AUGUST 2022
ecmweb.com

THE MAGAZINE OF ELECTRICAL DESIGN, CONSTRUCTION AND MAINTENANCE

EC&M®

How to Troubleshoot AC Induction Motors

Causes and cures for the most common types of motor failure and operation disruption.
Read more on pg. 24

IN THIS ISSUE

You don't need multiple manufacturers. You need one better one.

That's why Atkore Regional Distribution Centers are a one-stop shop. One order, one delivery and one invoice for a faster and simpler process. Tell us what you need, and we'll bundle a complete portfolio of products tailored to your exact specifications.

- Co-Load Capabilities
- Breadth of Product
- Four Centers
- Will Call App

Atkore™

Allied Tube & Conduit ▲ AFC Cable Systems ▲ Heritage Plastics ▲ Unistrut
Unistrut Construction ▲ United Poly Systems ▲ Calbrite ▲ Calbond ▲ Cii ▲ US Tray
Power-Strut ▲ Calconduit ▲ Razor Ribbon ▲ Calpipe Security ▲ Vergokan ▲ Marco
Columbia-MBF ▲ Eastern Wire + Conduit ▲ ACS/Uni-Fab ▲ Sasco Strut ▲ Kaf-Tech
Cope ▲ FRE Composites ▲ Queen City Plastics ▲ Four Star Industries ▲ Flexicon

Learn more at atkore.com

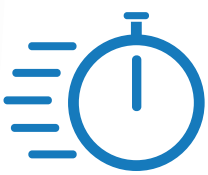
PRESEMBLER

18IN OFF-FLOOR ASSEMBLY WITH/4 IN HINGED SQUARE BOX INSTALLED

ALL-IN-ONE BETWEEN-STUD ASSEMBLY W/4IN HINGED MULTI-BOX

NEW

PREASSEMBLIES AND ASSEMBLY CUSTOMIZATION



SAVE UP TO 18 MINUTES ON INSTALLATION PER UNIT

View more

Visit our website **www.presembler.com**

Email **presembler@sinoample.com**

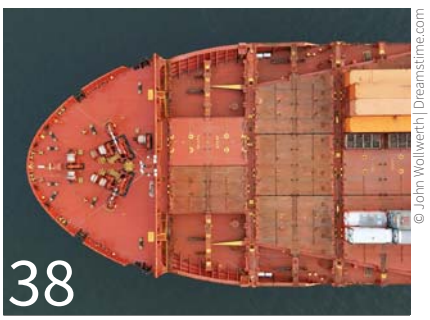
CONTENTS

COVER STORY

OTHER FEATURES

NATIONAL ELECTRICAL CODE

EC&M®
August 2022 • Volume 121 • Number 8



DEPARTMENTS

ISSN 1082-295X (print); ISSN 2771-6384 (digital)
EC&M, August 2022, Volume 121, Issue 8 is published monthly for no charge only to electrical contractors and their employees, consulting electrical engineers, and persons performing electrical construction, installation, and maintenance work in manufacturing, commercial, and institutional facilities in the U.S. by Endeavor Business Media, LLC. 1233 Janesville Ave, Fort Atkinson, WI, 53538. Printed in the U.S.A.

Periodicals postage paid at Fort Atkinson, WI, and additional mailing offices. Current and back issues and additional resources, including subscription request forms and an editorial calendar, are available on the Web at www.ecmweb.com. Canadian GST #R126431964. Postmaster: Send address changes to EC&M, P.O. Box 3257, Northbrook, IL 60065-3257.

Cover Photo: Doin Oakenhelm/Adobe Stock

The BNT Nonmetallic Cable Support For Power Manholes And Vaults

UNDERGROUND DEVICES
BNT NONMETALLIC CABLE SUPPORTS:

- High Load Capacity
- Arms Can be Used With Nonmetallic or Steel Stanchions
- Will Not Rust or Corrode
- Insulators Not Required
- Excellent Dielectric Properties
- Multiple Stanchion Lengths Available
- Arms Available in Multiple Lengths With Integrated Saddles or a Flat Surface
- Molded from UL Listed Glass Reinforced Polymer

BNT Saddle Arms Installed in a Nonmetallic Stanchion

UNDERGROUND DEVICES
INCORPORATED

420 ACADEMY DRIVE
NORTHBROOK, IL 60062
Phone: 847-205-9000 • Fax: 847-205-9004
Website: www.udevices.com

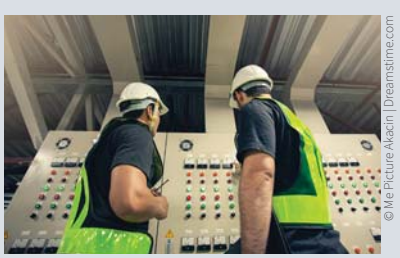
@ ECMWEB.COM

With its exclusive online content, ecmweb.com is a valuable source of industry insight for electrical professionals. Here's a sample of what you can find on our site right now:

© Stocksnapper | Dreamstime.com

DIMMING FLUORESCENT LIGHTING

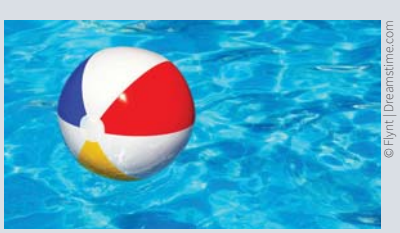
Lighting & Control ▶ Tom Zind looks at a Vermont law phasing out fluorescent tubes that is drawing praise, fire, and copycats.
bit.ly/3PZlevS



© Me Picture Akacin | Dreamstime.com

THE CHALLENGE OF HIGH ACHIEVERS

Maintenance, Repair & Operations ▶ Mark Lamendola discusses how to view high achievers as opportunities instead of threats.
https://bit.ly/3BI5jgU



© Flynt | Dreamstime.com

CODE QUIZ OF THE WEEK: NO. 344

Quiz ▶ Test your knowledge of the 2020 National Electrical Code (NEC) requirements with this weekly quiz.
https://bit.ly/3oRa0h0

EC&M®

Editorial Office: Endeavor Business Media, LLC, 1233 Janesville Ave, Fort Atkinson, WI, 53538.

Subscription Rates: Free and controlled circulation to qualified subscribers. Non-qualified persons may subscribe at the following rates: USA (one year) $55.00; Canada (one year) $90.00; international (one year) $130.00. Single copy prices are $10.00 (USA) and $15 (Canada), and $20 (International). Prices subject to change.

Subscription Services Department: For subscriber services or to order single copies, call customer service at (847) 559-7598 or send an email to electricalconstmaint@omeda.com.

Postmaster: Send address changes to EC&M, P.O. Box 3257, Northbrook, IL 60065-3257 U.S.A.

Reprints: Contact reprints@endeavorb2b.com to purchase custom reprints or e-prints of articles appearing in this publication.

Photocopies: Authorization to photocopy articles for internal corporate, personal, or instructional use may be obtained from the Copyright Clearance Center (CCC) at (978) 750-8400. Obtain further information at www.copyright.com.

Archives and Microform: This magazine is available for research and retrieval of selected archived articles from leading electronic databases and online search services, including Factiva, LexisNexis, and ProQuest.

Privacy Policy: Your privacy is a priority to us. For a detailed policy statement about privacy and information dissemination practices related to Endeavor Business Media products, please visit our website at www.endeavorbusinessmedia.com.

Please Note: The designations "National Electrical Code," "NE Code," and "NEC" refer to the National Electrical Code®, which is a registered trademark of the National Fire Protection Association.

Corporate Office: Endeavor Business Media, LLC, 331 54th Ave. N., Nashville, TN 37209 USA,www.endeavorbusinessmedia.com

MADE IN USA

SP PRODUCTS, INC.

Productivity and value thru ideas

FOR SAFER BETTER FASTER JOBS

We're Proud to be the Electricians' Friend for Over 50 Years!

Qwik Duct

Safer Better Faster

HDPE CUSTOM TEMPLATES

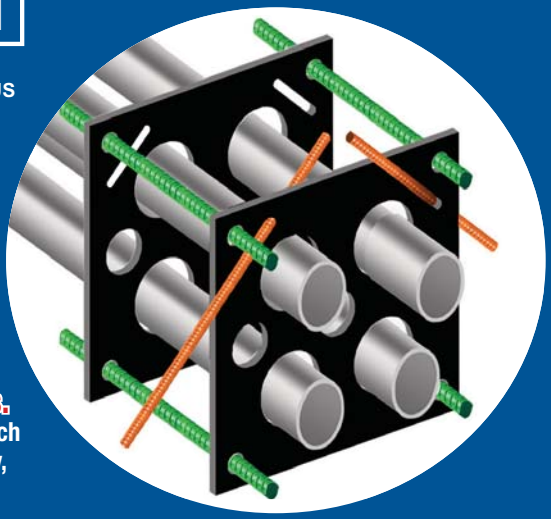
In Any Configuration Required

Save on Installation!

IP1

c UL us

Patent Pending



Assemble Conduit Above Trench-

No Workers Below - Prevents Injuries and Deaths.

Also Allows Digging a Narrower Trench for Less: Excavation, Concrete, Slurry, Backfill & Shoring.

IP3b

Patent Pending

PVC Offset

Sizes 1/2" thru 6"

Meets Flexible Mandrel Test Requirements

Bore Spacers **IP2**

Sizes 1/2" thru 6"

Roll assembled conduit into caissons and under obstructions

c UL us

IP13A-F

Conduit Transition Couplings

c UL us

PVC Schedule 40 & 80

Transitions in Less Than

5 Minutes

PATENT PENDING

IP15

End Bell Adapter

Schedule 40/80 PVC

c UL us PATENT PENDING

Save Cost on the Rigid Nipple, Tape & Labor

Use for Entire Job - Not Just for Repair

IP15

1 Piece Reaming Bit

1/2" thru 6"

Schedule 40/80

Plus More Being Invented for **SAFER BETTER FASTER** *Jobs . . . Call With Your Ideas!*

SPProducts.com **800-233-8595** info@SPProducts.com

Product of the Year Entries Demonstrate Industry Innovation at Its Finest

By Ellen Parson, Editor-in-Chief

More than 20 years after unveiling the first *EC&M* Product of the Year winner (in 2001), I am still amazed at the diversity and quality of new product innovation and development on display in our annual competition. Like several of my coworkers, I was on staff more than two decades ago when we started this program. Since that time, it has grown into an *EC&M* institution. I can say from personal experience that it never gets old to have a front-row seat to the products that are driving the electrical industry forward, helping our readers perform their jobs more safely, efficiently, and effectively. It's always exciting to see what types of new features, updates, and technological advancements manufacturers incorporate into these new product launches.

Required to be introduced to market in 2021, this year's Product of the Year garnered 103 entries, representing a multitude of product specialties. Although the submission, review, and judging process is quite lengthy (beginning in January and ending with the winners' announcement in August), the final outcome is well worth the wait. After the entries are received, a panel of industry experts scores each submission based on a predetermined set of criteria, ultimately selecting category winners for the first phase of the competition. These category winners, which are featured in a special print supplement that accompanies our April issue as well as online, are then narrowed down to three finalists — from which our entire reader base votes via an online poll. From these votes, which exclude manufacturers or manufacturers' reps, the platinum, gold, and silver winners are determined.

I cannot emphasize enough the variety of submissions we receive, and this year was no exception. When all of the votes were in, the On-Demand Safety Labeling Solution from Brother Mobile Solutions took the coveted top spot as the 2022 platinum award winner. Streamlining the process of creating and implementing safety signage labels, this product ensures compliance and enables end-users to adhere to changing regulations. Thanks to its LabelSuite safety label design software (included free with the purchase of the printer), users can design compliant signs on demand in the facility or in the field. Read the full article on page 16 to see what features led our readers to name it as their favorite product along with descriptions of the first and second runner ups. Securing the gold award, ABB's ReliaGear LV Motor Control Center is designed for up to 3,200A bus, across-the-line starters through size 6, and variable-speed drives up to 500 hp. An optional Bluetooth control panel also provides remote monitoring and control outside the arc flash boundaries. Capturing the silver award, Milwaukee Tools' M18 Utility Remote Control Search Light Kit with Portable Base also impressed readers. This IP56-rated searchlight can be used to illuminate inaccessible areas while mounted to a bucket truck or attached to the M18 portable base.

Speaking of innovation, here's a throwback to the very first winner of our inaugural competition back in 2001: Encore Wire's color-coded residential wire and cable. The back story on this product launch involved the company looking for a solution to simplify the arduous and tedious task of pulling (and identifying) hundreds of feet of cable for dozens of circuits on extremely large projects, which was previously done with phase tape or other identification products. This novel idea — each conductor in a different color — enabled electrical contractors to streamline installation and inspection, simplify inventory management, and provide a safer, more efficient work environment. To geek out on more Product of the Year nostalgia, visit https://bit.ly/3BQ41k0 to peruse all of our past winners from the last 20-plus years.

Ellen Parson

Are You Profitable Installing Hospital Cabling Projects?

A Maryland medical center awarded a **CAT 6A** data cabling contract to an ICC Certified Elite Installer™.

A Nevada health center awarded a **CAT 6A** data cabling contract to an ICC Elite Installer™.

A Montana health center awarded a **CAT 6A** data cabling contract to an ICC Certified Elite Installer.

For over 30 years, ICC has been the top choice among hospitals and medical centers for their data cabling needs. Our **CAT 6A** UTP Patch Panels perform better than the big brands, but cost 40% less.* Our solutions fit hospitals' budgets and help installers increase margin; it's a win-win! So, if you are struggling to make a profit installing the big brands, it is time to try ICC. Check us out at icc.com/success.

CAT 6A 110-Style Patch Panels

100+ Re-terminations

CAT 6A Modular Patch Panels

Flexible Upgrades

We sell through distribution partners only; we have hundreds of distributors nationwide who would love to have your business. Find them on icc.com/distributor or contact us at cs@icc.com.

ICC®

JENNE®	TELEDYNAMICS®	TARGET DISTRIBUTING	Beach wire and cable	Coleman's TELECOM	fontel
Ohio	Texas	Maryland	California	Utah	Nebraska
800.422.6191	800.847.5629	888.792.7463	800.309.2322	801.484.5238	800.238.0787

icc.com cs@icc.com

Premise Cables · Workstation Outlets · Patch Panels · RCM · Fiber Optics · Residential Enclosures

*Compared to big brands.

The History of Supply-Side Interconnections and the National Electrical Code

How the NEC has evolved to bring clarity to how supply-side interconnections are made

By Doug Smith, IAEI

Supply-side interconnections have long been permitted by the National Electrical Code (NEC) as a method of interconnecting a power production system with the electrical system of a building. Common power production systems in modern times include solar photovoltaic (PV), generators, fuel cells, energy storage systems, and wind generation systems. To clarify, per the definition of "power production systems" found in Art. 100 of the 2020 NEC, services for electric utilities are *not* considered as power production equipment.

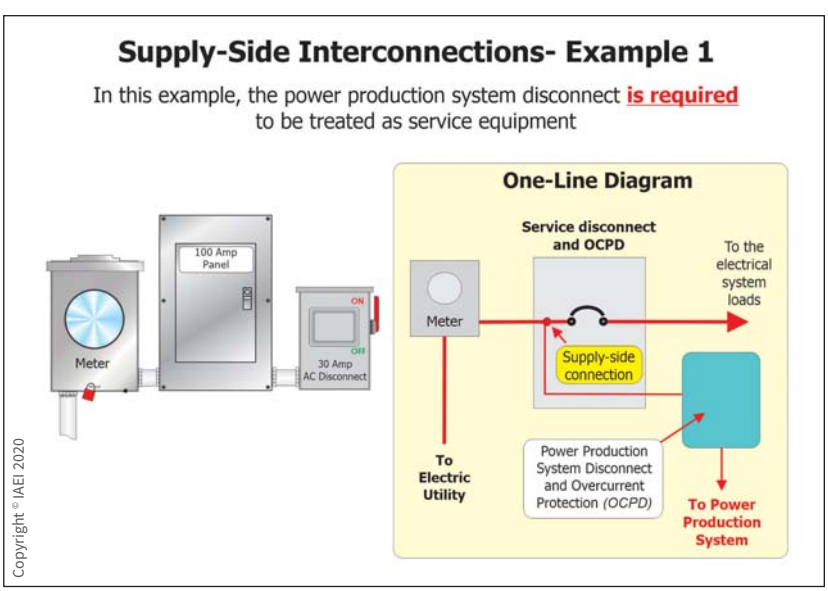


Fig. 1. The disconnect must meet the overcurrent protection requirements of Part VII of Art. 230

REQUIREMENTS FOR SUPPLY-SIDE INTERCONNECTIONS?

Even though NEC editions prior to the 2020 NEC allowed for supply-side interconnections for power production sources, there was not a lot of clarity on the requirements that needed to be followed when performing such a method of interconnection. From the 1999 edition of the NEC to the 2005 edition, the language for supply-side interconnections was: "A photovoltaic power source shall be permitted to be connected to the supply side of the service disconnecting means as permitted in 230.82…" This language was found under NEC Sec. 690.64(A).

In the 2008 NEC, the same language was moved from Sec. 690.64(A) to Sec. 705.12(A), but only the words "photovoltaic power source" were replaced with "electric power production source." In the 2011 edition of the NEC, additional language was added to Sec. 705.12(A) to clarify that the sum of the ratings of overcurrent devices for power production sources are not permitted to exceed the rating of the service that such system is connecting to [paraphrased].

Such language continued to be unchanged through the 2017 NEC. As far as NEC Sec. 230.82 was concerned (prior to the 2020 edition), such language was also not specific on what was required for supply-side interconnections. Rather, it only noted that other types of systems, such as solar photovoltaic, fuel cell, wind electric, or other electric power production sources, are permitted to be connected on the supply-side of the service disconnecting means.

So, essentially it was clear that the NEC allowed for supply-side interconnections of power production systems, but it wasn't very clear *how* such interconnections needed to be installed.

SERVICE EQUIPMENT OR NOT?

There was another issue causing confusion — the definition of "service" found in Art. 100 of the NEC appears to indicate that a service is only for delivering or connecting a serving utility to the

American Pros Use American-Made Steel Conduit

Atkore™
Allied Tube & Conduit

Saluting a workforce that will never quit.

For over 60 years, our American-made products* have helped American workers get the job done. And get it done right. Because with an unbreakable domestic supply chain and the highest quality EMT, IMC and GRC steel conduit providing the foundation, Atkore – Allied Tube & Conduit and the rock-solid American workforce will never stop building better together.

Learn more at alliedeg.us

electrical system for the premises. This definition was leading some individuals to believe that the first point of disconnecting equipment used for the power production system to connect to the supply-side of the premises electrical system was not required to be considered as "service equipment," primarily because a power production source is not considered as an electric utility as explained at the beginning of this article.

However, by not treating the first point of disconnect for the power production system as service equipment, it created issues such as improper bonding and grounding of the disconnect equipment. For example, there were installers that were not providing a neutral-to-ground main bonding jumper and grounding electrode conductor (GEC) for the power production disconnect equipment. This was a concerning trend for some in the industry, and many felt that changes were necessary.

CHANGES MADE

In the 2020 NEC, a change was made to Sec. 230.82(6) that clarified when making a supply-side interconnection, the disconnecting means for the power production source must be listed as "suitable for use as service equipment," and the disconnect must meet the overcurrent protection requirements of Part VII of Art. 230 (see **Fig. 1** on page 8).

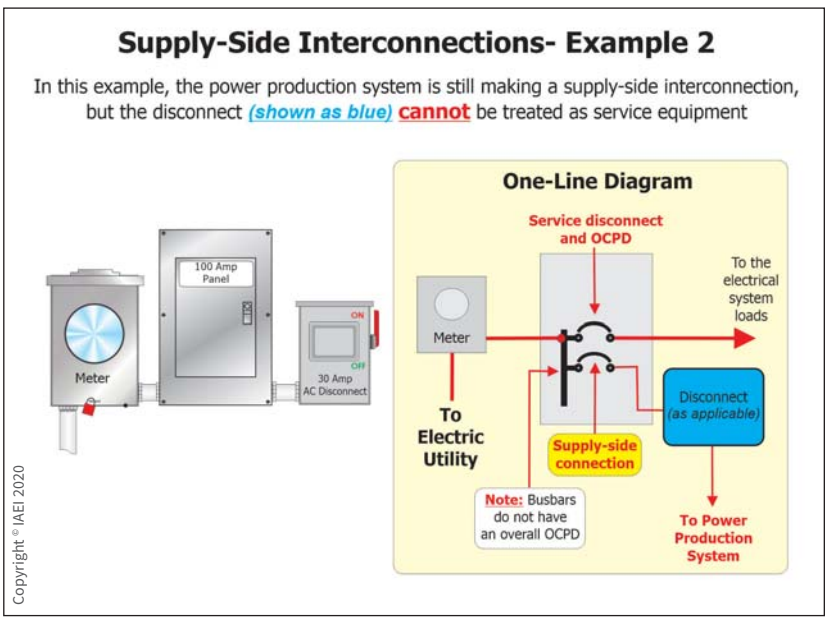


Fig. 2. Since the power production breaker is in the same enclosure as the service equipment, the provisions of Sec. 250.25 do not apply to any downstream disconnects for the power production system.

In addition, Sec. 250.25 was added to the 2020 NEC to clarify that the disconnecting means for the power production source must meet the grounding and bonding provisions of Sec. 250.24(A) through (D). This essentially clarifies that a neutral-to-ground main bonding jumper and GEC are required for the power production source disconnect.

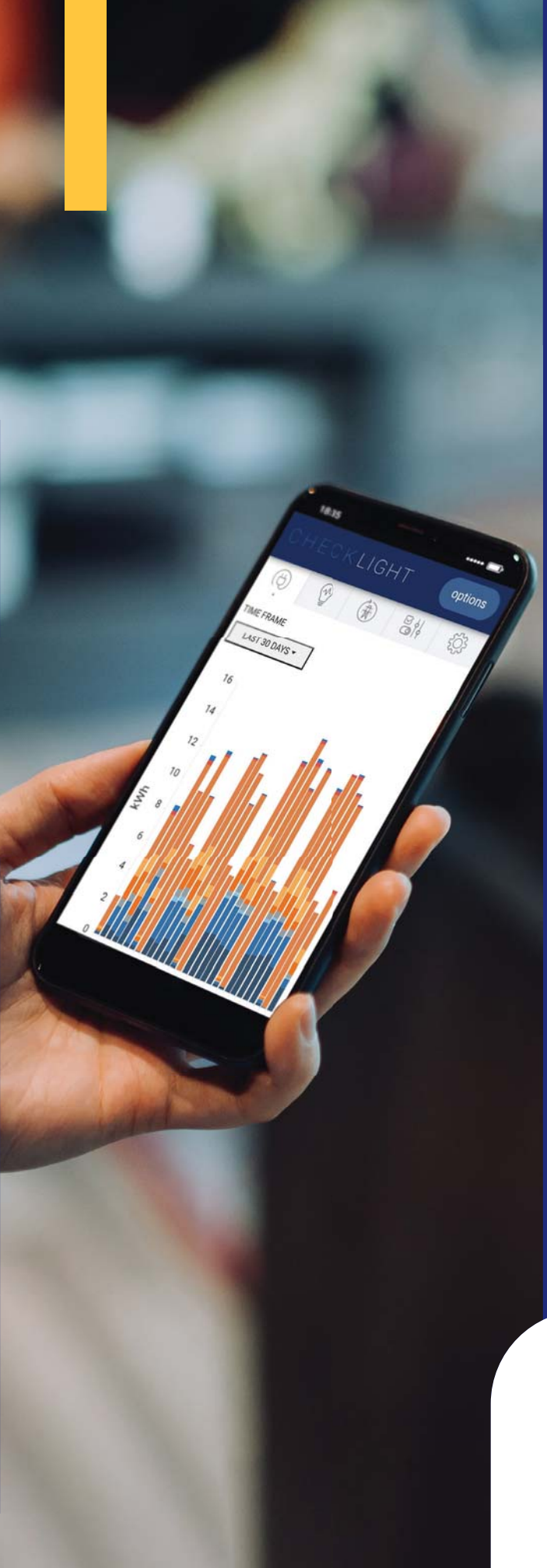
Although it is important to understand that this requirement only applies when the disconnecting means for the power production source is located in a separate enclosure from the premises service equipment, there are sometimes situations and service equipment where a breaker for the power production source can be connected in an available service breaker slot in the premises service equipment, which is also considered as a supply-side connection if the service equipment busbars that the power production breaker connects to is not protected by an overall main breaker. But in such a scenario — since the power production breaker is in the same enclosure as the service equipment — the provisions of Sec. 250.25 of the 2020 NEC do not apply to any downstream disconnects for the power production system (see **Fig. 2**).

THE FUTURE

The changes made to the 2020 NEC help provide guidance on what is required for the disconnecting means when making a supply-side interconnection. Additional changes will occur in the 2023 NEC to help provide further clarity for such methods of interconnections.

Supply-side interconnection requirements found in the NEC continue to evolve and provide more clarity for installers, AHJs, and the industry. The NEC is on the right path. Such methods of interconnection will continue to be an important option for connecting power production sources to premises electrical systems, but doing so safely (and in an appropriate manner) is essential. EC&M

Doug Smith is the energy division manager for West Coast Code Consultants (WC3) and has been an inspector/plan reviewer for more than 17 years. He currently serves on NEC Code Making Panel 10 representing IAEI and serves as an STP Member for UL 9540, UL 1741, UL 1703/61730, UL 2703, and UL 6703. He has been teaching solar PV, energy storage, and general electrical classes for over 10 years. He can be reached at dougs@wc-3.com.



End-to-end solutions without all the back and forth.

Gone are the days of sourcing multiple companies to complete a single project. Universal Douglas is the commercial lighting partner that supplies, manufactures and distributes everything from LED lighting fixtures to today's most innovative controls. It's how we're customizing and fully networking complete lighting systems and achieving the most efficient, stress-free results.

