous support with the supplying of materials by Copperweld, Eaton, Hubbell, Legrand, Leviton, and Siemens are acknowledged and appreciated. The following materials were used to complete the setups as described above.

- 1) The circuit breakers for the copper-clad aluminum testing were single pole 10 Amp 120/240 Volt, 10,000 interrupting rating with five (5) each of the following (two (2) breakers to be used and the others as backup):
 - a) Eaton BR110,
 - b) Schneider QO110, and
 - c) Siemens QP110.
- 2) The circuit breakers for the copper testing were single pole 15 Amp 120/240 Volt, 10,000 interrupting rating with five (5) each of the following (two (2) breakers to be used and the others as backup):
 - a) Eaton BR115,
 - b) Schneider QO115, and
 - c) Siemens QP115.
- 3) The yellow wire-splicing devices were as follows:
 - a) Gardner-Bender Ultra WingGard
 - b) Ideal Wing-Twist
 - c) 3M Performance Plus Red/Yellow+
 - d) Commercial Electric WT4

- 4) The receptacles for both the copper-clad aluminum and copper testing were:
 - a) Eaton (Cooper) model TR6250W, 5-15R single receptacle with wire binding screw and pressure plate terminals (back and side wired)
 - b) Hubbell model HBL 5261, 5-15R single receptacle with both wire binding screw and pressure plate terminals (back and side wired)
 - c) Legrand (Pass & Seymour) model TR 5251, 5-15R single receptacle with both wire binding screw and pressure plate terminals (back and side wired)
 - d) Leviton model T 5015, 5-15R single receptacle with both wire binding screw and pressure plate terminals (back and side wired)
- 5) Thermocouples, UL calibrated, model UL 3055, with sufficient length to connect and route to datalogger recording device.
- 6) Datalogger recording device and laptop or another required device for the datalogger.
- 7) Programable power supplies from Eaton laboratory. Maximum current for the copper was 30 Amps and for the copper-clad aluminum was 20 amps.
- 8) Approximately 50 feet each of 14-2 w/ground copper-clad aluminum NM-B cable and of 14-2 w/ground copper NM-B cable.
- 9) Approximately 50 feet each of 14 AWG solid THHN copper-clad aluminum and 14 AWG solid THHN copper single conductors.

4.0 Test Procedures

4.1 Conductor Material Testing

A sample of each the 14-2 NM-B and 14 AWG THHN copper-clad aluminum conductors used for the testing was returned to the Copperweld factory laboratory for analysis. The testing was performed to confirm the conductors that were used for the testing at Eaton were in fact 14 AWG and met the requirements for copper-clad aluminum as specified in UL 83 Annex E and ASTM B566. The packaging was photo documented from the Eaton laboratory and the opening of the package at the Copperweld laboratory photo documented.

The Copperweld laboratory technician, who routinely performs the full ASTM B566 battery of testing, completed all the testing and documented it on a Copperweld laboratory test data sheet.

Standard materials testing was completed by Copperweld laboratory technicians including:

- DC resistance
- Copper thickness
- Copper Volume
- Tensile strength
- Elongation
- Adhesion
- Cohesion

The following tests, as completed by the Copperweld laboratory technician, were witnessed and documented by the UL Field Representative that normally completes follow-up inspections of copper-clad aluminum conductors as part of the recognized component program, under category DVVU2:

- DC resistance
- Copper thickness
- Tensile strength
- Elongation

4.2 Terminal Temperature Testing

The following test procedures, except the flexing test, used references from parts of UL 486(A)(B); UL 486(C); UL 489; UL 20; and UL 498.

As stated, the tests 1 through 4 were completed with all three (3) manufacturer's circuit breakers in three circuits at one time. These tests are identified with the test number from below with an "a", "b" or "c" representing the representative circuit breaker used:

- a. mfg. 1 circuit breaker
- b. mfg. 2 circuit breaker
- c. mfg. 3 circuit breaker

This same nomenclature is used in the data sheets found in Appendix C. To minimize test setups, and the number of times terminations are completed or taken apart, all four (4) static heating tests were completed for the "a", "b", and "c" circuit setups. After these tests were completed, then the next setup was assembled by changing the wire splicing devices and receptacles or changing the conductors from copper-clad aluminum to copper as applicable.

All static heating tests, tests 1 through 4 commenced with all components at ambient temperature.

For all testing temperature equilibrium is three consecutive readings taken at no less than 5-minute intervals indicating no further rise in temperature above the ambient temperature. For tests where the circuit breaker trips, which may be before temperature equilibrium was attained, the last three recorded temperatures were recorded onto the data sheets.

Test #1 – Rated Current Temperature

Each circuit was operated at 100% of the branch circuit rating (CCA - 10 Amps or Cu - 15 Amps) until temperature equilibrium was achieved. The final temperatures were recorded. All terminations were inspected for evidence of thermal damage. Temperature measurements were recorded at one-minute intervals.

Test #2 – Circuit Breaker Overload Temperature

Each circuit was operated at 135% of the branch circuit rating (CCA - 13.5 Amps or CU - 20.25 Amps) until temperature equilibrium was achieved or the circuit breaker tripped whichever came first. The circuit breaker elapsed trip time was recorded. Table 1, in section 4.3 below, provides the expected circuit breaker trip times from the manufacturer's time current curves. If the circuit breaker tripped, the last three recorded temperatures of the conductor, wire-splicing devices and wiring device were recorded on the datasheet. All terminations were inspected for evidence of thermal damage. Temperature measurements were recorded at 20-second intervals.

Test #3 – Wiring Device Overload Temperature

Each circuit was operated at 150% of the branch circuit rating (CCA - 15 Amps, or CU - 22.5 Amps) until temperature equilibrium was achieved or the circuit breaker tripped whichever came first. The circuit breaker elapsed trip time was recorded. Expected circuit breaker trip times are in a table 1 below in section 4.3 of procedure. If the circuit breaker tripped, the last three recorded temperatures of the conductor, wire-splicing devices and wiring device were recorded on the datasheet. All terminations were inspected for evidence of thermal damage. Temperature measurements were recorded at 10 second intervals.

Test #4 – Circuit Breaker Overload Temperature

Each circuit was operated at 200% of the branch circuit rating (CCA - 20 Amps, or CU 30 Amps) until temperature equilibrium was achieved or the circuit breaker trip tripped whichever came first. The circuit breaker elapsed trip time was recorded. Expected circuit breaker trip times are in a table 1 below in section 4.3 of procedure. If the circuit breaker tripped, the last three recorded temperatures of the conductor, wire-splicing devices and wiring device were recorded on the datasheet. All terminations were inspected for evidence of thermal damage. Temperature measurements were recorded at 7 second intervals.

Test #5 – Wiring Device Thermal Cycling

The thermocycling testing is underway at the time this report is being written. In order to meet NFPA public input deadlines, this report is for all testing completed at this time. A subsequent report will be written for the thermocycling testing.

Test # 6 – Conductor Flexing Test

- a) A standard 2 x 3 device box was mounted to a wood stud fixed to a table for support. See Appendix A photo 15. The device box was mounted with screws through the back of the box.
- b) A length of 14-2 AWG copper-clad aluminum NM-B cable was installed into the device box using NM cable clamps. The NM-B had a minimum of 1/4 inch of cable jacket projecting into the box past the clamping device.
- c) The outside end of the NM-B cable was connected to a digital multimeter to indicate continuity of the circuit through the receptacle, see Appendix A photo 16.

- d) The NM-B cable jacket was stripped and cut to length so that 6 inches of conductor projected beyond the cable entry to the box and 3 inches beyond the front edge of the device box. A receptacle was terminated to the NM-B cable conductors and the conductors shaped to fit back in the box so the receptacle yoke mated with the box front edge.
- e) For the first test, the NM-B conductors were installed using the wire binding screw with the conductors wrapped counter-clockwise around the screw shank under the screw head, for 2/3 to 3/4 of wire binding screw circumference.
- f) A shorting plug was installed into the receptacle.
- g) The 6-32 screws were removed and approximately 4-inch-long 10-32 screws were fixed to the device box ears and through the yoke of the receptacle providing a guideway for repeated insertion and removal. The 10-32 screws had nuts installed in the inside and outside of the device box ears to make rigid to the box, see Appendix A photo 15.
- h) With the assembly complete, the receptacle was pushed into and retracted from the box for 10 cycles and the continuity monitored on the digital multimeter, see Appendix A photos 17 through 19.
- i) Steps 'b' through 'h' were repeated two more times with new lengths of 14-2 NM-B copper-clad aluminum cable.
 - For the second test the receptacle was assembled with the back-wiring pressure plate terminal and a single conductor.
 - For the third test the receptacle was assembled with the back-wiring pressure plate terminal and two conductors for mechanical balance on the wiring terminal.

4.3 Bimetallics Testing Circuit Breaker Trip Times

The below table provides the expected trip times based on the manufacturers time current curves at 40°C. The testing for this project was completed at about 22°C, based on the ambient temperatures recorded. Therefore, the trip times recorded from this testing may be somewhat higher but should not exceed the limits set in the UL Standard.

The UL standard specifies that calibration testing be completed at an ambient temperature of 25°C. The UL standard calibration testing at 25°C specifies that at:

- 135% of rating the maximum trip time for a 0 - 50-amp circuit breaker is 1 hour
- 200% of rating the maximum trip time for a breaker 0 – 30 amps is 2 minutes.

Table 1

Manufacturer	Catalog No.	Trip Time Range in Seconds @ 40°C			
		100% rated current	135% rated current	150% rated current	200% rated current
Eaton	BR110	No trip	35 - 3600	20 - 500	12 - 40
	BR115	No trip	35 - 3600	20 - 500	12 - 40
Schneider	QO110	No trip	40 - 500	26 - 240	10 - 60
	QO115	No trip	30 - 210	21 - 100	8 - 28
Siemens	QP110	No trip	60 - 800	40 - 450	19 - 150
	QP115	No trip	30 - 250	20 - 100	9 - 38

5.0 Test Results

5.1 Copper-Clad Aluminum Conductor Material Testing

After the static heating testing was completed, Eaton laboratory technicians packed and shipped samples of the copper-clad aluminum conductor, NM-B cable and THHN single conductor, that had been used for the testing to Copperweld's laboratory for verification testing. Appendix A photos 22 to 24 show the samples the Eaton laboratory technicians packaged into the bag and shipped to the Copperweld laboratory. Note the date on these photos as August 24, 2020. Appendix B pages B1 and B2 show photos of the received package and opening of that package with these samples for the testing.

The samples of the 14 AWG copper-clad aluminum NM-B cable and the 14 AWG copper-clad aluminum THHN single conductors were tested in the Copperweld factory laboratory on August 27, 2020. The Copperweld laboratory testing data is provided in Appendix B page B3 and the calibration of the test equipment on pages B4 through B6.

The UL field engineer that routinely completes the quarterly follow-up inspections for the copper-clad aluminum conductor witnessed the testing required under the UL standard follow-up program that was completed on August 27, 2020. As shown in Appendix B, page B7, the UL field engineer confirmed that *"the 14 Awg from the NMB and THHN samples passed the UL tests for DVVUs, including Tensile, Elongation, copper thickness and DC resistance"*

The test results for the copper-clad aluminum confirm that the conductors used for this testing were 14 AWG and that the material tested met the requirements in ASTM B566.

5.2 Test Setup and Torquing

The test setups were as described in Section 2.0 of this report and shown with photographs in Appendix A. The terminations were tightened to the applicable torque value with a calibrated torque wrench. For the static heating testing the following tables show the torque values applied for each setup and device terminal.

Copper-Clad Aluminum conductors with mfg. 11 and mfg. 8 Receptacles

Torques applied:

Item being torqued	in/lbs	mfr. spec	default
mfg. 1 brkr	20	yes	no
mfg. 2 brkr	36	yes	no
mfg. 3 brkr	25	yes	no
mfg. 4 wire splicing device	2.47	no	yes
mfg. 5 wire splicing device	2.47	no	yes
mfg. 11 receptacles	9	no	yes
mfg. 8 receptacles	12	yes	no

Copper-Clad Aluminum conductors with mfg. 10 and mfg. 9 Receptacles

Torques applied:

Item being torqued	in/lbs	mfr. spec	default
mfg. 1 brkr	20	yes	no
mfg. 2 brkr	36	yes	no
mfg. 3 brkr	25	yes	no
mfg. 6 wire splicing device	2.47	no	yes
mfg. 7 wire splicing device	2.47	no	yes
mfg. 10 receptacles	9	no	yes
mfg. 9 receptacles	9	no	yes

Copper conductors with mfg. 11 and mfg. 8 Receptacles

Torques applied:

Item being torqued	in/lbs	mfr. spec	default
mfg. 1 brkr	20	yes	no
mfg. 2 brkr	36	yes	no
mfg. 3 brkr	25	yes	no
mfg. 4 wire splicing device	4.11	no	yes
mfg. 5 wire splicing device	4.11	no	yes
mfg. 11 receptacle	9	no	yes
mfg. 8 receptacle	12	yes	no

Copper conductors with mfg. 10 and mfg. 9 Receptacles

Torques applied:

Item being torqued	in/lbs	mfr. spec	default
mfg. 1 brkr	20	yes	no
mfg. 2 brkr	36	yes	no
mfg. 3 brkr	25	yes	no
mfg. 6wire splicing device	4.11	no	yes
mfg. 7 wire splicing device	4.11	no	yes
mfg. 10 receptacle	9	no	yes
mfg. 9 receptacle	9	no	yes

5.3 Static Heating Test

The following are the results of the static heating testing, tests 1 through 4 with references to the applicable appendix pages. For all the testing data, the final three recorded temperature values are shown at either temperature equilibrium or the final three temperatures recorded before a circuit breaker tripped. All testing commenced with all test measurement points at ambient temperature. Also shown in the tables in the appendix are:

- The elapsed time from the start of the test,
- The ambient temperature recorded at the time of the recorded values, and
- The current at the time of the recorded values.

Since the UL standards reference temperature rise for most of the devices, those calculated values are shown immediately adjacent to the recorded values. The temperature rise was calculated by taking the recorded temperature and subtracting the ambient temperature recorded for that time.

Since the method of termination on each the three receptacles from one manufacturer was different (wire binding screw, back wired with pressure plate with one conductor and back wired with pressure plate with two conductors) exact data comparison of terminal temperature needs to be done line by line. For example, from appendix page C1 – 1, the line 1a for copper-clad aluminum, top table, needs to compare with line 1a for copper, bottom table.

Otherwise, data in general for terminal temperatures of specific devices, circuit breakers, wire splicing devices and receptacles as well as the conductor, can be compared in general. To facilitate ease of comparison, the pages in appendices C1 through C4 have been arranged so that each page has the copper-clad aluminum data in the top table and the related copper data in the bottom table.

5.3.1 Static Heating at 100% Rated Current

The data for the static heating testing at 100 percent of rated current are shown in Appendix C1. The recorded values are all after the temperatures being recorded had achieved temperature equilibrium. As can be seen in line by line or with general comparisons, the terminal and conductor temperatures for the copper-clad aluminum were less than those recorded for copper when operating at rated current. All temperatures recorded were less than the allowances in the applicable UL standards.

5.3.2 Static Heating at 135% Rated Current

The data for the static heating testing at 135 percent of rated current are shown in Appendix C2. The 135 percent current level is a calibration point for circuit breakers, rated up to 50 amps, where they are required to trip within 1 hour. The recorded values are the last three recorded temperatures before the circuit breaker tripped.

In doing analysis consideration must be given to the fact the temperatures recorded were still rising when the circuit breaker tripped. Therefore, when doing line by line or general comparisons, the circuit breaker trip time must be considered. It is noted the mfg. 1 10-amp circuit breaker tripped approximately twice as fast as the 15-amp circuit breaker, 8 vs. 19 seconds, and this resulted in higher recorded temperatures for copper. The test results with the mfg. 2 circuit breakers was reversed with the 15-amp breaker tripping in approximately half the time of the 10-amp circuit breaker, 3.5 vs. 5.5 seconds. Even with this time disparity the copper-clad aluminum with the longer time recorded lower temperatures than the copper. The trip times for the mfg. 3 circuit breakers had the 10-amp breaker tripping 3 times longer than the 15-amp breaker, but the copper-clad aluminum terminal temperatures still were less than or near to the copper terminal temperatures.

All temperatures recorded were less than the allowances in the applicable UL standards.

5.3.3 Static Heating at 150% Rated Current

The data for the static heating testing at 150 percent of rated current are shown in Appendix C3. The 150 percent current level is a static heating test current for wiring devices. The recorded values are the last three recorded temperatures before the circuit breaker tripped.

In doing analysis consideration must be given to the fact the temperatures recorded were still rising when the circuit breaker tripped. Therefore, when doing line by line or general comparisons, the circuit breaker trip time must be considered. The test data results shown in appendix C3 generally follow that same pattern as occurred with the 135 percent testing.

All temperatures recorded were less than the allowances in the applicable UL standards.

5.3.4 Static Heating at 200% Rated Current

The data for the static heating testing at 200 percent of rated current are shown in Appendix C4. The 200 percent current level is a calibration point for circuit breakers, rated up to 30 amps, where they are required to trip within 2 minutes. The recorded values are the last three recorded temperatures before the circuit breaker tripped.

In doing analysis consideration must be given to the fact the temperatures recorded were still rising when the circuit breaker tripped. Therefore, when doing line by line or general comparisons, the circuit breaker trip time must be considered. The test data results shown in appendix C4 generally follows the same pattern as occurred with the 135 percent and 150 percent testing.

All temperatures recorded were less than the allowances in the applicable UL standards.

5.3.5 Static Heating at 135% Rated Current – Circuit Breaker Did Not Trip

The first attempt at the 135 percent testing found the mfg. 2 10-amp circuit breaker not to trip within the required 1-hour time. The data for this static heating test at 100 percent and at 135 percent of rated current are shown in Appendix C5. The top table on this appendix page is the 100 percent test data and the bottom table is the 135 percent test data. As stated before, the 135 percent current level is a calibration point for circuit breakers, rated up to 50 amps, where they are required to trip within 1 hour.

Since the circuit breaker failed to trip the test was stopped shortly after the 1-hour time had elapsed. Analysis of the 135 percent data recorded found that after 1-hour at this current level, above the proposed rated current, none of the terminal or conductor temperatures had risen above UL standards allowances.

5.3.6 Flexing Tests

The data for the flexing testing is shown in Appendix D. There is no UL or other known industry standard for this specific test and the test process used was established and agreed to by the task group to represent an installation condition. Three tests were conducted, one with the receptacle terminated with the 14 AWG copper-clad aluminum wrapped around the wiring binding screw, the second with a single conductor back wired into the pressure plate and the third with two conductors back wired into the pressure plate.

The test results found that after 10 cycles of fully inserting and removing the receptacle to the full extended position, the copper-clad aluminum

conductors for the back wired assemblies did not break and therefore passed this test.

For the wire binding screw termination, the first test found the flexing for the 10 cycles passed where the conductors did not break. But when the conductors were being removed both the black and white conductors broke off near the end of the insulation, see Appendix A photo 20. A second test was conducted and the black conductor was found to break off near the end of the insulation on the eighth cycle. A third test was completed, using a 14 AWG NM-B sample from another coil, and this assembly passed the 10 cycles and removal of conductors with no breaking or signs of weakening in the stripped portion of the conductor, see Appendix A photo 21.

As stated, there is no industry standard for completing this flexing test and the test was conducted due to specific questions asked by members of the task group. The results demonstrate that there may be limits to the amount of flexing these conductors can withstand, but it should be noted that in normal installations the insertion and removal of a wiring device occurs far less than the eight to ten times as conducted in this test.

6.0 Conclusions

The results from the temperature testing conducted in this project found the 14 AWG copper-clad aluminum to have terminal and conductor temperatures generally less than copper when tested at the 60°C ampacity values. In all cases, the temperature and temperature rise recorded were below those provided in the referenced UL standards. The flexing testing found that there may be some limitations to the number of flexing operations a 14 AWG copper-clad aluminum conductor can withstand, but the number of flexing operations to breakage is above those normally encountered in any installation.

As stated in the introduction, this testing project was to answer specific questions raised by the Bimetallics Task Group regarding temperature performance of 14 AWG copper-clad aluminum compared with 14 AWG copper in typical applications. **While testing conducted followed parts of several UL standards, it is to be understood the testing was only conducted to provide specific performance data and information as requested by the task group. The testing does not provide performance or data for certification of any of the components used for the testing.**

7.0 Test Equipment and Calibration

The following test and measurement equipment was used for the testing. The certificates of calibration for each of the above items is provided in Appendix E.

Description	manufacturer	Eaton Asset #	Cal Date	Cal Due
Thermocouples	Pacific Test and Measurement	N/A	7/10/2020	N/A
DACQ datalogger	Agilent (HP)	EM7054	7/16/2020	7/16/2021
DVM	Fluke	EM4437	7/16/2020	7/16/2021
DVM	Fluke	EM7014	7/16/2020	7/16/2021
DVM	Fluke	EM7024	7/16/2020	7/16/2021
CT	AEMC	EM6996	7/16/2020	7/16/2021
CT	AEMC	EM6997	7/16/2020	7/16/2021
CT	AEMC	EM8032	7/16/2020	7/16/2021
Torque wrench	CDI	EM8363	7/14/2020	7/14/2021
Tape measure	Stanley	EM6927	7/16/2020	7/16/2021

Appendix A - Photos



Photo 1 – Laboratory View



Photo 2 – Test Board and Test Equipment Arrangement

Appendix A - Photos

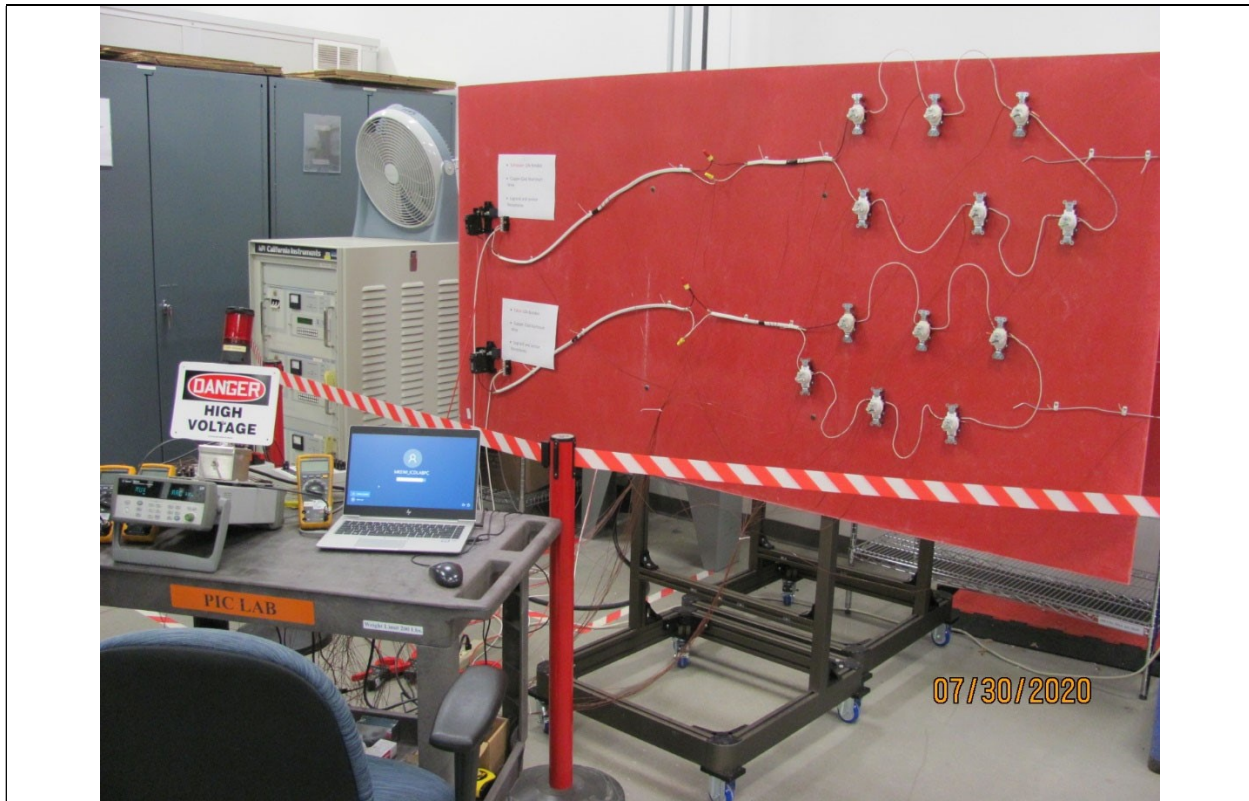


Photo 3 – Test Board and Test Equipment Arrangement

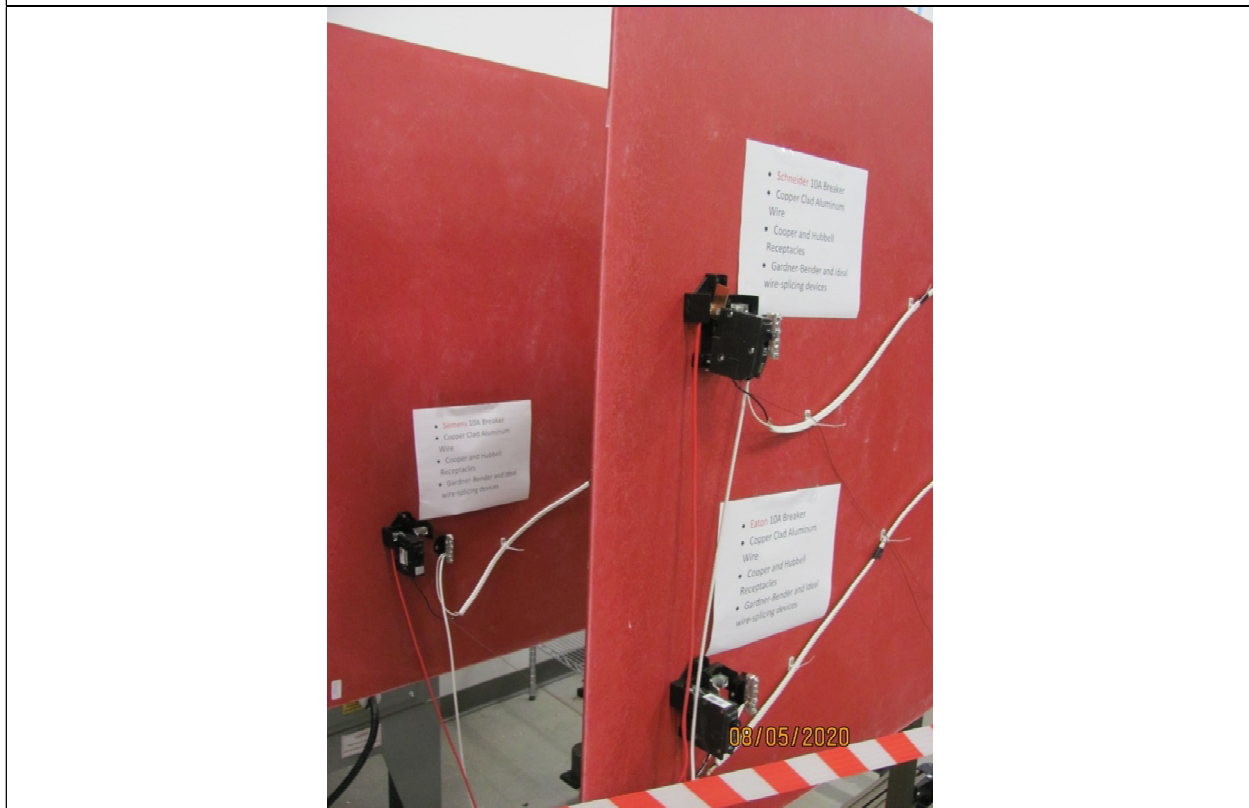


Photo 4 – Copper-Clad Aluminum with Eaton and Hubbell Receptacles

Appendix A - Photos

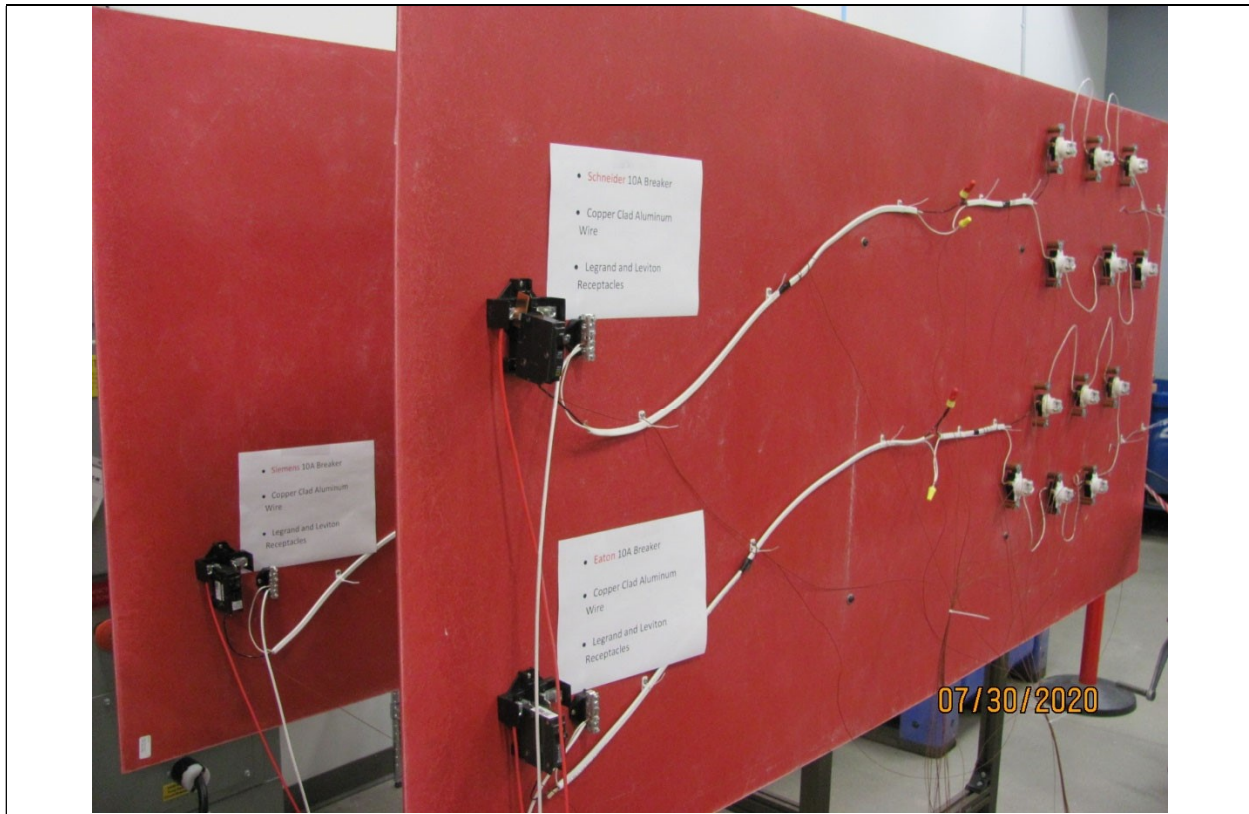


Photo 5 – Copper-Clad Aluminum with Legrand and Leviton Receptacles

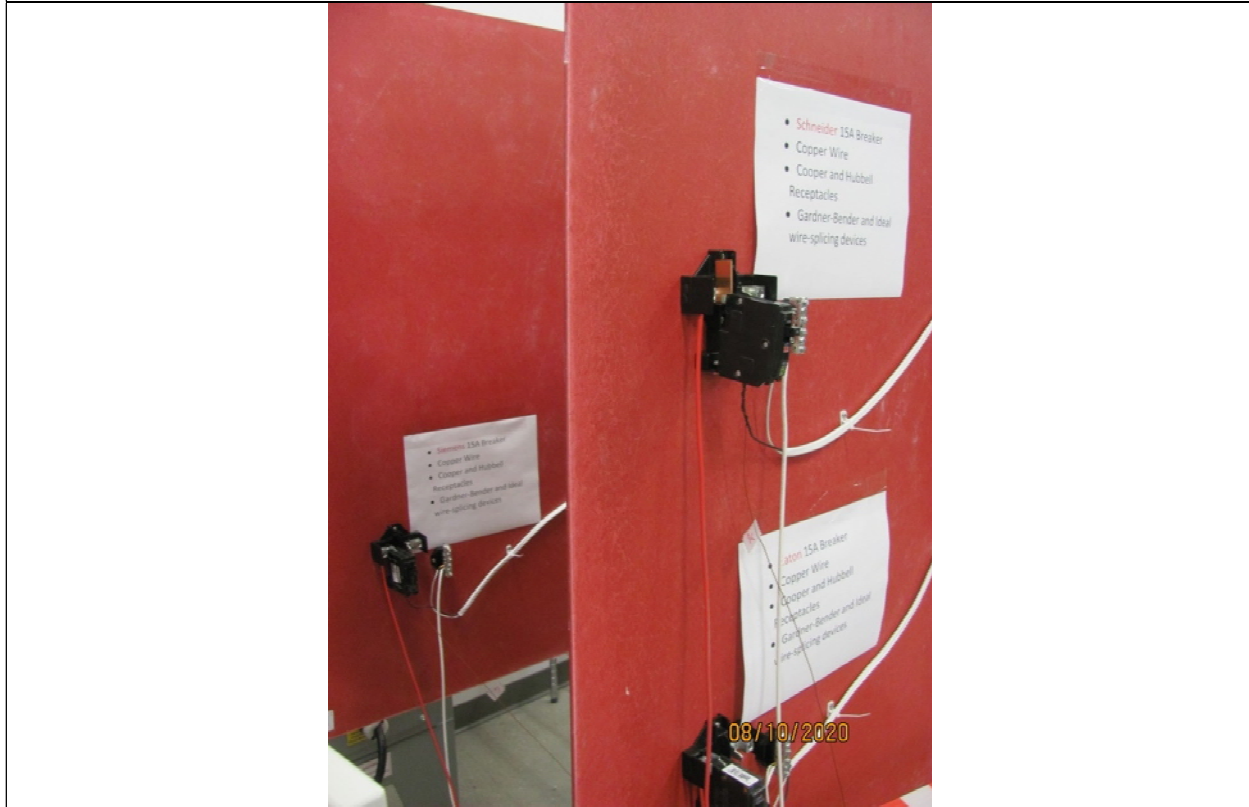


Photo 6 – Copper with Eaton and Hubbell Receptacles

Appendix A - Photos



Photo 7 – Copper with Legrand and Leviton Receptacles

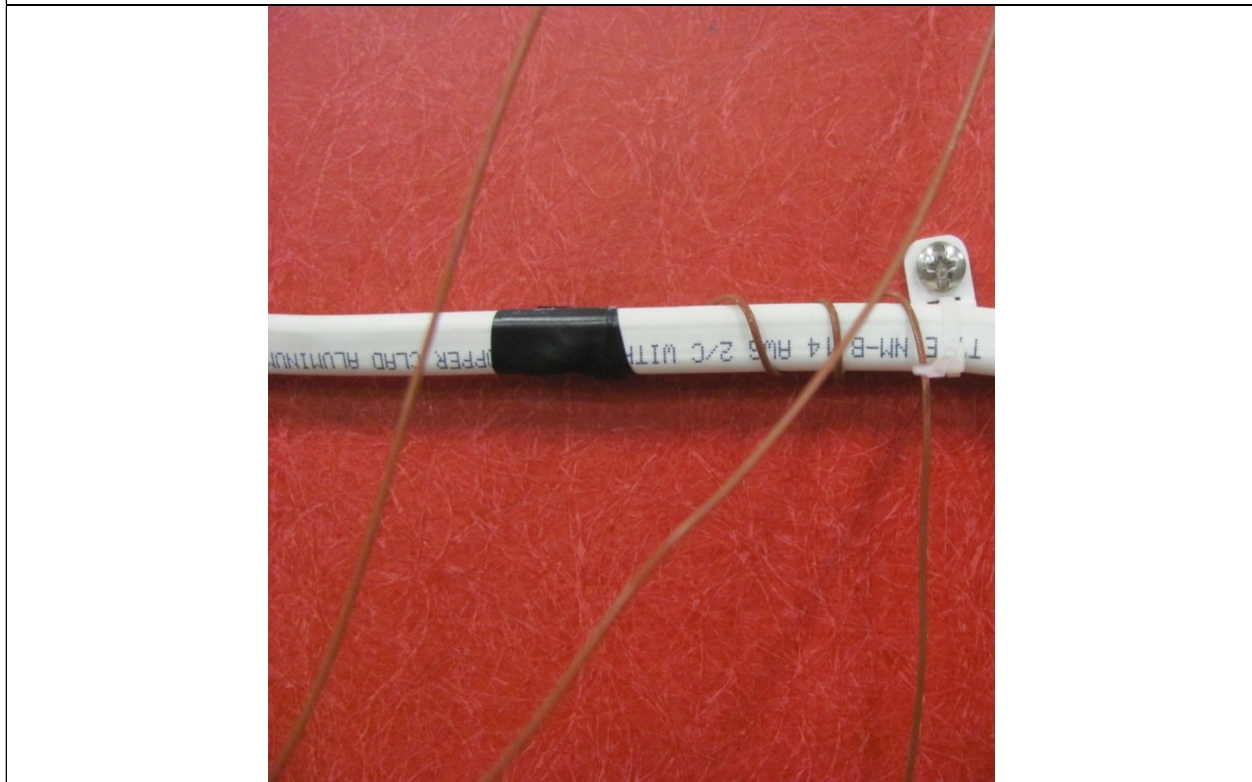


Photo 8 – Copper-Clad Aluminum NM-B Cable

Appendix A - Photos

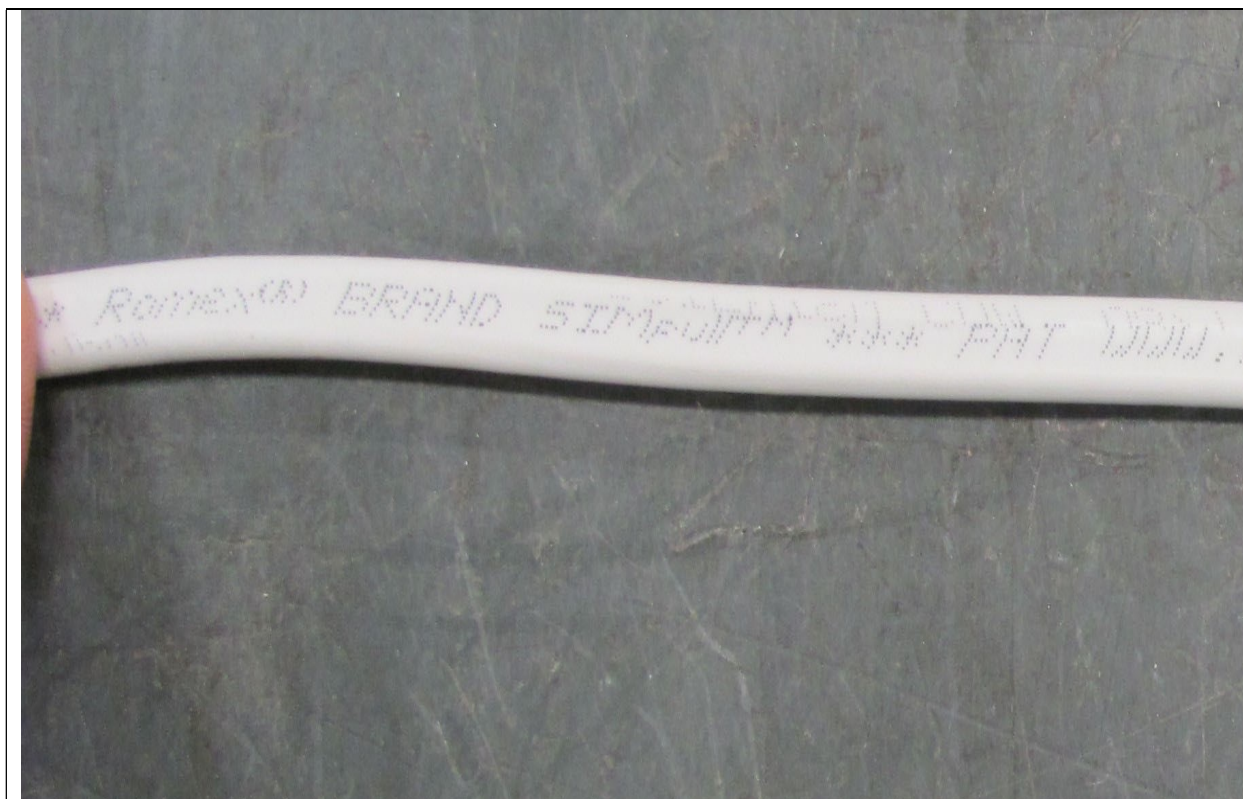


Photo 9 – Copper NM-B Cable



Photo 10 – Copper NM-B Cable Packaging

Appendix A - Photos

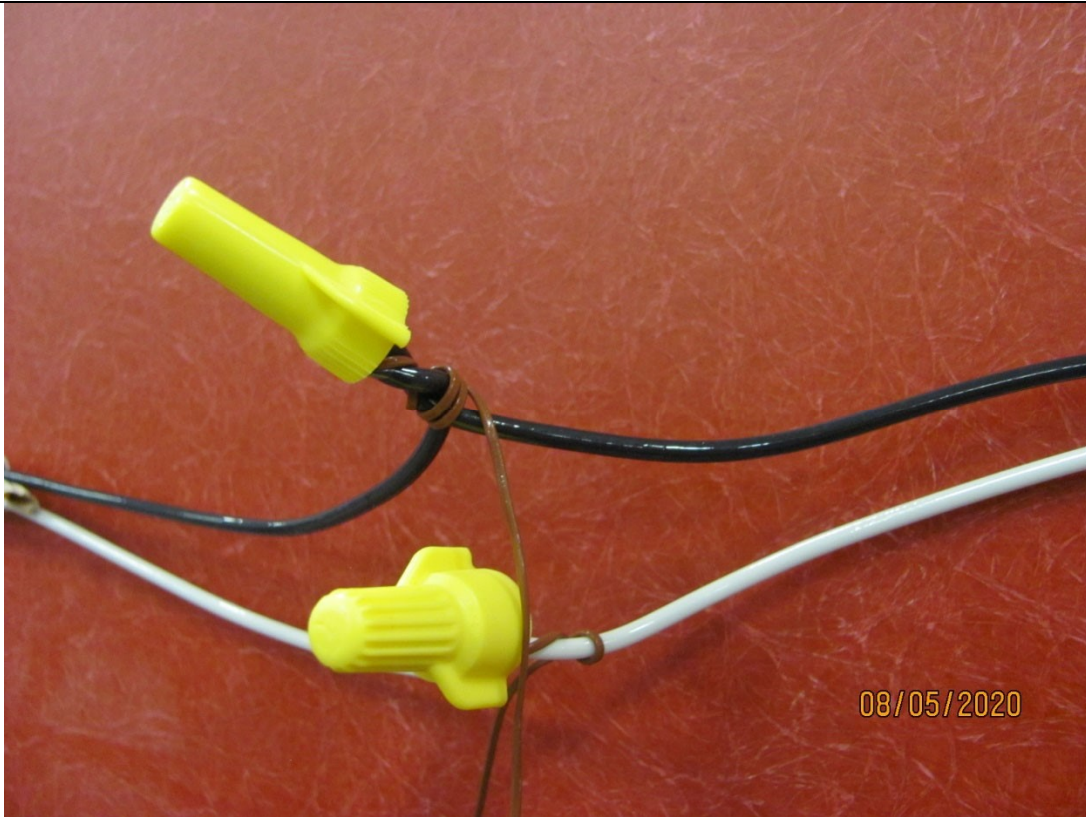


Photo 11 – Typical Installation of Wire Splicing Devices with Thermocouple



Photo 12 – Typical Installation of Receptacle using Wire Binding Screw

Appendix A - Photos

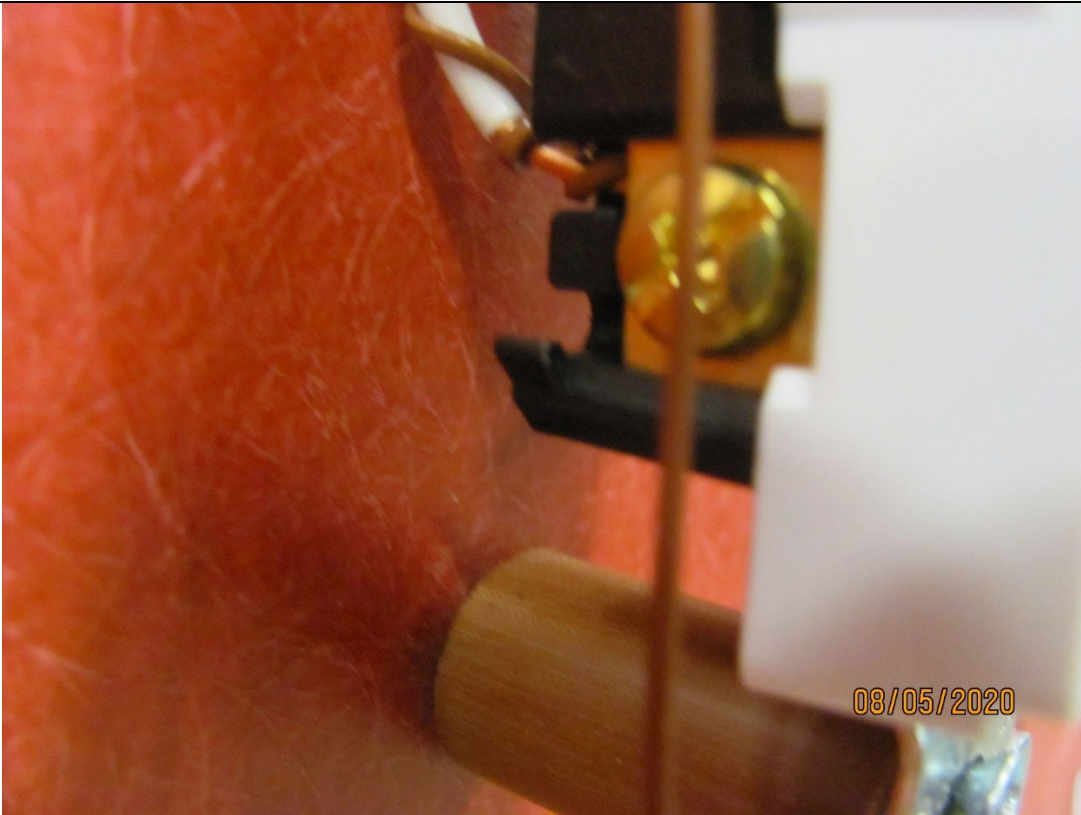


Photo 13 – Typical Installation of Receptacle Since Conductor Back Wired

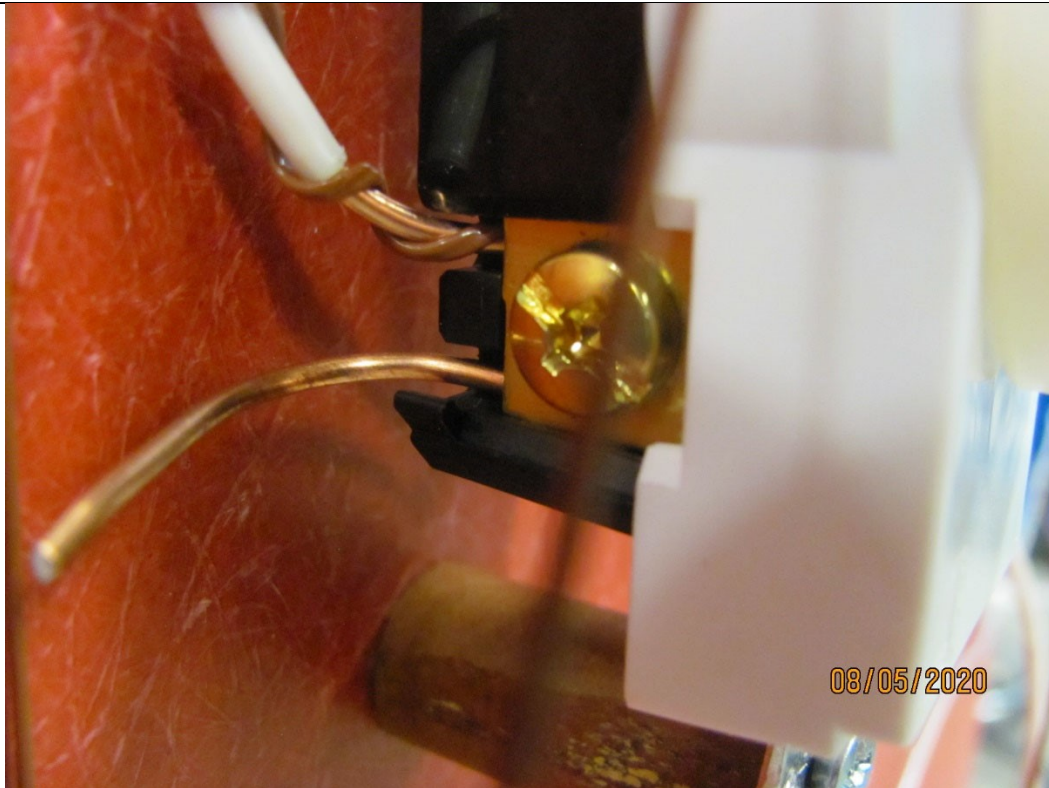


Photo 14 – Typical Installation of Receptacle Two Conductors Back Wired

Appendix A - Photos

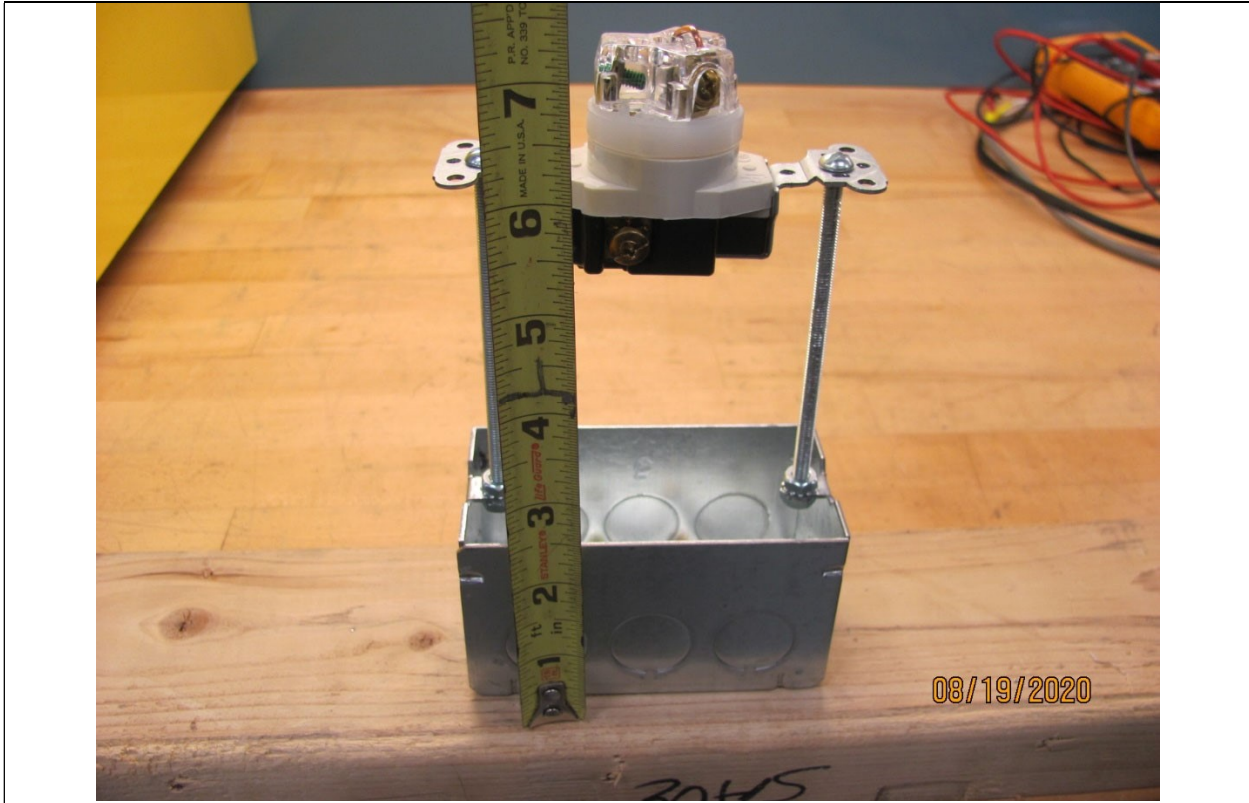


Photo 15 – Flexing Test Setup

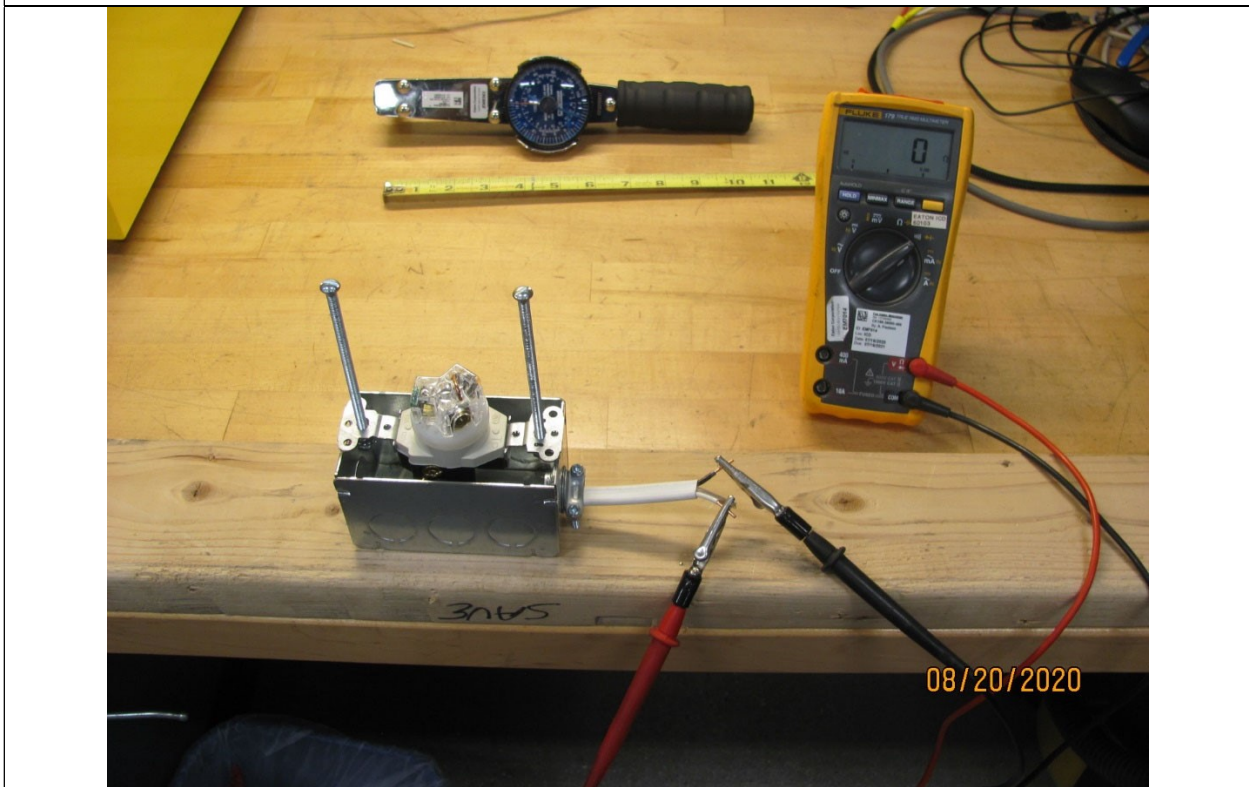


Photo 16 – Flexing Test Setup

Appendix A - Photos

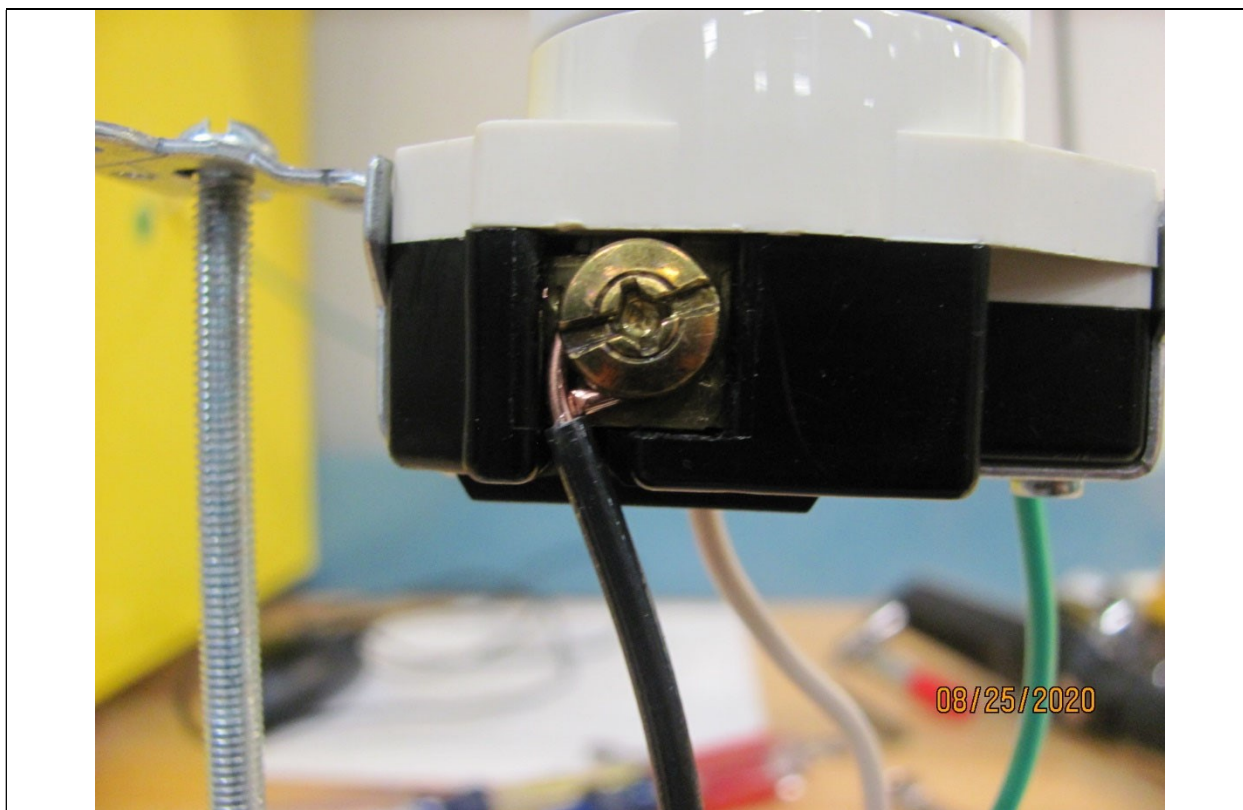


Photo 17 – Flexing Test Fully Extended

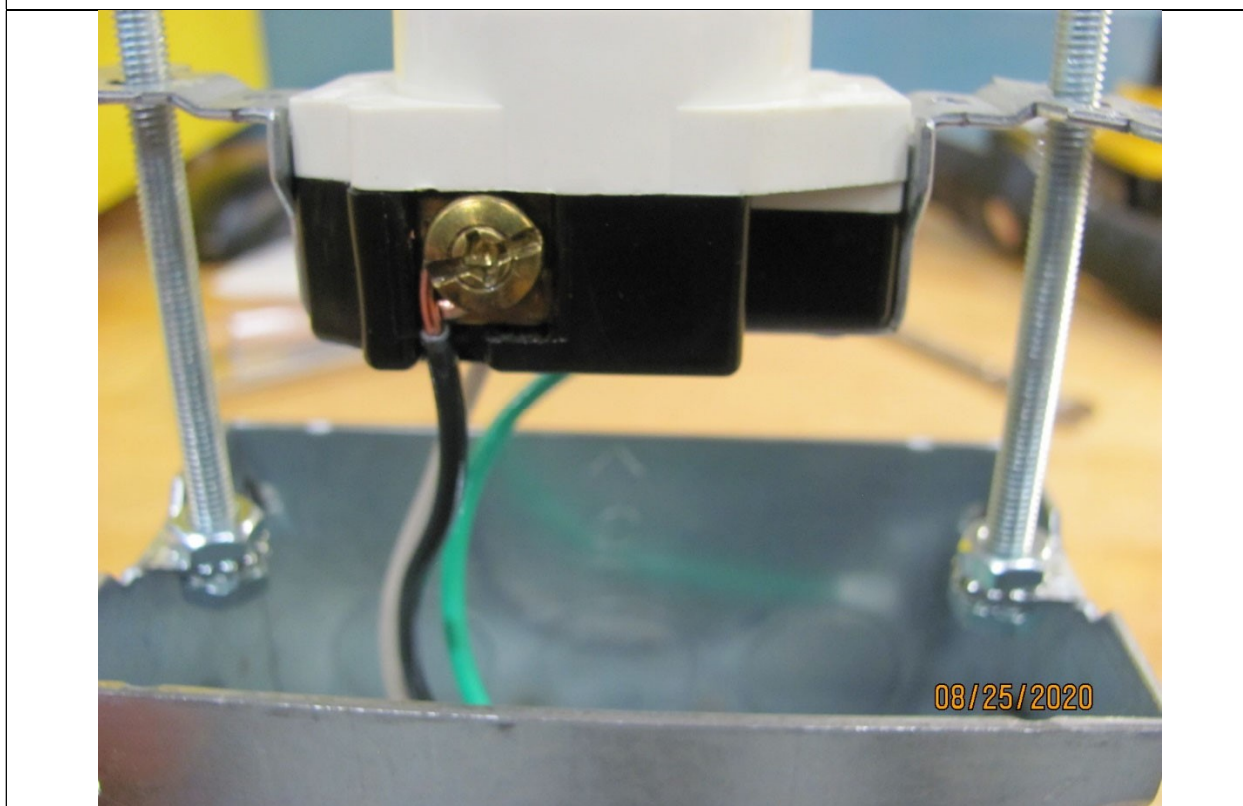


Photo 18 – Flexing Test Partial Insertion

Appendix A - Photos

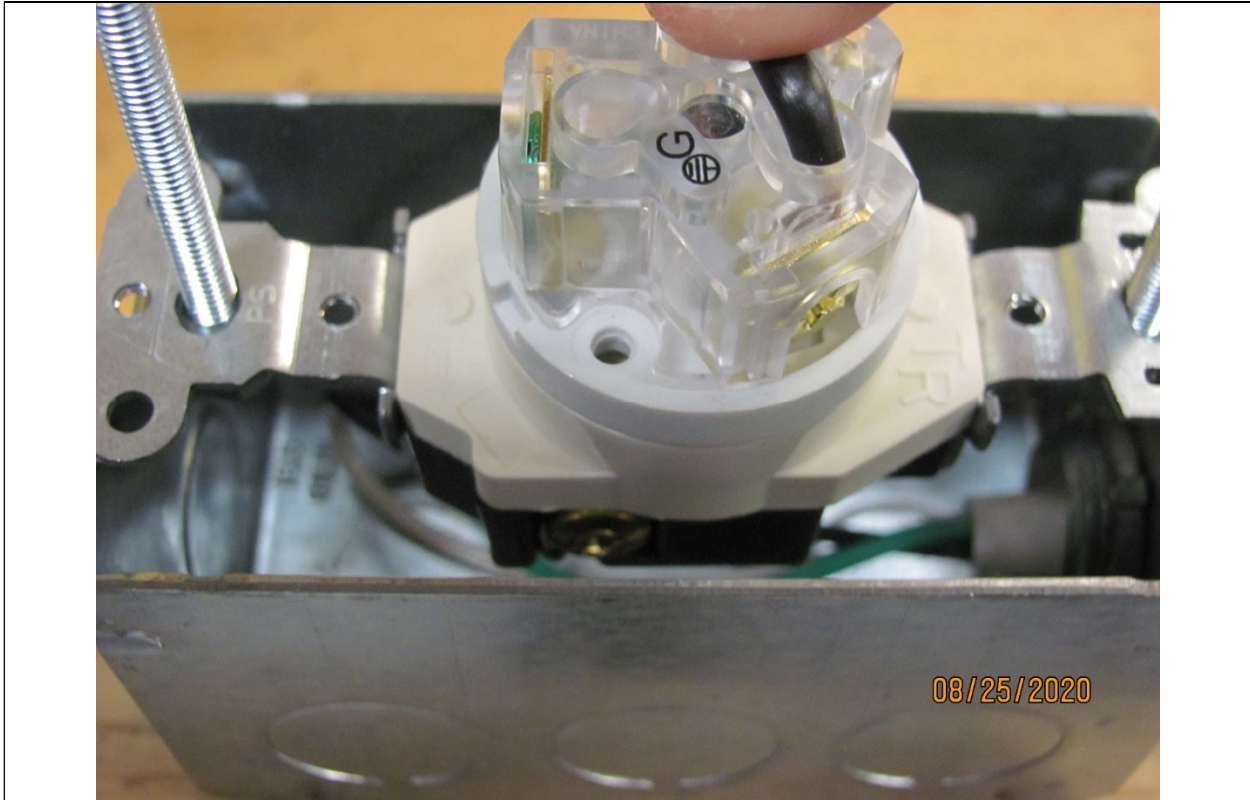


Photo 19 – Flexing Test Fully Inserted

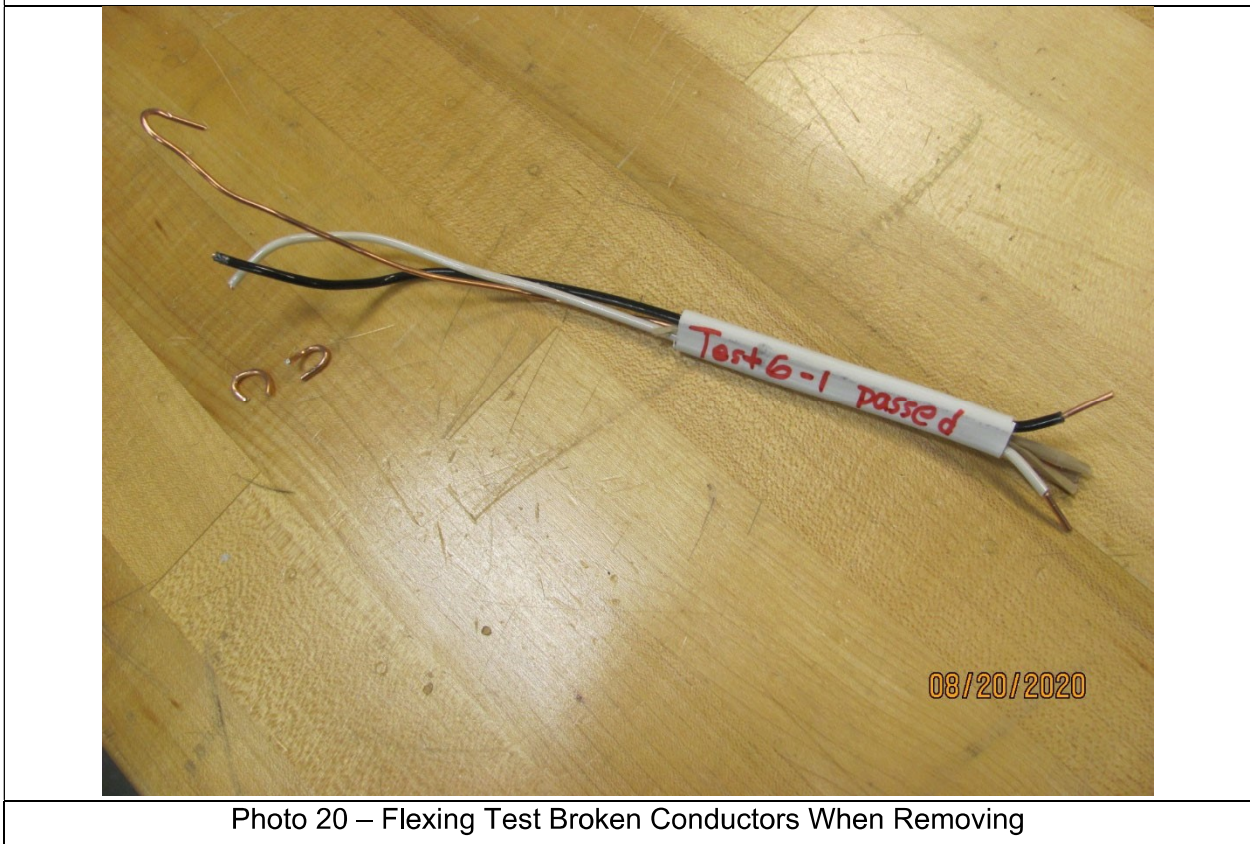


Photo 20 – Flexing Test Broken Conductors When Removing

Appendix A - Photos

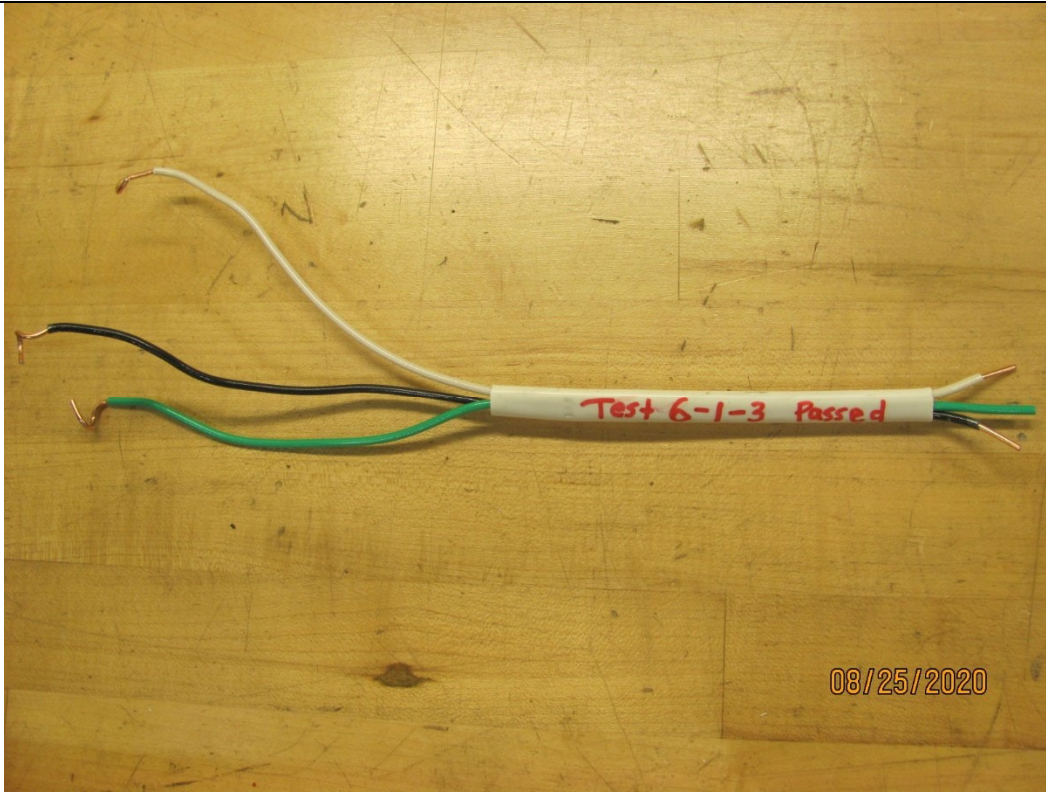


Photo 21 – Flexing Test Repeat No Conductor Breakage

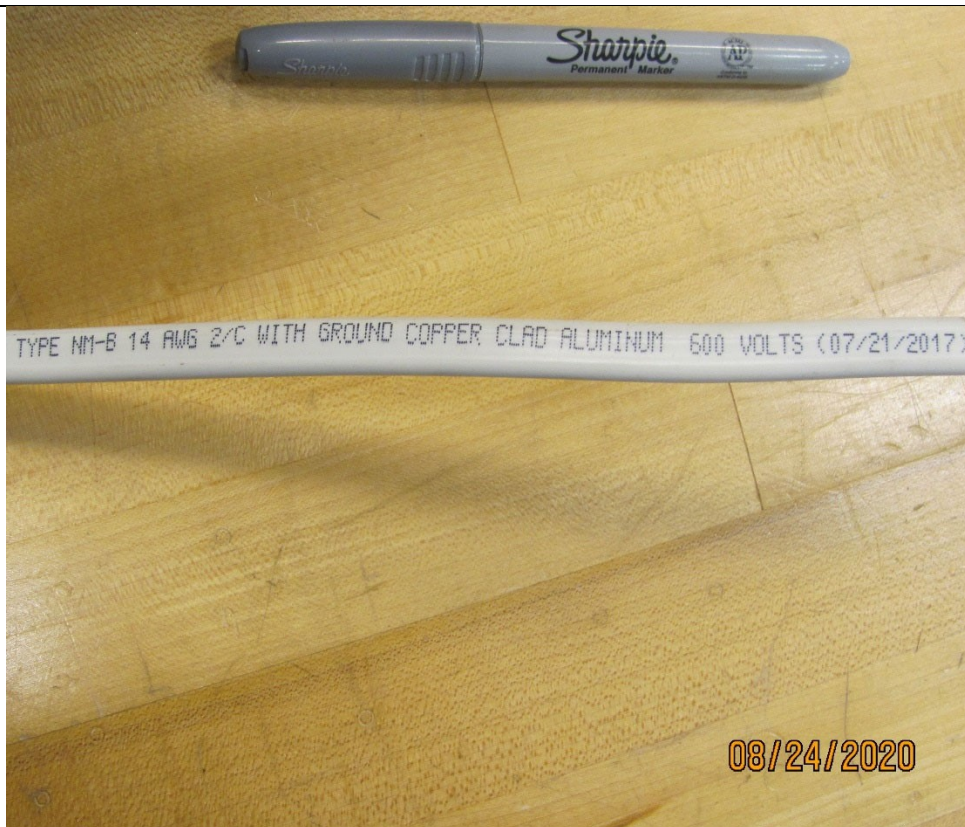


Photo 22 – Copper-Clad Aluminum NM-B Sample Packaging at Eaton

Appendix A - Photos



Photo 23 – Copper-Clad Aluminum THHN Sample Packaging at Eaton



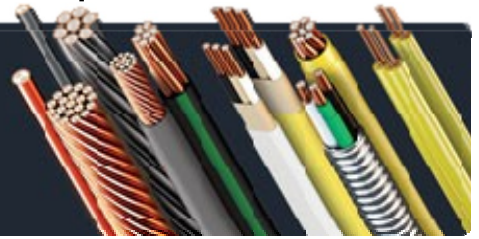
Photo 24 – Copper-Clad Aluminum Sample Packaging at Eaton

Appendix B - Copper-Clad Aluminum Lab Report



COPPERWELD

Wired to Protect



The power of two

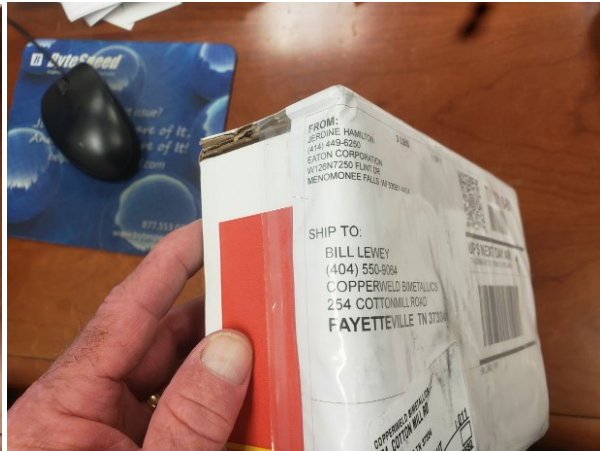
Metallurgical Laboratory Report

Customer:	NEC Bimetallics Task Group		
Subject:	14 AWG Building Wire—NMB and THHN		
Date:	8-27-2020	Report No:	456

Analysis By:	Sammy Hampton --Metallographer
Authored By:	Sammy Hampton --Metallographer
Approved By:	Bill Lewey-- QA Manager

Tested to ASTM Designation: B 566-- 04a

The NM and THHN class samples in this report were sent to Copperweld via a sealed package by Eaton Menomonee Falls test lab. The chain of custody was not broken. The testing was witnessed by a third party as part of routine auditing service. The witnessing session was recorded. The copper clad aluminum conductor material from these samples that was tested on August 27, 2020 by the Copperweld Metallurgical Lab was manufactured by Copperweld Bimetallics to ASTM B566 standards.

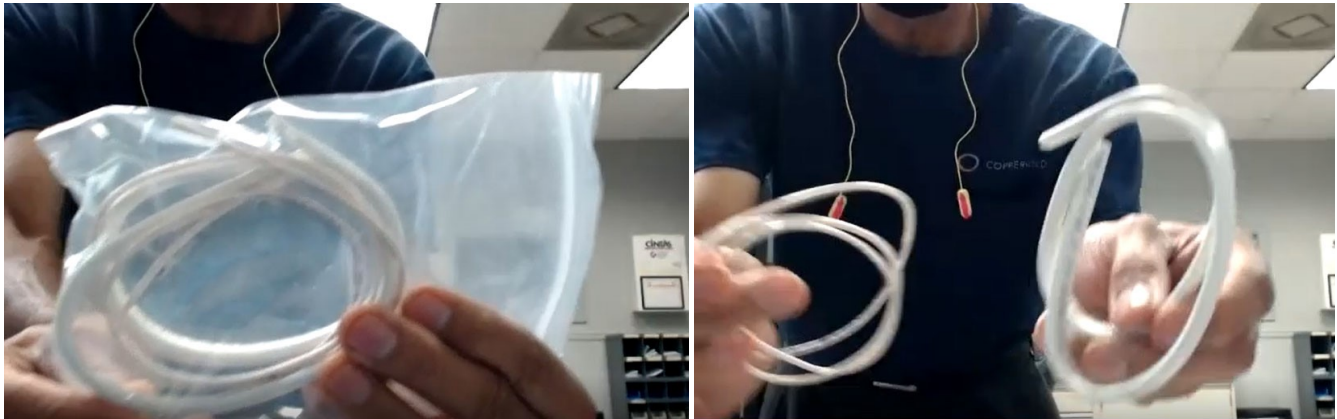


Package as received from Eaton

Appendix B - Copper-Clad Aluminum Lab Report



Opening the Package



Package Contents

Appendix B - Copper-Clad Aluminum Lab Report

The wire consists of a core of aluminum with a continuous outer cladding of copper metallurgically bonded to the core throughout and meets the requirements of this specification (5.1).

Test required	Test result	ASTM B 566 requirement	Result
Diameter	0.0641"	± 0.0001 0.0640" minimum 0.0642" maximum	Pass
Break load (lbs.)	55 pounds	64.4 pounds maximum	Pass
Tensile strength (psi)	17195 psi	20000 (psi) maximum	Pass
% elongation	22.78%	15.0% minimum	Pass
Copper thickness (minimum)	0.00148" = 4.6% of wire radius	minimum copper thickness= 3.5% of wire radius	Pass
Copper volume	10.05%	8% minimum 12% maximum	Pass
Adhesion test	No separation (see attached image 1)	The wire shall be repeatedly reverse bent to fracture by any convenient means. The copper clad aluminum wire shall be free from cladding delamination.	Pass
Cohesion test	No seams or splits (see attached images 2 and 3)	The copper clad aluminum wire shall be free from seams or splits	Pass

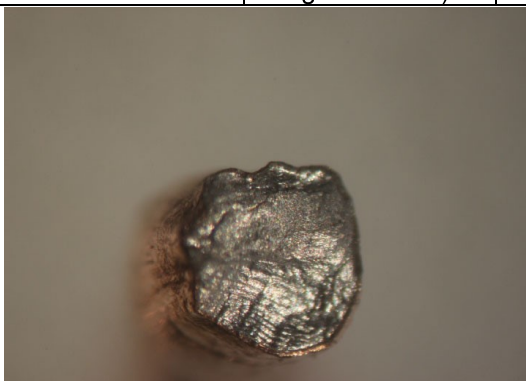


Image 1: adhesion test

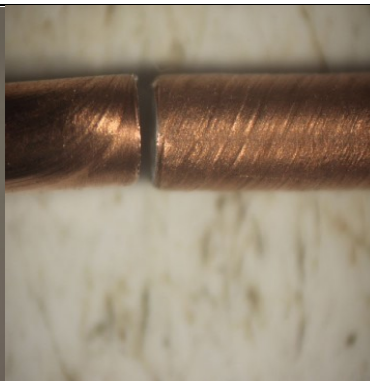


Image 2: cohesion test
(torsion)



image 3: cohesion test
(reverse torsion)

Test and measurement equipment

Equipment	Gauge ID	In calibration	Next due calibration
Micrometer	CP-01	Yes	April 2021
Tensile tester	1755-2000	Yes	January 2022
Ohmmeter	62-1625	Yes	December 2020
Calibration Certificates Attached below			

Appendix B - Copper-Clad Aluminum Lab Report



PRECISION
CALIBRATION
SYSTEMS

107 N Porter St
Winchester, TN 37398
E-mail: info@pcslcm.com
Phone: 866-521-3823
Website: www.pcslcm.com

INSTRUMENT CALIBRATION REPORT



Copperweld

Instrument ID CP-01

Description Micrometer

Calibrated 8/3/2020

Performed At Customer Location

Manufacturer Mitutoyo

Model Number 293-344-30

Location Main

Building 254 Cotton Mill Rd.

Fayetteville, TN 37334

Frequency Semi-Annual

Certificate # CO080320JM-03

Serial Number 66936496

Cal Procedure QS0003JB2010

Department Quality

Status In Service

Temp 73°F

Humidity 59%

Calibration Specifications

Group # 1		Group Name OD							
Nom In Val / In Val	In Type	Std Accy	Acc %	+/-	Out Val	Out Type	End As	Lft As	In Tol
0.25000 / 0.25000	Inch	Plus / Minus	0.000000	±0.00010	0.25000	Inch	0.25000	0.25000	Yes
0.50000 / 0.50000	Inch	Plus / Minus	0.000000	±0.00010	0.50000	Inch	0.50000	0.50000	Yes
1.00000 / 1.00000	Inch	Plus / Minus	0.000000	±0.00010	1.00000	Inch	1.00000	1.00000	Yes

Test Instruments Used During the Calibration

Test Instrument ID	Description	Manufacturer	Model Number	Serial Number	(As Of Cal Entry Date)	
					Last Cal Date	Next Cal Date
Z-GA-010 GAGE	Gage Block 81pc Set Standard	China	Rectangular Steel	E1599	4/8/2016	4/30/2021
BLCK SET STD SHOP						

Notes about this calibration

Uncertainty = ± (64.9+5.2L) μin (95%CL; K=2)

Calibration Result Calibration Successful

Who Calibrated James Meadows

Finalized By James Meadows

Date Finalized 8/3/2020 9:19:05AM

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). Decision Rule: The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. This is considered "shared responsibility." This calibration was conducted using standards traceable to the SI through NIST. The results on this certificate of accuracy apply only to the item described above.

Accredited to ISO/IEC 17025: 2017.

This document may not be reproduced except in full.

Laboratory Authorized Signature *James Meadows*

Revision Date: 05/08/2020
Rev: 04

Page 1 of 1

QF0016

Confidential

Page 4

9/2/2020

This document may contain confidential and proprietary information which is the exclusive property of Copperweld. It is delivered on the express condition that it is not to be disclosed, reproduced or used, in whole or part, for the manufacture, sales or use by anyone other than Copperweld without its express written consent.

Page B4

Appendix B - Copper-Clad Aluminum Lab Report

INSTRUMENT CALIBRATION REPORT

Copperweld

Instrument ID 1755-2000		Description Tensile Tester (2 Load cells)		Performed At Customer Location	
Calibrated 8/4/2020					
Manufacturer	Thwing-Albert Instruments	Location	Main	Frequency	Semi-Annual
Model Number	EJA	Building	254 Cotton Mill Rd. Fayetteville, TN 37334	Certificate #	CO080420JM-13
Serial Number	1755-2000	Department	Quality	Temp	70°F
Cal Procedure	QS0033BG2013	Status	In Service	Humidity	57%

Calibration Specifications									
Group # 1									
Group Name 0-11lb Load Cell 627022									
Nom In Val / In Val	In Type	Std Accy	Acc %	±/-	Out Val	Out Type	End As	Lft As	In Tol
1 / 1	lbf	Pct of Range	0.500000	0.00	1.00	lbf	1.01	1.01	Yes
2 / 2	lbf	Pct of Range	0.500000	0.00	2.00	lbf	2.01	2.01	Yes
3 / 3	lbf	Pct of Range	0.500000	0.00	3.00	lbf	3.01	3.01	Yes
5 / 5	lbf	Pct of Range	0.500000	0.00	5.00	lbf	5.02	5.02	Yes
7 / 7	lbf	Pct of Range	0.500000	0.00	7.00	lbf	7.03	7.03	Yes
10 / 10	lbf	Pct of Range	0.500000	0.00	10.00	lbf	10.04	10.04	Yes

Group # 2									
Group Name 0-225 lb Load cell 608236									
Nom In Val / In Val	In Type	Std Accy	Acc %	±/-	Out Val	Out Type	End As	Lft As	In Tol
5 / 5	lbf	Pct of Range	0.500000	0.00	5.00	lbf	5.00	5.00	Yes
20.446 / 20.446	lbf	Pct of Range	0.500000	0.00	20.45	lbf	20.48	20.48	Yes
50.414 / 50.414	lbf	Pct of Range	0.500000	0.00	50.41	lbf	50.48	50.48	Yes
88.532 / 88.532	lbf	Pct of Range	0.500000	0.00	88.53	lbf	88.64	88.64	Yes
99.044 / 99.044	lbf	Pct of Range	0.500000	0.00	99.04	lbf	99.15	99.15	Yes
117.60 / 117.60	lbf	Pct of Range	0.500000	0.00	117.60	lbf	117.73	117.73	Yes
131.71 / 131.71	lbf	Pct of Range	0.500000	0.00	131.71	lbf	131.83	131.83	Yes
151.04 / 151.04	lbf	Pct of Range	0.500000	0.00	151.04	lbf	151.22	151.22	Yes
161.19 / 161.19	lbf	Pct of Range	0.500000	0.00	161.19	lbf	161.38	161.38	Yes
207.76 / 207.76	lbf	Pct of Range	0.500000	0.00	207.76	lbf	207.99	207.99	Yes

Revision Date: 05/08/2020
Rev: 04

Page 1 of 2

QF0016

INSTRUMENT CALIBRATION REPORT

Copperweld

Instrument ID 1755-2000		Description Tensile Tester (2 Load cells)		Performed At Customer Location	
Calibrated 8/4/2020					

Test Instruments Used During the Calibration					
Test Instrument ID	Description	Manufacturer	Model Number	Serial Number	(As Of Cal Entry Date)
Z-LO-005 5K LOAD	Load Cell, 5000lb, Tension & Compression	Futek	LSB453	575093	Last Cal Date: 1/7/2020 Next Cal Date: 1/31/2022
Z-WE-003 HANGING WEIGHTS	Weight Set, 1-20lbs, Cast Iron	Rice Lake	ASTM Class 6	D7-D10 (20), D1-D4 (10), D1-D2 (2), 8MB8 (1), 8MB4 (2), 8MB5 (5)	3/26/2019 3/31/2021

Notes about this calibration

Uncertainty = ± 0.23% of Reading (95%CL; K=2)

Calibration Result Calibration Successful

Who Calibrated James Meadows

Finalized By James Meadows

Date Finalized 8/4/2020 1:12:08PM

Total expanded measurement uncertainties expressed are based on a confidence level of 95%, coverage factor of (k=2). Decision Rule: The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. This is considered "shared responsibility." This calibration was conducted using standards traceable to the SI through NIST. The results on this certificate of accuracy apply only to the items described above. Accredited to ISO/IEC 17025:2017.

This document may not be reproduced except in full.

Laboratory Authorized Signature

James Meadows

Revision Date: 05/08/2020
Rev: 04

Page 2 of 2

QF0016

Confidential

Page 5

9/2/2020

This document may contain confidential and proprietary information which is the exclusive property of Copperweld. It is delivered on the express condition that it is not to be disclosed, reproduced or used, in whole or part, for the manufacture, sales or use by anyone other than Copperweld without its express written consent.

Page B5

Appendix B - Copper-Clad Aluminum Lab Report



PRECISION
CALIBRATION
SYSTEMS

107 N Porter St
Winchester, TN 37398
E-mail: info@pcslcm.com
Phone: 866-521-3823
Website: www.pcslcm.com

INSTRUMENT CALIBRATION REPORT



Copperweld

Instrument ID 62-1625

Description Micro Ohm Meter

Calibrated 8/4/2020

Performed At Customer Location

Manufacturer Valhalla Scientific
Model Number 4176

Location Main
Building 254 Cotton Mill Rd.
Fayetteville, TN 37334

Frequency Semi-Annual
Certificate # CO080420JM-03

Serial Number 62-1625

Cal Procedure QS0011JB2010

Department Quality
Status In Service

Temp 70°F
Humidity 57%

Calibration Specifications

Group # 1									
Group Name Ohm - Source									
Nom In Val / In Val	In Type	Std Accy	Acc %	±/±	Out Val	Out Type	End As	Lft As	In Tol
1.000 / 1.000	Ohm	Pct of Reading	0.040000	0.0000	1.0000	Ohm	0.9998	0.9998	Yes
10.000 / 10.000	Ohm	Pct of Reading	0.040000	0.000	10.000	Ohm	9.999	9.999	Yes
100.000 / 100.000	Ohm	Pct of Reading	0.040000	0.00	100.00	Ohm	99.99	99.99	Yes

Test Instruments Used During the Calibration

Test Instrument ID	Description	Manufacturer	Model Number	Serial Number	(As Of Cal Entry Date)	
					Last Cal Date	Next Cal Date
Z-EL-020 DECADE RESISTANCE BOX	General Radio Small Decade Resistance Box	General Radio	1433-U	2545	12/18/2018	12/31/2020

Notes about this calibration

Uncertainty = ± 2 mOhm (95%CL; K=2)

Calibration Result Calibration Successful

Who Calibrated James Meadows

Finalized By James Meadows

Date Finalized 8/4/2020 12:47:33PM

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). Decision Rule: The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. This is considered "shared responsibility." This calibration was conducted using standards traceable to the SI through NIST. The results on this certificate of accuracy apply only to the item described above.

Accredited to ISO/IEC 17025:2017.

This document may not be reproduced except in full.

Laboratory Authorized Signature *James Meadows*

Revision Date: 05/08/2020
Rev: 04

Page 1 of 1

QF0016

Confidential

Page 6

9/2/2020

This document may contain confidential and proprietary information which is the exclusive property of Copperweld. It is delivered on the express condition that it is not to be disclosed, reproduced or used, in whole or part, for the manufacture, sales or use by anyone other than Copperweld without its express written consent.

Page B6

Appendix B - Copper-Clad Aluminum Lab Report



Follow-up Service Inspection Report E4911851200827165202

INSPECTION DETAILS			
Date:	2020-08-27	File Number.:	E491185
Responsible Office:	Melville	Volume:	1
Inspection Center:	232	CCN:	DVVU2
Product Type:	CCA Conductor	UL Rep Name:	Gregory Cornett
Deliverable Type:	Recognized	UL Rep ID:	20708
Party Site Number:	1626131	Subscriber Factory No.:	
Manufacturer Name:	Copperweld Bimetallics LLC	Factory Rep Name	Mr. Sammy Hampton
Manufacturer Address:	254 Cotton Mill Rd Fayetteville, TN 37334	Factory Rep Phone:	931-433-0495
		Factory Rep Email:	shampton@copperweld.com
Nature of visit:	Regular Inspection	Sample Status:	Sample requirements fulfilled for sample period
UL Marks Used?	Yes	UL Marks Removed?	No
Variation Notice Issued?	No	Inspection Conducted Remotely?	Yes
Comments After Submission:			

PRODUCT DOCUMENTS/PRODUCTION READY VISIT			
Model	Product	Section	Multiple Listed
14 Awg Class 10A	Copper Clad Aluminum	1	No

SAMPLE DOCUMENTS			
If samples are required to be sent to UL, indicate below. If required samples are not sent, explain in the Comments area.			
No Samples			
Additional Comments	14 Awg conductors from the NMB and THHN samples passed the UL tests for DVVU2, including Tensile, Elongation, copper thickness and DC Resistance.		

In addition to the requirements specified in the applicable UL Services agreement and Follow-Up Service Procedure, UL further defines responsibilities, duties and requirements for both manufacturers and UL representatives in the document titled "UL Mark Surveillance Requirements" that can be located at www.ul.com/fus, and in accordance with the applicable terms and conditions of the document at www.ul.com/responsibilities. Manufacturers without Internet access may obtain the current versions of these documents from their local UL customer service representative or UL field representative.

