Public Input No. 3085, Assigned to Code-Making Panel 1, Refer to Code-Making Panels 2 - 18

Public Input No. 3085-NFPA 70-2023 [Global Input]

This Global Public Input is for all Technical Committees and review their informational notes and the requirements in the NEC Style Manual Section 2.1.10 for informational notes.

Statement of Problem and Substantiation for Public Input

This Global Public Input is for all Technical Committees and review their informational notes and the requirements in the NEC Style Manual Section 2.1.10 for informational notes.
2.1.10.3 Format. Informational notes shall be structured as shown in the example, using the word “See” followed by the reference standard, the title of the standard and section if used, and an explanation for the reference.
Example:
"See" "Referenced Standard", "Standard Title", "Section Number", "Explanation of the reference"
Informational Note: See NFPA 101, Life Safety Code, 7.8, for illumination of means of egress.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

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Submittal Date: Tue Aug 29 11:15:17 EDT 2023
Committee: NEC-P01

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Public Input No. 3086, Assigned to Code-Making Panel 2, Refer to Code Making Panels 3 - 18

Public Input No. 3086-NFPA 70-2023 [Global Input]

This Global Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document.
Articles may need to be revised to comply with the NEC Style Manual Section 2.2 for Numbering Conventions.

Statement of Problem and Substantiation for Public Input

This Global Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document.
Articles may need to be revised to comply with the NEC Style Manual Section 2.2 for Numbering Conventions. The Changes in 2.2.1 are requirements that may need to be revised.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning
requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

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Public Input No. 3099, Assigned to Code-Making Panel 15, Refer to Code-Making Panels 3, 4, 6, 10, 11, 12, 13, 14, 16, 17 and 18

Public Input No. 3099-NFPA 70-2023 [Global Input]

Add Informational Notes to Scopes identifying Article specific and/or important definitions in one of the following formats:

Format A – the style used in NFPA Link's Enhanced Content material:

Informational Note No. x: Definitions. Each of the following terms has a definition in Article 100 that is unique to its use in "Article xxx":

Term 1

Term 2

Term 3

...

If needed:

Informational Note No. y: Definitions. Each of the following terms has a definition in Article 100 that appears in several articles but is important in its use in "Article xxx":

Term a

Term b

Term c

...

Format B – the style used in several places within the NEC itself:

Informational Note: See Article 100 for definitions of Term 1, Term 2, and Term 3 . . .

Statement of Problem and Substantiation for Public Input

The change to locations of definitions in the 2023 Edition of the NEC was controversial for many people because it reduced usability. Even though other NFPA codes and standards use this structure and was stated as a justification to the change in the 'NEC Style Manual' (some NFPA codes and standards include definitions within articles *), many believe this relocation leads to confusion among users, especially for those articles that are specialty topics – i.e., the articles in Chapters 5 through 8. There are over 37 pages of definitions in Article 100 to search through.

Common language terms often have more specific meanings within an article. One only needs to look at the multiple definitions for 'Portable Equipment' to get a sense of this issue. While the term 'Directly Controlled Emergency Luminaire' used in Article 700 seems self-explanatory, the actual definition is quite important. Without the proximate reference within Article 700, that distinction is not clear.

Article 200 does the following:
200.1 Scope.
This article provides requirements for the following:
(1) Identification of terminals
(2) Grounded conductors in premises wiring systems
(3) Identification of grounded conductors
Informational Note: See Article 100 for definitions of Grounded Conductor, Equipment Grounding Conductor, and Grounding Electrode Conductor.

Article 380 also adds a definition reference in an Informational Note to the scope.

There are approximately 30 references to Article 100 definitions within specific sections of the Code.

Under the current structure, important specialty definitions are lost in the sheer size of the Article 100 list. The usability of the NEC has been damaged, and users of specialty articles in Chapters 5 through 8 need help with this structure.

To restore the usability of the NEC, what is needed is a way to clearly identify and point to specialty definitions in a standardized location within articles (like we used to have with the .2 sections), while leaving the definitions themselves in Article 100. NFPA Link and the NEC Handbook add this information as Enhanced Content. Additionally, this “definition identification” model has proven its usability in other codes such as NFPA 1, NFPA 99, and NFPA 101. The NEC deserves no less.
* Example: NFPA 101 – Section 6.1.2.1 ‘Assembly Occupancy’ is one of several definitions in an Article; and in this instance it is duplicated from 3.3.205.2]. In fact, there are multiple definitions throughout NFPA 101.

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Public Input No. 4050, Assigned to Code-Making Panel 10, Refer to Code-Making Panels 1 - 9 and 11 - 18

Public Input No. 4050-NFPA 70-2023 [Global Input]

Review the terms regarding overcurrent protection and determine if the correct term is being used.

(1) Branch-Circuit Overcurrent Protective Device

(2) Current-Limiting Overcurrent Protective Device

(3) Current-Limiting

(4) Current-Limiting Overcurrent

(5) Overcurrent Protection

(6) Overcurrent Protection Device

(7) Overcurrent Protective Device

(8) Supplementary Overcurrent Protective Device

(9) Supplementary Overcurrent Protection

Statement of Problem and Substantiation for Public Input

The defined terms regarding overcurrent protection need to be reviewed by all code making panels and determine if the correct term is being used. The code has too many terms regarding overcurent protection, some that are defined and some that are not defined. These terms are often used interchangeably in the wrong context.

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Public Input No. 4287, Assigned to Code-Making Panel 1, Refer to Code-Making Panels 2 - 18

Public Input No. 4287-NFPA 70-2023 [Global Input]

Clearly identify any requirements which are not applicable to DC circuits by incorporating the recommended terminology as applicable:

“Applicable to…[ac][single-phase][three-phase][wye][delta] circuits only”.

“Not applicable to dc circuits”

“[Volts] ac only”

Other terminology that clearly applies to a specific ac (or dc) application, such as through a defined term or unique equipment.

Statement of Problem and Substantiation for Public Input

This Public Input is submitted on behalf of a Correlating Committee DC Task Group consisting of Danish Zia, Jason Fisher, Randy Dollar, Larry Wildermuth, Scott Higgins, Scott Harding, Mark Earley, Jason Hopkins, Christopher Vance, Chad Kennedy and Derrick Atkins. This Public Input, along with other Public Inputs, was developed with the goal of improving usability and accuracy on requirements associated with DC circuits.

DC residential and commercial installations are emerging in the electrical infrastructure and are expected to be a growing alternative to the traditional AC utility fed building. Examples include the US DOE Grid-interactive Efficient Buildings project (Note 1), the Purdue University RENEWW house (Note 2), and a DC Microgrid community in Vermont (Note 3). These installations may involve buildings that are distributed entirely with DC, or with an AC/DC hybrid distribution.

Although DC electrical distribution topics are covered by the NEC, the focus of most residential and commercial installations and the Code has historically been AC power. Many requirements are written using AC terminology or referencing only AC technology, but without distinction as to whether the requirement is also applicable to DC circuits or installations. Usage of terms such as “2-wire” and “3-wire”, or listing AC only voltages as informative references without appropriate mandatory language or further clarification may not provide sufficient clarity as to whether a requirement applies to DC circuits. This may leave the AHJ and other users of the Code confused. This public input recommends that such requirements be reviewed and clarified using the recommended terminology proposed.

Note 1 - https://www.energy.gov/sites/default/files/2020/09/f79/bto-geb-project-summary-093020.pdf
Note 2 - https://engineering.purdue.edu/ME/News/2022/purdue-house-runs-entirely-on-dc-power
Note 3 - https://www.efficiencyvermont.com/Media/Default/docs/white-papers/Energy_Resilience.pdf

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Committee:	NEC-P01

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Public Input No. 158-NFPA 70-2023 [Definition: Ampacity.]

Ampacity.

The maximum current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding ~~its temperature rating.~~ the temperature rating of it or its wiring method. (CMP-6)

Statement of Problem and Substantiation for Public Input

The wiring method within which a conductor is installed may limit the maximum allowable operating temperature of the conductor. Namely, for LFMC 350.10(4); PVC 352.10(J); HDPE 353.10(6); RTRC 355.10(I); LFNC 356.10(9); and ENT 362.10(10). There is some confusion in the field about whether the limitations in the enumerated sections cause a reduction of ampacity, or whether they are an additional restriction that applies independent of ampacity.

For example, say #8 Cu THWN is installed in LFMC in a wet location for an application with 75C terminations and with no ampacity adjustment or correction required. All LFMC is limited to a 60C wet location rating per UL standard 360. Is (A) the ampacity of the #8 Cu THWN within the LFMC 40A, because 350.10(4) limits the conductor maximum operating temperature to 60C? Or is (B) the ampacity still 50A per the 75C rating of the THWN, but 350.10(4) imposes a separate restriction that the conductor may never be used for more than 40A?

This distinction makes a difference for the case of a 40A continuous load--that application requires a 50A ampacity conductor per 210.19(A)(1)(a), although the conductor is never expected to see a load exceeding 40A. So under interpretation (A) the connected load could not be a 40A continuous load, because 350.10(4) lowers the conductor ampacity; while under interpretation (B), the connected load could be a 40A continuous load, as the ampacity is still 50A, and the operating current does not exceed 40A.

The proposed definitional change would clarify the confusion in favor of interpretation (A), that the conductor ampacity is reduced within the LFMC.

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Public Input No. 897-NFPA 70-2023 [Definition: Cable, Nonmetallic-Sheathed (Type NM).]

Cable, Nonmetallic-Sheathed (Type NM).

Insulated circuit conductors and a bare or covered equipment grounding conductor enclosed within an overall nonmetallic jacket. (CMP-6)

Statement of Problem and Substantiation for Public Input

As currently written, only a cable containing an insulated equipment grounding conductor meets this definition.

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Public Input No. 898-NFPA 70-2023 [Definition: Cable, Nonmetallic-Sheathed (Type NMC).]

Cable, Nonmetallic-Sheathed (Type NMC).

Insulated circuit conductors and a bare or covered equipment grounding conductor enclosed within an overall, corrosion resistant, nonmetallic jacket. (CMP-6)

Statement of Problem and Substantiation for Public Input

As currently written, this definition only applies if the EGC is insulated.

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Public Input No. 3463-NFPA 70-2023 [New Definition after Definition: Riser Cable, Cable Routing...]

TITLE OF NEW CONTENT Running Board

A rigid member attached to fixed structure, equipment, or both, or installed as a barrier, in order to protect and often support wiring, with or without raised extensions to protect wiring from potential injury coming from the sides.

Statement of Problem and Substantiation for Public Input

Running boards are referred to in more than one article. While 398.15 offers precise specifications, other locations that use the term are less specific. History suggests that running boards were intended to provide more than just support, in every context. They were expected to be wide compared to the wiring they bore, and substantial enough to be relied upon. This is reason enough to mention both support and protection.

I'll list some of the indications that this has been true over the century and more that we've used these with different wiring methods. The 1897 Middle Department rule 35 d requires greater protection of open wiring on insulators carrying between 300V and 3000 V at least up to 7 ft above the floor, but adds that elsewhere if they " . . . might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden board."

This rule developed, and very shortly was applied to wiring at lower voltages. In the 1915 NEC, the NBFU applied Rule 26e to open wiring in any low-potential systems. They could be protected by running boards or by guard strips. Over the years we've gone in different directions about where to use them and whether running boards themselves needed to incorporate side guard strips.
In 1925 the rule had been numbered 501-m, referred to risk of "mechanical injury," and just specified a running board at least 3 in. wide.
In the 1928 NEC, and the rule parenthetically mentions the height of the side protection, elements that also have been called railings. It doesn't read like a new rule, just a clarification of a characteristic that was understood.
In the 1930 NEC, Rule 507-l even required running boards where NM cable was run through bored holes in floor joists, studs and rafters, similar to what we find today in 394.23(A) and 398.23(A) for K&T and Open Wiring respectively in accessible attics.

Presently, open wiring is considered not suitable for all occupancies. However, 398.15(C) Exposed to Physical Damage, does offer specs for running boards, in Option (2).
Outside of that article and 394.23(A), which says they are to extend 1 in to each side of the conductors, there are no specs for the boards themselves. It is not clear why the last sentence of 394.23(A) mentions "running boards and guard strips," as guard strips are not mentioned anywhere else in 394. Perhaps this is left over from the assumption that seems to have existed in 1928, that running boards of course incorporate guard strips or railings to give side protection.

The inconsistency is disturbing. 300.5(F) mentions "suitable running boards" as one means of protecting direct-buried cables, raceways, or conductors. Where the issue is protection from rough fill, it is understandable that context-specific judgment of suitability is necessary. However, there is zero description of running board design for some other uses. 320.15 allows AC cable to closely follow the surface of the building finish "or of running boards." 330.15 offers this same language for MC cable, 334.15(A) and 334.15(C) for NM. Do these need to be "substantial," as in a former description? Wider than the conductors they support? Article 100 is not the place for specifications, but description at least gives users a sense of the purposes we have when we use this term in a rule.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3864-NFPA 70-2023 [Section No. 394.23(A)]	Clarifies that this section is using running boards solely for protection.
Public Input No. 3464-NFPA 70-2023 [Section No. 320.15]	

Public Input No. 3466-NFPA 70-2023 [Section No. 330.15]

Public Input No. 3468-NFPA 70-2023 [Section No. 334.15(A)]

Public Input No. 3469-NFPA 70-2023 [Section No. 334.15(C)]

Public Input No. 3471-NFPA 70-2023 [New Section after 300.4(H)]

Public Input No. 3864-NFPA 70-2023 [Section No. 394.23(A)]

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Public Input No. 3494-NFPA 70-2023 [New Section after 310.1]

310.2 Listing Requirements

Copper-clad aluminum conductor material shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

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Public Input No. 625-NFPA 70-2023 [New Section after 310.1]

310.2 Reconditioned Equipment

Conductors for general wiring shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Conductors, Raceways, Strut-type Channel Raceways, Fixture Wires, Cablebus, Cables, Conduits, Tubings, Flexible Cords, Flexible Cables, Cable Trays, MV Cables, Wireways, etc. etc. are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	Reconditioned Equipment

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Committee:	NEC-P06

Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]

(A) Minimum Size of Conductors.

The minimum size of conductors for voltage ratings up to and including 2000 volts shall ~~be 14 AWG copper or 12 AWG aluminum or~~ be 14 AWG copper and copper-clad aluminum or 12 AWG aluminum , except as permitted elsewhere in this *Code*.

Additional Proposed Changes

File Name	Description	Approved
14_AWG_Thermal_Insulation_Testing_Report_Inc_App2.pdf	Comparative Study of 14 AWG CCA and 14 AWG Copper in Net Zero Attic and Wall Insulation	

Statement of Problem and Substantiation for Public Input

The 2026 NEC cycle is the third attempt to add 14 AWG copper-clad aluminum (CCA) into section 310.3(A) as a branch circuit conductor. Over six years sufficient technical knowledge has been shared with Technical Panel 6 to permit thoughtful evaluation of 14 AWG CCA. Within this span Panel 6 has evaluated 14 AWG CCA's thermal stability at 90° C, 120° C and 150° C; its corrosion profile; mechanical characteristics; heat-rise under normal conditions in open air as well as when embedded in attic and wall insulation; heat-rise in over-current conditions in open air and embedded in attic and wall insulation; heat-rise at breaker terminals in normal and over-current conditions; breaker trip times with listed circuit breakers at 135%, 150% and 200% of 10 ampere current; heat-rise at receptacle terminals of listed receptacles in normal and over-current conditions; 500 cycles of over-current thermal testing with four separate brands of listed Cu-rated twist-on splice connectors; heat-rise of the conductor's core in open air; heat-rise of the conductor's insulation in open air; and finally, heat-rise of its PVC insulation under wall and attic insulation. In every case, except with those test reports used as substantiation to support Public Comments during the 2023 cycle, the panel has had the opportunity to evaluate 14 AWG CCA's performance side-by-side with 14 AWG copper – currently the smallest sized conductor for branch circuits. Considering all this research, 14 AWG CCA has more than surpassed the minimum safety requirements for acceptance into this code.

In terms of how 14 AWG CCA performed as stated in every test report from the last two cycles, "tests using NM/NM-B and THHN cables of sizes 14 AWG CCA…with an applied current of 10 A did not exceed the insulation temperature rating of 90°C for any test configurations including those installed in ceiling cavities with R43 thermal insulation and wall cavities with R26 thermal insulation." This quote is referenced in section 3.1.2.1 and illustrated by Table 4 found on page 12 of the NFPA Research Foundation's recently published report, Evaluation of Electrical Conductors in Thermal Insulation: Literature Review, Gap Analysis & Development of a Research Plan. RF_Electrical_Conductors.pdf (nfpa.org) According to Table 4, and considering all 19 individual tests, a temperature of 20.7° C is the average Rise Over Ambient (ROA) of a continuously loaded 14 AWG CCA at 10 amperes. Hampton Tedder (contracted by the Copper Development Association) reported 47° C as the highest ROA of the 19 individual tests. That test design sandwiched CCA 14/2 NM-B cable between R38 (top) insulation and R13 (bottom) insulation to mimic poor workmanship in an attic installation. The cable was secured inside the test fixture in a "back and forth" serpentine fashion atypical of any real-world application. The design better ensured that heat would be retained inside the test configuration next to the conductors. Even then, the CCA conductors did not overheat. In short, Panel 6 has performed its due diligence, and has more than sufficient knowledge upon which to make an informed decision in favor of accepting 14 AWG CCA into code as a branch circuit conductor.

In addition to the existing body of knowledge, a new report on the performance of 14 AWG CCA has nevertheless been included as substantiation for this set of Public Inputs. It is entitled, Comparative Analysis of the Heating of 14 AWG Copper-clad Aluminum Conductors and 14 AWG Copper Conductors in Attic and Wall Insulation. The report is the result of a collaboration between materials scientists with expertise in thermodynamics, electrical engineers with expertise in circuit design, accreditors with expertise in testing procedures, and building scientists with expertise in construction materials and building codes. In addition to presenting comparative data on the performance of both copper and CCA, the report also brings perspective. Within the report's appendix are sections written by the scientists themselves where they share their knowledge and experience as it relates to the data.

As in 2020 and 2023, 14 AWG CCA did not disappoint in 2026. When tested at the proposed rating of 10 amps it performed better in terms of heat rise than 14 AWG copper at its long-established 15 ampacity rating. When testing three current-carrying conductors in thermal insulation at the maximum allowed amperage, 14 AWG CCA never surpassed the rating of its 90° C THHN insulation. To be fair, at 15 amps 14 AWG copper also performed well. 14 AWG copper has been a dependable workhorse for the industry, and it will continue to be. Nothing in the 20 years of statistics from 2002 – 2022 in the National Fire Incident Reporting System (NFIRS) indicates that 14 AWG copper conductors with a 15 ampacity rating are inherently dangerous. Fire officials have never singled out 14 AWG copper THHN or NM-B cable (or any other size for that matter!) as a fire hazard.

This conclusion is echoed by UL Solutions in research published in a 2012 report, The Influence of Damage and Degradation on Breakdown Voltage on NM Cable authored by Dr. Fan He and Dr. Paul Brazis. In this study thermal aging techniques were applied to copper NM-B cable and THHN conductors at temperatures of 150° C continuously administered over 15 days. The study established a direct relationship between the weight loss of the thermoplastic insulation of THHN and arc-faulting. The study also demonstrated that nylon, which applies to both THHN and NM-B cable, contributes strongly to preventing PVC insulation weight loss at temperatures at 150° C and below. Sustained heating over 14 days of 150° C does create a situation where a very small percentage of insulation is lost in THHN and NM-B cable, but not to a level where the breakdown voltage creates a fire hazard. The report concludes the following: "The test results also indicate that the breakdown event (of the insulation) is unlikely to initiate arcing that is sustained long enough to ignite the cable insulation or surrounding materials."

UL standards also govern the PVC insulation of THHN conductors. Specifically, UL 83 requires that THHN PVC insulation retains a percentage of its unaged mechanical properties after accelerated aging at 136° C for 7 days without nylon. 75% of the insulation's tensile strength and 65% of its elongation must be maintained after aging. In other words, UL safety standards adequately consider conductor performance after being subjected to elevated heating. To be a listed conductor with thermoplastic insulation, a product must meet or exceed UL 83.

Considering the movement towards more energy efficient buildings and "Net Zero" construction, equipment and luminaires have become more efficient. Their loads are falling, and as a result, so is the heat lost to impedance – a positive in terms of fire prevention. Key provisions allowing for 10 amp circuits were adopted last cycle, so the provision to permit a 10 amp circuit conductor has become necessary for users of this code. The data supplied over the last two cycles, and now a third, clearly supports 14 AWG CCA's capacity to safely fill that need.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1016-NFPA 70-2023 [Section No. 310.16]	
Public Input No. 1017-NFPA 70-2023 [Section No. 310.17]	
Public Input No. 1009-NFPA 70-2023 [Section No. 330.104]	
Public Input No. 1010-NFPA 70-2023 [Section No. 334.104]	
Public Input No. 1014-NFPA 70-2023 [Section No. 336.104 [Excluding any Sub-Sections]]	
Public Input No. 1015-NFPA 70-2023 [Section No. 340.104]	
Public Input No. 1019-NFPA 70-2023 [Section No. 324.100(A)]	
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Comparative Heating Analysis of 14 AWG Copper-Clad Aluminum Conductors and 14 AWG Copper Conductors in Thermal Insulation

For

Copperweld Bimetallics

Conducted at

Construction Instruction
6850 Argonne St, Unit 100
Denver, Colorado
and
Copperweld Bimetallics Performance Laboratory

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Date: September 1, 2023

Intertek Report No. 105499019CSLT-001

Table of Contents

Appendices

Executive Summary

Are electrical conductors made with 14 AWG copper-clad aluminum (CCA) unsafe to use with the thermal insulation typically found in walls and attics? If safe now, will they become unsafe sometime in the future as insulation becomes more thermally efficient? This report addresses those fundamental questions. At the 10-ampere ampacity 14 AWG CCA conductors are safe, and should continue to be. Bringing insight and perspective, a team of experts representing building science, materials science, and electrical engineering has been assembled to execute this project plan and aid with the explanation of its results. With fire safety being the foundation of this endeavor, we believe new knowledge has been gained through this collaboration that can assist standards setters and regulators to settle the 10-ampere circuit question and possibly others.

This report compares the performance of the following conductors and cables within three test fixtures designed to accurately reflect insulated spaces using extremely efficient thermal insulation generally referred to as “net zero insulation.”

The Conductors and Wiring Methods (Test Subjects):

1. 14-3 AWG copper-clad aluminum (CCA) NM-B cable (containing three THHN conductors)
2. 14-3 AWG copper NM-B cable (containing three THHN conductors)
3. 14 AWG copper-clad aluminum (CCA) THHN conductors in electrical non-metallic conduit (ENT)
4. 14 AWG copper THHN conductors in electric non-metallic conduit (ENT).

The Test Fixtures:

1. Test Fixture 1: Wall Fixture with Fiber Glass Batt Insulation (R21)
2. Test Fixture 2: Wall Fixture with Spray Foam Insulation (R30)
3. Test Fixture 3: Attic Fixture with Blown in Fiber Glass Insulation (R60)

It is important to keep in mind that this report represents a worst-case scenario for these wiring methods. First, each wiring method evaluated contained three current carrying conductors, and each of the three conductors was loaded to its full ampacity. Second, each wiring method was tested in extremely efficient thermal insulation. These two situations happening together would be a rarity for real-world small circuits.

For one, most small circuit cables used in residential construction, such as NM-B cable for example, use two conductor constructions, not three. The power is single phase. If a third conductor is utilized, it is normally a traveler between switches or the neutral on a multi-wire branch circuit that carries only part of the load. Further, given the nationwide movement towards utilizing ever-more energy efficient equipment and LED lighting, loading demands of circuits are steadily decreasing for residential buildings. The push to conserve energy particularly pertains to new commercial and industrial buildings where small circuit wire in conduit is often used. In short, three heavily loaded current-carrying conductors in a cable or conduit is not the norm.

Two, society is far from settling on the idea of requiring net zero insulation in buildings. And even if it does eventually happen, the trend is towards having less insulation in contact with wires inside walls and attics, and more insulation on the exterior of walls and under roof decks. Perhaps the knowledge gained from this project will aid the industry as to the best course of action.

As the data demonstrates, an increase in the R-value of insulation surrounding a conductor will trap more heat generated by its load. Under that condition, when the load on a conductor increases, so too will the heat that surrounds the conductor. Setting up laboratory experiments to gain insight into the performance of conductor materials and wiring methods under extreme conditions is useful, for it benchmarks what could happen, even remotely so, in the real world. This approach gives industry a roadmap and a clear vision of which direction to take, and more than anything else, what not to do. As it pertains to the results presented in this report, limitations on a conductor's interaction with highly efficient insulation (high R-values) might be considered for certain materials and wiring methods in limited cases. Such limitations can be dealt with in the sections of the NEC for wiring methods in "Uses Not Permitted." However, because no overwhelming evidence of a problem exists in the "real world," the need to propose change is debatable.

The project team evaluated 14 AWG CCA conductors tested at 10 amperes (its proposed ampacity at 60°C) and 14 AWG copper conductors tested at 15 amperes (its established ampacity at 60°C). When comparing the data from the three test fixtures, the CCA consistently exhibited a lower maximum temperature than the copper. At no point did the temperature of the CCA reach the 90°C rating of its THHN insulation whereas copper only exceeded 90°C twice -- in the test fixture that used highly efficient R30 spray foam insulation in a wall (Test Fixture 2). It should be noted that R30 insulation is considered extreme even by net zero standards. R30 surpasses code requirements. Please see section 5.0 of this report for complete details of the testing results.

Maximum Conductor Temperatures: Copper vs. CCA

Test Fixture	Copper			CCA			Temp Difference Copper vs CCA (°C)
	Type	Amp	Max Temp (°C)	Type	Amp	Max Temp (°C)	
1	NMB	15	85.06	NMB	10	65.48	19.58
2	NMB	15	107.08	NMB	10	77.00	30.08
3	NMB	15	89.81	NMB	10	71.90	17.91
1	THHN	15	75.76	THHN	10	62.35	13.41
2	THHN	15	98.11	THHN	10	72.55	25.56
3	THHN	15	85.70	THHN	10	74.02	11.68

Overload testing was also performed at 135% of the 60°C rating of each conductor when protected by a circuit breaker. At no point did the insulation temperature of the conductors exceed 90°C for any of the wiring methods. The longest trip time was 12 minutes 14 seconds. The highest maximum temperature recorded was 81.7° C. Please see section 5.4 for all the results.

The analysis of the results from a materials science perspective can be found in the appendix. Please see Appendix C for comments provided by Dr. David Pope, PhD and Dr. Mark Licurse, PhD. From a building science perspective, please review Appendix B for the commentary written by Construction Instruction (CI) pertaining to the direction of thermal insulation in the construction industry.

1.0 Introduction

1.1 Purpose

The purpose of this project is to provide data on the temperature performance under net zero, worst-case thermal insulation conditions of 14 AWG copper-clad aluminum (CCA) relative to the performance of the smallest size copper conductor, 14 AWG, when used with different types of thermal insulation. Research and evaluation of small circuit conductors is on-going. This report is provided as substantiation for adding 14 AWG CCA to article 310 as well as to certain sections of Chapter 3 wiring methods. The wiring methods and size conductors reported here are 14 AWG NM-B cables and 14 AWG THHN conductors in conduit.

1.2 This project was initiated by Copperweld as part of the ongoing evaluation of the suitability for 14 AWG CCA for use as branch circuit wiring where loads are 10 amperes or less. The construction of the test fixtures was completed at the Construction Instruction facility in Denver, Colorado between June 26, and August 2, 2023.

The test fixture construction, framing and insulation installations, was completed by Mr. Justin Wilson and Mr. Sam Keefe with Construction Instruction. The spray foam insulation was installed by Insulation of North Denver under contract to Construction Instruction. Installation of the electrical wiring, thermocouples and connection to the test instruments was completed by Mr. Chuck Mello, Mr. Steve Conrad, and Mr. Brandon Allen.

The testing was completed between August 3 to 10, 2023. Testing was completed by Mr. Chuck Mello, Mr. Brandon Allen and Mr. Sam Keefe. All testing was witnessed by Mr. Harry van der Meer with Intertek and Mr. John Kovacik with Trusted Safety Solutions. Please see Appendix A for Intertek's test witnessing letter.

2.0 Equipment Tested

2.1 The following conductors or cable assemblies were evaluated in the test structures described below.

2.1.1 10-ampere circuits:

.1 14 AWG THHN solid CCA

.2 14-3 without ground NM-B solid CCA with THHN insulated conductors.

2.1.2 15-ampere circuits:

.1 14 AWG THHN/THWN solid copper

.2 14-3 with ground NM-B solid copper

3.0 Test Assembly and Testing Setup Description

The test assemblies consisted of three test fixtures to represent wall and ceiling (attic) installations as described below. The testing arrangement described below allows for the testing of 10-, 15-, and 20-ampere branch circuit conductors in the different types and ratings of insulation. This report covers only the 10- and 15-ampere circuits.

3.1 There were two separate wall assemblies constructed to allow testing with both fiberglass batt and spray foam types of thermal insulation. Drawings of the wall framing configuration and photos of early framing are shown in Appendix D, photos 1 to 3. The wall units had three thermally independent sections of 2x6 construction stacked with an additional thermal insulating layer between levels. The lowest level was used for the 10-ampere testing, the middle level for the 15-ampere testing, and the top level for the 20-ampere testing. The interior of the wall fixtures was finished with ½ inch drywall screwed to the studs, bottom plate, and top plate. The exterior was finished with LP's (Louisiana Pacific's) weather logic. It is 7/16 OSB with an integrated weather resistive coating (the blue finish) exterior sheathing was screwed or nailed to the studs, top plate, and bottom plate.

3..2 Each assembly had the applicable conductors, as indicated in the equipment tested list, installed in their respective section. See Figure 1 below for basic circuit schematic. The wall units had the NM-B cable and the ENT installed in the approximate center of the stud, as would be normal in construction. The ceiling assembly had the NM-B and ENT installed on top of and secured with standard NM-B staples or conduit straps to hold it in place. The ENT had three copper and three CCA THHN conductors installed and identified by wire numbers for tracking purposes.

3..3 The conductors were installed to DIN rail mounted terminal blocks, TB-1 and TB-2, shown in Appendix D, photos 4 and 5, to provide either connection to the circuit breaker, or jumpers to form a 3-conductor series circuit. The ending terminal block for each circuit had a separate 10 AWG copper conductor installed to a common bus bar and then to the neutral bar of the panelboard. After the NM-B cables and conduits were installed, the applicable type of insulation was installed.

3.4 For the wall assemblies a 4 square device box with 1-gang ring was installed for both the NM-B cables and for the conduit installations. Each wall circuit had a receptacle installed in series with one of the circuit conductors. The receptacle installation had the connecting tabs removed to allow the copper conductors to be installed on the top receptacle and the CCA conductors installed on the bottom receptacle to maintain circuit separation. Shorting plugs were inserted into the applicable receptacle to complete the series circuit for the test being conducted, copper or CCA. See figure 1 below for the wall circuit layout with the relative receptacle locations. The ceiling assembly had the same circuit schematic except the ceiling did not have any wiring devices or luminaire boxes installed.

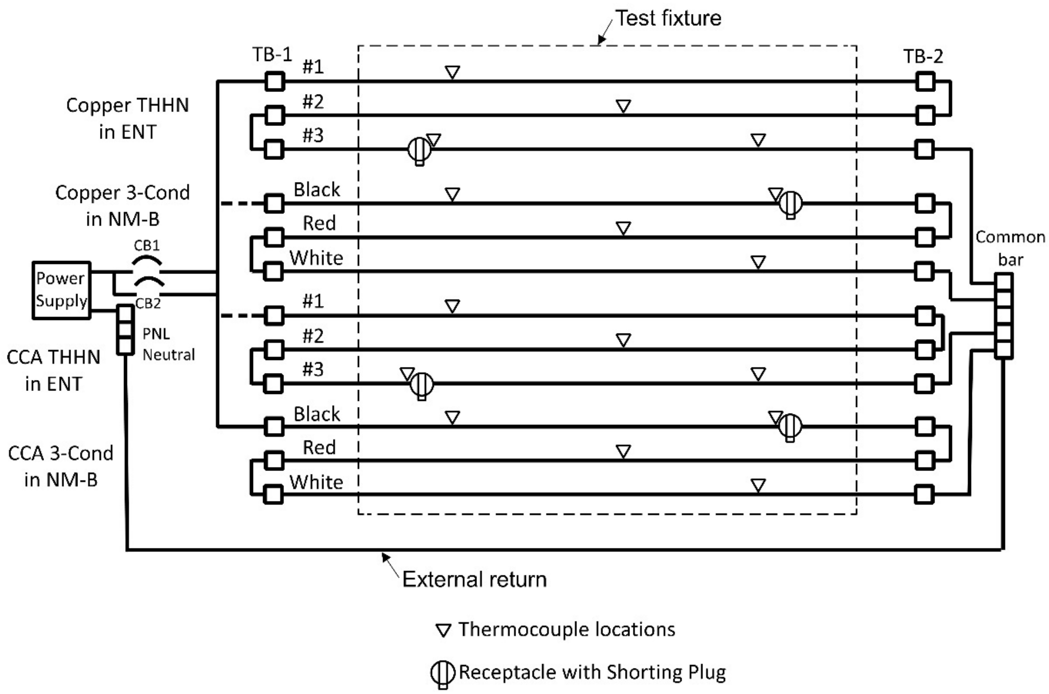

Figure 1 – Test Circuit Schematic

3.5 One wall test fixture, designated as Test Fixture 1, or TF-1, had Owens Corning's next gen fiberglass batt insulation rated R21 installed as shown in Appendix D, photo 6. This is the type of insulation most used for residential construction and this R value meets the wood construction wall requirements for Climate Zones 5, 6 and 7 which are the most stringent. See Appendix E for map of the United States and the climate zones with insulation requirements.

3.6 The second wall test fixture, designated as Test Fixture 2, or TF-2, had Carlisle's SealTite Pro HFO closed cell spray foam with an R-value of 7.2 per inch. The application was completed by Insulation of North Denver with 4-5 inches of spray foam insulation installed in all the bays covering the NM-B cable and electrical nonmetallic tubing (ENT) conduit. To achieve the proper thickness the application was done in two passes. The minimum coverage was 4 inches and this insulation value in these wall sections would then be rated R30. This level of insulation exceeds all requirements for climate zones 6, 7, and 8, as shown on the climate zone map on Appendix page E1, where the maximum wall insulation is only required to be R-13 to R-21. See Appendix D, photo 7 for the spray foam installation.

3.7 The ceiling test fixture, Test Fixture 3 or TF-3, had 20 inches of Owens Corning's AttiCat expanding fiberglass blown-in insulation installed. There were 3 ½ inches below the wire installation and approximately 16 ½ inches above the cables or conduit. The “bottom” of this fixture had ½ inch drywall installed supported by the 2x4 joists that would be typical of truss type assemblies commonly used in residential construction. The top was open to ambient conditions. This insulation system has an insulation value of R60. A drawing and photo showing the conductor installation is shown in Appendix D, photos 8 to 10.

3.8 As shown in Appendix D, photos 9 and 11, each wall assembly and the ceiling test fixture had three circuit breaker panels installed, one for each 10-, 15-, and 20-ampere circuits to be tested. Each panel had two breakers installed, one for the copper circuits and one for the CCA circuits. The circuit breakers were rated for the applicable conductor ratings to be tested. An Amp Line Corporation model AL-300-CR-H/S AC constant current power supply was connected to each circuit breaker panelboard to provide a constant current at the applicable set point of 10-, 15-, or 20 amps. The power supply capability to maintain a constant current is 60-amps at 5-volts or 150-amps at 2-volts. The connection for this project was to the 60-amp 5-volt terminals. The separate circuit breakers were to control which conductor set was being tested and to facilitate ease to move from one test to another. See figure 1 above for typical circuit drawing and note that for the ceiling test fixture there were no receptacles and associated thermocouples included.

3.9 As seen in figure 1 above for the typical circuit arrangements, each of the wall circuits had four calibrated type J thermocouples installed on the conductor insulation. These were installed for spacing approximately 5 feet, 9 feet, and 14 feet from the entry into the test fixture by the power panels. The same approximate spacing was used for both the NM-B cables and the THHN conductors in conduit installed in the insulated wall. All thermocouples were positioned in the wall bay encapsulated by thermal insulation and not located in framing members.

3.10 The ceiling Test Fixture 3 conduit or cable layout is shown in photo 9. The thermocouples for both the NM-B cables and the THHN conductors in conduit were spaced approximately 4 feet, 10 feet and 16 feet from the entry by the power panels.

3.11 For the NM-B cables the jacket was opened to expose the applicable conductor and the thermocouple attached the indicated conductor using thermocouple cement. The jacket was then closed back with wraps of black insulating tape.

3.11 For the conductors in the ENT, thermocouples were attached with thermocouple cement to the THHN insulation and supported near the thermocouple with black insulating tape to mitigate the stress from the conductor installation through the device box and around up to three 90-degree bends.

3.12 The thermocouples wires were identified with the circuit and location for connection to the data loggers used to record data. As shown in Figure 1 above, each conductor in the series circuit had one thermocouple installed. The thermocouple for the circuit conductor that was connected to the receptacle was placed opposite the receptacle installation, farthest away, to minimize any effect of the receptacle terminal heating on the recording of that conductor.

A thermocouple was installed on one terminal of each receptacle, one for copper and one for CCA, to record the temperature of that termination. These thermocouples were attached mechanically with the circuit conductor on the pressure plate of the receptacle. See Appendix D, photo 12 for receptacle installation.

3.13 Two thermocouples to monitor ambient were installed for each test fixture. For the wall test fixtures one ambient thermocouple was centered vertically and horizontally in the center of the interior portion. The second ambient thermocouple was installed centered vertically and approximately 2 feet from the rear wall outside the test fixture. For the ceiling test fixture, a thermocouple was installed approximately 2 feet above the top of the blown in insulation, and the other was installed below the drywall "ceiling" centered on the test fixture and approximately 12 inches below the drywall. Ambient temperatures were continually recorded throughout all the testing sequences.

3.14 The thermocouples for each test fixture were installed onto the cards for a data logger dedicated to each of the three test fixtures. The data logger channel identification was documented as the thermocouples were being terminated onto the data logger card.

4.0 Testing Procedures

4.1 All testing was conducted based on the exiting (15-amps for 14 AWG copper) or proposed (10-amps for 14 AWG CCA) 60°C ampacity rating of the conductors.

4.2 Testing of Wall Assemblies

4.2.1 The four 14 AWG cable or wire-in-conduit constructions were tested in the following sequence.

- The first test was for the 14 AWG THHN CCA conductors.
- The second test was for 14-3 copper NM-B conductors.
- The third test was for 14 AWG copper THHN conductors.
- The fourth test was for the 14-3 CCA NM-B conductors.

4.2.2 Test Procedure

.1 The test circuit was verified as complete with the power supply conductor to the correct input terminal on the terminal block and the shorting plug inserted into the correct receptacle.

.2 The data logger was programmed to scan the two ambient temperature thermocouples and the channels for the applicable thermocouples installed on the conductors and the receptacle in the circuit under test.

.3 The data logger was initiated to start scanning and recording data at an interval of 2 minutes.

.4 The circuit breaker was turned on and the power supply adjusted to the applicable output current of 10-, or 15-amperes.

.5 The current was verified as being correct with the calibrated digital multimeter and current clamp probe.

.6 The testing was monitored, and temperature data recorded by the data logger.

.7 The current and temperatures were also manually recorded at approximately 10- to 20-minute intervals with the shorter interval used when temperature equilibrium was approaching. This provided a backup set of data and provided for monitoring when temperature equilibrium was achieved.

8. For the purposes of this project, temperature equilibrium is defined as three temperature recordings at minimum of 10-minutes apart with no greater than 1°C change over the 30-minute time interval. This criterion was determined after reviewing temperature testing requirements in several UL standards.

.9 When temperature equilibrium was achieved the test was terminated.

.10 If after 2 or more hours temperature equilibrium had not been achieved for any of the circuits under test and the temperatures were exceeding 90°C, the test was terminated.

.11 Upon completion, the manual results were reviewed, and the data logger recorded data downloaded to a separate storage device.

.12 Once a test was completed, the next test in the sequence was set up. For the wall test fixtures, where the test was for the THHN conductors in conduit, the next test was set for one of the NM-B cables, again to minimize thermal influence from the previous testing.

.13 The next test in the sequence was set up and steps 1 through 11 were repeated for the next set of conductors.

4.3 Testing of Ceiling Assemblies

4.3.1 The ceiling test fixture was set up for only two tests at a time to maintain separation between the test circuits and mitigate any mutual heating between conductors under test.

- The first test was for the 14-3 Copper NM-B conductors
- The second test was for 14 AWG CCA THHN conductors
- The third test was for the 14-3 CCA NM-B conductors
- The fourth test was 14 AWG copper THHN

4.3.2 After reviewing the testing data and to confirm there was not mutual heating influences between sets of conductors in the first testing sequences, single circuit testing was completed for:

- 14-3 copper NM-B conductors
- 14-3 CCA NM-B conductors

4.3.3 Testing Procedure

.1 The test circuit was verified as complete with the power supply conductor to the correct input terminal on the terminal block.

.2 The data logger was programmed to scan the two ambient temperature thermocouples and the channels for the applicable thermocouples installed on the conductors under test.

.3 The data logger was initiated to start scanning and recording data at an interval of 2 minutes.

.4 The circuit breaker was turned on and the power supply adjusted to the applicable output current of 10- or 15-amperes.

.5 The current was verified as being correct with the calibrated digital multimeter and current clamp probe.

.6 The testing was monitored, and temperature data recorded by the data logger.

.7 The current and temperatures were also manually recorded at approximately 10- to 20-minute intervals with the shorter interval used when temperature equilibrium was approaching as a backup and to monitor when temperature equilibrium was achieved.

8. For the purposes of this project, temperature equilibrium is defined as three temperature recordings at minimum of 10-minutes apart with no greater than 1°C change over the 30-minute time interval. This criterion was determined after reviewing temperature testing requirements in several UL standards.

.9 When temperature equilibrium was achieved the test was terminated.

.10 If after 2 or more hours temperature equilibrium had not been achieved for any of the circuits under test and the temperatures were exceeding 90°C, the test was terminated.

.11 Upon completion, the manual results were reviewed, and the data logger recorded data downloaded to a separate storage device.

.12 Once a test was completed, the next test in the sequence was set up as shown in the above list of testing sequence.

.13 The next test in the sequence had steps 1 through 11 repeated for the next set of conductors.

4.4 135 Percent Testing

4.4.1 Starting at ambient, the copper NM-B and CCA NM-B circuits were tested at 135 percent of rating until the respective circuit breaker tripped.

.1 The 10- amp circuit was tested at 13.5-amps.

.2 The 15-amp circuit was tested at 20.3-amps.

4.4.2 The testing was completed using the following steps.

.1 The test circuit was verified as complete with the power supply conductor to the correct input terminal on the terminal block.

.2 The data logger was programmed to scan the two ambient temperature thermocouples and the channels for the applicable thermocouples installed on the conductors under test.

.3 The data logger was initiated to start scanning and recording data at an interval of 2 minutes.

.4 The circuit breaker was turned on and the power supply confirmed to be at the applicable output current of 13.5- or 20.3-amperes.

.5 The current was verified as being correct with the calibrated digital multimeter and clamp-on ammeter.

.6 The testing was monitored, and temperature data recorded manually and by the data logger until the circuit breaker tripped.

.7 The trip time in minutes from initializing current was recorded.

5.0 Results

5.1 General

5.1.1 Ambient temperatures ranged from 19°C – 23°C. For each test the ambient temperature remained very steady throughout the test time. The calculated temperature rise took the highest final recorded temperature and subtracted to lowest ambient recorded at that time.

5.1.2 Three current carrying conductors were tested for each test circuit in the different types of thermal insulation. For residential single phase branch circuits there are only two current carrying conductors, therefore this data represents a more severe introduction of heat than what would typically be seen both from having three current carrying conductors and having those at full rated ampacity. Even with multi-wire branch circuits in single phase installations, the third or neutral conductor will only have the unbalanced current present and not full rated ampacity load from the two ungrounded conductors. In addition, the levels of thermal insulation used in this project represent the highest required for Climate Zones 6, 7 and 8 that apply to very few locations in the lower 48 states and to most of Alaska.

5.1.3 Time for data logger is based on PDT, but the testing was completed at MDT.

5.2 14 AWG NM-B at 60°C Ampacities

The following sections provide the testing results for 14-3 copper NM-B and 14-3 CCA NM-B in the three insulation types.

5.2.1 Wall with R-21 Fiberglass Batt Insulation (Test Fixture 1)

The testing data indicates that at temperature equilibrium the highest temperature for 14 AWG copper NM-B cable, at 15 amps, installed in R-21 fiberglass batt insulation, to be 85.06ºC or 62.35ºC temperature rise above ambient. See figure 5.2.1.1 below.

The testing data in the same configuration indicates the highest temperature for the 14 AWG copper-clad aluminum NM-B cable, at 10 amps, to be 65.48ºC or 42.51ºC temperature rise above ambient. See figure 5.2.1.2 below. Neither of these cable assemblies attained the 90°C temperature rating of the internal THHN conductors.

The CCA application is operating at a temperature of 19.58ºC, or 23 percent, less than the steady state 14 AWG copper NM-B cable.

It was noted the data provided from the thermocouple identified as channel 212 was not reliable and this data was not used.

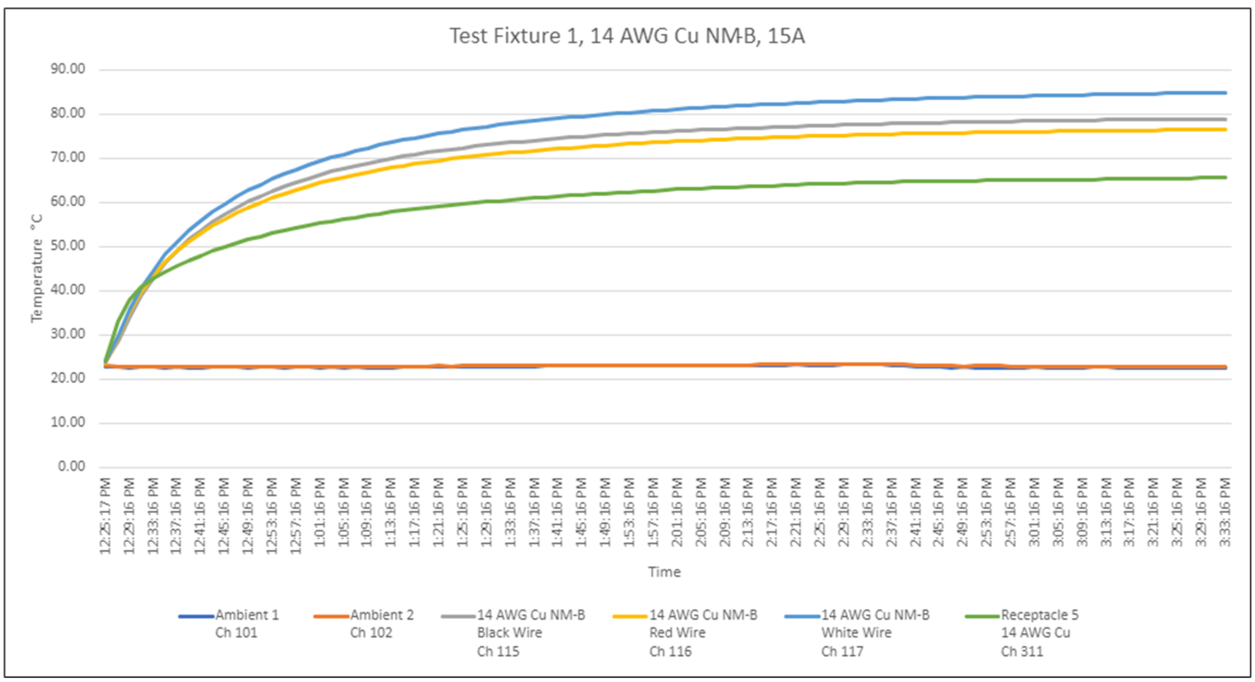

Figure 5.2.1.1 – 14 AWG Copper NM-B at 15-amps in R-21 Insulation

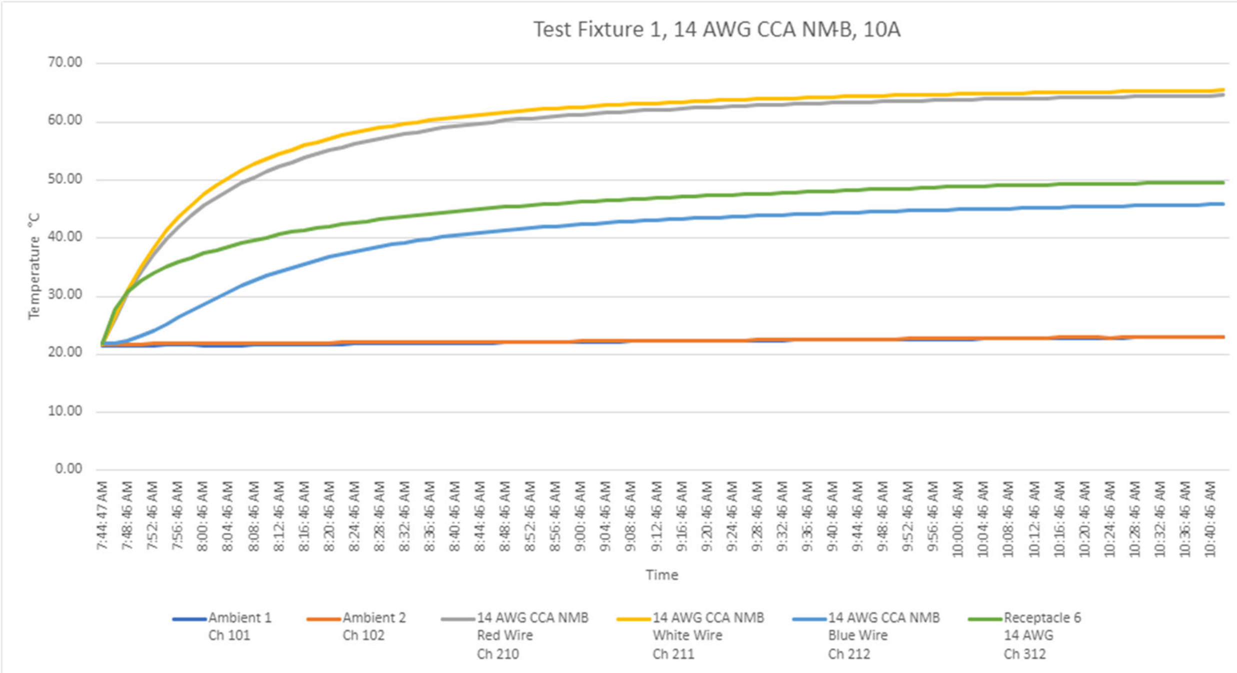

Figure 5.2.1.2 – 14 AWG CCA NM-B at 10-amps in R-21 Insulation

5.2.2 Wall with R-30 Spray Foam Insulation (Test Fixture 2)

The testing data indicates the highest temperature for 14 AWG copper NM-B cable, at 15 amps, installed in R-30 spray foam insulation, to be 107.08ºC or 84.1ºC temperature rise above ambient. The final temperature was not at equilibrium and was continuing to slowly rise when the testing was terminated. See figure 5.2.2.1 below.

The testing data in the same configuration indicates the temperature at temperature equilibrium for the 14 AWG copper-clad aluminum NM-B cable, at 10 amps, to be 77.0ºC or 54.29ºC temperature rise above ambient. See figure 5.2.2.2 below. While the 14-3 NM-B copper conductors exceeded the 90°C insulation rating of the internal conductors, the 14-3 NM-B CCA conductors did not.

The CCA application is operating at a temperature of 30.08ºC, or 28.1 percent, less than the 14 AWG copper NM-B cable.

It was noted the data provided from the thermocouple identified as channel 115 was not reliable and this data was not used. The testing of the 14-3 NM-B CCA was restarted at 11 AM when a wiring error was discovered and corrected after approximately 10-minutes of being deenergized. This is why the initial temperatures in the graph are elevated.

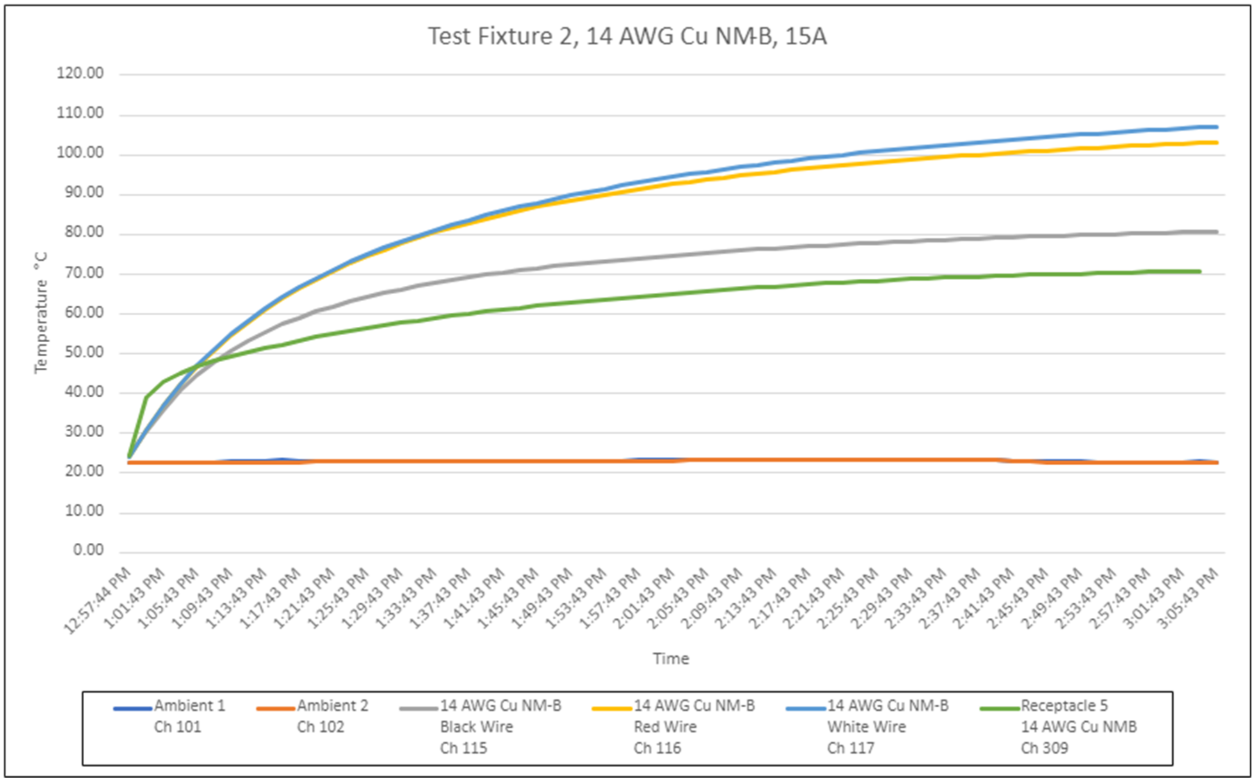

Figure 5.2.2.1 – 14 AWG Copper NM-B at 15-amps in R-30 Insulation

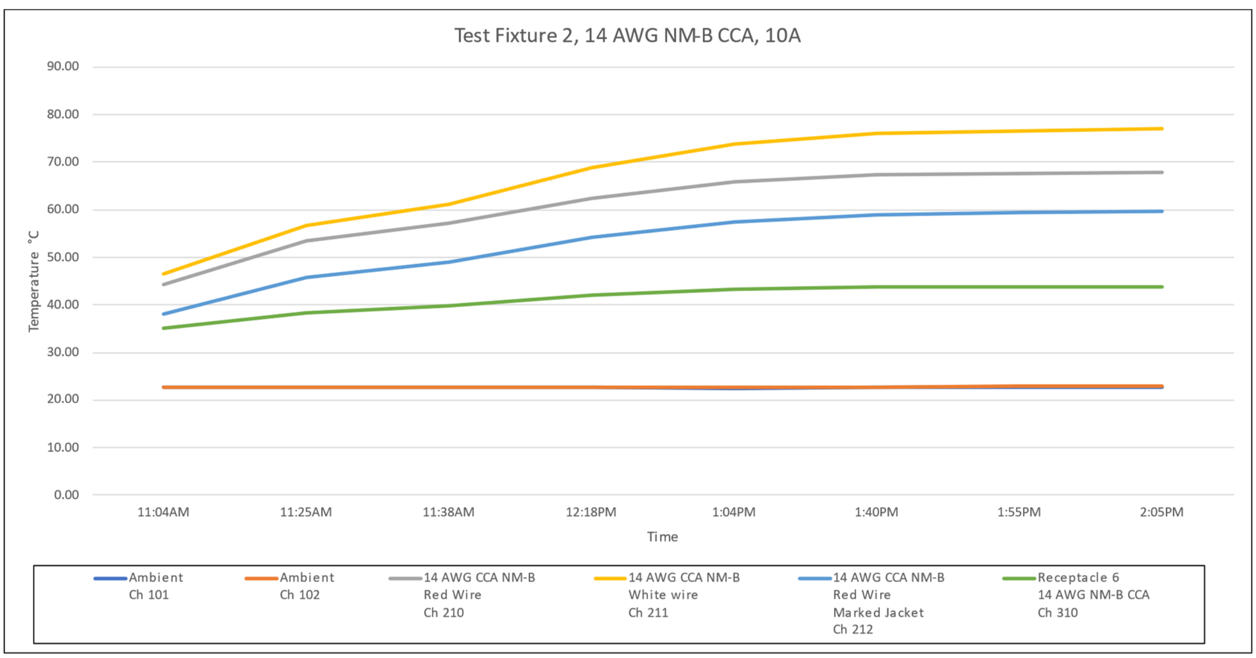

Figure 5.2.2.2 – 14 AWG CCA NM-B at 10-amps in R-30 Insulation

5.2.3 Ceiling with R-60 Blown Insulation (Test Fixture 3)

The testing data indicates that at temperature equilibrium the highest temperature for 14 AWG copper NM-B cable, at 15 amps, installed in R-60 blown in insulation, to be 89.81ºC or 69.41ºC temperature rise above ambient. See figure 5.2.3.1 below.

The testing data in the same configuration indicates the highest temperature for the 14 AWG copper-clad aluminum NM-B cable, at 10 amps, to be 71.9ºC or 52.87ºC temperature rise above ambient. See figure 5.2.3.2 below. Although the copper was close, neither of these cable assemblies attained the 90°C temperature rating of the internal THHN conductors.

The CCA application is operating at a temperature of 17.91ºC, or 19.9 percent, less than the steady state 14 AWG copper NM-B cable.

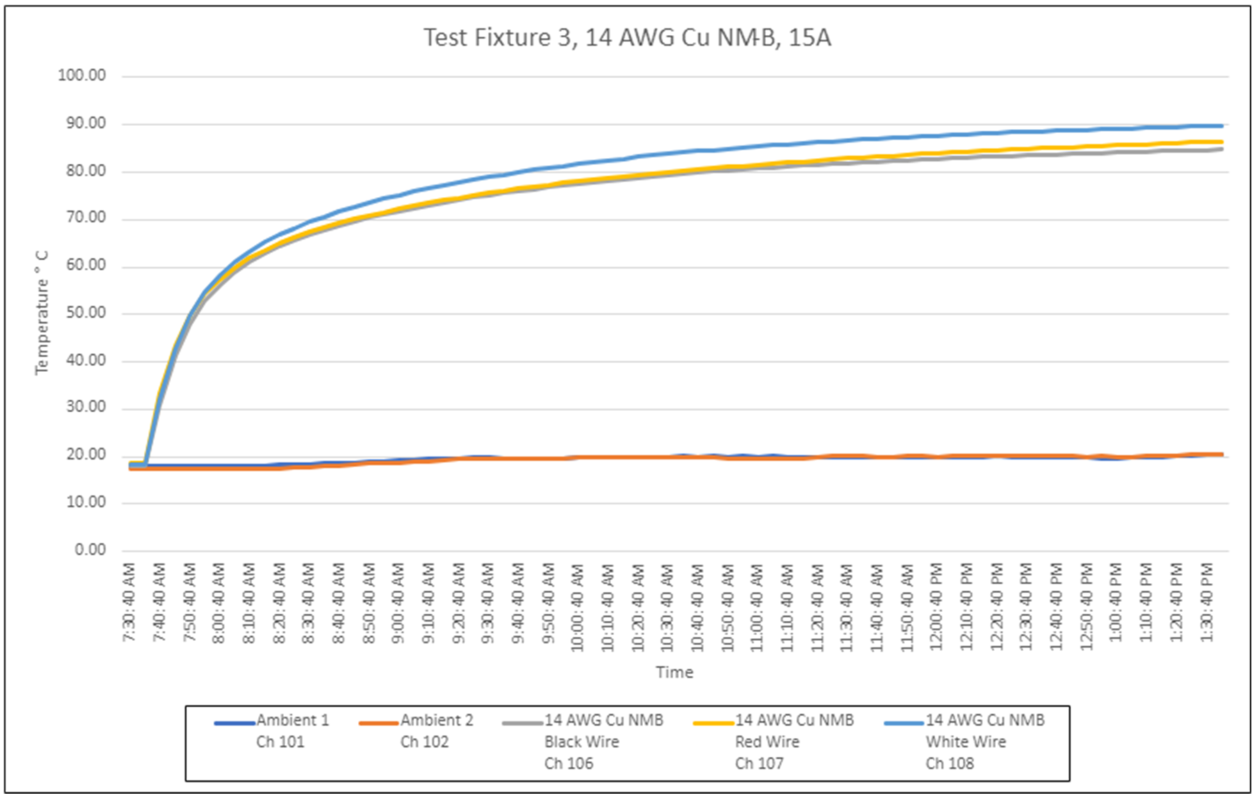

Figure 5.2.3.1 – 14 AWG Copper NM-B at 15-amps in R-60 Insulation

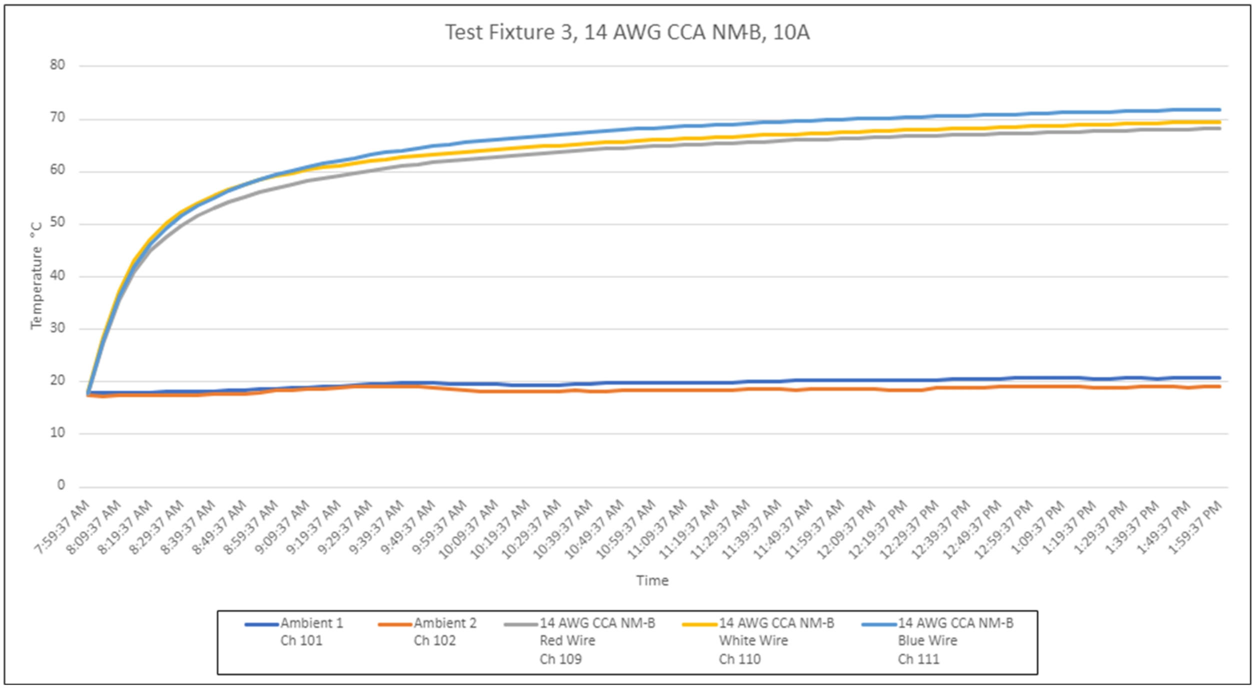

Figure 5.2.3.2 – 14 AWG CCA NM-B at 10-amps in R-60 Insulation

5.3 14 AWG THHN at 60°C Ampacities

The following sections provide the testing results for 14 AWG copper and 14 AWG CCA THHN installed in electrical non-metallic tubing (ENT) in the three insulation types.

5.3.1 Wall with R-21 Fiberglass Batt Insulation (Test Fixture 1)

The testing data indicates that at temperature equilibrium the highest temperature for 14 AWG copper THHN installed in ENT, at 15 amps, installed in R-21 fiberglass batt insulation, to be 75.76ºC or 52.57ºC temperature rise above ambient. See figure 5.3.1.1 below.

The testing data in the same configuration indicates the highest temperature for the 14 AWG CCA THHN installed in (ENT), at 10 amps, to be 62.35 or 39.64ºC temperature rise above ambient. See figure 5.3.1.2 below. Neither of these cable assemblies attained the 90°C temperature rating of the THHN conductors.

The CCA application is operating at a temperature of 13.41ºC, or 17.7 percent, less than the steady state 14 AWG copper THHN conductors.