Visit universaldouglas.com to get started.

universaldouglas

TRUSTED NLB NATIONAL LIGHTING BUREAU WARRANTY

With 125 shared years of industry expertise, Universal Douglas is a trusted name in lighting fixture, retrofit, and integrated controls solutions. Unlike most, we complement our innovative LED portfolio with a line of traditional products for the most comprehensive service possible.

Measuring and Improving Underbillings

A way to maximize your profits

By Jennifer Daneshgari and Dr. Perry Daneshgari, MCA, Inc.

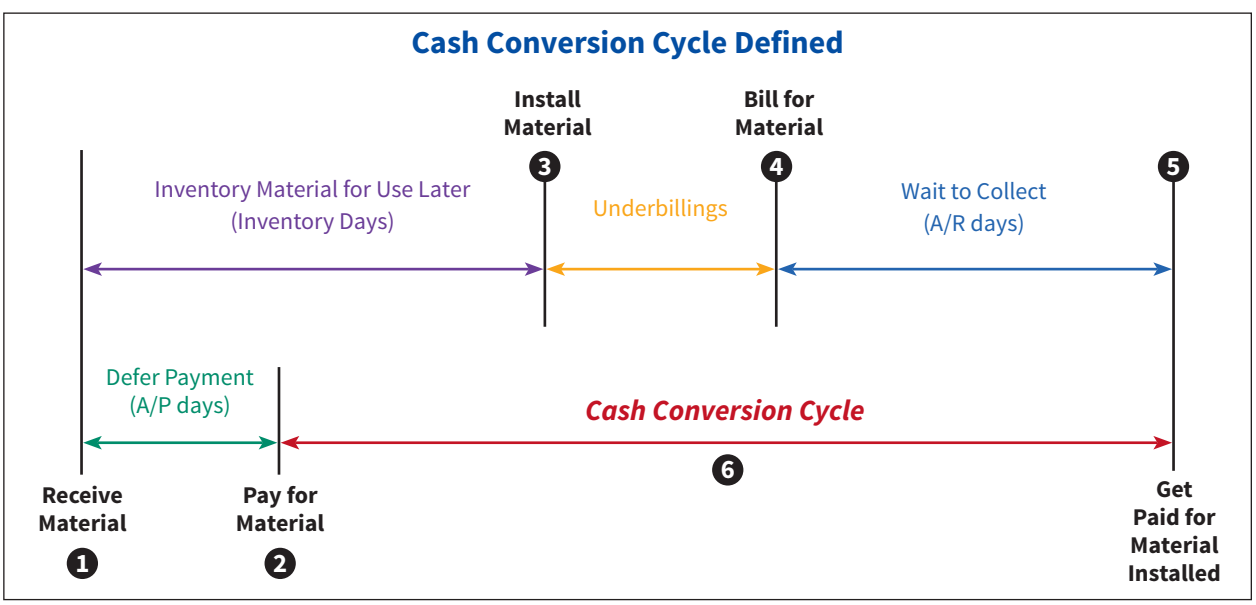


Fig. 1. Follow the numbed circles to identify the cash conversion cycle.

Many of us live by and believe in the motto, "cash is king," meaning that an overall positive cash flow will keep your business healthy and successful. Without positive cash flow, banks and other financial institutions may not allow you to continue to function.

Cash flow is often measured via a cash conversion cycle. A long cash conversion cycle (CCC) means you're funding jobs and even payroll from your pocket. A shorter cash conversion cycle reduces that issue and leaves cash available in the business for use as needed, including demonstrating business profits. Recognizing and improving under billings is key to improving your company's cash flow. The best way to do this is not via accounting, which is often looking backward, it's in the field — assessing where you are today and looking forward to what's remaining.

WHAT'S YOUR CCC?

A graphic of the CCC is shown in **Fig. 1**. To explain the movement in the graphic, follow the numbering in yellow:

1. You receive the material that you've ordered (this could be at the job site or in your warehouse or prefabrication shop).
2. You pay for the material.
3. You install or use the material
4. You bill for the material
5. You get paid for the material installed The time between when you pay for materials and when you're paid for installation of those materials is defined as the CCC. The longer this cycle, the longer you and your company are paying for this job. The knobs that are available to turn to reduce the CCC are your underbillings and your accounts receivables.

HOW ARE YOU BILLING, AND HOW DOES THAT IMPACT UNDERBILLINGS?

Before we talk about how to improve underbillings, it's likely best to think through how billing is done and how you choose what to bill. Are you using the Cost-to-Cost method or the Observed Percent Complete method? It's important, as the project manager/person doing the billing, that you bill based on the one that is higher. This will keep your cash flow higher. If you're using the Cost Accounting

Method when the Observed Percent Complete is higher than the costs, **Fig. 2** demonstrates that you may be leaving money on the table without recognizing it. An example is a $1-million dollar contract. The most obvious/known underbilling would be the difference between the $500,000 that you've billed and the $620,000 in cost you've spent. This is traditional accounting underbilling. This tracks costs spent to dollars billed. This is available by looking back into your accounting system. What you may be missing is: How complete is the work? Do not forget that with the Observed Percent Complete method through ASTM E2691, you can get paid for the pre-job and non-installation

> Recognizing and improving under billings is key to improving your company's cash flow.

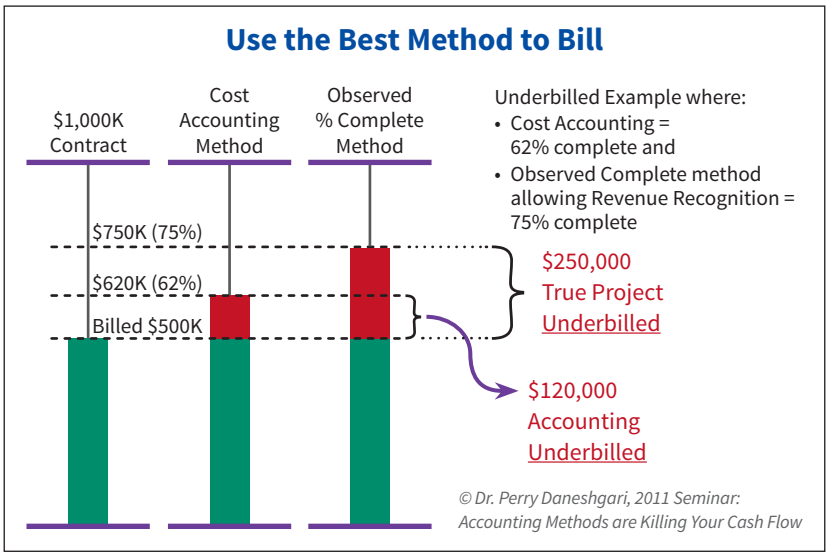


Fig. 2. If you're using the Cost Accounting Method when the Observed Percent Complete is higher than the costs, you may be leaving money on the table without recognizing it.

The Cost of Money: Underbillings and Uncollected Receivables		
What Do Underbilling and Uncollected Receivables Actually Cost You? (Contractor Example)		
A/R older than 60 days + underbillings	1	$323,561
Opportunity cost *(A/R + underbillings) x 12% stock market return/year =*	2	$38,827
Revenues required to cover cost *Opportunity cost / 34.5% GP =*	3	$112,542
Amount of work that needs to be bid to cover revenues *Revenues / 10% industry average hit ratio of $ bid to $won*	4	$1,125,420
MCA, Inc.		

What a company must do to cover for underbillings and aged A/R.

activities if you can track them and show how they contribute to fulfilling performance.

ASTM E2691 is the standard for construction productivity that uses Job Productivity Management (JPM). This begins at the job planning stage of the project and uses a work breakdown structure (WBS). Tracking against this WBS using the independent variable of work completed, the electrician can report the Observed Percent Complete for each task and recover revenue (including profits) for the actual percent completed on the job. The amount of true underbillings, per **Fig. 2** on page 13, would be $250,000 instead of $120,000. It's key to note that while accounting underbilling would show zero if you've billed $620,000, you are actually at $130,000 underbilled if you used the Observed Complete Method. Billing for this work is critical to your company's success.

LINKING THE COSTS OF UNDERBILLING AND ACCOUNTS RECEIVABLE (A/R)

Using an example of dollars involved in the CCC, let's see what the true cost of money is for your company. The **Table** on explains the work a company must do to cover for the underbillings and aged A/R.

1. The amount tied up in A/R older than 60 days plus the underbillings in the company — you can modify this to your value.

2. Opportunity cost: When money is not received, not only do you not have the actual money, but you also don't have the use of the money. The stock market's typical 30-year average return is 12% per year, so every month you do not have those funds, you're losing market gains (or paying interest on lines of credit).

3. Revenues required: Insert your gross profit number here. You must make additional money to pay for the money that is tied up in your CCC.

4. It's likely your estimating hit ratio is not 100%. The industry average is 10%. So, you have to bid 10 times the work to get a job that will give you the revenue to cover the money in your CCC.

What's the lesson to be learned here? It's critical that you reduce underbillings and collect on your A/R so that you do not have to tie up estimators and profits to cover this.

MAKE A PLAN TO MAXIMIZE YOUR PROFITS BY MEASURING AND IMPROVING YOUR UNDERBILLINGS

The key to this equation is shown in **Fig. 3.** You must minimize or eliminate underbillings. Your accounting team must track company profits based on FASBs ASC606 for Revenue Recognition. If you are not billing for either Cost-to-Cost or Observed Percent Completion on the job, your company will show a loss. You must truly know your Observed Percent Complete by using ASTM E2691 *Standard for Job Productivity Management* on your jobs. Do this by walking the job and comparing the work breakdown structure that defined the work. Track this with a job productivity management tool. Bill based on that percent complete and then be sure to collect that money. EC&M

Jennifer Daneshgari is vice president of financial services at MCA, Inc., Grand Blanc, Mich. She can be reached at jennifer@mca.net. Dr. Perry Daneshgari is president and CEO of MCA, Inc., Grand Blanc, Mich. He can be reached at perry@mca.net.

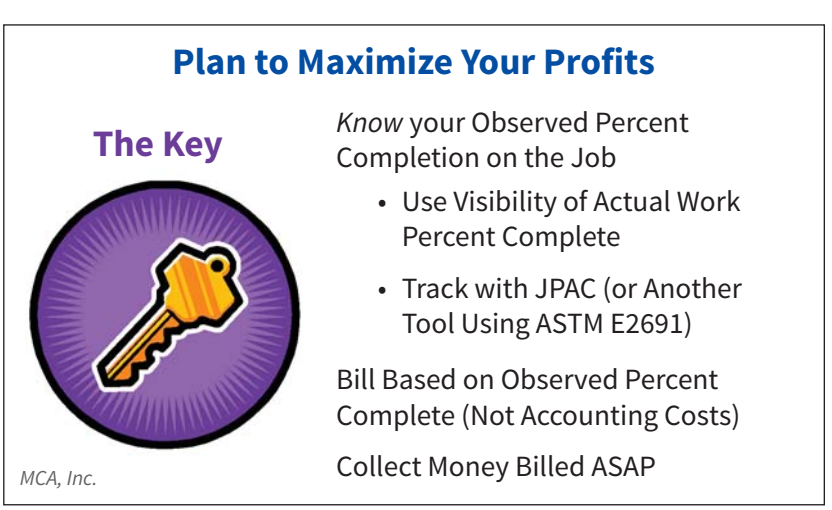


Fig. 3. How you can minimize/eliminate underbillings and maximize profit.

ARISTA™

Simple Installation, Limitless Applications

Take the hassle out of commercial lighting projects with the new **ARISTA™** Advanced Lighting Control System. The contractor-focused solution makes it easy for installers of all technology backgrounds to integrate wireless, code-compliant lighting control in a wide range of indoor applications.

Coming Soon:
More Applications,
Fewer Devices

Learn more today at **Intermatic.com/ARISTA**

INTERMATIC®

Streamlining Safety Labeling

The 2022 Platinum Award-winning product prints on-demand signage labels to ensure compliance and help protect workers.

By Amy Fischbach, Freelance Writer

To alert workers of hazards in industrial facilities, managers searched for a way to print safety labels on site. The labels needed to not only stay in place, but they also had to be compliant and adhere to changing regulations. By launching the On-Demand Safety Labeling Solution in September 2021, Westminster, Colo.-based Brother Mobile Solutions met the needs of its customers. The product also just won the Platinum Award in the 2022 *EC&M* Product of the Year competition based on reader votes.

"We wanted to provide users with an easy way to design and print compliant safety labels, specific to the needs of their facilities," says Kelly Swift, senior marketing manager for Brother Mobile Solutions, a provider of mobile, handheld, and industrial printing/labeling solutions. "The labels needed to be durable to the elements and rigors of the industrial environment with a variety of colors and types to meet compliance at an affordable price point."

The product has been on the company's radar for the last five years. While the company has had requests from customers to print safety labels with its printers, it didn't have the right material to print the colors, size, and durability needed for safety signage.

Over the course of 18 to 24 months, the company performed extensive testing on matching substrates with thermal transfer ribbons as well as print driver and internal printer settings. Various adjustments had to be made during the testing process, and printer, media and driver settings all had to be fine-tuned.

"With extensive testing, we made a lot of small adjustments to print speed and darkness so we could maximize the image and print quality for each media type," Swift says.

The engineering, sales, and marketing departments worked together to create the transportable and easy-to-use solution, which includes printers, software, and supplies. Users can now create and apply safety signage in different formats to follow OSHA, ANSI, NEC, and other safety standards. The Brother TD-4750TNWBCS facility and label printer, which offers lifetime technical support, produces durable, high-resolution (300 dpi) labels. The integrated cutter eliminates the need for scissors.

"The durable labels and ribbons stand up to the harshest environments and when paired with the power of thermal transfer printing, can stay adhered and readable for years," says Duane Yamashita, senior product manager for Brother Mobile Solutions.

The LabelSuite safety label design software, which is included free with the purchase of the printer, makes it easy to design compliant signs on demand right on site, Swift says. Users can print high-quality, durable, and compliant labels in the desired colors and sizes to meet their needs.

When designing pipe markers and secondary GHS labels, a virtual design wizard guides users through the process. After answering a series of questions, the software designs the appropriate label and directs users to the correct label to use. Customers can also use the software, labels, and printer

solution to print other labels around a facility ,including 5S, rack/bin labels, and labels for shipping and pallets with different label types.

"There are hundreds of templates and thousands of symbols to make designing compliant signs for arc flash, general OSHA compliant safety labels, and more easy," Swift says. "Also, the wide variety of label options in compliant colors and formats supports compliance so you don't have to be an expert to design and print compliant safety signs."

Designed for safety managers, EHS managers, and facilities managers, the labeling solution allows customers to print exactly what they need — in the quantity they are looking for — to fit the size of their facility at a lower price point than competitive products.

"Pre-printed safety signs require a minimum purchase, and you usually have to purchase more than you need," Swift says. "They also have lead times for shipping and aren't specific to your facility."

Swift says that users can help keep workers safe and increase efficiency by printing the safety signs they need right when they need them.

"They can identify and communicate a hazard to their workers immediately rather than waiting a week to get the right signage in place," she says. "At the end of the day, worker safety is the most important. Being able to create clear, compliant safety labels as soon as a hazard is identified that will last and remain readable is critical."

GOLD AWARD

MOTORS, DRIVES & MOTOR CONTROLS

ABB won the Gold Award for its ReliaGear LV Motor Control Center. With a compact footprint and flexible construction, the UL/cUL 845-listed product is designed for up to 3,200A bus, across-the-line starters through size 6, and variable-speed drives up to 500 hp. The optional Bluetooth control panel provides remote monitoring and control outside the arc flash boundaries.

SILVER AWARD

WORK LIGHTS

Milwaukee Tool won the Silver Award for its M18 Utility Remote Control Search Light Kit w/ Portable Base. The IP56-rated searchlight can be used to illuminate inaccessible areas while mounted to a bucket truck or attached to the M18 portable base. The wireless joystick remote gives linemen complete control over the light's positioning. The light can switch from spot mode, which produces up to 1,250 yd of beam distance, to flood mode, which provides 4,250 lm of visibility over a larger area.

THE *EC&M* TRADITION ENDURES

Established in 2001, the *EC&M* Product of the Year competition recognizes excellence in new product development for the electrical industry. Honoring inventiveness in product design, as well as improvements in safety and efficiency, the competition's two-fold judging and voting process determines the most ground-breaking products of the past year that allow electrical design professionals, installers, and maintenance personnel to perform their jobs more efficiently and effectively.

Products eligible for this year's competition were those introduced to the market between Jan. 1, 2021, and Dec. 31, 2021. A hand-picked panel of judges ranked the 103 products entered into this year's contest based on a uniform list of scoring criteria, ultimately selecting 31 category winners for the first phase of the competition. These category winners were then narrowed down to just three finalists through an online poll available to our readers on the *EC&M* website. *EC&M* subscribers determined the platinum, gold, and silver award-winning products of the year by casting their votes.

Laying the Ground Work for EV Chargers

Tips for best serving your customers' EV charger needs

By Gerald Talbot, Mister Sparky

As gas prices continue to rise, so does the demand for electric vehicles (EVs). People want to switch to a vehicle that doesn't cost them an arm and a leg to "fill up." And having a home EV charger adds a whole new level of convenience.

But what does this mean for the electrical contractors who install the chargers for these vehicles? Whether EV chargers will be the everyday service call or an occasional job, we must be ready to provide proper power and know all the little tricks of the trade when it comes to the installation of this equipment.

Here are a few things to keep in mind when pricing and installing EV chargers.

- Stay up to date on the cost of wire. Most EV chargers require at least a 50A to 60A capacity. The market price of this cable is expensive, so count every foot.
- Help lead the client toward picking a charger that will charge the car faster than 12 to 14 hours. We have seen that people think they want to go cheap on the EV charger install, but, in the end, complain about charging times. Therefore, I would suggest a Level 2 or even better, a Level 3 charger.
- Most chargers require copper wire only, so don't make the mistake of running aluminum circuitry thinking you are saving money. You will just end up voiding the warranty on the unit.

Gerald Talbot

- Install the charging unit in a place that will not get hit by the actual vehicle while also in an accessible location.
- Make sure the service is large enough to provide power to a large charging unit. This means 60A or more added to the overall power consumption on the main service.
- With efficiency top of mind, now would be a good time to suggest other cost-saving solutions. Occupancy sensors, lighting dimmers, LED bulb conversion, and smart home add-ons can be some of the topics of discussion.
- Remember to educate the client on the unit. They are trusting us to be the experts. Sometimes, it may even help to guide the client toward the best charger or at least present options for the client to consider.
- Article 625 of the National Electrical Code (NEC) should be referenced when installing vehicle charging stations. Remember to follow all applicable codes from your local jurisdiction.

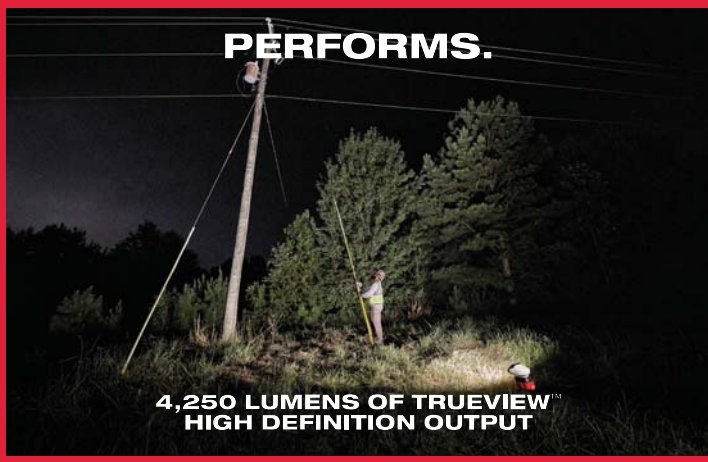
The jury is still out on the longevity of EV charger equipment or the hazards associated with them, so follow all safety protocols while installing these units. As the years pass, we will continue to learn more about what to expect. EC&M

The jury is still out on the longevity of EV charger equipment or the hazards associated with them, so follow all safety protocols while installing these units. As the years pass, we will continue to learn more about what to expect.

Gerald Talbot is a licensed, master electrician in Georgia, where he was born and raised. He has been in the industry for 22 years and is currently the operations manager for Mister Sparky Atlanta, where he manages a team of technicians. In his spare time, he plays with his kids, volunteers, and enjoys flipping houses. He can be reached at gerald.talbot@mistersparky.com.

NEW

SPOT LINES. FLOOD FIELDS. GO ANYWHERE.



M18™ Utility Remote Control Search Light

KIT
2123-21HD
Remote Control Search Light Head, (1) M18™ REDLITHIUM™ HIGH OUTPUT™ HD12.0 Battery Pack, M18™ & M12™ Rapid Charger, 12V DC Permanent Base, M18™ Portable Base, Remote Control, Dash Mount, Lanyard and Carry Bag

TOOL-ONLY
2123-20
Remote Control Search Light Head, 12V DC Permanent Base, M18™ Portable Base, Remote Control, Dash Mount, Lanyard and Carry Bag

TOOL-ONLY
2123
Remote Control Search Light Head, 12V DC Permanent Base, Remote Control, Dash Mount and Lanyard

TOOL-ONLY
49-16-2123B
M18™ Portable Base and Carry Bag

M18
PERFORMANCE DRIVEN
TRADE FOCUSED
SYSTEM WIDE

Navigating Codes for Solar and Solar-Plus-Storage

What codes and standards should PV and ESS installers be familiar with?

By Ryan Mayfield, Mayfield Renewables

Photo courtesy of Mayfield Renewables

Electricians and solar installers are required to navigate several codes and standards when installing solar photovoltaic (PV) and energy storage systems (ESSs). Solar and energy storage equipment manufacturers introduce new equipment at seemingly lightning speed; therefore it can be difficult to stay on top of all the requirements. This article highlights the key codes and requirements contractors working with solar PV and battery storage systems should be familiar with.

NATIONAL ELECTRICAL CODE

The most common code that system designers, installers, and inspectors refer to for PV and ESS installation is NFPA 70, *National Electrical Code* (NEC). PV systems have requirements that span multiple Articles in the NEC. Technicians need to navigate these requirements to install Code-compliant PV and ESS installations.

Article 690 [Solar Photovoltaic (PV) Systems] is the primary Article to reference when designing and installing PV systems. This Article supplements — and, in some cases, modifies — the general requirements located in Chapters 1 through 4 of the NEC. Article 690 has seen substantial changes over the last several Code cycles. These changes are not surprising given the rapidly advancing nature of the solar-plus-storage industry. Admittedly, the Code is often playing catch-up with advancements in solar technology and system components.

Everything in Art. 690 is important for technicians to understand, but here are a few of the key Sections that should be well understood and often lead to the most confusion.

IDENTIFICATION OF PV SYSTEM COMPONENTS IN COMMON CONFIGURATIONS

There are five different images in Fig. 90.1(b) of the NEC, which was updated in the 2017 Code cycle. These images are important to examine because they visually help installers understand how to apply Code requirements to different solar PV components and circuits. For example, the **Figure** shown on page 22 — based on NEC Fig. 90.1(b) — shows a direct grid-tie system that does not incorporate storage. A direct grid-tie or "batteryless" PV system is the most common system type solar companies install across the country today. The

image is helpful because it defines the PV system disconnect, a point of demarcation for the PV system.

The PV system disconnect does not necessarily need to be a knife switch. It can also be a breaker that interconnects the inverter to the electric utility supply. Additionally, it is important to note that this image may not represent all required system components.

SECTION 690.12

Rapid shutdown requirements were added to the NEC during the 2014 Code cycle. The intention of rapid shutdown is to protect firefighters from the shock hazards they may encounter when interacting with a rooftop PV array while doing fire-suppression activities. When installed to Code with good attention to installation details, solar PV systems are inherently as safe as any other electrical system installed per Code. Note that these rapid shutdown systems are not meant to be used during routine system-maintenance activities.

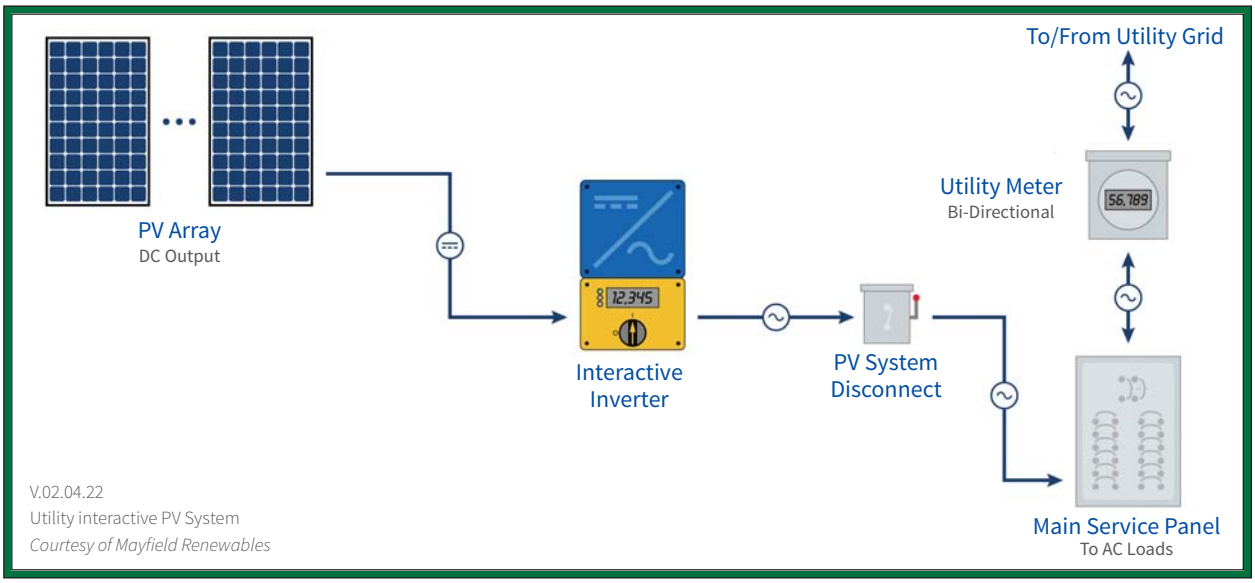
Rooftop solar PV array circuits must be controlled to reduce potential shock hazards to firefighters. To meet this requirement, the rapid shutdown section of the NEC provides multiple ways to meet the requirements based on the location of the circuit in relation to the PV array.