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1a - thru Mfg. 1 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		124	129	134			
time (HH:MM:SS)		1:53:00	1:58:00	2:03:00			
1a	Mfg. 11 - 1	28.70	28.86	28.73	6.47	6.63	6.50
2a	Mfg. 11 - 2	28.89	29.01	28.84	6.66	6.78	6.61
3a	Mfg. 11 - 3	27.88	28.00	27.72	5.65	5.77	5.49
4a	Mfg. 8 - 1	29.18	29.27	29.25	6.95	7.04	7.02
5a	Mfg. 8 - 2	28.99	29.11	28.99	6.76	6.88	6.76
6a	Mfg. 8 - 3	29.00	29.15	28.92	6.77	6.92	6.69
7a	circuit breaker	32.68	32.65	32.75	10.45	10.42	10.52
8a	line wire	32.25	32.29	32.43	10.02	10.06	10.20
9a	line wire splicing device	29.84	29.65	29.07	7.61	7.42	6.84
10a	load wire	30.67	30.92	30.94	8.44	8.69	8.71
11a	load wire splicing device	30.11	29.88	29.27	7.88	7.65	7.04
12a	room ambient	22.39	22.44	21.87			
13a	current (amps)	10.03	10.03	10.03			

Test 1a - thru Mfg. 1 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		80	85	90			
time (HH:MM:SS)		1:17:00	1:22:00	1:27:00			
1a	Mfg. 11 - 1	33.06	33.61	33.40	11.02	11.58	11.36
2a	Mfg. 11 - 2	33.64	33.95	33.94	11.60	11.91	11.90
3a	Mfg. 11 - 3	31.05	31.56	31.60	9.01	9.52	9.56
4a	Mfg. 8 - 1	34.10	34.15	34.23	12.06	12.11	12.19
5a	Mfg. 8 - 2	33.60	34.20	33.86	11.56	12.16	11.82
6a	Mfg. 8 - 3	32.94	33.68	33.29	10.91	11.64	11.25
7a	circuit breaker	40.86	40.44	40.64	18.82	18.41	18.60
8a	line wire	33.93	34.21	33.87	11.89	12.17	11.83
9a	line wire splicing device	36.89	37.11	36.82	14.85	15.07	14.78
10a	load wire	32.70	33.48	32.99	10.66	11.44	10.95
11a	load wire splicing device	32.72	33.49	32.70	10.68	11.45	10.66
12a	room ambient	21.84	22.27	22.01			
13a	current (amps)	15.02	15.01	15.02			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1b - thru Mfg. 2 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		124	129	134			
time (HH:MM:SS)		1:53:00	1:58:00	2:03:00			
1b	Mfg. 11 - 1	28.57	28.60	28.36	6.49	6.52	6.27
2b	Mfg. 11 - 2	28.65	28.68	28.48	6.57	6.60	6.40
3b	Mfg. 11 - 3	27.37	27.39	27.10	5.28	5.31	5.02
4b	Mfg. 8 - 1	29.14	29.23	29.15	7.05	7.15	7.07
5b	Mfg. 8 - 2	30.65	30.75	30.48	8.57	8.66	8.40
6b	Mfg. 8 - 3	28.04	28.10	27.73	5.96	6.02	5.64
7b	circuit breaker	36.63	36.79	37.20	14.55	14.70	15.12
8b	line wire	30.98	31.03	30.93	8.90	8.95	8.85
9b	line wire splicing device	28.97	28.69	28.06	6.89	6.61	5.98
10b	load wire	28.60	28.55	28.00	6.52	6.47	5.92
11b	load wire splicing device	28.64	28.49	27.92	6.56	6.41	5.84
12b	room ambient	22.35	22.28	21.62			
13b	current (amps)	10.00	10.00	10.00			

Test 1b - thru Mfg. 2 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		80	85	90			
time (HH:MM:SS)		1:17:00	1:22:00	1:27:00			
1b	Mfg. 11 - 1	33.38	33.85	33.55	11.43	11.89	11.59
2b	Mfg. 11 - 2	33.29	33.49	33.67	11.34	11.54	11.72
3b	Mfg. 11 - 3	30.94	31.47	31.45	8.99	9.52	9.49
4b	Mfg. 8 - 1	34.03	34.28	34.44	12.07	12.32	12.48
5b	Mfg. 8 - 2	33.61	34.03	33.75	11.66	12.08	11.80
6b	Mfg. 8 - 3	33.00	33.71	33.25	11.05	11.75	11.29
7b	circuit breaker	44.97	44.86	45.02	23.02	22.91	23.06
8b	line wire	33.21	33.70	33.32	11.25	11.74	11.37
9b	line wire splicing device	30.81	31.77	30.80	8.86	9.82	8.85
10b	load wire	32.53	33.49	32.83	10.58	11.54	10.88
11b	load wire splicing device	31.51	32.52	31.43	9.56	10.56	9.47
12b	room ambient	21.76	22.22	21.88			
13b	current (amps)	15.01	15.01	15.01			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1c - thru Mfg. 3 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		124	129	134			
time (HH:MM:SS)		1:53:00	1:58:00	2:03:00			
1c	Mfg. 11 - 1	29.46	29.56	29.18	7.40	7.50	7.12
2c	Mfg. 11 - 2	28.97	29.12	28.68	6.91	7.06	6.62
3c	Mfg. 11 - 3	27.82	28.02	27.47	5.76	5.96	5.41
4c	Mfg. 8 - 1	29.30	29.40	29.33	7.24	7.34	7.27
5c	Mfg. 8 - 2	28.68	28.72	28.43	6.62	6.66	6.37
6c	Mfg. 8 - 3	28.19	28.27	27.81	6.13	6.21	5.75
7c	circuit breaker	35.04	35.28	35.13	12.98	13.22	13.07
8c	line wire	31.23	31.27	30.87	9.17	9.21	8.81
9c	line wire splicing device	28.59	28.61	27.53	6.53	6.55	5.47
10c	load wire	30.74	30.84	30.26	8.68	8.78	8.20
11c	load wire splicing device	29.74	29.67	28.50	7.68	7.61	6.44
12c	room ambient	22.29	22.23	21.67			
13c	current (amps)	10.01	10.01	10.01			

Test 1c - thru Mfg. 3 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		80	85	90			
time (HH:MM:SS)		1:17:00	1:22:00	1:27:00			
1c	Mfg. 11 - 1	32.95	33.38	33.25	11.06	11.48	11.36
2c	Mfg. 11 - 2	33.50	33.89	33.73	11.61	12.00	11.84
3c	Mfg. 11 - 3	32.27	32.60	32.50	10.38	10.71	10.61
4c	Mfg. 8 - 1	33.33	33.66	33.62	11.44	11.77	11.72
5c	Mfg. 8 - 2	33.87	34.28	34.11	11.98	12.39	12.21
6c	Mfg. 8 - 3	32.50	32.88	32.80	10.61	10.99	10.91
7c	circuit breaker	42.51	42.65	42.50	20.62	20.75	20.60
8c	line wire	31.74	32.44	32.16	9.84	10.54	10.27
9c	line wire splicing device	32.46	33.55	32.53	10.57	11.66	10.64
10c	load wire	32.23	33.29	32.70	10.34	11.40	10.81
11c	load wire splicing device	29.96	31.50	30.18	8.07	9.61	8.29
12c	room ambient	21.65	22.13	21.90			
13c	current (amps)	15.02	15.02	15.02			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1a - thru Mfg. 1 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		67	72	77			
time (HH:MM:SS)		1:04:00	1:09:00	1:14:00			
1a	Mfg. 10 - 1	33.35	33.09	33.35	11.17	10.90	11.17
2a	Mfg. 10 - 2	29.93	29.88	29.88	7.75	7.70	7.70
3a	Mfg. 10 - 3	28.83	28.80	28.74	6.65	6.62	6.56
4a	Mfg. 9 - 1	28.96	28.89	28.94	6.78	6.71	6.76
5a	Mfg. 9 - 2	29.33	29.07	29.09	7.15	6.89	6.91
6a	Mfg. 9 - 3	28.20	28.02	27.93	6.01	5.84	5.75
7a	circuit breaker	32.75	32.55	32.65	10.57	10.37	10.47
8a	line wire	32.76	32.27	32.44	10.58	10.09	10.26
9a	line wire splicing device	29.85	29.45	29.15	7.67	7.27	6.97
10a	load wire	31.09	30.73	31.01	8.91	8.55	8.83
11a	load wire splicing device	30.90	30.16	30.15	8.72	7.98	7.97
12a	room ambient	22.53	22.20	21.82			
13a	current (amps)	10.02	10.02	10.02			

Test 1a - thru Mfg. 1 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		122	127	132			
time (HH:MM:SS)		2:00:00	2:05:00	2:10:00			
1a	Mfg. 10 - 1	38.41	38.10	38.31	17.09	16.78	16.99
2a	Mfg. 10 - 2	39.48	39.23	39.28	18.16	17.91	17.96
3a	Mfg. 10 - 3	34.47	34.18	34.12	13.15	12.87	12.80
4a	Mfg. 9 - 1	37.47	37.35	37.38	16.16	16.03	16.06
5a	Mfg. 9 - 2	38.46	38.17	38.12	17.14	16.85	16.80
6a	Mfg. 9 - 3	31.54	31.29	31.18	10.22	9.97	9.86
7a	circuit breaker	40.70	40.66	40.65	19.38	19.34	19.33
8a	line wire	34.07	34.00	34.12	12.75	12.69	12.80
9a	line wire splicing device	35.66	35.31	35.13	14.34	13.99	13.81
10a	load wire	32.81	32.43	32.75	11.49	11.11	11.43
11a	load wire splicing device	33.16	32.96	32.94	11.84	11.64	11.62
12a	room ambient	21.37	21.31	21.27			
13a	current (amps)	15.02	15.02	15.02			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1b - thru Mfg. 2 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		129	134	139			
time (HH:MM:SS)		2:06:07	2:11:06	2:16:07			
1b	Mfg. 10 - 1	31.13	31.54	31.37	9.64	10.05	9.88
2b	Mfg. 10 - 2	30.12	30.39	30.44	8.63	8.90	8.95
3b	Mfg. 10 - 3	28.95	29.13	29.19	7.46	7.64	7.70
4b	Mfg. 9 - 1	28.47	28.67	28.85	6.98	7.18	7.36
5b	Mfg. 9 - 2	28.62	29.01	28.85	7.13	7.52	7.36
6b	Mfg. 9 - 3	29.94	30.21	30.11	8.45	8.72	8.62
7b	circuit breaker	41.81	41.46	41.80	20.32	19.97	20.31
8b	line wire	31.66	31.83	32.15	10.17	10.34	10.66
	line wire splicing device						
9b		29.57	30.02	30.13	8.08	8.53	8.64
10b	load wire	28.92	29.64	29.57	7.43	8.15	8.08
	load wire splicing device						
11b		30.62	31.06	31.03	9.13	9.57	9.54
12b	room ambient	21.30	21.89	21.28			
13b	current (amps)	10.01	10.01	10.01			

Test 1b - thru Mfg. 2 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		122	127	132			
time (HH:MM:SS)		2:00:00	2:05:00	2:10:00			
1b	Mfg. 10 - 1	39.02	38.87	38.81	17.86	17.72	17.65
2b	Mfg. 10 - 2	38.54	38.42	38.37	17.38	17.26	17.22
3b	Mfg. 10 - 3	35.00	34.94	34.56	13.84	13.78	13.40
4b	Mfg. 9 - 1	34.32	34.17	34.19	13.16	13.01	13.03
5b	Mfg. 9 - 2	33.68	33.52	33.44	12.52	12.36	12.29
6b	Mfg. 9 - 3	32.62	32.41	32.27	11.46	11.25	11.11
7b	circuit breaker	44.60	44.48	44.38	23.44	23.32	23.22
8b	line wire	33.27	33.12	33.14	12.11	11.96	11.98
	line wire splicing device						
9b		31.50	31.19	31.26	10.34	10.03	10.10
10b	load wire	31.96	31.65	31.72	10.81	10.49	10.56
	load wire splicing device						
11b		30.27	29.89	29.93	9.12	8.73	8.78
12b	room ambient	21.26	21.14	21.08			
13b	current (amps)	15.01	15.01	15.01			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1c - thru Mfg. 3 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		67	72	77			
time (HH:MM:SS)		1:04:00	1:09:00	1:14:00			
1c	Mfg. 10 - 1	31.05	30.92	30.45	9.04	8.91	8.44
2c	Mfg. 10 - 2	32.97	32.85	32.26	10.96	10.84	10.25
3c	Mfg. 10 - 3	29.07	28.94	28.28	7.06	6.93	6.27
4c	Mfg. 9 - 1	29.52	29.28	29.21	7.51	7.27	7.20
5c	Mfg. 9 - 2	30.06	29.90	29.40	8.05	7.89	7.39
6c	Mfg. 9 - 3	28.41	28.41	27.55	6.40	6.40	5.54
7c	circuit breaker	34.97	34.66	34.67	12.96	12.65	12.66
8c	line wire	31.77	31.18	30.88	9.76	9.17	8.87
9c	line wire splicing device	28.89	28.20	27.63	6.88	6.19	5.62
10c	load wire	31.27	30.69	30.26	9.26	8.68	8.25
11c	load wire splicing device	31.39	30.47	29.53	9.38	8.46	7.52
12c	room ambient	22.35	21.99	21.69			
13c	current (amps)	10.01	10.01	10.01			

Test 1c - thru Mfg. 3 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		122	127	132			
time (HH:MM:SS)		2:00:00	2:05:00	2:10:00			
1c	Mfg. 10 - 1	36.19	35.94	35.85	15.02	14.77	14.68
2c	Mfg. 10 - 2	39.95	39.76	39.70	18.78	18.59	18.53
3c	Mfg. 10 - 3	39.01	39.15	38.69	17.85	17.98	17.52
4c	Mfg. 9 - 1	33.32	33.13	33.09	12.15	11.96	11.92
5c	Mfg. 9 - 2	34.01	33.90	33.74	12.84	12.74	12.57
6c	Mfg. 9 - 3	32.95	32.95	32.64	11.78	11.78	11.47
7c	circuit breaker	41.75	41.55	41.58	20.59	20.38	20.41
8c	line wire	30.73	30.68	30.61	9.56	9.51	9.44
9c	line wire splicing device	32.20	31.82	31.87	11.04	10.65	10.70
10c	load wire	31.34	31.12	31.14	10.17	9.95	9.97
11c	load wire splicing device	29.64	29.52	29.42	8.47	8.35	8.25
12c	room ambient	21.29	21.13	21.09			
13c	current (amps)	15.01	15.01	15.01			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2a - thru Mfg. 1 10-amp breaker at 135% current (10A * 135% = 13.5A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #							
time (MM:SS)		7:20	7:40	8:00			
	Breaker trip time	8:20					
1a	Mfg. 11 - 1	30.60	30.69	30.76	8.65	8.73	8.80
2a	Mfg. 11 - 2	30.73	30.83	30.87	8.78	8.88	8.92
3a	Mfg. 11 - 3	29.72	29.82	29.85	7.76	7.87	7.89
4a	Mfg. 8 - 1	30.66	30.77	30.88	8.70	8.81	8.93
5a	Mfg. 8 - 2	30.87	30.96	31.05	8.91	9.01	9.09
6a	Mfg. 8 - 3	30.39	30.50	30.55	8.43	8.54	8.59
7a	circuit breaker	34.21	34.43	34.65	12.26	12.47	12.70
8a	line wire	38.55	38.70	38.80	16.59	16.74	16.85
9a	line wire splicing device	34.64	34.68	34.50	12.68	12.72	12.55
10a	load wire	36.44	36.44	36.36	14.49	14.48	14.40
11a	load wire splicing device	35.04	35.05	34.84	13.09	13.09	12.88
12a	room ambient	22.00	21.97	21.91			
13a	current (amps)	13.52	13.52	13.52			

Test 2a - thru Mfg. 1 15-amp breaker at 135% current (15A * 135% = 20.25A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		60	61	62			
time (MM:SS)		18:20	18:40	19:00			
	Breaker trip time	19:20					
1a	Mfg. 11 - 1	39.87	39.91	39.90	18.05	18.09	18.08
2a	Mfg. 11 - 2	40.66	40.69	40.70	18.84	18.87	18.88
3a	Mfg. 11 - 3	36.77	36.77	36.76	14.95	14.95	14.94
4a	Mfg. 8 - 1	40.83	40.88	40.89	19.01	19.06	19.07
5a	Mfg. 8 - 2	40.41	40.45	40.47	18.59	18.63	18.65
6a	Mfg. 8 - 3	39.06	39.09	39.15	17.24	17.27	17.33
7a	circuit breaker	51.78	51.96	52.02	29.96	30.14	30.20
8a	line wire	43.47	43.51	43.49	21.65	21.69	21.67
9a	line wire splicing device	48.83	48.80	48.22	27.02	26.99	26.40
10a	load wire	41.01	41.02	41.12	19.19	19.20	19.30
11a	load wire splicing device	42.69	42.60	42.48	20.87	20.78	20.66
12a	room ambient	21.84	21.84	21.78			
13a	current (amps)	19.97	19.97	20.24			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2b - thru Mfg. 2 10-amp breaker at 135% current ($10A * 135\% = 13.5A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		16	17	18		
time (MM:SS)		4:20	4:40	5:00		
	Breaker trip time	5:20				
1b	Mfg. 11 - 1	29.25	29.41	29.55	6.91	7.21
2b	Mfg. 11 - 2	28.86	29.03	29.22	6.52	6.88
3b	Mfg. 11 - 3	28.34	28.44	28.54	6.00	6.20
4b	Mfg. 8 - 1	29.37	29.59	29.79	7.03	7.45
5b	Mfg. 8 - 2	30.27	30.43	30.67	7.93	8.33
6b	Mfg. 8 - 3	28.84	28.97	29.10	6.50	6.76
7b	circuit breaker	34.99	35.63	36.29	12.65	13.95
8b	line wire	34.20	34.58	34.92	11.86	12.58
9b	line wire splicing device	33.21	33.11	33.12	10.87	10.77
10b	load wire	30.95	31.14	31.38	8.61	9.04
11b	load wire splicing device	32.76	32.73	32.78	10.42	10.44
12b	room ambient	22.40	22.34	22.29		
13b	current (amps)	13.51	13.51	13.51		

Test 2b - thru Mfg. 2 15-amp breaker at 135% current ($15A * 135\% = 20.25A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		13	14	15		
time (MM:SS)		2:20	2:40	3:00		
	Breaker trip time	3:20				
1b	Mfg. 11 - 1	31.85	32.56	33.17	9.91	11.23
2b	Mfg. 11 - 2	31.27	32.00	32.64	9.33	10.70
3b	Mfg. 11 - 3	30.01	30.61	31.08	8.07	9.14
4b	Mfg. 8 - 1	31.78	32.43	33.07	9.84	11.13
5b	Mfg. 8 - 2	32.35	32.97	33.48	10.41	11.54
6b	Mfg. 8 - 3	31.74	32.37	32.83	9.80	10.89
7b	circuit breaker	36.50	38.10	39.50	14.56	17.56
8b	line wire	32.89	33.90	34.83	10.95	12.89
9b	line wire splicing device	34.98	35.61	36.11	13.04	14.17
10b	load wire	33.90	34.76	35.58	11.96	13.64
11b	load wire splicing device	35.84	36.48	37.04	13.90	15.10
12b	room ambient	21.94	21.93	21.96		
13b	current (amps)	20.28	20.27	20.27		

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2c - thru Mfg. 3 10-amp breaker at 135% current ($10A * 135\% = 13.5A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		59	60	61			
time (MM:SS)		18:40	19:00	19:20			
	Breaker trip time	19:40					
1c	Mfg. 11 - 1	34.08	34.15	34.18	11.70	11.78	11.81
2c	Mfg. 11 - 2	33.23	33.27	33.31	10.85	10.89	10.93
3c	Mfg. 11 - 3	31.22	31.25	31.28	8.85	8.87	8.90
4c	Mfg. 8 - 1	33.48	33.50	33.56	11.10	11.13	11.19
5c	Mfg. 8 - 2	32.68	32.75	32.80	10.31	10.37	10.42
6c	Mfg. 8 - 3	31.96	32.03	32.09	9.58	9.66	9.71
7c	circuit breaker	43.05	43.08	43.19	20.67	20.71	20.81
8c	line wire	38.04	38.09	38.14	15.67	15.72	15.76
9c	line wire splicing device	33.55	33.75	33.89	11.17	11.38	11.51
10c	load wire	37.55	37.62	37.70	15.17	15.24	15.33
11c	load wire splicing device	35.83	36.09	36.28	13.46	13.71	13.91
12c	room ambient	22.51	22.28	22.34			
13c	current (amps)	13.51	13.51	13.51			

Test 2c - thru Mfg. 3 15-amp breaker at 135% current ($15A * 135\% = 20.25A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		20	21	22			
time (MM:SS)		5:00	5:20	5:40			
	Breaker trip time	6:00					
1c	Mfg. 11 - 1	34.62	34.96	35.21	12.63	12.97	13.22
2c	Mfg. 11 - 2	35.65	35.96	36.17	13.65	13.97	14.18
3c	Mfg. 11 - 3	33.85	34.05	34.25	11.85	12.05	12.25
4c	Mfg. 8 - 1	34.94	35.23	35.47	12.95	13.24	13.48
5c	Mfg. 8 - 2	35.87	36.13	36.37	13.87	14.13	14.38
6c	Mfg. 8 - 3	34.38	34.60	34.74	12.38	12.61	12.75
7c	circuit breaker	42.69	43.47	44.15	20.69	21.47	22.16
8c	line wire	36.07	36.49	36.77	14.08	14.50	14.78
9c	line wire splicing device	38.93	39.23	39.49	16.94	17.24	17.49
10c	load wire	37.64	37.92	38.15	15.64	15.92	16.16
11c	load wire splicing device	35.65	35.84	35.95	13.66	13.85	13.96
12c	room ambient	21.95	22.09	21.93			
13c	current (amps)	20.19	20.19	20.17			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2a - thru Mfg. 1 10-amp breaker at 135% current (10A * 135% = 13.5A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		26	27	28			
time (MM:SS)		7:40	8:00	8:20			
	Breaker trip time	8:40					
1a	Mfg. 10 - 1	33.38	33.55	33.72	11.54	11.72	11.89
2a	Mfg. 10 - 2	32.41	32.50	32.60	10.58	10.67	10.77
3a	Mfg. 10 - 3	30.50	30.58	30.68	8.66	8.75	8.85
4a	Mfg. 9 - 1	30.51	30.62	30.74	8.67	8.79	8.91
5a	Mfg. 9 - 2	30.63	30.73	30.86	8.80	8.89	9.02
6a	Mfg. 9 - 3	29.45	29.52	29.63	7.62	7.69	7.79
7a	circuit breaker	34.35	34.60	34.84	12.51	12.77	13.00
8a	line wire	38.69	38.85	39.02	16.85	17.01	17.18
9a	line wire splicing device	34.03	34.11	34.24	12.19	12.27	12.40
10a	load wire	36.42	36.48	36.58	14.59	14.65	14.74
11a	load wire splicing device	36.28	36.41	36.59	14.45	14.58	14.76
12a	room ambient	21.84	21.90	21.76			
13a	current (amps)	13.52	13.52	13.52			

Test 2a - thru Mfg. 1 15-amp breaker at 135% current (15A * 135% = 20.25A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		65	66	67			
time (MM:SS)		20:00	20:20	20:40			
	Breaker trip time	21:00					
1a	Mfg. 10 - 1	47.14	47.05	47.05	26.19	26.10	26.09
2a	Mfg. 10 - 2	49.33	49.35	49.30	28.38	28.39	28.35
3a	Mfg. 10 - 3	43.32	43.29	43.14	22.36	22.34	22.19
4a	Mfg. 9 - 1	45.67	45.67	45.73	24.72	24.71	24.78
5a	Mfg. 9 - 2	46.98	46.95	46.85	26.03	25.99	25.90
6a	Mfg. 9 - 3	38.91	38.80	38.65	17.95	17.84	17.69
7a	circuit breaker	52.18	52.30	52.40	31.23	31.34	31.45
8a	line wire	43.36	43.34	43.31	22.40	22.39	22.35
9a	line wire splicing device	46.95	46.94	46.87	26.00	25.99	25.91
10a	load wire	41.51	41.36	41.20	20.56	20.41	20.25
11a	load wire splicing device	42.93	42.85	42.57	21.97	21.89	21.62
12a	room ambient	20.94	20.94	20.98			
13a	current (amps)	20.29	20.28	20.28			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2b - thru Mfg. 2 10-amp breaker at 135% current ($10A * 135\% = 13.5A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		21	22	23			
time (MM:SS)		5:40	6:00	6:20			
	Breaker trip time	6:40					
1b	Mfg. 10 - 1	31.86	32.13	32.38	9.94	10.21	10.46
2b	Mfg. 10 - 2	32.09	32.28	32.45	10.17	10.36	10.53
3b	Mfg. 10 - 3	30.06	30.24	30.38	8.14	8.32	8.46
4b	Mfg. 9 - 1	29.45	29.60	29.73	7.53	7.68	7.81
5b	Mfg. 9 - 2	30.16	30.32	30.49	8.23	8.40	8.57
6b	Mfg. 9 - 3	29.34	29.52	29.64	7.42	7.60	7.72
7b	circuit breaker	37.11	37.68	38.17	15.19	15.76	16.25
8b	line wire	35.37	35.59	35.81	13.44	13.67	13.88
9b	line wire splicing device	32.21	32.37	32.46	10.28	10.45	10.54
10b	load wire	31.36	31.58	31.73	9.44	9.66	9.80
11b	load wire splicing device	35.28	35.40	35.49	13.36	13.47	13.56
12b	room ambient	21.93	21.95	21.88			
13b	current (amps)	13.50	13.50	13.50			

Test 2b - thru Mfg. 2 15-amp breaker at 135% current ($15A * 135\% = 20.25A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		13	14	15			
time (MM:SS)		2:40	3:00	3:20			
	Breaker trip time	3:40					
1b	Mfg. 10 - 1	34.43	35.44	36.33	13.42	14.43	15.32
2b	Mfg. 10 - 2	35.56	36.51	37.33	14.56	15.51	16.33
3b	Mfg. 10 - 3	33.00	33.73	34.31	12.00	12.73	13.30
4b	Mfg. 9 - 1	32.70	33.42	34.00	11.69	12.41	13.00
5b	Mfg. 9 - 2	32.65	33.31	33.89	11.64	12.30	12.89
6b	Mfg. 9 - 3	30.85	31.44	31.99	9.85	10.43	10.98
7b	circuit breaker	36.44	37.96	39.35	15.44	16.96	18.34
8b	line wire	32.46	33.42	34.28	11.45	12.41	13.28
9b	line wire splicing device	35.23	35.84	36.40	14.22	14.84	15.39
10b	load wire	33.42	34.26	35.03	12.42	13.26	14.02
11b	load wire splicing device	33.28	33.92	34.50	12.27	12.91	13.49
12b	room ambient	20.93	21.01	21.08			
13b	current (amps)	20.28	20.28	20.28			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2c - thru Mfg. 3 10-amp breaker at 135% current (10A * 135% = 13.5A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature (°C)		Rise
scan #		53	54	55			
time (MM:SS)		16:20	16:40	17:00			
	Breaker trip time	17:20					
1c	Mfg. 10 - 1	35.58	35.62	35.62	13.37	13.41	13.41
2c	Mfg. 10 - 2	36.59	36.62	36.62	14.38	14.41	14.41
3c	Mfg. 10 - 3	32.94	32.95	32.98	10.73	10.74	10.77
4c	Mfg. 9 - 1	33.08	33.07	33.07	10.87	10.86	10.86
5c	Mfg. 9 - 2	33.95	33.93	33.90	11.73	11.72	11.69
6c	Mfg. 9 - 3	31.62	31.62	31.58	9.40	9.41	9.37
7c	circuit breaker	41.72	41.81	41.92	19.51	19.60	19.71
8c	line wire	38.68	38.60	38.52	16.47	16.39	16.31
9c	line wire splicing device	33.41	33.23	33.04	11.19	11.02	10.83
10c	load wire	37.53	37.41	37.27	15.31	15.20	15.06
11c	load wire splicing device	38.23	37.83	37.38	16.01	15.62	15.17
12c	room ambient	22.28	22.22	22.14			
13c	current (amps)	13.50	13.50	13.50			

Test 2c - thru Mfg. 3 15-amp breaker at 135% current (15A * 135% = 20.25A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature		Rise (°C)
scan #		22	23	24			
time (MM:SS)		5:40	6:00	6:20			
	Breaker trip time	6:40					
1c	Mfg. 10 - 1	37.66	38.19	38.64	16.09	16.61	17.07
2c	Mfg. 10 - 2	44.95	45.50	45.96	23.38	23.93	24.39
3c	Mfg. 10 - 3	44.95	45.37	45.69	23.38	23.80	24.12
4c	Mfg. 9 - 1	35.48	35.83	36.20	13.90	14.26	14.63
5c	Mfg. 9 - 2	38.33	38.69	39.10	16.75	17.12	17.52
6c	Mfg. 9 - 3	36.86	37.22	37.59	15.28	15.65	16.02
7c	circuit breaker	42.83	43.50	44.14	21.26	21.93	22.56
8c	line wire	35.89	36.21	36.61	14.32	14.64	15.04
9c	line wire splicing device	40.91	41.17	41.52	19.33	19.60	19.95
10c	load wire	37.99	38.35	38.72	16.42	16.78	17.15
11c	load wire splicing device	39.30	39.51	39.86	17.72	17.93	18.29
12c	room ambient	21.55	21.59	21.59			
13c	current (amps)	20.30	20.26	20.27			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3a - thru Mfg. 1 10-amp breaker at 150% current (10A * 150% = 15A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		19	20	21			
time (MM:SS)		2:00	2:10	2:20			
	Breaker trip time	2:30					
1a	Mfg. 11 - 1	27.90	28.21	28.45	5.51	5.83	6.06
2a	Mfg. 11 - 2	27.85	28.17	28.44	5.46	5.79	6.06
3a	Mfg. 11 - 3	27.44	27.71	27.97	5.05	5.32	5.58
4a	Mfg. 8 - 1	28.03	28.30	28.55	5.64	5.91	6.17
5a	Mfg. 8 - 2	28.67	28.93	29.21	6.28	6.55	6.83
6a	Mfg. 8 - 3	28.12	28.37	28.63	5.73	5.98	6.24
7a	circuit breaker	29.23	29.65	30.04	6.84	7.27	7.65
8a	line wire	33.45	33.99	34.55	11.06	11.60	12.16
9a	line wire splicing device	33.38	33.88	34.38	10.99	11.49	11.99
10a	load wire	32.35	32.80	33.28	9.96	10.41	10.89
11a	load wire splicing device	34.69	35.13	35.60	12.30	12.74	13.21
12a	room ambient	22.40	22.39	22.37			
13a	current (amps)	15.02	15.02	15.02			

Test 3a - thru Mfg. 1 15-amp breaker at 150% current (15A * 150% = 22.5A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		31	32	33			
time (MM:SS)		3:40	3:50	4:00			
	Breaker trip time	4:10					
1a	Mfg. 11 - 1	36.08	36.34	36.60	13.46	13.72	13.98
2a	Mfg. 11 - 2	36.41	36.67	36.97	13.79	14.05	14.35
3a	Mfg. 11 - 3	34.72	34.88	35.08	12.10	12.26	12.46
4a	Mfg. 8 - 1	36.33	36.58	36.86	13.71	13.96	14.24
5a	Mfg. 8 - 2	37.14	37.38	37.62	14.53	14.76	15.00
6a	Mfg. 8 - 3	36.40	36.56	36.84	13.78	13.94	14.22
7a	circuit breaker	40.83	41.35	41.83	18.21	18.73	19.21
8a	line wire	39.85	40.31	40.75	17.23	17.69	18.13
9a	line wire splicing device	49.53	49.93	50.18	26.91	27.31	27.56
10a	load wire	40.21	40.60	40.99	17.60	17.98	18.37
11a	load wire splicing device	45.48	45.83	46.22	22.86	23.21	23.60
12a	room ambient	22.65	22.62	22.58			
13a	current (amps)	22.56	22.53	22.53			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3b - thru Mfg. 2 10-amp breaker at 150% current (10A * 150% = 15A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		19	20	21		
time (MM:SS)		2:00	2:10	2:20		
	Breaker trip time	2:30				
1b	Mfg. 11 - 1	28.11	28.40	28.72	5.67	6.28
2b	Mfg. 11 - 2	27.73	27.97	28.26	5.29	5.82
3b	Mfg. 11 - 3	27.57	27.80	28.05	5.12	5.60
4b	Mfg. 8 - 1	28.38	28.63	28.91	5.93	6.47
5b	Mfg. 8 - 2	29.23	29.50	29.82	6.79	7.37
6b	Mfg. 8 - 3	28.00	28.25	28.53	5.56	6.09
7b	circuit breaker	30.38	30.93	31.50	7.94	9.06
8b	line wire	31.30	31.79	32.30	8.85	9.86
9b	line wire splicing device	32.82	33.29	33.71	10.38	11.27
10b	load wire	28.66	29.10	29.50	6.21	7.06
11b	load wire splicing device	33.26	33.63	33.95	10.82	11.51
12b	room ambient	22.47	22.43	22.43		
13b	current (amps)	15.01	15.01	15.01		

Test 3b - thru Mfg. 2 15-amp breaker at 150% current (15A * 150% = 22.5A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		13	14	15		
time (MM:SS)		:40	:50	1:00		
	Breaker trip time	1:10				
1b	Mfg. 11 - 1	26.84	27.76	28.60	4.39	6.15
2b	Mfg. 11 - 2	26.26	27.11	27.94	3.81	5.49
3b	Mfg. 11 - 3	26.03	26.75	27.44	3.58	4.99
4b	Mfg. 8 - 1	26.61	27.54	28.41	4.16	5.96
5b	Mfg. 8 - 2	27.59	28.55	29.46	5.14	7.01
6b	Mfg. 8 - 3	27.23	28.09	28.93	4.78	6.48
7b	circuit breaker	27.33	28.59	29.90	4.88	7.45
8b	line wire	26.59	27.53	28.44	4.14	5.99
9b	line wire splicing device	29.28	30.58	31.77	6.83	9.32
10b	load wire	27.88	28.93	29.91	5.43	7.46
11b	load wire splicing device	29.84	31.22	32.45	7.39	10.00
12b	room ambient	22.46	22.43	22.45		
13b	current (amps)	22.51	22.49	22.49		

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3c - thru Mfg. 3 10-amp breaker at 150% current (10A * 150% = 15A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature (°C)		Rise
scan #		37	38	39			
time (MM:SS)		5:00	5:10	5:20			
	Breaker trip time	5:30					
1c	Mfg. 11 - 1	32.34	32.46	32.62	9.83	9.96	10.12
2c	Mfg. 11 - 2	31.80	31.94	32.06	9.30	9.44	9.56
3c	Mfg. 11 - 3	29.96	30.07	30.17	7.46	7.56	7.67
4c	Mfg. 8 - 1	31.82	31.94	32.07	9.32	9.44	9.57
5c	Mfg. 8 - 2	31.64	31.77	31.86	9.13	9.26	9.36
6c	Mfg. 8 - 3	31.07	31.17	31.31	8.57	8.67	8.81
7c	circuit breaker	37.24	37.53	37.80	14.74	15.03	15.30
8c	line wire	38.50	38.75	39.00	16.00	16.25	16.50
9c	line wire splicing device	35.73	35.83	35.94	13.23	13.33	13.43
10c	load wire	37.84	38.06	38.26	15.33	15.56	15.75
11c	load wire splicing device	38.75	38.81	38.93	16.24	16.31	16.43
12c	room ambient	22.50	22.49	22.52			
13c	current (amps)	15.01	15.01	15.01			

Test 3c - thru Mfg. 3 15-amp breaker at 150% current (15A * 150% = 22.5A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature (°C)		Rise
scan #		23	24	25			
time (MM:SS)		2:20	2:30	2:40			
	Breaker trip time	2:50					
1c	Mfg. 11 - 1	32.80	33.29	33.73	10.40	10.89	11.33
2c	Mfg. 11 - 2	34.13	34.67	35.12	11.73	12.27	12.72
3c	Mfg. 11 - 3	32.29	32.77	33.17	9.89	10.37	10.77
4c	Mfg. 8 - 1	33.21	33.67	34.07	10.81	11.27	11.67
5c	Mfg. 8 - 2	34.62	35.08	35.48	12.22	12.68	13.08
6c	Mfg. 8 - 3	32.76	33.21	33.64	10.36	10.81	11.24
7c	circuit breaker	37.29	38.07	38.83	14.89	15.67	16.43
8c	line wire	33.28	33.93	34.55	10.88	11.53	12.15
9c	line wire splicing device	40.01	40.55	41.07	17.61	18.15	18.67
10c	load wire	36.15	36.74	37.30	13.75	14.34	14.90
11c	load wire splicing device	37.79	38.32	38.82	15.39	15.92	16.42
12c	room ambient	22.38	22.41	22.41			
13c	current (amps)	22.43	22.44	22.42			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3a - thru Mfg. 1 10-amp breaker at 150% current (10A * 150% = 15A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		23	24	25			
time (MM:SS)		2:20	2:30	2:40			
	Breaker trip time	2:50					
1a	Mfg. 10 - 1	29.81	30.21	30.55	7.56	7.96	8.30
2a	Mfg. 10 - 2	29.70	30.02	30.29	7.44	7.77	8.04
3a	Mfg. 10 - 3	28.37	28.62	28.85	6.12	6.37	6.60
4a	Mfg. 9 - 1	28.22	28.46	28.69	5.97	6.21	6.44
5a	Mfg. 9 - 2	28.46	28.71	28.94	6.21	6.46	6.69
6a	Mfg. 9 - 3	27.73	27.96	28.13	5.48	5.71	5.88
7a	circuit breaker	29.83	30.21	30.53	7.58	7.96	8.28
8a	line wire	34.40	34.90	35.38	12.15	12.65	13.13
9a	line wire splicing device	32.53	32.88	33.18	10.28	10.63	10.93
10a	load wire	33.43	33.88	34.25	11.17	11.63	12.00
11a	load wire splicing device	37.25	37.47	37.66	15.00	15.22	15.41
12a	room ambient	22.28	22.24	22.24			
13a	current (amps)	15.02	15.02	15.02			

Test 3a - thru Mfg. 1 15-amp breaker at 150% current (15A * 150% = 22.5A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		38	39	40			
time (MM:SS)		4:00	4:10	4:20			
	Breaker trip time	4:30					
1a	Mfg. 10 - 1	40.53	40.89	41.27	18.74	19.10	19.48
2a	Mfg. 10 - 2	42.28	42.67	43.05	20.49	20.88	21.26
3a	Mfg. 10 - 3	39.25	39.54	39.81	17.46	17.75	18.02
4a	Mfg. 9 - 1	39.03	39.37	39.68	17.24	17.58	17.89
5a	Mfg. 9 - 2	40.06	40.40	40.75	18.27	18.61	18.96
6a	Mfg. 9 - 3	35.92	36.14	36.35	14.14	14.35	14.56
7a	circuit breaker	41.66	42.13	42.62	19.87	20.34	20.83
8a	line wire	40.15	40.56	40.91	18.36	18.77	19.12
9a	line wire splicing device	47.60	47.94	48.23	25.81	26.16	26.44
10a	load wire	40.83	41.12	41.46	19.04	19.33	19.67
11a	load wire splicing device	46.50	46.62	46.74	24.72	24.83	24.95
12a	room ambient	21.81	21.79	21.76			
13a	current (amps)	22.35	22.35	22.35			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3b - thru Mfg. 2 10-amp breaker at 150% current (10A * 150% = 15A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		21	22	23			
time (MM:SS)		2:00	2:10	2:20			
	Breaker trip time	2:30					
1b	Mfg. 10 - 1	28.72	29.12	29.50	6.58	6.98	7.36
2b	Mfg. 10 - 2	29.55	29.94	30.33	7.41	7.80	8.19
3b	Mfg. 10 - 3	28.01	28.30	28.56	5.87	6.16	6.42
4b	Mfg. 9 - 1	27.72	28.02	28.27	5.58	5.88	6.13
5b	Mfg. 9 - 2	27.97	28.28	28.55	5.83	6.14	6.41
6b	Mfg. 9 - 3	27.58	27.82	28.09	5.44	5.68	5.95
7b	circuit breaker	30.55	31.13	31.74	8.41	8.99	9.60
8b	line wire	31.18	31.69	32.20	9.04	9.55	10.06
9b	line wire splicing device	31.46	31.83	32.14	9.32	9.69	10.00
10b	load wire	28.42	28.81	29.21	6.28	6.67	7.07
11b	load wire splicing device	36.24	36.63	36.93	14.10	14.49	14.79
12b	room ambient	22.20	22.13	22.09			
13b	current (amps)	15.00	15.00	15.00			

Test 3b - thru Mfg. 2 15-amp breaker at 150% current (15A * 150% = 22.5A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		18	19	20			
time (MM:SS)		:40	:50	1:00			
	Breaker trip time	1:10					
1b	Mfg. 10 - 1	25.84	26.82	27.77	4.13	5.12	6.06
2b	Mfg. 10 - 2	29.58	31.10	32.54	7.88	9.40	10.83
3b	Mfg. 10 - 3	32.64	34.09	35.41	10.93	12.39	13.71
4b	Mfg. 9 - 1	25.84	26.77	27.65	4.14	5.07	5.94
5b	Mfg. 9 - 2	27.74	28.90	29.94	6.03	7.19	8.24
6b	Mfg. 9 - 3	27.36	28.35	29.32	5.65	6.65	7.62
7b	circuit breaker	26.69	27.90	29.05	4.98	6.20	7.35
8b	line wire	25.29	26.13	26.94	3.59	4.42	5.23
9b	line wire splicing device	28.85	30.25	31.50	7.14	8.54	9.80
10b	load wire	27.35	28.42	29.40	5.65	6.72	7.70
11b	load wire splicing device	29.03	30.42	31.68	7.33	8.71	9.98
12b	room ambient	21.68	21.70	21.73			
13b	current (amps)	22.56	22.55	22.52			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3c - thru Mfg. 3 10-amp breaker at 150% current ($10A * 150\% = 15A$); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		44	45	46			
time (MM:SS)		5:50	6:00	6:10			
	Breaker trip time	6:20					
1c	Mfg. 10 - 1	33.95	34.06	34.18	12.26	12.38	12.49
2c	Mfg. 10 - 2	34.86	35.03	35.17	13.17	13.34	13.48
3c	Mfg. 10 - 3	32.06	32.16	32.23	10.37	10.47	10.55
4c	Mfg. 9 - 1	31.67	31.77	31.89	9.98	10.08	10.20
5c	Mfg. 9 - 2	31.89	31.99	32.07	10.20	10.30	10.39
6c	Mfg. 9 - 3	30.51	30.58	30.63	8.82	8.89	8.94
7c	circuit breaker	37.51	37.73	37.94	15.82	16.04	16.25
8c	line wire	38.17	38.32	38.46	16.48	16.63	16.77
9c	line wire splicing device	33.48	33.53	33.58	11.79	11.84	11.89
10c	load wire	37.25	37.38	37.51	15.57	15.70	15.82
11c	load wire splicing device	39.05	39.08	39.09	17.36	17.39	17.40
12c	room ambient	21.68	21.69	21.69			
13c	current (amps)	15.00	15.00	15.00			

Test 3c - thru Mfg. 3 15-amp breaker at 150% current ($15A * 150\% = 22.5A$); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		28	29	30			
time (MM:SS)		2:20	2:30	2:40			
	Breaker trip time	2:50					
1c	Mfg. 10 - 1	28.08	27.72	27.38	6.22	5.87	5.53
2c	Mfg. 10 - 2	27.85	27.43	27.08	5.99	5.58	5.23
3c	Mfg. 10 - 3	26.82	26.45	26.13	4.97	4.59	4.27
4c	Mfg. 9 - 1	26.62	26.30	26.02	4.76	4.45	4.17
5c	Mfg. 9 - 2	26.78	26.44	26.12	4.92	4.58	4.27
6c	Mfg. 9 - 3	26.00	25.71	25.47	4.15	3.86	3.62
7c	circuit breaker	30.09	29.81	29.54	8.23	7.95	7.68
8c	line wire	27.46	27.28	27.08	5.61	5.42	5.22
9c	line wire splicing device	27.03	26.55	26.12	5.18	4.69	4.26
10c	load wire	27.36	27.10	26.84	5.50	5.24	4.98
11c	load wire splicing device	27.70	27.09	26.53	5.84	5.23	4.67
12c	room ambient	21.89	21.86	21.82			
13c	current (amps)	22.40	22.39	22.39			

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4a - thru Mfg. 1 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		10	11	12		
time (MM:SS)		:15	:21	:28		
	Breaker trip time	:35				
1a	Mfg. 11 - 1	24.11	24.67	25.32	2.07	3.28
2a	Mfg. 11 - 2	24.06	24.59	25.25	2.02	3.20
3a	Mfg. 11 - 3	24.07	24.57	25.16	2.03	3.12
4a	Mfg. 8 - 1	24.08	24.69	25.40	2.03	3.35
5a	Mfg. 8 - 2	24.66	25.33	26.11	2.61	4.06
6a	Mfg. 8 - 3	24.22	24.83	25.55	2.17	3.50
7a	circuit breaker	24.11	24.82	25.62	2.07	3.57
8a	line wire	27.40	28.75	30.11	5.35	8.06
9a	line wire splicing device	25.44	26.76	28.29	3.40	6.24
10a	load wire	26.61	27.77	28.96	4.57	6.91
11a	load wire splicing device	26.63	28.24	30.08	4.59	8.04
12a	room ambient	22.05	22.06	22.03		
13a	current (amps)	19.99	20.01	20.01		

Test 4a - thru Mfg. 1 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		20	21	22		
time (MM:SS)		:28	:35	:42		
	Breaker trip time	:49				
1a	Mfg. 11 - 1	27.71	28.87	30.04	5.22	7.55
2a	Mfg. 11 - 2	27.71	28.87	30.05	5.22	7.56
3a	Mfg. 11 - 3	27.95	28.97	30.04	5.46	7.54
4a	Mfg. 8 - 1	27.60	28.90	30.19	5.11	7.70
5a	Mfg. 8 - 2	28.56	29.91	31.25	6.06	8.76
6a	Mfg. 8 - 3	29.13	30.23	31.51	6.63	9.02
7a	circuit breaker	27.85	29.29	30.80	5.35	8.30
8a	line wire	29.17	30.44	31.74	6.68	9.24
9a	line wire splicing device	36.20	38.78	41.38	13.71	18.89
10a	load wire	29.69	31.07	32.48	7.20	9.98
11a	load wire splicing device	36.64	39.18	41.65	14.14	19.15
12a	room ambient	22.48	22.48	22.52		
13a	current (amps)	29.87	29.79	29.76		

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4b - thru Mfg. 2 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		10	11	12			
time (MM:SS)		:15	:21	:28			
	Breaker trip time	:35					
1b	Mfg. 11 - 1	23.92	24.53	25.23	2.00	2.60	3.30
2b	Mfg. 11 - 2	23.87	24.40	25.03	1.95	2.48	3.10
3b	Mfg. 11 - 3	24.04	24.56	25.19	2.11	2.64	3.27
4b	Mfg. 8 - 1	24.03	24.67	25.43	2.11	2.74	3.51
5b	Mfg. 8 - 2	24.81	25.54	26.38	2.89	3.62	4.46
6b	Mfg. 8 - 3	24.09	24.69	25.38	2.17	2.77	3.46
7b	circuit breaker	23.99	24.68	25.52	2.07	2.75	3.60
8b	line wire	25.64	26.65	27.71	3.72	4.73	5.78
9b	line wire splicing device	25.15	26.44	27.96	3.22	4.52	6.03
10b	load wire	23.65	24.33	25.10	1.73	2.41	3.18
11b	load wire splicing device	26.05	27.55	29.19	4.13	5.63	7.27
12b	room ambient	21.94	21.92	21.90			
13b	current (amps)	20.00	20.00	20.00			

Test 4b - thru Mfg. 2 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		16	17	18			
time (MM:SS)		:00	:09	:15			
	Breaker trip time	:21					
1b	Mfg. 11 - 1	22.78	24.58	25.64	0.28	2.08	3.14
2b	Mfg. 11 - 2	22.55	23.95	24.94	0.05	1.45	2.44
3b	Mfg. 11 - 3	22.78	24.32	25.15	0.28	1.82	2.65
4b	Mfg. 8 - 1	22.67	24.22	25.26	0.17	1.72	2.76
5b	Mfg. 8 - 2	23.01	25.35	26.56	0.52	2.85	4.06
6b	Mfg. 8 - 3	23.06	25.22	26.32	0.57	2.72	3.83
7b	circuit breaker	22.89	24.64	25.66	0.39	2.15	3.17
8b	line wire	22.78	24.14	25.26	0.28	1.64	2.76
9b	line wire splicing device	22.80	25.27	27.08	0.30	2.77	4.59
10b	load wire	22.73	25.29	26.72	0.23	2.79	4.22
11b	load wire splicing device	22.84	25.76	27.75	0.34	3.26	5.26
12b	room ambient	22.49	22.49	22.51			
13b	current (amps)	29.72	29.67	29.65			

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4c - thru Mfg. 3 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		16	17	18			
time (MM:SS)		:56	1:03	1:10			
	Breaker trip time	1:17					
1c	Mfg. 11 - 1	27.91	28.45	29.02	5.96	6.50	7.07
2c	Mfg. 11 - 2	27.83	28.34	28.85	5.88	6.39	6.90
3c	Mfg. 11 - 3	26.46	26.84	27.26	4.51	4.89	5.31
4c	Mfg. 8 - 1	28.33	28.89	29.46	6.38	6.94	7.51
5c	Mfg. 8 - 2	28.77	29.28	29.81	6.82	7.33	7.86
6c	Mfg. 8 - 3	27.76	28.25	28.71	5.81	6.30	6.76
7c	circuit breaker	30.95	31.72	32.52	8.99	9.77	10.56
8c	line wire	32.07	32.86	33.68	10.12	10.91	11.73
9c	line wire splicing device	31.50	32.36	33.19	9.54	10.41	11.24
10c	load wire	32.53	33.29	34.09	10.58	11.34	12.14
11c	load wire splicing device	36.35	37.44	38.34	14.40	15.49	16.39
12c	room ambient	22.03	21.91	21.92			
13c	current (amps)	20.00	20.00	20.00			

Test 4c - thru Mfg. 3 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		18	19	20			
time (MM:SS)		:15	:21	:28			
	Breaker trip time	:35					
1c	Mfg. 11 - 1	24.86	25.82	26.97	2.56	3.52	4.67
2c	Mfg. 11 - 2	25.87	27.00	28.27	3.57	4.70	5.97
3c	Mfg. 11 - 3	25.45	26.38	27.49	3.15	4.08	5.19
4c	Mfg. 8 - 1	25.11	26.19	27.48	2.81	3.89	5.18
5c	Mfg. 8 - 2	26.49	27.73	29.14	4.19	5.43	6.85
6c	Mfg. 8 - 3	25.08	26.08	27.24	2.78	3.78	4.94
7c	circuit breaker	25.44	26.60	28.04	3.14	4.30	5.74
8c	line wire	24.49	25.44	26.52	2.20	3.15	4.22
9c	line wire splicing device	27.39	29.24	31.37	5.09	6.95	9.07
10c	load wire	26.18	27.74	29.43	3.88	5.44	7.13
11c	load wire splicing device	26.21	27.89	29.79	3.91	5.59	7.49
12c	room ambient	22.31	22.30	22.29			
13c	current (amps)	29.59	29.78	29.83			

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4a - thru Mfg. 1 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		27	28	29		
time (MM:SS)		:15	:21	:28		
	Breaker trip time	:35				
1a	Mfg. 10 - 1	24.20	24.89	25.74	2.53	4.07
2a	Mfg. 10 - 2	24.11	24.81	25.65	2.45	3.99
3a	Mfg. 10 - 3	23.82	24.42	25.12	2.16	3.45
4a	Mfg. 9 - 1	23.70	24.28	24.96	2.04	3.29
5a	Mfg. 9 - 2	23.89	24.51	25.23	2.22	3.57
6a	Mfg. 9 - 3	23.66	24.22	24.90	1.99	3.23
7a	circuit breaker	23.81	24.47	25.29	2.14	3.63
8a	line wire	26.99	28.37	29.76	5.32	8.09
9a	line wire splicing device	24.05	25.15	26.46	2.39	4.79
10a	load wire	26.61	27.85	29.13	4.94	7.47
11a	load wire splicing device	28.24	30.24	32.42	6.58	10.75
12a	room ambient	21.68	21.67	21.66		
13a	current (amps)	20.02	20.03	20.03		

Test 4a - thru Mfg. 1 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		17	18	19		
time (MM:SS)		:28	:35	:42		
	Breaker trip time	:49				
1a	Mfg. 10 - 1	27.27	28.75	30.17	5.77	8.67
2a	Mfg. 10 - 2	28.89	30.53	32.07	7.38	10.56
3a	Mfg. 10 - 3	27.89	29.33	30.74	6.38	9.24
4a	Mfg. 9 - 1	27.16	28.54	29.90	5.66	8.39
5a	Mfg. 9 - 2	28.09	29.55	30.97	6.58	9.46
6a	Mfg. 9 - 3	27.93	29.14	30.27	6.43	8.77
7a	circuit breaker	26.82	28.27	29.71	5.32	8.20
8a	line wire	28.15	29.45	30.67	6.65	9.17
9a	line wire splicing device	34.08	36.63	38.99	12.57	17.49
10a	load wire	28.54	29.95	31.29	7.03	9.79
11a	load wire splicing device	35.97	38.68	41.18	14.47	19.67
12a	room ambient	21.49	21.52	21.51		
13a	current (amps)	29.88	29.83	29.82		

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4b - thru Mfg. 2 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		27	28	29		
time (MM:SS)		:15	:21	:28		
	Breaker trip time	:35				
1b	Mfg. 10 - 1	23.68	24.31	25.08	2.15	3.55
2b	Mfg. 10 - 2	24.00	24.79	25.66	2.47	4.13
3b	Mfg. 10 - 3	23.96	24.59	25.27	2.43	3.74
4b	Mfg. 9 - 1	23.67	24.25	24.93	2.14	3.40
5b	Mfg. 9 - 2	23.75	24.36	25.10	2.22	3.58
6b	Mfg. 9 - 3	23.79	24.37	25.03	2.26	3.50
7b	circuit breaker	23.69	24.36	25.21	2.16	3.69
8b	line wire	25.34	26.37	27.40	3.81	5.88
9b	line wire splicing device	24.37	25.54	26.91	2.84	5.38
10b	load wire	23.38	24.06	24.84	1.86	3.32
11b	load wire splicing device	28.62	30.57	32.60	7.09	11.07
12b	room ambient	21.54	21.54	21.50		
13b	current (amps)	19.99	19.99	19.99		

Test 4b - thru Mfg. 2 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		13	14	15		
time (MM:SS)		0:00	:09	:15		
	Breaker trip time	:21				
1b	Mfg. 10 - 1	21.91	23.26	24.56	0.52	3.16
2b	Mfg. 10 - 2	21.93	24.79	26.37	0.54	4.97
3b	Mfg. 10 - 3	21.91	23.93	25.26	0.52	3.87
4b	Mfg. 9 - 1	21.95	24.22	25.49	0.56	4.10
5b	Mfg. 9 - 2	21.93	24.57	25.87	0.54	4.48
6b	Mfg. 9 - 3	21.90	24.12	25.30	0.51	3.90
7b	circuit breaker	22.03	23.68	24.72	0.64	3.33
8b	line wire	22.07	23.08	24.22	0.68	2.83
9b	line wire splicing device	21.89	24.14	26.27	0.50	4.87
10b	load wire	21.93	24.17	25.69	0.54	4.30
11b	load wire splicing device	21.95	26.40	28.99	0.56	7.60
12b	room ambient	21.40	21.38	21.40		
13b	current (amps)	30.03	29.98	29.94		

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4c - thru Mfg. 3 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		33	34	35		
time (MM:SS)		:56	1:03	1:10		
	Breaker trip time	1:17				
1c	Mfg. 10 - 1	28.89	29.56	30.22	7.33	8.67
2c	Mfg. 10 - 2	29.13	29.80	30.47	7.57	8.92
3c	Mfg. 10 - 3	28.24	28.82	29.43	6.69	7.87
4c	Mfg. 9 - 1	27.96	28.54	29.11	6.41	6.98
5c	Mfg. 9 - 2	27.95	28.55	29.13	6.40	6.99
6c	Mfg. 9 - 3	27.87	28.37	28.89	6.31	6.82
7c	circuit breaker	30.46	31.20	31.96	8.91	9.65
8c	line wire	31.76	32.54	33.32	10.20	10.99
9c	line wire splicing device	30.32	31.15	31.96	8.77	9.60
10c	load wire	32.17	32.94	33.69	10.62	11.39
11c	load wire splicing device	39.40	40.57	41.66	17.85	19.02
12c	room ambient	21.59	21.54	21.53		
13c	current (amps)	20.00	20.00	20.00		

Test 4c - thru Mfg. 3 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		16	17	18		
time (MM:SS)		:21	:28	:35		
	Breaker trip time	:42				
1c	Mfg. 10 - 1	24.57	25.84	27.05	3.19	4.45
2c	Mfg. 10 - 2	28.42	30.54	32.56	7.04	9.16
3c	Mfg. 10 - 3	33.47	35.78	37.86	12.09	14.40
4c	Mfg. 9 - 1	24.87	26.08	27.27	3.49	4.70
5c	Mfg. 9 - 2	27.04	28.63	30.11	5.66	7.25
6c	Mfg. 9 - 3	26.95	28.35	29.72	5.57	6.97
7c	circuit breaker	25.75	27.15	28.60	4.37	5.77
8c	line wire	24.57	25.65	26.68	3.19	4.27
9c	line wire splicing device	27.76	29.81	31.74	6.38	8.43
10c	load wire	26.52	28.22	29.72	5.14	6.84
11c	load wire splicing device	27.66	29.85	31.88	6.28	8.47
12c	room ambient	21.40	21.37	21.36		
13c	current (amps)	29.34	29.29	30.17		

Appendix C5 Static Heating Testing Schneider Circuit Breaker

Test 1b - thru Mfg. 2 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		67	72	77			
time (HH:MM:SS)		1:04:00	1:09:00	1:14:00			
1b	Mfg. 10 - 1	33.66	33.62	33.48	12.17	12.13	11.99
2b	Mfg. 10 - 2	30.46	30.56	30.61	8.97	9.07	9.12
3b	Mfg. 10 - 3	28.97	29.03	28.87	7.48	7.54	7.38
4b	Mfg. 9 - 1	28.59	28.61	28.68	7.10	7.12	7.19
5b	Mfg. 9 - 2	29.99	29.94	29.81	8.50	8.45	8.32
6b	Mfg. 9 - 3	28.44	28.40	28.15	6.95	6.91	6.66
7b	circuit breaker	41.26	41.48	41.60	19.77	19.99	20.11
8b	line wire	31.15	30.97	30.89	9.66	9.48	9.40
9b	line wire splicing device	28.63	28.27	28.01	7.14	6.78	6.52
10b	load wire	28.45	28.20	28.09	6.96	6.71	6.60
11b	load wire splicing device	30.47	29.94	29.87	8.98	8.45	8.38
12b	room ambient	22.46	22.07	21.66			
13b	current (amps)	10.01	10.01	10.01			

Test 2b - thru Mfg. 2 10-amp breaker at 135% current (10A * 135% = 13.5A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		202	203	204			
time (MM:SS)		66:20	66:40	67:00			
	Breaker trip time	> 67 mins. (no trip)					
1b	Mfg. 10 - 1	40.89	40.89	40.88	18.96	18.97	18.96
2b	Mfg. 10 - 2	37.03	37.03	37.04	15.11	15.11	15.12
3b	Mfg. 10 - 3	34.24	34.26	34.21	12.31	12.34	12.29
4b	Mfg. 9 - 1	33.52	33.50	33.53	11.60	11.58	11.61
5b	Mfg. 9 - 2	35.79	35.78	35.75	13.87	13.86	13.83
6b	Mfg. 9 - 3	33.44	33.45	33.39	11.52	11.53	11.47
7b	circuit breaker	56.60	56.56	56.59	34.68	34.64	34.67
8b	line wire	38.73	38.68	38.65	16.81	16.76	16.72
9b	line wire splicing device	33.69	33.57	33.57	11.76	11.65	11.65
10b	load wire	33.57	33.50	33.50	11.65	11.57	11.58
11b	load wire splicing device	37.08	36.99	37.04	15.16	15.07	15.12
12b	room ambient	22.10	22.03	21.97			
13b	current (amps)	13.49	13.49	13.49			

Appendix D Flexing Tests

Conductor Flexing tests on 14-2 AWG copper-clad aluminum NMB cable:

test #	wire connection method	pass / fail (10x flexion)	comments
6-1	wrap around terminal screw	pass	ends of hot and neutral wires broke when removing them from their terminals after the test
6-2	single compression	pass	
6-3	double compression	pass	
6-1-1	wrap around terminal screw	failed	retest of 6-1; hot wire (black) broke on 8th flexion
6-1-2	wrap around terminal screw	pass	retest of 6-1 using copper wire
6-1-3	wrap around terminal screw	pass	retest of 6-1

NOTE: One Legrand receptacle was used for all 3 tests above and 9in/lbs was applied to all three terminal screws.

Appendix E - Certificates of Calibration



PO Box 2363, Clackamas, OR 97015
15648 114th Ave. Suite 109, Clackamas OR 97015
Phone: 503-406-4373 Fax: 503 905 0457
www.pacifictestandmeasurement.com

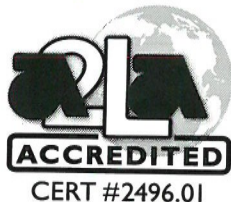
Certificate of Conformance

Issued to:	CDCMello Consulting LLC PO Box 872317 Vancouver, WA 98687
Customer PO:	Verbal Chuck Mello
Model:	UL3055
Lot Number:	952103-019
Report:	JK202006300-003
Description:	Type J, 30 Gauge FEP/FEP Teflon, Special Limits of Error Tolerance, 15 feet length, Thermocouple

Pacific Test and Measurement Inc certifies that the order of thermocouples meets all applicable instructions, specifications, and in accordance with DAP UL 00-OP-C0037 version 10.0. The preferred method of welding to produce a single point weld or bead using ThermX model 258B welder has been used to assemble the thermocouple junction which has been proven as reliable and repeatable through validation. The finish products were assembled from UL4047, a spool of described wire calibrated to accredited standards as described in the calibration report.

Certified by: 
(Quality Department)

Date: 7-10-2020



Appendix E - Certificates of Calibration

Report of Calibration

Eustis Co., Inc./Pyrocom Calibration lab
12407-B Mukilteo Speedway #200
Lynnwood, wa 98087

Report No: JK202006300-003

Page 1 of 2

Model: UL4047 Serial: 952103-019 Description: TYPE J, 30AWG, FEP/FEP	Customer:
Calibration Range: Limited Received Condition: New Current: N/A Procedure: ECP 339/341	CDCMello Consulting LLC PO Box 872317 Vancouver, WA 98687

The unit under test (UUT) on this certificate has been calibrated by comparison method as covered by ASTM E220-13, and calibrated against standards traceable to the National Institute of Standards and Technology (NIST). Eustis Co., Inc./Pyrocom Calibration Lab meets the requirements of ANSI/NCSL Z540-1-1994 and ISO/IEC 17025 and is accredited by A2LA via Certificate Number 2496.01 for calibrations within the scope to which it applies. The uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of $k=2$. All results contained within this certificate relate only to the item calibrated. Any number of factors may cause the calibrated item to drift out of calibration.

Nominal Value (Set-point) (C)	Actual Value (Reference) (C)	UUT (Test Sensor) (C)	Error (C)	Measurement Uncertainty (C)	Method of Realization
21.00	21.41	21.38	-0.03	+/- 0.31	COMP
40.00	40.08	40.02	-0.06	+/- 0.40	COMP
95.00	95.02	94.97	-0.05	+/- 0.40	COMP
150.00	150.02	150.10	0.08	+/- 0.50	COMP
200.00	200.01	200.23	0.22	+/- 0.50	COMP

Test Equipment

Manufacturer	Model	Description	Serial Number	Recall Date
Hart Scientific	1560	"Black Stack" Base Unit	96539	NCR
Hart Scientific	2560	SPRT Module	A25631	3/24/2021
Fluke	5628	4 Wire SPRT	4303	3/26/2021
Fluke	2566	Thermocouple Scanner	B7A380	3/24/2021
Fluke	9173	Metrology Well, 700 C	B47975	NCR
Fluke	7380	Bath, Ultra Low-Temperature	B2A527	NCR

Calibration Date: 6/18/2020
Temperature: 23.0 C
Humidity: 47%
Customer Order: 74523

Technician:

Julia Kulin

Approved By:

Walter Paulson
QA Manager

Appendix E - Certificates of Calibration
Report of Calibration

Report No: JK202006300-003
Page 2 of 2

Notes: The thermocouple wire meets or exceeds the criteria established for type "J" SPECIAL LIMITS OF ERROR per ASTM E230/E230M-17 table 1 & ISA-MC96.1-1982 Par. 2.5 Table 8 $\pm 1.1^{\circ}\text{C}$ OR $\pm .4\%$ whichever is greater. Lot calibration data supplied for your reference.

Calibrated item meets special limits of error for all results given according to the comparison of "error" reading to the specifications found in ASTM E230/E230M-17 table 1 & MC96.1-1982 table 8; acceptance determination is ultimately the responsibility of the customer, taking into account all uncertainties and other factors. The closer the results are to the specification limits, the greater the risk that the unit under test will be out of tolerance.

Report issue date: JUN 19 2020

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-33105-466 For Eaton Corporation - ICD W126 N7250 Flint Drive Menomonee Falls, WI 53051 Purchase Order # 4044-671109 Test Instrument Data Acquisition Unit Make Keysight Model 34972A Serial Number MY49002695 Identification EM7054 Customer Location ICD Condition Received In Tolerance Condition Returned In Tolerance Calibrated By Alex Paulsen Technical Review By Tim Bending Calibration Location FVM Calibration Conditions 67.8°F, 19.9°C, 57.3%RH Calibration Date 07/16/2020 Recalibration Due 07/16/2021		Procedures Followed FVE-000 rev. 2 FVE-006 rev. 2 Standards Used <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Instrument</th> <th style="text-align: left;">Serial Number</th> <th style="text-align: left;">Trace Number</th> <th style="text-align: left;">Next Cal</th> </tr> </thead> <tbody> <tr> <td>FVS-275A</td> <td>RY11838</td> <td>CJ191-70508-513</td> <td>07/28/2020</td> </tr> <tr> <td>FVS-737</td> <td>4542903</td> <td>CK041-57440-531</td> <td>02/28/2021</td> </tr> </tbody> </table>		Instrument	Serial Number	Trace Number	Next Cal	FVS-275A	RY11838	CJ191-70508-513	07/28/2020	FVS-737	4542903	CK041-57440-531	02/28/2021
Instrument	Serial Number	Trace Number	Next Cal												
FVS-275A	RY11838	CJ191-70508-513	07/28/2020												
FVS-737	4542903	CK041-57440-531	02/28/2021												

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated. Form Revision 6: 02/04/2012

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
Root Difference Square guardbanding method used.						
UUT IDENTIFICATION						
Serial Number: MY49002695 Firmware Level: 1.11-1.12-02-01						
INPUT MODULE CHARACTERISTI CS						
Model: 34901A Firmware Level: 2.3						
SELF TEST				Pass	Pass	

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
INTERNAL DMM VERIFICATION						
ZERO OFFSET VERIFICATION						
DC CURRENT						
10 mA Range 0.00000 mA	0.00000	-0.00200	0.00200	0.00003	0.00003	0.000007
100 mA Range 0.0000 mA	0.0000	-0.0050	0.0050	0.0000	0.0000	0.00006
1 A Range 0.000000 A	0.000000	-0.000100	0.000100	0.000001	0.000001	0.0000006
DC VOLTS						
100 mV Range 0.0000 mV	0.0000	-0.0040	0.0040	0.0004	0.0004	0.00007
1 V Range 0.000000 V	0.000000	-0.000007	0.000007	0.000001	0.000001	0.0000007
10 V Range 0.00000 V	0.00000	-0.00005	0.00005	0.00000	0.00000	0.000007
100 V Range 0.0000 V	0.0000	-0.0006	0.0006	0.0000	0.0000	0.00006
300 V Range 0.000 V	0.000	-0.009	0.009	0.000	0.000	0.0006
2 WIRE						
100 Range 0.0000 Ohm	0.0000	-4.0040	4.0040	0.0626	0.0626	0.00007
1 k Range 0.000000 kOhm	0.000000	-0.004010	0.004010	0.000065	0.000065	0.0000006
10 k Range 0.00000 kOhm	0.00000	-0.00410	0.00410	0.00008	0.00008	0.000006
100 k Range 0.0000 kOhm	0.0000	-0.0050	0.0050	0.0002	0.0002	0.00007
1 M Range 0.000000 MOhm	0.000000	-0.000014	0.000014	0.000000	0.000000	0.0000007
10 M Range						

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
0.00000 MOhm	0.00000	-0.00010	0.00010	0.00000	0.00000	0.000007
100 M? Range						
0.0000 MOhm	0.0000	-0.0100	0.0100	0.0000	0.0000	0.00006
4 WIRE						
100 Range						
0.0000 Ohm	0.0000	-0.0040	0.0040	-0.0023	-0.0023	0.00006
1 k Range						
0.000000 kOhm	0.000000	-0.000010	0.000010	0.000000	0.000000	0.0000006
10 k Range						
0.00000 kOhm	0.00000	-0.00010	0.00010	0.00000	0.00000	0.000007
100 k Range						
0.0000 kOhm	0.0000	-0.0010	0.0010	0.0000	0.0000	0.00007
1 M Range						
0.000000 MOhm	0.000000	-0.000010	0.000010	0.000000	0.000000	0.0000006
10 M Range						
0.00000 MOhm	0.00000	-0.00010	0.00010	0.00000	0.00000	0.000006
100 M Range						
0.0000 MOhm	0.0000	-0.0100	0.0100	0.0000	0.0000	0.00007
GAIN VERIFICATION						
DC VOLTS						
100 mV Range						
100.0000 mV	100.0000	99.9910	100.0090	100.0000	100.0000	0.00006
-100.0000 mV	-100.0000	-100.0090	-99.9910	-99.9987	-99.9987	0.00007
1 V Range						
1.000000 V	1.000000	0.999953	1.000047	0.999993	0.999993	0.0000007
-1.000000 V	-1.000000	-1.000047	-0.999953	-0.999989	-0.999989	0.0000007
10 V Range						
10.00000 V	10.00000	9.99960	10.00040	9.99994	9.99994	0.000006
-10.00000 V	-10.00000	-10.00040	-9.99960	-9.99992	-9.99992	0.000006
100 V Range						
100.0000 V	100.0000	99.9949	100.0051	99.9996	99.9996	0.00007
-100.0000 V	-100.0000	-100.0051	-99.9949	-99.9993	-99.9993	0.00007
300 V Range						
300.000 V	300.000	299.978	300.022	299.998	299.998	0.0006

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
2 WIRE						
100 Range 100.0000 Ohm	100.0000	95.9860	104.0140	100.0067	100.0067	0.00007
1 k Range 1.000000 kOhm	1.000000	0.995890	1.004110	1.000032	1.000032	0.0000006
10 k Range 10.00000 kOhm	10.00000	9.99490	10.00510	10.00035	10.00035	0.000007
100 k Range 100.0000 kOhm	100.0000	99.9850	100.0150	100.0029	100.0029	0.00006
1 M Range 1.000000 MOhm	1.000000	0.999886	1.000114	1.000016	1.000016	0.0000006
10 M Range 10.00000 MOhm	10.00000	9.99590	10.00410	9.99768	9.99768	0.000006
100 M Range 100.0000 MOhm	100.0000	99.1900	100.8100	100.3688	100.3688	0.00007
4 WIRE						
100 Range 100.0000 Ohm	100.0000	99.9860	100.0140	100.0039	100.0039	0.00006
1 k Range 1.000000 kOhm	1.000000	0.999890	1.000110	1.000030	1.000030	0.0000007
10 k Range 10.00000 kOhm	10.00000	9.99890	10.00110	10.00032	10.00032	0.000006
100 k Range 100.0000 kOhm	100.0000	99.9890	100.0110	100.0021	100.0021	0.00007
1 M Range 1.000000 MOhm	1.000000	0.999890	1.000110	0.999970	0.999970	0.0000007
10 M Range 10.00000 MOhm	10.00000	9.99590	10.00410	9.99595	9.99595	0.000006
100 M Range 100.0000 MOhm	100.0000	99.1900	100.8100	99.8275	99.8275	0.00006
DC CURRENT						
10 mA Range 10.00000 mA	10.00000	9.99300	10.00700	9.99898	9.99898	0.000007
-10.00000 mA	-10.00000	-10.00700	-9.99300	-9.99887	-9.99887	0.000007

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
100 mA Range						
100.0000 mA	100.0000	99.9450	100.0550	99.9882	99.9882	0.00006
-100.0000 mA	-100.0000	-100.0550	-99.9450	-99.9879	-99.9879	0.00006
1 A Range						
1.000000 A	1.000000	0.998900	1.001100	0.999534	0.999534	0.0000006
-1.000000 A	-1.000000	-1.001100	-0.998900	-0.999537	-0.999537	0.0000006
AC VOLTS						
100 mV Range						
10.0000 mV @ 1 kHz	10.0000	9.9540	10.0460	9.9997	9.9997	0.00006
100.0000 mV @ 1 kHz	100.0000	99.9000	100.1000	99.9912	99.9912	0.00006
100.0000 mV @ 50 kHz	100.0000	99.8300	100.1700	99.9383	99.9383	0.00006
1 V Range						
1.000000 V @ 20 Hz	1.000000	0.999000	1.001000	0.999803	0.999803	0.0000006
1.000000 V @ 1 kHz	1.000000	0.999000	1.001000	0.999950	0.999950	0.0000006
1.000000 V @ 20 kHz	1.000000	0.999000	1.001000	0.999888	0.999888	0.0000006
1.000000 V @ 50 kHz	1.000000	0.998300	1.001700	0.999504	0.999504	0.0000007
1.000000 V @ 100 kHz	1.000000	0.993200	1.006800	0.998811	0.998811	0.0000006
1.000000 V @ 200 kHz	1.000000	0.955000	1.045000	0.999068	0.999068	0.0000006
1.000000 V @ 250 kHz	1.000000	0.955000	1.045000	0.999202	0.999202	0.0000007
1.000000 V @ 300 kHz	1.000000	0.955000	1.045000	0.998797	0.998797	0.0000006
10 V Range						
0.10000 V @ 1 kHz	0.10000	0.08594	0.11406	0.10086	0.10086	0.000006
1.00000 V @ 1 kHz	1.00000	0.99540	1.00460	0.99992	0.99992	0.000006
10.00000 V @ 10 Hz	10.00000	9.99000	10.01000	9.99743	9.99743	0.000007
10.00000 V @ 1 kHz	10.00000	9.99000	10.01000	9.99855	9.99855	0.000006
10.00000 V @ 50 kHz	10.00000	9.98300	10.01700	9.99499	9.99499	0.000006
100 V Range						
100.0000 V @ 1 kHz	100.0000	99.9000	100.1000	99.9653	99.9653	0.00006
100.0000 V @ 50 kHz	100.0000	99.8300	100.1700	99.8943	99.8943	0.00006

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
300 V Range						
300.000 V @ 1 kHz	300.000	299.580	300.420	299.884	299.884	0.0006
200.000 V @ 50 kHz	200.000	199.400	200.600	199.750	199.750	0.0007
AC CURRENT						
10 mA Range						
10.00000 mA @ 1 kHz	10.00000	9.98600	10.01400	9.99766	9.99766	0.000007
100 mA Range						
100.0000 mA @ 1 kHz	100.0000	99.4000	100.6000	99.9484	99.9484	0.00007
1 A Range						
0.010000 A @ 1 kHz	0.010000	0.008590	0.011410	0.009960	0.009960	0.0000007
1.000000 A @ 1 kHz	1.000000	0.998600	1.001400	0.999502	0.999502	0.0000006
FREQUENCY						
100 Hz Range						
100.0000 Hz	100.0000	99.9000	100.1000	100.0056	100.0056	0.00007
100 kHz Range						
100.0000 kHz	100.0000	99.9900	100.0100	100.0001	100.0001	0.00007

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-39504-466

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109

Test Instrument Multimeter
Digital Multimeter

Make Fluke

Model 179

Serial Number 77840008

Identification EM4437



Customer Location ICD

Condition Received In Tolerance

Condition Returned In Tolerance

Calibrated By Alex Paulsen

Technical Review By Tim Bending

Calibration Location FVM

Calibration Conditions 68.3°F, 20.2°C, 56.2%RH

Calibration Date 07/16/2020

Recalibration Due 07/16/2021

Procedures Followed

FVE-000 rev. 2
FVE-001 rev. 2

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVS-275A	RY11838	CJ191-70508-513	07/28/2020
FVS-737	4542903	CK041-57440-531	02/28/2021

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in base units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS						
600 mV Range						
300.0 mV @ 45 Hz	300.0	296.7	303.3	299.2	299.2	0.07
6 V Range						
5.000 V @ 500 Hz	5.000	4.947	5.053	4.987	4.987	0.0007
5.000 V @ 1 kHz	5.000	4.897	5.103	4.949	4.949	0.0007
60 V Range						
50.00 V @ 45 Hz	50.00	49.47	50.53	49.98	49.98	0.007
50.00 V @ 1 kHz	50.00	48.97	51.03	50.02	50.02	0.007
600 V Range						
300.0 V @ 45 Hz	300.0	296.7	303.3	299.9	299.9	0.07
500.0 V @ 500 Hz	500.0	494.7	505.3	500.5	500.5	0.06
500.0 V @ 1 kHz	500.0	489.7	510.3	500.5	500.5	0.06
1000 V Range						
1000 V @ 45 Hz	1000	987	1013	1002	1002	0.7

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS FREQUENCY						
45.00 Hz @ 1 V	45.00	44.95	45.06	45.01	45.01	0.007
50.00 kHz @ 5 V	50.00	49.94	50.06	50.00	50.00	0.006
DC VOLTAGE						
6 V Range						
5.000 V	5.000	4.994	5.007	4.997	4.997	0.0006
600 V Range						
300.0 V	300.0	299.5	300.5	299.8	299.8	0.06
1000 V Range						
1000 V	1000	997	1004	999	999	0.6
-1000 V	-1000	-1004	-997	-1000	-1000	0.7
DC VOLTS FREQUENCY						
45.00 Hz @ 3 V	45.00	44.95	45.06	45.01	45.01	0.007
50.00 kHz @ 30 V	50.00	49.94	50.06	50.00	50.00	0.007
DC MILLIVOLTS						
30.0 mV	30.0	29.8	30.2	30.0	30.0	0.06
-300.0 mV	-300.0	-300.5	-299.5	-299.9	-299.9	0.06
600.0 mV	600.0	599.3	600.7	599.7	599.7	0.07
TEMPERATURE						
0.0 °C	0.0	-1.0	1.0	1.0	1.0	0.06
-40.0 °C	-40.0	-41.4	-38.6	-39.0	-39.0	0.07
400.0 °C	400.0	395.0	405.0	400.9	400.9	0.06
OHMS						
600 Ohm Range						
19.0 Ohm	19.0	18.6	19.4	19.3	19.3	0.07
50 MOhm Range						
19.00 MOhm	19.00	18.68	19.32	19.00	19.00	0.006
CAPACITANCE						
1000 nF Range						
900 nF	900	887	913	899	899	0.6
CONTINUITY						
0 Ohms: Beeper On				Pass	Pass	
190 Ohms: Beeper Off				Pass	Pass	
DIODE TEST						

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
2.000 V	2.000	1.978	2.022	2.000	2.000	0.0007
AC MILLIAMPS						
60 mA Range						
3.00 mA @ 45 Hz	3.00	2.92	3.08	3.00	3.00	0.007
50.00 mA @ 1 kHz	50.00	49.22	50.78	50.06	50.06	0.006
400 mA Range						
400.0 mA @ 1 kHz	400.0	393.7	406.3	400.4	400.4	0.07
AC AMPS						
6 A Range						
4.000 A @ 45 Hz	4.000	3.937	4.063	4.005	4.005	0.0007
10A Range						
9.00 A @ 1 kHz	9.00	8.84	9.16	9.04	9.04	0.007
DC MILLIAMPS						
60 mA Range						
3.00 mA	3.00	2.94	3.06	3.00	3.00	0.006
50.00 mA	50.00	49.47	50.53	49.92	49.92	0.007
400 mA Range						
-400.0 mA	-400.0	-404.3	-395.7	-399.8	-399.8	0.07
DC AMPS						
6 A Range						
4.000 A	4.000	3.957	4.043	3.999	3.999	0.0007
10 A Range						
-9.00 A	-9.00	-9.12	-8.88	-9.01	-9.01	0.006

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-38060-466		Procedures Followed FVE-000 rev. 2 FVE-001 rev. 2		This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated. Form Revision 6: 02/04/2012
For Eaton Corporation - ICD W126 N7250 Flint Drive Menomonee Falls, WI 53051				
Purchase Order #	4044-671109	Standards Used		
Test Instrument	Multimeter Digital Multimeter	Instrument	Serial Number	Trace Number
Make	Fluke	FVS-275A	RY11838	CJ191-70508-513
Model	175	FVS-737	4542903	CK041-57440-531
Serial Number	13700492			Next Cal
Identification	EM7014			07/28/2020
Customer Location	ICD			02/28/2021
Condition Received	In Tolerance	Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in base units. All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.		
Condition Returned	In Tolerance			
Calibrated By	Alex Paulsen			
Technical Review By	Tim Bending			
Calibration Location	FVM			
Calibration Conditions	68.2°F, 20.1°C, 56.6%RH			
Calibration Date	07/16/2020			
Recalibration Due	07/16/2021			

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS						
600 mV Range						
300.0 mV @ 45 Hz	300.0	296.7	303.3	299.9	299.9	0.07
6 V Range						
5.000 V @ 500 Hz	5.000	4.947	5.053	4.994	4.994	0.0007
5.000 V @ 1 kHz	5.000	4.897	5.103	4.955	4.955	0.0006
60 V Range						
50.00 V @ 45 Hz	50.00	49.47	50.53	49.94	49.94	0.007
50.00 V @ 1 kHz	50.00	48.97	51.03	50.06	50.06	0.006
600 V Range						
300.0 V @ 45 Hz	300.0	296.7	303.3	299.8	299.8	0.07
500.0 V @ 500 Hz	500.0	494.7	505.3	500.4	500.4	0.07
500.0 V @ 1 kHz	500.0	489.7	510.3	500.4	500.4	0.06
1000 V Range						
1000 V @ 45 Hz	1000	987	1013	996	996	0.6

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS FREQUENCY						
45.00 Hz @ 1 V	45.00	44.95	45.06	45.00	45.00	0.007
50.00 kHz @ 5 V	50.00	49.94	50.06	50.00	50.00	0.007
DC VOLTAGE						
6 V Range						
5.000 V	5.000	4.990	5.010	5.000	5.000	0.0007
600 V Range						
300.0 V	300.0	299.4	300.6	300.0	300.0	0.06
1000 V Range						
1000 V	1000	997	1004	1000	1000	0.7
-1000 V	-1000	-1004	-997	-1000	-1000	0.7
DC VOLTS FREQUENCY						
45.00 Hz @ 3 V	45.00	44.95	45.06	45.00	45.00	0.007
50.00 kHz @ 30 V	50.00	49.94	50.06	50.00	50.00	0.007
DC MILLIVOLTS						
30.0 mV	30.0	29.8	30.2	30.0	30.0	0.07
-300.0 mV	-300.0	-300.6	-299.4	-299.9	-299.9	0.06
600.0 mV	600.0	598.9	601.1	599.9	599.9	0.06
OHMS						
600 Ohm Range						
19.0 Ohm	19.0	18.6	19.4	19.0	19.0	0.07
50 MOhm Range						
19.00 MOhm	19.00	18.68	19.32	18.99	18.99	0.006
CAPACITANCE						
1000 nF Range						
900 nF	900	887	913	900	900	0.7
CONTINUITY						
0 Ohms: Beeper On				Pass	Pass	
190 Ohms: Beeper Off				Pass	Pass	
DIODE TEST						
2.000 V	2.000	1.978	2.022	2.001	2.001	0.0006
AC MILLIAMPS						
60 mA Range						

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
3.00 mA @ 45 Hz	3.00	2.92	3.08	3.01	3.01	0.007
50.00 mA @ 1 kHz	50.00	49.22	50.78	49.96	49.96	0.007
400 mA Range						
400.0 mA @ 1 kHz	400.0	393.7	406.3	399.4	399.4	0.06
AC AMPS						
6 A Range						
4.000 A @ 45 Hz	4.000	3.937	4.063	3.997	3.997	0.0007
10A Range						
9.00 A @ 1 kHz	9.00	8.84	9.16	9.00	9.00	0.007
DC MILLIAMPS						
60 mA Range						
3.00 mA	3.00	2.94	3.06	3.02	3.02	0.006
50.00 mA	50.00	49.47	50.53	49.99	49.99	0.006
400 mA Range						
-400.0 mA	-400.0	-404.3	-395.7	-400.0	-400.0	0.07
DC AMPS						
6 A Range						
4.000 A	4.000	3.957	4.043	3.999	3.999	0.0007
10 A Range						
-9.00 A	-9.00	-9.12	-8.88	-9.00	-9.00	0.007

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-38779-466		Procedures Followed FVE-000 rev. 2 FVE-001 rev. 2		This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated. Form Revision 6: 02/04/2012
For Eaton Corporation - ICD W126 N7250 Flint Drive Menomonee Falls, WI 53051				
Purchase Order #	4044-671109	Standards Used		
Test Instrument	Multimeter	Instrument	Serial Number	Trace Number
	Digital Multimeter	FVS-275A	RY11838	CJ191-70508-513
Make	Fluke	FVS-737	4542903	CK041-57440-531
Model	179			07/28/2020
Serial Number	14370601			02/28/2021
Identification	EM7024			
Customer Location	ICD			
Condition Received	In Tolerance	Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.		
Condition Returned	In Tolerance			
Calibrated By	Alex Paulsen	All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.		
Technical Review By	Tim Bending			
Calibration Location	FVM			
Calibration Conditions	68.2°F, 20.1°C, 56.6%RH			
Calibration Date	07/16/2020			
Recalibration Due	07/16/2021			

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS						
600 mV Range						
300.0 mV @ 45 Hz	300.0	296.7	303.3	300.0	300.0	0.06
6 V Range						
5.000 V @ 500 Hz	5.000	4.947	5.053	4.997	4.997	0.0006
5.000 V @ 1 kHz	5.000	4.897	5.103	4.961	4.961	0.0006
60 V Range						
50.00 V @ 45 Hz	50.00	49.47	50.53	49.97	49.97	0.006
50.00 V @ 1 kHz	50.00	48.97	51.03	50.10	50.10	0.007
600 V Range						
300.0 V @ 45 Hz	300.0	296.7	303.3	300.0	300.0	0.07
500.0 V @ 500 Hz	500.0	494.7	505.3	500.9	500.9	0.06
500.0 V @ 1 kHz	500.0	489.7	510.3	500.8	500.8	0.06
1000 V Range						
1000 V @ 45 Hz	1000	987	1013	997	997	0.7

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS FREQUENCY						
45.00 Hz @ 1 V	45.00	44.95	45.06	45.00	45.00	0.007
50.00 kHz @ 5 V	50.00	49.94	50.06	50.00	50.00	0.006
DC VOLTAGE						
6 V Range						
5.000 V	5.000	4.994	5.007	5.000	5.000	0.0006
600 V Range						
300.0 V	300.0	299.5	300.5	299.9	299.9	0.06
1000 V Range						
1000 V	1000	997	1004	1000	1000	0.7
-1000 V	-1000	-1004	-997	-1000	-1000	0.7
DC VOLTS FREQUENCY						
45.00 Hz @ 3 V	45.00	44.95	45.06	45.00	45.00	0.007
50.00 kHz @ 30 V	50.00	49.94	50.06	50.00	50.00	0.006
DC MILLIVOLTS						
30.0 mV	30.0	29.8	30.2	30.0	30.0	0.06
-300.0 mV	-300.0	-300.5	-299.5	-299.9	-299.9	0.06
600.0 mV	600.0	599.3	600.7	599.8	599.8	0.06
TEMPERATURE						
0.0 °C	0.0	-1.0	1.0	0.5	0.5	0.06
-40.0 °C	-40.0	-41.4	-38.6	-39.3	-39.3	0.06
400.0 °C	400.0	395.0	405.0	400.4	400.4	0.06
OHMS						
600 Ohm Range						
19.0 Ohm	19.0	18.6	19.4	19.0	19.0	0.06
50 MOhm Range						
19.00 MOhm	19.00	18.68	19.32	18.98	18.98	0.006
CAPACITANCE						
1000 nF Range						
900 nF	900	887	913	900	900	0.6
CONTINUITY						
0 Ohms: Beeper On				Pass	Pass	
190 Ohms: Beeper Off				Pass	Pass	
DIODE TEST						

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
2.000 V	2.000	1.978	2.022	2.001	2.001	0.0007
AC MILLIAMPS						
60 mA Range						
3.00 mA @ 45 Hz	3.00	2.92	3.08	3.02	3.02	0.006
50.00 mA @ 1 kHz	50.00	49.22	50.78	50.03	50.03	0.006
400 mA Range						
400.0 mA @ 1 kHz	400.0	393.7	406.3	399.9	399.9	0.06
AC AMPS						
6 A Range						
4.000 A @ 45 Hz	4.000	3.937	4.063	4.004	4.004	0.0006
10A Range						
9.00 A @ 1 kHz	9.00	8.84	9.16	9.01	9.01	0.007
DC MILLIAMPS						
60 mA Range						
3.00 mA	3.00	2.94	3.06	3.01	3.01	0.007
50.00 mA	50.00	49.47	50.53	49.99	49.99	0.007
400 mA Range						
-400.0 mA	-400.0	-404.3	-395.7	-399.9	-399.9	0.06
DC AMPS						
6 A Range						
4.000 A	4.000	3.957	4.043	3.998	3.998	0.0006
10 A Range						
-9.00 A	-9.00	-9.12	-8.88	-9.00	-9.00	0.007

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-41226-466

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109

Test Instrument Clamp Meter

Make AEMC

Model SR759

Serial Number 224137GKDV

Identification EM6996



Customer Location ICD

Condition Received In Tolerance

Condition Returned In Tolerance

Calibrated By Alex Paulsen

Technical Review By Tim Bending

Calibration Location FVM

Calibration Conditions 67.8°F, 19.9°C, 56.3%RH

Calibration Date 07/16/2020

Recalibration Due 07/16/2021

Procedures Followed

FVE-007 rev. 2

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVS-275A	RY11838	CJ191-70508-513	07/28/2020
FVS-546	24560221	CK093-41519-573	04/30/2021
FVS-737	4542903	CK041-57440-531	02/28/2021

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
1A Range; 1000mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 mA	10.0	8.7	11.3	10.1	10.1	0.07
100 mA	100.0	96.0	104.0	101.3	101.3	0.06
500 mA	500.0	495.5	504.5	504.5	504.5	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
1 A	1.000	0.992	1.008	1.008	1.008	0.0006
10A Range; 100mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
100 mA	10.0	9.7	10.3	10.0	10.0	0.07
1 A	100.0	99.3	100.7	100.4	100.4	0.07
5 A	500.0	497.5	502.5	501.8	501.8	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
10 A	1.000	0.995	1.005	1.004	1.004	0.0007
100A Range; 10mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
1 A	10.0	9.7	10.3	10.0	10.0	0.07
10 A	100.0	99.3	100.7	100.1	100.1	0.06

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive

Oshkosh, WI 54902

(920) 426-5894 • Fax (920) 426-8120

<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
50 A	500.0	498.5	501.5	500.3	500.3	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
100 A	1.000	0.998	1.002	1.001	1.001	0.0006
1000A Range; 1mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 A	10.0	9.7	10.3	10.0	10.0	0.06
100 A	100.0	99.3	100.7	100.1	100.1	0.07
500 A	500.0	499.0	501.0	500.5	500.5	0.07
900 A	900.0	898.0	902.0	901.2	901.2	0.07

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-40179-466

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109

Test Instrument Clamp Meter

Make AEMC

Model SR759

Serial Number 224139GKDV

Identification EM6997



Customer Location ICD

Condition Received In Tolerance

Condition Returned In Tolerance

Calibrated By Alex Paulsen

Technical Review By Tim Bending

Calibration Location FVM

Calibration Conditions 67.8°F, 19.9°C, 56.3%RH

Calibration Date 07/16/2020

Recalibration Due 07/16/2021

Procedures Followed

FVE-007 rev. 2

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVS-275A	RY11838	CJ191-70508-513	07/28/2020
FVS-546	24560221	CK093-41519-573	04/30/2021
FVS-737	4542903	CK041-57440-531	02/28/2021

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
1A Range; 1000mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 mA	10.0	8.7	11.3	10.1	10.1	0.06
100 mA	100.0	96.0	104.0	101.1	101.1	0.06
500 mA	500.0	495.5	504.5	504.5	504.5	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
1 A	1.000	0.992	1.008	1.008	1.008	0.0006
10A Range; 100mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
100 mA	10.0	9.7	10.3	10.0	10.0	0.07
1 A	100.0	99.3	100.7	100.2	100.2	0.06
5 A	500.0	497.5	502.5	500.9	500.9	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
10 A	1.000	0.995	1.005	1.002	1.002	0.0006
100A Range; 10mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
1 A	10.0	9.7	10.3	10.0	10.0	0.06
10 A	100.0	99.3	100.7	100.1	100.1	0.07

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
50 A	500.0	498.5	501.5	500.1	500.1	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
100 A	1.000	0.998	1.002	1.001	1.001	0.0006
1000A Range; 1mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 A	10.0	9.7	10.3	10.0	10.0	0.07
100 A	100.0	99.3	100.7	100.1	100.1	0.06
500 A	500.0	499.0	501.0	500.3	500.3	0.06
900 A	900.0	898.0	902.0	901.4	901.4	0.06

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-41583-466

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109
Test Instrument Clamp Meter

Make AEMC
Model SR759
Serial Number 239584HKDV
Identification EM8032



Customer Location ICD

Condition Received In Tolerance
Condition Returned In Tolerance
Calibrated By Alex Paulsen
Technical Review By Tim Bending
Calibration Location FVM
Calibration Conditions 67.8°F, 19.9°C, 56.3%RH
Calibration Date 07/16/2020
Recalibration Due 07/16/2021

Procedures Followed
FVE-007 rev. 2

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVS-275A	RY11838	CJ191-70508-513	07/28/2020
FVS-546	24560221	CK093-41519-573	04/30/2021
FVS-737	4542903	CK041-57440-531	02/28/2021

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
1A Range; 1000mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 mA	10.0	8.7	11.3	10.2	10.2	0.07
100 mA	100.0	96.0	104.0	101.1	101.1	0.07
500 mA	500.0	495.5	504.5	504.3	504.3	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
1 A	1.000	0.992	1.008	1.007	1.007	0.0007
10A Range; 100mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
100 mA	10.0	9.7	10.3	10.0	10.0	0.07
1 A	100.0	99.3	100.7	100.2	100.2	0.07
5 A	500.0	497.5	502.5	500.7	500.7	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
10 A	1.000	0.995	1.005	1.002	1.002	0.0006
100A Range; 10mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
1 A	10.0	9.7	10.3	10.0	10.0	0.07
10 A	100.0	99.3	100.7	100.0	100.0	0.07

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive

Oshkosh, WI 54902

(920) 426-5894 • Fax (920) 426-8120

<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
50 A	500.0	498.5	501.5	500.0	500.0	0.07
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
100 A	1.000	0.998	1.002	1.000	1.000	0.0007
1000A Range; 1mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 A	10.0	9.7	10.3	10.0	10.0	0.07
100 A	100.0	99.3	100.7	100.0	100.0	0.06
500 A	500.0	499.0	501.0	500.3	500.3	0.07
900 A	900.0	898.0	902.0	900.6	900.6	0.07

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK196-72143-379 For Eaton Corporation - ICD W126 N7250 Flint Drive Menomonee Falls, WI 53051 Purchase Order # 4044-671109 Test Instrument Torque Wrench Make CDI Model 1502LDIN (3%) Serial Number 0312910937 Identification EM8363 Customer Location ICD Condition Received In Tolerance Condition Returned In Tolerance Calibrated By Jim Peterson Technical Review By Kevin Dehne Calibration Location FVM Calibration Conditions 69.0°F, 20.6°C, 54.2%RH Calibration Date 07/14/2020 Recalibration Due 07/14/2021		Procedures Followed FVE-014 rev. 2 Standards Used <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;">Instrument</th> <th style="text-align: left;">Serial Number</th> <th style="text-align: left;">Trace Number</th> <th style="text-align: left;">Next Cal</th> </tr> <tr> <td>FVS-093</td> <td>03111</td> <td>CK191-31886-628</td> <td>10/31/2020</td> </tr> <tr> <td>FVS-275A</td> <td>RY11838</td> <td>CJ191-70508-513</td> <td>07/28/2020</td> </tr> </table>		Instrument	Serial Number	Trace Number	Next Cal	FVS-093	03111	CK191-31886-628	10/31/2020	FVS-275A	RY11838	CJ191-70508-513	07/28/2020	This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated. Form Revision 6: 02/04/2012
Instrument	Serial Number	Trace Number	Next Cal													
FVS-093	03111	CK191-31886-628	10/31/2020													
FVS-275A	RY11838	CJ191-70508-513	07/28/2020													
Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units. All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.																

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
Clockwise	(in lb)	(in lb)	(in lb)	(in lb)	(in lb)	(in lb)
	30.00	29.10	30.90	29.89	29.89	0.091
	90.00	87.30	92.70	90.23	90.23	0.271
	150.00	145.50	154.50	152.00	152.00	0.450
Counter Clockwise	(in lb)	(in lb)	(in lb)	(in lb)	(in lb)	(in lb)
	30.00	29.10	30.90	30.31	30.31	0.091
	90.00	87.30	92.70	89.53	89.53	0.271
	150.00	145.50	154.50	148.58	148.58	0.450

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-49542-348

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109
Test Instrument Tape Measure

Make Stanley
Model 30-824

Serial Number
Identification EM6927



Customer Location ICD
Tony

Condition Received In Tolerance
Condition Returned In Tolerance
Calibrated By Matthew Roughen
Technical Review By Laura Fuhrmann
Calibration Location FVM
Calibration Conditions 69.5°F, 20.8°C, 34.8%RH
Calibration Date 07/16/2020
Recalibration Due 07/16/2021

Procedures Followed
FVM-042 rev. 1

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVM-044	C404R	CH121-20770-384	05/28/2022
FVM-079A	RY11924	CJ191-72229-513	07/28/2020

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCCL Z540-1-1994 and ANSI/NCCL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
Length	(in)	(in)	(in)	(in)	(in)	
	12.000	11.969	12.031	11.995	11.995	0.0006
	24.000	23.938	24.062	23.995	23.995	0.0007
	48.000	47.938	48.062	47.995	47.995	0.0007
	72.000	71.938	72.062	71.995	71.995	0.0007
	144.000	143.938	144.062	143.995	143.995	0.0006
	216.000	215.938	216.062	215.995	215.995	0.0006
	312.000	311.938	312.062	311.995	311.995	0.0007
Length	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
	500.00	499.00	501.00	499.87	499.87	0.007
	1000.00	999.00	1001.00	999.87	999.87	0.006
	5000.00	4999.00	5001.00	4999.87	4999.87	0.008
	8000.00	7999.00	8001.00	7999.87	7999.87	0.012

240.4 Protection of Conductors.

(D) Small Conductors. Unless specifically permitted in 240.4(E) or (G), the overcurrent protection shall not exceed that required by (D)(1) through (D)(78) after any correction factors for ambient temperature and number of conductors have been applied.

(1) **18 AWG Copper.** 7 amperes, provided all the following conditions are met:

(1) Continuous loads do not exceed 5.6 amperes.

(2) Overcurrent protection is provided by one of the following:

- a. Branch-circuit-rated circuit breakers listed and marked for use with 18 AWG copper wire
- b. Branch-circuit-rated fuses listed and marked for use with 18 AWG copper wire
- c. Class CC, Class J, or Class T fuses

(2) **16 AWG Copper.** 10 amperes, provided all the following conditions are met:

(1) Continuous loads do not exceed 8 amperes.

(2) Overcurrent protection is provided by one of the following:

- a. Branch-circuit-rated circuit breakers listed and marked for use with 16 AWG copper wire
- b. Branch-circuit-rated fuses listed and marked for use with 16 AWG copper wire
- c. Class CC, Class J, or Class T fuses

(3) **14 AWG Copper-Clad Aluminum.** 10 amperes

(4) **14 AWG Copper.** 15 amperes

(4)(5) **12 AWG Aluminum and Copper-Clad Aluminum.** 15 amperes

(5)(6) **12 AWG Copper.** 20 amperes

(6)(7) **10 AWG Aluminum and Copper-Clad Aluminum.** 25 amperes

(7)(8) **10 AWG Copper.** 30 amperes

Substantiation:

Task Group Statement

This public input is submitted on behalf of the task group formed in accordance with the direction of the NFPA Standards Council in their Decisions D#19-2 and D#19-23. This task group was appointed to identify potential proposed changes to the 2020 edition of the NEC in the form of proposed Tentative Interim Amendments (TIAs) or to the 2023 edition of the NEC in the form of Public Inputs (PIs) that within the Task Group's scope of activity as specified by the Standards Council.

These proposed PIs relate to new requirements covering the use of copper-clad aluminum conductors throughout the NEC as a coordinated set of new or revised requirements. These Public Inputs should not be misconstrued by the CMPs as precluding consideration of other Public Inputs, with supporting test data, submitted now or in the future, for other potentially eligible conductor materials or sizes.

The task group members are; David Hittinger-Chair, Todd Crisman, Roland Deike, Thomas Domitrovich, Peter Graser, Christel Hunter, Chuck Mello, Ken Riedl, Susan Newman Scearce, Susan Stene, George Straniero, Frank Tse and Brian Rock. This task group of balanced interests provided the expertise to develop these public inputs covering the use of copper-clad aluminum conductors.

Public Inputs are being submitted in the following sections: Article 100, definition of “copper-clad aluminum”, 210.12, 210.18, 210.21(B)(1), 210.23, 210.24, 210.52(B), 240.4(D), 240.6, 310.3(A), 310.3(B), Table 310.16, Table 310.17, 330.104, 334.104, 336.104, 340.104, 404.14(D), and 406.3(D).

Summary of Changes

This Public Input is part of a coordinated effort to introduce 14 AWG Copper-Clad Aluminum (CCA) into the NEC® for branch-circuit wiring. This is being done by adding an ampacity for 14 AWG CCA to the ampacity tables, and other coordinated changes needed throughout the Code. The change provided in this Public Input is one of those needed to accommodate 14 AWG Copper-Clad Aluminum for branch circuit installations. 14 AWG Copper-Clad Aluminum will have an ampacity of 10 Amps at 60°C in Table 310.16. The revision to this Section is to add a new listing item (3) for 14 AWG Copper-Clad Aluminum and then renumber the succeeding list items. The requirement establishes 14 AWG Copper-Clad Aluminum with a maximum overcurrent protection rating of 10 Amps and aligns with the other small conductors provided in 240.4(D).

Technical Substantiation

The application of energy efficient equipment and the implementation of Energy Codes for modern construction, provides more options for reduced branch circuit loading. The result is that many branch circuits are capable of having a conductor current rating and overcurrent device rating of 10-Amperes. For example, a typical 75-watt equivalent LED lamp has a load rating of 12 watts. At 120 volts this is a load of 0.1 amps per lamp. A continuously loaded 10-ampere branch circuit for fixed lighting would be allowed to have 8 amps of load current, which would equate to 80 of these LED lamps. This is more lamps than found in a typical 2000 square foot home. Other examples are specific limited loads such as fire or burglar alarm panels, kitchen instant hot water dispensers, attic exhaust fans, and others. These specific loads on individual branch circuits only need one or a few amperes and could safely be installed on a 10-Ampere branch circuit. These lighting and specific appliance applications exist in both dwelling unit as well as commercial and industrial installations. There are cases today where equipment is being protected by a 15-Ampere circuit breaker, whereas a 10-Ampere overcurrent device and using 14 AWG Copper-Clad Aluminum conductors would provide a safe level of protection.



Public Input No. 1565-NFPA 70-2020 [Sections 240.4(D)(1), 240.4(D)(2)]

Sections 240.4(D)(1), 240.4(D)(2)

(1) 18 AWG Copper.

7 amperes, provided all the following conditions are met:

- (1) Continuous loads do not exceed 5.6 amperes.
- (2) Overcurrent protection is provided by one of the following:
 - (3) Branch-circuit-rated circuit breakers listed and marked for use with 18 AWG copper

wire

- a. conductors
- b. Branch-circuit-rated

fuses

- a. fuseholders listed and marked for use with 18 AWG copper
wire Class CC, Class J, or Class T fuses
 - a. conductors, and having Class CC, Class J, or Class T fuses installed

(2) 16 AWG Copper.

10 amperes, provided all the following conditions are met:

- (1) Continuous loads do not exceed 8 amperes.
- (2) Overcurrent protection is provided by one of the following:
 - (3) Branch-circuit-rated circuit breakers listed and marked for use with 16 AWG copper

wire

- a. conductors
- b. Branch-circuit-rated

fuses

- a. fuseholders listed and marked for use with 16 AWG copper
wire Class CC, Class J, or Class T fuses
 - a. conductors, and having Class CC, Class J, or Class T fuses installed

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Public_Input_No._1565-NFPA_70-2020_Sections_240.4_D_1_240.4_D_2_.docx	Clean MSWord DOCX copy of this Public Input No. 1565 WITHOUT TerraView alteration of the Submitter's intent.	

Statement of Problem and Substantiation for Public Input

See the uploaded attachment of a manual entry of this Public Input with text content that hasn't been Terra-sized and is consequently readable.

These 240.4(D) errors were noticed during the Correlating Committee Bimetal Task Group on which I also serve. Because these sub-sub-sections involved solely copper conductors, the TG deemed the corrections to be outside of the TG scope for copper-clad aluminum conductors directed by Standards Council Decisions D#19-2 and D#19-23, and should be submitted separately as an individual Public Input.

The Section [240.4] is entitled "Protection of CONDUCTORS" and the Subsection [240.4(D)] is entitled "Small CONDUCTORS". Accordingly, the word "wires" should be replaced with "conductors" in four places.

Further, (2)(b) in each presently reflects "FUSES ... FOR USE WITH ... WIRES". In reality, FUSES themselves do NOT have terminals for use with conductors; to permit fuse replacement, it's the FUSEHOLDERS that have such terminals.

In the charging text in (2) of each, it indicates that overcurrent protection shall be "provided by ONE of the following". You can't use the fuses of existing (2)(c) in each without FUSEHOLDERS of (2)(b) for termination to CONDUCTORS. The choice should be between a circuit breaker versus the COMBINATION of a fuseholder PLUS fuse(s). Therefore (2)(b) and existing (2)(c) should be concatenated in each to a combined (2)(b) in each.

Submitter Information Verification

Submitter Full Name: Brian Rock

Organization: Hubbell Incorporated

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 18 15:37:20 EDT 2020

Committee: NEC-P10

The Section [240.4] is entitled "Protection of CONDUCTORS" and the Subsection [240.4(D)] is entitled "Small CONDUCTORS". Accordingly, the word "wires" should be replaced with "conductors" in four places.

Further, (2)(b) in each presently reflects "FUSES ... FOR USE WITH ... WIRES". In reality, FUSES themselves do NOT have terminals for use with conductors; to permit fuse replacement, it's the FUSEHOLDERS that have such terminals.

In the charging text in (2) of each, it indicates that overcurrent protection shall be "provided by ONE of the following". You can't use the fuses of existing (2)(c) in each without FUSEHOLDERS of (2)(b) for termination to CONDUCTORS. The choice should be between a circuit breaker and the COMBINATION of a fuseholder PLUS fuse(s). Therefore (2)(b) and existing (2)(c) should be concatenated in each to a combined (2)(b) in each.

5. Copyright Assignment

- (a) ☒ I am the author of the text or other material (such as illustrations, graphs) proposed in the Public Input.
- (b) ☐ Some or all of the text or other material proposed in this Public Input was not authored by me. Its source is as follows: (please identify which material and provide complete information on its source)

I hereby grant and assign to the NFPA all and full rights in copyright in this Public Input (including both the Proposed Text and the Statement of Problem and Substantiation). I understand that I acquire no rights in any publication of NFPA in which this Public Input in this or another similar or analogous form is used. Except to the extent that I do not have authority to make an assignment in materials that I have identified in (b) above, I hereby warrant that I am the author of this Public Input and that I have full power and authority to enter into this assignment.

Signature (Required)



PLEASE USE SEPARATE FORM FOR EACH PUBLIC INPUT

To: Secretary, Standards Council National Fire Protection Association
1 Batterymarch Park · Quincy, MA 02169-7471 OR
Fax to: (617) 770-3500 OR Email to: proposals_comments@nfpa.org

9/16/2020

**Public Input No. 2022-NFPA 70-2020 [New Section after 240.4(F)]****240.4(G) Dwelling Unit Service Conductors**

Dwelling unit service conductors shall be permitted to have be protected at 120% of their ampacity in accordance with the sizing rules for these conductors 310.12.