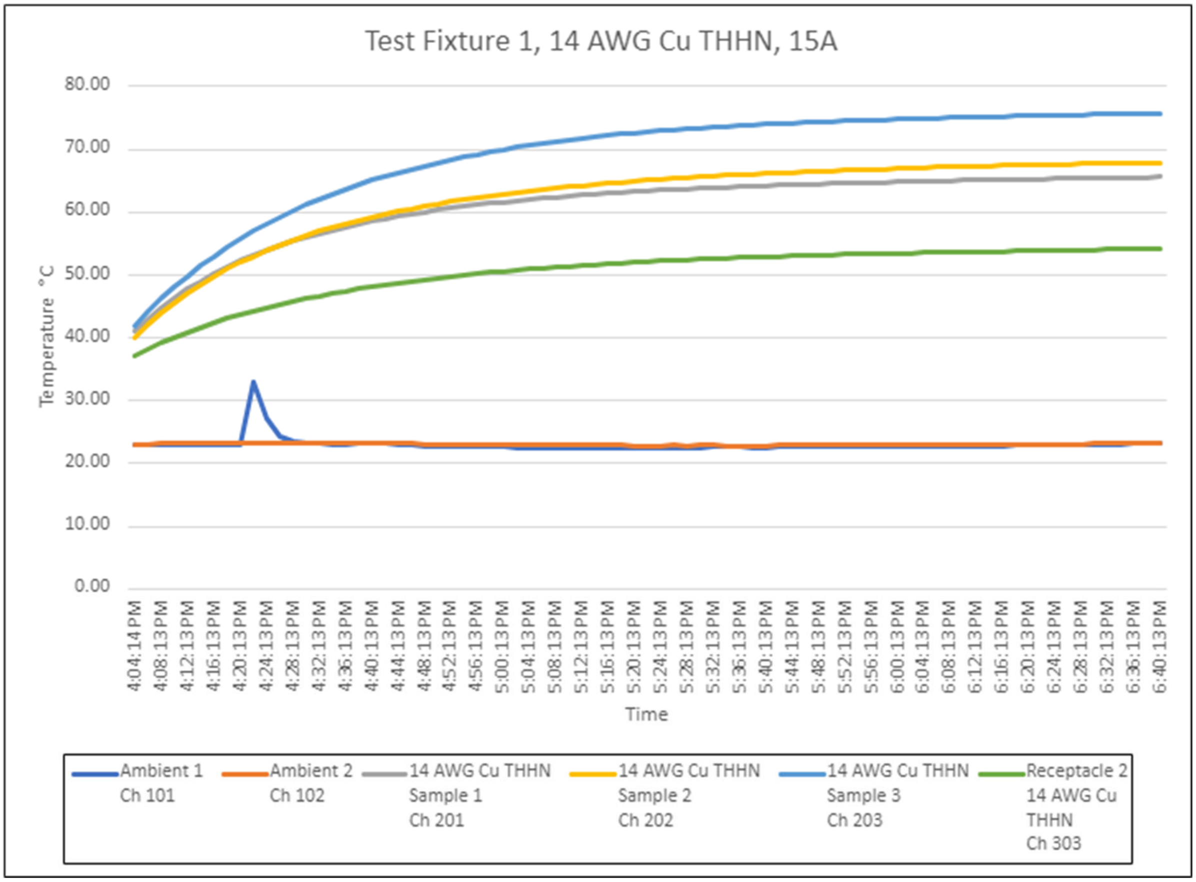

Figure 5.3.1.1 – 14 AWG Copper THHN at 15-amps in R-21 Insulation

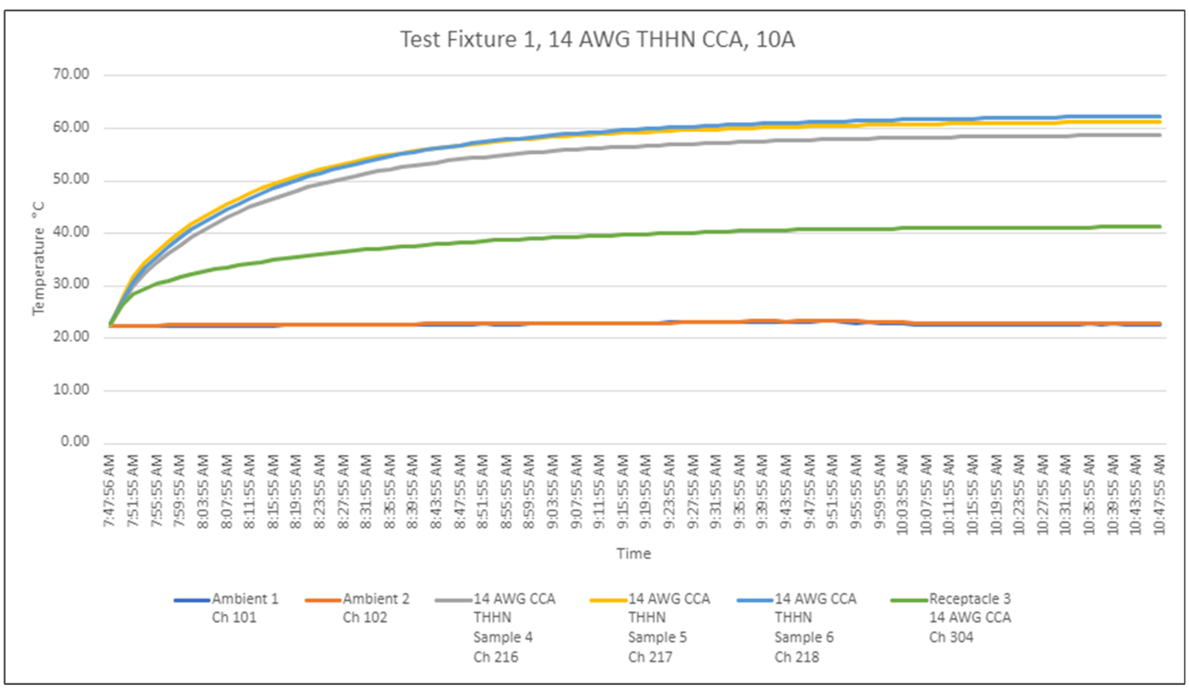

Figure 5.3.1.2 – 14 AWG CCA THHN at 10-amps in R-21 Insulation

5.3.2 Wall with R-30 Spray Foam Insulation (Test Fixture 2)

The testing data indicates the highest temperature for 14 AWG copper THHN installed in ENT, at 15 amps, installed in R-30 spray foam insulation, to be 98.11ºC or 74.94.1ºC temperature rise above ambient. The temperature was not at equilibrium and was slowly climbing when the testing was terminated. See figure 5.2.2.1 below.

The testing data in the same configuration indicates the steady state temperature for the 14 AWG copper-clad aluminum THNN, at 10 amps, to be 72.55ºC or 49.52ºC temperature rise above ambient. See figure 5.2.2.2 below. While the 14 AWG THHN copper conductors exceeded the 90°C insulation rating of the internal conductors, the 14 AWG THHN CCA conductors did not.

The CCA application is operating at a temperature of 25.56ºC, or 26.1 percent, less than the steady state 14 AWG copper THHN.

It was noted the data provided from the thermocouple identified as channel 216 was not reliable and this data was not used.

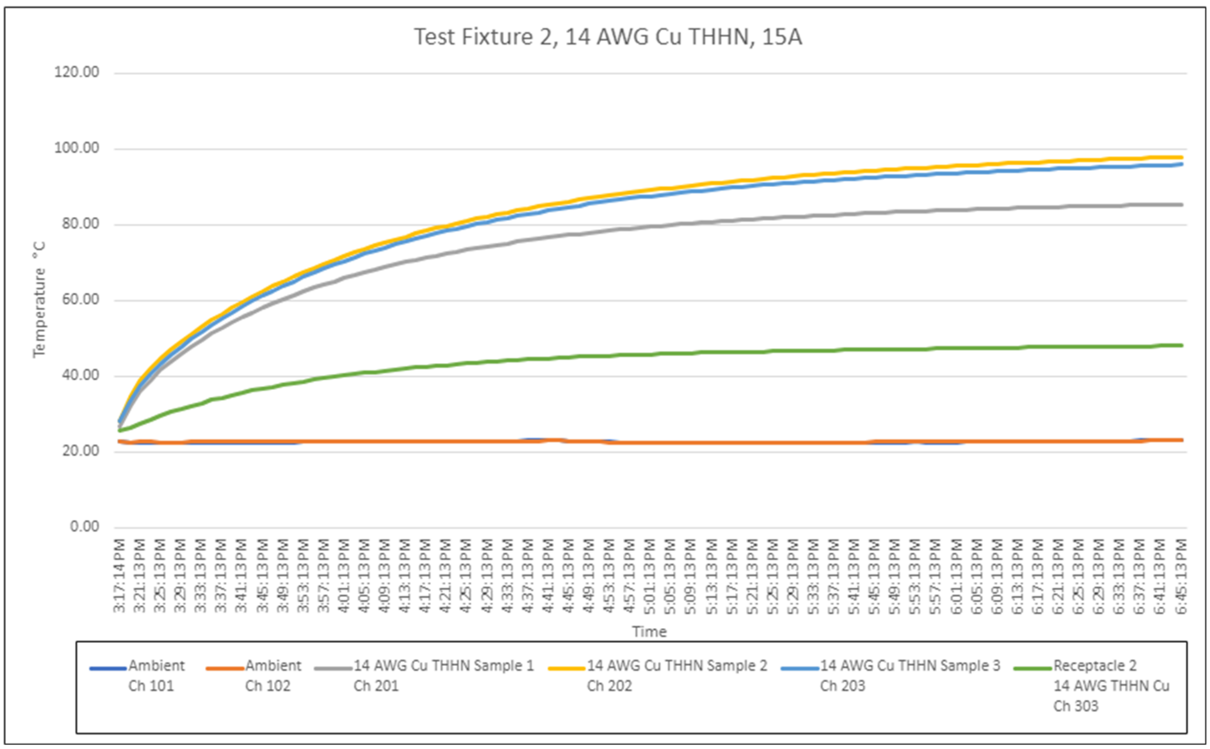

Figure 5.3.2.1 – 14 AWG Copper THHN at 15-amps in R-30 Insulation

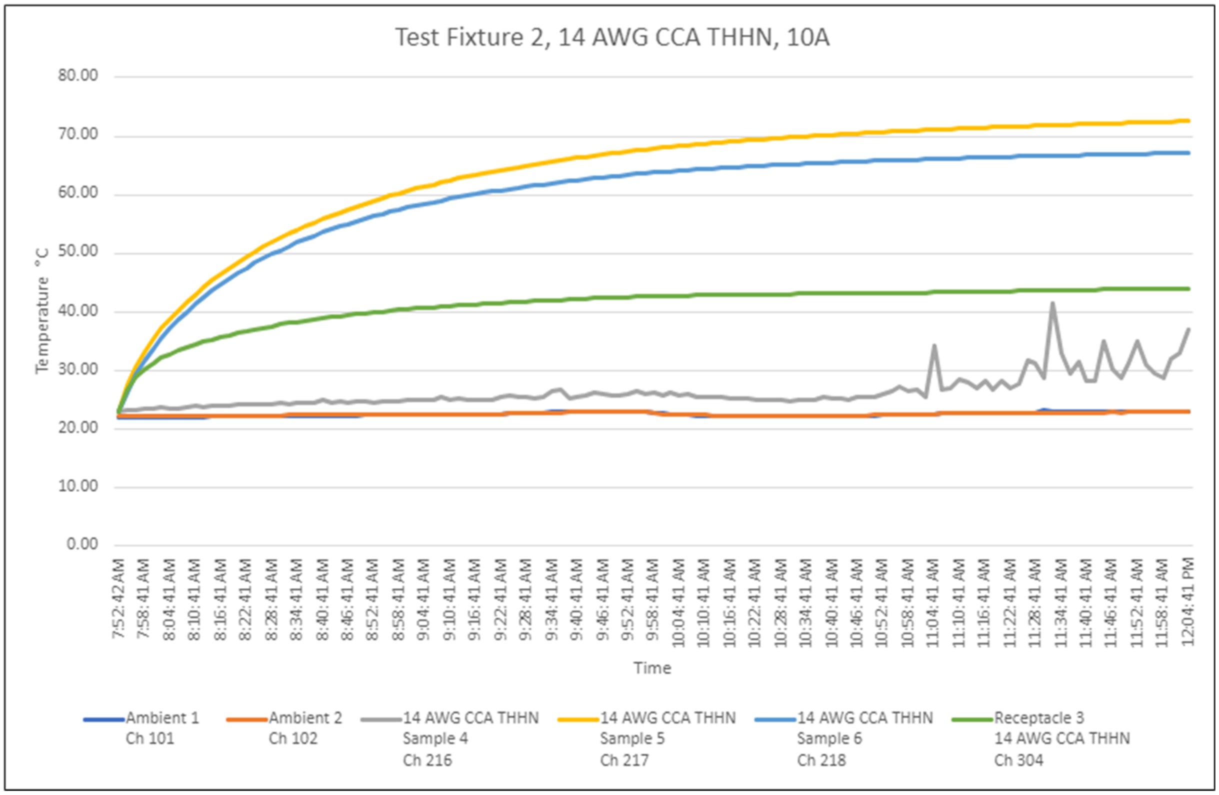

Figure 5.3.2.2 – 14 AWG CCA THHN at 10-amps in R-30 Insulation

5.3.3 Ceiling with R-60 Blown Insulation (Test Fixture 3)

The testing data indicates the highest temperature for 14 AWG copper THHN installed in ENT, at 15 amps, installed in R-60 blown insulation, to be 85.7ºC or 62.07ºC temperature rise above ambient. The final temperature was not at equilibrium and was continuing to slowly rise when the testing was terminated. See figure 5.2.3.1 below.

The testing data in the same configuration indicates the temperature at temperature equilibrium for the 14 AWG CCA THHN, at 10 amps, to be 74.02ºC or 52.02ºC temperature rise above ambient. See figure 5.2.3.2 below. It is noted that the 14 AWG THHN conductors at temperature equilibrium were below the 90°C insulation temperature rating. Since the copper conductors were still rising in temperature it cannot be concluded that they would not eventually exceed the 90°C rating.

The CCA application is operating at a temperature of 11.68ºC, or 13.6 percent, less than the steady state 14 AWG copper THHN.

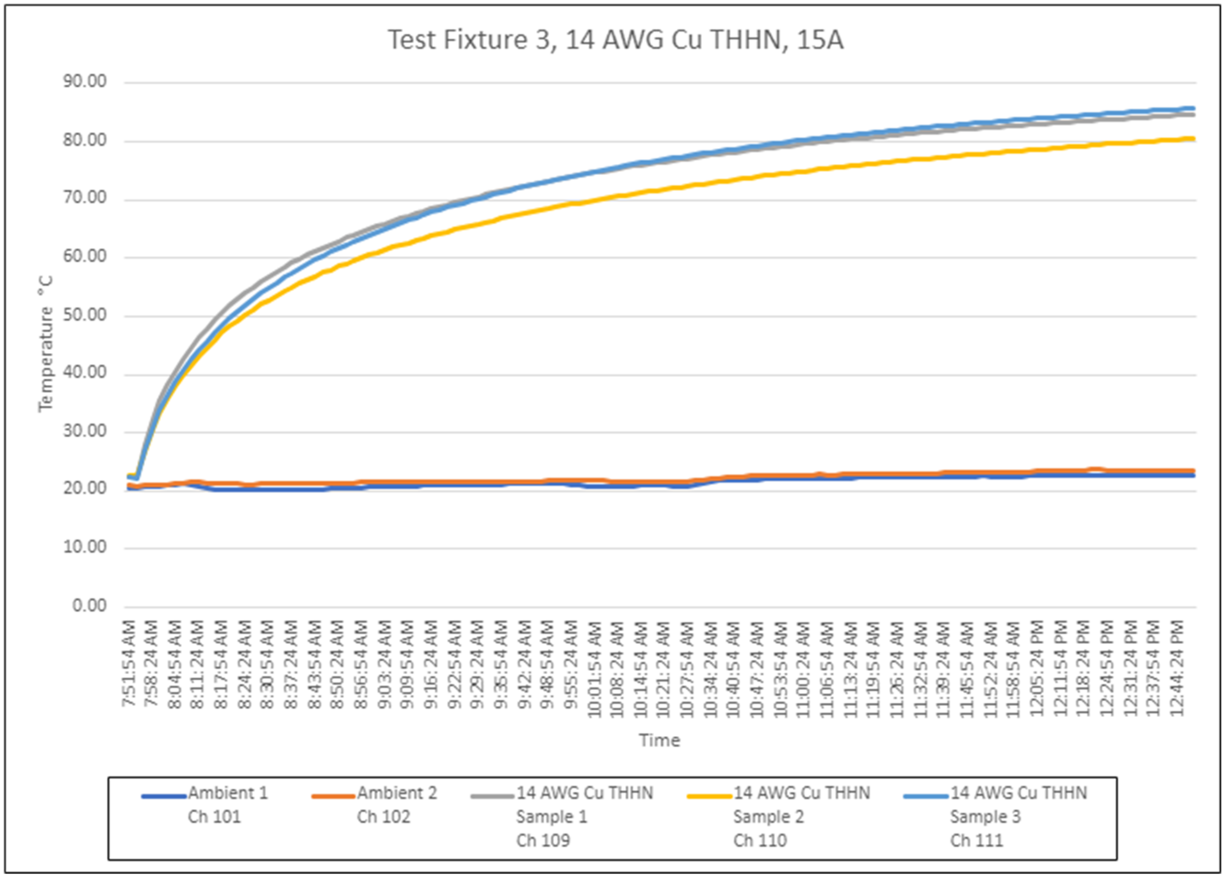

Figure 5.3.3.1 – 14 AWG Copper THHN at 15-amps in R-60 Insulation

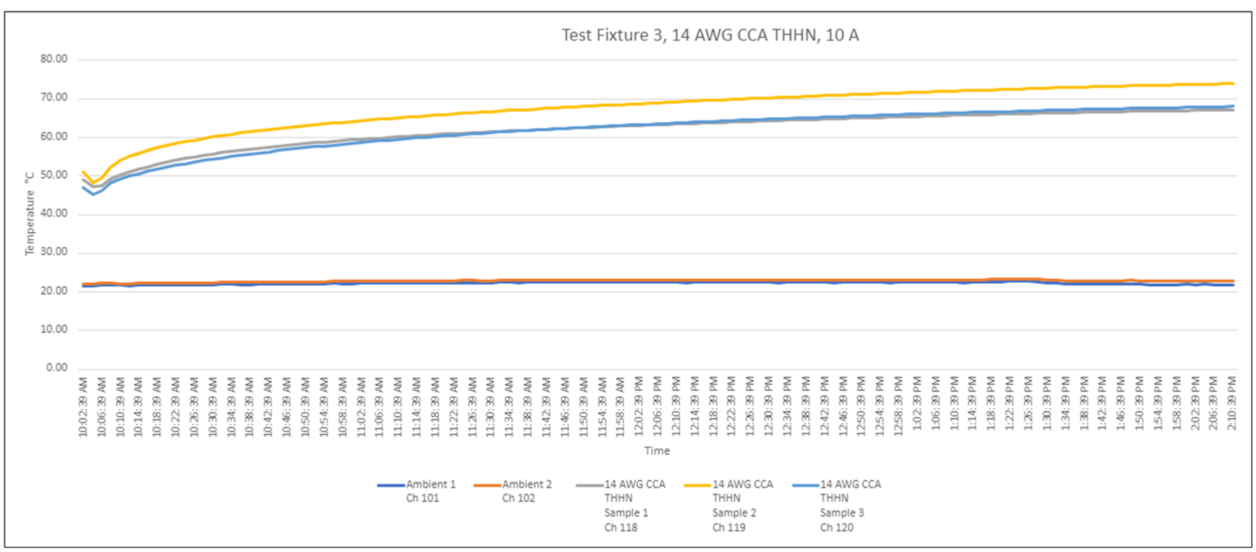

Figure 5.3.3.2 – 14 AWG CCA THHN at 10-amps in R-60 Insulation

5.4 Overload Test Results

The following table shows the results of operating the circuit at 135 percent of rating, the trip time for the molded case circuit breaker in this overload condition, and the maximum conductor temperature recorded at the time of tripping. The 135 percent test value was chosen based on UL 489 standard for molded case circuit breakers. At this current level circuit breakers rated 50-amperes or less shall trip within 60 minutes.

Test Fixture #	Circuit Breaker Rating	Cable Type	Test Current (amps)	Trip Time	Max Temperature Recorded
1	10	14 AWG CCA NM-B	13.5	8 min 17 sec	32.60
	15	14 AWG Cu NM-B	20.3	5 min 0 sec	77.60
2	10	14 AWG CCA NM-B	13.5	12 min 14 sec	47.30
	15	14 AWG NM-B	20.3	5 min 45 sec	81.70

6.0 Summary and Conclusions

6.1 Since the 14 AWG copper conductors applied at 15 amperes for small branch circuits are deemed acceptable by Code and have long been used in attic and wall insulation without incidents, the results from this project demonstrate that 14 AWG CCA at the proposed value of 10 ampacity presents even less of a hazard than the current smallest sized branch circuit conductor for copper in all insulation systems that are currently employed in typical residential and commercial construction. This is summarized in the table below.

Test Fixture	Copper				CCA				Temp Difference Copper vs CCA (CCA less than Copper °C)
	Type	Amp	Max Temp °C	Temp Rise °C	Type	Amp	Max Temp °C	Temp Rise °C	
1	NMB	15	85.06	62.35	NMB	10	65.48	42.51	19.58
2	NMB	15	107.08	84.34	NMB	10	77.0	54.29	30.08
3	NMB	15	89.81	69.41	NMB	10	71.9	52.87	17.91
1	THHN	15	75.76	52.57	THHN	10	62.35	39.64	13.41
2	THHN	15	98.11	74.94	THHN	10	72.55	49.52	25.56
3	THHN	15	85.70	62.07	THHN	10	74.02	52.02	11.68

6.2 Of the two wiring methods tested, NM-B cable and THHN in conduit, the one that recorded the higher temperatures in the wall test fixtures (# 1 and 2) regardless of the conductor material was the NM-B cable. Three current carrying conductors near each other inside a jacket is the reason for the elevated heating. In contrast, a conduit containing three current carrying conductors allows for more area for heat to dissipate, as well as air flow. In contrast, in the attic test fixture (# 3) the two wiring methods were approximately equivalent in terms of heating.

6.3 The test design aimed to create the worst-case scenario for residential small branch circuit conductors, so this report should not be considered to represent a normal real-world condition. In each test circuit, testing was done with three current carrying conductors, at full rated current, in each of the different types of "net zero" thermal insulation. Testing in this manner results in an atypical level of heating from having three fully loaded current carrying conductors near each other (inside a cable or conduit) while under thermal insulation.

For perspective, residential single phase branch circuits generally have only two current carrying conductors in an NM-B cable. Even with single phase multi-wire branch circuits, the third or neutral conductor will only carry a small current from any unbalanced loads present in the circuit, and therefore is not fully loaded as was required by this test design. So, the data in this report should be viewed considering how residential circuits under insulation would normally be loaded.

For example, if the conductor set that had the highest measured temperature in this report (copper NM-B embedded in R-30 spray foam insulation in a wall panel measured at 107.8° C) only had two current carrying conductors, the resulting temperature would definitely be lower and even possibly below the 90°C conductor insulation rating.

6.4 Finally, the levels of thermal insulation used in this project represent the highest required for Climate Zones 6, 7 and 8 that apply to very few locations in the lower 48 states and mostly to Alaska. They do, however, represent the R-values one might expect in net zero residences considering such strict ordinances become adopted for new residential construction. It is uncertain that net zero residential construction will ever be widely employed throughout the nation. In any event, this testing was geared as if it were.

6.5 The test results found that in all the test conditions the 14 AWG CCA conductor maximum temperature was well below 90°C conductor insulation rating. The test results also found that in the spray foam R30 insulation, both the 14 AWG copper NM-B and THHN conductors in ENT exceeded the 90°C insulation rating.

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 below items are provided in Appendix F.

Description	manufacturer	Asset/Serial #	Cal Date	Cal Due
Digital Multi-Meter TX-3	Tektronix	B029681	6/28/2023	6/28/2024
Current Clamp Probe Y8101A	Fluke	66463670	6/27/2023	6/27/2024
Current Clamp Probe 80-i600	Fluke	----	6/27/2023	6/27/2024
Thermocouples, UL 3055, Type J, 15 feet	Pacific Test and Measurement	991576-0171	6/28/2023	N/A
Thermocouples, UL 3031, Type J, 20 feet	Pacific Test and Measurement	991576-0171	6/28/2023	N/A
Thermocouples, UL 4097, Type J, 25 feet	Pacific Test and Measurement	991576-0171	6/28/2023	N/A
Data Logger Fluk- 2638A-60/C120	Fluke	18560 / 33850016	7/13/2023	7/13/2024
Data Logger Fluk- 2638A-60/C120	Fluke	19917 / 37280008	7/13/2023	7/13/2024
Data Logger Agil-34970A	Agilent Technologies	33448 / US37008217	1/13/2021	1/13/2024 [1]
Data Logger Card Agil-34901A	Agilent Technologies	9512 / MY41057880	3/17/2023	3/17/2024
Data Logger Card Agil-34901A	Agilent Technologies	3427/ MY41051501	3/17/2023	3/17/2024
Clamp-on Ammeter	Fluke 374FC	45213066SV	1/20/2023	1/2024
Data Logger	Keysight DAQ970A	MY58029603	5/12/2023	5/2024

Note: 1. The calibration cycle has been extended based on usage in accordance with the policy and procedure shown in Appendix F, page F16

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INTERTEK ASSURANCE
Copperweld Witness Test.
Witness and Certification

SCOPE OF WORK
WITNESS TESTING AT CONSTRUCTION INSTRUCTION LLC

REPORT NUMBER
105499019CSLT-001

ISSUE DATE
Aug 31, 2023

PAGES
Page **1** of **2**

intertek
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Letter for witness testing at Construction Instruction LLC, 6850 Argonne St., Unit 100, Denver, CO 80249

Intertek Report No. 105499019CSLT-001
Intertek Project No. G105499019

Peter Graser
Vice President – Building Wire
Copperweld
5141 Virginia Way, Suite 410
Brentwood, TN 37027
404-550-9064
pgraser@copperweld.com

Subject: Witness testing at Construction Instruction LLC

To whom it may concern,

During Aug 2, 3, 4, 7, 8 and 9, 2023, Harry van der Meer, Contract Consultant for Intertek, witnessed testing at Construction Instruction LLC, 6850 Argonne St., Unit 100, Denver, CO 80249 as described in report 105499019CSLT-001.

This is to certify that:

1. The test fixtures were constructed as described in report 105499019CSLT-001
2. The test equipment used were as described in report 105499019CSLT-001
3. The test equipment calibration reports were reviewed and deemed up to date
4. The testing procedures as outlined in report 105499019CSLT-001 were adhered to
5. The test results of Test Fixture 1 and Test Fixture 2 as reported were verified for accuracy
6. The cables in Test Fixture 3 were initially tested at CI but because of the significant time required to obtain temperature stability and subsequent cooling back to room temperature, it was decided to retest at the Copperweld Performance Lab located on 2550 Huntsville Highway Fayetteville, TN 37334. Even though Intertek was not present during this testing, Intertek is confident that the results reported in 105499019CSLT-001 for Test Fixture 3 are accurate based on the fact that:
    a. The same Test Fixture 3 is used
    b. The same test equipment is used
    c. The engineers testing the cables at the CI facility were the same as those that tested the cables at the CW lab.

Harry van der Meer
Contract Consultant
Intertek

Peter Graser
Copperweld

Construction Instruction® Build Better in Minutes

Executive Summary

1. Construction Instruction (Ci) is a research firm dedicated to building science, industry education, and advancing construction best-practices. The Ci research facility is in Denver, Colorado where the test rigs for this study were built, and the testing was conducted. Visit the Ci website for more information.
2. Since the early 2000s, Ci has been working with insulation manufacturers and major residential builders on advancing air sealing and thermal products for residential and light commercial new construction in route to a net zero future.
3. A major trend in construction points to less insulation interfacing with electrical wiring inside of walls, and more insulation on the exterior of walls (thermal boards) and the roof deck (spray foam). This trend will reduce the amount of insulation in contact with electrical wires, thus reducing the retained heat inside of walls and attics resulting from electrical wires.
4. Future net zero energy goals for buildings will require the use of an exterior insulation product or system to boost wall thermal values in every climate zone.
5. Traditional vented attic systems have seen increasing levels of insulation placed on the attic floor and in many climate zones R60 is now required. In climates where slab on grade construction is prevalent there is a trend towards conditioned attics using net and blow, or spray polyurethane foam insulation, are applied directly to the underside of the roof sheathing. This creates a semi-conditioned attic space where the mechanical, ductwork, and electrical systems are no longer buried within the insulation or residing in the attic space.

Construction Instruction is a training and consulting company with four of the most-respected building scientists in the country, Justin Wilson, Gord Cooke, Mark LaLiberte, and Andrew Oding. We help North America's biggest (and smaller) builders, architects, and developers improve and refine their construction details, processes, and product selection to build higher performing homes that exceed energy codes towards a net zero and low carbon future. With this critical information, we also help major building product manufacturers develop new products that will promote more durable, healthier, better performing buildings.

Ci also teaches high performance building best-practices to thousands of building professionals each year at trade shows, industry conferences, and our Ci live experience center located in Denver, CO. Ci Productions is the media wing of the company. Ci Productions manages the Ci HD app, the website (https://constructioninstruction.com/), and Ci's VIP Newsletter. The Ci app began as a leave-behind for big builders after we consulted on their job sites — an information safety-net that could help them continue to make sense of what we teach. The app has since grown in popularity into the most-downloaded construction mobile application in Apple's app store with more than 300,000 downloads and over 60,000 active users. Ci's key customers are product manufacturers, builders, remodelers, engineers, and designers.

Ci has been working with both manufacturers and builders on advanced air sealing, water management, and thermal products and applications since the early 2000's. We have reviewed numerous building and insulation materials with a focus on application in the field, durability measures, occupant comfort, and decreases in mechanical heating and cooling loads. Our recent focus in the Ci lab has been a 2-year study regarding the durability, water retention, and impact resistance of various continuous exterior insulation applications. The rationale behind this is that our client base has accepted the notion above grade walls in light frame residential construction will require thermal improvements to meet energy and carbon goals of the future.

The main types of building cavity insulation used in today's homes include fiberglass estimated usage 50-60% of residential insulation installations, blown cellulose estimated usage 15-20% of residential insulation installations, spray foam estimated usage 10-20% of residential insulation installations, and mineral wool estimated usage 5-10% of residential insulation installations. The R value of each material varies per inch with most fiberglass insulation being around 3-4 per inch and up to 6-7 per inch for closed cell spray foam. R value is a measure of a materials thermal resistance which indicates how effective the insulation material can resist the flow of heat. The higher the R value the greater the performance and resistance to heat transfer. It is important to note that fiberglass batt insulation must be installed to a RESNET grade 1 installation. A grade 1 Installation requires that insulation material should uniformly fill wall cavities, filling each cavity from side to side and top to bottom, without substantial gaps or voids around obstructions and with an air barrier on all 6 sides. Batt insulation should be cut to fit around any wiring or piping installed in the wall cavities. Gaps, voids, and compressions all create areas for convection loops reducing the labeled R-value of fibrous insulation. A grade 1 instillation ensures the best performance for fiberglass batt insulation. Follow the links for more reading on insulation and how heat flows.

Since the 1950's buildings have transitioned to insulating, starting in the colder climates and made its way to warmer climates to help reduce the energy costs associated with heating and cooling. Walls were typically 2 x 4 light frame wood constructed with insulation in the wall cavities. In the 2000's energy conscious codes were implemented and a transition to 2 x 6 walls to allow for more wall cavity insulation. It can be noted that in the 80's North American walls saw the first uses of exterior insulation due to the energy crisis.

Code developments since the early 2000's have increased insulation levels with objectives of new construction to meet net zero goals in the coming decade. Building science has been a driving factor to advance the enclosure performance through the understanding of heat, air, and moisture flows. This leads us to a key understanding of thermal performance is to install insulation outboard the structure keeping components closer to the conditioned space. This provides excellent thermal control, while contribution to increased durability measures by controlling air leakage and moisture loading of the wall assembly. Manufacturers have seen the need for developing products to meet the construction industry's ever-increasing demands to increase thermal performance of the enclosure with new systems that combine reasonable cavity R-values with exterior thermal insulation to create walls and roof systems that are cost effective and readily constructable.

This can be seen in the exhibit below of the 2021 prescriptive insulation values where you see the wood framed walls listed with the plus… which is indicative of exterior insulation. This table is adapted from Table R402.1.2 in the 2015 and 2018 IECC, and Table R402.1.3 in the 2021 IECC. Yellow lined boxes indicate changes from previous codes.

Climate Zone	Ceilings		Wood Frame Walls		Basement Walls	
	2015/2018	2021	2015/2018	2021	2015/2018	2021
1	30	30	13	13 or **0+10**	0	0
2	38	**49**	13	13 or **0+10**	0	0
3	38	**49**	20 or 13+5	**20 or 13+5 or 0+15**	5/13	5/13
4	49	**60**	20 or 13+5	**20+5 or 13+10 or 0+15**	10/13	10/13
5	49	**60**	20 or 13+5	**20+5 or 13+10 or 0+15**	10/13	**15/19 or 13+5**
6	49	**60**	20+5 or 13+10	20+5 or 13+10 or **0+20**	15/19	**15/19 or 13+5**
7	49	**60**	20+5 or 13+10	20+5 or 13+10 or **0+20**	15/19	**15/19 or 13+5**
8	49	**60**	20+5 or 13+10	20+5 or 13+10 or **0+20**	15/19	**15/19 or 13+5**

2015-2021 IECC Minimum Insulation Requirements for New Homes

"Exterior Continuous Insulation" is insulation that is continuous across all framing members without any thermal bridges other than the fasteners used to adhere it to the building. Typically, these include materials such as foam bords like EPS (expanded polystyrene), XPS (extruded polystyrene), and polyisocyanurate. Other types of continuous insulation include mineral wool and cork board.

The trend with wall insulation is the same for attics/ceilings. We have seen typical attic insulation values rise from R20 to R38, and R49 in the recent decades. This is done because it is relatively simple and cost effective to increase the heel height of a truss allowing more insulation along the perimeter of an attic and increase the overall depth of the remaining attic insulation. As seen in the above table regarding prescribed energy codes for the 2021 IECC, attic insulation values will be increased by 25% – 30% in nearly all climate zones.

Conditioned attics using net and blow, or spray polyurethane foam insulation, are applied directly to the underside of the roof sheathing. This creates a semi-conditioned attic space where the mechanical, ductwork, and electrical systems are no longer buried within the insulation or residing in the attic space. This trend is growing with builders in regions constructing homes using a slab on grade foundation where mechanical systems were traditionally placed in an attic space above the ceiling insulation.

The following analysis is provided by Dr. David Pope PhD and Dr. Mark Licurse PhD. Drs. Pope & Licurse are both PhD materials scientists (Pope earned his degree from the California Institute of Technology & Licurse from the University of Pennsylvania). They teach at the University of Pennsylvania in the Materials Science & Engineering department, including a class on Failure Analysis of Engineering Materials. Together they have written hundreds of reports & peer reviewed journal articles on materials related issues.

A Materials Science Perspective:

In this section we summarize key results of this study from our perspective as Materials Scientists to interpret the data. We show that all the major trends can actually be predicted from the application of established physical laws, even though some of the trends may initially appear to be surprising. For example, the relative heat generation from 14 AWG Cu vs. CCA, as well as the relative temperature rise can all be calculated and matches the trends seen in our tests. Likewise, the temperature rise of a conductor will necessarily increase as the surrounding thermal insulation (i.e., R-value) is also increased.

Summary points:

1. Joule's Law predicts that 14 AWG CCA at 10 amps will generate less heat than 14 AWG copper at 15 amps. This law shows that heat generation is equal to current squared multiplied by electrical resistance. Although the combination of aluminum and copper in CCA wires creates a higher combined resistance per unit length, the increase in current for copper (15 amps) leads to an increase in heat generation relative to CCA (10 amps). Our tests completely agree with this.
2. 14 AWG CCA operating at maximum current (ampacity) always runs cooler than 14 AWG Cu operating at maximum current (ampacity). Our tests completely agree with this.
3. Increasing the thermal insulation (R-value) around a conductor necessarily increases the temperature of the conductor under load.
4. Under equivalent conditions (surrounding insulation, wire configuration, conductor size, current, etc.) two adjacent current carrying conductors will always run cooler than three adjacent current carrying conductors.

Conductor Properties

For the sake of simplicity, we start by describing the materials in the two sets of 14 AWG wires used in these tests, both of which have a diameter of 0.064 inches. The 14 AWG Cu wires for both the THHN conductors and within the NM-B cables have a diameter of 0.064 inches, and the copper used in them is referred to as "electrolytic tough pitch (ETP) copper" – this means that it is very high purity copper with oxygen levels in the range of 100-650 ppm (0.01-0.065%). The CCA wires have an AA-8000 series aluminum alloy core, specified by ASTM B800, with a metallurgically bonded continuous copper outer layer, which makes up at least 10% of the cross-sectional area. This copper outer layer is "high conductivity oxygen-free copper" specified by ASTM B152 that contains less than 10 ppm (0.001%) oxygen. Note, the copper used in the CCA wires is therefore even higher quality than that used in conventional copper wiring, which translates into superior properties including a higher conductivity and improved corrosion resistance.

Insulation and Cable Construction

The Cu & CCA wires in the THHN conductors are insulated with polyvinyl chloride (PVC) and covered with nylon (both of these materials are thermoplastics). The 14 AWG NM-B cables (both Cu & CCA) utilized in these tests are all 14-3, in which three THHN conductors and a bare ground, (when included) are held together in a flat row throughout the length by a paper covering and an outer PVC jacket.

Conductor Resistance and Power Dissipation

14 AWG CCA wires have a higher resistance than 14 AWG Cu wires because aluminum has a higher electrical resistivity than copper. As a result, the 14 AWG Cu wires do have a lower overall electrical resistance than the 14 AWG CCA wires, 0.00252 and 0.00399 ohms/ft respectively, however, the ampacity of the Cu wires is 15A, while that of the CCA is lower, 10A. Therefore, the power dissipation in individual Cu wires (I^2R) at ampacity is 0.5677W/ft, while that of the CCA wires is 0.3967 W/ft. Because of the higher power dissipation in the Cu wires, they are expected to operate hotter than the CCA wires at their rated ampacity. The testing results are in complete agreement with this expectation: the CCA conductors always operated at lower temperatures (at the rated ampacities in the same insulation) in these tests than the Cu conductors.

Thermal Insulation Discussion

Next, we consider the nature and amount of thermal insulation in the cavity surrounding the wires since they strongly affect the temperature rise in the wires. The wires are simply long, thin heaters that generate heat at a constant rate, and the thermal insulation is the medium that conducts that heat away from the wires. Viewing the insulation as the medium that removes the heat from the wires makes it easy to understand that as the thermal insulation in the wall or ceiling cavity becomes more efficient, i.e., it becomes a less efficient heat conductor, the wire temperature increases, and this was also clearly seen in the tests. The wire temperatures were lowest in the simulated wall insulated by 5.5” of R-21 fiberglass batt insulation, then higher in the simulated ceiling insulated with 18” of R-60 blown in fiberglass insulation, and highest in the simulated walls insulated with 4” of spray foam insulation. This result can be further understood by considering the wire locations and the specific insulations utilized. Returning to the lowest recorded temperatures – for the fiberglass batt insulated walls – the wires were in the center of a 5.5” thick cavity and so there was ~2.75” of insulation in front of and behind the conductor. The insulation provides R-3.8/inch and so there is effectively ~R-10.5 on the front and back of the wire. Likewise, for the blown-in fiberglass insulation in the ceiling configuration, the wires have 3.5” of insulation below and 16.5” above and the insulation provides R-5/inch. Considering the insulation below the wires, they see as low as ~R-11.7. Finally, the spray foam insulation led to the highest recorded temperatures in which the wires were surrounded by about 2” of insulation (front & back), providing an effective ~R-15 on each side of the wire for a total R value of 30. The relative temperature increases observed in these tests correlate well with these R values.

The time to reach a stable temperature in a conductor also varies with the amount and type of surrounding insulation. Since more and/or more efficient insulation causes slower heat flow, it takes longer for temperatures to stabilize in those environments.

Temperature Measurement Discussion

Finally, we now consider the temperature measurements on the individual conductors. We would expect the CCA conductors to run at a lower temperature compared to Cu conductors when both operate at ampacity and are surrounded by equivalent insulation. This held true in all the experiments discussed here. As a result, CCA consistently came to equilibrium below 90°C for both THHN conductors and NM-B cables embedded in all three insulations. However, the Cu conductors (both THHN & NM-B) not only ran hotter but were heated above 90°C when embedded in spray foam insulation. Furthermore, they did not completely stabilize before the specific test sequence was terminated and may have heated a bit more if given more time (note, they generally were close to stability).

Another contribution to the heating of the individual wires arises from their relative positions and orientations. The 14-3 NM-B cables contain three conductors. The red conductor is on the outside on one side, then the white conductor and then the black conductor on the other side (note, for the 14-3 Cu cable, there is additionally an unused bare ground wire sandwiched between the white and black conductor). While the Cu & CCA 14-3 NM-B configurations differ slightly with the additional ground in Cu, the white wire is always sandwiched in the middle and therefore would be expected to run hotter than the outer wires that can lose heat to the surroundings. However, the individual THHN conductors inside a conduit are all randomly orientated, and therefore their relative temperature differences are also random (but commonly are somewhat different).

Is Exceeding 90°C always a Fire Hazard?

Here, we address the issue of measured wire temperatures that exceed 90°C in conductors embedded in spray foam insulation. Temperatures that exceed 90°C by a few degrees for short times are not of major concern. UL testing of NM-B cables has shown that significant insulation weight losses (by loss of plasticizer) are not observed even when cables are exposed at temperatures of 120°C for 20 days.[1] Instead, only about 2% weight loss was observed after continuous exposure to 120°C for 20 days, and this exposure actually increased the breakdown voltage. Therefore, exposure to temperatures as high as 120°C for tens of days has little effect on cables insulated with plasticized, nylon-coated PVC. By comparison, the maximum wire temperature observed in these tests was 107.08°C in the 14 AWG copper NM-B cable embedded in R-30 spray foam insulation, which is considerably less than 120°C. Since spray foam insulation has become more popular in the US and since there are over 100 million insulated residential buildings in the US, those buildings certainly contain many NM-B cables that have been exposed to temperatures above 90°C. However, despite the widespread use of sprayed-in foam insulation, the THHN conductors (within NM-B cables with 90°C rated

[1] He, Fan & Brazis, Paul, "Influence of Damage and Degradation on Breakdown Voltage of NM Cables." UL report, Nov. 16, 2012.

insulation) appear to continue working well without causing significant fire risk, nor raising the concern of local fire officials.

Is Future Investigation Necessary?

The above short discussion shows that further investigation of the temperatures in NM-B cable embedded specifically in spray foam insulation might warrant further study of the more realistic situation of two fully loaded current carrying conductors rather than three. However, the results presented in this document do suggest that meeting the 90°C temperature limit on three fully loaded THHN conductors requires only a derating of the ampacity of copper conductors (**not** of CCA conductors) embedded in highly efficient thermal insulation, like spray foam. However, this discussion also suggests that such derating may not be necessary due to the improbability of such conditions and the characteristics of the PVC and Nylon insulation.

While the recent test results on copper NM-B raise issues about conductor temperatures rising above the 90°C limit when embedded in highly efficient thermal insulation, it should be underscored that these tests were performed under worst case scenarios. Again, all three conductors in the 14-3 cables were energized simultaneously for extended periods of time – at 100% rated ampacity. In a real-world residential scenario where NM-B cable is typically used, a single phase residential electrical system would typically only utilize two of the three conductors and operation at 100% ampacity for extended times would be very unusual. However, under equivalent conditions (surrounding insulation, wire configuration, conductor size, current, etc.) two adjacent current carrying conductors will always run cooler than three adjacent current carrying conductors because of the reduced Joule heating.

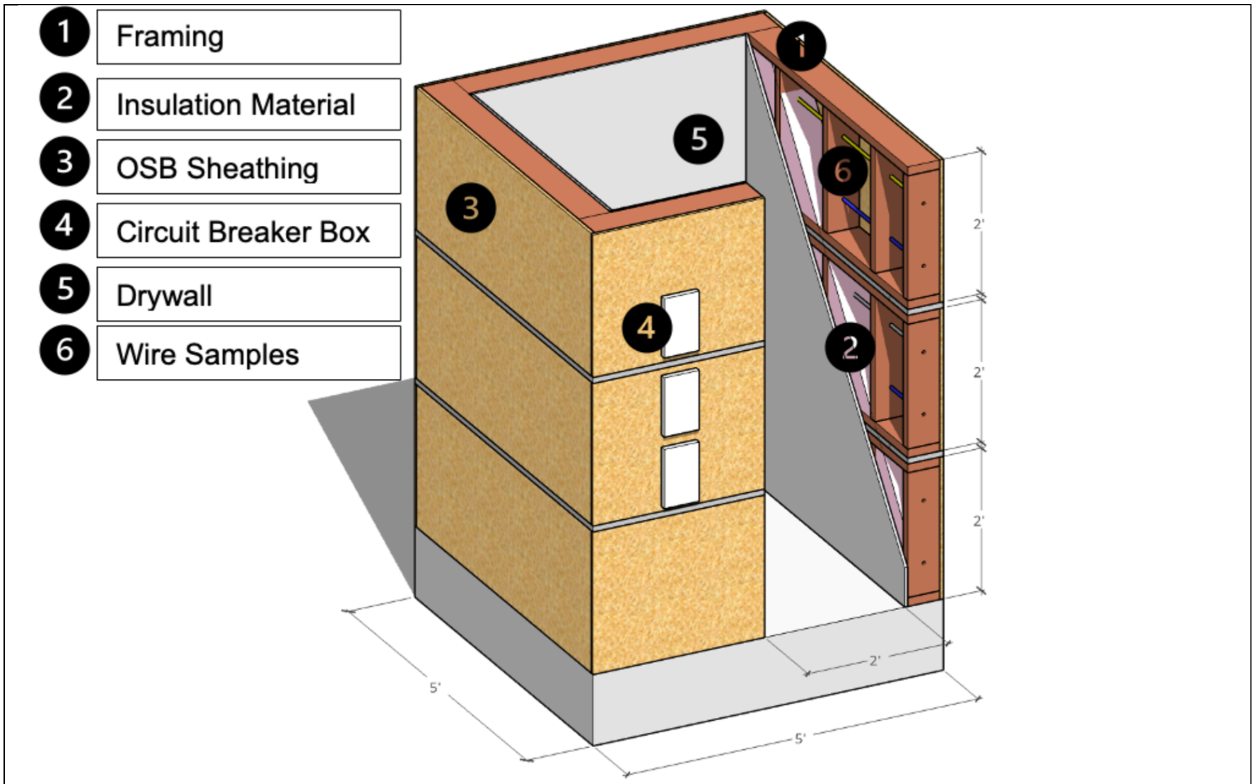

Photo 1 – Wall Test Fixture Design

Photo 2 – 2x6 Framing Assembly of Lowest Level

Photo 3 – Wall Test Fixture with Rough Wiring Installed

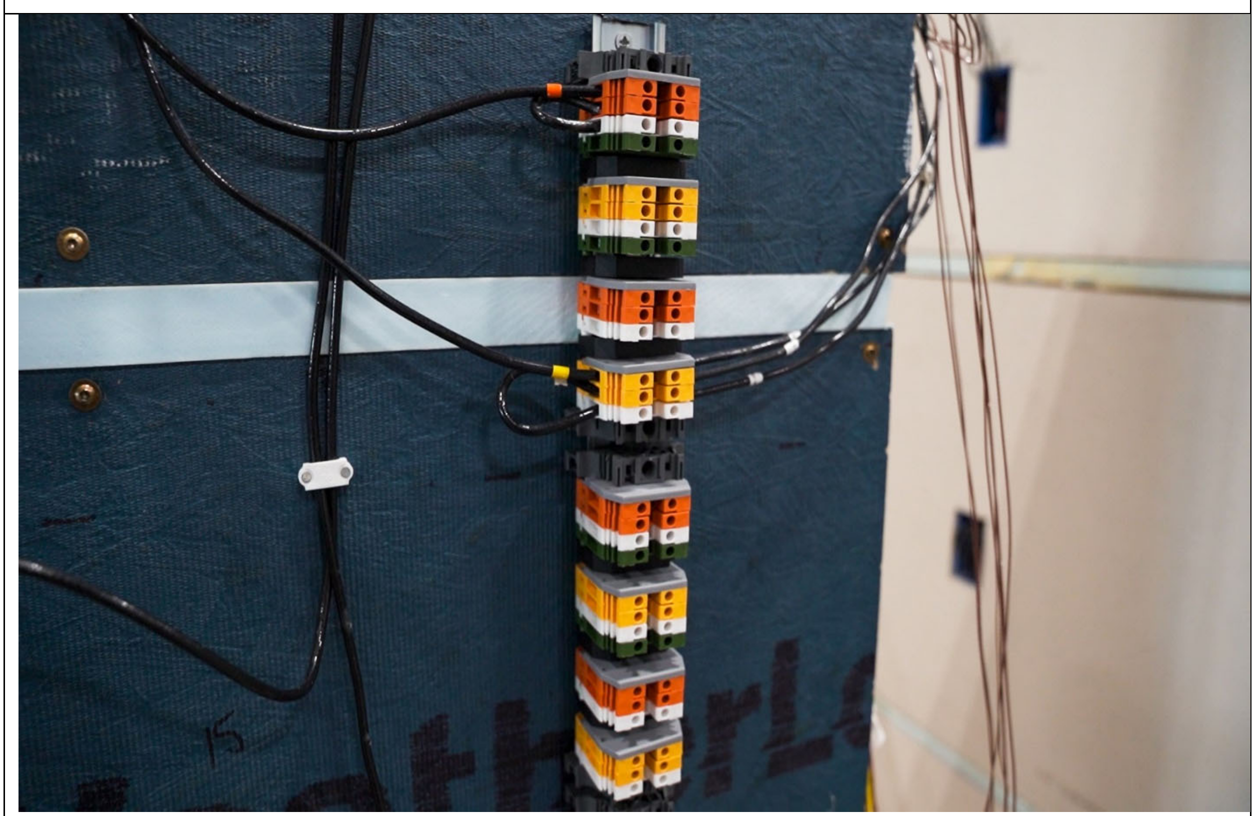

Photo 4 – Terminal Blocks on Wall Test Fixture

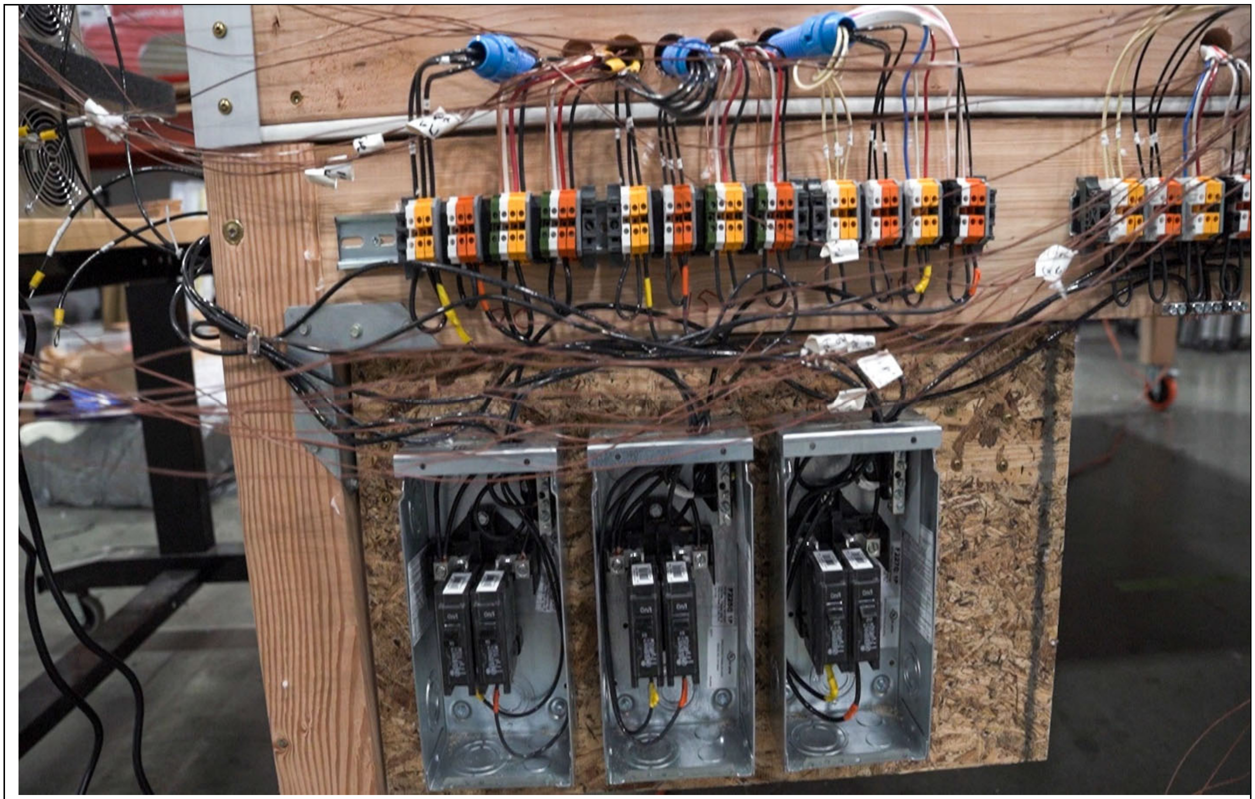

Photo 5 – Terminal Blocks and Circuit Breakers on Ceiling Test Fixture

Photo 6 – Test Fixture 1 R-21 Fiberglass Insulation

Photo 7 – Test Fixture 2 R30 Spray Foam Insulation

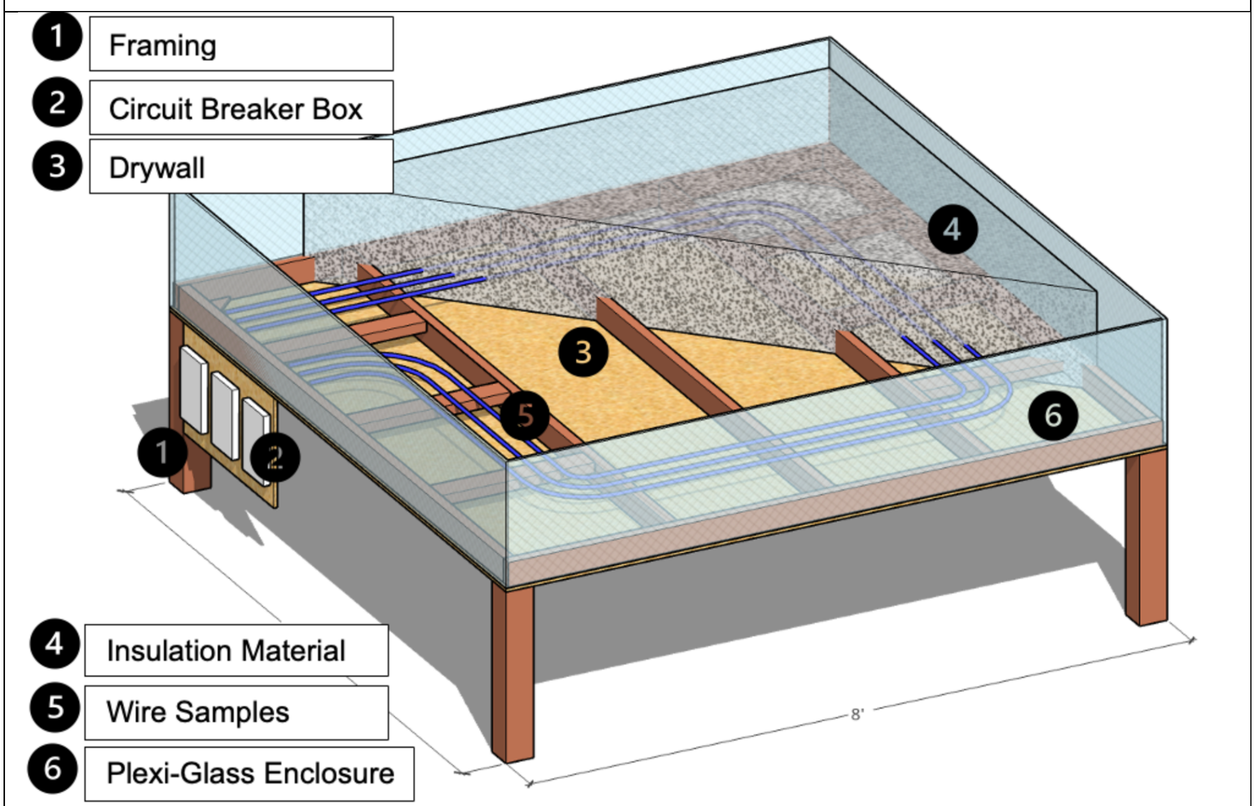

Photo 8 – Ceiling Test Fixture Design

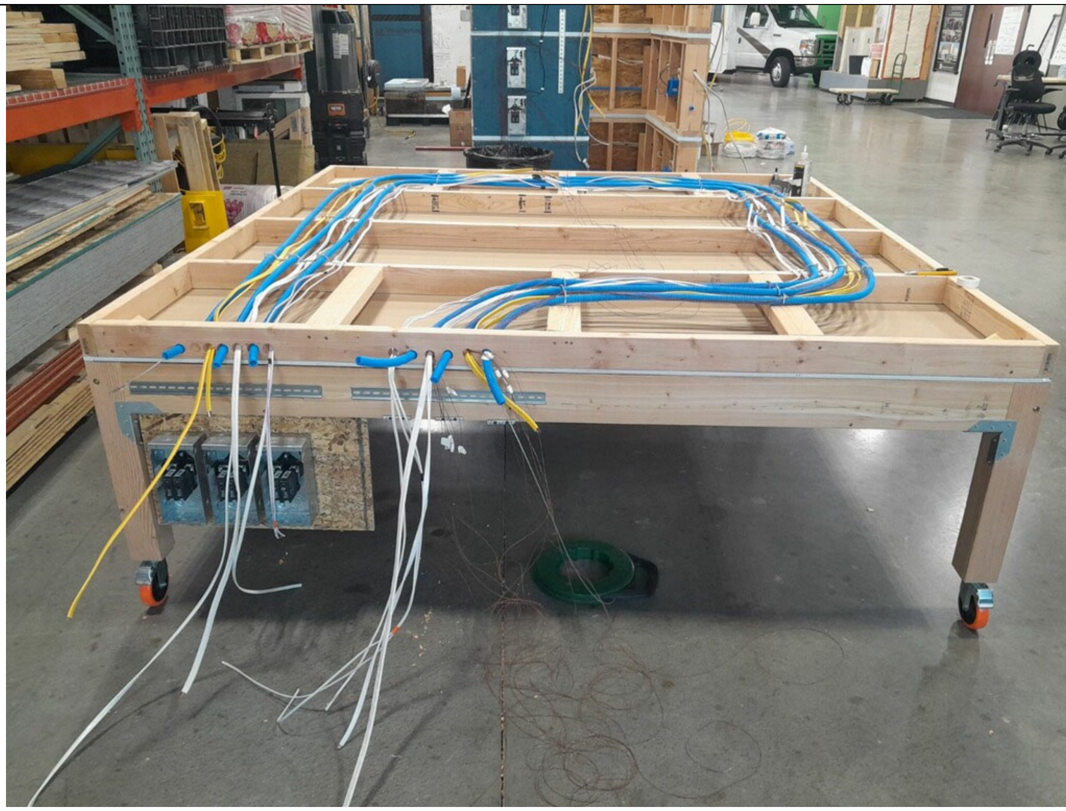

Photo 9 – Ceiling Test Fixture with Rough Wiring

Photo 10 – Ceiling Test Fixture Blown In Insulation

Photo 11 – Wall Fixtures Supply Circuit Breakers

Photo 12 – Receptacle with Thermocouple and Shorting Plug

Recommended Insulation Levels *New, Wood-Framed Homes*

Zone	Heating System	Attic	Cathedral Ceiling	Wall Cavity	Floor
1	All	R30 to R49	R22 to R15	R13 to R15	R13
2	Gas, oil, heat pump	R30 to R60	R22 to R38	R13 to R15	R13
	Electric furnace				R19 to 25
3	All	R30 to R60	R22 to R38	R13 to R15	R25
4	All	R38 to R60	R30 to R38	R13 to R15	R25 to R30
5	Gas, oil, heat pump	R38 to R60	R30 to R38	R13 to R15	R25 to R30
	Electric furnace		R30 to R60	R13 to R21	
6 7 8	All	R49 to R60	R30 to R60	R13 to R21	R25 to R30

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ACCREDITED
CERT #4986.01

Report #: 29937-212051-5 **Customer PO#:**
Customer Name: CDC Mello
Customer Address: P.O. Box 872317
City: Vancouver **State:** WA **Zip:** 98687
Contact: Chuck Mello
Service Address: 5777 SE International Way Milwaukie, OR 97222

Calibration Standards

LP-00050 l Electrical Meter l Fluke l SN: 6725008 l Cal: 03/15/2023 l Due: 03/15/2024 l Vendor: Fluke l Report #: EVL870557
LP-01347 l Thermo-Hygrometer l Comark l SN: 06210350163 l Cal: 04/18/2023 l Due: 04/30/2024 l Vendor: Cal-Cert l Range: 122 °F 95 %RH l Report #: 28945-67214-3646

Instrument Data

Calibration Date:	June 28, 2023
Recommended Due Date:	June 28, 2024
Calibration Frequency:	12 Months
Manufacturer:	Tektronix
Type:	Multi-Meter
Model Number:	TX3
Serial #:	B029681

Reference:	Euramet cg-15
Cal-Cert Procedure:	CP-033
Indicating System:	Digital
Temperature:	72 °F
Humidity:	43% RH
Cal Factor:	None
Asset #:	None
Service Location:	Cal-Cert Lab
As Found:	PASS
As Left:	PASS

AC Volts @ 60Hz

Standard Applied	UUT
330mV	329.9
3.3V	3.299
33V	32.98
330V	329.8
500V	499.7

AC Volts

Standard Applied	UUT
600mV@13kHz	599
3.3V@20kHz	3.293
33V@20kHz	32.96
300V@2.5kHz	300.1
1000V@1kHz	1001

mV DC

Std	UUT
33mV	33.0
330mV	329.9

AC Hz

Standard Applied	UUT
150mV@99.95kHz	99.95
150mv@199.50kHz	199.5

AC Hz Sensitivity

Standard Applied	UUT
0.7V@99.95kHz	99.95
7V@99.95kHz	99.95

DC Hz Trigger Level

Standard Applied	UUT
3.4V 1kHz Sq. Wave	N/A

DC Hz Duty Cycle

Standard Applied	UUT
5V, 1kHz, DC offset 2.5V, Sq. Wave	N/A

DC Volts

Standard Applied	UUT
3.3V	3.299
33V	32.99
330V	329.9
1000V	1000.00

nS Conductance

Standard Applied	UUT
Open input	N/A
100MΩ	N/A

Ω Ohms

Standard Applied	UUT
330Ω 2 Wire Comp	330.1
3.3kΩ 2 Wire Comp	3.300
33kΩ	33.00
330kΩ	329.9
3.3MΩ	3.298
30MΩ	29.99

AC mA/AC μA

Standard Applied	UUT
33mA@60Hz	32.97
330mA@60Hz	329.8
30μA@60Hz	30.0
330μA@60Hz	299.9

-▶+ Diode

Standard Applied	UUT
1.0VDC	0.999

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Manufacturer: Tektronix **Type:** Multi-Meter **Serial #:** B029681

AC Amps

Standard Applied	UUT
3.0A@60Hz	2.999

DC Amps

Standard Applied	UUT
3.0A	2.998
10.0A	10.00

mV DC Temperature

Standard Applied	UUT
0°C	-1
100°C	100

DC mAmps

Standard Applied	UUT
33mA	32.98
330mA	329.9

DC MicroAmps

Standard Applied	UUT
30µA	30.0
300µA	299.9

Capacitance

Standard Applied	UUT
Open input	0.000
5nf	5.04
9.5nf	9.55

AC Volts Low Pass Filter

Standard Applied	UUT
400V@400Hz	N/A
400V@800Hz	N/A

VDC Peak Min/Max

Standard Applied	UUT
8 Vpp, 2 kHz Sq. Wave, DC offset 2V	N/A
8 Vpp, 2 kHz Sq. Wave, DC offset 2V	N/A

Remarks:

We sincerely thank you for your business. Please call us at 503-654-9620 for all your sales and calibration needs.
Cleaning and preventative maintenance were performed as part of this service.

Cal-Cert is accredited by A2LA under Calibration Laboratory Code #4986.01.
A2LA is recognized under the ILAC mutual recognition agreement (MRA).

This certificate is hereby issued that the above instrument was tested for accuracy with calibrated standards traceable to the National Institute of Standards and Technology (NIST). The information provided on this form complies with the data gathering and reporting requirements of ISO/IEC 17025 and ANSI/NCSL Z540.1, and meets the requirements of all applicable references and Cal-Cert procedures listed above.
Any stated measurement uncertainty includes the uncertainty of the Calibration standards used, combined with the uncertainty of the measurement process using the RSS method with a k=2 for an approximate 95% level of confidence. The calibration process meets or exceeds a ratio of 4:1 unless otherwise stated.
All tolerances were derived from the applicable standards and pass/fail determination is based on those tolerances. The customer determined any recommended due dates indicated on the certificate.

This report shall not be reproduced except in full, without written approval from Cal-Cert.

Service Engineer: Cameron Walling **Date:** June 28, 2023

Technical Manager: Marshall Doyle **Signature:** M Doyle

Electrical Multi Meter Fluke 87V CF-033-16

Report #: 29937-212051-5
Revision 4 **8/25/2016**

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Report #: 29937-212134-5
Customer PO#:
Customer Name: CDC Mello
Customer Address: P.O. Box 872317
City: Vancouver **State:** WA **Zip:** 98687
Contact: Chuck Mello
Service Address: 5777 SE International Way Milwaukie, OR 97222

Calibration Standards

LP-00050 | Electrical Meter | Fluke | SN: 6725008 | Cal: 03/15/2023 | Due: 03/15/2024 | Vendor: Fluke | Report #: EVL870557
LP-00051 | Electrical Meter | Fluke | SN: 9663004 | Cal: 01/10/2023 | Due: 01/10/2024 | Vendor: Fluke | Report #: EVL861119
LP-01347 | Thermo-Hygrometer | Comark | SN: 06210350163 | Cal: 04/18/2023 | Due: 04/30/2024 | Vendor: Cal-Cert | Range: 122 °F 95 %RH | Report #: 28945-67214-3646
LP-01710 | Electrical Meter | Fluke | SN: 5692901 | Cal: 03/27/2023 | Due: 03/31/2024 | Vendor: Fluke | Report #: EVL873898

Instrument Data

Calibration Date:	June 27, 2023	**Reference:**	Euramet cg-15
Recommended Due Date:	June 27, 2024	**Cal-Cert Procedure:**	CP-033
Calibration Frequency:	12 Months	**Indicating System:**	Gauge
Manufacturer:	Fluke	**Temperature:**	73 °F
Type:	Current Clamp Probe	**Humidity:**	40% RH
Model Number:	Y8101A	**Cal Factor:**	1mA/Amp
Serial #:	66463670	**Asset #:**	None
Range Resolution:	0.01 AC Amperes	**Service Location:**	Cal-Cert Lab
Capacity:	150.0 AC Amperes	**As Found:**	Pass
Tolerance:	See Remarks AC Amperes See Remarks of full scale	**As Left:**	Pass

Instrument Range: 150 **Range Resolution:** 0.01 **Mode Verified:** AC Amperes

Instrument Reading	As Found	Verification Reading #1	Error	Verification Reading #2	Error
0.00	0.00	0.00	0.00	0.00	0.00
1.00	0.98	0.97	-0.03	0.98	-0.02
10.00	9.96	9.96	-0.04	9.96	-0.04
20.00	19.96	19.95	-0.05	19.96	-0.04
40.00	40.04	40.04	0.04	40.04	0.04
70.00	70.29	70.29	0.29	70.29	0.29
140.00	139.47	139.47	-0.53	139.48	-0.52
0.00	0.00	0.00	0.00	0.00	0.00

Expanded Uncertainty ± 0.0182941 AC Amperes

Remarks:

Tolerance is ±2.5% +0.15A from 48Hz to 440Hz and ±3%+0.15A from 440Hz to 1200Hz

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Cleaning and preventative maintenance were performed as part of this service.

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A2LA is recognized under the ILAC mutual recognition agreement (MRA).