Many PV installers use module-level power electronics (MLPE) to meet these rapid shutdown requirements. MLPE devices are typically mounted directly to the same racking system that supports the PV modules and are wired directly to the modules. These devices may be DC-to-DC converters or DC-to-AC inverters. MLPE can control the voltage on their respective circuits through a rapid shutdown initiation. The most common initiation is the loss of AC power that sends a signal to the MLPE devices to reduce the circuit voltage to an acceptable level per Code requirements. Other initiation devices that are properly labeled and accessible are acceptable as well.

A recently released UL standard, "UL 3741 Photovoltaic Hazard Control," is being employed by some manufacturers. This standard provides testing mechanisms for equipment manufacturers to prove their equipment provides effective and compliant shock protection for firefighters. This new standard and its application on the rooftop lead to new array configurations, inverter location strategies, and reducing (or possibly eliminating) the need for MLPE devices within the array while still meeting Sec. 690.12 requirements.

ARTICLE 705 [INTERCONNECTED ELECTRIC POWER PRODUCTION SOURCES]

This Article covers the requirements for interconnecting all power production sources, so it isn't unique to solar. Most installed PV systems are interconnected with the electric utility grid; therefore, Art. 705 is an integral part of installations.



The PV system disconnect does not necessarily need to be a knife switch. It can also be a breaker that interconnects the inverter to the electric utility supply. Additionally, it is important to note that this image may not represent all required system components.

The most often-cited section of Art. 705 are Sec. 705.11 [Supply-Side Source Connections] and Sec. 705.12 [Load-Side Source Connections]. The reference to "side" is the main service-disconnecting means. Article 705 allows for the connection of power-production sources to either side of the main service-disconnecting means. This is an important consideration, as the associated requirements can be dramatically different depending on where the connection is located in relation to the main service disconnect.

Additional Articles that impact PV installations include: Art. 691 [Large-Scale Photovoltaic (PV) Electric Supply Stations]; Art. 706 [Energy Storage Systems]; Art. 480 [Storage Batteries]; and the entirety of Chapters 1 through 4 — with Art. 250 and Art. 300 being commonly referenced.

The addition of battery storage to existing or new PV systems is growing rapidly across the U.S. In many cases, jurisdictions do not have much, if any, experience with these systems. Authorities Having Jurisdiction (AHJs) often rely on solar-plus-storage system installers for help understanding the proper Code requirements that apply to a given system. This information-sharing partnership is similar to general PV systems 20 years ago, when the learning curve for Code officials was also steep. It is important for installers to recognize the codes and standards that apply to solar and energy storage systems. Be prepared to help educate your local code officials, especially in regions where solar PV is less common or when manufacturers release new equipment and technologies.

FIRE CODES

Outside of the NEC, technicians need to be cognizant of the fire codes their jurisdictions enforce and how PV systems are regulated within those codes. The most common fire codes are NFPA 1, *Fire Code* and ICC's International Fire Code (IFC). These codes typically impact the physical layout of PV modules on the roof of a building. The intent is to provide safe access around the equipment in the case of a first responder suppressing a structure fire from a building's rooftop.

The rules typically vary based on the type of structure — residential versus commercial, the roof pitch, and the overall area of the array. Pathways around the perimeter of the array are a general requirement per IFC 605.11.3.2.1. Residential requirements start with 3-ft pathways for firefighter access. For larger commercial rooftops, it is common to require pathways across the roof at least every 150 ft.

Fire codes also regulate the use and location of ESSs. Chapter 15 of NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*, provides requirements for residential systems. ESS spacing, unit capacity limitations, and maximum allowable quantities (MAQ) depending on location.

STRUCTURAL CODES

PV systems also have structural requirements and codes associated with them. Many jurisdictions use ICC's International Building Code (IBC) and ASCE 7 to guide the structural components of a PV installation. The IBC addresses the installation methods of roof attachments in Sec. 1503, fire classifications for PV systems in relation to the roofing material in Sec. 1509, and structural loading considerations in Sec. 3403. This aspect of PV installations can vary widely between jurisdictions, so it is best to familiarize yourself with the local requirements prior to system design and installation. EC&M

Ryan Mayfield is the CEO and founder of Mayfield Renewables, Corvallis, Ore., a technical consultancy and system design and engineering firm well known for solar-plus-storage expertise. He has more than 20 years of experience designing and consulting on solar PV projects while also teaching NABCEP-certified courses on the NEC. He can be reached at ryan@mayfield.energy.

Atkore™
Calbrite

The Most Stainless Steel Electrical Conduit Solutions

...To Help Lower Material, Shipping and Labor Costs

From the reliability of rigid conduit, to the versatility of IMC, to the lightweight affordability of EMT conduit, Atkore has the optimum stainless steel conduit solution for any application.

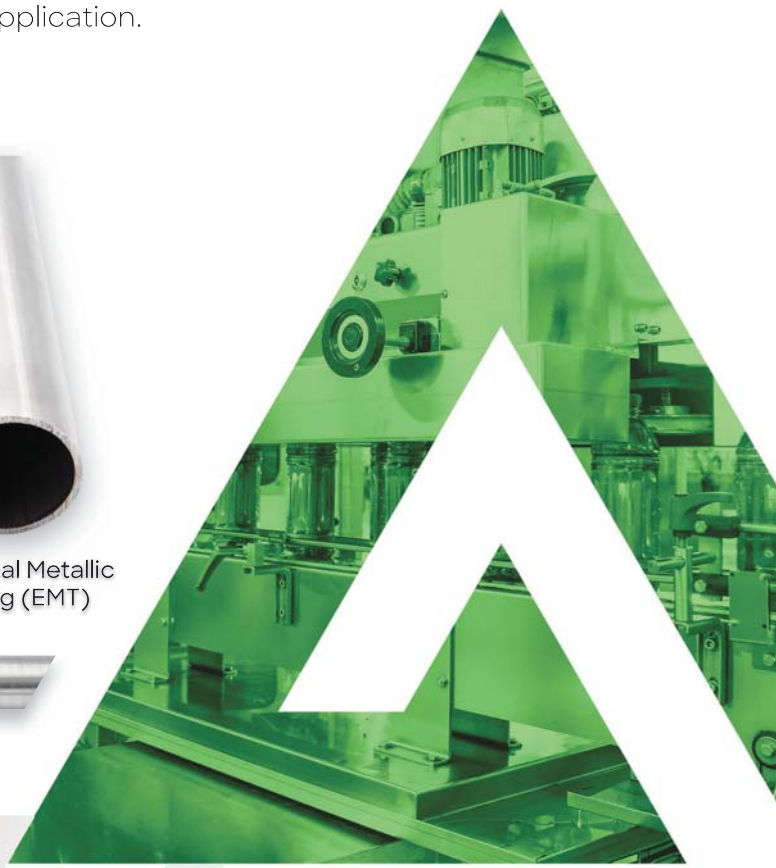
Call for a quote today.

Rigid Conduit

Intermediate Metal Conduit (IMC)

Electrical Metallic Tubing (EMT)

All Calbrite Stainless Conduit and Fittings now with Laser Etched Labels



(800) 536-2248
Atkore.com/calbrite

How to Troubleshoot AC Induction Motors Effectively

Causes and cures for the most common types of motor failure and operation disruption plus best practices for increased performance

By Mike Howell, EASA, Inc.

Small and medium AC induction motors account for more than 75% of motor electrical energy demand; however, they typically receive less maintenance than their larger counterparts. This leaves them vulnerable to unexpected failures and costly downtime. Besides providing some basic troubleshooting tips for these machines, this article explores common motor symptoms, associated problems, and when to involve an electric motor service center.

Definitions of small, medium, and large motors vary by standard and manufacturer, but this discussion uses the values in **Table 1** on page 26.

STARTING

No power — If the motor fails to start and there is no rotation, electrical humming noise, or signs of heating, tripped overload relays are the most likely issue. While it is permissible to reset the relays and start the motor, always investigate the cause of the trip — even when the motor operates normally after the start.

If the relays have not tripped, investigate the motor's power supply. If the input voltage is okay, perform diagnostic testing on the motor.

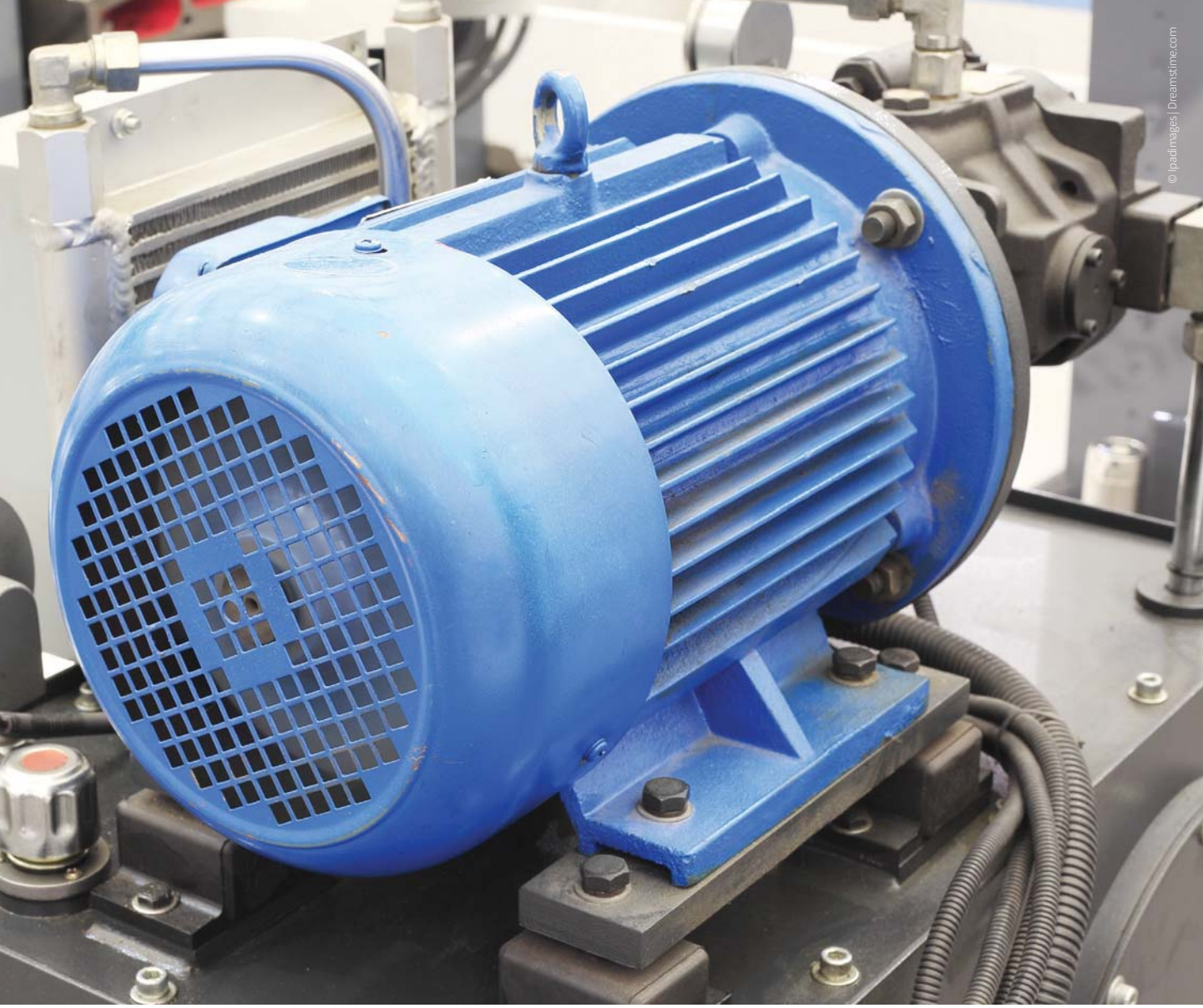
Power, but no rotation — If the shaft fails to rotate, and the motor emits a humming noise or shows signs of heating, shut off the power immediately. In a stationary position at rated voltage and frequency, an induction motor will undergo significant heating that can damage components quickly.

This condition can occur if the motor input circuit is in a single-phased condition and thus unable to produce a rotating magnetic field and an accompanying accelerating torque. A technician can verify this by checking the input line-to-line voltages, which should be balanced and within 10% of the motor's rated voltage.

If the motor previously has operated in a single-phased condition, it will have experienced significant heating and may have operated until an operator shut it down. If the motor winding is single-phased, restarting will not be possible. Inspection usually will confirm this condition with one-third or two-thirds of the winding discolored, but this requires at least partial disassembly (**Photo 1** on page 26).

If the motor is locked mechanically, uncouple it from the load, and turn the shaft manually to determine if the bind is due to the driven equipment, the motor bearings, or the rotor. A smooth manual rotation of the motor shaft indicates an issue with the driven load.

Trips — If the overload relays are tripping during starting, there are a couple of potential issues. First, verify that the relays are the size specified by code for the motor's nameplate current and service factor. Additionally, when replacing an old motor with a new one, check the starting current. Newer motors with higher efficiency ratings tend to have significantly higher starting current than their older counterparts. Evaluating starting current should be part of the procurement process, but many organizations miss this.



One advantage of solid-state overload relays over the bimetallic type is that they often allow for adjustment of the trip class, which gives some flexibility in starting characteristics for different motors in an application.

Low acceleration — Lower than rated supply voltage magnitude or excessive voltage drop during starting will reduce the motor's accelerating torque. Torque is roughly proportional to the square of the voltage, so a 10% voltage reduction will reduce torque by 20%.

A variable-voltage, fixed-frequency starter (e.g., wye-delta, part-winding, autotransformer, or electronic soft start) will reduce the accelerating torque. Often, this is desired. However, if the acceleration time is too long, it will be necessary to reduce the starting load, use a larger motor, or modify the starting method. On the other hand, using a variable-voltage, variable-frequency drive (VFD) will allow for much more controlled acceleration without sacrificing accelerating torque.

Many small and medium induction motors are manufactured with six, nine, or 12 winding terminals to facilitate use with various supply voltages and starting methods. Misconnecting the motor to the supply lines commonly causes low acceleration. For example, a 12-lead motor may be configured for connection to a 230V supply or 460V supply and be suitable for wye-delta starting on either voltage or part-winding starting on 230V. However, if the motor is designed to start direct online for 230V but is instead connected for 460V (or connected wye when it should be delta), it will be significantly weaker than intended. In some cases, it will run for some time and fail with an appearance of overload (**Photo 2** on page 28); in other cases, it will not start. Note that connecting the motor for 230V when it should be 460V (or connecting it delta when it should be wye) will have the opposite effect — very high starting current likely to trip on start.

RUNNING

Overheating — Most electric motors are manufactured with a specified maximum ambient temperature of 40°C (104°F). While maximum allowable temperatures vary by standard, motor size, service factor, rated voltage, and method of measurement, they will be near the motor's insulation system thermal class (**Table 2** on page 28).

The surface or skin temperature of electric motors varies widely by design. Absent guidance from the manufacturer, it is usually not a reliable location to evaluate winding temperature rise. However, comparing skin temperature with data from previous measurements (or other identical motors in the same application) may be helpful. Embedded detectors like thermistors, resistance temperature detectors (RTDs), or

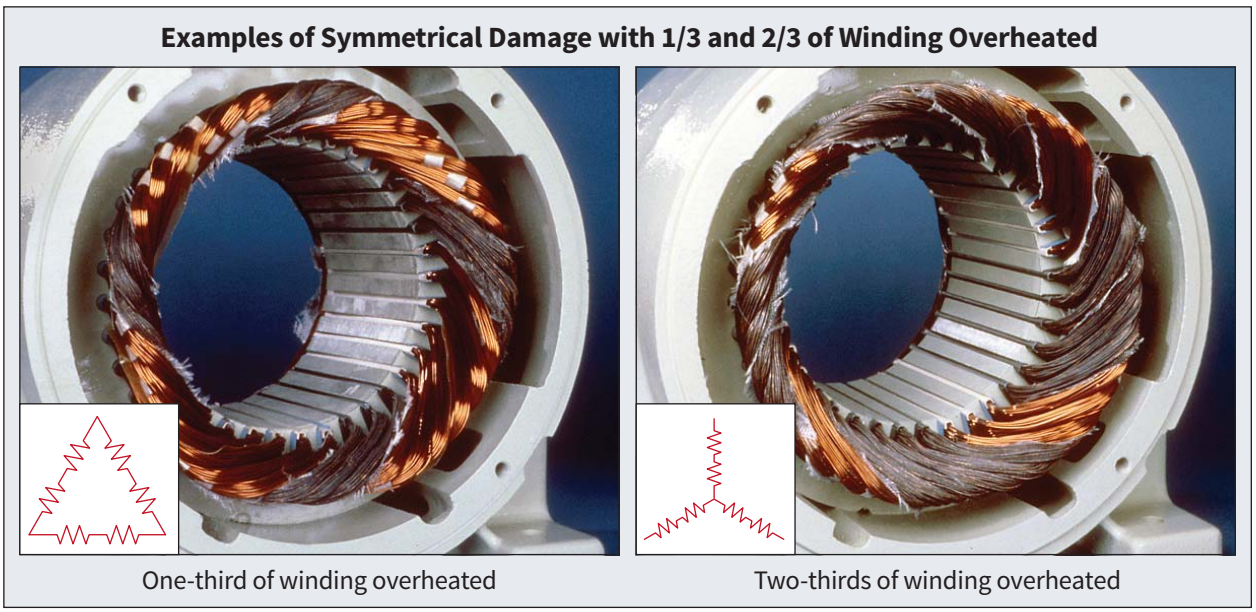


Photo 1. Examples of symmetrical damage with one-third and two-thirds of winding overheated.

thermostats are much better options for evaluating winding temperature. While thermostats cannot provide numerical data, they can indicate a specific temperature has been reached. Many small and medium motors might not be equipped with embedded temperature detectors, but a service center can add them.

If a motor is overheating, first verify that the input current in all three phases does not exceed the motor's ratings. If it is overloaded, either reduce the load enough that the total winding temperature is within permissible limits, or install a motor with an appropriate output rating. Sometimes service centers can redesign machines to alleviate the problem.

Excessive starting or exceeding a motor's rated duty cycle also can cause overheating. Both topics are beyond the scope of this article but merit evaluation when selecting a motor for an application or investigating an overheating problem. A qualified service center can help end-users with these tasks.

Another common cause of overheating is poor ventilation. The installation and maintenance manuals for new motors usually describe the ventilation requirements for proper operation. Common issues include installing the motor too close to walls, structures, or other equipment that restricts the flow of cooling air or increases the ambient temperature.

Very low operating speed — Sometimes, a motor starts but runs well below its rated speed when supplied with rated voltage/frequency. This usually trips an overload relay (based on its current setting and trip class), but the behavior should be observable before the trip. Significant overload is a common cause of this condition, but others are worth mentioning.

Motor Size	Maximum hp (kW)	Median hp (kW)	Motor Electrical Energy Demand (%)
Small	1.0 (0.75)	0.21 (0.16)	9
Medium	500 (375)	12.7 (9.5)	68
Large	—	1,000 (750)	23

Table 1. Motor electrical energy demand based on data from "Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems," International Energy Agency, 2011.

The **Figure** on page 28 shows speed-torque curves for two different motors with the same horsepower (kilowatt) rating and the same number of poles, along with two load-torque curves — one for constant torque and one for variable torque. Relative to the load-torque curves, Motor 1 has a positive accelerating torque from zero speed to normal running speed, so it would accelerate either load up to the intersection of the speed-torque and load-torque curve.

Although Motor 2 has greater starting torque (torque at zero speed) and greater breakdown torque (maximum torque) than Motor 1, it has a lower pull-up torque (minimum torque between locked-rotor and breakdown). Since its speed-torque curve intersects the constant-load torque curve between locked-rotor and breakdown, Motor 2 would operate at that point and accelerate no further. Either motor would accelerate the variable-torque load.

The scenario that the **Figure** on page 28 presents can be puzzling to encounter because the basic performance data (starting and breakdown torque) might seem "stronger" for Motor 2 than Motor 1, even though both motors have almost the same nameplate data. This potential issue is more likely with medium and large motors than small motors and requires comparative pull-up torque values to identify.

Remember that even though it is generally permissible to operate small and medium motors as low as 90% of rated voltage, the roughly 20% reduction in torque could prevent acceleration of an appreciable load.

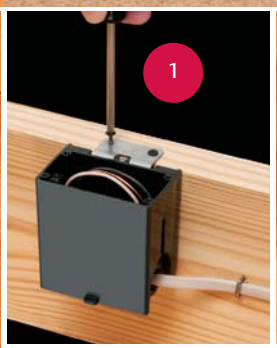
High vibration/noise — High vibration levels or mechanical noise are often caused by improper mounting or a change in mounting of the motor or driven equipment. These issues can often be resolved by ensuring that foundations are rigid, motor feet are co-planar (properly shimmed if needed), and fasteners are tightened properly.

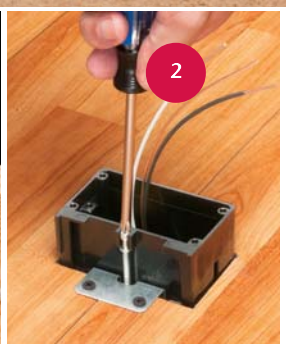
Other common causes of high vibration or mechanical noise include an out-of-balance condition in either the motor, coupling (sheave), or driven load. Determine the source of imbalance by operating the motor uncoupled

ADJUSTABLE NON-METALLIC BOX **WITH MULTIPLE COVER OPTIONS** Made in USA

FLOOR BOX KITS

FLUSH-TO-THE-FLOOR RECEPTACLE INSTALLATIONS *THE EASY WAY!*

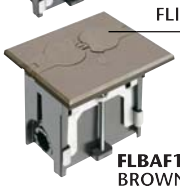




Designed for New or Retrofit work, Arlington's UL LISTED ADJUSTABLE FLOOR BOXES fit varying floor heights up to 2".

They're the low cost, *easy way* to install a duplex receptacle flush with the floor.

- **Gasketed covers with ONE or TWO FLIP LIDS** prevent water intrusion and protect the box when not in use
- **Non-Metallic Covers** Black, brown, light almond and **Metal Covers** in brass and nickel-plated brass.



FLBAF101BR
BROWN

UL LISTED

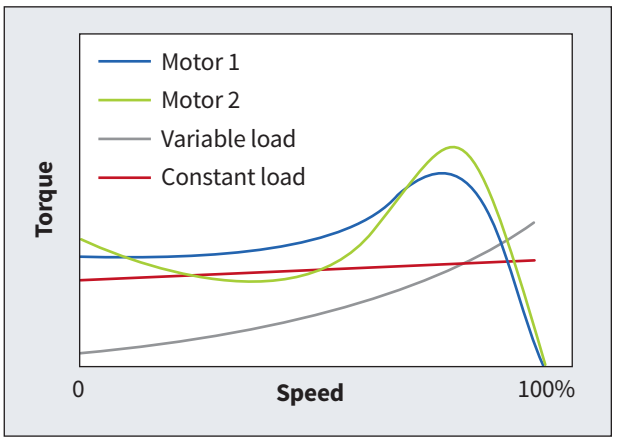
FLBAF101LA
LIGHT ALMOND

Arlington® TM

www.aifittings.com Scranton, PA 18517 **800/233-4717** Patented

Product info http://www.aifittings.com/landing/flbaf-floorboxes

Photo 2. Excessive overheating failure caused by an overload condition.



Example of motor speed-torque curves.

Thermal Class	Class Temperature	
B	130°C	266°F
F	155°C	311°F
H	180°C	356°F

Table 2. Common motor insulation system thermal classes.

from the load with the coupling (or sheave) installed and then, if necessary, without it. Next, verify the alignment between the motor shaft and driven load, and correct it if needed. A less common issue is a resonance in the mounted system that requires dampening or modification to resolve.

Vibration analysis with a spectrum analyzer can save a lot of time in determining the issue and the best course of action. If plant maintenance personnel are not trained and equipped to perform the analysis, it's usually worthwhile to contact a service center for assistance.

Bearing noise — Most small and medium induction motors have rolling element bearings (the types considered here). Once these bearings become noisy, they are damaged and should be replaced. When replacing damaged bearings, however, invest the time to determine the cause. Any of the conditions described under "high vibration/noise" above could lead to bearing failure.

Additionally, either loose or tight internal fit will reduce bearing life. This includes bearing housings and shaft bearing journals that are too large or small — or less commonly a bearing manufactured out of tolerance. Bearings last longest when they are mounted and lubricated correctly and protected from foreign materials, including water and dirt. But rolling element bearings have finite lives that generally decrease with increasing load or higher speed. So, expect them to fail at some interval, regardless of application, environment or mounting quality. It's also worth mentioning that many more bearings fail due to over-lubrication than under-lubrication.

WHEN TO SEEK HELP

Reliability — Motors are expensive assets, and, in many applications, unplanned downtime exceeds the cost of the motor exponentially. When feasible, systems analysis should include condition monitoring to prevent failures and unplanned downtime.

Online or real-time data monitoring that can accurately diagnose potential or developing faults within a system is preferred. Where measurement of parameters is impossible or cost-prohibitive, use preventive and then corrective maintenance approaches. Based on condition monitoring and consistent with industry standards, typical decisions would include:

- No action; continue routine monitoring.
- Reduce the interval to the next required measurement.
- Change the machine load, speed, or throughput.
- Shut down the machine.
- Inspect the machine or bring forward planned maintenance.
- Carry out corrective maintenance.

A qualified service center can help you establish maintenance practices that improve system reliability.

Diagnostic tools — Many diagnostic tools are available for testing electric motors and vary widely in cost, function, and learning curve. End-user needs also vary widely depending on their maintenance personnel, motor population, and reliability program. Before investing in test equipment, spend sufficient time learning what it can and cannot do and how its capabilities support your objectives. A qualified service center can be helpful with these evaluations and recommendations.