Statement of Problem and Substantiation for Public Input

There has been a longstanding provision in Article 310 to permit dwelling unit service conductors to be used for services with a higher rating than the normal conductor ampacity. The current version of this rule permits the service conductors to have an ampacity of 83% of the service rating. The service rating is based on the rating of the service overcurrent protective device. The rule in 310 does not change the ampacity of those conductors, so conductors installed under the sizing provisions of 310.12 are not protected in accordance with the rules in 240.4. This proposed change corrects that issue. The 120% value was selected as it is the inverse of the 83% conductor sizing rule in 310.12.

Submitter Information Verification

Submitter Full Name: Don Ganiere

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 25 17:15:59 EDT 2020

Committee: NEC-P10

**Public Input No. 2024-NFPA 70-2020 [Section No. 240.4(G)]****(G) Overcurrent Protection for Specific Conductor Applications.**

Overcurrent protection for the specific conductors shall be permitted to be provided as referenced in Table 240.4(G).

Table 240.4(G) Specific Conductor Applications

<u>Conductor</u>	<u>Article</u>	<u>Section</u>
Air-conditioning and refrigeration equipment circuit conductors	440, Parts III, IV VI	-
Capacitor circuit conductors	460	460.8(B) and 460.25
Control and instrumentation circuit conductors (Type ITC)	727	727.9
Electric welder circuit conductors	630	630.12 and 630.32
Fire alarm system circuit conductors	760	760.43, 760.45, 760.121, and Chapter 9, Tables 12(A) and 12(B)
Motor-operated appliance circuit conductors	422, Part II	-
Motor and motor-control circuit conductors	430, Parts II, III, IV, V, VI, VII	-
Phase converter supply conductors	455	455.7
Remote-control, signaling, and power-limited circuit conductors	725	725.43, 725.45, 725.121, and Chapter 9, Tables 11(A) and 11(B)
Secondary tie conductors	450	450.6

Statement of Problem and Substantiation for Public Input

This table applies to the protection of the conductors, but the current reference for Article 440 does not include Part IV, Branch-Circuit Conductors. This just adds the required reference. This will make it clear that we can actually do what we think we can do for air conditioning circuits. Without a reference to the conductor sizing in this section, it appears to me that the Article 440 branch circuit conductors have to be sized based on the conductor ampacity and the OCPD rating.

The addition is consistent with the references for Article 430.

This reference has been missing all the way back to the creation of Article 440.

Submitter Information Verification

Submitter Full Name: Don Ganiere

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jul 25 17:33:33 EDT 2020

Committee: NEC-P10



Public Input No. 2752-NFPA 70-2020 [Section No. 240.4(G)]

(G) Overcurrent Protection for Specific Conductor Applications.

Overcurrent protection for the specific conductors shall be permitted to be provided as referenced in Table 240.4(G).

Table 240.4(G) Specific Conductor Applications

<u>Conductor</u>	<u>Article</u>	<u>Section</u>
Air-conditioning and refrigeration equipment circuit conductors	440, Parts III, VI	-
Capacitor circuit conductors	460	460.8(B) and 460.25
Control and instrumentation circuit conductors (Type ITC)	727	727.9
Electric welder circuit conductors	630	630.12 and 630.32
Fire alarm system circuit conductors	760	760.43, 760.45, 760.121, and Chapter 9, Tables 12(A) and 12(B)
Motor-operated appliance circuit conductors	422, Part II	-
Motor and motor-control circuit conductors	430, Parts II, III, IV, V, VI, VII	-
Phase converter supply conductors	455	455.7
Remote-control, signaling, and power-limited circuit conductors	725	725.43, 725.45, 725.121, and Chapter 9, Tables 11(A) and 11(B)
Secondary tie conductors	450	450.6

Statement of Problem and Substantiation for Public Input

This Public Comment is submitted on behalf of a task group appointed by the Chairs of NEC® CMP-3 & CMP-6. This Task Group was appointed to review whether NEC® Article 727 should be relocated to Chapter 3 where it was originally proposed. Task Group members are Dennis Nielsen, George Zimmerman, Jerry Kent, Ron Tellas, Kelly Lamp and Keith Waters.

Task Group members noted that ITC tray cable was originally accepted by CMP-6 for Chapter 3, however, the correlating committee at the time chose to have it put in Chapter 7. This Task Group's work confirmed that the material should be moved, but changes needed to be made to meet the chapter 3 style manual requirements. The Task Group recommends acceptance of this public input to move requirements for Instrumentation Tray Cable (ITC) to Chapter 3 and placed under the purview of CMP-6.

Article 727 contained a reference to table 240.4 G as reference for overcurrent protection. Chapter 3 would utilize Article 240 requirements for so the overcurrent protection section was deleted as part of PI 2696

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2696-NFPA 70-2020 [Article 727]	PI that creates the need for this change

Submitter Information Verification

Submitter Full Name: Keith Waters
Organization: Schneider Electric
Street Address:
City:
State:
Zip:
Submittal Date: Mon Aug 31 08:48:38 EDT 2020
Committee: NEC-P10



Public Input No. 398-NFPA 70-2020 [Section No. 240.4(G)]

(G) Overcurrent Protection for Specific Conductor Applications.

Overcurrent protection for the specific conductors shall be permitted to be provided as referenced in Table 240.4(G).

Table 240.4(G) Specific Conductor Applications

<u>Conductor</u>	<u>Article</u>	<u>Section</u>
	440, Parts III,	
Air-conditioning and refrigeration equipment circuit conductors		VI
-		
Capacitor circuit conductors	460	460.8(B) and 460.25
Control and instrumentation circuit conductors (Type ITC)	727	727.9
Electric welder circuit conductors	630	630.12 and 630.32
Dwelling services	230	230.90(A)
Dwelling services and feeders	310	310.12
Fire alarm system circuit conductors	760	760.43, 760.45, 760.121, and Chapter 9, Tables 12(A) and 12(B)
Motor-operated appliance circuit conductors	422, Part II	
-		
Motor and motor-control circuit conductors		430, Parts II, III, IV, V, VI, VII
-		
Phase converter supply conductors	455	455.7
Remote-control, signaling, and power-limited circuit conductors	725	725.43, 725.45, 725.121, and Chapter 9, Tables 11(A) and 11(B)
Secondary tie conductors	450	450.6

Statement of Problem and Substantiation for Public Input

Nothing in 240.4, except for 240.4(B), allows dwelling unit service or feeder conductors sized in accordance with 310.12 to be protected at anything other than their ampacity. Since 310.12 allows conductors to be sized to only 83% of the overcurrent device rating, a reference is needed in Table 240.4(G) to correlate these 2 rules. The same can be said for 230.90(A). There are several exception there that allow conductor overload protection that is very different than the requirements in 240.4! A reference in Table 240.4(G) is needed to correlate these rules also. I have submitted a companion proposal for 230.90(A) to include 208Y/120-volt systems as well.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 397-NFPA 70-2020 [Section No. 230.90(A)]	

Submitter Information Verification

Submitter Full Name: Russ Leblanc
Organization: Leblanc Consulting Services
Street Address:
City:
State:
Zip:

Submittal Date:	Sun Feb 02 08:13:35 EST 2020
Committee:	NEC-P10

**Public Input No. 1886-NFPA 70-2020 [Section No. 240.5(B)(3)]****(3) Extension Cord Sets.**

Flexible cord used in listed extension cord sets shall be considered to be protected when applied within the extension cord listing requirements.

Line 1

"Extension cord sets shall be listed."

Problem to Be Solved / Substantiation

Lack of a requirement that they be listed invites companies to make extension cord sets that do not meet even the most basic of safety standards, opening up the unwitting end-user to unnecessary hazards. These types of extension cord sets are currently readily available.

It is well known that extension cords present a significant hazard and have a history of creating fires, which have been well documented by the CPSC and other safety-related organizations. This does not represent a change to the legitimate manufacturers of such.

Line 2

"An extension cord set shall be considered to be protected where the load connected to it does not exceed its listing requirements and ratings."

Problem to be Solved / Substantiation

In the existing wording, the use of the word "applied" is ambiguous – it is not clear and decisive if it is referring to the circuit breaker rating or the connected load.

Statement of Problem and Substantiation for Public Input

Noted on earlier page.

Submitter Information Verification

Submitter Full Name: JAMES REIZNER

Organization: Jim Reizner Consulting LLC

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 13 20:00:00 EDT 2020

Committee: NEC-P10

**Public Input No. 1930-NFPA 70-2020 [Section No. 240.5(B)(4)]****(4) Field Assembled Extension Cord Sets.**

Flexible cord used in extension cords made with separately listed and installed components shall be permitted to be supplied by a branch circuit in accordance with the following:

20-ampere circuits — 16 AWG and larger

Line 1

“Flexible cord used in extension cords made with separately listed and installed components shall be permitted where supplied by a branch circuit where the connected load is within the flexible cord ratings as shown in Table 400.4 and Table 400.5(A)(1).”

Problem That Would Be Resolved / Substantiation

The way it is currently written, the reference to 16 AWG for 20-ampere circuits is inconsistent with 110.4(B), 240.5(A), 240.5(B)(3), Table 400.4 and Table 400.5(A)(1), and UL 817 *Cord Sets and Power Supply Cords* Tables 114 and 115.

Line 2

“The rating of a field assembled extension cord set shall be the lesser of the ampere rating of the attachment plug, flexible cord, or switch (if provided), whichever is less.”

Problem That Would Be Resolved/Substantiation

This is per 110.4(B) and is added for clarity.

Line 3

“The electrical voltage and current ratings of the line and load attachment plugs of a cord set shall both be the same but may be of different blade/slot configurations (for example, parallel-blade line attachment plug with locking-type load attachment plug).”

Problem That Would Be Resolved/Substantiation

Without this requirement the assembler could believe it is acceptable, for example, to use a NEMA 6-50P (250 volt, 50-ampere, grounding-type) male attachment plug for the line side with a NEMA 6-15P (250 volt, 15-ampere, grounding type) female attachment plug for the load side, which could result in the overcurrent protection to be significantly oversized for the connected appliance cord and equipment.

Line 4

“Line and load attachment plugs on a cord set shall be of the same type with respect to grounding (for example, a nonpolarized line attachment plug cannot be employed on a cord set with a polarized load attachment plug).”

Problem That Would Be Resolved/Substantiation

Without this requirement the assembler could believe it is acceptable to use a female polarized attachment plug on the load side and a male non-polarized attachment plug at the line side, resulting in an obvious hazard.

Line 5

“In a cord set there shall be a conductor attached to each terminal in each attachment plug, and a terminal in each attachment plug for each conductor.”

Problem That Would Be Resolved/Substantiation

Without this requirement the assembler could believe it is acceptable to connect a two-conductor cord to grounding-type attachment plugs, or a three wire cord to non-grounding type attachment plugs.

Line 6

“Corresponding terminals of line and load attachment plugs shall be connected to the same conductor of the cord.”

Problem That Would Be Resolved/Substantiation

Added for clarity and decisiveness. Without this requirement the assembler could believe it is acceptable to miss-wire the cord set.

Noted on previous page with the revised text.

Submitter Information Verification

Submitter Full Name: JAMES REIZNER

Organization: Jim Reizner Consulting LLC

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 17 10:17:10 EDT 2020

Committee: NEC-P10

**Public Input No. 3364-NFPA 70-2020 [New Section after 240.6]****240.7 Listing Requirements.**

Branch-circuit overcurrent protective devices shall be listed.

Statement of Problem and Substantiation for Public Input

This public input requires listing of “branch-circuit overcurrent protective devices” defined in Article 100.

Overcurrent protection devices protecting branch, feeder or service circuits are safety critical devices that have long been required by AHJs to be listed by third party laboratories. Requiring branch-circuit overcurrent protective devices in the National Electrical Code to be listed provides a basis for Authority Having Jurisdiction to approve the overcurrent protective devices. When electrical equipment is not listed, AHJ's must examine the electrical equipment in accordance with Section 110.3(A) as a basis for approval. Due to the inherent design and complexity of these devices, AHJ's do not have the expertise and test equipment to examine non-listed equipment for suitability.

There are many sections of the Code requiring listing already. Examples include:

- Section 240.4(D) requiring branch-circuit fuses and circuit breakers to be listed and marked for use with 18 AWG or 16 AWG copper wire.
- Section 240.8 requiring fuses or circuit breakers used in parallel to be factory assembled in parallel and listed as a unit.
- Section 240.83 (D) requiring circuit breakers used as switches for 120V or 277V fluorescent lighting circuit to be listed and marked for SWD or HID, as applicable.
- Section 690.9(B) requiring overcurrent devices used in dc circuits to be listed for use in PV systems.

These examples and others through the NEC already require listing for specific applications.

Additionally, Section 240.88 requires reconditioned equipment to be listed as “reconditioned”. If reconditioned equipment is required to be listed, then new equipment should also be listed.

This new section solidifies a long understood practice in the code and the field.

Submitter Information Verification

Submitter Full Name: Danish Zia

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 10:49:11 EDT 2020

Committee: NEC-P10



Public Input No. 3239-NFPA 70-2020 [Section No. 240.6(A)]

(A) Fuses and Fixed-Trip Circuit Breakers.

The standard ampere ratings for fuses and inverse time circuit breakers shall be considered as shown in Table 240.6(A). Additional standard ampere ratings for fuses shall be 1, 3, 6, 40, and 601. The use of fuses and inverse time circuit breakers with nonstandard ampere ratings shall be permitted.

Table 240.6(A) Standard Ampere Ratings for Fuses and Inverse Time Circuit Breakers

Standard Ampere Ratings				
<u>10</u>	<u>15</u>	<u>20</u>	<u>25</u>	<u>30</u>
<u>35</u>	<u>40</u>	<u>45</u>	<u>50</u>	<u>60</u>
<u>70</u>	<u>80</u>	<u>90</u>	<u>100</u>	<u>110</u>
<u>125</u>	<u>150</u>	<u>175</u>	<u>200</u>	<u>225</u>
<u>250</u>	<u>300</u>	<u>350</u>	<u>400</u>	<u>450</u>
<u>500</u>	<u>600</u>	<u>700</u>	<u>800</u>	<u>1000</u>
<u>1200</u>	<u>1600</u>	<u>2000</u>	<u>2500</u>	<u>3000</u>
<u>4000</u>	<u>5000</u>	<u>6000</u>	<u>—</u>	<u>—</u>

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Proposed_240.6_Draft_Fnl.docx	Word file attached for clarity	
Terminal_and_Conductor_Temperature_Testing_Part_I_Fnl.pdf	Terminal temperature static heating test report as requested by task group.	

Statement of Problem and Substantiation for Public Input

Task Group Statement

This public input is submitted on behalf of the task group formed in accordance with the direction of the NFPA Standards Council in their Decisions D#19-2 and D#19-23. This task group was appointed to identify potential proposed changes to the 2020 edition of the NEC in the form of proposed Tentative Interim Amendments (TIAs) or to the 2023 edition of the NEC in the form of Public Inputs (PIs) that within the Task Group's scope of activity as specified by the Standards Council.

These proposed PIs relate to new requirements covering the use of copper-clad aluminum conductors throughout the NEC as a coordinated set of new or revised requirements. These Public Inputs should not be misconstrued by the CMPs as precluding consideration of other Public Inputs, with supporting test data, submitted now or in the future, for other potentially eligible conductor materials or sizes.

The task group members are; David Hittinger-Chair, Todd Crisman, Roland Deike, Thomas Domitrovich, Peter Graser, Christel Hunter, Chuck Mello, Ken Riedl, Susan Newman Searce, Susan Stene, George Straniero, Frank Tse and Brian Rock. This task group of balanced interests provided the expertise to develop these public inputs covering the use of copper-clad aluminum conductors.

Public Inputs are being submitted in the following sections: Article 100, definition of "copper-clad aluminum", 210.12, 210.18, 210.21(B)(1), 210.23, 210.24, 210.52(B), 240.4(D), 240.6, 310.3(A), 310.3(B), Table 310.16, Table 310.17, 330.104, 334.104, 336.104, 340.104, 404.14(D), and 406.3(D).

Technical Substantiation

The application of energy efficient equipment and the implementation of Energy Codes for modern construction, provides more options for reduced branch circuit loading. The result is that many branch circuits are capable of having a conductor current rating and overcurrent device rating of 10-Amperes. For example, a typical 75-watt equivalent LED lamp has a load rating of 12 watts. At 120 volts this is a load of 0.1 amps per lamp. A continuously loaded 10-ampere branch circuit for fixed lighting would be allowed to have 8 amps of load current, which would equate to 80 of these LED lamps. This is more lamps than found in a typical 2000 square foot home. Other examples are specific limited loads such as fire or burglar alarm panels, kitchen instant hot water dispensers, attic exhaust fans, and others. These specific loads on individual branch

circuits only need one or a few amperes and could safely be installed on a 10-Ampere branch circuit. These lighting and specific appliance applications exist in both dwelling unit as well as commercial and industrial installations. There are cases today where equipment is being protected by a 15-Ampere circuit breaker, whereas a 10-Ampere overcurrent device would provide a safe level of protection.

Every one of the major manufacturers of thermal-magnetic circuit breakers have listed circuit breakers rated for 10 Amps listed for branch circuit applications. These available devices include both circuit breakers for panelboards as well as "miniature circuit breakers" used in control panel construction permitted in Article 409. The allowance for 10 Amp fuses has been included in existing 240.6 text and separate from the table/list for many Code cycles. This change is to only add 10 Amps as a standard size overcurrent device to include fixed trip circuit breakers and fuses. The listing in the text for 10 Amps fuses was deleted as it is now included in the table of standard sizes. The values in the Table 240.6(A) have all been moved up one position to provide a place at the beginning for 10 Amps. No other changes are intended for the existing table or text.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2865-NFPA 70-2020 [Section No. 210.12]	Branch circuit AFCI ratings added 10 amps
Public Input No. 2864-NFPA 70-2020 [Section No. 210.18]	Branch circuit ratings added 10 amps
Public Input No. 2866-NFPA 70-2020 [Section No. 210.21(B)]	Individual branch circuit receptacle applications and limitations for 10 amp branch circuits
Public Input No. 3261-NFPA 70-2020 [Section No. 210.23]	Branch circuit applications and limitations added 10 amps
Public Input No. 3940-NFPA 70-2020 [Section No. 210.24]	Summary branch circuit applications and limitations added 10 amps
Public Input No. 3238-NFPA 70-2020 [Section No. 240.4(D)]	Added 10 amp OCPD for 14 AWG copper-clad aluminum
Public Input No. 3241-NFPA 70-2020 [Section No. 310.3(A)]	Branch circuit conductors permitted
Public Input No. 3960-NFPA 70-2020 [Section No. 310.21]	Table 310.16 added ampacities for 14 AWG copper-clad aluminum
Public Input No. 3247-NFPA 70-2020 [Section No. 330.104]	14 AWG copper-clad aluminum added for cables at 10 amps
Public Input No. 3248-NFPA 70-2020 [Section No. 334.104]	14 AWG copper-clad aluminum added for cables at 10 amps
Public Input No. 3249-NFPA 70-2020 [Section No. 336.104 [Excluding any Sub-Sections]]	14 AWG copper-clad aluminum added for cables at 10 amps
Public Input No. 3251-NFPA 70-2020 [Section No. 340.104]	14 AWG copper-clad aluminum added for cables at 10 amps
Public Input No. 2864-NFPA 70-2020 [Section No. 210.18]	
Public Input No. 2866-NFPA 70-2020 [Section No. 210.21(B)]	
Public Input No. 3237-NFPA 70-2020 [Section No. 210.52(B)(1)]	
Public Input No. 3238-NFPA 70-2020 [Section No. 240.4(D)]	
Public Input No. 3241-NFPA 70-2020 [Section No. 310.3(A)]	
Public Input No. 3247-NFPA 70-2020 [Section No. 330.104]	
Public Input No. 3248-NFPA 70-2020 [Section No. 334.104]	
Public Input No. 3249-NFPA 70-2020 [Section No. 336.104 [Excluding any Sub-Sections]]	
Public Input No. 3251-NFPA 70-2020 [Section No. 340.104]	
Public Input No. 3261-NFPA 70-2020 [Section No. 210.23]	
Public Input No. 3940-NFPA 70-2020 [Section No. 210.24]	

[Public Input No. 3960-NFPA 70-2020 \[Section No. 310.21\]](#)

Submitter Information Verification

Submitter Full Name: David Hittinger

Organization: IEC

Affiliation: NEC Correlating Committee Appointed Task Group

Street Address:

City:

State:

Zip:

Submittal Date: Mon Sep 07 09:58:30 EDT 2020

Committee: NEC-P10

Terminal and Conductor Temperature Testing of 14 AWG Copper-Clad Aluminum and 14 AWG Copper Conductors

Part I – Static Heating and Flexing Tests

For

Bimetallics Task Group

Conducted at

Eaton Laboratories
Menomonee Falls, Wisconsin

Report by

Chuck Mello
on behalf of Bimetallics Task Group

Report Date

August 28, 2020

Table of Contents

1.0	Introduction and Purpose	1
2.0	Testing Arrangement and Setup.....	2
3.0	Materials for Testing	6
4.0	Test Procedures	7
5.0	Test Results	11
6.0	Conclusions.....	16
7.0	Test Equipment and Calibration	17

Appendices

A – Photos.....	A1 – A12
B – Copper-Clad Aluminum Material Verification	B1 – B7
C – Static Heating Test Data	
C1 – Static Heating Test at 100% Rated Current	C1-1 – C1-6
C2 – Static Heating Test at 135% Rated Current	C2-1 – C2-6
C3 – Static Heating Test at 150% Rated Current	C3-1 – C3-6
C4 – Static Heating Test at 200% Rated Current	C4-1 – C4-6
C5 – Static Heating Original 100% and 135% Trip Failure	C5-1
D – Flexing Tests Data.....	D1
E – Certificates of Calibration.....	E1 – E26

1.0 Introduction and Purpose

At the direction of the NFPA Standards Council in their Decisions D#19-2 and D#19-23, a Bimetallics Task Group of balanced interest was appointed. The scope was to review the proposed changes to the 2020 edition of the *NEC*® that relate to copper-clad aluminum conductors and recommend changes through tentative interim amendment(s) and/or to provide public inputs for the next revision cycle.

As the task group conducted the work, it was determined that testing data had been provided substantiating the ampacity of 14 AWG copper-clad aluminum but a number of related questions about 14 AWG copper-clad aluminum applications arose regarding terminal temperatures when applied to circuit breakers, wire splicing devices and device terminals. A testing plan was developed, reviewed over several task group meetings, and accepted by the task group to address the terminal temperature questions. This testing was completed at the Eaton Corporation laboratory facilities in Menomonee Falls, Wisconsin. The helpful assistance of Mr. Tom Domitrovich, Mr. Kevin Arnold, Mr. James Parrett, and Mr. Steve Averbek with Eaton Corporation is greatly appreciated in arranging for and executing the testing.

This test report provides the testing arrangement, testing procedures and results for the static heating and the flexing tests. The Part I testing detailed in this report commenced July 30, 2020 and completed on August 26, 2020. Thermocycling testing is presently being conducted and those test results will be provided in a separate report. The separation of the reports is necessary to meet the NFPA deadline of September 10, 2020 to submit public inputs and any supporting data.

The purpose of this testing is to provide data, as requested by the Bimetallics Task Group, to understand certain installation and operating conditions when considering the application of 14 AWG copper-clad aluminum conductors at the proposed ampacity for branch circuits. The testing being completed also includes 14 AWG copper conductors at its *NEC*® ampacity for comparison and performance. The basis for comparison is at the 60°C ampacity rating for copper (15 amps) and the proposed 60°C ampacity rating for copper-clad aluminum (10 amps). This testing is designed to represent a typical installation to determine the following:

- 1) The temperature (temperature rise) on the terminals and conductor immediately adjacent to a 10 Amp and 15 Amp molded case circuit breaker, under normal and identified abnormal conditions
- 2) The temperature (temperature rise) on wire-splicing devices (e.g., Ideal Wire Nuts® or similar), and conductor immediately adjacent, commonly used for splicing in junction or device boxes or attaching leads from utilization equipment, under normal and abnormal conditions
- 3) The temperature (temperature rise) on wiring devices (single receptacle as representative) and conductor immediately adjacent under normal and abnormal conditions
- 4) Conductor retention on wiring devices after abnormal thermal-cycling
- 5) The flexing durability of 14 AWG copper-clad aluminum when installed and removed from a single-gang device box

Since the various product standards do not presently have requirements, procedures or parameters for 14 AWG copper-clad aluminum, the testing being conducted is based on the 10-ampere branch circuit rating at 60°C and percentage multipliers taken from the applicable standards. Where the standard does not provide a percentage value, then the current for the testing was interpolated from the values for relative copper and/or aluminum conductors from the standard. The values for testing of 14 AWG copper are taken from the applicable product safety standards with an ampacity basis of 15 Amps at 60°C

It is to be understood this testing is only being conducted to provide specific performance data and information as requested by the task group. The testing does not provide performance or data for certification of any of the components used for the testing. If 14 AWG copper-clad aluminum is accepted into the 2023 *NEC*®, then numerous UL standards will need to be revised and testing completed under the requirements established in those standards. This testing for certification could be more extensive and take much more time to complete than what is provided here. The goal again is to provide information for a typical installation specific to terminal temperatures. The changes to UL standards will not begin to occur until 14 AWG copper-clad aluminum is recognized for installation in the *NEC*®.

To provide a basis to consider the test results for 14 AWG copper-clad aluminum, duplicate test set ups were constructed using 14 AWG copper conductors. The only difference in the setup for 14 AWG copper is the circuit breaker was rated 15 Amps and the testing values were based on the 15 Amp ampacity. This additional testing data provides a direct comparison in the same environment at the 60°C ampacity values for these two conductor types and assemblies.

2.0 Testing Arrangement and Setup

The test was conducted in a suitable facility with environmental controls and documented monitoring. The facility was free from extraneous changes in ambient temperature and from having random air flow (drafts) through the testing area. Ambient temperature was maintained between 20°C and 25°C and recorded with thermocouples positioned in the testing area while temperature testing was completed.

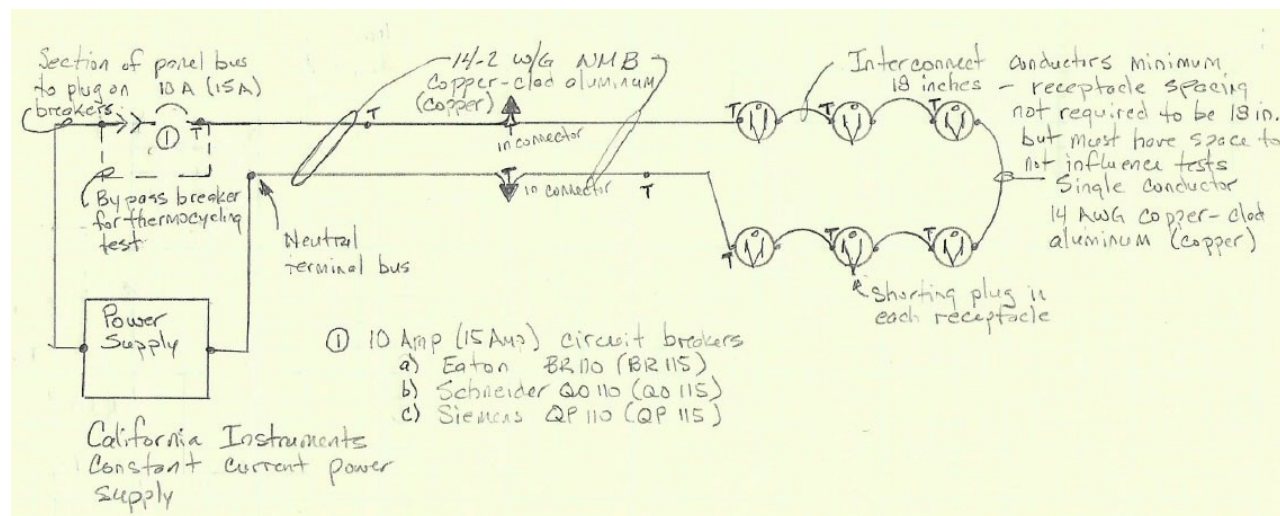


Figure 1 – Typical Test Circuit Diagram

The Eaton facility, being a division within a manufacturing company of wiring devices and circuit breakers, has laboratory technicians that are very familiar with testing of circuit components and equipment to UL standards.

The test circuit diagram shown in figure 1 above provides the basic layout of one (1) testing circuit consisting of one (1) circuit breaker, the conductor (14 AWG copper-clad aluminum or copper NM-B cable) two wire-splicing devices, and six (6) single receptacles. To complete tests 1 through 4 as described below, three (3) of these test circuits were assembled at a time. Photos 1 through 3 in Appendix A show the general test setup for completing the static heating testing. Each of the three (3) circuits have one of the manufacturer's (mfg. 1, mfg. 2, and mfg. 3) circuit breaker, the wire splicing devices on the black and white wire as described below, and three (3) each of receptacles from two of the manufacturers. Photos 4 through 7 show each of the setups with a sign indicating the circuit breaker, conductor material, wire splicing devices, and receptacles in that circuit.

For example, a setup had three (3) circuits with:

- Three different 10-amp circuit breakers (one each mfg. 1, mfg. 2, and mfg. 3)
- 14 AWG copper-clad aluminum NM-B conductors
- Mfg. 4 and mfg.5 wire splicing devices respectively, on the black and white conductors
- Three each of the mfg. 8 and mfg. 9 receptacles, and
- 14 AWG THHN copper-clad aluminum conductors for interconnection of the receptacles

These components were connected together to form a complete circuit. The second setup for 14 AWG copper-clad aluminum were same circuit breakers but with mfg.6 and mfg.7 wire splicing devices and with mfg. 10 and mfg.11 receptacles. The third and fourth setups were the same as 1 and 2 except using 15-amp circuit breakers and 14 AWG copper conductors.

Due to testing of several different circuit breakers, receptacles, and wire-splicing devices, the test arrangement was different than what may be used for certification testing of a single type of device. The test purpose was to approximate an actual installation under laboratory type conditions and not to establish certification type testing for any one device.

For tests 1 through 4 the three power supplies used were programmable constant current power supply sources. Each power supply was connected to one of the circuits and provided the current level specified for the tests being conducted.

For each of the four setups the following description is provided, see circuit diagram in figure 1 and Appendix A photos 1 through 7:

- 1) The three (3) circuits were mounted on an insulating sheet approximately 4 feet high and 8 feet wide. The partition had suitable framing to provide structural support for the partition to be in a vertical orientation to the floor.
- 2) During all testing, suitable barrier tape, safety cones, barriers, or other means was in place in accordance with the laboratory safety procedures to keep unauthorized persons out of the area and away from exposed live parts.
- 3) The individual conductors and devices were arranged horizontally with approximately 12 inches of vertical spacing between each horizontal assembly. Staples, or other fastening devices, such as cable ties, were used to keep the NM-B cable aligned with the respective test assembly.

- 4) For the circuit breaker testing the following was assembled:
- a) For the copper-clad aluminum conductors, three (3) 10-amp plug-on type panelboard circuit breakers were installed on sections of panelboard bus that are mounted onto the insulating board partition.
 - b) For the copper conductors, three (3) 15-amp plug-on type panelboard circuit breakers were installed on sections of panelboard bus that are mounted onto the insulating board partition. The panelboard bus had a terminal for connection of one conductor from the power supply.
- 5) From the circuit breaker approximately 4 feet of 14-2 NM-B cable was installed and supported as provided above. From this center junction another 2 feet of 14-2 NM-B cable (copper-clad aluminum or copper as applicable) was installed. The junction in the middle had approximately 6 inches of exposed conductor and a splice completed with yellow wire-splicing devices as provided for the black, white and equipment grounding conductors. The following was applied to the two setups for the copper-clad aluminum conductors respectfully and repeated for the copper conductor setups.
- a) The black wire for the first circuit set of three used a mfg. 4 yellow wire-splicing devices
 - b) The white wire for the first circuit set of three used an mfg. 5 yellow Wire Nuts®
 - c) The black wire of the second circuit set of three used a mfg. 6 yellow wire-splicing devices
 - d) The white wire of the second circuit set of three used a mfg. 7 yellow wire-splicing devices

The manufacturer and location of the wire-splicing devices used was recorded for each test setup.

- 6) Six (6) receptacles were installed at the end of each horizontal assembly.
- a) The first set of circuits of copper-clad aluminum or of copper had three (3) mfg. 11 receptacles and then three (3) receptacles from mfg. 8 all connected in series.
 - b) The second circuit of copper-clad aluminum or of copper had three (3) receptacles from mfg. 10 and then three (3) receptacles from mfg. 9 all connected in series.

The receptacles were spaced a minimum of six (6) inches apart horizontally and/or vertically and were interconnected with a minimum of eighteen (18) inches of 14 AWG solid THHN copper-clad aluminum or copper conductors respectfully.

The receptacles were mounted to the wall surface with screws, so that the face of the receptacle was approximately 1 1/2 inches from the insulating board partition surface.

For each manufacturer the receptacles were connected to terminals as follows:

- a) One receptacle had the conductors installed at each wire binding screw and the conductors were wrapped counter-clockwise around the screw shank under the screw head, for 2/3 to 3/4 of wire binding screw circumference.

- b) The second receptacle had the conductors installed into one side back terminal (entry hole) of the pressure plate terminal.
- c) The third receptacle had two conductors installed into each back-side pressure plate terminal as follows: one conductor of the test circuit into each side (hot and neutral) of the pressure plate terminal and one additional short conductor of equal diameter and material into the other side (entry hole) of the same pressure plate terminal. The second conductor was to fill the slot only and is not required for any other purpose than to balance the mechanical clamping forces applied.

Each receptacle had a shorting plug installed as follows:

- a) The ungrounded (BLACK) and grounded (WHITE) contacts of each receptacle being tested were connected together by a mated attachment plug having rigidly-attached solid blades.
 - b) The terminals of each attachment plug were short-circuited by the shortest feasible length of 14 AWG stranded copper conductor from type SJ flexible cord.
 - c) The flexible cord shorting conductor was mechanically terminated into the pressure plate terminals and the connection torqued to the manufacturer's specification.
- 7) The conductor from the neutral terminal of the last receptacle in the series was routed back using the white wire in the NM-B cable, through the wire-splicing devices and terminated at a terminal bar mounted to the support board for connection back to the power supply.
- 8) All connections were tightened as follows. Torquing tools were calibrated and calibration documented:
- a) The circuit breaker terminals were torqued as specified on the circuit breaker nameplate.
 - b) The wire-splicing devices were torqued to the manufacturer's specification in the instructions. If there was no specification, then the 14 AWG copper-clad aluminum conductors were torqued to 2.47 lbf-in and the 14 AWG copper conductors were torqued to 4.11 lbf-in [Specification from UL 486C – 9.1.9.4]
 - c) The terminals of the receptacles and of the attachment plugs were torqued to the manufacturer's specification in the installation instructions. If there was no torque specification provided, then the terminals were torqued to 9 lbf-in.
- 9) Thermocouples were connected as shown in the diagram, figure 1 and as shown in Appendix A photos 8 and 11 through 14.
- a) Thermocouples were installed on device terminals so that it did not interfere with the terminal.

For the wire-splicing devices, the thermocouples were attached into the wire bundle within the wire-splicing devices.

- b) The thermocouples that measured center wire temperatures had a flap of the NM-B jacket and the conductor insulation peeled back to expose the conductor. The thermocouple was attached with thermo-cement to the conductor and the conductor insulation and jacket flap folded back to the original position with two wraps of black electrical tape wrapped to hold the flap in place.
 - c) A thermocouple was positioned midway in elevation to the test setup for each circuit and recorded the ambient temperature as testing was completed.
- 10) The power supply was a programable constant current power supply. The current was monitored and recorded by the data logger along with the temperature recordings. The power supply was connected to the lug on the panelboard bus serving the circuit breaker and to the neutral terminal bar where the return white conductor from the NM-B cable was terminated.

3.0 Materials for Testing

The generous support with the supplying of materials by Copperweld, Eaton, Hubbell, Legrand, Leviton, and Siemens are acknowledged and appreciated. The following materials were used to complete the setups as described above.

- 1) The circuit breakers for the copper-clad aluminum testing were single pole 10 Amp 120/240 Volt, 10,000 interrupting rating with five (5) each of the following (two (2) breakers to be used and the others as backup):
 - a) Eaton BR110,
 - b) Schneider QO110, and
 - c) Siemens QP110.
- 2) The circuit breakers for the copper testing were single pole 15 Amp 120/240 Volt, 10,000 interrupting rating with five (5) each of the following (two (2) breakers to be used and the others as backup):
 - a) Eaton BR115,
 - b) Schneider QO115, and
 - c) Siemens QP115.
- 3) The yellow wire-splicing devices were as follows:
 - a) Gardner-Bender Ultra WingGard
 - b) Ideal Wing-Twist
 - c) 3M Performance Plus Red/Yellow+
 - d) Commercial Electric WT4

- 4) The receptacles for both the copper-clad aluminum and copper testing were:
 - a) Eaton (Cooper) model TR6250W, 5-15R single receptacle with wire binding screw and pressure plate terminals (back and side wired)
 - b) Hubbell model HBL 5261, 5-15R single receptacle with both wire binding screw and pressure plate terminals (back and side wired)
 - c) Legrand (Pass & Seymour) model TR 5251, 5-15R single receptacle with both wire binding screw and pressure plate terminals (back and side wired)
 - d) Leviton model T 5015, 5-15R single receptacle with both wire binding screw and pressure plate terminals (back and side wired)
- 5) Thermocouples, UL calibrated, model UL 3055, with sufficient length to connect and route to datalogger recording device.
- 6) Datalogger recording device and laptop or another required device for the datalogger.
- 7) Programable power supplies from Eaton laboratory. Maximum current for the copper was 30 Amps and for the copper-clad aluminum was 20 amps.
- 8) Approximately 50 feet each of 14-2 w/ground copper-clad aluminum NM-B cable and of 14-2 w/ground copper NM-B cable.
- 9) Approximately 50 feet each of 14 AWG solid THHN copper-clad aluminum and 14 AWG solid THHN copper single conductors.

4.0 Test Procedures

4.1 Conductor Material Testing

A sample of each the 14-2 NM-B and 14 AWG THHN copper-clad aluminum conductors used for the testing was returned to the Copperweld factory laboratory for analysis. The testing was performed to confirm the conductors that were used for the testing at Eaton were in fact 14 AWG and met the requirements for copper-clad aluminum as specified in UL 83 Annex E and ASTM B566. The packaging was photo documented from the Eaton laboratory and the opening of the package at the Copperweld laboratory photo documented.

The Copperweld laboratory technician, who routinely performs the full ASTM B566 battery of testing, completed all the testing and documented it on a Copperweld laboratory test data sheet.

Standard materials testing was completed by Copperweld laboratory technicians including:

- DC resistance
- Copper thickness
- Copper Volume
- Tensile strength
- Elongation
- Adhesion
- Cohesion

The following tests, as completed by the Copperweld laboratory technician, were witnessed and documented by the UL Field Representative that normally completes follow-up inspections of copper-clad aluminum conductors as part of the recognized component program, under category DVVU2:

- DC resistance
- Copper thickness
- Tensile strength
- Elongation

4.2 Terminal Temperature Testing

The following test procedures, except the flexing test, used references from parts of UL 486(A)(B); UL 486(C); UL 489; UL 20; and UL 498.

As stated, the tests 1 through 4 were completed with all three (3) manufacturer's circuit breakers in three circuits at one time. These tests are identified with the test number from below with an "a", "b" or "c" representing the representative circuit breaker used:

- a. mfg. 1 circuit breaker
- b. mfg. 2 circuit breaker
- c. mfg. 3 circuit breaker

This same nomenclature is used in the data sheets found in Appendix C. To minimize test setups, and the number of times terminations are completed or taken apart, all four (4) static heating tests were completed for the "a", "b", and "c" circuit setups. After these tests were completed, then the next setup was assembled by changing the wire splicing devices and receptacles or changing the conductors from copper-clad aluminum to copper as applicable.

All static heating tests, tests 1 through 4 commenced with all components at ambient temperature.

For all testing temperature equilibrium is three consecutive readings taken at no less than 5-minute intervals indicating no further rise in temperature above the ambient temperature. For tests where the circuit breaker trips, which may be before temperature equilibrium was attained, the last three recorded temperatures were recorded onto the data sheets.

Test #1 – Rated Current Temperature

Each circuit was operated at 100% of the branch circuit rating (CCA - 10 Amps or Cu - 15 Amps) until temperature equilibrium was achieved. The final temperatures were recorded. All terminations were inspected for evidence of thermal damage. Temperature measurements were recorded at one-minute intervals.

Test #2 – Circuit Breaker Overload Temperature

Each circuit was operated at 135% of the branch circuit rating (CCA - 13.5 Amps or CU - 20.25 Amps) until temperature equilibrium was achieved or the circuit breaker tripped whichever came first. The circuit breaker elapsed trip time was recorded. Table 1, in section 4.3 below, provides the expected circuit breaker trip times from the manufacturer's time current curves. If the circuit breaker tripped, the last three recorded temperatures of the conductor, wire-splicing devices and wiring device were recorded on the datasheet. All terminations were inspected for evidence of thermal damage. Temperature measurements were recorded at 20-second intervals.

Test #3 – Wiring Device Overload Temperature

Each circuit was operated at 150% of the branch circuit rating (CCA - 15 Amps, or CU - 22.5 Amps) until temperature equilibrium was achieved or the circuit breaker tripped whichever came first. The circuit breaker elapsed trip time was recorded. Expected circuit breaker trip times are in a table 1 below in section 4.3 of procedure. If the circuit breaker tripped, the last three recorded temperatures of the conductor, wire-splicing devices and wiring device were recorded on the datasheet. All terminations were inspected for evidence of thermal damage. Temperature measurements were recorded at 10 second intervals.

Test #4 – Circuit Breaker Overload Temperature

Each circuit was operated at 200% of the branch circuit rating (CCA - 20 Amps, or CU 30 Amps) until temperature equilibrium was achieved or the circuit breaker trip tripped whichever came first. The circuit breaker elapsed trip time was recorded. Expected circuit breaker trip times are in a table 1 below in section 4.3 of procedure. If the circuit breaker tripped, the last three recorded temperatures of the conductor, wire-splicing devices and wiring device were recorded on the datasheet. All terminations were inspected for evidence of thermal damage. Temperature measurements were recorded at 7 second intervals.

Test #5 – Wiring Device Thermal Cycling

The thermocycling testing is underway at the time this report is being written. In order to meet NFPA public input deadlines, this report is for all testing completed at this time. A subsequent report will be written for the thermocycling testing.

Test # 6 – Conductor Flexing Test

- a) A standard 2 x 3 device box was mounted to a wood stud fixed to a table for support. See Appendix A photo 15. The device box was mounted with screws through the back of the box.
- b) A length of 14-2 AWG copper-clad aluminum NM-B cable was installed into the device box using NM cable clamps. The NM-B had a minimum of 1/4 inch of cable jacket projecting into the box past the clamping device.
- c) The outside end of the NM-B cable was connected to a digital multimeter to indicate continuity of the circuit through the receptacle, see Appendix A photo 16.

- d) The NM-B cable jacket was stripped and cut to length so that 6 inches of conductor projected beyond the cable entry to the box and 3 inches beyond the front edge of the device box. A receptacle was terminated to the NM-B cable conductors and the conductors shaped to fit back in the box so the receptacle yoke mated with the box front edge.
- e) For the first test, the NM-B conductors were installed using the wire binding screw with the conductors wrapped counter-clockwise around the screw shank under the screw head, for 2/3 to 3/4 of wire binding screw circumference.
- f) A shorting plug was installed into the receptacle.
- g) The 6-32 screws were removed and approximately 4-inch-long 10-32 screws were fixed to the device box ears and through the yoke of the receptacle providing a guideway for repeated insertion and removal. The 10-32 screws had nuts installed in the inside and outside of the device box ears to make rigid to the box, see Appendix A photo 15.
- h) With the assembly complete, the receptacle was pushed into and retracted from the box for 10 cycles and the continuity monitored on the digital multimeter, see Appendix A photos 17 through 19.
- i) Steps 'b' through 'h' were repeated two more times with new lengths of 14-2 NM-B copper-clad aluminum cable.
 - For the second test the receptacle was assembled with the back-wiring pressure plate terminal and a single conductor.
 - For the third test the receptacle was assembled with the back-wiring pressure plate terminal and two conductors for mechanical balance on the wiring terminal.

4.3 Bimetallics Testing Circuit Breaker Trip Times

The below table provides the expected trip times based on the manufacturers time current curves at 40°C. The testing for this project was completed at about 22°C, based on the ambient temperatures recorded. Therefore, the trip times recorded from this testing may be somewhat higher but should not exceed the limits set in the UL Standard.

The UL standard specifies that calibration testing be completed at an ambient temperature of 25°C. The UL standard calibration testing at 25°C specifies that at:

- 135% of rating the maximum trip time for a 0 - 50-amp circuit breaker is 1 hour
- 200% of rating the maximum trip time for a breaker 0 – 30 amps is 2 minutes.

Table 1

Manufacturer	Catalog No.	Trip Time Range in Seconds @ 40°C			
		100% rated current	135% rated current	150% rated current	200% rated current
Eaton	BR110	No trip	35 - 3600	20 - 500	12 - 40
	BR115	No trip	35 - 3600	20 - 500	12 - 40
Schneider	QO110	No trip	40 - 500	26 - 240	10 - 60
	QO115	No trip	30 - 210	21 - 100	8 - 28
Siemens	QP110	No trip	60 - 800	40 - 450	19 - 150
	QP115	No trip	30 - 250	20 - 100	9 - 38

5.0 Test Results

5.1 Copper-Clad Aluminum Conductor Material Testing

After the static heating testing was completed, Eaton laboratory technicians packed and shipped samples of the copper-clad aluminum conductor, NM-B cable and THHN single conductor, that had been used for the testing to Copperweld's laboratory for verification testing. Appendix A photos 22 to 24 show the samples the Eaton laboratory technicians packaged into the bag and shipped to the Copperweld laboratory. Note the date on these photos as August 24, 2020. Appendix B pages B1 and B2 show photos of the received package and opening of that package with these samples for the testing.

The samples of the 14 AWG copper-clad aluminum NM-B cable and the 14 AWG copper-clad aluminum THHN single conductors were tested in the Copperweld factory laboratory on August 27, 2020. The Copperweld laboratory testing data is provided in Appendix B page B3 and the calibration of the test equipment on pages B4 through B6.

The UL field engineer that routinely completes the quarterly follow-up inspections for the copper-clad aluminum conductor witnessed the testing required under the UL standard follow-up program that was completed on August 27, 2020. As shown in Appendix B, page B7, the UL field engineer confirmed that *"the 14 Awg from the NMB and THHN samples passed the UL tests for DVVUs, including Tensile, Elongation, copper thickness and DC resistance"*

The test results for the copper-clad aluminum confirm that the conductors used for this testing were 14 AWG and that the material tested met the requirements in ASTM B566.

5.2 Test Setup and Torquing

The test setups were as described in Section 2.0 of this report and shown with photographs in Appendix A. The terminations were tightened to the applicable torque value with a calibrated torque wrench. For the static heating testing the following tables show the torque values applied for each setup and device terminal.

Copper-Clad Aluminum conductors with mfg. 11 and mfg. 8 Receptacles

Torques applied:

Item being torqued	in/lbs	mfr. spec	default
mfg. 1 brkr	20	yes	no
mfg. 2 brkr	36	yes	no
mfg. 3 brkr	25	yes	no
mfg. 4 wire splicing device	2.47	no	yes
mfg. 5 wire splicing device	2.47	no	yes
mfg. 11 receptacles	9	no	yes
mfg. 8 receptacles	12	yes	no

Copper-Clad Aluminum conductors with mfg. 10 and mfg. 9 Receptacles

Torques applied:

Item being torqued	in/lbs	mfr. spec	default
mfg. 1 brkr	20	yes	no
mfg. 2 brkr	36	yes	no
mfg. 3 brkr	25	yes	no
mfg. 6 wire splicing device	2.47	no	yes
mfg. 7 wire splicing device	2.47	no	yes
mfg. 10 receptacles	9	no	yes
mfg. 9 receptacles	9	no	yes

Copper conductors with mfg. 11 and mfg. 8 Receptacles

Torques applied:

Item being torqued	in/lbs	mfr. spec	default
mfg. 1 brkr	20	yes	no
mfg. 2 brkr	36	yes	no
mfg. 3 brkr	25	yes	no
mfg. 4 wire splicing device	4.11	no	yes
mfg. 5 wire splicing device	4.11	no	yes
mfg. 11 receptacle	9	no	yes
mfg. 8 receptacle	12	yes	no

Copper conductors with mfg. 10 and mfg. 9 Receptacles

Torques applied:

Item being torqued	in/lbs	mfr. spec	default
mfg. 1 brkr	20	yes	no
mfg. 2 brkr	36	yes	no
mfg. 3 brkr	25	yes	no
mfg. 6wire splicing device	4.11	no	yes
mfg. 7 wire splicing device	4.11	no	yes
mfg. 10 receptacle	9	no	yes
mfg. 9 receptacle	9	no	yes

5.3 Static Heating Test

The following are the results of the static heating testing, tests 1 through 4 with references to the applicable appendix pages. For all the testing data, the final three recorded temperature values are shown at either temperature equilibrium or the final three temperatures recorded before a circuit breaker tripped. All testing commenced with all test measurement points at ambient temperature. Also shown in the tables in the appendix are:

- The elapsed time from the start of the test,
- The ambient temperature recorded at the time of the recorded values, and
- The current at the time of the recorded values.

Since the UL standards reference temperature rise for most of the devices, those calculated values are shown immediately adjacent to the recorded values. The temperature rise was calculated by taking the recorded temperature and subtracting the ambient temperature recorded for that time.

Since the method of termination on each the three receptacles from one manufacturer was different (wire binding screw, back wired with pressure plate with one conductor and back wired with pressure plate with two conductors) exact data comparison of terminal temperature needs to be done line by line. For example, from appendix page C1 – 1, the line 1a for copper-clad aluminum, top table, needs to compare with line 1a for copper, bottom table.

Otherwise, data in general for terminal temperatures of specific devices, circuit breakers, wire splicing devices and receptacles as well as the conductor, can be compared in general. To facilitate ease of comparison, the pages in appendices C1 through C4 have been arranged so that each page has the copper-clad aluminum data in the top table and the related copper data in the bottom table.

5.3.1 Static Heating at 100% Rated Current

The data for the static heating testing at 100 percent of rated current are shown in Appendix C1. The recorded values are all after the temperatures being recorded had achieved temperature equilibrium. As can be seen in line by line or with general comparisons, the terminal and conductor temperatures for the copper-clad aluminum were less than those recorded for copper when operating at rated current. All temperatures recorded were less than the allowances in the applicable UL standards.

5.3.2 Static Heating at 135% Rated Current

The data for the static heating testing at 135 percent of rated current are shown in Appendix C2. The 135 percent current level is a calibration point for circuit breakers, rated up to 50 amps, where they are required to trip within 1 hour. The recorded values are the last three recorded temperatures before the circuit breaker tripped.

In doing analysis consideration must be given to the fact the temperatures recorded were still rising when the circuit breaker tripped. Therefore, when doing line by line or general comparisons, the circuit breaker trip time must be considered. It is noted the mfg. 1 10-amp circuit breaker tripped approximately twice as fast as the 15-amp circuit breaker, 8 vs. 19 seconds, and this resulted in higher recorded temperatures for copper. The test results with the mfg. 2 circuit breakers was reversed with the 15-amp breaker tripping in approximately half the time of the 10-amp circuit breaker, 3.5 vs. 5.5 seconds. Even with this time disparity the copper-clad aluminum with the longer time recorded lower temperatures than the copper. The trip times for the mfg. 3 circuit breakers had the 10-amp breaker tripping 3 times longer than the 15-amp breaker, but the copper-clad aluminum terminal temperatures still were less than or near to the copper terminal temperatures.

All temperatures recorded were less than the allowances in the applicable UL standards.

5.3.3 Static Heating at 150% Rated Current

The data for the static heating testing at 150 percent of rated current are shown in Appendix C3. The 150 percent current level is a static heating test current for wiring devices. The recorded values are the last three recorded temperatures before the circuit breaker tripped.

In doing analysis consideration must be given to the fact the temperatures recorded were still rising when the circuit breaker tripped. Therefore, when doing line by line or general comparisons, the circuit breaker trip time must be considered. The test data results shown in appendix C3 generally follow that same pattern as occurred with the 135 percent testing.

All temperatures recorded were less than the allowances in the applicable UL standards.

5.3.4 Static Heating at 200% Rated Current

The data for the static heating testing at 200 percent of rated current are shown in Appendix C4. The 200 percent current level is a calibration point for circuit breakers, rated up to 30 amps, where they are required to trip within 2 minutes. The recorded values are the last three recorded temperatures before the circuit breaker tripped.

In doing analysis consideration must be given to the fact the temperatures recorded were still rising when the circuit breaker tripped. Therefore, when doing line by line or general comparisons, the circuit breaker trip time must be considered. The test data results shown in appendix C4 generally follows the same pattern as occurred with the 135 percent and 150 percent testing.

All temperatures recorded were less than the allowances in the applicable UL standards.

5.3.5 Static Heating at 135% Rated Current – Circuit Breaker Did Not Trip

The first attempt at the 135 percent testing found the mfg. 2 10-amp circuit breaker not to trip within the required 1-hour time. The data for this static heating test at 100 percent and at 135 percent of rated current are shown in Appendix C5. The top table on this appendix page is the 100 percent test data and the bottom table is the 135 percent test data. As stated before, the 135 percent current level is a calibration point for circuit breakers, rated up to 50 amps, where they are required to trip within 1 hour.

Since the circuit breaker failed to trip the test was stopped shortly after the 1-hour time had elapsed. Analysis of the 135 percent data recorded found that after 1-hour at this current level, above the proposed rated current, none of the terminal or conductor temperatures had risen above UL standards allowances.

5.3.6 Flexing Tests

The data for the flexing testing is shown in Appendix D. There is no UL or other known industry standard for this specific test and the test process used was established and agreed to by the task group to represent an installation condition. Three tests were conducted, one with the receptacle terminated with the 14 AWG copper-clad aluminum wrapped around the wiring binding screw, the second with a single conductor back wired into the pressure plate and the third with two conductors back wired into the pressure plate.

The test results found that after 10 cycles of fully inserting and removing the receptacle to the full extended position, the copper-clad aluminum

conductors for the back wired assemblies did not break and therefore passed this test.

For the wire binding screw termination, the first test found the flexing for the 10 cycles passed where the conductors did not break. But when the conductors were being removed both the black and white conductors broke off near the end of the insulation, see Appendix A photo 20. A second test was conducted and the black conductor was found to break off near the end of the insulation on the eighth cycle. A third test was completed, using a 14 AWG NM-B sample from another coil, and this assembly passed the 10 cycles and removal of conductors with no breaking or signs of weakening in the stripped portion of the conductor, see Appendix A photo 21.

As stated, there is no industry standard for completing this flexing test and the test was conducted due to specific questions asked by members of the task group. The results demonstrate that there may be limits to the amount of flexing these conductors can withstand, but it should be noted that in normal installations the insertion and removal of a wiring device occurs far less than the eight to ten times as conducted in this test.

6.0 Conclusions

The results from the temperature testing conducted in this project found the 14 AWG copper-clad aluminum to have terminal and conductor temperatures generally less than copper when tested at the 60°C ampacity values. In all cases, the temperature and temperature rise recorded were below those provided in the referenced UL standards. The flexing testing found that there may be some limitations to the number of flexing operations a 14 AWG copper-clad aluminum conductor can withstand, but the number of flexing operations to breakage is above those normally encountered in any installation.

As stated in the introduction, this testing project was to answer specific questions raised by the Bimetallics Task Group regarding temperature performance of 14 AWG copper-clad aluminum compared with 14 AWG copper in typical applications. **While testing conducted followed parts of several UL standards, it is to be understood the testing was only conducted to provide specific performance data and information as requested by the task group. The testing does not provide performance or data for certification of any of the components used for the testing.**

7.0 Test Equipment and Calibration

The following test and measurement equipment was used for the testing. The certificates of calibration for each of the above items is provided in Appendix E.

Description	manufacturer	Eaton Asset #	Cal Date	Cal Due
Thermocouples	Pacific Test and Measurement	N/A	7/10/2020	N/A
DACQ datalogger	Agilent (HP)	EM7054	7/16/2020	7/16/2021
DVM	Fluke	EM4437	7/16/2020	7/16/2021
DVM	Fluke	EM7014	7/16/2020	7/16/2021
DVM	Fluke	EM7024	7/16/2020	7/16/2021
CT	AEMC	EM6996	7/16/2020	7/16/2021
CT	AEMC	EM6997	7/16/2020	7/16/2021
CT	AEMC	EM8032	7/16/2020	7/16/2021
Torque wrench	CDI	EM8363	7/14/2020	7/14/2021
Tape measure	Stanley	EM6927	7/16/2020	7/16/2021

Appendix A - Photos



Photo 1 – Laboratory View



Photo 2 – Test Board and Test Equipment Arrangement

Appendix A - Photos

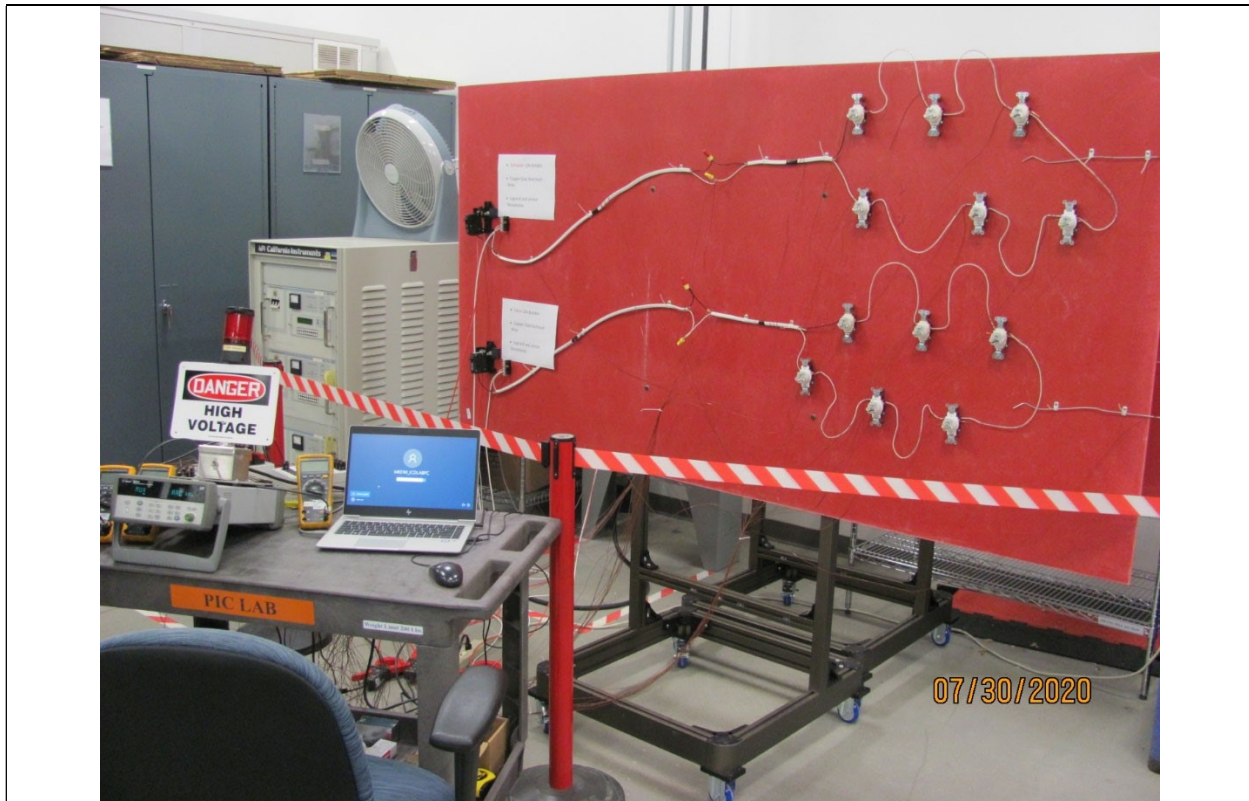


Photo 3 – Test Board and Test Equipment Arrangement

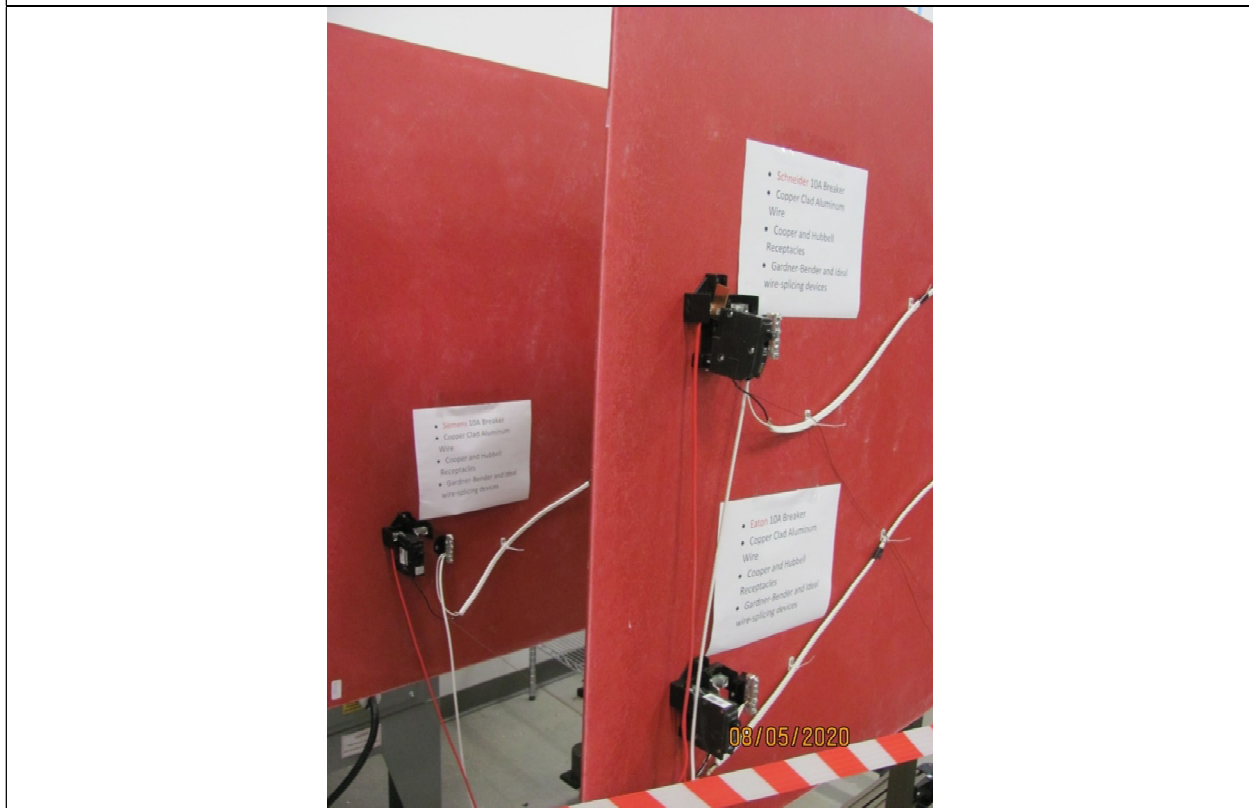


Photo 4 – Copper-Clad Aluminum with Eaton and Hubbell Receptacles

Appendix A - Photos

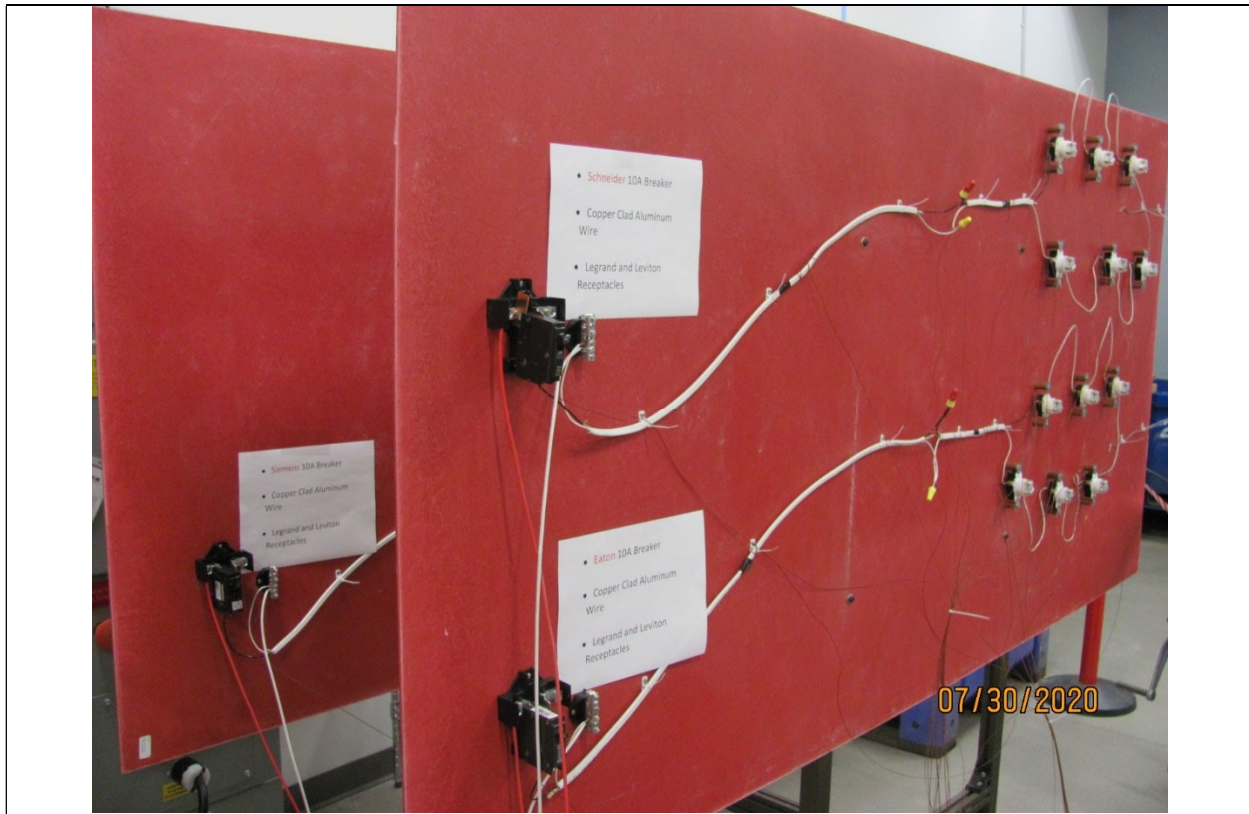


Photo 5 – Copper-Clad Aluminum with Legrand and Leviton Receptacles

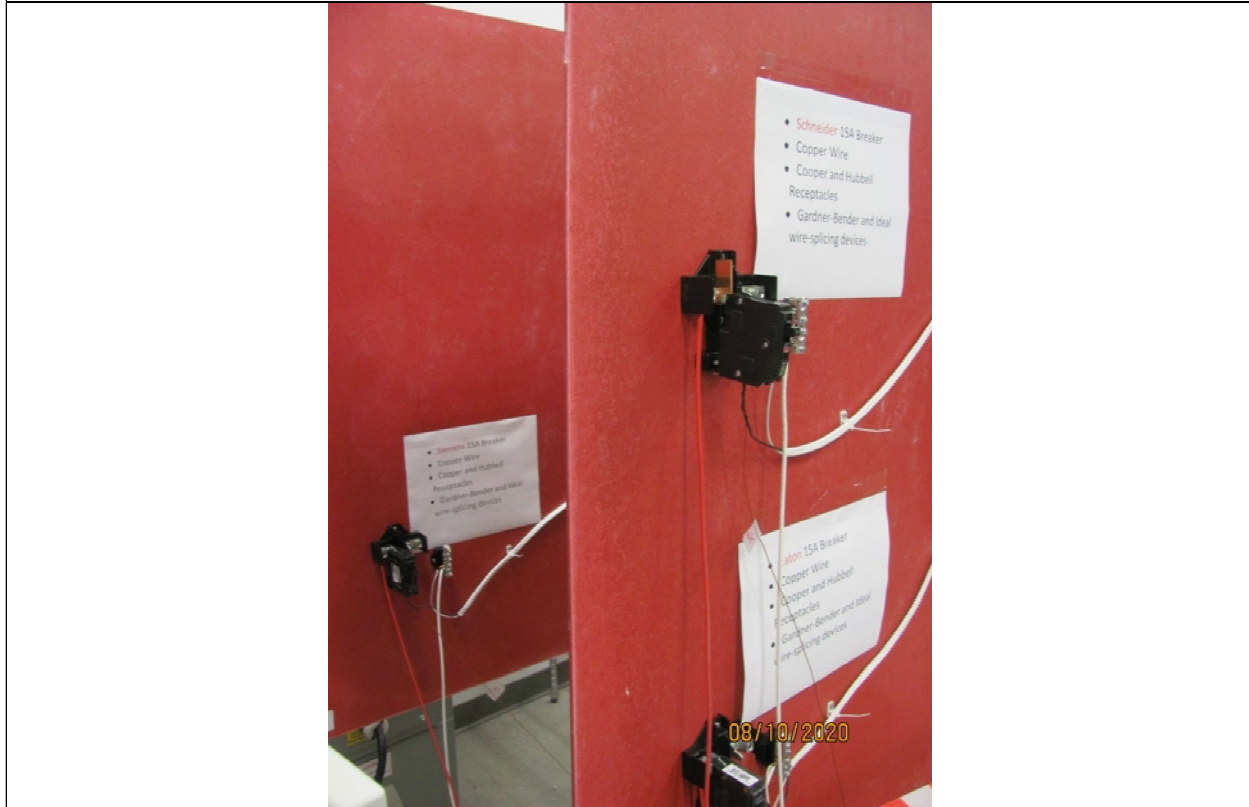


Photo 6 – Copper with Eaton and Hubbell Receptacles

Appendix A - Photos



Photo 7 – Copper with Legrand and Leviton Receptacles

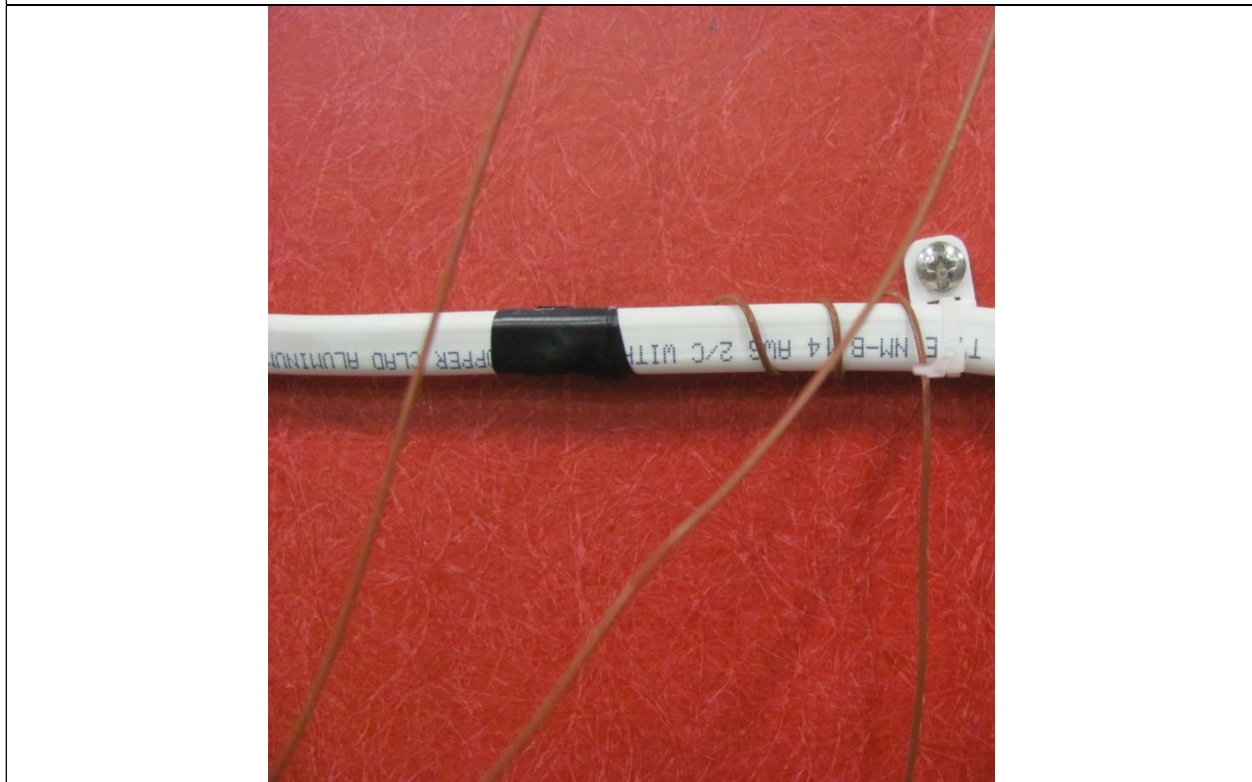


Photo 8 – Copper-Clad Aluminum NM-B Cable

Appendix A - Photos

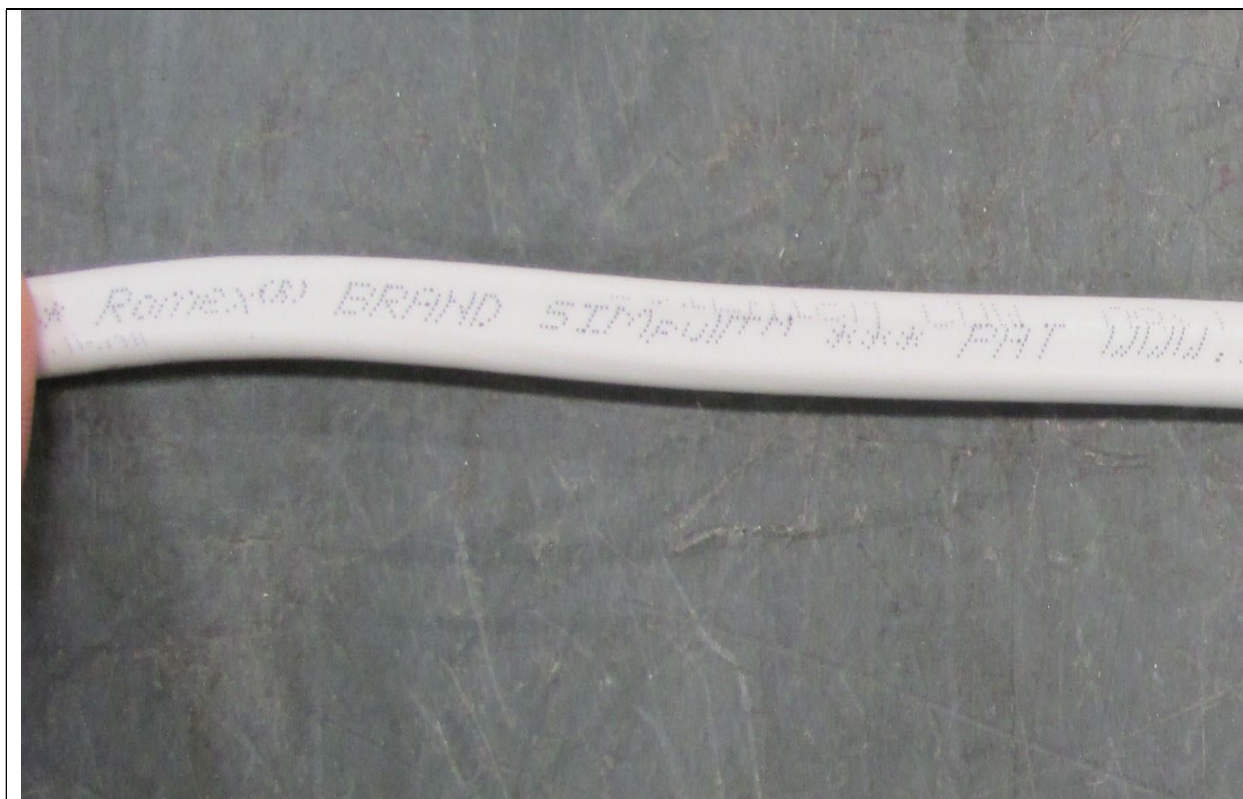


Photo 9 – Copper NM-B Cable



Photo 10 – Copper NM-B Cable Packaging

Appendix A - Photos

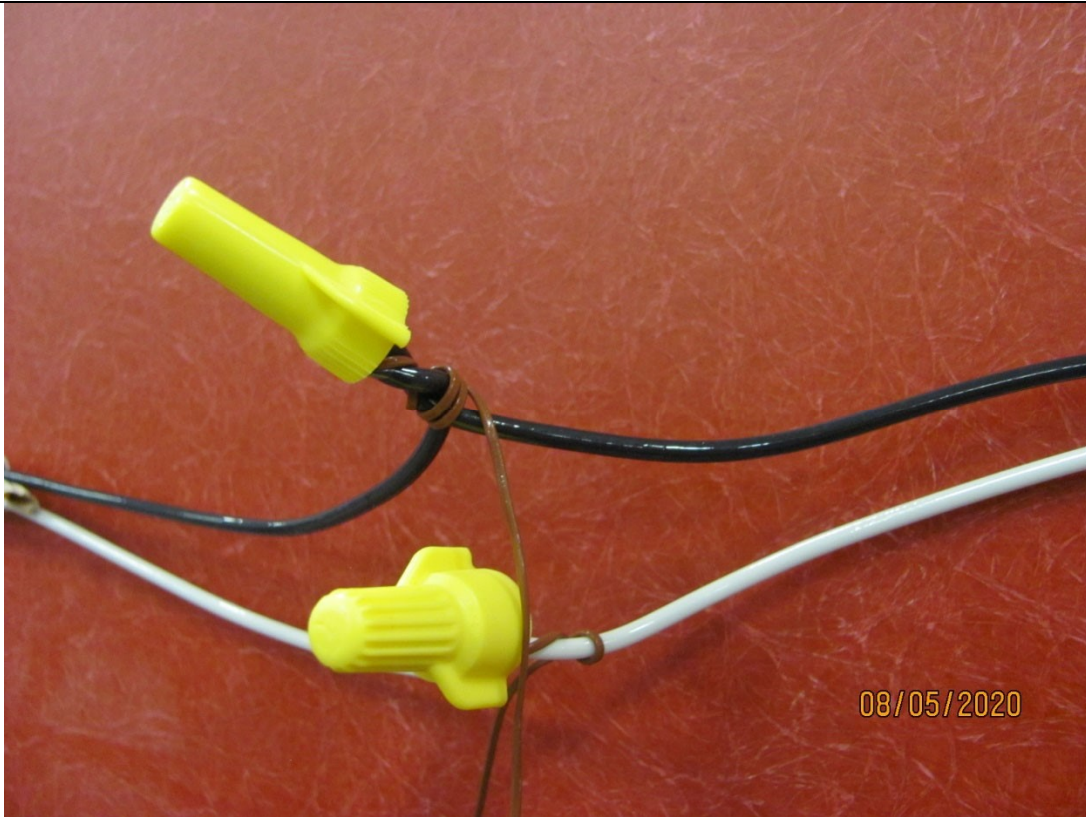


Photo 11 – Typical Installation of Wire Splicing Devices with Thermocouple



Photo 12 – Typical Installation of Receptacle using Wire Binding Screw

Appendix A - Photos

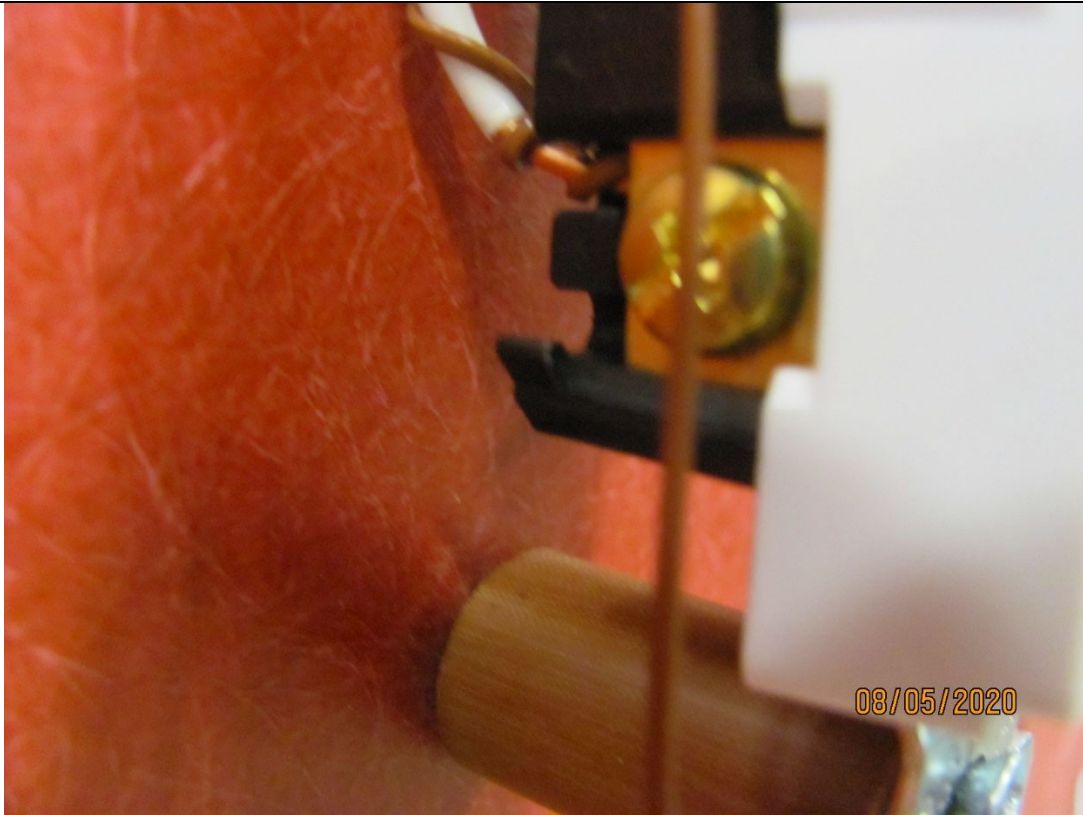


Photo 13 – Typical Installation of Receptacle Since Conductor Back Wired

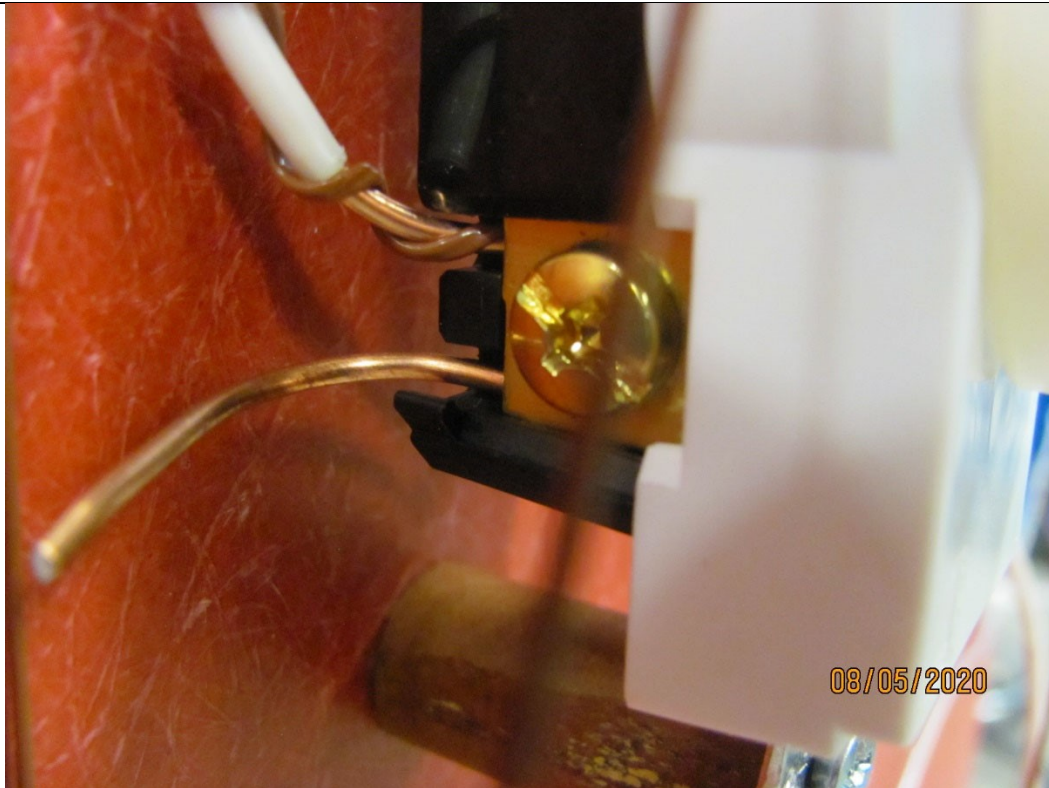


Photo 14 – Typical Installation of Receptacle Two Conductors Back Wired

Appendix A - Photos

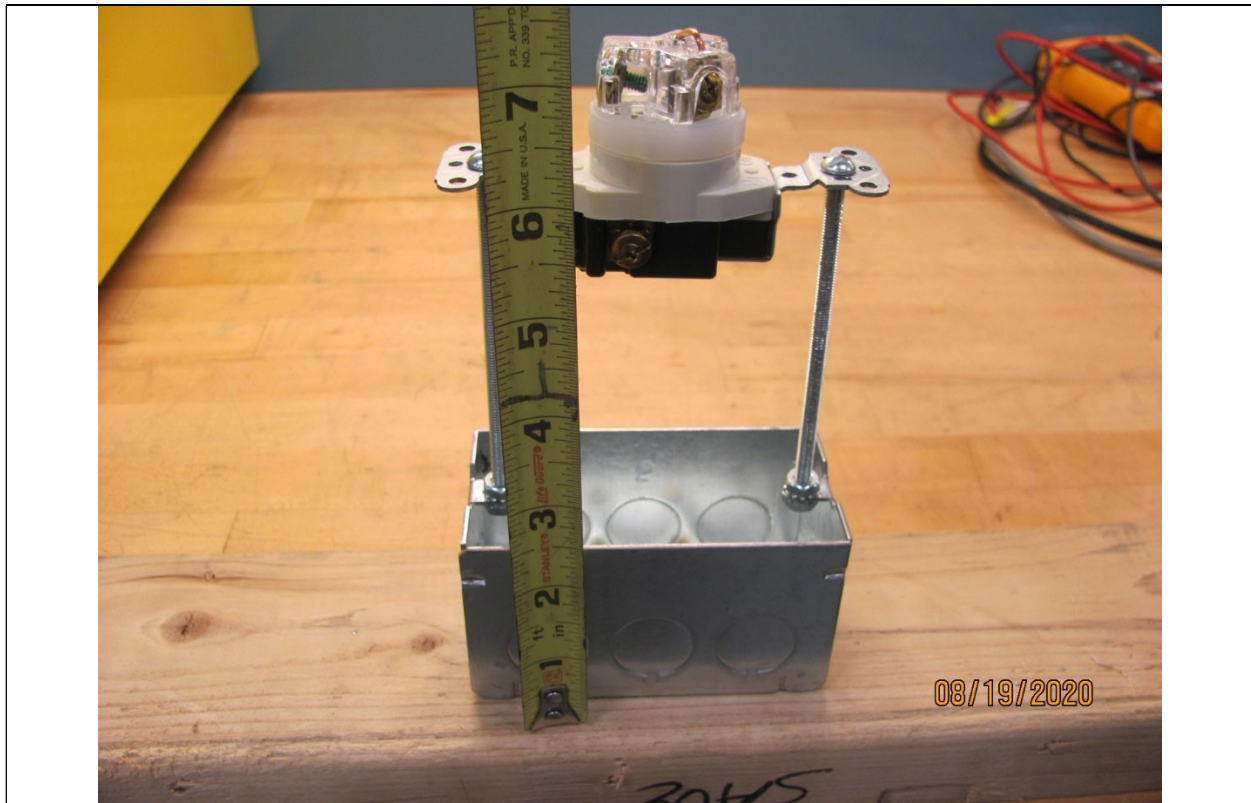


Photo 15 – Flexing Test Setup

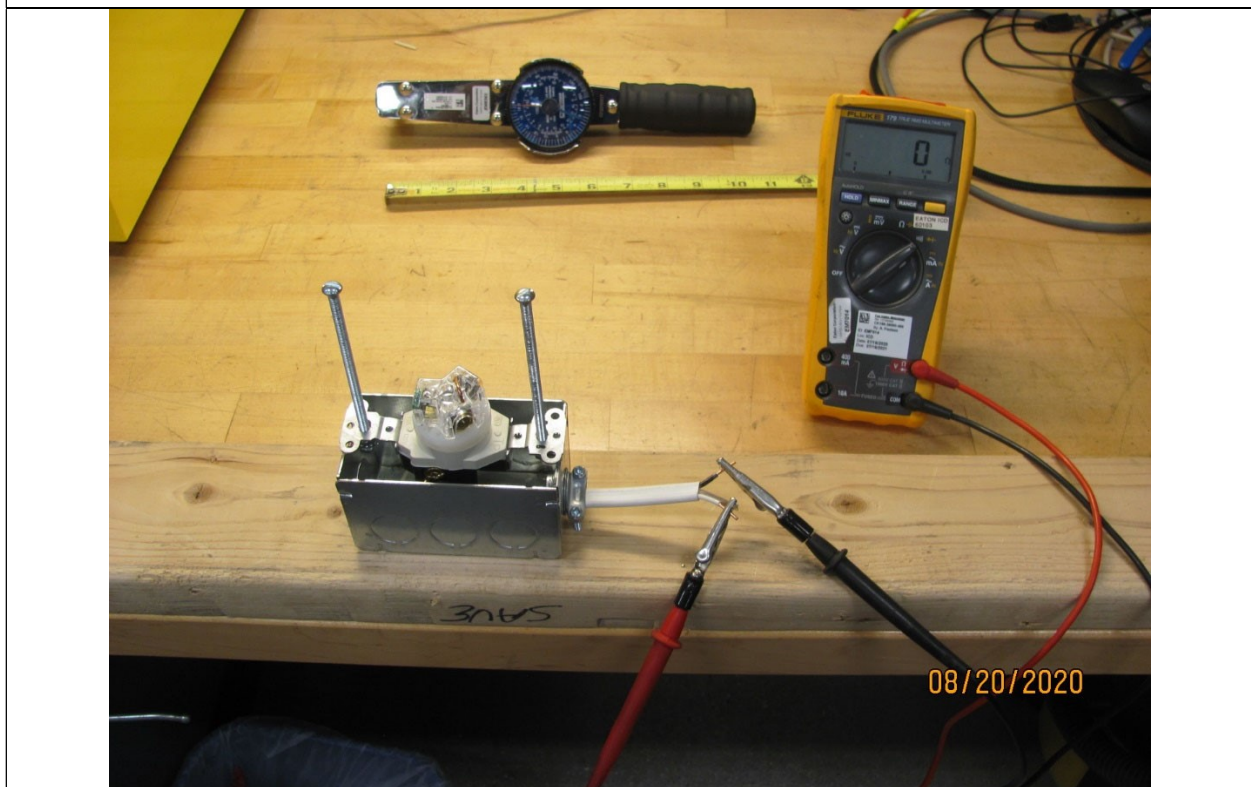


Photo 16 – Flexing Test Setup

Appendix A - Photos

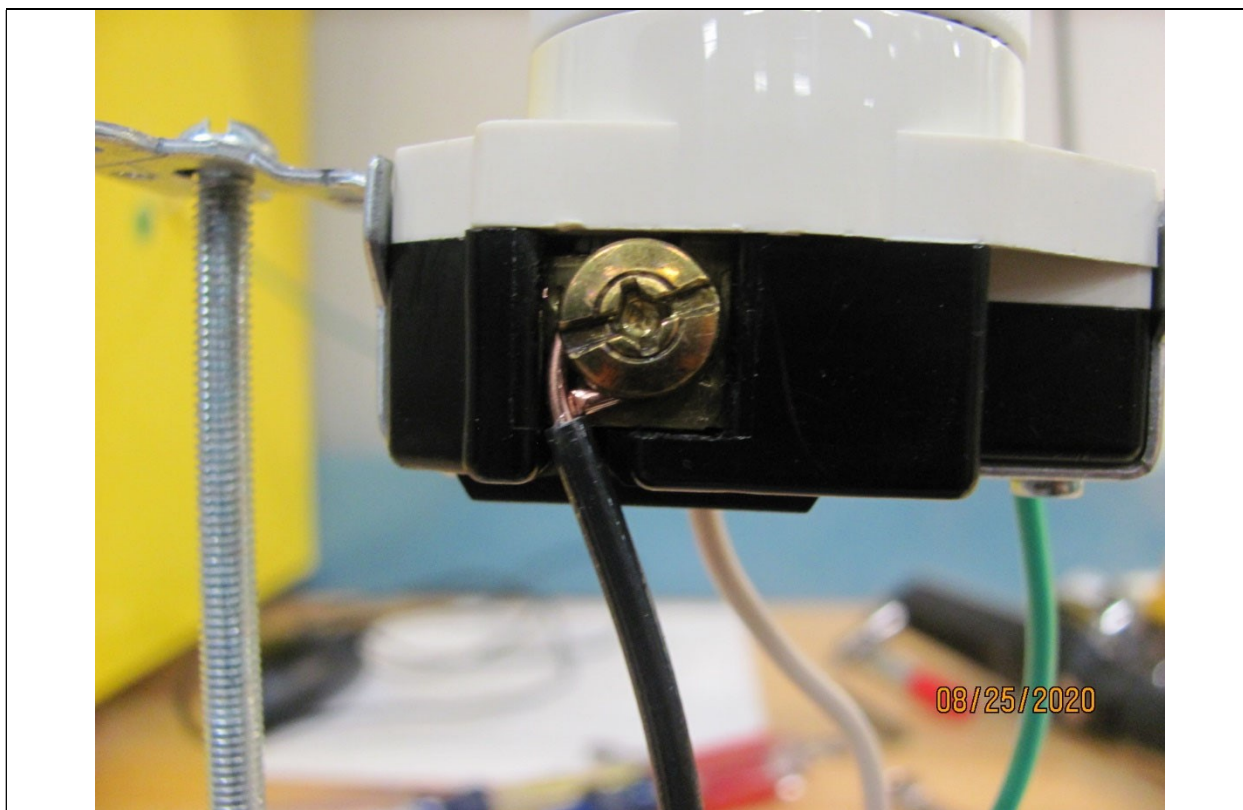


Photo 17 – Flexing Test Fully Extended

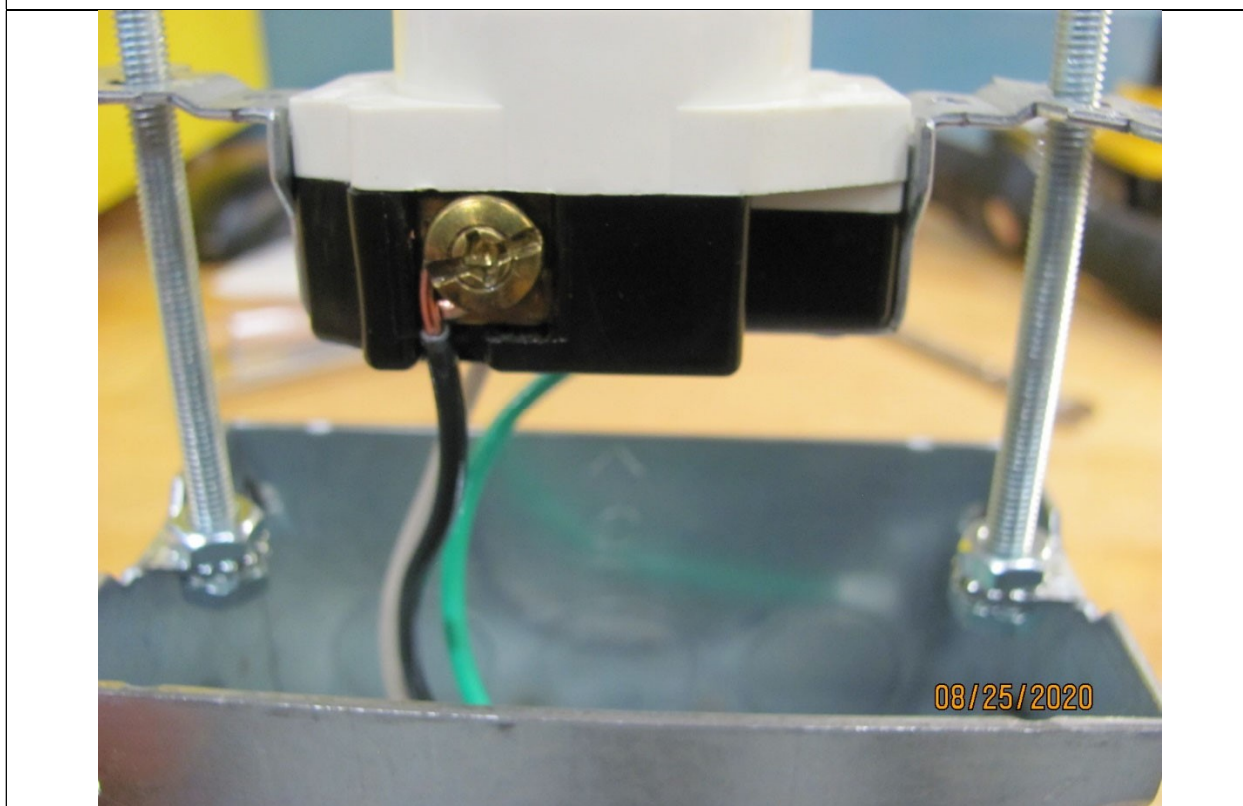


Photo 18 – Flexing Test Partial Insertion

Appendix A - Photos

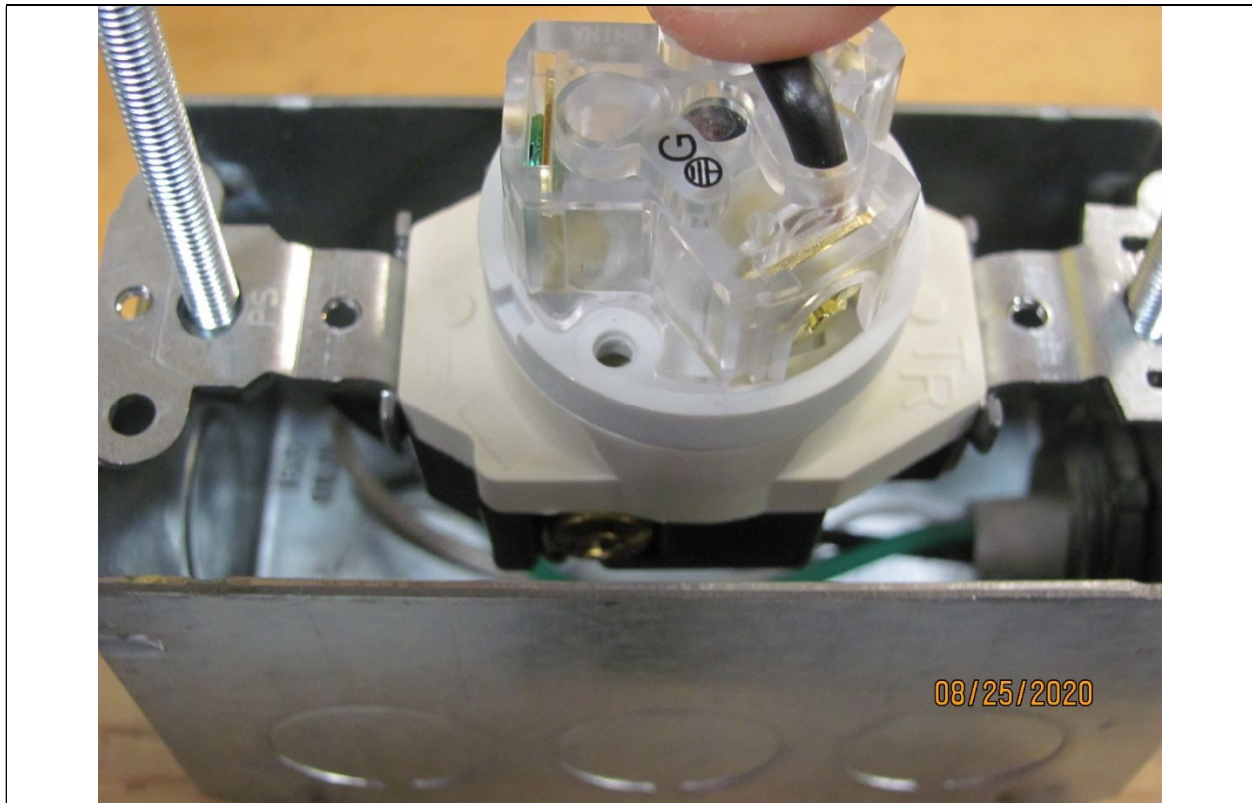


Photo 19 – Flexing Test Fully Inserted

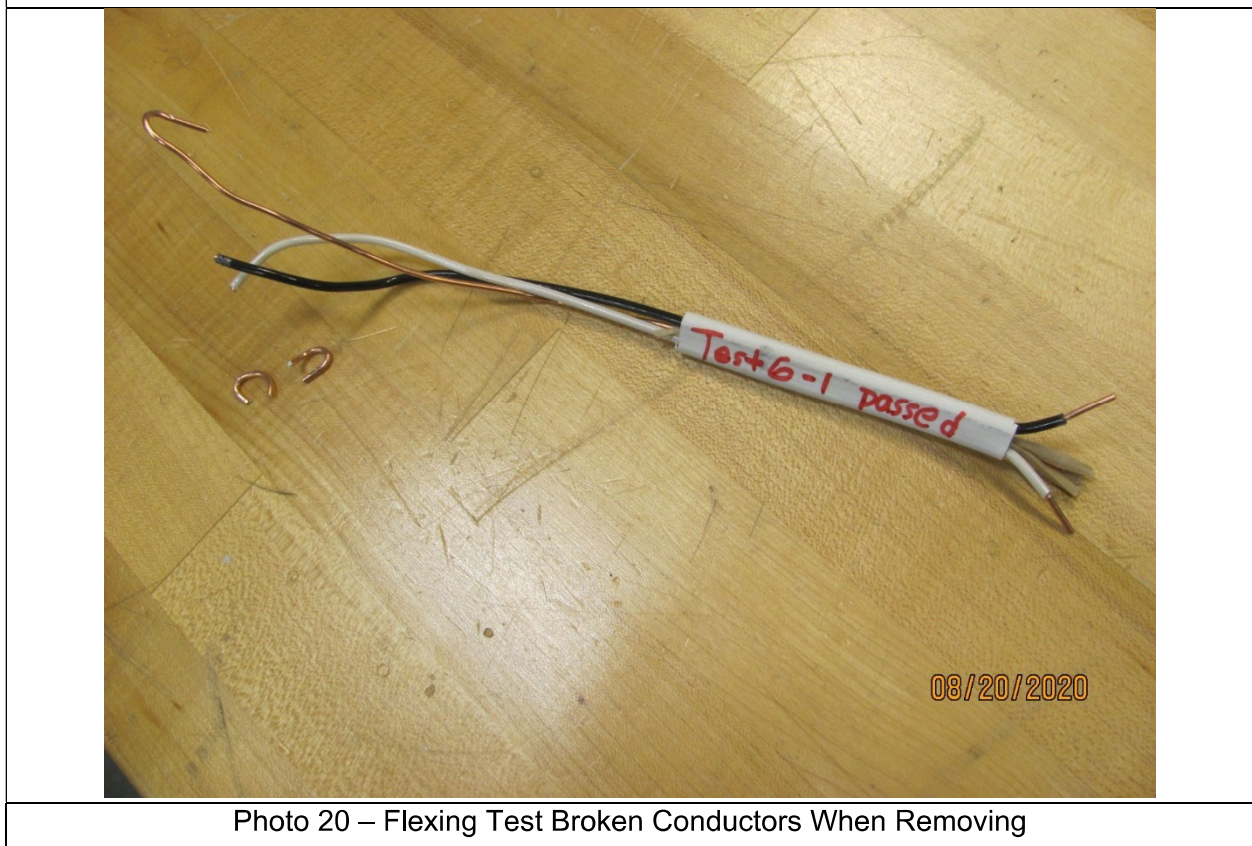


Photo 20 – Flexing Test Broken Conductors When Removing

Appendix A - Photos

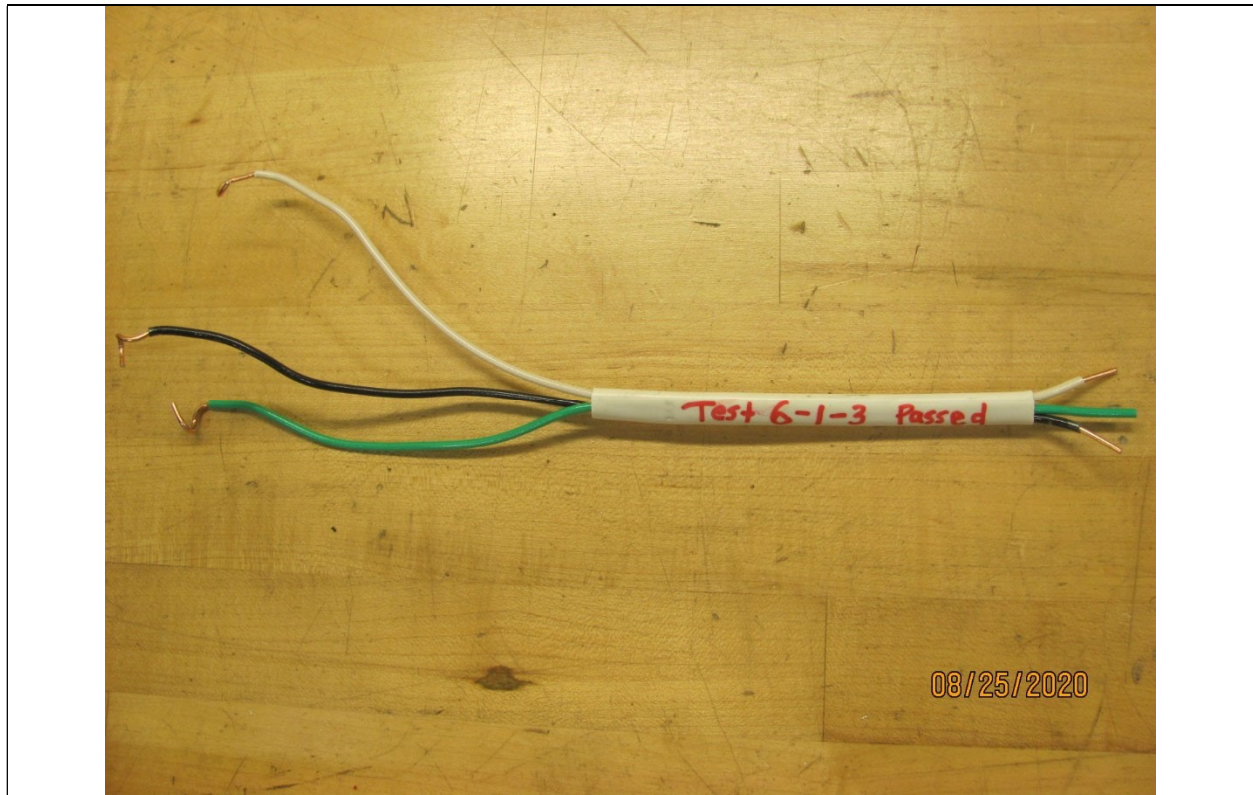


Photo 21 – Flexing Test Repeat No Conductor Breakage

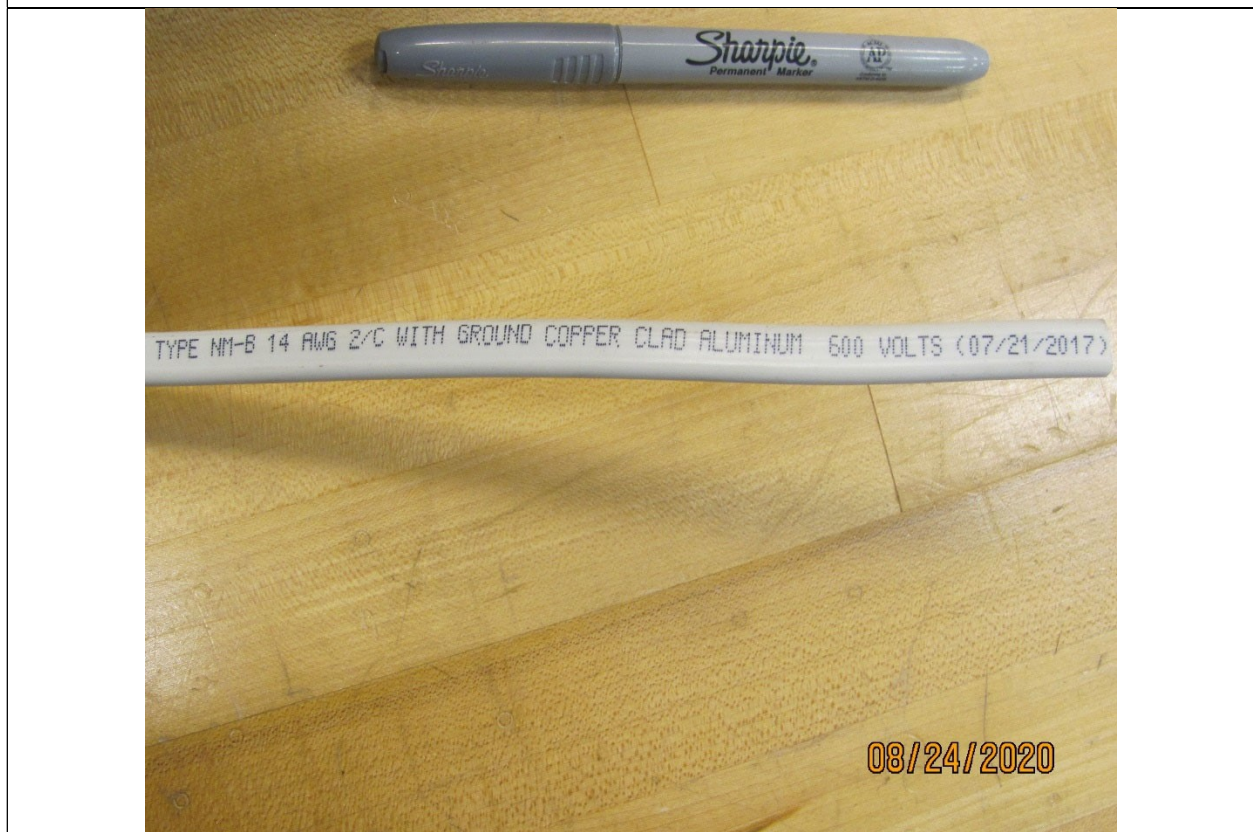


Photo 22 – Copper-Clad Aluminum NM-B Sample Packaging at Eaton

Appendix A - Photos



Photo 23 – Copper-Clad Aluminum THHN Sample Packaging at Eaton



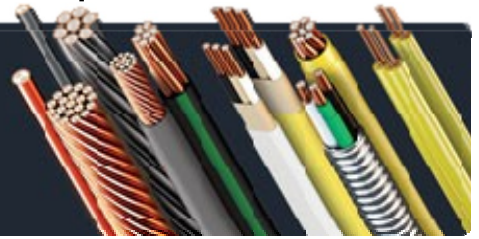
Photo 24 – Copper-Clad Aluminum Sample Packaging at Eaton

Appendix B - Copper-Clad Aluminum Lab Report



COPPERWELD

Wired to Protect



The power of two

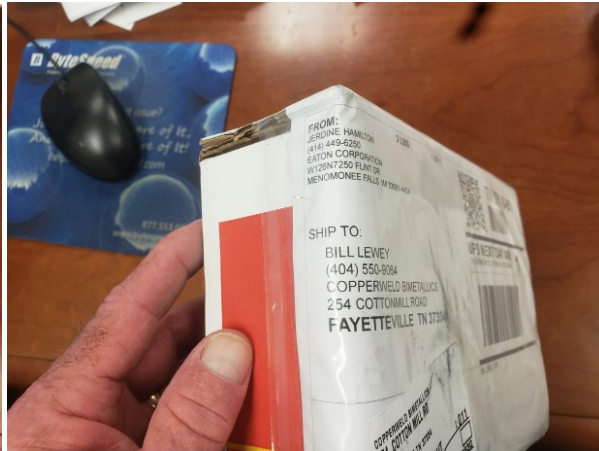
Metallurgical Laboratory Report

Customer:	NEC Bimetallics Task Group		
Subject:	14 AWG Building Wire—NMB and THHN		
Date:	8-27-2020	Report No:	456

Analysis By:	Sammy Hampton --Metallographer
Authored By:	Sammy Hampton --Metallographer
Approved By:	Bill Lewey-- QA Manager

Tested to ASTM Designation: B 566-- 04a

The NM and THHN class samples in this report were sent to Copperweld via a sealed package by Eaton Menomonee Falls test lab. The chain of custody was not broken. The testing was witnessed by a third party as part of routine auditing service. The witnessing session was recorded. The copper clad aluminum conductor material from these samples that was tested on August 27, 2020 by the Copperweld Metallurgical Lab was manufactured by Copperweld Bimetallics to ASTM B566 standards.