This certificate is hereby issued that the above instrument was tested for accuracy with calibrated standards traceable to the National Institute of Standards and Technology (NIST). The information provided on this form complies with the data gathering and reporting requirements of ISO/IEC 17025 and ANSI/NCSL Z540.1, and meets the requirements of all applicable references and Cal-Cert procedures listed above.

Any stated measurement uncertainty includes the uncertainty of the Calibration standards used, combined with the uncertainty of the measurement process using the RSS method with a k=2 for an approximate 95% level of confidence. The calibration process meets or exceeds a ratio of 4:1 unless otherwise stated.

All tolerances were derived from the applicable standards and pass/fail determination is based on those tolerances. The customer determined any recommended due dates indicated on the certificate.

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Service Engineer: Cameron Walling **Date:** June 27, 2023

Technical Manager: Marshall Doyle **Signature:** M Doyle

Electrical Meter CF-033-07

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Revision 4 **8/25/2016**

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Report #: 29937-212135-5
Customer PO#:
Customer Name: CDC Mello
Customer Address: P.O. Box 872317
City: Vancouver **State:** WA **Zip:** 98687
Contact: Chuck Mello
Service Address: 5777 SE International Way Milwaukie, OR 97222

Calibration Standards

LP-00050 | Electrical Meter | Fluke | SN: 6725008 | Cal: 03/15/2023 | Due: 03/15/2024 | Vendor: Fluke | Report #: EVL870557
LP-00051 | Electrical Meter | Fluke | SN: 9663004 | Cal: 01/10/2023 | Due: 01/10/2024 | Vendor: Fluke | Report #: EVL861119
LP-01347 | Thermo-Hygrometer | Comark | SN: 06210350163 | Cal: 04/18/2023 | Due: 04/30/2024 | Vendor: Cal-Cert | Range: 122 °F 95 %RH | Report #: 28945-67214-3646

Instrument Data

Calibration Date: June 27, 2023
Recommended Due Date: June 27, 2024
Calibration Frequency: 12 Months
Manufacturer: Fluke
Type: Current Clamp Probe
Model Number: Unknown
Serial #: Unknown
Range Resolution: 0.01 AC Amperes
Capacity: 2,000.0 AC Amperes
Tolerance: See Remarks AC Amperes See Remarks of full scale

Reference: Euramet cg-15
Cal-Cert Procedure: CP-033
Indicating System: Gauge
Temperature: 73 °F
Humidity: 41% RH
Cal Factor: 1mA/Amp
Asset #: None
Service Location: Cal-Cert Lab
As Found: Pass
As Left: Pass

Instrument Range: 2,000 **Range Resolution:** 0.01 **Mode Verified:** AC Amperes

Instrument Reading	As Found	Verification Reading #1	Error	Verification Reading #2	Error
0.00	0.00	0.00	0.00	0.00	0.00
5.00	4.98	4.97	-0.03	4.98	-0.02
50.00	49.91	49.91	-0.09	49.91	-0.09
100.00	99.87	99.87	-0.13	99.87	-0.13
250.00	249.79	249.78	-0.22	249.79	-0.21
500.00	499.71	499.69	-0.31	499.62	-0.38
550.00	548.21	548.21	-1.79	549.44	-0.56
0.00	0.00	0.00	0.00	0.00	0.00

Expanded Uncertainty ± 1.7395214 AC Amperes

Remarks:

Per Manufacturer, Probe accuracy specified as ±2% of reading from 50 Hz AC to 1kHz AC.

We sincerely thank you for your business. Please call us at 503-654-9620 for all your sales and calibration needs.
Cleaning and preventative maintenance were performed as part of this service.

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This certificate is hereby issued that the above instrument was tested for accuracy with calibrated standards traceable to the National Institute of Standards and Technology (NIST). The information provided on this form complies with the data gathering and reporting requirements of ISO/IEC 17025 and ANSI/NCSL Z540.1, and meets the requirements of all applicable references and Cal-Cert procedures listed above.
Any stated measurement uncertainty includes the uncertainty of the Calibration standards used, combined with the uncertainty of the measurement process using the RSS method with a k=2 for an approximate 95% level of confidence. The calibration process meets or exceeds a ratio of 4:1 unless otherwise stated.
All tolerances were derived from the applicable standards and pass/fail determination is based on those tolerances. The customer determined any recommended due dates indicated on the certificate.
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Service Engineer: Cameron Walling **Date:** June 27, 2023

Technical Manager: Marshall Doyle **Signature:** M Doyle

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Report of Calibration

Eustis Co., Inc./Pyrocom Calibration Lab
12407-B Mukilteo Speedway #200
Lynnwood, WA 98087

Report No: WL202306148-003

Model: UL3055 Serial: 991576-0171 Description: TYPE J, 30AWG, L=15FT, FEP/FEP	Customer: CDC Mello Consulting Chuck Mello PPO Box 872317 Vancouver, WA 98687
Calibration Range: Limited Received Condition: New Current: N/A Procedure: ECP 339/342	

The unit under test (UUT) on this certificate has been calibrated by comparison method as covered by ASTM E220, and calibrated against standards traceable to the International System of Units (SI) through recognized national metrology institutes such as NIST, or ratiometric techniques, or natural physical constants. 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	21.40	21.51	0.11	+/- 0.31	COMP
40.00	40.07	40.09	0.02	+/- 0.40	COMP
95.00	95.03	94.94	-0.09	+/- 0.40	COMP
150.00	149.98	150.00	0.02	+/- 0.50	COMP
200.00	199.96	200.08	0.12	+/- 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	4/20/2024
Fluke	5628	4 Wire SPRT	4303	5/2/2024
Fluke	2566	Thermocouple Scanner	B7A380	4/21/2024
Fluke	7380	Bath, Ultra Low-Temperature	B2A527	NCR
Fluke	9173	Metrology Well, 700 C	B47975	NCR

Calibration Date: 6/28/2023
Temperature: 24.0 C
Humidity: 40%
Customer Order: 310729-C

Technician: W. LeMesurier

Approved By: Walter Paulson
QA Manager

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Report of Calibration

Report No: WL202306148-003

Notes: The thermocouple wire used in the manufacturing of the above listed thermocouples 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 +/- 1.1°C OR +/- .4% whichever is greater. Thermocouples manufactured in accordance with UL 00-OP-C0037. 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.

Manufacturing date: JUN 2 9 2023

Report issue date: JUN 2 9 2023

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Report of Calibration

Eustis Co., Inc./Pyrocom Calibration Lab
12407-B Mukilteo Speedway #200
Lynnwood, WA 98087

Report No: WL202306148-004

Model: UL3031 Serial: 991576-0171 Description: TYPE J, 30AWG, L=20FT, FEP/FEP	Customer: CDC Mello Consulting Chuck Mello PPO Box 872317 Vancouver, WA 98687
Calibration Range: Limited Received Condition: New Current: N/A Procedure: ECP 339/342	

The unit under test (UUT) on this certificate has been calibrated by comparison method as covered by ASTM E220, and calibrated against standards traceable to the International System of Units (SI) through recognized national metrology institutes such as NIST, or ratiometric techniques, or natural physical constants. 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	21.39	21.49	0.10	+/- 0.31	COMP
40.00	40.07	40.06	-0.01	+/- 0.40	COMP
95.00	95.03	94.94	-0.09	+/- 0.40	COMP
150.00	149.98	149.98	0.00	+/- 0.50	COMP
200.00	199.97	200.04	0.07	+/- 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	4/20/2024
Fluke	5628	4 Wire SPRT	4303	5/2/2024
Fluke	2566	Thermocouple Scanner	B7A380	4/21/2024
Fluke	7380	Bath, Ultra Low-Temperature	B2A527	NCR
Fluke	9173	Metrology Well, 700 C	B47975	NCR

Calibration Date: 6/28/2023
Temperature: 24.0 C
Humidity: 40%
Customer Order: 310729-C

Technician: W. LeMesurier

Approved By: Walter Paulson
QA Manager

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Report of Calibration

Notes: The thermocouple wire used in the manufacturing of the above listed thermocouples 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 +/- 1.1°C OR +/- .4% whichever is greater. Thermocouples manufactured in accordance with UL 00-OP-C0037. 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.

Manufacturing date: JUN 29 2023

Report issue date: JUN 29 2023

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CERT #2496.01

Report of Calibration

Eustis Co., Inc./Pyrocom Calibration Lab
12407-B Mukilteo Speedway #200
Lynnwood, WA 98087

Report No: WL202306148-005
Page 1 of 2

Model: UL4097 Serial: 991576-0171 Description: TYPE J, 30AWG, L=25FT, FEP/FEP	Customer: CDC Mello Consulting Chuck Mello PPO Box 872317 Vancouver, WA 98687
Calibration Range: Limited Received Condition: New Current: N/A Procedure: ECP 339/342	

The unit under test (UUT) on this certificate has been calibrated by comparison method as covered by ASTM E220, and calibrated against standards traceable to the International System of Units (SI) through recognized national metrology institutes such as NIST, or ratiometric techniques, or natural physical constants. 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	21.53	0.12	+/- 0.31	COMP
40.00	40.07	40.08	0.01	+/- 0.40	COMP
95.00	95.03	94.99	-0.04	+/- 0.40	COMP
150.00	149.99	150.02	0.03	+/- 0.50	COMP
200.00	199.97	200.08	0.11	+/- 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	4/20/2024
Fluke	5628	4 Wire SPRT	4303	5/2/2024
Fluke	2566	Thermocouple Scanner	B7A380	4/21/2024
Fluke	7380	Bath, Ultra Low-Temperature	B2A527	NCR
Fluke	9173	Metrology Well, 700 C	B47975	NCR

Calibration Date: 6/28/2023
Temperature: 24.0 C
Humidity: 40%
Customer Order: 310729-C

Technician: W. LeMesurier

Approved By: Walter Paulson
QA Manager

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Report of Calibration

Notes: The thermocouple wire used in the manufacturing of the above listed thermocouples 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 +/- 1.1°C OR +/- .4% whichever is greater. Thermocouples manufactured in accordance with UL 00-OP-C0037. 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.

Manufacturing date: JUN 29 2023

Report issue date: JUN 29 2023

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CALIBRATION CERTIFICATE

ATEC Asset ID
18560

Work Order
2023004517

Certificate Number: 2023004517-Rev1

Asset ID	18560
Manufacturer	Fluke
Model Number	FLUK-2638A-60/C120
Serial Number	33850016
Description	60ch Hydra Series III Data Acquisition System, 120V

Initial Condition	In Tolerance
Final Condition	In Tolerance
Calibration Date	7/13/2023
Due Date	7/13/2024
Temperature C°	23.54
Humidity	52.4
Procedure	Fluke 2638A Manual Performance Verification Rev. Revision

Customer Name: Advanced Test Equipment Corporation
Customer Address: 10401 Roselle St San Diego , CA 92121
Comments:

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes (NIST, PTB, NRC, NPL, etc.), ratiometric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval of Advanced Test Equipment Corporation (ATEC). The calibration has been completed in accordance with ATEC's Active Use Calibration System. ATEC conforms to the requirements of the Quality Management System registered to ISO 9001:2015 (QAS International; US2790).

Standards Used

Model	Manufacturer	Serial	Asset ID	Due Date
FLUK-5720A-003	Fluke	9190206	11771	12/15/2023

Calibrated by: Emmanuel Mojica

Approved by: Javier Estrada

ATEC Corporation
10401 Roselle St.
San Diego, CA 92121

Telephone
888-488-2832

Facsimile
858-588-6570

Internet
www.ATECorp.com

7/18/2023

Advanced Test Equipment Corp.
Rentals • Sales • Calibration • Service

CALIBRATION CERTIFICATE

ATEC Asset ID
19917

Work Order
2023004515

Certificate Number: 2023004515-Rev1

Asset ID	19917
Manufacturer	Fluke
Model Number	FLUK-2638A-60/C120
Serial Number	37280008
Description	60ch Hydra Series III Data Acquisition System, 120V

Initial Condition	In Tolerance
Final Condition	In Tolerance
Calibration Date	7/13/2023
Due Date	7/13/2024
Temperature C°	24.29
Humidity	51.3
Procedure	Fluke 2638A Manual Performance Verification Rev. Revision

Customer Name: Advanced Test Equipment Corporation
Customer Address: 10401 Roselle St San Diego , CA 92121
Comments:

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes (NIST, PTB, NRC, NPL, etc.), ratiometric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval of Advanced Test Equipment Corporation (ATEC). The calibration has been completed in accordance with ATEC's Active Use Calibration System. ATEC conforms to the requirements of the Quality Management System registered to ISO 9001:2015 (QAS International; US2790).

Standards Used

Model	Manufacturer	Serial	Asset ID	Due Date
FLUK-5720A-003	Fluke	9190206	11771	12/15/2023

Calibrated by: Emmanuel Mojica

Approved by: Javier Estrada

CALIBRATION CERTIFICATE

ATEC Asset ID
33448

Work Order
2021002058

Certificate Number: 2021002058-Rev2

		Initial Condition	**In Tolerance**
		Final Condition	**In Tolerance**
Asset ID	**33448**	Calibration Date	1/13/2021
Manufacturer	Agilent Technologies	Due Date	1/13/2024
Model Number	AGIL-34970A	Temperature C°	22.31
Serial Number	US37008217	Humidity	34.8
Description	3-Slot Data Acquisition/ Switching/Datalogger Unit 6 1/2 Digi	Procedure	**Agilent 34970A Data Acq./Switch Unit Service Guide Rev. Revision**

Customer Name: Advanced Test Equipment Corporation
Customer Address: 10401 Roselle St San Diego , CA 92121
Comments: Calibration performed by an Authorized Subcontractor.

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes (NIST, PTB, NRC, NPL, etc.), ratiometric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval of Advanced Test Equipment Corporation (ATEC). The calibration has been completed in accordance with ATEC's Active Use Calibration System. ATEC conforms to the requirements of the Quality Management System registered to ISO 9001:2015 (QAS International; US2790).

Standards Used

Model	Manufacturer	Serial	Asset ID	Due Date

No standards recorded

Calibrated by: Maurice Heath

Approved by: Javier Estrada

Advanced Test Equipment Corp.
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CALIBRATION CERTIFICATE

ATEC Asset ID
9512

Work Order
2021022028

Certificate Number: 2021022028-Rev1

Asset ID	9512
Manufacturer	Agilent Technologies
Model Number	AGIL-34901A
Serial Number	MY41057880
Description	20ch Multiplexer/Input Card, 2-Wire Armature for Data Logger

Initial Condition	In Tolerance
Final Condition	In Tolerance
Calibration Date	3/17/2023
Due Date	3/17/2024
Temperature C°	22.6
Humidity	42.4
Procedure	Agilent 34907A Manual Performance Verification Rev. Revision

Customer Name: Advanced Test Equipment Corporation
Customer Address: 10401 Roselle St San Diego , CA 92121
Comments:

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes (NIST, PTB, NRC, NPL, etc.), ratiometric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval of Advanced Test Equipment Corporation (ATEC). The calibration has been completed in accordance with ATEC's Active Use Calibration System. ATEC conforms to the requirements of the Quality Management System registered to ISO 9001:2015 (QAS International; US2790).

Standards Used

Model	Manufacturer	Serial	Asset ID	Due Date
FLUK-5720A-003	Fluke	9190206	11771	12/15/2023

Calibrated by: Pedro Delgado

Approved by: Javier Estrada

ATEC Corporation
10401 Roselle St.
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888-488-2832

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858-588-6570

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7/18/2023

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CALIBRATION CERTIFICATE

ATEC Asset ID
3427

Work Order
2021022029

Certificate Number: 2021022029-Rev1

Asset ID	3427
Manufacturer	Agilent Technologies
Model Number	AGIL-34901A
Serial Number	MY41051501
Description	20ch Multiplexer/Input Card, 2-Wire Armature for Data Logger

Initial Condition	In Tolerance
Final Condition	In Tolerance
Calibration Date	3/17/2023
Due Date	3/17/2024
Temperature C°	22.58
Humidity	42.4
Procedure	Agilent 34907A Manual Performance Verification Rev. Revision

Customer Name: Advanced Test Equipment Corporation
Customer Address: 10401 Roselle St San Diego , CA 92121
Comments:

This Calibration is traceable to the International System of Units (SI), through National Metrology Institutes (NIST, PTB, NRC, NPL, etc.), ratiometric techniques, or natural physical constants. This certificate applies only to the item identified and shall not be reproduced other than in full, without the specific written approval of Advanced Test Equipment Corporation (ATEC). The calibration has been completed in accordance with ATEC's Active Use Calibration System. ATEC conforms to the requirements of the Quality Management System registered to ISO 9001:2015 (QAS International; US2790).

Standards Used

Model	Manufacturer	Serial	Asset ID	Due Date
FLUK-5720A-003	Fluke	9190206	11771	12/15/2023

Calibrated by: Pedro Delgado

Approved by: Javier Estrada

Advanced Test Equipment Corporation
Rentals • Sales • Calibration • Service
10401 Roselle Street, San Diego, CA 92121
800-404-ATEC (2832) www.atecorp.com

ATEC Active-Use Calibration System

In what has become common practice for many laboratories, ATEC has adopted a calibration recall system based on the active use of test and measurement equipment. Calibration due dates are recommended based on subject matter expertise, data recorded, and the time equipment has been utilized. The active use of equipment will always be less than the established calibration interval on the equipment, or it will be considered in need of re-calibration (5.3.5). Most items with internal calibration dates tied to the calibration itself will follow the traditional calendar-based timeframe. The customer has the right to request any specific calibration interval on their rental equipment. If no such request is given, this policy will be used. The following has been taken directly from ATEC's Procedure Manual (PM9 – Inspection and Calibration) which has been reviewed and approved by A2LA during the most recent ISO17025 Accreditation (A2LA Cert# 3410.01)

5.3.4. The initial interval between calibrations will be determined by referencing the manufacturer's recommendation. This may be adjusted based on the purpose, stability, controlled storage, degree of usage, current equipment in the Calibrated Equipment Database, and whether Company personnel or an external Calibration Agency will carry out the calibration.

5.3.4.1. Equipment that has an adjusted calibration interval based on Active-Use data will only be considered calibrated with a successful post-rental laboratory function check and if the total time spent out on rent does not exceed the calibration interval.

5.3.4.2. No calibration will last more than 3years unless recommended by the manufacturer.

5.3.5. An Active-Use calibration recall system will be maintained to keep track of the time remaining on a piece of equipment's calibration interval. This Active-Use calibration recall system is defined as the period of time that elapses between the dates a piece of rental pool equipment is shipped to a rental customer and the date it is received back from the customer at the end of the rental.

5.3.6. Calibration cycle time will not accrue for the time which the piece of equipment is being stored in a controlled environment at ATEC after the equipment has passed its end of rental confidence inspection.

5.3.7. All rental equipment being returned to ATEC will receive an end of rental confidence inspection in which a technician will evaluate the returned equipment using NIST traceable standards, if the technician verifies that the equipment is not meeting the manufactures specifications, he or she will reject the equipment and segregate it as not available for rental. This end of rental confidence inspection will also serve the purpose of insuring that the equipment was not damaged while being out on rent as well as an inspection of the equipment's standard accessories.

KEYSIGHT TECHNOLOGIES

Keysight Technologies Malaysia Sdn Bhd (463532-M)
Bayan Lepas Free Industrial Zone
11900 Penang
Malaysia

5962-0476

Certificate Of Calibration

Certificate No: DAQ970AMY58029603

Manufacturer: Keysight Technologies
Model No: DAQ970A
Options Tested: N/A

Description: Data Acquisition System
Serial No: MY58029603

Date of Calibration: 12 May 2023
Temperature: (23 ± 5) deg. C
Procedure: ATM-09-A7014

Humidity: (20 to 80)% RH

This certifies that the equipment has been calibrated using applicable Keysight Technologies procedures in compliance with a quality management system registered to ISO 9001:2015.

As Received Conditions: Not applicable, as this calibration certificate applies to the initial calibration of a new, refurbished or upgraded equipment.

Action Taken:

- No corrective actions were necessary.

As Completed Conditions: The measured values of the equipment were observed in specification at the points tested.

Remarks or special requirements:

This calibration report shall not be reproduced, except in full.

Traceability Information: Measurements are traceable to the International System of Units (SI) via national metrology institutes (www.keysight.com/find/NMI) that are signatories to the CIPM Mutual Recognition Arrangement.

Calibration Equipment Used:

Date Used:* *Date equipment used in this Calibration

Model Number	Model Description	Equipment ID	Date Used	Cal Due Date
5730A	Fluke Calibrator	5737503	12 May 2023	14 Apr 2024

Print Date: 12-May-23

Kang Chia Chiek
Quality Manager

Keysight Technologies

	DD	MM	YY	BY:
CAL	12	05	23	S.Y
DUE				

PCS PRECISION CALIBRATION SYSTEMS
107 N Porter St
Winchester, TN 37398
E-mail: info@pcsllctn.com
Phone: 866-521-3823
Website: www.pcsllctn.com

INSTRUMENT CALIBRATION REPORT

ilac-MRA PJLA Calibration Accreditation# 73403

Copperweld

Instrument ID EL-124
Description Clamp meter
Calibrated 1/20/2023
Performed At PCS Lab

Manufacturer	Fluke	**Location**	254 Cotton Mill Rd. Fayetteville, TN 37334	**Frequency**	Annual
Model Number	374 FC	**Building**	Main	**Certificate #**	CO012523NF-11
Serial Number	45213066SV	**Department**	Electrical Lab	**Temp**	70°F
Cal Procedure	QS0011JB2010	**Status**	In Service	**Humidity**	35%

This is a cover sheet. Please see subsequent pages for calibration results and details.

Test Instruments Used During the Calibration

Test Instrument ID					Last Cal Date (As Of Cal Entry Date)	Next Cal Date (As Of Cal Entry Date)
Z-EL-008 FLUKE 5522A CALIBRATOR	Fluke 5522A Multi-Product Electrical Calibrator	FLUKE	5522A	3364904	1/4/2023	1/4/2025
Z-EL-009 CURRENT COIL	Fluke 5500A Current Coil	FLUKE	5500A	20082689	3/2/2022	3/31/2023

Notes about this calibration

Calibration Result Calibration Successful
Who Calibrated Nathan Flatt
Finalized By Nathan Flatt
Date Finalized 1/25/2023 10:39:31AM

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 Rayburn Flatt

EL-124

DC VOLTS

Nominal	Unit	Found As	Left As	Found As Result	Left As Result	Range	% of Nominal	% of Range	Count	+ / -	Low	High	Uncertainty
60	V	59.9	59.9	TRUE	TRUE	600	1%	0%	0.5	1.1	58.9	61.1	± 6.1 mV
300	V	299.7	299.7	TRUE	TRUE	600	1%	0%	0.5	3.5	296.5	303.5	± 6.1 mV
540	V	539.7	539.7	TRUE	TRUE	600	1%	0%	0.5	5.9	534.1	545.9	± 19.9 mV

AC VOLTS

Nominal	Unit	Found As	Left As	Found As Result	Left As Result	Range	% of Nominal	% of Range	Count	+ / -	Low	High	Uncertainty
60	V	60	60	TRUE	TRUE	600	1.5%	0%	0.5	1.4	58.6	61.4	± 0.34 V
300	V	299.9	299.9	TRUE	TRUE	600	1.5%	0%	0.5	5	295	305	± 0.34 V
540	V	539.7	539.7	TRUE	TRUE	600	1.5%	0%	0.5	8.6	531.4	548.6	± 0.31 V

RESISTANCE

Nominal	Unit	Found As	Left As	Found As Result	Left As Result	Range	% of Nominal	% of Range	Count	+ / -	Low	High	Uncertainty
600	Ω	599.9	599.9	TRUE	TRUE	6000	1%	0%	0.5	6.5	593.5	606.5	± 0.04 Ohm
3000	Ω	3000	3000	TRUE	TRUE	6000	1%	0%	5	35	2965	3035	± 0.1 Ohm
5400	Ω	5399	5399	TRUE	TRUE	6000	1%	0%	5	59	5341	5459	± 0.3 Ohm

DC CURRENT

Nominal	Unit	Found As	Left As	Found As Result	Left As Result	Range	% of Nominal	% of Range	Count	+ / -	Low	High	Uncertainty
60	A	59.2	59.2	TRUE	TRUE	600	2%	0%	0.5	1.7	58.30000	61.70000	± 2.2 A
300	A	299.4	299.4	TRUE	TRUE	600	2%	0%	0.5	6.5	293.50000	306.50000	± 2.2 A
540	A	539.4	539.4	TRUE	TRUE	600	2%	0%	0.5	11.3	528.70000	551.30000	± 2.2 A

AC CURRENT

Nominal	Unit	Found As	Left As	Found As Result	Left As Result	Range	% of Nominal	% of Range	Count	+ / -	Low	High	Uncertainty
60	A	59.8	59.8	TRUE	TRUE	600	2%	0%	0.5	1.7	58.30000	61.70000	± 2.2 A
300	A	299.9	299.9	TRUE	TRUE	600	2%	0%	0.5	6.5	293.50000	306.50000	± 2.2 A
540	A	539.8	539.8	TRUE	TRUE	600	2%	0%	0.5	11.3	528.70000	551.30000	± 2.2 A

CAPACITANCE

Nominal	Unit	Found As	Left As	Found As Result	Left As Result	Range	% of Nominal	% of Range	Count	+ / -	Low	High	Uncertainty
100	uF	100	100	TRUE	TRUE	1000	2%	0%	0.4	2.4	97.60	102.40	± 0.02 mF
500	uF	500	500	TRUE	TRUE	1000	2%	0%	4	14	486.00	514.00	± 0.02 mF
900	uF	900	900	TRUE	TRUE	1000	2%	0%	4	22	878.00	922.00	± 0.02 mF

END OF REPORT

Public Input No. 2861-NFPA 70-2023 [Section No. 310.3(A)]

(A) Minimum Size of Conductors.

1) The minimum size of conductors for voltage ratings up to and including 2000 volts shall be 14 AWG copper or 12 AWG aluminum or copper-clad aluminum, except as permitted elsewhere in this *Code*.

2) The minimum size of conductors shall be sufficient to limit voltage drop to five percent or less from the service point to each outlet.

Statement of Problem and Substantiation for Public Input

Voltage drop can create significant safety hazards where the voltage is insufficient to operate equipment within its required parameters.

Submitter Information Verification

Submitter Full Name:	Christel Hunter
Organization:	Cerro Wire
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Aug 25 16:31:05 EDT 2023
Committee:	NEC-P06

Public Input No. 2656-NFPA 70-2023 [Section No. 310.4]

310.4 Conductor Constructions and Applications.

Insulated conductors shall comply with Table 310.4(1) and Table 310.4(2).

Informational Note: Thermoplastic insulation may stiffen at temperatures lower than −10°C (+14°F). Thermoplastic insulation may also be deformed at normal temperatures where subjected to pressure, such as at points of support.

Table 310.4(1) Conductor Applications and Insulations Rated 600 Volts

Trade Name	Type Letter	Maximum Operating Temperature	Application Provisions	Insulation	Thickness of Insulation				
					AWG or kcmil	mm	mils		
Fluorinated ethylene propylene	FEP or FEPB	90°C (194°F)	Dry and damp locations	Fluorinated ethylene propylene	14–10	0.51	20		
					8–2	0.76	30		
		200°C (392°F)	Dry locations — special applications[2]	Fluorinated ethylene propylene	14–8	0.36	14		
					6–2	0.36	14		
Mineral insulation (metal sheathed)	MI	90°C (194°F)	Dry and wet locations	Magnesium oxide	18–16[3]	0.58	23		
					16–10	0.91	36		
		250°C (482°F)	For special applications[2]		9–4	1.27	50		
					3–500	1.40	55		
Moisture-, heat-, and oil-resistant thermoplastic	MTW	60°C (140°F)	Machine tool wiring in wet locations	Flame-retardant, moisture-, heat-, and oil-resistant thermoplastic	-		(A)	(B)	(A)
		90°C (194°F)	Machine tool wiring in dry locations.		22–12	0.76	0.38	30	15
					10	0.76	0.51	30	20
					-	8	1.14	0.76	45
			-		Informational Note: See NFPA 79-2021, *Electrical Standard for Industrial Machinery*.	6	1.52	0.76	60
			-			4–2	1.52	1.02	60
			-			1–4/0	2.03	1.27	80
			-			213–500	2.41	1.52	95
			-			501–1000	2.79	1.78	110
Paper	-		85°C (185°F)	For underground service conductors, or by special permission	Paper	-	-	-	
Perfluoro-alkoxy	PFA	90°C (194°F)	Dry and damp locations	Perfluoro-alkoxy	14–10	0.51	20		
					8–2	0.76	30		
		200°C (392°F)	Dry locations — special applications[2]		1–4/0	1.14	45		
					-	-	-		
Perfluoro-alkoxy	PFAH	250°C (482°F)	Dry locations. Only for leads within apparatus or within raceways connected to	Perfluoro-alkoxy	14–10	0.51	20		
					8–2	0.76	30		

Trade Name	**Type Letter**	**Maximum Operating Temperature**	**Application Provisions**	**Insulation**	**Thickness of Insulation**		
					AWG or kcmil	**mm**	**mils**
			apparatus (nickel or nickel-coated copper only)		1–4/0	1.14	45
Thermoset	RHH	90°C (194°F)	Dry and damp locations	-		14-10 8–2 1–4/0 213–500 501–1000 1001–2000	1.14 1.52 2.03 2.41 2.79 3.18
Moisture-resistant thermoset	RHW	75°C (167°F)	Dry and wet locations	Flame-retardant, moisture-resistant thermoset	14–10 8–2 1–4/0 213–500 501–1000 1001–2000	1.14 1.52 2.03 2.41 2.79 3.18	45 60 80 95 110 125
	RHW-2	90°C (194°F)					
Silicone	SA	90°C (194°F) 200°C (392°F)	Dry and damp locations For special application[2]	Silicone rubber	14–10 8–2 1–4/0 213–500 501–1000 1001–2000	1.14 1.52 2.03 2.41 2.79 3.18	45 60 80 95 110 125
Thermoset	SIS	90°C (194°F)	Switchboard and switchgear wiring only	Flame-retardant thermoset	14–10 8–2 1–4/0	0.76 1.14 1.40	30 45 55
Thermoplastic and fibrous outer braid	TBS	90°C (194°F)	Switchboard and switchgear wiring only	Thermoplastic	14–10 8 6–2 1–4/0	0.76 1.14 1.52 2.03	30 45 60 80
Extended polytetra-fluoro-ethylene	TFE	250°C (482°F)	Dry locations only. Only for leads within apparatus or within raceways connected to apparatus, or as open wiring (nickel or nickel-coated copper only)	Extruded polytetra-fluoroethylene	14–10 8–2 1–4/0	0.51 0.76 1.14	20 30 45
Heat-resistant thermoplastic	THHN	90°C (194°F)	Dry and damp locations	Flame-retardant, heat-resistant thermoplastic	14–12 10 8–6 4–2 1–4/0 250–500 501–1000	0.38 0.51 0.76 1.02 1.27 1.52 1.78	15 20 30 40 50 60 70

Trade Name	Type Letter	Maximum Operating Temperature	Application Provisions	Insulation	Thickness of Insulation		
					AWG or kcmil	mm	mils
Moisture- and heat-resistant thermoplastic	THHW	75°C (167°F) 90°C (194°F)	Wet location Dry location	Flame-retardant, moisture- and heat-resistant thermoplastic	14–10	0.76	30
					8	1.14	45
					6–2	1.52	60
					1–4/0	2.03	80
					213–500	2.41	95
					501–1000	2.79	110
					1001–2000	3.18	125
Moisture- and heat-resistant thermoplastic	THW	75°C (167°F) 90°C (194°F)	Dry and wet locations Special applications within electric discharge lighting equipment. Limited to 1000 open-circuit volts or less. (Size 14-8 only as permitted in 410.68.)	Flame-retardant, moisture- and heat-resistant thermoplastic	14–10	0.76	30
					8	1.14	45
					6–2	1.52	60
					1–4/0	2.03	80
					213–500	2.41	95
					501–1000	2.79	110
					1001–2000	3.18	125
	-	THW-2	90°C (194°F)	Dry and wet locations	-	-	-
Moisture- and heat-resistant thermoplastic	THWN THWN-2	75°C (167°F) 90°C (194°F)	Dry and wet locations	Flame-retardant, moisture- and heat-resistant thermoplastic	14–12	0.38	15
					10	0.51	20
					8–6	0.76	30
					4–2	1.02	40
					1–4/0	1.27	50
					250–500	1.52	60
					501–1000	1.78	70
Moisture-resistant thermoplastic	TW	60°C (140°F)	Dry and wet locations	Flame-retardant, moisture-resistant thermoplastic	14–10	0.76	30
					8	1.14	45
					6–2	1.52	60
					1–4/0	2.03	80
					213–500	2.41	95
					501–1000	2.79	110
					1001–2000	3.18	125
Underground feeder and branch-circuit cable — single conductor (for Type UF cable employing more than one conductor, see ~~Part II of~~	UF	60°C (140°F) 75°C	See ~~Part II of~~ Article 340, Part II .	Moisture-resistant Moisture- and	14–10	1.52	60[5]
					8–2	2.03	80[5]
					1–4/0	2.41	95[5]

Trade Name	Type Letter	Maximum Operating Temperature	Application Provisions	Insulation	Thickness of Insulation		
					AWG or kcmil	mm	mils
Article 340, Part II).		(167°F)[4]		heat-resistant			
Underground service-entrance cable — single conductor (for Type USE cable employing more than one conductor, see ~~Part II of~~ Article 338, Part II).	USE	75°C (167°F)[4]	See ~~Part II of~~ Article 338, Part II .	Heat- and moisture-resistant	14–10 8–2 1–4/0 213–500 501–1000 1001–2000	1.14 1.52 2.03 2.41 2.79 3.18	45 60 80 95 [6] 110 125
	USE-2	90°C (194°F)	Dry and wet locations				
Thermoset	XHH	90°C (194°F)	Dry and damp locations	Flame-retardant thermoset	14–10 8–2 1–4/0 213–500 501–1000 1001–2000	0.76 1.14 1.40 1.65 2.03 2.41	30 45 55 65 80 95
Thermoset	XHHN	90°C (194°F)	Dry and damp locations	Flame-retardant thermoset	14–12 10 8–6 4–2 1–4/0 250–500 501–1000	0.38 0.51 0.76 1.02 1.27 1.52 1.78	15 20 30 40 50 60 70
Moisture-resistant thermoset	XHHW	90°C (194°F)	Dry and damp locations	Flame-retardant, moisture-resistant thermoset	14–10 8–2 1–4/0 213–500 501–1000 1001–2000	0.76 1.14 1.40 1.65 2.03 2.41	30 45 55 65 80 95
		75°C (167°F)	Wet locations				
Moisture-resistant thermoset	XHHW-2	90°C (194°F)	Dry and wet locations	Flame-retardant, moisture-resistant thermoset	14–10 8–2 1–4/0 213–500 501–1000 1001–2000	0.76 1.14 1.40 1.65 2.03 2.41	30 45 55 65 80 95
Moisture-resistant thermoset	XHWN	75°C (167°F)	Dry and wet locations	Flame-retardant, moisture-resistant thermoset	14–12 10 8–6 4–2 1–4/0 250–500 501–1000	0.38 0.51 0.76 1.02 1.27 1.52 1.78	15 20 30 40 50 60 70
	XHWN-2	90°C (194°F)					

Trade Name	Type Letter	Maximum Operating Temperature	Application Provisions	Insulation	Thickness of Insulation		
					AWG or kcmil	mm	mils
Modified ethylene tetrafluoro-ethylene	Z	90°C (194°F)	Dry and damp locations	Modified ethylene tetrafluoro-ethylene	14–12	0.38	15
					10	0.51	20
		150°C (302°F)	Dry locations — special applications[2]		8–4	0.64	25
					3–1	0.89	35
					1/0–4/0	1.14	45
Modified ethylene tetrafluoro-ethylene	ZW	75°C (167°F)	Wet locations	Modified ethylene tetrafluoro-ethylene	14–10	0.76	30
		90°C (194°F)	Dry and damp locations				
		150°C (302°F)	Dry locations — special applications[2]		8–2	1.14	45
	ZW-2	90°C (194°F)	Dry and wet locations				

Note: Conductors in Table 310.4(1) shall be permitted to be rated up to 1000 volts if listed and marked.

[1]Outer coverings shall not be required where listed without a covering.

[2]Higher temperature rated constructions shall be permitted where design conditions require maximum conductor operating temperatures above 90°C (194°F).

[3]Conductor sizes shall be permitted for signaling circuits permitting 300-volt insulation.

[4]The ampacity of Type UF cable shall be limited in accordance with 340.80.

[5]Type UF insulation thickness shall include the integral jacket.

[6]Insulation thickness shall be permitted to be 2.03 mm (80 mils) for listed Type USE conductors that have been subjected to special investigations. The nonmetallic covering over individual rubber-covered conductors of aluminum-sheathed cable and of lead-sheathed or multiconductor cable shall not be required to be flame retardant.

Table 310.4(2) Thickness of Insulation for Nonshielded Types RHH and RHW Solid Dielectric Insulated Conductors Rated 2000 Volts

Conductor Size	-	Column A[1]		-	Column B[2]	
(AWG or kcmil)	-	mm	mils	-	mm	mils
14–10	-	2.03	80	-	1.52	60
8	-	2.03	80	-	1.78	70
6–2	-	2.41	95	-	1.78	70
1–2/0	-	2.79	110	-	2.29	90
3/0–4/0	-	2.79	110	-	2.29	90
213–500	-	3.18	125	-	2.67	105
501–1000	-	3.56	140	-	3.05	120
1001–2000	-	3.56	140	-	3.56	140

[1]Column A insulations shall be limited to natural, SBR, and butyl rubbers.

[2]Column B insulations shall be materials such as cross-linked polyethylene, ethylene propylene rubber, and composites thereof.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name:	David Williams
Organization:	Delta Charter Township
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Aug 24 08:02:22 EDT 2023
Committee:	NEC-P06

Public Input No. 1798-NFPA 70-2023 [New Section after 310.6]

TITLE OF NEW CONTENT

Type your content here ...

760.53 A.

Proposal to require power limited fire alarm cables and non-power limited fire alarm cable to be installed in a separate raceway with no other cables.

Reasoning: It is favored by the electrical inspector and the fire marshal during inspections to be able to trace the system. I believe this would also reduce the risk of damage during the installation for future cables when intermixed in the same raceway.

Additional Proposed Changes

File Name	Description	Approved
Code_Proposal_1_2026.docx	Fire Alarm Cable	

Statement of Problem and Substantiation for Public Input

This would make the inspection process easier and help to eliminate damage when other systems are modified after the fire cable has been installed.

Submitter Information Verification

Submitter Full Name: Edward Weaver
Organization: City of East Lansing
Street Address:
City:
State:
Zip:
Submittal Date: Thu Aug 03 13:45:17 EDT 2023
Committee: NEC-P06

Code Proposal

2026

Proposal to require power limited fire alarm cables and non-power limited fire alarm cable to be installed in a separate raceway with no other cables.

Reasoning: It is favored by the electrical inspector and the fire marshal during inspections to be able to trace the system. I believe this would also reduce the risk of damage during the installation for future cables when intermixed in the same raceway.

Scott Weaver

Code Panel 16

27-July 2023

Public Input No. 3062-NFPA 70-2023 [Section No. 310.6(C)]

(C) Ungrounded Conductors.

Conductors that are intended for use as ungrounded conductors <u>supplied from one nominal voltage system</u> , whether used as a single conductor or in multiconductor cables, shall be finished to be clearly distinguishable from grounded conductors and equipment grounding conductors. Distinguishing markings shall not conflict in any manner with the surface markings required by 310.8(B)(1). Branch-circuit ungrounded conductors <u>supplied from more than one nominal voltage system</u> shall be identified in accordance with 210.5(C). Feeders <u>supplied from more than one nominal voltage system</u> shall be identified in accordance with 215.12(C)

Exception: Conductor identification shall be permitted in accordance with 200.7.

Statement of Problem and Substantiation for Public Input

Adding text to inform Code users how to identify ungrounded conductors ‘supplied from one nominal voltage system’ and how to identify both branch-circuit and feeder ungrounded conductors ‘supplied from more than one nominal voltage system.’ This proposed revision correlates with public inputs submitted for 210.5(C) and 215.12(C).

Submitter Information Verification

Submitter Full Name:	Mike Holt
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Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Aug 29 10:03:44 EDT 2023
Committee:	NEC-P06

Public Input No. 3947-NFPA 70-2023 [Section No. 310.6(C)]

(C) Ungrounded Conductors.

(1) General. Conductors that are intended for use as ungrounded conductors, whether used as a single conductor or in multiconductor cables, shall be finished to be clearly distinguishable from grounded conductors and equipment grounding conductors. Distinguishing markings shall not conflict in any manner with the surface markings required by 310.8(B)(1).

(2) Branch-Circuit(s). Branch- circuit ungrounded conductors shall be identified in accordance with 210.5(C).

(3) Feeder(s). Feeders shall be identified in accordance with 215.12(C)

Exception: Conductor identification shall be permitted in accordance with 200.7.

Statement of Problem and Substantiation for Public Input

Breaking up 310.6(C) into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Sep 06 11:05:28 EDT 2023
Committee:	NEC-P06

Public Input No. 4485-NFPA 70-2023 [Section No. 310.8(A)]

(A) Required Information.

All conductors and cables shall be marked to indicate the following information, using the applicable method described in 310.8(B)

÷

Each ungrounded, grounded and grounding conductor 4 AWG and larger in size must be visibly mark at each connection point with 18 inches.

A cable type wiring method 4 AWG and larger does not require marking at the termination if it is marked on the outside of the cable visibly after installation.

(1) The maximum rated voltage.

(2) The proper type letter or letters for the type of wire or cable as specified elsewhere in this *Code*.

(3) The manufacturer's name, trademark, or other distinctive marking by which the organization responsible for the product can be readily identified.

(4) The AWG size or circular mil area.

Informational Note: See Chapter 9, Table 8, Conductor Properties, for conductor area expressed in SI units for conductor sizes specified in AWG or circular mil area.

(5) Cable assemblies where the neutral conductor is smaller than the ungrounded conductors shall be so marked.

Statement of Problem and Substantiation for Public Input

As a electrical inspector in the City of Portsmouth NH I always see conductor in panels, switchboard wireways, and large junction boxes that the marking of the conductor are not visible .
By making this change inspector can see the conductor sizes and types to see if it is code compliant.

Submitter Information Verification

Submitter Full Name: John Plourde
Organization: Portsmouth Nh City Of
Affiliation: Performance Electrical Training LLC.
Street Address:
City:
State:
Zip:

Submittal Date: Thu Sep 07 16:18:50 EDT 2023
Committee: NEC-P06

Public Input No. 254-NFPA 70-2023 [Section No. 310.10(D)]

(D) Locations Exposed to Direct Sunlight.

Insulated conductors or cables used where exposed to direct rays of the sun shall comply with one of the following:

(1) Conductors and cables shall be ~~listedas being~~ listed as being sunlight resistant.

(2) Conductors and cables shall be covered with insulating material, such as tape or sleeving, that is llisted as being sunlight resistant.

Exception: Conductors that are permitted to be bare shall not be required to comply with this requirement.

Statement of Problem and Substantiation for Public Input

Add an exception allowing conductors that could otherwise be bare to be excluded from this requirement. I know installers who were told by the AHJ to install bare grounding electrode conductors or strip the installation off of the GEC because the green insulation on the GEC is not sunlight resistant. This concern about sunlight damage to the insulation should be irrelevant since these conductors don't even need any insulation in the first place!

Submitter Information Verification

Submitter Full Name: Russ Leblanc
Organization: Leblanc Consulting Services
Street Address:
City:
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Zip:
Submittal Date: Tue Jan 31 14:29:26 EST 2023
Committee: NEC-P06

Public Input No. 2621-NFPA 70-2023 [New Section after 310.10(G)]

310.10(H) **Conductors in Loop Circuit.**

(1) General. Aluminum, copper-clad aluminum, or copper circuit conductors for each ungrounded conductor, grounded conductor, or neutral conductor shall be permitted to connected in a loop with each ungrounded conductor connected together at each end to the same overcurrent protection device (pole) and the grounded or neutral conductor connected together at each end. The overcurrent protective device shall be sized to protect a single conductor, not the sum of the ampacity of both conductors in a loop .

(2) Separate Cables or Raceways. Where run in separate cables or raceways, at any point in a loop circuit a minimum set of conductors (the ungrounded, grounded and equipment grounding conductors) shall be run in the same cable or raceway. All the loop conductors may be run in the same cable or raceway. The loop circuit can be run in a series of different cables or raceways at different points in the circuit.

(3) Ampacity Correction or Adjustment. Conductors installed in ring circuits shall comply with 310.15(B) and (C).

(4) Equipment Grounding Conductors. An equipment grounding conductor associated with a loop circuit shall be connected at both ends. [1]

(5) Multi-Wire Branch Circuit, A MWBC can be implemented using loop circuit conductors.

(6) Loop Conductors Connected in Parallel. Loop conductors are not parallel conductors. Individual current-carrying conductors in a loop circuit may be connected in parallel to form a single loop conductor. 310.10(G) applies to these conductors.

> Informational Note: The purpose of the loop circuit is to provide two conductor paths to one or more loads connected to the circuit, reducing voltage drop in a more economical way than simply up-sizing the conductors. The combination of MWBC and loop circuits offer even lower voltage drop potential.

1 In general only a single EGC is required for a raceway or cable as long as it meets the minium size for the largest current-carrying conductor no matter how many CCCs are present. However EGCs associated with CCCs that are up-sized for voltage drop purposes need to be up-sized as well. Which rule should we use?

Statement of Problem and Substantiation for Public Input

See 2642 which is part of this submission

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2642-NFPA 70-2023 [New Section after 310.15(C)(1)]	additional rule of loop circuits

Submitter Information Verification

Submitter Full Name:	James WILLIAMS
Organization:	Retired Master Electrician
Affiliation:	Member of IAEI, not representing IAEI
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 23 20:51:38 EDT 2023
Committee:	NEC-P06

Public Input No. 2201-NFPA 70-2023 [Section No. 310.10(G)(3)]

(3) Separate Cables or Raceways.

(A) Cable or Raceways. Where run in separate cables or raceways, the cables or raceways with conductors shall have the same number of conductors and the cables or raceways shall have the same electrical characteristics.

(B) Conductors. Conductors composing one paralleled set shall not be required to have the same physical characteristics as those of another paralleled set.

Statement of Problem and Substantiation for Public Input

Formatted this rule into two second level subdivisions to make it clear for Code users that this single paragraph contains multiple requirements. In accordance with NEC Style Manual section 3.5.1.2 multiple requirements within a single subdivision shall be avoided. Additional subdivisions or lists shall be used to express independent requirements.
Adding ''cables and raceways'' to this requirement will make it clear it's the cable or raceway that is required to have the same electrical characteristics and not the conductors.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Aug 14 14:17:52 EDT 2023
Committee:	NEC-P06

Public Input No. 3868-NFPA 70-2023 [New Section after 310.10(G)(4)]

(5) Neutral Conductors

Paralleled Neutral conductors shall be permitted to be smaller than 1/0 but in no case are they permitted to be smaller that that which is required by Table 250.102(C)(1).

Statement of Problem and Substantiation for Public Input

1/0 conductors are rated at 150 amps, per Table 310.16. Oftentimes, in a larger service with multiple conductors per phase, the combination of 1/0 Neutrals far exceed the calculated Neutral load.

Submitter Information Verification

Submitter Full Name:	Eric Stromberg
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Affiliation:	Self
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City:	
State:	
Zip:	
Submittal Date:	Tue Sep 05 21:38:42 EDT 2023
Committee:	NEC-P06

Public Input No. 648-NFPA 70-2023 [New Section after 310.12]

310.12 (E)

(1) The conductors as determined in Table 310.12 with no adjustment corrections shall be permitted to meet the requirements of 240.4.

(2) The conductors as determined in 310.12 (A) and (B) with adjustment corrections shall be permitted to meet the requirements of 240.4.

(3) Calculated loads shall be permitted to be applied up to the Service or Feeder Ratings as shown in Table 310.12 or as calculated in 310.12 (A) or (B) after correction factors have been applied.

310.12 Informational Note.

See 240.4(G) for Overcurrent Protection for Specific Conductor Applications.

240.4 (G) Single Phase Dwelling Services and Feeders as calculated in 310.12.

Statement of Problem and Substantiation for Public Input

310.12 intends to acknowledge that Residential Services should be considered differently than other loads due to diversification and lack of simultaneous loads. With or without correction factors being applied, the conductors permitted in 310.12 do not meet the requirements of 240.4. Therefore, a section should be added to 240.4 (G) called Single Phase Dwelling Services and Feeders as calculated in 310.12. An Informational Note in 310.12 should be added referring the reader to 240.4 (G). It should be made clear that for example, a 400 amp service being fed with #400 is permitted to serve a calculated load of 400 amps. It is not necessary to increase the wire size above #400 to meet the 400 amp calculated load. Note that there is no continuous loads for residential services since the maximum load can never be on for more than 3 hours per the definition of continuous load. Therefore, the overcurrent device is permitted to serve 100% of the non-continuous load.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 649-NFPA 70-2023 [New Section after 240.4]	
Public Input No. 651-NFPA 70-2023 [New Section after 310.12]	

Submitter Information Verification

Submitter Full Name:	Gabe Kaprelian
Organization:	GK Electric
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Apr 17 15:11:36 EDT 2023
Committee:	NEC-P06

Public Input No. 651-NFPA 70-2023 [New Section after 310.12]

Add Informational Note that corresponds with the commentary found in 2020 NEC Handbook after 240.4 (B) (3):

"Section 310.12 permits the conductor types and sizes specified in that section to supply calculated loads based on the ratings specified.

The Service and main power feeder loads permitted to be supplied by the conductor types and sizes exceed the conductor ampacities for the same conductor types and sizes specified in Table 310.16.

The overcurrent protection for these residential supply conductors is also permitted to be based on the increased rating allowed by 310.12. The increased ratings are based on the significant diversity inherent to most dwelling unit loads and the fact that only the two ungrounded service or feeder conductors are considered to be current carrying".

Statement of Problem and Substantiation for Public Input

310.12 does not make it clear that the calculated loads, conductor types and sizes plus overcurrent protection as shown in this section override the requirements in 240.4 and 310.16. Adding the informational note that the 2020 NEC Handbook deemed relevant would clarify.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 648-NFPA 70-2023 [New Section after 310.12]	supportive

Submitter Information Verification

Submitter Full Name: Gabe Kaprelian
Organization: GK Electric
Street Address:
City:
State:
Zip:

Submittal Date: Tue Apr 18 12:41:49 EDT 2023
Committee: NEC-P06

Public Input No. 1038-NFPA 70-2023 [Section No. 310.12]

310.12 Single-Phase Dwelling Services and Feeders.

For one-family dwellings and the individual dwelling units of two-family ~~and~~ , townhouses with an approved firewall from the basement or slab to the bottom of the roof, and multifamily dwellings, service and feeder conductors supplied by a single-phase, 120/240-volt system shall be permitted to be sized in accordance with 310.12(A) through (D).

For one-family dwellings and the individual dwelling units of two-family, townhouse and multifamily dwellings, single-phase feeder conductors consisting of two ungrounded conductors and the neutral conductor from a 208Y/120 volt system shall be permitted to be sized in accordance with 310.12(A) through (C).

In townhouses the service, feeder or branch circuit conductors shall not pass thru another unit to feed another dwelling unit thru a rated fire wall.

(A) Services.

For a service rated 100 amperes through 400 amperes, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83 percent of the service rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied.

Table 310.12(A) Single-Phase Dwelling Services and Feeders

Service or Feeder Rating (Amperes)	-	Conductor (AWG or kcmil)
	Copper	**Aluminum or Copper-Clad Aluminum**
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
~~350~~ ownhouseu another talled thr shall not be inst350	350	500
400	400	600

Note: If no adjustment or correction factors are required, this table shall be permitted to be applied.

(B) Feeders.

For a feeder rated 100 amperes through 400 amperes, the feeder conductors supplying the entire load associated with a one-family dwelling, or the feeder conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83 percent of the feeder rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied.

(C) Feeder Ampacities.

In no case shall a feeder for an individual dwelling unit be required to have an ampacity greater than that specified in 310.12(A) or (B).

(D) Grounded Conductors.

Grounded conductors shall be permitted to be sized smaller than the ungrounded conductors, if the requirements of 220.61 and 230.42 for service conductors or the requirements of 215.2 and 220.61 for feeder conductors are met.

Where correction or adjustment factors are required by 310.15(B) or (C), they shall be permitted to be applied to the ampacity associated with the temperature rating of the conductor.

Informational Note No. 1: See 240.6(A) for standard ampere ratings for fuses and inverse time circuit breakers.

Informational Note No. 2: See Informative Annex D, Example D7.

Statement of Problem and Substantiation for Public Input

If a building is a 12 unit townhouse and the building code required a fire rating from the concrete floor to the underside of the roof structure for each unit, Cable should not be installed thru another unit exposed or behind a barrier of sheetrock.
Unit 1 of 12 will have 12 cables thru that unit.
If that person want to remodel there unit, they should not have to deal with 11 cables.
The mechanical, and plumbing code does not allow plumbing, drainage or water between units.
The electrical industry should not allow this installation to continue in the NEC

Submitter Information Verification

Submitter Full Name:	John Plourde
Organization:	Portsmouth Nh City Of
Affiliation:	Performance Electrical Training LLC.
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Jun 12 14:17:26 EDT 2023
Committee:	NEC-P06

Public Input No. 884-NFPA 70-2023 [Section No. 310.12]

310.12 Single-Phase Dwelling Services and Feeders.

For one-family dwellings and the individual dwelling units of two-family and multifamily dwellings, service and feeder conductors supplied by a single-phase, 120/240-volt system shall be permitted to be sized in accordance with 310.12(A) through (D).

For one-family dwellings and the individual dwelling units of two-family and multifamily dwellings, single-phase feeder conductors consisting of two ungrounded conductors and the neutral conductor from a 208Y/120 volt system shall be permitted to be sized in accordance with 310.12(A) through (C).

Where correction or adjustment factors are required by 310.15 (B) or (C), they shall be permitted to be applied to the ampacity associated with the temperature rating of the conductor.

(A) Services.

For a service rated 100 amperes through 400 amperes, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83 percent of the service rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied.

Table 310.12(A) Single-Phase Dwelling Services and Feeders

Service or Feeder Rating (Amperes)	Conductor (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600

Note: If no adjustment or correction factors are required, this table shall be permitted to be applied.

(B) Feeders.

For a feeder rated 100 amperes through 400 amperes, the feeder conductors supplying the entire load associated with a one-family dwelling, or the feeder conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83 percent of the feeder rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied.

(C) Feeder Ampacities.

In no case shall a feeder for an individual dwelling unit be required to have an ampacity greater than that specified in 310.12(A) or (B).

(D) Grounded Conductors.

Grounded conductors shall be permitted to be sized smaller than the ungrounded conductors, if the requirements of 220.61 and 230.42 for service conductors or the requirements of 215.2 and 220.61 for feeder conductors are met.

~~Where correction or adjustment factors are required by 310.15(B) or (C), they shall be permitted to be applied to the ampacity associated with the temperature rating of the conductor.~~

Informational Note No. 1: See 240.6(A) for standard ampere ratings for fuses and inverse time circuit breakers.

Informational Note No. 2: See Informative Annex D , Example D7.

Statement of Problem and Substantiation for Public Input

This PI seeks to relocate text from (D) to the parent language of 310.12. As currently written, the language regarding temperature correction and ampacity adjustment apply only to the grounded conductor(s).

Submitter Information Verification

Submitter Full Name: Ryan Jackson
Organization: Self-employed
Street Address:
City:
State:
Zip:
Submittal Date: Wed May 24 11:21:12 EDT 2023
Committee: NEC-P06

Public Input No. 2175-NFPA 70-2023 [Section No. 310.12(A)]

(A) Services.

For a service rated 100 amperes through 400 amperes, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83 percent of the service rating. If no adjustment or correction factors (add clarity and/or an Informational Note if voltage drop calculations negate the use of Table 310.12.) are required, Table 310.12(A) shall be permitted to be applied.

Table 310.12(A) Single-Phase Dwelling Services and Feeders

Service or Feeder Rating (Amperes)	Conductor (AWG or kcmil) Copper	Aluminum or Copper-Clad Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600

Note: If no adjustment or correction factors are required, this table shall be permitted to be applied.

Statement of Problem and Substantiation for Public Input

310.12 (A) - to lessen ambiguity add clarity and/or an Informational Note if voltage drop calculations negate the use of Table 310.12.

Submitter Information Verification

Submitter Full Name: Gary Hein
Organization: [Not Specified]
Street Address:
City:
State:
Zip:

Submittal Date: Mon Aug 14 12:23:25 EDT 2023
Committee: NEC-P06

Public Input No. 447-NFPA 70-2023 [Section No. 310.12(A)]

(A) Services.

For a service rated 100 amperes through 400 amperes, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83 percent of the service rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied.

Table 310.12(A) Single-Phase Dwelling Services and Feeders

-

For Conductors Not Limited to 60C Ampacity

Service or Feeder Rating (Amperes)	Conductor (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600

Note: If no adjustment or correction factors are required, this table shall be permitted to be applied.

Statement of Problem and Substantiation for Public Input

As currently written, Table 310.12 would allow #4 NM cable to be utilized for a 100A feeder "supplying the entire load associated with a one-family dwelling," since there is no restriction on the wiring method mentioned. However, the ampacity of #4 NM cable is limited to 70A per 334.80, so this would provide a ratio of ampacity to rating of 70%, much less than the 83% specified in section 310.12.

Thus it is my understanding that the use of Table 310.12 is intended to be limited to wiring methods that can make use of the 75C ampacity columns in Tables 310.16 et al. Therefore that restriction needs to be placed on Table 310.12. Since multiple paragraphs refer to Table 310.12, putting the restriction in the table heading seems simplest.

Submitter Information Verification

Submitter Full Name: Wayne Whitney
Organization: [Not Specified]
Street Address:
City:
State:

Zip:	
Submittal Date:	Mon Mar 13 15:14:51 EDT 2023
Committee:	NEC-P06

Public Input No. 742-NFPA 70-2023 [Sections 310.12(A), 310.12(B)]

Sections 310.12(A), 310.12(B)

(A) Services.

~~For a service rated 100 amperes through 400 amperes, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall~~ Any service shall not be permitted to have an ~~ampacity not less~~ ampacity less than ~~83 percent~~ 100 percent of the service rating. ~~If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied.~~

~~Table 310.12~~

(

~~A) Single-Phase Dwelling Services and Feeders - Conductor~~

~~(AWG or kcmil) Service or Feeder Rating~~

~~(Amperes) Copper Aluminum or Copper-Clad Aluminum 100 4 2 110 3 1 125 2 1/0 150 1 2/0 175 1 /0 3/0 200 2/0 4/0 225 3/0 250 250 4/0 300 300 250 350 350 350 500 400 400 600~~

~~Note: If no adjustment or correction factors are required, this table shall be permitted to be applied.~~

~~(~~B) Feeders.

~~For a feeder rated 100 amperes through 400 amperes, the feeder~~ Any feeder conductors supplying the entire load associated with a one-family dwelling ~~, or the feeder conductors supplying the~~ or the entire load associated with an individual dwelling unit in a two-family or multifamily ~~dwelling, shall~~ dwelling shall not be permitted to have an ~~ampacity not less~~ ampacity less than ~~83 percent~~ 100 percent of the feeder rating. ~~If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied.~~

Statement of Problem and Substantiation for Public Input

One would argue that having a service or whole-dwelling feeder being loaded to above 83% of its rating for 3+ hours is rare, so allowing the ampacity to be less than the rating (presumably to prevent nuisance tripping) is essentially safe. However, in the rare case that it is continuously loaded to substantially above 83% but below 100% of the circuit rating, the main breaker of the service or whole-dwelling feeder will not trip, which would lead to overheating.

Using the same logic, I argue that it would be rare in the first place for the main breaker to trip if it were set to the ampacity (consequently setting the overall circuit rating) rather than 120% (100%/83.333%) of the ampacity. Because of trip curves, even if the breaker were set exactly to ampacity, the breaker would not trip even if the current exceeded 120% of the ampacity by a substantial but not huge margin for a short time (such as under 30 minutes). As a result, save for allowing the next higher standard OCPD size, the setting of an OCPD should never be allowed to be higher than the ampacity of the conductors being protected.

Also, 240.4 does not give an exception to single-phase dwelling services and feeders by not listing 310.12 in 240.4(G). Furthermore, none of the following among 215.2, 215.3, 225.5, 225.50, 230.23(A), and 230.31(A) give an exception to 310.12. This makes 310.12 in direct contradiction with 240.4, 215.2, 215.3, 225.5, 225.50, 230.23, and 230.31 because Chapter 3 is not part of the grouping that "supplements or modifies chapters 1 through 7" as given in Figure 90.3. As a result, Chapter 3 is not allowed to modify other Chapters within the grouping of "Applies generally to all electrical installations", of which itself is within that grouping.

Submitter Information Verification

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Submittal Date:	Wed Apr 26 03:44:30 EDT 2023
Committee:	NEC-P06

Public Input No. 2176-NFPA 70-2023 [Section No. 310.12(B)]

(B) Feeders.

For a feeder rated 100 amperes through 400 amperes, the feeder conductors supplying the entire load associated with a one-family dwelling, or the feeder conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83 percent of the feeder rating. If no adjustment or correction factors (add clarity and/or an Informational Note if voltage drop calculations negate the use of Table 310.12) are required, Table 310.12(A) shall be permitted to be applied.

Statement of Problem and Substantiation for Public Input

310.12 (B) - to lessen ambiguity add clarity and/or an Informational Note if voltage drop calculations negate the use of Table 310.12.

Submitter Information Verification

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Submittal Date:	Mon Aug 14 12:26:41 EDT 2023
Committee:	NEC-P06

Public Input No. 4123-NFPA 70-2023 [Section No. 310.12(B)]

(B) Feeders.

For a feeder rated 100 amperes through 400 amperes, the feeder conductors supplying ~~the entire~~ a load associated with a one-family dwelling, or the feeder conductors supplying ~~the entire load~~ a load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83 percent of the feeder rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied.

Statement of Problem and Substantiation for Public Input

Section 225.30 allows more than one feeder to a building or structure. The text “the entire load” is confusing and in conflict with allowing more than one feeder to a building. The calculation for the feeder would be in accordance with Article 220 Part III and the feeder would be sized for the entire load supplied and not the entire load for the building or structure.

Typically in services over 200 amps, two feeders are installed. Loads in dwelling units have been significantly reduced by the use of LED lighting and high efficiency appliances.

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City:

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Submittal Date: Wed Sep 06 17:15:30 EDT 2023

Committee: NEC-P06

Public Input No. 2312-NFPA 70-2023 [Section No. 310.12 [Excluding any Sub-Sections]]

For one-family dwellings and the individual dwelling units of two-family and multifamily dwellings, service and feeder conductors supplied by a single-phase, 120/240-volt system shall be permitted to be sized in accordance with 310.12(A) through (D).

For one-family dwellings and the individual dwelling units of two-family and multifamily dwellings, single-phase feeder conductors consisting of two ungrounded conductors and the neutral conductor from a 208Y/120 volt system shall be permitted to be sized in accordance with 310.12(A) through (~~C~~ D).

Statement of Problem and Substantiation for Public Input

Adding subdivision (D) would give Code users guidance on how to properly size the neutral. There is no reason why to exclude (D) from 310.12 because it simply refers us to 220.61 for how to size the neutral,

Submitter Information Verification

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Submittal Date: Tue Aug 15 20:53:15 EDT 2023
Committee: NEC-P06

Public Input No. 749-NFPA 70-2023 [Section No. 310.14(A)(2)]

(2) Selection of Ampacity.

Where more than one ampacity applies for a given circuit length, the lowest value shall be used.

Exception: Where different ampacities <u>resulting from ampacity adjustment and/or correction</u> apply to portions of a circuit, the higher ampacity shall be permitted to be used if the total portion(s) of the circuit with lower ampacity does not exceed the lesser of 3.0 m (10 ft) or 10 percent of the total circuit.

Informational Note: See 110.14(C) for conductor temperature limitations due to termination provisions.

Statement of Problem and Substantiation for Public Input

Different ampacities can result from a variety of differences: different ambient temperature, a different number of current carrying conductors, a change in conductor material, or a change in conductor size. To my understanding, this exception is intended only for the first two reasons, a change in the ampacity adjustment or correction along the length of a circuit. The proposed language makes it clear that changing conductor size or conductor material is not covered by the exception.

Without this change, a change in conductor size could reasonably be considered to be covered by the exception. So for example 10' of #8 Cu conductor could be inserted into a 100' long 125A feeder, and the exception as currently worded would allow the use of the higher 125A ampacity for the entire circuit.

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Submittal Date:	Thu Apr 27 12:48:50 EDT 2023
Committee:	NEC-P06

Public Input No. 993-NFPA 70-2023 [Section No. 310.14(A)(3)]

(3) Temperature Limitation of Conductors.

No conductor shall be used in such a manner that its operating temperature exceeds that designated for the type of insulated conductor involved. In no case shall conductors be associated together in such a way, with respect to type of circuit, the wiring method employed, or the number of conductors, that the limiting temperature of any conductor is exceeded.

Informational Note No. 1: See Table 310.4(1) and Table 315.10(A) for the temperature rating of a conductor that is the maximum temperature, at any location along its length, that the conductor can withstand over a prolonged time period without serious degradation. The ampacity tables of ~~Article 310~~ this article and the ampacity tables of Informative Annex B, the ambient temperature correction factors in 310.15(B), and the notes to the tables provide guidance for coordinating conductor sizes, types, ampacities, ambient temperatures, and number of associated conductors. The principal determinants of operating temperature are as follows:

(1) Ambient temperature — ambient temperature may vary along the conductor length as well as from time to time.

(2) Heat generated internally in the conductor as the result of load current flow, including fundamental and harmonic currents.

(3) The rate at which generated heat dissipates into the ambient medium. Thermal insulation that covers or surrounds conductors affects the rate of heat dissipation.

(4) Adjacent load-carrying conductors — adjacent conductors have the dual effect of raising the ambient temperature and impeding heat dissipation.

Informational Note No. 2: Refer to 110.14(C) for the temperature limitation of terminations.

Statement of Problem and Substantiation for Public Input

Section 4.1.4 of the NEC(r) Style Manual prohibits referencing an entire article except Article 100 or where required for context. As such, it is recommended to revise this informational note as shown for compliance and to improve usability of the Code.

Submitter Information Verification

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Submittal Date: Thu Jun 08 13:07:27 EDT 2023

Committee: NEC-P06

Public Input No. 2466-NFPA 70-2023 [Section No. 310.15(A)]

(A) General.

Ampacities for conductors rated 0 volts to 2000 volts shall be as specified in the Ampacity Table 310.16 through Table 310.21, as modified by 310.15(A) through (F) and 310.12. Under engineering supervision, ampacities of sizes not shown in ampacity tables for conductors meeting the general wiring requirements shall be permitted to be determined by interpolation of the adjacent conductors based on the conductor's circular-mil area.

~~The temperature correction and adjustment factors shall be permitted to be applied to the ampacity for the temperature rating of the conductor, if the corrected and adjusted ampacity does not exceed the ampacity for the temperature rating of the termination in accordance with 110.14(C) .~~

Informational Note No. 1: Table 310.16 through Table 310.19 are application tables for use in determining conductor sizes on loads calculated in accordance with Part II, Part III, Part IV, or Part V of Article 220. Ampacities result from consideration of one or more of the following:

(1) Temperature compatibility with connected equipment, especially the connection points

(2) Coordination with circuit and system overcurrent protection

(3) Compliance with the requirements of product listings or certifications.