And remember, it is not always necessary to diagnose a problem initially — just knowing something is wrong can often prevent catastrophic failures. For example, a wireless vibration/temperature sensor can alert you to vibration or temperature changes without assessing the nature of the vibration or correlating the motor surface temperature with the winding temperature. Maintenance personnel should follow advancements in the Industrial Internet of Things (IIoT) but proceed cautiously because online systems pose cybersecurity threats.

A few other technologies that maintenance personnel should become familiar with (even if the purchase is currently out of the question) include motor circuit analysis (MCA), infrared thermography (IRT), and motion amplification. Service center personnel interact with a variety of customers and see many different installations, technologies, and maintenance strategies. So, don't hesitate to solicit their advice before making a decision. EC&M

Mike Howell is a technical support specialist at EASA, Inc., St. Louis, www.easa.com. EASA is an international trade association of more 1,700 firms in nearly 70 countries that sell and service electromechanical apparatus. He can be reached at mhowell@easa.com.

NO TOOLS! • EASY CABLE INSERTION

Made in USA

SNAP²IT® 90° CONNECTORS

WITH and WITHOUT INSULATED THROAT

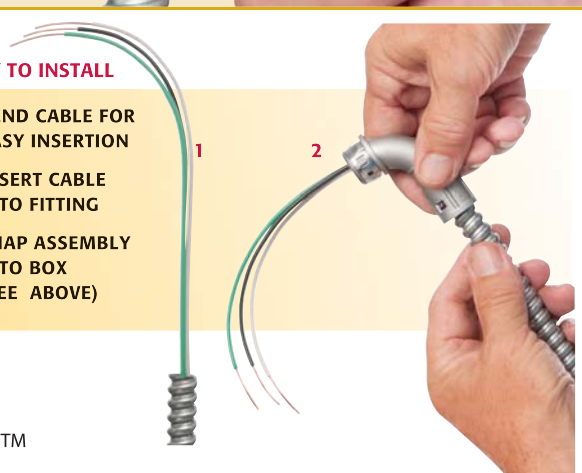
- Easy snap-in cable installation...SAVES A MINUTE each over 2-screw 90° styles
- Handles widest range & variety of cables: 14/2 to 10/2 AC, MC, HCF, MC continuous corrugated aluminum cable, MCI-A cables (steel and aluminum), AC90 and ACG90
- Fast, super-secure installation...No pullout
- Easy to remove from box...reusable

90° SNAP2IT® CABLE RANGES

CABLE TYPE	38900AST 38900ST		4010900AST 40900ST	
	Dia. Range	Cable Range	Dia. Range	Cable Range
MC/HCF/AC Steel & Aluminum	.380 to .600	14/2, and 12/2 with & w/o ground. 14/3, 14/4 12/3, 12/4 10/2	.490 to .600	14/3, 12/2, and 12/3 with & w/o ground. 14/4 12/4 10/2
MCI-A Steel & Aluminum	.440 to .550		.480 to .550	
AC90, ACG90			.480 to .550	
Flexible Metal Conduit Steel & Aluminum (RWFMC)	3/8" Flex* *CSA Listed w anti-short bushing ONLY			

EASY TO INSTALL

1. BEND CABLE FOR EASY INSERTION
2. INSERT CABLE INTO FITTING
3. SNAP ASSEMBLY INTO BOX (SEE ABOVE)



TM

c UL us

with and without insulated throat

Arlington®

www.aifittings.com Scranton, PA 18517 800/233-4717

Patented

Product Info aifittings.com/landing/90-degree-connectors/

10 Sure Ways to Tell the Difference Between Bonding & Grounding

An in-depth look at how to apply all 10 Parts of NEC Art. 250 in the field

By Randy Barnett, NTT Training

Article 250 of the National Electrical Code (NEC) focuses on grounding and bonding. This Code Article is divided into 10 separate parts — each identified by a Roman numeral. Because of the terminology and extensive Code rules (along with their many exceptions), Art. 250 is often considered difficult to understand and apply.

This article offers an overview of the content of each one of those 10 parts. Applying the rules for grounding and bonding requires in-depth study and familiarity by electrical workers with the rules, their exceptions, the associated tables, their notes, and the use of informational notes. Referral should always be made to Art. 100 [Definitions] ,as needed, when reading Art. 250. See the **Photo** at right for typical grounding and bonding system components.

The grounded conductor (white) is terminated in the panelboard on the grounded busbar. The green screw is the main bonding jumper connecting the grounded busbar to the enclosure. A threaded hub (upper right) provides secure bonding to metal enclosures. The smaller bare copper conductor on the left is the equipment grounding conductor providing bonding. The larger bare copper on the right is the grounding electrode conductor that connects the grounded busbar to the grounding electrode system (i.e., the ground rod held in the upper left).

PART I [GENERAL]

Part I details what must be accomplished through proper grounding and bonding. It is unusual for an NEC Article to provide such performance requirements. However, Sec. 250.4 does just that. The remainder of this Article tells us how to meet those requirements.

Part I provides two important visual items. Table 250.3 provides a list of an additional 37 Code Articles containing specific equipment and locations for grounding and bonding requirements found elsewhere in the NEC. Figure 250.1 (see **Flowchart** on page 32) provides a much-needed overview of the layout of grounding and bonding requirements. Note the grouping of the various parts into a logical format.

To help understand the performance requirements for grounded distribution systems, pay attention to the general requirements found in Sec. 250.4(A). Electrical systems are grounded for two reasons:

1) Limiting voltages imposed by lightning strikes, line surges, or unintentional contact with overhead lines, and

2) For stabilizing the voltage to earth during normal operation.

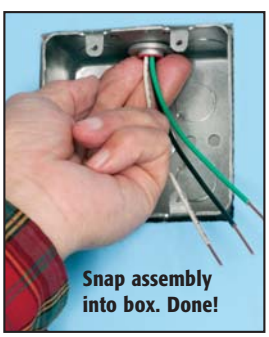
NO TOOLS • EASY SNAP-IN INSTALLATION • *SAVES TIME!*

SNAP2IT® CONNECTORS

FOR RETROFIT INSTALLATIONS

Arlington's new one-piece **RETROFIT SNAP2IT®** fittings are *easy to use in an OLD WORK installation*, and handle the widest variety of cables! They're ideal for adding additional circuits to a load center. And you get the same labor-savings in a retrofit installation!

Easy snap-in installation - NO TOOLS. Install connector into the knockout in an ***existing* box**, pulling cable/conduit through the knockout. Slip the fitting onto the cable, then snap the assembly into the box. That's it... a secure installation with *no pullout*.



Patented

Widest total cable ranges 14/2 to 10/3
Widest variety of cables AC, MC, HCF, MC continuous corrugated aluminum cable, MCI-A cables (steel and aluminum), AC90, ACG90 and FLEX

Arlington® 800/233-4717 • www.aifittings.com

Product info aifittings.com/landing/38rast-40rast/

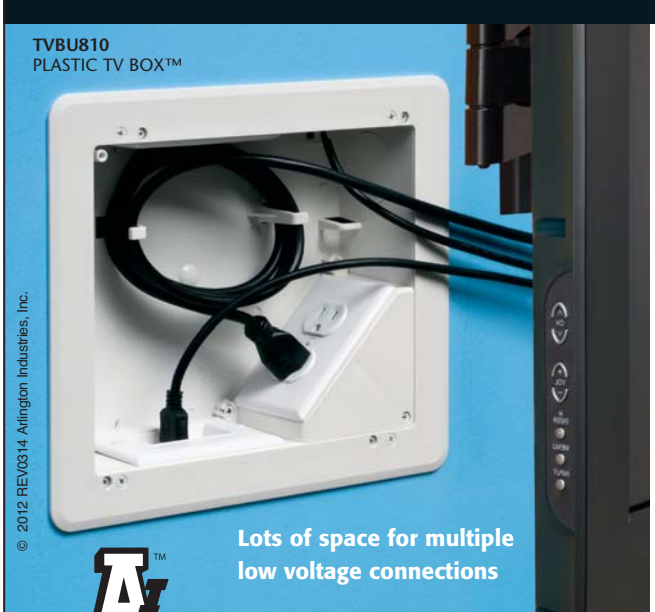
c UL us Made in USA

VERTICAL OR HORIZONTAL • RETROFIT & NEW WORK INSTALLATIONS

Made in USA

Non-Metallic 8x10 TV BOX™

PERFECT FOR HOME THEATER SYSTEMS



Arlington® 800/233-4717 • www.aifittings.com

Arlington's PLASTIC 8X10 **TV Box**™ delivers the *ultimate in versatility* for installing flat screen TVs in new *and* retrofit projects. There's more room in the box for wires and it installs horizontally or vertically to properly position low voltage connections behind the TV.

- Ideal for home theater systems: multiple connections for sound systems, satellite TV, CATV, DVRs
- Brackets for neater cables, with a 1-1/2" knockout for ENT and other low voltage wiring
- Box mounts to stud in new work; for retrofit, mounting wing screws secure box in wall

includes box, trim plate, duplex receptacle, line voltage box, wall plates, cable entry device, knockout plugs

Mounts to stud in NEW work

Secure installation in RETROFIT

c UL us

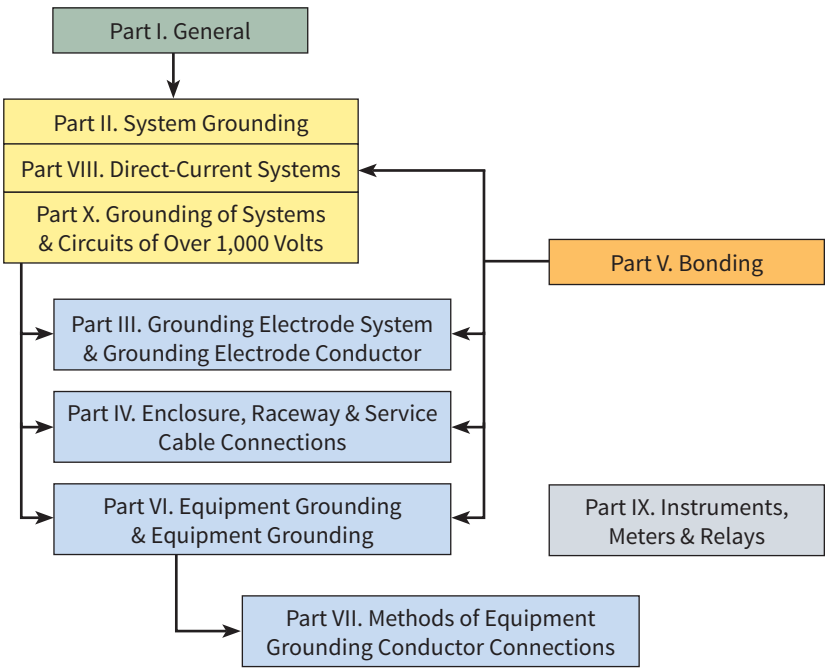
Patented

Product info aifittings.com/landing/TVBU810

Thus, improper grounding could result in equipment damage and fire — and the voltage-to-ground would be unstable and not usable.

The 250.4 subsections on the bonding of electrical equipment and effective ground-fault current paths help you understand the purpose of bonding. Bonding joins non-current metal parts of the system together to provide a low-impedance path for current to flow from these metal components back to the source should they become energized during a ground fault. This path allows the overcurrent protective device (fuse or circuit breaker) to operate and clear the fault.

Sec. 250.8 [Connection of Grounding and Bonding Equipment] identifies seven specific methods that must be used for connecting equipment and conductors for grounding and bonding purposes. Examples include listed pressure connectors, exothermic welding, machine screws, and thread-forming screws that meet specific installation requirements. An eighth item uses a common term found throughout the Code: "other listed means." The *UL White Book* is one resource to find these additional methods.



This graphic shows the layout of Art. 250 [Grounding and Bonding]. This Article is divided into 10 Parts. The color coding and arrows help to understand the interrelationships between parts.

PART II [SYSTEM GROUNDING]

This part identifies what systems are required to be grounded, systems that may be grounded but are not required to do so, and systems that must be grounded. Though this may sound confusing, it is simple to identify the applicable Code section by voltage and type system — and then apply the rules. If the electric utility provides a grounded service, which will be the general rule, then the premises' wiring system must also be grounded. Rules for main bonding jumpers, system bonding jumpers, and grounding electrode conductors (GECs) begin to appear in Part II.

Of special interest are the grounding requirements for separately derived AC systems. The key to understanding whether systems are separately derived is to determine if the grounded conductor of the separate source remains connected to the grounded conductor of the service system grounded conductor. For example, if a standby generator supplies loads through an automatic transfer switch, is the grounded conductor switched in the transfer switch? If so, then the standby generator becomes a separate source of supply, and the rules found in this Part must be applied. This separately derived system will use a system bonding jumper anywhere between the generator and the first disconnecting means. This system bonding jumper performs the same function as a main bonding jumper at the service. However, in a separately derived system, this jumper is defined as the "system bonding jumper." For sizing the system bonding jumper at the generator and the main bonding jumper at the service, Table 250.102(C)(1) is supplied in Part V Bonding. Using this example, it's easy to see why the use of Art. 250 requires study and practice.

PART III [GROUNDING ELECTRODE SYSTEM AND GROUNDING ELECTRODE CONDUCTOR]

The grounding electrode system resides under the earth, and the GEC connects that system to the supply source (transformer or generator windings for example).

There are eight items permitted to perform grounding as part of the grounding electrode system, each of which has its own specific requirements, including its installation. For example, copper rods fall under rod and pipe electrodes. These rods must be at least 2.44 m (8 ft) in length and be 15.87 mm ($^5/_8$ in.) in diameter unless listed. A subsequent section provides details on installation; rods need to be in contact with the earth for 8 ft, and they must be below the permanent moisture level (if practicable). Installation details are even provided for what must be done if rock bottom is encountered when driving the rod.

The size of the GEC is based upon the size of the ungrounded conductors (or equivalent area if parallel ungrounded conductors are installed), as shown in **Table 1** on page 34. Connection requirements for the grounding and bonding connections to electrodes are addressed as well as the need for bonding jumpers around insulated joints in metal piping systems.

PART IV [ENCLOSURE, RACEWAY, AND SERVICE CABLE CONNECTIONS]

Part IV contains only three sections. These address service raceways and enclosures for grounded systems, underground service cable, and other conductor enclosures and raceways that are not part of the service.

PART V [BONDING]

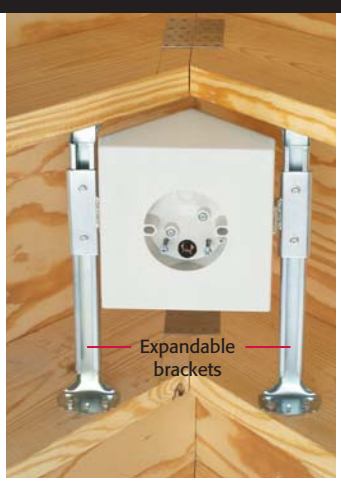
Given the obvious importance of proper bonding, Part V contains 10 different

FOR CATHEDRAL CEILINGS IN NEW CONSTRUCTION

CENTERED. SIMPLE.

WITH ARLINGTON'S FAN/FIXTURE BOX

Position box between framing members by sliding it along the expandable brackets



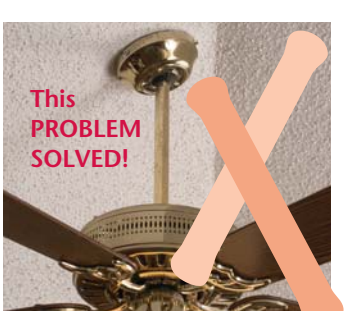
Get a centered, safe installation with Arlington's one-piece FBX900 Fan and Fixture Box. *Save time and money too.*

FBX900 has expandable brackets that mount securely between joists, eliminating the need to cut and nail 2X4s to center a fan or fixture in the room.

- Self-contained – No loose parts
- Supplied template levels, positions bracket between rafters
- Fits cathedral ceilings with angles greater than 80°
- Large, 8" square mounting surface handles fans with large canopies

UL Ratings
FBX900 Fan/Fixture: 70 lbs
FB900 Fan: 70 lbs, Fixture: 200 lbs

Use FB900 to install a fan/fixture box *next to a rafter*



Arlington™

www.aifittings.com Scranton, PA 18517 **800/233-4717** Patented

Product info aifittings.com/landing/fb900-series

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1,100	Over 900 through 1,750	2/0	4/0
Over 1,100	Over 1,750	3/0	250

Table 1. NEC Table 250.66 is used for sizing the grounding electrode conductor based on the size of the largest ungrounded conductor.

sections with many subsections. Bonding services, communication systems, and bonding of systems over 250V are examples of topics. Rules for bonding piping systems and exposed structural metal are extensive. Of particular importance is Table 250.102(C)(1) for sizing grounded conductors, the main bonding jumper, the system bonding jumper, and the supply-side bonding jumper for AC systems (**Table 2** on page 36).

PART VI [EQUIPMENT GROUNDING CONDUCTOR]

The equipment grounding conductor's (EGC's) purpose is to provide an effective ground-fault current path (low impedance) from the non-current-carrying metal components of the system back to the source of supply and to the ground as well. As mentioned previously, this fault current path must allow for sufficient current flow such that the overcurrent protective device will operate and clear the fault. Part VI begins by identifying rules for some specific equipment. For example, Sec. 250.112 requires that motor frames, switchgear and switchboard frames, elevators and cranes, electric signs and luminaires have their metal frames connected to an EGC.

Three important sections of this part are:

- Sec. 250.118, which lists what can be used as an EGC.
- Sec. 250.119, which explains how to identify the EGC.
- Sec. 250.122, which provides a table for sizing the EGC.

Items that can be used as the EGC include copper, copper-clad aluminum, or aluminum wire type or busbar. In dwelling unit applications when using Type NMC cable, a bare copper conductor serves as the EGC. In commercial and industrial applications, a copper conductor with green insulation is typical. In addition, rigid and intermediate metal conduit, electrical metallic tubing, listed flexible and liquidtight metal conduits, and Type MC cable are common examples of different EGCs.

Since the purpose of the EGC is to carry the ground-fault current back to the source to allow the fuse or circuit breaker to open, the size of the EGC is based on the rating or setting of the overcurrent protective ahead of the equipment (see **Table 3** on page 36 as an example).

PART VII [METHODS OF EQUIPMENT GROUNDING CONDUCTOR CONNECTIONS]

Part VII is the "how-to" for connecting EGCs. Since connections for separately derived systems were covered in Part II, Sec. 250.130 of this Part addresses connections made at the service equipment. For grounded systems, bonding the EGC to the grounded service conductor and the GEC is required. The main bonding jumper is used to accomplish this. In panelboard systems, this is often a green screw located in the grounded conductor busbar, which must be tightened down to make good contact with the enclosure.

Section 250.146 is an commonly used section of this Part. It requires a bonding jumper to connect the grounding terminal of a receptacle (green screw) to the metal box; with the metal box then connected to the system EGC. However, the additional subsections point out that meeting certain provisions is not required. For example, if using a metal surface-mounted box where one of the insulating washers is removed such that the yoke of the receptacle makes metal-to-metal contact with the box, a bonding jumper is not required. Other provisions exist for self-grounding type receptacles, floor boxes, and isolated ground receptacles.

PART VIII [DIRECT CURRENT SYSTEMS]

Direct-current (DC) systems must comply with this part, as well as the remainder of Art. 250 that are not specifically intended for AC systems. In general, 2-wire DC systems operating at greater than 60V, but not more than 300V used to supply premises wiring systems, must be grounded. If a 3-wire DC system is supplying premises wiring, the neutral must be grounded.

The GEC for DC systems is sized differently than for AC systems. Where the AC systems utilize a table to size these conductors (Table 250.66), Sec. 250.166 provides the rules for the DC system with no table available. Just as in AC ungrounded systems, ground-fault detection is required in ungrounded DC systems. With an ungrounded system, a single ground fault will not be recognized by the upstream protective device as insufficient fault current will flow back to the source. The breaker will not trip! Should there be a ground fault on the opposite polarity conductor, a positive-to-negative fault occurs.

PART IX [INSTRUMENT METERS AND RELAYS]

Part IX addresses the grounding and bonding requirements for current/potential transformers and relays used for protection typically found in switchgear. Secondary circuits of voltage and

CONVENIENT • LOW COST

FLOOR BOX KITS

FOR EXISTING FLOORS

FLUSH TO FLOOR INSTALLATION

Nickel **FLBR101NL**
Brass **FLBR101MB**

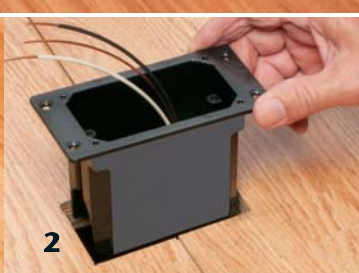
Brown **FLBR101BR**

Non-Metallic covers in FOUR COLORS

Brass **FLBRF101MB**
Nickel **FLBRF101NL**

EASY TO INSTALL!

1



2

3

4

UL LISTED FLOOR BOXES... the low cost way to install a receptacle flush in an EXISTING FLOOR

WHITE
FLBRF101W
ASSEMBLED

BLACK
FLBRF101BL

LIGHT ALMOND
FLBRF101LA

BROWN **FLBRF101BR**
KIT COMPONENTS

- Oversized rectangular covers hide miscut flooring; gaskets prevent water intrusion; **threaded plugs or flip lids** protect box when it's not in use
- **Rectangular Covers**
  Non-Metallic
  White, light almond, brown, black
  Metal Nickel-plated brass and Brass

UL LISTED

Arlington® TM

www.aifittings.com Scranton, PA 18517 800/233-4717 Patented

Product info aifittings.com/landing/flbr101-flbrf101

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounding Conductor or Bonding Jumper (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1,100	Over 900 through 1,750	2/0	4/0
Over 1,100	Over 1,750	See Notes 1 and 2.	

Table 2. Use Table 250.102(C)(1) for sizing grounded conductors, main bonding jumper, system bonding jumper and supply-side bonding jumper for AC systems based on the size of the largest ungrounded conductor. Notice the requirement to use the notes found at the bottom of the table if ungrounded conductors are over 1,100 kcmil. This is different than the table in Fig. 2 for sizing the grounding electrode conductor.

current instrument transformers must be grounded if the primary voltage is 300V. However, if these instrument circuits are mounted in switchgear or switchboards (as is typically the case), they must be grounded no matter the voltage.

Instrument transformers, meters, and relays operating at 1,000V or less are connected to the EGC. For these systems operating at more than 1,000V, they are not connected to the EGC but must be isolated by elevation and other means. As always, read the exception if you are applying such rules.

PART X [GROUNDING OF SYSTEMS AND CIRCUITS OF OVER 1,000V]

All previous rules apply if grounding systems are over 1,000V. Quite often, these systems are connected to ground through an impedance. Solidly grounded systems (no intentional resistance or impedance to ground) — unlike lower voltage systems — can be either single-point ground or multipoint grounded. Multipoint grounding involves the neutral being grounded at more than one point.

Also in this part are rules for grounding service-supplied AC systems, including impedance grounded systems. The grounding impedance must be inserted between the grounding electrode itself and the neutral point of the supply. It must be insulated for 57.7% of the phase-to-phase voltage.

SUMMARY

Grounding and bonding continue to be one of the more difficult topics in the NEC. Remember this article is only an overview. Use Part I to understand why we ground and bond. Refer to the definitions in Art. 100. All 10 parts of Art. 250 work together to define the requirements for grounding and bonding. As proper grounding and bonding is necessary to protect people and property from the hazards of electricity, make sure you understand the rules and apply them correctly. EC&M

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, Etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
15	14	12
20	12	10
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1,000	2/0	4/0
1,200	3/0	250
1,600	4/0	350
2,000	250	400
2,500	350	600
3,000	400	600
4,000	500	750
5,000	700	1,250
6,000	800	1,250

Table 3. NEC Table 250.122 provides the minimum size for equipment grounding conductors based on the rating or setting of the overcurrent device ahead of the equipment in the system.

Randy Barnett is the electrical codes and safety program manager for NTT Training in Centennial, Colo. A certified electrical safety compliance professional (CESCP), he can be reached at electricrb@yahoo.com.

SNAP²IT® CONNECTORS

EASIEST CABLE INSERTION • NO TOOLS • SECURE HOLD

Fully assembled, **SNAP²IT®** fittings **handle the widest variety of MC cable *AND THE NEW MC-PCS cables.***

Compared to fittings with a locknut and screw, you can't beat these snap in connectors for time-savings!

- **Fits widest range and variety of MC cable** 14/2 to 3/3 AC, MC, HCF, MC continuous corrugated aluminum cable and MCI-A cables (steel and aluminum)...*including the new MC-PCS cable that combines power and low voltage in the same MC cable*

  ANY Snap2It Connectors LISTED for MC cable are also LISTED for MC-PCS cable! *These products offer the greatest time-savings.*
- **Fast, secure snap-on installation**
- **Easy to remove, reusable connector**
  From cable Loosen screw on top. Remove connector from cable.
  From box Slip screwdriver under notch in Snap-Tite® ring. Twist. Remove connector.

CATALOG NUMBER	DESCRIPTION Snap2It® connectors	CABLE OUTSIDE DIA (OD)
4010AST	Snap in, 1/2" KO w insulated throat	.405 to .610
5010AST	Snap in, 1/2" KO w insulated throat	.580 to .780
505010AST	Duplex Snap in, 3/4" KO w insulated throat	(2) .590 to .820
4110ST	Snap in, 1/2" KO	.525 to .705
414110ST	Duplex Snap in, 1/2" KO	(2) .525 to .640
NEW! **4141107ST**	Duplex Snap in, 3/4" KO	(2) .525 to .690

Easy to Snap into Box!