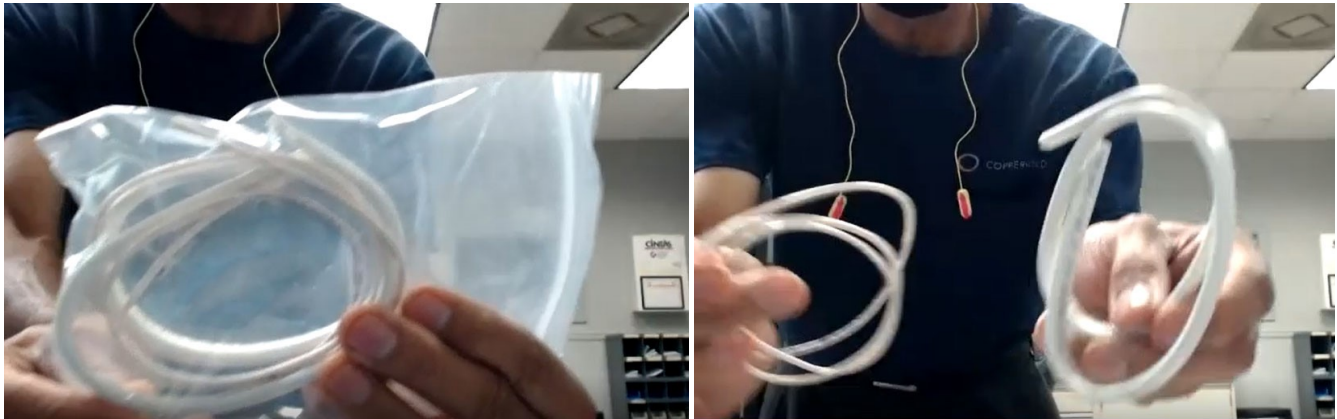


Package as received from Eaton

Appendix B - Copper-Clad Aluminum Lab Report



Opening the Package



Package Contents

Appendix B - Copper-Clad Aluminum Lab Report

The wire consists of a core of aluminum with a continuous outer cladding of copper metallurgically bonded to the core throughout and meets the requirements of this specification (5.1).

Test required	Test result	ASTM B 566 requirement	Result
Diameter	0.0641"	± 0.0001 0.0640" minimum 0.0642" maximum	Pass
Break load (lbs.)	55 pounds	64.4 pounds maximum	Pass
Tensile strength (psi)	17195 psi	20000 (psi) maximum	Pass
% elongation	22.78%	15.0% minimum	Pass
Copper thickness (minimum)	0.00148" = 4.6% of wire radius	minimum copper thickness= 3.5% of wire radius	Pass
Copper volume	10.05%	8% minimum 12% maximum	Pass
Adhesion test	No separation (see attached image 1)	The wire shall be repeatedly reverse bent to fracture by any convenient means. The copper clad aluminum wire shall be free from cladding delamination.	Pass
Cohesion test	No seams or splits (see attached images 2 and 3)	The copper clad aluminum wire shall be free from seams or splits	Pass

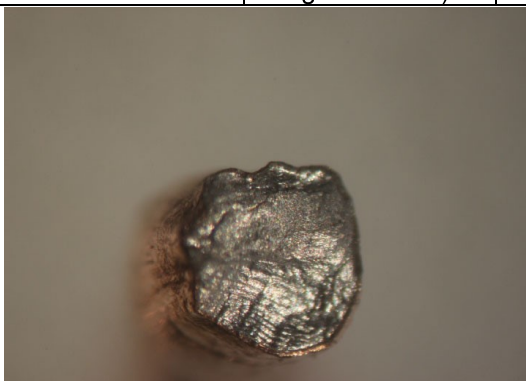


Image 1: adhesion test

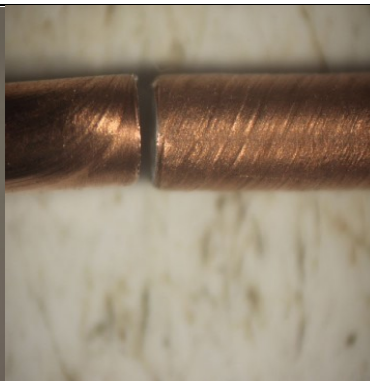


Image 2: cohesion test
(torsion)



image 3: cohesion test
(reverse torsion)

Test and measurement equipment

Equipment	Gauge ID	In calibration	Next due calibration
Micrometer	CP-01	Yes	April 2021
Tensile tester	1755-2000	Yes	January 2022
Ohmmeter	62-1625	Yes	December 2020
Calibration Certificates Attached below			

Appendix B - Copper-Clad Aluminum Lab Report



PRECISION
CALIBRATION
SYSTEMS

107 N Porter St
Winchester, TN 37398
E-mail: info@pcslcm.com
Phone: 866-521-3823
Website: www.pcslcm.com

INSTRUMENT CALIBRATION REPORT



Copperweld

Instrument ID CP-01

Description Micrometer

Calibrated 8/3/2020

Performed At Customer Location

Manufacturer Mitutoyo

Model Number 293-344-30

Location Main

Building 254 Cotton Mill Rd.

Fayetteville, TN 37334

Frequency Semi-Annual

Certificate # CO080320JM-03

Serial Number 66936496

Cal Procedure QS0003JB2010

Department Quality

Status In Service

Temp 73°F

Humidity 59%

Calibration Specifications

Group # 1		Group Name OD							
Nom In Val / In Val	In Type	Std Accy	Acc %	+/-	Out Val	Out Type	End As	Lft As	In Tol
0.25000 / 0.25000	Inch	Plus / Minus	0.000000	±0.00010	0.25000	Inch	0.25000	0.25000	Yes
0.50000 / 0.50000	Inch	Plus / Minus	0.000000	±0.00010	0.50000	Inch	0.50000	0.50000	Yes
1.00000 / 1.00000	Inch	Plus / Minus	0.000000	±0.00010	1.00000	Inch	1.00000	1.00000	Yes

Test Instruments Used During the Calibration

Test Instrument ID	Description	Manufacturer	Model Number	Serial Number	(As Of Cal Entry Date)	
					Last Cal Date	Next Cal Date
Z-GA-010 GAGE	Gage Block 81pc Set Standard	China	Rectangular Steel	E1599	4/8/2016	4/30/2021
BLCK SET STD SHOP						

Notes about this calibration

Uncertainty = ± (64.9+5.2L) μin (95%CL; K=2)

Calibration Result Calibration Successful

Who Calibrated James Meadows

Finalized By James Meadows

Date Finalized 8/3/2020 9:19:05AM

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). Decision Rule: The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. This is considered "shared responsibility." This calibration was conducted using standards traceable to the SI through NIST. The results on this certificate of accuracy apply only to the item described above.

Accredited to ISO/IEC 17025: 2017.

This document may not be reproduced except in full.

Laboratory Authorized Signature *James Meadows*

Revision Date: 05/08/2020
Rev: 04

Page 1 of 1

QF0016

Appendix B - Copper-Clad Aluminum Lab Report

INSTRUMENT CALIBRATION REPORT

Copperweld

Instrument ID 1755-2000		Description Tensile Tester (2 Load cells)		Performed At Customer Location	
Calibrated 8/4/2020					
Manufacturer	Thwing-Albert Instruments	Location	Main	Frequency	Semi-Annual
Model Number	EJA	Building	254 Cotton Mill Rd. Fayetteville, TN 37334	Certificate #	CO080420JM-13
Serial Number	1755-2000	Department	Quality	Temp	70°F
Cal Procedure	QS0033BG2013	Status	In Service	Humidity	57%

Calibration Specifications									
Group # 1									
Group Name 0-11lb Load Cell 627022									
Nom In Val / In Val	In Type	Std Accy	Acc %	±/-	Out Val	Out Type	End As	Lft As	In Tol
1 / 1	lbf	Pct of Range	0.500000	0.00	1.00	lbf	1.01	1.01	Yes
2 / 2	lbf	Pct of Range	0.500000	0.00	2.00	lbf	2.01	2.01	Yes
3 / 3	lbf	Pct of Range	0.500000	0.00	3.00	lbf	3.01	3.01	Yes
5 / 5	lbf	Pct of Range	0.500000	0.00	5.00	lbf	5.02	5.02	Yes
7 / 7	lbf	Pct of Range	0.500000	0.00	7.00	lbf	7.03	7.03	Yes
10 / 10	lbf	Pct of Range	0.500000	0.00	10.00	lbf	10.04	10.04	Yes

Group # 2									
Group Name 0-225 lb Load cell 608236									
Nom In Val / In Val	In Type	Std Accy	Acc %	±/-	Out Val	Out Type	End As	Lft As	In Tol
5 / 5	lbf	Pct of Range	0.500000	0.00	5.00	lbf	5.00	5.00	Yes
20.446 / 20.446	lbf	Pct of Range	0.500000	0.00	20.45	lbf	20.48	20.48	Yes
50.414 / 50.414	lbf	Pct of Range	0.500000	0.00	50.41	lbf	50.48	50.48	Yes
88.532 / 88.532	lbf	Pct of Range	0.500000	0.00	88.53	lbf	88.64	88.64	Yes
99.044 / 99.044	lbf	Pct of Range	0.500000	0.00	99.04	lbf	99.15	99.15	Yes
117.60 / 117.60	lbf	Pct of Range	0.500000	0.00	117.60	lbf	117.73	117.73	Yes
131.71 / 131.71	lbf	Pct of Range	0.500000	0.00	131.71	lbf	131.83	131.83	Yes
151.04 / 151.04	lbf	Pct of Range	0.500000	0.00	151.04	lbf	151.22	151.22	Yes
161.19 / 161.19	lbf	Pct of Range	0.500000	0.00	161.19	lbf	161.38	161.38	Yes
207.76 / 207.76	lbf	Pct of Range	0.500000	0.00	207.76	lbf	207.99	207.99	Yes

Revision Date: 05/08/2020
Rev: 04

Page 1 of 2

QF0016

INSTRUMENT CALIBRATION REPORT

Copperweld

Instrument ID 1755-2000		Description Tensile Tester (2 Load cells)		Performed At Customer Location	
Calibrated 8/4/2020					

Test Instruments Used During the Calibration					
Test Instrument ID	Description	Manufacturer	Model Number	Serial Number	(As Of Cal Entry Date)
Z-LO-005 5K LOAD	Load Cell, 5000lb, Tension & Compression	Futek	LSB453	575093	1/7/2020
Z-WE-003 HANGING WEIGHTS	Weight Set, 1-20lbs, Cast Iron	Rice Lake	ASTM Class 6	D7-D10 (20), D1-D4 (10), D1-D2 (2), 8MB4 (2), 8MB5 (5)	3/26/2019
					3/31/2021

Notes about this calibration

Uncertainty = ± 0.23% of Reading (95%CL; K=2)

Calibration Result Calibration Successful

Who Calibrated James Meadows

Finalized By James Meadows

Date Finalized 8/4/2020 1:12:08PM

Total expanded measurement uncertainties expressed are based on a confidence level of 95%, coverage factor of (k=2). Decision Rule: The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. This is considered "shared responsibility." This calibration was conducted using standards traceable to the SI through NIST. The results on this certificate of accuracy apply only to the items described above. Accredited to ISO/IEC 17025:2017.

This document may not be reproduced except in full.

Laboratory Authorized Signature

James Meadows

Revision Date: 05/08/2020
Rev: 04

Page 2 of 2

QF0016

Confidential

Page 5

9/2/2020

This document may contain confidential and proprietary information which is the exclusive property of Copperweld. It is delivered on the express condition that it is not to be disclosed, reproduced or used, in whole or part, for the manufacture, sales or use by anyone other than Copperweld without its express written consent.

Page B5

Appendix B - Copper-Clad Aluminum Lab Report



PRECISION
CALIBRATION
SYSTEMS

107 N Porter St
Winchester, TN 37398
E-mail: info@pcslcm.com
Phone: 866-521-3823
Website: www.pcslcm.com

INSTRUMENT CALIBRATION REPORT



Copperweld

Instrument ID 62-1625

Description Micro Ohm Meter

Calibrated 8/4/2020

Performed At Customer Location

Manufacturer Valhalla Scientific
Model Number 4176

Location Main
Building 254 Cotton Mill Rd.
Fayetteville, TN 37334

Frequency Semi-Annual
Certificate # CO080420JM-03

Serial Number 62-1625

Cal Procedure QS0011JB2010

Department Quality
Status In Service

Temp 70°F
Humidity 57%

Calibration Specifications

Group # 1									
Group Name Ohm - Source									
Nom In Val / In Val	In Type	Std Accy	Acc %	±/±	Out Val	Out Type	End As	Lft As	In Tol
1.000 / 1.000	Ohm	Pct of Reading	0.040000	0.0000	1.0000	Ohm	0.9998	0.9998	Yes
10.000 / 10.000	Ohm	Pct of Reading	0.040000	0.000	10.000	Ohm	9.999	9.999	Yes
100.000 / 100.000	Ohm	Pct of Reading	0.040000	0.00	100.00	Ohm	99.99	99.99	Yes

Test Instruments Used During the Calibration

Test Instrument ID	Description	Manufacturer	Model Number	Serial Number	(As Of Cal Entry Date)	
					Last Cal Date	Next Cal Date
Z-EL-020 DECADE RESISTANCE BOX	General Radio Small Decade Resistance Box	General Radio	1433-U	2545	12/18/2018	12/31/2020

Notes about this calibration

Uncertainty = ± 2 mOhm (95%CL; K=2)

Calibration Result Calibration Successful

Who Calibrated James Meadows

Finalized By James Meadows

Date Finalized 8/4/2020 12:47:33PM

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). Decision Rule: The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. This is considered "shared responsibility." This calibration was conducted using standards traceable to the SI through NIST. The results on this certificate of accuracy apply only to the item described above.

Accredited to ISO/IEC 17025:2017.

This document may not be reproduced except in full.

Laboratory Authorized Signature *James Meadows*

Revision Date: 05/08/2020
Rev: 04

Page 1 of 1

QF0016

Confidential

Page 6

9/2/2020

This document may contain confidential and proprietary information which is the exclusive property of Copperweld. It is delivered on the express condition that it is not to be disclosed, reproduced or used, in whole or part, for the manufacture, sales or use by anyone other than Copperweld without its express written consent.

Page B6

Appendix B - Copper-Clad Aluminum Lab Report



Follow-up Service Inspection Report E4911851200827165202

INSPECTION DETAILS			
Date:	2020-08-27	File Number.:	E491185
Responsible Office:	Melville	Volume:	1
Inspection Center:	232	CCN:	DVVU2
Product Type:	CCA Conductor	UL Rep Name:	Gregory Cornett
Deliverable Type:	Recognized	UL Rep ID:	20708
Party Site Number:	1626131	Subscriber Factory No.:	
Manufacturer Name:	Copperweld Bimetallics LLC	Factory Rep Name	Mr. Sammy Hampton
Manufacturer Address:	254 Cotton Mill Rd Fayetteville, TN 37334	Factory Rep Phone:	931-433-0495
		Factory Rep Email:	shampton@copperweld.com
Nature of visit:	Regular Inspection	Sample Status:	Sample requirements fulfilled for sample period
UL Marks Used?	Yes	UL Marks Removed?	No
Variation Notice Issued?	No	Inspection Conducted Remotely?	Yes
Comments After Submission:			

PRODUCT DOCUMENTS/PRODUCTION READY VISIT			
Model	Product	Section	Multiple Listed
14 Awg Class 10A	Copper Clad Aluminum	1	No

SAMPLE DOCUMENTS			
If samples are required to be sent to UL, indicate below. If required samples are not sent, explain in the Comments area.			
No Samples			
Additional Comments	14 Awg conductors from the NMB and THHN samples passed the UL tests for DVVU2, including Tensile, Elongation, copper thickness and DC Resistance.		

In addition to the requirements specified in the applicable UL Services agreement and Follow-Up Service Procedure, UL further defines responsibilities, duties and requirements for both manufacturers and UL representatives in the document titled "UL Mark Surveillance Requirements" that can be located at www.ul.com/fus, and in accordance with the applicable terms and conditions of the document at www.ul.com/responsibilities. Manufacturers without Internet access may obtain the current versions of these documents from their local UL customer service representative or UL field representative.

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1a - thru Mfg. 1 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		124	129	134			
time (HH:MM:SS)		1:53:00	1:58:00	2:03:00			
1a	Mfg. 11 - 1	28.70	28.86	28.73	6.47	6.63	6.50
2a	Mfg. 11 - 2	28.89	29.01	28.84	6.66	6.78	6.61
3a	Mfg. 11 - 3	27.88	28.00	27.72	5.65	5.77	5.49
4a	Mfg. 8 - 1	29.18	29.27	29.25	6.95	7.04	7.02
5a	Mfg. 8 - 2	28.99	29.11	28.99	6.76	6.88	6.76
6a	Mfg. 8 - 3	29.00	29.15	28.92	6.77	6.92	6.69
7a	circuit breaker	32.68	32.65	32.75	10.45	10.42	10.52
8a	line wire	32.25	32.29	32.43	10.02	10.06	10.20
	line wire splicing device						
9a		29.84	29.65	29.07	7.61	7.42	6.84
10a	load wire	30.67	30.92	30.94	8.44	8.69	8.71
	load wire splicing device						
11a		30.11	29.88	29.27	7.88	7.65	7.04
12a	room ambient	22.39	22.44	21.87			
13a	current (amps)	10.03	10.03	10.03			

Test 1a - thru Mfg. 1 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		80	85	90			
time (HH:MM:SS)		1:17:00	1:22:00	1:27:00			
1a	Mfg. 11 - 1	33.06	33.61	33.40	11.02	11.58	11.36
2a	Mfg. 11 - 2	33.64	33.95	33.94	11.60	11.91	11.90
3a	Mfg. 11 - 3	31.05	31.56	31.60	9.01	9.52	9.56
4a	Mfg. 8 - 1	34.10	34.15	34.23	12.06	12.11	12.19
5a	Mfg. 8 - 2	33.60	34.20	33.86	11.56	12.16	11.82
6a	Mfg. 8 - 3	32.94	33.68	33.29	10.91	11.64	11.25
7a	circuit breaker	40.86	40.44	40.64	18.82	18.41	18.60
8a	line wire	33.93	34.21	33.87	11.89	12.17	11.83
	line wire splicing device						
9a		36.89	37.11	36.82	14.85	15.07	14.78
10a	load wire	32.70	33.48	32.99	10.66	11.44	10.95
	load wire splicing device						
11a		32.72	33.49	32.70	10.68	11.45	10.66
12a	room ambient	21.84	22.27	22.01			
13a	current (amps)	15.02	15.01	15.02			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1b - thru Mfg. 2 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		124	129	134			
time (HH:MM:SS)		1:53:00	1:58:00	2:03:00			
1b	Mfg. 11 - 1	28.57	28.60	28.36	6.49	6.52	6.27
2b	Mfg. 11 - 2	28.65	28.68	28.48	6.57	6.60	6.40
3b	Mfg. 11 - 3	27.37	27.39	27.10	5.28	5.31	5.02
4b	Mfg. 8 - 1	29.14	29.23	29.15	7.05	7.15	7.07
5b	Mfg. 8 - 2	30.65	30.75	30.48	8.57	8.66	8.40
6b	Mfg. 8 - 3	28.04	28.10	27.73	5.96	6.02	5.64
7b	circuit breaker	36.63	36.79	37.20	14.55	14.70	15.12
8b	line wire	30.98	31.03	30.93	8.90	8.95	8.85
9b	line wire splicing device	28.97	28.69	28.06	6.89	6.61	5.98
10b	load wire	28.60	28.55	28.00	6.52	6.47	5.92
11b	load wire splicing device	28.64	28.49	27.92	6.56	6.41	5.84
12b	room ambient	22.35	22.28	21.62			
13b	current (amps)	10.00	10.00	10.00			

Test 1b - thru Mfg. 2 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		80	85	90			
time (HH:MM:SS)		1:17:00	1:22:00	1:27:00			
1b	Mfg. 11 - 1	33.38	33.85	33.55	11.43	11.89	11.59
2b	Mfg. 11 - 2	33.29	33.49	33.67	11.34	11.54	11.72
3b	Mfg. 11 - 3	30.94	31.47	31.45	8.99	9.52	9.49
4b	Mfg. 8 - 1	34.03	34.28	34.44	12.07	12.32	12.48
5b	Mfg. 8 - 2	33.61	34.03	33.75	11.66	12.08	11.80
6b	Mfg. 8 - 3	33.00	33.71	33.25	11.05	11.75	11.29
7b	circuit breaker	44.97	44.86	45.02	23.02	22.91	23.06
8b	line wire	33.21	33.70	33.32	11.25	11.74	11.37
9b	line wire splicing device	30.81	31.77	30.80	8.86	9.82	8.85
10b	load wire	32.53	33.49	32.83	10.58	11.54	10.88
11b	load wire splicing device	31.51	32.52	31.43	9.56	10.56	9.47
12b	room ambient	21.76	22.22	21.88			
13b	current (amps)	15.01	15.01	15.01			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1c - thru Mfg. 3 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		124	129	134			
time (HH:MM:SS)		1:53:00	1:58:00	2:03:00			
1c	Mfg. 11 - 1	29.46	29.56	29.18	7.40	7.50	7.12
2c	Mfg. 11 - 2	28.97	29.12	28.68	6.91	7.06	6.62
3c	Mfg. 11 - 3	27.82	28.02	27.47	5.76	5.96	5.41
4c	Mfg. 8 - 1	29.30	29.40	29.33	7.24	7.34	7.27
5c	Mfg. 8 - 2	28.68	28.72	28.43	6.62	6.66	6.37
6c	Mfg. 8 - 3	28.19	28.27	27.81	6.13	6.21	5.75
7c	circuit breaker	35.04	35.28	35.13	12.98	13.22	13.07
8c	line wire	31.23	31.27	30.87	9.17	9.21	8.81
9c	line wire splicing device	28.59	28.61	27.53	6.53	6.55	5.47
10c	load wire	30.74	30.84	30.26	8.68	8.78	8.20
11c	load wire splicing device	29.74	29.67	28.50	7.68	7.61	6.44
12c	room ambient	22.29	22.23	21.67			
13c	current (amps)	10.01	10.01	10.01			

Test 1c - thru Mfg. 3 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		80	85	90			
time (HH:MM:SS)		1:17:00	1:22:00	1:27:00			
1c	Mfg. 11 - 1	32.95	33.38	33.25	11.06	11.48	11.36
2c	Mfg. 11 - 2	33.50	33.89	33.73	11.61	12.00	11.84
3c	Mfg. 11 - 3	32.27	32.60	32.50	10.38	10.71	10.61
4c	Mfg. 8 - 1	33.33	33.66	33.62	11.44	11.77	11.72
5c	Mfg. 8 - 2	33.87	34.28	34.11	11.98	12.39	12.21
6c	Mfg. 8 - 3	32.50	32.88	32.80	10.61	10.99	10.91
7c	circuit breaker	42.51	42.65	42.50	20.62	20.75	20.60
8c	line wire	31.74	32.44	32.16	9.84	10.54	10.27
9c	line wire splicing device	32.46	33.55	32.53	10.57	11.66	10.64
10c	load wire	32.23	33.29	32.70	10.34	11.40	10.81
11c	load wire splicing device	29.96	31.50	30.18	8.07	9.61	8.29
12c	room ambient	21.65	22.13	21.90			
13c	current (amps)	15.02	15.02	15.02			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1a - thru Mfg. 1 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		67	72	77			
time (HH:MM:SS)		1:04:00	1:09:00	1:14:00			
1a	Mfg. 10 - 1	33.35	33.09	33.35	11.17	10.90	11.17
2a	Mfg. 10 - 2	29.93	29.88	29.88	7.75	7.70	7.70
3a	Mfg. 10 - 3	28.83	28.80	28.74	6.65	6.62	6.56
4a	Mfg. 9 - 1	28.96	28.89	28.94	6.78	6.71	6.76
5a	Mfg. 9 - 2	29.33	29.07	29.09	7.15	6.89	6.91
6a	Mfg. 9 - 3	28.20	28.02	27.93	6.01	5.84	5.75
7a	circuit breaker	32.75	32.55	32.65	10.57	10.37	10.47
8a	line wire	32.76	32.27	32.44	10.58	10.09	10.26
9a	line wire splicing device	29.85	29.45	29.15	7.67	7.27	6.97
10a	load wire	31.09	30.73	31.01	8.91	8.55	8.83
11a	load wire splicing device	30.90	30.16	30.15	8.72	7.98	7.97
12a	room ambient	22.53	22.20	21.82			
13a	current (amps)	10.02	10.02	10.02			

Test 1a - thru Mfg. 1 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		122	127	132			
time (HH:MM:SS)		2:00:00	2:05:00	2:10:00			
1a	Mfg. 10 - 1	38.41	38.10	38.31	17.09	16.78	16.99
2a	Mfg. 10 - 2	39.48	39.23	39.28	18.16	17.91	17.96
3a	Mfg. 10 - 3	34.47	34.18	34.12	13.15	12.87	12.80
4a	Mfg. 9 - 1	37.47	37.35	37.38	16.16	16.03	16.06
5a	Mfg. 9 - 2	38.46	38.17	38.12	17.14	16.85	16.80
6a	Mfg. 9 - 3	31.54	31.29	31.18	10.22	9.97	9.86
7a	circuit breaker	40.70	40.66	40.65	19.38	19.34	19.33
8a	line wire	34.07	34.00	34.12	12.75	12.69	12.80
9a	line wire splicing device	35.66	35.31	35.13	14.34	13.99	13.81
10a	load wire	32.81	32.43	32.75	11.49	11.11	11.43
11a	load wire splicing device	33.16	32.96	32.94	11.84	11.64	11.62
12a	room ambient	21.37	21.31	21.27			
13a	current (amps)	15.02	15.02	15.02			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1b - thru Mfg. 2 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		129	134	139			
time (HH:MM:SS)		2:06:07	2:11:06	2:16:07			
1b	Mfg. 10 - 1	31.13	31.54	31.37	9.64	10.05	9.88
2b	Mfg. 10 - 2	30.12	30.39	30.44	8.63	8.90	8.95
3b	Mfg. 10 - 3	28.95	29.13	29.19	7.46	7.64	7.70
4b	Mfg. 9 - 1	28.47	28.67	28.85	6.98	7.18	7.36
5b	Mfg. 9 - 2	28.62	29.01	28.85	7.13	7.52	7.36
6b	Mfg. 9 - 3	29.94	30.21	30.11	8.45	8.72	8.62
7b	circuit breaker	41.81	41.46	41.80	20.32	19.97	20.31
8b	line wire	31.66	31.83	32.15	10.17	10.34	10.66
	line wire splicing device						
9b		29.57	30.02	30.13	8.08	8.53	8.64
10b	load wire	28.92	29.64	29.57	7.43	8.15	8.08
	load wire splicing device						
11b		30.62	31.06	31.03	9.13	9.57	9.54
12b	room ambient	21.30	21.89	21.28			
13b	current (amps)	10.01	10.01	10.01			

Test 1b - thru Mfg. 2 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		122	127	132			
time (HH:MM:SS)		2:00:00	2:05:00	2:10:00			
1b	Mfg. 10 - 1	39.02	38.87	38.81	17.86	17.72	17.65
2b	Mfg. 10 - 2	38.54	38.42	38.37	17.38	17.26	17.22
3b	Mfg. 10 - 3	35.00	34.94	34.56	13.84	13.78	13.40
4b	Mfg. 9 - 1	34.32	34.17	34.19	13.16	13.01	13.03
5b	Mfg. 9 - 2	33.68	33.52	33.44	12.52	12.36	12.29
6b	Mfg. 9 - 3	32.62	32.41	32.27	11.46	11.25	11.11
7b	circuit breaker	44.60	44.48	44.38	23.44	23.32	23.22
8b	line wire	33.27	33.12	33.14	12.11	11.96	11.98
	line wire splicing device						
9b		31.50	31.19	31.26	10.34	10.03	10.10
10b	load wire	31.96	31.65	31.72	10.81	10.49	10.56
	load wire splicing device						
11b		30.27	29.89	29.93	9.12	8.73	8.78
12b	room ambient	21.26	21.14	21.08			
13b	current (amps)	15.01	15.01	15.01			

Appendix C1 Static Heating Testing at 100% Rated Current

Test 1c - thru Mfg. 3 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		67	72	77			
time (HH:MM:SS)		1:04:00	1:09:00	1:14:00			
1c	Mfg. 10 - 1	31.05	30.92	30.45	9.04	8.91	8.44
2c	Mfg. 10 - 2	32.97	32.85	32.26	10.96	10.84	10.25
3c	Mfg. 10 - 3	29.07	28.94	28.28	7.06	6.93	6.27
4c	Mfg. 9 - 1	29.52	29.28	29.21	7.51	7.27	7.20
5c	Mfg. 9 - 2	30.06	29.90	29.40	8.05	7.89	7.39
6c	Mfg. 9 - 3	28.41	28.41	27.55	6.40	6.40	5.54
7c	circuit breaker	34.97	34.66	34.67	12.96	12.65	12.66
8c	line wire	31.77	31.18	30.88	9.76	9.17	8.87
9c	line wire splicing device	28.89	28.20	27.63	6.88	6.19	5.62
10c	load wire	31.27	30.69	30.26	9.26	8.68	8.25
11c	load wire splicing device	31.39	30.47	29.53	9.38	8.46	7.52
12c	room ambient	22.35	21.99	21.69			
13c	current (amps)	10.01	10.01	10.01			

Test 1c - thru Mfg. 3 15-amp breaker at 100% current (15A * 100% = 15A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		122	127	132			
time (HH:MM:SS)		2:00:00	2:05:00	2:10:00			
1c	Mfg. 10 - 1	36.19	35.94	35.85	15.02	14.77	14.68
2c	Mfg. 10 - 2	39.95	39.76	39.70	18.78	18.59	18.53
3c	Mfg. 10 - 3	39.01	39.15	38.69	17.85	17.98	17.52
4c	Mfg. 9 - 1	33.32	33.13	33.09	12.15	11.96	11.92
5c	Mfg. 9 - 2	34.01	33.90	33.74	12.84	12.74	12.57
6c	Mfg. 9 - 3	32.95	32.95	32.64	11.78	11.78	11.47
7c	circuit breaker	41.75	41.55	41.58	20.59	20.38	20.41
8c	line wire	30.73	30.68	30.61	9.56	9.51	9.44
9c	line wire splicing device	32.20	31.82	31.87	11.04	10.65	10.70
10c	load wire	31.34	31.12	31.14	10.17	9.95	9.97
11c	load wire splicing device	29.64	29.52	29.42	8.47	8.35	8.25
12c	room ambient	21.29	21.13	21.09			
13c	current (amps)	15.01	15.01	15.01			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2a - thru Mfg. 1 10-amp breaker at 135% current (10A * 135% = 13.5A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #							
time (MM:SS)		7:20	7:40	8:00			
	Breaker trip time	8:20					
1a	Mfg. 11 - 1	30.60	30.69	30.76	8.65	8.73	8.80
2a	Mfg. 11 - 2	30.73	30.83	30.87	8.78	8.88	8.92
3a	Mfg. 11 - 3	29.72	29.82	29.85	7.76	7.87	7.89
4a	Mfg. 8 - 1	30.66	30.77	30.88	8.70	8.81	8.93
5a	Mfg. 8 - 2	30.87	30.96	31.05	8.91	9.01	9.09
6a	Mfg. 8 - 3	30.39	30.50	30.55	8.43	8.54	8.59
7a	circuit breaker	34.21	34.43	34.65	12.26	12.47	12.70
8a	line wire	38.55	38.70	38.80	16.59	16.74	16.85
9a	line wire splicing device	34.64	34.68	34.50	12.68	12.72	12.55
10a	load wire	36.44	36.44	36.36	14.49	14.48	14.40
11a	load wire splicing device	35.04	35.05	34.84	13.09	13.09	12.88
12a	room ambient	22.00	21.97	21.91			
13a	current (amps)	13.52	13.52	13.52			

Test 2a - thru Mfg. 1 15-amp breaker at 135% current (15A * 135% = 20.25A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		60	61	62			
time (MM:SS)		18:20	18:40	19:00			
	Breaker trip time	19:20					
1a	Mfg. 11 - 1	39.87	39.91	39.90	18.05	18.09	18.08
2a	Mfg. 11 - 2	40.66	40.69	40.70	18.84	18.87	18.88
3a	Mfg. 11 - 3	36.77	36.77	36.76	14.95	14.95	14.94
4a	Mfg. 8 - 1	40.83	40.88	40.89	19.01	19.06	19.07
5a	Mfg. 8 - 2	40.41	40.45	40.47	18.59	18.63	18.65
6a	Mfg. 8 - 3	39.06	39.09	39.15	17.24	17.27	17.33
7a	circuit breaker	51.78	51.96	52.02	29.96	30.14	30.20
8a	line wire	43.47	43.51	43.49	21.65	21.69	21.67
9a	line wire splicing device	48.83	48.80	48.22	27.02	26.99	26.40
10a	load wire	41.01	41.02	41.12	19.19	19.20	19.30
11a	load wire splicing device	42.69	42.60	42.48	20.87	20.78	20.66
12a	room ambient	21.84	21.84	21.78			
13a	current (amps)	19.97	19.97	20.24			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2b - thru Mfg. 2 10-amp breaker at 135% current ($10A * 135\% = 13.5A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		16	17	18		
time (MM:SS)		4:20	4:40	5:00		
	Breaker trip time	5:20				
1b	Mfg. 11 - 1	29.25	29.41	29.55	6.91	7.21
2b	Mfg. 11 - 2	28.86	29.03	29.22	6.52	6.88
3b	Mfg. 11 - 3	28.34	28.44	28.54	6.00	6.20
4b	Mfg. 8 - 1	29.37	29.59	29.79	7.03	7.45
5b	Mfg. 8 - 2	30.27	30.43	30.67	7.93	8.33
6b	Mfg. 8 - 3	28.84	28.97	29.10	6.50	6.76
7b	circuit breaker	34.99	35.63	36.29	12.65	13.95
8b	line wire	34.20	34.58	34.92	11.86	12.58
9b	line wire splicing device	33.21	33.11	33.12	10.87	10.77
10b	load wire	30.95	31.14	31.38	8.61	9.04
11b	load wire splicing device	32.76	32.73	32.78	10.42	10.44
12b	room ambient	22.40	22.34	22.29		
13b	current (amps)	13.51	13.51	13.51		

Test 2b - thru Mfg. 2 15-amp breaker at 135% current ($15A * 135\% = 20.25A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		13	14	15		
time (MM:SS)		2:20	2:40	3:00		
	Breaker trip time	3:20				
1b	Mfg. 11 - 1	31.85	32.56	33.17	9.91	11.23
2b	Mfg. 11 - 2	31.27	32.00	32.64	9.33	10.70
3b	Mfg. 11 - 3	30.01	30.61	31.08	8.07	9.14
4b	Mfg. 8 - 1	31.78	32.43	33.07	9.84	11.13
5b	Mfg. 8 - 2	32.35	32.97	33.48	10.41	11.54
6b	Mfg. 8 - 3	31.74	32.37	32.83	9.80	10.89
7b	circuit breaker	36.50	38.10	39.50	14.56	17.56
8b	line wire	32.89	33.90	34.83	10.95	12.89
9b	line wire splicing device	34.98	35.61	36.11	13.04	14.17
10b	load wire	33.90	34.76	35.58	11.96	13.64
11b	load wire splicing device	35.84	36.48	37.04	13.90	15.10
12b	room ambient	21.94	21.93	21.96		
13b	current (amps)	20.28	20.27	20.27		

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2c - thru Mfg. 3 10-amp breaker at 135% current ($10A * 135\% = 13.5A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		59	60	61			
time (MM:SS)		18:40	19:00	19:20			
	Breaker trip time	19:40					
1c	Mfg. 11 - 1	34.08	34.15	34.18	11.70	11.78	11.81
2c	Mfg. 11 - 2	33.23	33.27	33.31	10.85	10.89	10.93
3c	Mfg. 11 - 3	31.22	31.25	31.28	8.85	8.87	8.90
4c	Mfg. 8 - 1	33.48	33.50	33.56	11.10	11.13	11.19
5c	Mfg. 8 - 2	32.68	32.75	32.80	10.31	10.37	10.42
6c	Mfg. 8 - 3	31.96	32.03	32.09	9.58	9.66	9.71
7c	circuit breaker	43.05	43.08	43.19	20.67	20.71	20.81
8c	line wire	38.04	38.09	38.14	15.67	15.72	15.76
9c	line wire splicing device	33.55	33.75	33.89	11.17	11.38	11.51
10c	load wire	37.55	37.62	37.70	15.17	15.24	15.33
11c	load wire splicing device	35.83	36.09	36.28	13.46	13.71	13.91
12c	room ambient	22.51	22.28	22.34			
13c	current (amps)	13.51	13.51	13.51			

Test 2c - thru Mfg. 3 15-amp breaker at 135% current ($15A * 135\% = 20.25A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		20	21	22			
time (MM:SS)		5:00	5:20	5:40			
	Breaker trip time	6:00					
1c	Mfg. 11 - 1	34.62	34.96	35.21	12.63	12.97	13.22
2c	Mfg. 11 - 2	35.65	35.96	36.17	13.65	13.97	14.18
3c	Mfg. 11 - 3	33.85	34.05	34.25	11.85	12.05	12.25
4c	Mfg. 8 - 1	34.94	35.23	35.47	12.95	13.24	13.48
5c	Mfg. 8 - 2	35.87	36.13	36.37	13.87	14.13	14.38
6c	Mfg. 8 - 3	34.38	34.60	34.74	12.38	12.61	12.75
7c	circuit breaker	42.69	43.47	44.15	20.69	21.47	22.16
8c	line wire	36.07	36.49	36.77	14.08	14.50	14.78
9c	line wire splicing device	38.93	39.23	39.49	16.94	17.24	17.49
10c	load wire	37.64	37.92	38.15	15.64	15.92	16.16
11c	load wire splicing device	35.65	35.84	35.95	13.66	13.85	13.96
12c	room ambient	21.95	22.09	21.93			
13c	current (amps)	20.19	20.19	20.17			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2a - thru Mfg. 1 10-amp breaker at 135% current ($10A * 135\% = 13.5A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		26	27	28			
time (MM:SS)		7:40	8:00	8:20			
	Breaker trip time	8:40					
1a	Mfg. 10 - 1	33.38	33.55	33.72	11.54	11.72	11.89
2a	Mfg. 10 - 2	32.41	32.50	32.60	10.58	10.67	10.77
3a	Mfg. 10 - 3	30.50	30.58	30.68	8.66	8.75	8.85
4a	Mfg. 9 - 1	30.51	30.62	30.74	8.67	8.79	8.91
5a	Mfg. 9 - 2	30.63	30.73	30.86	8.80	8.89	9.02
6a	Mfg. 9 - 3	29.45	29.52	29.63	7.62	7.69	7.79
7a	circuit breaker	34.35	34.60	34.84	12.51	12.77	13.00
8a	line wire	38.69	38.85	39.02	16.85	17.01	17.18
9a	line wire splicing device	34.03	34.11	34.24	12.19	12.27	12.40
10a	load wire	36.42	36.48	36.58	14.59	14.65	14.74
11a	load wire splicing device	36.28	36.41	36.59	14.45	14.58	14.76
12a	room ambient	21.84	21.90	21.76			
13a	current (amps)	13.52	13.52	13.52			

Test 2a - thru Mfg. 1 15-amp breaker at 135% current ($15A * 135\% = 20.25A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		65	66	67			
time (MM:SS)		20:00	20:20	20:40			
	Breaker trip time	21:00					
1a	Mfg. 10 - 1	47.14	47.05	47.05	26.19	26.10	26.09
2a	Mfg. 10 - 2	49.33	49.35	49.30	28.38	28.39	28.35
3a	Mfg. 10 - 3	43.32	43.29	43.14	22.36	22.34	22.19
4a	Mfg. 9 - 1	45.67	45.67	45.73	24.72	24.71	24.78
5a	Mfg. 9 - 2	46.98	46.95	46.85	26.03	25.99	25.90
6a	Mfg. 9 - 3	38.91	38.80	38.65	17.95	17.84	17.69
7a	circuit breaker	52.18	52.30	52.40	31.23	31.34	31.45
8a	line wire	43.36	43.34	43.31	22.40	22.39	22.35
9a	line wire splicing device	46.95	46.94	46.87	26.00	25.99	25.91
10a	load wire	41.51	41.36	41.20	20.56	20.41	20.25
11a	load wire splicing device	42.93	42.85	42.57	21.97	21.89	21.62
12a	room ambient	20.94	20.94	20.98			
13a	current (amps)	20.29	20.28	20.28			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2b - thru Mfg. 2 10-amp breaker at 135% current ($10A * 135\% = 13.5A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		21	22	23			
time (MM:SS)		5:40	6:00	6:20			
	Breaker trip time	6:40					
1b	Mfg. 10 - 1	31.86	32.13	32.38	9.94	10.21	10.46
2b	Mfg. 10 - 2	32.09	32.28	32.45	10.17	10.36	10.53
3b	Mfg. 10 - 3	30.06	30.24	30.38	8.14	8.32	8.46
4b	Mfg. 9 - 1	29.45	29.60	29.73	7.53	7.68	7.81
5b	Mfg. 9 - 2	30.16	30.32	30.49	8.23	8.40	8.57
6b	Mfg. 9 - 3	29.34	29.52	29.64	7.42	7.60	7.72
7b	circuit breaker	37.11	37.68	38.17	15.19	15.76	16.25
8b	line wire	35.37	35.59	35.81	13.44	13.67	13.88
9b	line wire splicing device	32.21	32.37	32.46	10.28	10.45	10.54
10b	load wire	31.36	31.58	31.73	9.44	9.66	9.80
11b	load wire splicing device	35.28	35.40	35.49	13.36	13.47	13.56
12b	room ambient	21.93	21.95	21.88			
13b	current (amps)	13.50	13.50	13.50			

Test 2b - thru Mfg. 2 15-amp breaker at 135% current ($15A * 135\% = 20.25A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		13	14	15			
time (MM:SS)		2:40	3:00	3:20			
	Breaker trip time	3:40					
1b	Mfg. 10 - 1	34.43	35.44	36.33	13.42	14.43	15.32
2b	Mfg. 10 - 2	35.56	36.51	37.33	14.56	15.51	16.33
3b	Mfg. 10 - 3	33.00	33.73	34.31	12.00	12.73	13.30
4b	Mfg. 9 - 1	32.70	33.42	34.00	11.69	12.41	13.00
5b	Mfg. 9 - 2	32.65	33.31	33.89	11.64	12.30	12.89
6b	Mfg. 9 - 3	30.85	31.44	31.99	9.85	10.43	10.98
7b	circuit breaker	36.44	37.96	39.35	15.44	16.96	18.34
8b	line wire	32.46	33.42	34.28	11.45	12.41	13.28
9b	line wire splicing device	35.23	35.84	36.40	14.22	14.84	15.39
10b	load wire	33.42	34.26	35.03	12.42	13.26	14.02
11b	load wire splicing device	33.28	33.92	34.50	12.27	12.91	13.49
12b	room ambient	20.93	21.01	21.08			
13b	current (amps)	20.28	20.28	20.28			

Appendix C2 Static Heating Tests at 135% Rated Current

Test 2c - thru Mfg. 3 10-amp breaker at 135% current ($10A * 135\% = 13.5A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature (°C)		Rise
scan #		53	54	55			
time (MM:SS)		16:20	16:40	17:00			
	Breaker trip time	17:20					
1c	Mfg. 10 - 1	35.58	35.62	35.62	13.37	13.41	13.41
2c	Mfg. 10 - 2	36.59	36.62	36.62	14.38	14.41	14.41
3c	Mfg. 10 - 3	32.94	32.95	32.98	10.73	10.74	10.77
4c	Mfg. 9 - 1	33.08	33.07	33.07	10.87	10.86	10.86
5c	Mfg. 9 - 2	33.95	33.93	33.90	11.73	11.72	11.69
6c	Mfg. 9 - 3	31.62	31.62	31.58	9.40	9.41	9.37
7c	circuit breaker	41.72	41.81	41.92	19.51	19.60	19.71
8c	line wire	38.68	38.60	38.52	16.47	16.39	16.31
9c	line wire splicing device	33.41	33.23	33.04	11.19	11.02	10.83
10c	load wire	37.53	37.41	37.27	15.31	15.20	15.06
11c	load wire splicing device	38.23	37.83	37.38	16.01	15.62	15.17
12c	room ambient	22.28	22.22	22.14			
13c	current (amps)	13.50	13.50	13.50			

Test 2c - thru Mfg. 3 15-amp breaker at 135% current ($15A * 135\% = 20.25A$); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature		Rise (°C)
scan #		22	23	24			
time (MM:SS)		5:40	6:00	6:20			
	Breaker trip time	6:40					
1c	Mfg. 10 - 1	37.66	38.19	38.64	16.09	16.61	17.07
2c	Mfg. 10 - 2	44.95	45.50	45.96	23.38	23.93	24.39
3c	Mfg. 10 - 3	44.95	45.37	45.69	23.38	23.80	24.12
4c	Mfg. 9 - 1	35.48	35.83	36.20	13.90	14.26	14.63
5c	Mfg. 9 - 2	38.33	38.69	39.10	16.75	17.12	17.52
6c	Mfg. 9 - 3	36.86	37.22	37.59	15.28	15.65	16.02
7c	circuit breaker	42.83	43.50	44.14	21.26	21.93	22.56
8c	line wire	35.89	36.21	36.61	14.32	14.64	15.04
9c	line wire splicing device	40.91	41.17	41.52	19.33	19.60	19.95
10c	load wire	37.99	38.35	38.72	16.42	16.78	17.15
11c	load wire splicing device	39.30	39.51	39.86	17.72	17.93	18.29
12c	room ambient	21.55	21.59	21.59			
13c	current (amps)	20.30	20.26	20.27			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3a - thru Mfg. 1 10-amp breaker at 150% current (10A * 150% = 15A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		19	20	21			
time (MM:SS)		2:00	2:10	2:20			
	Breaker trip time	2:30					
1a	Mfg. 11 - 1	27.90	28.21	28.45	5.51	5.83	6.06
2a	Mfg. 11 - 2	27.85	28.17	28.44	5.46	5.79	6.06
3a	Mfg. 11 - 3	27.44	27.71	27.97	5.05	5.32	5.58
4a	Mfg. 8 - 1	28.03	28.30	28.55	5.64	5.91	6.17
5a	Mfg. 8 - 2	28.67	28.93	29.21	6.28	6.55	6.83
6a	Mfg. 8 - 3	28.12	28.37	28.63	5.73	5.98	6.24
7a	circuit breaker	29.23	29.65	30.04	6.84	7.27	7.65
8a	line wire	33.45	33.99	34.55	11.06	11.60	12.16
9a	line wire splicing device	33.38	33.88	34.38	10.99	11.49	11.99
10a	load wire	32.35	32.80	33.28	9.96	10.41	10.89
11a	load wire splicing device	34.69	35.13	35.60	12.30	12.74	13.21
12a	room ambient	22.40	22.39	22.37			
13a	current (amps)	15.02	15.02	15.02			

Test 3a - thru Mfg. 1 15-amp breaker at 150% current (15A * 150% = 22.5A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		31	32	33			
time (MM:SS)		3:40	3:50	4:00			
	Breaker trip time	4:10					
1a	Mfg. 11 - 1	36.08	36.34	36.60	13.46	13.72	13.98
2a	Mfg. 11 - 2	36.41	36.67	36.97	13.79	14.05	14.35
3a	Mfg. 11 - 3	34.72	34.88	35.08	12.10	12.26	12.46
4a	Mfg. 8 - 1	36.33	36.58	36.86	13.71	13.96	14.24
5a	Mfg. 8 - 2	37.14	37.38	37.62	14.53	14.76	15.00
6a	Mfg. 8 - 3	36.40	36.56	36.84	13.78	13.94	14.22
7a	circuit breaker	40.83	41.35	41.83	18.21	18.73	19.21
8a	line wire	39.85	40.31	40.75	17.23	17.69	18.13
9a	line wire splicing device	49.53	49.93	50.18	26.91	27.31	27.56
10a	load wire	40.21	40.60	40.99	17.60	17.98	18.37
11a	load wire splicing device	45.48	45.83	46.22	22.86	23.21	23.60
12a	room ambient	22.65	22.62	22.58			
13a	current (amps)	22.56	22.53	22.53			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3b - thru Mfg. 2 10-amp breaker at 150% current (10A * 150% = 15A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		19	20	21		
time (MM:SS)		2:00	2:10	2:20		
	Breaker trip time	2:30				
1b	Mfg. 11 - 1	28.11	28.40	28.72	5.67	6.28
2b	Mfg. 11 - 2	27.73	27.97	28.26	5.29	5.82
3b	Mfg. 11 - 3	27.57	27.80	28.05	5.12	5.60
4b	Mfg. 8 - 1	28.38	28.63	28.91	5.93	6.47
5b	Mfg. 8 - 2	29.23	29.50	29.82	6.79	7.37
6b	Mfg. 8 - 3	28.00	28.25	28.53	5.56	6.09
7b	circuit breaker	30.38	30.93	31.50	7.94	9.06
8b	line wire	31.30	31.79	32.30	8.85	9.86
9b	line wire splicing device	32.82	33.29	33.71	10.38	11.27
10b	load wire	28.66	29.10	29.50	6.21	7.06
11b	load wire splicing device	33.26	33.63	33.95	10.82	11.51
12b	room ambient	22.47	22.43	22.43		
13b	current (amps)	15.01	15.01	15.01		

Test 3b - thru Mfg. 2 15-amp breaker at 150% current (15A * 150% = 22.5A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		13	14	15		
time (MM:SS)		:40	:50	1:00		
	Breaker trip time	1:10				
1b	Mfg. 11 - 1	26.84	27.76	28.60	4.39	6.15
2b	Mfg. 11 - 2	26.26	27.11	27.94	3.81	5.49
3b	Mfg. 11 - 3	26.03	26.75	27.44	3.58	4.99
4b	Mfg. 8 - 1	26.61	27.54	28.41	4.16	5.96
5b	Mfg. 8 - 2	27.59	28.55	29.46	5.14	7.01
6b	Mfg. 8 - 3	27.23	28.09	28.93	4.78	6.48
7b	circuit breaker	27.33	28.59	29.90	4.88	7.45
8b	line wire	26.59	27.53	28.44	4.14	5.99
9b	line wire splicing device	29.28	30.58	31.77	6.83	9.32
10b	load wire	27.88	28.93	29.91	5.43	7.46
11b	load wire splicing device	29.84	31.22	32.45	7.39	10.00
12b	room ambient	22.46	22.43	22.45		
13b	current (amps)	22.51	22.49	22.49		

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3c - thru Mfg. 3 10-amp breaker at 150% current (10A * 150% = 15A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature (°C)		Rise
scan #		37	38	39			
time (MM:SS)		5:00	5:10	5:20			
	Breaker trip time	5:30					
1c	Mfg. 11 - 1	32.34	32.46	32.62	9.83	9.96	10.12
2c	Mfg. 11 - 2	31.80	31.94	32.06	9.30	9.44	9.56
3c	Mfg. 11 - 3	29.96	30.07	30.17	7.46	7.56	7.67
4c	Mfg. 8 - 1	31.82	31.94	32.07	9.32	9.44	9.57
5c	Mfg. 8 - 2	31.64	31.77	31.86	9.13	9.26	9.36
6c	Mfg. 8 - 3	31.07	31.17	31.31	8.57	8.67	8.81
7c	circuit breaker	37.24	37.53	37.80	14.74	15.03	15.30
8c	line wire	38.50	38.75	39.00	16.00	16.25	16.50
9c	line wire splicing device	35.73	35.83	35.94	13.23	13.33	13.43
10c	load wire	37.84	38.06	38.26	15.33	15.56	15.75
11c	load wire splicing device	38.75	38.81	38.93	16.24	16.31	16.43
12c	room ambient	22.50	22.49	22.52			
13c	current (amps)	15.01	15.01	15.01			

Test 3c - thru Mfg. 3 15-amp breaker at 150% current (15A * 150% = 22.5A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature (°C)		Rise
scan #		23	24	25			
time (MM:SS)		2:20	2:30	2:40			
	Breaker trip time	2:50					
1c	Mfg. 11 - 1	32.80	33.29	33.73	10.40	10.89	11.33
2c	Mfg. 11 - 2	34.13	34.67	35.12	11.73	12.27	12.72
3c	Mfg. 11 - 3	32.29	32.77	33.17	9.89	10.37	10.77
4c	Mfg. 8 - 1	33.21	33.67	34.07	10.81	11.27	11.67
5c	Mfg. 8 - 2	34.62	35.08	35.48	12.22	12.68	13.08
6c	Mfg. 8 - 3	32.76	33.21	33.64	10.36	10.81	11.24
7c	circuit breaker	37.29	38.07	38.83	14.89	15.67	16.43
8c	line wire	33.28	33.93	34.55	10.88	11.53	12.15
9c	line wire splicing device	40.01	40.55	41.07	17.61	18.15	18.67
10c	load wire	36.15	36.74	37.30	13.75	14.34	14.90
11c	load wire splicing device	37.79	38.32	38.82	15.39	15.92	16.42
12c	room ambient	22.38	22.41	22.41			
13c	current (amps)	22.43	22.44	22.42			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3a - thru Mfg. 1 10-amp breaker at 150% current ($10A * 150\% = 15A$); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		23	24	25			
time (MM:SS)		2:20	2:30	2:40			
	Breaker trip time	2:50					
1a	Mfg. 10 - 1	29.81	30.21	30.55	7.56	7.96	8.30
2a	Mfg. 10 - 2	29.70	30.02	30.29	7.44	7.77	8.04
3a	Mfg. 10 - 3	28.37	28.62	28.85	6.12	6.37	6.60
4a	Mfg. 9 - 1	28.22	28.46	28.69	5.97	6.21	6.44
5a	Mfg. 9 - 2	28.46	28.71	28.94	6.21	6.46	6.69
6a	Mfg. 9 - 3	27.73	27.96	28.13	5.48	5.71	5.88
7a	circuit breaker	29.83	30.21	30.53	7.58	7.96	8.28
8a	line wire	34.40	34.90	35.38	12.15	12.65	13.13
9a	line wire splicing device	32.53	32.88	33.18	10.28	10.63	10.93
10a	load wire	33.43	33.88	34.25	11.17	11.63	12.00
11a	load wire splicing device	37.25	37.47	37.66	15.00	15.22	15.41
12a	room ambient	22.28	22.24	22.24			
13a	current (amps)	15.02	15.02	15.02			

Test 3a - thru Mfg. 1 15-amp breaker at 150% current ($15A * 150\% = 22.5A$); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		38	39	40			
time (MM:SS)		4:00	4:10	4:20			
	Breaker trip time	4:30					
1a	Mfg. 10 - 1	40.53	40.89	41.27	18.74	19.10	19.48
2a	Mfg. 10 - 2	42.28	42.67	43.05	20.49	20.88	21.26
3a	Mfg. 10 - 3	39.25	39.54	39.81	17.46	17.75	18.02
4a	Mfg. 9 - 1	39.03	39.37	39.68	17.24	17.58	17.89
5a	Mfg. 9 - 2	40.06	40.40	40.75	18.27	18.61	18.96
6a	Mfg. 9 - 3	35.92	36.14	36.35	14.14	14.35	14.56
7a	circuit breaker	41.66	42.13	42.62	19.87	20.34	20.83
8a	line wire	40.15	40.56	40.91	18.36	18.77	19.12
9a	line wire splicing device	47.60	47.94	48.23	25.81	26.16	26.44
10a	load wire	40.83	41.12	41.46	19.04	19.33	19.67
11a	load wire splicing device	46.50	46.62	46.74	24.72	24.83	24.95
12a	room ambient	21.81	21.79	21.76			
13a	current (amps)	22.35	22.35	22.35			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3b - thru Mfg. 2 10-amp breaker at 150% current (10A * 150% = 15A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		21	22	23			
time (MM:SS)		2:00	2:10	2:20			
	Breaker trip time	2:30					
1b	Mfg. 10 - 1	28.72	29.12	29.50	6.58	6.98	7.36
2b	Mfg. 10 - 2	29.55	29.94	30.33	7.41	7.80	8.19
3b	Mfg. 10 - 3	28.01	28.30	28.56	5.87	6.16	6.42
4b	Mfg. 9 - 1	27.72	28.02	28.27	5.58	5.88	6.13
5b	Mfg. 9 - 2	27.97	28.28	28.55	5.83	6.14	6.41
6b	Mfg. 9 - 3	27.58	27.82	28.09	5.44	5.68	5.95
7b	circuit breaker	30.55	31.13	31.74	8.41	8.99	9.60
8b	line wire	31.18	31.69	32.20	9.04	9.55	10.06
9b	line wire splicing device	31.46	31.83	32.14	9.32	9.69	10.00
10b	load wire	28.42	28.81	29.21	6.28	6.67	7.07
11b	load wire splicing device	36.24	36.63	36.93	14.10	14.49	14.79
12b	room ambient	22.20	22.13	22.09			
13b	current (amps)	15.00	15.00	15.00			

Test 3b - thru Mfg. 2 15-amp breaker at 150% current (15A * 150% = 22.5A); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		18	19	20			
time (MM:SS)		:40	:50	1:00			
	Breaker trip time	1:10					
1b	Mfg. 10 - 1	25.84	26.82	27.77	4.13	5.12	6.06
2b	Mfg. 10 - 2	29.58	31.10	32.54	7.88	9.40	10.83
3b	Mfg. 10 - 3	32.64	34.09	35.41	10.93	12.39	13.71
4b	Mfg. 9 - 1	25.84	26.77	27.65	4.14	5.07	5.94
5b	Mfg. 9 - 2	27.74	28.90	29.94	6.03	7.19	8.24
6b	Mfg. 9 - 3	27.36	28.35	29.32	5.65	6.65	7.62
7b	circuit breaker	26.69	27.90	29.05	4.98	6.20	7.35
8b	line wire	25.29	26.13	26.94	3.59	4.42	5.23
9b	line wire splicing device	28.85	30.25	31.50	7.14	8.54	9.80
10b	load wire	27.35	28.42	29.40	5.65	6.72	7.70
11b	load wire splicing device	29.03	30.42	31.68	7.33	8.71	9.98
12b	room ambient	21.68	21.70	21.73			
13b	current (amps)	22.56	22.55	22.52			

Appendix C3 Static Heating Tests at 150% Rated Current

Test 3c - thru Mfg. 3 10-amp breaker at 150% current ($10A * 150\% = 15A$); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		44	45	46			
time (MM:SS)		5:50	6:00	6:10			
	Breaker trip time	6:20					
1c	Mfg. 10 - 1	33.95	34.06	34.18	12.26	12.38	12.49
2c	Mfg. 10 - 2	34.86	35.03	35.17	13.17	13.34	13.48
3c	Mfg. 10 - 3	32.06	32.16	32.23	10.37	10.47	10.55
4c	Mfg. 9 - 1	31.67	31.77	31.89	9.98	10.08	10.20
5c	Mfg. 9 - 2	31.89	31.99	32.07	10.20	10.30	10.39
6c	Mfg. 9 - 3	30.51	30.58	30.63	8.82	8.89	8.94
7c	circuit breaker	37.51	37.73	37.94	15.82	16.04	16.25
8c	line wire	38.17	38.32	38.46	16.48	16.63	16.77
9c	line wire splicing device	33.48	33.53	33.58	11.79	11.84	11.89
10c	load wire	37.25	37.38	37.51	15.57	15.70	15.82
11c	load wire splicing device	39.05	39.08	39.09	17.36	17.39	17.40
12c	room ambient	21.68	21.69	21.69			
13c	current (amps)	15.00	15.00	15.00			

Test 3c - thru Mfg. 3 15-amp breaker at 150% current ($15A * 150\% = 22.5A$); max temps, reading every 10s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		28	29	30			
time (MM:SS)		2:20	2:30	2:40			
	Breaker trip time	2:50					
1c	Mfg. 10 - 1	28.08	27.72	27.38	6.22	5.87	5.53
2c	Mfg. 10 - 2	27.85	27.43	27.08	5.99	5.58	5.23
3c	Mfg. 10 - 3	26.82	26.45	26.13	4.97	4.59	4.27
4c	Mfg. 9 - 1	26.62	26.30	26.02	4.76	4.45	4.17
5c	Mfg. 9 - 2	26.78	26.44	26.12	4.92	4.58	4.27
6c	Mfg. 9 - 3	26.00	25.71	25.47	4.15	3.86	3.62
7c	circuit breaker	30.09	29.81	29.54	8.23	7.95	7.68
8c	line wire	27.46	27.28	27.08	5.61	5.42	5.22
9c	line wire splicing device	27.03	26.55	26.12	5.18	4.69	4.26
10c	load wire	27.36	27.10	26.84	5.50	5.24	4.98
11c	load wire splicing device	27.70	27.09	26.53	5.84	5.23	4.67
12c	room ambient	21.89	21.86	21.82			
13c	current (amps)	22.40	22.39	22.39			

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4a - thru Mfg. 1 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		10	11	12		
time (MM:SS)		:15	:21	:28		
	Breaker trip time	:35				
1a	Mfg. 11 - 1	24.11	24.67	25.32	2.07	3.28
2a	Mfg. 11 - 2	24.06	24.59	25.25	2.02	3.20
3a	Mfg. 11 - 3	24.07	24.57	25.16	2.03	3.12
4a	Mfg. 8 - 1	24.08	24.69	25.40	2.03	3.35
5a	Mfg. 8 - 2	24.66	25.33	26.11	2.61	4.06
6a	Mfg. 8 - 3	24.22	24.83	25.55	2.17	3.50
7a	circuit breaker	24.11	24.82	25.62	2.07	3.57
8a	line wire	27.40	28.75	30.11	5.35	8.06
9a	line wire splicing device	25.44	26.76	28.29	3.40	6.24
10a	load wire	26.61	27.77	28.96	4.57	6.91
11a	load wire splicing device	26.63	28.24	30.08	4.59	8.04
12a	room ambient	22.05	22.06	22.03		
13a	current (amps)	19.99	20.01	20.01		

Test 4a - thru Mfg. 1 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		20	21	22		
time (MM:SS)		:28	:35	:42		
	Breaker trip time	:49				
1a	Mfg. 11 - 1	27.71	28.87	30.04	5.22	7.55
2a	Mfg. 11 - 2	27.71	28.87	30.05	5.22	7.56
3a	Mfg. 11 - 3	27.95	28.97	30.04	5.46	7.54
4a	Mfg. 8 - 1	27.60	28.90	30.19	5.11	7.70
5a	Mfg. 8 - 2	28.56	29.91	31.25	6.06	8.76
6a	Mfg. 8 - 3	29.13	30.23	31.51	6.63	9.02
7a	circuit breaker	27.85	29.29	30.80	5.35	8.30
8a	line wire	29.17	30.44	31.74	6.68	9.24
9a	line wire splicing device	36.20	38.78	41.38	13.71	18.89
10a	load wire	29.69	31.07	32.48	7.20	9.98
11a	load wire splicing device	36.64	39.18	41.65	14.14	19.15
12a	room ambient	22.48	22.48	22.52		
13a	current (amps)	29.87	29.79	29.76		

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4b - thru Mfg. 2 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		10	11	12			
time (MM:SS)		:15	:21	:28			
	Breaker trip time	:35					
1b	Mfg. 11 - 1	23.92	24.53	25.23	2.00	2.60	3.30
2b	Mfg. 11 - 2	23.87	24.40	25.03	1.95	2.48	3.10
3b	Mfg. 11 - 3	24.04	24.56	25.19	2.11	2.64	3.27
4b	Mfg. 8 - 1	24.03	24.67	25.43	2.11	2.74	3.51
5b	Mfg. 8 - 2	24.81	25.54	26.38	2.89	3.62	4.46
6b	Mfg. 8 - 3	24.09	24.69	25.38	2.17	2.77	3.46
7b	circuit breaker	23.99	24.68	25.52	2.07	2.75	3.60
8b	line wire	25.64	26.65	27.71	3.72	4.73	5.78
9b	line wire splicing device	25.15	26.44	27.96	3.22	4.52	6.03
10b	load wire	23.65	24.33	25.10	1.73	2.41	3.18
11b	load wire splicing device	26.05	27.55	29.19	4.13	5.63	7.27
12b	room ambient	21.94	21.92	21.90			
13b	current (amps)	20.00	20.00	20.00			

Test 4b - thru Mfg. 2 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		16	17	18			
time (MM:SS)		:00	:09	:15			
	Breaker trip time	:21					
1b	Mfg. 11 - 1	22.78	24.58	25.64	0.28	2.08	3.14
2b	Mfg. 11 - 2	22.55	23.95	24.94	0.05	1.45	2.44
3b	Mfg. 11 - 3	22.78	24.32	25.15	0.28	1.82	2.65
4b	Mfg. 8 - 1	22.67	24.22	25.26	0.17	1.72	2.76
5b	Mfg. 8 - 2	23.01	25.35	26.56	0.52	2.85	4.06
6b	Mfg. 8 - 3	23.06	25.22	26.32	0.57	2.72	3.83
7b	circuit breaker	22.89	24.64	25.66	0.39	2.15	3.17
8b	line wire	22.78	24.14	25.26	0.28	1.64	2.76
9b	line wire splicing device	22.80	25.27	27.08	0.30	2.77	4.59
10b	load wire	22.73	25.29	26.72	0.23	2.79	4.22
11b	load wire splicing device	22.84	25.76	27.75	0.34	3.26	5.26
12b	room ambient	22.49	22.49	22.51			
13b	current (amps)	29.72	29.67	29.65			

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4c - thru Mfg. 3 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		16	17	18			
time (MM:SS)		:56	1:03	1:10			
	Breaker trip time	1:17					
1c	Mfg. 11 - 1	27.91	28.45	29.02	5.96	6.50	7.07
2c	Mfg. 11 - 2	27.83	28.34	28.85	5.88	6.39	6.90
3c	Mfg. 11 - 3	26.46	26.84	27.26	4.51	4.89	5.31
4c	Mfg. 8 - 1	28.33	28.89	29.46	6.38	6.94	7.51
5c	Mfg. 8 - 2	28.77	29.28	29.81	6.82	7.33	7.86
6c	Mfg. 8 - 3	27.76	28.25	28.71	5.81	6.30	6.76
7c	circuit breaker	30.95	31.72	32.52	8.99	9.77	10.56
8c	line wire	32.07	32.86	33.68	10.12	10.91	11.73
9c	line wire splicing device	31.50	32.36	33.19	9.54	10.41	11.24
10c	load wire	32.53	33.29	34.09	10.58	11.34	12.14
11c	load wire splicing device	36.35	37.44	38.34	14.40	15.49	16.39
12c	room ambient	22.03	21.91	21.92			
13c	current (amps)	20.00	20.00	20.00			

Test 4c - thru Mfg. 3 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		18	19	20			
time (MM:SS)		:15	:21	:28			
	Breaker trip time	:35					
1c	Mfg. 11 - 1	24.86	25.82	26.97	2.56	3.52	4.67
2c	Mfg. 11 - 2	25.87	27.00	28.27	3.57	4.70	5.97
3c	Mfg. 11 - 3	25.45	26.38	27.49	3.15	4.08	5.19
4c	Mfg. 8 - 1	25.11	26.19	27.48	2.81	3.89	5.18
5c	Mfg. 8 - 2	26.49	27.73	29.14	4.19	5.43	6.85
6c	Mfg. 8 - 3	25.08	26.08	27.24	2.78	3.78	4.94
7c	circuit breaker	25.44	26.60	28.04	3.14	4.30	5.74
8c	line wire	24.49	25.44	26.52	2.20	3.15	4.22
9c	line wire splicing device	27.39	29.24	31.37	5.09	6.95	9.07
10c	load wire	26.18	27.74	29.43	3.88	5.44	7.13
11c	load wire splicing device	26.21	27.89	29.79	3.91	5.59	7.49
12c	room ambient	22.31	22.30	22.29			
13c	current (amps)	29.59	29.78	29.83			

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4a - thru Mfg. 1 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		27	28	29			
time (MM:SS)		:15	:21	:28			
	Breaker trip time	:35					
1a	Mfg. 10 - 1	24.20	24.89	25.74	2.53	3.23	4.07
2a	Mfg. 10 - 2	24.11	24.81	25.65	2.45	3.14	3.99
3a	Mfg. 10 - 3	23.82	24.42	25.12	2.16	2.76	3.45
4a	Mfg. 9 - 1	23.70	24.28	24.96	2.04	2.62	3.29
5a	Mfg. 9 - 2	23.89	24.51	25.23	2.22	2.84	3.57
6a	Mfg. 9 - 3	23.66	24.22	24.90	1.99	2.55	3.23
7a	circuit breaker	23.81	24.47	25.29	2.14	2.80	3.63
8a	line wire	26.99	28.37	29.76	5.32	6.71	8.09
9a	line wire splicing device	24.05	25.15	26.46	2.39	3.48	4.79
10a	load wire	26.61	27.85	29.13	4.94	6.19	7.47
11a	load wire splicing device	28.24	30.24	32.42	6.58	8.58	10.75
12a	room ambient	21.68	21.67	21.66			
13a	current (amps)	20.02	20.03	20.03			

Test 4a - thru Mfg. 1 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		17	18	19			
time (MM:SS)		:28	:35	:42			
	Breaker trip time	:49					
1a	Mfg. 10 - 1	27.27	28.75	30.17	5.77	7.24	8.67
2a	Mfg. 10 - 2	28.89	30.53	32.07	7.38	9.02	10.56
3a	Mfg. 10 - 3	27.89	29.33	30.74	6.38	7.82	9.24
4a	Mfg. 9 - 1	27.16	28.54	29.90	5.66	7.04	8.39
5a	Mfg. 9 - 2	28.09	29.55	30.97	6.58	8.05	9.46
6a	Mfg. 9 - 3	27.93	29.14	30.27	6.43	7.64	8.77
7a	circuit breaker	26.82	28.27	29.71	5.32	6.77	8.20
8a	line wire	28.15	29.45	30.67	6.65	7.95	9.17
9a	line wire splicing device	34.08	36.63	38.99	12.57	15.13	17.49
10a	load wire	28.54	29.95	31.29	7.03	8.45	9.79
11a	load wire splicing device	35.97	38.68	41.18	14.47	17.17	19.67
12a	room ambient	21.49	21.52	21.51			
13a	current (amps)	29.88	29.83	29.82			

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4b - thru Mfg. 2 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		27	28	29		
time (MM:SS)		:15	:21	:28		
	Breaker trip time	:35				
1b	Mfg. 10 - 1	23.68	24.31	25.08	2.15	3.55
2b	Mfg. 10 - 2	24.00	24.79	25.66	2.47	4.13
3b	Mfg. 10 - 3	23.96	24.59	25.27	2.43	3.74
4b	Mfg. 9 - 1	23.67	24.25	24.93	2.14	3.40
5b	Mfg. 9 - 2	23.75	24.36	25.10	2.22	3.58
6b	Mfg. 9 - 3	23.79	24.37	25.03	2.26	3.50
7b	circuit breaker	23.69	24.36	25.21	2.16	3.69
8b	line wire	25.34	26.37	27.40	3.81	5.88
9b	line wire splicing device	24.37	25.54	26.91	2.84	5.38
10b	load wire	23.38	24.06	24.84	1.86	3.32
11b	load wire splicing device	28.62	30.57	32.60	7.09	11.07
12b	room ambient	21.54	21.54	21.50		
13b	current (amps)	19.99	19.99	19.99		

Test 4b - thru Mfg. 2 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		13	14	15		
time (MM:SS)		0:00	:09	:15		
	Breaker trip time	:21				
1b	Mfg. 10 - 1	21.91	23.26	24.56	0.52	3.16
2b	Mfg. 10 - 2	21.93	24.79	26.37	0.54	4.97
3b	Mfg. 10 - 3	21.91	23.93	25.26	0.52	3.87
4b	Mfg. 9 - 1	21.95	24.22	25.49	0.56	4.10
5b	Mfg. 9 - 2	21.93	24.57	25.87	0.54	4.48
6b	Mfg. 9 - 3	21.90	24.12	25.30	0.51	3.90
7b	circuit breaker	22.03	23.68	24.72	0.64	3.33
8b	line wire	22.07	23.08	24.22	0.68	2.83
9b	line wire splicing device	21.89	24.14	26.27	0.50	4.87
10b	load wire	21.93	24.17	25.69	0.54	4.30
11b	load wire splicing device	21.95	26.40	28.99	0.56	7.60
12b	room ambient	21.40	21.38	21.40		
13b	current (amps)	30.03	29.98	29.94		

Appendix C4 Static Heating Tests at 200% Rated Current

Test 4c - thru Mfg. 3 10-amp breaker at 200% current (10A * 200% = 20A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		33	34	35		
time (MM:SS)		:56	1:03	1:10		
	Breaker trip time	1:17				
1c	Mfg. 10 - 1	28.89	29.56	30.22	7.33	8.67
2c	Mfg. 10 - 2	29.13	29.80	30.47	7.57	8.92
3c	Mfg. 10 - 3	28.24	28.82	29.43	6.69	7.87
4c	Mfg. 9 - 1	27.96	28.54	29.11	6.41	6.98
5c	Mfg. 9 - 2	27.95	28.55	29.13	6.40	6.99
6c	Mfg. 9 - 3	27.87	28.37	28.89	6.31	6.82
7c	circuit breaker	30.46	31.20	31.96	8.91	9.65
8c	line wire	31.76	32.54	33.32	10.20	10.99
9c	line wire splicing device	30.32	31.15	31.96	8.77	9.60
10c	load wire	32.17	32.94	33.69	10.62	11.39
11c	load wire splicing device	39.40	40.57	41.66	17.85	19.02
12c	room ambient	21.59	21.54	21.53		
13c	current (amps)	20.00	20.00	20.00		

Test 4c - thru Mfg. 3 15-amp breaker at 200% current (15A * 200% = 30A); max temps, reading every 7s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)	
scan #		16	17	18		
time (MM:SS)		:21	:28	:35		
	Breaker trip time	:42				
1c	Mfg. 10 - 1	24.57	25.84	27.05	3.19	4.45
2c	Mfg. 10 - 2	28.42	30.54	32.56	7.04	9.16
3c	Mfg. 10 - 3	33.47	35.78	37.86	12.09	14.40
4c	Mfg. 9 - 1	24.87	26.08	27.27	3.49	4.70
5c	Mfg. 9 - 2	27.04	28.63	30.11	5.66	7.25
6c	Mfg. 9 - 3	26.95	28.35	29.72	5.57	6.97
7c	circuit breaker	25.75	27.15	28.60	4.37	5.77
8c	line wire	24.57	25.65	26.68	3.19	4.27
9c	line wire splicing device	27.76	29.81	31.74	6.38	8.43
10c	load wire	26.52	28.22	29.72	5.14	6.84
11c	load wire splicing device	27.66	29.85	31.88	6.28	8.47
12c	room ambient	21.40	21.37	21.36		
13c	current (amps)	29.34	29.29	30.17		

Appendix C5 Static Heating Testing Schneider Circuit Breaker

Test 1b - thru Mfg. 2 10-amp breaker at 100% current (10A * 100% = 10A); max temps, reading every 60s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		67	72	77			
time (HH:MM:SS)		1:04:00	1:09:00	1:14:00			
1b	Mfg. 10 - 1	33.66	33.62	33.48	12.17	12.13	11.99
2b	Mfg. 10 - 2	30.46	30.56	30.61	8.97	9.07	9.12
3b	Mfg. 10 - 3	28.97	29.03	28.87	7.48	7.54	7.38
4b	Mfg. 9 - 1	28.59	28.61	28.68	7.10	7.12	7.19
5b	Mfg. 9 - 2	29.99	29.94	29.81	8.50	8.45	8.32
6b	Mfg. 9 - 3	28.44	28.40	28.15	6.95	6.91	6.66
7b	circuit breaker	41.26	41.48	41.60	19.77	19.99	20.11
8b	line wire	31.15	30.97	30.89	9.66	9.48	9.40
9b	line wire splicing device	28.63	28.27	28.01	7.14	6.78	6.52
10b	load wire	28.45	28.20	28.09	6.96	6.71	6.60
11b	load wire splicing device	30.47	29.94	29.87	8.98	8.45	8.38
12b	room ambient	22.46	22.07	21.66			
13b	current (amps)	10.01	10.01	10.01			

Test 2b - thru Mfg. 2 10-amp breaker at 135% current (10A * 135% = 13.5A); max temps, reading every 20s

data logger CH #	Location	Recorded Temperatures (°C)			Calculated Temperature Rise (°C)		
scan #		202	203	204			
time (MM:SS)		66:20	66:40	67:00			
	Breaker trip time	> 67 mins. (no trip)					
1b	Mfg. 10 - 1	40.89	40.89	40.88	18.96	18.97	18.96
2b	Mfg. 10 - 2	37.03	37.03	37.04	15.11	15.11	15.12
3b	Mfg. 10 - 3	34.24	34.26	34.21	12.31	12.34	12.29
4b	Mfg. 9 - 1	33.52	33.50	33.53	11.60	11.58	11.61
5b	Mfg. 9 - 2	35.79	35.78	35.75	13.87	13.86	13.83
6b	Mfg. 9 - 3	33.44	33.45	33.39	11.52	11.53	11.47
7b	circuit breaker	56.60	56.56	56.59	34.68	34.64	34.67
8b	line wire	38.73	38.68	38.65	16.81	16.76	16.72
9b	line wire splicing device	33.69	33.57	33.57	11.76	11.65	11.65
10b	load wire	33.57	33.50	33.50	11.65	11.57	11.58
11b	load wire splicing device	37.08	36.99	37.04	15.16	15.07	15.12
12b	room ambient	22.10	22.03	21.97			
13b	current (amps)	13.49	13.49	13.49			

Appendix D Flexing Tests

Conductor Flexing tests on 14-2 AWG copper-clad aluminum NMB cable:

test #	wire connection method	pass / fail (10x flexion)	comments
6-1	wrap around terminal screw	pass	ends of hot and neutral wires broke when removing them from their terminals after the test
6-2	single compression	pass	
6-3	double compression	pass	
6-1-1	wrap around terminal screw	failed	retest of 6-1; hot wire (black) broke on 8th flexion
6-1-2	wrap around terminal screw	pass	retest of 6-1 using copper wire
6-1-3	wrap around terminal screw	pass	retest of 6-1

NOTE: One Legrand receptacle was used for all 3 tests above and 9in/lbs was applied to all three terminal screws.

Appendix E - Certificates of Calibration



PO Box 2363, Clackamas, OR 97015
15648 114th Ave. Suite 109, Clackamas OR 97015
Phone: 503-406-4373 Fax: 503 905 0457
www.pacifictestandmeasurement.com

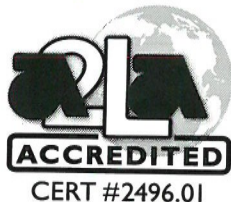
Certificate of Conformance

Issued to:	CDCMello Consulting LLC PO Box 872317 Vancouver, WA 98687
Customer PO:	Verbal Chuck Mello
Model:	UL3055
Lot Number:	952103-019
Report:	JK202006300-003
Description:	Type J, 30 Gauge FEP/FEP Teflon, Special Limits of Error Tolerance, 15 feet length, Thermocouple

Pacific Test and Measurement Inc certifies that the order of thermocouples meets all applicable instructions, specifications, and in accordance with DAP UL 00-OP-C0037 version 10.0. The preferred method of welding to produce a single point weld or bead using ThermX model 258B welder has been used to assemble the thermocouple junction which has been proven as reliable and repeatable through validation. The finish products were assembled from UL4047, a spool of described wire calibrated to accredited standards as described in the calibration report.

Certified by: 
(Quality Department)

Date: 7-10-2020



Appendix E - Certificates of Calibration

Report of Calibration

Eustis Co., Inc./Pyrocom Calibration lab
12407-B Mukilteo Speedway #200
Lynnwood, wa 98087

Report No: JK202006300-003

Page 1 of 2

Model: UL4047 Serial: 952103-019 Description: TYPE J, 30AWG, FEP/FEP	Customer:
Calibration Range: Limited Received Condition: New Current: N/A Procedure: ECP 339/341	CDCMello Consulting LLC PO Box 872317 Vancouver, WA 98687

The unit under test (UUT) on this certificate has been calibrated by comparison method as covered by ASTM E220-13, and calibrated against standards traceable to the National Institute of Standards and Technology (NIST). Eustis Co., Inc./Pyrocom Calibration Lab meets the requirements of ANSI/NCSL Z540-1-1994 and ISO/IEC 17025 and is accredited by A2LA via Certificate Number 2496.01 for calibrations within the scope to which it applies. The uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of $k=2$. All results contained within this certificate relate only to the item calibrated. Any number of factors may cause the calibrated item to drift out of calibration.

Nominal Value (Set-point) (C)	Actual Value (Reference) (C)	UUT (Test Sensor) (C)	Error (C)	Measurement Uncertainty (C)	Method of Realization
21.00	21.41	21.38	-0.03	+/- 0.31	COMP
40.00	40.08	40.02	-0.06	+/- 0.40	COMP
95.00	95.02	94.97	-0.05	+/- 0.40	COMP
150.00	150.02	150.10	0.08	+/- 0.50	COMP
200.00	200.01	200.23	0.22	+/- 0.50	COMP

Test Equipment

Manufacturer	Model	Description	Serial Number	Recall Date
Hart Scientific	1560	"Black Stack" Base Unit	96539	NCR
Hart Scientific	2560	SPRT Module	A25631	3/24/2021
Fluke	5628	4 Wire SPRT	4303	3/26/2021
Fluke	2566	Thermocouple Scanner	B7A380	3/24/2021
Fluke	9173	Metrology Well, 700 C	B47975	NCR
Fluke	7380	Bath, Ultra Low-Temperature	B2A527	NCR

Calibration Date: 6/18/2020
Temperature: 23.0 C
Humidity: 47%
Customer Order: 74523

Technician:

Julia Kulin

Approved By:

Walter Paulson
QA Manager

Appendix E - Certificates of Calibration
Report of Calibration

Report No: JK202006300-003
Page 2 of 2

Notes: The thermocouple wire meets or exceeds the criteria established for type "J" SPECIAL LIMITS OF ERROR per ASTM E230/E230M-17 table 1 & ISA-MC96.1-1982 Par. 2.5 Table 8 $\pm 1.1^{\circ}\text{C}$ OR $\pm .4\%$ whichever is greater. Lot calibration data supplied for your reference.

Calibrated item meets special limits of error for all results given according to the comparison of "error" reading to the specifications found in ASTM E230/E230M-17 table 1 & MC96.1-1982 table 8; acceptance determination is ultimately the responsibility of the customer, taking into account all uncertainties and other factors. The closer the results are to the specification limits, the greater the risk that the unit under test will be out of tolerance.