(4) Preservation of the safety benefits of established industry practices and standardized procedures

Informational Note No. 2: See Chapter 9, Table 8, Conductor Properties, for conductor area. Interpolation is based on the conductor circular-mil area and not the conductor overall area.

Informational Note No. 3: See 400.5 for the ampacities of flexible cords and cables. See 402.5 for the ampacities of fixture wires.

Informational Note No. 4: See Table 310.4(1) and Table 310.4(2) for explanation of type letters used in tables and for recognized sizes of conductors for the various conductor insulations. See 310.1 through 310.14 and the various articles of this *Code* for installation requirements. See Table 400.4, Table 400.5(A)(1), and Table 400.5(A)(2) for flexible cords.

Statement of Problem and Substantiation for Public Input

This requirement makes no technical sense, if you calculate ampacity there is a high likely hood of the corrected or adjusted ampacity exceeds the ampacity of the temperature rating of the termination based on 110.14(C). Other requirements such as 210.19, 215.2 & 230.42 cover this already and there is no need to have it here. 110.14(C) has to do with conductor sizing based on selecting a conductor from Table 310.16 and has nothing to do with ampacity calculations.

Submitter Information Verification

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City:

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Submittal Date: Thu Aug 17 13:59:55 EDT 2023

Committee: NEC-P06

Public Input No. 2657-NFPA 70-2023 [Section No. 310.15(A)]

(A) General.

Ampacities for conductors rated 0 volts to 2000 volts shall be as specified in the Ampacity Table 310.16 through Table 310.21, as modified by 310.15(A) through (F) and 310.12. Under engineering supervision, ampacities of sizes not shown in ampacity tables for conductors meeting the general wiring requirements shall be permitted to be determined by interpolation of the adjacent conductors based on the conductor's circular-mil area.

The temperature correction and adjustment factors shall be permitted to be applied to the ampacity for the temperature rating of the conductor, if the corrected and adjusted ampacity does not exceed the ampacity for the temperature rating of the termination in accordance with 110.14(C).

Informational Note No. 1: Table 310.16 through Table 310.19 are application tables for use in determining conductor sizes on loads calculated in accordance with Article 220, Part II, Part III, Part IV, or Part V ~~of Article 220~~ . Ampacities result from consideration of one or more of the following:

(1) Temperature compatibility with connected equipment, especially the connection points

(2) Coordination with circuit and system overcurrent protection

(3) Compliance with the requirements of product listings or certifications.

(4) Preservation of the safety benefits of established industry practices and standardized procedures

Informational Note No. 2: See Chapter 9, Table 8, Conductor Properties, for conductor area. Interpolation is based on the conductor circular-mil area and not the conductor overall area.

Informational Note No. 3: See 400.5 for the ampacities of flexible cords and cables. See 402.5 for the ampacities of fixture wires.

Informational Note No. 4: See Table 310.4(1) and Table 310.4(2) for explanation of type letters used in tables and for recognized sizes of conductors for the various conductor insulations. See 310.1 through 310.14 and the various articles of this *Code* for installation requirements. See Table 400.4, Table 400.5(A)(1), and Table 400.5(A)(2) for flexible cords.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Submittal Date: Thu Aug 24 08:05:17 EDT 2023
Committee: NEC-P06

Public Input No. 450-NFPA 70-2023 [Section No. 310.15(A)]

(A) General.

Ampacities for conductors rated 0 volts to 2000 volts shall be as specified in the Ampacity Table 310.16 through Table 310.21, as modified by 310.15(A) through (F) and 310.12. Under engineering supervision, ampacities of sizes not shown in ampacity tables for conductors meeting the general wiring requirements shall be permitted to be determined by interpolation of the adjacent conductors based on the conductor's circular-mil area.

The temperature correction and adjustment factors shall be permitted to be applied to the ampacity for the temperature rating of the conductor, ~~if the corrected and adjusted ampacity does~~ but the resulting ampacity may not exceed the ~~ampacity for~~ ampacity before adjustment and correction factors for the temperature rating of the termination in accordance with 110.14(C).

Informational Note No. 1: Table 310.16 through Table 310.19 are application tables for use in determining conductor sizes on loads calculated in accordance with Part II, Part III, Part IV, or Part V of Article 220. Ampacities result from consideration of one or more of the following:

(1) Temperature compatibility with connected equipment, especially the connection points

(2) Coordination with circuit and system overcurrent protection

(3) Compliance with the requirements of product listings or certifications.

(4) Preservation of the safety benefits of established industry practices and standardized procedures

Informational Note No. 2: See Chapter 9, Table 8, Conductor Properties, for conductor area. Interpolation is based on the conductor circular-mil area and not the conductor overall area.

Informational Note No. 3: See 400.5 for the ampacities of flexible cords and cables. See 402.5 for the ampacities of fixture wires.

Informational Note No. 4: See Table 310.4(1) and Table 310.4(2) for explanation of type letters used in tables and for recognized sizes of conductors for the various conductor insulations. See 310.1 through 310.14 and the various articles of this *Code* for installation requirements. See Table 400.4, Table 400.5(A)(1), and Table 400.5(A)(2) for flexible cords.

Statement of Problem and Substantiation for Public Input

This proposal seeks to improve the clarity of meaning of this part of 310.15(A). The current language is open to the following misinterpretation from an overly literal reading:

"First you look up the unadjusted and uncorrected ampacity at the termination temperature rating, call that A. Then you take the tabular ampacity at the insulation temperature rating and apply the adjustment and correction factors, call that B. If B > A, you can't use the insulation temperature tabular ampacity, so you need to apply the adjustment and correction factors to A to get the ampacity."

Since the intention is that the ampacity is just the minimum of A and B, as shown in Annex D Example D3(a) in the section "Ungrounded Feeder Conductors," the proposed language more clearly reflects the intention and precludes the above misinterpretation.

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Submittal Date: Tue Mar 14 12:36:53 EDT 2023

Committee: NEC-P06

Public Input No. 1309-NFPA 70-2023 [Section No. 310.15(B)(2)]

(2) Rooftop.

(1) For raceways or cables exposed to direct sunlight on or above rooftops where the distance above the roof to the bottom of the raceway or cable is less than 19 mm (3/4 in.), a temperature adder of

~~33°C~~

(1) **16°C (**

~~60°F~~

(1) **60.8°F)** shall be added to the outdoor temperature to determine the applicable ambient temperature for application of the correction factors in Table 310.15(B)(1)(1) or Table 310.15(B)(1)(2) .

Exception: Type XHHW-2 insulated conductors shall not be subject to this ampacity adjustment.

Informational Note: The *ASHRAE Handbook — Fundamentals* is one source for the ambient temperatures in various locations.

Table 310.15(B)(1)(1) Ambient Temperature Correction Factors Based on 30°C (86°F)

For ambient temperatures other than 30°C (86°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	**Temperature Rating of Conductor**			**Ambient Temperature (°F)**
	60°C	**75°C**	**90°C**	
10 or less	1.29	1.20	1.15	50 or less
11–15	1.22	1.15	1.12	51–59
16–20	1.15	1.11	1.08	60–68
21–25	1.08	1.05	1.04	69–77
26–30	1.00	1.00	1.00	78–86
31–35	0.91	0.94	0.96	87–95
36–40	0.82	0.88	0.91	96–104
41–45	0.71	0.82	0.87	105–113
46–50	0.58	0.75	0.82	114–122
51–55	0.41	0.67	0.76	123–131
56–60	—	0.58	0.71	132–140
61–65	—	0.47	0.65	141–149
66–70	—	0.33	0.58	150–158
71–75	—	—	0.50	159–167
76–80	—	—	0.41	168–176
81–85	—	—	0.29	177–185

Note: Table 310.15(B)(1)(1) shall be used with Table 310.16 and Table 310.17 as required.

Table 310.15(B)(1)(2) Ambient Temperature Correction Factors Based on 40ºC (104ºF)

For ambient temperatures other than 40°C (104°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	**Temperature Rating of Conductor**						**Ambient Temperature (°F)**
	60°C	**75°C**	**90°C**	**150°C**	**200°C**	**250°C**	
10 or less	1.58	1.36	1.26	1.13	1.09	1.07	50 or less
11–15	1.50	1.31	1.22	1.11	1.08	1.06	51–59
16–20	1.41	1.25	1.18	1.09	1.06	1.05	60–68
21–25	1.32	1.2	1.14	1.07	1.05	1.04	69–77
26–30	1.22	1.13	1.10	1.04	1.03	1.02	78–86

For ambient temperatures other than 40°C (104°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	Temperature Rating of Conductor						Ambient Temperature (°F)
	60°C	75°C	90°C	150°C	200°C	250°C	
31–35	1.12	1.07	1.05	1.02	1.02	1.01	87–95
36–40	1.00	1.00	1.00	1.00	1.00	1.00	96–104
41–45	0.87	0.93	0.95	0.98	0.98	0.99	105–113
46–50	0.71	0.85	0.89	0.95	0.97	0.98	114–122
51–55	0.50	0.76	0.84	0.93	0.95	0.96	123–131
56–60	—	0.65	0.77	0.90	0.94	0.95	132–140
61–65	—	0.53	0.71	0.88	0.92	0.94	141–149
66–70	—	0.38	0.63	0.85	0.90	0.93	150–158
71–75	—	—	0.55	0.83	0.88	0.91	159–167
76–80	—	—	0.45	0.80	0.87	0.90	168–176
81–90	—	—	—	0.74	0.83	0.87	177–194
91–100	—	—	—	0.67	0.79	0.85	195–212
101–110	—	—	—	0.60	0.75	0.82	213–230
111–120	—	—	—	0.52	0.71	0.79	231–248
121–130	—	—	—	0.43	0.66	0.76	249–266
131–140	—	—	—	0.30	0.61	0.72	267–284
141–160	—	—	—	—	0.50	0.65	285–320
161–180	—	—	—	—	0.35	0.58	321–356
181–200	—	—	—	—	—	0.49	357–392
201–225	—	—	—	—	—	0.35	393–437

Note: Table 310.15(B)(1)(2) shall be used with Table 310.18, Table 310.19, Table 310.20, and Table 310.21 as required.

Statement of Problem and Substantiation for Public Input

33 degrees Celsius converts to 91.4 degrees Fahrenheit, not 60 degrees Fahrenheit.
16 degrees Celsius converts to 60.8 degrees Fahrenheit:
16°C×9/5+32 = 60.8°F

Submitter Information Verification

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Submittal Date: Fri Jul 07 17:03:25 EDT 2023
Committee: NEC-P06

Public Input No. 960-NFPA 70-2023 [Section No. 310.15(B)(2)]

(2) Rooftop.

For raceways or cables exposed to direct sunlight on or above rooftops where the distance above the roof to the bottom of the raceway or cable is less than 19 mm (¾ in.), a temperature adder of 33°C (60°F) shall be added to the outdoor temperature to determine the applicable ambient temperature for application of the correction factors in Table 310.15(B)(1)(1) or Table 310.15(B)(1)(2).

Exception: Type XHHW-2 insulated conductors shall not be subject to this ~~ampacity adjustment~~ ampacity correction .

Informational Note: The *ASHRAE Handbook — Fundamentals* is one source for the ambient temperatures in various locations.

Table 310.15(B)(1)(1) Ambient Temperature Correction Factors Based on 30°C (86°F)

For ambient temperatures other than 30°C (86°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.				
Ambient Temperature (°C)	Temperature Rating of Conductor			Ambient Temperature (°F)
	60°C	75°C	90°C	
10 or less	1.29	1.20	1.15	50 or less
11–15	1.22	1.15	1.12	51–59
16–20	1.15	1.11	1.08	60–68
21–25	1.08	1.05	1.04	69–77
26–30	1.00	1.00	1.00	78–86
31–35	0.91	0.94	0.96	87–95
36–40	0.82	0.88	0.91	96–104
41–45	0.71	0.82	0.87	105–113
46–50	0.58	0.75	0.82	114–122
51–55	0.41	0.67	0.76	123–131
56–60	—	0.58	0.71	132–140
61–65	—	0.47	0.65	141–149
66–70	—	0.33	0.58	150–158
71–75	—	—	0.50	159–167
76–80	—	—	0.41	168–176
81–85	—	—	0.29	177–185

Note: Table 310.15(B)(1)(1) shall be used with Table 310.16 and Table 310.17 as required.

Table 310.15(B)(1)(2) Ambient Temperature Correction Factors Based on 40ºC (104ºF)

For ambient temperatures other than 40°C (104°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.							
Ambient Temperature (°C)	Temperature Rating of Conductor						Ambient Temperature (ºF)
	60°C	75°C	90°C	150°C	200°C	250°C	
10 or less	1.58	1.36	1.26	1.13	1.09	1.07	50 or less
11–15	1.50	1.31	1.22	1.11	1.08	1.06	51–59
16–20	1.41	1.25	1.18	1.09	1.06	1.05	60–68
21–25	1.32	1.2	1.14	1.07	1.05	1.04	69–77
26–30	1.22	1.13	1.10	1.04	1.03	1.02	78–86
31–35	1.12	1.07	1.05	1.02	1.02	1.01	87–95
36–40	1.00	1.00	1.00	1.00	1.00	1.00	96–104
41–45	0.87	0.93	0.95	0.98	0.98	0.99	105–113

For ambient temperatures other than 40°C (104°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	Temperature Rating of Conductor						Ambient Temperature (°F)
	60°C	75°C	90°C	150°C	200°C	250°C	
46–50	0.71	0.85	0.89	0.95	0.97	0.98	114–122
51–55	0.50	0.76	0.84	0.93	0.95	0.96	123–131
56–60	—	0.65	0.77	0.90	0.94	0.95	132–140
61–65	—	0.53	0.71	0.88	0.92	0.94	141–149
66–70	—	0.38	0.63	0.85	0.90	0.93	150–158
71–75	—	—	0.55	0.83	0.88	0.91	159–167
76–80	—	—	0.45	0.80	0.87	0.90	168–176
81–90	—	—	—	0.74	0.83	0.87	177–194
91–100	—	—	—	0.67	0.79	0.85	195–212
101–110	—	—	—	0.60	0.75	0.82	213–230
111–120	—	—	—	0.52	0.71	0.79	231–248
121–130	—	—	—	0.43	0.66	0.76	249–266
131–140	—	—	—	0.30	0.61	0.72	267–284
141–160	—	—	—	—	0.50	0.65	285–320
161–180	—	—	—	—	0.35	0.58	321–356
181–200	—	—	—	—	—	0.49	357–392
201–225	—	—	—	—	—	0.35	393–437

Note: Table 310.15(B)(1)(2) shall be used with Table 310.18, Table 310.19, Table 310.20, and Table 310.21 as required.

Statement of Problem and Substantiation for Public Input

The correct term when the ampacity is changed based on temperature is "ampacity correction". The term ampacity adjustment is for the cases where there are more than 3 current carrying conductors in a raceway or cable as covered in 310.15(C).

Submitter Information Verification

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Zip:
Submittal Date: Tue Jun 06 20:51:45 EDT 2023
Committee: NEC-P06

Public Input No. 2642-NFPA 70-2023 [New Section after 310.15(C)(1)]

Additional text to "*" note

For each pair of loop conductors contained in the same cable or raceway, that are connected to each other at each end, only one shall be counted. ...

Statement of Problem and Substantiation for Public Input

Reduction of energy usage is a coming trend. By the time 2026 is adopted there may well be energy codes that require lower voltage drops. The loop circuit is one economical way to reduce voltage drops. ALSO APPLIES to PI-2640

In designing an energy efficient building it occurred to me that reducing voltage drop was one way to reduce energy usage.I worked on a design to supply receptacles a 10-foot intervals around a 20×20 room. A simple circuit produced 4.82% voltage drop for a 20A load at the end of the circuit. Splitting the circuit and going both clockwise and counterclockwise around the room gave 2.57% Finally making a loop circuit going completely around the room and connecting the conductors in the circuit at both ends gave a worst case voltage drop of 1.36%. This was accomplished by adding about 10% more circuit feet.

Additional information being send to NFPA: Calculations, Graphs, and Circuit diagram.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2621-NFPA 70-2023 [New Section after 310.10(G)]	

Submitter Information Verification

Submitter Full Name: James WILLIAMS
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Submittal Date: Wed Aug 23 21:33:53 EDT 2023
Committee: NEC-P06

Public Input No. 3958-NFPA 70-2023 [Section No. 310.15(C)(1)]

(1) More than Three Current-Carrying Conductors.

The ampacity of each conductor shall be reduced as shown in Table 310.15(C)(1) where the number of current-carrying conductors in a raceway or cable exceeds three, ~~or where single~~ installed without maintaining spacing for a continuous length longer than 600 mm (24 in.).

The ampacity of each conductor shall be reduced as shown in Table 310.15(C)(1) where single conductors or multiconductor cables not installed in raceways are installed without maintaining spacing for a continuous length longer than 600 mm (24 in.).

Each current-carrying conductor of a paralleled set of conductors shall be counted as a current-carrying conductor.

Where conductors of different systems, as provided in 300.3, are installed in a common raceway or cable, the adjustment factors shown in Table 310.15(C)(1) shall apply only to the number of power and lighting conductors.

Informational Note No. 1: See Informative Annex B for adjustment factors for more than three current-carrying conductors in a raceway or cable with load diversity.

Informational Note No. 2: See 366.23 for adjustment factors for conductors and ampacity for bare copper and aluminum bars in auxiliary gutters and 376.22(B) for adjustment factors for conductors in metal wireways.

(a) Where conductors are installed in cable trays, 392.80 shall apply.

(b) Adjustment factors shall not apply to conductors in raceways having a length not exceeding 600 mm (24 in.).

(c) Adjustment factors shall not apply to underground conductors entering or leaving an outdoor trench if those conductors have physical protection in the form of rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit (PVC), or reinforced thermosetting resin conduit (RTRC) having a length not exceeding 3.05 m (10 ft), and if the number of conductors does not exceed four.

(d) Adjustment factors shall not apply to Type AC cable or to Type MC cable under the following conditions:

(5) The cables do not have an overall outer jacket.

(6) Each cable has not more than three current-carrying conductors.

(7) The conductors are 12 AWG copper.

(8) Not more than 20 current-carrying conductors are installed without maintaining spacing, are stacked, or are supported on “bridle rings.”

Exception to (4): If cables meeting the requirements in 310.15(C)(1)(d)(1) through (C)(1)(d)(3) with more than 20 current-carrying conductors are installed longer than 600 mm (24 in.) without maintaining spacing, are stacked, or are supported on bridle rings, a 60 percent adjustment factor shall be applied.

Table 310.15(C)(1) Adjustment Factors for More Than Three Current-Carrying Conductors

Number of Conductors*	**Percent of Values in Table 310.16 Through Table 310.19 as Adjusted for Ambient Temperature if Necessary**
4–6	80
7–9	70
10–20	50
21–30	45
31–40	40
41 and above	35

*Number of conductors is the total number of conductors in the raceway or cable, including spare conductors. The count shall be adjusted in accordance with 310.15(E) and (F). The count shall not include conductors that are connected to electrical components that cannot be simultaneously energized.

Statement of Problem and Substantiation for Public Input

Splitting up the requirement in 310.15(C)(1) by separating ‘conductors in raceways or cables’ from ‘cables bundled together’. This proposed revision will add clarity to Code users that there are actually two requirements in the first sentence of 310.15(C)(1).

Submitter Information Verification

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Submittal Date:	Wed Sep 06 11:22:42 EDT 2023
Committee:	NEC-P06

Public Input No. 875-NFPA 70-2023 [Section No. 310.15(C)(1)]

(1) More than Three Current-Carrying Conductors.

The ampacity of each conductor shall be reduced as shown in Table 310.15(C)(1) where the number of current-carrying conductors in a raceway or cable exceeds three, or where single conductors or multiconductor cables not installed in raceways are installed without maintaining spacing for a continuous length longer than 600 mm (24 in.). Each current-carrying conductor of a paralleled set of conductors shall be counted as a current-carrying conductor.

Where conductors of different systems, as provided in 300.3, are installed in a common raceway or cable, the adjustment factors shown in Table 310.15(C)(1) shall apply only to the number of power and lighting conductors.

Informational Note No. 1: See Informative Annex B for adjustment factors for more than three current-carrying conductors in a raceway or cable with load diversity.

Informational Note No. 2: See 366.23 for adjustment factors for conductors and ampacity for bare copper and aluminum bars in auxiliary gutters and 376.22(B) for adjustment factors for conductors in metal wireways.

(a) Where conductors are installed in cable trays, 392.80 shall apply.

(b) Adjustment factors shall not apply to conductors in raceways having a length not exceeding 600 mm (24 in.).

(c) Adjustment factors shall not apply to underground conductors entering or leaving an outdoor trench if those conductors have physical protection in the form of rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit (PVC), or reinforced thermosetting resin conduit (RTRC) having a length not exceeding 3.05 m (10 ft), and if the number of conductors does not exceed four.

(d) Adjustment factors shall not apply to Type AC cable or to Type MC cable under the following conditions:

(5) The cables do not have an overall outer jacket.

(6) Each cable has not more than three current-carrying conductors.

(7) The conductors are 12 AWG copper.

(8) Not more than 20 current-carrying conductors are installed without maintaining spacing, are stacked, or are supported on “bridle rings.”

Exception to (4): If cables meeting the requirements in 310.15(C)(1)(d)(1) through (C)(1)(d)(3) with more than 20 current-carrying conductors are installed longer than 600 mm (24 in.) without maintaining spacing, are stacked, or are supported on bridle rings, a 60 percent adjustment factor shall be applied.

Table 310.15(C)(1) Adjustment Factors for More Than Three Current-Carrying Conductors

Number of Conductors*	**Percent of Values in Table 310.16 ~~Through~~ ; Table 310.~~19~~ 18; Table 310.20 as Adjusted for Ambient Temperature if Necessary**
4–6	80
7–9	70
10–20	50
21–30	45
31–40	40
41 and above	35

*Number of conductors is the total number of conductors in the raceway or cable, including spare conductors. The count shall be adjusted in accordance with 310.15(E) and (F). The count shall not include conductors that are connected to electrical components that cannot be simultaneously energized.

Statement of Problem and Substantiation for Public Input

In the notes section of Table 310.16,18,20 it calls out a reference for using section 310.15 C (1). The header in the column of the table incorrectly calls out Table 310.17 and Table 310.19 even though both of those tables do not allow for derating for multiple conductors.

Submitter Information Verification

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Committee:	NEC-P06

Public Input No. 2056-NFPA 70-2023 [Section No. 310.15(C)(2)]

~~**(2)** Raceway Spacing.~~

~~Spacing between raceways shall be maintained.~~

Statement of Problem and Substantiation for Public Input

Move 310.15 (C) (2) “Raceway Spacing” requirements to 300.18 “Raceway Installations”. Article 310.15 (C) is dedicated to adjustment factors Article 310.15 (C) (2) covers raceway spacing but offers no information on any associated adjustment factors. Moving 310.15 (C) (2) “Raceway Spacing” to 300.18 “Raceway Installations” is a more suitable article to cover raceway spacing.

Submitter Information Verification

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Submittal Date:	Fri Aug 11 12:55:22 EDT 2023
Committee:	NEC-P06

Public Input No. 3111-NFPA 70-2023 [Section No. 310.15(C)(2)]

~~**(2)** Raceway Spacing.~~

~~Spacing between raceways shall be maintained.~~

Statement of Problem and Substantiation for Public Input

Deleting 310.15(C)(2) about maintaining raceway spacing. There is no requirement in the NEC to space raceways a given distance apart. This language is vague and unenforceable. In accordance with the NEC Style manual section 3.2.1. “The documents shall not contain references or requirements that use unenforceable or vague terms.”

Submitter Information Verification

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Submittal Date:	Tue Aug 29 12:15:52 EDT 2023
Committee:	NEC-P06

Public Input No. 3112-NFPA 70-2023 [Section No. 310.15(E)]

(E) Neutral Conductor.

Neutral conductors shall be considered current carrying in accordance with any of the following:

(1) A neutral conductor in a 2-wire circuit consisting of one phase conductor and a neutral conductor shall be considered a current carrying conductor when applying the provisions of 310.15(C)(1).

(2) A neutral conductor that carries only the unbalanced current from other conductors of the same circuit shall not be required to be counted when applying the provisions of 310.15(C)(1).

(3) ~~In~~ A neutral conductor in a 3-wire circuit consisting of two phase conductors and the neutral conductor of a 4-wire, 3-phase, wye-connected system, the neutral conductor carries approximately the same current as the line-to-neutral load currents of the other conductors and shall be counted when applying 310.15(C)(1).

(4) ~~On~~ A neutral conductor in a 4-wire, 3-phase wye circuit where the major portion of the load consists of nonlinear loads, harmonic currents are present in the neutral conductor; the neutral conductor shall therefore be considered a current-carrying conductor.

Statement of Problem and Substantiation for Public Input

The added text to this requirement is intended to make it easier to understand when a neutral conductor is considered a current carrying conductor. Adding a new list item (1) stating a neutral conductor from a 2-wire circuit is considered a current carrying conductor when apply the provisions of 310.15(C)(1). The revised language will bring clarity and consistency in the requirements of 310.15(E)(1) through (4).

Submitter Information Verification

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Submittal Date: Tue Aug 29 12:24:11 EDT 2023
Committee: NEC-P06

Public Input No. 779-NFPA 70-2023 [Section No. 310.15(E)]

(E) Neutral Conductor.

Neutral conductors shall be considered current carrying in accordance with any of the following:

(1) ~~A neutral conductor that carries only the unbalanced current from other conductors of the same circuit shall not be required to be counted when applying the provisions of 310.15(C)(1) .~~ This should be removed and made into an exception, because it is the exact opposite of the sentence above

(2) In a 3-wire circuit consisting of two phase conductors and the neutral conductor of a 4-wire, 3-phase, wye-connected system, the neutral conductor carries approximately the same current as the line-to-neutral load currents of the other conductors and shall be counted when applying 310.15(C)(1).

(3) On a 4-wire, 3-phase wye circuit where the major portion of the load consists of nonlinear loads, harmonic currents are present in the neutral conductor; the neutral conductor shall therefore be considered a current-carrying conductor.

(4) Exc #1 should be the old #1 from above. It does not fit into the "shall be" because in the sentence it says "shall not be requried".

Statement of Problem and Substantiation for Public Input

310.15 (E) says "shall be considered current carrying", but then immediately in #1, it says "shall not be required to be counted". #2 and #3 then go back to "shall be counted".

Submitter Information Verification

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Submittal Date: Mon May 08 22:20:28 EDT 2023
Committee: NEC-P06

Public Input No. 1016-NFPA 70-2023 [Section No. 310.16]

310.16 Ampacities of Insulated Conductors in Raceway, Cable, or Earth (Directly Buried).

The ampacities shall be as specified in Table 310.16 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 60°C (140°F), 75°C (167°F), or 90°C (194°F).

(3) Wiring is installed in a 30°C (86°F) ambient temperature.

(4) There are not more than three current-carrying conductors.

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

—

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	10** 15** 20** 14**
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	445	800

900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	525	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	555	665	750	470	560	630	2000

Notes:

1. Section 310.15(B) shall be referenced for ampacity correction factors where the ambient temperature is other than 30°C (86°F).

2. Section 310.15(C)(1) shall be referenced for more than three current-carrying conductors.

3. Section 310.16 shall be referenced for conditions of use.

*Section 240.4(D) shall be referenced for conductor overcurrent protection limitations, except as modified elsewhere in the *Code*.

**Aplicable only to copper-clad aluminum conductors

Additional Proposed Changes

File Name	Description	Approved
Proposed_Table_310.16_Ampacity_2026_Draft_Fnl_-_Copy.docx	Proposed Table 310.16	

Statement of Problem and Substantiation for Public Input

See Substantiation in 1008

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]	
Public Input No. 1017-NFPA 70-2023 [Section No. 310.17]	

Submitter Information Verification

Submitter Full Name: Peter Graser
Organization: Copperweld
Affiliation: American Bimetallic Association
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Submittal Date: Sun Jun 11 14:58:11 EDT 2023
Committee: NEC-P06

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

	Temperature Rating of Conductor [See Table 310.4(A)]						
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
Size AWG or kcmil	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	Size AWG or kcmil
	COPPER			ALUMINUM OR COPPERCLAD ALUMINUM			
18*	-	-	14	-	-	-	-
16*	-	-	18	-	-	-	-
14*	15	20	25	- 10**	- 15**	- 20**	- 14*
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	445	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	525	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	555	665	750	470	560	630	2000

Notes:
1. Section 310.15(B) shall be referenced for ampacity correction factors where the ambient temperature is other than 30°C (86°F).
2. Section 310.15(C)(1) shall be referenced for more than three current-carrying conductors.
3. Section 310.16 shall be referenced for conditions of use.

* Section 240.4(D) shall be referenced for conductor overcurrent protection limitations, except as modified elsewhere in the *Code*.

** Applicable only to copper-clad aluminum conductors

Public Input No. 1432-NFPA 70-2023 [Section No. 310.16]

310.16 Ampacities of Insulated Conductors in Raceway, Cable, or Earth (Directly Buried).

The ampacities shall be as specified in Table 310.16 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 60°C (140°F), 75°C (167°F), or 90°C (194°F).

(3) Wiring is installed in a 30°C (86°F) ambient temperature.

(4) There are not more than three current-carrying conductors.

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	445	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	525	625	705	435	520	585	1500

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
1750	545	650	735	455	545	615	1750
2000	555	665	750	470	560	630	2000

Notes:

1. Section 310.15(B)(1)(1) shall be referenced for ampacity correction factors where the ambient temperature is other than 30°C (86°F).

2. Section 310.15(C)(1) shall be referenced for more than three current-carrying conductors.

3. Section 310.16 shall be referenced for conditions of use.

*Section 240.4(D) shall be referenced for conductor overcurrent protection limitations, except as modified elsewhere in the *Code*.

Statement of Problem and Substantiation for Public Input

Note 1 to Table 310.16 has an incomplete reference to Table 310.15(B) there are two tables based on 30 deg C or 40 deg C respectively but T310.15(B)(1)(1) is the only one that applies to Table 310.16. There is confusion in the industry with the proper application of the temperature adjustment tables. By completely listing the correct table we will help insure the proper application of the code.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1433-NFPA 70-2023 [Section No. 310.17]	
Public Input No. 1434-NFPA 70-2023 [Section No. 310.18]	
Public Input No. 1435-NFPA 70-2023 [Section No. 310.19]	
Public Input No. 1436-NFPA 70-2023 [Section No. 310.20]	

Submitter Information Verification

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Zip:

Submittal Date: Sun Jul 16 10:56:42 EDT 2023

Committee: NEC-P06

Public Input No. 221-NFPA 70-2023 [Section No. 310.16]

310.16 Ampacities of Insulated Conductors in Raceway, Cable, or Earth (Directly Buried).

The ampacities shall be as specified in Table 310.16 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 60°C (140°F), 75°C (167°F), or 90°C (194°F).

(3) Wiring is installed in a 30°C (86°F) ambient temperature.

(4) There are not more than three current-carrying conductors.

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	445	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	525	625	705	435	520	585	1500

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
1750	545	650	735	455	545	615	1750
2000	555	665	750	470	560	630	2000

Notes:

1. Section 310.15(B)(1)(1) shall be referenced for ampacity correction factors where the ambient temperature is other than 30°C (86°F).

2. Section 310.15(C)(1) shall be referenced for more than three current-carrying conductors.

3. Section 310.16 shall be referenced for conditions of use.

*Section 240.4(D) shall be referenced for conductor overcurrent protection limitations, except as modified elsewhere in the *Code*.

Statement of Problem and Substantiation for Public Input

Note 1 to table 310.16 is incomplete by just noting Table 310.15(B) for the temperature correction table. Table 310.16 is based on 30 deg. C and should use
Table 310.15(B)(1)(1). There is confusion with users of the code with which temperature correction Table is the correct table(T310.15(B)(1)(1) or T310.15(b)(1)(2)). I think when "Based on 30 Deg C" was removed from the heading of Table 310.16 and put it in Note 1 it created some confusion.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 222-NFPA 70-2023 [Section No. 310.17]	
Public Input No. 223-NFPA 70-2023 [Section No. 310.18]	
Public Input No. 224-NFPA 70-2023 [Section No. 310.19]	
Public Input No. 225-NFPA 70-2023 [Section No. 310.20]	

Submitter Information Verification

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Committee: NEC-P06

Public Input No. 773-NFPA 70-2023 [Section No. 310.16]

310.16 Ampacities of Insulated Conductors in Raceway, Cable, or Earth (Directly Buried).

The ampacities shall be as specified in Table 310.16 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 60°C (140°F), 75°C (167°F), or 90°C (194°F).

(3) Wiring is installed in a 30°C (86°F) ambient temperature.

(4) There are not more than three current-carrying conductors.

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ~~XHWN,~~ ~~XHWN~~ XHWN -2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	445	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	525	625	705	435	520	585	1500

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, ~~XHWN,~~ ~~XHWN~~ XHWN -2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
1750	545	650	735	455	545	615	1750
2000	555	665	750	470	560	630	2000

Notes:

1. Section 310.15(B) shall be referenced for ampacity correction factors where the ambient temperature is other than 30°C (86°F).

2. Section 310.15(C)(1) shall be referenced for more than three current-carrying conductors.

3. Section 310.16 shall be referenced for conditions of use.

*Section 240.4(D) shall be referenced for conductor overcurrent protection limitations, except as modified elsewhere in the *Code*.

Statement of Problem and Substantiation for Public Input

Table 310.4(1) identifies XHWN Max operating temperature of 75C. Tables 310.16 and 310.17 list XHWN in the 75C and 90C columns.

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Committee:	NEC-P06

Public Input No. 1017-NFPA 70-2023 [Section No. 310.17]

310.17 Ampacities of Single-Insulated Conductors in Free Air.

The ampacities shall be as specified in Table 310.17 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 60°C (140°F), 75°C (167°F), or 90°C (194°F).

(3) Wiring is installed in a 30°C (86°F) ambient temperature.

Table 310.17 Ampacities of Single-Insulated Conductors in Free Air

—

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil			
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)				
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN				
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM						
18	—	—	18	—	—	—	—			
16	—	—	24	—	—	—	—			
14*	25	30	35	—	—	—	20**	25**	30**	14**
12*	30	35	40	25	30	35	12*			
10*	40	50	55	35	40	45	10*			
8	60	70	80	45	55	60	8			
6	80	95	105	60	75	85	6			
4	105	125	140	80	100	115	4			
3	120	145	165	95	115	130	3			
2	140	170	190	110	135	150	2			
1	165	195	220	130	155	175	1			
1/0	195	230	260	150	180	205	1/0			
2/0	225	265	300	175	210	235	2/0			
3/0	260	310	350	200	240	270	3/0			
4/0	300	360	405	235	280	315	4/0			
250	340	405	455	265	315	355	250			
300	375	445	500	290	350	395	300			
350	420	505	570	330	395	445	350			
400	455	545	615	355	425	480	400			
500	515	620	700	405	485	545	500			
600	575	690	780	455	545	615	600			
700	630	755	850	500	595	670	700			
750	655	785	885	515	620	700	750			
800	680	815	920	535	645	725	800			
900	730	870	980	580	700	790	900			
1000	780	935	1055	625	750	845	1000			

1250	890	1065	1200	710	855	965	1250
1500	980	1175	1325	795	950	1070	1500
1750	1070	1280	1445	875	1050	1185	1750
2000	1155	1385	1560	960	1150	1295	2000

Notes:

1. Section 310.15(B) shall be referenced for ampacity correction factors where the ambient temperature is other than 30°C (86°F).

2. Section 310.17 shall be referenced for conditions of use.

*Section 240.4(D) shall be referenced for conductor overcurrent protection limitations, except as modified elsewhere in the *Code*.

**Applicable only to copper-clad aluminum conductors

Additional Proposed Changes

File Name	Description	Approved
Proposed_Table_310.17_Ampacity_2026_Draft_Fnl_-_Copy.docx	Proposed Table 310.17	

Statement of Problem and Substantiation for Public Input

See substantiation in PI 1008

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1016-NFPA 70-2023 [Section No. 310.16]	
Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]	

Submitter Information Verification

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Submittal Date: Sun Jun 11 15:05:35 EDT 2023
Committee: NEC-P06

Table 310.17 Ampacities of Single-Insulated Conductors in Free Air

Size AWG or kcmil	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	Size AWG or kcmil
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPERCLAD ALUMINUM			
18*	-	-	18	-	-	-	-
16*	-	-	24	-	-	-	-
14*	25	30	35	- 20**	- 25**	- 30**	- 14*
12*	30	35	40	25	30	35	12*
10*	40	50	55	35	40	45	10*
8	60	70	80	45	55	60	8
6	80	95	105	60	75	85	6
4	105	125	140	80	100	115	4
3	120	145	165	95	115	130	3
2	140	170	190	110	135	150	2
1	165	195	220	130	155	175	1
1/0	195	230	260	150	180	205	1/0
2/0	225	265	300	175	210	235	2/0
3/0	260	310	350	200	240	270	3/0
4/0	300	360	405	235	280	315	4/0
250	340	405	455	265	315	355	250
300	375	445	500	290	350	395	300
350	420	505	570	330	395	445	350
400	455	545	615	355	425	480	400
500	515	620	700	405	485	545	500
600	575	690	780	455	545	615	600
700	630	755	850	500	595	670	700
750	655	785	885	515	620	700	750
800	680	815	920	535	645	725	800
900	730	870	980	580	700	790	900
1000	780	935	1055	625	750	845	1000
1250	890	1065	1200	710	855	965	1250
1500	980	1175	1325	795	950	1070	1500
1750	1070	1280	1445	875	1050	1185	1750
2000	1155	1385	1560	960	1150	1295	2000

Notes:
1. Section 310.15(B) shall be referenced for ampacity correction factors where the ambient temperature is other than 30°C (86°F).
2. Section 310.17 shall be referenced for conditions of use.
* Section 240.4(D) shall be referenced for conductor overcurrent protection limitations, except as modified elsewhere in the *Code*.
** Applicable only to copper-clad aluminum conductors

Public Input No. 1433-NFPA 70-2023 [Section No. 310.17]

310.17 Ampacities of Single-Insulated Conductors in Free Air.

The ampacities shall be as specified in Table 310.17 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 60°C (140°F), 75°C (167°F), or 90°C (194°F).

(3) Wiring is installed in a 30°C (86°F) ambient temperature.

Table 310.17 Ampacities of Single-Insulated Conductors in Free Air

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18	—	—	18	—	—	—	—
16	—	—	24	—	—	—	—
14*	25	30	35	—	—	—	—
12*	30	35	40	25	30	35	12*
10*	40	50	55	35	40	45	10*
8	60	70	80	45	55	60	8
6	80	95	105	60	75	85	6
4	105	125	140	80	100	115	4
3	120	145	165	95	115	130	3
2	140	170	190	110	135	150	2
1	165	195	220	130	155	175	1
1/0	195	230	260	150	180	205	1/0
2/0	225	265	300	175	210	235	2/0
3/0	260	310	350	200	240	270	3/0
4/0	300	360	405	235	280	315	4/0
250	340	405	455	265	315	355	250
300	375	445	500	290	350	395	300
350	420	505	570	330	395	445	350
400	455	545	615	355	425	480	400
500	515	620	700	405	485	545	500
600	575	690	780	455	545	615	600
700	630	755	850	500	595	670	700
750	655	785	885	515	620	700	750
800	680	815	920	535	645	725	800
900	730	870	980	580	700	790	900
1000	780	935	1055	625	750	845	1000
1250	890	1065	1200	710	855	965	1250
1500	980	1175	1325	795	950	1070	1500
1750	1070	1280	1445	875	1050	1185	1750
2000	1155	1385	1560	960	1150	1295	2000

Notes:

1. Section 310.15(B)(1)(1) shall be referenced for ampacity correction factors where the ambient temperature is other than 30°C (86°F).

2. Section 310.17 shall be referenced for conditions of use.

*Section 240.4(D) shall be referenced for conductor overcurrent protection limitations, except as modified elsewhere in the *Code*.

Statement of Problem and Substantiation for Public Input

Note 1 to Table 310.17 has an incomplete reference to Table 310.15(B) there are two tables based on 30 deg C or 40 deg C respectively but T310.15(B)(1)(1) is the only one that applies to Table 310.17. There is confusion in the industry with the proper application of the temperature adjustment tables. By completely listing the correct table we will help insure the proper application of the code.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1432-NFPA 70-2023 [Section No. 310.16]	
Public Input No. 1434-NFPA 70-2023 [Section No. 310.18]	
Public Input No. 1435-NFPA 70-2023 [Section No. 310.19]	
Public Input No. 1436-NFPA 70-2023 [Section No. 310.20]	

Submitter Information Verification

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Submittal Date:	Sun Jul 16 11:20:12 EDT 2023
Committee:	NEC-P06

Public Input No. 222-NFPA 70-2023 [Section No. 310.17]

310.17 Ampacities of Single-Insulated Conductors in Free Air.

The ampacities shall be as specified in Table 310.17 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 60°C (140°F), 75°C (167°F), or 90°C (194°F).

(3) Wiring is installed in a 30°C (86°F) ambient temperature.

Table 310.17 Ampacities of Single-Insulated Conductors in Free Air

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18	—	—	18	—	—	—	—
16	—	—	24	—	—	—	—
14*	25	30	35	—	—	—	—
12*	30	35	40	25	30	35	12*
10*	40	50	55	35	40	45	10*
8	60	70	80	45	55	60	8
6	80	95	105	60	75	85	6
4	105	125	140	80	100	115	4
3	120	145	165	95	115	130	3
2	140	170	190	110	135	150	2
1	165	195	220	130	155	175	1
1/0	195	230	260	150	180	205	1/0
2/0	225	265	300	175	210	235	2/0
3/0	260	310	350	200	240	270	3/0
4/0	300	360	405	235	280	315	4/0
250	340	405	455	265	315	355	250
300	375	445	500	290	350	395	300
350	420	505	570	330	395	445	350
400	455	545	615	355	425	480	400
500	515	620	700	405	485	545	500
600	575	690	780	455	545	615	600
700	630	755	850	500	595	670	700
750	655	785	885	515	620	700	750
800	680	815	920	535	645	725	800
900	730	870	980	580	700	790	900
1000	780	935	1055	625	750	845	1000
1250	890	1065	1200	710	855	965	1250
1500	980	1175	1325	795	950	1070	1500
1750	1070	1280	1445	875	1050	1185	1750
2000	1155	1385	1560	960	1150	1295	2000

Notes:

1. Section 310.15(B)(1)(1) shall be referenced for ampacity correction factors where the ambient temperature is other than 30°C (86°F).

2. Section 310.17 shall be referenced for conditions of use.

*Section 240.4(D) shall be referenced for conductor overcurrent protection limitations, except as modified elsewhere in the *Code*.

Statement of Problem and Substantiation for Public Input

Note 1 to table 310.17 is incomplete by just noting Table 310.15(B) for the temperature correction table. Table 310.17 is based on 30 deg. C and should use
Table 310.15(B)(1)(1). There is confusion with users of the code with which temperature correction Table is the correct table(T310.15(B)(1)(1) or T310.15(b)(1)(2)). I think when "Based on 30 Deg C" was removed from the heading of Table 310.17 and put it in Note 1 it created some confusion.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 221-NFPA 70-2023 [Section No. 310.16]	
Public Input No. 223-NFPA 70-2023 [Section No. 310.18]	
Public Input No. 224-NFPA 70-2023 [Section No. 310.19]	
Public Input No. 225-NFPA 70-2023 [Section No. 310.20]	

Submitter Information Verification

Submitter Full Name: Jon Coulimore
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Submittal Date: Tue Jan 24 22:23:23 EST 2023
Committee: NEC-P06

Public Input No. 1434-NFPA 70-2023 [Section No. 310.18]

310.18 Ampacities of Insulated Conductors in Raceway or Cable.

The ampacities shall be as specified in Table 310.18 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 150°C (302°F), 200°C (392°F), or 250°C (482°F).

(3) Wiring is installed in a 40°C (104°F) ambient temperature.

(4) There are not more than three current-carrying conductors.

Table 310.18 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway or Cable

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]				Size AWG or kcmil
	150°C (302°F)	200°C (392°F)	250°C (482°F)	150°C (302°F)	
	Type Z	Types FEP, FEPB, PFA, SA	Types PFAH, TFE	Type Z	
	COPPER		NICKEL OR NICKEL-COATED COPPER	ALUMINUM OR COPPER-CLAD ALUMINUM	
14	34	36	39	—	14
12	43	45	54	30	12
10	55	60	73	44	10
8	76	83	93	57	8
6	96	110	117	75	6
4	120	125	148	94	4
3	143	152	166	109	3
2	160	171	191	124	2
1	186	197	215	145	1
1/0	215	229	244	169	1/0
2/0	251	260	273	198	2/0
3/0	288	297	308	227	3/0
4/0	332	346	361	260	4/0

Notes:

1. Section 310.15(B)(1)(2) shall be referenced for ampacity correction factors where the ambient temperature is other than 40°C (104°F).

2. Section 310.15(C)(1) shall be referenced for more than three current-carrying conductors.

3. Section 310.18 shall be referenced for conditions of use.

Statement of Problem and Substantiation for Public Input

Note 1 to Table 310.18 has an incomplete reference to Table 310.15(B) there are two tables based on 30 deg C or 40 deg C respectively but T310.15(B)(1)(2) is the only one that applies to Table 310.18. There is confusion in the industry with the proper application of the temperature adjustment tables. By completely listing the correct table we will help insure the proper application of the code.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1432-NFPA 70-2023 [Section No. 310.16]	
Public Input No. 1433-NFPA 70-2023 [Section No. 310.17]	
Public Input No. 1435-NFPA 70-2023 [Section No. 310.19]	
Public Input No. 1436-NFPA 70-2023 [Section No. 310.20]	

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Submitter Full Name: IEC National
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Submittal Date: Sun Jul 16 11:22:35 EDT 2023
Committee: NEC-P06

Public Input No. 223-NFPA 70-2023 [Section No. 310.18]

310.18 Ampacities of Insulated Conductors in Raceway or Cable.

The ampacities shall be as specified in Table 310.18 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 150°C (302°F), 200°C (392°F), or 250°C (482°F).

(3) Wiring is installed in a 40°C (104°F) ambient temperature.

(4) There are not more than three current-carrying conductors.

Table 310.18 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway or Cable

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]				Size AWG or kcmil
	150°C (302°F)	200°C (392°F)	250°C (482°F)	150°C (302°F)	
	Type Z	Types FEP, FEPB, PFA, SA	Types PFAH, TFE	Type Z	
	COPPER		NICKEL OR NICKEL-COATED COPPER	ALUMINUM OR COPPER-CLAD ALUMINUM	
14	34	36	39	—	14
12	43	45	54	30	12
10	55	60	73	44	10
8	76	83	93	57	8
6	96	110	117	75	6
4	120	125	148	94	4
3	143	152	166	109	3
2	160	171	191	124	2
1	186	197	215	145	1
1/0	215	229	244	169	1/0
2/0	251	260	273	198	2/0
3/0	288	297	308	227	3/0
4/0	332	346	361	260	4/0

Notes:

1. Section 310.15(B)(1)(2) shall be referenced for ampacity correction factors where the ambient temperature is other than 40°C (104°F).

2. Section 310.15(C)(1) shall be referenced for more than three current-carrying conductors.

3. Section 310.18 shall be referenced for conditions of use.

Statement of Problem and Substantiation for Public Input

Note 1 to table 310.18 is incomplete by just noting Table 310.15(B) for the temperature correction table. Table 310.18 is based on 40 deg. C and should use
Table 310.15(B)(1)(2). There is confusion with users of the code with which temperature correction Table is the correct table(T310.15(B)(1)(1) or T310.15(b)(1)(2)). I think when "Based on 40 Deg C" was removed from the heading of Table 310.18 and put it in Note 1 it created some confusion.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 221-NFPA 70-2023 [Section No. 310.16]	Note 1 to table
Public Input No. 222-NFPA 70-2023 [Section No. 310.17]	Note 1 toTable
Public Input No. 224-NFPA 70-2023 [Section No. 310.19]	
Public Input No. 225-NFPA 70-2023 [Section No. 310.20]	

Submitter Information Verification

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Committee: NEC-P06

Public Input No. 1435-NFPA 70-2023 [Section No. 310.19]

310.19 Ampacities of Single-Insulated Conductors in Free Air.

The ampacities shall be as specified in Table 310.19 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated up to 250°C (482°F).

(3) Wiring is installed in a 40°C (104°F) ambient temperature.

Table 310.19 Ampacities of Single-Insulated Conductors in Free Air

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]				Size AWG or kcmil
	150°C (302°F)	200°C (392°F)	250°C (482°F)	150°C (302°F)	
	Type Z	Types FEP, FEPB, PFA, SA	Types PFAH, TFE	Type Z	
	COPPER		NICKEL, OR NICKEL-COATED COPPER	ALUMINUM OR COPPER-CLAD ALUMINUM	
14	46	54	59	—	14
12	60	68	78	47	12
10	80	90	107	63	10
8	106	124	142	83	8
6	155	165	205	112	6
4	190	220	278	148	4
3	214	252	327	170	3
2	255	293	381	198	2
1	293	344	440	228	1
1/0	339	399	532	263	1/0
2/0	390	467	591	305	2/0
3/0	451	546	708	351	3/0
4/0	529	629	830	411	4/0

Notes:

1. Section 310.15(B)(1)(2) shall be referenced for ampacity correction factors where the ambient temperature is other than 40°C (104°F).

2. Section 310.19 shall be referenced for conditions of use.

Statement of Problem and Substantiation for Public Input

Note 1 to Table 310.19 has an incomplete reference to Table 310.15(B) there are two tables based on 30 deg C or 40 deg C respectively but T310.15(B)(1)(2) is the only one that applies to Table 310.19. There is confusion in the industry with the proper application of the temperature adjustment tables. By completely listing the correct table we will help insure the proper application of the code.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1432-NFPA 70-2023 [Section No. 310.16]	
Public Input No. 1433-NFPA 70-2023 [Section No. 310.17]	

Public Input No. 1434-NFPA 70-2023 [Section No. 310.18]
Public Input No. 1436-NFPA 70-2023 [Section No. 310.20]

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Public Input No. 224-NFPA 70-2023 [Section No. 310.19]

310.19 Ampacities of Single-Insulated Conductors in Free Air.

The ampacities shall be as specified in Table 310.19 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated up to 250°C (482°F).

(3) Wiring is installed in a 40°C (104°F) ambient temperature.

Table 310.19 Ampacities of Single-Insulated Conductors in Free Air

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]				Size AWG or kcmil
	150°C (302°F)	200°C (392°F)	250°C (482°F)	150°C (302°F)	
	Type Z	Types FEP, FEPB, PFA, SA	Types PFAH, TFE	Type Z	
	COPPER		NICKEL, OR NICKEL-COATED COPPER	ALUMINUM OR COPPER-CLAD ALUMINUM	
14	46	54	59	—	14
12	60	68	78	47	12
10	80	90	107	63	10
8	106	124	142	83	8
6	155	165	205	112	6
4	190	220	278	148	4
3	214	252	327	170	3
2	255	293	381	198	2
1	293	344	440	228	1
1/0	339	399	532	263	1/0
2/0	390	467	591	305	2/0
3/0	451	546	708	351	3/0
4/0	529	629	830	411	4/0

Notes:

1. Section 310.15(B)(1)(2) shall be referenced for ampacity correction factors where the ambient temperature is other than 40°C (104°F).

2. Section 310.19 shall be referenced for conditions of use.

Statement of Problem and Substantiation for Public Input

Note 1 to table 310.19 is incomplete by just noting Table 310.15(B) for the temperature correction table. Table 310.19 is based on 40 deg. C and should use
Table 310.15(B)(1)(2). There is confusion with users of the code with which temperature correction Table is the correct table(T310.15(B)(1)(1) or T310.15(b)(1)(2)). I think when "Based on 40 Deg C" was removed from the heading of Table 310.19 and put it in Note 1 it created some confusion.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 221-NFPA 70-2023 [Section No. 310.16]	Note 1 to Table

Public Input No. 222-NFPA 70-2023 [Section No. 310.17]	Note 1 to Table
Public Input No. 223-NFPA 70-2023 [Section No. 310.18]	Note 1 to Table
Public Input No. 225-NFPA 70-2023 [Section No. 310.20]	

Submitter Information Verification

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Committee:	NEC-P06

Public Input No. 1436-NFPA 70-2023 [Section No. 310.20]

310.20 Ampacities of Conductors Supported on a Messenger.

The ampacities shall be as specified in Table 310.20 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 75°C (167°F) or 90°C (194°F).

(3) Wiring is installed in a 40°C (104°F) ambient temperature.

(4) There are not more than three single-insulated conductors.

Table 310.20 Ampacities of Conductors on a Messenger

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]				Size AWG or kcmil
	75°C (167°F)	90°C (194°F)	75°C (167°F)	90°C (194°F)	
	Types RHW, THHW, THW, THWN, XHHW, XHWN, ZW	Types MI, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHHW, XHHW-2, XHWN-2, ZW-2	Types RHW, THW, THWN, THHW, XHHW, XHWN	Types THHN, THHW, RHH, XHHW, RHW-2, XHHW-2, THW-2, THWN-2, XHWN-2, USE-2, ZW-2	
	COPPER		ALUMINUM OR COPPER-CLAD ALUMINUM		
8	57	66	44	51	8
6	76	89	59	69	6
4	101	117	78	91	4
3	118	138	92	107	3
2	135	158	106	123	2
1	158	185	123	144	1
1/0	183	214	143	167	1/0
2/0	212	247	165	193	2/0
3/0	245	287	192	224	3/0
4/0	287	335	224	262	4/0
250	320	374	251	292	250
300	359	419	282	328	300
350	397	464	312	364	350
400	430	503	339	395	400
500	496	580	392	458	500
600	553	647	440	514	600
700	610	714	488	570	700
750	638	747	512	598	750
800	660	773	532	622	800
900	704	826	572	669	900
1000	748	879	612	716	1000

Notes:

1. Section 310.15(B)(1)(2) shall be referenced for ampacity correction factors where the ambient temperature is other than 40°C (104°F).

2. Section 310.15(C)(1) shall be referenced for more than three current-carrying conductors.

3. Section 310.20 shall be referenced for conditions of use.

Statement of Problem and Substantiation for Public Input

Note 1 to Table 310.20 has an incomplete reference to Table 310.15(B) there are two tables based on 30 deg C or 40 deg C respectively but T310.15(B)(1)(2) is the only one that applies to Table 310.20. There is confusion in the industry with the proper application of the temperature adjustment tables. By completely listing the correct table we will help insure the proper application of the code.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1432-NFPA 70-2023 [Section No. 310.16]	
Public Input No. 1433-NFPA 70-2023 [Section No. 310.17]	
Public Input No. 1434-NFPA 70-2023 [Section No. 310.18]	
Public Input No. 1435-NFPA 70-2023 [Section No. 310.19]	

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Committee:	NEC-P06

Public Input No. 225-NFPA 70-2023 [Section No. 310.20]

310.20 Ampacities of Conductors Supported on a Messenger.

The ampacities shall be as specified in Table 310.20 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2) Conductors are rated 75°C (167°F) or 90°C (194°F).

(3) Wiring is installed in a 40°C (104°F) ambient temperature.

(4) There are not more than three single-insulated conductors.

Table 310.20 Ampacities of Conductors on a Messenger

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]				Size AWG or kcmil
	75°C (167°F)	90°C (194°F)	75°C (167°F)	90°C (194°F)	
	Types RHW, THHW, THW, THWN, XHHW, XHWN, ZW	Types MI, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHHW, XHHW-2, XHWN-2, ZW-2	Types RHW, THW, THWN, THHW, XHHW, XHWN	Types THHN, THHW, RHH, XHHW, RHW-2, XHHW-2, THW-2, THWN-2, XHWN-2, USE-2, ZW-2	
	COPPER		ALUMINUM OR COPPER-CLAD ALUMINUM		
8	57	66	44	51	8
6	76	89	59	69	6
4	101	117	78	91	4
3	118	138	92	107	3
2	135	158	106	123	2
1	158	185	123	144	1
1/0	183	214	143	167	1/0
2/0	212	247	165	193	2/0
3/0	245	287	192	224	3/0
4/0	287	335	224	262	4/0
250	320	374	251	292	250
300	359	419	282	328	300
350	397	464	312	364	350
400	430	503	339	395	400
500	496	580	392	458	500
600	553	647	440	514	600
700	610	714	488	570	700
750	638	747	512	598	750
800	660	773	532	622	800
900	704	826	572	669	900
1000	748	879	612	716	1000

Notes:

1. Section 310.15(B)(1)(2) shall be referenced for ampacity correction factors where the ambient temperature is other than 40°C (104°F).

2. Section 310.15(C)(1) shall be referenced for more than three current-carrying conductors.

3. Section 310.20 shall be referenced for conditions of use.

Statement of Problem and Substantiation for Public Input

Note 1 to table 310.20 is incomplete by just noting Table 310.15(B) for the temperature correction table. Table 310.20 is based on 40 deg. C and should use
Table 310.15(B)(1)(2). There is confusion with users of the code with which temperature correction Table is the

correct table(T310.15(B)(1)(1) or T310.15(b)(1)(2)). I think when "Based on 40 Deg C" was removed from the heading of Table 310.20 and put it in Note 1 it created some confusion.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 221-NFPA 70-2023 [Section No. 310.16]	Note 1 to Table
Public Input No. 222-NFPA 70-2023 [Section No. 310.17]	Note 1 to Table
Public Input No. 223-NFPA 70-2023 [Section No. 310.18]	Note 1 to table
Public Input No. 224-NFPA 70-2023 [Section No. 310.19]	Note 1 to Table

Submitter Information Verification

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Submittal Date: Tue Jan 24 22:36:18 EST 2023
Committee: NEC-P06

Public Input No. 1291-NFPA 70-2023 [New Section after 310.21]

310.22 Busbar Ampacity

(A) The current carried continuously in copper or aluminum busbars shall not exceed as follows.

(1) Copper 1.55 amperes/mm^2 (1000 amperes/in^2) of cross section of the busbar.

(2) Alumimum 1.09 amperes/mm^2 (700 amperes/in^2) of cross section of the busbar.

..

Statement of Problem and Substantiation for Public Input

This places the busbar ampacities in the same article for the ampacities of conductors. This will make it simple for people to find and use. Its location now in 366.23 (A) does not seem to be the correct location.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1293-NFPA 70-2023 [Section No. 366.23(A)]	Moving of Section
Public Input No. 1293-NFPA 70-2023 [Section No. 366.23(A)]	

Submitter Information Verification

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Submittal Date: Thu Jul 06 15:49:15 EDT 2023
Committee: NEC-P06

Public Input No. 342-NFPA 70-2023 [New Section after 310.21]

TITLE OF NEW CONTENT

310.22 Busbar Ampacity

(A) The current carried continuously in copper or aluminum busbars shall not exceed as follows.

(1) Copper 1.55 amperes/mm^2 (1000 amperes/in^2) of cross section of the busbar.

(2) Alumimum 1.09 amperes/mm^2 (700 amperes/in^2) of cross section of the busbar.

Statement of Problem and Substantiation for Public Input

This places the busbar ampacities in the same article for the ampacities of conductors. This will make it simple for people to find and use. Its location now in 366.23 (A) does not seem to be the correct location.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 341-NFPA 70-2023 [Section No. 366.23(A)]	delted from 366.23(A) to add to 310.22
Public Input No. 341-NFPA 70-2023 [Section No. 366.23(A)]	

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Submittal Date: Thu Feb 16 09:06:09 EST 2023
Committee: NEC-P06

Public Input No. 604-NFPA 70-2023 [New Section after 320.1]

320.2 Reconditioned Equipment

Type AC cable shall not be reconditioned

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

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Submittal Date: Sun Apr 16 08:03:04 EDT 2023

Committee: NEC-P06

Public Input No. 2881-NFPA 70-2023 [Section No. 320.6]

320.~~6~~ 2 Listing Requirements.

Type ~~AC cable and associated fittings~~ AC cable, associated fittings and support and securement hardware shall be listed.

Statement of Problem and Substantiation for Public Input

To avoid damage to Type AC cable and undue stress being transferred to electrical connections from sagging cables the use of listed hardware for support and securement of Type AC Cables is necessary by the NEC. The ANSI/UL Standard for Safety for Hardware for the Support of Conduit, Tubing, and Cable, UL 2239, was first published nearly 20 years ago and contains all necessary hardware construction, performance, marking and installation instructions necessary to provide installers and AHJs the guidance to properly support and secure Type AC cables when using listed hardware.
Additionally, per the 2023 NEC style manual, clause 2.2.1, “Required Parallel Numbering Format” Listing requirements should be relocated from 320.6 to 320.2.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2882-NFPA 70-2023 [Section No. 320.30(A)]	

Submitter Information Verification

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Committee:	NEC-P06

Public Input No. 3505-NFPA 70-2023 [Section No. 320.6]

320.~~6~~ 2 Listing Requirements.

Type AC cable and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Submittal Date: Mon Sep 04 17:13:11 EDT 2023
Committee: NEC-P06

Public Input No. 3464-NFPA 70-2023 [Section No. 320.15]

320.15 Exposed Work.

Exposed runs of cable, except as provided in 300.11(B), shall closely follow the surface of the building finish or of running boards. Running boards shall be wider than the cable or cables they support, and shall not sag as installed. They shall be constructed of nominal two-by lumber, or use other designs approved by the Authority having Jurisdiction as providing suitable support and protection. Exposed runs shall also be permitted to be installed on the underside of joists where supported at each joist and located so as not to be subject to physical damage.

Statement of Problem and Substantiation for Public Input

Because there are no specifications for running boards, and no definition, presently this falls into the category of "I know what I mean" inspection. The dictionary definition isn't enough. How much support do the boards need to give? If you want to use a 1x3 rather than a 2x, or a strip of 5/8 plywood, or a different material altogether, let the inspector approve based on how long the run is between supports. But this sets a basic, reasonable spec. If an installer wants to use a 2x2, the run had better not be too long or it will sag, violating that requirement. One reason to add that restriction is because if it is not sturdy enough as installed to prevent sagging, it probably is not sturdy enough to last, especially after the first time someone knocks into it.

Historically, and elsewhere in the NEC, running boards sometimes have required side protection, sometimes have had a specific minimum width, sometimes required a specific width to each side of the wiring they support.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3463-NFPA 70-2023 [New Definition after Definition: Riser Cable, Cable Routing...]	Defines the purpose of a Running Board
Public Input No. 3466-NFPA 70-2023 [Section No. 330.15]	
Public Input No. 3468-NFPA 70-2023 [Section No. 334.15(A)]	

Submitter Information Verification

Submitter Full Name: David Shapiro

Organization: Safety First Electrical

Street Address:

City:

State:

Zip:

Submittal Date: Sun Sep 03 15:26:13 EDT 2023

Committee: NEC-P06

Public Input No. 3050-NFPA 70-2023 [Section No. 320.23(A)]

(A) Cables Run Across the Top of Framing Members.

(1) Accessible by Permanent Means. Where run across the top of framing members, or across the face of rafters or studding within 2.1 m (7 ft) of the floor or horizontal surface, the cable shall be protected by guard strips that are at least as high as the cable where the space is accessible by permanent installed stairs or ladders .

(2) Not Accessible by Permanent Means. Where this space is not accessible by permanently installed stairs or ladders, protection shall only be required within 1.8 m (6 ft) of the nearest edge of the scuttle hole or attic entrance.

Statement of Problem and Substantiation for Public Input

Adding language to make it clear for Code users that where the attics or roof spaces have permanent stairs or ladders the cables must be protected by guard strips within 7 ft of the floor or horizontal surface of the entire attics or roof space. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:

Submittal Date: Tue Aug 29 09:28:13 EDT 2023
Committee: NEC-P06

Public Input No. 2244-NFPA 70-2023 [Section No. 320.30]

320.30 Securing and Supporting.

(A) General.

Type AC cable shall be supported and secured by staples; cable ties listed and identified for securement and support; straps, hangers, or similar fittings; or other approved means designed and installed so as not to damage the cable.

~~Type AC cable fittings shall be permitted as a means of cable support.~~

(B) Securing.

Unless otherwise permitted, Type AC cable shall be secured within 300 mm (12 in.) of every outlet box, junction box, cabinet, or fitting and at intervals not exceeding 1.4 m (4½ ft).

(C) Supporting.

Unless otherwise permitted, Type AC cable shall be supported at intervals not exceeding 1.4 m (4½ ft).

Horizontal runs of Type AC cable installed in wooden or metal framing members or similar supporting means shall be considered supported and secured where such support does not exceed 1.4 m (4½ ft) intervals.

Type AC cable fittings shall be permitted as a means of cable support.

(D) Unsupported Cables.

Type AC cable shall be permitted to be unsupported and unsecured where the cable complies with any of the following:

(1) Is fished between access points through concealed spaces in finished buildings or structures and supporting is impracticable

(2) Is not more than 600 mm (2 ft) in length at terminals where flexibility is necessary

(3) Is not more than 1.8 m (6 ft) in length from the last point of cable support to the point of connection to a luminaire(s) or other electrical equipment and the cable and point of connection are within an accessible ceiling

Statement of Problem and Substantiation for Public Input

Relocating from 320.30(A) to 320.30(C) in order to group the supporting requirements all together. This proposed revision will enhance clarity and usability for Code users.

Submitter Information Verification

Submitter Full Name: Mike Holt

Organization: Mike Holt Enterprises Inc

Street Address:

City:

State:

Zip:

Submittal Date: Tue Aug 15 13:20:01 EDT 2023

Committee: NEC-P06

Public Input No. 3259-NFPA 70-2023 [Section No. 320.30]

320.

~~30~~

30 Securing

~~and Supporting~~

.

~~**(A)** General.~~

Type AC cable shall be

~~supported and~~

secured

~~by staples; cable ties listed and identified for securement and support; straps, hangers, or similar fittings; or other approved means designed and installed so as not to damage the cable.~~

~~Type AC cable fittings shall be permitted as a means of cable support.~~

~~**(B)** Securing.~~

~~Unless otherwise permitted, Type AC cable shall be secured within 300 mm (12 in~~

within 300 mm (12 in .) of every outlet box, junction box, cabinet, or fitting and at intervals not exceeding 1.

~~4 m~~

4 m (4 1

~~⁄~~

⁄2 ft).