NEW! 4141107ST

Arlington®

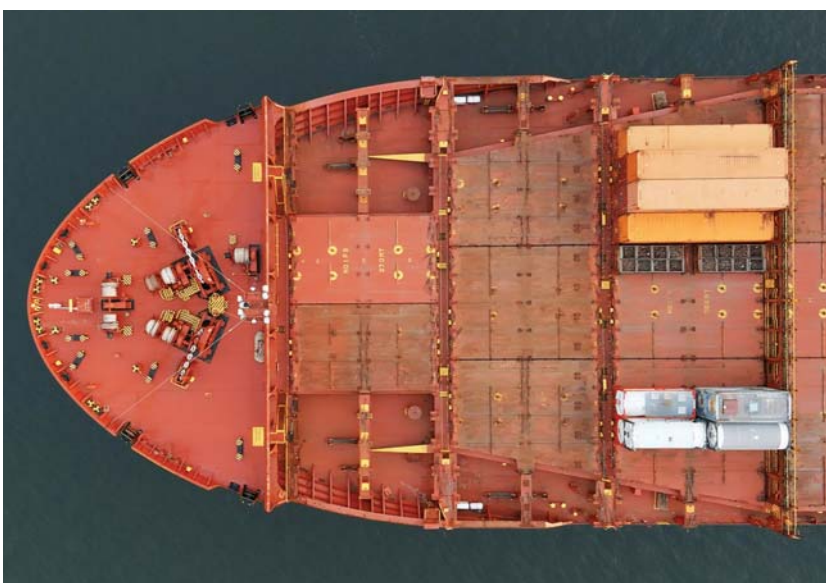
Patented. Other patents pending.

www.aifittings.com • Scranton, PA 18517 • 800/233-4717 Made in USA

Product info aifittings.com/landing/snap2it-mc-cable-connectors

Caught Between Supply and Demand

There's no shortage of work, but there is a shortage of just about everything required to do that work.



© John Wollwerth| Dreamstime.com

Photo 1. This aerial view of the bow of an empty cargo ship demonstrates the severity of the current supply chain distribution problem.

By Tim Kridel, Freelance Writer

At the end of 2021, there were 28% more single-family homes under construction than one year earlier, according to the National Association of Home Builders (NAHB). Add in equally strong starts in multifamily housing, along with a robust commercial sector, and that means there's no shortage of work for every type of electrical contractor.

The dark lining to that silver cloud is supply chain woes (**Photo 1**). Like the chronic shortage of journeymen, electricians, electrical foremen, and other positions, the acute shortage of circuit breakers, receptacle outlets, conduit, and other products make it difficult for contractors to meet that demand. This article examines why so many products can't be found for love nor money — and why that situation is unlikely to improve anytime soon.

Just ask Frank Massiglia, vice president of purchasing at Electrical Dynamics in North Reading, Mass.

"It's the unknown that is killing us," he says. "Factories have no clue as to what's shipping and when. The everyday stuff like black plastic boxes, plugs, and switches we're being allocated. We can't get panel covers. We can't get transfer switches. I don't see any end in sight."

More money also doesn't necessarily make a difference.

"We had a customer who wanted to give us $150,000 up front to get his generator in a hurry," Massiglia says. "No, 40 weeks."

PHOTOVOLTAIC

NEW CABLE CONNECTORS

CONNECTS, PROTECTS MULTIPLE PV1000 CABLES

Arlington's non-metallic NMPV series photovoltaic cable connectors are ideal for solar, and other jobs, requiring the connection of multiple cables into raceways, fittings, and combiner or junction boxes. This connector series is perfect for PV1000 cable.

NO Sealant Required. *No need to seal off raceway where wires exit fitting.* Grommet (included) seals and separates wires and prevents moisture, debris and insects from entering the raceway.

- **For PV1000 and other cables** from .245 to .280
- 3/4" **NMPV753** holds up to 3 cables...
  1" **NMPV1005** holds up to 5...
  1-1/4" **NMPV1257** holds up to 7

LISTED

Arlington® 800/233-4717 • www.aifittings.com

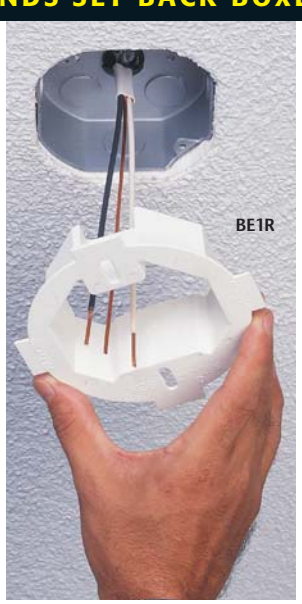
Product info aifittings.com/landing/nmpv

UL LISTED

Made in USA

BOX EXTENDERS

EXTENDS SET BACK BOXES UP TO 1-1/2 INCHES



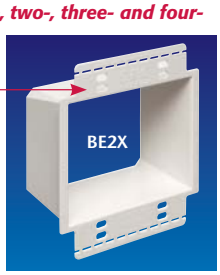
Arlington's **UL/CSA Listed** Box Extenders extend set back electrical boxes up to 1-1/2".

Made of heavy-duty, non-conductive plastic, they level and support wiring devices, protecting wires against damage and stripping.

BE1R for round or octagonal boxes, the single-gang (BE1), two-gang (BE2) for all standard devices, switches and GFCIs and **three- and four-gang box extenders for multiple gang boxes!**

*Try them all, including our **'Larger Flange' one-, two-, three- and four-gang styles**, for the safe, easy way to obtain Listed installations in set back boxes!*

Larger Flanges



Product info http://www.aifittings.com/landing/box-extenders/

Arlington® 800/233-4717 • www.aifittings.com

Patented

What once looked like a temporary problem brought on by the pandemic has officially crossed into chronic territory. That makes it akin to high blood pressure, arthritis, or diabetes: an aggravating, debilitating condition that must be managed indefinitely while holding out hope for a cure somewhere down the road.

"The supply chain issues have been evolving, meaning that what was a problem four to six months ago is now caught up, and we are seeing different products become an issue," says Cory Borchardt, senior vice president of operations at Fisk Electric in Houston. "Unistrut and fittings were a problem earlier, and are now caught up. Fiberglass conduit and fiber optic cable are now in short supply.

"One segment that has been consistently impacted is the electronic components and circuit boards. Everything from fire alarms to switchgear to LED lighting and GFCI/AFCI outlets have been impacted with price and lead time issues."

Those fluctuations make it difficult to price jobs — and turn a profit (**Photo 2**).

"We've gone back to a few general contractors looking for relief, especially on copper wire," Massiglia says. "These are jobs that we wrote in 2020 and 2019. So any job we recorded in 2019 and early 2020, we're paying the price now that things have tripled and quadrupled in some instances.

"It's day to day. You get quotes from people: 'These quotes are good for 24 hours.' I've been doing this for 40 years, and I've never seen it this bad."

Getty Images

Photo 2. Wire and cable continue to see some of the biggest month-to-month (MTM) and year-over-year (YOY) price increases of any of the 20-plus product categories tracked by *Electrical Marketing's* Electrical Price Index (EPI), a sister publication to *EC&M*.

WEAK LINKS IN THE SUPPLY CHAIN

How did things get so bad? There are multiple reasons, starting with COVID, which came in and crimped production of everything from raw materials to finished products at a time when they were already in high demand. So when mines and factories reopened, they faced an even bigger backlog. This problem persists two years later, as FMI senior economist Brian Strawberry noted in a recent survey.

"One of the respondents is involved in the electrical vehicle and battery plant market," says Strawberry, who leads FMI's research in construction material pricing and consumption trends. "He said that their backlog is three times larger than he's ever seen it."

Electric vehicles (EVs) also are an example of how a fast-growing sector can be a double-edged sword (**Photo 3**): On the plus side, EVs mean more business for contractors that install chargers and other infrastructure. But EVs also mean more competition for raw materials.

"The demand for electronics and copper for electrical vehicles is going to have a long-term impact on the supply chain," says Fisk's Borchardt.

COVID also continues to rear its ugly head in the worst possible places from a supply chain perspective. Take Baise, a Chinese city that produces a big chunk of the world's aluminum. When it went into a COVID lockdown in February, global aluminum prices spiked to a 14-year high (**Photo 4** on page 42). And similar shortages plague other metals.

"That's the problem with plugs and switches: They can't get brass," says Electrical Dynamics' Massiglia. "And we're talking major manufacturers: ABB, Siemens, Cutler-Hammer."

The war in Ukraine is just the latest disruptor. It's part of the reason why fuel prices keep setting new records, leading to shipping surcharges that get passed down the line. Even if peace were struck tomorrow, prices would remain high because of other factors, such as declining refining capacity in the United States.

Another example is tungsten, found in a wide variety of products used by the electrical industry, including semiconductors, halogen lamp filaments, and cutting tools such as drill bits.

"When you get into precision [cutting] work, you can't substitute it," says Lewis Black, CEO of Almonty Industries, an international company that specializes in mining tungsten.

© Chon Kit Leong | Dreamstime.com

Photo 3. The anticipated buildout of electric vehicle charging infrastructure in the next five years, as outlined in the Infrastructure Investment and Jobs Act, will likely experience supply chain issues.

And in the case of semiconductors, the tungsten shortage's impact goes beyond just electrical products such as industrial breakers and LED lighting. For example, the semiconductor shortage is also hammering automakers, making it tough for contractors to find enough new work trucks and vans.

Why is tungsten in such short supply? As with the rest of the supply chain, there are multiple factors, such as older mines whose yields are diminishing due to age, stringent new environmental regulations in China, and geopolitical tensions.

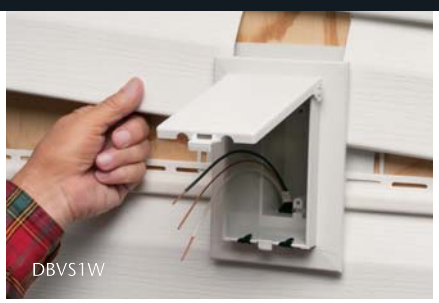
"You've seen energy supply issues, especially in China's ongoing argument with Australia, who's their largest provider

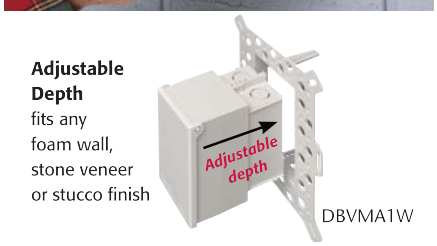
SAVES TIME • LOOKS GREAT!

Made in USA

IN BOX® RECESSED BOX

EXTRA-DUTY, LOW PROFILE COVER





No extra parts to buy or handle mean you save big on labor and materials!

One-piece **IN BOX**®, the recessed, EXTERIOR electrical box, eliminates installing multiple pieces: the box, then the bubble cover assembly, and a mounting block on siding. Plus, the job looks great because IN BOX installs *in the wall.* It's that simple.

Cost savings. Time savings. UL Listing. Great Looks. Get it all in Arlington's one-piece IN BOX!

- Non-metallic, 22.0 cu. inch electrical box with *extra duty* weatherproof-while-in-use white or clear cover
- Single and two-gang, vertical and horizontal, for a variety of new and old work applications
- Accepts single-gang devices - no gaskets required

IN BOX meets 2020 NEC, Section 406.9 *for the protection of exterior outlets which require the use of an extra-duty weatherproof while-in-use cover for all outdoor 15 or 20 AMP receptacles.*

Arlington™

Patented. Other patents pending.

www.aifittings.com Scranton, PA 18517 800/233-4717

Product info aifittings.com/landing/outdoor-inbox/

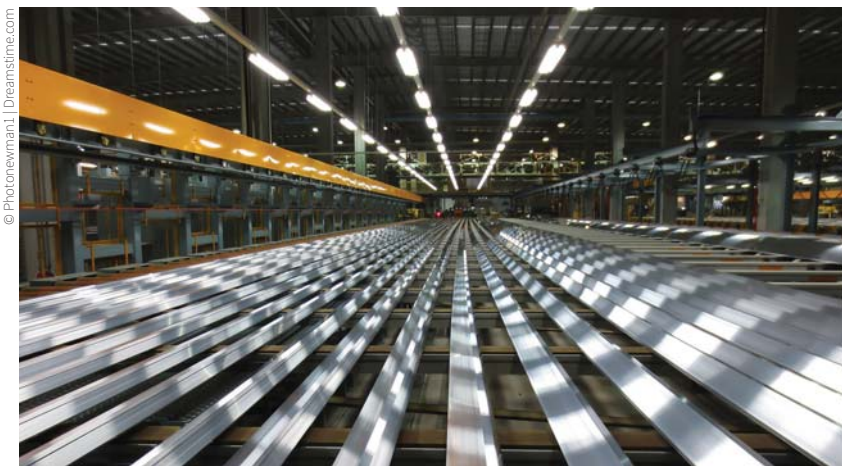


Photo 4. Aluminum is another construction material in short supply, a reality that's causing project delays and increased costs.

of coal," Black says. "When you have no power, and mines shut down, it takes some time to reopen. But more importantly, you need energy just to keep the water out to preserve the mine. You can't have extended periods without energy."

POLITICS IN PLAY

Wars and disputes aren't the only political factors affecting the supply chain. In addition to the already overwhelming marketplace-driven demand, there's also the $1.2-trillion Infrastructure Investment and Jobs Act (IIJA).

"Critical labor and material shortages, along with delivery (trucking) resources, may impact speed of equipment availability for the infrastructure envisioned by the IIJA and the American Rescue Plan Act (ARPA), as well," says Marty Travers, executive director at Overland Park, Kan.-based Black & Veatch.

Fisk is hearing about the transportation aspect from some of its suppliers.

"We are being told the problem is mostly related to transportation and raw materials and less about COVID shutdowns at this point," Borchardt says. "That was not the case in spring/summer 2021. Transportation costs are impacting pricing dramatically."

In a March *EC&M* article, electrical contractors and officials from organizations such as the National Electrical Manufacturers Association (NEMA) said they expect the bulk of IIJA-funded projects to begin next year. So even if manufacturers and their suppliers miraculously cleared their backlogs in the next six months, they'd face a crush of new IIJA-related orders.

"I think a small portion of it [will be] in 2022, but I think it's going to have a larger impact over the following years — 2023, 2024, 2025 — especially with the magnitude and the size of the projects," Russ Lancey, president and CEO of Ozone Park, N.Y.-based Five Star Electric, told *EC&M* in a previous article on infrastructure revitalization.

The IIJA also has "Buy America" provisions, which create additional supply chain limitations because many projects need products that currently aren't manufactured in the United States. On the plus side, there are signs that the federal government recognizes this challenge. For example, in May, the Department of Transportation issued a temporary waiver for construction materials — albeit only through November 10, 2022, rather than the 12 to 24 months advocated by groups such as the American Association of State Highway and Transportation Officials.

Shortages also threaten adjunct markets such as broadband.

"You're looking at very long lead times on fiber, in particular," says Steve Truebner, a Black & Veatch director who oversees broadband projects. "Once you have a project ready and the community is excited about improved connectivity, nothing slows the momentum of the effort like an added 10-month delay. Some public entities are taking an alternative route by allocating a portion of grant dollars to place advanced orders of the fiber that they know will be needed, in lieu of direct financial grants. It's an innovative model — and requires the right level of planning to match up with all of the other network components that are associated."

Could the feds do more than issue waivers? Should they, for that matter? Some say it's best to let the marketplace work things out.

"Unfortunately, there's nothing anybody can do," says Almonty's Black. "The worst thing that can actually happen is if governments try to fix it. That would be an unmitigated disaster because it's not a domestic issue. It's a global issue. Politicians generally aren't really the best to fix problems, especially complex ones that they have no real understanding of. So, it's better if they just take a back seat and let the markets find the balance — because the markets will find balance. It'll just take time."

COPING STRATEGIES

To keep projects on track, some contractors are turning to refurbished/reconditioned equipment. As Joseph Martin, manager of procurement at Pittsburgh-based Sargent Electric told *EC&M* more than a year ago in a related article: "Plants are shut down. Things are backordered. We've gone to our customers and said: 'Here's an option. We can get this completed in the five weeks you want, or it's going to take us 12 just to get the materials.'"

Other contractors say that refurbs often aren't an option.

"At Fisk Electric, we have been doing a lot of substitutions and alternate products to cut down on lead times," Borchardt says. "Having an open dialogue with the owner and engineering team early has helped us minimize the impacts. We have not been able to utilize reconditioned or used equipment on any of our projects. When a substitution is not possible or approved by the owner/engineer, we are finding ways to continue the project with temporary items and trying to minimize rework when permanent materials do come available."

In some cases, refurb equipment isn't an option because it's not available, either.

"You can't get [new] transfer switches," says Electrical Dynamics' Massiglia. "I reached out to a lot of used people on the transfer switch side. I had no luck with anything. I hate to use the term 'new normal,' but I think we're seeing it." EC&M

Tim Kridel is an independent analyst and freelance writer. He can be reached at tim@timkridel.com.

NON-METALLIC

Made in USA

FIXTURE BOXES for Siding

EASY INSTALLATION

Arlington's **8141F** and **8081F** boxes deliver the fastest, easiest way to install light fixtures and receptacles on siding. *Good looks. Smooth vertical mounting!*

- Easy to install one or two-piece styles for any siding type
- NM cable connector included
- UV rated for long outdoor use
- Textured, paintable finish

ONE piece 8141F Fixture Box	VS	TWO piece 8081F Electrical Box
No extra cover to lose or store		Separate cover and box
For light fixtures		For light fixtures, standard receptacles
Costs less than 8081F		

Arlington® 800/233-4717 • www.aifittings.com

aifittings.com/catalog/siding-mounting-blocks/siding-mounting-block/8141F

WHITE BUTTON® • NON-METALLIC

Made in USA

NEW

CABLE CONNECTORS

EASY PUSH-IN INSTALLATION OF ONE OR TWO CABLES

from ***OUTSIDE*** *a* ***New Work Box...***

Save money with Arlington's non-metallic NM cable connectors – the *lowest cost* NM cable connectors on the market – and the fastest to install! Easy push-in installation...

Listed for single or multiple cables, Arlington's new **White Button**® 1/2" NM94X and the ***NEW 3/4" NM95X*** offers smooth, easy cable insertion of one *or two* cables into a single opening from inside or outside the box.

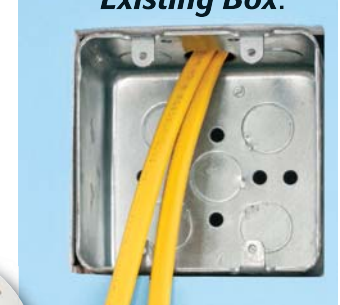
NM94X... BETTER than our popular NM94 AT THE SAME PRICE!

- 1/2" trade size NM94X holds:
  (1) 14/2 to 6/2, (1) 14/2/2, (1) 12/4,
  (1) 12/2/2, (1) 14/3 to 10/3,
  (2) 14/2 to 10/2, (2) 14/3,
  (2) 12/3,
  (1) 14/2 and (1) 12/2,
  (1) 14/2 and (1) 10/2,
  (1) 12/2 and (1) 10/2
- **Easy** removal with pliers or screwdriver
- **Listed.** Exceeds UL/CSA pullout requirements

NM94X

Patented

or ***INSIDE*** *an* ***Existing Box.***

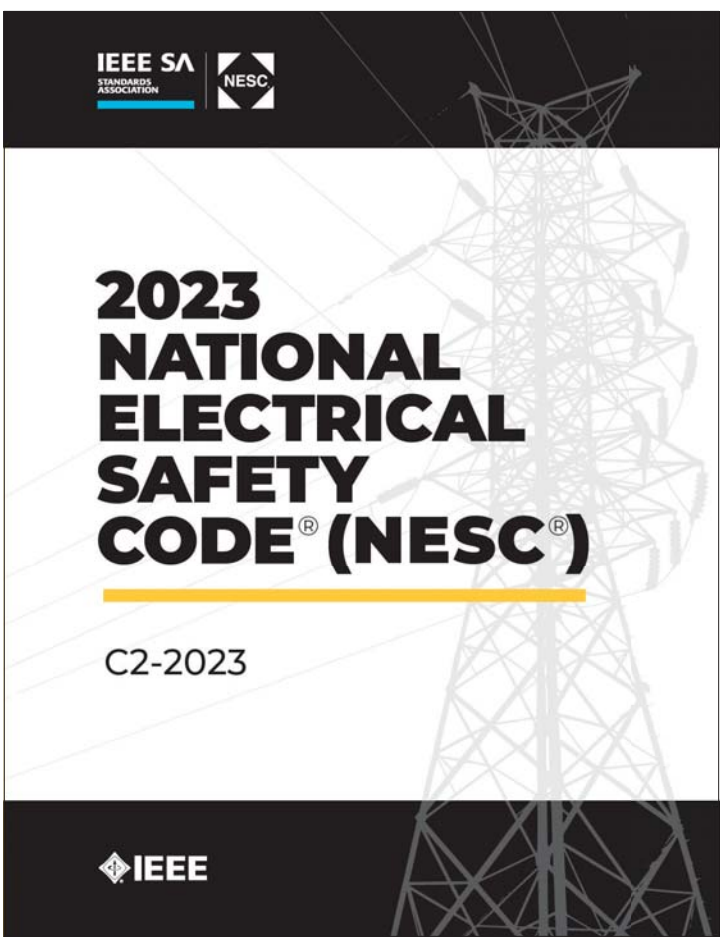


Arlington® 800/233-4717 • www.aifittings.com

Product info aifittings.com/landing/NM94X

Highlights of the New 2023 National Electrical Safety Code

Everything electrical professionals need to know about upcoming updates and changes to the latest edition of the NESC



By Ernesto Vega Jánica, IEEE

Since 1914, the National Electrical Safety Code® (NESC®) has been the go-to safety standard for electric and telecom utility companies of all sizes and ownership of structures. Updated every five years, the 2023 edition of the NESC was released on Aug. 1, 2022, and it will become effective on Feb. 1, 2023. Edited and published by the IEEE

SAVE TIME...FAST, EASY *PUSH ON* INSTALLATION

PUSH-ON CONNECTORS

FOR NON-METALLIC LIQUID-TIGHT CONDUIT

PUSH ON
installation

17 seconds
per connector

VS

Conventional
installation

57 seconds
per connector

SAVE 40 seconds or *33¢ per push-on connector!

Arlington's push-on connectors offer the fastest, easiest way to install non-metallic liquid-tight conduit, type B.

Our one-piece connectors reduce labor steps and eliminate lost pieces. They ship fully assembled with no disassembly needed – and are removable and reusable.

Save time and money with our user-friendly, straight and 90° push-on connectors.

*at $30.00/hour labor rate

NON-METALLIC

Catalog Number	Trade Size	Straight	90°
NMLT5	1/2"	✔	
NMLT905	1/2"		✔
NMLT7	3/4"	✔	
NMLT907	3/4"		✔
NMLT10	1"	✔	
NMLT9010	1"		✔

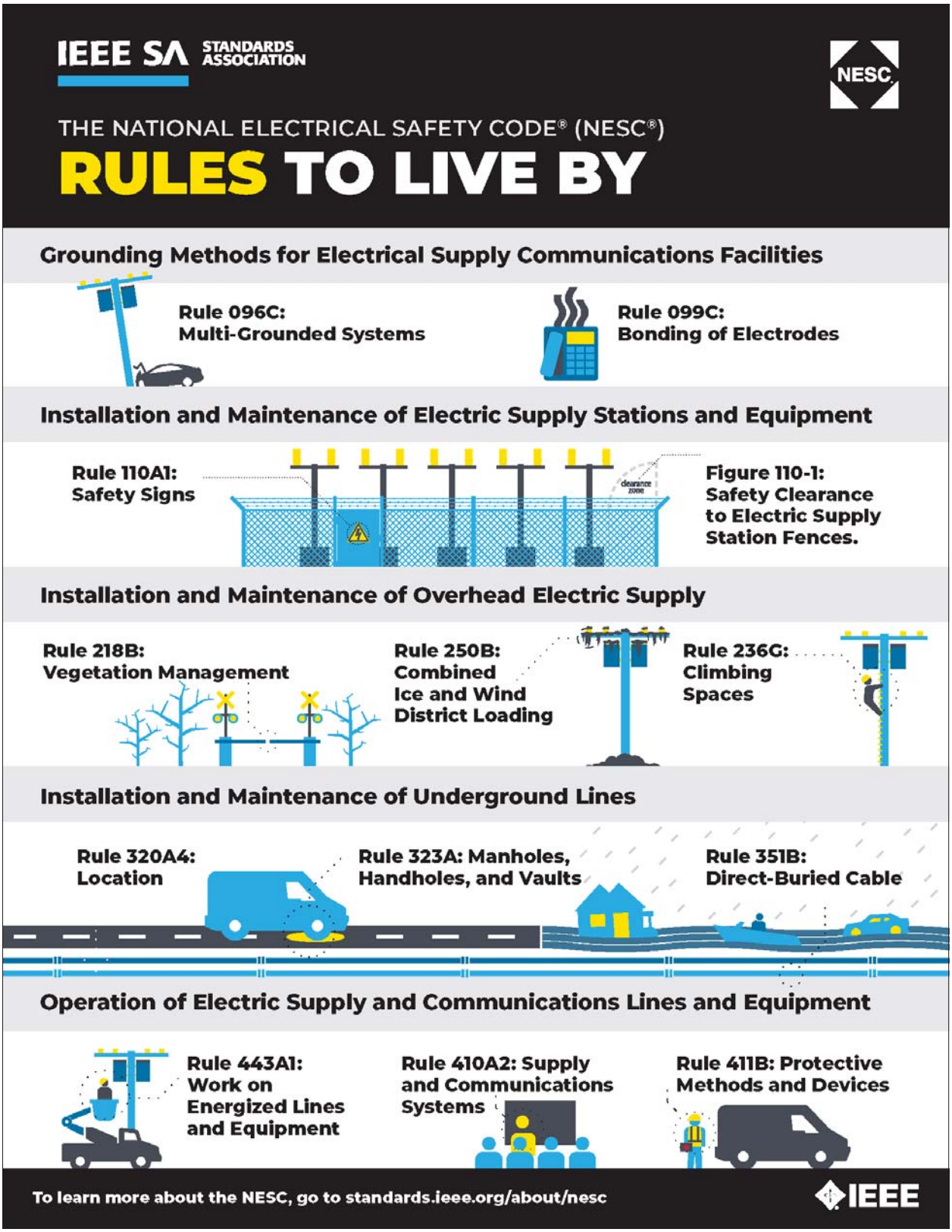
Arlington™

LISTED

Made in USA

www.aifittings.com Scranton, PA 18517 800/233-4717 Patented.