Report issue date: JUN 19 2020

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-33105-466

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109

Test Instrument Data Acquisition Unit

Make Keysight

Model 34972A

Serial Number MY49002695

Identification EM7054



Customer Location ICD

Condition Received In Tolerance

Condition Returned In Tolerance

Calibrated By Alex Paulsen

Technical Review By Tim Bending

Calibration Location FVM

Calibration Conditions 67.8°F, 19.9°C, 57.3%RH

Calibration Date 07/16/2020

Recalibration Due 07/16/2021

Procedures Followed

FVE-000 rev. 2

FVE-006 rev. 2

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated. Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVS-275A	RY11838	CJ191-70508-513	07/28/2020
FVS-737	4542903	CK041-57440-531	02/28/2021

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
Root Difference Square guardbanding method used.						
UUT IDENTIFICATION						
Serial Number: MY49002695 Firmware Level: 1.11-1.12-02-01						
INPUT MODULE CHARACTERISTI CS						
Model: 34901A Firmware Level: 2.3						
SELF TEST				Pass	Pass	

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
INTERNAL DMM VERIFICATION						
ZERO OFFSET VERIFICATION						
DC CURRENT						
10 mA Range 0.00000 mA	0.00000	-0.00200	0.00200	0.00003	0.00003	0.000007
100 mA Range 0.0000 mA	0.0000	-0.0050	0.0050	0.0000	0.0000	0.00006
1 A Range 0.000000 A	0.000000	-0.000100	0.000100	0.000001	0.000001	0.0000006
DC VOLTS						
100 mV Range 0.0000 mV	0.0000	-0.0040	0.0040	0.0004	0.0004	0.00007
1 V Range 0.000000 V	0.000000	-0.000007	0.000007	0.000001	0.000001	0.0000007
10 V Range 0.00000 V	0.00000	-0.00005	0.00005	0.00000	0.00000	0.000007
100 V Range 0.0000 V	0.0000	-0.0006	0.0006	0.0000	0.0000	0.00006
300 V Range 0.000 V	0.000	-0.009	0.009	0.000	0.000	0.0006
2 WIRE						
100 Range 0.0000 Ohm	0.0000	-4.0040	4.0040	0.0626	0.0626	0.00007
1 k Range 0.000000 kOhm	0.000000	-0.004010	0.004010	0.000065	0.000065	0.0000006
10 k Range 0.00000 kOhm	0.00000	-0.00410	0.00410	0.00008	0.00008	0.000006
100 k Range 0.0000 kOhm	0.0000	-0.0050	0.0050	0.0002	0.0002	0.00007
1 M Range 0.000000 MOhm	0.000000	-0.000014	0.000014	0.000000	0.000000	0.0000007
10 M Range						

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
0.00000 MOhm	0.00000	-0.00010	0.00010	0.00000	0.00000	0.000007
100 M? Range						
0.0000 MOhm	0.0000	-0.0100	0.0100	0.0000	0.0000	0.00006
4 WIRE						
100 Range						
0.0000 Ohm	0.0000	-0.0040	0.0040	-0.0023	-0.0023	0.00006
1 k Range						
0.000000 kOhm	0.000000	-0.000010	0.000010	0.000000	0.000000	0.0000006
10 k Range						
0.00000 kOhm	0.00000	-0.00010	0.00010	0.00000	0.00000	0.000007
100 k Range						
0.0000 kOhm	0.0000	-0.0010	0.0010	0.0000	0.0000	0.00007
1 M Range						
0.000000 MOhm	0.000000	-0.000010	0.000010	0.000000	0.000000	0.0000006
10 M Range						
0.00000 MOhm	0.00000	-0.00010	0.00010	0.00000	0.00000	0.000006
100 M Range						
0.0000 MOhm	0.0000	-0.0100	0.0100	0.0000	0.0000	0.00007
GAIN VERIFICATION						
DC VOLTS						
100 mV Range						
100.0000 mV	100.0000	99.9910	100.0090	100.0000	100.0000	0.00006
-100.0000 mV	-100.0000	-100.0090	-99.9910	-99.9987	-99.9987	0.00007
1 V Range						
1.000000 V	1.000000	0.999953	1.000047	0.999993	0.999993	0.0000007
-1.000000 V	-1.000000	-1.000047	-0.999953	-0.999989	-0.999989	0.0000007
10 V Range						
10.00000 V	10.00000	9.99960	10.00040	9.99994	9.99994	0.000006
-10.00000 V	-10.00000	-10.00040	-9.99960	-9.99992	-9.99992	0.000006
100 V Range						
100.0000 V	100.0000	99.9949	100.0051	99.9996	99.9996	0.00007
-100.0000 V	-100.0000	-100.0051	-99.9949	-99.9993	-99.9993	0.00007
300 V Range						
300.000 V	300.000	299.978	300.022	299.998	299.998	0.0006

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
2 WIRE						
100 Range 100.0000 Ohm	100.0000	95.9860	104.0140	100.0067	100.0067	0.00007
1 k Range 1.000000 kOhm	1.000000	0.995890	1.004110	1.000032	1.000032	0.0000006
10 k Range 10.00000 kOhm	10.00000	9.99490	10.00510	10.00035	10.00035	0.000007
100 k Range 100.0000 kOhm	100.0000	99.9850	100.0150	100.0029	100.0029	0.00006
1 M Range 1.000000 MOhm	1.000000	0.999886	1.000114	1.000016	1.000016	0.0000006
10 M Range 10.00000 MOhm	10.00000	9.99590	10.00410	9.99768	9.99768	0.000006
100 M Range 100.0000 MOhm	100.0000	99.1900	100.8100	100.3688	100.3688	0.00007
4 WIRE						
100 Range 100.0000 Ohm	100.0000	99.9860	100.0140	100.0039	100.0039	0.00006
1 k Range 1.000000 kOhm	1.000000	0.999890	1.000110	1.000030	1.000030	0.0000007
10 k Range 10.00000 kOhm	10.00000	9.99890	10.00110	10.00032	10.00032	0.000006
100 k Range 100.0000 kOhm	100.0000	99.9890	100.0110	100.0021	100.0021	0.00007
1 M Range 1.000000 MOhm	1.000000	0.999890	1.000110	0.999970	0.999970	0.0000007
10 M Range 10.00000 MOhm	10.00000	9.99590	10.00410	9.99595	9.99595	0.000006
100 M Range 100.0000 MOhm	100.0000	99.1900	100.8100	99.8275	99.8275	0.00006
DC CURRENT						
10 mA Range 10.00000 mA	10.00000	9.99300	10.00700	9.99898	9.99898	0.000007
-10.00000 mA	-10.00000	-10.00700	-9.99300	-9.99887	-9.99887	0.000007

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
100 mA Range						
100.0000 mA	100.0000	99.9450	100.0550	99.9882	99.9882	0.00006
-100.0000 mA	-100.0000	-100.0550	-99.9450	-99.9879	-99.9879	0.00006
1 A Range						
1.000000 A	1.000000	0.998900	1.001100	0.999534	0.999534	0.0000006
-1.000000 A	-1.000000	-1.001100	-0.998900	-0.999537	-0.999537	0.0000006
AC VOLTS						
100 mV Range						
10.0000 mV @ 1 kHz	10.0000	9.9540	10.0460	9.9997	9.9997	0.00006
100.0000 mV @ 1 kHz	100.0000	99.9000	100.1000	99.9912	99.9912	0.00006
100.0000 mV @ 50 kHz	100.0000	99.8300	100.1700	99.9383	99.9383	0.00006
1 V Range						
1.000000 V @ 20 Hz	1.000000	0.999000	1.001000	0.999803	0.999803	0.0000006
1.000000 V @ 1 kHz	1.000000	0.999000	1.001000	0.999950	0.999950	0.0000006
1.000000 V @ 20 kHz	1.000000	0.999000	1.001000	0.999888	0.999888	0.0000006
1.000000 V @ 50 kHz	1.000000	0.998300	1.001700	0.999504	0.999504	0.0000007
1.000000 V @ 100 kHz	1.000000	0.993200	1.006800	0.998811	0.998811	0.0000006
1.000000 V @ 200 kHz	1.000000	0.955000	1.045000	0.999068	0.999068	0.0000006
1.000000 V @ 250 kHz	1.000000	0.955000	1.045000	0.999202	0.999202	0.0000007
1.000000 V @ 300 kHz	1.000000	0.955000	1.045000	0.998797	0.998797	0.0000006
10 V Range						
0.10000 V @ 1 kHz	0.10000	0.08594	0.11406	0.10086	0.10086	0.000006
1.00000 V @ 1 kHz	1.00000	0.99540	1.00460	0.99992	0.99992	0.000006
10.00000 V @ 10 Hz	10.00000	9.99000	10.01000	9.99743	9.99743	0.000007
10.00000 V @ 1 kHz	10.00000	9.99000	10.01000	9.99855	9.99855	0.000006
10.00000 V @ 50 kHz	10.00000	9.98300	10.01700	9.99499	9.99499	0.000006
100 V Range						
100.0000 V @ 1 kHz	100.0000	99.9000	100.1000	99.9653	99.9653	0.00006
100.0000 V @ 50 kHz	100.0000	99.8300	100.1700	99.8943	99.8943	0.00006

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
300 V Range						
300.000 V @ 1 kHz	300.000	299.580	300.420	299.884	299.884	0.0006
200.000 V @ 50 kHz	200.000	199.400	200.600	199.750	199.750	0.0007
AC CURRENT						
10 mA Range						
10.00000 mA @ 1 kHz	10.00000	9.98600	10.01400	9.99766	9.99766	0.000007
100 mA Range						
100.0000 mA @ 1 kHz	100.0000	99.4000	100.6000	99.9484	99.9484	0.00007
1 A Range						
0.010000 A @ 1 kHz	0.010000	0.008590	0.011410	0.009960	0.009960	0.0000007
1.000000 A @ 1 kHz	1.000000	0.998600	1.001400	0.999502	0.999502	0.0000006
FREQUENCY						
100 Hz Range						
100.0000 Hz	100.0000	99.9000	100.1000	100.0056	100.0056	0.00007
100 kHz Range						
100.0000 kHz	100.0000	99.9900	100.0100	100.0001	100.0001	0.00007

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-39504-466

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109

Test Instrument Multimeter
Digital Multimeter

Make Fluke

Model 179

Serial Number 77840008

Identification EM4437



Customer Location ICD

Condition Received In Tolerance

Condition Returned In Tolerance

Calibrated By Alex Paulsen

Technical Review By Tim Bending

Calibration Location FVM

Calibration Conditions 68.3°F, 20.2°C, 56.2%RH

Calibration Date 07/16/2020

Recalibration Due 07/16/2021

Procedures Followed

FVE-000 rev. 2
FVE-001 rev. 2

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVS-275A	RY11838	CJ191-70508-513	07/28/2020
FVS-737	4542903	CK041-57440-531	02/28/2021

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in base units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS						
600 mV Range						
300.0 mV @ 45 Hz	300.0	296.7	303.3	299.2	299.2	0.07
6 V Range						
5.000 V @ 500 Hz	5.000	4.947	5.053	4.987	4.987	0.0007
5.000 V @ 1 kHz	5.000	4.897	5.103	4.949	4.949	0.0007
60 V Range						
50.00 V @ 45 Hz	50.00	49.47	50.53	49.98	49.98	0.007
50.00 V @ 1 kHz	50.00	48.97	51.03	50.02	50.02	0.007
600 V Range						
300.0 V @ 45 Hz	300.0	296.7	303.3	299.9	299.9	0.07
500.0 V @ 500 Hz	500.0	494.7	505.3	500.5	500.5	0.06
500.0 V @ 1 kHz	500.0	489.7	510.3	500.5	500.5	0.06
1000 V Range						
1000 V @ 45 Hz	1000	987	1013	1002	1002	0.7

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS FREQUENCY						
45.00 Hz @ 1 V	45.00	44.95	45.06	45.01	45.01	0.007
50.00 kHz @ 5 V	50.00	49.94	50.06	50.00	50.00	0.006
DC VOLTAGE						
6 V Range						
5.000 V	5.000	4.994	5.007	4.997	4.997	0.0006
600 V Range						
300.0 V	300.0	299.5	300.5	299.8	299.8	0.06
1000 V Range						
1000 V	1000	997	1004	999	999	0.6
-1000 V	-1000	-1004	-997	-1000	-1000	0.7
DC VOLTS FREQUENCY						
45.00 Hz @ 3 V	45.00	44.95	45.06	45.01	45.01	0.007
50.00 kHz @ 30 V	50.00	49.94	50.06	50.00	50.00	0.007
DC MILLIVOLTS						
30.0 mV	30.0	29.8	30.2	30.0	30.0	0.06
-300.0 mV	-300.0	-300.5	-299.5	-299.9	-299.9	0.06
600.0 mV	600.0	599.3	600.7	599.7	599.7	0.07
TEMPERATURE						
0.0 °C	0.0	-1.0	1.0	1.0	1.0	0.06
-40.0 °C	-40.0	-41.4	-38.6	-39.0	-39.0	0.07
400.0 °C	400.0	395.0	405.0	400.9	400.9	0.06
OHMS						
600 Ohm Range						
19.0 Ohm	19.0	18.6	19.4	19.3	19.3	0.07
50 MOhm Range						
19.00 MOhm	19.00	18.68	19.32	19.00	19.00	0.006
CAPACITANCE						
1000 nF Range						
900 nF	900	887	913	899	899	0.6
CONTINUITY						
0 Ohms: Beeper On				Pass	Pass	
190 Ohms: Beeper Off				Pass	Pass	
DIODE TEST						

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
2.000 V	2.000	1.978	2.022	2.000	2.000	0.0007
AC MILLIAMPS						
60 mA Range						
3.00 mA @ 45 Hz	3.00	2.92	3.08	3.00	3.00	0.007
50.00 mA @ 1 kHz	50.00	49.22	50.78	50.06	50.06	0.006
400 mA Range						
400.0 mA @ 1 kHz	400.0	393.7	406.3	400.4	400.4	0.07
AC AMPS						
6 A Range						
4.000 A @ 45 Hz	4.000	3.937	4.063	4.005	4.005	0.0007
10A Range						
9.00 A @ 1 kHz	9.00	8.84	9.16	9.04	9.04	0.007
DC MILLIAMPS						
60 mA Range						
3.00 mA	3.00	2.94	3.06	3.00	3.00	0.006
50.00 mA	50.00	49.47	50.53	49.92	49.92	0.007
400 mA Range						
-400.0 mA	-400.0	-404.3	-395.7	-399.8	-399.8	0.07
DC AMPS						
6 A Range						
4.000 A	4.000	3.957	4.043	3.999	3.999	0.0007
10 A Range						
-9.00 A	-9.00	-9.12	-8.88	-9.01	-9.01	0.006

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-38060-466 For Eaton Corporation - ICD W126 N7250 Flint Drive Menomonee Falls, WI 53051 Purchase Order # 4044-671109 Test Instrument Multimeter Digital Multimeter Make Fluke Model 175 Serial Number 13700492 Identification EM7014 Customer Location ICD Condition Received In Tolerance Condition Returned In Tolerance Calibrated By Alex Paulsen Technical Review By Tim Bending Calibration Location FVM Calibration Conditions 68.2°F, 20.1°C, 56.6%RH Calibration Date 07/16/2020 Recalibration Due 07/16/2021		Procedures Followed FVE-000 rev. 2 FVE-001 rev. 2 Standards Used <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;">Instrument</th> <th style="text-align: left;">Serial Number</th> <th style="text-align: left;">Trace Number</th> <th style="text-align: left;">Next Cal</th> </tr> <tr> <td>FVS-275A</td> <td>RY11838</td> <td>CJ191-70508-513</td> <td>07/28/2020</td> </tr> <tr> <td>FVS-737</td> <td>4542903</td> <td>CK041-57440-531</td> <td>02/28/2021</td> </tr> </table>		Instrument	Serial Number	Trace Number	Next Cal	FVS-275A	RY11838	CJ191-70508-513	07/28/2020	FVS-737	4542903	CK041-57440-531	02/28/2021	This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated. Form Revision 6: 02/04/2012
Instrument	Serial Number	Trace Number	Next Cal													
FVS-275A	RY11838	CJ191-70508-513	07/28/2020													
FVS-737	4542903	CK041-57440-531	02/28/2021													
Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in base units. All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.																

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS						
600 mV Range						
300.0 mV @ 45 Hz	300.0	296.7	303.3	299.9	299.9	0.07
6 V Range						
5.000 V @ 500 Hz	5.000	4.947	5.053	4.994	4.994	0.0007
5.000 V @ 1 kHz	5.000	4.897	5.103	4.955	4.955	0.0006
60 V Range						
50.00 V @ 45 Hz	50.00	49.47	50.53	49.94	49.94	0.007
50.00 V @ 1 kHz	50.00	48.97	51.03	50.06	50.06	0.006
600 V Range						
300.0 V @ 45 Hz	300.0	296.7	303.3	299.8	299.8	0.07
500.0 V @ 500 Hz	500.0	494.7	505.3	500.4	500.4	0.07
500.0 V @ 1 kHz	500.0	489.7	510.3	500.4	500.4	0.06
1000 V Range						
1000 V @ 45 Hz	1000	987	1013	996	996	0.6

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS FREQUENCY						
45.00 Hz @ 1 V	45.00	44.95	45.06	45.00	45.00	0.007
50.00 kHz @ 5 V	50.00	49.94	50.06	50.00	50.00	0.007
DC VOLTAGE						
6 V Range						
5.000 V	5.000	4.990	5.010	5.000	5.000	0.0007
600 V Range						
300.0 V	300.0	299.4	300.6	300.0	300.0	0.06
1000 V Range						
1000 V	1000	997	1004	1000	1000	0.7
-1000 V	-1000	-1004	-997	-1000	-1000	0.7
DC VOLTS FREQUENCY						
45.00 Hz @ 3 V	45.00	44.95	45.06	45.00	45.00	0.007
50.00 kHz @ 30 V	50.00	49.94	50.06	50.00	50.00	0.007
DC MILLIVOLTS						
30.0 mV	30.0	29.8	30.2	30.0	30.0	0.07
-300.0 mV	-300.0	-300.6	-299.4	-299.9	-299.9	0.06
600.0 mV	600.0	598.9	601.1	599.9	599.9	0.06
OHMS						
600 Ohm Range						
19.0 Ohm	19.0	18.6	19.4	19.0	19.0	0.07
50 MOhm Range						
19.00 MOhm	19.00	18.68	19.32	18.99	18.99	0.006
CAPACITANCE						
1000 nF Range						
900 nF	900	887	913	900	900	0.7
CONTINUITY						
0 Ohms: Beeper On				Pass	Pass	
190 Ohms: Beeper Off				Pass	Pass	
DIODE TEST						
2.000 V	2.000	1.978	2.022	2.001	2.001	0.0006
AC MILLIAMPS						
60 mA Range						

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
3.00 mA @ 45 Hz	3.00	2.92	3.08	3.01	3.01	0.007
50.00 mA @ 1 kHz	50.00	49.22	50.78	49.96	49.96	0.007
400 mA Range						
400.0 mA @ 1 kHz	400.0	393.7	406.3	399.4	399.4	0.06
AC AMPS						
6 A Range						
4.000 A @ 45 Hz	4.000	3.937	4.063	3.997	3.997	0.0007
10A Range						
9.00 A @ 1 kHz	9.00	8.84	9.16	9.00	9.00	0.007
DC MILLIAMPS						
60 mA Range						
3.00 mA	3.00	2.94	3.06	3.02	3.02	0.006
50.00 mA	50.00	49.47	50.53	49.99	49.99	0.006
400 mA Range						
-400.0 mA	-400.0	-404.3	-395.7	-400.0	-400.0	0.07
DC AMPS						
6 A Range						
4.000 A	4.000	3.957	4.043	3.999	3.999	0.0007
10 A Range						
-9.00 A	-9.00	-9.12	-8.88	-9.00	-9.00	0.007

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-38779-466 For Eaton Corporation - ICD W126 N7250 Flint Drive Menomonee Falls, WI 53051 Purchase Order # 4044-671109 Test Instrument Multimeter Digital Multimeter Make Fluke Model 179 Serial Number 14370601 Identification EM7024 Customer Location ICD Condition Received In Tolerance Condition Returned In Tolerance Calibrated By Alex Paulsen Technical Review By Tim Bending Calibration Location FVM Calibration Conditions 68.2°F, 20.1°C, 56.6%RH Calibration Date 07/16/2020 Recalibration Due 07/16/2021		Procedures Followed FVE-000 rev. 2 FVE-001 rev. 2 Standards Used <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;">Instrument</th> <th style="text-align: left;">Serial Number</th> <th style="text-align: left;">Trace Number</th> <th style="text-align: left;">Next Cal</th> </tr> <tr> <td>FVS-275A</td> <td>RY11838</td> <td>CJ191-70508-513</td> <td>07/28/2020</td> </tr> <tr> <td>FVS-737</td> <td>4542903</td> <td>CK041-57440-531</td> <td>02/28/2021</td> </tr> </table>		Instrument	Serial Number	Trace Number	Next Cal	FVS-275A	RY11838	CJ191-70508-513	07/28/2020	FVS-737	4542903	CK041-57440-531	02/28/2021	This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated. Form Revision 6: 02/04/2012
Instrument	Serial Number	Trace Number	Next Cal													
FVS-275A	RY11838	CJ191-70508-513	07/28/2020													
FVS-737	4542903	CK041-57440-531	02/28/2021													
Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units. All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.																

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS						
600 mV Range						
300.0 mV @ 45 Hz	300.0	296.7	303.3	300.0	300.0	0.06
6 V Range						
5.000 V @ 500 Hz	5.000	4.947	5.053	4.997	4.997	0.0006
5.000 V @ 1 kHz	5.000	4.897	5.103	4.961	4.961	0.0006
60 V Range						
50.00 V @ 45 Hz	50.00	49.47	50.53	49.97	49.97	0.006
50.00 V @ 1 kHz	50.00	48.97	51.03	50.10	50.10	0.007
600 V Range						
300.0 V @ 45 Hz	300.0	296.7	303.3	300.0	300.0	0.07
500.0 V @ 500 Hz	500.0	494.7	505.3	500.9	500.9	0.06
500.0 V @ 1 kHz	500.0	489.7	510.3	500.8	500.8	0.06
1000 V Range						
1000 V @ 45 Hz	1000	987	1013	997	997	0.7

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
AC VOLTS FREQUENCY						
45.00 Hz @ 1 V	45.00	44.95	45.06	45.00	45.00	0.007
50.00 kHz @ 5 V	50.00	49.94	50.06	50.00	50.00	0.006
DC VOLTAGE						
6 V Range						
5.000 V	5.000	4.994	5.007	5.000	5.000	0.0006
600 V Range						
300.0 V	300.0	299.5	300.5	299.9	299.9	0.06
1000 V Range						
1000 V	1000	997	1004	1000	1000	0.7
-1000 V	-1000	-1004	-997	-1000	-1000	0.7
DC VOLTS FREQUENCY						
45.00 Hz @ 3 V	45.00	44.95	45.06	45.00	45.00	0.007
50.00 kHz @ 30 V	50.00	49.94	50.06	50.00	50.00	0.006
DC MILLIVOLTS						
30.0 mV	30.0	29.8	30.2	30.0	30.0	0.06
-300.0 mV	-300.0	-300.5	-299.5	-299.9	-299.9	0.06
600.0 mV	600.0	599.3	600.7	599.8	599.8	0.06
TEMPERATURE						
0.0 °C	0.0	-1.0	1.0	0.5	0.5	0.06
-40.0 °C	-40.0	-41.4	-38.6	-39.3	-39.3	0.06
400.0 °C	400.0	395.0	405.0	400.4	400.4	0.06
OHMS						
600 Ohm Range						
19.0 Ohm	19.0	18.6	19.4	19.0	19.0	0.06
50 MOhm Range						
19.00 MOhm	19.00	18.68	19.32	18.98	18.98	0.006
CAPACITANCE						
1000 nF Range						
900 nF	900	887	913	900	900	0.6
CONTINUITY						
0 Ohms: Beeper On				Pass	Pass	
190 Ohms: Beeper Off				Pass	Pass	
DIODE TEST						

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
2.000 V	2.000	1.978	2.022	2.001	2.001	0.0007
AC MILLIAMPS						
60 mA Range						
3.00 mA @ 45 Hz	3.00	2.92	3.08	3.02	3.02	0.006
50.00 mA @ 1 kHz	50.00	49.22	50.78	50.03	50.03	0.006
400 mA Range						
400.0 mA @ 1 kHz	400.0	393.7	406.3	399.9	399.9	0.06
AC AMPS						
6 A Range						
4.000 A @ 45 Hz	4.000	3.937	4.063	4.004	4.004	0.0006
10A Range						
9.00 A @ 1 kHz	9.00	8.84	9.16	9.01	9.01	0.007
DC MILLIAMPS						
60 mA Range						
3.00 mA	3.00	2.94	3.06	3.01	3.01	0.007
50.00 mA	50.00	49.47	50.53	49.99	49.99	0.007
400 mA Range						
-400.0 mA	-400.0	-404.3	-395.7	-399.9	-399.9	0.06
DC AMPS						
6 A Range						
4.000 A	4.000	3.957	4.043	3.998	3.998	0.0006
10 A Range						
-9.00 A	-9.00	-9.12	-8.88	-9.00	-9.00	0.007

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-41226-466

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109
Test Instrument Clamp Meter

Make AEMC
Model SR759
Serial Number 224137GKDV
Identification EM6996



Customer Location ICD

Condition Received In Tolerance
Condition Returned In Tolerance
Calibrated By Alex Paulsen
Technical Review By Tim Bending
Calibration Location FVM
Calibration Conditions 67.8°F, 19.9°C, 56.3%RH
Calibration Date 07/16/2020
Recalibration Due 07/16/2021

Procedures Followed
FVE-007 rev. 2

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVS-275A	RY11838	CJ191-70508-513	07/28/2020
FVS-546	24560221	CK093-41519-573	04/30/2021
FVS-737	4542903	CK041-57440-531	02/28/2021

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
1A Range; 1000mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 mA	10.0	8.7	11.3	10.1	10.1	0.07
100 mA	100.0	96.0	104.0	101.3	101.3	0.06
500 mA	500.0	495.5	504.5	504.5	504.5	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
1 A	1.000	0.992	1.008	1.008	1.008	0.0006
10A Range; 100mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
100 mA	10.0	9.7	10.3	10.0	10.0	0.07
1 A	100.0	99.3	100.7	100.4	100.4	0.07
5 A	500.0	497.5	502.5	501.8	501.8	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
10 A	1.000	0.995	1.005	1.004	1.004	0.0007
100A Range; 10mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
1 A	10.0	9.7	10.3	10.0	10.0	0.07
10 A	100.0	99.3	100.7	100.1	100.1	0.06

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
50 A	500.0	498.5	501.5	500.3	500.3	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
100 A	1.000	0.998	1.002	1.001	1.001	0.0006
1000A Range; 1mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 A	10.0	9.7	10.3	10.0	10.0	0.06
100 A	100.0	99.3	100.7	100.1	100.1	0.07
500 A	500.0	499.0	501.0	500.5	500.5	0.07
900 A	900.0	898.0	902.0	901.2	901.2	0.07

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-40179-466

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109

Test Instrument Clamp Meter

Make AEMC

Model SR759

Serial Number 224139GKDV

Identification EM6997



Customer Location ICD

Condition Received In Tolerance

Condition Returned In Tolerance

Calibrated By Alex Paulsen

Technical Review By Tim Bending

Calibration Location FVM

Calibration Conditions 67.8°F, 19.9°C, 56.3%RH

Calibration Date 07/16/2020

Recalibration Due 07/16/2021

Procedures Followed

FVE-007 rev. 2

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVS-275A	RY11838	CJ191-70508-513	07/28/2020
FVS-546	24560221	CK093-41519-573	04/30/2021
FVS-737	4542903	CK041-57440-531	02/28/2021

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
1A Range; 1000mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 mA	10.0	8.7	11.3	10.1	10.1	0.06
100 mA	100.0	96.0	104.0	101.1	101.1	0.06
500 mA	500.0	495.5	504.5	504.5	504.5	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
1 A	1.000	0.992	1.008	1.008	1.008	0.0006
10A Range; 100mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
100 mA	10.0	9.7	10.3	10.0	10.0	0.07
1 A	100.0	99.3	100.7	100.2	100.2	0.06
5 A	500.0	497.5	502.5	500.9	500.9	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
10 A	1.000	0.995	1.005	1.002	1.002	0.0006
100A Range; 10mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
1 A	10.0	9.7	10.3	10.0	10.0	0.06
10 A	100.0	99.3	100.7	100.1	100.1	0.07

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive

Oshkosh, WI 54902

(920) 426-5894 • Fax (920) 426-8120

<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
50 A	500.0	498.5	501.5	500.1	500.1	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
100 A	1.000	0.998	1.002	1.001	1.001	0.0006
1000A Range; 1mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 A	10.0	9.7	10.3	10.0	10.0	0.07
100 A	100.0	99.3	100.7	100.1	100.1	0.06
500 A	500.0	499.0	501.0	500.3	500.3	0.06
900 A	900.0	898.0	902.0	901.4	901.4	0.06

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-41583-466

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109
Test Instrument Clamp Meter

Make AEMC
Model SR759
Serial Number 239584HKDV
Identification EM8032



Customer Location ICD

Condition Received In Tolerance
Condition Returned In Tolerance
Calibrated By Alex Paulsen
Technical Review By Tim Bending
Calibration Location FVM
Calibration Conditions 67.8°F, 19.9°C, 56.3%RH
Calibration Date 07/16/2020
Recalibration Due 07/16/2021

Procedures Followed
FVE-007 rev. 2

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVS-275A	RY11838	CJ191-70508-513	07/28/2020
FVS-546	24560221	CK093-41519-573	04/30/2021
FVS-737	4542903	CK041-57440-531	02/28/2021

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCCL Z540-1-1994 and ANSI/NCCL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
1A Range; 1000mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 mA	10.0	8.7	11.3	10.2	10.2	0.07
100 mA	100.0	96.0	104.0	101.1	101.1	0.07
500 mA	500.0	495.5	504.5	504.3	504.3	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
1 A	1.000	0.992	1.008	1.007	1.007	0.0007
10A Range; 100mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
100 mA	10.0	9.7	10.3	10.0	10.0	0.07
1 A	100.0	99.3	100.7	100.2	100.2	0.07
5 A	500.0	497.5	502.5	500.7	500.7	0.06
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
10 A	1.000	0.995	1.005	1.002	1.002	0.0006
100A Range; 10mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
1 A	10.0	9.7	10.3	10.0	10.0	0.07
10 A	100.0	99.3	100.7	100.0	100.0	0.07

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
50 A	500.0	498.5	501.5	500.0	500.0	0.07
	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)	(V AC)
100 A	1.000	0.998	1.002	1.000	1.000	0.0007
1000A Range; 1mV/A @60 Hz	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)	(mV AC)
10 A	10.0	9.7	10.3	10.0	10.0	0.07
100 A	100.0	99.3	100.7	100.0	100.0	0.06
500 A	500.0	499.0	501.0	500.3	500.3	0.07
900 A	900.0	898.0	902.0	900.6	900.6	0.07

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK196-72143-379 For Eaton Corporation - ICD W126 N7250 Flint Drive Menomonee Falls, WI 53051 Purchase Order # 4044-671109 Test Instrument Torque Wrench Make CDI Model 1502LDIN (3%) Serial Number 0312910937 Identification EM8363 Customer Location ICD Condition Received In Tolerance Condition Returned In Tolerance Calibrated By Jim Peterson Technical Review By Kevin Dehne Calibration Location FVM Calibration Conditions 69.0°F, 20.6°C, 54.2%RH Calibration Date 07/14/2020 Recalibration Due 07/14/2021		Procedures Followed FVE-014 rev. 2 Standards Used <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;">Instrument</th> <th style="text-align: left;">Serial Number</th> <th style="text-align: left;">Trace Number</th> <th style="text-align: left;">Next Cal</th> </tr> <tr> <td>FVS-093</td> <td>03111</td> <td>CK191-31886-628</td> <td>10/31/2020</td> </tr> <tr> <td>FVS-275A</td> <td>RY11838</td> <td>CJ191-70508-513</td> <td>07/28/2020</td> </tr> </table>		Instrument	Serial Number	Trace Number	Next Cal	FVS-093	03111	CK191-31886-628	10/31/2020	FVS-275A	RY11838	CJ191-70508-513	07/28/2020
Instrument	Serial Number	Trace Number	Next Cal												
FVS-093	03111	CK191-31886-628	10/31/2020												
FVS-275A	RY11838	CJ191-70508-513	07/28/2020												

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated. Form Revision 6: 02/04/2012

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
Clockwise	(in lb)	(in lb)	(in lb)	(in lb)	(in lb)	(in lb)
	30.00	29.10	30.90	29.89	29.89	0.091
	90.00	87.30	92.70	90.23	90.23	0.271
	150.00	145.50	154.50	152.00	152.00	0.450
Counter Clockwise	(in lb)	(in lb)	(in lb)	(in lb)	(in lb)	(in lb)
	30.00	29.10	30.90	30.31	30.31	0.091
	90.00	87.30	92.70	89.53	89.53	0.271
	150.00	145.50	154.50	148.58	148.58	0.450

Appendix E - Certificates of Calibration

Fox Valley Metrology

3114 Medalist Drive
Oshkosh, WI 54902
(920) 426-5894 • Fax (920) 426-8120
<http://www.FoxValleyMetrology.com>

CERTIFICATE OF CALIBRATION



Certificate No. ACT-1272

Certification Number CK198-49542-348

For Eaton Corporation - ICD
W126 N7250 Flint Drive
Menomonee Falls, WI 53051

Purchase Order # 4044-671109
Test Instrument Tape Measure

Make Stanley
Model 30-824

Serial Number
Identification EM6927



Customer Location ICD
Tony

Condition Received In Tolerance
Condition Returned In Tolerance
Calibrated By Matthew Roughen
Technical Review By Laura Fuhrmann
Calibration Location FVM
Calibration Conditions 69.5°F, 20.8°C, 34.8%RH
Calibration Date 07/16/2020
Recalibration Due 07/16/2021

Procedures Followed
FVM-042 rev. 1

This certificate shall not be altered in any form or reproduced, except in full, without prior written approval from originating lab. These results relate only to the item(s) calibrated.
Form Revision 6: 02/04/2012

Standards Used

Instrument	Serial Number	Trace Number	Next Cal
FVM-044	C404R	CH121-20770-384	05/28/2022
FVM-079A	RY11924	CJ191-72229-513	07/28/2020

Total expanded measurement uncertainties expressed are based on a confidence level of 95%; coverage factor of (k=2). The statement of compliance in this certificate was issued without taking the uncertainty of measurement into consideration. The customer shall assess the results and uncertainty when determining if the results meet their needs. (This is considered "shared responsibility.") Uncertainties expressed in nominal units.

All instruments have been calibrated against standards traceable to NIST. Calibration was completed in accordance with ISO/IEC 17025:2017, ANSI/NCSL Z540-1-1994 and ANSI/NCSL Z540.3-2006. Other standards listed upon request.

Calibration Results

* denotes "Out of Tolerance"

Feature	Nominal	Lower Limit	Upper Limit	As Found	As Left	Uncertainty
Length	(in)	(in)	(in)	(in)	(in)	
	12.000	11.969	12.031	11.995	11.995	0.0006
	24.000	23.938	24.062	23.995	23.995	0.0007
	48.000	47.938	48.062	47.995	47.995	0.0007
	72.000	71.938	72.062	71.995	71.995	0.0007
	144.000	143.938	144.062	143.995	143.995	0.0006
	216.000	215.938	216.062	215.995	215.995	0.0006
Length	312.000	311.938	312.062	311.995	311.995	0.0007
	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
	500.00	499.00	501.00	499.87	499.87	0.007
	1000.00	999.00	1001.00	999.87	999.87	0.006
	5000.00	4999.00	5001.00	4999.87	4999.87	0.008
	8000.00	7999.00	8001.00	7999.87	7999.87	0.012

240.6(A)

(A) Fuses and Fixed-Trip Circuit Breakers.

The standard ampere ratings for fuses and inverse time circuit breakers shall be considered as shown in Table 240.6(A). Additional standard ampere ratings for fuses shall be 1, 3, 6, 10 and 601. The use of fuses and inverse time circuit breakers with nonstandard ampere ratings shall be permitted.

Table 240.6(A) Standard Ampere Ratings for Fuses and Inverse Time Circuit Breakers

Standard Ampere Ratings				
<u>10</u>	15	20	25	30
35	40	45	50	60
70	80	90	100	110
125	150	175	200	225
250	300	350	400	450
500	600	700	800	1000
1200	1600	2000	2500	3000
4000	5000	6000	—	—

Substantiation:

Task Group Statement

This public input is submitted on behalf of the task group formed in accordance with the direction of the NFPA Standards Council in their Decisions D#19-2 and D#19-23. This task group was appointed to identify potential proposed changes to the 2020 edition of the NEC in the form of proposed Tentative Interim Amendments (TIAs) or to the 2023 edition of the NEC in the form of Public Inputs (PIs) that within the Task Group's scope of activity as specified by the Standards Council.

These proposed PIs relate to new requirements covering the use of copper-clad aluminum conductors throughout the NEC as a coordinated set of new or revised requirements. These Public Inputs should not be misconstrued by the CMPs as precluding consideration of other Public Inputs, with supporting test data, submitted now or in the future, for other potentially eligible conductor materials or sizes.

The task group members are; David Hittinger-Chair, Todd Crisman, Roland Deike, Thomas Domitrovich, Peter Graser, Christel Hunter, Chuck Mello, Ken Riedl, Susan Newman Scearce, Susan Stene, George Straniero, Frank Tse and Brian Rock. This task group of balanced interests provided the expertise to develop these public inputs covering the use of copper-clad aluminum conductors.

Public Inputs are being submitted in the following sections: Article 100, definition of "copper-clad aluminum", 210.12, 210.18, 210.21(B)(1), 210.23, 210.24, 210.52(B), 240.4(D), 240.6,

310.3(A), 310.3(B), Table 310.16, Table 310.17, 330.104, 334.104, 336.104, 340.104, 404.14(D), and 406.3(D).

Technical Substantiation

The application of energy efficient equipment and the implementation of Energy Codes for modern construction, provides more options for reduced branch circuit loading. The result is that many branch circuits are capable of having a conductor current rating and overcurrent device rating of 10-Amperes. For example, a typical 75-watt equivalent LED lamp has a load rating of 12 watts. At 120 volts this is a load of 0.1 amps per lamp. A continuously loaded 10-ampere branch circuit for fixed lighting would be allowed to have 8 amps of load current, which would equate to 80 of these LED lamps. This is more lamps than found in a typical 2000 square foot home. Other examples are specific limited loads such as fire or burglar alarm panels, kitchen instant hot water dispensers, attic exhaust fans, and others. These specific loads on individual branch circuits only need one or a few amperes and could safely be installed on a 10-Ampere branch circuit. These lighting and specific appliance applications exist in both dwelling unit as well as commercial and industrial installations. There are cases today where equipment is being protected by a 15-Ampere circuit breaker, whereas a 10-Ampere overcurrent device would provide a safe level of protection.

Every one of the major manufacturers of thermal-magnetic circuit breakers have listed circuit breakers rated for 10 Amps listed for branch circuit applications. These available devices include both circuit breakers for panelboards as well as "miniature circuit breakers" used in control panel construction permitted in Article 409. The allowance for 10 Amp fuses has been included in existing 240.6 text and separate from the table/list for many Code cycles. This change is to only add 10 Amps as a standard size overcurrent device to include fixed trip circuit breakers and fuses. The listing in the text for 10 Amps fuses was deleted as it is now included in the table of standard sizes. The values in the Table 240.6(A) have all been moved up one position to provide a place at the beginning for 10 Amps. No other changes are intended for the existing table or text.

**Public Input No. 4026-NFPA 70-2020 [Section No. 240.6(C)]****(C) Restricted Access Adjustable-Trip Circuit Breakers.**

A circuit breaker(s) that has restricted access to the adjusting means shall be permitted to have an ampere rating(s) that is equal to the adjusted current setting (long-time pickup setting). Restricted access shall be achieved by one of the following methods:

- (1) Located behind removable and sealable covers over the adjusting means
- (2) Located behind bolted equipment enclosure doors
- (3) Located behind locked doors accessible only to qualified personnel
- (4) Password protected, with password accessible only to qualified personnel

Adjustable settings of the circuit breaker shall be accessible on the circuit breaker, or connected directly through a local non-networked interface, and shall not be remotely accessible.

Exception: Restricted access shall be permitted by remote access where the remote interface complies with any of the provisions in 240.6(C)(1), (2), (3) or (4), and the circuit breaker and associated software for adjusting the settings is identified as being evaluated for cybersecurity.

Statement of Problem and Substantiation for Public Input

SMART devices are becoming more commonplace, especially with regards to industrial and life-safety equipment such as circuit breakers. Along with this technology, comes the increased threat of cyberattacks. These attacks cost millions of dollars and could potentially affect the way life-safety equipment and critical systems are supposed to operate. A cybersecurity plan for these types of devices should be considered to ensure all critical systems quality attributes, such as integrity and availability are maintained. The concern is around the safety related security of these devices and not concerns about privacy or data protection.

Section 240.6(C) allows a circuit breaker to be rated based on the adjusted setting if considered to have restricted access. Restricted access is achieved where the circuit breaker is located behind a physical barrier, such as a sealable cover over the adjusting knobs or locked door with access only to qualified personnel, or is password protected where the password is accessible only to qualified personnel. These means are effective only when the adjustable setting is accessible only from the circuit breaker. There are circuit breakers available on the market where the setting may also be configured by remote access through another interface device, such as an accessory interface module, computer or a smartphone/tablet. These devices communicate with the circuit breaker through unsecured networks which are subject to cyber threats. Intentional or unintentional tampering of the adjustable setting through remote access could result in damage to property and/or loss of life, and would defeat the purpose of 240.6(C).

This public input clarifies Section 240.6(C) to allow circuit breakers to be considered as having restricted access per 240.6(C)(1), (2), (3) or (4) if the adjustment means is accessible only on the circuit breaker. In installations where the adjustment means may be remote, an exception is added for both the remote and local interfaces to be in compliance with 240.6(C)(1), (2), (3) or (4), and additionally require evaluation of the device and associated software for cybersecurity.

Submitter Information Verification

Submitter Full Name: John Kovacik

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submission Date: Wed Sep 09 18:09:45 EDT 2020

Committee: NEC-P10



Public Input No. 162-NFPA 70-2019 [Section No. 240.8]

240.8 Fuses or Circuit Breakers in Parallel.

(A) Fuses and circuit breakers shall be permitted to be connected in parallel where they are factory assembled in parallel and listed as a unit.- Individual fuses, circuit breakers, or

(B) Under engineering supervision, individual fuses or circuit breakers shall be permitted to be connected in parallel and have an equivalent overcurrent protection rating equal to the sum of the overcurrent protection ratings of the individual devices provided the following conditions are met:

- (1) The arrangement is made with either all fuses or all circuit breakers, not combinations thereof.
- (2) The fuses or circuit breakers connected in parallel have identical characteristics.
- (3) In the case of circuit breakers with adjustable settings, they shall be configured to the same settings.
- (4) The paralalled devices are located within the same enclosure.
- (5) In the case of circuit breakers, they shall be physically tied such that they can both be actuated at the same time.
- (6) The line and load sides of the paralalled devices are electrically joined within the enclosure.
- (7) The feeder being protected by the paralleled devices is composed of a single set of conductors or multiple sets of conductors in parallel in accordance with 310.10(H).
- (8) The number of devices paralalled does not exceed three.
- (9) The equipment supplied is located a minimum of 50 ft from the equipment containing the paralalled devices.
- (10) The equipment containing the paralleled devices is not considered part of an emergency, critical, or life safety system.
- (11) The equipment containing the paralleled devices shall be labeled as containing paralleled devices and the identity of which devices are paralleled shall be made apparent.
- (12) In the case of multiple sets of paralleled devices being located in the same enclosure; it shall be made apparent which devices are paralleled together in a manner that distinguishes each set of paralalled devices from every other other set.

(C) Except in cases covered by 240.8(B), Individual fuses, circuit breakers, or combinations thereof shall not otherwise be connected in parallel.

Statement of Problem and Substantiation for Public Input

When upgrading existing systems it is possible to require a load, (say 400A) from a panel capable of supplying it except that a 400A breaker will not fit. Two 200A paralleled breakers in the panel should provide the same protection as a 400A breaker. The current will be evenly divided between them such they should trip at roughly the same time. And if they didn't, the devices that didn't trip will trip very shortly after as the current rises as it attempts to handle double its rated load.

Most of my conditions were to increase safety and I believe the only required conditions are that they have identical characteristics and are located close enough together such that the path from the load to line side through any OCPD has roughly equal impedance. (More correctly the difference in impedance between the paths is negligible when compared to the impedance of the feeder.)

Submitter Information Verification

Submitter Full Name: Mike Wagner

Organization: Frey Electric

Street Address:

City:

State:

Zip:

Submittal Date: Tue Dec 03 10:15:57 EST 2019

Committee:	NEC-P10
-------------------	---------

**Public Input No. 691-NFPA 70-2020 [New Section after 240.10]****TITLE OF NEW CONTENT**

Type your content here ...

240.11 Selective Coordination. If one or more feeder overcurrent protective devices are required to be selectively coordinated with a service overcurrent protective device by other requirements in this Code, all feeder overcurrent protective devices shall be selectively coordinated with the service overcurrent protective device.

Statement of Problem and Substantiation for Public Input

Often times there are feeder overcurrent protective devices that must selectively coordinate with the service overcurrent protective device, such as is required for emergency systems in 700.32. It is also quite common for other feeder overcurrent protective devices to be fed from that same service overcurrent protective device, but those other feeder overcurrent protective devices don't need to selectively coordinate with the service device. Unfortunately, the existing NEC® allows an overcurrent condition on one of the feeders that are not required to selectively coordinate with the service device, to open the service overcurrent device. This proposed requirement would assure that the service overcurrent protective device would not open due to an overcurrent condition on a feeder that is not currently required to selectively coordinate with the service overcurrent protective device.

For example, refer to Informational Note Figure 700.32. Feeder device OCPD C is currently required to selectively coordinate with feeder Device OCPD B and service OCPD A. However, feeder device OCPD B is not currently required to selectively coordinate with service device OCPD A because feeder device OCPD B is not part of the emergency system. This proposed requirement would require feeder device OCPD B to also selectively coordinate with service device OCPD A. If service device OCPD A also supplied an additional feeder device (OCPD G), that feeder device (OCPD G) would need to selectively coordinate with service device OCPD A.

Submitter Information Verification

Submitter Full Name: Vincent Saporita

Organization: Saporita Consulting

Affiliation: Saporita Consulting

Street Address:

City:

State:

Zip:

Submittal Date: Wed Mar 18 16:13:04 EDT 2020

Committee: NEC-P10

**Public Input No. 2288-NFPA 70-2020 [Section No. 240.12]****240.12** Electrical System Coordination.

Where an orderly shutdown is required to minimize the hazard(s) to personnel ~~and~~ or equipment, a system of coordination based on the following two conditions shall be permitted:

- (1) Coordinated short-circuit protection
- (2) Overload indication based on monitoring systems or devices

Informational Note: The monitoring system may cause the condition to go to alarm, allowing corrective action or an orderly shutdown, thereby minimizing personnel hazard and equipment damage.

Statement of Problem and Substantiation for Public Input

The logical operator for the intent requires an 'OR' rather than 'AND'. e.g. 'personnel and equipment' versus 'personnel or equipment', an alternative is to use '...and/or...'

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submittal Date: Thu Aug 13 16:19:55 EDT 2020

Committee: NEC-P10

**Public Input No. 692-NFPA 70-2020 [Section No. 240.12]****240.12 ~~Electrical System Coordination~~ Orderly Shutdown .**

Where an orderly shutdown is required to minimize the hazard(s) to personnel and equipment, a system of coordination based on the following two conditions shall be permitted:

- (1) Coordinated short-circuit protection
- (2) Overload indication based on monitoring systems or devices

Informational Note: The monitoring system may cause the condition to go to alarm, allowing corrective action or an orderly shutdown, thereby minimizing personnel hazard and equipment damage.

Statement of Problem and Substantiation for Public Input

The title to existing 240.12 does not match the permissive language of the text as the text does not really contain a requirement or permission for "coordination", but rather provides permissive language for overload indication where an orderly shutdown is required. The title of "Orderly Shutdown" would be more appropriate for this permissive language.

Submitter Information Verification

Submitter Full Name: Vincent Saporita

Organization: Saporita Consulting

Affiliation: Saporita Consulting

Street Address:

City:

State:

Zip:

Submittal Date: Wed Mar 18 16:20:07 EDT 2020

Committee: NEC-P10



Public Input No. 696-NFPA 70-2020 [Section No. 240.13]

240.13 Ground-Fault Protection of Equipment.

Ground-fault protection of equipment shall be provided in accordance with 230.95 for solidly grounded wye electrical systems of more than 150 volts to ground but not exceeding 1000 volts phase-to-phase for each individual device used as a building or structure main disconnecting means rated 1000 amperes or more.

This section shall not apply to the disconnecting means for the following:

- (1) Continuous industrial processes where a nonorderly shutdown will introduce additional or increased hazards
- (2) Installations where ground-fault protection is provided by other requirements for services or feeders
- (3) Fire pumps
- (4) For a fused disconnect that complies with Section 240.67, except that 240.67(B)(2) cannot be utilized.
- (5) For a circuit breaker that complies with Section 240.87, except that 240.87 (B)(3) cannot be utilized.

Statement of Problem and Substantiation for Public Input

A requirement (230.95) for ground fault protection of equipment (GFPE) was added to the 1971 NEC® because 480/277 volt, solidly grounded wye services, protected by 1000 ampere and larger overcurrent protective devices, were burning down due to arcing faults. 208/120 volt services and those services protected by smaller overcurrent protective devices were not burning down, so they weren't included in the new requirement. Over many Code cycles, GFPE requirements were also added for branch circuits (210.13), feeders (215.10), and equipment (240.13). In all cases, the intent was to limit damage to the switchboard, switchgear, panelboard or equipment, not the downstream conductors or busway. The electrical industry has evolved considerably since those early GFPE requirements were introduced. IEEE 1584 now predicts the magnitude of the arcing current along with the incident energy to which a worker could be exposed while working on energized equipment. It has become clearly evident that the level of protection required to limit arcing fault damage to equipment is nowhere near the level of protection needed to protect employees. Said another way, the level of protection necessary to protect an employee is orders of magnitude greater than that required to protect equipment. With that in mind, this Public Input takes advantage of the arc-energy reduction requirements found in 240.67 and 240.87. It provides an exception for GFPE requirements whenever the 240.67 and 240.87 methods to reduce clearing time are utilized. The methods to reduce clearing time will limit the arcing fault damage to the equipment to a level that is less than currently allowed by the requirements found in 230.95. The arbitrary value of 1200 amperes found in 230.95(A) is not needed for the exceptions because the arcing current can now be accurately predicted (IEEE 1584). The arbitrary one second maximum delay (230.95(A)) at 3000 amperes is not necessary for the exceptions because the methods in 240.67 and 240.87 have delays that are much less than one second. (Practically speaking, the methods in 240.67 and 240.87 couldn't protect workers if they were delayed for anywhere close to one second.) Energy reducing maintenance switches (240.67(B)(2) and 240.87(B)(3)) are excluded from the exceptions because an energy-reducing maintenance switch is typically turned off when a worker is not working on energized equipment, whereas ground fault protection is constantly protecting the equipment, whether or not a worker is working on the energized equipment. If energy reducing maintenance switches are utilized, the requirements of 230.95, 210.13, 215.10, and 240.13 must continue.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 693-NFPA 70-2020 [Section No. 230.95 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: Vincent Saporita
Organization: Saporita Consulting
Affiliation: Saporita Consulting
Street Address:
City:
State:
Zip:
Submission Date: Wed Mar 18 18:13:23 EDT 2020

Committee: NEC-P10



Public Input No. 1748-NFPA 70-2020 [Section No. 240.21]

240.21 Location in Circuit.

Overcurrent protection shall be provided in each ungrounded circuit conductor and shall be located at the point where the conductors receive their supply except as specified in 240.21(A) through (H). Conductors supplied under 240.21(A) through (H) shall not supply another conductor except through an overcurrent protective device meeting the requirements of 240.4.

(A) Branch-Circuit Conductors.

Branch-circuit tap conductors meeting the requirements specified in 210.19 shall be permitted to have overcurrent protection as specified in 210.20.

(B) Feeder Taps.

Conductors shall be permitted to be tapped, without overcurrent protection at the tap, to a feeder as specified in 240.21(B)(1) through (B)(5). The tap shall be permitted at any point on the load side of the feeder overcurrent protective device. ~~Section- Feeder tap conductors shall not be permitted to be sized in accordance with the next size up rule contained in 240.4(B)- shall not be permitted for tap conductors .~~

(1) Taps Not over 3 m (10 ft) Long.

If the length of the tap conductors does not exceed 3 m (10 ft) and the tap conductors comply with all of the following:

- (1) The ampacity of the tap conductors is
- (2) Not less than the combined calculated loads on the circuits supplied by the tap conductors
- (3) Not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or not less than the rating of the overcurrent protective device at the termination of the tap conductors

Exception to b: Where listed equipment, such as a surge-protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.

- (4) The tap conductors ~~do shall~~ not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- (5) Except at the point of connection to the feeder, the tap conductors are enclosed in a raceway, which extends from the tap to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices, or to the back of an open switchboard.
- (6) For field installations, if the tap conductors leave the enclosure or vault in which the tap is made, the ampacity of the tap conductors is ~~shall~~ not be less than one-tenth of the rating of the overcurrent device protecting the feeder conductors.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

(2) Taps Not over 7.5 m (25 ft) Long.

Where the length of the tap conductors ~~does are~~ not exceed greater than 7.5 m (25 ft) ~~and the~~ , tap conductors ~~shall~~ comply with all the following:

- (1) The ampacity of the tap conductors is ~~shall~~ not be less than one-third of the rating of the overcurrent device protecting the feeder conductors.
- (2) The tap conductors shall terminate in a single circuit breaker or ~~a single enclosure containing a single~~ set of fuses that limit the load to the ampacity of the tap conductors. This device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(3) Taps Supplying a Transformer [Primary Plus Secondary Not over 7.5 m (25 ft) Long].

Where the tap conductors supply a transformer and comply with all the following conditions:

- (1) The conductors supplying the primary of a transformer shall have an ampacity at least one-third the rating of the overcurrent device protecting the feeder conductors.
- (2) The conductors supplied by the secondary of the transformer shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the overcurrent device protecting the feeder conductors.
- (3) The total length of one primary plus one secondary conductor, excluding any portion of the primary conductor that is protected at its ampacity, ~~is- shall~~ not over- exceed 7.5 m (25 ft).
- (4) The primary and secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.
- (5) The secondary conductors terminate in a single circuit breaker or enclosure containing a single set of fuses that limit the load current to ~~not more than- the conductor ampacity that is permitted by- 310.14 - ampacity of the conductors.~~

(4) Taps over 7.5 m (25 ft) Long.

Where the feeder is in a high bay manufacturing building over 11 m (35 ft) high at walls and the installation complies with all the following conditions:

- (1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
- (2) The tap conductors are over 3 m (10 ft) but not over 7.5 m (25 ft) long horizontally and not over 30 m (100 ft) total length.
- (3) The ampacity of the tap conductors ~~is-not-~~ shall have an ampacity no less than one-third the rating of the overcurrent device protecting the feeder conductors.
- (4) The tap conductors terminate at a single circuit breaker or enclosure containing a single set of fuses that limit the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (5) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.
- (6) The tap conductors are continuous from end-to-end and contain no splices.
- (7) The tap conductors are sized 6 AWG copper or 4 AWG aluminum or larger.
- (8) The tap conductors do not penetrate walls, floors, or ceilings.
- (9) The tap is made no less than 9 m (30 ft) from the floor.

(5) Outside Taps of Unlimited Length.

Where the conductors are located outside of a building or structure, except at the point of load termination, and comply with all of the following conditions:

- (1) The tap conductors are protected from physical damage in an approved manner.
- (2) The tap conductors terminate at a single circuit breaker or enclosure containng a single set of fuses that limits the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The overcurrent protective device for the tap conductors is an integral part of a disconnecting means or the disconnecting means shall be located immediately adjacent thereto the overcurrent protective device.
- (4) The disconnecting means for the tap conductors ~~is installed-~~ conductor shall be installed at a readily accessible location complying with one of the following:
 - (5) Outside of a building or structure
 - (6) Inside, nearest the point of entrance of the tap conductors
 - (7) Where installed in accordance with 230.6 , nearest the point of entrance of the tap conductors

(C) Transformer Secondary Conductors.

A set of conductors feeding a single load, or each set of conductors feeding separate loads, shall be permitted to be connected to a transformer secondary, without overcurrent protection at the secondary, as specified in 240.21(C)(1) through (C)(6). Section 240.4(B) shall not be permitted for transformer secondary conductors.

Informational Note: For overcurrent protection requirements for transformers, see 450.3.

(1) Protection by Primary Overcurrent Device.

Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary, or a three-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary, shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors are not considered to be protected by the primary overcurrent protective device.

(2) Transformer Secondary Conductors Not over 3 m (10 ft) Long.

If the length of secondary conductor does not exceed 3 m (10 ft) and complies with all of the following:

- (1) The ampacity of the secondary conductors is
- (2) Not less than the combined calculated loads on the circuits supplied by the secondary conductors, and
- (3) Not less than the rating of the equipment containing an overcurrent device(s) supplied by the secondary conductors or not less than the rating of the overcurrent protective device at the termination of the secondary conductors.

Exception: Where listed equipment, such as a surge protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.

- (4) The secondary conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- (5) The secondary conductors are enclosed in a raceway, which shall extend from the transformer to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices or to the back of an open switchboard.
- (6) For field installations where the secondary conductors leave the enclosure or vault in which the supply connection is made, the rating of the overcurrent device protecting the primary of the transformer, multiplied by the primary to secondary transformer voltage ratio, shall not exceed 10 times the ampacity of the secondary conductor.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

(3) Industrial Installation Secondary Conductors Not over 7.5 m (25 ft) Long.

For the supply of switchgear or switchboards in industrial installations only, where the length of the secondary conductors does not exceed 7.5 m (25 ft) and complies with all of the following:

- (1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
- (2) The ampacity of the secondary conductors is not less than the secondary current rating of the transformer, and the sum of the ratings of the overcurrent devices does not exceed the ampacity of the secondary conductors.
- (3) All overcurrent devices are grouped.
- (4) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(4) Outside Secondary Conductors.

Where the conductors are located outside of a building or structure, except at the point of load termination, and comply with all of the following conditions:

- (1) The conductors are protected from physical damage in an approved manner.
- (2) The conductors terminate at a single circuit breaker or enclosure containing a single set of fuses that limit the load to the ampacity of the conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The overcurrent protective device for the conductors is an integral part of a disconnecting means or ~~shall be~~ the disconnecting means is located immediately adjacent thereto.
- (4) The disconnecting means for the conductors is installed at a readily accessible location complying with one of the following:
 - (5) Outside of a building or structure
 - (6) Inside, nearest the point of entrance of the conductors
 - (7) Where installed in accordance with 230.6, nearest the point of entrance of the conductors

(5) Secondary Conductors from a Feeder Tapped Transformer.

Transformer secondary conductors installed in accordance with 240.21(B)(3) shall be permitted to have overcurrent protection as specified in that section.

(6) Secondary Conductors Not over 7.5 m (25 ft) Long.

Where the length of secondary conductor does not exceed 7.5 m (25 ft) and complies with all of the following:

- (1) The secondary conductors shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the overcurrent device protecting the primary of the transformer.
- (2) The secondary conductors terminate in a single circuit breaker or enclosure containing a single set of fuses that limit the load current to not more than the conductor ampacity that is permitted by 310.14.
- (3) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

(D) Service Conductors.

Service conductors shall be ~~permitted to be protected by overcurrent devices~~ protected against overload in accordance with 230.91.

(E) Busway Taps.

Busways and busway taps shall be permitted to be protected against overcurrent in accordance with 368.17.

(F) Motor Circuit Taps.

Motor-feeder and branch-circuit conductors shall be permitted to be protected against overcurrent in accordance with 430.28 and 430.53, respectively.

(G) Conductors from Generator Terminals.

Conductors from generator terminals that meet the size requirement in 445.13 shall be permitted to be protected against overload by the generator overload protective device(s) required by 445.12.

(H) Battery Conductors.

Overcurrent protection shall be permitted to be installed as close as practicable to the storage battery terminals in an unclassified location. Installation of the overcurrent protection within a hazardous (classified) location shall also be permitted.

Statement of Problem and Substantiation for Public Input

All of my edits are editorial so that the rules are clear and consistent to the reader.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submission Date: Thu Jun 25 19:58:27 EDT 2020

Committee: NEC-P10

**Public Input No. 2257-NFPA 70-2020 [Section No. 240.21]****240.21 Location in Circuit.**

Overcurrent protection shall be provided in each ungrounded circuit conductor and shall be located at the point where the conductors receive their supply except as specified in 240.21(A) through (H). Conductors supplied under 240.21(A) through (H) shall not supply another conductor except through an overcurrent protective device meeting the requirements of 240.4.

(A) Branch-Circuit Conductors.

Branch-circuit tap conductors meeting the requirements specified in 210.19 shall be permitted to have overcurrent protection as specified in 210.20.

(B) Feeder Taps.

Conductors shall be permitted to be tapped, without overcurrent protection at the tap, to a feeder as specified in 240.21(B)(1) through (B)(5). The tap shall be permitted at any point on the load side of the feeder overcurrent protective device. Section 240.4(B) shall not be permitted for tap conductors.

(1) Taps Not over 3 m (10 ft) Long.

If the length of the tap conductors does not exceed 3 m (10 ft) and the tap conductors comply with all of the following:

- (1) The ampacity of the tap conductors is
 - (2) Not less than the combined calculated loads on the circuits supplied by the tap conductors
 - (3) Not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or not less than the rating of the overcurrent protective device at the termination of the tap conductors

Exception to b: Where listed equipment, such as a surge-protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.
- (4) The tap conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- (5) Except at the point of connection to the feeder, the tap conductors are enclosed in ~~a raceway, which~~ a wiring method which extends from the tap to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices, or to the back of an open switchboard.
- (6) For field installations, if the tap conductors leave the enclosure or vault in which the tap is made, the ampacity of the tap conductors is not less than one-tenth of the rating of the overcurrent device protecting the feeder conductors.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

(2) Taps Not over 7.5 m (25 ft) Long.

Where the length of the tap conductors does not exceed 7.5 m (25 ft) and the tap conductors comply with all the following:

- (1) The ampacity of the tap conductors is not less than one-third of the rating of the overcurrent device protecting the feeder conductors.
- (2) The tap conductors terminate in a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The tap conductors are protected from physical damage ~~by being enclosed in an approved raceway or by other approved means~~.

(3) Taps Supplying a Transformer [Primary Plus Secondary Not over 7.5 m (25 ft) Long].

Where the tap conductors supply a transformer and comply with all the following conditions:

- (1) The conductors supplying the primary of a transformer have an ampacity at least one-third the rating of the overcurrent device protecting the feeder conductors.
- (2) The conductors supplied by the secondary of the transformer shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the overcurrent device protecting the feeder conductors.
- (3) The total length of one primary plus one secondary conductor, excluding any portion of the primary conductor that is protected at its ampacity, is not over 7.5 m (25 ft).
- (4) The primary and secondary conductors are protected from physical damage ~~by being enclosed in an approved raceway or by other approved means~~.
- (5) The secondary conductors terminate in a single circuit breaker or set of fuses that limit the load current to not more than the conductor ampacity that is permitted by 310.14.

(4) Taps over 7.5 m (25 ft) Long.

Where the feeder is in a high bay manufacturing building over 11 m (35 ft) high at walls and the installation complies with all the following conditions:

- (1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
- (2) The tap conductors are not over 7.5 m (25 ft) long horizontally and not over 30 m (100 ft) total length.
- (3) The ampacity of the tap conductors is not less than one-third the rating of the overcurrent device protecting the feeder conductors.
- (4) The tap conductors terminate at a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (5) The tap conductors are protected from physical damage ~~by being enclosed in an approved raceway or by other approved means~~.
- (6) The tap conductors are continuous from end-to-end and contain no splices.
- (7) The tap conductors are sized 6 AWG copper or 4 AWG aluminum or larger.
- (8) The tap conductors do not penetrate walls, floors, or ceilings.
- (9) The tap is made no less than 9 m (30 ft) from the floor.

(5) Outside Taps of Unlimited Length.

Where the conductors are located outside of a building or structure, except at the point of load termination, and comply with all of the following conditions:

- (1) The tap conductors are protected from physical damage ~~in an approved manner~~.
- (2) The tap conductors terminate at a single circuit breaker or a single set of fuses that limits the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The overcurrent device for the tap conductors is an integral part of a disconnecting means or shall be located immediately adjacent thereto.
- (4) The disconnecting means for the tap conductors is installed at a readily accessible location complying with one of the following:
 - (5) Outside of a building or structure
 - (6) Inside, nearest the point of entrance of the tap conductors
 - (7) Where installed in accordance with 230.6, nearest the point of entrance of the tap conductors

(C) Transformer Secondary Conductors.

A set of conductors feeding a single load, or each set of conductors feeding separate loads, shall be permitted to be connected to a transformer secondary, without overcurrent protection at the secondary, as specified in 240.21(C)(1) through (C)(6). Section 240.4(B) shall not be permitted for transformer secondary conductors.

Informational Note: For overcurrent protection requirements for transformers, see 450.3.

(1) Protection by Primary Overcurrent Device.

Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary, or a three-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary, shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors are not considered to be protected by the primary overcurrent protective device.

(2) Transformer Secondary Conductors Not over 3 m (10 ft) Long.

If the length of secondary conductor does not exceed 3 m (10 ft) and complies with all of the following:

- (1) The ampacity of the secondary conductors is
 - (2) Not less than the combined calculated loads on the circuits supplied by the secondary conductors, and
 - (3) Not less than the rating of the equipment containing an overcurrent device(s) supplied by the secondary conductors or not less than the rating of the overcurrent protective device at the termination of the secondary conductors.

Exception: Where listed equipment, such as a surge protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.

- (4) The secondary conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- (5) The secondary conductors are enclosed in a raceway wiring method, which shall extend from the transformer to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices or to the back of an open switchboard.
- (6) For field installations where the secondary conductors leave the enclosure or vault in which the supply connection is made, the rating of the overcurrent device protecting the primary of the transformer, multiplied by the primary to secondary transformer voltage ratio, shall not exceed 10 times the ampacity of the secondary conductor.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

(3) Industrial Installation Secondary Conductors Not over 7.5 m (25 ft) Long.

For the supply of switchgear or switchboards in industrial installations only, where the length of the secondary conductors does not exceed 7.5 m (25 ft) and complies with all of the following:

- (1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
- (2) The ampacity of the secondary conductors is not less than the secondary current rating of the transformer, and the sum of the ratings of the overcurrent devices does not exceed the ampacity of the secondary conductors.
- (3) All overcurrent devices are grouped.
- (4) The secondary conductors are protected from physical damage ~~by being enclosed in an approved raceway or by other approved means.~~

(4) Outside Secondary Conductors.

Where the conductors are located outside of a building or structure, except at the point of load termination, and comply with all of the following conditions:

- (1) The conductors are protected from physical damage ~~in an approved manner.~~
- (2) The conductors terminate at a single circuit breaker or a single set of fuses that limit the load to the ampacity of the conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located immediately adjacent thereto.
- (4) The disconnecting means for the conductors is installed at a readily accessible location complying with one of the following:
 - (5) Outside of a building or structure
 - (6) Inside, nearest the point of entrance of the conductors
 - (7) Where installed in accordance with 230.6, nearest the point of entrance of the conductors

(5) Secondary Conductors from a Feeder Tapped Transformer.

Transformer secondary conductors installed in accordance with 240.21(B)(3) shall be permitted to have overcurrent protection as specified in that section.

(6) Secondary Conductors Not over 7.5 m (25 ft) Long.

Where the length of secondary conductor does not exceed 7.5 m (25 ft) and complies with all of the following:

- (1) The secondary conductors shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the rating of the overcurrent device protecting the primary of the transformer.
- (2) The secondary conductors terminate in a single circuit breaker or set of fuses that limit the load current to not more than the conductor ampacity that is permitted by 310.14.
- (3) The secondary conductors are protected from physical damage ~~by being enclosed in an approved raceway or by other approved means.~~

(D) Service Conductors.

Service conductors shall be permitted to be protected by overcurrent devices in accordance with 230.91.

(E) Busway Taps.

Busways and busway taps shall be permitted to be protected against overcurrent in accordance with 368.17.

(F) Motor Circuit Taps.

Motor-feeder and branch-circuit conductors shall be permitted to be protected against overcurrent in accordance with 430.28 and 430.53, respectively.

(G) Conductors from Generator Terminals.

Conductors from generator terminals that meet the size requirement in 445.13 shall be permitted to be protected against overload by the generator overload protective device(s) required by 445.12.

(H) Battery Conductors.

Overcurrent protection shall be permitted to be installed as close as practicable to the storage battery terminals in an unclassified location. Installation of the overcurrent protection within a hazardous (classified) location shall also be permitted.

Statement of Problem and Substantiation for Public Input

This PI seeks to allow any wiring method for feeder taps and transformer secondary conductors, provided that it is protected from physical damage. There is no reason that a flexible metal conduit with field-installed conductors is allowed but an MC cable with factory-installed conductors is prohibited. There is also no reason that a wireway (which is a raceway) is allowed but an auxiliary gutter (which is not a raceway) is not. The same issue applies with busway versus cablebus. The language regarding "other approved means" is marked for deletion because it is unnecessary. All equipment must be approved [110.2], and all wiring methods must be protected from physical damage [300.4].

Submitter Information Verification

Submitter Full Name: Ryan Jackson

Organization: Ryan Jackson

Street Address:

City:

State:

Zip:

Submission Date: Wed Aug 12 13:58:31 EDT 2020

Committee: NEC-P10

**Public Input No. 134-NFPA 70-2019 [Section No. 240.21(B)(1)]****(1) Taps Not over 3 m (10 ft) Long.**

If the length of the tap conductors does not exceed 3 m (10 ft) and the tap conductors comply with all of the following:

- (1) The ampacity of the tap conductors is
 - (2) Not less than the combined calculated loads on the circuits supplied by the tap conductors
 - (3) Not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or not less than the rating of the overcurrent protective device at the termination of the tap conductors
Exception to b: Where listed equipment, such as a surge-protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.
- (4) The tap conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- (5) Except at the point of connection to the feeder, the tap conductors are enclosed in a raceway, which extends from the tap to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices, or to the back of an open switchboard.
- (6) For field installations, if the tap conductors leave the enclosure or vault in which the tap is made, the ampacity of the tap conductors is not less than one-tenth of the rating of the overcurrent device protecting the feeder conductors.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

Exception: If taps and tap feeder conductors are located in same electrical or switchboard room, tap conductor length will be allowed to increase up to 50 feet.

Statement of Problem and Substantiation for Public Input

In service equipment most of the time spare switches or breakers or space normally are not available.

If new load to be added then taps on existing switchboard or main distribution panel is required. Most electrical rooms or switchboard rooms it is difficult to find a space on wall of the same room for new switch or circuit breaker required for tap feeder within 10 or 25 feet.

I recommend to revise NEC and permit tap feeder conductor length up to 50 feet if switchboard or main distribution panel, tap feeder and overcurrent device for the tap feeder are located within same electrical room.

Submitter Information Verification

Submitter Full Name: Ramesh Patel

Organization: Princeton Engineering Services

Affiliation: None

Street Address:

City:

State:

Zip:

Submittal Date: Thu Nov 21 12:01:03 EST 2019

Committee: NEC-P10

**Public Input No. 3162-NFPA 70-2020 [Section No. 240.21(B)(1)]****(1) Taps Not over 3 m (10 ft) Long.**

If the length of the tap conductors does not exceed 3 m (10 ft) and the tap conductors comply with all of the following:

- (1) The ampacity of the tap conductors is
 - (2) Not less than the combined calculated loads on the circuits supplied by the tap conductors
 - (3) Not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or not less than the rating of the overcurrent protective device at the termination of the tap conductors
Exception to b: Where listed equipment, such as a surge-protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.
- (4) The tap conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- (5) Except at the point of connection to the feeder, the tap conductors are enclosed in a raceway, which extends from the tap to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices, or to the back of an open switchboard. Exception: A current transformer cabinet or a meter socket enclosure is permitted to be installed between the tap conductor connection to the feeder and tap conductor termination. The current transformer cabinet or meter socket enclosure bus bar length are to be included in the 10 foot length calculation.
- (6) For field installations, if the tap conductors leave the enclosure or vault in which the tap is made, the ampacity of the tap conductors is not less than one-tenth of the rating of the overcurrent device protecting the feeder conductors.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

Statement of Problem and Substantiation for Public Input

See public input 3161 for substantiation

Submitter Information Verification

Submitter Full Name: Kyle Mackenzie
Organization: Polise Consulting Engineer
Street Address:
City:
State:
Zip:
Submittal Date: Sun Sep 06 06:49:20 EDT 2020
Committee: NEC-P10



Public Input No. 504-NFPA 70-2020 [Section No. 240.21(B)(1)]

(1) Taps Not over 3 m (10 ft) Long.

If the length of the tap conductors does not exceed 3 m (10 ft) and the tap conductors comply with all of the following:

- (1) The ampacity of the tap conductors is
 - (2) Not less than the combined calculated loads on the circuits supplied by the tap conductors
 - (3) Not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or not less than the rating of the overcurrent protective device at the termination of the tap conductors

Exception to b: Where listed equipment, such as a surge-protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.
- (4) The tap conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply. Where the tap conductors terminate to a circuit breaker or a single set of fuses, this device shall be permitted to supply any number of additional branch circuit overcurrent protective devices on its load side.
- (5) Except at the point of connection to the feeder, the tap conductors are enclosed in a raceway, which extends from the tap to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices, or to the back of an open switchboard.
- (6) For field installations, if the tap conductors leave the enclosure or vault in which the tap is made, the ampacity of the tap conductors is not less than one-tenth of the rating of the overcurrent device protecting the feeder conductors.

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

Statement of Problem and Substantiation for Public Input

As the language exists in 240.21(B)(2), for feeder taps of less than 25 feet, no express permissive language exists for supplying any number of overcurrent protective devices on the load side of the tap OCPD in 240.21(B)(1). In 240.21(B)(2)(2), this language is explicitly stated, but the language does not exist for 240.21(B)(1). The interpretation of the code, as it exists, could be justified to use the rules of the 25 foot tap rule, if the tap conductors are feeding a panel. Installing the same language in the 10 foot tap rule would provide clear intent, that a 10 foot tap rule could supply a feeder panel, and be subject to the rules for 240.21(B)(1). However, if the intent is implied for a tap conductor of less than ten feet (which is still less than 25 feet), protecting an additional number of overcurrent devices on the load side of the OCPD to which they terminate, to be subject to the 25 foot tap rule, restrictive language should be placed in 240.21(B)(1) to prohibit an installation of this nature.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 431-NFPA 70-2020 [Section No. 240.21(B)(2)]	Change of language from "overcurrent devices" to "branch circuit overcurrent protective devices"

Submitter Information Verification

Submitter Full Name: Steven Worsley
Organization: NECA IBEW Electrical JATC
Street Address:
City:
State:
Zip:
Submission Date: Thu Feb 20 12:42:14 EST 2020
Committee: NEC-P10

**Public Input No. 3161-NFPA 70-2020 [Section No. 240.21(B)(2)]****(2) Taps Not over 7.5 m (25 ft) Long.**

Where the length of the tap conductors does not exceed 7.5 m (25 ft) and the tap conductors comply with all the following:

- (1) The ampacity of the tap conductors is not less than one-third of the rating of the overcurrent device protecting the feeder conductors.
- (2) The tap conductors terminate in a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This device shall be permitted to supply any number of additional overcurrent devices on its load side.
- (3) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

Exception: A current transformer cabinet or a meter socket enclosure is permitted to be installed between the tap conductor connection to the feeder and tap conductor termination. The current transformer cabinet or meter socket enclosure bus bar length are to be included in the 25 foot length calculation.

Statement of Problem and Substantiation for Public Input

In NYC the utility requires hot sequence meter installation for 208V services but permits a service disconnect on the line side. To accommodate multiple retail tenants a wire trough is often installed on the load side of the service disconnecting means and then several meters and disconnect switches are connected to the load side. this installation is currently a code violation but due to utility company requirements is standard practice.

Submitter Information Verification

Submitter Full Name: Kyle Mackenzie

Organization: Polise Consulting Engineer

Street Address:

City:

State:

Zip:

Submittal Date: Sun Sep 06 06:33:20 EDT 2020

Committee: NEC-P10

**Public Input No. 431-NFPA 70-2020 [Section No. 240.21(B)(2)]****(2) Taps Not over 7.5 m (25 ft) Long.**

Where the length of the tap conductors does not exceed 7.5 m (25 ft) and the tap conductors comply with all the following:

- (1) The ampacity of the tap conductors is not less than one-third of the rating of the overcurrent device protecting the feeder conductors.
- (2) The tap conductors terminate in a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This device shall be permitted to supply any number of additional branch circuit overcurrent protective devices on its load side.
- (3) The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

Statement of Problem and Substantiation for Public Input

The language as it exists for 240.21(B)(2)(2) does not expressly state the type of overcurrent protection intended to be used on the load side of the tap overcurrent protective device. Clarification would alleviate the confusion as to whether or not the inference is branch circuit overcurrent protection, or supplementary overcurrent protection. As an aside, the language for this subsection changed between 1965 and 1971, where prior language stated that any additional circuit breakers or fuses were permitted to be protected, to the current language of overcurrent devices. The delineation between the definition of branch circuit and supplementary overcurrent protective devices had not yet been made, it is my interpretation that this language was intended for the former, and not the latter.

Related Public Inputs for This Document**Related Input**

Public Input No. 430-NFPA 70-2020 [Section No. 240.21(B)(1)]

Public Input No. 504-NFPA 70-2020 [Section No. 240.21(B)(1)]

Relationship

Proposal of additional language includes the clarification being sought

Submitter Information Verification

Submitter Full Name: Steven Worsley

Organization: NECA IBEW JATC

Street Address:

City:

State:

Zip:

Submittal Date: Thu Feb 06 13:11:21 EST 2020

Committee: NEC-P10

**Public Input No. 2250-NFPA 70-2020 [Section No. 240.21(C)(2)]****(2) Transformer Secondary Conductors Not over 3 m (10 ft) Long.**

If the length of secondary conductor does not exceed 3 m (10 ft) and complies with all of the following:

- (1) The ampacity of the secondary conductors is
 - (2) Not less than the combined calculated loads on the circuits supplied by the secondary conductors, and
 - (3) Not less than the rating of the equipment containing an overcurrent device(s) supplied by the secondary conductors or not less than the rating of the overcurrent protective device at the termination of the secondary conductors.

Exception: Where listed equipment, such as a surge protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.

- (4) The secondary conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- (5) The secondary conductors are enclosed in a raceway, which shall extend from the transformer to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices or to the back of an open switchboard.
- (6) For field installations where the secondary conductors leave the enclosure or vault in which the supply connection is made, the secondary conductors shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-tenth of the rating of the overcurrent device protecting the primary of the transformer , multiplied by the primary to secondary transformer voltage ratio, shall not exceed 10 times the ampacity of the secondary conductor .

Informational Note: For overcurrent protection requirements for panelboards, see 408.36.

Statement of Problem and Substantiation for Public Input

This brings the wording of the requirement in line with that of 240.21 (C) (6) (1). The protection of the conductors is not affected, it simply makes the requirements easier to understand and follow.

Submitter Information Verification

Submitter Full Name: David Hittinger

Organization: IEC

Street Address:

City:

State:

Zip:

Submittal Date: Wed Aug 12 12:48:48 EDT 2020

Committee: NEC-P10



Public Input No. 2091-NFPA 70-2020 [Section No. 240.21(C)(3)]

(3) Industrial Installation- Secondary Conductors, in controlled access locations, Not over 7.5 m (25 ft) Long.

For the supply of switchgear or switchboards in industrial- controlled access installations only, where the length of the secondary conductors does not exceed 7.5 m (25 ft) and complies with all of the following:

- (1) Conditions of maintenance and supervision ensure that only qualified persons service the systems.
- (2) The ampacity of the secondary conductors is not less than the secondary current rating of the transformer, and the sum of the ratings of the overcurrent devices does not exceed the ampacity of the secondary conductors.
- (3) All overcurrent devices are grouped.
- (4) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

Statement of Problem and Substantiation for Public Input

This exception shouldn't be limited to industrial locations. It should apply to any location that has controlled access where only trained workers are able to service the installation. The Department of Energy facilities, for example, are not necessarily "industrial" but have extremely strict rules for working on the premises. The contractors must undergo extensive training, work packages must be created, means and methods must all be approved. This is part of a series of proposals to change "industrial locations/premises/occupancies/wiring-systems/..." to "controlled access locations."

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2047-NFPA 70-2020 [Section No. 110.21(A)(2)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2048-NFPA 70-2020 [Section No. 110.24(B)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2049-NFPA 70-2020 [Section No. 110.70]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2050-NFPA 70-2020 [Section No. 210.8(B)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2051-NFPA 70-2020 [Section No. 210.8(B)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2052-NFPA 70-2020 [Section No. 210.9]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2053-NFPA 70-2020 [Section No. 210.18]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2054-NFPA 70-2020 [Section No. 215.11]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2087-NFPA 70-2020 [Section No. 225.37]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2088-NFPA 70-2020 [Section No. 225.52(A)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2090-NFPA 70-2020 [Section No. 230.205(C)]	part of global proposal to change 'industrial locations' to 'controlled access locations'
Public Input No. 2092-NFPA 70-2020 [Section No. 300.50(A) [Excluding any Sub-Sections]]	
Public Input No. 2093-NFPA 70-2020 [Section No. 336.10]	
Public Input No. 2094-NFPA 70-2020 [Section No. 368.56(B)]	

Submitter Information Verification

Submitter Full Name: Eric Stromberg
Organization: Los Alamos National Laboratory
Affiliation: Self

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jul 29 21:06:41 EDT 2020

Committee: NEC-P10

**Public Input No. 1032-NFPA 70-2020 [New Section after 240.22]****TITLE OF NEW CONTENT 240.23 Change in Size of Grounded Conductor**

Type your content here ...

Where ungrounded conductors are increased in size from the minimum size allowed that has sufficient ampacity for the intended installation, grounded conductors, where installed, shall be increased in size proportionately, according to the circular mil area of the ungrounded conductors of that circuit.

Statement of Problem and Substantiation for Public Input

Whether conductor sizes are increased for voltage drop or any other reason from their minimum size that has sufficient ampacity, the increased fault current carried by the ungrounded conductors is introduced to the grounding or grounded conductors, depending on the fault. The grounded conductor is now expected to carry increased currents, for the duration of the fault, as is the case with proportionately up-sized equipment grounding conductors of 250.122B.

240.23 was deleted from the 2023 NEC. It belongs like 250.122B belongs. Also, 240.23 belongs with the added text I provided from what was written in the 2017 NEC for 2 reasons

1. To resemble 250.122B more.
2. 2017's 240.23 says 'shall be permitted'. It should be mandatory not permissible.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Mon May 11 18:28:57 EDT 2020

Committee: NEC-P10

**Public Input No. 4296-NFPA 70-2020 [Section No. 240.24(A)]****(A) Accessibility.**

Circuit breakers and switches containing fuses shall be readily accessible and installed so that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, is not more than 2.0 m (6 ft 7 in.) above the floor or working platform, unless one of the following applies:

- (1) For busways, as provided in 368.17(C).
- (2) For supplementary overcurrent protection, as described in 240.10.
- (3) For overcurrent devices, as described in 225.40 and 230.92.
- (4) For overcurrent devices adjacent to utilization equipment that they supply, access shall be permitted to be by portable means.

. Exception: - The use of a tool shall be permitted to access overcurrent devices located within listed industrial control panels, or ~~similar enclosures~~, within enclosures designed for hazardous (classified) locations or adverse environmental conditions. An enclosure within the scope of this exception, and all overcurrent device(s) within such enclosures as judged with the enclosure open, shall comply with the accessibility provisions of 240.24(A).

Statement of Problem and Substantiation for Public Input

This proposed revision addresses two crucial issues left unaddressed by the existing wording and that continue to cause enforcement problems in the NEC:

1. "Similar enclosures" is quite vague and very arguably would not address many legitimate applications. For example, many NEMA 4X stainless steel panels with bolted covers are designed with a series of bolts around the perimeter; these enclosures are not industrial control panels, nor are they very similar enclosures. The same comment applies to hazardous location equipment.
2. The NEC exception requires clarification that when it is applied, any readily accessible requirements that would normally apply to the overcurrent devices must still be applied to the enclosure itself, and to any enclosed device(s) with the door or cover in the open position. For example, if the overcurrent device(s) must not be elevated [e.g. 240.24(A)(4) not applicable] then the enclosure and the enclosed overcurrent device(s) must also not be elevated, with the measured height evaluated with the door open.

Submitter Information Verification

Submitter Full Name: Frederic Hartwell

Organization: Hartwell Electrical Services, Inc.

Affiliation: self

Street Address:

City:

State:

Zip:

Submittal Date: Thu Sep 10 09:39:04 EDT 2020

Committee: NEC-P10

**Public Input No. 3120-NFPA 70-2020 [Section No. 240.24(B)(2)]****(2) Branch-Circuit Overcurrent Devices.**

Where electric service and electrical maintenance are provided by the building management and where these are under continuous building management supervision, the branch-circuit overcurrent devices supplying any guest rooms or guest suites, and sleeping units in dormitories without permanent provisions for cooking shall be permitted to be accessible only to authorized management personnel.

Statement of Problem and Substantiation for Public Input

In section 210.60 Dormitories are considered to be similar occupancies to Guest Rooms and Guest Suites as indicated in the title of that section. For similar reasons as Guest Rooms and Guest Suites it would be prudent design for the branch circuit overcurrent devices to be located outside of the dorm room proper accessed by only by building management.

Submitter Information Verification

Submitter Full Name: Kyle Mackenzie

Organization: Polise Consltng Engineer

Street Address:

City:

State:

Zip:

Submittal Date: Sat Sep 05 06:43:19 EDT 2020

Committee: NEC-P10

**Public Input No. 1033-NFPA 70-2020 [Section No. 240.24(E)]**

(E) Not Located in Bathrooms.

~~In dwelling units, dormitory units, and guest rooms or guest suites, overcurrent~~ Overcurrent devices, other than supplementary overcurrent protection, shall not be located in bathrooms, showering facilities, or locker rooms with showering facilities.

Statement of Problem and Substantiation for Public Input

Overcurrent protection devices are installed at the wet location outdoors all day and everyday. Even so showers mean no shoes, no clothes, almost guaranteed wet conditions and it would be best to prohibit overcurrent protective devices in these environments even if the panelboards were 110.28 compliant. 210.8B7 does require GFCI protection for personnel in locker rooms with showering facilities, for comparison. Dwelling, dormitories, guest rooms or guest suites shouldn't factor in since the same conditions apply in other than dwelling type bathrooms and showering facilities.

Submitter Information Verification

Submitter Full Name: Norman Feck

Organization: State of Colorado

Street Address:

City:

State:

Zip:

Submittal Date: Tue May 12 08:26:29 EDT 2020

Committee: NEC-P10

**Public Input No. 3468-NFPA 70-2020 [Section No. 240.24(E)]**

(E) Not Located in Bathrooms.

~~In dwelling units, dormitory units, and guest rooms or guest suites, overcurrent~~ Overcurrent devices, other than supplementary overcurrent protection, shall not be located in bathrooms.

Statement of Problem and Substantiation for Public Input

It is substantiated that many installations are installing overcurrent devices in bathrooms including latrines, school buildings and commercial space that are locating panelboards in rooms or areas that meet the definition of "bathroom". The overcurrent devices are still exposed to the same elements whether they are installed in a dwelling, a school bathroom or a latrine built for a military installation.

Submitter Information Verification

Submitter Full Name: Rudolph Garza

Organization: IAEI

Affiliation: IAEI

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 16:08:28 EDT 2020

Committee: NEC-P10

**Public Input No. 799-NFPA 70-2020 [Section No. 240.24(E)]**

(E) Not Located in Bathrooms.

~~In dwelling units, dormitory units, and guest rooms or guest suites, overcurrent~~ Overcurrent devices, other than supplementary overcurrent protection, shall not be located in bathrooms.

Statement of Problem and Substantiation for Public Input

During my 29 years in the electrical industry as an electrician, inspector and now instructor, I have seen overcurrent devices installed in several commercial bathrooms. These have been in gas stations, strip malls and even an elementary school. The same hazards that may be present in a dwelling unit, water or condensation, may also be found in the bathroom of any commercial or industrial establishment. I would argue these locations could contain more hazards. The panels or disconnects may be accessed more often for maintenance purposes than those in a dwelling unit. This could lead to enclosures being inadvertently left unlocked giving unauthorized and unqualified persons access to the enclosure interior. Fuses could be exposed. Missing breaker closures would expose live buss. Other hazards could be created if disconnects or breakers feeding critical loads are shut off by unauthorized people. Because bathrooms are private areas curious children may be tempted to investigate the enclosures or certain people may wish to cause harm/disruption knowing these areas would not be monitored. Removing overcurrent devices from all bathrooms regardless of the occupancy would alleviate these hazards or risks.

Submitter Information Verification

Submitter Full Name: Curt Elliott

Organization: E Light Electric Services

Street Address:

City:

State:

Zip:

Submittal Date: Fri Mar 27 12:20:26 EDT 2020

Committee: NEC-P10

**Public Input No. 390-NFPA 70-2020 [New Section after 240.60]****(E) Fuse Reducers**

Fuse Reducers shall only be used for temporary use only.

Statement of Problem and Substantiation for Public Input

Fuse reducers create an additional two connection points within a fuse holder which creates a total of six connections between the wire to holder, holder to reducer, reducer to fuse. In addition, the design of fuse reducers is likely to create a poor connection. Over time it is possibly that heating issues will occur and possibly result in a fire. In recent years there seems to have been an increase in the use of fuse reducers as a permanent solution and even being used in brand new equipment.

Submitter Information Verification

Submitter Full Name: David Komm

Organization: Mersen

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jan 30 14:27:32 EST 2020

Committee: NEC-P10

**Public Input No. 1470-NFPA 70-2020 [New Section after 240.62]****TITLE OF NEW CONTENT 240.63**

Type your content here Current limiting protective devices

...Where current limiting overcurrent protective devices are used to reduce fault current at a piece of electrical equipment the peak let-through values shall be used.

Informational note: as by referenced by UL 508a sb4.2 (The peak let through values are typically 2.3 times the RMS) values

Additional Proposed Changes**File Name****Description Approved**

.1591492768097

Statement of Problem and Substantiation for Public Input

A lingering problem that needs to be addressed in protecting rooftop units. The use of current limiting fuses is a common practice but to go a step further and to incorporate peak let-through values is a different story. UL 508a sb 4.2 states that peak let through values or 2.3 times the RMS values be used. This information is found in the expensive UL 508A document that most electrician, electrical inspectors or even engineers do not have. Therefor, this needs to be inserted into the NEC for future compliance. Its amazing how that 2.3 multiplier puts fuses out of range of protecting equipment with a scrr of 5k.

Submitter Information Verification

Submitter Full Name: James Dorsey

Organization: Douglas County Electrical Insp

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jun 06 18:57:15 EDT 2020

Committee: NEC-P10

**Public Input No. 964-NFPA 70-2020 [Section No. 240.62]****240.62 Reconditioned Equipment.**

Low-voltage fuseholders and low-voltage nonrenewable fuses shall not be permitted to be reconditioned.

Exception: Existing fuse holders that have not been previously placed in service shall be permitted to be installed in existing equipment.

Statement of Problem and Substantiation for Public Input

The proposed new exception provides needed relief and addresses and apparent gap in the restrictions for reconditioned equipment. Here is the scenario we do a lot in large industrial settings. We complete an IR Scan, we find fuse holders overheating, we take some of the unused holders out of a spare disconnect or a disconnect that has been replaced and no longer needed, bring them back to the shop, run them through an ultrasonic cleaner, we inspect them, grease them take them back during the next maintenance shutdown and install them, check the connections with a digital low resistance ohmmeter and place back in service. Per the definition of reconditioning, this would no longer be allowed. We are removing them from the site, "refurbishing" I guess you would call it and reinstalling later. This is not a replacement part since it is an existing part that was never originally placed in service. I don't see any safety hazards being created. The proposed new exception appears to provide the necessary relief for scenarios like the one described.

Submitter Information Verification

Submitter Full Name: Agnieszka Golriz

Organization: NECA

Street Address:

City:

State:

Zip:

Submittal Date: Wed May 06 09:37:09 EDT 2020

Committee: NEC-P10



Public Input No. 317-NFPA 70-2020 [Section No. 240.67]

240.67 Arc Energy Reduction.

Where fuses rated 1200 A or higher are installed, 240.67(A) ~~and~~ (B) ~~and~~ (C) shall apply. ~~This requirement shall become effective January 1, 2020.~~

(A) Documentation.

Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the fuses.

Documentation shall also be provided to demonstrate that the method chosen to reduce clearing time is set to operate at a value below the available arcing current.

(B) Method to Reduce Clearing Time.

A fuse shall have a clearing time of 0.07 seconds or less at the available arcing current, or one of the following means shall be provided and shall be set to operate at less than the available arcing current:

- (1) Differential relaying
- (2) Energy-reducing maintenance switching with local status indicator
- (3) Energy-reducing active arc-flash mitigation system
- (4) Current-limiting, electronically actuated fuses
- (5) An approved equivalent means

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a disconnect switch to reduce the clearing time while the worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*, and then to set the disconnect switch back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc-flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the disconnect switch or the settings of other devices is required during maintenance when a worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*.

Informational Note No. 3: IEEE 1584-2002, *IEEE Guide for Performing Arc Flash Hazard Calculations*, is one of the available methods that provides guidance in determining arcing current.

(C) Performance Testing.

The arc energy reduction protection system shall be performance tested by primary current injection testing or another approved method when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions.

A written record of this testing shall be made and shall be available to the authority having jurisdiction.

Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.

Statement of Problem and Substantiation for Public Input

240.87 is now separated into three first level sub-divisions including (A), (B) and (C). The parent text of this section should reflect this fact.

The effective date is no longer required.

Submitter Information Verification

Submitter Full Name: Thomas Domitrovich

Organization: Eaton Corporation

Street Address:

City:

State:

Zip:

Submission Date: Fri Jan 17 15:35:14 EST 2020

Committee:

NEC-P10

**Public Input No. 3095-NFPA 70-2020 [Section No. 240.67(A)]****(A) Documentation.**

Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the fuses.

Documentation shall also be provided to demonstrate that the method chosen to reduce clearing time is set to operate at a value below the available arcing current. If the method is the use of a specific fuse or fuses, the fuse catalog numbers(s) of the maximum ampere rating shall be documented.

Statement of Problem and Substantiation for Public Input

Not all Class L fuses are the same. For example, a 2000 amp Class L fuse of one variation may meet the .07 second clearing time requirement while a different variation of 2000 amp Class L fuse may not.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 15:12:41 EDT 2020

Committee: NEC-P10

**Public Input No. 1998-NFPA 70-2020 [Section No. 240.67(B)]****(B) Method to Reduce Clearing Time.**

A fuse shall have a clearing time of ~~0.07 seconds or less at the available arcing current fast enough to reduce incident energy to less than or equal to 8cal/cm2 at the working distance~~ , or one of the following means shall be provided and shall be set to operate ~~at less than the available arcing current to reduce the incident energy to less than or equal to 8cal/cm2~~ :

- (1) Differential relaying
- (2) Energy-reducing maintenance switching with local status indicator
- (3) Energy-reducing active arc-flash mitigation system
- (4) Current-limiting, electronically actuated fuses
- (5) An approved equivalent means

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a disconnect switch to reduce the clearing time while the worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*, and then to set the disconnect switch back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc-flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the disconnect switch or the settings of other devices is required during maintenance when a worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*.

Informational Note No. 3: IEEE 1584-2002 2018 , *IEEE Guide for Performing Arc Flash Hazard Calculations*, is one of the available methods that provides guidance in determining arcing current and incident energy .

Statement of Problem and Substantiation for Public Input

The current wording is inadequate to address the arc-flash issue. IEEE 1584 utilizes two currents to calculate incident energy. The first is noted as the arc-fault current and is a maximum arc-fault current. The second is noted as a minimum arc-fault current. The wording implies that the maximum value can be utilized as it is not implicit in how it is applied. Utilizing the minimum arc fault current in many cases will result in higher incident energy values and potentially defeat the purpose of this code requirement. It is proposed that instead the incident energy benchmark of 8 cal/cm2 be used. This aligns with daily wear PPE requirements for most electrical workers. It will also force a full calculation to IEEE 1584-2018 (also noted as a change) to evaluate the installation.

Submitter Information Verification

Submitter Full Name: Jeremy Lieland

Organization: Mersen

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 24 14:35:59 EDT 2020

Committee: NEC-P10

**Public Input No. 3094-NFPA 70-2020 [Section No. 240.67(B)]****(B) Method to Reduce Clearing Time.**

A fuse shall have a clearing time of 0.07 seconds or less at the available arcing current, or one of the following means shall be provided and shall be set to operate at less than the available arcing current:

- (1) Differential relaying
- (2) Energy-reducing maintenance switching with local status indicator
- (3) Energy-reducing active arc-flash mitigation system
- (4) Current-limiting, electronically actuated fuses
- (5) An approved equivalent means

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a disconnect switch to reduce the clearing time while the worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*, and then to set the disconnect switch back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc-flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the disconnect switch or the settings of other devices is required during maintenance when a worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*.

Informational Note No. 3: IEEE 1584-2002 2018 , *IEEE Guide for Performing Arc Flash Hazard Calculations*, is one of the available methods that provides guidance in determining arcing current.

Statement of Problem and Substantiation for Public Input

The latest standard date should be referenced.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 15:10:27 EDT 2020

Committee: NEC-P10

**Public Input No. 3972-NFPA 70-2020 [Section No. 240.67(B)]****(B) Method to Reduce Clearing Time.**

A fuse shall have a clearing time of 0.07 seconds or less at the available arcing current, or one of the following means shall be provided and shall be set to operate at less than the available arcing current as calculated at the load, or the next smaller downstream series connected overcurrent device :

- (1) Differential relaying
- (2) Energy-reducing maintenance switching with local status indicator
- (3) Energy-reducing active arc-flash mitigation system
- (4) Current-limiting, electronically actuated fuses
- (5) An approved equivalent means

Exception: When the 1200A or larger circuit breaker is in series with an equal sized overcurrent protective device upstream, fuse or circuit breaker, which meets the requirements of 240.67 or 240.87, the downstream circuit breaker shall not be subject to the requirements of 240.87.

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a disconnect switch to reduce the clearing time while the worker is working within an arc-flash boundary as defined in *NFPA 70E-2018 2021*, *Standard for Electrical Safety in the Workplace*, and then to set the disconnect switch back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc-flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the disconnect switch or the settings of other devices is required during maintenance when a worker is working within an arc-flash boundary as defined in *NFPA 70E-2018 2021*, *Standard for Electrical Safety in the Workplace*.

Informational Note No. 3: IEEE 1584-2002 2018, *IEEE Guide for Performing Arc Flash Hazard Calculations*, is one of the available methods that provides guidance in determining arcing current.

Statement of Problem and Substantiation for Public Input

Worker safety will be enhanced by applying the arc reduction methods so that they operate to protect against downstream arcing currents all the way to the load or next smaller overcurrent protective device. This concept is illustrated by figure 100.1, pg. 70-36 added in the previous code cycle.

The new exception assumes that the first suggested change was incorporated.

The proposed new Exception would eliminate the mandate for an unnecessary redundant requirement. If the first upstream device provides arc flash protection for the entire circuit as it should and the first part of this PI requires, then similar AF protection in the second, equal sized device is redundant and unnecessary. This removes the requirement from local disconnects usually implement not for their overcurrent protection properties but to serve as a local disconnect to machinery or local distribution equipment. Mains serving a bus with multiple feeders would not be exempt as the feeders are smaller than the main, unless the main is fed from an equal sized feeder with adequate AF protection.

The reference to the IEEE 1584 standard is editorially updated to the latest revision date in Informational Note 4.

The concept applies equally well to 240.67 and 240.87 and should be implemented on both, or neither.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3977-NFPA 70-2020 [Section No. 240.87(B)]	similar requirement as safety need is the same regardless of OCPD type
Public Input No. 3977-NFPA 70-2020 [Section No. 240.87(B)]	

Submitter Information Verification

Submitter Full Name: Marcelo Valdes

Organization: ABB

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 16:30:46 EDT 2020

Committee: NEC-P10

**Public Input No. 2615-NFPA 70-2020 [Section No. 240.67(C)]****(C) Performance Testing.**

The arc energy reduction protection system shall be performance tested by ~~primary current injection testing or another approved method~~ when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions ~~that shall be provided with the equipment~~.

A written record of this testing shall be made and shall be available to the authority having jurisdiction.

~~Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.~~

Statement of Problem and Substantiation for Public Input

This input is being submitted on behalf of the Minnesota Department of Labor and Industry. The Department's 15 office/field staff, and 65 plus contract electrical inspectors complete over 150,000 electrical inspections annually and are involved in the daily enforcement and interpretation of the National Electrical Code.

The referenced language regarding primary current injection testing leads to confusion as it displays you have two option for the required performance test; primary injection test or another approved method. The manufacture of the equipment needs to provide approved and proper test methods, also noting the proper test equipment required for performance test. I believe the only test method for the arc energy reduction protection system that shall be acceptable is the one recommended by the manufacturer's in their instructions. In addition to removing the primary current injection testing text in 240.67(C) the informational note should also be removed as the manufacture can provide "warnings" regarding incorrect test methods or use of incorrect test equipment.

Related Public Inputs for This Document**Related Input****Relationship**

Public Input No. 2616-NFPA 70-2020 [Section No. 240.87(C)]

Submitter Information Verification

Submitter Full Name: Dean Hunter

Organization: Minnesota Department of Labor

Street Address:

City:

State:

Zip:

Submittal Date: Tue Aug 25 20:55:22 EDT 2020

Committee: NEC-P10

**Public Input No. 2876-NFPA 70-2020 [Section No. 240.67(C)]****(C) Performance Testing Commissioning .**

~~The Commissioning of the arc energy reduction protection system shall be performance tested by primary current injection testing or another approved method when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions.~~

~~A written record of this testing shall be made and shall be available to the authority having jurisdiction.~~

~~Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.~~

~~performed at installation in compliance with 110.17 to verify system operation.~~

Statement of Problem and Substantiation for Public Input

Common requirements for device and system commissioning are being proposed to Article 110 in PI 2844 that will help drive consistency in the actions necessary prior to devices and systems being placed into service. This public input is part of a series of revisions proposed throughout the code to include commissioning where the existing requirements only mention testing.

Confirming the installation, setup, and initial performance for devices and equipment necessary for proper system operation and safety extend well beyond a simple testing requirement. Existing requirements for specific tests are not focused on how the device or equipment fits within the overall system. In addition to verifying operational controls and sequence of operation, this revision also adds clarity that overcurrent and protective devices must have settings that have been adjusted and verified when inspected by the AHJ. The requirement to include as-built documentation and a record of the actions taken to correct any shortcomings will enhance the safety of those who will operate, maintain, and service the equipment.

There are multiple methods for verifying the performance of arc energy reduction based on the technologies implemented. The commissioning of these systems often includes multiple verification steps as required by the manufacturer. This revision would remove the concept of single test and focus users on the complete set of settings, tests, and verification steps provided in the manufacturer's instructions.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2844-NFPA 70-2020 [New Section after 110.16]	
Public Input No. 2875-NFPA 70-2020 [Section No. 240.87(C)]	
Public Input No. 2887-NFPA 70-2020 [Definition: Commissioning.]	
Public Input No. 2875-NFPA 70-2020 [Section No. 240.87(C)]	

Submitter Information Verification

Submitter Full Name: Chad Kennedy
Organization: Schneider Electric
Street Address:
City:
State:
Zip:
Submittal Date: Thu Sep 03 07:41:51 EDT 2020
Committee: NEC-P10

**Public Input No. 555-NFPA 70-2020 [Section No. 240.67(C)]****(C) Performance Testing.**

The arc energy reduction protection system shall be performance tested by primary current injection testing or another approved method when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions.

A written record of this testing shall be made and shall be available to the authority having jurisdiction.

Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
CMP_10_TIA_1451_issued_TIA_70_20_4.pdf	NEC TIA 20-4 Log No. 1451	

Statement of Problem and Substantiation for Public Input

NOTE: This public input originates from Tentative Interim Amendment No. 20-4 (Log 1451) issued by the Standards Council on August 6, 2019 and per the NFPA Regs., needs to be reconsidered by the Code Making Panel for the next edition of the Document.

Substantiation: The language established by CMP-10 in the Second Draft of the 2020 NEC in SR 8020 recognizes the need to performance test the system for providing energy reduction for electrical worker safety, however it currently requires only primary current injection testing of "instantaneous elements of the protective device." Not ALL energy reduction systems will utilize the instantaneous functionality of the overcurrent protective device to meet the main requirement to reduce arc energy. Therefore, the language must be revised to reference the manufacturer's instructions that will ensure the system is properly performance tested without: 1) performing unnecessary tests, 2) damaging the equipment, or 3) omitting necessary performance testing for the specific technology.

The informational note is also added to this new requirement to alert the reader of potential equipment damage and that other means of compliance may be necessary in accordance with the manufacturer's instruction to conduct the performance test to comply with 240.67(C).

Emergency Nature: The standard contains an error or an omission that was overlooked during the regular revision process. The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action.

The performance testing requirement for energy reduction is new for the 2020 NEC. Numerous voting comments supported performance testing of the energy reduction system with similar concerns about omission of testing on certain technology and requiring unnecessary testing on other systems. Therefore, after the second draft meeting, a task group from CMP-10 consisting of Jim Dollard, Alan Manche, Tom Domitrovich, David Williams, Roy Sparks and Scott Blizard reviewed the voting comments submitted by many of the committee members. The comments recognized that performance of an energy reduction system may not be dependent on the instantaneous element of the overcurrent device. Other methods such as light detection sensors or single-use items such as fuses or a crowbar where the instantaneous function of the overcurrent device is not utilized or does not exist must be tested according to the manufacturer's instructions. Not ALL energy reduction systems will utilize the instantaneous functionality of the overcurrent protective device to meet the main requirement to reduce arc energy. Therefore, the language must be revised to reference the manufacturers instructions that will ensure the system is properly performance tested without performing unnecessary tests, tests that could damage the equipment, or omit necessary performance testing. The second paragraph can impose unnecessary testing that serves no role in enhancing safety. The revised language addresses inadvertent impact and complete omission of performance testing on some arc energy reduction systems. This TIA request has been circulated to the members of CMP-10 and the following members replied in support of moving this TIA forward; Jim Dollard, Scott Blizard, Kevin Lippert, Ken Rempe, David Williams, Ed Koepke, Paul Barnhart, Danish Zia, Nathan Philips, Peter Walsh; Steve Stuble, Steve Townsend, and Alan Manche.