~~**(C)** Supporting.~~

~~Unless otherwise permitted, Type AC cable shall be supported at intervals not exceeding 1.4 m (4 1⁄2 ft).~~

~~Securement shall be by the use of staples; cable ties listed and identified for securement.~~

~~Exception 1: Horizontal runs of Type AC cable~~

~~installed~~

~~in wooden or metal framing members or similar supporting means~~

~~shall be considered supported and secured where such support does not exceed 1.4 m~~

~~, it is not required to be secured at 1.4 m (4 1~~

~~⁄s~~

~~⁄ 2 - ft) intervals.~~

~~**(D)** Unsupported Cables.~~

~~Type AC cable shall be permitted to be unsupported and unsecured where the cable complies with any of the following:~~

~~Exception 2. If Type AC cable is fished between access points through concealed spaces in finished buildings or structures~~

~~and supporting is impracticableIs~~

~~, it is not required to be secured at 1.4 m (4 1 ⁄ 2 - ft) intervals.~~

~~Exception 3. Type AC cable in lengths not more than~~

~~600 mm~~

~~600 mm (~~

~~2 ft~~

~~2 ft)~~

~~in length~~

~~at terminals where flexibility is necessary~~

~~Is~~

~~is not required to be secured.~~

~~Exception 4. Type AC cable in lengths not more than 1.~~

~~8 m~~

~~8 m (~~

~~6 ft~~

~~6 ft)~~

~~in length~~

~~from the last point of cable~~

~~support~~

~~securement to the point of connection to a luminaire(s) or other electrical equipment~~

~~and~~

~~, where the cable and point of connection are within an accessible ceiling , are not required to be secured. Type AC cable fittings shall be permitted as a means of cable securement.~~

Statement of Problem and Substantiation for Public Input

Since the cable is required to be secured within 300 mm (12 in.) of every outlet box, junction box, cabinet, or fitting and at intervals not exceeding 1.4 m (4 1⁄2 ft), then there is no need to have any rules about its support. Simply state the requirements on securing and provide the exceptions needed.

Submitter Information Verification

Submitter Full Name:	Mike Holt
Organization:	Mike Holt Enterprises Inc
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Aug 30 20:20:20 EDT 2023
Committee:	NEC-P06

Public Input No. 1869-NFPA 70-2023 [Section No. 320.30(A)]

(A) General.

Type AC cable shall be supported and secured by staples; cable ties listed and identified for securement and support; straps, hangers, or similar fittings; or other approved means designed and installed so as not to damage the cable.

~~Type AC cable fittings shall be permitted as a means of cable support.~~

Statement of Problem and Substantiation for Public Input

There is no provision in any of the first level subdivisions where the deleted language serves any purpose. (B) requires securing, and the deleted language only applies to supporting. (C) applies along the run of the cable, and a cable connector could not be used to support a cable mid-run. (D) permits the cable to be unsupported and unsecured, so again no use for language that permits the connector to support the cable.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1863-NFPA 70-2023 [Section No. 330.30(A)]	same issue
Public Input No. 1863-NFPA 70-2023 [Section No. 330.30(A)]	

Submitter Information Verification

Submitter Full Name: Don Ganiere
Organization: none
Street Address:
City:
State:
Zip:
Submittal Date: Sun Aug 06 17:42:34 EDT 2023
Committee: NEC-P06

Public Input No. 2882-NFPA 70-2023 [Section No. 320.30(A)]

(A) General.

Type AC cable shall be supported and secured by ~~staples;~~ cable ties listed and identified for securement and support; listed staples straps, hangers, or similar ~~fittings; or other approved means designed~~ fittings designed and installed so as not to damage the cable.

Type AC cable fittings shall be permitted as a means of cable support.

Statement of Problem and Substantiation for Public Input

To avoid damage to Type AC cable and undue stress being transferred to electrical connections from sagging cables a requirement for listed hardware for support and securement of Type AC Cables is necessary by the NEC. The need for the NEC to require listed staples, straps, hangers and fittings became more crucial on account of advancements installation tool technology and today's tools that provide staple depth control. The ANSI/UL Standard for Safety for Hardware for the Support of Conduit, Tubing, and Cable, UL 2239, was first published nearly 20 years ago and contains all necessary hardware construction, performance, marking and installation instructions necessary to provide installers and AHJs the guidance to properly use today's tools to support and secure Type AC cables when using listed hardware.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2881-NFPA 70-2023 [Section No. 320.6]	requires hardware listing in 320.2

Submitter Information Verification

Submitter Full Name: David Gerstetter
Organization: Ul Solutions
Affiliation: UL Solutions
Street Address:
City:
State:
Zip:

Submittal Date: Fri Aug 25 20:55:12 EDT 2023
Committee: NEC-P06

Public Input No. 2245-NFPA 70-2023 [Section No. 320.30(D)]

(D) Unsupported <u>and Unsecured</u> Cables.

Type AC cable shall be permitted to be unsupported and unsecured where the cable complies with any of the following:

(1) Is fished between access points through concealed spaces in finished buildings or structures and supporting is impracticable

(2) Is not more than 600 mm (2 ft) in length at terminals where flexibility is necessary

(3) Is not more than 1.8 m (6 ft) in length from the last point of cable support to the point of connection to a luminaire(s) or other electrical equipment and the cable and point of connection are within an accessible ceiling

Statement of Problem and Substantiation for Public Input

This requirement applies to both securing and supporting. Adding ‘’and Unsecured” to the subdivision title to bring clarity for Code users.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
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Submittal Date: Tue Aug 15 13:21:28 EDT 2023
Committee: NEC-P06

Public Input No. 3987-NFPA 70-2023 [Section No. 320.80(A)]

(A) Thermal Insulation.

(1) General. Armored cable installed in thermal insulation shall have conductors rated at 90°C (194°F). The ampacity of cable installed in these applications shall not exceed that of a 60°C (140°F) rated conductor. The 90°C (194°F) rating shall be permitted to be used for ampacity adjustment and correction calculations; however, the ampacity shall not exceed that of a 60°C (140°F) rated conductor.

(2) Ampacity Adjustment. Where more than two Type AC cables containing two or more current-carrying conductors in each cable are installed in contact with thermal insulation, caulk, or sealing foam without maintaining spacing between cables, the ampacity of each conductor shall be adjusted in accordance with Table 310.15(C)(1).

Statement of Problem and Substantiation for Public Input

Breaking up 320.80(A) into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

Submitter Information Verification

Submitter Full Name: Mike Holt
Organization: Mike Holt Enterprises Inc
Street Address:
City:
State:
Zip:
Submittal Date: Wed Sep 06 12:23:21 EDT 2023
Committee: NEC-P06

Public Input No. 605-NFPA 70-2023 [New Section after 322.1]

322.2 Reconditioned Equipment

Flat Cable Assemblies, Type FC shall not be reconditioned

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

Submitter Full Name: Russ Leblanc

Organization: Leblanc Consulting Services

Street Address:

City:

State:

Zip:

Submittal Date: Sun Apr 16 08:05:12 EDT 2023

Committee: NEC-P06

Public Input No. 2863-NFPA 70-2023 [Section No. 322.6]

322.~~6~~ 2 Listing Requirements.

Type FC and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

Per the 2023 NEC style manual, clause 2.2.1, “Required Parallel Numbering Format” Listing requirements should be relocated from 322.6 to 322.2.

Submitter Information Verification

Submitter Full Name: David Gerstetter
Organization: Ul Solutions
Affiliation: Ul Solutions
Street Address:
City:
State:
Zip:
Submittal Date: Fri Aug 25 17:38:24 EDT 2023
Committee: NEC-P06

Public Input No. 3507-NFPA 70-2023 [Section No. 322.6]

322.~~6~~ 2 Listing Requirements.

Type FC and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name: David Williams
Organization: Delta Charter Township
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 04 17:16:47 EDT 2023
Committee: NEC-P06

Public Input No. 1020-NFPA 70-2023 [Section No. 322.104]

322.104 Conductors.

Flat cable assemblies shall have conductors of ~~10 AWG~~ 10 AWG special stranded copper wires, or 8 AWG special stranded copper-clad aluminum wires.

Statement of Problem and Substantiation for Public Input

See substantiation in PI 1008

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]	

Submitter Information Verification

Submitter Full Name: Peter Graser
Organization: Copperweld
Affiliation: American Bimetallic Association
Street Address:
City:
State:
Zip:

Submittal Date: Sun Jun 11 16:13:55 EDT 2023
Committee: NEC-P06

Public Input No. 606-NFPA 70-2023 [New Section after 324.1]

324.2 Reconditioned Equipment

Type FCC cable shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

Submitter Full Name: Russ Leblanc
Organization: Leblanc Consulting Services
Street Address:
City:
State:
Zip:

Submittal Date: Sun Apr 16 08:09:24 EDT 2023
Committee: NEC-P06

Public Input No. 2864-NFPA 70-2023 [Section No. 324.6]

324.~~6~~ 2 Listing Requirements.

Type FCC cable and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

Per the 2023 NEC style manual, clause 2.2.1, “Required Parallel Numbering Format” Listing requirements should be relocated from 324.6 to 324.2.

Submitter Information Verification

Submitter Full Name:	David Gerstetter
Organization:	Ul Solutions
Affiliation:	UL Solutions
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Aug 25 17:43:24 EDT 2023
Committee:	NEC-P06

Public Input No. 3508-NFPA 70-2023 [Section No. 324.6]

~~324.6~~ 2 Listing Requirements.

Type FCC cable and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name: David Williams
Organization: Delta Charter Township
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 04 17:18:32 EDT 2023
Committee: NEC-P06

Public Input No. 1019-NFPA 70-2023 [Section No. 324.100(A)]

(A) Type FCC Cable.

Type FCC cable shall be listed for use with the FCC system and shall consist of three, four, or five flat copper or copper-clad aluminum conductors, one of which shall be an equipment grounding conductor.

Statement of Problem and Substantiation for Public Input

See substantiation in PI 1008.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]	

Submitter Information Verification

Submitter Full Name:	Peter Graser
Organization:	Copperweld
Affiliation:	American Bimetallic Association
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sun Jun 11 16:10:06 EDT 2023
Committee:	NEC-P06

Public Input No. 607-NFPA 70-2023 [New Section after 326.1]

326.2 Reconditioned Equipment

Type IGS cable shall not be reconditioned

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

Submitter Full Name:	Russ Leblanc
Organization:	Leblanc Consulting Services
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Sun Apr 16 08:11:13 EDT 2023
Committee:	NEC-P06

Public Input No. 608-NFPA 70-2023 [New Section after 330.1]

330.2 Reconditioned Equipment

Type MC cable shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

Submitter Full Name: Russ Leblanc
Organization: Leblanc Consulting Services
Street Address:
City:
State:
Zip:
Submittal Date: Sun Apr 16 08:12:34 EDT 2023
Committee: NEC-P06

Public Input No. 2883-NFPA 70-2023 [Section No. 330.6]

330.~~6~~ 2 Listing Requirements.

Type MC cable, support and securement hardware shall be listed. Fittings used for connecting Type MC cable to boxes, cabinets, or other equipment shall be listed and identified for such use.

Statement of Problem and Substantiation for Public Input

To avoid damage to MC cable and undue stress on electrical connections, the use of listed hardware for support and securement Type MC Cable is necessary. The need for the NEC to require listed staples, straps, hangers and fittings became more crucial on account of advancements installation tool technology and today's tools that provide staple depth control. UL 2239, the Standard for Safety for Hardware for the Support of Conduit, Tubing, and Cable, was first published nearly 20 years ago and contains all necessary hardware construction, performance, marking and installation instructions necessary to provide installers the guidance to properly use today's tools to support and secure Type MC cable using hardware installed per the manufacturers' installation instructions.

Additionally, per the 2023 NEC style manual, clause 2.2.1, "Required Parallel Numbering Format" Listing requirements should be relocated from 330.6 to 330.2.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2884-NFPA 70-2023 [Section No. 330.30(A)]	

Submitter Information Verification

Submitter Full Name: David Gerstetter

Organization: Ul Solutions

Affiliation: UL Solutions

Street Address:

City:

State:

Zip:

Submittal Date: Fri Aug 25 21:17:14 EDT 2023

Committee: NEC-P06

Public Input No. 3509-NFPA 70-2023 [Section No. 330.6]

330.~~6~~ 2 _ Listing Requirements.

Type MC cable shall be listed. Fittings used for connecting Type MC cable to boxes, cabinets, or other equipment shall be listed and identified for such use.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name: David Williams
Organization: Delta Charter Township
Street Address:
City:
State:
Zip:

Submittal Date: Mon Sep 04 17:20:49 EDT 2023
Committee: NEC-P06

Public Input No. 3615-NFPA 70-2023 [Section No. 330.10(A)]

(A) General Uses.

Type MC cable shall be permitted as follows:

(1) For services, feeders, and branch circuits.

(2) For power, lighting, control, ~~and signal~~ **and non-power limited & Remote Control signaling circuits.**

(3) Indoors or outdoors.

(4) Exposed or concealed.

(5) To be direct buried where identified for such use.

(6) In cable tray where identified for such use.

(7) In any raceway.

(8) As aerial cable on a messenger.

(9) In hazardous (classified) locations where ~~specifically~~ specific ally permitted by other articles in this *Code*.

(10) In dry locations and embedded in plaster finish on brick or other masonry except in damp or wet locations.

(11) In damp or wet locations where a corrosion-resistant jacket is provided over the metallic covering and any of the following conditions are met:

(12) The metallic covering is impervious to moisture.

(13) A jacket resistant to moisture is provided under the metal covering.

(14) The insulated conductors under the metallic covering are listed for use in wet locations.

(15) Where single-conductor cables are used, all phase conductors and, where used, the grounded conductor shall be grouped together to minimize induced voltage on the sheath.

Statement of Problem and Substantiation for Public Input

The added text in 330.10 (A) (2) will enhance usability and clarity to the code for non-power limited installations.

Submitter Information Verification

Submitter Full Name: Donald Iverson
Organization: Schneider Electric
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 05 08:13:03 EDT 2023
Committee: NEC-P06

Public Input No. 3788-NFPA 70-2023 [Section No. 330.10(A)]

(A) General Uses.

Type MC cable shall be permitted as follows:

(1) For services, feeders, and branch circuits.

(2) For power, lighting, control, and signal circuits.

(3) Indoors or outdoors.

(4) Exposed or concealed.

(5) To be direct buried where identified for such use.

(6) In cable tray where identified for such use.

(7) In any raceway.

(8) As aerial cable on a messenger.

(9) In hazardous (classified) locations where specifically permitted by other articles in this *Code*.

(10) In dry locations and embedded in plaster finish on brick or other masonry except in damp or wet locations.

(11) In ~~damp or~~ wet locations ~~where a corrosion-resistant jacket is provided over the metallic covering and~~ where and any of the following conditions are met:

(12) The metallic covering is impervious to moisture.

(13) A moisture-impervious jacket

~~resistant to moisture~~

a. is provided under the metal covering.

b. The insulated conductors under the metallic covering are listed for use in wet locations , and a corrosion-resistant jacket is provided over the metallic sheath .

(14) Where single-conductor cables are used, all phase conductors and, where used, the grounded conductor shall be grouped together to minimize induced voltage on the sheath.

Statement of Problem and Substantiation for Public Input

From NFPA 70 – 2014 Edition and on, all Type MC cable must have a corrosion resistant jacket over the metallic covering and comply with additional conditions to be wet rated.

Up to the NFPA 70 – 2011 Edition, Type MC cable use in wet locations was recognized when any of the following conditions were met:

a) The metallic covering is impervious to moisture.

b) A moisture-impervious jacket is provided under the metal covering.

c) The insulated conductors under the metallic covering are listed for use in wet locations, and a corrosion resistant jacket is provided over the metallic sheath.

These conditions sufficiently covered wet ratings for the entire range of Type MC cable as explained below:

Condition ‘a’ covered smooth sheath, and corrugated sheaths, which are inherently impervious to moisture.

Condition ‘b’ covered interlocked armors, which are not impervious to water.

Condition ‘c’ provided another option for interlocked armors.

Furthermore, condition 'a' in either 2011 or 2023 editions fully addresses wet listing requirements as stated per the 'impervious to moisture' wording. Requiring the addition of jacket for impervious sheathed Type MC cable is redundant as already addressed by the 'impervious' nature of the sheath.

The proposed changes also address a conflict stemming from NFPA 70 Article 310.10(C), where one of the conditions that grant a wet rating is to be moisture-impervious metal sheathed.

Therefore, we request that the wording used in the 2011 Edition of the National Electrical Code be reinstated to properly permit corrugated and smooth Types MC cable that are impervious to moisture to be used in wet locations.

Submitter Information Verification

Submitter Full Name:	Alex Marciano
Organization:	Marmon IEI
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Sep 05 16:24:02 EDT 2023
Committee:	NEC-P06

Public Input No. 2661-NFPA 70-2023 [Section No. 330.10(B)]

(B) Specific Uses.

Type MC cable shall be permitted to be installed in compliance with Article 725, Parts II and ~~III of Article 725 and~~ III and 770.133 as applicable and in accordance with 330.10(B)(1) through (B)(4).

Informational Note: The "Uses Permitted" is not an all-inclusive list.

(1) Cable Tray.

Type MC cable installed in cable tray shall comply with 392.10, 392.12, 392.18, 392.20, 392.22, 392.30, 392.46, 392.56, 392.60(C), and 392.80.

(2) Direct Buried.

Direct-buried cable shall comply with 300.5 or 305.15, as appropriate.

(3) Installed as Service-Entrance Cable.

Type MC cable installed as service-entrance cable shall be permitted in accordance with 230.43.

(4) Installed Outside of Buildings or Structures or as Aerial Cable.

Type MC cable installed outside of buildings or structures or as aerial cable shall comply with 225.10, 396.10, and 396.12.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Submittal Date:	Thu Aug 24 08:09:58 EDT 2023
Committee:	NEC-P06

Public Input No. 3466-NFPA 70-2023 [Section No. 330.15]

330.15 Exposed Work.

Exposed runs of cable, except as provided in 300.11(B), shall closely follow the surface of the building finish or of running boards. Running boards shall be wider than the cable or cables they support, and shall not sag as installed. They shall be constructed of nominal two-by lumber, or use other designs approved by the Authority Having Jurisdiction as providing suitable support and protection. Exposed runs shall also be permitted to be installed on the underside of joists where supported at each joist and located so as not to be subject to physical damage.

Statement of Problem and Substantiation for Public Input

Because there are no specifications for running boards, and no definition, presently this falls into the category of "I know what I mean" inspection. The dictionary definition of "board" isn't enough. How much support do the boards need to give? If you want to use a 1x3 rather than a 2x, or a strip of 5/8 plywood, or a different material altogether, let the inspector approve based on how long the run is between supports. But this sets a basic, reasonable spec. If an installer wants to use a 2x2, the run had better not be too long or it will sag, violating that requirement. One reason to add that restriction is because if it is not sturdy enough as installed to prevent sagging, it probably is not sturdy enough to last, especially after the first time something knocks into it.

Historically, and elsewhere in the NEC, running boards sometimes have required side protection, sometimes have had a specific minimum width, sometimes required a specific width to each side of the wiring they support. This is far simpler.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3463-NFPA 70-2023 [New Definition after Definition: Riser Cable, Cable Routing...]	Definition shows the purpose of these without setting specs.
Public Input No. 3464-NFPA 70-2023 [Section No. 320.15]	A comparable spec where AC cable is used.
Public Input No. 3468-NFPA 70-2023 [Section No. 334.15(A)]	

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Submittal Date: Sun Sep 03 16:03:03 EDT 2023

Committee: NEC-P06

Public Input No. 2247-NFPA 70-2023 [Section No. 330.30]

330.30 Securing and Supporting.

(A) General.

Type MC cable shall be supported and secured by staples; cable ties listed and identified for securement and support; straps, hangers, or similar fittings; or other approved means designed and installed so as not to damage the cable.

~~Type MC cable fittings shall be permitted as a means of cable support.~~

(B) Securing.

Unless otherwise permitted in this *Code*, cables shall be secured at intervals not exceeding 1.8 m (6 ft). Cables containing four or fewer conductors sized no larger than 10 AWG shall be secured within 300 mm (12 in.) of every box, cabinet, fitting, or other cable termination. In vertical installations, listed cables with ungrounded conductors 250 kcmil and larger shall be permitted to be secured at intervals not exceeding 3 m (10 ft).

(C) Supporting.

Unless otherwise permitted in this *Code*, cables shall be supported at intervals not exceeding 1.8 m (6 ft).

Horizontal runs of Type MC cable installed in wooden or metal framing members or similar supporting means shall be considered supported and secured where such support does not exceed 1.8m (6ft) intervals.

Type MC cable fittings shall be permitted as a means of cable support.

(D) Unsupported Cables.

Type MC cable shall be permitted to be unsupported and unsecured where the cable complies with any of the following:

(1) Is fished between access points through concealed spaces in finished buildings or structures and supporting is impractical

(2) Is not more than 1.8 m (6 ft) in length from the last point of cable support to the point of connection to luminaires or other electrical equipment and the cable and point of connection are within an accessible ceiling

(3) Is Type MC of the interlocked armor type in lengths not exceeding 900 mm (3 ft) from the last point where it is securely fastened and is used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation

Statement of Problem and Substantiation for Public Input

Relocating from 330.30(A) to 330.30(C) in order to group the supporting requirements all together. This proposed revision will enhance clarity and usability for Code users.

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Committee: NEC-P06

Public Input No. 3260-NFPA 70-2023 [Section No. 330.30]

330.

~~30~~

30 Securing

~~and Supporting~~

~~:~~

~~**(A)** General.~~

Type MC cable shall be

~~supported and secured by staples; cable ties listed and identified for securement and support; straps, hangers, or similar fittings; or other approved means designed and installed so as not to damage the cable.~~

~~Type MC cable fittings shall be permitted as a means of cable support.~~

~~**(B)** Securing.~~

~~Unless otherwise permitted in this *Code* , cables shall be secured at intervals not exceeding 1.8 m (6 ft). Cables containing four or fewer conductors sized no larger than 10 AWG shall be secured within 300 mm (12 in.) of every box, cabinet, fitting, or other cable termination. In vertical installations, listed cables with ungrounded conductors 250 kcmil and larger shall be permitted to be secured at intervals not exceeding 3 m (10 ft).~~

~~(C) Supporting.~~

~~Unless otherwise permitted in this *Code* , cables shall be supported at intervals not exceeding 1.8 m (6 ft).~~

secured within 300 mm (12 in.) of every outlet box, junction box, cabinet, or fitting and at intervals not exceeding 1.4 m (4 1⁄2 ft). Securement shall be by the use of staples; cable ties listed and identified for securement.

Exception 1: Horizontal runs of Type MC cable

~~installed~~

in wooden or metal framing members or similar supporting means

~~shall be considered supported and secured where such support does not exceed 1.8m (6ftls~~

, it is not required to be secured at 1.4 m (4 1⁄2 ft) intervals.

~~(D) Unsupported Cables.~~

~~Type MC cable shall be permitted to be unsupported and unsecured where the cable complies with any of the following:~~

Exception 2. If Type MC cable is fished between access points through concealed spaces in finished buildings or structures

~~and supporting is impracticalls not more than 1.8 m (6 ft) in length~~

, it is not required to be secured at 1.4 m (4 1⁄2 ft) intervals.

Exception 3. Type MC cable in lengths not more than 600 mm (2 ft) at terminals where flexibility is necessary is not required to be secured.

Exception 4. Type MC cable in lengths not more than 1.8 m (6 ft) from the last point of cable

~~support~~

securement to the point of connection to

~~luminaires~~

a luminaire(s) or other electrical equipment

~~and~~

, where the cable and point of connection are within an accessible ceiling

~~Is Type MC of the interlocked armor type in lengths not exceeding 900 mm (3 ft) from the last point where it is securely fastened and is used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation~~

~~, are not required to be secured. Type MC cable fittings shall be permitted as a means of cable securement.~~

Statement of Problem and Substantiation for Public Input

Since the cable is required to be secured within 300 mm (12 in.) of every outlet box, junction box, cabinet, or fitting and at intervals not exceeding 1.4 m (41⁄2 ft), then there is no need to have any rules about its support. Simply state the requirements on securing and provide the exceptions needed.

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Committee: NEC-P06

Public Input No. 1863-NFPA 70-2023 [Section No. 330.30(A)]

(A) General.

Type MC cable shall be supported and secured by staples; cable ties listed and identified for securement and support; straps, hangers, or similar fittings; or other approved means designed and installed so as not to damage the cable.

~~Type MC cable fittings shall be permitted as a means of cable support.~~

Statement of Problem and Substantiation for Public Input

There is no provision in any of the first level subdivisions where the deleted language serves any purpose. (B) requires securing, and the deleted language only applies to supporting. (C) applies along the run of the cable, and a cable connector could not be used to support a cable mid-run. (D) permits the cable to be unsupported and unsecured, so again no use for language that permits the connector to support the cable.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1869-NFPA 70-2023 [Section No. 320.30(A)]	same issue
Public Input No. 1869-NFPA 70-2023 [Section No. 320.30(A)]	

Submitter Information Verification

Submitter Full Name: Don Ganiere

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Submittal Date: Sun Aug 06 16:48:34 EDT 2023

Committee: NEC-P06

Public Input No. 2884-NFPA 70-2023 [Section No. 330.30(A)]

(A) General.

Type MC cable shall be supported and secured by ~~staples;~~ cable ties listed and identified for securement and support; listed staples straps, hangers, or similar fittings; ~~or other approved means designed~~ designed and installed so as not to damage the cable.

Type MC cable fittings shall be permitted as a means of cable support.

Statement of Problem and Substantiation for Public Input

Removal of other approved since listed hardware is being proposed in 330.2 and 330.30(A).
To avoid damage to Type MC cable and undue stress being transferred to electrical connections from sagging cables a requirement for listed hardware for support and securement of Type MC Cables is necessary by the NEC. The need for the NEC to require listed staples, straps, hangers and fittings became more crucial on account of advancements installation tool technology and today's tools that provide staple depth control. The ANSI/UL Standard for Safety for Hardware for the Support of Conduit, Tubing, and Cable, UL 2239, was first published nearly 20 years ago and contains all necessary hardware construction, performance, marking and installation instructions necessary to provide installers and AHJs the guidance to properly use today's tools to support and secure Type MC cables when using listed hardware.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2883-NFPA 70-2023 [Section No. 330.6]	

Submitter Information Verification

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Committee:	NEC-P06

Public Input No. 2248-NFPA 70-2023 [Section No. 330.30(D)]

(D) Unsupported and Unsecured Cables.

Type MC cable shall be permitted to be unsupported and unsecured where the cable complies with any of the following:

(1) Is fished between access points through concealed spaces in finished buildings or structures and supporting is impractical

(2) Is not more than 1.8 m (6 ft) in length from the last point of cable support to the point of connection to luminaires or other electrical equipment and the cable and point of connection are within an accessible ceiling

(3) Is Type MC of the interlocked armor type in lengths not exceeding 900 mm (3 ft) from the last point where it is securely fastened and is used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation

Statement of Problem and Substantiation for Public Input

This requirement applies to both securing and supporting. Adding ''and Unsecured" to the subdivision title to bring clarity for Code users.

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Public Input No. 1264-NFPA 70-2023 [New Section after 330.31]

TITLE OF NEW CONTENT

330.42 Connectors or Fittings

Connectors or fittings shall be shall be used at all terminations of type MC cable. Connectors utilizing locknuts shall be made "wrench tight". Other connectors and fittings shall be used and installed in accordance with the manufacturers installation instructions.

Statement of Problem and Substantiation for Public Input

Multiple manufacturers market connectors that don't require a locknut and have been tested to ensure a suitable ground is made at the box. I have inspected many installations where type MC/AP was used along with threaded connectors using a locknut where the locknut had not been made tight to the box. This poses a huge problem with proper grounding since the MC/AP cable (especially when using MC/AP-HP) gets its bonding from the connector. By adding this new section (consistent with other sections in raceway chapters) the code makes it clear to the user that the threaded connectors need to be made tight. The term "wrench tight" simply refers to the use of pump pliers tightening the connector down or working the locknut around with a screwdriver and linesman pliers ensuring a better than "hand tight" outcome.

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Public Input No. 1009-NFPA 70-2023 [Section No. 330.104]

330.104 Conductors.

For ungrounded, grounded, and equipment grounding conductors, the minimum conductor sizes shall be 14 AWG copper, nickel, ~~or~~ nickel-coated copper ~~and 12 AWG aluminum~~ , or copper-clad aluminum and 12 AWG aluminum .

For control and signal conductors, minimum conductor sizes shall be 18 AWG copper, nickel, or nickel-coated copper, 14 AWG copper-clad aluminum, and 12 AWG aluminum.

Statement of Problem and Substantiation for Public Input

See substantiation in PI 1008

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]	

Submitter Information Verification

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Submittal Date: Sun Jun 11 08:29:32 EDT 2023

Committee: NEC-P06

Public Input No. 1018-NFPA 70-2023 [Section No. 330.104]

330.104 Conductors.

For ungrounded, grounded, and equipment grounding conductors, the minimum conductor sizes shall be 14 AWG copper, nickel, or nickel-coated copper and 12 AWG aluminum or copper-clad aluminum.

For control and signal conductors, minimum conductor sizes shall be 18 AWG copper, nickel, or nickel-coated copper, ~~14 AWG~~ 16 AWG copper-clad aluminum, and 12 AWG aluminum.

Additional Proposed Changes

File Name	Description	Approved
PGFinal.SW-2023-001_-_Electrical_Characteristic_Comparison_between_Copper_and_CCA_Thermostat_Wire_002_.pdf	Electrical Characteristics of 16 AWG CCA relative to 18 AWG Copper	

Statement of Problem and Substantiation for Public Input

Performance testing has indicated that 16 AWG copper-clad aluminum is suitable for use as a remote control and signaling wire. 16 AWG conductors and smaller have long been used as coaxial cable conductors. Currently in UL 13. 16 AWG CCA referenced by UL 13 for thermostat wire. 16 AWG CCA and smaller conductors have long been used as data conductors in the coaxial cable.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1022-NFPA 70-2023 [Section No. 336.104 [Excluding any Sub-Sections]]	
Public Input No. 1023-NFPA 70-2023 [Section No. 337.104]	
Public Input No. 1431-NFPA 70-2023 [Section No. 402.5]	

Submitter Information Verification

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Submittal Date: Sun Jun 11 15:13:58 EDT 2023

Committee: NEC-P06

Electrical Test Laboratory Report SW-2023-002

Market:	Class 4 Conductors		
Subject:	Electrical Characteristic Comparison between 16 AWG CCA vs 18 AWG Cu		
Date:	8/29/23	Report No:	002

Analysis By:	Brandon Allen – Product Engineer
Authored By:	Brandon Allen– Product Engineer
Approved By:	Tom Sterling – Product Development Manager

Objective:

To perform electrical analysis to show the characteristic comparison of 16 AWG Copper Clad Aluminum (CCA) to 18 AWG Copper (Cu).

Samples/Equipment Provided:

Materials

- Test Samples: 16 AWG Copper Clad Aluminum (CCA)
- Test Samples: 18 AWG Copper (Cu)

Wire Tested:

- *500 ft. of 18 AWG Solid Copper, annealed*
- *500 ft. of 16 AWG solid CCA 10%, annealed*
- *Minimum of 6 mils of PVC insulation on both Cu and CCA wire*

Physical Attributes	Diameter (in)	Cross-Sectional Area (in²)	Weight (lb/kft)	Copper Thickness (in)	DC Resistance (Ω/kft)
18 AWG Cu	0.0403	0.001276	4.917	0.04030	6.610
16 AWG CCA 10%	0.0508	0.002027	2.919	0.00127	6.524

Test Equipment / Calibration Requirements

- Data Acquisition System
- Thermocouple
- Power Source (24 VAC at 40VA)

Test Procedure 1: Temperature Readings with Incremental Current

1. Set the configuration for the AC power/current source to begin the test.
2. Using the 16 AWG Copper Clad Aluminum (CCA) samples, prepare the test samples by connecting the thermocouples to the test samples for the temperature readings.
3. With the thermocouples attached to the test samples, connect the opposite end of the thermocouple wire to the Data acquisition system.
4. Set the current source to the initial current of 3A then increment by 3A in 10-minute intervals for the duration of the test. Step up current to a final level of 24 amperes.
5. All testing conducted in open-air.
6. At the completion of the test, store the data and repeat each step for 18 AWG Copper (Cu).

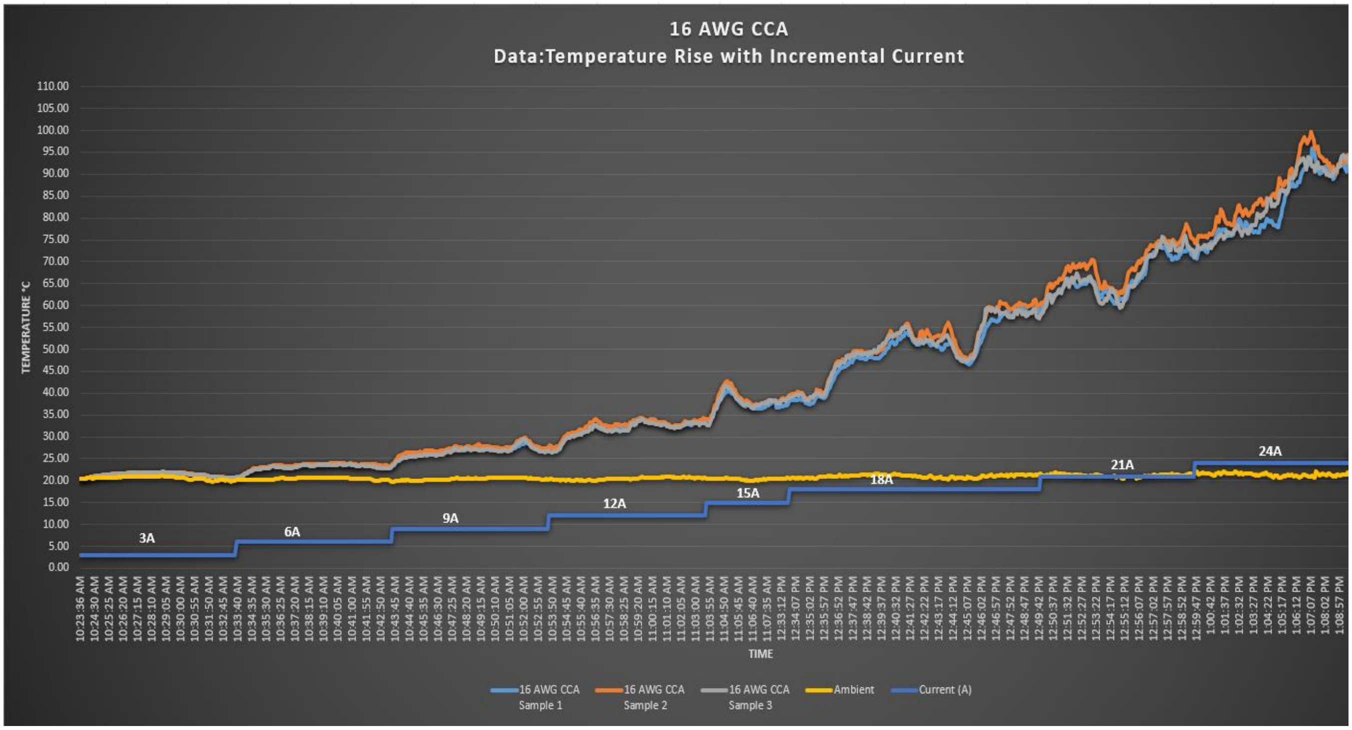
Test Results 1: Temperature Readings with Incremental Current

During testing, the data revealed that the increase in current was proportional to the increase in temperature. In comparison, the three samples of 16 AWG CCA ran slightly cooler than the three samples of 18 AWG Cu. Below Table 1 presents values stepped up from 3 amperes to 12 amperes. 16 AWG CCA for Class 4 circuits should never see 12 amperes of AC current in the real world.

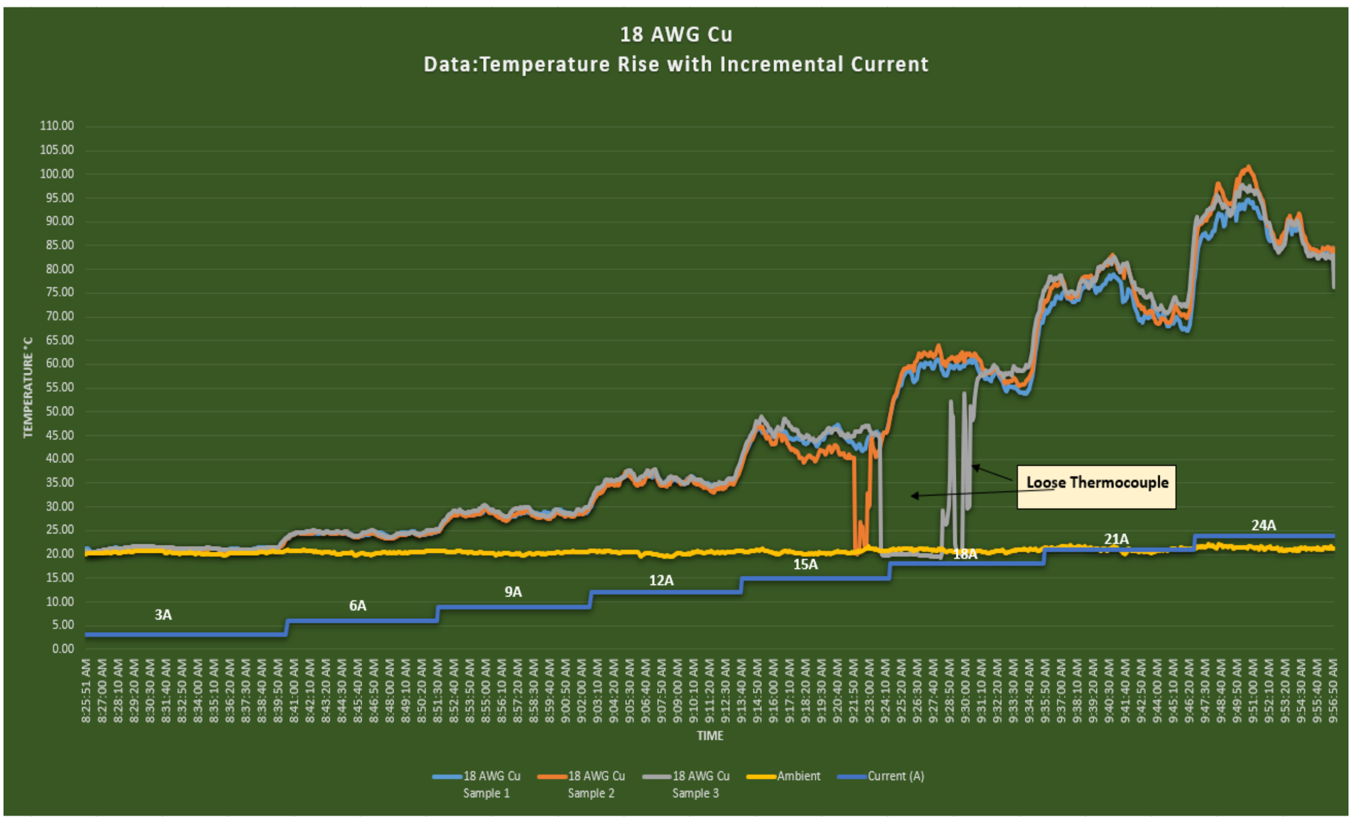
See Table 1 and graphs 1 & 2 below for more details:

TABLE 1:

16 AWG CCA				18 AWG Copper			
Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise	Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise
3	**21.96**	**20.58**	**1.38**	**3**	**23.38**	**20.38**	**3.00**
6	**24.13**	**20.43**	**3.70**	**6**	**25.3**	**20.43**	**4.87**
9	**29.79**	**20.38**	**9.41**	**9**	**30.46**	**20.34**	**10.12**
12	**34.28**	**20.44**	**13.84**	**12**	**39.75**	**20.33**	**19.42**



Graph 1: 16 AWG CCA



Graph 2: 18 AWG Cu

Test Results 2: Electrical Characteristic Measurements

The Voltage drop was calculated using the voltage drop calculator formula at 3 Amps.

VOLTAGE DROP CALCULATOR FORMULA

$$VD = (2 \cdot A \cdot L \cdot R) / 1000$$

Where:

VD = Voltage Drop (Volts) per unit circuit length

A = Full Load Current (Amps)

L = One-Way Circuit Length (ft)

R = Resistance (Ohms/Kft)

		Run Length (ft)			
Voltage Drop (Vac)	VAC++	50	100	150	200
18 AWG Cu	24.00	1.98	3.96	5.95	7.93
16 AWG CCA 10%	24.00	1.95	3.91	5.87	7.82

** With a supply voltage of 24 Vac, what is the Drop Voltage across the hot and common legs of circuit, at specified Lengths of wire?*

** Set Load Resistance to drawn 3.0 Amps*

Conclusion:

When comparing 16 AWG Copper Clad Aluminum to 18 AWG Copper, the electrical measurements of the 16 AWG Copper Clad Aluminum conductor measured at a slightly lower resistance than the 18 AWG Copper. The analysis of the thermal test also showed that when the same current is applied to both conductors for the same duration, 16 AWG Copper Clad Aluminum measured at slightly lower temperatures than 18 AWG Copper. Lower conductor temperatures generally support the notion that the connected equipment will last longer and run more efficiently. The lower Voltage Drop of 16 AWG CCA as compared to that of 18 AWG copper will also likely improve equipment performance. The heating profiles of both the 16 AWG CCA and 18 AWG copper are not expected to pose problems for class 4 circuits.

Public Input No. 3143-NFPA 70-2023 [Section No. 330.130]

330.~~130~~ 126 Hazardous (Classified) Locations.

Where required to be marked MC-HL, the cable shall be listed and shall have a gas/vapor tight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material, and a separate equipment grounding conductor.

Statement of Problem and Substantiation for Public Input

This section was renumbered to comply with the NEC Style Manual. The parallel number of the wiring method articles was developed for the 2002 code cycle. Section 2.2.1.1. of the NEC Style Manual requires the use of parallel numbers to the extent possible. the xxx.130 section has been used in other wiring method articles for Standard Lengths and should remain remain for that criteria. xxx.126 has not been used and may provide a location to cover hazardous location previsions.

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Public Input No. 609-NFPA 70-2023 [New Section after 332.1]

332.2 Reconditioned Equipment

Type MI cable shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

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Submittal Date:	Sun Apr 16 08:13:55 EDT 2023
Committee:	NEC-P06

Public Input No. 2885-NFPA 70-2023 [Section No. 332.6]

~~332.6~~ 2 Listing Requirements.

Type MI cable ~~and associated fittings~~ , associated fittings, support and securement hardware shall be listed.

Statement of Problem and Substantiation for Public Input

To avoid damage to MI cable and undue stress on electrical connections, the use of listed hardware for support and securement Type MI Cable should be required. UL 2239, the Standard for Safety for Hardware for the Support of Conduit, Tubing, and Cable, was first published nearly 20 years ago and contains all necessary hardware construction, performance, marking and installation instructions necessary to provide installers the guidance to properly support and secure Type MI cable using hardware installed per the manufacturers' installation instructions.

Additionally, per the 2023 NEC style manual, clause 2.2.1, "Required Parallel Numbering Format" Listing requirements should be relocated from 332.6 to 332.2.

Submitter Information Verification

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Submittal Date: Fri Aug 25 21:34:39 EDT 2023
Committee: NEC-P06

Public Input No. 3510-NFPA 70-2023 [Section No. 332.6]

332.~~6~~ 2 Listing Requirements.

Type MI cable and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Submittal Date:	Mon Sep 04 17:22:49 EDT 2023
Committee:	NEC-P06

Public Input No. 610-NFPA 70-2023 [New Section after 334.1]

334.2 Reconditioned Equipment

Type NM and Type NMC cables shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

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Submittal Date:	Sun Apr 16 08:15:23 EDT 2023
Committee:	NEC-P06

Public Input No. 2886-NFPA 70-2023 [Section No. 334.6]

334.~~6~~ 2 Listing Requirements.

Type NM and Type NMC cables ~~and associated fittings~~ , associated fittings, support and securement hardware shall be listed.

Statement of Problem and Substantiation for Public Input

To avoid damage to Type NM cable and undue stress being transferred to electrical connections from sagging cables a requirement for listed hardware for support and securement of Type NM Cables is necessary by the NEC. The need for the NEC to require listed staples, straps, hangers and fittings became more crucial on account of advancements installation tool technology and today's tools that provide staple depth control. The ANSI/UL Standard for Safety for Hardware for the Support of Conduit, Tubing, and Cable, UL 2239, was first published nearly 20 years ago and contains all necessary hardware construction, performance, marking and installation instructions necessary to provide installers and AHJs the guidance to properly use today's tools to support and secure Type NM cables when using listed hardware.
Additionally, per the 2023 NEC style manual, clause 2.2.1, "Required Parallel Numbering Format" Listing requirements should be relocated from 334.6 to 334.2.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2887-NFPA 70-2023 [Section No. 334.30]	

Submitter Information Verification

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Committee: NEC-P06

Public Input No. 3511-NFPA 70-2023 [Section No. 334.6]

~~334.6~~ 2 Listing Requirements.

Type NM and Type NMC cables and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Submittal Date:	Mon Sep 04 17:25:11 EDT 2023
Committee:	NEC-P06

Public Input No. 2595-NFPA 70-2023 [Sections 334.10(A), 334.10(B)]

Sections 334.10(A), 334.10(B)

(A) Type NM.

Type NM cable shall be permitted as follows:

(1) For both exposed and concealed work in normally dry locations except as prohibited in 334.10(3). When used in concealed work must be protected by 334.15(B) or by an AFCI protection device.

(2) To be installed or fished in air voids in masonry block or tile walls

(B) Type NMC.

Type NMC cable shall be permitted as follows:

(1) For both exposed and concealed work in dry, wet, damp, or corrosive locations, except as prohibited by 334.10(3) When used in concealed work must be protected by 334.15(B) or by an AFCI protection device.

(2) In outside and inside walls of masonry block or tile

(3) In a shallow chase in masonry, concrete, or adobe protected against nails or screws by a steel plate at least 1.59 mm (1⁄16 in.) thick ~~and~~ , metal conduit or tubing or an AFCI circuit breaker and covered with plaster, adobe, or similar finish

Statement of Problem and Substantiation for Public Input

NM and NMC cable do not provide physical protection and once concealed behind ones in a home or building the owner has no idea where the cable is located. This can cause damage to the cable when making modifications or penetrating the wall. Also staples when installing these cables can be applied to tight compromising the sheath of the cable leading to early breakdown of the outer jacket and sheath allowing arcing between the conductors. NM Cable is a popular and reliable wiring method, but we do need to take some steps to protect it and the residents of homes and building where it is used. Below you will see some residential fire statistics from 2015 - 2019 provided by the NFPA in two different reports:
https://www.nfpa.org/News-and-Research/Data-research-and-tools/Electrical/Electrical
Electrical Failures or malfunctions caused an estimated 390 civilian deaths and 1330 injuries a year. The fires also caused an estimated 1.5 billion dollars in direct property damage a year. It was the second leading cause of home structure fires accounting for 13% percent of all fires. Arcing was estimated to cause three in five residential home fires from 2015-2019.

Electrical Distribution and lighting equipment was the cause of an estimated 32,160 home fires a year from 2015-2019. These fires caused an estimated 430 civilian deaths and 1070 civilian injuries each year. Wiring and related equipment caused an estimated 68% of these fires.

By protecting our most common residential wiring either physically with conduit or with an Arc fault interrupter increases fire safety in our residential buildings. If this increased safety results in saving one person's life per year it is worth it.

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Submittal Date: Wed Aug 23 17:33:14 EDT 2023

Committee: NEC-P06

Public Input No. 1028-NFPA 70-2023 [Section No. 334.10 [Excluding any Sub-Sections]]

Type NM and Type NMC cables shall be permitted to be used in the following, except as prohibited in 334.12:

(1) One- and two-family dwellings ~~and~~ , townhouses, and their attached or detached garages, and their storage buildings.

(2) Multi-family dwellings and their detached garages permitted to be of Types III, IV, and V construction~~.~~

~~Other structures permitted to be of Types III, IV, and V construction. Cables shall be concealed within walls, floors, or ceilings that provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies. Informational Note~~

(3) Informational Note

(4) No. 1: See NFPA 220-2021, *Standard on Types of Building Construction* , or the applicable building code, or both for types of building construction and occupancy classification definitions.

(5) Informational Note No. 2: See Informative Annex E for determination of building types.

(6) ~~Cable trays in structures permitted to be Types III, IV, or V where the cables are identified for the use.~~

~~Informational Note No. 3: See 310.14(A)(3) for temperature limitation of conductors.~~

(7) ~~Types I and II construction where installed within raceways permitted to be installed in Types I and II construction.~~

Statement of Problem and Substantiation for Public Input

In Portsmouth NH , I adopted amendments that NM cable can only be installed in one and two family dwelling and added townhouse because they are single family due to the fire rating from concrete floor to under roof structure. In townhouses, there is no other unit above or below unlike a multi-family dwelling.

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Committee:	NEC-P06

Public Input No. 1895-NFPA 70-2023 [Section No. 334.10 [Excluding any Sub-Sections]]

Type NM and Type NMC cables shall be permitted to be used in the following, except as prohibited in 334.12:

(1) One- and two-family dwellings and their attached or detached garages, and their storage buildings.

(2) Multi-family dwellings and their detached garages permitted to be of Types III, IV, and V construction.

(3) Other structures permitted to be of Types III, IV, and V construction. Cables shall be concealed within walls, floors, or ceilings that provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies.

Informational Note No. 1: See NFPA 220-2021, *Standard on Types of Building Construction*, or the applicable building code, or both for types of building construction and occupancy classification definitions.

Informational Note No. 2: See Informative Annex E for determination of building types.

(4) Cable trays in structures permitted to be Types III, IV, or V where the cables are identified for the use.

Informational Note No. 3: See 310.14(A)(3) for temperature limitation of conductors.

(5) Types I and II construction where installed within raceways permitted to be installed in Types I and II construction.

<u>Exception to (3): Other non-habitable storage garages and storage buildings shall be permitted to use Type NM cables without the 15- minute thermal barrier in Types III, IV, V construction.</u>

Statement of Problem and Substantiation for Public Input

This public input is being submitted on behalf of the Minnesota Department of Labor and Industry. Currently, the Department's inspection staff includes 14 office/field staff, 12 state field inspectors, 2-virtual inspectors and 50 plus contract electrical inspectors that complete over 170,000 electrical inspections annually.
Non-habitable storage garages and storage buildings should be allowed to use NM cable without the 15-minute thermal barrier. If an installer wanted to use NM cable in a storage garage or storage building, the requirements would fall under (3). (3) requires the cable to be installed behind a 15- minute thermal barrier. The thermal barrier is used mainly to allow the occupants time to exit a building in the event of a fire without inhaling toxins from the cable jacket. Typically, the detached storage garage and storage building(s) have minimal provisions for receptacles and/or lights, so requirements for a thermal barrier in non-habitable building(s) does not compromise electrical safety. NM cable has a proven track record of being a safe, and less expensive wiring method if installed properly.

Submitter Information Verification

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Submittal Date:	Mon Aug 07 12:06:54 EDT 2023
Committee:	NEC-P06

Public Input No. 1950-NFPA 70-2023 [Section No. 334.10 [Excluding any Sub-Sections]]

Type NM and Type NMC cables shall be permitted to be used in the following, except as prohibited in 334.12:

(1) One- and two-family dwellings and their attached or detached garages, ~~and their~~ storage buildings, <u>or other accessory structures</u> .

(2) Multi-family dwellings and their detached garages permitted to be of Types III, IV, and V construction.

(3) Other structures permitted to be of Types III, IV, and V construction. Cables shall be concealed within walls, floors, or ceilings that provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies.

Informational Note No. 1: See NFPA 220-2021, *Standard on Types of Building Construction*, or the applicable building code, or both for types of building construction and occupancy classification definitions.

Informational Note No. 2: See Informative Annex E for determination of building types.

(4) Cable trays in structures permitted to be Types III, IV, or V where the cables are identified for the use.

Informational Note No. 3: See 310.14(A)(3) for temperature limitation of conductors.

(5) Types I and II construction where installed within raceways permitted to be installed in Types I and II construction.

Statement of Problem and Substantiation for Public Input

If a residential property owner builds a roofed structure with supporting posts only (no walls) on their property, currently that structure type would not fall under item (1) as it is not a “detached garage or storage building”. As such the installation would be required to follow item (3) meaning that the cable would need be concealed within a ceiling type that provides a 15 minute finish rating, which seams excessive for an accessary structure that is really an open space with a roof.

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Public Input No. 68-NFPA 70-2023 [Section No. 334.10 [Excluding any Sub-Sections]]

Type NM and Type NMC cables shall be permitted to be used in the following, except as prohibited in 334.12:

(1) One- and two-family dwellings and their attached or detached garages, and their storage buildings.

(2) Multi-family dwellings and their detached garages permitted to be of Types III, IV, and V construction.

(3) Other structures permitted to be of Types III, IV, and V construction. Cables shall be ~~concealed within~~ installed within walls, floors, or ceilings that provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies.

Informational Note No. 1: See NFPA 220-2021, *Standard on Types of Building Construction*, or the applicable building code, or both for types of building construction and occupancy classification definitions.

Informational Note No. 2: See Informative Annex E for determination of building types.

(4) Cable trays in structures permitted to be Types III, IV, or V where the cables are identified for the use.

Informational Note No. 3: See 310.14(A)(3) for temperature limitation of conductors.

(5) Types I and II construction where installed within raceways permitted to be installed in Types I and II construction.

Additional Proposed Changes

File Name	Description	Approved
IMG_4420.JPG	Fire-rated hatch	

Statement of Problem and Substantiation for Public Input

This revision is needed to allow NM cables to be installed in walls, ceilings and floors where located behind building items such as a hinged, fire-rated access panel that commonly get installed in sheetrock ceilings to provide access to plumbing shut-off valves and other systems where access may be needed. NM cables installed in the ceiling space above one of these panels in a sheetrock ceiling may not meet the Article 100 definition of "concealed" but would still be provided with a protective 15-min rated thermal barrier. See photo of fire-rated hatch in sheetrock ceiling.

Submitter Information Verification

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Submittal Date: Sat Jan 07 08:04:41 EST 2023
Committee: NEC-P06

Public Input No. 104-NFPA 70-2023 [Section No. 334.12]

334.12 Uses Not Permitted.

(A) Types NM and NMC.

Types NM and NMC cables shall not be permitted as follows:

(1) In any dwelling or structure not specifically permitted in 334.10(1), (2), (3), and (5)

(2) Exposed within a dropped or suspended ceiling cavity in other than one- and two-family and multifamily dwellings

(3) As service-entrance cable

(4) In commercial garages having hazardous (classified) locations as defined in 511.3

(5) In theaters and similar locations, except where permitted in 518.4(C)

(6) In motion picture studios

(7) In storage battery rooms

(8) In hoistways or on elevators or escalators

(9) Embedded in poured cement, concrete, or aggregate

(10) In hazardous (classified) locations, except where specifically permitted by other articles in this *Code*

(11) For direct earth burial

(B) Type NM.

Type NM cables shall not be used under the following conditions or in the following locations:

(1) Where exposed to corrosive fumes or vapors

(2) Where embedded in masonry, concrete, adobe, fill, or plaster

(3) In a shallow chase in masonry, concrete, or adobe and covered with plaster, adobe, or similar finish

(4) In wet or damp locations

(5) For direct earth burial

Statement of Problem and Substantiation for Public Input

This revision seeks to clarify that these cables are not permitted to be directly buried in the earth.

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Submittal Date: Wed Jan 11 13:24:04 EST 2023
Committee: NEC-P06

Public Input No. 1041-NFPA 70-2023 [Section No. 334.12(A)]

(A) Types NM and NMC.

Types NM and NMC cables shall not be permitted as follows:

(1) In any dwelling or structure not specifically permitted in 334.10(1), (2), (3), and (5)

(2) Exposed within a dropped or suspended ceiling cavity in other than one- and two-family and multifamily dwellings

(3) As service-entrance cable

(4) In commercial garages having hazardous (classified) locations as defined in 511.3

(5) In theaters and similar locations, except where permitted in 518.4(C)

(6) In motion picture studios

(7) In storage battery rooms

(8) In hoistways or on elevators or escalators

(9) Embedded in poured cement, concrete, or aggregate

(10) In hazardous (classified) locations, except where specifically permitted by other articles in this *Code*

(11) *Type 1 and 2 structures.*

(12) *Thru townhouse firewalls to another dwelling or structure.*

(13) *Any electrical for PV systems.*

Statement of Problem and Substantiation for Public Input

NM cable should not be used for PV systems with Micro-Inverters, and in townhouse to feed another unit.

Submitter Information Verification

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Committee: NEC-P06

Public Input No. 2116-NFPA 70-2023 [Section No. 334.12(A)]

(A) Types NM and NMC.

Types NM and NMC cables shall not be permitted as follows:

(1) In any dwelling or structure not specifically permitted in 334.10(1), (2), (3), and (5)

(2) Exposed within a dropped or suspended ceiling cavity in other than one- and two-family and multifamily dwellings

(3) As service-entrance cable

(4) In commercial garages having hazardous (classified) locations as defined in 511.3

(5) In theaters and similar locations, except where permitted in 518.4(C)

(6) In motion picture studios

(7) In storage battery rooms

(8) In hoistways or on elevators or escalators

(9) Embedded in poured cement, concrete, or aggregate

(10) In hazardous (classified) locations, except where specifically permitted by other articles in this *Code*

(11) Where embedded in spray foam insulation where the cable is more than 1 (inch) from open air

Informational Note: Spray froam insulation in a thickness of 24.5 mm (1 inch) equates to approximately an 8 R-Value

Statement of Problem and Substantiation for Public Input

See substantiation of PI 1008

Submitter Information Verification

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Submittal Date:	Sat Aug 12 10:14:50 EDT 2023
Committee:	NEC-P06

Public Input No. 2178-NFPA 70-2023 [Section No. 334.12(A)]

(A) Types NM and NMC.

Types NM and NMC cables shall not be permitted as follows:

(1) In any dwelling or structure not specifically permitted in 334.10(1), (2), (3), and (5)

(2) Exposed within a dropped or suspended ceiling cavity in other than one- and two-family and multifamily dwellings

(3) As service-entrance cable

(4) In commercial garages having hazardous (classified) locations as defined in 511.3

(5) In theaters and similar locations, except where permitted in 518.4(C)

(6) In motion picture studios

(7) In storage battery rooms

(8) In hoistways or on elevators or escalators

(9) Embedded in poured cement, concrete, or aggregate

(10) In hazardous (classified) locations, except where specifically permitted by other articles in this *Code*

(11) *Where subject to physical damage*

Statement of Problem and Substantiation for Public Input

334.12 (A) Clearly state that NM and NMC cables are not permitted to be exposed to physical damage. Add clarity will less ambiguity and subjectiveness. Change aligns with other uses not permitted articles including 340.12 (10).

Submitter Information Verification

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Committee: NEC-P06

Public Input No. 3468-NFPA 70-2023 [Section No. 334.15(A)]

(A) To Follow Surface.

Cable shall closely follow the surface of the building finish or of running boards. Running boards shall be wider than the cable or cables they support, and shall not sag as installed. They shall be constructed of nominal two-by lumber, or use other designs approved by the Authority Having Jurisdiction as providing suitable support and protection. Where there is a reasonable possibility of physical damage coming from the side, the running boards shall include guard strips at least as high as the installed cable or cables.

Statement of Problem and Substantiation for Public Input

Because there are no specifications for running boards, and no definition, presently this falls into the category of "I know what I mean" inspection. The dictionary definition of “board” isn't enough. How much support do the boards need to give? If you want to use a 1x3 rather than a 2x, or a strip of 5/8 plywood, or a different material altogether, let the inspector approve based on how long the run is between supports. But this sets a basic, reasonable spec. If an installer wants to use a 2x2, the run had better not be too long or the weight of the wood itself will make it sag, violating that requirement. One reason to add that restriction is because if it is not sturdy enough as installed to prevent sagging, it probably is not sturdy enough to last, especially after the first time something knocks into it.

Historically, and elsewhere in the NEC, running boards sometimes have required side protection, sometimes have had a specific minimum width, sometimes required a specific width to each side of the wiring they support. This is far simpler. Because the sheath of NM cable provides minimal mechanical protection, it is important to add the side railing or guard strip requirement in contexts where a flat board might not protect adequately.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3463-NFPA 70-2023 [New Definition after Definition: Riser Cable, Cable Routing...]	Definition of Running Board clarifies our use of the concept.
Public Input No. 3464-NFPA 70-2023 [Section No. 320.15]	Specification for running boards used with Armored cable
Public Input No. 3466-NFPA 70-2023 [Section No. 330.15]	Specification for running boards used with metal-clad cable.
Public Input No. 3469-NFPA 70-2023 [Section No. 334.15(C)]	

Submitter Information Verification

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Submittal Date: Sun Sep 03 16:15:21 EDT 2023
Committee: NEC-P06

Public Input No. 3988-NFPA 70-2023 [Section No. 334.15(B)]

(B) Protection from Physical Damage.

(1) General. Cable shall be protected from physical damage where necessary by rigid metal conduit, intermediate metal conduit, electrical metallic tubing, Schedule 80 PVC conduit, RTRC marked with the suffix -XW, or other approved means.

(2) Passing Through a Floor. Where passing through a floor, the cable shall be enclosed in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, Schedule 80 PVC conduit, RTRC marked with the suffix -XW, or other approved means extending at least 150 mm (6 in.) above the floor.

(3) Protection form Abrasion. Conduit or tubing shall be provided with a bushing or adapter that provides protection from abrasion at the point the cable enters and exits the raceway.

(4) Protection in Shallow Grooves. Type NMC cable installed in shallow chases or grooves in masonry, concrete, or adobe shall be protected in accordance with the requirements in 300.4(F) and covered with plaster, adobe, or similar finish.

Statement of Problem and Substantiation for Public Input

Breaking up 334.15(B) into a list item format to facilitate understanding for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

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Committee:	NEC-P06

Public Input No. 3469-NFPA 70-2023 [Section No. 334.15(C)]

(C) In Unfinished Basements and Crawl Spaces.

Where cable is run at angles with joists in unfinished basements and crawl spaces, it shall be permissible to secure cables not smaller than two 6 AWG or three 8 AWG conductors directly to the lower edges of the joists. Smaller cables shall be run either through bored holes in joists or on running boards complying with 334 .15(A). Nonmetallic-sheathed cable installed on the wall of an unfinished basement shall be permitted to be installed in a listed conduit or tubing or shall be protected in accordance with 300.4. Conduit or tubing shall be provided with a bushing or adapter that provides protection from abrasion at the point the cable enters and exits the raceway. The sheath of the nonmetallic-sheathed cable shall extend through the conduit or tubing and into the outlet, device, or junction box not less than 6 mm (¼ in.). The cable shall be secured within 300 mm (12 in.) of the point where the cable enters the conduit or tubing. Metal conduit, tubing, and metal outlet boxes shall be connected to an equipment grounding conductor complying with 250.86 and 250.148.

Statement of Problem and Substantiation for Public Input

PI 3468 offers basic specs for NM running boards to incorporate in 334.15(A), providing that they are sufficiently robust so that their adequacy is not totally left up to the inspector's call.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3463-NFPA 70-2023 [New Definition after Definition: Riser Cable, Cable Routing...]	Definition of Running Board
Public Input No. 3468-NFPA 70-2023 [Section No. 334.15(A)]	Proposed baseline specifications for NM running boards

Submitter Information Verification

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Submittal Date: Sun Sep 03 16:28:23 EDT 2023

Committee: NEC-P06

Public Input No. 1128-NFPA 70-2023 [Section No. 334.19]

334.19 Cable Entries.

The sheath on nonmetallic-sheathed cable shall extend not less than 6 mm (¼ in.) <u>and not greater than 25.4 mm (1 in.)</u> beyond any cable clamp or cable entry.

Statement of Problem and Substantiation for Public Input

Adding the maximum allowed cable sheath prevents the additional volume that would be taken up by unnecessary excess sheathing.

Submitter Information Verification

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Submittal Date: Mon Jun 19 07:18:42 EDT 2023

Committee: NEC-P06

Public Input No. 1555-NFPA 70-2023 [Section No. 334.24]

334.24 Bending Radius.

Bends in Types NM and NMC cable shall be so made that the cable will not be damaged. The radius of the curve of the inner edge of any bend during or after installation shall not be less than five times the diameter of the cable. For flat cables, the ~~major~~ minor diameter dimension of the cable shall be used to determine the bending radius.

Statement of Problem and Substantiation for Public Input

The change to the 2023 attempting to clarify the bending radius of a non-round cable such as NM-B was welcome. The problem was that the wrong dimension was chosen for the clarification. Namely, the number of conductors in a flattened assembly is not nearly important for the bending radius as the diameter of each of the conductors.

To use a specific example refer to https://www.southwire.com/wire-cable/building-wire/romex-brand-simpull-type-nm-b-cable/p/BW7

Southwire 12/2 has a nominal minor dimension of 186mils and major of 422mils. This 2023 change changed the minimum radius from 930mils to 2110mils which often won't even fit through a stud corner. And it gets worse is 12/3 which nominal dimensions of 190x524mils. The old bending radius was almost the same as 12/2 at 950mils (increase of .02"), but now has been increased to 2620mils for an increase of over .5" over 12/2. Ironically 12/4 which is a 395mil round cable only has a bending radius of 1975 mils.

And this says nothing of the specialized NM cables such as https://www.southwire.com/wire-cable/building-wire/romex-brand-simpull-type-nm-b-pcs-duo-cable/p/67962901 which were previously nearly the same as 12/3, but now requires a bending radius of over 4"

Submitter Information Verification

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Committee: NEC-P06

Public Input No. 409-NFPA 70-2023 [Section No. 334.24]

334.24 Bending Radius.

Bends in Types NM and NMC cable shall be so made that the cable will not be damaged. The radius of the curve of the inner edge of any bend during or after installation shall not be less than five times the diameter of the cable. For flat cables, the ~~major~~ minor diameter dimension ~~of the cable~~ shall permitted to be used to determine the bending radius when bending on the flat side of the cable . For all other bends the major diameter dimension shall be used.

Statement of Problem and Substantiation for Public Input

This revision is needed to provide relief for installations where the cable is bent on the flat side. Installing these flat cables in conduit bodies may be difficult if not impossible now, unless a ridiculously oversized conduit body is used, because of the much larger bending radius required. Using the minor diameter dimension should be permitted when bending cables on the flat side. Using the major diameter dimension should be required otherwise. See related PI for 338.24 and 340.24

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 408-NFPA 70-2023 [Section No. 338.24]	bending flat cables
Public Input No. 410-NFPA 70-2023 [Section No. 340.24]	bending flat cables
Public Input No. 408-NFPA 70-2023 [Section No. 338.24]	
Public Input No. 410-NFPA 70-2023 [Section No. 340.24]	

Submitter Information Verification

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Submittal Date: Sat Mar 04 10:38:26 EST 2023
Committee: NEC-P06

Public Input No. 2887-NFPA 70-2023 [Section No. 334.30]

334.30 Securing and Supporting.

Nonmetallic-sheathed cable shall be supported and secured by ~~staples,~~ cable ties listed and identified for securement and support, or listed staples, straps, hangers, or similar fittings designed and installed so as not to damage the cable, at intervals not exceeding 1.4 m (4½ ft) and within 300 mm (12 in.) of every cable entry into enclosures such as outlet boxes, junction boxes, cabinets, or fittings. The cable length between the cable entry and the closest cable support shall not exceed 450 mm (18 in.). Flat cables shall not be stapled on edge.

Sections of cable protected from physical damage by raceway shall not be required to be secured within the raceway.

(A) Horizontal Runs Through Holes and Notches.

In other than vertical runs, cables installed in accordance with 300.4 shall be considered to be supported and secured where such support does not exceed 1.4-m (4½-ft) intervals and the nonmetallic-sheathed cable is securely fastened in ~~place by an approved means within~~ place within 300 mm (12 in.) of each box, cabinet, conduit body, or other nonmetallic-sheathed cable termination.

Informational Note: See 314.17(B)(1) for support where nonmetallic boxes are used.