Product info aifittings.com/landing/nmlt20



Standards Association (IEEE SA), with the approval of the American National Standards Institute (ANSI), the NESC has contributed to major electrical safety codes in most states in the United States and other parts of the world.

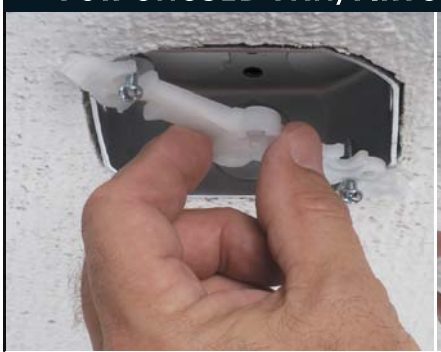
The NESC sets the ground rules and guidelines for its primary focus: the practical safeguarding of utility workers and the public during the installation, operation, and maintenance of electric supply, communication lines, and

A NEAT COVER UP...

Made in USA

NON-METALLIC BOX COVER

FOR UNUSED FAN/FIXTURE BOXES – FITS PAN BOXES TOO!



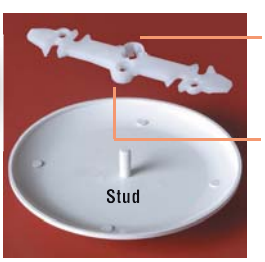
Our non-metallic, paintable **CP3540** Box Cover is the neatest way to cover unused fan/fixture boxes, pan boxes or poorly cut drywall.

- No visible screws on ceiling plate
- Fits 3.5", 4" round or octagonal boxes

Versatile bracket design with 'A' and 'B' openings for use on flat or uneven ceilings.

Versatile Bracket Design

Easy installation. Attach the bracket to the box with #8 or #10 screws. Back the screws out enough to slip the bracket on.



'A' for flat ceilings
Push stud into opening to seat cover

'B' for uneven or textured ceilings
Thread stud into opening until tight

Arlington® 800/233-4717 • www.aifittings.com

Patented

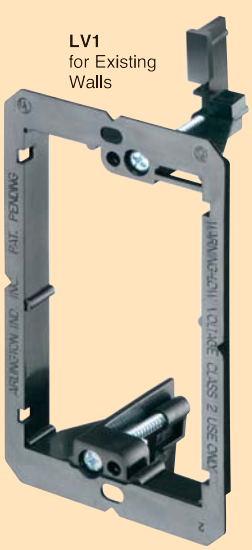
Product Info aifittings.com/landing/CP3540

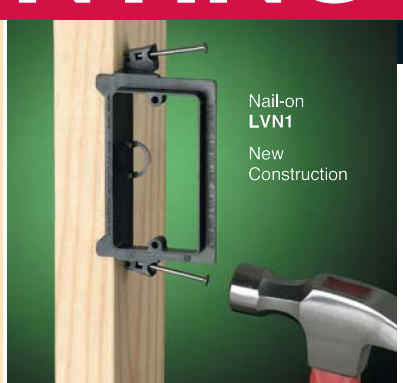
LOW VOLTAGE • NON-METALLIC

Made in USA

MOUNTING BRACKETS

FOR CLASS 2 LOW VOLTAGE WIRING





Patented

Arlington® 800/233-4717 • www.aifittings.com

Arlington's non-metallic mounting brackets offer the best way to install Class 2 wiring! They seat wall plates flush with the mounting surface, install faster and cost less than metal!

In *existing* construction, centered mounting wing screws pull the bracket securely against the wall. The LV series – LV1, LV2 and multiple gang brackets – adjust to fit 1/4" to 1" wall thicknesses.

For *new construction*, the nail or screw-on LVN series brackets attach to a wood stud. They cost less than extension rings and install faster than mud rings. For *screw-on, steel stud* installations, try the LVS or LVMB series.

We also offer a variety of low voltage brackets for specialty applications.

LISTED

Product Info aifittings.com/landing/low-voltage-mounting-brackets

associated equipment.

Adherence to the NESC is vast. Most of the outside plant networks of communications and power grid installations in the United States follow the NESC. Utilities use the NESC as the basis for their joint use agreements within state and local jurisdictions. Most, if not all, of the "make-ready work" — and its associated fees that telecom companies pay electric utilities to connect to their facilities and/or infrastructure — is largely based on

RAIN-TIGHT • CONCRETE-TIGHT FITTINGS FOR

Made in USA

PVC JACKETED MC CABLE

ONE FITTING FITS MULTIPLE CABLE SIZES

1/2"
LTMC50
(components)

Arlington®

800/233-4717 • www.aifittings.com

Save time and money with Arlington's *rain-tight, concrete-tight* fittings for PVC jacketed MC cable.

ONE fitting FITS MULTIPLE cable sizes!

LTMC50 *ships ready to use on #10, #12 or #14 PVC jacketed MC cable. Try the NEW SIZES too... LTMC507 and LTMC75.*

Because they fit more than one cable size, these fittings reduce inventory, saving the cost of stocking several *different* fittings.

Ideal for Parking Decks,
High-rise Residential

c UL us

Catalog Number	Cable Ranges (Outer Cable Diameter)	
LTMC50	.415" - .565"	
LTMC507	.550" - .765"	goes into 1/2" KO
LTMC75	.725" - .980"	goes into 3/4" KO

Patented

Product Info aifittings.com/landing/ltmc507-ltmc75/

LOWEST COST • L-SHAPED

Made in USA

FAN/FIXTURE BOX

SECURE MOUNTING TO SINGLE, DOUBLE JOISTS

Super-secure installation! Our lowest cost, L-shaped fan/fixture box mounts to single or double joists with a captive center screw.

No loose parts! Installation screws ship captive, ready to install box and bracket.

- For 1/2" or 5/8" drywall
- Fast, easy installation
- Locator posts assure proper positioning of fan/fixture bracket
- 2-hour Fire Rating

Patented

Product info
aifittings.com/landing/joist-mount-fan-fixture-box

Arlington®

800/233-4717 • www.aifittings.com

WEATHERPROOF

Made in USA

OUTLET BOX

EASY TO INSTALL ON ANY SIDING TYPE

Our one-piece FS8091F outlet box is your best buy for a fast, easy device installation on siding.

- Works with all single-gang devices, including GFCIs
- Installs on any siding, before or after it's up
- For use where a weatherproof-in-use cover is not required – Accommodates a weatherproof-in-use cover for wet locations

Product info aifittings.com/catalog/siding-mounting-blocks/weatherproof-fs-outlet-box/FS8091F

Arlington®

800/233-4717 • www.aifittings.com

Join Our Efforts

The 2023 NESC is the product of hundreds of contributors and peer reviewers and the careful editing of the IEEE Standards Association. To further address new technologies in subsequent editions of the Code:

- A new subcommittee was created focusing on generating stations with the original subcommittee continuing to address substations.
- A working group is investigating Fault Managed Power Systems (FMPS) cables (as the technology may be used for 5G networks). The team is looking at possible impacts, including clearances and work rules.

We welcome your participation in these efforts. For more information, please visit standards.ieee.org where you can learn more.

installation and compliance requirements found in the NESC.

FORMAT HIGHLIGHTS

Like previous versions, the 2023 edition will be available in digital, printed, e-Learnings, redline versions, and mobile-app formats. The edition consists of initial sections covering scope, purpose, and grounding methods, followed by sections that include specific rules for electric supply stations, overhead lines, underground lines, and safety-related work practices.

A companion *2023 NESC Handbook*, published at the same time as the Code, includes all the rules of the Code but also provides insights and commentary on the rules and how to apply them from the experts who helped develop the Code. The new handbook format will be more user-friendly, providing historical notes that give context for revisions and additions. The previous edition of the handbook (2017 edition) is available in Spanish and Chinese, and the 2023 handbook will be translated soon.

Another key improvement to the user experience — and to help prevent critical errors — are the notable changes made to units of measurement. All stand-alone tables for metric measurements have been removed from the main body and moved to Annex 1. For tables that include both English and metric values, the revised Code presents numerical values in the customary "inch-foot-pound" system first and the corresponding metric values following in parentheses. These and other changes were introduced to help prevent users from making serious errors caused by misreading a value as being metric when, in fact, they are U.S. values.

STRUCTURE AND UPDATE HIGHLIGHTS

The 2023 NESC is divided into several major sections. Following are highlights of revisions and additions:

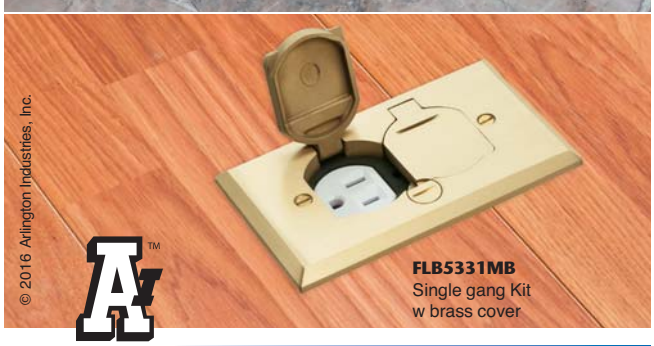
- **Section 1 [Scope and Purpose]** — Several practical editorials, clarifications, and format revisions were made in Sec. 1 and throughout the Code to emphasize the primary focus as being the safety of persons, leaving the protection of facilities as a secondary benefit (Scope Rule 010). In addition, Rule 013 on the "Application of Rules to Existing installations and New Construction" was clarified to provide operational flexibility for maintenance replacements, adding facilities to existing poles/structures, and modifications to existing poles.
- **Section 2 [Definitions of Special Terms]** helps clarify the intent of the detailed rules throughout the NESC as well as maintain consistency across the Code.
- **Section 9 [Grounding Methods for Electrical Supply and Communications Facilities]** provides methods for grounding to help prevent injury that may be caused by differences in electrical potential. This section contains the means for grounding and bonding for communications equipment and where intersystem bonding (power and communications) is necessary (Rule 097).
- **Part 1 (Sections 10-19) [Rules for the Installation and Maintenance of Electric Supply Stations and Equipment]** covers protective arrangements

STEEL BOX WITH BRASS COVER

LISTED SINGLE GANG FLOOR BOX KITS

CONVENIENT, FLUSH-TO-THE-FLOOR RECEPTACLE INSTALLATION

FLB5331NL
Single gang
steel box kit
w nickel-plated brass cover



FLB5331MB
Single gang Kit
w brass cover

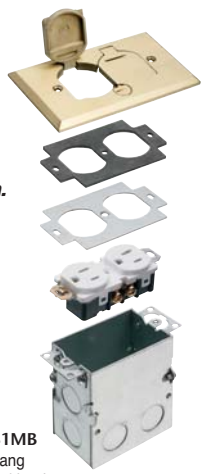
Arlington® 800/233-4717 • www.aifittings.com

Arlington's **STEEL FLOOR BOX KITS** give installers a low cost, *convenient* way to install a receptacle *in a new or existing floor*.

Our Listed Single Gang Steel Floor Boxes deliver easy, flush-to-the-floor installation.

- Brass covers hide miscut flooring; gaskets prevent water intrusion; flip lids protect the box when it's not in use.
- Single gang brass and nickel-plated **Brass Covers** fit our boxes *and other manufacturers' single gang boxes.*

Covers also sold separately.



FLB5331MB
Single gang
steel box kit w brass cover

for NEW or existing floors

c UL us

Product info aifittings.com/landing/flb5331-flb5551-kits

IN BOX® RECESSED COVER KITS

INSTALLS INSIDE 4.5" CONCRETE BOXES

NEW!

c UL us

Arlington® 800/233-4717 • www.aifittings.com

Arlington's **IN BOX® Recessed Cover Kits** are the neat way to install a receptacle in an installed 4.5" concrete floor box, *including our FLBC4500 or FLBC4502 boxes.*

IN BOX covers install fast, *inside the can* reducing trip hazards caused by plugs sticking out of the box. They look great. And, you can have power and low voltage in the *same* box.

Assembled IN BOX, comes with matching in-use slotted cover and cover blank for unused boxes in **brass** or **nickel-plated brass**

...and **plastic** in FIVE colors.

Product info aifittings.com/landing/inbox-cover-kits/

and enclosures as well as rotating equipment (such as generators and motors), batteries, transformers and regulators conductors, circuit breakers, switches, fuses, switchgear, surge arresters, and other items encountered within a supply station. The explicit inclusion of grid-connected generation facilities in Part 1 of the 2023 Code included a major update to the battery rules (Sec. 14) and the addition of a new Sec. 19 for photovoltaic systems.

- **Part 2** is divided into two sub-parts.
- **Sections 20-23 [Overhead Lines — Clearances]** define the organization and location of communication and supply conductors on the overhead facilities, clearances between conductors, structures, buildings, and the arrangement of circuits and associated overhead equipment and hardware. While it is recognized that physical protection is not practical or required for supporting structures located outside of established parking areas, alleys, or driveways, revisions in the 2023 NESC emphasize that every guy wire should be routinely marked at vulnerable or susceptible locations.
- **Sections 24-27 [Overhead Lines - Strength and Loading]** define various grades of construction and the corresponding storm loading and strength requirements for support structures and associated hardware as well as the conductors and messengers. Rules for power line insulators (including characteristics, mechanical strength, and application) are also included. For the 2023 Code, Sec. 25 and Sec. 26 were modernized by adding the most up-to-date wind maps from ASCE 7 and ASCE 74 (i.e., the 50- and 100-year MRI, or the Mean Return Interval, loading maps) as well as revising the rules for defining which construction grade (Table 242-1) is to be used for a given installation and application.
- **Part 3 (Sections 30-39) [Safety Rules for the Installation and Maintenance of Underground Electric Supply and Communication Lines]** provides requirements for cables and equipment deployed in underground, or direct buried systems as well as installations in tunnels. This section also covers where these facilities interconnect and terminate with equipment located at the ground surface or on poles.
- **Part 4 (Sections 40-44) [Rules for the Operation of Electric Supply and Communications Lines and Equipment]** addresses safe work practices for employees, including the responsibilities of employers, contractors, and host employers. Work rules on arc-flash protection, RF exposure management, and battery facilities were all updated and made more practical to match the latest technologies and facilities.

The 2023 *NESC Handbook* will include an appendix (Handbook Appendix 8) listing all the expected major changes.

EMERGING TECHNOLOGIES AND SUBSTANTIVE CHANGES

As technology changes and evolves, so does the NESC. The 2023 NESC includes updates throughout, many of which address emerging technologies such as solar and wind energy, distributed energy/microgrids, batteries/energy storage, and wireless small cell networks. Notable updates and refinements to the code include:

- A new Sec. 19 covers photovoltaic generating stations, with sections addressing general codes, location, grounding configurations, vegetation management, DC overcurrent protection, and DC conductors. These new rules accommodate large-scale solar power projects.
- Significant revisions were made to Sec. 14 covering batteries. Previous editions of the Code were based on lead-acid technology and batteries only used for backup power. The 2023 Code incorporates the new battery technologies and addresses energy storage along with backup power.
- In the "Clearances" section, all rules for wireless antenna structures have been consolidated in the equipment section (Rule 238 and 239), which makes the Code more user-friendly. EC&M

Ernesto Vega Jánica serves as senior manager of opportunities development for the IEEE Standards Association. Recognized as the 2017 Fire Protection Engineer of the Year by the Society of Fire Protection Engineers (SFPE), New Jersey Chapter, and awarded the 2011 Tyco Patent Prize as the author of a patent application on visual fire alarm notification devices, Vega Jánica has authored multiple technical papers and international presentations in the engineering fields, as well as in applications of optimization models. He earned a Bachelor of Science in Electrical Engineering from Universidad del Norte and a Master of Science in Project Management from Escuela Colombiana de Ingenieria, in Colombia, South America, after which he earned a master's degree in Fire Protection Engineering from the University of Maryland College Park. Vega Jánica is also an instructor of international standards.

ADJUSTABLE • NON-METALLIC

Made in USA

IN/OUT™ BOX for Fans & Fixtures

EASY TO INSTALL... IN NEW CONSTRUCTION

Arlington® 800/233-4717 • www.aifittings.com

Arlington's IN/OUT BOX ***for fans and fixtures*** adjusts up to 1-1/2" to accommodate varying ceiling thicknesses, like single or double drywall.

- Pre-set for 1/2" ceiling...use depth adjustment screw *after the ceiling's in place* to position the box flush with the ceiling
- Complies with 2020 NEC, 314.20 for set back boxes
- (4) screws attach box securely to joist in new work
- **2-Hour Fire Rating** ***Listed for fans up to 70 lbs; fixtures up to 100 lbs***

Product info aifittings.com/landing/fba426

1 Cutaway: Box set back in double drywall

2 After ceiling's installed, (if necessary) use the depth adjustment screw to position box flush with ceiling.

Patented

ADJUSTABLE BRACKET • EASY INSTALLATION IN EXISTING CEILING

FAN/FIXTURE BOX

HIGHER WEIGHT RATINGS

Arlington® 800/233-4717 • www.aifittings.com

Arlington's extra heavy-duty, plated steel fan/fixture box with adjustable bracket has ***higher UL Weight Ratings***:
at 24" on-center: **70 lb Fan, 90 lb fixture**
at 16" on-center: **70 lb Fan, 150 lb fixture**

The 20.0 cu. inch FBRS4200R installs *between* rafters with 16" to 24" on-center spacing, holding a fan or fixture securely in place. It's easy...

REMOVE BOX from bar.
INSERT BAR in opening. Embed bracket ends in joist. Tighten hex, first by hand then with a wrench. Pull wire.
REATTACH BOX to bar.

No parts to lose. Installation screws ship captive, along with a mud cover and installed NM cable connector.

FBRS4200R
Patented

CSA Rated: at 16" or 24" oc 50 lb fan or fixture

Product info aifittings.com/landing/fbrs4200r

Personal Protective Equipment

Safety Glasses

Spike eye protection combines a two-pronged strategy for vision protection with comfort features. The product comes equipped with BK-Anti-Fog+ fused directly to the lens to deliver fog-free protection. According to the company, Spike's ultraviolet protection eliminates 99.99% of damaging UV rays. Finally, the product comes with various features designed to create an easily customizable fit for virtually any face, including a five-step angle-adjustable temple, reinforced-rubber nosepieces, and an integrated soft brow guard.

Brass Knuckle

PPE Task Wear

The Contractor series of arc flash protective clothing PPE provides a total system of arc-rated protective clothing with kits that include a hood, hard hat, coats, pants, coveralls, ear canal hearing protection, and safety glasses or goggles. This PPE is available in 8 CAL/cm² and 40 CAL/cm² levels of protection and complies with the NFPA 70E and CSA Z462 standards. According to the company, it covers Category 1 and 2 with the 8 CAL/cm² and Category 3 and 4 with the 40 CAL/cm² for complete protection with minimal redundancy.

Cementex

Safety Vest

The SV500 lighted safety vest is equipped with high-vis yellow mesh and two-tone reflective accent stripes. In addition, the product enhances visibility with the addition of patented CIRCLIGHT safety technology — a built-in, rechargeable, and wire-free LED light tube that runs 360° around the wearer's torso. From a full charge, the vest delivers up to 28 hr of light, according to the company. Other features include 11 internal and external pockets, two mic tabs, a D-ring access slot, and a secure zipper closure.

COAST

Flame-Resistant Pants

The flame-resistant (FR) pant collection is designed for women within oil, gas, electrical, utility, and heavy industries where the need for electrical arc and flash flame protection is required. FR workwear collection consists of two core pant designs — Britt Utility and DX Bootcut — in varying material weights (each with flame resistant properties). The FR pants serve as a walking toolbox with 11 pockets for safety glasses and tools, articulated knees for mobility, tough cuffs for added abrasion resistance, plus increased range of movement on the job with the EZWaist and crotch gusset features. According to the company, all FR pants meet safety standards PPE Category 2, ASTM F106, and NFPA 2112 and 70E.

Dovetail

EASY TO INSTALL...FOR TV INSTALLATIONS

TV BRIDGE™ KIT

GOOD LOOKS • A GREAT FINISH IN RETROFIT PROJECTS

Arlington's **TVBR2505K TV Bridge™ kit** includes TWO recessed power/low voltage combo boxes and all the connections needed *except NM cable* to install a TV in an existing wall.

There's no need to run cable from a panel box *or to cut into the framing members.* Just cut two openings in the wall to access power from an existing, nearby source.

- Fast, easy, convenient; saves time and money!
- **Cables stay hidden behind the wall – no wires running down the wall from TV to components.**
- Plugs stay inside electrical box without protruding past the wall
- Mounting wing screws pull boxes snug against wall
- 18.0 cu. inch recessed boxes with paintable trim plate(s)

TVBR2505K

Arlington® 800/233-4717 • www.aifittings.com

Made in USA

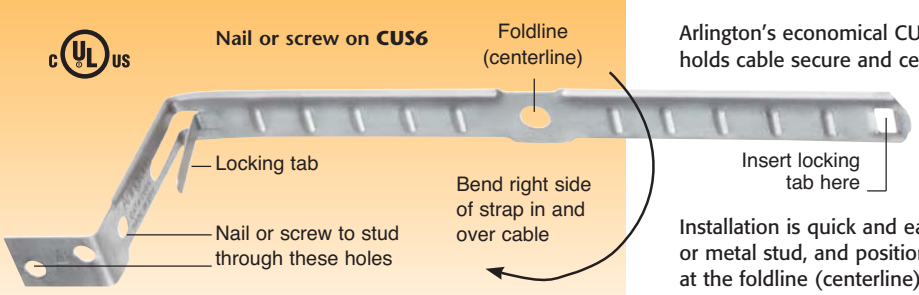
GALVANIZED STEEL

Made in USA

NEW

CABLE SUPPORT

ECONOMICAL...HOLDS UP TO FOUR MC CABLES • EASY TO INSTALL



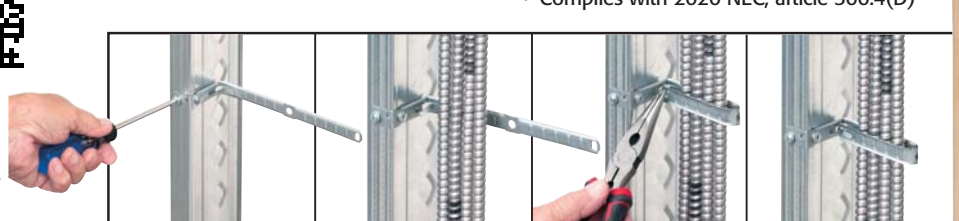
Arlington's economical CUS6 galvanized steel Cable Support holds cable secure and centered on a metal or wood stud.

It's perfect for fastening and positioning *up to four* individual metal clad cables – or six NM cables on a 2x4.

Installation is quick and easy. Nail or screw ***CUS6*** to a wood or metal stud, and position the cables. Next bend the strap at the foldline (centerline). Fold the strap over the cables and insert the locking tab in the opening as shown to hold them securely in place.

- Complies with 2020 NEC, article 300.4(D)

Holds up to four MC cables centered on a 2x4!



CUS6 holds **FOUR metal cables**...or **SIX NM cables**

Arlington® 800/233-4717 • www.aifittings.com

Product info aifittings.com/landing/cus6/

Work Gloves

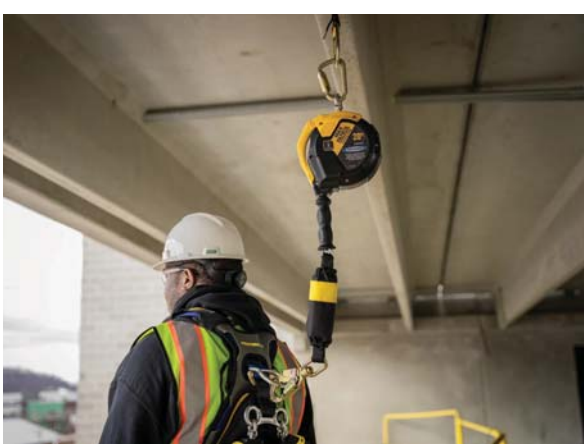
Dura-Knit work gloves eliminate all the seams along the fingers of the gloves for increased precision, control, and comfort. Coupled with a breathable fabric that offers 360° stretch, Dura-Knit is digitally optimized to mold to the hand for a second-skin fit and all-day comfort. The durable, synthetic leather with grip-enhanced palm delivers confidence to safely handle tools or small parts.

Firm Grip

Hard Hats

The new line of Type II+ full-brimmed hard hats, the WaveCel T2+MAX vented hard hat for all-day wear and the WaveCel T2+PRO non-vented hard hat for electrical jobs are designed to better protect workers in the field. The entire hard hat shell, crown, and sides are lined with collapsible WaveCel spatial cellular structure to provide 360° of protection. Each hard hat contains a network of hundreds of interconnected shock absorbers, attenuating impacts through three principal mechanisms: flex, crumple, and glide. Cells crumple to absorb linear forces, and they flex and glide to attenuate rotational forces.

WaveCel



Lifeline

The Bantam and Max Patrol self-retracting lifeline (SRL) families have been updated to meet or exceed ANSI standards in every category, according to the company. The compact and versatile SRLs, which are now smaller and lighter, are approved for use on steel beams, precast concrete, and B-deck. In addition, the company says the new Bantam 6-ft web leading edge SRL saves weight using a webbing that weighs 30% less than steel cable of the same length. Finally, the products feature unique labels and visual markings to help customers better understand product application usage.

Werner

Flame-Resistant Fabric

The Polartec FR collection of flame-resistant (FR), arc-rated (AR) knit fabric introduces three unique Polartec fabric constructions engineered with Westex FR/AR fabric technology that provides thermal hazard protection. The products span shirting, insulation, and weather resistance fabrics that, according to the company, meet or exceed worldwide protection standards. The collection knits patented tri-blend yarn into flame-resistant, temperature-regulating fabrics, meaning dual-hazard thermal protection is engineered directly into the fiber and is guaranteed by the company for the life of the garment.