Submitter Information Verification

Submitter Full Name: CMP ON NEC-P10

Organization: Code Making Panel 10

Street Address:

City:

State:

Zip:

Submittal Date: Fri Feb 28 10:56:51 EST 2020

Committee: NEC-P10



Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2020 Edition

Reference: 240.67(C) and Informational Note (new)

TIA 20-4

(SC 19-8-22 / TIA Log #1451)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. *Revise 240.67(C) to read as follows:*

240.67(C) Performance Testing. ~~Where a method to reduce clearing time is required in 240.67(B), the~~ The arc energy reduction protection system shall be performance tested by primary current injection testing or another approved method when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions.

~~Performance testing of an instantaneous element of the protective device shall be conducted by a qualified person(s) using a test process of primary current injection and the manufacturer's recommended test procedures.~~

A written record of this testing shall be made and shall be available to the authority having jurisdiction.

Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.

Issue Date: August 6, 2019

Effective Date: August 26, 2019

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo)

Copyright © 2019 All Rights Reserved
NATIONAL FIRE PROTECTION ASSOCIATION

**Public Input No. 1889-NFPA 70-2020 [Section No. 240.67 [Excluding any Sub-Sections]]**

Where fuses rated 1200 A or higher are installed, 240.67(A)- and- , (B), and (C) shall apply. This requirement shall become effective January 1, 2020.

Statement of Problem and Substantiation for Public Input

240.67(C) was added in the 2020 NEC, but a reference to it was not added in the charging text. The edit proposed in this PI provides a correction.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 1890-NFPA 70-2020 [Section No. 240.87 [Excluding any Sub-Sections]]	
Public Input No. 1890-NFPA 70-2020 [Section No. 240.87 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: John Cowans
Organization: Siemens
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jul 14 08:34:39 EDT 2020
Committee: NEC-P10

**Public Input No. 2886-NFPA 70-2020 [Section No. 240.67 [Excluding any Sub-Sections]]**

Where fuses rated ~~1200 A or~~ 1000 amps or higher are installed, 240.67(A) and (B) shall apply. This requirement shall become effective January 1, 2020.

Statement of Problem and Substantiation for Public Input

This is a sister PI to PI 2867 which seeks to modify 240.87. Arc energy reduction requirements for circuit breakers rated at 1200 amps have been in the NEC since the 2011 edition. Means, methods and technologies to provide arc energy reduction for circuit breakers and fuses rated at 1200 amps or more have increased significantly. There is no practical reason not to expand this level of protection to 1000 amp feeders.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2867-NFPA 70-2020 [Section No. 240.87 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: James Dollard
Organization: IBEW Local Union 98
Street Address:
City:
State:
Zip:
Submittal Date: Thu Sep 03 08:23:59 EDT 2020
Committee: NEC-P10

**Public Input No. 1071-NFPA 70-2020 [New Section after 240.83(E)]****TITLE OF NEW CONTENT**

Type your content here ...

(F) Individual Pole-Interrupting Capability. Two and three-pole molded-case circuit breakers, intended for use on corner-grounded delta systems, ungrounded systems, and impedance-grounded systems, shall be marked with an individual pole-interrupting capability that is indicative of their ability for an individual pole to safely interrupt phase-to-phase fault current at phase-to-phase voltage. This requirement shall become effective January 1, 2026.

Statement of Problem and Substantiation for Public Input

When a phase-to-phase fault occurs on a three phase, solidly grounded wye system, the fault current is shared by two poles of the circuit breaker, and the circuit breaker operates safely as long as its marked interrupting rating (multi-pole) is not exceeded. But what happens if that same fault, at full phase-to-phase voltage, must be cleared by only one pole of the circuit breaker? In that case, the circuit breaker's individual pole-interrupting capability must be used. The individual pole-interrupting capability is often much lower than the marked (multi-pole) interrupting rating that is marked on the circuit breaker. That individual pole rating is needed when there is one fault on a corner-grounded delta system, and is needed when there are faults on two different phases of an ungrounded system or impedance-grounded system.

It is extremely difficult for design engineers, electrical contractors, and electrical inspectors to easily determine a circuit breaker's individual pole-interrupting capability, which is needed for applications on corner grounded delta systems, ungrounded systems, and impedance grounded systems. Currently, the only way to determine the individual pole-interrupting capability is to thoroughly search manufacturers' literature or in some cases the manufacturer has to be contacted to obtain the information. Because it is so difficult to determine, individual pole-interrupting capability applications for corner-grounded delta systems, ungrounded systems, and impedance-grounded systems, are often overlooked. This Public Input adds the requirement for the individual pole-interrupting capability to be marked on the circuit breaker, making it much easier for the entire industry to safely comply.

An example is helpful to understand the need for this requirement. Assume a 480 volt, 1600 ampere, 3 pole molded case circuit breaker with a marked interrupting rating of 65,000 amperes. That marked rating signifies that the circuit breaker can safely interrupt up to 65,000 amperes on a 480/277 volt solidly grounded wye system. But if that circuit breaker is utilized on a 480 volt corner-grounded delta system, a 480 volt ungrounded system, or a 480 volt impedance-grounded system, the individual pole-interrupting capability, per UL 489, Table 7.1.7.3, could be as low as 14,000 amperes. Assume now that the available three phase bolted fault current is 50,000 amperes. In that case the available phase-to-phase bolted fault current would be 43,300 amperes. For a 480/277 volt solidly grounded wye system, the 1600 ampere circuit breaker, marked with a 65,000 ampere interrupting rating, is a suitable solution. But for a corner-grounded delta system, ungrounded system, or impedance-grounded system, an individual pole-interrupting capability of 14,000 amperes is inadequate for a 43,300 ampere phase-to-phase fault, possibly resulting in a catastrophic event. This Public Input will help to prevent this type of misapplication from occurring.

See PI 1076 which adds a new first paragraph to 240.85, requiring the proper application of individual pole-interrupting capabilities and deletes the existing Informational Note as it is no longer needed.

While molded case circuit breakers are already tested for their single pole-interrupting capability per Table 7.1.7.3 of UL 489, an effectivity date of January 1, 2026 is chosen to provide industry (product standards and manufacturers) the necessary time to comply.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 1076-NFPA 70-2020 [Section No. 240.85]	Proper application
Public Input No. 1076-NFPA 70-2020 [Section No. 240.85]	

Submitter Information Verification

Submitter Full Name: Vincent Saporita
Organization: Saporita Consulting
Affiliation: Saporita Consulting
Street Address:
City:
State:

Zip:	
Submittal Date:	Fri May 15 14:57:03 EDT 2020
Committee:	NEC-P10

**Public Input No. 1076-NFPA 70-2020 [Section No. 240.85]****240.85 Applications.**

Two and three-pole molded-case circuit breakers, applied on corner-grounded delta systems, ungrounded systems, and impedance-grounded systems, intended to interrupt current at fault levels, shall have an individual pole-interrupting capability at nominal circuit voltage at least equal to the available phase-to-phase fault current at the line terminals of the equipment. This requirement shall become effective January 1, 2026.

Informational Note: Available phase-to-phase fault current is equal to 87% of three phase available fault current.

A circuit breaker with a straight voltage rating, such as 240V or 480V, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the circuit breaker's voltage rating. A two-pole circuit breaker shall not be used for protecting a 3-phase, corner-grounded delta circuit unless the circuit breaker is marked 1 ϕ -3 ϕ to indicate such suitability.

A circuit breaker with a slash rating, such as 120/240V or 480Y/277V, shall be permitted to be applied in a solidly grounded circuit where the nominal voltage of any conductor to ground does not exceed the lower of the two values of the circuit breaker's voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the circuit breaker's voltage rating.

~~Informational Note: Proper application of molded case circuit breakers on 3-phase systems, other than solidly grounded wye, particularly on corner grounded delta systems, considers the circuit breakers' individual pole interrupting capability.~~

Statement of Problem and Substantiation for Public Input

The existing NEC contains only an Informational Note about the necessity for a circuit breaker to have the ability to safely interrupt fault currents on other than solidly grounded wye systems. Unfortunately, this is not a requirement, but should be a requirement. This Public Input modifies the existing Informational Note into required text and is modeled after the requirements in Section 110.9. By adding "ungrounded systems" and "impedance-grounded systems", it now explicitly states all types of systems where the individual pole-interrupting capability must not be exceeded.

An example is helpful to understand the need for this requirement. Assume a 480 volt, 1600 ampere, 3 pole molded case circuit breaker with a marked interrupting rating of 65,000 amperes. That marked rating signifies that the circuit breaker can safely interrupt up to 65,000 amperes on a 480/277 volt solidly grounded wye system. But if that circuit breaker is utilized on a 480 volt corner-grounded delta system, a 480 volt ungrounded system, or a 480 volt impedance-grounded system, the individual pole-interrupting capability, per UL 489, Table 7.1.7.3, could be as low as 14,000 amperes. Assume now that the available three phase bolted fault current is 50,000 amperes. In that case the available phase-to-phase bolted fault current would be 43,300 amperes. For a 480/277 volt solidly grounded wye system, the 1600 ampere circuit breaker, marked with a 65,000 ampere interrupting rating, is a suitable solution. But for a corner-grounded delta system, ungrounded system, or impedance-grounded system, an individual pole-interrupting capability of 14,000 amperes is inadequate for a 43,300 ampere phase-to-phase fault, possibly resulting in a catastrophic event. This Public Input will help to prevent this type of misapplication from occurring.

An Informational Note is added to clarify that the available phase-to-phase fault current is 87% of the available three phase fault current.

Because the existing Informational Note is modified into required text, it is no longer needed and is therefore deleted. See PI 1071 for a new 240.83 (F) which adds a requirement for marking the individual pole-interrupting capability.

While molded case circuit breakers are already tested for their single pole-interrupting capability per Table 7.1.7.3 of UL 489, an effectivity date of January 1, 2026 is chosen to provide industry (product standards and manufacturers) the necessary time to comply.

Related Public Inputs for This Document**Related Input**

[Public Input No. 1071-NFPA 70-2020 \[New Section after 240.83\(E\)\]](#)

[Public Input No. 1071-NFPA 70-2020 \[New Section after 240.83\(E\)\]](#)

Relationship

Marking requirement

Submitter Information Verification

Submitter Full Name: Vincent Saporita

Organization: Saporita Consulting

Affiliation:	Saporita Consulting
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri May 15 15:10:57 EDT 2020
Committee:	NEC-P10

**Public Input No. 3220-NFPA 70-2020 [Section No. 240.85]****240.85 Applications.**

A circuit breaker with a straight voltage rating, such as 240V or 480V, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the circuit breaker's voltage rating. A two-pole circuit breaker shall not be used for protecting a 3-phase, corner-grounded delta circuit unless the circuit breaker is marked 1 ϕ -3 ϕ to indicate such suitability.

A circuit breaker with a slash rating, such as 120/240V or 480Y/277V, shall be permitted to be applied in a solidly grounded circuit where the nominal voltage of any conductor to ground does not exceed the lower of the two values of the circuit breaker's voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the circuit breaker's voltage rating.

Informational Note 1 : Proper application of molded case circuit breakers on 3-phase systems, other than solidly grounded wye, particularly on corner grounded delta systems, considers the circuit breakers' individual pole-interrupting capability.

Informational Note 2: See IEEE 3005.-2014 Recommended Practice for the Application of Low-Voltage Circuit Breakers in Industrial and Commercial Power Systems for additional information.

Statement of Problem and Substantiation for Public Input

Information for selecting the proper circuit breaker for a particular application is provided. Application engineers are aided in specifying the type of circuit breaker, ratings, trip functions, and accessories. Circuit breakers for special applications, e.g., instantaneous only and switches are discussed. In addition, information for applying circuit breakers at different locations in the power system and for protecting specific components is provided

https://standards.ieee.org/standard/3004_5-2014.html

Submitter Information Verification

Submitter Full Name: Michael Anthony

Organization: Standards Michigan

Affiliation: IEEE Education & Healthcare Facility Electrotechnology Committee

Street Address:

City:

State:

Zip:

Submission Date: Sun Sep 06 19:29:17 EDT 2020

Committee: NEC-P10

**Public Input No. 2744-NFPA 70-2020 [Section No. 240.87]****240.87 Arc Energy Reduction.**

Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200 A or higher, 240.87(A) and (B) shall apply. The provisions of 240.6 (C) shall not apply.

(A) Documentation.

Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the circuit breaker(s). Documentation shall also be provided to demonstrate that the method chosen to reduce clearing time is set to operate at a value below the available arcing current.

(B) Method to Reduce Clearing Time.

One of the following means shall be provided and shall be set to operate at less than the available arcing current:

- (1) Zone-selective interlocking
- (2) Differential relaying
- (3) Energy-reducing maintenance switching with local status indicator
- (4) Energy-reducing active arc flash mitigation system
- (5) An instantaneous trip setting. Temporary adjustment of the instantaneous trip setting to achieve arc energy reduction shall not be permitted.
- (6) An instantaneous override
- (7) An approved equivalent means

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to "no intentional delay" to reduce the clearing time while the worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*, and then to set the trip unit back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc-flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the circuit breaker or the settings of other devices is required during maintenance when a worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*.

Informational Note No. 3: An instantaneous trip is a function that causes a circuit breaker to trip with no intentional delay when currents exceed the instantaneous trip setting or current level. If arcing currents are above the instantaneous trip level, the circuit breaker will trip in the minimum possible time.

Informational Note No. 4: IEEE 1584-2002, *IEEE Guide for Performing Arc Flash Hazard Calculations*, is one of the available methods that provide guidance in determining arcing current.

(C) Performance Testing.

The arc energy reduction protection system shall be performance tested by primary current injection testing or another approved method when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions.

A written record of this testing shall be made and shall be available to the authority having jurisdiction.

Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.

Statement of Problem and Substantiation for Public Input

adding the reference to 240.6 (C) will make it clear that an ampere rating based on restricted access adjustable trip circuit breakers is not a permitted option for required arc energy reduction.

Submitter Information Verification

Submitter Full Name: Michael Dempsey

Organization: trinity code inspections

Street Address:

City:

State:

Zip:

Submittal Date: Sun Aug 30 14:55:51 EDT 2020

Committee: NEC-P10

**Public Input No. 316-NFPA 70-2020 [Section No. 240.87]****240.87 Arc Energy Reduction.**

Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200 A or higher, 240.87(A)- and- (B) and (C) shall apply.

(A) Documentation.

Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the circuit breaker(s). Documentation shall also be provided to demonstrate that the method chosen to reduce clearing time is set to operate at a value below the available arcing current.

(B) Method to Reduce Clearing Time.

One of the following means shall be provided and shall be set to operate at less than the available arcing current:

- (1) Zone-selective interlocking
- (2) Differential relaying
- (3) Energy-reducing maintenance switching with local status indicator
- (4) Energy-reducing active arc flash mitigation system
- (5) An instantaneous trip setting. Temporary adjustment of the instantaneous trip setting to achieve arc energy reduction shall not be permitted.
- (6) An instantaneous override
- (7) An approved equivalent means

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to "no intentional delay" to reduce the clearing time while the worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*, and then to set the trip unit back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc-flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the circuit breaker or the settings of other devices is required during maintenance when a worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*.

Informational Note No. 3: An instantaneous trip is a function that causes a circuit breaker to trip with no intentional delay when currents exceed the instantaneous trip setting or current level. If arcing currents are above the instantaneous trip level, the circuit breaker will trip in the minimum possible time.

Informational Note No. 4: IEEE 1584-2002, *IEEE Guide for Performing Arc Flash Hazard Calculations*, is one of the available methods that provide guidance in determining arcing current.

(C) Performance Testing.

The arc energy reduction protection system shall be performance tested by primary current injection testing or another approved method when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions.

A written record of this testing shall be made and shall be available to the authority having jurisdiction.

Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.

Statement of Problem and Substantiation for Public Input

240.87 is now separated into three first level sub-divisions including (A), (B) and (C). The parent text of this section should reflect this fact.

Submitter Information Verification

Submitter Full Name: Thomas Domitrovich

Organization: Eaton Corporation

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jan 17 15:32:28 EST 2020

Committee: NEC-P10

**Public Input No. 1999-NFPA 70-2020 [Section No. 240.87(B)]****(B) Method to Reduce Clearing Time.**

One of the following means shall be provided and shall be set to operate at less than the available arcing current:

- (1) Zone-selective interlocking
- (2) Differential relaying
- (3) Energy-reducing maintenance switching with local status indicator
- (4) Energy-reducing active arc flash mitigation system
- (5) An instantaneous trip setting. Temporary adjustment of the instantaneous trip setting to achieve arc energy reduction shall not be permitted.
- (6) An instantaneous override
- (7) An approved equivalent means

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to "no intentional delay" to reduce the clearing time while the worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*, and then to set the trip unit back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc-flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the circuit breaker or the settings of other devices is required during maintenance when a worker is working within an arc-flash boundary as defined in *NFPA 70E-2018, Standard for Electrical Safety in the Workplace*.

Informational Note No. 3: An instantaneous trip is a function that causes a circuit breaker to trip with no intentional delay when currents exceed the instantaneous trip setting or current level. If arcing currents are above the instantaneous trip level, the circuit breaker will trip in the minimum possible time.

Informational Note No. 4: IEEE 1584-2002 2018 , *IEEE Guide for Performing Arc Flash Hazard Calculations*, is one of the available methods that provide guidance in determining arcing current.

Statement of Problem and Substantiation for Public Input

Current Revision of IEEE 1584 is 2018.

Submitter Information Verification

Submitter Full Name: Jeremy Lieland

Organization: Mersen

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 24 15:03:37 EDT 2020

Committee: NEC-P10

**Public Input No. 3977-NFPA 70-2020 [Section No. 240.87(B)]****(B) Method to Reduce Clearing Time.**

One of the following means shall be provided and shall be set to operate at less than the available arcing current calculated at the load, or the next smaller downstream series connected overcurrent device :

- (1) Zone-selective interlocking
- (2) Differential relaying
- (3) Energy-reducing maintenance switching with local status indicator
- (4) Energy-reducing active arc flash mitigation system
- (5) An instantaneous trip setting. Temporary adjustment of the instantaneous trip setting to achieve arc energy reduction shall not be permitted.
- (6) An instantaneous override
- (7) An approved equivalent means

Exception: When the 1200A or larger circuit breaker is in series with an overcurrent protective device upstream of equal current rating, fuse or circuit breaker, which meets the requirements of 240.67 or 240.87, the circuit breaker shall not be subject to the requirements of 240.87.

Informational Note No. 1: An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to "no intentional delay" to reduce the clearing time while the worker is working within an arc-flash boundary as defined in *NFPA 70E-2018 2021* , *Standard for Electrical Safety in the Workplace*, and then to set the trip unit back to a normal setting after the potentially hazardous work is complete.

Informational Note No. 2: An energy-reducing active arc-flash mitigation system helps in reducing arcing duration in the electrical distribution system. No change in the circuit breaker or the settings of other devices is required during maintenance when a worker is working within an arc-flash boundary as defined in *NFPA 70E-2018 2021* , *Standard for Electrical Safety in the Workplace*.

Informational Note No. 3: An instantaneous trip is a function that causes a circuit breaker to trip with no intentional delay when currents exceed the instantaneous trip setting or current level. If arcing currents are above the instantaneous trip level, the circuit breaker will trip in the minimum possible time.

Informational Note No. 4: IEEE 1584-2002 2018 , *IEEE Guide for Performing Arc Flash Hazard Calculations*, is one of the available methods that provide guidance in determining arcing current.

Statement of Problem and Substantiation for Public Input

Worker safety will be enhanced by applying the arc reduction methods so that they operate to protect against downstream arcing currents all the way to the load or next smaller overcurrent protective device. This concept is illustrated by figure 100.1, pg. 70-36 added in the previous code cycle. If a feeder CB has protection such as the ERMS function that protection's major benefit is to reduce the AF incident energy at the downstream equipment such as an MCC, or machinery were energize work may be contemplated. At the location of the CB the important AF protection comes from the next device upstream, usually the main, as it protects the line and load side of that feeder CB.

The new exception assumes that the first suggested change was incorporated.

The proposed new Exception would eliminate the mandate for an unnecessary redundant requirement. An OCPD should provide AF protection for the circuit it protects down to the load or next distribution bus. That requirement is now explicitly stated in the first part of this PI and should have been accepted good engineering practice regardless. However, if that circuit is interrupted by a device used as a local disconnect to mandate that 2nd device provide the same OC protection as the upstream device meeting 240.87 or 240.67 is redundant and potentially unnecessarily onerous.

The reference to the IEEE 1584 standard is editorially updated to the latest revision date in Informational Note 4.

The concept applies equally well to 240.67 and 240.87. Both should be accepted together with similar language and requirements.

Related Public Inputs for This Document**Related Input****Relationship**

[Public Input No. 3972-NFPA 70-2020](#)
[\[Section No. 240.67\(B\)\]](#)

[Public Input No. 3972-NFPA 70-2020](#)
[\[Section No. 240.67\(B\)\]](#)

Essentially the same requirements apply to both types of protection as the need for safety are the same.

Submitter Information Verification

Submitter Full Name: Marcelo Valdes

Organization: ABB

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 16:37:13 EDT 2020

Committee: NEC-P10

**Public Input No. 2616-NFPA 70-2020 [Section No. 240.87(C)]****(C) Performance Testing.**

The arc energy reduction protection system shall be performance tested by ~~primary current injection testing or another approved method~~ when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions that shall be provided with the equipment .

A written record of this testing shall be made and shall be available to the authority having jurisdiction.

~~Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.~~

Statement of Problem and Substantiation for Public Input

This input is being submitted on behalf of the Minnesota Department of Labor and Industry. The Department's 15 office/field staff, and 65 plus contract electrical inspectors complete over 150,000 electrical inspections annually and are involved in the daily enforcement and interpretation of the National Electrical Code.

The referenced language regarding primary current injection testing leads to confusion, as it displays you have two options for the required performance test; primary injection test or another approved method. The manufacture of the equipment needs to provide approved and proper test methods, also noting the proper test equipment required for the performance test. I believe the only test method for the arc energy reduction protection system that shall be acceptable is the one recommended by the manufacturer's in their instructions. In addition to removing the primary current injection testing text in 240.87(C) the informational note should also be removed as the manufacture can provide "warnings" regarding incorrect test methods or use of incorrect test equipment. The added text "that shall be provided with the equipment" is necessary to ensure the manufacture provides the proper performance test method and instructions along with the equipment as a requirement.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
<u>Public Input No. 2615-NFPA 70-2020 [Section No. 240.67(C)]</u>	

Submitter Information Verification

Submitter Full Name: Dean Hunter
Organization: Minnesota Department of Labor
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 25 20:57:49 EDT 2020
Committee: NEC-P10

**Public Input No. 2875-NFPA 70-2020 [Section No. 240.87(C)]****(C) Performance Testing Commissioning .**

~~The Commissioning of the arc energy reduction protection system shall be performance tested by primary current injection testing or another approved method when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions.~~

~~A written record of this testing shall be made and shall be available to the authority having jurisdiction.~~

~~Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.~~

~~performed at installation in compliance with 110.17 to verify system operation.~~

Statement of Problem and Substantiation for Public Input

Common requirements for device and system commissioning are being proposed to Article 110 in PI 2844 that will help drive consistency in the actions necessary prior to devices and systems being placed into service. This public input is part of a series of revisions proposed throughout the code to include commissioning where the existing requirements only mention testing.

Confirming the installation, setup, and initial performance for devices and equipment necessary for proper system operation and safety extend well beyond a simple testing requirement. Existing requirements for specific tests are not focused on how the device or equipment fits within the overall system. In addition to verifying operational controls and sequence of operation, this revision also adds clarity that overcurrent and protective devices must have settings that have been adjusted and verified when inspected by the AHJ. The requirement to include as-built documentation and a record of the actions taken to correct any shortcomings will enhance the safety of those who will operate, maintain, and service the equipment.

There are multiple methods for verifying the performance of arc energy reduction based on the technologies implemented. The commissioning of these systems often includes multiple verification steps as required by the manufacturer. This revision would remove the concept of single test and focus users on the complete set of settings, tests, and verification steps provided in the manufacturer's instructions.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2844-NFPA 70-2020 [New Section after 110.16]	
Public Input No. 2876-NFPA 70-2020 [Section No. 240.67(C)]	
Public Input No. 2887-NFPA 70-2020 [Definition: Commissioning.]	
Public Input No. 2876-NFPA 70-2020 [Section No. 240.67(C)]	

Submitter Information Verification

Submitter Full Name: Chad Kennedy
Organization: Schneider Electric
Street Address:
City:
State:
Zip:
Submittal Date: Thu Sep 03 07:37:00 EDT 2020
Committee: NEC-P10

**Public Input No. 556-NFPA 70-2020 [Section No. 240.87(C)]****(C) Performance Testing.**

The arc energy reduction protection system shall be performance tested by primary current injection testing or another approved method when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions.

A written record of this testing shall be made and shall be available to the authority having jurisdiction.

Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
CMP_10_TIA_1452_issued_TIA_70_20_5.pdf	NEC TIA 20-5 Log No. 1452	

Statement of Problem and Substantiation for Public Input

NOTE: This public input originates from Tentative Interim Amendment No. 20-5 (Log 1452) issued by the Standards Council on August 6, 2019 and per the NFPA Regs., needs to be reconsidered by the Code Making Panel for the next edition of the Document.

Substantiation: The language established by CMP-10 in the Second Draft of the 2020 NEC in SR 8030 recognizes the need to performance test the system for providing energy reduction for electrical worker safety, however it currently requires only primary current injection testing of "instantaneous elements of the protective device." Not ALL energy reduction systems will utilize the instantaneous functionality of the overcurrent protective device to meet the main requirement to reduce arc energy. Therefore, the language must be revised to reference the manufacturer's instructions that will ensure the system is properly performance tested without: 1) performing unnecessary tests, 2) damaging the equipment, or 3) omitting necessary performance testing for the specific technology.

The informational note is also added to this new requirement to alert the reader of potential equipment damage and that other means of compliance may be necessary in accordance with the manufacturer's instruction to conduct the performance test to comply with 240.87(C).

Emergency Nature: The standard contains an error or an omission that was overlooked during the regular revision process. The proposed TIA intends to correct a circumstance in which the revised NFPA Standard has resulted in an adverse impact on a product or method that was inadvertently overlooked in the total revision process or was without adequate technical (safety) justification for the action.

The performance testing requirement for energy reduction is new for the 2020 NEC. Numerous voting comments supported performance testing of the energy reduction system with similar concerns about omission of testing on certain technology and requiring unnecessary testing on other systems. Therefore, after the second draft meeting, a task group from CMP-10 consisting of Jim Dollard, Alan Manche, Tom Domitrovich, David Williams, Roy Sparks and Scott Blizard reviewed the voting comments submitted by many of the committee members. The comments recognized that performance of an energy reduction system may not be dependent on the instantaneous element of the overcurrent device. Other methods such as light detection sensors or single-use items such as fuses or a crowbar where the instantaneous function of the overcurrent device is not utilized or does not exist must be tested according to the manufacturer's instructions. Not ALL energy reduction systems will utilize the instantaneous functionality of the overcurrent protective device to meet the main requirement to reduce arc energy. Therefore, the language must be revised to reference the manufacturers instructions that will ensure the system is properly performance tested without performing unnecessary tests, tests that could damage the equipment, or omit necessary performance testing. The second paragraph can impose unnecessary testing that serves no role in enhancing safety. The revised language addresses inadvertent impact and complete omission of performance testing on some arc energy reduction systems. This TIA request has been circulated to the members of CMP-10 and the following members replied in support of moving this TIA forward; Jim Dollard, Scott Blizard, Kevin Lippert, Ken Rempe, David Williams, Ed Koepke, Paul Barnhart, Danish Zia, Nathan Philips, Peter Walsh; Steve Stuble, Steve Townsend, and Alan Manche.

Submitter Information Verification

Submitter Full Name: CMP ON NEC-P10

Organization: Code Making Panel 10

Street Address:

City:
State:
Zip:
Submittal Date: Fri Feb 28 11:10:05 EST 2020
Committee: NEC-P10



Tentative Interim Amendment

NFPA[®] 70[®]

National Electrical Code[®]

2020 Edition

Reference: 240.87(C) and Informational Note (new)

TIA 20-5

(SC 19-8-23 / TIA Log #1452)

Note: Text of the TIA was issued and approved for incorporation into the document prior to printing.

1. *Revise 240.87(C) to read as follows:*

240.87(C) Performance Testing. The arc energy reduction protection system shall be performance tested by primary current injection testing or another approved method when first installed on site. This testing shall be conducted by a qualified person(s) in accordance with the manufacturer's instructions.

~~Performance testing of an instantaneous element of the protective device shall be conducted by a qualified person(s) using a test process of primary current injection and the manufacturer's recommended test procedures.~~

A written record of this testing shall be made and shall be available to the authority having jurisdiction.

Informational Note: Some energy reduction protection systems cannot be tested using a test process of primary current injection due to either the protection method being damaged such as with the use of fuse technology or because current is not the primary method of arc detection.

Issue Date: August 6, 2019

Effective Date: August 26, 2019

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo)

Copyright © 2019 All Rights Reserved
NATIONAL FIRE PROTECTION ASSOCIATION

**Public Input No. 1890-NFPA 70-2020 [Section No. 240.87 [Excluding any Sub-Sections]]**

Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200 A or higher, 240.87(A) ~~and~~ , (B), and (C) shall apply.

Statement of Problem and Substantiation for Public Input

240.87(C) was added in the 2020 NEC, but a reference to it was not added in the charging text. The edit proposed in this PI provides a correction.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 1889-NFPA 70-2020 [Section No. 240.67 [Excluding any Sub-Sections]]	
Public Input No. 1889-NFPA 70-2020 [Section No. 240.67 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: John Cowans
Organization: Siemens
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jul 14 08:55:55 EDT 2020
Committee: NEC-P10

**Public Input No. 2867-NFPA 70-2020 [Section No. 240.87 [Excluding any Sub-Sections]]**

Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is ~~1200 A~~ 1000 A or higher, 240.87(A) and (B) shall apply.

Statement of Problem and Substantiation for Public Input

Arc energy reduction requirements for circuit breakers rated at 1200 amps have been in the NEC since the 2011 edition. Means, methods and technologies to provide arc energy reduction for circuit breakers rated at 1200 amps or more have increased significantly. There is no practical reason not to expand this level of protection to 1000 amp feeders.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2886-NFPA 70-2020 [Section No. 240.67 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: James Dollard

Organization: IBEW Local Union 98

Street Address:

City:

State:

Zip:

Submission Date: Thu Sep 03 06:43:46 EDT 2020

Committee: NEC-P10

**Public Input No. 3054-NFPA 70-2020 [New Section after 240.88]****240.89 Replacement Trip Units**

Replacement trip units shall be listed for use with the circuit breaker type in which it is installed.

Statement of Problem and Substantiation for Public Input

The components discussed in this text are critical to the safe and proper operation of the circuit breaker in which they are installed. Trip units generally accept inputs from protective relays and/or current transformers to sense faults and output signals to the mechanical operating mechanism to clear faults based on design parameters of the circuit breaker. Generally, engineers design trip units to account for special performance characteristic of the sensing and tripping components within the circuit breaker. Mismatching any of these components could cause the breaker assembly to function outside of the design parameters which could compromise safety and other protective functions.

To ensure safety, retrofit component for circuit breakers that are critical to performance should be listed for use with the circuit breaker type for which it is installed.

See related changes on medium voltage breakers included in the 2020 NEC.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 11:19:40 EDT 2020

Committee: NEC-P10

**Public Input No. 3361-NFPA 70-2020 [New Section after 240.88]****240.89 Retrofit Trip Units**

Retrofit trip units shall be listed for use with the specific circuit breaker with which it is installed.

Statement of Problem and Substantiation for Public Input

Retrofit trip units are currently available on the market intended to modernize legacy low-voltage power circuit breakers. These trip units allow for older circuit breakers to be provided with additional functionality, such as metering, external communication or more adjustable settings. These devices replace the original circuit breaker trip unit, and can change the time-current tripping characteristics as well. They are listed for use with only specific circuit breakers where the combination has been tested, and should not be used generically with any low-voltage power circuit breaker. This new section is intended to follow the action taken by CMP9 on Section 490.21(A)(5) for medium voltage circuit breakers that was added for the 2020 Edition of NFPA 70.

Submitter Information Verification

Submitter Full Name: Danish Zia

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 10:42:00 EDT 2020

Committee: NEC-P10



Public Input No. 2396-NFPA 70-2020 [Section No. 240.88]

240.88 Reconditioned Equipment.

~~Reconditioned~~ Circuit breaker equipment shall be listed as “reconditioned” and the original listing mark removed. be permitted to be reconditioned where the following conditions are met. The reconditioning process shall use design qualified parts verified under applicable standards and be performed in accordance with any instructions provided by the manufacturer. Reconditioned switchboards and switchgear shall comply with one of the following;

(1) Retain original manufacturer's nameplate and listing marks. Or, if illegible, shall be replaced with new that mimics the content and detail of the original. The equipment's original listing(s) shall be qualified as valid, including where applicable to original equipment, all: ratings, performance attributes, terms of use, and compliance to qualified standard(s).

(2) Field labeled as reconditioned. Previously applied listing marks, if any, associated with reconditioned elements shall be removed. Previously applied nameplate, if any, shall be replaced with new nameplate indicating date of recondition work, and shall include revision(s) to ratings as appropriate.

If equipment has been damaged by fire, products of combustion, or water, it shall be specifically evaluated by its manufacturer or a qualified testing laboratory prior to being returned to service. Provide label briefly summarizing extent of recondition event and each subsequent recondition event, with date of completion for each, and contact information for entity performing the work for each. .

(A) Circuit Breakers.

The use of reconditioned circuit breakers shall comply with (1) through (3 4):

- (1) Molded-case circuit breakers shall not be permitted to be reconditioned.
- (2) Insulated-case circuit breakers shall be permitted to be reconditioned.
- (3) Low- and medium-voltage power circuit breakers shall be permitted to be reconditioned.
- (4) High-voltage circuit breakers shall be permitted to be reconditioned.

(B) Components.

The use of reconditioned trip units, protective relays, and current transformers shall comply with (1) and (2):

- (1) Low-voltage power circuit breaker electronic trip units shall not be permitted to be reconditioned.
- (2) Electromechanical protective relays and current transformers shall be permitted to be reconditioned.

Informational Note; refer to 110.21(A)(2) for additional requirements.

Statement of Problem and Substantiation for Public Input

- 1) The existing statement “reconditioned equipment shall be listed” requires clarification as it may be construed that reconditioned equipment can be listed anew. Or, that a caveat for equipment to be reconditioned is that it must have first been listed, or some other interpretation.
- 2) Insulated-case type circuit breakers have neither been approved nor disapproved.
- 3) If there are terms for listed equipment to be reconditioned so as to retain the equipment's original ratings and specifications, the terms for this are not yet identified clearly.
- 4) If there is an intent that the nameplate ratings may be allowed to differ from the original, or not, then integrity to this effect this needs to be clarified.
- 5) If there are terms for equipment that has been reconditioned once already, to be permitted to be reconditioned again, these terms have yet to be clarified.
- 6) if there is to be an intent that component level reconditioning is to be permitted, then perhaps some way of labeling a summary of reconditioning events should be clarified.
- 7) the name of the reconditioning entity and the date of recondition is required by 110.21(A)(2), but an informational note isn't provided as reference nor text to identify this requirement.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2395-NFPA 70-2020 [Section No. 490.49]	similar topic
Public Input No. 2298-NFPA 70-2020 [Section No. 408.8(B)]	similar topic
Public Input No. 2298-NFPA 70-2020 [Section No. 408.8(B)]	
Public Input No. 2395-NFPA 70-2020 [Section No. 490.49]	

Submitter Information Verification**Submitter Full Name:** John Blissett**Organization:** Bernhard TME**Street Address:****City:****State:****Zip:****Submittal Date:** Tue Aug 18 18:55:18 EDT 2020**Committee:** NEC-P10

**Public Input No. 582-NFPA 70-2020 [Section No. 240.88]****240.88 Reconditioned Equipment.**

Reconditioned equipment shall be listed as "reconditioned" and the original listing mark removed.

(A) Circuit Breakers.

~~The use of reconditioned circuit breakers shall comply with (1) through (3): Molded Mol ded -case circuit breakers shall not be permitted to be reconditioned.~~

- ~~• Low- and medium-voltage power circuit breakers shall be permitted to be reconditioned.~~
- ~~• High-voltage circuit breakers shall be permitted to be reconditioned.~~

(B) Components.

The use of reconditioned trip units, protective relays, and current transformers shall comply with (1) and (2):

- (1) Low-voltage power circuit breaker electronic trip units shall not be permitted to be reconditioned.
- (2) Electromechanical protective relays and current transformers shall be permitted to be reconditioned.

Statement of Problem and Substantiation for Public Input

Medium and high voltage circuit breakers are covered in Part IX

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 583-NFPA 70-2020 [New Part after IX.]	

Submitter Information Verification

Submitter Full Name: Ryan Jackson
Organization: Ryan Jackson
Street Address:
City:
State:
Zip:
Submittal Date: Mon Mar 02 15:24:55 EST 2020
Committee: NEC-P10



Public Input No. 3362-NFPA 70-2020 [Sections 240.88(A), 240.88(B)]

Sections 240.88(A), 240.88(B)

(A) Circuit Breakers.

The use of reconditioned circuit breakers shall comply with (1) through (3):

- (1) Molded-case circuit breakers shall not be permitted to be reconditioned unless the circuit breaker is identified as serviceable or maintainable by the original equipment manufacturers' instructions .
- (2) Low- and medium-voltage power circuit breakers shall be permitted to be reconditioned.
- (3) High-voltage circuit breakers shall be permitted to be reconditioned.

(B) Components.

The use of reconditioned trip units ~~and~~ protective relays ~~and current transformers~~ shall comply with (1) and (2):

- (1) Low-voltage power circuit breaker electronic trip units shall not be permitted to be reconditioned.
- (2) Electromechanical protective ~~relays and current transformers shall~~ relays shall be permitted to be reconditioned.

Statement of Problem and Substantiation for Public Input

This public input is submitted on behalf of the task group formed in accordance with the direction of the NFPA Standards Council in Decision D#19-11. This task group was appointed to identify potential proposed changes to the 2020 edition of the NEC in the form of proposed Tentative Interim Amendments (TIAs) or to the 2023 edition of the NEC in the form of Public Inputs (PIs) that are within the Task Group's scope of activity as specified by the Standards Council.

These proposed Public Inputs relate to requirements covering the use of reconditioned electrical equipment throughout the NEC as a coordinated set of new or revised requirements. These Public Inputs should not be misconstrued by the CMPs as precluding equal consideration of other Public Inputs, with supporting information, submitted now or in the future by individuals.

The task group members are: G. Scott Harding (Chair), Tom Bishop, Casey Blevins, John Catlett, Dave Dagenais, James Dollard, Robert Fahey, Paul Grein, Howard Herndon, David Hittinger, Christel Hunter, Bob Jordan, David Kendall, Dave King, Jack Lyons, Ryan McClarnon, Robert Osborne, Chris Paxton, David Rosenfield, Michael Savage, Bill Schofield and Ron Widup. This task group of balanced interests provided the expertise to develop these public inputs. Multiple sub task groups were set up during the process with the results of the sub task group work shared with and voted on by the full task group.

Public Inputs are being submitted as follows:

- Revised to Article 100 definition of Reconditioned
- Revisions to Sections 110.21(A)(2), 240.88 and 210.15(3)
- New requirements/Sections 110.17, 110.20, 430.3 and 445.3

Section 240.88

Molded case circuit breakers include various styles of design, including insulated case circuit breakers, which might have some serviceable procedures that are recommended by the OEM. The procedures and the use of qualified parts on the various designs will vary significantly from model to model. This public input reflects the fact the level of serviceability is a function of the specific design and hence it requires that the original manufacturer identify what parts and subsystems may be maintained. The proposal allows circuit breakers that may be reconditioned when the OEM has guidance on such service or maintenance and may provide or recommend qualified parts to be used.

NEMA AB 4-2017 Guidelines for Inspection and Preventative Maintenance of Molded Case Circuit Breakers and Pearl EERS 2018, Electrical Equipment Reconditioning Standard for Electrical Apparatus and Equipment explains the designs and procedures that are required to ensure safety and compliance with the product standard. Qualified parts and proper testing are components of reconditioning and may offer AHJs the basis of approval of reconditioned products.

Current transformers are not recommended to be reconditioned and the only servicing or maintenance that could be performed would be cleaning only and this would not be considered reconditioned.

Submitter Information Verification

Submitter Full Name: G. Scott Harding
Organization: F. B. Harding, Inc.
Affiliation: Independent Electrical Contractors
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 08 10:42:37 EDT 2020
Committee: NEC-P10

**Public Input No. 327-NFPA 70-2020 [Section No. 240.88 [Excluding any Sub-Sections]]**

Reconditioned equipment shall be ~~listed as~~ identified as "reconditioned" and the original listing mark removed.

Statement of Problem and Substantiation for Public Input

This PI is an attempt to correlate the language in 240.88 with the language in 110.21(A)(2). The first sentence of the second paragraph of 110.21(A)(2) states: "Reconditioned equipment shall be identified as reconditioned and the original listing mark removed".

Submitter Information Verification

Submitter Full Name: Vincent Della Croce

Organization:

Street Address:

City:

State:

Zip:

Submission Date: Tue Jan 21 12:09:53 EST 2020

Committee: NEC-P10

**Public Input No. 4508-NFPA 70-2020 [Section No. 240.88 [Excluding any Sub-Sections]]**

Reconditioned equipment shall be listed as “reconditioned” and the original listing mark removed, except where permitted by Section 110 . 21(A)(2).

Statement of Problem and Substantiation for Public Input

Added language for addition to 110.21(A)(2)

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 4496-NFPA 70-2020 [Section No. 110.21(A)(2)]	

Submitter Information Verification

Submitter Full Name: Joshua Brackett

Organization:

Street Address:

City:

State:

Zip:

Submission Date: Thu Sep 10 14:25:22 EDT 2020

Committee: NEC-P10

**Public Input No. 2988-NFPA 70-2020 [Section No. 240.101(A)]****(A) Rating or Setting of Overcurrent Protective Devices.**

The continuous ampere rating of a fuse shall not exceed three times the ampacity of the conductors. The long-time trip element setting of a breaker or the minimum trip setting of an electronically actuated fuse shall not exceed six times the ampacity of the conductor. For fire pumps, conductors shall be permitted to be protected for overcurrent in accordance with 695 703 .4(B)(2).

Statement of Problem and Substantiation for Public Input

This public input was prepared by the correlating committee task group focused on alternative energy requirements. This task group consisted of the following members: Derrick Atkins (CMP 5), Greg Ball (CMP 13) Ken Boyce (CMP 1), Bill Brooks (CMP 4), Bruce Campbell, Thomas Domitrovich (CMP 2, CMP 10), Jason Fisher (CMP 4), Scott Harding (CMP 5), Pete Jackson (CMP 8), David Kendall (CMP 8, CC), Chad Kennedy (CMP 13), Christine Porter (CMP 5, CC), Timothy Windey (CMP 13).

This change aligns with an effort to re-organize the alternative energy sources NEC Articles into a series of articles closely located together. This reorganization places all sources alternate sources as follows:

689 On-Site Energy Sources
690 Solar Photovoltaic (PV) Systems
691 Large-Scale Photovoltaic (PV) Systems
692 Fuel Cell Systems
693 Generators
694 Wind Electric Systems
695 Energy Storage Systems
696 Storage Batteries

This public input aligns with changes that move 695 to 703. This input supports this effort and to better align with the fact that this Article is closely related to emergency systems. The requirements of this new 703 focus on more than just a fire pump and arguably more so focuses on fire pump systems which is closely aligned with Chapter 7 of the NEC. This move makes way for alignment of alternative energy sources article arrangement. These articles are closely related to each other and this change is in alignment with the direction by the correlating committee to review alternative energy sources for conflicts and usability. This new alignment will create a similar structure as that found for hazardous locations. The new Article 689 is the a combination of Articles 705, 710 and 712 and will act to be the new general requirements for this series of alternative energy sources.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2987-NFPA 70-2020 [Article 695]	move of article 697 to 703

Submitter Information Verification

Submitter Full Name: Thomas Domitrovich
Organization: Eaton Corporation
Street Address:
City:
State:
Zip:
Submission Date: Thu Sep 03 19:28:37 EDT 2020
Committee: NEC-P10

**Public Input No. 3365-NFPA 70-2020 [New Section after 240.102]****240.106 Listing Requirements.**

Branch-circuit overcurrent protective devices rated over 1000 volts shall be listed.

Statement of Problem and Substantiation for Public Input

This public input requires listing of “branch-circuit overcurrent protective devices”, defined in Article 100, that are rated over 1000 volts.

Requiring branch-circuit overcurrent protective devices in the National Electrical Code to be listed provides a basis for Authority Having Jurisdiction to approve the overcurrent protective devices. When electrical equipment is not listed, AHJ's must examine the electrical equipment in accordance with Section 110.3(A) as a basis for approval. Due to the inherent design and complexity of these devices, AHJ's do not have the expertise and test equipment to examine non-listed equipment for suitability.

Additionally, Section 240.88 already requires reconditioned circuit breakers over 1000 volts to be listed as “reconditioned”, but there is no current requirement that the original equipment be listed. If reconditioned equipment is required to be listed, then new equipment should also be listed.

The new section is numbered 240.106 to align with similarly numbered sections in Chapter 3 and Chapter 6 of the Code reflecting listing requirements.

Submitter Information Verification

Submitter Full Name: Danish Zia

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 11:00:58 EDT 2020

Committee: NEC-P10



Public Input No. 3203-NFPA 70-2020 [New Article after 242]

TITLE OF NEW CONTENT

Type your content here ...

Part IV. Voltage Stabilizing Ground Reference (VSGR) systems.

242.68 Listing.

A VSGR shall be a listed device or system composed of listed components.

242.70 Short-Circuit Current Rating.

The VSGR shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating.

242.71 Voltage Rating.

The rating of the VSGR shall be equal to or greater than the maximum system continuous operating voltage at the point of application.

242.72 Installation.

VSGRs shall be installed in accordance with 242.72(A) through (C).

242.72(A) Service-Supplied Building or Structure.

VSGR shall be connected anywhere on the load side of a service disconnect overcurrent device required in 230.91 unless installed in accordance with 230.82 (8).

242.72(B) Feeder-Supplied Building or Structure.

VSGR shall be connected at the building or structure anywhere on the load side of the first overcurrent device at the building or structure.

242.72(C) Separately Derived System.

VSGR shall be connected on the load side of the first overcurrent device in a separately derived system.

242.82 Location.

VSGRs shall be permitted to be located indoors or outdoors and shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.84 Conductor Size.

Line and grounding conductors shall not be smaller than 14 AWG copper or 12 AWG aluminum.

242.90 Connection Between Conductors.

VSGR connections shall follow the manufacturer's instructions for the system connections.

242.92 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, VSGR grounding connections shall be made as specified in Article 250, Part III. Grounding electrode conductors installed in metal enclosures shall comply with 250.64(E).

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Code_Input.docx	Input to improve OVERVOLTAGE protection requirements	

Statement of Problem and Substantiation for Public Input

In the 2020 NEC cycle, ARTICLES 280 and 285 were combined to make ARTICLE 242. This was a positive change that

began to address the issue of OVERVOLTAGE as a technical subject apart from particular product methods (SPDs and Surge Arresters). There are other technologies and products to address the issue of OVERVOLTAGE. This input attempts to add one such technology as well as correlate the other code references to the subject of OVERVOLTAGE, surge protective devices, and surge arresters to be consistent. This is important to allow for other technologies to be utilized without prejudice to certain products promoted by manufacturers.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3200-NFPA 70-2020 [Section No. 242.1]	
Public Input No. 3202-NFPA 70-2020 [New Article after 100]	
Public Input No. 3205-NFPA 70-2020 [Section No. 501.35]	
Public Input No. 3206-NFPA 70-2020 [Section No. 502.35]	
Public Input No. 3208-NFPA 70-2020 [Section No. 551.72(E)]	
Public Input No. 3209-NFPA 70-2020 [Section No. 490.24]	
Public Input No. 3210-NFPA 70-2020 [Section No. 490.48(A)]	
Public Input No. 3211-NFPA 70-2020 [Section No. 620.51(E)]	
Public Input No. 3212-NFPA 70-2020 [Section No. 645.18]	
Public Input No. 3214-NFPA 70-2020 [Section No. 670.6]	
Public Input No. 3216-NFPA 70-2020 [Section No. 694.7(D)]	
Public Input No. 3217-NFPA 70-2020 [Section No. 695.15]	
Public Input No. 3218-NFPA 70-2020 [Section No. 700.8]	
Public Input No. 3219-NFPA 70-2020 [Section No. 708.20(D)]	

Submitter Information Verification

Submitter Full Name: Karl Cunningham

Organization: Self Employed

Street Address:

City:

State:

Zip:

Submittal Date: Sun Sep 06 18:07:49 EDT 2020

Committee: NEC-P10

Substantiation for Changes: In the 2020 NEC cycle, ARTICLES 280 and 285 were combined to make ARTICLE 242. This was a positive change that began to address the issue of **OVERVOLTAGE** as a technical subject apart from particular product methods (SPDs and Surge Arresters). There are other technologies and products to address the issue of **OVERVOLTAGE**. This input attempts to add one such technology as well as correlate the other code references to the subject of **OVERVOLTAGE**, surge protective devices, and surge arresters to be consistent. This is important to allow for other technologies to be utilized without prejudice to certain products promoted by manufacturers.

ARTICLE 100 - DEFINITIONS

Voltage Stabilizing Ground Reference (VSGR) System – an engineered assembly of interconnected passive inductive devices that utilize mutual counter electro-magnetic inductance to stabilize phase voltages of a connected supply system with respect to each other and to ground.

ARTICLE 242 Overvoltage Protection

Part I. General

242.1 Scope.

This article provides the general requirements, installation requirements, and connection requirements for overvoltage protection and overvoltage protective devices. Part II covers surge-protective devices (SPDs) permanently installed on premises wiring systems of not more than 1000 volts, nominal, while Part III covers surge arresters permanently installed on premises wiring systems over 1000 volts, nominal. [Part IV covers Voltage Stabilizing Ground Reference \(VSGR\) systems permanently installed on premises wiring systems for any voltage.](#)

Informational Note: Article [242](#) combines and replaces Articles 280 and 285 in *NFPA 70-2017*.

242.3 Other Articles.

Equipment shall be protected against overvoltage in accordance with the article in this *Code* that covers the type of equipment or location specified in [Table 242.3](#).

Table 242.3 Other Articles

Equipment	Article
Class I locations	501
Class II locations	502
Community antenna television and radio distribution systems	820
Critical operations power systems	708

Table 242.3 Other Articles

Equipment	Article
Elevators, dumbwaiters, escalators, moving walks, platform lifts, and stairway chairlifts	620
Emergency systems	700
Equipment over 1000 volts, nominal	490
Fire pumps	695
Industrial machinery	670
Information technology equipment	645
Modular data centers	646
Outdoor overhead conductors over 1000 volts	399
Radio and television equipment	810
Receptacles, cord connectors, and attachment plugs (caps)	406
Wind electric systems	694

Part II. Surge-Protective Devices (SPDs), 1000 Volts or Less

Informational Note: Surge arresters 1000 volts or less are also known as Type 1 SPDs.

242.6 Uses Not Permitted.

An SPD device shall not be installed in the following:

1. (1)

Circuits over 1000 volts

2. (2)

On ungrounded systems, impedance grounded systems, or corner grounded delta systems unless listed specifically for use on these systems

3. (3)

Where the rating of the SPD is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application

242.8 Listing.

An SPD shall be a listed device.

242.10 Short-Circuit Current Rating.

The SPD shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating. This marking requirement shall not apply to receptacles.

242.12 Type 1 SPDs.

Type 1 SPDs shall be installed in accordance with [242.12\(A\)](#) and (B).

242.12(A) Installation.

Type 1 SPDs shall be permitted to be connected in accordance with one of the following:

1. (1)

To the supply side of the service disconnect as permitted in [230.82](#)(4)

2. (2)

As specified in [242.14](#)

242.12(B) At the Service.

When installed at services, Type 1 SPDs shall be connected to one of the following:

1. (1)

Grounded service conductor

2. (2)

Grounding electrode conductor

3. (3)

Grounding electrode for the service

4. (4)

Equipment grounding terminal in the service equipment

242.14 Type 2 SPDs.

Type 2 SPDs shall be installed in accordance with [242.14\(A\)](#) through (C).

242.14(A) Service-Supplied Building or Structure.

Type 2 SPDs shall be connected anywhere on the load side of a service disconnect overcurrent device required in [230.91](#) unless installed in accordance with [230.82](#)(8).

242.14(B) Feeder-Supplied Building or Structure.

Type 2 SPDs shall be connected at the building or structure anywhere on the load side of the first overcurrent device at the building or structure.

242.14(C) Separately Derived System.

The SPD shall be connected on the load side of the first overcurrent device in a separately derived system.

242.16 Type 3 SPDs.

Type 3 SPDs shall be permitted to be installed on the load side of branch-circuit overcurrent protection up to the equipment served. If included in the manufacturer's instructions, the Type 3 SPD connection shall be a minimum 10 m (30 ft) of conductor distance from the service or separately derived system disconnect.

242.18 Type 4 and Other Component Type SPDs.

Type 4 component assemblies and other component type SPDs shall only be installed by the equipment manufacturer.

242.20 Number Required.

Where used at a point on a circuit, the SPD shall be connected to each ungrounded conductor.

242.22 Location.

SPDs shall be permitted to be located indoors or outdoors and shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.24 Routing of Connections.

The conductors used to connect the SPD to the line or bus and to ground shall not be any longer than necessary and shall avoid unnecessary bends.

242.26 Connection.

Where an SPD device is installed, it shall comply with [242.12](#), [242.14](#), [242.16](#), [242.28](#), and [242.30](#).

242.28 Conductor Size.

Line and grounding conductors shall not be smaller than 14 AWG copper or 12 AWG aluminum.

242.30 Connection Between Conductors.

An SPD shall be permitted to be connected between any two conductors — ungrounded conductor(s), grounded conductor, equipment grounding conductor, or grounding electrode conductor. The grounded conductor and the equipment grounding conductor shall be interconnected only by the normal operation of the SPD during a surge.

242.32 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, SPD grounding connections shall be made as specified in Article [250](#), Part III. Grounding electrode conductors installed in metal enclosures shall comply with [250.64\(E\)](#).

Part III. Surge Arresters, Over 1000 Volts**242.40 Uses Not Permitted.**

A surge arrester shall not be installed where the rating of the surge arrester is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application.

242.42 Surge Arrester Selection.

The surge arresters shall comply with [242.42\(A\)](#) and (B).

242.42(A) Rating.

The rating of a surge arrester shall be equal to or greater than the maximum continuous operating voltage available at the point of application.

242.42(A)(1) Solidly Grounded Systems.

The maximum continuous operating voltage shall be the phase-to-ground voltage of the system.

242.42(A)(2) Impedance or Ungrounded System.

The maximum continuous operating voltage shall be the phase-to-phase voltage of the system.

242.42(B) Silicon Carbide Types.

The rating of a silicon carbide-type surge arrester shall be not less than 125 percent of the rating specified in [242.42\(A\)](#).

Informational Note No. 1: For further information on surge arresters, see IEEE C62.11-2012, *Standard for Metal-Oxide Surge Arresters for Alternating-Current Power Circuits (>1 kV)*, and IEEE C62.22-2009, *Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems*.

Informational Note No. 2: The selection of a properly rated metal oxide arrester is based on considerations of maximum continuous operating voltage and the magnitude and duration of overvoltages at the arrester location as affected by phase-to-ground faults, system grounding techniques, switching surges, and other causes. See the manufacturer's application rules for selection of the specific arrester to be used at a particular location.

242.44 Number Required.

Where used at a point on a circuit, a surge arrester shall be connected to each ungrounded conductor. A single installation of such surge arresters shall be permitted to protect a number of interconnected circuits if no circuit is exposed to surges while disconnected from the surge arresters.

242.46 Location.

Surge arresters shall be permitted to be located indoors or outdoors. Surge arresters shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.48 Routing of Surge Arrester Equipment Grounding Conductors.

The conductor used to connect the surge arrester to line, bus, or equipment and to an equipment grounding conductor or grounding electrode connection point as provided in [242.50](#) shall not be any longer than necessary and shall avoid unnecessary bends.

242.50 Connection.

The arrester shall be connected to one of the following:

1. (1)
Grounded service conductor
2. (2)
Grounding electrode conductor
3. (3)
Grounding electrode for the service
4. (4)
Equipment grounding terminal in the service equipment

242.52 Surge-Arrester Conductors.

The conductor between the surge arrester and the line, and the surge arrester and the grounding connection, shall not be smaller than 6 AWG copper or aluminum.

242.54 Interconnections.

The surge arrester protecting a transformer that supplies a secondary distribution system shall be interconnected as specified in [242.54\(A\)](#), (B), or (C).

242.54(A) Metal Interconnections.

A metal interconnection shall be made to the secondary grounded circuit conductor or the secondary circuit grounding electrode conductor, if, in addition to the direct grounding connection at the surge arrester, the connection complies with [242.54\(A\)\(1\)](#) or (A)(2).

242.54(A)(1) Additional Grounding Connection.

The grounded conductor of the secondary has a grounding connection elsewhere to a continuous metal underground water piping system. In urban water-pipe areas where there are at least four water-pipe connections on the neutral conductor and not fewer than four such connections in each mile of neutral conductor, the metal interconnection shall be permitted to be made to the secondary neutral conductor with omission of the direct grounding connection at the surge arrester.

242.54(A)(2) Multigrounded Neutral System Connection.

The grounded conductor of the secondary system is part of a multigrounded neutral system or static wire of which the primary neutral conductor or static wire has at least four grounding connections in each 1.6 km (1 mile) of line in addition to a grounding connection at each service.

242.54(B) Through Spark Gap or Device.

Where the surge arrester grounding electrode conductor is not connected as in [242.54\(A\)](#), or where the secondary is not grounded as in [242.54\(A\)](#) but is otherwise grounded as in [250.52](#), an interconnection shall be made through a spark gap or listed device as required by [242.54\(B\)\(1\)](#) or (B)(2).

242.54(B)(1) Ungrounded or Ungrounded Primary System.

For ungrounded or ungrounded primary systems, the spark gap for a listed device shall have a 60-Hz breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge-arrester grounding electrode.

242.54(B)(2) Multigrounded Neutral Primary System.

For multigrounded neutral primary systems, the spark gap or listed device shall have a 60-Hz breakdown of not more than 3 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge-arrester grounding electrode.

242.54(C) By Special Permission.

An interconnection of the surge-arrester ground and the secondary neutral conductor, other than as provided in [242.54\(A\)](#) or (B), shall be permitted to be made only by special permission.

242.56 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, surge-arrester grounding electrode conductor connections shall be made as specified in Article [250](#), Parts III and X. Grounding electrode conductors installed in metal enclosures shall comply with [250.64\(E\)](#).

Part IV. Voltage Stabilizing Ground Reference (VSGR) systems.**242.68 Listing.**

A VSGR shall be a listed device or system composed of listed components.

242.70 Short-Circuit Current Rating.

The VSGR shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating.

242.71 Voltage Rating.

The rating of the VSGR shall be equal to or greater than the maximum system continuous operating voltage at the point of application.

242.72 Installation.

VSGRs shall be installed in accordance with 242.72(A) through (C).

242.72(A) Service-Supplied Building or Structure.

VSGR shall be connected anywhere on the load side of a service disconnect overcurrent device required in 230.91 unless installed in accordance with 230.82(8).

242.72(B) Feeder-Supplied Building or Structure.

VSGR shall be connected at the building or structure anywhere on the load side of the first overcurrent device at the building or structure.

242.72(C) Separately Derived System.

VSGR shall be connected on the load side of the first overcurrent device in a separately derived system.

242.82 Location.

VSGRs shall be permitted to be located indoors or outdoors and shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.84 Conductor Size.

Line and grounding conductors shall not be smaller than 14 AWG copper or 12 AWG aluminum.

242.90 Connection Between Conductors.

VSGR connections shall follow the manufacturer's instructions for the system connections.

242.92 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, VSGR grounding connections shall be made as specified in Article 250, Part III. Grounding electrode conductors installed in metal enclosures shall comply with 250.64(E).

501.35 Overvoltage Surge Protection.**501.35(A) Class I, Division 1.**

Overvoltage protection devices, surge arresters, surge-protective devices, and capacitors shall be installed in enclosures identified for Class I, Division 1 locations. Surge-protective capacitors shall be of a type designed for specific duty.

501.35(B) Class I, Division 2.

Overvoltage protection devices, surge arresters and surge-protective devices shall be nonarcing, such as metal-oxide varistor (MOV) sealed type, and surge-protective capacitors shall be of a type designed for specific duty. Enclosures shall be permitted to be of the general-purpose type. Overvoltage Surge protection of types other than described in this paragraph shall be installed in enclosures identified for Class I, Division 1 locations.

502.35 Overvoltage Surge Protection — Class II, Divisions 1 and 2.

Overvoltage protection devices, surge arresters and surge-protective devices installed in a Class II, Division 1 location shall be in suitable enclosures. Surge-protective capacitors shall be of a type designed for specific duty.

551.72(E) Connected Devices.

The use of autotransformers shall not be permitted. The use of listed overvoltage and surge protective devices shall be permitted.

Table 490.24 Minimum Clearance of Live Parts

Note: The values given are the minimum clearance for rigid parts and bare conductors under favorable service conditions. They shall be increased for conductor movement or under unfavorable service conditions or wherever space limitations permit. The selection of the associated impulse withstand voltage for a particular system voltage is determined by the characteristics of the [overvoltage surge](#) protective equipment.

490.48(A) Design and Documentation.

(12) [Overvoltage Surge](#) arresters

620.51(E) [Overvoltage Surge](#) Protection.

[Overvoltage protection shall be provided](#) where any of the disconnecting means in [620.51](#) has been designated as supplying an emergency system load, a legally required system load, or a critical operation power system load, ~~listed surge protection shall be provided.~~

645.18 [Overvoltage Surge](#) Protection for Critical Operations Data Systems.

[Overvoltage Listed surge](#) protection shall be provided for critical operations data systems.

670.6 Surge Protection.

Industrial machinery with safety interlock ~~control devices not effectively protected from voltage surges on the incoming supply circuit~~ shall have [overvoltage surge](#) protection installed.

694.7(D) [Overvoltage Protection Surge Protective Devices \(SPD\)](#).

[Overvoltage protection A surge protective device](#) shall be installed between a wind electric system and any loads served by the premises electrical system. The [surge](#) protective device shall be permitted to be a [VSGR](#), or a Type 3 SPD on the circuit serving a wind electric system, or a Type 2 SPD located anywhere on the load side of the service disconnect. [Overvoltage Surge](#) protective devices shall be installed in accordance with Part II of Article [242](#).

695.15 [Overvoltage Surge](#) Protection.

[Overvoltage A listed surge](#) protection ~~device~~ shall be [provided for installed in or on](#) the fire pump controller.

700.8 [Overvoltage Surge](#) Protection.

[Overvoltage protection A listed SPD](#) shall be [provided installed in or on for](#) all emergency systems switchboards and panelboards.

708.20(D) Overvoltage Surge Protection Devices.

Surge protection devices shall be provided at all facility distribution voltage levels



Public Input No. 3200-NFPA 70-2020 [Section No. 242.1]

242.1 Scope.

This article provides the general requirements, installation requirements, and connection requirements for overvoltage protection and overvoltage protective devices. Part II covers surge-protective devices (SPDs) permanently installed on premises wiring systems of not more than 1000 volts, nominal, while Part III covers surge arresters permanently installed on premises wiring systems over 1000 volts, nominal. [Part IV covers Voltage Stabilizing Ground Reference \(VSGR\) systems permanently installed on premises wiring systems for any voltage.](#)

Informational Note: Article 242 combines and replaces Articles 280 and 285 in *NFPA 70-2017*.

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Code_Input.docx	Description of all inputs related to OVERVOLTAGE PROTECTION	

Statement of Problem and Substantiation for Public Input

Substantiation for Changes: In the 2020 NEC cycle, ARTICLES 280 and 285 were combined to make ARTICLE 242. This was a positive change that began to address the issue of OVERVOLTAGE as a technical subject apart from particular product methods (SPDs and Surge Arresters). There are other technologies and products to address the issue of OVERVOLTAGE. This input attempts to add one such technology as well as correlate the other code references to the subject of OVERVOLTAGE, surge protective devices, and surge arresters to be consistent. This is important to allow for other technologies to be utilized without prejudice to certain products promoted by manufacturers.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
<u>Public Input No. 3202-NFPA 70-2020 [New Article after 100]</u>	
<u>Public Input No. 3203-NFPA 70-2020 [New Article after 242]</u>	
<u>Public Input No. 3205-NFPA 70-2020 [Section No. 501.35]</u>	
<u>Public Input No. 3206-NFPA 70-2020 [Section No. 502.35]</u>	
<u>Public Input No. 3208-NFPA 70-2020 [Section No. 551.72(E)]</u>	
<u>Public Input No. 3209-NFPA 70-2020 [Section No. 490.24]</u>	
<u>Public Input No. 3210-NFPA 70-2020 [Section No. 490.48(A)]</u>	
<u>Public Input No. 3211-NFPA 70-2020 [Section No. 620.51(E)]</u>	
<u>Public Input No. 3212-NFPA 70-2020 [Section No. 645.18]</u>	
<u>Public Input No. 3214-NFPA 70-2020 [Section No. 670.6]</u>	
<u>Public Input No. 3216-NFPA 70-2020 [Section No. 694.7(D)]</u>	
<u>Public Input No. 3217-NFPA 70-2020 [Section No. 695.15]</u>	
<u>Public Input No. 3218-NFPA 70-2020 [Section No. 700.8]</u>	
<u>Public Input No. 3219-NFPA 70-2020 [Section No. 708.20(D)]</u>	

Submitter Information Verification

Submitter Full Name: Karl Cunningham
Organization: Self Employed
Street Address:
City:
State:
Zip:
Submittal Date: Sun Sep 06 17:52:26 EDT 2020
Committee: NEC-P10

Substantiation for Changes: In the 2020 NEC cycle, ARTICLES 280 and 285 were combined to make ARTICLE 242. This was a positive change that began to address the issue of **OVERVOLTAGE** as a technical subject apart from particular product methods (SPDs and Surge Arresters). There are other technologies and products to address the issue of **OVERVOLTAGE**. This input attempts to add one such technology as well as correlate the other code references to the subject of **OVERVOLTAGE**, surge protective devices, and surge arresters to be consistent. This is important to allow for other technologies to be utilized without prejudice to certain products promoted by manufacturers.

ARTICLE 100 - DEFINITIONS

Voltage Stabilizing Ground Reference (VSGR) System – an engineered assembly of interconnected passive inductive devices that utilize mutual counter electro-magnetic inductance to stabilize phase voltages of a connected supply system with respect to each other and to ground.

ARTICLE 242 Overvoltage Protection

Part I. General

242.1 Scope.

This article provides the general requirements, installation requirements, and connection requirements for overvoltage protection and overvoltage protective devices. Part II covers surge-protective devices (SPDs) permanently installed on premises wiring systems of not more than 1000 volts, nominal, while Part III covers surge arresters permanently installed on premises wiring systems over 1000 volts, nominal. Part IV covers Voltage Stabilizing Ground Reference (VSGR) systems permanently installed on premises wiring systems for any voltage.

Informational Note: Article [242](#) combines and replaces Articles 280 and 285 in *NFPA 70-2017*.

242.3 Other Articles.

Equipment shall be protected against overvoltage in accordance with the article in this *Code* that covers the type of equipment or location specified in [Table 242.3](#).

Table 242.3 Other Articles

Equipment	Article
Class I locations	501
Class II locations	502
Community antenna television and radio distribution systems	820
Critical operations power systems	708

Table 242.3 Other Articles

Equipment	Article
Elevators, dumbwaiters, escalators, moving walks, platform lifts, and stairway chairlifts	620
Emergency systems	700
Equipment over 1000 volts, nominal	490
Fire pumps	695
Industrial machinery	670
Information technology equipment	645
Modular data centers	646
Outdoor overhead conductors over 1000 volts	399
Radio and television equipment	810
Receptacles, cord connectors, and attachment plugs (caps)	406
Wind electric systems	694

Part II. Surge-Protective Devices (SPDs), 1000 Volts or Less

Informational Note: Surge arresters 1000 volts or less are also known as Type 1 SPDs.

242.6 Uses Not Permitted.

An SPD device shall not be installed in the following:

1. (1)

Circuits over 1000 volts

2. (2)

On ungrounded systems, impedance grounded systems, or corner grounded delta systems unless listed specifically for use on these systems

3. (3)

Where the rating of the SPD is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application

242.8 Listing.

An SPD shall be a listed device.

242.10 Short-Circuit Current Rating.

The SPD shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating. This marking requirement shall not apply to receptacles.

242.12 Type 1 SPDs.

Type 1 SPDs shall be installed in accordance with [242.12\(A\)](#) and (B).

242.12(A) Installation.

Type 1 SPDs shall be permitted to be connected in accordance with one of the following:

1. (1)

To the supply side of the service disconnect as permitted in [230.82](#)(4)

2. (2)

As specified in [242.14](#)

242.12(B) At the Service.

When installed at services, Type 1 SPDs shall be connected to one of the following:

1. (1)

Grounded service conductor

2. (2)

Grounding electrode conductor

3. (3)

Grounding electrode for the service

4. (4)

Equipment grounding terminal in the service equipment

242.14 Type 2 SPDs.

Type 2 SPDs shall be installed in accordance with [242.14\(A\)](#) through (C).

242.14(A) Service-Supplied Building or Structure.

Type 2 SPDs shall be connected anywhere on the load side of a service disconnect overcurrent device required in [230.91](#) unless installed in accordance with [230.82](#)(8).

242.14(B) Feeder-Supplied Building or Structure.

Type 2 SPDs shall be connected at the building or structure anywhere on the load side of the first overcurrent device at the building or structure.

242.14(C) Separately Derived System.

The SPD shall be connected on the load side of the first overcurrent device in a separately derived system.

242.16 Type 3 SPDs.

Type 3 SPDs shall be permitted to be installed on the load side of branch-circuit overcurrent protection up to the equipment served. If included in the manufacturer's instructions, the Type 3 SPD connection shall be a minimum 10 m (30 ft) of conductor distance from the service or separately derived system disconnect.

242.18 Type 4 and Other Component Type SPDs.

Type 4 component assemblies and other component type SPDs shall only be installed by the equipment manufacturer.

242.20 Number Required.

Where used at a point on a circuit, the SPD shall be connected to each ungrounded conductor.

242.22 Location.

SPDs shall be permitted to be located indoors or outdoors and shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.24 Routing of Connections.

The conductors used to connect the SPD to the line or bus and to ground shall not be any longer than necessary and shall avoid unnecessary bends.

242.26 Connection.

Where an SPD device is installed, it shall comply with [242.12](#), [242.14](#), [242.16](#), [242.28](#), and [242.30](#).

242.28 Conductor Size.

Line and grounding conductors shall not be smaller than 14 AWG copper or 12 AWG aluminum.

242.30 Connection Between Conductors.

An SPD shall be permitted to be connected between any two conductors — ungrounded conductor(s), grounded conductor, equipment grounding conductor, or grounding electrode conductor. The grounded conductor and the equipment grounding conductor shall be interconnected only by the normal operation of the SPD during a surge.

242.32 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, SPD grounding connections shall be made as specified in Article [250](#), Part III. Grounding electrode conductors installed in metal enclosures shall comply with [250.64\(E\)](#).

Part III. Surge Arresters, Over 1000 Volts**242.40 Uses Not Permitted.**

A surge arrester shall not be installed where the rating of the surge arrester is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application.

242.42 Surge Arrester Selection.

The surge arresters shall comply with [242.42\(A\)](#) and (B).

242.42(A) Rating.

The rating of a surge arrester shall be equal to or greater than the maximum continuous operating voltage available at the point of application.

242.42(A)(1) Solidly Grounded Systems.

The maximum continuous operating voltage shall be the phase-to-ground voltage of the system.

242.42(A)(2) Impedance or Ungrounded System.

The maximum continuous operating voltage shall be the phase-to-phase voltage of the system.

242.42(B) Silicon Carbide Types.

The rating of a silicon carbide-type surge arrester shall be not less than 125 percent of the rating specified in [242.42\(A\)](#).

Informational Note No. 1: For further information on surge arresters, see IEEE C62.11-2012, *Standard for Metal-Oxide Surge Arresters for Alternating-Current Power Circuits (>1 kV)*, and IEEE C62.22-2009, *Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems*.

Informational Note No. 2: The selection of a properly rated metal oxide arrester is based on considerations of maximum continuous operating voltage and the magnitude and duration of overvoltages at the arrester location as affected by phase-to-ground faults, system grounding techniques, switching surges, and other causes. See the manufacturer's application rules for selection of the specific arrester to be used at a particular location.

242.44 Number Required.

Where used at a point on a circuit, a surge arrester shall be connected to each ungrounded conductor. A single installation of such surge arresters shall be permitted to protect a number of interconnected circuits if no circuit is exposed to surges while disconnected from the surge arresters.

242.46 Location.

Surge arresters shall be permitted to be located indoors or outdoors. Surge arresters shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.48 Routing of Surge Arrester Equipment Grounding Conductors.

The conductor used to connect the surge arrester to line, bus, or equipment and to an equipment grounding conductor or grounding electrode connection point as provided in [242.50](#) shall not be any longer than necessary and shall avoid unnecessary bends.

242.50 Connection.

The arrester shall be connected to one of the following:

1. (1)
Grounded service conductor
2. (2)
Grounding electrode conductor
3. (3)
Grounding electrode for the service
4. (4)
Equipment grounding terminal in the service equipment

242.52 Surge-Arrester Conductors.

The conductor between the surge arrester and the line, and the surge arrester and the grounding connection, shall not be smaller than 6 AWG copper or aluminum.

242.54 Interconnections.

The surge arrester protecting a transformer that supplies a secondary distribution system shall be interconnected as specified in [242.54\(A\)](#), (B), or (C).

242.54(A) Metal Interconnections.

A metal interconnection shall be made to the secondary grounded circuit conductor or the secondary circuit grounding electrode conductor, if, in addition to the direct grounding connection at the surge arrester, the connection complies with [242.54\(A\)\(1\)](#) or (A)(2).

242.54(A)(1) Additional Grounding Connection.

The grounded conductor of the secondary has a grounding connection elsewhere to a continuous metal underground water piping system. In urban water-pipe areas where there are at least four water-pipe connections on the neutral conductor and not fewer than four such connections in each mile of neutral conductor, the metal interconnection shall be permitted to be made to the secondary neutral conductor with omission of the direct grounding connection at the surge arrester.

242.54(A)(2) Multigrounded Neutral System Connection.

The grounded conductor of the secondary system is part of a multigrounded neutral system or static wire of which the primary neutral conductor or static wire has at least four grounding connections in each 1.6 km (1 mile) of line in addition to a grounding connection at each service.

242.54(B) Through Spark Gap or Device.

Where the surge arrester grounding electrode conductor is not connected as in [242.54\(A\)](#), or where the secondary is not grounded as in [242.54\(A\)](#) but is otherwise grounded as in [250.52](#), an interconnection shall be made through a spark gap or listed device as required by [242.54\(B\)\(1\)](#) or (B)(2).

242.54(B)(1) Ungrounded or Ungrounded Primary System.

For ungrounded or ungrounded primary systems, the spark gap for a listed device shall have a 60-Hz breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge-arrester grounding electrode.

242.54(B)(2) Multigrounded Neutral Primary System.

For multigrounded neutral primary systems, the spark gap or listed device shall have a 60-Hz breakdown of not more than 3 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge-arrester grounding electrode.

242.54(C) By Special Permission.

An interconnection of the surge-arrester ground and the secondary neutral conductor, other than as provided in [242.54\(A\)](#) or (B), shall be permitted to be made only by special permission.

242.56 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, surge-arrester grounding electrode conductor connections shall be made as specified in Article [250](#), Parts III and X. Grounding electrode conductors installed in metal enclosures shall comply with [250.64\(E\)](#).

Part IV. Voltage Stabilizing Ground Reference (VSGR) systems.**242.68 Listing.**

A VSGR shall be a listed device or system composed of listed components.

242.70 Short-Circuit Current Rating.

The VSGR shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating.

242.71 Voltage Rating.

The rating of the VSGR shall be equal to or greater than the maximum system continuous operating voltage at the point of application.

242.72 Installation.

VSGRs shall be installed in accordance with 242.72(A) through (C).

242.72(A) Service-Supplied Building or Structure.

VSGR shall be connected anywhere on the load side of a service disconnect overcurrent device required in 230.91 unless installed in accordance with 230.82(8).

242.72(B) Feeder-Supplied Building or Structure.

VSGR shall be connected at the building or structure anywhere on the load side of the first overcurrent device at the building or structure.

242.72(C) Separately Derived System.

VSGR shall be connected on the load side of the first overcurrent device in a separately derived system.

242.82 Location.

VSGRs shall be permitted to be located indoors or outdoors and shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.84 Conductor Size.

Line and grounding conductors shall not be smaller than 14 AWG copper or 12 AWG aluminum.

242.90 Connection Between Conductors.

VSGR connections shall follow the manufacturer's instructions for the system connections.

242.92 Grounding Electrode Conductor Connections and Enclosures.

Except as indicated in this article, VSGR grounding connections shall be made as specified in Article 250, Part III. Grounding electrode conductors installed in metal enclosures shall comply with 250.64(E).

501.35 Overvoltage Surge Protection.**501.35(A) Class I, Division 1.**

Overvoltage protection devices, surge arresters, surge-protective devices, and capacitors shall be installed in enclosures identified for Class I, Division 1 locations. Surge-protective capacitors shall be of a type designed for specific duty.

501.35(B) Class I, Division 2.

Overvoltage protection devices, surge arresters and surge-protective devices shall be nonarcing, such as metal-oxide varistor (MOV) sealed type, and surge-protective capacitors shall be of a type designed for specific duty. Enclosures shall be permitted to be of the general-purpose type. Overvoltage Surge protection of types other than described in this paragraph shall be installed in enclosures identified for Class I, Division 1 locations.

502.35 Overvoltage Surge Protection — Class II, Divisions 1 and 2.

Overvoltage protection devices, surge arresters and surge-protective devices installed in a Class II, Division 1 location shall be in suitable enclosures. Surge-protective capacitors shall be of a type designed for specific duty.

551.72(E) Connected Devices.

The use of autotransformers shall not be permitted. The use of listed overvoltage and surge protective devices shall be permitted.

Table 490.24 Minimum Clearance of Live Parts

Note: The values given are the minimum clearance for rigid parts and bare conductors under favorable service conditions. They shall be increased for conductor movement or under unfavorable service conditions or wherever space limitations permit. The selection of the associated impulse withstand voltage for a particular system voltage is determined by the characteristics of the [overvoltage surge](#) protective equipment.

490.48(A) Design and Documentation.

(12) [Overvoltage Surge](#) arresters

620.51(E) [Overvoltage Surge](#) Protection.

[Overvoltage protection shall be provided](#) where any of the disconnecting means in [620.51](#) has been designated as supplying an emergency system load, a legally required system load, or a critical operation power system load, ~~listed surge protection shall be provided.~~

645.18 [Overvoltage Surge](#) Protection for Critical Operations Data Systems.

[Overvoltage Listed surge](#) protection shall be provided for critical operations data systems.

670.6 Surge Protection.

Industrial machinery with safety interlock ~~control devices not effectively protected from voltage surges on the incoming supply circuit~~ shall have [overvoltage surge](#) protection installed.

694.7(D) [Overvoltage Protection Surge Protective Devices \(SPD\)](#).

[Overvoltage protection A surge protective device](#) shall be installed between a wind electric system and any loads served by the premises electrical system. The [surge](#) protective device shall be permitted to be a [VSGR](#), or a Type 3 SPD on the circuit serving a wind electric system, or a Type 2 SPD located anywhere on the load side of the service disconnect. [Overvoltage Surge](#) protective devices shall be installed in accordance with Part II of Article [242](#).

695.15 [Overvoltage Surge](#) Protection.

[Overvoltage A listed surge](#) protection ~~device~~ shall be [provided for installed in or on](#) the fire pump controller.

700.8 [Overvoltage Surge](#) Protection.

[Overvoltage protection A listed SPD](#) shall be [provided installed in or on for](#) all emergency systems switchboards and panelboards.

708.20(D) Overvoltage Surge Protection Devices.

Surge protection devices shall be provided at all facility distribution voltage levels



Public Input No. 3802-NFPA 70-2020 [Section No. 242.1]

242.1 Scope.

This article provides the general requirements, installation requirements, and connection requirements for overvoltage protection and overvoltage protective devices. Part II covers surge-protective devices (SPDs) permanently installed on premises wiring systems of not more than 1000 volts, nominal, while Part III covers surge arresters permanently installed on premises wiring systems over 1000 volts, nominal.

Informational Note: - ~~Article 242~~ - This article combines and replaces Articles 280 and 285 in *NFPA 70-2017*.

Statement of Problem and Substantiation for Public Input

Section 4.1.4 of the 2020 NEC(r) Style Manual prohibits reference to an entire article, other than Article 100. The reference to Article 242 can be changed to "This article" to comply, while it appears the references to the former article numbers in the 2017 NEC(r) may need to stay as written for clarity.

Submitter Information Verification

Submitter Full Name: Richard Holub

Organization: The DuPont Company, Inc.

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 13:10:25 EDT 2020

Committee: NEC-P10

**Public Input No. 2990-NFPA 70-2020 [Section No. 242.3]****242.3 Other Articles.**

Equipment shall be protected against overvoltage in accordance with the article in this *Code* that covers the type of equipment or location specified in Table 242.3.

Table 242.3 Other Articles

<u>Equipment</u>	<u>Article</u>
Class I locations	501
Class II locations	502
Community antenna television and radio distribution systems	820
Critical operations power systems	708
Elevators, dumbwaiters, escalators, moving walks, platform lifts, and stairway chairlifts	620
Emergency systems	700
Equipment over 1000 volts, nominal	490
Fire pumps	695 <u>703</u>
Industrial machinery	670
Information technology equipment	645
Modular data centers	646
Outdoor overhead conductors over 1000 volts	399
Radio and television equipment	810
Receptacles, cord connectors, and attachment plugs (caps)	406
Wind electric systems	694

Statement of Problem and Substantiation for Public Input

This public input was prepared by the correlating committee task group focused on alternative energy requirements. This task group consisted of the following members: Derrick Atkins (CMP 5), Greg Ball (CMP 13) Ken Boyce (CMP 1), Bill Brooks (CMP 4), Bruce Campbell, Thomas Domitrovich (CMP 2, CMP 10), Jason Fisher (CMP 4), Scott Harding (CMP 5), Pete Jackson (CMP 8), David Kendall (CMP 8, CC), Chad Kennedy (CMP 13), Christine Porter (CMP 5, CC), Timothy Windey (CMP 13). This change aligns with an effort to re-organize the alternative energy sources NEC Articles into a series of articles closely located together. This reorganization places all sources alternate sources as follows: 689 On-Site Energy Sources 690 Solar Photovoltaic (PV) Systems 691 Large-Scale Photovoltaic (PV) Systems 692 Fuel Cell Systems 693 Generators 694 Wind Electric Systems 695 Energy Storage Systems 696 Storage Batteries This public input aligns with changes that move 695 to 703. This input supports this effort and to better align with the fact that this Article is closely related to emergency systems. The requirements of this new 703 focus on more than just a fire pump and arguably more so focuses on fire pump systems which is closely aligned with Chapter 7 of the NEC. This move makes way for alignment of alternative energy sources article arrangement. These articles are closely related to each other and this change is in alignment with the direction by the correlating committee to review alternative energy sources for conflicts and usability. This new alignment will create a similar structure as that found for hazardous locations. The new Article 689 is the a combination of Articles 705, 710 and 712 and will act to be the new general requirements for this series of alternative energy sources.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2987-NFPA 70-2020 [Article 695]	Move of 695 to 703

Submitter Information Verification

Submitter Full Name: Thomas Domitrovich
Organization: Eaton Corporation
Street Address:
City:

State:

Zip:

Submittal Date: Thu Sep 03 19:38:57 EDT 2020

Committee: NEC-P10

**Public Input No. 3084-NFPA 70-2020 [New Section after 242.6]****24.7 Reconditioned Equipment**

Surge Protective Devices shall not be permitted to be reconditioned. This excludes manufacturer approved serviceable components.

Statement of Problem and Substantiation for Public Input

Surge protective devices are not suitable for reconditioning because replacing or reconditioning may violate the listing of the surge protective device.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 14:19:52 EDT 2020

Committee: NEC-P10

**Public Input No. 699-NFPA 70-2020 [Sections 242.6, 242.8, 242.10, 242.12]****Sections 242.6, 242.8, 242.10, 242.12****242.6–12 Uses Not Permitted.**

An SPD device shall not be installed in the following:

- (1) Circuits over 1000 volts
- (2) On ungrounded systems, impedance grounded systems, or corner grounded delta systems unless listed specifically for use on these systems
- (3) Where the rating of the SPD is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application

242.8–6 Listing.

An SPD shall be a listed device.

242.10–8 Short-Circuit Current Rating.

The SPD shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating. This marking requirement shall not apply to receptacles.

242.12–13 Type 1 SPDs.

Type 1 SPDs shall be installed in accordance with 242.12(A) and (B).

(A) Installation.

Type 1 SPDs shall be permitted to be connected in accordance with one of the following:

- (1) To the supply side of the service disconnect as permitted in 230.82(4)
- (2) As specified in 242.14

(B) At the Service.

When installed at services, Type 1 SPDs shall be connected to one of the following:

- (1) Grounded service conductor
- (2) Grounding electrode conductor
- (3) Grounding electrode for the service
- (4) Equipment grounding terminal in the service equipment

Statement of Problem and Substantiation for Public Input

The numbering system used in Article 242 of the 2020 version does not match the majority of the code standard numbering system. Changing the numbers complies with the NEC Style Manual.

Submitter Information Verification

Submitter Full Name: David Hittinger

Organization: IEC

Street Address:

City:

State:

Zip:

Submission Date: Thu Mar 19 12:21:44 EDT 2020

Committee: NEC-P10

**Public Input No. 3470-NFPA 70-2020 [New Section after 242.8]****242.9 Indicating.**

An SPD shall have an indicator of protection failure.

Statement of Problem and Substantiation for Public Input

This could be inserted as new language; thus the reason for assignment into a new paragraph. The Code has begun requiring SPD's and they are great products for protection of equipment. However, should one be damaged or defaced, there is not a standard to indicate failure. Thus, this leaves the occupant/owner without protection and unknowingly unprotected. This could be something that may be proactive on enforcement date to allow manufacturers to meet the requirement.

Submitter Information Verification

Submitter Full Name: Rudolph Garza

Organization: IAEI

Affiliation: IAEI

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 16:12:23 EDT 2020

Committee: NEC-P10



Public Input No. 479-NFPA 70-2020 [Section No. 242.12 [Excluding any Sub-Sections]]

Type 1 SPDs shall ~~may~~ be installed in accordance with 242.12(A) and (B).

Statement of Problem and Substantiation for Public Input

Requiring SPDs in residential units is problematic because after installation and inspection it may be decades before the SPD is inspected or serviced. SPDs lose the effectiveness by assaults over time. The standard for usage of type 3 SPDs is to simply replace them at intervals or after a known surge event. Replacing type 3 SPDs is inexpensive and can be performed by a home owner. Replacing Type 1 and 2 SPDs is expensive and not advised except by trained personnel. Thus as the decades role by, homeowners will have a false sense of protection.

Thus the installation of SPDs should be optional, as it is not the best solution for residences where regular inspection and maintenance is not likely to be performed.

As an example, my home was built in 1929 with knob and tube wiring and a fuse box. In the 1950s a Square D breaker box was installed upstream of the fuse box to allow for an electric kitchen. New circuits were added to the breaker box over the decades. Mini-breakers were installed to replace fuses. The system has major parts over 90 years old. The modern part of the system is 60 years old. The 90 year old wires are of very high quality, The 1950s Square D components are of the highest quality for that time and still work well.

Can we be assured that a Type 1 or 2 SPD will be working in 60 years let alone 90 or 100?

Because SPDs will fail in time, there should be a system to replace type 1 and 2 SPDs easily. The standard should include:

1. a shut off upstream of the SPD
2. a plug in for the SPD. when the current is shut off to the SPD it should be able to be removed without tools similar to how meters are unplugged
3. an emergency bypass for the SPD should be provided by a mechanically activated switch in SPD enclosure. This is required for when SPDs fail and the resident has medical or other equipment.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 480-NFPA 70-2020 [Section No. 242.14 [Excluding any Sub-Sections]]	
Public Input No. 481-NFPA 70-2020 [Section No. 242.14(A)]	
Public Input No. 486-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 487-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 488-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 489-NFPA 70-2020 [Section No. 230.67(B)]	
Public Input No. 491-NFPA 70-2020 [Section No. 230.67(C)]	
Public Input No. 492-NFPA 70-2020 [Section No. 230.67(D)]	

Submitter Information Verification

Submitter Full Name: saul roe
Organization: HRTM LLC
Street Address:
City:
State:
Zip:
Submission Date: Tue Feb 18 18:32:00 EST 2020
Committee: NEC-P10

**Public Input No. 481-NFPA 70-2020 [Section No. 242.14(A)]**

(A) Service-Supplied Building or Structure.

Type 2 SPDs ~~shall~~ may be connected anywhere on the load side of a service disconnect overcurrent device required in 230.91 unless installed in accordance with 230.82(8).

Statement of Problem and Substantiation for Public Input

this should be permissive, for economic reasons and that in residences, SPDs are unlikely to be inspected or maintained during the life of the building.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 479-NFPA 70-2020 [Section No. 242.12 [Excluding any Sub-Sections]]	same
Public Input No. 480-NFPA 70-2020 [Section No. 242.14 [Excluding any Sub-Sections]]	same
Public Input No. 486-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 487-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 488-NFPA 70-2020 [Section No. 230.67(A)]	
Public Input No. 489-NFPA 70-2020 [Section No. 230.67(B)]	

Submitter Information Verification

Submitter Full Name: saul roe

Organization: HRTM LLC

Street Address:

City:

State:

Zip:

Submittal Date: Tue Feb 18 19:45:34 EST 2020

Committee: NEC-P10

**Public Input No. 480-NFPA 70-2020 [Section No. 242.14 [Excluding any Sub-Sections]]**

Type 2 SPDs shall- may be installed in accordance with 242.14(A) through (C).

Statement of Problem and Substantiation for Public Input

installation of an SPD should be optional. The SPD is for economic protection not safety. Thus economic decisions should be made by the owner or builder. Further SPDs wear out over time and in residences it is unlikely that they will be inspected or maintained during there life time.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
<u>Public Input No. 479-NFPA 70-2020 [Section No. 242.12 [Excluding any Sub-Sections]]</u>	same issue, different SPD type
<u>Public Input No. 481-NFPA 70-2020 [Section No. 242.14(A)]</u>	
<u>Public Input No. 486-NFPA 70-2020 [Section No. 230.67(A)]</u>	
<u>Public Input No. 487-NFPA 70-2020 [Section No. 230.67(A)]</u>	
<u>Public Input No. 488-NFPA 70-2020 [Section No. 230.67(A)]</u>	
<u>Public Input No. 489-NFPA 70-2020 [Section No. 230.67(B)]</u>	
<u>Public Input No. 491-NFPA 70-2020 [Section No. 230.67(C)]</u>	
<u>Public Input No. 492-NFPA 70-2020 [Section No. 230.67(D)]</u>	

Submitter Information Verification

Submitter Full Name: saul roe
Organization: HRTM LLC
Street Address:
City:
State:
Zip:
Submittal Date: Tue Feb 18 19:40:07 EST 2020
Committee: NEC-P10

**Public Input No. 2284-NFPA 70-2020 [Section No. 242.26]****242.26**– Connection.

Where an SPD device is installed, it shall comply with 242.12 , 242.14 , 242.16 , 242.28 , and 242.30 .

Statement of Problem and Substantiation for Public Input

This section serves no purpose. Are we insinuating that the rest of the article is optional?

Submitter Information Verification

Submitter Full Name: Ryan Jackson

Organization: Ryan Jackson

Street Address:

City:

State:

Zip:

Submittal Date: Thu Aug 13 15:37:26 EDT 2020

Committee: NEC-P10

**Public Input No. 3049-NFPA 70-2020 [New Section after 242.40]****242.41 Reconditioned Equipment**

Surge arresters shall not be permitted to be reconditioned.

Statement of Problem and Substantiation for Public Input

Surge arresters are not suitable for re-conditioning for two reasons. First, they are hermetically sealed at the factory to prevent moisture ingress. Second, there are no commercially available components i.e. arrester OEMs manufacture their own components and do not offer them for sale.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 11:00:23 EDT 2020

Committee: NEC-P10

**Public Input No. 3088-NFPA 70-2020 [Section No. 242.42(A)]****(A) Rating.**

The duty cycle rating of a surge arrester shall be ~~equal to or greater than the maximum continuous operating~~ not less than 125 percent of the maximum system voltage available at the point of application.

(1) Solidly Grounded Systems.

The maximum continuous operating voltage shall be the phase-to-ground voltage of the system.

(2) Impedance or Ungrounded System.

The maximum continuous operating voltage shall be the phase-to-phase voltage of the system.

Statement of Problem and Substantiation for Public Input

The revisions to this section are an attempt to better align the NEC rating requirements for surge arresters with the IEEE C62.11 Standard. The duty cycle rating of a surge arrester is a short-term temporary overvoltage the arrester can withstand based on the maximum system voltage present and should not be less than 125% of the maximum system voltage. The current rating requirements are inadequate and do not properly reflect the industry standards for surge arrester duty cycle ratings.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 14:24:32 EDT 2020

Committee: NEC-P10

**Public Input No. 3089-NFPA 70-2020 [Section No. 242.42(B)]****(B)– Silicon Carbide Types.**

The rating of a silicon carbide-type surge arrester shall be not less than 125 percent of the rating specified in 242.42(A) .

Informational Note No. 1: For further information on surge arresters, see IEEE C62.11-2012, *Standard for Metal-Oxide Surge Arresters for Alternating-Current Power Circuits (>1 kV)* , and IEEE C62.22-2009, *Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems* .

Informational Note No. 2: The selection of a properly rated metal oxide arrester is based on considerations of maximum continuous operating voltage and the magnitude and duration of overvoltages at the arrester location as affected by phase-to-ground faults, system grounding techniques, switching surges, and other causes. See the manufacturer's application rules for selection of the specific arrester to be used at a particular location.

Statement of Problem and Substantiation for Public Input

The requirements of this section apply to a product that is no longer manufactured nor has a valid industry standard. The IEEE C62.1 Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits was withdrawn from publication on June 3, 2000. Maintaining this requirement in the code has no useful purpose and therefore should be deleted.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 14:28:13 EDT 2020

Committee: NEC-P10

**Public Input No. 2289-NFPA 70-2020 [Section No. 242.54(B)(2)]****(2) Multigrounded Neutral Primary System.**

For multigrounded neutral primary systems, the spark gap ~~or for a~~ listed device shall have a 60-Hz breakdown of not more than 3 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge-arrester grounding electrode.

Statement of Problem and Substantiation for Public Input

Refer to example of correct wording in 242.54(B)(1); ' the spark gap for a listed device'. Whereas the correct wording for 242.54(B)(2) is ' the spark gap or listed device'

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 2290-NFPA 70-2020 [Section No. 242.54(B) [Excluding any Sub-Sections]]	
Public Input No. 2290-NFPA 70-2020 [Section No. 242.54(B) [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: John Blissett
Organization: Bernhard TME
Street Address:
City:
State:
Zip:
Submittal Date: Thu Aug 13 16:31:17 EDT 2020
Committee: NEC-P10

**Public Input No. 2290-NFPA 70-2020 [Section No. 242.54(B) [Excluding any Sub-Sections]]**

Where the surge arrester grounding electrode conductor is not connected as in 242.54(A) , or where the secondary is not grounded as in 242.54(A) but is otherwise grounded as in 250.52 , an interconnection shall be made through a spark gap

or

of a listed device as required by 242.54(B)(1) or (B)(2).

Statement of Problem and Substantiation for Public Input

242.54(B)(1) uses the phrase 'the spark gap for a listed device'

242.54(B)(2) uses the phrase 'the spark gap or listed device', but should be revised to ' the spark gap for a listed device'.

So for consistency, revise 242.52(B) text to 'a spark gap of a listed device'.

Related Public Inputs for This Document**Related Input****Relationship**

Public Input No. 2289-NFPA 70-2020 [Section No. 242.54(B)(2)]

Public Input No. 2289-NFPA 70-2020 [Section No. 242.54(B)(2)]

Submitter Information Verification

Submitter Full Name: John Blissett

Organization: Bernhard TME

Street Address:

City:

State:

Zip:

Submittal Date: Thu Aug 13 16:37:57 EDT 2020

Committee: NEC-P10



Public Input No. 3500-NFPA 70-2020 [Definition: Circuit Breaker. [Excluding any Sub-Sections]]

Circuit Breaker

A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. (CMP-10)

Informational Note: The automatic opening means can be integral, direct acting with the circuit breaker, or remote from the circuit breaker.

Statement of Problem and Substantiation for Public Input

Adding the term prior to the definition will allow the sub-definitions to have their own title as well.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 18:02:12 EDT 2020

Committee: NEC-P10



Public Input No. 248-NFPA 70-2020 [Part I.]

Part I. General

Fuse. An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it. (CMP-10)

Informational Note: A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Statement of Problem and Substantiation for Public Input

The only definition of a fuse is found in Part II of Article 100 which is titled "Over 1000 Volts, Nominal". This new definition would be a general definition of a fuse, a term which is used in many locations within the NEC. This language does not conflict with that which is found in Part II of Article 100.

Submitter Information Verification

Submitter Full Name: Thomas Domitrovich

Organization: Eaton Corporation

Street Address:

City:

State:

Zip:

Submittal Date: Sat Jan 04 13:49:50 EST 2020

Committee: NEC-P10



Public Input No. 3090-NFPA 70-2020 [Part II.]

Part II. Surge-Protective Devices (SPDs), 1000 Volts or Less

~~Informational Note: Surge arresters 1000 volts or less are also known as Type 1 SPDs.~~

Statement of Problem and Substantiation for Public Input

This informational note is an artifact from previous editions of the NEC dating back to the 2008 edition when the title of Article 285 was changed from Transient Voltage Surge Suppressors (TVSS) to Surge-Protective Devices (SPDs), 1 kV or Less and when Article 280 covering Surge Arresters was changed to Over 1 kV. Two informational notes were added to Section 285.1 to remind the user of the code that Type 1 SPDs were previously referred to as surge arresters under Article 280 and Type 2 and Type 3 SPDs were previously referred to as TVSS. See Public Comment 5-168, Log #2351 of the 2007 ROP.

During the 2014 NEC development cycle, Public Comment 5-110, Log #1504 removed all references to surge arresters and TVSS under Article 285, however, informational note #1 unintendedly remained in the code. During the 2020 NEC development cycle, this remaining artifact of the 2008 NEC was relocated to Article 242 as an informational note under Part II.

This informational note is no longer valid nor serves any useful purpose. Surge arresters 1000 volts or less are not considered or known as Type 1 SPDs so this note is incorrect and confusing for the users of the code. Deleting this information note improves the clarity of the code.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 14:34:00 EDT 2020

Committee: NEC-P10



Public Input No. 3092-NFPA 70-2020 [Part II.]

Part II. Surge-Protective Devices (SPDs), 1000 Volts or Less

Informational Note: Surge arresters 1000 volts or less are also known as Type 1 SPDs.

Informational Note No. 2: The selection of property rated surge-protective device (SPD) is based on several factors and considerations such as the maximum continuous operating voltage, the magnitude and duration of surge current, and the available fault current present. For additional guidance on the selection of SPD ratings, see NEMA SPD 1.1-2019, Part 1-Surge-Protective Device Specification Guide for Low Voltage Power Distribution Systems. Further information on the susceptibility of electric and electronic equipment from surges, see NEMA VSP 1-2017, Susceptibility of Electrical and Electronic Components to Surge Damage and NEMA VSP P2-2019 Impact of Surges on Equipment: Susceptibility of Electronics to Surge Damage. For additional information on the selection and application of SPDs, see C62-2018-IEEE Standard Test Specifications for Surge-Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low-Voltage (1000 V and less) AC Power Circuits and 62.72-2016 -IEEE Guide for the Application of Surge-Protective Devices for Use on the Load Side of Service Equipment in Low-Voltage (1000 V or Less, 50Hz or 60 Hz) AC Power Circuits.