(B) Unsupported Cables.

Nonmetallic-sheathed cable shall be permitted to be unsupported where the cable:

(1) Is fished between access points through concealed spaces in finished buildings or structures and supporting is impracticable.

(2) Is not more than 1.4 m (4½ ft) from the last point of cable support to the point of connection to a luminaire or other piece of electrical equipment and the cable and point of connection are within an accessible ceiling in one-, two-, or multifamily dwellings.

(C) Wiring Device Without a Separate Outlet Box.

A wiring device identified for the use, without a separate outlet box, and incorporating an integral cable clamp shall be permitted where the cable is secured in place at intervals not exceeding 1.4 m (4½ ft) and within 300 mm (12 in.) from the wiring device wall opening, and there shall be at least a 300 mm (12 in.) loop of unbroken cable or 150 mm (6 in.) of a cable end available on the interior side of the finished wall to permit replacement.

Statement of Problem and Substantiation for Public Input

To avoid damage to Type NM cable and undue stress being transferred to electrical connections from sagging cables a requirement for listed hardware for support and securement of Type NM Cables is necessary by the NEC. The need for the NEC to require listed staples, straps, hangers and fittings became more crucial on account of advancements installation tool technology and today's tools that provide staple depth control. The ANSI/UL Standard for Safety for Hardware for the Support of Conduit, Tubing, and Cable, UL 2239, was first published nearly 20 years ago and contains all necessary hardware construction, performance, marking and installation instructions necessary to provide installers and AHJs the guidance to properly use today's tools to support and secure Type NM cables when using listed hardware.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2886-NFPA 70-2023 [Section No. 334.6]	proposed requirement for support and securement hardware to be listed

Submitter Information Verification

Submitter Full Name: David Gerstetter

Organization: Ul Solutions

Affiliation:	UL Solutions
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Fri Aug 25 22:15:58 EDT 2023
Committee:	NEC-P06

Public Input No. 3261-NFPA 70-2023 [Section No. 334.30]

334.

~~30~~

30 Securing

~~and Supporting~~

~~:~~

~~Nonmetallic-sheathed~~

Type NM cable shall be

~~supported and secured by staples, cable ties listed and identified for securement and support, or straps, hangers, or similar fittings designed and installed so as not to damage the cable,~~

secured within 300 mm (12 in.) of every outlet box, junction box, cabinet, or fitting and at intervals not exceeding 1.

~~4 m~~

4 m (4 1

~~⁄~~

⁄2 ft)

~~and within 300 mm (12 in.) of every cable entry into enclosures such as outlet boxes, junction boxes, cabinets, or fittings. The cable length between the cable entry and the closest cable support shall not exceed 450 mm (18 in.). Flat cables shall not be stapled on edge.~~

~~Sections of cable protected from physical damage by raceway shall not be required to be secured within the raceway.~~

~~**(A)** Horizontal Runs Through Holes and Notches.~~

~~In other than vertical runs, cables installed in accordance with 300.4 shall be considered to be supported and secured where such support does not exceed 1.4-m (4 1⁄2 ft) intervals and the nonmetallic-sheathed cable is securely fastened in place by an approved means within 300 mm (12 in.) of each box, cabinet, conduit body, or other nonmetallic-sheathed cable termination.~~

~~Informational Note: See 314.17(B)(1) for support where nonmetallic boxes are used.~~

~~(B) Unsupported Cables.~~

~~Nonmetallic-sheathed cable shall be permitted to be unsupported where the cable:~~

- ~~Is fished between access points through concealed spaces in finished buildings or structures and supporting is impracticable.~~

~~Is not more than 1.4 m (4 1⁄2~~

. Securement shall be by the use of staples; cable ties listed and identified for securement.

Exception 1: Horizontal runs of Type NM cable in wooden or metal framing members or similar supporting means, it is not required to be secured at 1.4 m (4 1⁄2 ft) intervals.

Exception 2. If Type NM cable is fished between access points through concealed spaces in finished buildings or structures, it is not required to be secured at 1.4 m (4 1⁄2 ft) intervals.

Exception 3. Type NM cable in lengths not more than 600 mm (2 ft) at terminals where flexibility is necessary is not required to be secured.

Exception 4. Type NM cable in lengths not more than 1.8 m (6 ft) from the last point of cable

~~support~~

securement to the point of connection to a luminaire (s) or other

~~piece of~~

electrical equipment

~~and~~

, where the cable and point of connection are within an accessible ceiling

~~in one-, two-, or multifamily dwellings.~~

~~(C) Wiring Device Without a Separate Outlet Box.~~

~~A wiring device identified for the use, without a separate outlet box, and incorporating an integral cable clamp shall be permitted where the cable is secured in place at intervals not exceeding 1.4 m (4 1⁄2 ft) and within 300 mm (12 in.) from the wiring device wall opening, and there shall be at least a 300 mm (12 in.) loop of unbroken cable or 150 mm (6 in.) of a cable end available on the interior side of the finished wall to permit replacement.~~

, are not required to be secured. Type NM cable fittings shall be permitted as a means of cable securement.

Statement of Problem and Substantiation for Public Input

Since the cable is required to be secured within 300 mm (12 in.) of every outlet box, junction box, cabinet, or fitting and at intervals not exceeding 1.4 m (4 1⁄2 ft), then there is no need to have any rules about its support. Simply state the requirements on securing and provide the exceptions needed.

Submitter Information Verification

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Submittal Date: Wed Aug 30 20:27:06 EDT 2023
Committee: NEC-P06

Public Input No. 2250-NFPA 70-2023 [Section No. 334.30(B)]

(B) Unsupported and Unsecured Cables.

Nonmetallic-sheathed cable shall be permitted to be unsupported where the cable:

(1) Is fished between access points through concealed spaces in finished buildings or structures and supporting and securing is impracticable.

(2) Is not more than 1.4 m (4½ ft) from the last point of cable support to the point of connection to a luminaire or other piece of electrical equipment and the cable and point of connection are within an accessible ceiling in one-, two-, or multifamily dwellings.

Statement of Problem and Substantiation for Public Input

This requirement applies to both securing and supporting. Adding ''and Unsecured" to the subdivision title to bring clarity for Code users.

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Submittal Date: Tue Aug 15 13:27:12 EDT 2023
Committee: NEC-P06

Public Input No. 253-NFPA 70-2023 [Section No. 334.30(B)]

(B) Unsupported Cables.

Nonmetallic-sheathed cable shall be permitted to be unsupported and unsecured where the cable:

(1) Is fished between access points through concealed spaces in finished buildings or structures and supporting is impracticable.

(2) Is not more than 1.4 m (4½ ft) from the last point of cable support to the point of connection to a luminaire or other piece of electrical equipment and the cable and point of connection are within an accessible ceiling in one-, two-, or multifamily dwellings.

Statement of Problem and Substantiation for Public Input

Believe it or not there is an inspector out there who insists the way needs to be opened to secure the cable since this section only states unsupported. In my opinion this is ridiculous that one should have to reword this section.

Submitter Information Verification

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State:	
Zip:	
Submittal Date:	Tue Jan 31 13:54:33 EST 2023
Committee:	NEC-P06

Public Input No. 2249-NFPA 70-2023 [Section No. 334.30 [Excluding any Sub-Sections]]

Nonmetallic-sheathed cable shall be supported and secured by staples, cable ties listed and identified for securement and support, or straps, hangers, or similar fittings designed and installed so as not to damage the cable, at intervals not exceeding 1.4 m (4½ ft) and within 300 mm (12 in.) of every cable entry into enclosures such as outlet boxes, junction boxes, cabinets, or fittings. ~~The cable length between the cable entry and the closest cable support shall not exceed 450 mm (18 in.).~~ Flat cables shall not be stapled on edge.

Sections of cable protected from physical damage by raceway shall not be required to be secured within the raceway.

Statement of Problem and Substantiation for Public Input

Removing the requirement of a maximum NM cable length of 18 in. between the box and the first cable support because this is an electrical installers decision. There are times where extra NM cable slack is necessary to facilitate a custom installation.

Submitter Information Verification

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Submittal Date:	Tue Aug 15 13:25:26 EDT 2023
Committee:	NEC-P06

Public Input No. 1129-NFPA 70-2023 [Section No. 334.80]

334.80 Ampacity.

The ampacity of Types NM and NMC cable shall be determined in accordance with 310.14. The ~~ampacity shall not exceed that of a 60°C (140°F) rated conductor. The~~ 90°C (194°F) rating shall be permitted to be used for ampacity adjustment and correction calculations, provided the final calculated ampacity does not exceed that of a ~~60°C~~ 75°C (~~140°F~~ 167°F) rated conductor. The ampacity of Types NM and NMC cable installed in cable trays shall be determined in accordance with 392.80(A).

Where more than two NM cables containing two or more current-carrying conductors are installed, without maintaining spacing between the cables, through the same opening in wood framing that is to be sealed with thermal insulation, caulk, or sealing foam, the ampacity of each conductor shall be adjusted in accordance with Table 310.15(C)(1) and 310.14(A)(2), Exception, shall not apply.

Where more than two NM cables containing two or more current-carrying conductors are installed in contact with thermal insulation without maintaining spacing between cables, the ampacity of each conductor shall be adjusted in accordance with Table 310.15(C)(1) and 310.14(A)(2), Exception shall not apply.

Statement of Problem and Substantiation for Public Input

The restriction of the 60 degrees Celsius column for a conductor rated at 90 degrees (per UL Category PWVX) is unjustified. The autoignition temperature of paper (enclosed within the jacket of type NM cable) is 218 degrees Celsius, far greater than the maximum temperature of the conductors within the jacket.

Submitter Information Verification

Submitter Full Name: Greg Chontow
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Submittal Date: Mon Jun 19 07:23:27 EDT 2023
Committee: NEC-P06

Public Input No. 3051-NFPA 70-2023 [Section No. 334.80]

334.80 Ampacity.

(A) General. The ampacity of Types NM and NMC cable shall be determined in accordance with 310.14. The ampacity shall not exceed that of a 60°C (140°F) rated conductor. The 90°C (194°F) rating shall be permitted to be used for ampacity adjustment and correction calculations, provided the final calculated ampacity does not exceed that of a 60°C (140°F) rated conductor. The ampacity of Types NM and NMC cable installed in cable trays shall be determined in accordance with 392.80(A).

(B) Cables Through Same Opening. Where more than two NM cables containing two or more current-carrying conductors are installed, without maintaining spacing between the cables, through the same opening in wood framing that is to be sealed with thermal insulation, caulk, or sealing foam, the ampacity of each conductor shall be adjusted in accordance with Table 310.15(C)(1) and 310.14(A)(2), Exception, shall not apply.

(C) Cables in Contact with Thermal Insulation. Where more than two NM cables containing two or more current-carrying conductors are installed in contact with thermal insulation without maintaining spacing between cables, the ampacity of each conductor shall be adjusted in accordance with Table 310.15(C)(1) and 310.14(A)(2), Exception shall not apply.

Statement of Problem and Substantiation for Public Input

Section 334.80 has multiple requirements dependent on different applications, therefore adding 3 new first level subdivisions to clarify this point for Code users. In accordance with NFPA Style Manual section 3.5.1.2 additional subdivisions shall be used where multiple requirements can be broken into independent requirements.

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Submittal Date: Tue Aug 29 09:30:18 EDT 2023
Committee: NEC-P06

Public Input No. 1010-NFPA 70-2023 [Section No. 334.104]

334.104 Conductors.

The 600-volt insulated power conductors shall be sizes 14 AWG through 2 AWG copper, or copper-clad aluminum conductors or sizes 12 AWG through 2 AWG aluminum ~~or copper-clad aluminum~~ conductors. Control and signaling conductors shall be no smaller than 18 AWG copper.

For control and signaling conductors minimum conductor sizes shall be 18 AWG copper, nickel, or nickel-coated copper, 14 AWG copper-clad aluminum, and 12 AWG aluminum.

Statement of Problem and Substantiation for Public Input

See substantiation in PI 1008

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]	

Submitter Information Verification

Submitter Full Name:	Peter Graser
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Affiliation:	American Bimetallic Association
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Submittal Date:	Sun Jun 11 08:33:45 EDT 2023
Committee:	NEC-P06

Public Input No. 1021-NFPA 70-2023 [Section No. 334.104]

334.104 Conductors.

The 600-volt insulated power conductors shall be sizes 14 AWG through 2 AWG copper conductors or sizes 12 AWG through 2 AWG aluminum or copper-clad aluminum conductors. Control and signaling conductors shall be no smaller than 18 AWG copper or 16 AWG copper-clad aluminum .

Additional Proposed Changes

File Name	Description	Approved
PGFinal.SW-2023-001_-_Electrical_Characteristic_Comparison_between_Copper_and_CCA_Thermostat_Wire_002_.pdf	Electrical Characteristics of 16 AWG CCA Relative to 18 AWG Copper	

Statement of Problem and Substantiation for Public Input

Also see substantiation for PI 1018. 16 AWG CCA proven safe as a remote control & signal wire. Currently in UL 13. 16 AWG CCA referenced by UL 13 for thermostat wire. 16 AWG CCA and smaller conductors have long been used as data conductors in the coaxial cable.

Submitter Information Verification

Submitter Full Name: Peter Graser
Organization: Copperweld
Affiliation: American Bimetallic Association
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Submittal Date: Sun Jun 11 16:17:03 EDT 2023
Committee: NEC-P06

Electrical Test Laboratory Report SW-2023-002

Market:	Class 4 Conductors		
Subject:	Electrical Characteristic Comparison between 16 AWG CCA vs 18 AWG Cu		
Date:	8/29/23	Report No:	002

Analysis By:	Brandon Allen – Product Engineer
Authored By:	Brandon Allen– Product Engineer
Approved By:	Tom Sterling – Product Development Manager

Objective:

To perform electrical analysis to show the characteristic comparison of 16 AWG Copper Clad Aluminum (CCA) to 18 AWG Copper (Cu).

Samples/Equipment Provided:

Materials

- Test Samples: 16 AWG Copper Clad Aluminum (CCA)
- Test Samples: 18 AWG Copper (Cu)

Wire Tested:

- *500 ft. of 18 AWG Solid Copper, annealed*
- *500 ft. of 16 AWG solid CCA 10%, annealed*
- *Minimum of 6 mils of PVC insulation on both Cu and CCA wire*

Physical Attributes	Diameter (in)	Cross-Sectional Area (in^2)	Weight (lb/kft)	Copper Thickness (in)	DC Resistance (Ω/kft)
18 AWG Cu	0.0403	0.001276	4.917	0.04030	6.610
16 AWG CCA 10%	0.0508	0.002027	2.919	0.00127	6.524

Test Equipment / Calibration Requirements

- Data Acquisition System
- Thermocouple
- Power Source (24 VAC at 40VA)

Test Procedure 1: Temperature Readings with Incremental Current

1. Set the configuration for the AC power/current source to begin the test.
2. Using the 16 AWG Copper Clad Aluminum (CCA) samples, prepare the test samples by connecting the thermocouples to the test samples for the temperature readings.
3. With the thermocouples attached to the test samples, connect the opposite end of the thermocouple wire to the Data acquisition system.
4. Set the current source to the initial current of 3A then increment by 3A in 10-minute intervals for the duration of the test. Step up current to a final level of 24 amperes.
5. All testing conducted in open-air.
6. At the completion of the test, store the data and repeat each step for 18 AWG Copper (Cu).

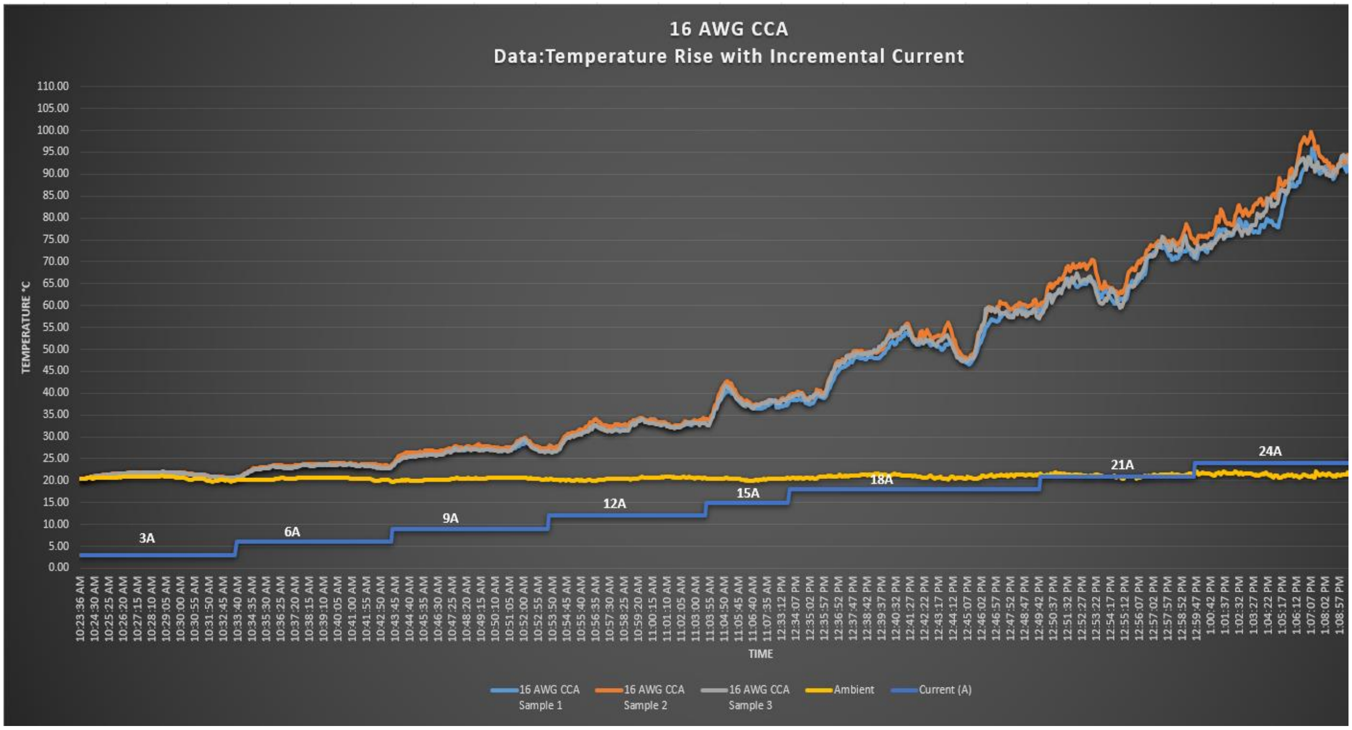
Test Results 1: Temperature Readings with Incremental Current

During testing, the data revealed that the increase in current was proportional to the increase in temperature. In comparison, the three samples of 16 AWG CCA ran slightly cooler than the three samples of 18 AWG Cu. Below Table 1 presents values stepped up from 3 amperes to 12 amperes. 16 AWG CCA for Class 4 circuits should never see 12 amperes of AC current in the real world.

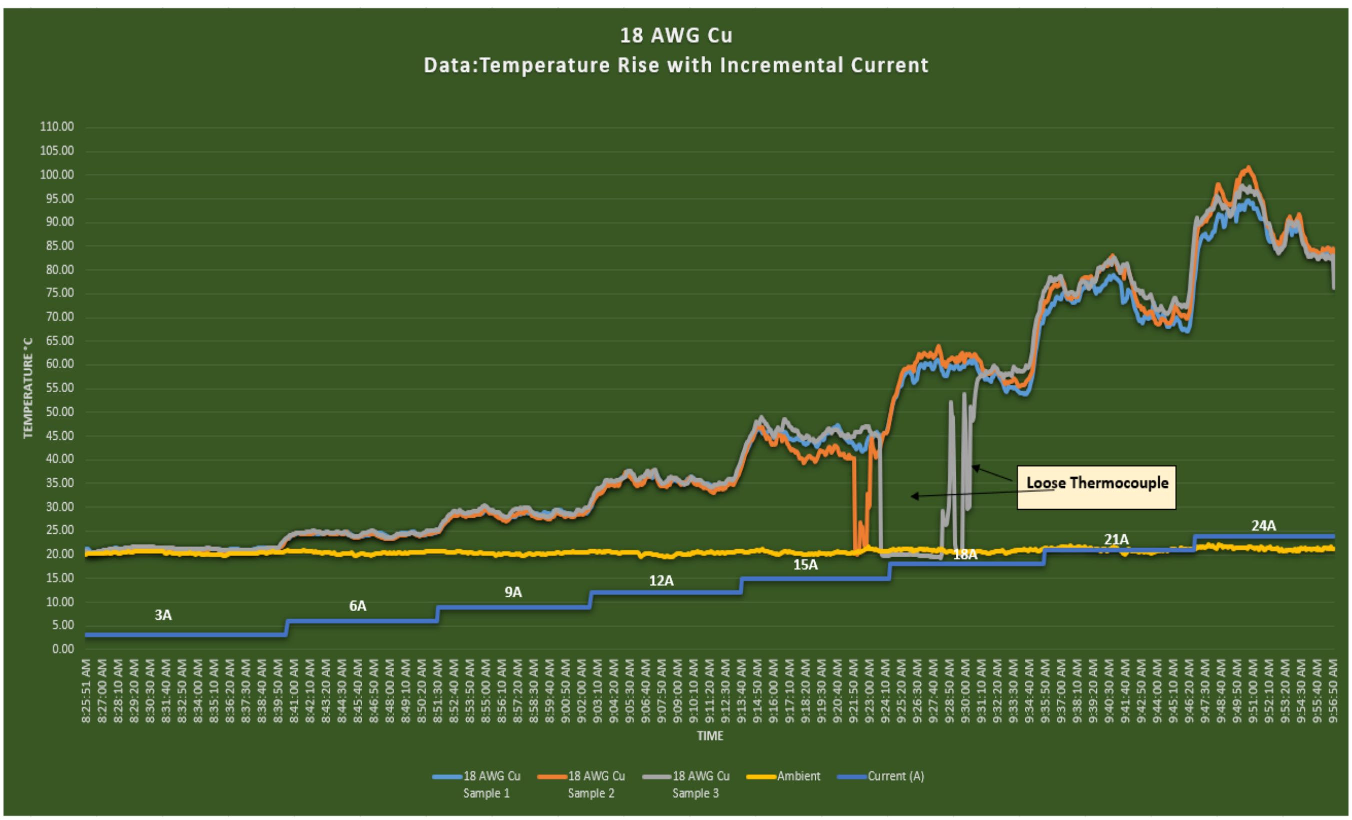
See Table 1 and graphs 1 & 2 below for more details:

TABLE 1:

16 AWG CCA				18 AWG Copper			
Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise	Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise
3	**21.96**	**20.58**	**1.38**	**3**	**23.38**	**20.38**	**3.00**
6	**24.13**	**20.43**	**3.70**	**6**	**25.3**	**20.43**	**4.87**
9	**29.79**	**20.38**	**9.41**	**9**	**30.46**	**20.34**	**10.12**
12	**34.28**	**20.44**	**13.84**	**12**	**39.75**	**20.33**	**19.42**



Graph 1: 16 AWG CCA



Graph 2: 18 AWG Cu

Test Results 2: Electrical Characteristic Measurements

The Voltage drop was calculated using the voltage drop calculator formula at 3 Amps.

VOLTAGE DROP CALCULATOR FORMULA

$$VD = (2 \cdot A \cdot L \cdot R) / 1000$$

Where:

VD = Voltage Drop (Volts) per unit circuit length

A = Full Load Current (Amps)

L = One-Way Circuit Length (ft)

R = Resistance (Ohms/Kft)

		Run Length (ft)			
Voltage Drop (Vac)	VAC++	50	100	150	200
18 AWG Cu	24.00	1.98	3.96	5.95	7.93
16 AWG CCA 10%	24.00	1.95	3.91	5.87	7.82

** With a supply voltage of 24 Vac, what is the Drop Voltage across the hot and common legs of circuit, at specified Lengths of wire?*

** Set Load Resistance to drawn 3.0 Amps*

Conclusion:

When comparing 16 AWG Copper Clad Aluminum to 18 AWG Copper, the electrical measurements of the 16 AWG Copper Clad Aluminum conductor measured at a slightly lower resistance than the 18 AWG Copper. The analysis of the thermal test also showed that when the same current is applied to both conductors for the same duration, 16 AWG Copper Clad Aluminum measured at slightly lower temperatures than 18 AWG Copper. Lower conductor temperatures generally support the notion that the connected equipment will last longer and run more efficiently. The lower Voltage Drop of 16 AWG CCA as compared to that of 18 AWG copper will also likely improve equipment performance. The heating profiles of both the 16 AWG CCA and 18 AWG copper are not expected to pose problems for class 4 circuits.

Public Input No. 613-NFPA 70-2023 [New Section after 336.1]

336.2 Reconditioned Equipment

Type TC cable shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

Submitter Full Name:	Russ Leblanc
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Submittal Date:	Sun Apr 16 08:20:10 EDT 2023
Committee:	NEC-P06

Public Input No. 3512-NFPA 70-2023 [Section No. 336.6]

~~336.6~~ 2 Listing Requirements.

Type TC cables and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name:	David Williams
Organization:	Delta Charter Township
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City:	
State:	
Zip:	
Submittal Date:	Mon Sep 04 17:27:57 EDT 2023
Committee:	NEC-P06

Public Input No. 1387-NFPA 70-2023 [Section No. 336.10]

336.10 Uses Permitted.

Type TC cable shall be permitted to be used as follows:

(1) For power, lighting, control, and signal circuits.

(2) In cable trays, including those with mechanically discontinuous segments up to 300 mm (1 ft).

(3) In raceways.

(4) In outdoor locations supported by a messenger wire.

(5) For Class 1 circuits as permitted in Parts II and III of Article 725.

(6) For non-power-limited fire alarm circuits if conductors comply with the requirements of 760.49.

(7) Between a cable tray and the utilization equipment or device(s), provided all of the following apply:

a. The cable is Type TC-ER.

b. The cable is installed in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation.

c. The cable is continuously supported and protected against physical damage using mechanical protection such as struts, angles, or channels.

d. The cable complies with the crush and impact requirements of Type MC cable and is identified with the marking “TC–ER.”

e. The cable is secured at intervals not exceeding 1.8 m (6 ft).

f. Equipment grounding for the utilization equipment is provided by an equipment grounding conductor within the cable. In cables containing conductors sized 6 AWG or smaller, the equipment grounding conductor shall be provided within the cable or, at the time of installation, one or more insulated conductors shall be permanently identified as an equipment grounding conductor in accordance with 250.119(C).

Exception to (7): Where not subject to physical damage, Type TC-ER shall be permitted to transition between cable trays and between cable trays and equipment or devices for a distance not to exceed 1.8 m (6 ft) without continuous support. The cable shall be mechanically supported where exiting the cable tray to ensure that the minimum bending radius is not exceeded.

(8) Type TC cable shall be resistant to moisture and corrosive agents where installed in wet locations.

(9) For one- and two-family dwelling units, Type TC-ER-JP cable containing conductors for both power and control circuits shall be permitted for branch circuits and feeders. Type TC-ER-JP cable used as interior wiring shall be installed per the requirements of Part II of Article 334 and where installed as exterior wiring shall be installed per the requirements of Part II of Article 340.

Exception: Where used to connect a generator and associated equipment having terminals rated 75°C (140°F) or higher, the cable shall not be limited in ampacity by 334.80 or 340.80.

Informational Note No. 1: See 725.136 for limitations on Class 2 or 3 circuits contained within the same cable with conductors of electric light, power, or Class 1 circuits.

(10) Direct buried, where identified for such use.

(11) In hazardous (classified) locations where specifically permitted by other articles in this *Code*.

(12) For service-entrance conductors where identified for such use and marked Type TC-ER.

Informational Note No. 2: See 310.14(A)(3) for temperature limitation of conductors.

Additional Proposed Changes

File Name	Description	Approved
336.10_revision.docx	Revised text for 336.10(7)	

Statement of Problem and Substantiation for Public Input

Original list item d makes item a redundant. Therefore propose to delete original a. and replace with d. Then renumber remainder of list. This removes improves clarity and brevity with no loss of information.
(If there is a reason why the text should explicitly state that the cable is Type TC-ER (as per original a.) as well as stating that it must be marked as TC-ER (as per d.); then this could still be accomplished in a single line as follows: The cable is Type TC-ER and complies with the crush and impact requirements of type MC cable and is identified with the marking "TC-ER").

Submitter Information Verification

Submitter Full Name:	Andrew Wood
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City:	
State:	
Zip:	
Submittal Date:	Wed Jul 12 11:28:59 EDT 2023
Committee:	NEC-P06

(7) Between a cable tray and the utilization equipment or device(s), provided all of the following apply:

a. The cable ~~is Type TC-ER.~~ complies with the crush and impact requirements of Type MC cable and is identified with the marking “TC-ER."

b. The cable is installed in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation.

c. The cable is continuously supported and protected against physical damage using mechanical protection such as struts , angles, or channels.

~~d. The cable complies with the crush and impact requirements of Type MC cable and is identified with the marking “TC-ER."~~

~~e.~~ d. The cable is secured at intervals not exceeding 1.8 m (6 ft).

~~f.~~ e. Equipment grounding for the utilization equipment is provided by an equipment grounding conductor within the cable. In cables containing conductors sized 6 AWG or smaller, the equipment grounding conductor shall be provided within the cable or, at the time of installation, one or more insulated conductors shall be permanently identified as an equipment grounding conductor in accordance with 250.119(C).

Public Input No. 1409-NFPA 70-2023 [Section No. 336.10]

336.10 Uses Permitted.

Type TC cable shall be permitted to be used as follows:

(1) For power, lighting, control, and signal circuits.

(2) In cable trays, including those with mechanically discontinuous segments up to 300 mm (1 ft).

(3) In raceways.

(4) In outdoor locations supported by a messenger wire.

(5) For Class 1 circuits as permitted in Parts II and III of Article 725.

(6) For non-power-limited fire alarm circuits if conductors comply with the requirements of 760.49.

(7) Between a cable tray ~~and~~ , raceway or enclosure, and the utilization equipment or device(s), provided all of the following apply:

(8) The cable is Type TC-ER.

(9) The cable is installed in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation.

(10) The cable is continuously supported and protected against physical damage using mechanical protection such as struts, angles, or channels.

(11) The cable complies with the crush and impact requirements of Type MC cable and is identified with the marking "TC–ER."

(12) The cable is secured at intervals not exceeding 1.8 m (6 ft).

(13) Equipment grounding for the utilization equipment is provided by an equipment grounding conductor within the cable. In cables containing conductors sized 6 AWG or smaller, the equipment grounding conductor shall be provided within the cable or, at the time of installation, one or more insulated conductors shall be permanently identified as an equipment grounding conductor in accordance with 250.119(C) .

Exception to (7): Where not subject to physical damage, Type TC-ER shall be permitted to transition between cable trays and between cable trays

~~and~~

a.

, raceways or enclosures, and equipment or devices , for a distance not to exceed 1.8 m (6 ft) without continuous support. The cable shall be mechanically supported where exiting the cable tray

~~to~~

a.

, raceway or enclosure to ensure that the minimum bending radius is not exceeded.

(14) Type TC cable shall be resistant to moisture and corrosive agents where installed in wet locations.

(15) For one- and two-family dwelling units, Type TC-ER-JP cable containing conductors for both power and control circuits shall be permitted for branch circuits and feeders. Type TC-ER-JP cable used as interior wiring shall be installed per the requirements of Part II of Article 334 and where installed as exterior wiring shall be installed per the requirements of Part II of Article 340.

Exception: Where used to connect a generator and associated equipment having terminals rated 75°C (140°F) or higher, the cable shall not be limited in ampacity by 334.80 or 340.80.

Informational Note No. 1: See 725.136 for limitations on Class 2 or 3 circuits contained within the same cable with conductors of electric light, power, or Class 1 circuits.

(16) Direct buried, where identified for such use.

(17) In hazardous (classified) locations where specifically permitted by other articles in this *Code*.

(18) For service-entrance conductors where identified for such use and marked Type TC-ER.

Informational Note No. 2: See 310.14(A)(3) for temperature limitation of conductors.

Statement of Problem and Substantiation for Public Input

336.10(7) currently states "...between cable tray and utilization equipment...". Type TC-ER cable is often installed in industrial settings in cable tray, conduits and other raceways, or even leaving enclosures immediately adjacent to equipment. If the concept is that TC-ER is rated to be run "exposed" per 336.10(7) wording, then why would it matter what the cable is exiting at the point it becomes exposed (specifically cable tray in current wording). My submission is simply to add additional words to make the statement more general - "...between cable tray, raceway or enclosure, and utilization equipment..." hence bringing it more into line with the conceptual statement "TC-ER cable can be run exposed, if:".

Submitter Information Verification

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Submittal Date:	Fri Jul 14 14:17:36 EDT 2023
Committee:	NEC-P06

Public Input No. 2662-NFPA 70-2023 [Section No. 336.10]

336.10 Uses Permitted.

Type TC cable shall be permitted to be used as follows:

(1) For power, lighting, control, and signal circuits.

(2) In cable trays, including those with mechanically discontinuous segments up to 300 mm (1 ft).

(3) In raceways.

(4) In outdoor locations supported by a messenger wire.

(5) For Class 1 circuits as permitted in Article 725, Parts II and III ~~of Article~~ 725 .

(6) For non-power-limited fire alarm circuits if conductors comply with the requirements of 760.49.

(7) Between a cable tray and the utilization equipment or device(s), provided all of the following apply:

(8) The cable is Type TC-ER.

(9) The cable is installed in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation.

(10) The cable is continuously supported and protected against physical damage using mechanical protection such as struts, angles, or channels.

(11) The cable complies with the crush and impact requirements of Type MC cable and is identified with the marking "TC–ER."

(12) The cable is secured at intervals not exceeding 1.8 m (6 ft).

(13) Equipment grounding for the utilization equipment is provided by an equipment grounding conductor within the cable. In cables containing conductors sized 6 AWG or smaller, the equipment grounding conductor shall be provided within the cable or, at the time of installation, one or more insulated conductors shall be permanently identified as an equipment grounding conductor in accordance with 250.119(C) .

Exception to (7): Where not subject to physical damage, Type TC-ER shall be permitted to transition between cable trays and between cable trays and equipment or devices for a distance not to exceed 1.8 m (6 ft) without continuous support. The cable shall be mechanically supported where exiting the cable tray to ensure that the minimum bending radius is not exceeded.

(14) Type TC cable shall be resistant to moisture and corrosive agents where installed in wet locations.

(15) For one- and two-family dwelling units, Type TC-ER-JP cable containing conductors for both power and control circuits shall be permitted for branch circuits and feeders. Type TC-ER-JP cable used as interior wiring shall be installed per the requirements of ~~Part II of~~ Article 334 ~~and~~ , Part II and where installed as exterior wiring shall be installed per the requirements of ~~Part II of~~ Article 340 , Part II .

Exception: Where used to connect a generator and associated equipment having terminals rated 75°C (140°F) or higher, the cable shall not be limited in ampacity by 334.80 or 340.80.

Informational Note No. 1: See 725.136 for limitations on Class 2 or 3 circuits contained within the same cable with conductors of electric light, power, or Class 1 circuits.

(16) Direct buried, where identified for such use.

(17) In hazardous (classified) locations where specifically permitted by other articles in this *Code*.

(18) For service-entrance conductors where identified for such use and marked Type TC-ER.

Informational Note No. 2: See 310.14(A)(3) for temperature limitation of conductors.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.

4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.

The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Submittal Date:	Thu Aug 24 08:11:03 EDT 2023
Committee:	NEC-P06

Public Input No. 3385-NFPA 70-2023 [Section No. 336.10]

336.10 Uses Permitted.

Type TC cable shall be permitted to be used as follows:

(1) For power, lighting, control, and signal circuits.

(2) In cable trays, including those with mechanically discontinuous segments up to 300 mm (1 ft).

(3) In raceways.

(4) In outdoor locations supported by a messenger wire.

(5) For Class 1 circuits ~~as permitted in Parts II and III of Article 725 .~~ installed in accordance with 724.46.

(6) For non-power-limited fire alarm circuits if conductors comply with the requirements of 760.49.

(7) Between a cable tray and the utilization equipment or device(s), provided all of the following apply:

(8) The cable is Type TC-ER.

(9) The cable is installed in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation.

(10) The cable is continuously supported and protected against physical damage using mechanical protection such as struts, angles, or channels.

(11) The cable complies with the crush and impact requirements of Type MC cable and is identified with the marking “TC–ER.”

(12) The cable is secured at intervals not exceeding 1.8 m (6 ft).

(13) Equipment grounding for the utilization equipment is provided by an equipment grounding conductor within the cable. In cables containing conductors sized 6 AWG or smaller, the equipment grounding conductor shall be provided within the cable or, at the time of installation, one or more insulated conductors shall be permanently identified as an equipment grounding conductor in accordance with 250.119(C) .

Exception to (7): Where not subject to physical damage, Type TC-ER shall be permitted to transition between cable trays and between cable trays and equipment or devices for a distance not to exceed 1.8 m (6 ft) without continuous support. The cable shall be mechanically supported where exiting the cable tray to ensure that the minimum bending radius is not exceeded.

(14) Type TC cable shall be resistant to moisture and corrosive agents where installed in wet locations.

(15) For one- and two-family dwelling units, Type TC-ER-JP cable containing conductors for both power and control circuits shall be permitted for branch circuits and feeders. Type TC-ER-JP cable used as interior wiring shall be installed per the requirements of Part II of Article 334 and where installed as exterior wiring shall be installed per the requirements of Part II of Article 340.

Exception: Where used to connect a generator and associated equipment having terminals rated 75°C (140°F) or higher, the cable shall not be limited in ampacity by 334.80 or 340.80.

Informational Note No. 1: See 725.136 for limitations on Class 2 or 3 circuits contained within the same cable with conductors of electric light, power, or Class 1 circuits.

(16) Direct buried, where identified for such use.

(17) In hazardous (classified) locations where specifically permitted by other articles in this *Code*.

(18) For service-entrance conductors where identified for such use and marked Type TC-ER.

Informational Note No. 2: See 310.14(A)(3) for temperature limitation of conductors.

Statement of Problem and Substantiation for Public Input

The 2023 NEC revision moved class 1 circuits from article 725 to 724, and this reference was missed in the update. Article 724 doesn't have the same parts structure, and the style manual prohibits referencing the entire article, so the wording of the reference is changed to reflect the wiring methods in 724.46, rather than the parts of 725.

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Public Input No. 3616-NFPA 70-2023 [Section No. 336.10]

336.10 Uses Permitted.

Type TC cable shall be permitted to be used as follows:

(1) For power, lighting, control, signal **and** ~~signal~~ **non-power limited circuits**.

(2) In cable trays, including those with mechanically discontinuous segments up to 300 mm (1 ft).

(3) In raceways.

(4) In outdoor locations supported by a messenger wire.

(5) For Class 1 circuits as permitted in Parts II and III of Article 725.

(6) For non-power-limited fire alarm circuits if conductors comply with the requirements of 760.49.

(7) Between a cable tray and the utilization equipment or device(s), provided all of the following apply:

(8) The cable is Type TC-ER.

(9) The cable is installed in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation.

(10) The cable is continuously supported and protected against physical damage using mechanical protection such as struts, angles, or channels.

(11) The cable complies with the crush and impact requirements of Type MC cable and is identified with the marking "TC–ER."

(12) The cable is secured at intervals not exceeding 1.8 m (6 ft).

(13) Equipment grounding for the utilization equipment is provided by an equipment grounding conductor within the cable. In cables containing conductors sized 6 AWG or smaller, the equipment grounding conductor shall be provided within the cable or, at the time of installation, one or more insulated conductors shall be permanently identified as an equipment grounding conductor in accordance with 250.119(C).

Exception to (7): Where not subject to physical damage, Type TC-ER shall be permitted to transition between cable trays and between cable trays and equipment or devices for a distance not to exceed 1.8 m (6 ft) without continuous support. The cable shall be mechanically supported where exiting the cable tray to ensure that the minimum bending radius is not exceeded.

(14) Type TC cable shall be resistant to moisture and corrosive agents where installed in wet locations.

(15) For one- and two-family dwelling units, Type TC-ER-JP cable containing conductors for both power and control circuits shall be permitted for branch circuits and feeders. Type TC-ER-JP cable used as interior wiring shall be installed per the requirements of Part II of Article 334 and where installed as exterior wiring shall be installed per the requirements of Part II of Article 340.

Exception: Where used to connect a generator and associated equipment having terminals rated 75°C (140°F) or higher, the cable shall not be limited in ampacity by 334.80 or 340.80.

Informational Note No. 1: See 725.136 for limitations on Class 2 or 3 circuits contained within the same cable with conductors of electric light, power, or Class 1 circuits.

(16) Direct buried, where identified for such use.

(17) In hazardous (classified) locations where specifically permitted by other articles in this *Code*.

(18) For service-entrance conductors where identified for such use and marked Type TC-ER.

Informational Note No. 2: See 310.14(A)(3) for temperature limitation of conductors.

Statement of Problem and Substantiation for Public Input

The added text in 336.10 (1) will enhance usability and clarity to the code for non-power limited installations.

Submitter Information Verification

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Public Input No. 459-NFPA 70-2023 [Section No. 336.10]

336.10 Uses Permitted.

Type TC cable shall be permitted to be used as follows:

(1) For power, lighting, control, and signal circuits.

(2) In cable trays, including those with mechanically discontinuous segments up to 300 mm (1 ft).

(3) In raceways.

(4) In outdoor locations supported by a messenger wire.

(5) For Class 1 circuits as permitted in Parts II and III of Article 725.

(6) For non-power-limited fire alarm circuits if conductors comply with the requirements of 760.49.

(7) Between a cable tray and the utilization equipment or device(s), provided all of the following apply:

(8) The cable is Type TC-ER.

(9) The cable is installed in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation.

(10) The cable is continuously supported and protected against physical damage using mechanical protection such as struts, angles, or channels.

(11) The cable complies with the crush and impact requirements of Type MC cable and is identified with the marking "TC–ER."

(12) The cable is secured at intervals not exceeding 1.8 m (6 ft).

(13) Equipment grounding for the utilization equipment is provided by an equipment grounding conductor within the cable. In cables containing conductors sized 6 AWG or smaller, the equipment grounding conductor shall be provided within the cable or, at the time of installation, one or more insulated conductors shall be permanently identified as an equipment grounding conductor in accordance with 250.119(C) .

Exception to (7): Where not subject to physical damage, Type TC-ER shall be permitted to transition between cable trays and between cable trays and equipment or devices for a distance not to exceed 1.8 m (6 ft) without continuous support. The cable shall be mechanically supported where exiting the cable tray to ensure that the minimum bending radius is not exceeded.

(14) Type TC cable shall be resistant to moisture and corrosive agents where installed in wet locations.

(15) For one- and two-family dwelling units, Type TC-ER-JP cable ~~containing conductors for both power and control circuits~~ shall be permitted for branch circuits and feeders. Type TC-ER-JP cable used as interior wiring shall be installed per the requirements of Part II of Article 334 and where installed as exterior wiring shall be installed per the requirements of Part II of Article 340.

Exception: Where used to connect a generator and associated equipment having terminals rated 75°C (140°F) or higher, the cable shall not be limited in ampacity by 334.80 or 340.80.

Informational Note No. 1: See 725.136 for limitations on Class 2 or 3 circuits contained within the same cable with conductors of electric light, power, or Class 1 circuits.

(16) Direct buried, where identified for such use.

(17) In hazardous (classified) locations where specifically permitted by other articles in this *Code*.

(18) For service-entrance conductors where identified for such use and marked Type TC-ER.

Informational Note No. 2: See 310.14(A)(3) for temperature limitation of conductors.

Statement of Problem and Substantiation for Public Input

This edit has been suggested several times but has been appropriately turned down for lack of substantiation. So let me know substantiate:

Upon original adoption of this permission, CMP 7 purged most of the language that constrained its use to generator installations, questioning why it couldn't be used as a more general substitute for NM, UF or SE (see Exhibit 1). It appears to be an oversight that the control/power conductor portion was left in.

Comparing the standards for TC-ER-JP (UL 1277) against SE (UL 854), NM (UL 719), or (UL 493) shows that TC-ER meets or exceeds all of those requirements. Indeed, TC-ER-JP cable meets the joist-pull requirements of NM cable, the impact and crush requirements of MC cable, comes standard with a gasoline and oil resistant nylon jacket, and most, if not all, iterations meet the sunlight resistance requirements of SE cable and the direct burial requirements of UF cable.

Our company uses the cable for inverter output circuits, allowable under the 2017 NEC since those conductors transmit data (Exhibit 2). The Commonwealth of Virginia issued a Formal Interpretation on this use, unable to identify a safety benefit from extra conductors in a cable that transmit data signals (Exhibit 3).

Allowing the use of TC-ER-JP cable for power-only circuits will increase safety by enabling simpler designs that require less splice boxes and wire connections.

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Committee:	NEC-P06

Public Input No. 2663-NFPA 70-2023 [Section No. 336.104(B)]

(B) Thermocouple Circuits.

Conductors in Type TC cable used for thermocouple circuits in accordance with ~~Part III of~~ Article 724 ~~shall~~ , Part III shall also be permitted to be any of the materials used for thermocouple extension wire.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

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Committee: NEC-P06

Public Input No. 1014-NFPA 70-2023 [Section No. 336.104 [Excluding any Sub-Sections]]

For ungrounded, grounded, and equipment grounding conductors, the conductor sizes shall be 14 AWG through 1000 kcmil copper, nickel, ~~or nickel~~ nickel -coated copper or copper-clad aluminum, and 12 AWG through 1000 kcmil aluminum ~~or copper-clad aluminum~~ . Insulation types shall be one of the types listed in Table 310.4(1) or Table 310.4(2) that is suitable for branch circuit and feeder circuits or one that is identified for such use.

For control and signal conductors, the minimum conductor sizes shall be 18 AWG copper, nickel, or nickel-coated copper, 14 AWG copper-clad aluminum, and 12 AWG aluminum.

Statement of Problem and Substantiation for Public Input

See substantiation in PI 1008

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]	

Submitter Information Verification

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Committee:	NEC-P06

Public Input No. 1022-NFPA 70-2023 [Section No. 336.104 [Excluding any Sub-Sections]]

For ungrounded, grounded, and equipment grounding conductors, the conductor sizes shall be 14 AWG through 1000 kcmil copper, nickel, or nickel-coated copper and 12 AWG through 1000 kcmil aluminum or copper-clad aluminum. Insulation types shall be one of the types listed in Table 310.4(1) or Table 310.4(2) that is suitable for branch circuit and feeder circuits or one that is identified for such use.

For control and signal conductors, the minimum conductor sizes shall be 18 AWG copper, nickel, or nickel-coated copper, ~~14 AWG~~ 16 AWG copper-clad aluminum, and 12 AWG aluminum.

Additional Proposed Changes

File Name	Description	Approved
PGFinal.SW-2023-001_-_Electrical_Characteristic_Comparison_between_Copper_and_CCA_Thermostat_Wire_002_.pdf	Electrical Characteristics Between 16 AWG CCA and 18 AWG Copper	

Statement of Problem and Substantiation for Public Input

Also see substantiation for PI 1018. 16 AWG CCA is referenced by UL 13 for thermostat wire. 16 AWG CCA and smaller conductors have long been used as data conductors in coaxial cable.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1018-NFPA 70-2023 [Section No. 330.104]	

Submitter Information Verification

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Committee:	NEC-P06

COPPERWELD

Electrical Test Laboratory Report SW-2023-002

Market:	**Class 4 Conductors**		
Subject:	**Electrical Characteristic Comparison between 16 AWG CCA vs 18 AWG Cu**		
Date:	**8/29/23**	**Report No:**	**002**

Analysis By:	**Brandon Allen – Product Engineer**
Authored By:	**Brandon Allen– Product Engineer**
Approved By:	**Tom Sterling – Product Development Manager**

Objective:

To perform electrical analysis to show the characteristic comparison of 16 AWG Copper Clad Aluminum (CCA) to 18 AWG Copper (Cu).

Samples/Equipment Provided:

Materials

- Test Samples: 16 AWG Copper Clad Aluminum (CCA)
- Test Samples: 18 AWG Copper (Cu)

Wire Tested:

- *500 ft. of 18 AWG Solid Copper, annealed*
- *500 ft. of 16 AWG solid CCA 10%, annealed*
- *Minimum of 6 mils of PVC insulation on both Cu and CCA wire*

Physical Attributes	**Diameter (in)**	**Cross-Sectional Area (in²)**	**Weight (lb/kft)**	**Copper Thickness (in)**	**DC Resistance (Ω/kft)**
18 AWG Cu	0.0403	0.001276	4.917	0.04030	6.610
16 AWG CCA 10%	0.0508	0.002027	2.919	0.00127	6.524

Test Equipment / Calibration Requirements

- Data Acquisition System
- Thermocouple
- Power Source (24 VAC at 40VA)

Test Procedure 1: Temperature Readings with Incremental Current

1. Set the configuration for the AC power/current source to begin the test.
2. Using the 16 AWG Copper Clad Aluminum (CCA) samples, prepare the test samples by connecting the thermocouples to the test samples for the temperature readings.
3. With the thermocouples attached to the test samples, connect the opposite end of the thermocouple wire to the Data acquisition system.
4. Set the current source to the initial current of 3A then increment by 3A in 10-minute intervals for the duration of the test. Step up current to a final level of 24 amperes.
5. All testing conducted in open-air.
6. At the completion of the test, store the data and repeat each step for 18 AWG Copper (Cu).

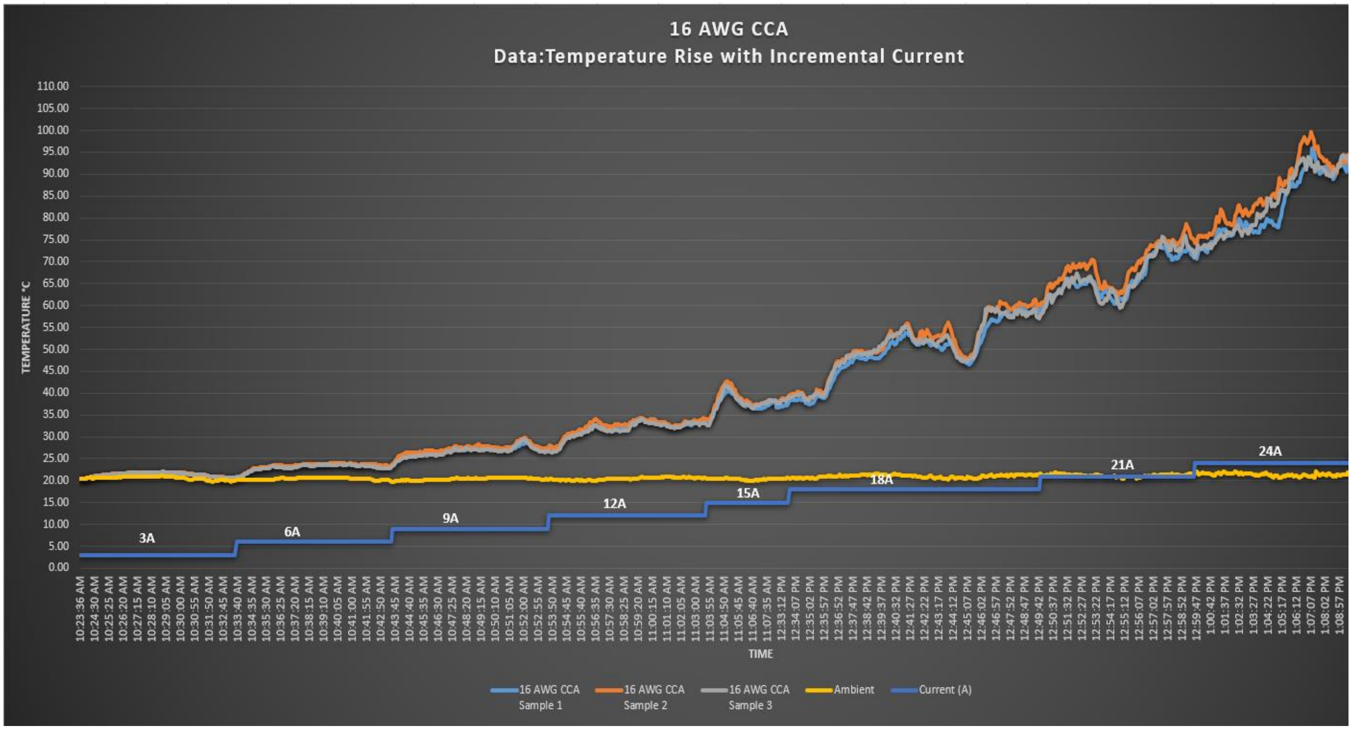
Test Results 1: Temperature Readings with Incremental Current

During testing, the data revealed that the increase in current was proportional to the increase in temperature. In comparison, the three samples of 16 AWG CCA ran slightly cooler than the three samples of 18 AWG Cu. Below Table 1 presents values stepped up from 3 amperes to 12 amperes. 16 AWG CCA for Class 4 circuits should never see 12 amperes of AC current in the real world.

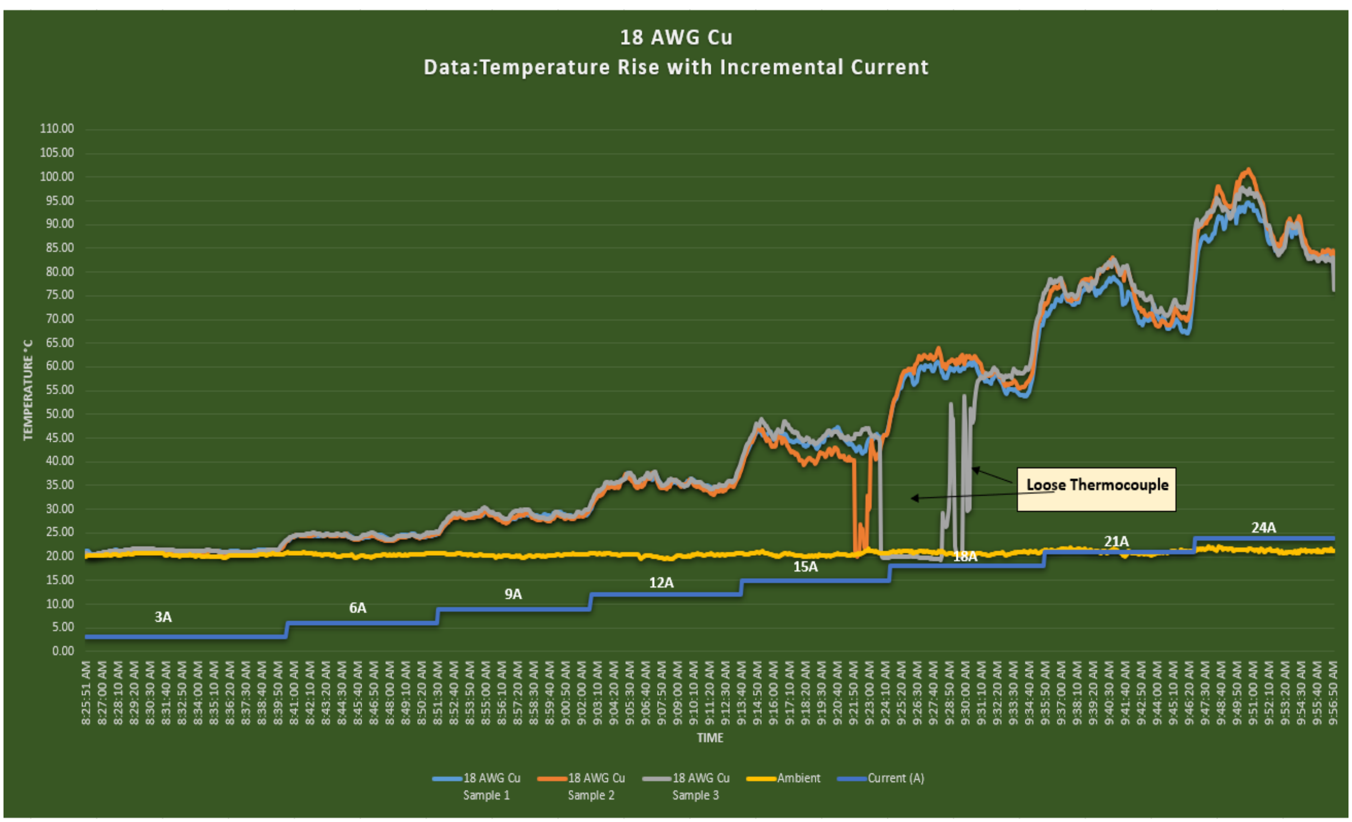
See Table 1 and graphs 1 & 2 below for more details:

TABLE 1:

16 AWG CCA				18 AWG Copper			
Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise	Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise
3	**21.96**	**20.58**	**1.38**	**3**	**23.38**	**20.38**	**3.00**
6	**24.13**	**20.43**	**3.70**	**6**	**25.3**	**20.43**	**4.87**
9	**29.79**	**20.38**	**9.41**	**9**	**30.46**	**20.34**	**10.12**
12	**34.28**	**20.44**	**13.84**	**12**	**39.75**	**20.33**	**19.42**



Graph 1: 16 AWG CCA



Graph 2: 18 AWG Cu

Test Results 2: Electrical Characteristic Measurements

The Voltage drop was calculated using the voltage drop calculator formula at 3 Amps.

VOLTAGE DROP CALCULATOR FORMULA

$$VD = (2 \cdot A \cdot L \cdot R) / 1000$$

Where:

VD = Voltage Drop (Volts) per unit circuit length

A = Full Load Current (Amps)

L = One-Way Circuit Length (ft)

R = Resistance (Ohms/Kft)

		Run Length (ft)			
Voltage Drop (Vac)	VAC++	50	100	150	200
18 AWG Cu	24.00	1.98	3.96	5.95	7.93
16 AWG CCA 10%	24.00	1.95	3.91	5.87	7.82

** With a supply voltage of 24 Vac, what is the Drop Voltage across the hot and common legs of circuit, at specified Lengths of wire?*

** Set Load Resistance to drawn 3.0 Amps*

Conclusion:

When comparing 16 AWG Copper Clad Aluminum to 18 AWG Copper, the electrical measurements of the 16 AWG Copper Clad Aluminum conductor measured at a slightly lower resistance than the 18 AWG Copper. The analysis of the thermal test also showed that when the same current is applied to both conductors for the same duration, 16 AWG Copper Clad Aluminum measured at slightly lower temperatures than 18 AWG Copper. Lower conductor temperatures generally support the notion that the connected equipment will last longer and run more efficiently. The lower Voltage Drop of 16 AWG CCA as compared to that of 18 AWG copper will also likely improve equipment performance. The heating profiles of both the 16 AWG CCA and 18 AWG copper are not expected to pose problems for class 4 circuits.

Public Input No. 1350-NFPA 70-2023 [Section No. 336.130]

336.130 Hazardous (Classified) Location Cable.

Cable listed and marked Type TC-ER-HL shall comply with the following:

(1) The overall nonmetallic jacket shall be suitable for the environment.

(2) The overall cable construction shall be essentially circular in cross-section.

(3) The overall nonmetallic jacket shall be continuous and gas/vapor tight.

(4) For construction greater than 25.4 mm (1 in.) in diameter, the following shall apply: DELETE ITEM 4

(5) The equipment grounding conductor shall be bare.

(6) A metallic shield shall be included over all conductors under the outer jacket.

Additional Proposed Changes

File Name	Description	Approved
Article_336.10_PI.docx	Justification to remove 336.130.4	

Statement of Problem and Substantiation for Public Input

Manufacturers of TC-ER-HL are being burdened by having to utilize an uninsulated grounding conductor in cables over 1.0 inch in diameter. It is much more difficult to pass the crushing and impact tests with a bare ground. There is no basis for this since teh 1.o inch restriction was put originally in Article 505 because of smaller MC-HL cables being damaged during installation. There is no technical justification for this requirement.

Submitter Information Verification

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Committee: NEC-P06

The limitation of 1.0 inch has absolutely nothing to do with cable power utilization. The 1.0 inch restriction was put in Article 505 in 2014 because MC-HL cables under 1.0 inch in OD were being damaged during installation. This restriction was NEVER included in Article 501. Manufacturers could not make cables over 1.0” inch because UL limited the listing to 1.0 inch based on the 505 restriction. Now we can go over an inch but with restrictions which have no technical basis.

If I have a 37 conductor control cable, I have to utilize an uninsulated ground conductor and an overall shield. Why? Because it’s over an inch in diameter? What if I have a 7C 14 AWG cable and my factory over insulates the conductor and puts an extra heavy jacket making the cable 1.05” in diameter. I have to take off insulation on the ground conductor and put a shield under the jacket whereby an identical cable that was not over insulated and jacket does not require a shield and may utilize an insulated ground – because it’s under an inch. This makes absolutely no sense whatsoever. The one inch limitation should be removed and these arbitrary restrictions need to be deleted from this article. If there is a concern about power utilization then specify the current loading that requires a shield and uninsulated ground.

Public Input No. 3144-NFPA 70-2023 [Section No. 336.130]

336.~~130~~ 126 Hazardous (Classified) Location Cable.

Cable listed and marked Type TC-ER-HL shall comply with the following:

(1) The overall nonmetallic jacket shall be suitable for the environment.

(2) The overall cable construction shall be essentially circular in cross-section.

(3) The overall nonmetallic jacket shall be continuous and gas/vapor tight.

(4) For construction greater than 25.4 mm (1 in.) in diameter, the following shall apply:

- (5) The equipment grounding conductor shall be bare.
- (6) A metallic shield shall be included over all conductors under the outer jacket.

Statement of Problem and Substantiation for Public Input

This section was renumbered to comply with the NEC Style Manual. The parallel number of the wiring method articles was developed for the 2002 code cycle. Section 2.2.1.1. of the NEC Style Manual requires the use of parallel numbers to the extent possible. the xxx.130 section has been used in other wiring method articles for Standard Lengths and should remain remain for that criteria. xxx.126 has not been used and may provide a location to cover hazardous location previsions.

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Public Input No. 611-NFPA 70-2023 [New Section after 337.1]

337.2 Reconditioned Equipment

Type P cable shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

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Submittal Date:	Sun Apr 16 08:17:14 EDT 2023
Committee:	NEC-P06

Public Input No. 3513-NFPA 70-2023 [Section No. 337.6]

337.~~6~~ 2 Listing Requirements.

Type P cables and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name:	David Williams
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Submittal Date:	Mon Sep 04 17:30:01 EDT 2023
Committee:	NEC-P06

Public Input No. 1023-NFPA 70-2023 [Section No. 337.104]

337.104 Conductors.

Conductors shall be of tinned copper or copper-clad aluminum . Conductors shall employ flexible stranding. The minimum conductor size shall be ~~18 AWG~~ 18 AWG copper or 16 AWG copper-clad aluminum .

Additional Proposed Changes

File Name	Description	Approved
PGFinal.SW-2023-001_-_Electrical_Characteristic_Comparison_between_Copper_and_CCA_Thermostat_Wire_002_.pdf	Electrical Characteristics of 16 AWG CCA Compared to 18 AWG Copper	

Statement of Problem and Substantiation for Public Input

No technical reason that CCA shouldn't be employed in P-Cable. Performance testing has indicated that 16 AWG copper-clad aluminum is suitable for use as a remote control and signaling wire. 16 AWG conductors and smaller have long been used as coaxial cable conductors. Currently in UL 13. 16 AWG CCA referenced by UL 13 for thermostat wire. 16 AWG CCA and smaller conductors have long been used as data conductors in the coaxial cable.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1018-NFPA 70-2023 [Section No. 330.104]	

Submitter Information Verification

Submitter Full Name: Peter Graser
Organization: Copperweld
Affiliation: American Bimetallic Association
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Submittal Date: Sun Jun 11 16:25:55 EDT 2023
Committee: NEC-P06

COPPERWELD

Electrical Test Laboratory Report SW-2023-002

Market:	**Class 4 Conductors**		
Subject:	**Electrical Characteristic Comparison between 16 AWG CCA vs 18 AWG Cu**		
Date:	**8/29/23**	**Report No:**	**002**

Analysis By:	**Brandon Allen – Product Engineer**
Authored By:	**Brandon Allen– Product Engineer**
Approved By:	**Tom Sterling – Product Development Manager**

Objective:

To perform electrical analysis to show the characteristic comparison of 16 AWG Copper Clad Aluminum (CCA) to 18 AWG Copper (Cu).

Samples/Equipment Provided:

Materials

- Test Samples: 16 AWG Copper Clad Aluminum (CCA)
- Test Samples: 18 AWG Copper (Cu)

Wire Tested:

- *500 ft. of 18 AWG Solid Copper, annealed*
- *500 ft. of 16 AWG solid CCA 10%, annealed*
- *Minimum of 6 mils of PVC insulation on both Cu and CCA wire*

Physical Attributes	Diameter (in)	Cross-Sectional Area (in²)	Weight (lb/kft)	Copper Thickness (in)	DC Resistance (Ω/kft)
18 AWG Cu	0.0403	0.001276	4.917	0.04030	6.610
16 AWG CCA 10%	0.0508	0.002027	2.919	0.00127	6.524

Test Equipment / Calibration Requirements

- Data Acquisition System
- Thermocouple
- Power Source (24 VAC at 40VA)

Test Procedure 1: Temperature Readings with Incremental Current

1. Set the configuration for the AC power/current source to begin the test.
2. Using the 16 AWG Copper Clad Aluminum (CCA) samples, prepare the test samples by connecting the thermocouples to the test samples for the temperature readings.
3. With the thermocouples attached to the test samples, connect the opposite end of the thermocouple wire to the Data acquisition system.
4. Set the current source to the initial current of 3A then increment by 3A in 10-minute intervals for the duration of the test. Step up current to a final level of 24 amperes.
5. All testing conducted in open-air.
6. At the completion of the test, store the data and repeat each step for 18 AWG Copper (Cu).