Westex and Polartec

ONE-PIECE. SAVES TIME – LOOKS GREAT!

Made in USA

RECESSED IN BOX®

LOW PROFILE, EXTRA DUTY COVER • *TWO STYLES* for *1-1/2"* and *Foam Wall Systems*

DBVMA1C
clear cover

DBVMA1W

ADJUSTABLE Depth

One-piece **IN BOX**®, the recessed electrical box for exterior use, eliminates installing an electrical box and bubble cover assembly, so *you save big* on labor and materials.

IN BOX installs in the wall – so less shows outside. Fewer parts to handle. Time savings. *A great-looking job with Arlington's IN BOX!*

- Non-metallic, 22.0 cu. in. box with EXTRA-DUTY weatherproof-in-use clear or white cover
- Accepts single-gang devices; no gaskets required

for Help in Maintaining CONTINUOUS INSULATION in foam sheathing applications

DBVME1W

Built-in FIXED FLANGE

Fits ANY foam board *on 2-3/4" to 5" wall or* ***custom stucco finishes*** *1/4" to 2-1/2" thick.*

DBVMA1W
white cover

Product Info aifittings.com/landing/db-series

IN BOX MEETS 2020 NEC Section 406.9 *for protection of exterior outlets which require the use of extra-duty weatherproof-in-use cover for all outdoor 15 or 20 AMP receptacles.*

For ***1-1/2" wall systems****, including foam. Eliminates separate flashing.*

DBVME1W
white cover

Patented/Additional patents pending

Arlington®

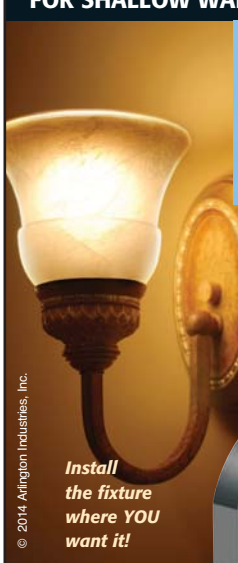
800/233-4717 • www.aifittings.com

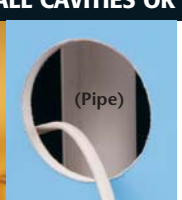
LOW PROFILE • 4" DIAMETER

Made in USA

SCONCE BOX

FOR SHALLOW WALL CAVITIES OR OBSTRUCTIONS





Arlington's **Low Profile Sconce Box** is perfect for retrofit installations with shallow wall cavities or obstructions in the wall.

This non-metallic box installs FAST in an existing 1/2" or 5/8" wall with a 4" hole saw.

- Mounting wing screws hold it firmly in place
- Accommodates most sconce light canopies

FSC405R
Sconce Box

c UL us

Patented

Product info aifittings.com/landing/sconce-box

Arlington®

800/233-4717 • www.aifittings.com

NON-METALLIC NM3100 SERIES

QUICKLATCH™

EASIER TO USE THAN A PIPE HANGER

Patent pending

Stainless steel screw

Pre-installed strut clip for **faster installation on strut**

NEW

MOUNT. PRESS PIPE INTO QUICKLATCH. DONE!

UV rated for use outdoors

Listed for environmental air handling spaces

c UL us

SAVES 20 SECONDS per Installation!

...about 33¢ each at $60/hr labor!

Arlington®

1/2" NM3105 for RIGID, IMC, PVC – **NM3100** for EMT
3/4" NM3115 for RIGID, IMC, PVC – **NM3110** for EMT
1" NM3125 for RIGID, IMC, PVC – **NM3120** for EMT

Info aifittings.com/landing/quicklatch_series

Lock collar

The Appleton Powertite lock collar is a device that fastens over plug/connector connections and is secured with a padlock, preventing unauthorized personnel from disconnecting the cable connection once in place. The product fits both the 60A and 100A versions of the Appleton Powertite pin-and-sleeve plugs and connectors as well as similar models from Crouse-Hinds. Its rugged, thick resin construction withstands extreme environments and punishing handling. The collar works with either the provided keyed padlock or all standard lock-out padlocks.

Emerson

LED wall pack

The color and wattage selectable LED adjustable wall pack Series is available in two units, each offering three color temperatures and three wattages. The wall pack series can be locked into any angle, ranging from 0° to 90° to deliver precise exterior security illumination and prevent skyglow. The LED wall packs can switch between three temperatures (3,000K, 4,000K, and 5,000K) and three wattages. The product delivers 130 lm/watt with an 80+ CRI. They produce 3,900 5,200, 6,500, 9,360, 12,480, and 15,600 initial lm, respectively. The wall packs accept 120/347VAC power supply for use in both the United States and Canada and are equipped with a 0V to 10V continuous dimming driver with a dimming range capability of 10% to 100%. The wall pack series also comes with a photocell for dusk-to-dawn operation.

EarthTronics

Truck bed slide

CargoGlide is a heavy-duty sliding bed platform that makes loading, unloading, organizing, and accessing gear more efficient. With the pull of a lever, CargoGlide rolls forward out of the truck bed from its locked position. According to the company, the product extends past the end of the bed by as much as 100%, putting gear that would be otherwise out of reach at chest level. CargoGlide comes in 1,000-, 1,500-, and 2,200-lb payload options, with either 75% or 100% extension of the tray available.

DECKED

Pliers wrench

The pliers wrench XS is a compact tool at only 4 in., with a jaw capacity of ¾ in. According to the company, the product is designed with smooth jaws that will not mar surfaces. It is ideal for gripping, holding, pressing, and bending applications. With the one-handed adjustment, users can quickly slide through 10 adjustment positions to find the right fit. The compact design and slim head allow easy access to confined areas, and texturized handles provide a better grip.

KNIPEX

Electrical metallic tubing

The Allied Tube and Conduit E-Z Pull electrical metallic tubing (EMT) is now available in 20-ft lengths. The new length offers an E-Z Pull interior coating for fast and easy wire pulling and a Flo-Coat exterior coating for protection against corrosion and abrasion, according to the company. With twice the length, the product helps contractors save time by using fewer fittings and connections on long conduit runs. The 20-ft EMT features straight and true conduit installations, and trade size ranges from ½ in. to 4 in.

Atkore

Lens attachment

The FlexView dual field-of-view (DFOV) lens attachment for FLIR Axxx and Txxx Series thermography cameras is designed to improve operational efficiency, safety, and accuracy from switchyards to the plant floor. With a single form factor just 6 mm longer than the standard single-lens setup, operators can have two lenses without adding weight. FlexView also offers fully radiometric performance and imaging quality, resulting in the ability to measure and record the temperature of every pixel in the scene for improved decision support.

Teledyne FLIR

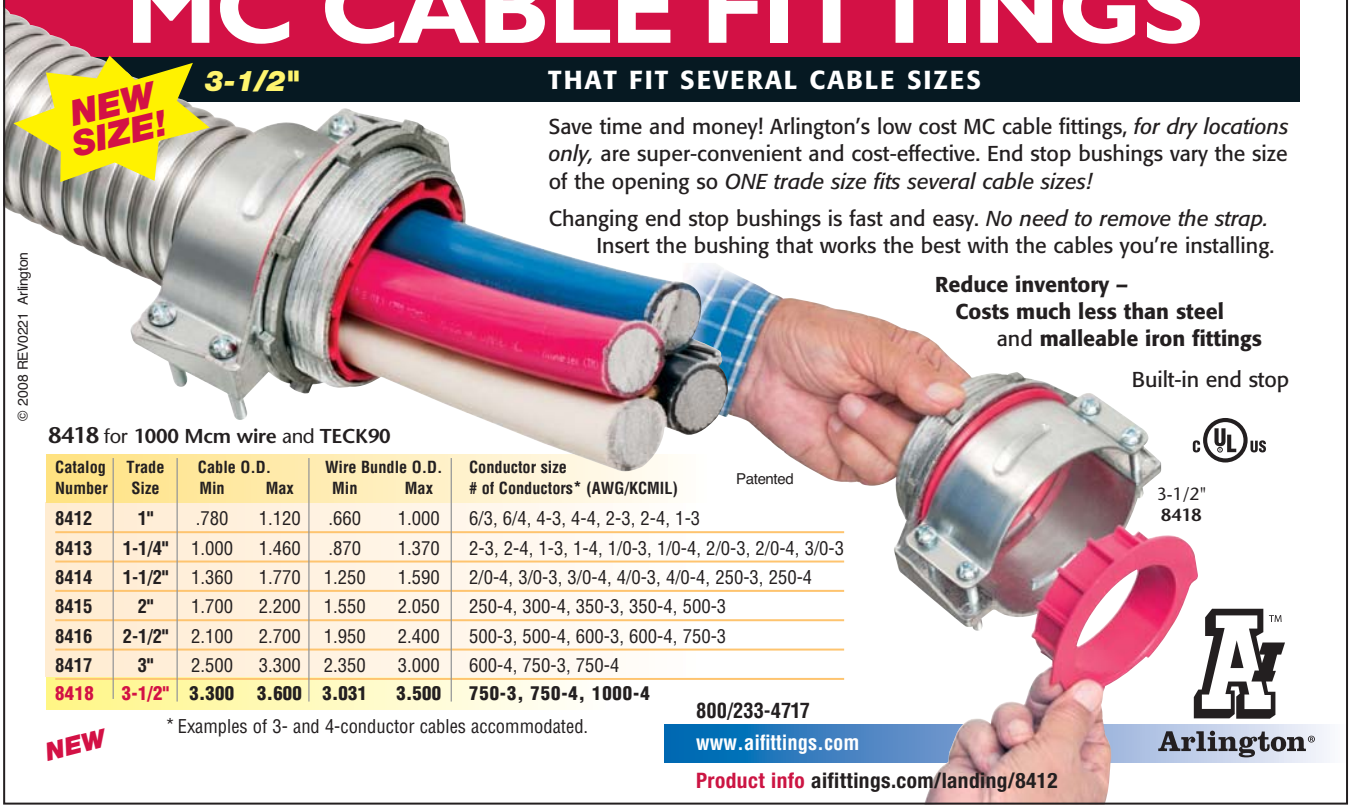
LOW COST • ZINC

Made in USA

MC CABLE FITTINGS

3-1/2" THAT FIT SEVERAL CABLE SIZES

NEW SIZE!



Save time and money! Arlington's low cost MC cable fittings, *for dry locations only,* are super-convenient and cost-effective. End stop bushings vary the size of the opening so *ONE trade size fits several cable sizes!*

Changing end stop bushings is fast and easy. *No need to remove the strap.* Insert the bushing that works the best with the cables you're installing.

Reduce inventory –
Costs much less than steel and malleable iron fittings

Built-in end stop

Patented

3-1/2"
8418

8418 for **1000 Mcm wire** and **TECK90**

Catalog Number	Trade Size	Cable O.D. Min	Cable O.D. Max	Wire Bundle O.D. Min	Wire Bundle O.D. Max	Conductor size # of Conductors* (AWG/KCMIL)
8412	1"	.780	1.120	.660	1.000	6/3, 6/4, 4-3, 4-4, 2-3, 2-4, 1-3
8413	1-1/4"	1.000	1.460	.870	1.370	2-3, 2-4, 1-3, 1-4, 1/0-3, 1/0-4, 2/0-3, 2/0-4, 3/0-3
8414	1-1/2"	1.360	1.770	1.250	1.590	2/0-4, 3/0-3, 3/0-4, 4/0-3, 4/0-4, 250-3, 250-4
8415	2"	1.700	2.200	1.550	2.050	250-4, 300-4, 350-3, 350-4, 500-3
8416	2-1/2"	2.100	2.700	1.950	2.400	500-3, 500-4, 600-3, 600-4, 750-3
8417	3"	2.500	3.300	2.350	3.000	600-4, 750-3, 750-4
8418	**3-1/2"**	**3.300**	**3.600**	**3.031**	**3.500**	**750-3, 750-4, 1000-4**

NEW

* Examples of 3- and 4-conductor cables accommodated.

800/233-4717
www.aifittings.com
Arlington®

Product info aifittings.com/landing/8412

FLUSH-WITH-THE-CEILING INSTALLATIONS

Made in USA

NEW FAN/FIXTURE BOX

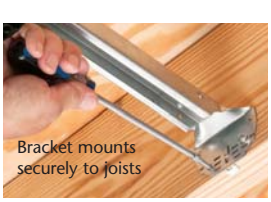
THE LOW COST BOX...WITH ADJUSTABLE STEEL BRACKET AND *PLASTIC* BOX

Arlington's low cost, economical *steel* fan/fixture bracket with *plastic* box delivers super-secure, versatile on-center mounting between joists spaced 16" to 24".

- Easy mounting in new construction... fan bracket installation screws ship captive
- Bracket ends adjust for flush installation on ceilings up to 1-1/4" thick. They're pre-set for a 1/2" ceiling. Bend along score line for other ceiling depths.

- 23.0 cu. in. plastic box is positionable anywhere along bracket
- UL/CSA Listed

*** 2-HOUR FIRE RATING**



Arlington® 800/233-4717 • www.aifittings.com

Product info aifittings.com/landing/fbr423

Remote Control and Signaling Circuits, Class 2

Using Class 2 circuits may eliminate shock or fire hazards, but only if you install them correctly.

By Mike Holt, NEC Consultant

Class 2 circuits are limited to voltage and current values that don't (usually) present a shock or fire hazard.

The power supply for a Class 2 circuit must be as follows [725.121(A)]:

(1) A listed Class 2 transformer (**Fig. 1**).

(2) A listed Class 2 power supply.

(3) Equipment listed as a Class 2 power source.

Exception No. 2: Where a circuit has an energy level at or below the limits in Chapter 9, Table 11(A) and 11(B), the equipment need not be listed as Class 2.

(4) Listed audio/video information technology equipment, communications, and industrial equipment limited-power circuits.

A fifth power supply available to Class 2 circuits is a battery source/system that is listed and identified as Class 2.

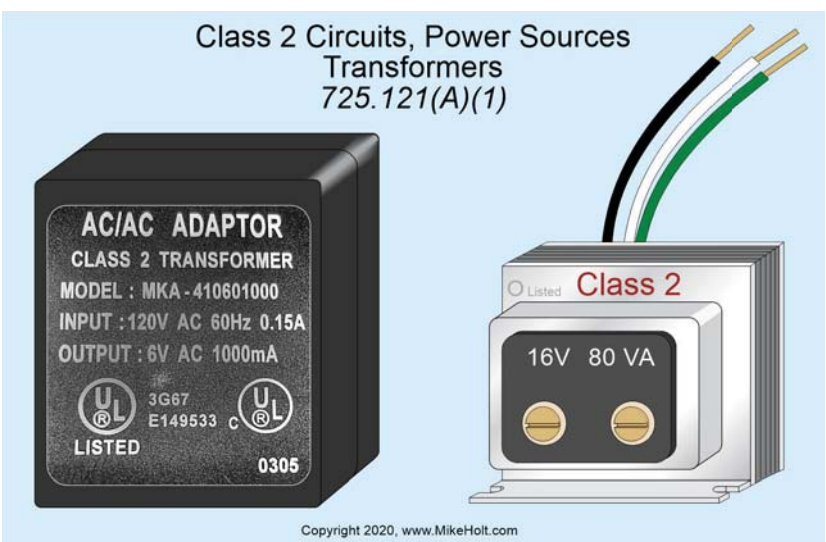


Fig. 1. Transformers used as a Class 2 power source must be listed.

CLASS 2 CABLES

For corrosive, damp, or wet locations, Class 2 cables must be identified for the location per Sec. 110.11 and Sec. 310.10(F). Conductors and cables in underground raceways [Sec. 300.5(B)] or in raceways above ground in wet locations [Sec. 300.9] must also be identified for wet locations. Where corrosion may occur, follow the requirements of Sec. 300.6 [Sec. 725.3(L)].

Class 2 cables can be installed in:

- Cable routing assemblies selected per Table 800.154(c), listed per Sec. 800.182, and installed per Sec. 800.110(C) and Sec. 800.113 [Sec. 725.3(M)].
- Communications raceways selected per Table 800.154(b), listed per Sec. 800.182, and installed per Sec. 800.113 and Sec. 362.24 through Sec. 362.56, where the requirements applicable to electrical nonmetallic tubing apply [Sec. 725.3(N)].

The requirements of Sec. 310.14(A)(3) for the temperature limitation of conductors apply to Class 2 cables [Sec. 725.3(O)]. The accessible portion of Class 2 cables not terminated at equipment or tagged for future use must be removed [Sec. 725.25].

MARKING

The power sources for power-limited circuits in Sec. 725.121(A)(3) and power-limited circuits for listed audio/video equipment, listed information technology equipment, listed communications equipment, and listed industrial equipment in Sec. 725.121(A)(4) must be labeled with the maximum voltage and rated current output per conductor for each connection point on the power source [Sec. 725.121(C)].

Equipment supplying Class 2 circuits must be durably marked to indicate each circuit that is Class 2 [Sec. 725.124].

WIRING METHODS

Conductors and equipment on the supply side of the Class 2 power supply must be installed per Chapters 1 through 4. The overcurrent protection for Class 2 transformers or power supplies must not exceed 20A [Sec. 725.127] (**Fig. 2** on page 62).

Class 2 circuits can use a Class 1 wiring method per Sec. 725.46 [Sec. 725.130(A)]. Class 2 circuits can be reclassified as Class 1 circuits if the Class 2 equipment markings are eliminated, and the circuit is installed using a Chapter 3 wiring method per Sec. 725.46 [Sec. 725.130(A), Exception No. 2].

ECONOMICAL SINGLE and TWO-GANG NON-METALLIC

Made in USA

VAPOR BOX for Devices

NAILS TO STUD IN NEW CONSTRUCTION

Arlington® 800/233-4717 • www.aifittings.com

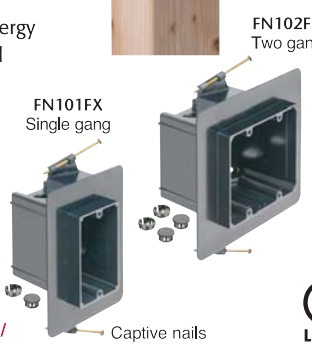
Designed for devices, Arlington's *economical* single and two-gang **Vapor Boxes** offer easy nail-on installation in new construction.

These cost-saving boxes don't include gaskets, but when caulked around the NM cable during installation, they **meet the requirements of NEMA 0S-4**. And help meet International Energy Conservation Codes (IECC), and other codes *where required.*

- Nails ship captive. Plugs and NM cable connectors supplied.

2-hour Fire Rating

Patented



Product info
aifittings.com/landing/fn101fx-fn102fx/

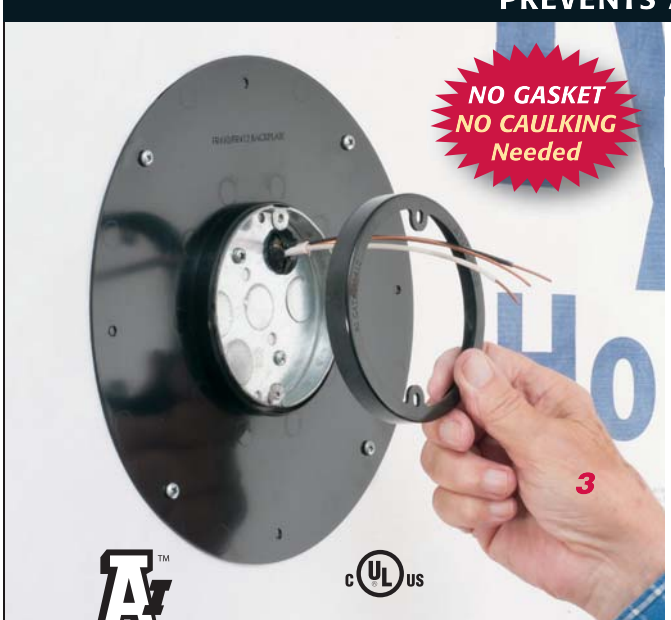
UL LISTED

NON-CORROSIVE • FOR INSTALLED EXTERIOR FIXTURE BOXES

Made in USA

VAPOR/WATER BARRIER

PREVENTS AIR & WATER FROM ENTERING BOX

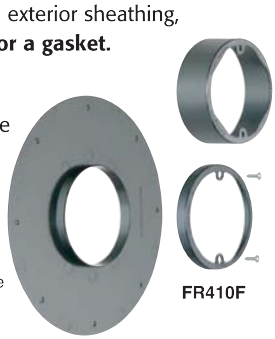


Arlington® 800/233-4717 • www.aifittings.com

Designed for exterior fixture boxes, Arlington's LISTED vapor/water barrier prevents water and air from entering around a box installed on exterior sheathing, **without the need for caulking – or a gasket.**

FR410F saves time and money!

Easy to install, the backplate flange mounts over an *installed* fixture box. And comes with two flanges for use on a pan box *or a deeper octagonal box.*



Easy to install on installed fixture box

Product info aifittings.com/landing/fr410F

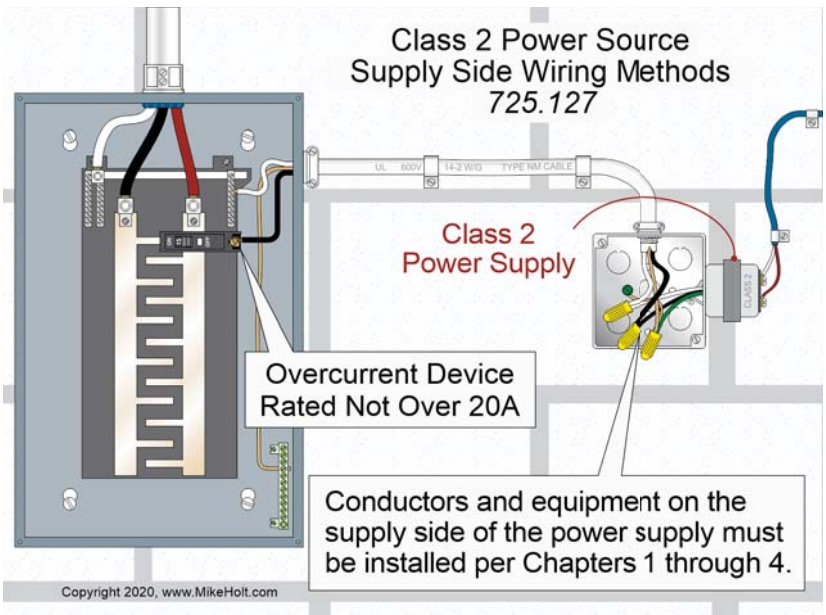


Fig. 2. The overcurrent protection for Class 2 transformers or power supplies must not exceed 20A.

Where a Class 2 circuit is reclassified as a Class 1 circuit, it can be run in the same raceway, cable, or enclosure with power conductors of functionally associated equipment [Sec. 725.48(B)]. Class 2 circuits reclassified and installed as Class 1 circuits are no longer Class 2 circuits, regardless of their continued connection to a Class 2 power source [Sec. 725.130(A) Note].

Class 2 circuits can use Class 2 wiring of the type in Sec. 725.179 if installed per Sec. 725.133 and Sec. 725.154 [Sec. 725.130(B)].

CABLE INSTALLATION

Class 2 cable installation must comply with Sec. 725.135(A) through (M). For example:

- Plenum-rated Class 2 cables can be installed within plenum air spaces per Sec. 725.3(C) Exception No. 2 if the Class 2 cables are plenum rated, except were installed in a metallic raceway per Sec. 300.22(C) [Sec. 725.135(C)].
- Cables installed in cable trays outdoors must be Type PLTC.

You'll see some overlap, also. For example, the following cables are permitted in cable trays inside buildings Sec. 725.135(H) and in dwelling units [Sec. 725.135(M)]: PLTC cables and types CL2P, CL3P, CL2R, CL3R, CL2, and CL3.

SEPARATION

Class 2 cables are not permitted in any enclosure or raceway with power and Class 1 circuits, except as permitted in Sec. 725.136(B) through (I).

For example, Class 2 circuit conductors can be installed with power conductors and Class 1 conductors if separated by a barrier [Sec. 725.136(B)].

You can mix conductors of different circuits, per Sec. 725.139(A) through (F). For example, Class 2 circuit conductors can be in the same:

- Cable, cable routing assembly, enclosure, or raceway with other Class 2 circuit conductors [Sec. 725.139(A)].
- Cable with conductors of communications circuits if the cable is a listed communications cable that has been installed per Part V of Art. 805 [Sec. 725.139(D)].

POWER AND DATA TRANSMISSION

Section 300.11 and Parts I and III of Art. 725 apply to Class 2 circuits that transmit power and data. Conductors that carry power and data must be copper, and the current cannot exceed the current limitation of the connectors [Sec. 725.144]. Six informational notes follow Sec. 725.144 (and these have been heavily revised with the 2020 cycle). For example:

• Note 1: Closed-circuit TV camera (CCTV) circuits are an example of cables that transmit power and data.

• Note 6: The rated current for power sources covered in Sec. 725.144 is the output current per conductor the power source is designed to deliver to an operational load at normal operating conditions, as declared by the manufacturer. In the design of these systems, the actual current in a given conductor might vary from the rated current per conductor by as much as 20%. An increase in current in one conductor is offset by a corresponding decrease in current in one or more conductors of the same cable.

Table 725.144 is an ampacity table for 4-pair Class 2 power/data cables. Make sure you understand the notes that come with it. For example, where only half of the conductors in each cable are carrying current, you can increase the values in the table by a factor of 1.40 [Table 725.144 Note 2].

Compliance with Table 725.144 is not required for conductors 24 AWG or larger where the rated current per conductor of the power source does not exceed 0.30A.

One example of the use of Class 2 cables is a network of closed-circuit TV cameras using 24 AWG, 60°C-rated, Type CL2R, Cat. 5e balanced twisted-pair cabling.