Statement of Problem and Substantiation for Public Input

The intent of this public input is to provide guidance to the user of the code on how to properly specify and select SPD ratings based on many specific factors, environmental conditions, risk exposure, and other important considerations by pointing them to three NEMA guidelines and two IEEE Standards. NEMA SPD 1.1-2019 is the first in a new series intended to guide the evaluation, specification, and use of SPD's deployed in low-voltage power distribution system applications. NEMA VSP 1-2017 presents the test results of actual devices in a real-world surge environment and generates information on the surge susceptibility for various electrical components. NEMA VSP P2-2019 provides evidence showing all electrical products, sensors, and systems containing electronic components are at risk of suffering damage from electrical surges to assist those who design electronic and electrical equipment and for those who install and use electronic and electrical equipment. The purpose of the C62.62-2018 standard is to provide users with test methods and test specifications applicable to low-voltage surge-protective devices used on the load side of the service equipment, intended for limiting transient overvoltages that can appear on ac power circuits of 1000 V (rms) or less. C62.72-2016 provides guidance to users on the application considerations of SPDs to power distribution systems and associated equipment. This guide applies to SPDs to be connected to the load side of the service equipment (and main over current protective device) of 50 Hz or 60 Hz ac power circuits rated 1000 V ac or less. Information on surge origins, effects of surges, number and magnitude of surge events, location categories, power distribution system (PDS) configurations, grounding and bonding, SPD specifications, SPD ratings, SPD characteristics, SPD lifetime, interactions of SPDs with a PDS, and SPD coordination considerations are provided in the guide.

Submitter Information Verification

Submitter Full Name: Megan Hayes

Organization: Nema

Street Address:

City:

State:

Zip:

Submittal Date: Fri Sep 04 14:38:53 EDT 2020

Committee: NEC-P10

**Public Input No. 583-NFPA 70-2020 [New Part after IX.]****TITLE OF NEW CONTENT**

Type your content here ...240.xxx

240.xxx Reconditioned Circuit Breakers. Low- and medium-voltage power circuit breakers, and high-voltage circuit breakers shall be permitted to be reconditioned

Statement of Problem and Substantiation for Public Input

This PI seeks to relocate some of the text in 240.88 to a new section in Part IX. I will be the first to admit that I am not sure which parts of "marking" versus "listing" are appropriate at these voltages, so I will have to defer to the expertise of CMP 10 for that.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
<u>Public Input No. 582-NFPA 70-2020 [Section No. 240.88]</u>	Relocation of text

Submitter Information Verification

Submitter Full Name: Ryan Jackson
Organization: Ryan Jackson
Street Address:
City:
State:
Zip:
Submittal Date: Mon Mar 02 15:27:31 EST 2020
Committee: NEC-P10

**Public Input No. 3106-NFPA 70-2020 [New Part after VII.]****TITLE OF NEW CONTENT**

Type your content here ...

[240.70 Listing](#)[Low Voltage Circuit Breakers covered in this section shall be listed.](#)

[Informational note: The standards that can be used for the listing of low voltage circuit breakers are UL 489 Standard for Safety: Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures. Or UL 1066 Standard for Safety: Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures.](#)

Statement of Problem and Substantiation for Public Input

The requirement for circuit breakers to be listed will add clarity to the code and provide users with the necessary confidence in the product safety. Questions arise consistently in the field as to whether circuit breakers are required to be listed by including the listing requirement specifically in the code, it will remove this confusion. There are a number of occurrences where Supplementary protectors are incorrectly used in applications specifically requiring listed circuit breakers and this issue will be easier to avoid.

Submitter Information Verification

Submitter Full Name: Randy Dollar
Organization: Siemens Industry
Affiliation: American Circuit Breaker Manufacturers Association (ACBMA)
Street Address:
City:
State:
Zip:
Submittal Date: Fri Sep 04 16:46:45 EDT 2020
Committee: NEC-P10

Copyright Assignment

I, Randy Dollar, 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 Randy Dollar, 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. 3819-NFPA 70-2020 [Global Input]

See Attached Word Document for Changes

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Article_235_Public_Input_-_Final2.docx	Global PI to Revise Articles 210, 215, 225, and 230, Adding New Article 235.	✓

Statement of Problem and Substantiation for Public Input

This Public Input is submitted on behalf of a Correlating Committee Long-Range Planning Task Group consisting of Robert Osborne (Chair), Paul Barnhart, Lou Grahor, David Temple, Donny Cook, Dean Hunter, Mike Querry, Roger McDaniel, Dave Burns, Rod Belisle, and Kevin Rogers. This Public Input, along with other companion Public Inputs, was developed with the goal of improving usability and providing a platform to increase the focus on requirements associated with Medium or High Voltage.

Installations, including campus-wide distribution systems, microgrids, alternative energy installations, etc., are covered by the Scope of the NEC®; however, requirements for conductors, equipment, and raceways used in applications operating in systems rated over 1000 volts are treated as an “after-thought” in how they are arranged in the document and covered by Technical Committees. In many cases, the “over 1000 volts” requirements exist in a dedicated “Part” within the Article – such is the case with existing Article 300. In other cases, similar products are handled in two separate Articles, such as with “switchgear”, with equipment rated 1000 volts and below addressed in Article 408, and equipment rated over 1000 volts addressed in Article 490. In addition to these two approaches, there are Articles where the “over 1000 volts” is intermingled with the “under 1000 volt” requirements, such as the case with Article 225. In many of these cases, the information for over 1000 volts is very limited (for example, Article 240 has only 3 Sections in the Part dedicated to requirements for over 1000 volts).

This Task Group’s initial task was to establish a demarcation for what can be referred to as Medium or High Voltage. The recommendation has been to establish this threshold as being equipment rated over 1000 Vac, 1500 Vdc. It is believed that levels below these voltages can be addressed with existing requirements for systems rated 1000 V ac max, and 1500 V dc, as this has been established as an upper limit for photovoltaic applications within Article 690, with requirements noting that those systems are not required to comply with Parts II and III of Article 490.

Using these limits, the Task Group then set out to identify a structure to better align requirements, improve consistency in approach, improve usability, and create the opportunity for a Code Making Panel to have an increased focus on higher voltage applications.

All changes to Articles 215, 225, and 230 related to installations over 1000 Vac and 1500 Vdc, along with what seem to be applicable requirements in Article 210, are incorporated into proposed Article 235. This is submitted as a Global Input, and includes deleted text that is relocated from Articles 215, 225, and 230. Below is a summary of those changes:

Add a new Article 235 “Services, Feeders, & Branch Circuits Over 1000 VAC, 1500 VDC, Nominal”

- Add a new Part I titled Scope and General to new Article 235
- Add a new section 235.1 with suggested scope of the Article

Branch Circuits – Part II

- o Add a new Part II titled Branch Circuits to new Article 235
- o Add a new 235.105 titled Identification for Branch Circuits with first level subdivisions for grounded

conductors, equipment grounding conductors, and ungrounded conductors to mirror the requirements in Article 210 for branch circuits under 1000 volts.

- o Add a new 235.106 titled Branch Circuit Voltage Limitations Over 1,000 volts Between Conductors to mirror the requirements in Article 210 for branch circuits under 1000 volts.
- o Add a new 235.111 titled Branch Circuits Required with first level subdivision for the number of circuits and distribution of the loads to mirror the requirements in Article 210 for branch circuits under 1000 volts.
- o Add a new 235.118 title Branch Circuit Rating to address the rating of the circuit and mirror the requirement in Article 210 for branch circuits under 1000 volts.
- o Add a new 235.119 titled Conductors-Minimum Ampacity and Size with second level subdivision for the general and supervised installations to mirror the requirements in Article 210 for branch circuits under 1000 volts.
- o Add a new 235.120 titled Overcurrent Protection with first level subdivisions for continuous and noncontinuous loads, conductor protection, and equipment protection to mirror the requirements in Article 210 for branch circuits under 1000 volts.

Feeders – Part III

- o Add a new Part III titled Feeders to new Article 235.
- o Delete 215.2 (B) and renumber accordingly.
- o Add a new 235.202 titled Minimum Rating and Size with three first level subdivisions feeders supplying transformers, feeders supplying transformers and utilization equipment, and supervised installations with the text deleted from 215.2 (B) for feeders over 1000 volts.
- o Add a new 235.203 titled Overcurrent Protection to mirror Article 215 for feeders under 1000 volts.
- o Add a new 235.205 titled Diagrams of Feeders to mirror Article 215 for feeders under 1000 volts.
- o Add a new 235.206 titled Feeder Equipment Grounding Conductor to mirror Article 215 for feeders under 1000 volts.
- o Add a new 235.212 titled Identification for Feeders with first level subdivisions for grounded conductors, equipment grounding conductors, and ungrounded conductors to mirror Article 215 for feeders under 1000 volts.

Outside Branch Circuits & Feeders – Part IV

- o Add a new Part IV titled Outside Branch Circuits & Feeders to Article 235
- o Delete current Part III from Article 225 and relocate that text to new Article 235 with the following minor edits for formatting and numbering in new Article 235:

- ☐ Add a new 235.301 titled Scope which describes the requirements of Article 235 Part IV
- ☐ Add a new 235.306 titled Conductor Size and Support with modified text from 225.06
- ☐ Add a new 235.310 titled Wiring on Buildings (or Other Structures) with modified text from 225.10
- ☐ Add a new 235.314 titled Open-Conductor Spacings with modified text from 225.14
- ☐ Add a new 235.339 titled Rating of Disconnect with modified text from 225.39
- ☐ Add a new 235.350, relocated from 225.50
- ☐ Add a new 235.351, relocated from 225.51
- ☐ Add a new 235.352, relocated from 225.52
- ☐ Add a new 235.353, relocated from 225.53
- ☐ Add a new 235.354, relocated from 225.54
- ☐ Add a new 235.355, relocated from 225.55
- ☐ Add a new 235.356, relocated from 225.56
- ☐ Add a new 235.357, relocated from 225.57
- ☐ Add a new 235.358, relocated from 225.58
- ☐ Add a new 235.359, relocated from 225.59
- ☐ Add a new 235.360, relocated from 225.60
- ☐ Add a new 235.361, relocated from 225.61

Services – Part V

- o Add a new Part V titled Services to new Article 235.
- o Delete current Part VII from Article 230 and relocate that text to new Article 235 with the following minor edits for formatting and numbering in new Article 235:
- ☐ Add a new 235.400 titled General includes text previously located in 230.200.
- ☐ Add a new 235.402 titled Service –Entrance Conductors with two first level subdivisions and include the text previously located in 230.202.
- ☐ Add a new 235.404 titled Isolating Switches with four first level subdivisions and include the text previously located in 230.204.
- ☐ Add a new 235.405 titled Disconnecting Means with three first level subdivisions and include the text

previously located in 230.205.

 Add a new 235.406 titled Overcurrent Devices as Disconnecting Means and include the text previously located in 230.206.

 Add a new 235.408 titled Protection Requirements with two first level subdivisions and include the text previously located in 230.208.

 Add a new 235.409 titled Surge Arresters and include the text previously located in 230.209.

 Add a new 235.410 titled Service Equipment and include the text previously located in 230.210.

 Add a new 235.411 titled Switchgear and include the text previously located in 230.211.

 Add a new 235.412 titled Over 35,000 Volts and include the text previously located in 230.212.

Note: There are other Public Inputs being submitted that address restructuring, and these are identified as “Companion Public Inputs”. Other Article or Section references may be impacted due restructuring activities by those companion Public Inputs; however, changes to references outside of Articles 210, 215, 225 and 230 are not shown in this Public Input.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3728-NFPA 70-2020 [Global Input]	Companion Public Input (Articles 245 and 495)
Public Input No. 3765-NFPA 70-2020 [New Section after 250.194(B)]	Companion Public Input (Article 255)
Public Input No. 3772-NFPA 70-2020 [New Section after 110.79]	Companion Public Input (Article 115)
Public Input No. 3815-NFPA 70-2020 [New Section after 200.11]	Companion Public Input (Article 205)
Public Input No. 3827-NFPA 70-2020 [Global Input]	Companion Public Input (Article 305)
Public Input No. 3838-NFPA 70-2020 [Section No. 690.31(A)]	Companion Public Input (Section 690.31(A))
Public Input No. 3846-NFPA 70-2020 [Section No. 694.30(A)]	Companion Public Input (Section 694.30(A))
Public Input No. 3849-NFPA 70-2020 [New Part after IV.]	Companion Public Input (Section 706.30)

Submitter Information Verification

Submitter Full Name: Robert Osborne

Organization: UL LLC

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 09 13:35:57 EDT 2020

Committee: NEC-P10

Copyright Assignment

I, Robert Osborne, 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 Robert Osborne, 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

Substantiation:

This Public Input is submitted on behalf of a Correlating Committee Long-Range Planning Task Group consisting of Robert Osborne (Chair), Paul Barnhart, Lou Grahor, David Temple, Donny Cook, Dean Hunter, Mike Querry, Roger McDaniel, Dave Burns, Rod Belisle, and Kevin Rogers. This Public Input, along with other companion Public Inputs, was developed with the goal of improving usability and providing a platform to increase the focus on requirements associated with Medium or High Voltage.

Installations, including campus-wide distribution systems, microgrids, alternative energy installations, etc., are covered by the Scope of the NEC®; however, requirements for conductors, equipment, and raceways used in applications operating in systems rated over 1000 volts are treated as an “after-thought” in how they are arranged in the document and covered by Technical Committees. In many cases, the “over 1000 volts” requirements exist in a dedicated “Part” within the Article – such is the case with existing Article 300. In other cases, similar products are handled in two separate Articles, such as with “switchgear”, with equipment rated 1000 volts and below addressed in Article 408, and equipment rated over 1000 volts addressed in Article 490. In addition to these two approaches, there are Articles where the “over 1000 volts” is intermingled with the “under 1000 volt” requirements, such as the case with Article 225. In many of these cases, the information for over 1000 volts is very limited (for example, Article 240 has only 3 Sections in the Part dedicated to requirements for over 1000 volts).

This Task Group’s initial task was to establish a demarcation for what can be referred to as Medium or High Voltage. The recommendation has been to establish this threshold as being equipment rated over 1000 Vac, 1500 Vdc. It is believed that levels below these voltages can be addressed with existing requirements for systems rated 1000 V ac max, and 1500 V dc, as this has been established as an upper limit for photovoltaic applications within Article 690, with requirements noting that those systems are not required to comply with Parts II and III of Article 490.

Using these limits, the Task Group then set out to identify a structure to better align requirements, improve consistency in approach, improve usability, and create the opportunity for a Code Making Panel to have an increased focus on higher voltage applications.

All changes to Articles 215, 225, and 230 related to installations over 1000 Vac and 1500 Vdc, along with what seem to be applicable requirements in Article 210, are incorporated into proposed Article 235. This is submitted as a Global Input, and includes deleted text that is relocated from Articles 215, 225, and 230. Below is a summary of those changes:

Add a new Article 235 “Services, Feeders, & Branch Circuits Over 1000 VAC, 1500 VDC, Nominal”

- Add a new Part I titled Scope and General to new Article 235
- Add a new section 235.1 with suggested scope of the Article

Branch Circuits – Part II

- Add a new Part II titled Branch Circuits to new Article 235

- Add a new 235.105 titled Identification for Branch Circuits with first level subdivisions for grounded conductors, equipment grounding conductors, and ungrounded conductors to mirror the requirements in Article 210 for branch circuits under 1000 volts.
- Add a new 235.106 titled Branch Circuit Voltage Limitations Over 1,000 volts Between Conductors to mirror the requirements in Article 210 for branch circuits under 1000 volts.
- Add a new 235.111 titled Branch Circuits Required with first level subdivision for the number of circuits and distribution of the loads to mirror the requirements in Article 210 for branch circuits under 1000 volts.
- Add a new 235.118 titled Branch Circuit Rating to address the rating of the circuit and mirror the requirement in Article 210 for branch circuits under 1000 volts.
- Add a new 235.119 titled Conductors-Minimum Ampacity and Size with second level subdivision for the general and supervised installations to mirror the requirements in Article 210 for branch circuits under 1000 volts.
- Add a new 235.120 titled Overcurrent Protection with first level subdivisions for continuous and noncontinuous loads, conductor protection, and equipment protection to mirror the requirements in Article 210 for branch circuits under 1000 volts.

Feeders – Part III

- Add a new Part III titled Feeders to new Article 235.
- Delete 215.2 (B) and renumber accordingly.
- Add a new 235.202 titled Minimum Rating and Size with three first level subdivisions feeders supplying transformers, feeders supplying transformers and utilization equipment, and supervised installations with the text deleted from 215.2 (B) for feeders over 1000 volts.
- Add a new 235.203 titled Overcurrent Protection to mirror Article 215 for feeders under 1000 volts.
- Add a new 235.205 titled Diagrams of Feeders to mirror Article 215 for feeders under 1000 volts.
- Add a new 235.206 titled Feeder Equipment Grounding Conductor to mirror Article 215 for feeders under 1000 volts.
- Add a new 235.212 titled Identification for Feeders with first level subdivisions for grounded conductors, equipment grounding conductors, and ungrounded conductors to mirror Article 215 for feeders under 1000 volts.

Outside Branch Circuits & Feeders – Part IV

- Add a new Part IV titled Outside Branch Circuits & Feeders to Article 235
- Delete current Part III from Article 225 and relocate that text to new Article 235 with the following minor edits for formatting and numbering in new Article 235:
 - Add a new 235.301 titled Scope which describes the requirements of Article 235 Part IV
 - Add a new 235.306 titled Conductor Size and Support with modified text from 225.06

- Add a new 235.310 titled Wiring on Buildings (or Other Structures) with modified text from 225.10
- Add a new 235.314 titled Open-Conductor Spacings with modified text from 225.14
- Add a new 235.339 titled Rating of Disconnect with modified text from 225.39
- Add a new 235.350, relocated from 225.50
- Add a new 235.351, relocated from 225.51
- Add a new 235.352, relocated from 225.52
- Add a new 235.353, relocated from 225.53
- Add a new 235.354, relocated from 225.54
- Add a new 235.355, relocated from 225.55
- Add a new 235.356, relocated from 225.56
- Add a new 235.357, relocated from 225.57
- Add a new 235.358, relocated from 225.58
- Add a new 235.359, relocated from 225.59
- Add a new 235.360, relocated from 225.60
- Add a new 235.361, relocated from 225.61

Services – Part V

- Add a new Part V titled Services to new Article 235.
- Delete current Part VII from Article 230 and relocate that text to new Article 235 with the following minor edits for formatting and numbering in new Article 235:
 - Add a new 235.400 titled General includes text previously located in 230.200.
 - Add a new 235.402 titled Service –Entrance Conductors with two first level subdivisions and include the text previously located in 230.202.
 - Add a new 235.404 titled Isolating Switches with four first level subdivisions and include the text previously located in 230.204.
 - Add a new 235.405 titled Disconnecting Means with three first level subdivisions and include the text previously located in 230.205.
 - Add a new 235.406 titled Overcurrent Devices as Disconnecting Means and include the text previously located in 230.206.
 - Add a new 235.408 titled Protection Requirements with two first level subdivisions and include the text previously located in 230.208.
 - Add a new 235.409 titled Surge Arresters and include the text previously located in 230.209.
 - Add a new 235.410 titled Service Equipment and include the text previously located in 230.210.
 - Add a new 235.411 titled Switchgear and include the text previously located in 230.211.
 - Add a new 235.412 titled Over 35,000 Volts and include the text previously located in 230.212.

Note: There are other Public Inputs being submitted that address restructuring, and these are identified as “Companion Public Inputs”. Other Article or Section references may be impacted

due restructuring activities by those companion Public Inputs; however, changes to references outside of Articles 210, 215, 225 and 230 are not shown in this Public Input.

ADD NEW ARTICLE 235

Article 235 Services, Feeders, & Branch Circuits Over 1000 VAC, 1500 VDC, Nominal

PART I. Scope and General.

235.1 Scope. This Article includes modified general requirements for installations for branch circuits, feeders, and services over 1,000 volts, nominal.

235.3 Other Articles. General requirements of 210, 215, 225, and 230 apply unless modified by this article.

Part II. Branch Circuits

235.105 Identification for Branch Circuits.

235.105(A) Grounded Conductor.

The grounded conductor of a branch circuit shall be identified in accordance with 200.6.

235.105(B) Equipment Grounding Conductor.

The equipment grounding conductor shall be identified in accordance with 250.119.

235.105(C) Identification of Ungrounded Conductors.

Where the premises wiring system has branch circuits supplied from more than one nominal voltage system, each ungrounded conductor of a branch circuit shall be identified by phase or line and by system voltage class at all termination, connection, and splice points in compliance with 235.105 (C) (a) and (b). Different systems within the same premises that have the same system voltage class shall be permitted to use the same identification.

(a) Means of Identification. The means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means.

(b) Posting of Identification Means. The method utilized for conductors originating within each branch-circuit panelboard or similar branch-circuit distribution equipment shall be documented in a manner that is readily available or shall be permanently posted at each branch-circuit panelboard or similar branch-circuit distribution equipment. The label shall be of sufficient durability to withstand the environment involved and shall not be handwritten.

Exception: In existing installations where a voltage system(s) already exists and a different voltage system is being added, it shall be permissible to mark only the new system voltage. Existing unidentified systems shall not be required to be identified at each termination, connection, and splice point in compliance with 235.105 (C) (1) (a) and (b). Labeling shall be required at each voltage system distribution equipment to identify that only one voltage system has been marked for a new system(s). The new system label(s) shall include the words "other unidentified systems exist on the premises."

235.106 Branch-Circuit Voltage Limitations Over 1,000 Volts Between Conductors.

Circuits exceeding 1,000 volts, nominal, between conductors shall be permitted to supply utilization equipment in installations where conditions of maintenance and supervision ensure that only qualified persons service the installation.

235.111 Branch Circuits Required. Branch circuits for equipment operating above 1,000 volts shall be provided for loads as specified in 235.11 (A) and (B).

235.111(A) Number of Branch Circuits.

The minimum number of branch circuits shall be determined from the total calculated load and the size or rating of the circuits used. In all installations, the number of circuits shall be sufficient to supply the load served.

235.111(B) Load Evenly Proportioned Among Branch Circuits.

Where the load is calculated, the wiring system up to and including the branch-circuit overcurrent device(s) shall be provided to serve not less than the calculated load. Branch-circuit overcurrent devices and circuits shall be required to be installed only to serve the connected load.

235.118 Branch-Circuit Rating.

Branch circuits recognized by this article shall be rated in accordance with the maximum permitted ampere rating or setting of the overcurrent device. Where conductors of higher ampacity are used for any reason, the ampere rating or setting of the specified overcurrent device shall determine the circuit rating.

235.119 Conductors — Minimum Ampacity and Size.

The ampacity of conductors shall be in accordance with 310.14 or 311.60, as applicable. Branch-circuit conductors over 1,000 volts shall be sized in accordance with 235.119(B)(1) or (B)(2).

235.119(A) General.

The ampacity of branch-circuit conductors shall not be less than 125 percent of the designed potential load of utilization equipment that will be operated simultaneously.

235.119(B) Supervised Installations.

For supervised installations, branch-circuit conductor sizing shall be permitted to be determined by qualified persons under engineering supervision. Supervised installations are defined as those portions of a facility where both of the following conditions are met:

- (1) Conditions of design and installation are provided under engineering supervision.
- (2) Qualified persons with documented training and experience in over 1000 volt systems provide maintenance, monitoring, and servicing of the system.

235.120 Overcurrent Protection.

Branch-circuit conductors and equipment shall be protected by overcurrent protective devices that have a rating or setting that complies with 235.120 (A) through (C).

235.120(A) Continuous and Noncontinuous Loads.

Where a branch circuit supplies continuous loads or any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than the noncontinuous load plus 125 percent of the continuous load.

Exception: Where the assembly, including the overcurrent devices protecting the branch circuit(s), is listed for operation at 100 percent of its rating, the ampere rating of the overcurrent device shall be permitted to be not less than the sum of the continuous load plus the noncontinuous load.

235.120(B) Conductor Protection.

Conductors shall be protected in accordance with their ampacities specified in 310.14 or 311.60, as applicable.

235.120(C) Equipment.

The rating or setting of the overcurrent protective device shall not exceed that specified in the applicable articles referenced in Table 240.3 for equipment.

Part III. Feeders

235.202 Minimum Rating and Size.

The ampacity of conductors shall be in accordance with 310.14 and 311.60 as applicable. Where installed, the size of the feeder-circuit grounded conductor shall not be smaller than that required by 250.122, except that 250.122(F) shall not apply where grounded conductors are run in parallel. Feeder conductors over 1000 volts shall be sized in accordance with 235.200(A), (B), or (C).

(A) Feeders Supplying Transformers.

The ampacity of feeder conductors shall not be less than the sum of the nameplate ratings of the transformers supplied when only transformers are supplied.

(B) Feeders Supplying Transformers and Utilization Equipment.

The ampacity of feeders supplying a combination of transformers and utilization equipment shall not be less than the sum of the nameplate ratings of the transformers and 125 percent of the designed potential load of the utilization equipment that will be operated simultaneously.

(C) Supervised Installations.

For supervised installations, feeder conductor sizing shall be permitted to be determined by qualified persons under engineering supervision in accordance with 310.14(B) or 311.60(B). Supervised installations are defined as those portions of a facility where all of the following conditions are met:

(1) Conditions of design and installation are provided under engineering supervision.

(2) Qualified persons with documented training and experience in over 1000-volt systems provide maintenance, monitoring, and servicing of the system.

235.203 Overcurrent Protection.

Feeders shall be protected against overcurrent in accordance with Part XI of Article 240.

235.205 Diagrams of Feeders.

If required by the authority having jurisdiction, a diagram showing feeder details shall be provided prior to the installation of the feeders. Such a diagram shall show the area in square feet of the building or other structure supplied by each feeder, the total calculated load before applying demand factors, the demand factors used, the calculated load after applying demand factors, and the size and type of conductors to be used.

235.206 Feeder Equipment Grounding Conductor.

Where a feeder supplies branch circuits in which equipment grounding conductors are required, the feeder shall include or provide an equipment grounding conductor, to which the equipment grounding conductors of the branch circuits shall be connected. Where the feeder supplies a separate building or structure, the requirements of 250.32 apply.

235.212 Identification for Feeders.

235.212(A) Grounded Conductor.

The grounded conductor of a feeder, if insulated, shall be identified in accordance with 200.6

235.212(B) Equipment Grounding Conductor.

The equipment grounding conductor shall be identified in accordance with 250.119.

235.212(C) Identification of Ungrounded Conductors.

Ungrounded conductors shall be identified in accordance with 235.212 (C) (1) or 235.212 (C) (2), where supplied from more than one nominal voltage system. Where the premises wiring system has feeders supplied from more than one nominal voltage system, each ungrounded conductor of a feeder shall be identified by phase or line and system at all termination, connection, and splice points in compliance with 235.212(C)(1) and (2).

- (1) *Means of Identification.* The means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means.
- (2) *Posting of Identification Means.* The method utilized for conductors originating within each feeder panelboard or similar feeder distribution equipment shall be documented in a manner that is readily available or shall be permanently posted at each feeder panelboard or similar feeder distribution equipment.

Part IV Outside Branch Circuits and Feeders

235.301 Scope. This section covers requirements for outside branch circuits and feeders run on or between buildings, structures, or poles on the premises; and electrical equipment and wiring for the supply of utilization equipment that is located on or attached to the outside of buildings, structures, or poles.

Informational Note: For additional information on wiring over 1000 volts, see ANSI/IEEE C2-2017, National Electrical Safety Code.

235.306 Conductor Size and Support.

For overhead spans, open individual conductors shall not be smaller than 6 AWG copper or 4 AWG aluminum where open individual conductors, and 8 AWG copper or 6 AWG aluminum where in cable.

235.310 Wiring on Buildings (or Other Structures). The installation of outside wiring on surfaces of buildings (or other structures) shall be installed as provided in 300.37.

235.314 Open-Conductor Spacings. Conductors shall comply with the spacings provided in 110.36 and 490.24.

235.339 Rating of Disconnect. The feeder or branch-circuit disconnecting means shall have a rating of not less than the calculated load to be supplied, determined in accordance with Parts I and II of Article 220 for branch circuits, Part III or IV of Article 220 for feeders, or Part V of Article 220 for farm loads. Where the branch circuit or feeder disconnecting means consists of more than one switch or circuit breaker, as permitted by 225.33, combining the ratings of all the switches or circuit breakers for determining the rating of the disconnecting means shall be permitted.

235.350 Sizing of Conductors. The sizing of conductors shall be in accordance with 235.119(A) for branch circuits and 235.200 for feeders.

235.351 Isolating Switches. Where oil switches or air, oil, vacuum, or sulfur hexafluoride circuit breakers constitute a building disconnecting means, an isolating switch with visible break contacts and meeting the requirements of 235.404(B), (C), and (D) shall be installed on the supply side of the disconnecting means and all associated equipment[.

Exception: The isolating switch shall not be required where the disconnecting means is mounted on removable truck panels or switchgear units that cannot be opened unless the circuit is disconnected and that, when removed from the normal operating position, automatically disconnect the circuit breaker or switch from all energized parts.

235.352 Disconnecting Means.

(A) Location. A building or structure disconnecting means shall be located in accordance with 225.32, or, if not readily accessible, it shall be operable by mechanical linkage from a readily accessible point. For multibuilding industrial installations under single management, it shall be permitted to be electrically operated by a readily accessible, remote-control device in a separate building or structure.

(B) Type. Each building or structure disconnect shall simultaneously disconnect all ungrounded supply conductors it controls and shall have a fault-closing rating not less than the available fault current available at its supply terminals.

Exception: Where the individual disconnecting means consists of fused cutouts, the simultaneous disconnection of all ungrounded supply conductors shall not be required if there is a means to disconnect the load before opening the cutouts. A permanent legible sign shall be installed adjacent to the fused cutouts and shall read DISCONNECT LOAD BEFORE OPENING CUTOUTS.

Where fused switches or separately mounted fuses are installed, the fuse characteristics shall be permitted to contribute to the fault closing rating of the disconnecting means.

(C) Locking. Disconnecting means shall be lockable open in accordance with 110.25.

Exception: Where an individual disconnecting means consists of fused cutouts, a suitable enclosure capable of being locked and sized to contain all cutout fuse holders shall be installed at a convenient location to the fused cutouts.

(D) Indicating. Disconnecting means shall clearly indicate whether they are in the open “off” or closed “on” position.

(E) Uniform Position. Where disconnecting means handles are operated vertically, the “up” position of the handle shall be the “on” position.

Exception: A switching device having more than one “on” position, such as a double throw switch, shall not be required to comply with this requirement.

(F) Identification. Where a building or structure has any combination of feeders, branch circuits, or services passing through or supplying it, a permanent plaque or directory shall be installed at each feeder and branch-circuit disconnect location that denotes all other services, feeders, or branch circuits supplying that building or structure or passing through that building or structure and the area served by each.

235.356 Inspections and Tests.

(A) Pre-Energization and Operating Tests. The complete electrical system design, including settings for protective, switching, and control circuits, shall be prepared in advance and made available on request to the authority having jurisdiction and shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the system design and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the authority having jurisdiction.

(1) Instrument Transformers. All instrument transformers shall be tested to verify correct polarity and burden.

(2) Protective Relays. Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.

(3) Switching Circuits. Each switching circuit shall be observed to operate the associated equipment being switched.

(4) Control and Signal Circuits. Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.

(5) Metering Circuits. All metering circuits shall be verified to operate correctly from voltage and current sources in a similar manner to protective relay circuits.

(6) Acceptance Tests. Complete acceptance tests shall be performed, after the substation installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.

(7) Relays and Metering Utilizing Phase Differences. All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.

(B) Test Report. A test report covering the results of the tests required in 235.356 ~~225.56~~(A) shall be delivered to the authority having jurisdiction prior to energization.

Informational Note: For an example of acceptance specifications, see ANSI/NETA ATS-2013, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems, published by the InterNational Electrical Testing Association.

235.360 Clearances over Roadways, Walkways, Rail, Water, and Open Land.

(A) 22 kV, Nominal, to Ground or Less. The clearances over roadways, walkways, rail, water, and open land for conductors and live parts up to 22 kV, nominal, to ground or less shall be not less than the values shown in Table 235.360~~225.60~~.

(B) Over 22 kV Nominal to Ground. Clearances for the categories shown in Table 235.360 ~~225.60~~ shall be increased by 10 mm (0.4 in.) per kV above 22,000 volts.

(C) Special Cases. For special cases, such as where crossings will be made over lakes, rivers, or areas using large vehicles such as mining operations, specific designs shall be engineered considering the special circumstances and shall be approved by the authority having jurisdiction.

Informational Note: For additional information, see ANSI/IEEE C2-2017, National Electrical Safety Code.

Table 235.360 Clearances over Roadways, Walkways, Rail, Water, and Open Land

<u>Location</u>	<u>Clearance</u>	
	<u>m</u>	<u>ft</u>
<u>Open land subject to vehicles, cultivation, or grazing</u>	<u>5.6</u>	<u>18.5</u>
<u>Roadways, driveways, parking lots, and alleys</u>	<u>5.6</u>	<u>18.5</u>
<u>Walkways</u>	<u>4.1</u>	<u>13.5</u>
<u>Rails</u>	<u>8.1</u>	<u>26.5</u>
<u>Spaces and ways for pedestrians and restricted traffic</u>	<u>4.4</u>	<u>14.5</u>
<u>Water areas not suitable for boating</u>	<u>5.2</u>	<u>17.0</u>

235.361 Clearances over Buildings and Other Structures.

(A) 22 kV Nominal to Ground or Less. The clearances over buildings and other structures for conductors and live parts up to 22 kV, nominal, to ground or less shall be not less than the values shown in Table 235.361~~225.61~~.

(B) Over 22 kV Nominal to Ground. Clearances for the categories shown in Table 235.361~~225.61~~ shall be increased by 10 mm (0.4 in.) per kV above 22,000 volts.

Informational Note: For additional information, see ANSI/IEEE C2-2017, National Electrical Safety Code.

Table 235.361 Clearances over Buildings and Other Structures

<u>Clearance from Conductors or Live Parts from:</u>	<u>Horizontal</u>		<u>Vertical</u>	
	<u>m</u>	<u>ft</u>	<u>m</u>	<u>ft</u>
<u>Building walls, projections, and windows</u>	<u>2.3</u>	<u>7.5</u>	<u>—</u>	<u>—</u>
<u>Balconies, catwalks, and similar areas accessible to people</u>	<u>2.3</u>	<u>7.5</u>	<u>4.1</u>	<u>13.5</u>
<u>Over or under roofs or projections not readily accessible to people</u>	<u>—</u>	<u>—</u>	<u>3.8</u>	<u>12.5</u>
<u>Over roofs accessible to vehicles but not trucks</u>	<u>—</u>	<u>—</u>	<u>4.1</u>	<u>13.5</u>
<u>Over roofs accessible to trucks</u>	<u>—</u>	<u>—</u>	<u>5.6</u>	<u>18.5</u>
<u>Other structures</u>	<u>2.3</u>	<u>7.5</u>	<u>—</u>	<u>—</u>

Part V. Services

235.400 General.

Service conductors and equipment used on circuits exceeding 1000 volts ac, 1500 volts dc, nominal, shall comply with all the applicable sections of article 230 and with the following Part V sections that supplement or modify article 230. In no case shall the provisions of Part V apply to equipment on the supply side of the service point.

Informational Note: For clearances of conductors of over 1000 volts, nominal, see ANSI/IEEE C2-2017, *National Electrical Safety Code*.

235.402 Service-Entrance Conductors.

Service-entrance conductors to buildings or enclosures shall be installed to conform to 235.402(A) and (B).

235.402 (A) Conductor Size.

Service-entrance conductors shall not be smaller than 6 AWG unless in multiconductor cable. Multiconductor cable shall not be smaller than 8 AWG.

235.402 (B) Wiring Methods.

Service-entrance conductors shall be installed by one of the wiring methods covered in 300.37 and 300.50.

235.404 Isolating Switches.

235.404 (A) Where Required.

Where oil switches or air, oil, vacuum, or sulfur hexafluoride circuit breakers constitute the service disconnecting means, an isolating switch with visible break contacts shall be installed on the supply side of the disconnecting means and all associated service equipment.

Exception: An isolating switch shall not be required where the circuit breaker or switch is mounted on removable truck panels or switchgear units where both of the following conditions apply:

(1) Cannot be opened unless the circuit is disconnected

(2) Where all energized parts are automatically disconnected when the circuit breaker or switch is removed from the normal operating position

235.404 (B) Fuses as Isolating Switch.

Where fuses are of the type that can be operated as a disconnecting switch, a set of such fuses shall be permitted as the isolating switch.

235.404 (C) Accessible to Qualified Persons Only.

The isolating switch shall be accessible to qualified persons only.

235.404 (D) Connection to Ground.

Isolating switches shall be provided with a means for readily connecting the load side conductors to a grounding electrode system, equipment ground busbar, or grounded steel structure when disconnected from the source of supply.

A means for grounding the load side conductors to a grounding electrode system, equipment grounding busbar, or grounded structural steel shall not be required for any duplicate isolating switch installed and maintained by the electric supply company.

235.405 Disconnecting Means.

235.405 (A) Location.

The service disconnecting means shall be located in accordance with 230.70.

For either overhead or underground primary distribution systems on private property, the service disconnect shall be permitted to be located in a location that is not readily accessible, if the disconnecting means can be operated by mechanical linkage from a readily accessible point, or electronically in accordance with 235.405(C), where applicable.

235.405 (B) Type.

Each service disconnect shall simultaneously disconnect all ungrounded service conductors that it controls and shall have a fault-closing rating that is not less than the available fault current at its supply terminals.

Where fused switches or separately mounted fuses are installed, the fuse characteristics shall be permitted to contribute to the fault-closing rating of the disconnecting means.

235.405 (C) Remote Control.

For multibuilding, industrial installations under single management, the service disconnecting means shall be permitted to be located at a separate building or structure. In such cases, the service disconnecting means shall be permitted to be electrically operated by a readily accessible, remote-control device.

235.406 Overcurrent Devices as Disconnecting Means.

Where the circuit breaker or alternative for it, as specified in 235.408 for service overcurrent devices, meets the requirements specified in 235.405, it shall constitute the service disconnecting means.

235.408 Protection Requirements.

A short-circuit protective device shall be provided on the load side of, or as an integral part of, the service disconnect, and shall protect all ungrounded conductors that it supplies. The protective device shall be capable of detecting and interrupting all values of current, in excess of its trip setting or melting point, that can occur at its location. A fuse rated in continuous amperes not to exceed three times the ampacity of the conductor, or a circuit breaker with a trip setting of not more than six times the ampacity of the conductors, shall be considered as providing the required short-circuit protection.

Informational Note: See Table 311.60(C)(67) through Table 311.60(C)(86) for ampacities of conductors rated 2001 volts to 35,000 volts.

Overcurrent devices shall conform to 235.408 (A) and (B).

(A) Equipment Type.

Equipment used to protect service-entrance conductors shall meet the requirements of Article 490, Part II.

(B) Enclosed Overcurrent Devices.

The restriction to 80 percent of the rating for an enclosed overcurrent device for continuous loads shall not apply to overcurrent devices installed in systems operating at over 1000 volts.

235.409 Surge Arresters.

Surge arresters installed in accordance with the requirements of Article 242 shall be permitted on each ungrounded overhead service conductor.

Informational Note: Surge arresters may be referred to as lightning arresters in older documents.

235.410 Service Equipment — General Provisions.

Service equipment, including instrument transformers, shall conform to Article 490, Part I.

235.411 Switchgear.

Switchgear shall consist of a substantial metal structure and a sheet metal enclosure. Where installed over a combustible floor, suitable protection thereto shall be provided.

235.412 Over 35,000 Volts.

Where the voltage exceeds 35,000 volts between conductors that enter a building, they shall terminate in a switchgear compartment or a vault conforming to the requirements of 450.41 through 450.48.

MODIFICATIONS TO ARTICLE 210:

210.1 Scope. This article provides the general requirements for branch circuits.

Informational Note: For requirements that supplement or modify this Article for Over 1000 Vac, 1500 Vdc installations, see article 235, Services, Feeders, & Branch Circuits Over 1000 Vac, 1500 Vdc, nominal

210.6(E) Over 600, But Not Exceeding 1000 Volts Between Conductors. Circuits exceeding 600 volts, nominal, but not exceeding 1000 volts, nominal, between conductors shall be permitted to supply utilization equipment in installations where conditions of maintenance and supervision ensure that only qualified persons service the installation.

MODIFICATIONS TO ARTICLE 215

215.1 Scope. This article covers the installation requirements, overcurrent protection requirements, minimum size, and ampacity of conductors for feeders.

Exception: Feeders for electrolytic cells as covered in 668.3(C)(1) and (C)(4).

Informational Note: For requirements that supplement or modify this Article for Over 1000 Vac, 1500 Vdc installations, see article 235, Services, Feeders, & Branch Circuits Over 1000 Vac, 1500 Vdc, nominal.

215.2(B) Feeders over 1000 Volts.

The ampacity of conductors shall be in accordance with 310.14 and 311.60 as applicable. Where installed, the size of the feeder circuit grounded conductor shall not be smaller than that required by 250.122, except that 250.122(F) shall not apply where grounded conductors are run in parallel. Feeder conductors over 1000 volts shall be sized in accordance with 215.2(B)(1), (B)(2), or (B)(3).

215.2(B)(1) Feeders Supplying Transformers.

The ampacity of feeder conductors shall not be less than the sum of the nameplate ratings of the transformers supplied when only transformers are supplied.

215.2(B)(2) Feeders Supplying Transformers and Utilization Equipment.

The ampacity of feeders supplying a combination of transformers and utilization equipment shall not be less than the sum of the nameplate ratings of the transformers and 125 percent of the designed potential load of the utilization equipment that will be operated simultaneously.

215.2(B)(3) Supervised Installations.

For supervised installations, feeder conductor sizing shall be permitted to be determined by qualified persons under engineering supervision in accordance with 310.14(B) or 311.60(B). Supervised installations are defined as those portions of a facility where all of the following conditions are met:

(1) Conditions of design and installation are provided under engineering supervision.

(2) Qualified persons with documented training and experience in over 1000-volt systems provide maintenance, monitoring, and servicing of the system.

MODIFICATIONS TO ARTICLE 225

225.1 Scope. This article covers requirements for outside branch circuits and feeders run on or between buildings, structures, or poles on the premises; and electrical equipment and wiring for the supply of utilization equipment that is located on or attached to the outside of buildings, structures, or poles

Informational Note: ~~For additional information on wiring over 1000 volts, see ANSI/IEEE C2-2017, National Electrical Safety Code~~ For requirements that supplement or modify this Article for Over 1000 Vac, 1500 Vdc installations, see article 235, Services, Feeders, & Branch Circuits Over 1000 Vac, 1500 Vdc, nominal.

Table 225.3 Other Articles

Equipment/Conductors	Article
Branch circuits	210
Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits	725
Communications circuits	805
Community antenna television and radio distribution systems	820
Conductors for general wiring	310
Electrically driven or controlled irrigation machines	675
Electric signs and outline lighting	600
Feeders	215
Fire alarm systems	760
Fixed outdoor electric deicing and snow-melting equipment	426
Floating buildings	553
Grounding and bonding	250
Hazardous (classified) locations	500

Table 225.3 Other Articles

Equipment/Conductors	Article
Hazardous (classified) locations — specific	510
Marinas and boatyards	555
Medium-voltage conductors and cable	311
Messenger-supported wiring	396
Mobile homes, manufactured homes, and mobile home parks	550
Open wiring on insulators	398
Over 1000 volts, general	490
Overcurrent protection	240
Radio and television equipment	810
Services	230
<u>Services, Feeders, & Branch Circuits Over 1000 VAC, 1500 VDC, Nominal</u>	<u>235</u>
Solar photovoltaic systems	690
Swimming pools, fountains, and similar installations	680
Use and identification of grounded conductors	200

225.6 Conductor Size and Support.

(A) Overhead Spans. Open individual conductors shall not be smaller than the following:

(1) For 1000 volts, nominal, or less, 10 AWG copper or 8 AWG aluminum for spans up to 15 m (50 ft) in length, and 8 AWG copper or 6 AWG aluminum for a longer span unless supported by a messenger wire

(2) For over 1000 volts, nominal, meet the requirements of 235.306. ~~6 AWG copper or 4 AWG aluminum where open individual conductors, and 8 AWG copper or 6 AWG aluminum where in cable~~

225.10 Wiring on Buildings (or Other Structures). The installation of outside wiring on surfaces of buildings (or other structures) shall be permitted for circuits not exceeding 1000 volts, nominal, as the following:

- (1) Auxiliary gutters
- (2) Busways
- (3) Cable trays
- (4) Cablebus
- (5) Electrical metallic tubing (EMT)
- (6) Flexible metal conduit (FMC)
- (7) Intermediate metal conduit (IMC)
- (8) Liquidtight flexible metal conduit (LFMC)
- (9) Liquidtight flexible nonmetallic conduit (LFNC)
- (10) Messenger-supported wiring
- (11) Open wiring on insulators
- (12) Reinforced thermosetting resin conduit (RTRC)
- (13) Rigid metal conduit (RMC)
- (14) Rigid polyvinyl chloride conduit (PVC)
- (15) Type MC cable
- (16) Type MI cable
- (17) Type SE cable
- (18) Type TC-ER cable
- (19) Type UF cable
- (20) Wireways

~~Circuits of over 1000 volts, nominal, shall be installed as provided in 300.37.~~

~~Part III. Over 1000 Volts.~~

~~225.50 Sizing of Conductors.~~

~~The sizing of conductors over 1000 volts shall be in accordance with 210.19(B) for branch circuits and 215.2(B) for feeders.~~

~~225.51 Isolating Switches.~~

~~Where oil switches or air, oil, vacuum, or sulfur hexafluoride circuit breakers constitute a building disconnecting means, an isolating switch with visible break contacts and meeting the requirements of 230.204(B), (C), and (D) shall be installed on the supply side of the disconnecting means and all associated equipment.~~

~~*Exception: The isolating switch shall not be required where the disconnecting means is mounted on removable truck panels or switchgear units that cannot be opened unless the circuit is disconnected and that, when removed from the normal operating position, automatically disconnect the circuit breaker or switch from all energized parts.*~~

225.52 Disconnecting Means.

225.52(A) Location.

A building or structure disconnecting means shall be located in accordance with 225.32, or, if not readily accessible, it shall be operable by mechanical linkage from a readily accessible point. For multibuilding industrial installations under single management, it shall be permitted to be electrically operated by a readily accessible, remote control device in a separate building or structure.

225.52(B) Type.

Each building or structure disconnect shall simultaneously disconnect all ungrounded supply conductors it controls and shall have a fault-closing rating not less than the available fault current at its supply terminals.

Exception: Where the individual disconnecting means consists of fused cutouts, the simultaneous disconnection of all ungrounded supply conductors shall not be required if there is a means to disconnect the load before opening the cutouts. A permanent legible sign shall be installed adjacent to the fused cutouts and shall read DISCONNECT LOAD BEFORE OPENING CUTOUTS.

Where fused switches or separately mounted fuses are installed, the fuse characteristics shall be permitted to contribute to the fault-closing rating of the disconnecting means.

225.52(C) Locking.

Disconnecting means shall be lockable open in accordance with 110.25.

Exception: Where an individual disconnecting means consists of fused cutouts, a suitable enclosure capable of being locked and sized to contain all cutout fuse holders shall be installed at a convenient location to the fused cutouts.

225.52(D) Indicating.

Disconnecting means shall clearly indicate whether they are in the open "off" or closed "on" position.

225.52(E) Uniform Position.

Where disconnecting means handles are operated vertically, the "up" position of the handle shall be the "on" position.

Exception: A switching device having more than one "on" position, such as a double throw switch, shall not be required to comply with this requirement.

225.52(F) Identification.

Where a building or structure has any combination of feeders, branch circuits, or services passing through or supplying it, a permanent plaque or directory shall be installed at each feeder and branch circuit disconnect location that denotes all other services, feeders, or branch circuits supplying that building or structure or passing through that building or structure and the area served by each.

225.56 Inspections and Tests.

225.56(A) Pre-Energization and Operating Tests.

The complete electrical system design, including settings for protective, switching, and control circuits, shall be prepared in advance and made available on request to the authority having jurisdiction and shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the system design and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the authority having jurisdiction.

225.56(A)(1) Instrument Transformers.

All instrument transformers shall be tested to verify correct polarity and burden.

225.56(A)(2) Protective Relays.

Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.

~~225.56(A)(3) Switching Circuits.~~

~~Each switching circuit shall be observed to operate the associated equipment being switched.~~

~~225.56(A)(4) Control and Signal Circuits.~~

~~Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.~~

~~225.56(A)(5) Metering Circuits.~~

~~All metering circuits shall be verified to operate correctly from voltage and current sources in a similar manner to protective relay circuits.~~

~~225.56(A)(6) Acceptance Tests.~~

~~Complete acceptance tests shall be performed, after the substation installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.~~

~~225.56(A)(7) Relays and Metering Utilizing Phase Differences.~~

~~All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.~~

~~225.56(B) Test Report.~~

~~A test report covering the results of the tests required in 225.56(A) shall be delivered to the authority having jurisdiction prior to energization.~~

Informational Note: For an example of acceptance specifications, see ANSI/NETA ATS-2013, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems, published by the InterNational Electrical Testing Association.

~~225.60 Clearances over Roadways, Walkways, Rail, Water, and Open Land.~~

~~225.60(A) 22 kV, Nominal, to Ground or Less.~~

~~The clearances over roadways, walkways, rail, water, and open land for conductors and live parts up to 22 kV, nominal, to ground or less shall be not less than the values shown in Table 225.60.~~

~~225.60(B) Over 22 kV Nominal to Ground.~~

~~Clearances for the categories shown in Table 225.60 shall be increased by 10 mm (0.4 in.) per kV above 22,000 volts.~~

~~225.60(C) Special Cases.~~

~~For special cases, such as where crossings will be made over lakes, rivers, or areas using large vehicles such as mining operations, specific designs shall be engineered considering the special circumstances and shall be approved by the authority having jurisdiction.~~

Informational Note: For additional information, see ANSI/IEEE C2-2017, National Electrical Safety Code.

~~Table 225.60 Clearances over Roadways, Walkways, Rail, Water, and Open Land~~

Location	Clearance	
	m	ft
Open land subject to vehicles, cultivation, or grazing	5.6	18.5

Table 225.60 Clearances over Roadways, Walkways, Rail, Water, and Open Land

Location	Clearance	
	m	ft
Roadways, driveways, parking lots, and alleys	5.6	18.5
Walkways	4.1	13.5
Rails	8.1	26.5
Spaces and ways for pedestrians and restricted traffic	4.4	14.5
Water areas not suitable for boating	5.2	17.0

225.61 Clearances over Buildings and Other Structures.

225.61(A) 22 kV Nominal to Ground or Less.

The clearances over buildings and other structures for conductors and live parts up to 22 kV, nominal, to ground or less shall be not less than the values shown in Table 225.61.

225.61(B) Over 22 kV Nominal to Ground.

Clearances for the categories shown in Table 225.61 shall be increased by 10 mm (0.4 in.) per kV above 22,000 volts.

Informational Note: For additional information, see ANSI/IEEE C2-2017, *National Electrical Safety Code*.

Table 225.61 Clearances over Buildings and Other Structures

Clearance from Conductors or Live Parts from:	Horizontal		Vertical	
	m	ft	m	ft
Building walls, projections, and windows	2.3	7.5	—	—
Balconies, catwalks, and similar areas accessible to people	2.3	7.5	4.1	13.5

Table 225.61 Clearances over Buildings and Other Structures

Clearance from Conductors or Live Parts from:	Horizontal		Vertical	
	m	ft	m	ft
Over or under roofs or projections not readily accessible to people	—	—	3.8	12.5
Over roofs accessible to vehicles but not trucks	—	—	4.1	13.5
Over roofs accessible to trucks	—	—	5.6	18.5
Other structures	2.3	7.5	—	—

MODIFICATIONS TO ARTICLE 230

230.1 Scope. This article covers service conductors and equipment for control and protection of services and their installation requirements.

Informational Note No. 1: See Figure 230.1.

Informational Note No. 2: For requirements that supplement or modify this Article for Over 1000 Vac, 1500 Vdc installations, see article 235, Services, Feeders, & Branch Circuits Over 1000 Vac, 1500 Vdc, nominal.

Part VIII. Services Exceeding 1000 Volts, Nominal

230.200 General.

~~Service conductors and equipment used on circuits exceeding 1000 volts, nominal, shall comply with all the applicable preceding sections of this article and with the following sections that supplement or modify the preceding sections. In no case shall the provisions of Part VIII apply to equipment on the supply side of the service point.~~

~~Informational Note: For clearances of conductors of over 1000 volts, nominal, see ANSI/IEEE C2-2017, National Electrical Safety Code.~~

230.202 Service Entrance Conductors.

~~Service entrance conductors to buildings or enclosures shall be installed to conform to 230.202(A) and (B).~~

230.202(A) Conductor Size.

~~Service entrance conductors shall not be smaller than 6 AWG unless in multiconductor cable. Multiconductor cable shall not be smaller than 8 AWG.~~

230.202(B) Wiring Methods.

~~Service entrance conductors shall be installed by one of the wiring methods covered in 300.37 and 300.50.~~

230.204 Isolating Switches.

230.204(A) Where Required.

~~Where oil switches or air, oil, vacuum, or sulfur hexafluoride circuit breakers constitute the service disconnecting means, an isolating switch with visible break contacts shall be installed on the supply side of the disconnecting means and all associated service equipment.~~

Exception: An isolating switch shall not be required where the circuit breaker or switch is mounted on removable truck panels or switchgear units where both of the following conditions apply:

(1) Cannot be opened unless the circuit is disconnected

(2) Where all energized parts are automatically disconnected when the circuit breaker or switch is removed from the normal operating position

~~230.204(B) Fuses as Isolating Switch.~~

~~Where fuses are of the type that can be operated as a disconnecting switch, a set of such fuses shall be permitted as the isolating switch.~~

~~230.204(C) Accessible to Qualified Persons Only.~~

~~The isolating switch shall be accessible to qualified persons only.~~

~~230.204(D) Connection to Ground.~~

~~Isolating switches shall be provided with a means for readily connecting the load side conductors to a grounding electrode system, equipment ground busbar, or grounded steel structure when disconnected from the source of supply.~~

~~A means for grounding the load side conductors to a grounding electrode system, equipment grounding busbar, or grounded structural steel shall not be required for any duplicate isolating switch installed and maintained by the electric supply company.~~

~~230.205 Disconnecting Means.~~

~~230.205(A) Location.~~

~~The service disconnecting means shall be located in accordance with 230.70.~~

~~For either overhead or underground primary distribution systems on private property, the service disconnect shall be permitted to be located in a location that is not readily accessible, if the disconnecting means can be operated by mechanical linkage from a readily accessible point, or electronically in accordance with 230.205(C), where applicable.~~

~~230.205(B) Type.~~

~~Each service disconnect shall simultaneously disconnect all ungrounded service conductors that it controls and shall have a fault-closing rating that is not less than the available fault current at its supply terminals.~~

~~Where fused switches or separately mounted fuses are installed, the fuse characteristics shall be permitted to contribute to the fault-closing rating of the disconnecting means.~~

~~230.205(C) Remote Control.~~

~~For multibuilding, industrial installations under single management, the service disconnecting means shall be permitted to be located at a separate building or structure. In such cases, the service disconnecting means shall be permitted to be electrically operated by a readily accessible, remote-control device.~~

~~230.206 Overcurrent Devices as Disconnecting Means.~~

~~Where the circuit breaker or alternative for it, as specified in 230.208 for service overcurrent devices, meets the requirements specified in 230.205, it shall constitute the service disconnecting means.~~

230.208 Protection Requirements.

~~A short-circuit protective device shall be provided on the load side of, or as an integral part of, the service disconnect, and shall protect all ungrounded conductors that it supplies. The protective device shall be capable of detecting and interrupting all values of current, in excess of its trip setting or melting point, that can occur at its location. A fuse rated in continuous amperes not to exceed three times the ampacity of the conductor, or a circuit breaker with a trip setting of not more than six times the ampacity of the conductors, shall be considered as providing the required short-circuit protection.~~

~~Informational Note: See Table 311.60(C)(67) through Table 311.60(C)(86) for ampacities of conductors rated 2001 volts to 35,000 volts.~~

~~Overcurrent devices shall conform to 230.208(A) and (B).~~

230.208(A) Equipment Type.

~~Equipment used to protect service-entrance conductors shall meet the requirements of Article 490, Part II.~~

230.208(B) Enclosed Overcurrent Devices.

~~The restriction to 80 percent of the rating for an enclosed overcurrent device for continuous loads shall not apply to overcurrent devices installed in systems operating at over 1000 volts.~~

230.209 Surge Arresters.

~~Surge arresters installed in accordance with the requirements of Article 242 shall be permitted on each ungrounded overhead service conductor.~~

~~Informational Note: Surge arresters may be referred to as lightning arresters in older documents.~~

230.210 Service Equipment — General Provisions.

~~Service equipment, including instrument transformers, shall conform to Article 490, Part I.~~

230.211 Switchgear.

~~Switchgear shall consist of a substantial metal structure and a sheet metal enclosure. Where installed over a combustible floor, suitable protection thereto shall be provided.~~

230.212 Over 35,000 Volts.

~~Where the voltage exceeds 35,000 volts between conductors that enter a building, they shall terminate in a switchgear compartment or a vault conforming to the requirements of 450.41 through 450.48.~~



Public Input No. 3728-NFPA 70-2020 [Global Input]

See Attached Word Document for Changes

Additional Proposed Changes

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
240_and_490_Public_Input_-_Final0.docx	Global PI to Revise Articles 240, 242 and Chapter 4, Adding New Articles 245 and 495.	✓

Statement of Problem and Substantiation for Public Input

This Public Input is submitted on behalf of a Correlating Committee Long-Range Planning Task Group consisting of Robert Osborne (Chair), Paul Barnhart, Lou Grahor, David Temple, Donny Cook, Dean Hunter, Mike Querry, Roger McDaniel, Dave Burns, Rod Belisle, and Kevin Rogers. This Public Input, along with other companion Public Inputs, was developed with the goal of improving usability and providing a platform to increase the focus on requirements associated with Medium or High Voltage.

Installations, including campus-wide distribution systems, microgrids, alternative energy installations, etc., are covered by the Scope of the NEC®; however, requirements for conductors, equipment, and raceways used in applications operating in systems rated over 1000 volts are treated as an “after-thought” in how they are arranged in the document and covered by Technical Committees. In many cases, the “over 1000 volts” requirements exist in a dedicated “Part” within the Article – such is the case with existing Article 300. In other cases, similar products are handled in two separate Articles, such as with “switchgear”, with equipment rated 1000 volts and below addressed in Article 408, and equipment rated over 1000 volts addressed in Article 490. In addition to these two approaches, there are Articles where the “over 1000 volts” is intermingled with the “under 1000 volt” requirements, such as the case with Article 225. In many of these cases, the information for over 1000 volts is very limited (for example, Article 240 has only 3 Sections in the Part dedicated to requirements for over 1000 volts).

This Task Group’s initial task was to establish a demarcation for what can be referred to as Medium or High Voltage. The recommendation has been to establish this threshold as being equipment rated over 1000 Vac, 1500 Vdc. It is believed that levels below these voltages can be addressed with existing requirements for systems rated 1000 V ac max, and 1500 V dc, as this has been established as a upper limit for photovoltaic applications within Article 690, with requirements noting that those systems are not required to comply with Parts II and III of Article 490.

Using these limits, the Task Group then set out to identify a structure to better align requirements, improve consistency in approach, improve usability, and create the opportunity for Code Making Panels to have an increased focus on higher voltage applications.

All changes to Articles 240 and 242, along with Chapter 4, are being submitted as a Global Input, and below is a summary of those changes:

- Overcurrent Protection requirements in Part IX of Article 240 (Overcurrent Protection over 1000 Volts, Nominal), and Overvoltage Protection requirements in Part III of Article 242 (Surge Arresters, Over 1000 Volts) are relocated to a new Article 245, “Overcurrent and Overvoltage Protection for Systems Rated Over 1000 VAC, 1500 VDC. In addition, requirements from Article 490 that are specific to overcurrent protection are relocated to the new Article 245. A summary of the relocated Sections is noted below:
 - o Reconditioning requirements in Section 240.88 and 240.102 that are specific to overcurrent devices rated over 1000 volts are relocated to Section 245.15
 - o Section 490.21 is relocated to Section 245.21.
 - o Sections 240.100 and 240.101 are relocated to Sections 245.26 and 245.27, respectively.
 - o Sections 242.40 – 242.56 are relocated to Sections 245.42 – 245.56.

- o Scope of 242 is revised to address only Overvoltage Protection rated not more than 1000 volts.
- o Over 1000 Volt Equipment Articles (490 and 399) are relocated from Table 242.3 to new Table 245.40
- o Article 242 is restructured to only have one Part to cover all Overvoltage Protection not more than 1000 volts.
- Article 490 has been renumbered to become Article 495 and remains “Equipment over 1000 Volts, Nominal”
- Article 495 now consists of 10 parts:
 - o Parts I–V are existing 490 text relocated and renumbered to “New” Article 495
 - o Part VI consists of relocated materials from Article 430 Part XI “Over 1000 Volts, Nominal,” with Sections 430.221 - 430.227 relocated to Sections 495.80 - 495.86
 - o  The over 1000 Volts portions of tables 430.249 and 430.250, including notes, have also been relocated o Part VI.
 - o Part VII contains the requirements from Article 450 regarding Transformers, Over 1000 Volts, including requirements for liquid-filled transformers. While liquid-filled transformers (including “less-flammable,” “non-flammable,” “askarel-insulated”) may be used in any installation, they are more common in installations over 1000 volts. While these requirements are relocated to Article 495, a new section 450.23 notes that the requirements in Part VII of 495 apply.
 - o Part VIII contains requirements from Article 450 Part III, Transformer Vaults. While transformer vaults may be used in any installation, they are more common in installations over 1000 volts. While these requirements are relocated to Article 495, a new section 450.40 notes that the requirements in Part VIII of 495 apply.
 - o Part IX contains the Requirements from Article 460 Part II, Capacitors, Over 1000 volts, nominal, (previously numbered 460.24 - 460.28).
 - o Part X contains the requirements from Article 470 (Resistors and Reactors), Part II Over 1000 volts, Nominal (previously numbered 470.18 - 470.20).

Note: There are other Public Inputs being submitted that address restructuring, and these are identified as “Companion Public Inputs”. Other Article or Section references may be impacted due restructuring activities by those companion Public Inputs; however, changes to references outside of Articles 240, 242, and Chapter 4 are not shown in this Public Input.

Related Public Inputs for This Document

<u>Related Input</u>	<u>Relationship</u>
Public Input No. 3765-NFPA 70-2020 [New Section after 250.194(B)]	Companion Public Input (Article 255)
Public Input No. 3772-NFPA 70-2020 [New Section after 110.79]	Companion Public Input (Article 115)
Public Input No. 3815-NFPA 70-2020 [New Section after 200.11]	Companion Public Input (Article 205)
Public Input No. 3819-NFPA 70-2020 [Global Input]	Companion Public Input (Article 235)
Public Input No. 3827-NFPA 70-2020 [Global Input]	Companion Public Input (Article 305)
Public Input No. 3838-NFPA 70-2020 [Section No. 690.31(A)]	Companion Public Input (Section 690.31(A))
Public Input No. 3846-NFPA 70-2020 [Section No. 694.30(A)]	Companion Public Input (Section 694.30(A))
Public Input No. 3849-NFPA 70-2020 [New Part after IV.]	Companion Public Input (Section 706.30)

Submitter Information Verification

Submitter Full Name: Robert Osborne

Organization: UL LLC

Street Address:

City:

State:**Zip:****Submittal Date:** Wed Sep 09 11:28:25 EDT 2020**Committee:** NEC-P09**Copyright Assignment**

I, Robert Osborne, 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 Robert Osborne, 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

Substantiation:

This Public Input is submitted on behalf of a Correlating Committee Long-Range Planning Task Group consisting of Robert Osborne (Chair), Paul Barnhart, Lou Grahor, David Temple, Donny Cook, Dean Hunter, Mike Querry, Roger McDaniel, Dave Burns, Rod Belisle, and Kevin Rogers. This Public Input, along with other companion Public Inputs, was developed with the goal of improving usability and providing a platform to increase the focus on requirements associated with Medium or High Voltage.

Installations, including campus-wide distribution systems, microgrids, alternative energy installations, etc., are covered by the Scope of the NEC®; however, requirements for conductors, equipment, and raceways used in applications operating in systems rated over 1000 volts are treated as an “after-thought” in how they are arranged in the document and covered by Technical Committees. In many cases, the “over 1000 volts” requirements exist in a dedicated “Part” within the Article – such is the case with existing Article 300. In other cases, similar products are handled in two separate Articles, such as with “switchgear”, with equipment rated 1000 volts and below addressed in Article 408, and equipment rated over 1000 volts addressed in Article 490. In addition to these two approaches, there are Articles where the “over 1000 volts” is intermingled with the “under 1000 volt” requirements, such as the case with Article 225. In many of these cases, the information for over 1000 volts is very limited (for example, Article 240 has only 3 Sections in the Part dedicated to requirements for over 1000 volts).

This Task Group’s initial task was to establish a demarcation for what can be referred to as Medium or High Voltage. The recommendation has been to establish this threshold as being equipment rated over 1000 Vac, 1500 Vdc. It is believed that levels below these voltages can be addressed with existing requirements for systems rated 1000 V ac max, and 1500 V dc, as this has been established as a upper limit for photovoltaic applications within Article 690, with requirements noting that those systems are not required to comply with Parts II and III of Article 490.

Using these limits, the Task Group then set out to identify a structure to better align requirements, improve consistency in approach, improve usability, and create the opportunity for Code Making Panels to have an increased focus on higher voltage applications.

All changes to Articles 240 and 242, along with Chapter 4, are being submitted as a Global Input, and below is a summary of those changes:

- Overcurrent Protection requirements in Part IX of Article 240 (Overcurrent Protection over 1000 Volts, Nominal), and Overvoltage Protection requirements in Part III of Article 242 (Surge Arresters, Over 1000 Volts) are relocated to a new Article 245, “Overcurrent and Overvoltage Protection for Systems Rated Over 1000 VAC, 1500 VDC. In addition, requirements from Article 490 that are specific to overcurrent protection are relocated to the new Article 245. A summary of the relocated Sections is noted below:
 - Reconditioning requirements in Section 240.88 and 240.102 that are specific to overcurrent devices rated over 1000 volts are relocated to Section 245.15
 - Section 490.21 is relocated to Section 245.21.
 - Sections 240.100 and 240.101 are relocated to Sections 245.26 and 245.27, respectively.
 - Sections 242.40 – 242.56 are relocated to Sections 245.42 – 245.56.
 - Scope of 242 is revised to address only Overvoltage Protection rated not more than 1000 volts.
 - Over 1000 Volt Equipment Articles (490 and 399) are relocated from Table 242.3 to new Table 245.40
 - Article 242 is restructured to only have one Part to cover all Overvoltage Protection not more than 1000 volts.
- Article 490 has been renumbered to become Article 495 and remains “Equipment over 1000 Volts, Nominal”
- Article 495 now consists of 10 parts:
 - Parts I –V are existing 490 text relocated and renumbered to “New” Article 495
 - Part VI consists of relocated materials from Article 430 Part XI “Over 1000 Volts, Nominal,” with Sections 430.221 - 430.227 relocated to Sections 495.80 - 495.86
 - The over 1000 Volts portions of tables 430.249 and 430.250, including notes, have also been relocated o Part VI.
 - Part VII contains the requirements from Article 450 regarding Transformers, Over 1000 Volts, including requirements for liquid-filled transformers. While liquid-filled transformers (including “less-

flammable," "non-flammable," "askarel-insulated") may be used in any installation, they are more common in installations over 1000 volts. While these requirements are relocated to Article 495, a new section 450.23 notes that the requirements in Part VII of 495 apply.

- Part VIII contains requirements from Article 450 Part III, Transformer Vaults. While transformer vaults may be used in any installation, they are more common in installations over 1000 volts. While these requirements are relocated to Article 495, a new section 450.40 notes that the requirements in Part VIII of 495 apply.
- Part IX contains the Requirements from Article 460 Part II, Capacitors, Over 1000 volts, nominal,(previously numbered 460.24 - 460.28).
- Part X contains the requirements from Article 470 (Resistors and Reactors), Part II Over 1000 volts, Nominal (previously numbered 470.18 - 470.20).

Note: There are other Public Inputs being submitted that address restructuring, and these are identified as "Companion Public Inputs". Other Article or Section references may be impacted due restructuring activities by those companion Public Inputs; however, changes to references outside of Articles 240, 242, and Chapter 4 are not shown in this Public Input.

Revisions to Article 240:

240.88 Reconditioned Equipment.

Reconditioned equipment shall be listed as "reconditioned" and the original listing mark removed.

(A) Circuit Breakers.

The use of reconditioned circuit breakers shall comply with (1) ~~through and (2)~~ (3):

- (1) Molded-case circuit breakers shall not be permitted to be reconditioned.
- (2) Low-~~and medium~~-voltage power circuit breakers shall be permitted to be reconditioned.

~~(3) High voltage circuit breakers shall be permitted to be reconditioned.~~

(B) Components.

The use of reconditioned trip units, protective relays, and current transformers shall comply with (1) and (2):

- (1) Low-voltage power circuit breaker electronic trip units shall not be permitted to be reconditioned.
- (2) Electromechanical protective relays and current transformers shall be permitted to be reconditioned.

~~Part IX. Overcurrent Protection over 1000 Volts, Nominal~~

~~240.100 Feeders and Branch Circuits.~~

~~(A) Location and Type of Protection:~~

~~Feeder and branch circuit conductors shall have overcurrent protection in each ungrounded conductor located at the point where the conductor receives its supply or at an alternative location in the circuit when designed under engineering supervision that includes but is not limited to considering the appropriate fault studies and time-current coordination analysis of the protective devices and the conductor damage curves. The overcurrent protection shall be permitted to be provided by either 240.100(A)(1) or (A)(2).~~

~~(1) Overcurrent Relays and Current Transformers.~~

~~Circuit breakers used for overcurrent protection of 3-phase circuits shall have a minimum of three overcurrent relay elements operated from three current transformers. The separate overcurrent relay elements (or protective functions) shall be permitted to be part of a single electronic protective relay unit. On 3-phase, 3-wire circuits, an overcurrent relay element in the residual circuit of the current transformers shall be permitted to replace one of the phase relay elements. An overcurrent relay element, operated from a current transformer that links all phases of a 3-phase, 3-wire circuit, shall be permitted to replace the residual relay element and one of the phase-conductor current transformers. Where the neutral conductor is not regrounded on the load side of the circuit as permitted in 250.184(B), the current transformer shall be permitted to link all 3-phase conductors and the grounded circuit conductor (neutral).~~

~~(2) Fuses.~~

~~A fuse shall be connected in series with each ungrounded conductor.~~

~~(B) Protective Devices:~~

~~The protective device(s) shall be capable of detecting and interrupting all values of current that can occur at their location in excess of their trip setting or melting point.~~

~~(C) Conductor Protection:~~

~~The operating time of the protective device, the available short-circuit current, and the conductor used shall be coordinated to prevent damaging or dangerous temperatures in conductors or conductor insulation under short-circuit conditions.~~

~~240.101 Additional Requirements for Feeders.~~

~~(A) Rating or Setting of Overcurrent Protective Devices:~~

The continuous ampere rating of a fuse shall not exceed three times the ampacity of the conductors. The long-time trip element setting of a breaker or the minimum trip setting of an electronically actuated fuse shall not exceed six times the ampacity of the conductor. For fire pumps, conductors shall be permitted to be protected for overcurrent in accordance with 695.4(B)(2).

~~(B) Feeder Taps.~~

Conductors tapped to a feeder shall be permitted to be protected by the feeder overcurrent device where that overcurrent device also protects the tap conductor.

~~240.102 Reconditioned Equipment.~~

Medium-voltage fuseholders and medium-voltage nonrenewable fuses shall not be permitted to be reconditioned.

Revisions to Article 242:

ARTICLE 242 Overvoltage Protection

Part I. General

242.1 Scope. This article provides the general requirements, installation requirements, and connection requirements for overvoltage protection and overvoltage ~~protective devices. Part II covers surge protective devices (SPDs) permanently installed on premises wiring systems of not more than 1000 volts, nominal, while Part III covers surge arresters permanently installed on premises wiring systems over 1000 volts, nominal.~~

Informational Note No. 1: Article 245~~2~~ covers surge arresters permanently installed on premises wiring systems over 1000 volts, nominal combines and replaces Articles 280 and 285 in NFPA 70-2017.

Informational Note No. 2: Surge arresters 1000 volts or less are also known as Type 1 surge protective devices (SPDs).

242.3 Other Articles. Equipment shall be protected against overvoltage in accordance with the article in this *Code* that covers the type of equipment or location specified in Table 242.3.

Table 242.3 Other Articles

Equipment	Article
Class I locations	501
Class II locations	502
Community antenna television and radio distribution systems	820
Critical operations power systems	708
Elevators, dumbwaiters, escalators, moving walks, platform lifts, and stairway chairlifts	620
Emergency systems	700
Equipment over 1000 volts, nominal	490
Fire pumps	695
Industrial machinery	670
Information technology equipment	645
Modular data centers	646
Outdoor overhead conductors over 1000 volts	399
Radio and television equipment	810
Receptacles, cord connectors, and attachment plugs (caps)	406
Wind electric systems	694

~~Part II. Surge Protective Devices (SPDs), 1000 Volts or Less~~

~~Informational Note: Surge arresters 1000 volts or less are also known as Type 1 SPDs.~~

242.6 Uses Not Permitted. An SPD device shall not be installed in the following:

- (1) Circuits over 1000 volts

(2) On ungrounded systems, impedance grounded systems, or corner grounded delta systems unless listed specifically for use on these systems

(3) Where the rating of the SPD is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application

242.8 Listing. An SPD shall be a listed device.

242.10 Short-Circuit Current Rating. The SPD shall be marked with a short-circuit current rating and shall not be installed at a point on the system where the available fault current is in excess of that rating. This marking requirement shall not apply to receptacles.

242.12 Type 1 SPDs. Type 1 SPDs shall be installed in accordance with 242.12(A) and (B).

(A) Installation. Type 1 SPDs shall be permitted to be connected in accordance with one of the following:

- (1) To the supply side of the service disconnect as permitted in 230.82(4)
- (2) As specified in 242.14

(B) At the Service. When installed at services, Type 1 SPDs shall be connected to one of the following:

- (1) Grounded service conductor
- (2) Grounding electrode conductor
- (3) Grounding electrode for the service
- (4) Equipment grounding terminal in the service equipment

242.14 Type 2 SPDs. Type 2 SPDs shall be installed in accordance with 242.14(A) through (C).

(A) Service-Supplied Building or Structure. Type 2 SPDs shall be connected anywhere on the load side of a service disconnect overcurrent device required in 230.91 unless installed in accordance with 230.82(8).

(B) Feeder-Supplied Building or Structure.

Type 2 SPDs shall be connected at the building or structure anywhere on the load side of the first overcurrent device at the building or structure.

(C) Separately Derived System.

The SPD shall be connected on the load side of the first overcurrent device in a separately derived system.

242.16 Type 3 SPDs. Type 3 SPDs shall be permitted to be installed on the load side of branch-circuit overcurrent protection up to the equipment served. If included in the manufacturer's instructions, the Type 3 SPD connection shall be a minimum 10 m (30 ft) of conductor distance from the service or separately derived system disconnect.

242.18 Type 4 and Other Component Type SPDs. Type 4 component assemblies and other component type SPDs shall only be installed by the equipment manufacturer.

242.20 Number Required. Where used at a point on a circuit, the SPD shall be connected to each ungrounded conductor.

242.22 Location. SPDs shall be permitted to be located indoors or outdoors and shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

242.24 Routing of Connections. The conductors used to connect the SPD to the line or bus and to ground shall not be any longer than necessary and shall avoid unnecessary bends.

242.26 Connection. Where an SPD device is installed, it shall comply with 242.12, 242.14, 242.16, 242.28, and 242.30.

242.28 Conductor Size. Line and grounding conductors shall not be smaller than 14 AWG copper or 12 AWG aluminum.

242.30 Connection Between Conductors. An SPD shall be permitted to be connected between any two conductors — ungrounded conductor(s), grounded conductor, equipment grounding conductor, or grounding electrode conductor. The grounded conductor and the equipment grounding conductor shall be interconnected only by the normal operation of the SPD during a surge.

242.32 Grounding Electrode Conductor Connections and Enclosures. Except as indicated in this article, SPD grounding connections shall be made as specified in Article 250, Part III. Grounding electrode conductors installed in metal enclosures shall comply with 250.64(E).

~~Part III. Surge Arresters, Over 1000 Volts~~

~~242.40 Uses Not Permitted.~~

~~A surge arrester shall not be installed where the rating of the surge arrester is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application.~~

~~242.42 Surge Arrester Selection.~~

~~The surge arresters shall comply with 242.42(A) and (B).~~

~~(A) Rating.~~

~~The rating of a surge arrester shall be equal to or greater than the maximum continuous operating voltage available at the point of application.~~

~~(1) Solidly Grounded Systems.~~

~~The maximum continuous operating voltage shall be the phase-to-ground voltage of the system.~~

~~(2) Impedance or Ungrounded System.~~

~~The maximum continuous operating voltage shall be the phase-to-phase voltage of the system.~~

~~(B) Silicon Carbide Types.~~

~~The rating of a silicon carbide type surge arrester shall be not less than 125 percent of the rating specified in 242.42(A).~~

~~Informational Note No. 1: For further information on surge arresters, see IEEE C62.11-2012, *Standard for Metal Oxide Surge Arresters for Alternating Current Power Circuits (>1 kV)*, and IEEE C62.22-2009, *Guide for the Application of Metal Oxide Surge Arresters for Alternating Current Systems*.~~

~~Informational Note No. 2: The selection of a properly rated metal oxide arrester is based on considerations of maximum continuous operating voltage and the magnitude and duration of overvoltages at the arrester location as affected by phase-to-ground faults, system grounding techniques, switching surges, and other causes. See the manufacturer's application rules for selection of the specific arrester to be used at a particular location.~~

~~242.44 Number Required.~~

~~Where used at a point on a circuit, a surge arrester shall be connected to each ungrounded conductor. A single installation of such surge arresters shall be permitted to protect a number of interconnected circuits if no circuit is exposed to surges while disconnected from the surge arresters.~~

~~242.46 Location.~~

~~Surge arresters shall be permitted to be located indoors or outdoors. Surge arresters shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.~~

~~242.48 Routing of Surge Arrester Equipment Grounding Conductors.~~

~~The conductor used to connect the surge arrester to line, bus, or equipment and to an equipment grounding conductor or grounding electrode connection point as provided in 242.50 shall not be any longer than necessary and shall avoid unnecessary bends.~~

~~242.50 Connection.~~

~~The arrester shall be connected to one of the following:~~

- ~~(1) Grounded service conductor~~
- ~~(2) Grounding electrode conductor~~
- ~~(3) Grounding electrode for the service~~
- ~~(4) Equipment grounding terminal in the service equipment~~

~~242.52 Surge Arrester Conductors.~~

The conductor between the surge arrester and the line, and the surge arrester and the grounding connection, shall not be smaller than 6 AWG copper or aluminum.

~~242.54 Interconnections:~~

The surge arrester protecting a transformer that supplies a secondary distribution system shall be interconnected as specified in 242.54(A), (B), or (C):

~~(A) Metal Interconnections:~~

A metal interconnection shall be made to the secondary grounded circuit conductor or the secondary circuit grounding electrode conductor, if, in addition to the direct grounding connection at the surge arrester, the connection complies with 242.54(A)(1) or (A)(2):

~~(1) Additional Grounding Connection:~~

The grounded conductor of the secondary has a grounding connection elsewhere to a continuous metal underground water piping system. In urban water pipe areas where there are at least four water pipe connections on the neutral conductor and not fewer than four such connections in each mile of neutral conductor, the metal interconnection shall be permitted to be made to the secondary neutral conductor with omission of the direct grounding connection at the surge arrester.

~~(2) Multigrounded Neutral System Connection:~~

The grounded conductor of the secondary system is part of a multigrounded neutral system or static wire of which the primary neutral conductor or static wire has at least four grounding connections in each 1.6 km (1 mile) of line in addition to a grounding connection at each service.

~~(B) Through Spark Gap or Device:~~

Where the surge arrester grounding electrode conductor is not connected as in 242.54(A), or where the secondary is not grounded as in 242.54(A) but is otherwise grounded as in 250.52, an interconnection shall be made through a spark gap or listed device as required by 242.54(B)(1) or (B)(2):

~~(1) Ungrounded or Unigrounded Primary System:~~

For ungrounded or unigrounded primary systems, the spark gap for a listed device shall have a 60-Hz breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge arrester grounding electrode.

~~(2) Multigrounded Neutral Primary System:~~

For multigrounded neutral primary systems, the spark gap or listed device shall have a 60-Hz breakdown of not more than 3 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge arrester grounding electrode.

~~(C) By Special Permission:~~

An interconnection of the surge arrester ground and the secondary neutral conductor, other than as provided in 242.54(A) or (B), shall be permitted to be made only by special permission.

~~242.56 Grounding Electrode Conductor Connections and Enclosures:~~

Except as indicated in this article, surge arrester grounding electrode conductor connections shall be made as specified in Article 250, Parts III and X. Grounding electrode conductors installed in metal enclosures shall comply with 250.64(E).

Proposed new Article 245:

Article 245 Overcurrent and Overvoltage Protection for Systems Rated Over 1000 VAC, 1500 VDC

Part I. General and Scope

245.1 Scope.

This article covers requirements for the installation of overcurrent protection of circuits and related electrical equipment and over and [overvoltage protection](#) (surge arresters) permanently installed on premises wiring systems over 1000 VAC, 1500 VDC, nominal.

245.15 Reconditioned Equipment.

Reconditioned equipment shall be listed as “reconditioned” and the original listing mark removed.

(A) Medium and high-voltage circuit breakers shall be permitted to be reconditioned

(B) Electromechanical protective relays and current transformers shall be permitted to be reconditioned

(C) Medium-voltage fuseholders and medium-voltage nonrenewable fuses shall not be permitted to be reconditioned.

Part II. Overcurrent Protection

245.21 Circuit Interrupting Devices

(A) Circuit Breakers

(1) Location.

(a) Circuit breakers installed indoors shall be mounted either in metal-enclosed units or fire-resistant cell-mounted units, or they shall be permitted to be open-mounted in locations accessible to qualified persons only.

(b) Circuit breakers used to control oil-filled transformers in a vault shall either be located outside the transformer vault or be capable of operation from outside the vault.

(c) Oil circuit breakers shall be arranged or located so that adjacent readily combustible structures or materials are safeguarded in an approved manner

(2) Operating Characteristics. Circuit breakers shall have the following equipment or operating characteristics:

1. An accessible mechanical or other identified means for manual tripping, independent of control power

2. Be release free (trip free)

3. If capable of being opened or closed manually while energized, main contacts that operate independently of the speed of the manual operation

4. A mechanical position indicator at the circuit breaker to show the open or closed position of the main contacts

5. A means of indicating the open and closed position of the breaker at the point(s) from which they may be operated

(3) Nameplate. A circuit breaker shall have a permanent and legible nameplate showing manufacturer's name or trademark, manufacturer's type or identification number, continuous current rating, interrupting rating in megavolt-amperes (MVA) or amperes, and maximum voltage rating. Modification of a circuit breaker affecting its rating(s) shall be accompanied by an appropriate change of nameplate information.

(4) Rating. Circuit breakers shall have the following ratings:

1. The continuous current rating of a circuit breaker shall not be less than the maximum continuous current through the circuit breaker.
2. The interrupting rating of a circuit breaker shall not be less than the available fault current the circuit breaker will be required to interrupt, including contributions from all connected sources of energy.
3. The closing rating of a circuit breaker shall not be less than the maximum asymmetrical fault current into which the circuit breaker can be closed.
4. The momentary rating of a circuit breaker shall not be less than the maximum asymmetrical fault current at the point of installation.
5. The rated maximum voltage of a circuit breaker shall not be less than the maximum circuit voltage.

(5) Retrofit Trip Units. Retrofit trip units shall be listed for use with the specific circuit breaker with which it is installed

(B) Power Fuses and Fuseholders.

(1) Use. Where fuses are used to protect conductors and equipment, a fuse shall be placed in each ungrounded conductor. Two power fuses shall be permitted to be used in parallel to protect the same load if both fuses have identical ratings and both fuses are installed in an identified common mounting with electrical connections that divide the current equally. Power fuses of the vented type shall not be used indoors, underground, or in metal enclosures unless identified for the use.

(2) Interrupting Rating. The interrupting rating of power fuses shall not be less than the available fault current the fuse is required to interrupt, including contributions from all connected sources of energy.

(3) Voltage Rating. The maximum voltage rating of power fuses shall not be less than the maximum circuit voltage. Fuses having a minimum recommended operating voltage shall not be applied below this voltage.

(4) Identification of Fuse Mountings and Fuse Units. Fuse mountings and fuse units shall have permanent and legible nameplates showing the manufacturer's type or designation, continuous current rating, interrupting current rating, and maximum voltage rating.

(5) Fuses. Fuses that expel flame in opening the circuit shall be designed or arranged so that they function properly without hazard to persons or property.

(6) Fuseholders. Fuseholders shall be designed or installed so that they are de-energized while a fuse is being replaced. A field-applied permanent and legible sign, in accordance with 110.21(B), shall be installed immediately adjacent to the fuseholders and shall be worded as follows:

DANGER — DISCONNECT CIRCUIT BEFORE REPLACING FUSES.

Exception: Fuses and fuseholders designed to permit fuse replacement by qualified persons using identified equipment without de-energizing the fuseholder shall be permitted.

(7) High-Voltage Fuses. Switchgear and substations that utilize high-voltage fuses shall be provided with a gang-operated disconnecting switch. Isolation of the fuses from the circuit shall be provided by either connecting a switch between the source and the fuses or providing roll-out switch and fuse-type construction. The switch shall be of the load-interrupter type, unless mechanically or electrically interlocked with a load-interrupting device arranged to reduce the load to the interrupting capability of the switch.

Exception: More than one switch shall be permitted as the disconnecting means for one set of fuses where the switches are installed to provide connection to more than one set of supply conductors. The switches shall be mechanically or electrically interlocked to permit access to the fuses only when all switches are open. A conspicuous sign shall be placed at the fuses identifying the presence of more than one source.

(C) Distribution Cutouts and Fuse Links — Expulsion Type.

(1) Installation. Cutouts shall be located so that they may be readily and safely operated and re-fused, and so that the exhaust of the fuses does not endanger persons. Distribution cutouts shall not be used indoors, underground, or in metal enclosures.

(2) Operation. Where fused cutouts are not suitable to interrupt the circuit manually while carrying full load, an approved means shall be installed to interrupt the entire load. Unless the fused cutouts are interlocked with the switch to prevent opening of the cutouts under load, a conspicuous sign shall be placed at such cutouts identifying that they shall not be operated under load.

(3) Interrupting Rating. The interrupting rating of distribution cutouts shall not be less than the available fault current the cutout is required to interrupt, including contributions from all connected sources of energy.

(4) Voltage Rating. The maximum voltage rating of cutouts shall not be less than the maximum circuit voltage.

(5) Identification. Distribution cutouts shall have on their body, door, or fuse tube a permanent and legible nameplate or identification showing the manufacturer's type or designation, continuous current rating, maximum voltage rating, and interrupting rating.

(6) Fuse Links. Fuse links shall have a permanent and legible identification showing continuous current rating and type.

(7) Structure Mounted Outdoors. The height of cutouts mounted outdoors on structures shall provide safe clearance between lowest energized parts (open or closed position) and standing surfaces, in accordance with 110.34(E).

(D) Oil-Filled Cutouts.

(1) Continuous Current Rating. The continuous current rating of oil-filled cutouts shall not be less than the maximum continuous current through the cutout.

(2) Interrupting Rating. The interrupting rating of oil-filled cutouts shall not be less than the available fault current the oil-filled cutout is required to interrupt, including contributions from all connected sources of energy.

(3) Voltage Rating. The maximum voltage rating of oil-filled cutouts shall not be less than the maximum circuit voltage.

(4) Fault Closing Rating. Oil-filled cutouts shall have a fault closing rating not less than the maximum asymmetrical fault current that can occur at the cutout location, unless suitable interlocks or operating procedures preclude the possibility of closing into a fault.

(5) Identification. Oil-filled cutouts shall have a permanent and legible nameplate showing the rated continuous current, rated maximum voltage, and rated interrupting current.

(6) Fuse Links. Fuse links shall have a permanent and legible identification showing the rated continuous current.

(7) Location. Cutouts shall be located so that they are readily and safely accessible for re-fusing, with the top of the cutout not over 1.5 m (5 ft) above the floor or platform.

(8) Enclosure. Suitable barriers or enclosures shall be provided to prevent contact with nonshielded cables or energized parts of oil-filled cutouts.

(E) Load Interrupters. Load-interrupter switches shall be permitted if suitable fuses or circuit breakers are used in conjunction with these devices to interrupt available fault currents. Where these devices are used in combination, they shall be coordinated electrically so that they will safely withstand the effects of closing, carrying, or interrupting all possible currents up to the assigned maximum short-circuit rating.

Where more than one switch is installed with interconnected load terminals to provide for alternate connection to different supply conductors, each switch shall be provided with a warning sign identifying the presence of more than one source. Each warning sign or label shall comply with 110.21.

(1) Continuous Current Rating. The continuous current rating of interrupter switches shall equal or exceed the maximum continuous current at the point of installation.

(2) Voltage Rating. The maximum voltage rating of interrupter switches shall equal or exceed the maximum circuit voltage.

(3) Identification. Interrupter switches shall have a permanent and legible nameplate including the following information: manufacturer's type or designation, continuous current rating, interrupting current rating, fault closing rating, maximum voltage rating.

(4) Switching of Conductors. The switching mechanism shall be arranged to be operated from a location where the operator is not exposed to energized parts and shall be arranged to open all ungrounded conductors of the circuit simultaneously with one operation. Switches shall be arranged to be locked in the open position. Metal-enclosed switches shall be operable from outside the enclosure.

245.26 Feeders and Branch Circuits

(A) Location and Type of Protection. Feeder and branch-circuit conductors shall have overcurrent protection in each ungrounded conductor located at the point where the conductor receives its supply or at an alternative location in the circuit when designed under engineering supervision that includes but is not limited to considering the appropriate fault studies and time-current coordination analysis of the protective devices and the conductor damage curves. The overcurrent protection shall be permitted to be provided by either 245.26(A)(1) or (A)(2).

(1) Overcurrent Relays and Current Transformers. Circuit breakers used for overcurrent protection of 3-phase circuits shall have a minimum of three overcurrent relay elements operated from three current transformers. The separate overcurrent relay elements (or protective functions) shall be permitted to be part of a single electronic protective relay unit.

On 3-phase, 3-wire circuits, an overcurrent relay element in the residual circuit of the current transformers shall be permitted to replace one of the phase relay elements.

An overcurrent relay element, operated from a current transformer that links all phases of a 3-phase, 3-wire circuit, shall be permitted to replace the residual relay element and one of the phase-conductor current transformers. Where the neutral conductor is not regrounded on the load side of the circuit as permitted in 250.184(B), the current transformer shall be permitted to link all 3-phase conductors and the grounded circuit conductor (neutral).

(2) Fuses. A fuse shall be connected in series with each ungrounded conductor.

(B) Protective Devices. The protective device(s) shall be capable of detecting and interrupting all values of current that can occur at their location in excess of their trip-setting or melting point.

(C) Conductor Protection. The operating time of the protective device, the available short-circuit current, and the conductor used shall be coordinated to prevent damaging or dangerous temperatures in conductors or conductor insulation under short-circuit conditions.

245.27 Additional Requirements for Feeders.

(A) Rating or Setting of Overcurrent Protective Devices. The continuous ampere rating of a fuse shall not exceed three times the ampacity of the conductors. The long-time trip element setting of a breaker or the minimum trip setting of an electronically actuated fuse shall not exceed six times the ampacity of the conductor. For fire pumps, conductors shall be permitted to be protected for overcurrent in accordance with 695.4(B)(2).

(B) Feeder Taps. Conductors tapped to a feeder shall be permitted to be protected by the feeder overcurrent device where that overcurrent device also protects the tap conductor.

Part III. Overvoltage Protection

245.40 Other Articles. Equipment shall be protected against overvoltage in accordance with the article in this Code that covers the type of equipment or location specified in Table 245.40.

Table 245.40 Other Articles

<u>Equipment</u>	<u>Article</u>
<u>Equipment over 1000 volts, nominal</u>	<u>495</u>
<u>Outdoor overhead conductors over 1000 volts</u>	<u>399</u>

245.41 Uses Not Permitted. A surge arrester shall not be installed where the rating of the surge arrester is less than the maximum continuous phase-to-ground voltage at the power frequency available at the point of application.

245.42 Surge Arrester Selection. The surge arresters shall comply with 245.42(A) and (B).

(A) Rating. The rating of a surge arrester shall be equal to or greater than the maximum continuous operating voltage available at the point of application.

(1) Solidly Grounded Systems. The maximum continuous operating voltage shall be the phase-to-ground voltage of the system.

(2) Impedance or Ungrounded System. The maximum continuous operating voltage shall be the phase-to-phase voltage of the system.

(B) Silicon Carbide Types. The rating of a silicon carbide-type surge arrester shall be not less than 125 percent of the rating specified in 245.42(A).

Informational Note No. 1: For further information on surge arresters, see IEEE C62.11-2012, *Standard for Metal-Oxide Surge Arresters for Alternating-Current Power Circuits (>1 kV)*, and IEEE C62.22-2009, *Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems*.

Informational Note No. 2: The selection of a properly rated metal oxide arrester is based on considerations of maximum continuous operating voltage and the magnitude and duration of overvoltages at the arrester location as affected by phase-to-ground faults, system grounding techniques, switching surges, and other causes. See the manufacturer's application rules for selection of the specific arrester to be used at a particular location.

245.44 Number Required. Where used at a point on a circuit, a surge arrester shall be connected to each ungrounded conductor. A single installation of such surge arresters shall be permitted to protect a number of interconnected circuits if no circuit is exposed to surges while disconnected from the surge arresters.

245.46 Location. Surge arresters shall be permitted to be located indoors or outdoors. Surge arresters shall be made inaccessible to unqualified persons unless listed for installation in accessible locations.

245.48 Routing of Surge Arrester Equipment Grounding Conductors. The conductor used to connect the surge arrester to line, bus, or equipment and to an equipment grounding conductor or grounding electrode connection point as provided in 245.50 shall not be any longer than necessary and shall avoid unnecessary bends.

245.50 Connection. The arrester shall be connected to one of the following:

1. Grounded service conductor
2. Grounding electrode conductor
3. Grounding electrode for the service
4. Equipment grounding terminal in the service equipment

245.52 Surge-Arrester Conductors. The conductor between the surge arrester and the line, and the surge arrester and the grounding connection, shall not be smaller than 6 AWG copper or aluminum.

245.54 Interconnections. The surge arrester protecting a transformer that supplies a secondary distribution system shall be interconnected as specified in 245.54(A), (B), or (C).

(A) Metal Interconnections. A metal interconnection shall be made to the secondary grounded circuit conductor or the secondary circuit grounding electrode conductor, if, in addition to the direct grounding connection at the surge arrester, the connection complies with 245.54(A)(1) or (A)(2).

(1) Additional Grounding Connection. The grounded conductor of the secondary has a grounding connection elsewhere to a continuous metal underground water piping system. In urban water-pipe areas where there are at least four water-pipe connections on the neutral conductor and not fewer than four such connections in each mile of neutral conductor, the metal interconnection shall be permitted to be made to the secondary neutral conductor with omission of the direct grounding connection at the surge arrester.

(2) Multigrounded Neutral System Connection. The grounded conductor of the secondary system is part of a multigrounded neutral system or static wire of which the primary neutral conductor or static wire has at least four grounding connections in each 1.6 km (1 mile) of line in addition to a grounding connection at each service.

(B) Through Spark Gap or Device. Where the surge arrester grounding electrode conductor is not connected as in 245.54(A), or where the secondary is not grounded as in 245.54(A) but is otherwise grounded as in 250.52, an interconnection shall be made through a spark gap or listed device as required by 245.54(B)(1) or (B)(2).

(1) Ungrounded or Unigrounded Primary System. For ungrounded or unigrounded primary systems, the spark gap for a listed device shall have a 60-Hz breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge-arrester grounding electrode.

(2) Multigrounded Neutral Primary System. For multigrounded neutral primary systems, the spark gap or listed device shall have a 60-Hz breakdown of not more than 3 kV, and there shall be at least one other ground on the grounded conductor of the secondary that is not less than 6.0 m (20 ft) distant from the surge-arrester grounding electrode.

(C) By Special Permission. An interconnection of the surge-arrester ground and the secondary neutral conductor, other than as provided in 245.54(A) or (B), shall be permitted to be made only by special permission.

245.56 Grounding Electrode Conductor Connections and Enclosures. Except as indicated in this article, surge-arrester grounding electrode conductor connections shall be made as specified in Article 250, Parts III and X. Grounding electrode conductors installed in metal enclosures shall comply with 250.64(E).

Revisions to Chapter 4

ARTICLE 430 Motors, Motor Circuits, and Controllers

(Only deleted / relocated text of Article 430 shown)_(relocated to Article 495 Part VI)

Part XI. Over 1000 Volts, Nominal

430.221 General. ~~Part XI recognizes the additional hazard due to the use of higher voltages. It adds to or amends the other provisions of this article.~~

430.222 Marking on Controllers. ~~In addition to the marking required by [430.8](#), a controller shall be marked with the control voltage.~~

430.223 Raceway Connection to Motors. ~~Flexible metal conduit or liquidtight flexible metal conduit not exceeding 1.8 m (6 ft) in length shall be permitted to be employed for raceway connection to a motor terminal enclosure.~~

430.224 Size of Conductors. ~~Conductors supplying motors shall have an ampacity not less than the current at which the motor overload protective device(s) is selected to trip.~~

430.225 Motor Circuit Overcurrent Protection.

(A) General. ~~Each motor circuit shall include coordinated protection to automatically interrupt overload and fault currents in the motor, the motor circuit conductors, and the motor control apparatus.
Exception: Where a motor is critical to an operation and the motor should operate to failure if necessary to prevent a greater hazard to persons, the sensing device(s) shall be permitted to be connected to a supervised annunciator or alarm instead of interrupting the motor circuit.~~

(B) Overload Protection.

(1) Type of Overload Device. ~~Each motor shall be protected against dangerous heating due to motor overloads and failure to start by a thermal protector integral with the motor or external current sensing devices, or both. Protective device settings for each motor circuit shall be determined under engineering supervision.~~

(2) Wound-Rotor Alternating-Current Motors. ~~The secondary circuits of wound-rotor ac motors, including conductors, controllers, and resistors rated for the application, shall be considered as protected against overcurrent by the motor overload protection means.~~

(3) Operation. ~~Operation of the overload interrupting device shall simultaneously disconnect all ungrounded conductors.~~

(4) Automatic Reset. ~~Overload sensing devices shall not automatically reset after trip unless resetting of the overload sensing device does not cause automatic restarting of the motor or there is no hazard to persons created by automatic restarting of the motor and its connected machinery.~~

(C) Fault-Current Protection.

(1) Type of Protection. ~~Fault current protection shall be provided in each motor circuit as specified by either [430.225\(C\)\(1\)\(a\)](#) or [\(C\)\(1\)\(b\)](#).~~

~~(a) A circuit breaker of suitable type and rating arranged so that it can be serviced without hazard. The circuit breaker shall simultaneously disconnect all ungrounded conductors. The circuit breaker shall be permitted to sense the fault current by means of integral or external sensing elements.~~

(b) Fuses of a suitable type and rating placed in each ungrounded conductor. Fuses shall be used with suitable disconnecting means, or they shall be of a type that can also serve as the disconnecting means. They shall be arranged so that they cannot be serviced while they are energized.

(2) Reclosing. Fault current interrupting devices shall not automatically reclose the circuit.

Exception: Automatic reclosing of a circuit shall be permitted where the circuit is exposed to transient faults and where such automatic reclosing does not create a hazard to persons.

(3) Combination Protection. Overload protection and fault current protection shall be permitted to be provided by the same device.

430.226 Rating of Motor Control Apparatus. The ultimate trip current of overcurrent (overload) relays or other motor protective devices used shall not exceed 115 percent of the controller's continuous current rating. Where the motor branch circuit disconnecting means is separate from the controller, the disconnecting means current rating shall not be less than the ultimate trip setting of the overcurrent relays in the circuit.