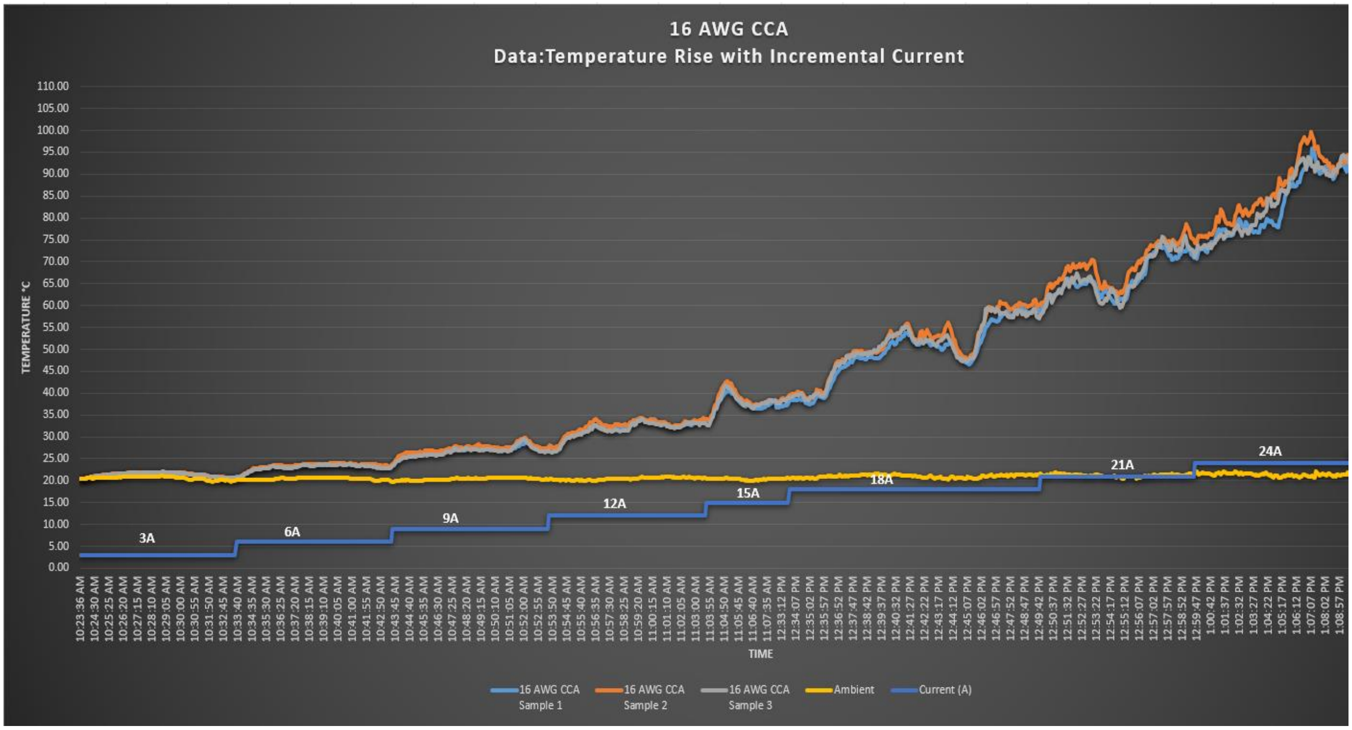
Test Results 1: Temperature Readings with Incremental Current

During testing, the data revealed that the increase in current was proportional to the increase in temperature. In comparison, the three samples of 16 AWG CCA ran slightly cooler than the three samples of 18 AWG Cu. Below Table 1 presents values stepped up from 3 amperes to 12 amperes. 16 AWG CCA for Class 4 circuits should never see 12 amperes of AC current in the real world.

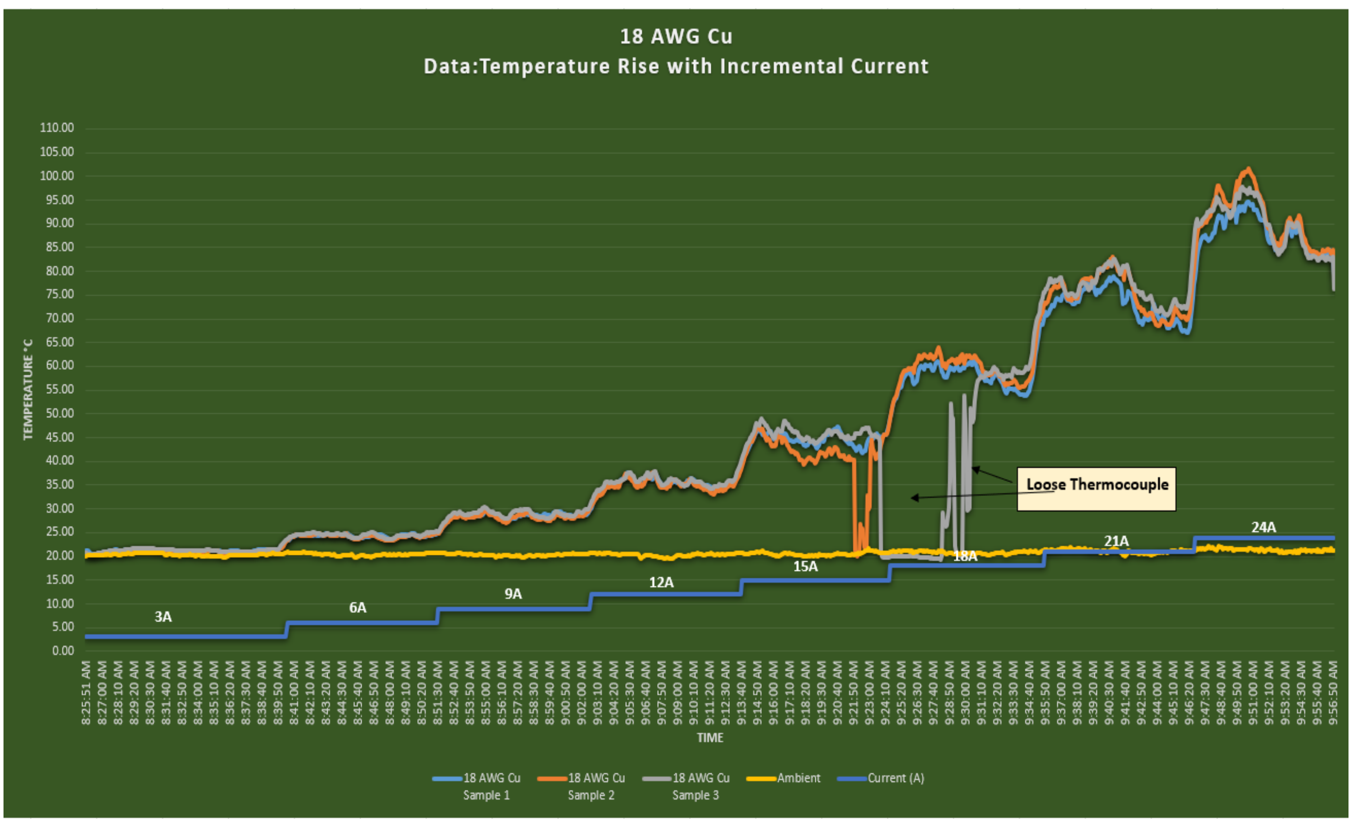
See Table 1 and graphs 1 & 2 below for more details:

TABLE 1:

16 AWG CCA				18 AWG Copper			
Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise	Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise
3	**21.96**	**20.58**	**1.38**	**3**	**23.38**	**20.38**	**3.00**
6	**24.13**	**20.43**	**3.70**	**6**	**25.3**	**20.43**	**4.87**
9	**29.79**	**20.38**	**9.41**	**9**	**30.46**	**20.34**	**10.12**
12	**34.28**	**20.44**	**13.84**	**12**	**39.75**	**20.33**	**19.42**



Graph 1: 16 AWG CCA



Graph 2: 18 AWG Cu

Test Results 2: Electrical Characteristic Measurements

The Voltage drop was calculated using the voltage drop calculator formula at 3 Amps.

VOLTAGE DROP CALCULATOR FORMULA

$$VD = (2 \cdot A \cdot L \cdot R) / 1000$$

Where:

VD = Voltage Drop (Volts) per unit circuit length

A = Full Load Current (Amps)

L = One-Way Circuit Length (ft)

R = Resistance (Ohms/Kft)

		Run Length (ft)			
Voltage Drop (Vac)	VAC++	50	100	150	200
18 AWG Cu	24.00	1.98	3.96	5.95	7.93
16 AWG CCA 10%	24.00	1.95	3.91	5.87	7.82

** With a supply voltage of 24 Vac, what is the Drop Voltage across the hot and common legs of circuit, at specified Lengths of wire?*

** Set Load Resistance to drawn 3.0 Amps*

Conclusion:

When comparing 16 AWG Copper Clad Aluminum to 18 AWG Copper, the electrical measurements of the 16 AWG Copper Clad Aluminum conductor measured at a slightly lower resistance than the 18 AWG Copper. The analysis of the thermal test also showed that when the same current is applied to both conductors for the same duration, 16 AWG Copper Clad Aluminum measured at slightly lower temperatures than 18 AWG Copper. Lower conductor temperatures generally support the notion that the connected equipment will last longer and run more efficiently. The lower Voltage Drop of 16 AWG CCA as compared to that of 18 AWG copper will also likely improve equipment performance. The heating profiles of both the 16 AWG CCA and 18 AWG copper are not expected to pose problems for class 4 circuits.

Public Input No. 612-NFPA 70-2023 [New Section after 338.1]

338.2 Reconditioned Equipment

Type SE and Type USE cables shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 614-NFPA 70-2023 [New Section after 340.1]	
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

Submitter Full Name:	Russ Leblanc
Organization:	Leblanc Consulting Services
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Submittal Date:	Sun Apr 16 08:18:40 EDT 2023
Committee:	NEC-P06

Public Input No. 3514-NFPA 70-2023 [Section No. 338.6]

~~338.6~~ 2 Listing Requirements.

Type SE and USE cables and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Submittal Date: Mon Sep 04 17:31:04 EDT 2023
Committee: NEC-P06

Public Input No. 2664-NFPA 70-2023 [Section No. 338.10]

338.10 Uses Permitted.

(A) Service-Entrance Conductors.

Service-entrance cable shall be permitted to be used as service-entrance conductors and shall be installed in accordance with 230.6, 230.7, and Article 230, Parts II, III, and IV ~~of Article 230~~ .

(B) Branch Circuits or Feeders.

(1) Grounded Conductor Insulated.

Type SE service-entrance cables shall be permitted in wiring systems where all of the circuit conductors of the cable are of the thermoset or thermoplastic type.

(2) Use of Uninsulated Conductor.

Type SE service-entrance cable shall be permitted for use where the insulated conductors are used for circuit wiring and the uninsulated conductor is used only for equipment grounding purposes.

Exception: In existing installations, uninsulated conductors shall be permitted as a grounded conductor in accordance with250.32 and 250.140, where the uninsulated grounded conductor of the cable originates in service equipment,and with 225.30 through 225.40.

(3) Temperature Limitations.

Type SE service-entrance cable used to supply appliances shall not be subject to conductor temperatures in excess of the temperature specified for the type of insulation involved.

(4) Installation Methods for Branch Circuits and Feeders.

(a) *Interior Installations.* Interior installations shall comply with the following:

(2) In addition to the provisions of this article, Type SE service-entrance cable used for interior wiring shall comply with the installation requirements of Part II of Article 334 , excluding 334.80 .

(3) Where more than two Type SE cables containing two or more current-carrying conductors in each cable are installed in contact with thermal insulation, caulk, or sealing foam without maintaining spacing between cables, the ampacity of each conductor shall be adjusted in accordance with Table 310.15(C)(1) .

(4) For Type SE cable with ungrounded conductor sizes 10 AWG and smaller, where installed in contact with thermal insulation, the ampacity shall be in accordance with 60°C (140°F) conductor temperature rating. The maximum conductor temperature rating shall be permitted to be used for ampacity adjustment and correction purposes, if the final ampacity does not exceed that for a 60°C (140°F) rated conductor.

(e) *Exterior Installations.* Exterior installations shall comply with the following:

(6) In addition to the provisions of this article, service-entrance cable used for feeders or branch circuits, where installed as exterior wiring, shall be installed in accordance with

~~Part I of~~

(1) Article 225 , Part I . The cable shall be supported in accordance with 334.30 .

(2) Type USE cable installed as underground feeder and branch circuit cable shall comply with Article 340, Part II

~~of Article 340~~

(1) .

Exception: Single-conductor Type USE and multi-rated USE conductors shall not be subject to the ampacity limitations of ~~Part II of~~ Article 340 , Part II .

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.

4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

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Submittal Date:	Thu Aug 24 08:15:12 EDT 2023
Committee:	NEC-P06

Public Input No. 896-NFPA 70-2023 [Section No. 338.10(B)(3)]

(3) Temperature Limitations.

Type SE service-entrance cable ~~used to supply appliances~~ shall not be ~~subject~~ subjected to ~~conductor~~ temperatures in excess of the temperature specified for the type of insulation involved.

Statement of Problem and Substantiation for Public Input

Is it really okay to melt the insulation off of SE cable, as long as it isn't supplying an appliance?

Submitter Information Verification

Submitter Full Name:	Ryan Jackson
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Committee:	NEC-P06

Public Input No. 2665-NFPA 70-2023 [Section No. 338.12]

338.12 Uses Not Permitted.

(A) Service-Entrance Cable.

Type SE cable shall not be used under the following conditions or in the following locations:

(1) Where subject to physical damage unless protected in accordance with 230.50(B)

(2) Underground with or without a raceway

(3) For exterior branch circuits and feeder wiring unless the installation complies with ~~Part I of~~ Article 225 ~~and~~ , Part I and is supported in accordance with 334.30 or is used as messenger-supported wiring as permitted in ~~Part II of~~ Article 396 , Part II

(B) Underground Service-Entrance Cable.

Type USE cable shall not be used under the following conditions or in the following locations:

(1) For interior wiring

(2) For aboveground installations except where USE cable emerges from the ground and is terminated in an enclosure at an outdoor location and the cable is protected in accordance with 300.5(D)

(3) As aerial cable unless it is a multiconductor cable identified for use aboveground and installed as messenger-supported wiring in accordance with 225.10 and ~~Part II of~~ Article 396 , Part II

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.

4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.

The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

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Submitter Full Name: David Williams

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Submittal Date: Thu Aug 24 08:21:17 EDT 2023

Committee: NEC-P06

Public Input No. 1042-NFPA 70-2023 [Section No. 338.12(A)]

(A) Service-Entrance Cable.

Type SE cable shall not be used under the following conditions or in the following locations:

(1) Where subject to physical damage unless protected in accordance with 230.50(B)

(2) Underground with or without a raceway

(3) For exterior branch circuits and feeder wiring unless the installation complies with Part I of Article 225 and is supported in accordance with 334.30 or is used as messenger-supported wiring as permitted in Part II of Article 396

(4) In stair towers.

(5) In townhouses, fire rated walls thru penetration to feed another unit.

Statement of Problem and Substantiation for Public Input

SER cable should not be used thru townhouse fire rated walls, and in stair towers per the IBC code

Submitter Information Verification

Submitter Full Name:	John Plourde
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Affiliation:	Performance Electrical Training LLC.
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Zip:	
Submittal Date:	Mon Jun 12 16:01:18 EDT 2023
Committee:	NEC-P06

Public Input No. 408-NFPA 70-2023 [Section No. 338.24]

338.24 Bending Radius.

Bends in Types USE and SE cable shall be so made that the cable will not be damaged. The radius of the curve of the inner edge of any bend, during or after installation, shall not be less than five times the diameter of the cable. For flat cables, the ~~major diameter~~ minor diameter dimension of the cable shall ~~be~~ permitted to be used to determine the bending radius when bending on the flat side of the cable . For all other bends the major diameter dimension shall be used.

Additional Proposed Changes

File Name	Description	Approved
338.24.pdf	SE cable bending	

Statement of Problem and Substantiation for Public Input

This revision is needed to provide relief for installations where the SE cable is bent on the flat side. The present wording makes it virtually impossible to use flat SE cables for installing services where the cable needs to enter through the outside wall of the building. See accompanying PDF showing just how big of a bend is needed! A bend of approximately 4.625" radius or 9.25" inch diameter (approximately the size of a soccer ball!) will be needed for a typical 2 AWG aluminum SE cable! Previously when making bends on the "flat' side of the cable using the minor dimension resulted in needing a 2.845" radius or 5.69" diameter bend. Using a sill plate to protect a cable with a 9" diameter bend is impossible now! Installing these flat cables in conduit bodies is all but impossible now too, unless a ridiculously oversized conduit body is used!!! This is absurd. Using the minor diameter dimension should be permitted when bending cables on the flat side. Using the major diameter dimension should be required otherwise.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 409-NFPA 70-2023 [Section No. 334.24]	bending flat cables
Public Input No. 410-NFPA 70-2023 [Section No. 340.24]	bending flat cables
Public Input No. 409-NFPA 70-2023 [Section No. 334.24]	
Public Input No. 410-NFPA 70-2023 [Section No. 340.24]	

Submitter Information Verification

Submitter Full Name: Russ Leblanc
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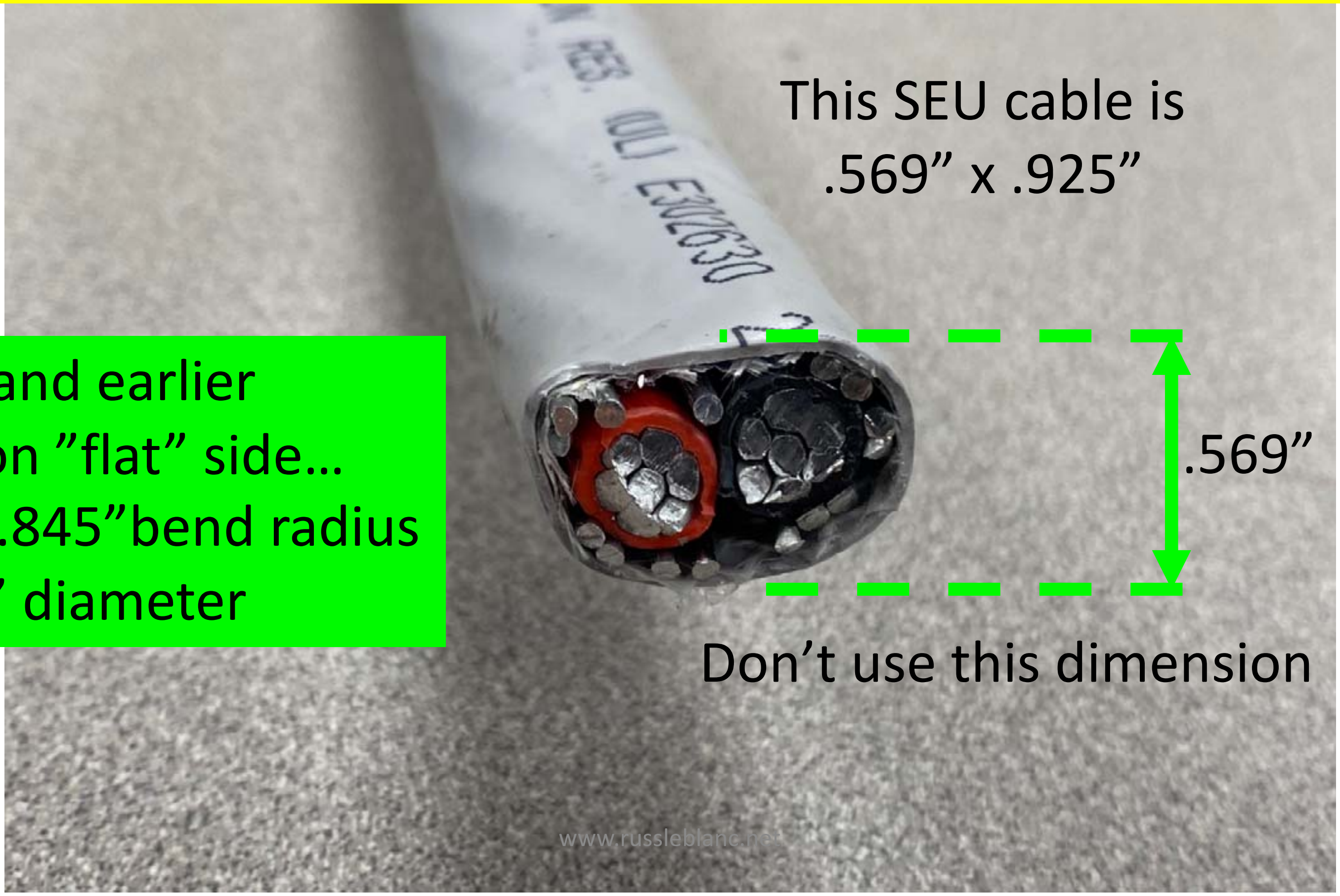
Submittal Date: Sat Mar 04 10:13:36 EST 2023
Committee: NEC-P06

338.24 Bending Radius

Bends in Types USE and SE cable shall be so made that the cable will not be damaged. The radius of the curve of the inner edge of any bend, during or after installation, shall not be less than five times the diameter of the cable. <u>For flat cables, the major diameter dimension of the cable shall be used to determine the bending radius.</u>

- To be consistent with other Sections the language was revised to include the word “major diameter” for clarity when using the diameter dimension to determine the radius of the bend of flat cables.

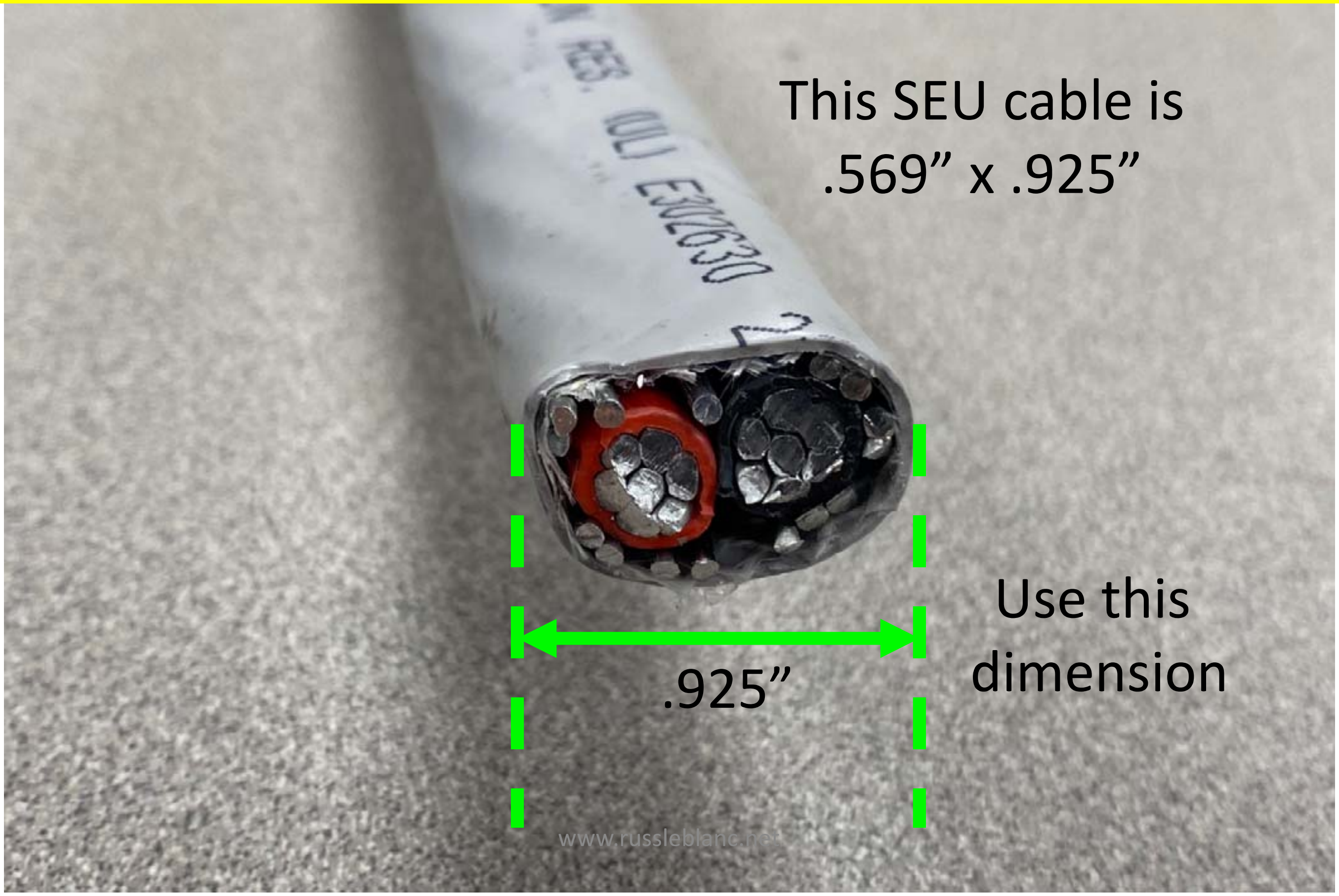
338.24- The radius of the curve of the inner edge of any bend shall not be less than five times the diameter of the cable. <u>For flat cables, the major diameter dimension of the cable shall be used to determine the bending radius.</u>



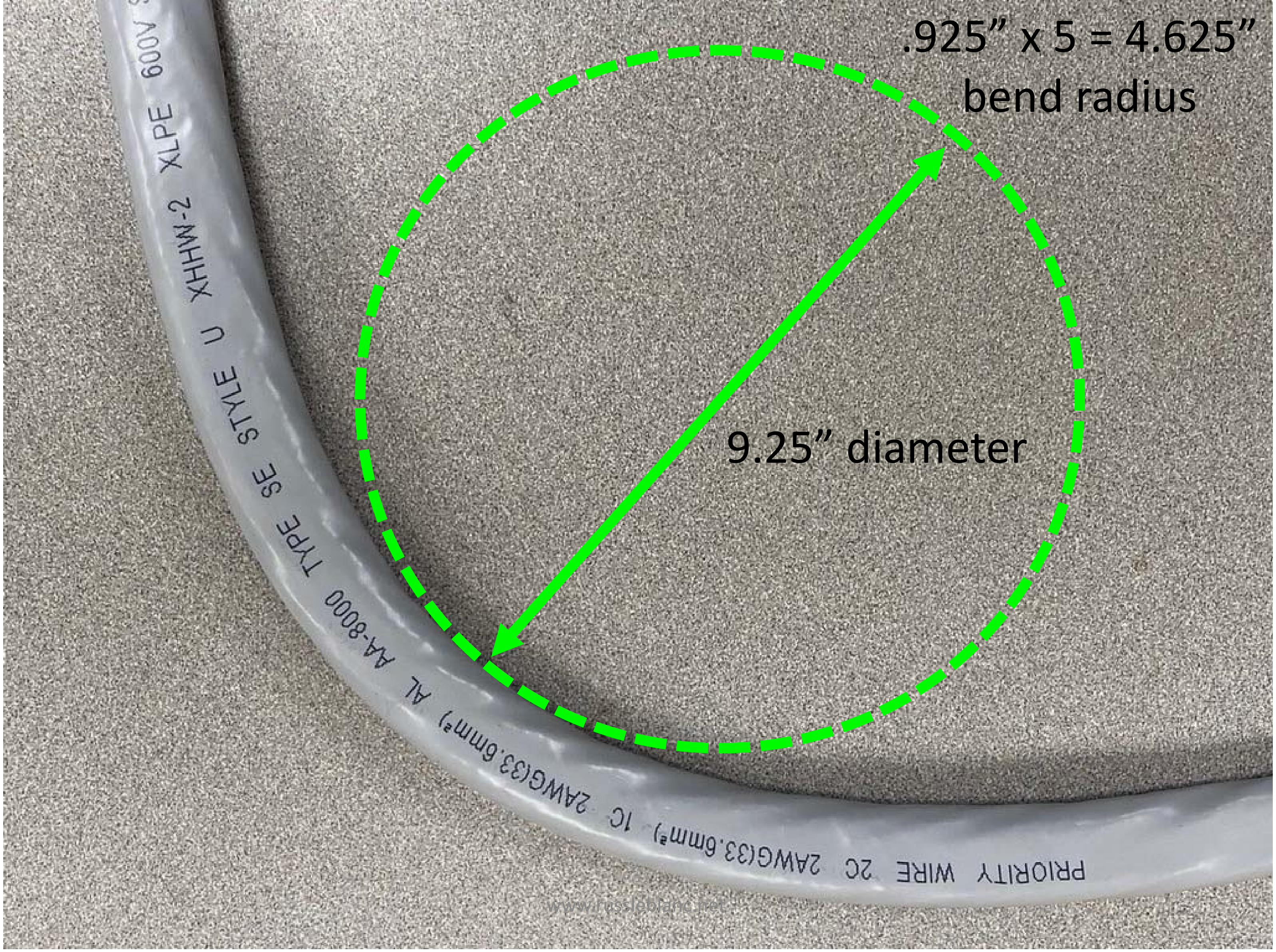
2020 and earlier
bending on ”flat” side…
.569” x 5 = 2.845”bend radius
5.69” diameter

www.russleblanc.net

338.24- The radius of the curve of the inner edge of any bend shall not be less than five times the diameter of the cable. <u>For flat cables, the major diameter dimension of the cable shall be used to determine the bending radius.</u>



www.russleblanc.net


.925” x 5 = 4.625”
bend radius
9.25” diameter
PRIORITY WIRE 2C 2AWG(33.6mm²) 1C 2AWG(33.6mm²) AL AA-8000 TYPE SE STYLE U XHHW-2 XLPE 600V

This applies even when bending on the “flat” side of cable!

Public Input No. 614-NFPA 70-2023 [New Section after 340.1]

340.2 Reconditioned Cables

Type UF cable shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Cables, Raceways, Conduits, and Tubings are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 598-NFPA 70-2023 [New Section after 356.1]	Reconditioned Equipment
Public Input No. 599-NFPA 70-2023 [New Section after 360.1]	Reconditioned Equipment
Public Input No. 600-NFPA 70-2023 [New Section after 352.1]	Reconditioned Equipment
Public Input No. 601-NFPA 70-2023 [New Section after 354.1]	Reconditioned Equipment
Public Input No. 602-NFPA 70-2023 [New Section after 353.1]	Reconditioned Equipment
Public Input No. 603-NFPA 70-2023 [New Section after 355.1]	Reconditioned Equipment
Public Input No. 604-NFPA 70-2023 [New Section after 320.1]	Reconditioned Equipment
Public Input No. 605-NFPA 70-2023 [New Section after 322.1]	Reconditioned Equipment
Public Input No. 606-NFPA 70-2023 [New Section after 324.1]	Reconditioned Equipment
Public Input No. 607-NFPA 70-2023 [New Section after 326.1]	Reconditioned Equipment
Public Input No. 608-NFPA 70-2023 [New Section after 330.1]	Reconditioned Equipment
Public Input No. 609-NFPA 70-2023 [New Section after 332.1]	Reconditioned Equipment
Public Input No. 610-NFPA 70-2023 [New Section after 334.1]	Reconditioned Equipment
Public Input No. 611-NFPA 70-2023 [New Section after 337.1]	Reconditioned Equipment
Public Input No. 612-NFPA 70-2023 [New Section after 338.1]	Reconditioned Equipment
Public Input No. 613-NFPA 70-2023 [New Section after 336.1]	Reconditioned Equipment
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

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Submittal Date: Sun Apr 16 08:21:49 EDT 2023
Committee: NEC-P06

Public Input No. 3515-NFPA 70-2023 [Section No. 340.6]

~~340.6~~ 2 Listing Requirements.

Type UF cable and associated fittings shall be listed.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name:	David Williams
Organization:	Delta Charter Township
Street Address:	
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State:	
Zip:	
Submittal Date:	Mon Sep 04 17:31:43 EDT 2023
Committee:	NEC-P06

Public Input No. 2666-NFPA 70-2023 [Section No. 340.10]

340.10 Uses Permitted.

Type UF cable shall be permitted as follows:

(1) For use underground, including direct burial in the earth.

(2) As single-conductor cables. Where installed as single-conductor cables, all conductors of the feeder or branch circuit, including the grounded conductor and equipment grounding conductor, if any, shall be installed in accordance with 300.3.

(3) For wiring in wet, dry, or corrosive locations.

(4) Installed as nonmetallic-sheathed cable. Where so installed, the installation and conductor requirements shall comply with Article 334, Parts II and III ~~of Article~~ 334 ,except for 334.12(B), and shall be of the multiconductor type.

(5) As single-conductor cables as the nonheating leads for heating cables as provided in 424.43.

(6) Supported by cable trays. Type UF cable supported by cable trays shall be of the multiconductor type.

Informational Note: See 310.14(A)(3) for temperature limitation of conductors.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

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Submittal Date: Thu Aug 24 08:23:45 EDT 2023
Committee: NEC-P06

Public Input No. 3052-NFPA 70-2023 [Section No. 340.10]

340.10 Uses Permitted.

Type UF cable shall be permitted as follows:

(1) For use underground, including direct burial in the earth.

(2) As single-conductor cables. Where installed as single-conductor cables, all conductors of the feeder or branch circuit, including the grounded conductor and equipment grounding conductor, if any, shall be installed in accordance with 300.3.

(3) For wiring in wet, dry, or corrosive locations.

(4) ~~Installed as nonmetallic-sheathed cable. Where so installed, the installation~~ Interior installations and conductor requirements shall comply with Parts II and III of Article 334,except for 334.12(B), and shall be of the multiconductor type.

(5) As single-conductor cables as the nonheating leads for heating cables as provided in 424.43.

(6) Supported by cable trays. Type UF cable supported by cable trays shall be of the multiconductor type.

Informational Note: See 310.14(A)(3) for temperature limitation of conductors.

Statement of Problem and Substantiation for Public Input

Deleting “Installed as nonmetallic-sheathed cable from list item (4) because UF cable is listed for wet location and NM cable is not. Stating UF cable can be installed as NM cable is technically inaccurate. Used similar language from 338.10(B)(4) for consistency pointing out to follow Part II of Article 334 for interior installations.

Submitter Information Verification

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Submittal Date:	Tue Aug 29 09:32:37 EDT 2023
Committee:	NEC-P06

Public Input No. 2667-NFPA 70-2023 [Section No. 340.12]

340.12 Uses Not Permitted.

Type UF cable shall not be used as follows:

(1) As service-entrance cable

(2) In commercial garages

(3) In theaters and similar locations

(4) In motion picture studios

(5) In storage battery rooms

(6) In hoistways or on elevators or escalators

(7) In hazardous (classified) locations, except as specifically permitted by other articles in this *Code*

(8) Embedded in poured cement, concrete, or aggregate, except where embedded in plaster as nonheating leads where permitted in 424.43

(9) Where exposed to direct rays of the sun, unless identified as sunlight resistant

Informational Note: The sunlight-resistant marking on the jacket does not apply to the individual conductors.

(10) Where subject to physical damage

(11) As overhead cable, except where installed as messenger-supported wiring in accordance with ~~Part II of~~ Article 396 , Part II

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name: David Williams
Organization: Delta Charter Township
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City:
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Submittal Date: Thu Aug 24 08:24:32 EDT 2023
Committee: NEC-P06

Public Input No. 410-NFPA 70-2023 [Section No. 340.24]

340.24 Bending Radius.

Bends in Type UF cable shall be so made that the cable is not damaged. The radius of the curve of the inner edge of any bend shall not be less than five times the diameter of the cable. For flat cables, the ~~major diameter~~ minor diameter dimension of the cable shall permitted to be used to determine the bending radius when bending on the flat side of the cable . For all other bends the major diameter dimension shall be used.

Statement of Problem and Substantiation for Public Input

This revision is needed to provide relief for installations where the cable is bent on the flat side. Installing these flat cables in conduit bodies may be difficult if not impossible now too! Using the minor diameter dimension should be permitted when bending cables on the flat side. Using the major diameter dimension should be required otherwise. See related PI for 334.24 and 338.24

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 409-NFPA 70-2023 [Section No. 334.24]	bending flat cables
Public Input No. 408-NFPA 70-2023 [Section No. 338.24]	bending flat cables
Public Input No. 408-NFPA 70-2023 [Section No. 338.24]	
Public Input No. 409-NFPA 70-2023 [Section No. 334.24]	

Submitter Information Verification

Submitter Full Name: Russ Leblanc
Organization: Leblanc Consulting Services
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Submittal Date: Sat Mar 04 10:45:35 EST 2023
Committee: NEC-P06

Public Input No. 1015-NFPA 70-2023 [Section No. 340.104]

340.104 Conductors.

The conductors shall be sizes ~~14 AWG~~ 14 AWG through 4/0 AWG copper or ~~12 AWG aluminum or~~ copper-clad aluminum ~~through~~ , or 12 AWG through 4/~~0 AWG~~ 0 AWG aluminum .

Statement of Problem and Substantiation for Public Input

See substantiation is PI 1008

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]	

Submitter Information Verification

Submitter Full Name:	Peter Graser
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Submittal Date:	Sun Jun 11 14:50:34 EDT 2023
Committee:	NEC-P06

Public Input No. 995-NFPA 70-2023 [Section No. 396.10(A)]

(A) Cable Types.

The ~~cable types in Table 396.10(A) shall~~ following cable types shall be permitted to be installed in messenger-supported wiring ~~under~~ , under the conditions described in ~~the article~~ their respective article or section ~~referenced for each.~~

~~Table 396.10(A) Cable Types~~

~~Cable Type Section Article~~

:

1. Medium-voltage cable

~~315~~

2. Metal-clad cable

~~330~~

3. Mineral-insulated, metal-sheathed cable

~~332~~

4. Multiconductor service-entrance cable

~~338~~

5. Multiconductor underground feeder and branch-circuit cable

~~340~~

6. Other factory-assembled, multiconductor control, signal, or power cables that are identified for the use

7. Power and control tray cable

~~336~~

.8. Power-limited tray cable

~~, in accordance with Table 722.135(B), 722.135(C), and 722.179(A)(6)~~

Statement of Problem and Substantiation for Public Input

Section 4.1.4 of the NEC(r) Style Manual prohibits referencing an entire article with the exception of Article 100 or where required for context. As such, it is recommended here to convert this to a list format. There is no change in meaning, here, as the charging language already directs the user to apply the language in the respective wiring method articles so nothing is lost. The index or the table of contents can easily lead the user to the correct article. As an alternative, the committee could also reference the specific part or section in the article as an alternative, but converting to a list would follow what many other articles are already doing, such as the hazardous location articles, Article 501 to 506, for instance.

Submitter Information Verification

Submitter Full Name: Richard Holub

Organization: The DuPont Company, Inc.

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City:	
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Submittal Date:	Thu Jun 08 13:49:30 EDT 2023
Committee:	NEC-P06

Public Input No. 3582-NFPA 70-2023 [Section No. 396.60]

396.60 Grounding and Bonding .

The messenger shall be grounded as required by 250.80 and 250.86 for enclosure grounding.

Statement of Problem and Substantiation for Public Input

There are 23 sections in Chapter 3 that have a .60 section. 19 of these sections are titled "Grounding." 3 of these sections are titled "Grounding and Bonding." 1 of these sections is titled "Equipment Grounding Conductor."
My suggestion is to rename all of these sections with "Grounding and Bonding."

Submitter Information Verification

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Submittal Date: Mon Sep 04 20:36:29 EDT 2023
Committee: NEC-P06

Public Input No. 2431-NFPA 70-2023 [Section No. 398.10]

398.10 Uses Permitted.

Open wiring on insulators shall be permitted only for industrial or agricultural establishments on systems of not over 1000 volts ac , 1500 volts dc, nominal, ~~or less,~~ as follows:

(1) Indoors or outdoors

(2) In wet or dry locations

(3) Where subject to corrosive vapors

(4) For services

Statement of Problem and Substantiation for Public Input

This Public Input is submitted on behalf of a Correlating Committee Task Group consisting of Robert Osborne (Chair), Paul Barnhart, Lou Grahor, Donny Cook, Scott Higgins, Mike Querry, Roger McDaniel, Dave Burns, Rod Belisle, Kevin Rogers, Tony Ricciuti, Paul Knapp, Paul Sullivan, George Smith, Eric Simmon, Kevin Arnold, Larry Wildermuth, and Kyle Krueger.

Requirements are revised to include the same voltage demarcation used in many places throughout the Code.

Submitter Information Verification

Submitter Full Name:	Robert Osborne
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Submittal Date:	Thu Aug 17 09:47:37 EDT 2023
Committee:	NEC-P06

Public Input No. 617-NFPA 70-2023 [New Section after 400.6]

400.7 Reconditioned Equipment

Flexible Cords and Flexible Cables shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Cablebus, Cables, Raceways, Conduits, Tubings, Flexible Cords, Flexible Cables, Cable Trays, MV Cables, Wireways, etc. etc. are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

Submitter Information Verification

Submitter Full Name:	Russ Leblanc
Organization:	Leblanc Consulting Services
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Submittal Date:	Sun Apr 16 08:38:10 EDT 2023
Committee:	NEC-P06

Public Input No. 4130-NFPA 70-2023 [Section No. 400.12]

400.12 Uses Not Permitted.

Unless specifically permitted in 400.10, flexible cords, flexible cables, cord sets, and power supply cords shall not be used for the following:

(1) As a substitute for the fixed wiring of a structure

(2) Where run through holes in walls, structural ceilings, suspended ceilings, dropped ceilings, or floors

(3) *Exception to (2): Flexible cord and flexible cable shall be permitted to be run through raised floors when passed thru an engineered cut out and under engineering supervision.*

(4) Where run through doorways, windows, or similar openings

(5) Where attached to building surfaces

Exception to (4): Flexible cord and flexible cable shall be permitted to be attached to building surfaces in accordance with 368.56(B) and 590.4.

(6) Where concealed by walls, floors, or ceilings or located above suspended or dropped ceilings

Exception to (5): Flexible cords, flexible cables, and power supply cords shall be permitted if contained within an enclosure for use in other spaces used for environmental air as permitted by 300.22(C)(3).

(7) Where installed in raceways, except as otherwise permitted in this *Code*

(8) Where subject to physical damage

Informational Note: See UL 817, *Cord Sets and Power-Supply Cords*, and UL 62, *Flexible Cords and Cables*, for proper application.

Statement of Problem and Substantiation for Public Input

I work in the semiconductor industry and routinely deal with situations where it would be extremely beneficial to be able to pass a flexible cord thru a cutout in the raised floor. In a fabrication plant, space above the raised floor is extremely limited, and there are many scenarios where a receptacle could be mounted under the raised floor, with flexible cable passing up thru a floor cut or pedestal opening. The flexible cord can be fed thru the floor cuout/pedestal opening and routed safely in the shadow of the equipment. If done properly, there is very very low chance of damage to the flexible cord.

Submitter Information Verification

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Submittal Date:	Wed Sep 06 17:34:06 EDT 2023
Committee:	NEC-P06

Public Input No. 2675-NFPA 70-2023 [Section No. 400.33]

400.33 Equipment Grounding Conductors.

Equipment grounding conductors shall be connected in accordance with Article 250, Parts VI and VII ~~of Article 250~~ .

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.

4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.

The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

Submitter Full Name: David Williams

Organization: Delta Charter Township

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Submittal Date: Thu Aug 24 09:28:49 EDT 2023

Committee: NEC-P06

Public Input No. 1269-NFPA 70-2023 [Section No. 400.34]

400.34 Minimum Bending Radii.

The minimum bending radii for portable cables during installation and handling in service shall be ~~adequate~~ made to prevent damage to the cable.

Statement of Problem and Substantiation for Public Input

According to the NEC Style Manual 2023 version, section 3.2 Word Choices; 3.2.1 Unenforceable Terms, the use of the word "adequate" is possibly an unenforceable or vague term and should not be used.

Submitter Information Verification

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City:

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Submittal Date: Mon Jul 03 17:30:32 EDT 2023

Committee: NEC-P06

Public Input No. 2676-NFPA 70-2023 [Section No. 400.46]

400.46 Equipment Grounding Conductors.

Equipment grounding conductors shall be connected in accordance with Article 250, Parts VI and VII ~~of Article 250~~ .

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

Submitter Information Verification

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Submittal Date:	Thu Aug 24 09:29:37 EDT 2023
Committee:	NEC-P06

Public Input No. 1270-NFPA 70-2023 [Section No. 400.47]

400.47 Minimum Bending Radii.

The minimum bending radii for portable power feeder cables ~~from~~ rated 2000 volts to 5000 volts shall not ~~exceed six~~ be less than six times the overall cable outer diameter. The minimum bending radii for portable power feeder cables ~~from 5001 volts~~ rated 5001 volts to 25,000 volts shall not ~~exceed~~ be less than eight times the overall cable outer diameter. The minimum radii values apply to the inner curve edge of the cable.

Statement of Problem and Substantiation for Public Input

The intent here is to provide clarification to the user and follow the NEC Style Manual 2023 version sections 3.2 Word Terms - 3.2.2 Expressing Maximum and Minimum (2nd example listed), and 3.5 Writing Styles - 3.5.3 Plural for the edits recommended. The addition of the last sentence is to clarify for the user where the minimum radius values are applied to the bend in the cable.

Submitter Information Verification

Submitter Full Name: Dennis Nielsen

Organization: Lawrence Berkeley National Lab

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 03 17:49:42 EDT 2023

Committee: NEC-P06

Public Input No. 4543-NFPA 70-2023 [Section No. 400.47]

400.47 ~~Minimum~~ 47 Conductor Bending ~~Radii~~ Radius .

~~The minimum bending radii for portable~~ Portable power feeder cables rated from 2000 volts to 5000 volts shall not ~~exceed~~ be bent to a radius less than six times the overall cable outer diameter. ~~The minimum bending radii for portable cables~~ Portable power feeder cables rated from 5001 volts to 25,000 volts shall not ~~exceed~~ be bent to a radius less than eight times the overall cable outer diameter.

Additional Proposed Changes

File Name	Description	Approved
TIA_1731_70_23_13.pdf	NEC TIA No. 23-13 Log No. 1731	

Statement of Problem and Substantiation for Public Input

NOTE: This public input originates from Tentative Interim Amendment No. 23-13 (Log 1731) issued by the Standards Council on August 25, 2023 and per the NFPA Regs., needs to be reconsidered by the Technical Committee for the next edition of the Document.

Substantiation: The purpose is to clarify and be uniform with other Code language. The original verbiage contradicted the title. (Title was concerning the “minimum” and verbiage was in conjunction with a “maximum” bending radius. The language was not consistent. (using “shall not exceed”). Radii is plural and should have been singular since we are speaking of a particular bend. Language was also corrected to correlate with 305.5.

Emergency Nature: The standard contains an error or an omission that was overlooked during the regular revision process.

This TIA proposed action will clarify a bending radius of the conductor which is vital to the integrity of the conductor.

Submitter Information Verification

Submitter Full Name: CMP ON NEC-P06
Organization: Code-Making Panel 6
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 12 19:07:22 EDT 2023
Committee: NEC-P06

Tentative Interim Amendment

NFPA® 70®

National Electrical Code®

2023 Edition

Reference: 400.47
TIA 23-13
(SC 23-8-57 / TIA Log #1731)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 70®, *National Electrical Code®*, 2023 edition. The TIA was processed by Code-Making Panel 6 and the Correlating Committee on National Electrical Code, and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise section 400.47 to read as follows:

400.47. ~~Minimum~~ Conductor Bending ~~Radii~~ Radius. ~~The minimum bending radii for~~ P~~p~~ortable power feeder cables rated from 2000 volts to 5000 volts shall not ~~exceed~~ be bent to a radius less than six times the overall cable outer diameter. ~~The minimum bending radii for~~ P~~p~~ortable power feeder cables rated from 5001 volts to 25,000 volts shall not ~~exceed~~ be bent to a radius less than eight times the overall cable outer diameter.

Issue Date: August 25, 2023

Effective Date: September 14, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo)

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NATIONAL FIRE PROTECTION ASSOCIATION

Public Input No. 515-NFPA 70-2023 [Section No. 400.47]

400.47 Minimum Bending Radii.

The minimum bending radii for portable power feeder cables from 2000 volts to 5000 volts shall not ~~exceed~~ be less than six times the overall cable outer diameter during or after installation . The minimum bending radii for portable cables from 5001 volts to 25,000 volts shall not ~~exceed~~ be less than eight times the overall cable outer diameter during or after installation .

Statement of Problem and Substantiation for Public Input

The current wording limits the radii to less than the limits prescribed and also does not limit the radii during installation. The requirement should be "not less than" the prescribed radii and should also include the same restrictions during installation.

Submitter Information Verification

Submitter Full Name: Dennis Querry

Organization: Trinity River Authority

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City:

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Submittal Date: Mon Mar 27 15:11:44 EDT 2023

Committee: NEC-P06

Public Input No. 836-NFPA 70-2023 [Article 402]

Article 402 ~~Fixture Wires~~ Luminaire Wires

402.1 Scope.

This article covers general requirements and construction specifications for ~~fixture~~ luminaire wires.

402.2 Other Articles.

~~Fixture~~ Luminaire wires shall comply with this article and also with the applicable provisions of other articles of this *Code*.

Informational Note: See Part VI of Article 410 for application in luminaires.

402.3 Types.

~~Fixture~~ Luminaire wires shall be of a type listed in Table 402.3, and they shall comply with all requirements of that table. The ~~fixture~~ luminaire wires listed in Table 402.3 are all suitable for service at 600 volts, nominal, unless otherwise specified.

Informational Note: Thermoplastic insulation may stiffen at temperatures lower than -10°C (+14°F). Thermoplastic insulation may also be deformed at normal temperatures where subjected to pressure, such as at points of support.

Table 402.~~3 Fixture~~ 3 Luminaire Wires

Name	Type Letter	Insulation	AWG	mm	mils	Outer Covering	Maximum Operating Temperature	Application Provisions
				Thickness of Insulation				
Heat-resistant rubber-covered ~~fixture~~ luminaire wire — flexible stranding	FFH-2	Heat-resistant rubber or cross-linked synthetic polymer	18–16	0.76	30	Nonmetallic covering	75°C (167°F)	~~Fixture~~ Luminaire wiring
	FFHH-2						90°C (194°F)	
ECTFE — solid or 7-strand	HF	Ethylene chloro- trifluoroethylene	18–14	0.38	15	None	150°C (302°F)	~~Fixture~~ Luminaire wiring
ECTFE — flexible stranding	HFF	Ethylene chlorotrifluo- roethylene	18–14	0.38	15	None	150°C (302°F)	~~Fixture~~ Luminaire wiring
Tape insulated ~~fixture~~ luminaire wire — solid or 7-strand	KF-1	Aromatic polyimide tape	18–10	0.14	5.5	None	200°C (392°F)	~~Fixture~~ Luminaire wiring — limited to 300 volts
	KF-2	Aromatic polyimide tape	18–10	0.21	8.4	None	200°C (392°F)	~~Fixture~~ Luminaire wiring
Tape insulated ~~fixture~~ luminaire wire — flexible stranding	KFF-1	Aromatic polyimide tape	18–10	0.14	5.5	None	200°C (392°F)	~~Fixture~~ Luminaire wiring — limited to 300 volts
	KFF-2	Aromatic polyimide tape	18–10	0.21	8.4	None	200°C (392°F)	~~Fixture~~ Luminaire wiring

Name	Type Letter	Insulation	AWG	mm	mils	Outer Covering	Maximum Operating Temperature	Application Provisions
				Thickness of Insulation				
Perfluoro-alkoxy — solid or 7-strand (nickel or nickel-coated copper)	PAF	Perfluoro-alkoxy	18–14	0.51	20	None	250°C (482°F)	~~Fixture~~ Luminaire wiring (nickel or nickel-coated copper)
Perfluoro-alkoxy — flexible stranding	PAFF	Perfluoro-alkoxy	18–14	0.51	20	None	150°C (302°F)	~~Fixture~~ Luminaire wiring
Fluorinated ethylene propylene ~~fixture~~ luminaire wire — solid or 7-strand	PF	Fluorinated ethylene propylene	18–14	0.51	20	None	200°C (392°F)	~~Fixture~~ Luminaire wiring
Fluorinated ethylene propylene ~~fixture~~ luminaire wire — flexible stranding	PFF	Fluorinated ethylene propylene	18–14	0.51	20	None	150°C (302°F)	~~Fixture~~ Luminaire wiring
Fluorinated ethylene propylene ~~fixture~~ luminaire wire — solid or 7-strand	PGF	Fluorinated ethylene propylene	18–14	0.36	14	Glass braid	200°C (392°F)	~~Fixture~~ Luminaire wiring
Fluorinated ethylene propylene ~~fixture~~ luminaire wire — flexible stranding	PGFF	Fluorinated ethylene propylene	18–14	0.36	14	Glass braid	150°C (302°F)	~~Fixture~~ Luminaire wiring
Extruded polytetrafluoroethylene — solid or 7-strand (nickel or nickel-coated copper)	PTF	Extruded polytetrafluo-roethylene	18–14	0.51	20	None	250°C (482°F)	~~Fixture~~ Luminaire wiring (nickel or nickel-coated copper)
Extruded polytetrafluoroethylene — flexible stranding 26-36 (AWG silver or nickel-coated copper)	PTFF	Extruded polytetrafluo-	18–14	0.51	20	None	150°C	~~Fixture~~ Luminaire wiring (silver or

Name	Type Letter	Insulation	AWG	mm	mils	Outer Covering	Maximum Operating Temperature	Application Provisions
							Thickness of Insulation	
		roethylene					(302°F)	nickel-coated copper)
Heat-resistant rubber-covered ~~fixture~~ luminaire wire — solid or 7-strand	RFH-1	Heat-resistant rubber	18	0.38	15	Nonmetallic covering	75°C (167°F)	~~Fixture~~ Luminaire wiring — limited to 300 volts
	RFH-2	Heat-resistant rubber Cross-linked synthetic polymer	18–16	0.76	30	None or non-metallic covering	75°C (167°F)	~~Fixture~~ Luminaire wiring
Heat-resistant cross-linked synthetic polymer-insulated ~~fixture~~ luminaire wire — solid or 7-strand	RFHH-2* RFHH-3*	Cross-linked synthetic polymer	18–16 18–16	0.76 1.14	30 45	None or non-metallic covering	90°C (194°F)	~~Fixture~~ Luminaire wiring
Silicone insulated ~~fixture~~ luminaire wire — solid or 7-strand	SF-1	Silicone rubber	18	0.38	15	Nonmetallic covering	200°C (392°F)	~~Fixture~~ Luminaire wiring — limited to 300 volts
	SF-2	Silicone rubber	18–12 10	0.76 1.14	30 45	Nonmetallic covering	200°C (392°F)	~~Fixture~~ Luminaire wiring
Silicone insulated ~~fixture~~ luminaire wire — flexible stranding	SFF-1	Silicone rubber	18	0.38	15	Nonmetallic covering	150°C (302°F)	~~Fixture~~ Luminaire wiring — limited to 300 volts
	SFF-2	Silicone rubber	18–12 10	0.76 1.14	30 45	Nonmetallic covering	150°C (302°F)	~~Fixture~~ Luminaire wiring
Thermoplastic covered ~~fixture~~ luminaire wire — solid or 7-strand	TF*	Thermoplastic	18–16	0.76	30	None	60°C (140°F)	~~Fixture~~ Luminaire wiring

Name	Type Letter	Insulation	AWG	mm	mils	Outer Covering	Maximum Operating Temperature	Application Provisions
				Thickness of Insulation				
Thermoplastic covered ~~fixture~~ luminaire wire — flexible stranding	TFF*	Thermoplastic	18–16	0.76	30	None	60°C (140°F)	~~Fixture~~ Luminaire wiring
Heat-resistant thermoplastic covered ~~fixture~~ luminaire wire — solid or 7-strand	TFN*	Thermoplastic	18–16	0.38	15	Nylon-jacket-ed or equivalent	90°C (194°F)	~~Fixture~~ Luminaire wiring
Heat-resistant thermoplastic covered ~~fixture~~ luminaire wire — flexible stranded	TFFN*	Thermoplastic	18–16	0.38	15	Nylon-jacket-ed or equivalent	90°C (194°F)	~~Fixture~~ Luminaire wiring
Cross-linked polyolefin insulated ~~fixture~~ luminaire wire — solid or 7-strand	XF*	Cross-linked polyolefin	18–14 12-10	0.76 1.14	30 45	None	150°C (302°F)	~~Fixture~~ Luminaire wiring — limited to 300 volts
Cross-linked polyolefin insulated ~~fixture~~ luminaire wire — flexible stranded	XFF*	Cross-linked polyolefin	18–14 12–10	0.76 1.14	30 45	None	150°C (302°F)	~~Fixture~~ Luminaire wiring — limited to 300 volts
Modified ETFE — solid or 7-strand	ZF	Modified ethylene tetrafluoro-ethylene	18–14	0.38	15	None	150°C (302°F)	~~Fixture~~ Luminaire wiring
Modified ETFE — flexible stranding	ZFF	Modified ethylene tetrafluoro-ethylene	18–14	0.38	15	None	150°C (302°F)	~~Fixture~~ Luminaire wiring
High temp. modified ETFE— solid or 7-strand	ZHF	Modified ethylene	18–14	0.38	15	None	200°C	~~Fixture~~ Luminaire wiring

Name	Type Letter	Insulation	AWG	mm	mils	Outer Covering	Thickness of Insulation Maximum Operating Temperature	Application Provisions
		tetrafluoro-ethylene					(392°F)	

*Insulations and outer coverings that meet the requirements of flame retardant, limited smoke, and are so listed, shall be permitted to be marked for limited smoke after the *Code* type designation.

402.5 Ampacities for ~~Fixture~~ Luminaire Wires.

The ampacity of ~~fixture~~ luminaire wire shall be as specified in Table 402.5.

No conductor shall be used under such conditions that its operating temperature exceeds the temperature specified in Table 402.3 for the type of insulation involved.

Informational Note: See 310.14(A)(3) for temperature limitation of conductors.

Table 402.5 Ampacity for ~~Fixture~~ Luminaire Wires

Size (AWG)	Ampacity
18	6
16	8
14	17
12	23
10	28

402.6 Minimum Size.

~~Fixture~~ Luminaire wires shall not be smaller than 18 AWG.

402.7 Number of Conductors in Conduit or Tubing.

The number of ~~fixture~~ luminaire wires permitted in a single conduit or tubing shall not exceed the percentage fill specified in Table 1, Chapter 9.

402.8 Grounded Conductor Identification.

~~Fixture~~ Luminaire wires that are intended to be used as grounded conductors shall be identified by one or more continuous white stripes on other than green insulation or by the means described in 400.22(A) through (E).

402.9 Marking.

(A) Method of Marking.

Thermoplastic insulated ~~fixture~~ luminaire wire shall be durably marked on the surface at intervals not exceeding 610 mm (24 in.). All other ~~fixture~~ luminaire wire shall be marked by means of a printed tag attached to the coil, reel, or carton.

(B) Optional Marking.

~~Fixture~~ Luminaire wire types listed in Table 402.3 shall be permitted to be surface marked to indicate special characteristics of the cable materials. These markings include, but are not limited to, markings for limited smoke, sunlight resistance, and so forth.

402.10 Uses Permitted.

Fixture wires shall be permitted (1) for installation in luminaires and in similar equipment where enclosed or protected and not subject to bending or twisting in use, or (2) for connecting luminaires to the branch-circuit conductors supplying the luminaires.

402.12 Uses Not Permitted.

~~Fixture~~ Luminaire wires shall not be used as branch-circuit conductors except as permitted elsewhere in this *Code*.

402.14 Overcurrent Protection.

Overcurrent protection for ~~fixture~~ Luminaire wires shall be as specified in 240.5.

Statement of Problem and Substantiation for Public Input

In Article 410 and throughout the NEC, the word "Luminaire" has replaced the word "Fixture" except in Article 402 Fixture Wires and Section 240.5(See Public Input No.837-NFPA 70-2023). I propose that a change of the wording "Fixture Wires" be done and switched to "Luminaire Wires" to keep continuity between the other articles.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 837-NFPA 70-2023 [Section No. 240.5]	Section Related to Topic of Revision

Submitter Information Verification

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Submittal Date: Tue May 16 21:20:28 EDT 2023

Committee: NEC-P06

Public Input No. 2677-NFPA 70-2023 [Section No. 402.2]

402.2 Other Articles.

Fixture wires shall comply with this article and also with the applicable provisions of other articles of this *Code*.

Informational Note: See ~~Part VI of~~ Article 410 ~~for~~ , Part VI for application in luminaires.

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. The text is revised to to comply with the NEC Style Manual Section 4.1.4, regarding the use of Parts.
4.1.4 References to an Entire Article. References shall not be made to an entire article, except for the Article 100 or where referenced to provide the necessary context. References to specific parts within articles shall be permitted. References to all parts of an article shall not be permitted. The article number shall precede the part number.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

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Public Input No. 1431-NFPA 70-2023 [Section No. 402.5]

402.5 Ampacities for Fixture Wires.

The ampacity of fixture wire shall be as specified in Table 402.5.

No conductor shall be used under such conditions that its operating temperature exceeds the temperature specified in Table 402.3 for the type of insulation involved.

Informational Note: See 310.14(A)(3) for temperature limitation of conductors.

~~Table 402.5 Ampacity for Fixture Wires~~

~~Size (AWG) Ampacity 18 6 16 8 14 17 12 23 10 28~~

Additional Proposed Changes

File Name	Description	Approved
Table_402.5_Ampacity_for_Fixture_Wires.png	Proposed Table 402.5 Ampacity for Fixture Wires	
PGFinal.SW-2023-001_-_Electrical_Characteristic_Comparison_between_Copper_and_CCA_Thermostat_Wire_002_.pdf	Electrical Characteristics of 16 AWG CCA Compared to 18 AWG Copper	

Statement of Problem and Substantiation for Public Input

The proposed ampacity table recognizes copper-clad aluminum. Please reference substantiation in PI 1008 and 1018 for technical information of sizes of CCA.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1008-NFPA 70-2023 [Section No. 310.3(A)]	
Public Input No. 1018-NFPA 70-2023 [Section No. 330.104]	

Submitter Information Verification

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Affiliation: American Bimetallics Association

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Submittal Date: Sun Jul 16 08:45:11 EDT 2023

Committee: NEC-P06

Table 402.5 Ampacity for Fixture Wires

Size (AWG)	Ampacity
18 copper or 16 CCA	6
16 copper	8
14 CCA	10
14 copper or 12 CCA	17
12 copper or 10 CCA	23
10 copper	28

Electrical Test Laboratory Report SW-2023-002

Market:	Class 4 Conductors		
Subject:	Electrical Characteristic Comparison between 16 AWG CCA vs 18 AWG Cu		
Date:	8/29/23	Report No:	002

Analysis By:	Brandon Allen – Product Engineer
Authored By:	Brandon Allen– Product Engineer
Approved By:	Tom Sterling – Product Development Manager

Objective:

To perform electrical analysis to show the characteristic comparison of 16 AWG Copper Clad Aluminum (CCA) to 18 AWG Copper (Cu).

Samples/Equipment Provided:

Materials

- Test Samples: 16 AWG Copper Clad Aluminum (CCA)
- Test Samples: 18 AWG Copper (Cu)

Wire Tested:

- *500 ft. of 18 AWG Solid Copper, annealed*
- *500 ft. of 16 AWG solid CCA 10%, annealed*
- *Minimum of 6 mils of PVC insulation on both Cu and CCA wire*

Physical Attributes	Diameter (in)	Cross-Sectional Area (in^2)	Weight (lb/kft)	Copper Thickness (in)	DC Resistance (Ω/kft)
18 AWG Cu	0.0403	0.001276	4.917	0.04030	6.610
16 AWG CCA 10%	0.0508	0.002027	2.919	0.00127	6.524

Test Equipment / Calibration Requirements

- Data Acquisition System
- Thermocouple
- Power Source (24 VAC at 40VA)

Test Procedure 1: Temperature Readings with Incremental Current

1. Set the configuration for the AC power/current source to begin the test.
2. Using the 16 AWG Copper Clad Aluminum (CCA) samples, prepare the test samples by connecting the thermocouples to the test samples for the temperature readings.
3. With the thermocouples attached to the test samples, connect the opposite end of the thermocouple wire to the Data acquisition system.
4. Set the current source to the initial current of 3A then increment by 3A in 10-minute intervals for the duration of the test. Step up current to a final level of 24 amperes.
5. All testing conducted in open-air.
6. At the completion of the test, store the data and repeat each step for 18 AWG Copper (Cu).

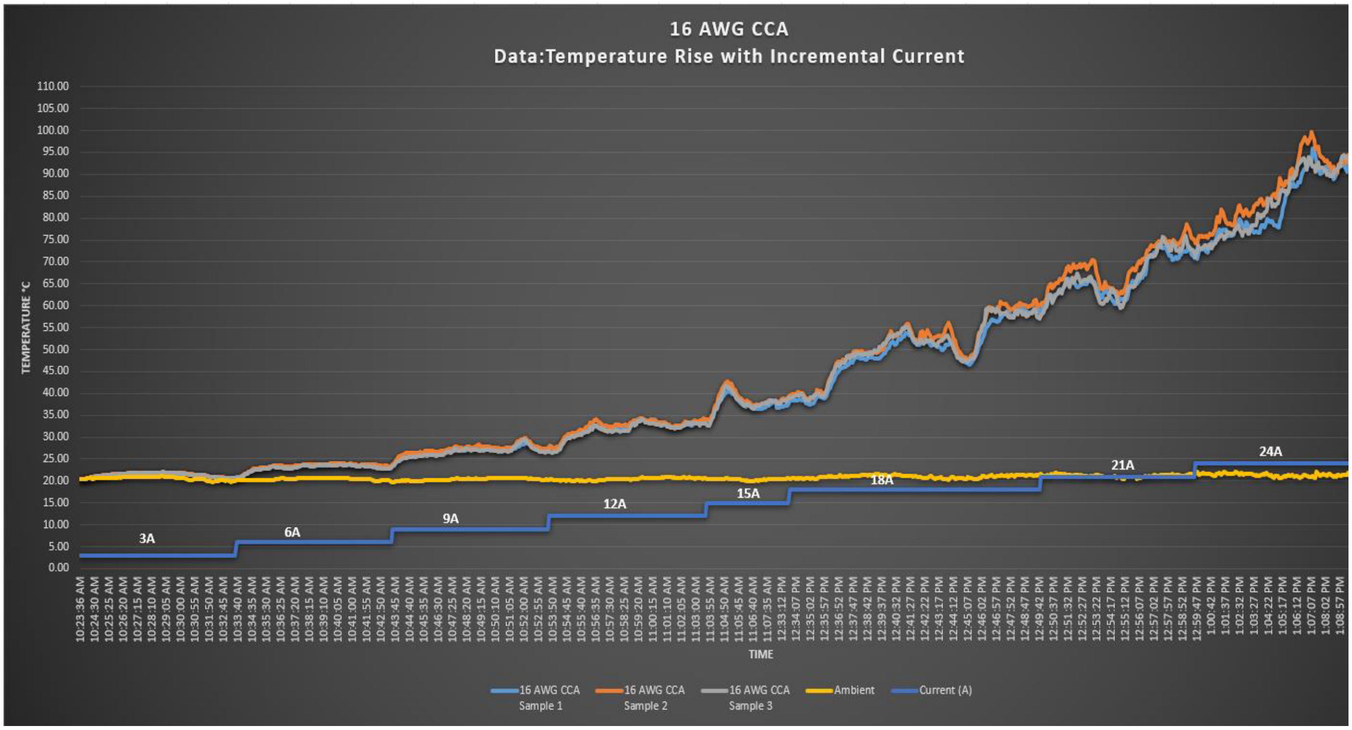
Test Results 1: Temperature Readings with Incremental Current

During testing, the data revealed that the increase in current was proportional to the increase in temperature. In comparison, the three samples of 16 AWG CCA ran slightly cooler than the three samples of 18 AWG Cu. Below Table 1 presents values stepped up from 3 amperes to 12 amperes. 16 AWG CCA for Class 4 circuits should never see 12 amperes of AC current in the real world.