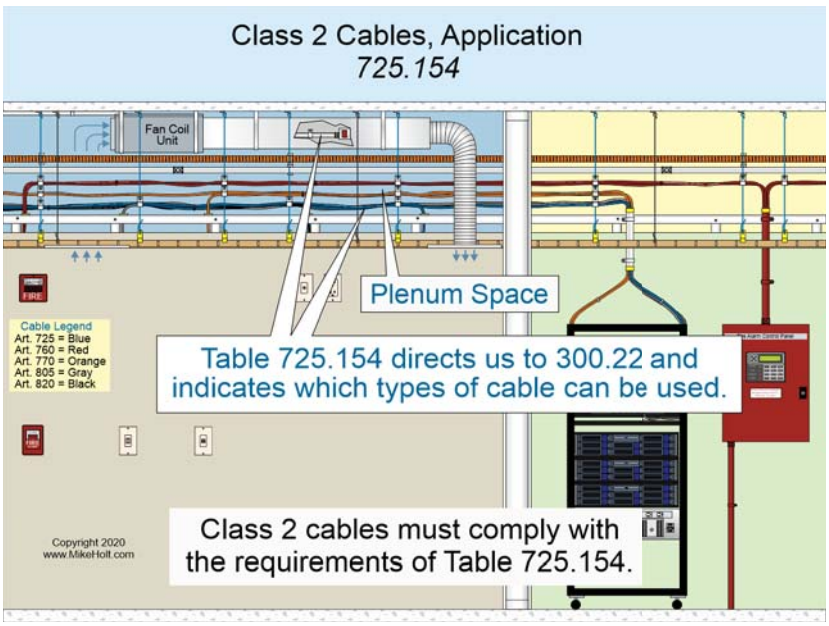


Fig. 3. Class 2 cables must comply with Sec. 725.154(A) through (C) and Table 725.154.

Table 725.144 is an ampacity table for 4-pair Class 2 power/data cables. Make sure you understand the notes that come with it.

Cable Types CL3P-LP, CL2P-LP, CL3R-LP, CL2R-LP, CL3-LP, or CL2-LP can supply power to equipment from a power source with a rated current per conductor up to the marked current limit located immediately following the suffix "-LP" and can transmit data to the equipment [Sec. 725.144(B)].

Where the number of bundled LP cables is 192 or less, and the selected ampacity of the cables per Table 725.144 exceeds the marked current limit of the cable, you can determine the ampacity from the table. For ambient temperatures above 30°C, you must apply the correction factors of Table 310.15(B)(1) or Equation 310.15(B)(2).

The Class 2-LP cables must comply with the following, as applicable:

(1) Cables with the suffix "-LP" can be installed in bundles, raceways, cable trays, communications raceways, and cable routing assemblies.

(2) Cables with the suffix "-LP" and a marked current limit must follow the substitution hierarchy of Table 725.154 and Figure 725.154(A) in the NEC for the cable type without the suffix "-LP" and without the marked current limit.

(3) System design is permitted by qualified persons under engineering supervision.

An example of a limited power (LP) cable is a cable marked Type CL2-LP (0.5A), 23 AWG.

Class 2 cables must comply with Sec. 725.154(A) through (C) and Table 725.154 (**Fig. 3**).

For example, cable substitutions can be made per Table 725.154(A) and Figure 725.154(A) Cable Substitution Hierarchy.

There is no Table 725.154(B), but preceding Table 725.154(A) — as you move through Art. 725 from front to back — is Table 725.154. This table shows you which of the 10 cable types you can use for a given application. For example, in a riser vertical run you can use CL2P, CL3P, CL2R, and CL3R, but not CL2, CL3, CL2X, CL3X, CMUC, or PLTC.

AVOIDING CLASS 2 ERRORS

The supply-side equipment and wiring of Class 2 circuits fall under Chapters 1 through 4, not under Art. 725. On the load side, you need to follow Art. 725 requirements. Remember that Class 2 circuits are limited to prevent shock or fire. That means you separate them from circuits that are not so limited. You also must use the cable type that is appropriate for the application.

If you have Class 1, Class 2, and Class 3 remote control and signaling circuits in the same facility, mark these at each panel and junction box (both on the drawings and physically), so they don't get mixed together. EC&M

These materials are provided by Mike Holt Enterprises in Leesburg, Fla. To view Code training materials offered by this company, visit www.mikeholt.com/code.

Stumped by the Code?

By Mike Holt, NEC Consultant

All questions and answers are based on the 2020 NEC.

Q. What are the Code requirements for electrical connections in marinas, boatyards, and docking facilities?

A. Floating piers [Sec. 555.30(A)] – Electrical connections must be located at least 12 in. above the deck of a floating pier (See **Figure**).

Fixed piers [Sec. 550.30(B)] – Electrical connections must be located at least 12 in. above the deck of a fixed pier and not below the electrical datum plane.

Replacements [Sec. 550.30(C)] – Replacement electrical connections for a floating pier must be located at least 12 in. above its deck.

Q. What are the NEC rules regarding ground-fault protection of equipment (GFPE) and ground-fault circuit interrupter (GFCI) protection for marinas, boatyards, and docking facilities?

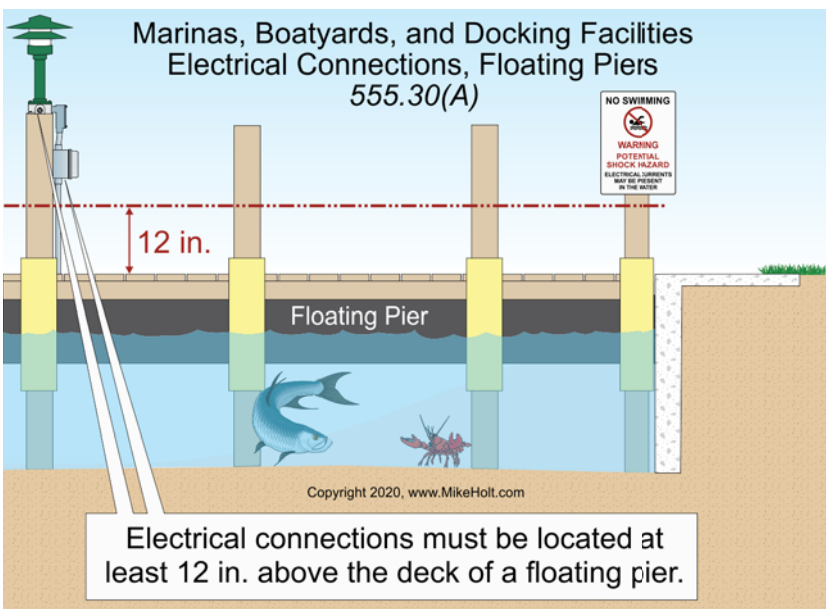
A. For other than floating buildings, ground-fault protection for docking facilities must be provided in accordance with the following [Sec. 555.35(A)]:

(1) GFPE protection. Receptacles installed in accordance with Sec. 555.33(A) can have individual GFPEs set to open at currents not exceeding 30mA.

(2) GFCI protection. All 15A and 20A, 125V receptacles for other than shore power must be protected in accordance with Sec. 555.19(B)(1) and (B)(2).

(3) Feeder and branch-circuit conductors with GFPE. Feeder and branch-circuit conductors that are installed on docking facilities must be provided with GFPEs set to open at currents not exceeding 100mA.

A review of reported electrical shock drowning (ESD) events shows that 50% of the ESD incidents may have been avoided by having the 30mA protection at the shore power receptacles.



Electrical connections must be located at least 12 in. above the deck of a floating pier.

Q. What are the general NEC requirements related to the installation of conductors?

A. Single conductors must be installed in a Chapter 3 wiring method such as in a raceway, cable, or enclosure [Sec. 300.3(A)].

All conductors of a circuit, including the neutral and equipment grounding conductors, must be installed together in the same raceway, cable, trench, cord, or cable tray; except as permitted by (1) through (4) [Sec. 300.3(B)].

(1) Paralleled Installations. Conductors installed in parallel in accordance with Sec. 310.10(G) must have all circuit conductor sets grouped together within the same raceway, cable tray, trench, or cable.

Author's comment: Grouping of all conductors of the circuit is to minimize heating of surrounding ferrous metal raceways and enclosures by induction for alternating-current circuits. See Sec. 300.20(A).

Connections, taps, or extensions made from paralleled conductors must connect to all conductors of the paralleled set.

Exception: Parallel phase and neutral conductors can be installed in individual underground nonmetallic raceways (Phase A in raceway 1, Phase B in raceway 2, and so forth) as permitted by Sec. 300.5(I) Exception No. 2 if the installation complies with Sec. 300.20(B).

(2) Outside a Raceway or an Enclosure. Equipment bonding jumpers can be located outside of a raceway if the bonding jumper is installed in accordance with Sec. 250.102(E)(2).

For direct-current circuits, the equipment grounding conductor can be run separately from the circuit conductors in accordance with Sec. 250.134(2) Exception No. 2. EC&M

These materials are provided to us by Mike Holt Enterprises in Leesburg, Fla. To view Code training materials offered by this company, visit www.mikeholt.com/code.

Resilient Harvests CONFERENCE

November 1-2, 2022
Hyatt Regency Long Beach
Long Beach, CA

POLICIES, PROGRAMS & PRACTICES TO ADVANCE EFFICIENT GREENHOUSE & VERTICAL FARMING

REGISTER AT:
RESILIENT**HARVESTS**CONFERENCE.COM




Presented by:

RESOURCE INNOVATION INSTITUTE

ENDEAVOR BUSINESS MEDIA

The Evolution of Bathroom Branch-Circuit Requirements

How Sec. 210.11(C)(3) evolved into a rule that is easy to understand and apply

By Russ LeBlanc, NEC Consultant

Based on the 2020 NEC.

One thing I've learned from studying and following Code changes over the last 37 years is that the wording of a new rule is not always perfect. Sometimes it takes a few Code revision cycles to get the literal wording to match the original intent of the rule. In some cases, it takes much longer to get it right. Section 210.11(C)(3) is one of the requirements that took a long time for the wording to evolve into a rule that is easy to understand and apply.

When first introduced in 1999, Sec. 210.11(C)(3) stated: "In addition to the number of branch circuits required by other parts of this Section, at least one 20A branch circuit shall be provided to supply bathroom receptacle outlet(s)." No voltage rating of the circuit was referenced, and it did not specify that the receptacle next to the sink was required to be on the 20A circuit. This main rule remained unchanged until 2014.

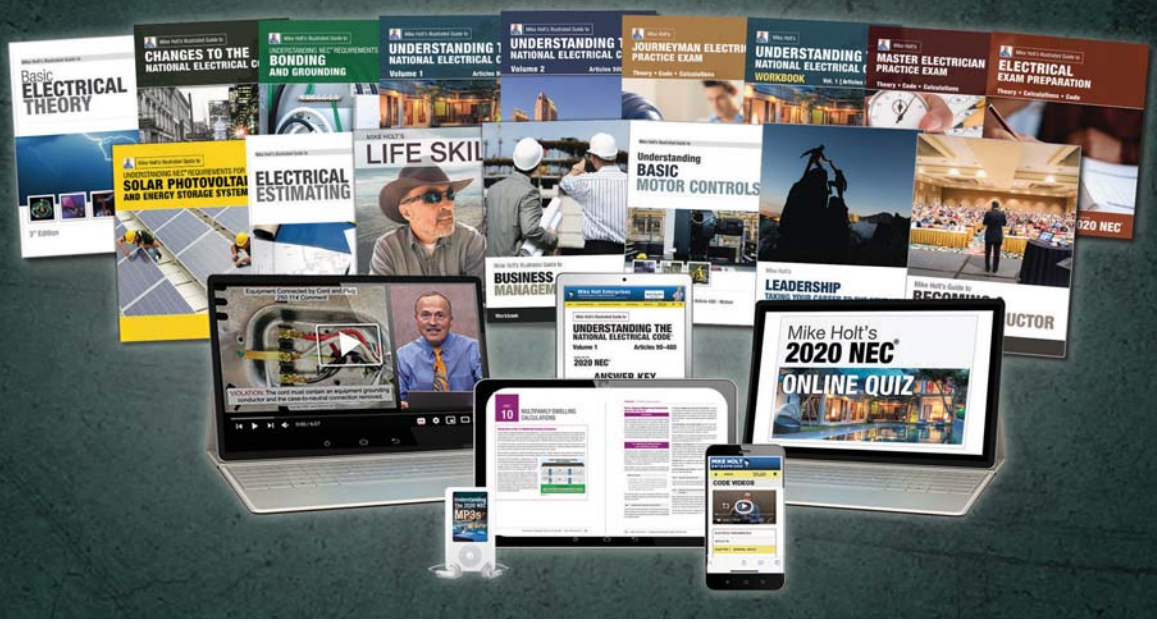
In 2014 it was revised to state: "In addition to the number of branch circuits required by other parts of this Section, at least one 120V, 20A branch circuit shall be provided to supply a bathroom receptacle outlet(s). Such circuits shall have no other outlets." A voltage was finally specified after 15 years, but the literal wording still required only one bathroom receptacle on a 20A circuit even if the house had four bathrooms.

In 2017 it was revised yet again to state: "In addition to the number of branch circuits required by other parts of this Section, at least one 120V, 20A branch circuit shall be provided to supply the bathroom(s) receptacle outlet(s). Such circuits shall have no other outlets." This revision required all bathroom receptacles to be on a 20A circuit. This rule finally included the receptacle near the sink; however, it also included receptacles for towel warmers, self-cleaning toilets, picture lights, sump pumps, etc.

For 2020, it was revised yet again and now states: "In addition to the number of branch circuits required by other parts of this section, one or more 120V, 20A branch circuit shall be provided to supply the bathroom(s) receptacle outlet(s) required by 210.52(D) and any countertop and similar work surface receptacle outlets. Such circuits shall have no other outlets." Now this rule only applies to receptacles installed within 3 ft of the sink to comply with Sec. 210.52(D) and receptacles for dressing/changing areas and other countertops/work surfaces.

I feel the 2020 edition closely matches what the original intent of the rule was in the first place. What do you think? EC&M

Invest in yourself with Mike Holt's ULTIMATE TRAINING LIBRARY



Ideal for In-house Training, Code Review, Exam Preparation and more...

This library includes:

- ✓ Code Training
- ✓ Electrical Exam Preparation
- ✓ Continuing Education
- ✓ Solar Photovoltaic Systems
- ✓ Business and Estimating
- ✓ and more ...

The Ultimate Training Library is your complete toolbox for electrical training. It's a great solution for teaching new employees the Code or for preparing for a state or county electrical exam. Ideal for updating yourself and your team on the Code changes, or reviewing the fundamentals that every working Electrical Professional should know. This library will give you the edge for your business and your career.

SAVE OVER 25%*

Use Code: ECMULT

List Price ~~$1,999.00~~ Now Only $1,450.00

www.MikeHolt.com/ultimate

or Call to Order 888.632.2633

* Special expires in 30 days and can't be combined with any other offer

Mike Holt Enterprises

"…as for me and my house, we will serve the Lord." [Joshua 24:15]

Illustrated Catastrophes

By Russ LeBlanc, NEC Consultant

All references are based on the 2020 edition of the NEC.

PICK YOUR POISON

I spotted this mess while visiting a local apple orchard. The UF cable emerging from the ground without any protection is a violation of Sec. 340.12(10). UF is not permitted to be used where subject to physical damage. The broken rigid PVC conduit is a clue that physical damage is occurring at this location. When rigid PVC conduit is installed in areas where it is subject to physical damage, Sec. 352.10(F) requires the PVC conduit to be identified for that use. Schedule 40 PVC conduit should not be used in this area. Similarly, Sec. 352.12(C) prohibits using PVC conduit where subject to physical damage unless the conduit is identified for that use. Schedule 80 PVC conduit is identified for use in areas exposed to physical damage. The broken PVC conduit can allow moisture, water, dust, insects, and all kinds of other critters and contaminants into the raceway. In my interpretation, this would be a violation of Sec. 110.12(B), which prohibits damaged parts that may adversely affect the safe operation or mechanical strength of the equipment. On a positive note, at least the installer used expansion fittings where the PVC conduit emerges from the ground to accommodate for ground movement in accordance with Sec. 300.5(J).

HONEY, I SHRUNK THE CONDUITS

Unfortunately, I see this type of shrinkage problem all too often on installations of rigid PVC conduit when expansion fittings are not installed. To compensate for thermal expansion and contraction, Sec. 352.44 requires expansion fittings to be used where the conduit length change is expected to be ¼ in. or greater in straight runs between boxes, cabinets, elbows, conduit terminations, and other securely mounted items. Table 352.44 provides information to determine the length change of the conduit. For example, a 100-ft run of conduit would experience a length change of 4.06 in. when exposed to a temperature change of 100°F. This means a 6-ft run would experience a length change of approximately ¼ in. when exposed to that same 100° temperature swing. Where I live in New England, the seasonal temperature can easily swing 100° or more as the weather transitions from summer to winter and back to summer again. Due to this temperature swing, expansion fittings must be used for PVC conduit runs of 6 ft or more in length; otherwise, the conduit run will not survive too long before the run bends and twists, the coupling breaks, or the PVC glue fails to hold the conduit in a connector, coupling, or fitting (as shown in this photo).

FACILITIES EXPO

including MANAGING GREEN BUILDINGS

WHERE FACILITY CHALLENGES FIND SOLUTIONS

NORTHERN CALIFORNIA
SEPTEMBER 21-22, 2022
SANTA CLARA CONVENTION CENTER
SANTA CLARA, CA

NORTH TEXAS
OCTOBER 5-6, 2022
ESPORTS STADIUM ARLINGTON
ARLINGTON, TX

Products & Services on Display:

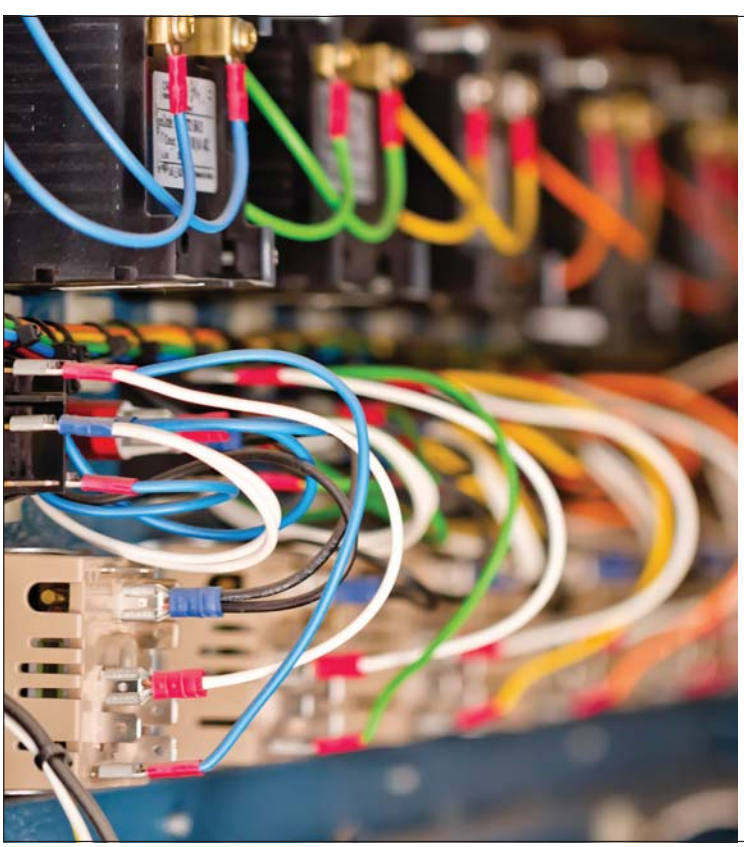
- HVAC
- Lighting
- Roofing
- Energy Management
- Electrical Systems
- Instruments & Controls
- Predictive Maintenance

For exhibiting information:
Lisa Nagle
(408) 829-5111
LNagle@facilitiesexpo.com

Register for FREE:
facilitiesexpo.com

OWNED & PRODUCED BY:

ENDEAVOR BUSINESS MEDIA



EC&M®

Get your own FREE subscription

EC&M is the industry's go-to, technical connection for electrical professionals in electrical contracting companies, industrial plants, commercial/institutional facilities, and engineering firms.

Each month you'll get the latest technical and operational information surrounding the National Electrical Code, electrical design methodologies, installation methods, trends and techniques, and maintenance procedures.

Sign up now at:
ecmweb.com/NewSub

ADVERTISER INDEX

Advertiser	Page #	Phone #	Web Address
Allied Tube & Conduit, a division of Atkore Int'l	9	—	www.alliedeg.us
Arlington Industries, Inc.	27	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	29	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	31	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	33	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	35	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	37	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	39	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	41	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	43	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	45	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	47	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	49	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	51	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	53	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	55	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	57	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	59	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	61	800-233-4717	www.aifittings.com
Arlington Industries, Inc.	72	800-233-4717	www.aifittings.com
Atkore	IFC	—	www.atkore.com
BaseTek, LLC	52	877-712-2273	www.basetek.com
Calbrite, a division of Atkore	23	—	www.calbrite.com
Champion Fiberglass, Inc.	BC	—	www.championfiberglass.com
Facilities Expo	69	—	www.facilitiesexpo.com
ICC Premise Wiring	7	—	www.icc.com/distributor
Intermatic, Inc.	15	—	www.Intermatic.com/ARISTA
Mike Holt Enterprises	67	888-632-2633	www.mikeholt.com
Milwaukee Tool Corporation	19	—	www.milwaukeetool.com
Orbit Industries, Inc.	13	844-909-0457	www.orbitelectric.com
Resilient Harvests Conference	65	—	ResilientHarvestsConference.com
simPRO Software Ltd	21	855-338-6041	www.simprogroup.com
Sinoample Group Limited LLC	1, IBC	—	www.presembler.com
S-P Products, Inc.	5	800-233-8595	www.SPProducts.com
Underground Devices, Inc.	3	847-205-9000	www.udevices.com
Universal Douglas Lighting America	11	—	www.universaldouglas.com

(Every effort is made to ensure the accuracy of this index. However, the publisher cannot be held responsible for errors or omissions.)

SALES STAFF

To place a display ad (1/6 page or larger), call the Advertising Sales Representative for your area.

Vice President
Mike Hellmann
Andover, MA
Phone: (978) 289-0098
E-mail: mhellmann@endeavorb2b.com

Western U.S. & Western Canada
Jim Carahalios – Account Manager
5921 S. Crestbrook Drive
Morrison, CO 80465
Phone: (303) 697-1701
Fax: (303) 697-1703
E-mail: jcarahalios@endeavorb2b.com

Northeast U.S. & Eastern Canada
David Sevin – Account Manager
24 Houghton Street
Barrington, RI 02806
Phone: (401) 246-1903
E-mail: dsevin@endeavorb2b.com

Midwest, Southeast, and Southwest
Jay Thompson – Account Manager
10955 Lowell Ave., 7th Floor
Overland Park, KS 66210
Phone: (913) 967-7543
E-mail: jthompson@endeavorb2b.com

Classifieds/Inside Sales
Steve Suarez – Media Account Exec
10955 Lowell Ave., 7th Floor
Overland Park, KS 66210
Phone: (816) 588-7372
E-mail: ssuarez@endeavorb2b.com

List Rental
Smart Reach
E-mail: sr-assets@endeavorb2b.com

What's Wrong Here?

By Russ LeBlanc, NEC Consultant

How well do you know the Code? Think you can spot violations the original installer either ignored or couldn't identify? Here's your chance to moonlight as an electrical inspector and second-guess someone else's work from the safety of your living room or office. Can you identify the specific Code violation(s) in this photo? *Note*: Submitted comments must include specific references from the 2020 NEC.

Hint: A cover calamity

'TELL THEM WHAT THEY'VE WON...'

Using the 2020 NEC, correctly identify the Code violation(s) in this month's photo — in 200 words or less — and you could win an Arlington Industries 18" Slider Bar and plastic box for mounting between studs with non-standard spacing. E-mail your response, including your name and mailing address, to russ@russleblanc.net, and Russ will select three winners (excluding manufacturers and prior winners) at random from the correct submissions. Note that submissions without an address will not be eligible to win.

JUNE WINNERS

Our three winners this month were Patrick Quirk, an electrical design engineer with Moore Consulting Engineers, LLC, in Shamong, N.J.; Robert Magsipoc, an *EC&M* reader from Fairfax, Va.; and Bill Nichols, a building inspections supervisor for Life Safety & Neighborhood Services in Manitowoc, Wisc.

This is yet another example of what happens to rigid PVC conduit installations when expansion fittings are not used. Ultimately, the forces of Mother Nature will impose their will on the PVC conduit, causing it to expand and contract over and over due to seasonal changes in temperature. When conduit runs expand between two securely mounted items, the conduit begins to bend and twist, which can, in turn, put extra stress on clips, couplings, and connectors leading to their eventual failure. That's what happened here. The installers failed to use expansion fittings to compensate for the length change of conduit as required by Sec. 352.44. It also appears that the spacing for some of the conduit clips does not comply with the maximum 3-ft spacing requirements in Sec. 352.30(B). This will also contribute to the eventual failure of the conduit run.

PRESEMBLER

NEW

PREASSEMBLIES AND ASSEMBLY CUSTOMIZATION

SAVE UP TO 18 MINUTES ON INSTALLATION PER UNIT

View more

Visit our website **www.presembler.com**

Email **presembler@sinoample.com**

CHAMPION FIBERGLASS®

KEEP THE POWER FLOWING WITH NO BURN-THROUGH ELBOWS

Our electrical conduit helps utilities keep the power flowing.

- No burn-through eliminates elbow repairs
- Low coefficient of friction allows for smooth pulls
- Fault resistance makes repairing cable easy
- Mechanical strength protects cable
- Light weight and gasket connections facilitate speedy installation
- Lower prices keep projects on budget

Learn how utility projects benefit from no burn-through fiberglass elbows.

Learn More

BIM models available at championfiberglass.com/BIM

Visit championfiberglass.com

MADE IN THE USA

MasterSpec® a product of The American Institute of Architects