430.227 Disconnecting Means. The controller disconnecting means shall be lockable in accordance with [110.25](#).

Table 430.249 Full-Load Current, Two-Phase Alternating-Current Motors (4-Wire)

The following values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Current in the common conductor of a 2-phase, 3-wire system will be 1.41 times the value given. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

Horsepower	Induction-Type Squirrel Cage and Wound Rotor (Amperes)				
	115 Volts	230 Volts	460 Volts	575 Volts	2300- Volts
$\frac{1}{2}$	4.0	2.0	1.0	0.8	—
$\frac{3}{4}$	4.8	2.4	1.2	1.0	—
1	6.4	3.2	1.6	1.3	—
$1\frac{1}{2}$	9.0	4.5	2.3	1.8	—
2	11.8	5.9	3.0	2.4	—
3	—	8.3	4.2	3.3	—
5	—	13.2	6.6	5.3	—
$7\frac{1}{2}$	—	19	9.0	8.0	—

Table 430.249 Full-Load Current, Two-Phase Alternating-Current Motors (4-Wire)

The following values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Current in the common conductor of a 2-phase, 3-wire system will be 1.41 times the value given. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

Horsepower	Induction-Type Squirrel Cage and Wound Rotor (Amperes)				
	115 Volts	230 Volts	460 Volts	575 Volts	2300- Volts
10	—	24	12	10	—
15	—	36	18	14	—
20	—	47	23	19	—
25	—	59	29	24	—
30	—	69	35	28	—
40	—	90	45	36	—
50	—	113	56	45	—
60	—	133	67	53	44
75	—	166	83	66	48
100	—	218	109	87	23
125	—	270	135	108	28
150	—	312	156	125	32
200	—	416	208	167	43

Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors

The following values of full-load currents are typical for motors running at speeds usual for belted motors and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

Horsepower	Induction-Type Squirrel Cage and Wound Rotor (Amperes)							Synchronous-Type Unity Power Factor* (Amperes)			
	115 V olts	200 V olts	208 V olts	230 V olts	460 V olts	575 V olts	2300 V olts	230 V olts	460 V olts	575 V olts	2300 V olts
$\frac{1}{2}$	4.4	2.5	2.4	2.2	1.1	0.9	—	—	—	—	—
$\frac{3}{4}$	6.4	3.7	3.5	3.2	1.6	1.3	—	—	—	—	—
1	8.4	4.8	4.6	4.2	2.1	1.7	—	—	—	—	—
$1\frac{1}{2}$	12.0	6.9	6.6	6.0	3.0	2.4	—	—	—	—	—
2	13.6	7.8	7.5	6.8	3.4	2.7	—	—	—	—	—
3	—	11.0	10.6	9.6	4.8	3.9	—	—	—	—	—
5	—	17.5	16.7	15.2	7.6	6.1	—	—	—	—	—
$7\frac{1}{2}$	—	25.3	24.2	22	11	9	—	—	—	—	—
10	—	32.2	30.8	28	14	11	—	—	—	—	—
15	—	48.3	46.2	42	21	17	—	—	—	—	—
20	—	62.1	59.4	54	27	22	—	—	—	—	—
25	—	78.2	74.8	68	34	27	—	53	26	21	—
30	—	92	88	80	40	32	—	63	32	26	—
40	—	120	114	104	52	41	—	83	41	33	—
50	—	150	143	130	65	52	—	104	52	42	—

Table 430.250 Full-Load Current, Three-Phase Alternating-Current Motors

The following values of full-load currents are typical for motors running at speeds usual for belted motors and motors with normal torque characteristics. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

Horsepower	Induction-Type Squirrel Cage and Wound Rotor (Amperes)							Synchronous-Type Unity Power Factor* (Amperes)			
	115 V olts	200 V olts	208 V olts	230 V olts	460 V olts	575 V olts	2300 V olts	230 V olts	460 V olts	575 V olts	2300 V olts
60	—	177	169	154	77	62	16	123	61	49	42
75	—	221	211	192	96	77	20	155	78	62	45
100	—	285	273	248	124	99	26	202	101	81	20
125	—	359	343	312	156	125	31	253	126	101	25
150	—	414	396	360	180	144	37	302	151	121	30
200		552	528	480	240	192	49	400	201	161	40
250	—	—	—	—	302	242	60	—	—	—	—
300	—	—	—	—	361	289	72	—	—	—	—
350	—	—	—	—	414	336	83	—	—	—	—
400	—	—	—	—	477	382	95	—	—	—	—
450	—	—	—	—	515	412	103	—	—	—	—
500	—	—	—	—	590	472	118	—	—	—	—

*For 90 and 80 percent power factor, the figures shall be multiplied by 1.1 and 1.25, respectively.

ARTICLE 450 Transformers ~~and Transformer Vaults~~ (Including Secondary Ties) (450 part III Vaults -deleted / relocated)(relocated to Article 495 Parts VII and VIII)(450.21(c) edit also)

Part I. General Provisions

450.1 Scope. This article covers the installation of all transformers.

Informational Note: Article 495 includes additional requirements for transformers rated over 1000 volts ac, 1500 volts dc, nominal on either or both the primary or the secondary.

Exception No. 1: Current transformers.

Exception No. 2: Dry-type transformers that constitute a component part of other apparatus and comply with the requirements for such apparatus.

Exception No. 3: Transformers that are an integral part of an X-ray, high-frequency, or electrostatic-coating apparatus.

Exception No. 4: Transformers used with Class 2 and Class 3 circuits that comply with Article 725.

Exception No. 5: Transformers for sign and outline lighting that comply with Article 600.

Exception No. 6: Transformers for electric-discharge lighting that comply with Article 410.

Exception No. 7: Transformers used for power-limited fire alarm circuits that comply with Part III of Article 760.

Exception No. 8: Transformers used for research, development, or testing, where effective arrangements are provided to safeguard persons from contacting energized parts.

This article covers the installation of transformers dedicated to supplying power to a fire pump installation as modified by Article 695.

This article also covers the installation of transformers in hazardous (classified) locations as modified by Articles 501 through 504.

450.2 Definition.

The definitions in this section shall apply only within this article.

Transformer.

An individual transformer, single- or polyphase, identified by a single nameplate, unless otherwise indicated in this article.

450.3 Overcurrent Protection. Overcurrent protection of transformers shall comply with 450.3(A) (B), or (C). As used in this section, the word *transformer* shall mean a transformer or polyphase bank of two or more single-phase transformers operating as a unit.

Informational Note No. 1: See 240.4, 240.21, 240.100, and 240.101 for overcurrent protection of conductors.

Informational Note No. 2: Nonlinear loads can increase heat in a transformer without operating its overcurrent protective device.

(A) Transformers Over 1000 Volts, Nominal. Overcurrent protection shall be provided in accordance with Table 495.103.

(B) Transformers 1000 Volts, Nominal, or Less. Overcurrent protection shall be provided in accordance with **Table 450.3(B)**.

*Exception: Where the transformer is installed as a motor control circuit transformer in accordance with **430.72(C)(1)** through (C)(5).*

Table 450.3(A) Maximum Rating or Setting of Overcurrent Protection for Transformers Over 1000 Volts (as a Percentage of Transformer Rated Current)

Location Limitations	Transformer Rated Impedance	Primary Protection over 1000 Volts		Secondary Protection (See Note 2.)		
				Over 1000 Volts		1000 Volts or Less
		Circuit Breaker (See Note 4.)	Fuse Rating	Circuit Breaker (See Note 4.)	Fuse Rating	Circuit Breaker or Fuse Rating
Any location	Not more than 6%	600% (See Note 1.)	300% (See Note 1.)	300% (See Note 1.)	250% (See Note 1.)	125% (See Note 1.)
	More than 6% and not more than 10%	400% (See Note 1.)	300% (See Note 1.)	250% (See Note 1.)	225% (See Note 1.)	125% (See Note 1.)
Supervised locations only (See Note 3.)	Any	300% (See Note 1.)	250% (See Note 1.)	Not required	Not required	Not required
	Not more than 6%	600%	300%	300% (See Note 5.)	250% (See Note 5.)	250% (See Note 5.)
	More than 6% and not more than 10%	400%	300%	250% (See Note 5.)	225% (See Note 5.)	250% (See Note 5.)

Notes:

1. Where the required fuse rating or circuit breaker setting does not correspond to a standard rating or setting, a higher rating or setting that does not exceed the following shall be permitted:

a. The next higher standard rating or setting for fuses and circuit breakers 1000 volts and below, or

b. The next higher commercially available rating or setting for fuses and circuit breakers above 1000 volts.

2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped in one location. Where multiple overcurrent devices are utilized, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device. If both circuit breakers and fuses are used as the overcurrent device, the total of the device ratings shall not exceed that allowed for fuses.

3. A supervised location is a location where conditions of maintenance and supervision ensure that only qualified persons monitor and service the transformer installation.

4. Electronically actuated fuses that may be set to open at a specific current shall be set in accordance with settings for circuit breakers.

5. A transformer equipped with a coordinated thermal overload protection by the manufacturer shall be permitted to have separate secondary protection omitted.

Table 450.3(B) Maximum Rating or Setting of Overcurrent Protection for Transformers 1000 Volts and Less (as a Percentage of Transformer-Rated Current)

Protection Method	Primary Protection			Secondary Protection (See Note 2.)	
	Currents of 9 Amperes or More	Currents Less Than 9 Amperes	Currents Less Than 2 Amperes	Currents of 9 Amperes or More	Currents Less Than 9 Amperes
Primary only protection	125% (See Note 1.)	167%	300%	Not required	Not required
Primary and secondary protection	250% (See Note 3.)	250% (See Note 3.)	250% (See Note 3.)	125% (See Note 1.)	167%

Notes:

1. Where 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, a higher rating that does not exceed the next higher standard rating shall be permitted.

2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped in one location. Where multiple overcurrent devices are utilized, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device.

3. A transformer equipped with coordinated thermal overload protection by the manufacturer and arranged to interrupt the primary current shall be permitted to have primary overcurrent protection rated or set at a current value that is not more than six times the rated current of the transformer for transformers having not more than 6 percent impedance and not more than four times the rated current of the transformer for transformers having more than 6 percent but not more than 10 percent impedance.

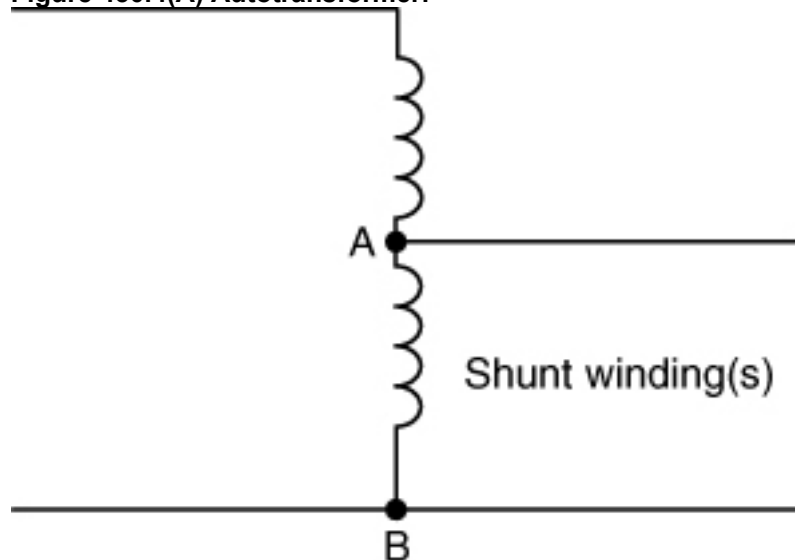
(C) Voltage (Potential) Transformers. Voltage (potential) transformers installed indoors or enclosed shall be protected with primary fuses.

Informational Note: For protection of instrument circuits including voltage transformers, see [408.52](#).

450.4 Autotransformers 1000 Volts, Nominal, or Less.

(A) Overcurrent Protection. Each autotransformer 1000 volts, nominal, or less shall be protected by an individual overcurrent device installed in series with each ungrounded input conductor. Such overcurrent device shall be rated or set at not more than 125 percent of the rated full-load input current of the autotransformer. Where this calculation does not correspond to a standard rating of a fuse or nonadjustable circuit breaker and the rated input current is 9 amperes or more, the next higher standard rating described in [240.6](#) shall be permitted. An overcurrent device shall not be installed in series with the shunt winding (the winding common to both the input and the output circuits) of the autotransformer between Points A and B as shown in [Figure 450.4\(A\)](#).

Figure 450.4(A) Autotransformer.



Exception: Where the rated input current of the autotransformer is less than 9 amperes, an overcurrent device rated or set at not more than 167 percent of the input current shall be permitted.

(B) Transformer Field-Connected as an Autotransformer. A transformer field-connected as an autotransformer shall be identified for use at elevated voltage.

Informational Note: For information on permitted uses of autotransformers, see [210.9](#) and [215.11](#).

450.5 Grounding Autotransformers. Grounding autotransformers covered in this section are zigzag or T-connected transformers connected to 3-phase, 3-wire ungrounded systems for the purpose of creating a 3-phase, 4-wire distribution system or providing a neutral point for grounding purposes. Such transformers shall have a continuous per-phase current rating and a continuous neutral current rating. Zigzag-connected transformers shall not

be installed on the load side of any system grounding connection, including those made in accordance with **250.24(B)**, **250.30(A)(1)**, or **250.32(B)**, Exception No. 1.

Informational Note: The phase current in a grounding autotransformer is one-third the neutral current.

(A) Three-Phase, 4-Wire System. A grounding autotransformer used to create a 3-phase, 4-wire distribution system from a 3-phase, 3-wire ungrounded system shall conform to **450.5(A)(1)** through (A)(4).

(1) Connections. The transformer shall be directly connected to the ungrounded phase conductors and shall not be switched or provided with overcurrent protection that is independent of the main switch and common-trip overcurrent protection for the 3-phase, 4-wire system.

(2) Overcurrent Protection. An overcurrent sensing device shall be provided that will cause the main switch or common-trip overcurrent protection referred to in **450.5(A)(1)** to open if the load on the autotransformer reaches or exceeds 125 percent of its continuous current per-phase or neutral rating. Delayed tripping for temporary overcurrents sensed at the autotransformer overcurrent device shall be permitted for the purpose of allowing proper operation of branch or feeder protective devices on the 4-wire system.

(3) Transformer Fault Sensing. A fault-sensing system that causes the opening of a main switch or common-trip overcurrent device for the 3-phase, 4-wire system shall be provided to guard against single-phasing or internal faults.

Informational Note: This can be accomplished by the use of two subtractive-connected donut-type current transformers installed to sense and signal when an unbalance occurs in the line current to the autotransformer of 50 percent or more of rated current.

(4) Rating. The autotransformer shall have a continuous neutral-current rating that is not less than the maximum possible neutral unbalanced load current of the 4-wire system.

(B) Ground Reference for Fault Protection Devices. A grounding autotransformer used to make available a specified magnitude of ground-fault current for operation of a ground-responsive protective device on a 3-phase, 3-wire ungrounded system shall conform to **450.5(B)(1)** and (B)(2).

(1) Rating. The autotransformer shall have a continuous neutral-current rating not less than the specified ground-fault current.

(2) Overcurrent Protection. Overcurrent protection shall comply with **450.5(B)(2)(a)** and **(B)(2)(b)**.

(a) *Operation and Interrupting Rating.* An overcurrent protective device having an interrupting rating in compliance with **110.9** and that will open simultaneously all ungrounded conductors when it operates shall be applied in the grounding autotransformer branch circuit.

(b) *Ampere Rating.* The overcurrent protection shall be rated or set at a current not exceeding 125 percent of the autotransformer continuous per-phase current rating or 42 percent of the continuous-current rating of any series-connected devices in the autotransformer neutral connection. Delayed tripping for temporary overcurrents to permit the proper operation of ground-responsive tripping devices on the main system shall be permitted but shall not exceed values that would be more than the short-time current rating of the grounding autotransformer or any series connected devices in the neutral connection thereto.

*Exception: For high-impedance grounded systems covered in **250.36**, where the maximum ground-fault current is designed to be not more than 10 amperes, and where the grounding autotransformer and the grounding impedance are rated for continuous duty, an overcurrent device rated not more than 20 amperes that will simultaneously open all ungrounded conductors shall be permitted to be installed on the line side of the grounding autotransformer.*

(C) Ground Reference for Damping Transitory Overvoltages. A grounding autotransformer used to limit transitory overvoltages shall be of suitable rating and connected in accordance with **450.5(A)(1)**.

450.6 Secondary Ties. As used in this article, a secondary tie is a circuit operating at 1000 volts, nominal, or less between phases that connects two power sources or power supply points, such as the secondaries of two

transformers. The tie shall be permitted to consist of one or more conductors per phase or neutral. Conductors connecting the secondaries of transformers in accordance with 450.7 shall not be considered secondary ties. As used in this section, the word *transformer* means a transformer or a bank of transformers operating as a unit.

(A) Tie Circuits. Tie circuits shall be provided with overcurrent protection at each end as required in Parts I, II, and VIII of Article 240.

Under the conditions described in 450.6(A)(1) and 450.6(A)(2), the overcurrent protection shall be permitted to be in accordance with 450.6(A)(3).

(1) Loads at Transformer Supply Points Only. Where all loads are connected at the transformer supply points at each end of the tie and overcurrent protection is not provided in accordance with Parts I, II, and VIII of Article 240, the ampacity of the tie shall not be less than 67 percent of the rated secondary current of the highest rated transformer supplying the secondary tie system.

(2) Loads Connected Between Transformer Supply Points. Where load is connected to the tie at any point between transformer supply points and overcurrent protection is not provided in accordance with Parts I, II, and VIII of Article 240, the ampacity of the tie shall not be less than 100 percent of the rated secondary current of the highest rated transformer supplying the secondary tie system.

Exception: Tie circuits comprised of multiple conductors per phase shall be permitted to be sized and protected in accordance with 450.6(A)(4).

(3) Tie Circuit Protection. Under the conditions described in 450.6(A)(1) and (A)(2), both supply ends of each ungrounded tie conductor shall be equipped with a protective device that opens at a predetermined temperature of the tie conductor under short-circuit conditions. This protection shall consist of one of the following: (1) a fusible link cable connector, terminal, or lug, commonly known as a limiter, each being of a size corresponding with that of the conductor and of construction and characteristics according to the operating voltage and the type of insulation on the tie conductors or (2) automatic circuit breakers actuated by devices having comparable time–current characteristics.

(4) Interconnection of Phase Conductors Between Transformer Supply Points. Where the tie consists of more than one conductor per phase or neutral, the conductors of each phase or neutral shall comply with 450.6(A)(4)(a) or (A)(4)(b).

(a) *Interconnected.* The conductors shall be interconnected in order to establish a load supply point, and the protective device specified in 450.6(A)(3) shall be provided in each ungrounded tie conductor at this point on both sides of the interconnection. The means of interconnection shall have an ampacity not less than the load to be served.

(b) *Not Interconnected.* The loads shall be connected to one or more individual conductors of a paralleled conductor tie without interconnecting the conductors of each phase or neutral and without the protection specified in 450.6(A)(3) at load connection points. Where this is done, the tie conductors of each phase or neutral shall have a combined capacity ampacity of not less than 133 percent of the rated secondary current of the highest rated transformer supplying the secondary tie system, the total load of such taps shall not exceed the rated secondary current of the highest rated transformer, and the loads shall be equally divided on each phase and on the individual conductors of each phase as far as practicable.

(5) Tie Circuit Control. Where the operating voltage exceeds 150 volts to ground, secondary ties provided with limiters shall have a switch at each end that, when open, de-energizes the associated tie conductors and limiters. The current rating of the switch shall not be less than the rated current ampacity of the conductors connected to the switch. It shall be capable of interrupting its rated current, and it shall be constructed so that it will not open under the magnetic forces resulting from short-circuit current.

(B) Overcurrent Protection for Secondary Connections. Where secondary ties are used, an overcurrent device rated or set at not more than 250 percent of the rated secondary current of the transformers shall be provided in the secondary connections of each transformer supplying the tie system. In addition, an automatic circuit breaker

actuated by a reverse-current relay set to open the circuit at not more than the rated secondary current of the transformer shall be provided in the secondary connection of each transformer.

(C) Grounding. Where the secondary tie system is grounded, each transformer secondary supplying the tie system shall be grounded in accordance with the requirements of **250.30** for separately derived systems.

450.7 Parallel Operation. Transformers shall be permitted to be operated in parallel and switched as a unit, provided the overcurrent protection for each transformer meets the requirements of **495.103450.3(A)** for primary and secondary protective devices over 1000 volts, or **450.3(B)** for primary and secondary protective devices 1000 volts or less.

450.8 Guarding. Transformers shall be guarded as specified in **450.8(A)** through (D).

(A) Mechanical Protection. Appropriate provisions shall be made to minimize the possibility of damage to transformers from external causes where the transformers are exposed to physical damage.

(B) Case or Enclosure. Dry-type transformers shall be provided with a noncombustible moisture-resistant case or enclosure that provides protection against the accidental insertion of foreign objects.

(C) Exposed Energized Parts. Switches or other equipment operating at 1000 volts, nominal, or less and serving only equipment within a transformer enclosure shall be permitted to be installed in the transformer enclosure if accessible to qualified persons only. All energized parts shall be guarded in accordance with **110.27** and **110.34**.

(D) Voltage Warning. The operating voltage of exposed live parts of transformer installations shall be indicated by signs or visible markings on the equipment or structures.

450.9 Ventilation. The ventilation shall dispose of the transformer full-load heat losses without creating a temperature rise that is in excess of the transformer rating.

Informational Note No. 1: See IEEE C57.12.00-2015, *General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers*, and IEEE C57.12.01-2015, *General Requirements for Dry-Type Distribution and Power Transformers*.

Informational Note No. 2: Additional losses occur in some transformers where nonsinusoidal currents are present, resulting in increased heat in the transformer above its rating. See IEEE C57.110-2008, *Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents*, where transformers are utilized with nonlinear loads.

Transformers with ventilating openings shall be installed so that the ventilating openings are not blocked by walls or other obstructions. The required clearances shall be clearly marked on the transformer. Transformer top surfaces that are horizontal and readily accessible shall be marked to prohibit storage.

450.10 Grounding.

(A) Dry-Type Transformer Enclosures. Where separate equipment grounding conductors and supply-side bonding jumpers are installed, a terminal bar for all grounding and bonding conductor connections shall be secured inside the transformer enclosure. The terminal bar shall be bonded to the enclosure in accordance with **250.12** and shall not be installed on or over any vented portion of the enclosure.

*Exception: Where a dry-type transformer is equipped with wire-type connections (leads), the grounding and bonding connections shall be permitted to be connected together using any of the methods in **250.8** and shall be bonded to the enclosure if of metal.*

(B) Other Metal Parts. Exposed non-current-carrying metal parts of transformer installations, including fences, guards, and so forth, shall be grounded and bonded under the conditions and in the manner specified for electrical equipment and other exposed metal parts in Parts V, VI, and VII of Article **250**.

450.11 Marking.

(A) General. Each transformer shall be provided with a nameplate giving the following information:

- (1) Name of manufacturer
- (2) Rated kilovolt-amperes
- (3) Frequency
- (4) Primary and secondary voltage
- (5) Impedance of transformers 25 kVA and larger
- (6) Required clearances for transformers with ventilating openings
- (7) Amount and kind of insulating liquid where used
- (8) For dry-type transformers, temperature class for the insulation system

(B) Source Marking. A transformer shall be permitted to be supplied at the marked secondary voltage, provided that the installation is in accordance with the manufacturer's instructions.

450.12 Terminal Wiring Space. The minimum wire-bending space at fixed, 1000-volt and below terminals of transformer line and load connections shall be as required in 312.6. Wiring space for pigtail connections shall conform to Table 314.16(B).

450.13 Accessibility. All transformers ~~and transformer vaults~~ shall be readily accessible to qualified personnel for inspection and maintenance or shall meet the requirements of 450.13(A) or 450.13(B).

(A) Open Installations. Dry-type transformers 1000 volts, nominal, or less, located in the open on walls, columns, or structures, shall not be required to be readily accessible.

(B) Hollow Space Installations. Dry-type transformers 1000 volts, nominal, or less and not exceeding 50 kVA shall be permitted in hollow spaces of buildings not permanently closed in by structure, provided they meet the ventilation requirements of 450.9 and separation from combustibles requirements of 450.21(A). Transformers so installed shall not be required to be readily accessible.

450.14 Disconnecting Means. Transformers, other than Class 2 or Class 3 transformers, shall have a disconnecting means located either in sight of the transformer or in a remote location. Where located in a remote location, the disconnecting means shall be lockable open in accordance with 110.25, and its location shall be field marked on the transformer.

Part II. Specific Provisions Applicable to Different Types of Transformers

450.21 Dry-Type Transformers Installed Indoors.

(A) Not Over 112½ kVA. Dry-type transformers installed indoors and rated 112½ kVA or less shall have a separation of at least 300 mm (12 in.) from combustible material unless separated from the combustible material by a fire-resistant, heat-insulated barrier.

Exception: This rule shall not apply to transformers rated for 1000 volts, nominal, or less that are completely enclosed, except for ventilating openings.

(B) Over 112½ kVA. Individual dry-type transformers of more than 112½ kVA rating shall be installed in a transformer room of fire-resistant construction having a minimum fire rating of 1 hour.

Exception No. 1: Transformers with Class 155 or higher insulation systems and separated from combustible material by a fire-resistant, heat-insulating barrier or by not less than 1.83 m (6 ft) horizontally and 3.7 m (12 ft) vertically.

Exception No. 2: Transformers with Class 155 or higher insulation systems and completely enclosed except for ventilating openings.

Informational Note: See ASTM E119-18a, *Standard Test Methods for Fire Tests of Building Construction and Materials*.

(C) Over 35,000 Volts. Dry-type transformers rated over 35,000 volts shall be installed in a vault complying with Part VIII of this article 495.

450.22 Dry-Type Transformers Installed Outdoors. Dry-type transformers installed outdoors shall have a weatherproof enclosure.

Transformers exceeding 112½ kVA shall not be located within 300 mm (12 in.) of combustible materials of buildings unless the transformer has Class 155 insulation systems or higher and is completely enclosed except for ventilating openings.

450.23 ~~Less-Flammable~~ Liquid-Insulated Transformers. ~~Liquid-insulated transformers shall comply with Part VII of article 495. Transformers insulated with listed less-flammable liquids that have a fire point of not less than 300°C shall be permitted to be installed in accordance with 450.23(A) or 450.23(B).~~

450.40 Transformer Vaults. Transformer vaults shall comply with Part VIII of article 495.

(A) Indoor Installations. Indoor installations shall be permitted in accordance with one of the following:-

(1) In Type I or Type II buildings, in areas where all of the following requirements are met:-

a. The transformer is rated 35,000 volts or less.

b. No combustible materials are stored.

c. A liquid confinement area is provided.

d. The installation complies with all the restrictions provided for in the listing of the liquid.

Informational Note: Such restrictions can include, but are not limited to, maximum pressure of the tank, use of a pressure relief valve, appropriate fuse types, and proper sizing of overcurrent protection.

(2) ~~If an automatic fire-extinguishing system and a liquid confinement area is present, provided the transformer is rated 35,000 volts or less~~

(3) ~~If the installation complies with 450.26~~

(B) Outdoor Installations. Less-flammable liquid-filled transformers shall be permitted to be installed outdoors, attached to, adjacent to, or on the roof of buildings, if installed in accordance with (1) or (2).

(1) For Type I and Type II buildings, the installation shall comply with all the restrictions provided for in the listing of the liquid.

Informational Note No. 1: Installations adjacent to combustible material, fire escapes, or door and window openings can require additional safeguards such as those listed in 450.27.

Informational Note No. 2: Such restrictions can include, but are not limited to: maximum pressure of the tank, use of a pressure relief valve, appropriate fuse types, and proper sizing of overcurrent protection.

(2) In accordance with 450.27.

Informational Note No. 1: As used in this section, *Type I and Type II buildings* refers to Type I and Type II building construction as defined in NFPA 220-2018, *Standard on Types of Building Construction*. *Combustible materials* refers to those materials not classified as noncombustible or limited-combustible as defined in NFPA 220-2018, *Standard on Types of Building Construction*.

Informational Note No. 2: See definition of *Listed* in Article 100.

450.24 Nonflammable Fluid-Insulated Transformers. Transformers insulated with a dielectric fluid identified as nonflammable shall be permitted to be installed indoors or outdoors. Such transformers installed indoors and rated over 35,000 volts shall be installed in a vault. Such transformers installed indoors shall be furnished with a liquid confinement area and a pressure-relief vent. The transformers shall be furnished with a means for absorbing any gases generated by arcing inside the tank, or the pressure-relief vent shall be connected to a chimney or flue that will carry such gases to an environmentally safe area.

Informational Note: Safety may be increased if fire hazard analyses are performed for such transformer installations.

For the purposes of this section, a nonflammable dielectric fluid is one that does not have a flash point or fire point and is not flammable in air.

450.25 Askarel-Insulated Transformers Installed Indoors. Askarel-insulated transformers installed indoors and rated over 25 kVA shall be furnished with a pressure-relief vent. Where installed in a poorly ventilated place, they shall be furnished with a means for absorbing any gases generated by arcing inside the case, or the pressure-relief vent shall be connected to a chimney or flue that carries such gases outside the building. Askarel-insulated transformers rated over 35,000 volts shall be installed in a vault.

450.26 Oil-Insulated Transformers Installed Indoors. Oil-insulated transformers installed indoors shall be installed in a vault constructed as specified in Part VIII of this article 495.

Exception No. 1: Where the total capacity does not exceed 112½ kVA, the vault specified in Part VIII of this article 495 shall be permitted to be constructed of reinforced concrete that is not less than 100 mm (4 in.) thick.

Exception No. 2: Where the nominal voltage does not exceed 1000, a vault shall not be required if suitable arrangements are made to prevent a transformer oil fire from igniting other materials and the total capacity in one location does not exceed 10 kVA in a section of the building classified as combustible or 75 kVA where the surrounding structure is classified as fire-resistant construction.

Exception No. 3: Electric furnace transformers that have a total rating not exceeding 75 kVA shall be permitted to be installed without a vault in a building or room of fire-resistant construction, provided suitable arrangements are made to prevent a transformer oil fire from spreading to other combustible material.

Exception No. 4: A transformer that has a total rating not exceeding 75 kVA and a supply voltage of 1000 volts or less that is an integral part of charged particle accelerating equipment shall be permitted to be installed without a vault in a building or room of noncombustible or fire-resistant construction, provided suitable arrangements are made to prevent a transformer oil fire from spreading to other combustible material.

Exception No. 5: Transformers shall be permitted to be installed in a detached building that does not comply with Part III of this article if neither the building nor its contents present a fire hazard to any other building or property, and if the building is used only in supplying electric service and the interior is accessible only to qualified persons.

Exception No. 6: Oil-insulated transformers shall be permitted to be used without a vault in portable and mobile surface mining equipment (such as electric excavators) if each of the following conditions is met:

- (1) Provision is made for draining leaking fluid to the ground.*
- (2) Safe egress is provided for personnel.*
- (3) A minimum 6 mm (¼ in.) steel barrier is provided for personnel protection.*

450.27 Oil-Insulated Transformers Installed Outdoors. Combustible material, combustible buildings, and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on roofs, attached to or adjacent to a building or combustible material. In cases where the transformer installation presents a fire hazard, one or more of the following safeguards shall be applied according to the degree of hazard involved:

- (1) Space separations*
- (2) Fire-resistant barriers*
- (3) Automatic fire suppression systems*

~~(4) Enclosures that confine the oil of a ruptured transformer tank~~

~~Oil enclosures shall be permitted to consist of fire-resistant dikes, curbed areas or basins, or trenches filled with coarse, crushed stone. Oil enclosures shall be provided with trapped drains where the exposure and the quantity of oil involved are such that removal of oil is important.~~

~~Informational Note: For additional information on transformers installed on poles or structures or under ground, see ANSI/IEEE C2-2017, National Electrical Safety Code.~~

~~**450.28 Modification of Transformers.**—When modifications are made to a transformer in an existing installation that change the type of the transformer with respect to Part II of this article, such transformer shall be marked to show the type of insulating liquid installed, and the modified transformer installation shall comply with the applicable requirements for that type of transformer.~~

Part III. Transformer Vaults

~~**450.41 Location.**—Vaults shall be located where they can be ventilated to the outside air without using flues or ducts wherever such an arrangement is practicable.~~

~~**450.42 Walls, Roofs, and Floors.**—The walls and roofs of vaults shall be constructed of materials that have approved structural strength for the conditions with a minimum fire resistance of 3 hours. The floors of vaults in contact with the earth shall be of concrete that is not less than 100 mm (4 in.) thick, but, where the vault is constructed with a vacant space or other stories below it, the floor shall have approved structural strength for the load imposed thereon and a minimum fire resistance of 3 hours. For the purposes of this section, studs and wallboard construction shall not be permitted.~~

~~*Exception: Where transformers are protected with automatic sprinkler, water spray, carbon dioxide, or halon, construction of 1-hour rating shall be permitted.*~~

~~Informational Note No. 1: For additional information, see ASTM E119 18a, *Methods for Fire Tests of Building Construction and Materials*.~~

~~Informational Note No. 2: A typical 3-hour construction is 150 mm (6 in.) thick reinforced concrete.~~

~~**450.43 Doorways.**—Vault doorways shall be protected in accordance with 450.43(A), (B), and (C).~~

~~**(A) Type of Door.**—Each doorway leading into a vault from the building interior shall be provided with a tight fitting door that has a minimum fire rating of 3 hours. The authority having jurisdiction shall be permitted to require such a door for an exterior wall opening where conditions warrant.~~

~~*Exception: Where transformers are protected with automatic sprinkler, water spray, carbon dioxide, or halon, construction of 1-hour rating shall be permitted.*~~

~~Informational Note: For additional information, see NFPA 80 2016, *Standard for Fire Doors and Other Opening Protectives*.~~

~~**(B) Sills.**—A door sill or curb that is of an approved height that will confine the oil from the largest transformer within the vault shall be provided, and in no case shall the height be less than 100 mm (4 in.).~~

~~**(C) Locks.**—Doors shall be equipped with locks, and doors shall be kept locked, with access being allowed only to qualified persons. Personnel doors shall open in the direction of egress and be equipped with listed fire exit hardware.~~

~~**450.45 Ventilation Openings.**—Where required by 450.9, openings for ventilation shall be provided in accordance with 450.45(A) through (F).~~

(A) Location.—Ventilation openings shall be located as far as possible from doors, windows, fire escapes, and combustible material.

(B) Arrangement.—A vault ventilated by natural circulation of air shall be permitted to have roughly half of the total area of openings required for ventilation in one or more openings near the floor and the remainder in one or more openings in the roof or in the sidewalls near the roof, or all of the area required for ventilation shall be permitted in one or more openings in or near the roof.

(C) Size.—For a vault ventilated by natural circulation of air to an outdoor area, the combined net area of all ventilating openings, after deducting the area occupied by screens, gratings, or louvers, shall not be less than 1900 mm² (3 in.²) per kVA of transformer capacity in service, and in no case shall the net area be less than 0.1 m² (1 ft²) for any capacity under 50 kVA.

(D) Covering.—Ventilation openings shall be covered with durable gratings, screens, or louvers, according to the treatment required in order to avoid unsafe conditions.

(E) Dampers.—All ventilation openings to the indoors shall be provided with automatic closing fire dampers that operate in response to a vault fire. Such dampers shall possess a standard fire rating of not less than 1½ hours. Informational Note: See ANSI/UL 555 ~~2016~~, *Standard for Fire Dampers*.

(F) Ducts.—Ventilating ducts shall be constructed of fire-resistant material.

450.46 Drainage.—Where practicable, vaults containing more than 100 kVA transformer capacity shall be provided with a drain or other means that will carry off any accumulation of oil or water in the vault unless local conditions make this impracticable. The floor shall be pitched to the drain where provided.

450.47 Water Pipes and Accessories.—Any pipe or duct system foreign to the electrical installation shall not enter or pass through a transformer vault. Piping or other facilities provided for vault fire protection, or for transformer cooling, shall not be considered foreign to the electrical installation.

450.48 Storage in Vaults.—Materials shall not be stored in transformer vaults.

ARTICLE 460 Capacitors

(Part II, Over 1000 Volts deleted / relocated to Article 495 Part IV. "Part I" is deleted as a Part in 460)

460.1 Scope. This article covers the installation of capacitors on electrical circuits operating at 1000 Volts ac, 1500 Volts dc, nominal or less.

Surge capacitors or capacitors included as a component part of other apparatus and conforming with the requirements of such apparatus are excluded from these requirements.

This article also covers the installation of capacitors in hazardous (classified) locations as modified by Articles 501 through 503.

Informational Note: Article 495 includes requirements for capacitors rated over 1000 volts ac, 1500 volts dc, nominal.

~~**460.2 Definitions.** The definition in this section shall apply only within this article.~~

~~**Safe Zone.** Low probability of damage other than a slight swelling of the capacitor case, as identified by the case rupture curve of the capacitor.~~

460.3 Enclosing and Guarding.

(A) Containing More Than 11 L (3 gal) of Flammable Liquid. Capacitors containing more than 11 L (3 gal) of flammable liquid shall be enclosed in vaults or outdoor fenced enclosures complying with Article 110, Part III. This limit shall apply to any single unit in an installation of capacitors.

(B) Accidental Contact. Where capacitors are accessible to unauthorized and unqualified persons, they shall be enclosed, located, or guarded so that persons cannot come into accidental contact or bring conducting materials into accidental contact with exposed energized parts, terminals, or buses associated with them. However, no additional guarding is required for enclosures accessible only to authorized and qualified persons.

~~Part I. 1000 Volts, Nominal, and Under~~

460.6 Discharge of Stored Energy. Capacitors shall be provided with a means of discharging stored energy.

(A) Time of Discharge. The residual voltage of a capacitor shall be reduced to 50 volts, nominal, or less within 1 minute after the capacitor is disconnected from the source of supply.

(B) Means of Discharge. The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank or provided with automatic means of connecting it to the terminals of the capacitor bank on removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used.

460.8 Conductors.

(A) Ampacity. The ampacity of capacitor circuit conductors shall not be less than 135 percent of the rated current of the capacitor. The ampacity of conductors that connect a capacitor to the terminals of a motor or to motor circuit conductors shall not be less than one-third the ampacity of the motor circuit conductors and in no case less than 135 percent of the rated current of the capacitor.

(B) Overcurrent Protection. An overcurrent device shall be provided in each ungrounded conductor for each capacitor bank. The rating or setting of the overcurrent device shall be as low as practicable.

Exception: A separate overcurrent device shall not be required for a capacitor connected on the load side of a motor overload protective device.

(C) Disconnecting Means. A disconnecting means shall be provided in each ungrounded conductor for each capacitor bank and shall meet the following requirements:

- (1) The disconnecting means shall open all ungrounded conductors simultaneously.
- (2) The disconnecting means shall be permitted to disconnect the capacitor from the line as a regular operating procedure.
- (3) The rating of the disconnecting means shall not be less than 135 percent of the rated current of the capacitor.

Exception: A separate disconnecting means shall not be required where a capacitor is connected on the load side of a motor controller.

460.9 Rating or Setting of Motor Overload Device. Where a motor installation includes a capacitor connected on the load side of the motor overload device, the rating or setting of the motor overload device shall be based on the improved power factor of the motor circuit.

The effect of the capacitor shall be disregarded in determining the motor circuit conductor rating in accordance with [430.22](#).

460.10 Grounding. Capacitor cases shall be connected to the equipment grounding conductor.

Exception: Capacitor cases shall not be connected to the equipment grounding conductor where the capacitor units are supported on a structure designed to operate at other than ground potential.

460.12 Marking. Each capacitor shall be provided with a nameplate giving the name of the manufacturer, rated voltage, frequency, kilovar or amperes, number of phases, and, if filled with a combustible liquid, the volume of liquid. Where filled with a nonflammable liquid, the nameplate shall so state. The nameplate shall also indicate whether a capacitor has a discharge device inside the case.

Part II. Over 1000 Volts, Nominal

~~460.24 Switching.~~

~~(A) Load Current.~~ ~~Group-operated switches shall be used for capacitor switching and shall be capable of the following:~~

- ~~(1) Carrying continuously not less than 135 percent of the rated current of the capacitor installation~~
- ~~(2) Interrupting the maximum continuous load current of each capacitor, capacitor bank, or capacitor installation that will be switched as a unit~~
- ~~(3) Withstanding the maximum inrush current, including contributions from adjacent capacitor installations~~
- ~~(4) Carrying currents due to faults on capacitor side of switch~~

~~B) Isolation.~~

~~(1) General.~~ ~~A means shall be installed to isolate from all sources of voltage each capacitor, capacitor bank, or capacitor installation that will be removed from service as a unit. The isolating means shall provide a visible gap in the electrical circuit adequate for the operating voltage.~~

~~(2) Isolating or Disconnecting Switches with No Interrupting Rating.~~ ~~Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load interrupting device or shall be provided with prominently displayed caution signs in accordance with [490.22](#) to prevent switching load current.~~

~~(C) Additional Requirements for Series Capacitors.~~ The proper switching sequence shall be ensured by use of one of the following:

- ~~(1) Mechanically sequenced isolating and bypass switches~~
- ~~(2) Interlocks~~
- ~~(3) Switching procedure prominently displayed at the switching location~~

460.25 Overcurrent Protection.

~~(A) Provided to Detect and Interrupt Fault Current.~~ A means shall be provided to detect and interrupt fault current likely to cause dangerous pressure within an individual capacitor.

~~(B) Single Pole or Multipole Devices.~~ Single pole or multipole devices shall be permitted for this purpose.

~~(C) Protected Individually or in Groups.~~ Capacitors shall be permitted to be protected individually or in groups.

~~(D) Protective Devices Rated or Adjusted.~~ Protective devices for capacitors or capacitor equipment shall be rated or adjusted to operate within the limits of the safe zone for individual capacitors.

460.26 Identification. Each capacitor shall be provided with a permanent nameplate giving the manufacturer's name, rated voltage, frequency, kilovar or amperes, number of phases, and the volume of liquid identified as flammable, if such is the case.

460.27 Grounding. Capacitor cases shall be connected to the equipment grounding conductor. If the capacitor neutral point is connected to a grounding electrode conductor, the connection shall be made in accordance with Part III of Article [250](#).

Exception: Capacitor cases shall not be connected to the equipment grounding conductor where the capacitor units are supported on a structure designed to operate at other than ground potential.

460.28 Means for Discharge.

~~(A) Means to Reduce the Residual Voltage.~~ A means shall be provided to reduce the residual voltage of a capacitor to 50 volts or less within 5 minutes after the capacitor is disconnected from the source of supply.

~~(B) Connection to Terminals.~~ A discharge circuit shall be either permanently connected to the terminals of the capacitor or provided with automatic means of connecting it to the terminals of the capacitor bank after disconnection of the capacitor from the source of supply. The windings of motors, transformers, or other equipment directly connected to capacitors without a switch or overcurrent device interposed shall meet the requirements of [460.28\(A\)](#).

ARTICLE 470 Resistors and Reactors

(Part II, Over 1000 Volts deleted / relocate to Article 495 Part X. Part I is deleted as a part in Article 470)

~~Part I. 1000 Volts, Nominal, and Under~~

470.1 Scope. This article covers the installation of separate resistors and reactors on electrical circuits rated no more than 1000 volts ac, 1500 volts dc, nominal.

Exception: Resistors and reactors that are component parts of other apparatus.

This article also covers the installation of resistors and reactors in hazardous (classified) locations as modified by Articles 501 through 504.

Informational Note: Article 495 includes requirements for resistors and reactors rated over 1000 volts ac, 1500 volts dc, nominal.

470.2 Location. Resistors and reactors shall not be placed where exposed to physical damage.

470.3 Space Separation. A thermal barrier shall be required if the space between the resistors and reactors and any combustible material is less than 305 mm (12 in.).

470.4 Conductor Insulation. Insulated conductors used for connections between resistance elements and controllers shall be suitable for an operating temperature of not less than 90°C (194°F).

Exception: Other conductor insulations shall be permitted for motor starting service.

~~Part II. Over 1000 Volts, Nominal~~

~~470.18 General.~~

~~(A) Protected Against Physical Damage.~~ Resistors and reactors shall be protected against physical damage.

~~(B) Isolated by Enclosure or Elevation.~~ Resistors and reactors shall be isolated by enclosure or elevation to protect personnel from accidental contact with energized parts.

~~(C) Combustible Materials.~~ Resistors and reactors shall not be installed in close enough proximity to combustible materials to constitute a fire hazard and shall have a clearance of not less than 305 mm (12 in.) from combustible materials.

~~(D) Clearances.~~ Clearances from resistors and reactors to grounded surfaces shall be adequate for the voltage involved.

~~(E) Temperature Rise from Induced Circulating Currents.~~ Metallic enclosures of reactors and adjacent metal parts shall be installed so that the temperature rise from induced circulating currents is not hazardous to personnel or does not constitute a fire hazard.

470.19 Grounding. Resistor and reactor cases or enclosures shall be connected to the equipment grounding conductor.

Exception: Resistor or reactor cases or enclosures supported on a structure designed to operate at other than ground potential shall not be connected to the equipment grounding conductor.

470.20 Oil-Filled Reactors. Installation of oil-filled reactors, in addition to the above requirements, shall comply with applicable requirements of Article ~~450~~.

ARTICLE 4950 Equipment Over 1000 Volts AC, 1500 VDC, Nominal

(Article 490 is renumbered Article 495. Changes to 490 shown below, along with additions from other Chapter 4 Articles where MV requirements have been relocated to 495)

Part I. General

4950.1 Scope. This article covers the general requirements for equipment operating at more than 1000 volts ac, 1500 volts dc, nominal.

Informational Note No. 1: See *NFPA 70E-2018*, *Standard for Electrical Safety in the Workplace*, for electrical safety requirements for employee workplaces.

Informational Note No. 2: For further information on hazard signs and labels, see ANSI Z535.4-2011, *Product Signs and Safety Labels*.

Informational Note No. 3: For information regarding power distribution apparatus, see IEEE 3001.5-2013, *Recommended Practice for the Application of Power Distribution Apparatus in Industrial and Commercial Power Systems*.

4950.2 Definition. The definition in this section shall apply only within this article.

High Voltage. A potential difference of more than 1000 volts, nominal.

Safe Zone. Low probability of damage other than a slight swelling of the capacitor case, as identified by the case rupture curve of the capacitor.

Transformer.

An individual transformer, single- or polyphase, identified by a single nameplate, unless otherwise indicated in this article

4950.3 Other Articles. Enclosures in damp or wet locations shall meet the requirements of 312.2.

~~(A) Oil-Filled Equipment.~~ Installation of electrical equipment, other than transformers covered in Article 450, containing more than 38 L (10 gal) of flammable oil per unit shall meet the requirements of Parts II and III of Article 450.

~~(AB) Enclosures in Damp or Wet Locations.~~ Enclosures in damp or wet locations shall meet the requirements of 312.2.

495.4 Flexible Cords and Flexible Cable Types.

Flexible cords and flexible cables over 1000 volts shall conform to the description in Table 49500.4. The use of flexible cords and flexible cables other than those in Table 49500.4 shall require permission by the authority having jurisdiction.

Table 40950.4 Flexible Cords and Flexible Cables

Trade - Name	Type Letter	Voltage	AW G or kcmil	Number of Conductors	Insulation	AW G or kcmil	Nominal Insulation Thickness	mil s	Braid on Each Conductor	Outer Covering	Use	
							mm					
<u>Portable power cable</u>	<u>G</u>	<u>2000</u>	<u>12–500</u>	<u>2–6 plus equipment grounding conductor(s)</u>	<u>Thermoset</u>	<u>12–2</u> <u>1–4/0</u>	<u>250–500</u>	<u>1.5</u> <u>2</u> <u>2.0</u> <u>3</u> <u>2.4</u> <u>1</u>	<u>60</u> <u>80</u> <u>95</u>		<u>Oil-resistant thermoset</u>	<u>Portable and extra-hard usage</u>
	<u>G-GC⁷</u>	<u>2000</u>	<u>12–500</u>	<u>3–6 plus equipment grounding conductors and 1 ground check conductor</u>	<u>Thermoset</u>	<u>12–2</u> <u>1–4/0</u>	<u>250–500</u>	<u>1.5</u> <u>2</u> <u>2.0</u> <u>3</u> <u>2.4</u> <u>1</u>	<u>60</u> <u>80</u> <u>95</u>		<u>Oil-resistant thermoset</u>	
Portable power cable	PPE ⁷	2000	12–500	1–6 plus optional equipment grounding conductor(s)	Thermoplastic elastomer	12–2 1–4/0	250–500	1.52 2.03 2.41	60 80 95		Oil-resistant thermoplastic elastomer	Portable, extra-hard usage
Portable power cable	W ⁷	2000	12–500 501–1000	1–6 1	Thermoset	12–2 1–4/0	250–500 501–1000	1.52 2.03 2.41 2.80	60 80 95 110		Oil-resistant thermoset	Portable, extra-hard usage

Notes:

⁷Types G, G-GC, S, SC, SCE, SCT, SE, SEO, SEOO, SEW, SEOW, SEOWW, SO, SOO, SOW, SOOW, ST, STO, STOO, STW, STOW, STOOW, PPE, and W shall be permitted for use on theater stages, in garages, and elsewhere where flexible cords are permitted by this Code.

Part II. Equipment — Specific Provisions

490.21 Circuit-Interrupting Devices.

490.21(A) Circuit Breakers.

490.21(A)(1) Location.

- (a) Circuit breakers installed indoors shall be mounted either in metal-enclosed units or fire-resistant cell-mounted units, or they shall be permitted to be open-mounted in locations accessible to qualified persons only.
- (b) Circuit breakers used to control oil-filled transformers in a vault shall either be located outside the transformer vault or be capable of operation from outside the vault.
- (c) Oil circuit breakers shall be arranged or located so that adjacent readily combustible structures or materials are safeguarded in an approved manner.

490.21(A)(2) Operating Characteristics.

Circuit breakers shall have the following equipment or operating characteristics:-

- (1) An accessible mechanical or other identified means for manual tripping, independent of control power
- (2) Be release free (trip free)
- (3) If capable of being opened or closed manually while energized, main contacts that operate independently of the speed of the manual operation
- (4) A mechanical position indicator at the circuit breaker to show the open or closed position of the main contacts
- (5) A means of indicating the open and closed position of the breaker at the point(s) from which they may be operated

490.21(A)(3) Nameplate.

A circuit breaker shall have a permanent and legible nameplate showing manufacturer's name or trademark, manufacturer's type or identification number, continuous current rating, interrupting rating in megavolt amperes (MVA) or amperes, and maximum voltage rating. Modification of a circuit breaker affecting its rating(s) shall be accompanied by an appropriate change of nameplate information.

490.21(A)(4) Rating.

Circuit breakers shall have the following ratings:-

- (1) The continuous current rating of a circuit breaker shall not be less than the maximum continuous current through the circuit breaker.
- (2) The interrupting rating of a circuit breaker shall not be less than the available fault current the circuit breaker will be required to interrupt, including contributions from all connected sources of energy.
- (3) The closing rating of a circuit breaker shall not be less than the maximum asymmetrical fault current into which the circuit breaker can be closed.
- (4) The momentary rating of a circuit breaker shall not be less than the maximum asymmetrical fault current at the point of installation.
- (5) The rated maximum voltage of a circuit breaker shall not be less than the maximum circuit voltage.

490.21(A)(5) Retrofit Trip Units.

Retrofit trip units shall be listed for use with the specific circuit breaker with which it is installed.

490.21(B) Power Fuses and Fuseholders.

490.21(B)(1) Use.

Where fuses are used to protect conductors and equipment, a fuse shall be placed in each ungrounded conductor. Two power fuses shall be permitted to be used in parallel to protect the same load if both fuses have identical ratings and both fuses are installed in an identified common mounting with electrical connections that divide the current equally. Power fuses of the vented type shall not be used indoors, underground, or in metal enclosures unless identified for the use.

490.21(B)(2) Interrupting Rating.

The interrupting rating of power fuses shall not be less than the **available** fault current the fuse is required to interrupt, including contributions from all connected sources of energy.

490.21(B)(3) Voltage Rating.

The maximum voltage rating of power fuses shall not be less than the maximum circuit voltage. Fuses having a minimum recommended operating voltage shall not be applied below this voltage.

490.21(B)(4) Identification of Fuse Mountings and Fuse Units.

Fuse mountings and fuse units shall have permanent and legible nameplates showing the manufacturer's type or designation, continuous current rating, interrupting current rating, and maximum voltage rating.

490.21(B)(5) Fuses.

Fuses that expel flame in opening the circuit shall be designed or arranged so that they function properly without hazard to persons or property.

490.21(B)(6) Fuseholders.

Fuseholders shall be designed or installed so that they are de-energized while a fuse is being replaced. A field-applied permanent and legible sign, in accordance with 110.21(B), shall be installed immediately adjacent to the fuseholders and shall be worded as follows:

DANGER — DISCONNECT CIRCUIT BEFORE REPLACING FUSES.

Exception: Fuses and fuseholders designed to permit fuse replacement by qualified persons using identified equipment without de-energizing the fuseholder shall be permitted.

490.21(B)(7) High-Voltage Fuses.

Switchgear and substations that utilize high-voltage fuses shall be provided with a gang-operated disconnecting switch. Isolation of the fuses from the circuit shall be provided by either connecting a switch between the source and the fuses or providing roll-out switch and fuse-type construction. The switch shall be of the load-interrupter type, unless mechanically or electrically interlocked with a load interrupting device arranged to reduce the load to the interrupting capability of the switch.

Exception: More than one switch shall be permitted as the disconnecting means for one set of fuses where the switches are installed to provide connection to more than one set of supply conductors. The switches shall be mechanically or electrically interlocked to permit access to the fuses only when all switches are open. A conspicuous sign shall be placed at the fuses identifying the presence of more than one source.

490.21(C) Distribution Cutouts and Fuse Links — Expulsion Type.

490.21(C)(1) Installation.

Cutouts shall be located so that they may be readily and safely operated and re-fused, and so that the exhaust of the fuses does not endanger persons. Distribution cutouts shall not be used indoors, underground, or in metal enclosures.

490.21(C)(2) Operation.

Where fused cutouts are not suitable to interrupt the circuit manually while carrying full load, an approved means shall be installed to interrupt the entire load. Unless the fused cutouts are interlocked with the switch to prevent opening of the cutouts under load, a conspicuous sign shall be placed at such cutouts identifying that they shall not be operated under load.

~~490.21(C)(3) Interrupting Rating.~~

The interrupting rating of distribution cutouts shall not be less than the ~~available~~ fault current the cutout is required to interrupt, including contributions from all connected sources of energy.

~~490.21(C)(4) Voltage Rating.~~

The maximum voltage rating of cutouts shall not be less than the maximum circuit voltage.

~~490.21(C)(5) Identification.~~

Distribution cutouts shall have on their body, door, or fuse tube a permanent and legible nameplate or identification showing the manufacturer's type or designation, continuous current rating, maximum voltage rating, and interrupting rating.

~~490.21(C)(6) Fuse Links.~~

Fuse links shall have a permanent and legible identification showing continuous current rating and type.

~~490.21(C)(7) Structure Mounted Outdoors.~~

The height of cutouts mounted outdoors on structures shall provide safe clearance between lowest energized parts (open or closed position) and standing surfaces, in accordance with 110.34(E).

~~490.21(D) Oil-Filled Cutouts.~~

~~490.21(D)(1) Continuous Current Rating.~~

The continuous current rating of oil-filled cutouts shall not be less than the maximum continuous current through the cutout.

~~490.21(D)(2) Interrupting Rating.~~

The interrupting rating of oil-filled cutouts shall not be less than the ~~available~~ fault current the oil-filled cutout is required to interrupt, including contributions from all connected sources of energy.

~~490.21(D)(3) Voltage Rating.~~

The maximum voltage rating of oil-filled cutouts shall not be less than the maximum circuit voltage.

~~490.21(D)(4) Fault Closing Rating.~~

Oil-filled cutouts shall have a fault closing rating not less than the maximum asymmetrical fault current that can occur at the cutout location, unless suitable interlocks or operating procedures preclude the possibility of closing into a fault.

~~490.21(D)(5) Identification.~~

Oil-filled cutouts shall have a permanent and legible nameplate showing the rated continuous current, rated maximum voltage, and rated interrupting current.

~~490.21(D)(6) Fuse Links.~~

Fuse links shall have a permanent and legible identification showing the rated continuous current.

~~490.21(D)(7) Location.~~

Cutouts shall be located so that they are readily and safely accessible for re-fusing, with the top of the cutout not over 1.5 m (5 ft) above the floor or platform.

~~490.21(D)(8) Enclosure.~~

Suitable barriers or enclosures shall be provided to prevent contact with nonshielded cables or energized parts of oil-filled cutouts.

490.21(E) Load Interrupters.

Load-interrupter switches shall be permitted if suitable fuses or circuit breakers are used in conjunction with these devices to interrupt available fault currents. Where these devices are used in combination, they shall be coordinated electrically so that they will safely withstand the effects of closing, carrying, or interrupting all possible currents up to the assigned maximum short-circuit rating.

Where more than one switch is installed with interconnected load terminals to provide for alternate connection to different supply conductors, each switch shall be provided with a warning sign identifying the presence of more than one source. Each warning sign or label shall comply with 110.21.

490.21(E)(1) Continuous Current Rating.

The continuous current rating of interrupter switches shall equal or exceed the maximum continuous current at the point of installation.

490.21(E)(2) Voltage Rating.

The maximum voltage rating of interrupter switches shall equal or exceed the maximum circuit voltage.

490.21(E)(3) Identification.

Interrupter switches shall have a permanent and legible nameplate including the following information: manufacturer's type or designation, continuous current rating, interrupting current rating, fault closing rating, maximum voltage rating.

490.21(E)(4) Switching of Conductors.

The switching mechanism shall be arranged to be operated from a location where the operator is not exposed to energized parts and shall be arranged to open all ungrounded conductors of the circuit simultaneously with one operation. Switches shall be arranged to be locked in the open position. Metal enclosed switches shall be operable from outside the enclosure.

490.21(E)(5) Stored Energy for Opening.

The stored-energy operator shall be permitted to be left in the uncharged position after the switch has been closed if a single movement of the operating handle charges the operator and opens the switch.

490.21(E)(6) Supply Terminals.

The supply terminals of fused interrupter switches shall be installed at the top of the switch enclosure, or, if the terminals are located elsewhere, the equipment shall have barriers installed so as to prevent persons from accidentally contacting energized parts or dropping tools or fuses into energized parts.

4950.22 Isolating Means. Means shall be provided to completely isolate an item of equipment from all ungrounded conductors. The use of isolating switches shall not be required where there are other ways of de-energizing the equipment for inspection and repairs, such as draw-out-type switchgear units and removable truck panels.

Isolating switches not interlocked with an approved circuit-interrupting device shall be provided with a sign warning against opening them under load. The warning sign(s) or label(s) shall comply with **110.21(B)**.

An identified fuseholder and fuse shall be permitted as an isolating switch.

4950.23 Voltage Regulators. Proper switching sequence for regulators shall be ensured by use of one of the following:

- (1) Mechanically sequenced regulator bypass switch(es)
- (2) Mechanical interlocks
- (3) Switching procedure prominently displayed at the switching location

4950.24 Minimum Space Separation. In field-fabricated installations, the minimum air separation between bare live conductors and between such conductors and adjacent grounded surfaces shall not be less than the values given in **Table 4950.24**. These values shall not apply to interior portions or exterior terminals of equipment designed, manufactured, and tested in accordance with accepted national standards.

Table 4950.24 Minimum Clearance of Live Parts

Minimum Clearance of Live Parts										
Nominal Voltage Rating (kV)	Impulse Withstand, Basic Impulse Level B.I.L (kV)		Phase-to-Phase				Phase-to-Ground			
			Indoors		Outdoors		Indoors		Outdoors	
	Indoors	Outdoors	mm	in.	mm	in.	mm	in.	Mm	in.
2.4–4.16	60	95	115	4.5	180	7	80	3.0	155	6
7.2	75	95	140	5.5	180	7	105	4.0	155	6
13.8	95	110	195	7.5	305	12	130	5.0	180	7
14.4	110	110	230	9.0	305	12	170	6.5	180	7
23	125	150	270	10.5	385	15	190	7.5	255	10
34.5	150	150	320	12.5	385	15	245	9.5	255	10
	200	200	460	18.0	460	18	335	13.0	335	13
46	—	200	—	—	460	18	—	—	335	13
	—	250	—	—	535	21	—	—	435	17
69	—	250	—	—	535	21	—	—	435	17
	—	350	—	—	790	31	—	—	635	25
115	—	550	—	—	1350	53	—	—	1070	42

Table 4950.24 Minimum Clearance of Live Parts

Nominal Voltage Rating (kV)	Impulse Withstand, Basic Impulse Level B.I.L (kV)		Minimum Clearance of Live Parts							
			Phase-to-Phase				Phase-to-Ground			
			Indoors		Outdoors		Indoors		Outdoors	
	Indoors	Outdoors	mm	in.	mm	in.	mm	in.	Mm	in.
138	—	550	—	—	1350	53	—	—	1070	42
	—	650	—	—	1605	63	—	—	1270	50
161	—	650	—	—	1605	63	—	—	1270	50
	—	750	—	—	1830	72	—	—	1475	58
230	—	750	—	—	1830	72	—	—	1475	58
	—	900	—	—	2265	89	—	—	1805	71
	—	1050	—	—	2670	105	—	—	2110	83

Note: The values given are the minimum clearance for rigid parts and bare conductors under favorable service conditions. They shall be increased for conductor movement or under unfavorable service conditions or wherever space limitations permit. The selection of the associated impulse withstand voltage for a particular system voltage is determined by the characteristics of the surge protective equipment.

4950.25 Backfeed. Installations where the possibility of backfeed exists shall comply with 4950.25(A) and (B), which follow.

(A) Sign. A permanent sign in accordance with 110.21(B) shall be installed on the disconnecting means enclosure or immediately adjacent to open disconnecting means with the following words or equivalent: DANGER — CONTACTS ON EITHER SIDE OF THIS DEVICE MAY BE ENERGIZED BY BACKFEED.

(B) Diagram. A permanent and legible single-line diagram of the local switching arrangement, clearly identifying each point of connection to the high-voltage section, shall be provided within sight of each point of connection.

495.26 (A) Oil-Filled Equipment. Installation of electrical equipment, other than transformers covered in Article Part VII 450, containing more than 38 L (10 gal) of flammable oil per unit shall meet the requirements of Parts VII and III of Article 450.

Informational Note: The same requirements for oil used in oil-filled transformers are also applicable to other oil-filled equipment.

Part III. Equipment — Switchgear and Industrial Control Assemblies

4950.30 General. Part III covers assemblies of switchgear and industrial control equipment including, but not limited to, switches and interrupting devices and their control, metering, protection, and regulating equipment where they are an integral part of the assembly, with associated interconnections and supporting structures.

4950.31 Arrangement of Devices in Assemblies. Arrangement of devices in assemblies shall be such that individual components can safely perform their intended function without adversely affecting the safe operation of other components in the assembly.

4950.32 Guarding of High-Voltage Energized Parts Within a Compartment. Where access for other than visual inspection is required to a compartment that contains energized high-voltage parts, barriers shall be provided to prevent accidental contact by persons, tools, or other equipment with energized parts. Exposed live parts shall only be permitted in compartments accessible to qualified persons. Fuses and fuseholders designed to enable future replacement without de-energizing the fuseholder shall only be permitted for use by qualified persons.

4950.33 Guarding of Energized Parts Operating at 1000 Volts, Nominal, or Less Within Compartments. Energized bare parts mounted on doors shall be guarded where the door must be opened for maintenance of equipment or removal of draw-out equipment.

4950.34 Clearance for Cable Conductors Entering Enclosure. The unobstructed space opposite terminals or opposite raceways or cables entering a switchgear or control assembly shall be approved for the type of conductor and method of termination.

4950.35 Accessibility of Energized Parts.

(A) High-Voltage Equipment. Doors that would provide unqualified persons access to high-voltage energized parts shall be locked. Permanent signs in accordance with **110.21(B)** shall be installed on panels or doors that provide access to live parts over 1000 volts and shall read DANGER — HIGH VOLTAGE — KEEP OUT.

(B) Control Equipment. Where operating at 1000 volts, nominal, or less, control equipment, relays, motors, and the like shall not be installed in compartments with high-voltage parts or high-voltage wiring, unless:

(1) The access means is interlocked with the high-voltage switch or disconnecting means to prevent the access means from being opened or removed when the high-voltage switch is in the closed position or a withdrawable disconnecting means is in the connected position, and

(2) All high-voltage parts or high-voltage wiring in the compartment that remain energized when a fixed mounted high-voltage switch is in the open position or a withdrawable disconnecting means is in the isolating (fully withdrawn) position are protected by insulating or grounded metal barriers to prevent accidental contact with energized high-voltage parts or wiring.

(C) High-Voltage Instruments or Control Transformers and Space Heaters. High-voltage instrument or control transformers and space heaters shall be permitted to be installed in the high-voltage compartment without access restrictions beyond those that apply to the high-voltage compartment generally.

4950.36 Grounding. Frames of switchgear and control assemblies shall be connected to an equipment grounding conductor or, where permitted, the grounded conductor.

4950.37 Grounding of Devices. The metal cases or frames, or both, such as those of instruments, relays, meters, and instrument and control transformers, located in or on switchgear or control assemblies, shall be connected to an equipment grounding conductor or, where permitted, the grounded conductor.

4950.38 Door Stops and Cover Plates. External hinged doors or covers shall be provided with stops to hold them in the open position. Cover plates intended to be removed for inspection of energized parts or wiring shall be

equipped with lifting handles and shall not exceed 1.1 m² (12 ft²) in area or 27 kg (60 lb) in weight, unless they are hinged and bolted or locked.

4950.39 Gas Discharge from Interrupting Devices. Gas discharged during operating of interrupting devices shall be directed so as not to endanger personnel.

4950.40 Visual Inspection Windows. Windows intended for visual inspection of disconnecting switches or other devices shall be of suitable transparent material.

4950.41 Location of Industrial Control Equipment. Routinely operated industrial control equipment shall meet the requirements of 4950.41(A) unless infrequently operated, as covered in 4950.41(B).

(A) Control and Instrument Transfer Switch Handles or Push Buttons. Control and instrument transfer switch handles or push buttons shall be in a readily accessible location at an elevation of not over 2.0 m (6 ft 7 in.).

Exception: Operating handles requiring more than 23 kg (50 lb) of force shall be located no higher than 1.7 m (66 in.) in either the open or closed position.

(B) Infrequently Operated Devices. Where operating handles for such devices as draw-out fuses, fused potential or control transformers and their primary disconnects, and bus transfer and isolating switches are only operated infrequently, the handles shall be permitted to be located where they are safely operable and serviceable from a portable platform.

4950.42 Interlocks — Interrupter Switches. Interrupter switches equipped with stored energy mechanisms shall have mechanical interlocks to prevent access to the switch compartment unless the stored energy mechanism is in the discharged or blocked position.

4950.43 Stored Energy for Opening. The stored energy operator shall be permitted to be left in the uncharged position after the switch has been closed if a single movement of the operating handle charges the operator and opens the switch.

4950.44 Fused Interrupter Switches.

(A) Supply Terminals. The supply terminals of fused interrupter switches shall be installed at the top of the switch enclosure or, if the terminals are located elsewhere, the equipment shall have barriers installed so as to prevent persons from accidentally contacting energized parts or dropping tools or fuses into energized parts.

(B) Backfeed. Where fuses can be energized by backfeed, a sign shall be placed on the enclosure door identifying this hazard.

(C) Switching Mechanism. The switching mechanism shall be arranged to be operated from a location outside the enclosure where the operator is not exposed to energized parts and shall be arranged to open all ungrounded conductors of the circuit simultaneously with one operation. Switches shall be lockable open in accordance with 110.25.

4950.45 Circuit Breakers — Interlocks.

(A) Circuit Breakers. Circuit breakers equipped with stored energy mechanisms shall be designed to prevent the release of the stored energy unless the mechanism has been fully charged.

(B) Mechanical Interlocks. Mechanical interlocks shall be provided in the housing to prevent the complete withdrawal of the circuit breaker from the housing when the stored energy mechanism is in the fully charged position, unless a suitable device is provided to block the closing function of the circuit breaker before complete withdrawal.

4950.46 Circuit Breaker Locking. Circuit breakers shall be capable of being locked in the open position or, if they are installed in a drawout mechanism, that mechanism shall be capable of being locked in such a position that the mechanism cannot be moved into the connected position. In either case, the provision for locking shall be lockable open in accordance with 110.25.

4950.47 Switchgear Used as Service Equipment. Switchgear installed as high-voltage service equipment shall include a ground bus for the connection of service cable shields and to facilitate the attachment of safety grounds for personnel protection. This bus shall be extended into the compartment where the service conductors are terminated. Where the compartment door or panel provides access to parts that can only be de-energized and visibly isolated by the serving utility, the warning sign required by 4950.35(A) shall include a notice that access is limited to the serving utility or is permitted only following an authorization of the serving utility.

4950.48 Substation Design, Documentation, and Required Diagram.

(A) Design and Documentation. Substations shall be designed by a qualified licensed professional engineer. Where components or the entirety of the substation are listed by a qualified electrical testing laboratory, documentation of internal design features subject to the listing investigation shall not be required. The design shall address but not be limited to the following topics, and the documentation of this design shall be made available to the authority having jurisdiction:

- (1) Clearances and exits
- (2) Electrical enclosures
- (3) Securing and support of electrical equipment
- (4) Fire protection
- (5) Safety ground connection provisions
- (6) Guarding live parts
- (7) Transformers and voltage regulation equipment
- (8) Conductor insulation, electrical and mechanical protection, isolation, and terminations
- (9) Application, arrangement, and disconnection of circuit breakers, switches, and fuses
- (10) Provisions for oil filled equipment
- (11) Switchgear
- (12) Surge arresters

4950.48(B) Diagram. A permanent, single-line diagram of the switchgear shall be provided in a readily visible location within the same room or enclosed area with the switchgear, and this diagram shall clearly identify interlocks, isolation means, and all possible sources of voltage to the installation under normal or emergency conditions, and the marking on the switchgear shall cross-reference the diagram.

Exception: Where the equipment consists solely of a single cubicle or metal-enclosed substation containing only one high-voltage switching device, diagrams shall not be required.

4950.49 Reconditioned Switchgear. Switchgear, or sections of switchgear, within the scope of this article shall be permitted to be reconditioned. The reconditioning process shall use design qualified parts verified under applicable standards and be performed in accordance with any instructions provided by the manufacturer. Reconditioned switchgear shall be listed or field labeled as *reconditioned*, and previously applied listing marks, if any, within the portions reconditioned shall be removed. If equipment has been damaged by fire, products of combustion, or water, it shall be specifically evaluated by its manufacturer or a qualified testing laboratory prior to being returned to service.

Part IV. Mobile and Portable Equipment

4950.51 General.

(A) Covered. The provisions of this part shall apply to installations and use of high-voltage power distribution and utilization equipment that is portable, mobile, or both, such as substations and switch houses mounted on skids, trailers, or cars; mobile shovels; draglines; cranes; hoists; drills; dredges; compressors; pumps; conveyors; underground excavators; and the like.

(B) Other Requirements. The requirements of this part shall be additional to, or amendatory of, those prescribed in Articles 100 through 725 of this Code. Special attention shall be paid to Article 250.

(C) Protection. Approved enclosures or guarding, or both, shall be provided to protect portable and mobile equipment from physical damage.

(D) Disconnecting Means. Disconnecting means shall be installed for mobile and portable high-voltage equipment according to the requirements of Part VIII of Article 230 and shall disconnect all ungrounded conductors.

4950.52 Overcurrent Protection. Motors driving single or multiple dc generators supplying a system operating on a cyclic load basis do not require overload protection, provided that the thermal rating of the ac drive motor cannot be exceeded under any operating condition. The branch-circuit protective device(s) shall provide short-circuit and locked-rotor protection and shall be permitted to be external to the equipment.

4950.53 Enclosures. All energized switching and control parts shall be enclosed in grounded metal cabinets or enclosures. These cabinets or enclosures shall be marked DANGER — HIGH VOLTAGE — KEEP OUT and shall be locked so that only authorized and qualified persons can enter. The danger marking(s) or label(s) shall comply with 110.21(B). Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosure so these units can be reset without opening locked doors. With doors closed, safe access for normal operation of these units shall be provided.

4950.54 Collector Rings. The collector ring assemblies on revolving-type machines (shovels, draglines, etc.) shall be guarded to prevent accidental contact with energized parts by personnel on or off the machine.

4950.55 Power Cable Connections to Mobile Machines. A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include terminal connections to the machine frame for the equipment grounding conductor. Ungrounded conductors shall be attached to insulators or be terminated in approved high-voltage cable couplers (which include equipment grounding conductor connectors) of proper voltage and ampere rating. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so that only authorized and qualified persons may open it and shall be marked as follows:

DANGER — HIGH VOLTAGE — KEEP OUT.

The danger marking(s) or label(s) shall comply with 110.21(B).

4950.56 High-Voltage Portable Cable for Main Power Supply. Flexible high-voltage cable supplying power to portable or mobile equipment shall comply with Article 250 and Article 400, Part III.

Part V. Electrode-Type Boilers

4950.70 General. The provisions of Part V shall apply to boilers operating over 1000 volts, nominal, in which heat is generated by the passage of current between electrodes through the liquid being heated.

4950.71 Electrical Supply System. Electrode-type boilers shall be supplied only from a 3-phase, 4-wire solidly grounded wye system, or from isolating transformers arranged to provide such a system. Control circuit voltages shall not exceed 150 volts, shall be supplied from a grounded system, and shall have the controls in the ungrounded conductor.

4950.72 Branch-Circuit Requirements.

(A) Rating. Each boiler shall be supplied from an individual branch circuit rated not less than 100 percent of the total load.

(B) Common-Trip Fault-Interrupting Device. The circuit shall be protected by a 3-phase, common-trip fault-interrupting device, which shall be permitted to automatically reclose the circuit upon removal of an overload condition but shall not reclose after a fault condition.

(C) Phase-Fault Protection. Phase-fault protection shall be provided in each phase, consisting of a separate phase-overcurrent relay connected to a separate current transformer in the phase.

(D) Ground Current Detection. Means shall be provided for detection of the sum of the neutral conductor and equipment grounding conductor currents and shall trip the circuit-interrupting device if the sum of those currents exceeds the greater of 5 amperes or $7\frac{1}{2}$ percent of the boiler full-load current for 10 seconds or exceeds an instantaneous value of 25 percent of the boiler full-load current.

(E) Grounded Neutral Conductor. The grounded neutral conductor shall be as follows:

- (1) Connected to the pressure vessel containing the electrodes
- (2) Insulated for not less than 1000 volts
- (3) Have not less than the ampacity of the largest ungrounded branch-circuit conductor
- (4) Installed with the ungrounded conductors in the same raceway, cable, or cable tray, or, where installed as open conductors, in close proximity to the ungrounded conductors
- (5) Not used for any other circuit

495.73 Pressure and Temperature Limit Control. Each boiler shall be equipped with a means to limit the maximum temperature, pressure, or both, by directly or indirectly interrupting all current flow through the electrodes. Such means shall be in addition to the temperature, pressure, or both, regulating systems and pressure relief or safety valves.

495.74 Bonding. All exposed non-current-carrying metal parts of the boiler and associated exposed metal structures or equipment shall be bonded to the pressure vessel or to the neutral conductor to which the vessel is connected in accordance with **250.102**, except the ampacity of the bonding jumper shall not be less than the ampacity of the neutral conductor.

Part VI. Motors, Motor Circuits and Controllers

495.80 430.224 General. Part ~~XI~~**VI** recognizes the additional hazard due to the use of higher voltages. It adds to or amends the other provisions of ~~this~~ article **430**.

430.222495.81 Marking on Controllers. In addition to the marking required by **430.8**, a controller shall be marked with the control voltage.

430.223495.82 Raceway Connection to Motors. Flexible metal conduit or liquidtight flexible metal conduit not exceeding 1.8 m (6 ft) in length shall be permitted to be employed for raceway connection to a motor terminal enclosure.

430.224495.83 Size of Conductors. Conductors supplying motors shall have an ampacity not less than the current at which the motor overload protective device(s) is selected to trip.

430.225495.84 Motor-Circuit Overcurrent Protection.

(A) General. Each motor circuit shall include coordinated protection to automatically interrupt overload and fault currents in the motor, the motor-circuit conductors, and the motor control apparatus.

Exception: Where a motor is critical to an operation and the motor should operate to failure if necessary to prevent a greater hazard to persons, the sensing device(s) shall be permitted to be connected to a supervised annunciator or alarm instead of interrupting the motor circuit.

(B) Overload Protection.

(1) Type of Overload Device. Each motor shall be protected against dangerous heating due to motor overloads and failure to start by a thermal protector integral with the motor or external current-sensing devices, or both. Protective device settings for each motor circuit shall be determined under engineering supervision.

(2) Wound-Rotor Alternating-Current Motors. The secondary circuits of wound-rotor ac motors, including conductors, controllers, and resistors rated for the application, shall be considered as protected against overcurrent by the motor overload protection means.

(3) Operation. Operation of the overload interrupting device shall simultaneously disconnect all ungrounded conductors.

(4) Automatic Reset. Overload sensing devices shall not automatically reset after trip unless resetting of the overload sensing device does not cause automatic restarting of the motor or there is no hazard to persons created by automatic restarting of the motor and its connected machinery.

(C) Fault-Current Protection.

(1) Type of Protection. Fault-current protection shall be provided in each motor circuit as specified by either 430.225(C)(1) 495.84(C)(1) (a) or (C)(1)(b).

(a) A circuit breaker of suitable type and rating arranged so that it can be serviced without hazard. The circuit breaker shall simultaneously disconnect all ungrounded conductors. The circuit breaker shall be permitted to sense the fault current by means of integral or external sensing elements.

(b) Fuses of a suitable type and rating placed in each ungrounded conductor. Fuses shall be used with suitable disconnecting means, or they shall be of a type that can also serve as the disconnecting means. They shall be arranged so that they cannot be serviced while they are energized.

(2) Reclosing. Fault-current interrupting devices shall not automatically reclose the circuit.

Exception: Automatic reclosing of a circuit shall be permitted where the circuit is exposed to transient faults and where such automatic reclosing does not create a hazard to persons.

(3) Combination Protection. Overload protection and fault-current protection shall be permitted to be provided by the same device.

430.226495.85 Rating of Motor Control Apparatus. The ultimate trip current of overcurrent (overload) relays or other motor-protective devices used shall not exceed 115 percent of the controller's continuous current rating. Where the motor branch-circuit disconnecting means is separate from the controller, the disconnecting means current rating shall not be less than the ultimate trip setting of the overcurrent relays in the circuit.

430.227495.86 Disconnecting Means. The controller disconnecting means shall be lockable in accordance with 110.25.

Part XIV. Tables

Table 495.87 Full-Load Current, Two-Phase Alternating-Current Motors (4-Wire)

The following values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Current in the common conductor of a 2-phase, 3-wire system will be 1.41 times the value given. The voltages listed are rated motor voltages. ~~The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts. The currents listed shall be permitted for system voltage ranges of 2300 to 2400 volts.~~

Horsepower	Induction-Type Squirrel Cage and Wound Rotor (Amperes)				
	115 Volts	230 Volts	460 Volts	575 Volts	2300 Volts
60	—	133	67	53	14
75	—	166	83	66	18
100	—	218	109	87	23
125	—	270	135	108	28
150	—	312	156	125	32
200	—	416	208	167	43

Table 495.88 Full-Load Current, Three-Phase Alternating-Current Motors

The following values of full-load currents are typical for motors running at speeds usual for belted motors and motors with normal torque characteristics. The voltages listed are rated motor voltages. ~~The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 2300 to 2400 volts.~~

Horsepower	Induction-Type Squirrel Cage and Wound Rotor (Amperes)								Synchronous-Type Unity Power Factor* (Amperes)			
	115 Volts	200 Volts	208 Volts	230 Volts	460 Volts	575 Volts	2300 Volts	230 Volts	460 Volts	575 Volts	2300 Volts	
	ts	ts	ts	ts	ts	ts	ts	ts	ts	ts	ts	
60	—	177	169	154	77	62	16	-	123	61	49	12
100	—	285	273	248	124	99	26	-	202	101	81	20
125	—	359	343	312	156	125	31	-	253	126	101	25
150	—	414	396	360	180	144	37	-	302	151	121	30
200	-	552	528	480	240	192	49	-	400	201	161	40

*For 90 and 80 percent power factor, the figures shall be multiplied by 1.1 and 1.25, respectively.

Part VII. Transformers

ARTICLE 450 Transformers and Transformer Vaults (Including Secondary Ties)

Part I. General Provisions

450.1495.100 ScopeGeneral Provisions. This ~~article~~ ~~Part~~ ~~section~~ covers the installation of all transformers over 1000 volts on either the Primary or Secondary. ~~Part VII supplements or amends the other provisions of article 450.~~

Exception No. 1: Current transformers.

Exception No. 2: Dry-type transformers that constitute a component part of other apparatus and comply with the requirements for such apparatus.

Exception No. 3: Transformers that are an integral part of an X-ray, high-frequency, or electrostatic-coating apparatus.

~~Exception No. 4: Transformers used with Class 2 and Class 3 circuits that comply with Article 725.~~

Exception No. ~~45~~: Transformers for sign and outline lighting that comply with Article ~~600~~.

Exception No. ~~56~~: Transformers for electric-discharge lighting that comply with Article ~~410~~.

~~Exception No. 7: Transformers used for power-limited fire alarm circuits that comply with Part III of Article 760.~~

Exception No. ~~68~~: Transformers used for research, development, or testing, where effective arrangements are provided to safeguard persons from contacting energized parts.

This article covers the installation of transformers dedicated to supplying power to a fire pump installation as modified by Article ~~695~~.

This article also covers the installation of transformers in hazardous (classified) locations as modified by Articles ~~501~~ through ~~504~~.

~~x450.2495.102 Definition.~~ The definitions in this section shall apply only within this article.

~~Transformer.~~ An individual transformer, single or polyphase, identified by a single nameplate, unless otherwise indicated in this article.

495.102 Exposed Energized Parts. Switches or other equipment operating at 1000 volts, nominal, or less and serving only equipment within a transformer enclosure shall be permitted to be installed in the transformer enclosure if accessible to qualified persons only. All energized parts shall be guarded in accordance with 110.27 and 110.34.

450.3495.103 Overcurrent Protection. Overcurrent protection of transformers shall comply with ~~-(B)-~~ or ~~(C)-495.103~~ As used in this section, the word *transformer* shall mean a transformer or polyphase bank of two or more single-phase transformers operating as a unit.

Informational Note No. 1: See ~~240.4~~, ~~240.21~~, ~~240.100~~, and ~~240.101~~ for overcurrent protection of conductors.

Informational Note No. 2: Nonlinear loads can increase heat in a transformer without operating its overcurrent protective device.

450.3(A) Transformers Over 1000 Volts, Nominal.
~~Overcurrent protection shall be provided in accordance with Table 450.3(A).~~

Table 450.3495.103 (A) Maximum Rating or Setting of Overcurrent Protection for Transformers Over 1000 Volts (as a Percentage of Transformer-Rated Current)

Location Limitations	Transformer Rated Impedance	Secondary Protection (See Note 2.)				
		Primary Protection over 1000 Volts		Over 1000 Volts		1000 Volts or Less
		Circuit Breaker (See Note 4.)	Fuse Rating	Circuit Breaker (See Note 4.)	Fuse Rating	Circuit Breaker or Fuse Rating
Any location	Not more than 6%	600% (See Note 1.)	300% (See Note 1.)	300% (See Note 1.)	250% (See Note 1.)	125% (See Note 1.)
	More than 6% and not more than 10%	400% (See Note 1.)	300% (See Note 1.)	250% (See Note 1.)	225% (See Note 1.)	125% (See Note 1.)
Supervised locations only (See Note 3.)	Any	300% (See Note 1.)	250% (See Note 1.)	Not required	Not required	Not required
	Not more than 6%	600%	300%	300% (See Note 5.)	250% (See Note 5.)	250% (See Note 5.)
	More than 6% and not more than 10%	400%	300%	250% (See Note 5.)	225% (See Note 5.)	250% (See Note 5.)

Notes:

1. Where the required fuse rating or circuit breaker setting does not correspond to a standard rating or setting, a higher rating or setting that does not exceed the following shall be permitted:

- a. The next higher standard rating or setting for fuses and circuit breakers 1000 volts and below, or
- b. The next higher commercially available rating or setting for fuses and circuit breakers above 1000 volts.

2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than six circuit breakers or six sets of fuses grouped in one location. Where multiple overcurrent devices are utilized, the total of all the device ratings shall not exceed the allowed value of a single overcurrent device. If both circuit breakers and fuses are used as the overcurrent device, the total of the device ratings shall not exceed that allowed for fuses.

3. A supervised location is a location where conditions of maintenance and supervision ensure that only qualified persons monitor and service the transformer installation.

4. Electronically actuated fuses that may be set to open at a specific current shall be set in accordance with settings for circuit breakers.

5. A transformer equipped with a coordinated thermal overload protection by the manufacturer shall be permitted to have separate secondary protection omitted.

450.21495.104 Dry-Type Transformers Installed Indoors.

(A) Not Over 112½ kVA. Dry-type transformers installed indoors and rated 112½ kVA or less shall have a separation of at least 300 mm (12 in.) from combustible material unless separated from the combustible material by a fire-resistant, heat-insulated barrier.

(B) Over 112½ kVA. Individual dry-type transformers of more than 112½ kVA rating shall be installed in a transformer room of fire-resistant construction having a minimum fire rating of 1 hour.

Exception No. 1: Transformers with Class 155 or higher insulation systems and separated from combustible material by a fire-resistant, heat-insulating barrier or by not less than 1.83 m (6 ft) horizontally and 3.7 m (12 ft) vertically.

Exception No. 2: Transformers with Class 155 or higher insulation systems and completely enclosed except for ventilating openings.

Informational Note: See ASTM E119-18a, *Standard Test Methods for Fire Tests of Building Construction and Materials*.

(C) Over 35,000 Volts. Dry-type transformers rated over 35,000 volts shall be installed in a vault complying with [Part III](#) the provisions of this article.

450.22495.105 Dry-Type Transformers Installed Outdoors. Dry-type transformers installed outdoors shall have a weatherproof enclosure.

Transformers exceeding 112½ kVA shall not be located within 300 mm (12 in.) of combustible materials of buildings unless the transformer has Class 155 insulation systems or higher and is completely enclosed except for ventilating openings.

450.23495.106 Less-Flammable Liquid-Insulated Transformers. Transformers insulated with listed less-flammable liquids that have a fire point of not less than 300°C shall be permitted to be installed in accordance with [495.106450.23\(A\)](#) or [495.106450.23\(B\)](#).

450.23495.106(A) Indoor Installations. Indoor installations shall be permitted in accordance with one of the following:

(1) In Type I or Type II buildings, in areas where all of the following requirements are met:

- a. The transformer is rated 35,000 volts or less.
- b. No combustible materials are stored.
- c. A liquid confinement area is provided.
- d. The installation complies with all the restrictions provided for in the listing of the liquid.

Informational Note: Such restrictions **can** include, but are not limited to, maximum pressure of the tank, use of a pressure relief valve, appropriate fuse types, and proper sizing of overcurrent protection.

(2) If an automatic fire extinguishing system and a liquid confinement area is present, provided the transformer is rated 35,000 volts or less

(3) If the installation complies with 495.109-450.26

(B) Outdoor Installations.

Less-flammable liquid-filled transformers shall be permitted to be installed outdoors, attached to, adjacent to, or on the roof of buildings, if installed in accordance with (1) or (2).

(1) For Type I and Type II buildings, the installation shall comply with all the restrictions provided for in the listing of the liquid.

Informational Note No. 1: Installations adjacent to combustible material, fire escapes, or door and window openings can require additional safeguards such as those listed in 495.110-450.27.

Informational Note No. 2: Such restrictions can include, but are not limited to: maximum pressure of the tank, use of a pressure relief valve, appropriate fuse types, and proper sizing of overcurrent protection.

(2) In accordance with 450.27-495.110.

Informational Note No. 1: As used in this section, *Type I and Type II buildings* refers to Type I and Type II building construction as defined in NFPA 220-2018, Standard on Types of Building Construction. *Combustible materials* refers to those materials not classified as noncombustible or limited-combustible as defined in NFPA 220-2018, Standard on Types of Building Construction.

Informational Note No. 2: See definition of *Listed* in Article 100.

450.24-495.107 Nonflammable Fluid-Insulated Transformers. Transformers insulated with a dielectric fluid identified as nonflammable shall be permitted to be installed indoors or outdoors. Such transformers installed indoors and rated over 35,000 volts shall be installed in a vault. Such transformers installed indoors shall be furnished with a liquid confinement area and a pressure-relief vent. The transformers shall be furnished with a means for absorbing any gases generated by arcing inside the tank, or the pressure-relief vent shall be connected to a chimney or flue that will carry such gases to an environmentally safe area.

Informational Note: Safety may be increased if fire hazard analyses are performed for such transformer installations.

For the purposes of this section, a nonflammable dielectric fluid is one that does not have a flash point or fire point and is not flammable in air.

450.25-495.108 Askarel-Insulated Transformers Installed Indoors. Askarel-insulated transformers installed indoors and rated over 25 kVA shall be furnished with a pressure-relief vent. Where installed in a poorly ventilated place, they shall be furnished with a means for absorbing any gases generated by arcing inside the case, or the pressure-relief vent shall be connected to a chimney or flue that carries such gases outside the building. Askarel-insulated transformers rated over 35,000 volts shall be installed in a vault.

495.109 Oil-Insulated Transformers Installed Indoors. Oil-insulated transformers installed indoors shall be installed in a vault constructed as specified in Part III of this article.

Exception No. 1: Where the total capacity does not exceed 112½ kVA, the vault specified in Part III of this article shall be permitted to be constructed of reinforced concrete that is not less than 100 mm (4 in.) thick.

Exception No. 2: Where the nominal voltage does not exceed 1000, a vault shall not be required if suitable arrangements are made to prevent a transformer oil fire from igniting other materials and the total capacity in one location does not exceed 10 kVA in a section of the building classified as combustible or 75 kVA where the surrounding structure is classified as fire-resistant construction.

Exception No. 3: Electric furnace transformers that have a total rating not exceeding 75 kVA shall be permitted to be installed without a vault in a building or room of fire-resistant construction, provided suitable arrangements are made to prevent a transformer oil fire from spreading to other combustible material.

Exception No. 4: A transformer that has a total rating not exceeding 75 kVA and a supply voltage of 1000 volts or less that is an integral part of charged-particle-accelerating equipment shall be permitted to be installed without a vault in a building or room of noncombustible or fire-resistant construction, provided suitable arrangements are made to prevent a transformer oil fire from spreading to other combustible material.

Exception No. 5: Transformers shall be permitted to be installed in a detached building that does not comply with Part III of this article if neither the building nor its contents present a fire hazard to any other building or property, and if the building is used only in supplying electric service and the interior is accessible only to qualified persons.

Exception No. 6: Oil-insulated transformers shall be permitted to be used without a vault in portable and mobile surface mining equipment (such as electric excavators) if each of the following conditions is met:

- (1) Provision is made for draining leaking fluid to the ground.
- (2) Safe egress is provided for personnel.
- (3) A minimum 6-mm (1/8-in.) steel barrier is provided for personnel protection.

495.110 Oil-Insulated Transformers Installed Outdoors.

Combustible material, combustible buildings, and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on roofs, attached to or adjacent to a building or combustible material.

In cases where the transformer installation presents a fire hazard, one or more of the following safeguards shall be applied according to the degree of hazard involved:

- (1) Space separations
- (2) Fire-resistant barriers
- (3) Automatic fire suppression systems
- (4) Enclosures that confine the oil of a ruptured transformer tank

Oil enclosures shall be permitted to consist of fire-resistant dikes, curbed areas or basins, or trenches filled with coarse, crushed stone. Oil enclosures shall be provided with trapped drains where the exposure and the quantity of oil involved are such that removal of oil is important.

Informational Note: For additional information on transformers installed on poles or structures or under ground, see ANSI/IEEE C2-2017, National Electrical Safety Code.

495.111 Modification of Transformers.

When modifications are made to a transformer in an existing installation that change the type of the transformer with respect to Part VII of this article, such transformer shall be marked to show the type of insulating liquid installed, and the modified transformer installation shall comply with the applicable requirements for that type of transformer.

Part ~~III~~VIII. Transformer Vaults

450.41495.112 Location. Vaults shall be located where they can be ventilated to the outside air without using flues or ducts wherever such an arrangement is practicable.

495.113 Accessibility. All transformer vaults shall be readily accessible to qualified personnel for inspection and maintenance or shall meet the requirements of 450.13(A) or 450.13(B).

450.42495.1143 Walls, Roofs, and Floors. The walls and roofs of vaults shall be constructed of materials that have approved structural strength for the conditions with a minimum fire resistance of 3 hours. The floors of vaults in contact with the earth shall be of concrete that is not less than 100 mm (4 in.) thick, but, where the vault is constructed with a vacant space or other stories below it, the floor shall have approved structural strength for the load imposed thereon and a minimum fire resistance of 3 hours. For the purposes of this section, studs and wallboard construction shall not be permitted.

Exception: Where transformers are protected with automatic sprinkler, water spray, carbon dioxide, or halon, construction of 1-hour rating shall be permitted.

Informational Note No. 1: For additional information, see ASTM E119-18a, *Methods for Fire Tests of Building Construction and Materials*.

Informational Note No. 2: A typical 3-hour construction is 150 mm (6 in.) thick reinforced concrete.

450.43495.1154 Doorways. Vault doorways shall be protected in accordance with 495.1154450.43(A), (B), and (C).

(A) Type of Door. Each doorway leading into a vault from the building interior shall be provided with a tight-fitting door that has a minimum fire rating of 3 hours. The authority having jurisdiction shall be permitted to require such a door for an exterior wall opening where conditions warrant.

Exception: Where transformers are protected with automatic sprinkler, water spray, carbon dioxide, or halon, construction of 1-hour rating shall be permitted.

Informational Note: For additional information, see NFPA 80-2016, *Standard for Fire Doors and Other Opening Protectives*.

(B) Sills. A door sill or curb that is of an approved height that will confine the oil from the largest transformer within the vault shall be provided, and in no case shall the height be less than 100 mm (4 in.).

(C) Locks. Doors shall be equipped with locks, and doors shall be kept locked, with access being allowed only to qualified persons. Personnel doors shall open in the direction of egress and be equipped with listed fire exit hardware.

450.45495.1165 Ventilation Openings. Where required by 450.9, openings for ventilation shall be provided in accordance with 495.1165450.45(A) through (F).

(A) Location. Ventilation openings shall be located as far as possible from doors, windows, fire escapes, and combustible material.

(B) Arrangement. A vault ventilated by natural circulation of air shall be permitted to have roughly half of the total area of openings required for ventilation in one or more openings near the floor and the remainder in one or more openings in the roof or in the sidewalls near the roof, or all of the area required for ventilation shall be permitted in one or more openings in or near the roof.

(C) Size. For a vault ventilated by natural circulation of air to an outdoor area, the combined net area of all ventilating openings, after deducting the area occupied by screens, gratings, or louvers, shall not be less than 1900 mm² (3 in.²) per kVA of transformer capacity in service, and in no case shall the net area be less than 0.1 m² (1 ft²) for any capacity under 50 kVA.

(D) Covering. Ventilation openings shall be covered with durable gratings, screens, or louvers, according to the treatment required in order to avoid unsafe conditions.

(E) Dampers. All ventilation openings to the indoors shall be provided with automatic closing fire dampers that operate in response to a vault fire. Such dampers shall possess a standard fire rating of not less than 1½ hours. Informational Note: See ANSI/UL 555-2016, *Standard for Fire Dampers*.

(F) Ducts. Ventilating ducts shall be constructed of fire-resistant material.

~~495.1176~~ 450.46 Drainage. Where practicable, vaults containing more than 100 kVA transformer capacity shall be provided with a drain or other means that will carry off any accumulation of oil or water in the vault unless local conditions make this impracticable. The floor shall be pitched to the drain where provided.

~~495.1187~~ 450.47 Water Pipes and Accessories. Any pipe or duct system foreign to the electrical installation shall not enter or pass through a transformer vault. Piping or other facilities provided for vault fire protection, or for transformer cooling, shall not be considered foreign to the electrical installation.

~~495.1198~~ 450.48 Storage in Vaults. Materials shall not be stored in transformer vaults.

Part IX. Capacitors

495.120419 Enclosing and Guarding.

(A) Containing More Than 11 L (3 gal) of Flammable Liquid. Capacitors containing more than 11 L (3 gal) of flammable liquid shall be enclosed in vaults or outdoor fenced enclosures complying with Article 110, Part III. This limit shall apply to any single unit in an installation of capacitors.

(B) Accidental Contact. Where capacitors are accessible to unauthorized and unqualified persons, they shall be enclosed, located, or guarded so that persons cannot come into accidental contact or bring conducting materials into accidental contact with exposed energized parts, terminals, or buses associated with them. However, no additional guarding is required for enclosures accessible only to authorized and qualified persons

495.1210 Not Covered.

Surge capacitors or capacitors included as a component part of other apparatus and conforming with the requirements of such apparatus are excluded from these requirements.

This Part also covers the installation of capacitors in hazardous (classified) locations as modified by Articles 501 through 503.

495.1224 Switching.

(A) Load Current. Group-operated switches shall be used for capacitor switching and shall be capable of the following:

- (1) Carrying continuously not less than 135 percent of the rated current of the capacitor installation
- (2) Interrupting the maximum continuous load current of each capacitor, capacitor bank, or capacitor installation that will be switched as a unit
- (3) Withstanding the maximum inrush current, including contributions from adjacent capacitor installations
- (4) Carrying currents due to faults on capacitor side of switch

(B) Isolation.

(1) General. A means shall be installed to isolate from all sources of voltage each capacitor, capacitor bank, or capacitor installation that will be removed from service as a unit. The isolating means shall provide a visible gap in the electrical circuit adequate for the operating voltage.

(2) Isolating or Disconnecting Switches with No Interrupting Rating. Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load-interrupting device or shall be provided with prominently displayed caution signs in accordance with [4950.22](#) to prevent switching load current.

(C) Additional Requirements for Series Capacitors. The proper switching sequence shall be ensured by use of one of the following:

- (1) Mechanically sequenced isolating and bypass switches
- (2) Interlocks
- (3) Switching procedure prominently displayed at the switching location

[495.1232](#) Overcurrent Protection.

(A) Provided to Detect and Interrupt Fault Current. A means shall be provided to detect and interrupt fault current likely to cause dangerous pressure within an individual capacitor.

(B) Single Pole or Multipole Devices. Single-pole or multipole devices shall be permitted for this purpose.

(C) Protected Individually or in Groups. Capacitors shall be permitted to be protected individually or in groups.

(D) Protective Devices Rated or Adjusted. Protective devices for capacitors or capacitor equipment shall be rated or adjusted to operate within the limits of the safe zone for individual capacitors.

[495.1243](#) ~~460.26~~ Identification. Each capacitor shall be provided with a permanent nameplate giving the manufacturer's name, rated voltage, frequency, kilovar or amperes, number of phases, and the volume of liquid identified as flammable, if such is the case.

[495.1254](#) ~~460.27~~ Grounding. Capacitor cases shall be connected to the equipment grounding conductor. If the capacitor neutral point is connected to a grounding electrode conductor, the connection shall be made in accordance with Part III of Article [250](#).

Exception: Capacitor cases shall not be connected to the equipment grounding conductor where the capacitor units are supported on a structure designed to operate at other than ground potential.

[495.1265](#) ~~460.28~~ Means for Discharge.

(A) Means to Reduce the Residual Voltage. A means shall be provided to reduce the residual voltage of a capacitor to 50 volts or less within 5 minutes after the capacitor is disconnected from the source of supply.

(B) Connection to Terminals. A discharge circuit shall be either permanently connected to the terminals of the capacitor or provided with automatic means of connecting it to the terminals of the capacitor bank after disconnection of the capacitor from the source of supply. The windings of motors, transformers, or other equipment directly connected to capacitors without a switch or overcurrent device interposed shall meet the requirements of [495.12660-28\(A\)](#).

Part [X](#). Resistors and Reactors

[470.18495.130](#) General.

(A) Protected Against Physical Damage.

Resistors and reactors shall be protected against physical damage.

(B) Isolated by Enclosure or Elevation. Resistors and reactors shall be isolated by enclosure or elevation to protect personnel from accidental contact with energized parts.

(C) Combustible Materials. Resistors and reactors shall not be installed in close enough proximity to combustible materials to constitute a fire hazard and shall have a clearance of not less than 305 mm (12 in.) from combustible materials.

(D) Clearances. Clearances from resistors and reactors to grounded surfaces shall be adequate for the voltage involved.

(E) Temperature Rise from Induced Circulating Currents. Metallic enclosures of reactors and adjacent metal parts shall be installed so that the temperature rise from induced circulating currents is not hazardous to personnel or does not constitute a fire hazard.

~~495.131 470.19~~ Grounding. Resistor and reactor cases or enclosures shall be connected to the equipment grounding conductor.

Exception: Resistor or reactor cases or enclosures supported on a structure designed to operate at other than ground potential shall not be connected to the equipment grounding conductor.

~~495.132 470.20~~ Oil-Filled Reactors. Installation of oil-filled reactors, in addition to the above requirements, shall comply with applicable requirements of Article ~~495. Part VII~~[450](#).



Public Input No. 3522-NFPA 70-2020 [Part I.]

Part I. General

(Relocate Part I. General. to immediately follow the title and prior to section 230.1.)

Statement of Problem and Substantiation for Public Input

Relocating the Scope to immediately follow the title will bring this article into compliance with the revised Style Manual. When an article has multiple parts Section 2.2.1 States Where an article has multiple parts, the scope shall be the first section in Part I. Section 2.4.2.1 states Where an article has multiple parts, Part I. shall be titled "General".

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

Street Address:

City:

State:

Zip:

Submittal Date: Tue Sep 08 20:52:35 EDT 2020

Committee: NEC-P10

Copyright Assignment

I, David Williams, 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 David Williams, 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