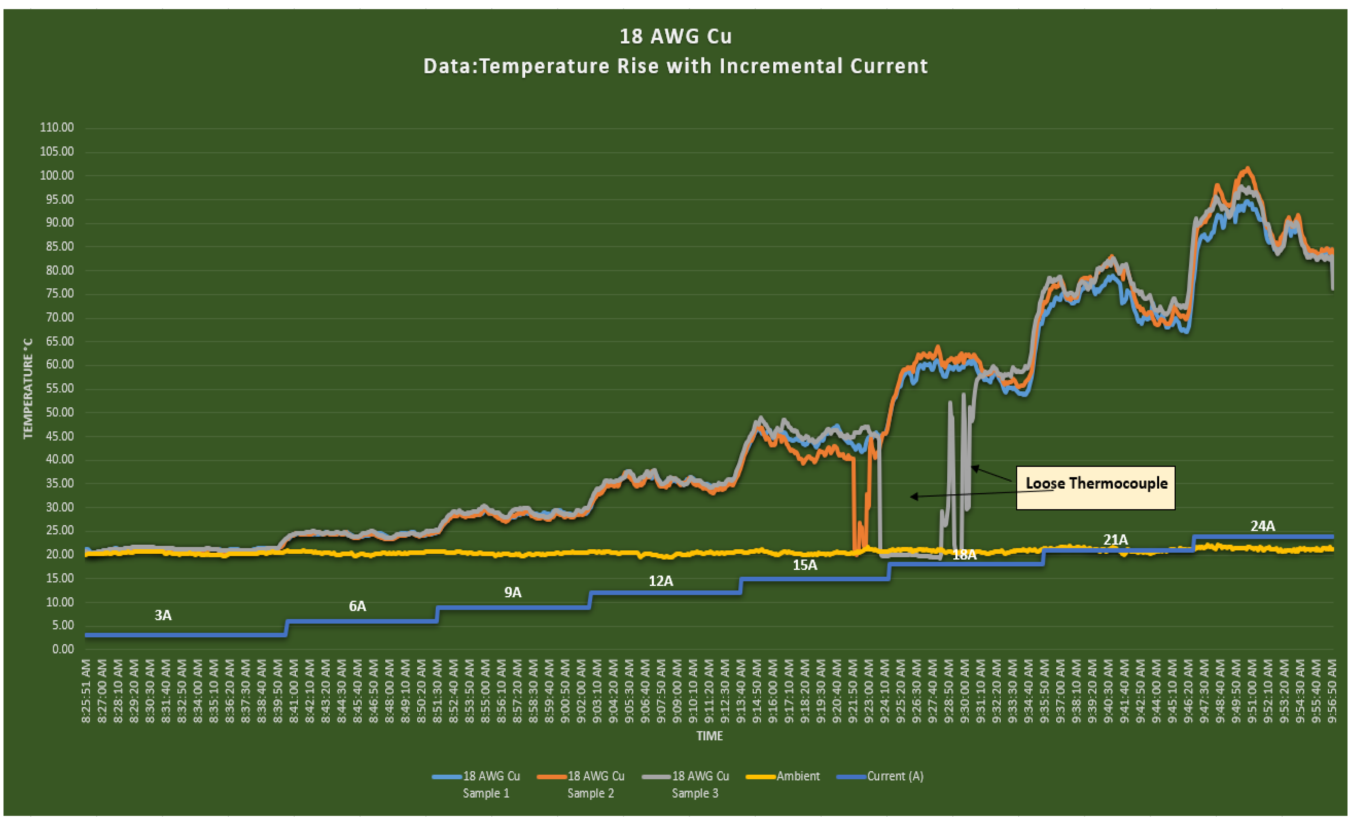
See Table 1 and graphs 1 & 2 below for more details:

TABLE 1:

16 AWG CCA				18 AWG Copper			
Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise	Amperes	Maximum Temp (C°)	AVG Ambient	Heat Rise
3	**21.96**	**20.58**	**1.38**	**3**	**23.38**	**20.38**	**3.00**
6	**24.13**	**20.43**	**3.70**	**6**	**25.3**	**20.43**	**4.87**
9	**29.79**	**20.38**	**9.41**	**9**	**30.46**	**20.34**	**10.12**
12	**34.28**	**20.44**	**13.84**	**12**	**39.75**	**20.33**	**19.42**



Graph 1: 16 AWG CCA



Graph 2: 18 AWG Cu

Test Results 2: Electrical Characteristic Measurements

The Voltage drop was calculated using the voltage drop calculator formula at 3 Amps.

VOLTAGE DROP CALCULATOR FORMULA

$$VD = (2 \cdot A \cdot L \cdot R) / 1000$$

Where:

VD = Voltage Drop (Volts) per unit circuit length

A = Full Load Current (Amps)

L = One-Way Circuit Length (ft)

R = Resistance (Ohms/Kft)

		Run Length (ft)			
Voltage Drop (Vac)	VAC++	50	100	150	200
18 AWG Cu	24.00	1.98	3.96	5.95	7.93
16 AWG CCA 10%	24.00	1.95	3.91	5.87	7.82

** With a supply voltage of 24 Vac, what is the Drop Voltage across the hot and common legs of circuit, at specified Lengths of wire?*

** Set Load Resistance to drawn 3.0 Amps*

Conclusion:

When comparing 16 AWG Copper Clad Aluminum to 18 AWG Copper, the electrical measurements of the 16 AWG Copper Clad Aluminum conductor measured at a slightly lower resistance than the 18 AWG Copper. The analysis of the thermal test also showed that when the same current is applied to both conductors for the same duration, 16 AWG Copper Clad Aluminum measured at slightly lower temperatures than 18 AWG Copper. Lower conductor temperatures generally support the notion that the connected equipment will last longer and run more efficiently. The lower Voltage Drop of 16 AWG CCA as compared to that of 18 AWG copper will also likely improve equipment performance. The heating profiles of both the 16 AWG CCA and 18 AWG copper are not expected to pose problems for class 4 circuits.

Public Input No. 1500-NFPA 70-2023 [Section No. 402.8]

402.8 Grounded Conductor Identification.

Fixture wires that are intended to be used as grounded conductors shall be identified by one or more continuous white stripes on other than green insulation or by the means described in 400.22(A) through (~~E~~ F).

Statement of Problem and Substantiation for Public Input

This may be a typo to remedy.

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Committee:	NEC-P06

Public Input No. 618-NFPA 70-2023 [New Section after 402.14]

402.15 Reconditioned Equipment

Fixture wires shall not be reconditioned.

Statement of Problem and Substantiation for Public Input

Fixture Wires, Cablebus, Cables, Raceways, Conduits, Tubings, Flexible Cords, Flexible Cables, Cable Trays, MV Cables, Wireways, etc. etc. are not permitted to be reconditioned per the NEMA Technical Position on Reconditioned Equipment (NEMA CS 100-2020, Appendix B.1)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 624-NFPA 70-2023 [New Section after 388.1]	

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Committee:	NEC-P06

Public Input No. 647-NFPA 70-2023 [Definition: Example D7 Sizing of Service Conductors for Dwe...]

Example D7 Sizing of Service Conductors for Dwelling(s)

Service conductors and feeders for certain dwellings are permitted to be sized in accordance with 310.12.

With No Required Adjustment or Correction Factors. If a 175-ampere service rating is selected, a service conductor is then sized as follows:

175 amperes × 0.83 = 145.25 amperes per 310.12.

If no other adjustments or corrections are required for the installation, then, in accordance with Table 310.16, a 1/0 AWG Cu or a 3/0 AWG Al meets this rating at 75°C (167°F).

With Required Temperature Correction Factor.

If a 175-ampere service rating is selected, a service conductor is then

175 amperes × 0.83 = 145.25 amperes per 310.12.

If the conductors are installed in an ambient temperature of 38°C (100°F), the conductor ampacity must be multiplied by the appropriate correction factor in Table 310.15(B)(1)(1). In this case, we will use an XHHW-2 conductor, so we use a correction factor of 0.91 to find the minimum conductor ampacity and size:

145.25/.91 = 159.6 amperes

In accordance with Table 310.16, a ~~2~~ 1 /0 AWG Cu or a ~~4~~ 3 /0 AWG Al would be required.

If no temperature correction or ampacity adjustment factors are required, the following table includes conductor sizes calculated using the requirements in 310.12. This table is based on 75°C terminations and without any adjustment or correction factors.

Service or Feeder Rating (Amperes)	Conductor (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600

Statement of Problem and Substantiation for Public Input

NEC 310.12 permits the ampacity and ambient temperature adjustment factors to be applied to the ampacity associated with the temperature rating of the conductor. In the example, XHHW-2 at 90 degrees yields 170 amps for 1/0 copper and 175 amps for 3/0 aluminum. The .91 factor results in adjustments of 154.7 and 159.25 respectively. Each of those permitted ampacities are greater than the 145.25 amps required in the example. Since the actual load before adjustments is 145.2 amps, the 75 degree ampacities of 150 and 155 are appropriate. If the adjustments were required to be made to the 75 degree ampacities the existing example would be correct but 310.12 does not specify that. The correct conductors should be 1/0 copper and 3/0 aluminum. Perhaps a second example with a 46-50 ambient condition requiring a .82 adjustment factor would be more illuminating.

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Public Input No. 451-NFPA 70-2023 [Definition: With Required Temperature Correction Factor.]

With Required Temperature Correction Factor.

If a 175-ampere service rating is selected, a service conductor is then

175 amperes × 0.83 = 145.25 amperes per 310.12.

If the conductors are installed in an ambient temperature of ~~38°C~~ 49°C (~~100°F~~ 120°F), the conductor ampacity must be multiplied by the appropriate correction factor in Table 310.15(B)(1)(1). In this case, we will use an XHHW-2 conductor, so we use a correction factor of 0.~~91 to~~ 82 to find the minimum conductor ampacity and size:

145.25/0 .~~91~~ 82 = ~~159~~ 177 .~~6 amperes~~ 1 amperes

In accordance with the 90°C column of Table 310.16, a 2/0 AWG Cu or a 4/0 AWG Al would be required.

If no temperature correction or ampacity adjustment factors are required, the following table includes conductor sizes calculated using the requirements in 310.12. This table is based on 75°C terminations and without any adjustment or correction factors.

Service or Feeder Rating (Amperes)	Conductor (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600

Statement of Problem and Substantiation for Public Input

The current example errs in applying the temperature correction factor to the 75C (termination temperature) ampacity column of Table 310.16, rather than the 90C (insulation temperature for XHHW-2). 110.14(C), 310.15(A), and Annex D Example D3(a) section "Ungrounded Feeder Conductors" all indicate that when applying temperature correction factors to determine ampacity, the insulation temperature rating may be used as the starting point for the ampacity calculation.

Therefore in keeping with the idea that the example is intended to show the need to upsize the conductors from the previous case, I have increased the ambient temperature to the minimum necessary to get that result. If the 49C / 120F temperature necessary is deemed unrealistic, I would suggest instead changing the conductor insulation type to one with only a 75C rating. Then the current example temperature of 38C / 100F gives a temperature correction factor of 0.88, and the resulting wire size is still the same.

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Committee:	NEC-P06

Public Input No. 79-NFPA 70-2023 [Definition: With Required Temperature Correction Factor.]

With Required Temperature Correction Factor.

If a 175-ampere service rating is selected, a service conductor is then

175 amperes × 0.83 = 145.25 amperes per 310.12.

If the conductors are installed in an ambient temperature of 38°C (100°F), the conductor ampacity must be multiplied by the appropriate correction factor in Table 310.15(B)(1)(1). In this case, we will use an XHHW-2 conductor, ~~so we use a~~ the ampacity value from the 90°C column of Table 310.16, and the correction factor of 0.91 to find the ~~minimum conductor~~ conductors corrected ampacity and size:

~~145~~ 170 x .~~25/.~~ 91 = ~~159~~ 154 .~~6 amperes~~ 7 amperes

In accordance with Table 310.16, a ~~2~~ 1 /0 AWG Cu or a 4 3 /0 AWG Al would be required.

If no temperature correction or ampacity adjustment factors are required, the following table includes conductor sizes calculated using the requirements in 310.12. This table is based on 75°C terminations and without any adjustment or correction factors.

Service or Feeder Rating (Amperes)	Conductor (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600

Statement of Problem and Substantiation for Public Input

Greetings CMP 6 Members -

When I submitted the language in the 2017 NEC cycle to make sure folks are aware that when conditions of use, such as adjustments and corrections, are to take place, the table 310.12 could not be utilized. When that was added, CMP 6 proceeded to create an example in the Informative Annex D7 to illustrate this situation. Sadly, the result was an inforrect calculation.

1) The language in the "example" directs the user of the code to use "multiplcation" and proceeds to give an example of using division. Now, the division works great when we are starting with an actual ampere value and divide it by the modifiers in 310.15(B)(1)(1) or 310.15(C)(1). However, that doesn't work for the example in D7 since we establish the 145.25 Amps in the existing example is the 83% that the conductors ampacity must not be less than under 310.12.

The actual process is slightly different and does actually use "multiplaction" as described in the language of the example. The size of the conductors sized at 75°C based on the table 310.12 is without any adjustments or corrections. As we do when sizing conductors normally in the NEC we are able to utilize the 90°C insulation ratings of the conductor no differently than they did in the example to get the .91 modifier from Table 310.15(B)(1)(1). So, we are able to use the 170 Amps from the 90°C column of Table 310.16, which is still a 1/0 CU, and now use the multiplication of 170 Amps x .91 = 154.7 Amps.

Now, the 154.7 Amps is adequate for the 145.25 Amps which maintains the 83% conductor sizing. There is no need to increase to a 2/0 in this example. Now, if that is or was the goal of the example then I suggest you increase the ambient temperature to 40°C and use the .82 in your example.

It would read as 170 Amps x .82 = 139.4 Amps and would result in needing to go up to the next size, which would be 2/0 CU or 4/0 AL and fix your example as that would be 195 Amps x .82 = 159.9 Amps and this can handle the 145.25 Amps at 83% as well.

Remember, 310.12 permits the use of conductors sized at least 83% of the service or feeders rating. There is no reason why I could not use 1/0 CU in this example rather than the 2/0 CU. Again, 1/0 CU is rated 170 Amps at the 90°C, which I am permitted in 310.15(A).

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Committee:	NEC-P06

Public Input No. 1359-NFPA 70-2023 [Annex E]

Informative Annex E Types of Construction

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

Table E.1 Fire Resistance Ratings for Type I Through Type V Construction (hr)

	Type I		Type II			Type III		Type IV	Type V	
	442	332	222	111	000	211	200	2HH	111	000
Exterior Bearing Walls [a]										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0 [b]	2	2	2	1	0 [b]
Supporting one floor only	4	3	2	1	0 [b]	2	2	2	1	0 [b]
Supporting a roof only	4	3	1	1	0 [b]	2	2	2	1	0 [b]
Interior Bearing Walls										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	2	1	0
Supporting one floor only	3	2	2	1	0	1	0	1	1	0
Supporting roofs only	3	2	1	1	0	1	0	1	1	0
Columns										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H	1	0
Supporting one floor only	3	2	2	1	0	1	0	H	1	0
Supporting roofs only	3	2	1	1	0	1	0	H	1	0
Beams, Girders, Trusses, and Arches										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H	1	0
Supporting one floor only	2	2	2	1	0	1	0	H	1	0
Supporting roofs only	2	2	1	1	0	1	0	H	1	0
Floor/Ceiling Assemblies	2	2	2	1	0	1	0	H	1	0
Roof/Ceiling Assemblies	2	1 1/2	1	1	0	1	0	H	1	0
Interior Nonbearing Walls	0	0	0	0	0	0	0	0	0	0
Exterior Nonbearing Walls [c]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]

Source: Table 7.2.1.1 from *NFPA 5000, Building Construction and Safety Code*, 2021 edition.

H: Heavy timber members.

[a] See 7.3.2.1 in *NFPA 5000*.

[b] See Section 7.3 in *NFPA 5000*.

[c] See 7.2.3.2.12, 7.2.4.2.3, and 7.2.5.6.8 in *NFPA 5000*.

Table E.1 contains the fire resistance rating, in hours, for Types I through V construction. The five different types of construction can be summarized briefly as follows (see also Table E.2):

~~Type I is a fire-resistive construction type. All structural elements and most interior elements are required to be noncombustible. Interior, nonbearing partitions are permitted to be 1- or 2-hour rated. For nearly all occupancy types, Type I construction can be of unlimited height.~~

~~Type II construction has three categories: fire-resistive, one-hour rated, and nonrated. The number of stories permitted for multifamily dwellings varies from two for nonrated and four for one-hour rated to 12 for fire-resistive construction.~~

~~Type III construction has two categories: one-hour rated and nonrated. Both categories require the structural framework and exterior walls to be of noncombustible material. One-hour rated construction requires all interior partitions to be one-hour rated. Nonrated construction allows nonbearing interior partitions to be of nonrated construction. The maximum permitted number of stories for multifamily dwellings and other structures is two for nonrated and four for one-hour rated.~~

~~Type IV construction includes traditional heavy timber construction and mass timber construction. In heavy timber construction, the structural framework and the exterior walls are required to be noncombustible except that wood members of certain minimum sizes are allowed. In mass timber construction, structural elements of cross-laminated timber (CLT) are permitted. Allowable building height for mass timber is much higher than for heavy timber.~~

~~Type V construction has two categories: one-hour rated and nonrated. One-hour rated construction requires a minimum of one-hour rated construction throughout the building. Nonrated construction allows nonrated interior partitions with certain restrictions. The maximum permitted number of stories for multifamily dwellings and other structures is two for nonrated and three for one-hour rated~~

Types I and II construction: Type I (442 or 332) and Type II (222, 111, or 000) construction shall be those types in which the fire walls, structural elements, walls, arches, floors, and roofs are of approved noncombustible or limited-combustible materials.

Type III Construction. Type III (211 or 200) construction shall be that type in which exterior walls and structural elements that are portions of exterior walls are of approved noncombustible or limited-combustible materials, and in which fire walls, interior structural elements, walls, arches, floors, and roofs are entirely or partially of wood of smaller dimensions than required for Type IV construction or are of approved noncombustible, limited-combustible, or other approved combustible materials.

Type IV construction. Type IV (2HH) construction shall be that type in which fire walls, exterior walls, and interior bearing walls and structural elements that are portions of such walls are of approved noncombustible or limited-combustible materials, except as allowed for exterior walls in 7.2.5.6.7 . Other interior structural elements, arches, floors, and roofs shall be of solid or laminated wood or cross-laminated timber without concealed spaces or with concealed spaces conforming to 7.2.5.6.7 and shall comply with the allowable dimensions of 7.2.5.5 .

Type V(111 or 000) Construction. Type V(111 or 000) construction shall be that type in which structural elements, walls, arches, floors, and roofs are entirely or partially of wood or other approved material .

Table E.2 Maximum Number of Stories for Types V, IV, and III Construction

Construction Type	**Maximum Number of Stories Permitted**
V Nonrated	2
V Nonrated, Sprinklered	3
V One-Hour Rated	3
V One-Hour Rated, Sprinklered	4
IV Heavy Timber	4
IV Heavy Timber, Sprinklered	5
IV Mass Timber	12
III Nonrated	2
III Nonrated, Sprinklered	3
III One-Hour Rated	4
III One-Hour Rated, Sprinklered	5

In Table E.1 the system of designating types of construction also includes a specific breakdown of the types of construction through the use of arabic numbers. These arabic numbers follow the roman numeral notation where identifying a type of construction [for example, Type I(442), Type II(111), Type III(200)] and indicate the fire resistance rating requirements for certain structural elements as follows:

(1) First arabic number — exterior bearing walls

(2) Second arabic number — columns, beams, girders, trusses and arches, supporting bearing walls, columns, or loads from more than one floor

(3) Third arabic number — floor construction

Table E.3 provides a comparison of the types of construction for various model building codes. [***5000*** : A.7.2.1.1]

Table E.3 Cross-Reference of Building Construction Types

NFPA 5000	**I (442)**	**I (332)**	**II (222)**	**II (111)**	**II (000)**	**III (211)**	**III (200)**	**IV (2HH)**	**V (111)**	**V (000)**
UBC	—	I FR	II FR	II 1 hr	II N	III 1 hr	III N	IV HT	V 1 hr	V N
B/NBC	1A	1B	2A	2B	2C	3A	3B	4	5A	5B
SBC	I	II	—	IV 1 hr	IV UNP	V 1 hr	V UNP	III	VI 1 hr	VI UNP
IBC	—	IA	IB	IIA	IIB	IIIA	IIIB	IV*	VA	VB

*Mass timber in the IBC is Type IV A, IV B, and IV C

Source: Table A.7.2.1.1 from *NFPA 5000, Building Construction and Safety Code* , 2021 edition.

UBC: *Uniform Building Code* .

FR: Fire rated.

N: Nonsprinklered.

HT: Heavy timber.

B/NBC: *National Building Code* .

SBC: *Standard Building Code* .

UNP: Unprotected.

IBC: *International Building Code* .

Statement of Problem and Substantiation for Public Input

This annex is not consistent with NFPA 5000. I did not provide all the language in NFPA 5000 but just showed what Types I through V construction is in NFPA 5000.

Also, the term "rated" is no longer the correct terminology; it should be fire resistance rated (and that is how it is in NFPA 5000 and the IBC).

I wonder whether references to old obsolete codes (UBC, NBC, SBC) is still needed.

With regard to limited combustible and noncombustible, NFPA 5000 (and NFPA 101) provides clarity on how to determine that.

I urge the CMP panel to set up a task group to update this annex because the information is incorrect as is.

NFPA 5000 states:
7.1.4.1 * Noncombustible Material.
7.1.4.1.1
A material that complies with any one of the following shall be considered a noncombustible material:

(1)*
The material, in the form in which it is used, and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

(2)
The material is reported as passing ASTM E136, Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C.

(3)
The material is reported as complying with the pass/fail criteria of ASTM E136 when tested in accordance with the test method and procedure in ASTM E2652, Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C.

7.1.4.1.2
Where the term limited-combustible is used in this Code, it shall also include the term noncombustible.

7.1.4.2
7.1.4.2 * Limited-Combustible Material.
A material shall be considered a limited-combustible material where one of the following is met:

(1)
The conditions of 7.1.4.2.1 and 7.1.4.2.2, and the conditions of either 7.1.4.2.3 or 7.1.4.2.4, shall be met.

(2)
The conditions of 7.1.4.2.5 shall be met.

7.1.4.2.1
The material does not comply with the requirements for a noncombustible material in accordance with 7.1.4.1.

7.1.4.2.2
The material, in the form in which it is used, exhibits a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg) when tested in accordance with NFPA 259.

7.1.4.2.3
The material shall have a structural base of noncombustible material with a surfacing not exceeding a thickness of 1⁄8 in. (3.2 mm) where the surfacing exhibits a flame spread index not greater than 50 when tested in accordance with ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials, or UL 723, Test for Surface Burning Characteristics of Building Materials.

7.1.4.2.4
The material shall be composed of materials that in the form and thickness used neither exhibit a flame spread index greater than 25 nor exhibit evidence of continued progressive combustion when tested in accordance with ASTM E84 or UL 723 and are of such composition that all surfaces that would be exposed by cutting through the material on any plane would neither exhibit a flame spread index greater than 25 nor exhibit evidence of continued progressive combustion when tested in accordance with ASTM E84 or UL 723.

7.1.4.2.5
Materials shall be considered limited-combustible materials where tested in accordance with ASTM E2965, Standard Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter, at an incident heat flux of 75 kW/m2 for a 20-minute exposure, and both the following conditions are met:

(1)
The peak heat release rate shall not exceed 150 kW/m2 for longer than 10 seconds.

(2)
The total heat released shall not exceed 8 MJ/m2.

7.1.4.2.6
Where the term limited-combustible is used in this Code, it shall also include the term noncombustible.

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Public Input No. 106-NFPA 70-2023 [Sections Part III., 320.100, 320.104, 320.108, 320.120]

~~**Sections Part III., 320.100, 320.104, 320.108, 320.120**~~

~~**Part III.** Construction Specifications~~

~~**320.100** Construction.~~

~~Type AC cable shall have an armor of flexible metal tape and shall have an internal bonding strip of copper or aluminum in intimate contact with the armor for its entire length.~~

~~**320.104** Conductors.~~

~~Insulated conductors shall be of a type listed in Table 310.4(1) or those identified for use in this cable. In addition, the conductors shall have an overall moisture-resistant and fire-retardant fibrous covering. For Type ACT, a moisture-resistant fibrous covering shall be required only on the individual conductors.~~

~~**320.108** Equipment Grounding Conductor.~~

~~Type AC cable shall provide an adequate path for fault current as required by 250.4(A)(5) or (B)(4) to act as an equipment grounding conductor.~~

~~**320.120** Marking.~~

~~The cable shall be marked in accordance with 310.8 , except that Type AC shall have ready identification of the manufacturer by distinctive external markings on the cable armor throughout its entire length.~~

Statement of Problem and Substantiation for Public Input

Part III can be deleted in its entirety since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 105-NFPA 70-2023 [Sections Part III., 334.100, 334.104, 334.108, 334.112, 334...]	removal of construction criteria for listed wiring methods
Public Input No. 107-NFPA 70-2023 [Sections Part III., 338.100, 338.120]	
Public Input No. 108-NFPA 70-2023 [Sections Part III., 322.100, 322.104, 322.112, 322.120]	
Public Input No. 109-NFPA 70-2023 [Sections Part III., 324.100, 324.101, 324.112, 324.120]	
Public Input No. 110-NFPA 70-2023 [Sections Part III., 330.104, 330.108, 330.112, 330.116, 330...]	
Public Input No. 111-NFPA 70-2023 [Sections Part III., 332.104, 332.108, 332.112, 332.116]	
Public Input No. 112-NFPA 70-2023 [Sections Part III., 336.100, 336.104, 336.116, 336.120, 336...]	
Public Input No. 113-NFPA 70-2023 [Sections Part III., 337.104, 337.108, 337.112, 337.114, 337...]	
Public Input No. 114-NFPA 70-2023 [Sections Part III., 340.104, 340.108, 340.112, 340.116]	
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Public Input No. 116-NFPA 70-2023 [Sections Part III., 344.100, 344.120]	
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Public Input No. 120-NFPA 70-2023 [Sections Part III., 354.100, 354.120]

Public Input No. 121-NFPA 70-2023 [Sections Part III., 355.100, 355.120]

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Public Input No. 123-NFPA 70-2023 [Sections Part III., 358.100, 358.120]

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~~**Sections Part III., 322.100, 322.104, 322.112, 322.120**~~

~~**Part III.** Construction Specifications~~

~~**322.100** Construction.~~

~~Flat cable assemblies shall consist of two, three, four, or five conductors.~~

~~**322.104** Conductors.~~

~~Flat cable assemblies shall have conductors of 10 AWG special stranded copper wires.~~

~~**322.112** Insulation.~~

~~The entire flat cable assembly shall be formed to provide a suitable insulation covering all the conductors and using one of the materials recognized in Table 310.4(1) for general branch-circuit wiring.~~

~~**322.120** Marking.~~

~~**(A)** Temperature Rating.~~

~~In addition to the provisions of 310.8 , Type FC cable shall have the temperature rating durably marked on the surface at intervals not exceeding 600 mm (24 in.).~~

~~**(B)** Identification of Grounded Conductor.~~

~~The grounded conductor shall be identified throughout its length by means of a distinctive and durable white or gray marking.~~

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

~~**(C)** Terminal Block Identification.~~

~~Terminal blocks identified for the use shall have distinctive and durable markings for color or word coding. The grounded conductor section shall have a white marking or other suitable designation. The next adjacent section of the terminal block shall have a black marking or other suitable designation. The next section shall have a red marking or other suitable designation. The final or outer section, opposite the grounded conductor section of the terminal block, shall have a blue marking or other suitable designation.~~

Statement of Problem and Substantiation for Public Input

Part III can be deleted in its entirety since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

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Public Input No. 105-NFPA 70-2023 [Sections Part III., 334.100, 334.104, 334.108, 334.112, 334...]	Removal of construction criteria for listed wiring methods
Public Input No. 109-NFPA 70-2023 [Sections Part III., 324.100, 324.101, 324.112, 324.120]	
Public Input No. 110-NFPA 70-2023 [Sections Part III., 330.104, 330.108, 330.112, 330.116, 330...]	
Public Input No. 111-NFPA 70-2023 [Sections Part III., 332.104, 332.108, 332.112, 332.116]	

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Public Input No. 120-NFPA 70-2023 [Sections Part III., 354.100, 354.120]

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~~**Sections Part III., 324.100, 324.101, 324.112, 324.120**~~

~~**Part III.** Construction Specifications~~

~~**324.100** Construction.~~

~~**(A)** Type FCC Cable.~~

~~Type FCC cable shall be listed for use with the FCC system and shall consist of three, four, or five flat copper conductors, one of which shall be an equipment grounding conductor.~~

~~**(B)** Shields.~~

~~**(1)** Materials and Dimensions.~~

~~All top and bottom shields shall be of designs and materials identified for their use. Top shields shall be metal. Both metallic and nonmetallic materials shall be permitted for bottom shields.~~

~~**(2)** Resistivity.~~

~~Metal shields shall have cross-sectional areas that provide for electrical resistivity of not more than that of one conductor of the Type FCC cable used in the installation.~~

~~**324.101** Corrosion Resistance.~~

~~Metal components of the system shall be either corrosion resistant, coated with corrosion-resistant materials, or insulated from contact with corrosive substances.~~

~~**324.112** Insulation.~~

~~The insulating material of the cable shall be moisture resistant and flame retardant. All insulating materials in the FCC systems shall be identified for their use.~~

~~**324.120** Markings.~~

~~**(A)** Cable Marking.~~

~~Type FCC cable shall be clearly and durably marked on both sides at intervals of not more than 610 mm (24 in.) with the information required by 310.8(A) and with the following additional information:~~

(1) ~~Material of conductors~~

(2) ~~Maximum temperature rating~~

(3) ~~Ampacity~~

~~**(B)** Conductor Identification.~~

~~Conductors shall be clearly and durably identified on both sides throughout their length as specified in 310.6 .~~

Statement of Problem and Substantiation for Public Input

Part III can be deleted in its entirety since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

Related Input	Relationship
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Public Input No. 105-NFPA 70-2023 [Sections Part III., 334.100, 334.104, 334.108, 334.112, 334...]	Removal of construction criteria for listed wiring methods
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Public Input No. 111-NFPA 70-2023 [Sections Part III., 332.104, 332.108, 332.112, 332.116]	
Public Input No. 112-NFPA 70-2023 [Sections Part III., 336.100, 336.104, 336.116, 336.120, 336...]	
Public Input No. 113-NFPA 70-2023 [Sections Part III., 337.104, 337.108, 337.112, 337.114, 337...]	
Public Input No. 114-NFPA 70-2023 [Sections Part III., 340.104, 340.108, 340.112, 340.116]	
Public Input No. 115-NFPA 70-2023 [Sections Part III., 342.100, 342.120]	
Public Input No. 116-NFPA 70-2023 [Sections Part III., 344.100, 344.120]	
Public Input No. 117-NFPA 70-2023 [Sections Part III., 350.120]	
Public Input No. 118-NFPA 70-2023 [Sections Part III., 352.100, 352.120]	
Public Input No. 119-NFPA 70-2023 [Sections Part III., 353.100, 353.120]	
Public Input No. 120-NFPA 70-2023 [Sections Part III., 354.100, 354.120]	
Public Input No. 121-NFPA 70-2023 [Sections Part III., 355.100, 355.120]	
Public Input No. 122-NFPA 70-2023 [Sections Part III., 356.100, 356.120]	
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~~**Sections Part III., 330.104, 330.108, 330.112, 330.116, 330.130**~~

~~**Part III.** Construction Specifications~~

~~**330.104** Conductors.~~

~~For ungrounded, grounded, and equipment grounding conductors, the minimum conductor sizes shall be 14 AWG copper, nickel, or nickel-coated copper and 12 AWG aluminum or copper-clad aluminum.~~

~~For control and signal conductors, minimum conductor sizes shall be 18 AWG copper, nickel, or nickel-coated copper, 14 AWG copper-clad aluminum, and 12 AWG aluminum.~~

~~**330.108** Equipment Grounding Conductor.~~

~~Where Type MC cable is used to provide an equipment grounding conductor, it shall comply with 250.118(A)(10) and 250.122 .~~

~~**330.112** Insulation.~~

~~Insulated conductors shall comply with 330.112(A) or (B).~~

~~**(A)** 1000 Volts or Less.~~

~~Insulated control and signal conductors in sizes 18 AWG and 16 AWG shall be of a type listed in Table 402.3 , with a maximum operating temperature not less than 90°C (194°F) and as permitted by 724.49. Ungrounded, grounded, and equipment grounding conductors 16 AWG and larger shall be of a type listed in Table 310.4(1) or of a type identified for use in Type MC cable.~~

~~**(B)** Over 1000 Volts.~~

~~Insulated conductors shall be of a type listed in Table 310.4(2) and Table 315.10(A) .~~

~~**330.116** Sheath.~~

~~Metallic covering shall be one of the following types: smooth metallic sheath, corrugated metallic sheath, or interlocking metal tape armor. The metallic sheath shall be continuous and close fitting. A nonmagnetic sheath or armor shall be used on single conductor Type MC. Supplemental protection of an outer covering of corrosion-resistant material shall be permitted and shall be required where such protection is needed. The sheath shall not be used as a current-carrying conductor.~~

~~Informational Note: See 300.6 for protection against corrosion.~~

~~**330.130** Hazardous (Classified) Locations.~~

~~Where required to be marked MC-HL, the cable shall be listed and shall have a gas/vapor tight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material, and a separate equipment grounding conductor.~~

Statement of Problem and Substantiation for Public Input

Part III can be deleted in its entirety since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 109-NFPA 70-2023 [Sections Part III., 324.100, 324.101, 324.112, 324.120]	Removal of construction criteria for listed wiring methods
Public Input No. 108-NFPA 70-2023 [Sections Part III., 322.100, 322.104, 322.112, 322.120]	Removal of construction criteria for listed wiring methods
Public Input No. 107-NFPA 70-2023 [Sections Part III., 338.100, 338.120]	Removal of construction criteria for listed wiring methods

Public Input No. 106-NFPA 70-2023 [Sections Part III., 320.100, 320.104, 320.108, 320.120]	Removal of construction criteria for listed wiring methods
Public Input No. 105-NFPA 70-2023 [Sections Part III., 334.100, 334.104, 334.108, 334.112, 334...]	Removal of construction criteria for listed wiring methods
Public Input No. 111-NFPA 70-2023 [Sections Part III., 332.104, 332.108, 332.112, 332.116]	
Public Input No. 112-NFPA 70-2023 [Sections Part III., 336.100, 336.104, 336.116, 336.120, 336...]	
Public Input No. 113-NFPA 70-2023 [Sections Part III., 337.104, 337.108, 337.112, 337.114, 337...]	
Public Input No. 114-NFPA 70-2023 [Sections Part III., 340.104, 340.108, 340.112, 340.116]	
Public Input No. 115-NFPA 70-2023 [Sections Part III., 342.100, 342.120]	
Public Input No. 116-NFPA 70-2023 [Sections Part III., 344.100, 344.120]	
Public Input No. 117-NFPA 70-2023 [Sections Part III., 350.120]	
Public Input No. 118-NFPA 70-2023 [Sections Part III., 352.100, 352.120]	
Public Input No. 119-NFPA 70-2023 [Sections Part III., 353.100, 353.120]	
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~~**Sections Part III., 332.104, 332.108, 332.112, 332.116**~~

~~**Part III.** Construction Specifications~~

~~**332.104** Conductors.~~

~~Type MI cable conductors shall be of solid copper, nickel, or nickel-coated copper with a resistance corresponding to standard AWG and kcmil sizes.~~

~~**332.108** Equipment Grounding Conductor.~~

~~Where the outer sheath is made of copper, it shall provide an adequate path to serve as an equipment grounding conductor. Where the outer sheath is made of steel, a separate equipment grounding conductor shall be provided.~~

~~**332.112** Insulation.~~

~~The conductor insulation in Type MI cable shall be a highly compressed refractory mineral that provides proper spacing for all conductors.~~

~~**332.116** Sheath.~~

~~The outer sheath shall be of a continuous construction to provide mechanical protection and moisture seal.~~

Statement of Problem and Substantiation for Public Input

Part III can be deleted in its entirety since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 110-NFPA 70-2023 [Sections Part III., 330.104, 330.108, 330.112, 330.116, 330...]	Removal of construction criteria for listed wiring methods
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Public Input No. 108-NFPA 70-2023 [Sections Part III., 322.100, 322.104, 322.112, 322.120]	Removal of construction criteria for listed wiring methods
Public Input No. 107-NFPA 70-2023 [Sections Part III., 338.100, 338.120]	Removal of construction criteria for listed wiring methods
Public Input No. 106-NFPA 70-2023 [Sections Part III., 320.100, 320.104, 320.108, 320.120]	Removal of construction criteria for listed wiring methods
Public Input No. 105-NFPA 70-2023 [Sections Part III., 334.100, 334.104, 334.108, 334.112, 334...]	Removal of construction criteria for listed wiring methods
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Public Input No. 113-NFPA 70-2023 [Sections Part III., 337.104, 337.108, 337.112, 337.114, 337...]	
Public Input No. 114-NFPA 70-2023 [Sections Part III., 340.104, 340.108, 340.112, 340.116]	
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Public Input No. 116-NFPA 70-2023 [Sections Part III., 344.100, 344.120]	
Public Input No. 117-NFPA 70-2023 [Sections Part III., 350.120]	

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Public Input No. 119-NFPA 70-2023 [Sections Part III., 353.100, 353.120]

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~~**Sections Part III., 334.100, 334.104, 334.108, 334.112, 334.116**~~

~~**Part III.** Construction Specifications~~

~~**334.100** Construction.~~

~~The outer cable sheath of nonmetallic-sheathed cable shall be a nonmetallic material.~~

~~**334.104** Conductors.~~

~~The 600-volt insulated power conductors shall be sizes 14 AWG through 2 AWG copper conductors or sizes 12 AWG through 2 AWG aluminum or copper-clad aluminum conductors. Control and signaling conductors shall be no smaller than 18 AWG copper.~~

~~**334.108** Equipment Grounding Conductor.~~

~~In addition to the insulated conductors, the cable shall have an insulated, covered, or bare equipment grounding conductor.~~

~~**334.112** Insulation.~~

~~The insulated power conductors shall be one of the types listed in Table 310.4(1) that are suitable for branch-circuit wiring or one that is identified for use in these cables. Conductor insulation shall be rated at 90°C (194°F).~~

> ~~Informational Note: Types NM and NMC cable identified by the markings NM-B and NMC-B meet this requirement.~~

~~**334.116** Sheath.~~

~~The outer sheath of nonmetallic-sheathed cable shall comply with 334.116(A) and (B).~~

~~**(A)** Type NM.~~

~~The overall covering shall be flame retardant and moisture resistant.~~

~~**(B)** Type NMC.~~

~~The overall covering shall be flame retardant, moisture resistant, fungus resistant, and corrosion resistant.~~

Statement of Problem and Substantiation for Public Input

The entirety of Part III can be deleted since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

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Public Input No. 108-NFPA 70-2023 [Sections Part III., 322.100, 322.104, 322.112, 322.120]	
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Public Input No. 112-NFPA 70-2023 [Sections Part III., 336.100, 336.104, 336.116, 336.120, 336...]

~~**Sections Part III., 336.100, 336.104, 336.116, 336.120, 336.130**~~

~~**Part III.** Construction Specifications~~

~~**336.100** Construction.~~

~~A metallic sheath or armor as defined in 330.116 shall not be permitted either under or over the nonmetallic jacket. Metallic shield(s) shall be permitted over groups of conductors, under the outer jacket, or both.~~

~~**336.104** Conductors.~~

~~For ungrounded, grounded, and equipment grounding conductors, the conductor sizes shall be 14 AWG through 1000 kcmil copper, nickel, or nickel-coated copper and 12 AWG through 1000 kcmil aluminum or copper-clad aluminum. Insulation types shall be one of the types listed in Table 310.4(1) or Table 310.4(2) that is suitable for branch circuit and feeder circuits or one that is identified for such use.~~

~~For control and signal conductors, the minimum conductor sizes shall be 18 AWG copper, nickel, or nickel-coated copper, 14 AWG copper-clad aluminum, and 12 AWG aluminum.~~

~~**(A)** Fire Alarm Systems.~~

~~Where used for fire alarm systems, conductors shall also be in accordance with 760.49 .~~

~~**(B)** Thermocouple Circuits.~~

~~Conductors in Type TC cable used for thermocouple circuits in accordance with Part III of Article 724 shall also be permitted to be any of the materials used for thermocouple extension wire.~~

~~**(C)** Class 1 Circuit Conductors.~~

~~Insulated conductors of 18 AWG and 16 AWG copper shall also be in accordance with 724.49 .~~

~~**336.116** Jacket.~~

~~The outer jacket shall be a flame-retardant, nonmetallic material.~~

~~**336.120** Marking.~~

~~There shall be no voltage marking on a Type TC cable employing thermocouple extension wire.~~

~~**336.130** Hazardous (Classified) Location Cable.~~

~~Cable listed and marked Type TC-ER-HL shall comply with the following:~~

(1) ~~The overall nonmetallic jacket shall be suitable for the environment.~~

(2) ~~The overall cable construction shall be essentially circular in cross-section.~~

(3) ~~The overall nonmetallic jacket shall be continuous and gas/vapor tight.~~

(4) ~~For construction greater than 25.4 mm (1 in.) in diameter, the following shall apply:~~

    (5) ~~The equipment grounding conductor shall be bare.~~

    (6) ~~A metallic shield shall be included over all conductors under the outer jacket.~~

Statement of Problem and Substantiation for Public Input

Part III can be deleted in its entirety since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 111-NFPA 70-2023 [Sections Part III., 332.104, 332.108, 332.112, 332.116]	Removal of construction criteria for listed wiring methods
Public Input No. 110-NFPA 70-2023 [Sections Part III., 330.104, 330.108, 330.112, 330.116, 330...]	Removal of construction criteria for listed wiring methods
Public Input No. 109-NFPA 70-2023 [Sections Part III., 324.100, 324.101, 324.112, 324.120]	Removal of construction criteria for listed wiring methods
Public Input No. 108-NFPA 70-2023 [Sections Part III., 322.100, 322.104, 322.112, 322.120]	Removal of construction criteria for listed wiring methods
Public Input No. 107-NFPA 70-2023 [Sections Part III., 338.100, 338.120]	Removal of construction criteria for listed wiring methods
Public Input No. 106-NFPA 70-2023 [Sections Part III., 320.100, 320.104, 320.108, 320.120]	Removal of construction criteria for listed wiring methods
Public Input No. 105-NFPA 70-2023 [Sections Part III., 334.100, 334.104, 334.108, 334.112, 334...]	Removal of construction criteria for listed wiring methods
Public Input No. 113-NFPA 70-2023 [Sections Part III., 337.104, 337.108, 337.112, 337.114, 337...]	
Public Input No. 114-NFPA 70-2023 [Sections Part III., 340.104, 340.108, 340.112, 340.116]	
Public Input No. 115-NFPA 70-2023 [Sections Part III., 342.100, 342.120]	
Public Input No. 116-NFPA 70-2023 [Sections Part III., 344.100, 344.120]	
Public Input No. 117-NFPA 70-2023 [Sections Part III., 350.120]	
Public Input No. 118-NFPA 70-2023 [Sections Part III., 352.100, 352.120]	
Public Input No. 119-NFPA 70-2023 [Sections Part III., 353.100, 353.120]	
Public Input No. 120-NFPA 70-2023 [Sections Part III., 354.100, 354.120]	
Public Input No. 121-NFPA 70-2023 [Sections Part III., 355.100, 355.120]	
Public Input No. 122-NFPA 70-2023 [Sections Part III., 356.100, 356.120]	
Public Input No. 123-NFPA 70-2023 [Sections Part III., 358.100, 358.120]	

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Public Input No. 113-NFPA 70-2023 [Sections Part III., 337.104, 337.108, 337.112, 337.114, 337...]

~~**Sections Part III., 337.104, 337.108, 337.112, 337.114, 337.115, 337.116, 337.120**~~

~~**Part III.** Construction Specifications~~

~~**337.104** Conductors.~~

~~Conductors shall be of tinned copper. Conductors shall employ flexible stranding. The minimum conductor size shall be 18 AWG.~~

~~**337.108** Equipment Grounding Conductor.~~

~~An equipment grounding conductor complying with 250.122 shall be provided within multiconductor Type P cable.~~

~~**337.112** Insulation.~~

~~Insulated conductors shall be a thermoset type identified for use in Type P cable. All conductors shall be suitable for wet locations. The minimum wall thickness shall be 0.76 mm (30 mils).~~

~~**337.114** Shield.~~

~~Metallic shield(s) shall be permitted over a single conductor or groups of conductors.~~

~~**337.115** Jacket.~~

~~Multiconductor cables shall have an overall nonmetallic jacket that is impervious to moisture, corrosion resistant, and sunlight resistant. When installed external to an enclosure or industrial machinery, single conductor cables shall have an overall nonmetallic jacket that is impervious to moisture, corrosion resistant, and sunlight resistant. Single conductor cables rated 2000 volts with conductor sizes equal to or larger than 4/0 AWG shall be permitted to use an increased insulation thickness in lieu of using a separate cable jacket. When the increased insulation thickness is used, the insulation material shall be sunlight resistant.~~

~~**337.116** Armor.~~

~~Armor shall be permitted over the jacket. If provided, the armor or metallic covering shall be a braided basket weave type consisting of wire laid closely together, flat and parallel, and forming a basket weave that shall firmly grip the cable. The wire shall be commercial bronze, tinned copper, stainless steel, or aluminum. The armor shall not be used as a current-carrying conductor or as an equipment grounding conductor. A nonmetallic jacket that conforms to 337.115 shall be provided over the armor.~~

~~**337.120** Marking.~~

~~Type P cable shall be marked in accordance with 310.8 . When an armor is provided, the cable shall be marked accordingly.~~

Statement of Problem and Substantiation for Public Input

Part III can be deleted in its entirety since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 112-NFPA 70-2023 [Sections Part III., 336.100, 336.104, 336.116, 336.120, 336...]	Removal of construction criteria for listed wiring methods
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Public Input No. 110-NFPA 70-2023 [Sections Part III., 330.104, 330.108, 330.112, 330.116, 330...]	Removal of construction criteria for listed wiring methods
Public Input No. 109-NFPA 70-2023 [Sections Part III., 324.100, 324.101, 324.112, 324.120]	Removal of construction criteria for listed wiring methods

Public Input No. 108-NFPA 70-2023 [Sections Part III., 322.100, 322.104, 322.112, 322.120]	Removal of construction criteria for listed wiring methods
Public Input No. 107-NFPA 70-2023 [Sections Part III., 338.100, 338.120]	Removal of construction criteria for listed wiring methods
Public Input No. 106-NFPA 70-2023 [Sections Part III., 320.100, 320.104, 320.108, 320.120]	Removal of construction criteria for listed wiring methods
Public Input No. 105-NFPA 70-2023 [Sections Part III., 334.100, 334.104, 334.108, 334.112, 334...]	Removal of construction criteria for listed wiring methods
Public Input No. 114-NFPA 70-2023 [Sections Part III., 340.104, 340.108, 340.112, 340.116]	
Public Input No. 115-NFPA 70-2023 [Sections Part III., 342.100, 342.120]	
Public Input No. 116-NFPA 70-2023 [Sections Part III., 344.100, 344.120]	
Public Input No. 117-NFPA 70-2023 [Sections Part III., 350.120]	
Public Input No. 118-NFPA 70-2023 [Sections Part III., 352.100, 352.120]	
Public Input No. 119-NFPA 70-2023 [Sections Part III., 353.100, 353.120]	
Public Input No. 120-NFPA 70-2023 [Sections Part III., 354.100, 354.120]	
Public Input No. 121-NFPA 70-2023 [Sections Part III., 355.100, 355.120]	
Public Input No. 122-NFPA 70-2023 [Sections Part III., 356.100, 356.120]	
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Public Input No. 107-NFPA 70-2023 [Sections Part III., 338.100, 338.120]

~~**Sections Part III., 338.100, 338.120**~~

~~**Part III.** Construction Specifications~~

~~**338.100** Construction.~~

~~**(A)** Assemblies.~~

~~Cabled assemblies of multiple single-conductor Type USE conductors shall be permitted for direct burial. All conductors shall be insulated.~~

~~Informational Note: The term "cabled" refers to a manufacturing process of twisting single conductors together and may also be referred to as "plexed."~~

~~**(B)** Uninsulated Conductor.~~

~~Type SE or USE cable with an overall covering containing two or more conductors shall be permitted to have one conductor uninsulated.~~

~~**338.120** Marking.~~

~~Service-entrance cable shall be marked as required in 310.8 . Cable with the neutral conductor smaller than the ungrounded conductors shall be so marked.~~

Statement of Problem and Substantiation for Public Input

Part III can be deleted in its entirety since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 106-NFPA 70-2023 [Sections Part III., 320.100, 320.104, 320.108, 320.120]	Removal of construction criteria for listed wiring methods
Public Input No. 105-NFPA 70-2023 [Sections Part III., 334.100, 334.104, 334.108, 334.112, 334...]	Removal of construction criteria for listed wiring methods
Public Input No. 108-NFPA 70-2023 [Sections Part III., 322.100, 322.104, 322.112, 322.120]	
Public Input No. 109-NFPA 70-2023 [Sections Part III., 324.100, 324.101, 324.112, 324.120]	
Public Input No. 110-NFPA 70-2023 [Sections Part III., 330.104, 330.108, 330.112, 330.116, 330...]	
Public Input No. 111-NFPA 70-2023 [Sections Part III., 332.104, 332.108, 332.112, 332.116]	
Public Input No. 112-NFPA 70-2023 [Sections Part III., 336.100, 336.104, 336.116, 336.120, 336...]	
Public Input No. 113-NFPA 70-2023 [Sections Part III., 337.104, 337.108, 337.112, 337.114, 337...]	
Public Input No. 114-NFPA 70-2023 [Sections Part III., 340.104, 340.108, 340.112, 340.116]	
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Public Input No. 117-NFPA 70-2023 [Sections Part III., 350.120]	
Public Input No. 118-NFPA 70-2023 [Sections Part III., 352.100, 352.120]	

Public Input No. 119-NFPA 70-2023 [Sections Part III., 353.100, 353.120]
Public Input No. 120-NFPA 70-2023 [Sections Part III., 354.100, 354.120]
Public Input No. 121-NFPA 70-2023 [Sections Part III., 355.100, 355.120]
Public Input No. 122-NFPA 70-2023 [Sections Part III., 356.100, 356.120]
Public Input No. 123-NFPA 70-2023 [Sections Part III., 358.100, 358.120]

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~~**Sections Part III., 340.104, 340.108, 340.112, 340.116**~~

~~**Part III.** Construction Specifications~~

~~**340.104** Conductors.~~

~~The conductors shall be sizes 14 AWG copper or 12 AWG aluminum or copper-clad aluminum through 4/0 AWG.~~

~~**340.108** Equipment Grounding Conductor.~~

~~In addition to the insulated conductors, the cable shall be permitted to have an insulated or bare equipment grounding conductor.~~

~~**340.112** Insulation.~~

~~The conductors of Type UF shall be one of the moisture-resistant types listed in Table 310.4(1) that is suitable for branch-circuit wiring or one that is identified for such use. Where installed as a substitute wiring method for NM cable, the conductor insulation shall be rated 90°C (194°F).~~

~~**340.116** Sheath.~~

~~The overall covering shall be flame retardant; moisture, fungus, and corrosion resistant; and suitable for direct burial in the earth.~~

Statement of Problem and Substantiation for Public Input

Part III can be deleted in its entirety since these cables are required to be listed and must meet product standards in order to achieve that listing.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 113-NFPA 70-2023 [Sections Part III., 337.104, 337.108, 337.112, 337.114, 337...]	Removal of construction criteria for listed wiring methods
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Public Input No. 111-NFPA 70-2023 [Sections Part III., 332.104, 332.108, 332.112, 332.116]	Removal of construction criteria for listed wiring methods
Public Input No. 110-NFPA 70-2023 [Sections Part III., 330.104, 330.108, 330.112, 330.116, 330...]	Removal of construction criteria for listed wiring methods
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Public Input No. 108-NFPA 70-2023 [Sections Part III., 322.100, 322.104, 322.112, 322.120]	Removal of construction criteria for listed wiring methods
Public Input No. 107-NFPA 70-2023 [Sections Part III., 338.100, 338.120]	Removal of construction criteria for listed wiring methods
Public Input No. 106-NFPA 70-2023 [Sections Part III., 320.100, 320.104, 320.108, 320.120]	Removal of construction criteria for listed wiring methods
Public Input No. 105-NFPA 70-2023 [Sections Part III., 334.100, 334.104, 334.108, 334.112, 334...]	Removal of construction criteria for listed wiring methods
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Public Input No. 116-NFPA 70-2023 [Sections Part III., 344.100, 344.120]	
Public Input No. 117-NFPA 70-2023 [Sections Part III., 350.120]	

Public Input No. 118-NFPA 70-2023 [Sections Part III., 352.100, 352.120]
Public Input No. 119-NFPA 70-2023 [Sections Part III., 353.100, 353.120]
Public Input No. 120-NFPA 70-2023 [Sections Part III., 354.100, 354.120]
Public Input No. 121-NFPA 70-2023 [Sections Part III., 355.100, 355.120]
Public Input No. 122-NFPA 70-2023 [Sections Part III., 356.100, 356.120]
Public Input No. 123-NFPA 70-2023 [Sections Part III., 358.100, 358.120]

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Public Input No. 1782-NFPA 70-2023 [New Section after Table]

Table 5B Conductor Properties and Resistivity Values

Copper @ 75C = 12.9 ohms/mil-ft

Aluminum @ 75C = 21.2 ohms/mil-ft

Copper @ 68F = 10.4 ohms/mil-ft

Aluminum @ 68F = 17.7 ohms/mil-ft

R = (K*L) / Cmil

Evdrop = (2*K*I*L) / Cmil

Cmil = (2*K*I*L) / Evdrop

NOTE: for 3-phase systems replace 2 with 1.732

Conversions of Square mils

Cmil = Square mils / 0.7854

Cmil = Square mil * 1.273

Informational Note: See 210.19 voltage drop recommendations

Additional Proposed Changes

File Name	Description	Approved
Conductor_properties.png	Conductor Properties, Resistivity, K-Values and Voltage Drops	

Statement of Problem and Substantiation for Public Input

Resistivity and conductor K-Value are an integral part of calculating voltage drop per 210.19
Having a chart which includes Ohms per mil-ft for wire and ambient temperature adjacent to Ch9 Table-8 puts all the information and formulas together to calculate and verify circuit performance.
There is ample blank space on the preceding NEC page below CH9 Table 5A to insert K-Values and Voltage Drop formulas
Cmil to Square calculations are helpful for those transitioning from wire bus to bus bar.

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Committee: NEC-P06

K Values = Resistivity Ohm / mil-ft

If E = IxR

For 3-Phase Replace 2 with 1.732

68F	Cu 10.4	**75C**	Cu 12.9
COLD	AL 17.7	**HOT**	AL 21.2

$$\boldsymbol{R = \frac{K \ x \ L}{A_{Cmil}}} \qquad \boldsymbol{E_{VD} = \frac{2KIL}{C_{mil}}} \qquad \boldsymbol{C_{mil} = \frac{2KIL}{E_{VD}}}$$

$$Cmil = \frac{Square\ mils}{0.7854}$$

Cmil = Square mil x 1.273

Public Input No. 2158-NFPA 70-2023 [Section No. Table]

Table 8

Table 8 Conductor Properties

Size (AWG or kcmil)	Area mm^2	Area Circular mils	Conductors Stranding Quantity	Stranding Diameter mm	Stranding Diameter in.	Overall Diameter mm	Overall Diameter in.	Overall Area mm^2	Overall Area in.^{2}	Dire… ohm/km
18	0.823	1620	1	—	—	1.02	0.040	0.823	0.001	25.5
18	0.823	1620	7	0.39	0.015	1.16	0.046	1.06	0.002	26.1
16	1.31	2580	1	—	—	1.29	0.051	1.31	0.002	16.0
16	1.31	2580	7	0.49	0.019	1.46	0.058	1.68	0.003	16.4
14	2.08	4110	1	—	—	1.63	0.064	2.08	0.003	10.1
14	2.08	4110	7	0.62	0.024	1.85	0.073	2.68	0.004	10.3
12	3.31	6530	1	—	—	2.05	0.081	3.31	0.005	6.34
12	3.31	6530	7	0.78	0.030	2.32	0.092	4.25	0.006	6.50
10	5.261	10380	1	—	—	2.588	0.102	5.26	0.008	3.984
10	5.261	10380	7	0.98	0.038	2.95	0.116	6.76	0.011	4.070
8	8.367	16510	1	—	—	3.264	0.128	8.37	0.013	2.506
8	8.367	16510	7	1.23	0.049	3.71	0.146	10.76	0.017	2.551
6	13.30	26240	7	1.56	0.061	4.67	0.184	17.09	0.027	1.608
4	21.15	41740	7	1.96	0.077	5.89	0.232	27.19	0.042	1.010
3	26.67	52620	7	2.20	0.087	6.60	0.260	34.28	0.053	0.802
2	33.62	66360	7	2.47	0.097	7.42	0.292	43.23	0.067	0.634
1	42.41	83690	19	1.69	0.066	8.43	0.332	55.80	0.087	0.505
1/0	53.49	105600	19	1.89	0.074	9.45	0.372	70.41	0.109	0.399
2/0	67.43	133100	19	2.13	0.084	10.62	0.418	88.74	0.137	0.3170
3/0	85.01	167800	19	2.39	0.094	11.94	0.470	111.9	0.173	0.2512
4/0	107.2	211600	19	2.68	0.106	13.41	0.528	141.1	0.219	0.1996
250	127	—	37	2.09	0.082	14.61	0.575	168	0.260	0.1687
300	152	—	37	2.29	0.090	16.00	0.630	201	0.312	0.1409
350	177	—	37	2.47	0.097	17.30	0.681	235	0.364	0.1205
400	203	—	37	2.64	0.104	18.49	0.728	268	0.416	0.1053
500	253	—	37	2.95	0.116	20.65	0.813	336	0.519	0.0845
600	304	—	61	2.52	0.099	22.68	0.893	404	0.626	0.0704
700	355	—	61	2.72	0.107	24.49	0.964	471	0.730	0.0603
750	380	—	61	2.82	0.111	25.35	0.998	505	0.782	0.0563
800	405	—	61	2.91	0.114	26.16	1.030	538	0.834	0.0528
900	456	—	61	3.09	0.122	27.79	1.094	606	0.940	0.0470
1000	507	—	61	3.25	0.128	29.26	1.152	673	1.042	0.0423
1250	633	—	91	2.98	0.117	32.74	1.289	842	1.305	0.0338
1500	760	—	91	3.26	0.128	35.86	1.412	1011	1.566	0.02814
1750	887	—	127	2.98	0.117	38.76	1.526	1180	1.829	0.02410
2000	1013	—	127	3.19	0.126	41.45	1.632	1349	2.092	0.02109

Notes:

1. These resistance values are valid **only** for the parameters as given. Using conductors having coated strands, different stranding type, and,

especially, other temperatures changes the resistance.

2. Equation for temperature change: $R_2 = R_1 [1 + a (T_2 - 75)]$, where α_{CU} = 0.00323, α_{AL} = 0.00330 at 75°C.

3. Conductors with compact and compressed stranding have

smaller bare conductor diameters than those shown. See Table 5A for actual compact cable dimensions.

4. The IACS conductivities used: bare copper = 100%, aluminum = 61%.

5. Class B stranding is listed as well as solid for some sizes. Its overall diameter and area are those of its circumscribing circle.

6, cmil equivalences for conductors rated in square millimetres shall not be used for ampacity calcualations. Ampacity tables are unique to each country and must be used accordingly.

Informational Note: NEMA WC/70-2009, *Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy*, or ANSI/UL 1581-2017, *Reference Standard for Electrical Wires, Cables, and Flexible Cords*, is the source for the construction information.

National Bureau of Standards Handbook 100, dated 1966, and

Handbook 109, dated 1972, is the reference where the resistance is calculated.

Statement of Problem and Substantiation for Public Input

I've received many questions over the years about conductors that have square millimetre sizes. There seems to be an assumption that ampacity can be calculated from cmils. Whereas this is one method of calculating ampacity in the US, it does not hold true for other countries. Also, there is more and more European, or Asian, equipment that is showing up in the US. The manufacturer's instructions show conductors in square millimetres. A direct equivalence to AWG is not allowed. The proper US conductor should be selected based on US ampacity tables and US wire sizes.

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Committee:	NEC-P06

Public Input No. 259-NFPA 70-2023 [Section No. Table]

Table 8

Table 8 Conductor Properties

Size (AWG or kcmil)	Area mm^2	Area Circular mils	Conductors Stranding Quantity	Stranding Diameter mm	Stranding Diameter in.	Overall Diameter mm	Overall Diameter in.	Overall Area mm^2	Overall Area in.^{2}	Di ohm/km
18	0.823	1620	1	—	—	1.02	0.040	0.823	0.001	25.5
18	0.823	1620	7	0.39	0.015	1.16	0.046	1.06	0.002	26.1
16	1.31	2580	1	—	—	1.29	0.051	1.31	0.002	16.0
16	1.31	2580	7	0.49	0.019	1.46	0.058	1.68	0.003	16.4
14	2.08	4110	1	—	—	1.63	0.064	2.08	0.003	10.1
14	2.08	4110	7	0.62	0.024	1.85	0.073	2.68	0.004	10.3
12	3.31	6530	1	—	—	2.05	0.081	3.31	0.005	6.34
12	3.31	6530	7	0.78	0.030	2.32	0.092	4.25	0.006	6.50
10	5.261	10380	1	—	—	2.588	0.102	5.26	0.008	3.984
10	5.261	10380	7	0.98	0.038	2.95	0.116	6.76	0.011	4.070
8	8.367	16510	1	—	—	3.264	0.128	8.37	0.013	2.506
8	8.367	16510	7	1.23	0.049	3.71	0.146	10.76	0.017	2.551
6	13.30	26240	7	1.56	0.061	4.67	0.184	17.09	0.027	1.608
4	21.15	41740	7	1.96	0.077	5.89	0.232	27.19	0.042	1.010
3	26.67	52620	7	2.20	0.087	6.60	0.260	34.28	0.053	0.802
2	33.62	66360	7	2.47	0.097	7.42	0.292	43.23	0.067	0.634
1	42.41	83690	19	1.69	0.066	8.43	0.332	55.80	0.087	0.505
1/0	53.49	105600	19	1.89	0.074	9.45	0.372	70.41	0.109	0.399
2/0	67.43	133100	19	2.13	0.084	10.62	0.418	88.74	0.137	0.3170
3/0	85.01	167800	19	2.39	0.094	11.94	0.470	111.9	0.173	0.2512
4/0	107.2	211600	19	2.68	0.106	13.41	0.528	141.1	0.219	0.1996
250	127	— 250000	37	2.09	0.082	14.61	0.575	168	0.260	0.1687
300	152	— 300000	37	2.29	0.090	16.00	0.630	201	0.312	0.1409
350	177	— 350000	37	2.47	0.097	17.30	0.681	235	0.364	0.1205
400	203	— 400000	37	2.64	0.104	18.49	0.728	268	0.416	0.1053
500	253	— 500000	37	2.95	0.116	20.65	0.813	336	0.519	0.0845
600	304	— 600000	61	2.52	0.099	22.68	0.893	404	0.626	0.0704
700	355	— 700000	61	2.72	0.107	24.49	0.964	471	0.730	0.0603
750	380	— 750000	61	2.82	0.111	25.35	0.998	505	0.782	0.0563
800	405	— 800000	61	2.91	0.114	26.16	1.030	538	0.834	0.0528
900	456	— 900000	61	3.09	0.122	27.79	1.094	606	0.940	0.0470
1000	507	— 1000000	61	3.25	0.128	29.26	1.152	673	1.042	0.0423
1250	633	— 1250000	91	2.98	0.117	32.74	1.289	842	1.305	0.0338
1500	760	— 1500000	91	3.26	0.128	35.86	1.412	1011	1.566	0.0281
1750	887	— 1750000	127	2.98	0.117	38.76	1.526	1180	1.829	0.0241
2000	1013	— 2000000	127	3.19	0.126	41.45	1.632	1349	2.092	0.0210

Notes:

1. These resistance values are valid **only** for the parameters as given. Using conductors having coated strands, different stranding type, and,

especially, other temperatures changes the resistance.

2. Equation for temperature change: $R_2 = R_1\ [1 + a\ (T_2 - 75)]$, where $\alpha_{cu} = 0.00323$, $\alpha_{AL} = 0.00330$ at 75°C.

3. Conductors with compact and compressed stranding have

smaller bare conductor diameters than those shown. See Table 5A for actual compact cable dimensions.

4. The IACS conductivities used: bare copper = 100%, aluminum = 61%.

5. Class B stranding is listed as well as solid for some sizes. Its overall diameter and area are those of its circumscribing circle.

Informational Note: NEMA WC/70-2009, *Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy*, or ANSI/UL 1581-2017, *Reference Standard for Electrical Wires, Cables, and Flexible Cords*, is the source for the construction information.

National Bureau of Standards Handbook 100, dated 1966, and

Handbook 109, dated 1972, is the reference where the resistance is calculated.

Statement of Problem and Substantiation for Public Input

I teach apprentice and journeyman classes and this is always a confusing table, to explain the circular mil cut off of numbers for the higher numbers. If you were to show the actual numbers it would be a better visual representation.

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Committee: NEC-P06

Public Input No. 2871-NFPA 70-2023 [Section No. 382.6]

382.~~6~~ 2 Listing Requirements.

Concealable nonmetallic extensions and associated fittings and devices shall be listed. ~~The starting/source tap device for the extension shall contain and provide the following protection for all load-side extensions and devices:~~

(1) ~~Supplementary overcurrent protection~~

(2) ~~Level of protection equivalent to a Class A GFCI~~

(3) ~~Level of protection equivalent to a portable GFCI~~

(4) ~~Line and load-side miswire protection~~

(5) ~~Provide protection from the effects of arc faults~~

Statement of Problem and Substantiation for Public Input

Per the 2023 NEC style manual, clause 2.2.1, "Required Parallel Numbering Format" Listing requirements should be relocated from 382.6 to 382.2.
Requirements for protection are relocated to a new Section as it is a separate topic from "listing requirements". See associated PI 2872

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2872-NFPA 70-2023 [New Section after 382.6]	moved requirements for protection to new section

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Public Input No. 2872-NFPA 70-2023 [New Section after 382.6]

382.4 Load-Side Protection.

The starting/source tap device for the extension shall contain and provide the following protection for all load-side extensions and devices:

(1) Supplementary overcurrent protection

(2) Level of protection equivalent to a Class A GFCI

(3) Level of protection equivalent to a portable GFCI

(4) Line and load-side miswire protection

(5) Provide protection from the effects of arc faults ...

Statement of Problem and Substantiation for Public Input

Requirements for protection are relocated to a new Section as it is a separate topic from "listing requirements".

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Public Input No. 3533-NFPA 70-2023 [Section No. 382.6]

382.~~6~~ 2 Listing Requirements.

Concealable nonmetallic extensions and associated fittings and devices shall be listed. The starting/source tap device for the extension shall contain and provide the following protection for all load-side extensions and devices:

(1) Supplementary overcurrent protection

(2) Level of protection equivalent to a Class A GFCI

(3) Level of protection equivalent to a portable GFCI

(4) Line and load-side miswire protection

(5) Provide protection from the effects of arc faults

Statement of Problem and Substantiation for Public Input

This Public Input is being submitted on behalf of the NEC Correlating Committee Usability Task Group in order to provide correlation throughout the document. A new section is added to comply with the NEC Style Manual Section 2.2.1 regarding Listing Requirements.
2.2.1 Parallel Numbering Required. Technical committees shall use the following section numbers for the same purposes within articles. This requirement shall not apply to Articles 90, 100, and 110. If the article does not contain listing or reconditioning requirements, the subdivisions shall not be included in the article.
Required Parallel Numbering Format
XXX.1 Scope.
XXX.2 Listing Requirements.
XXX.3 Reconditioned Equipment.
XXX.3(A) Permitted to be Installed.
XXX.3(B) Not Permitted to be Installed.
The Usability Task Group members are: Derrick Atkins, David Hittinger, Richard Holub, Dean Hunter, Chad Kennedy and David Williams.

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