Apprentice's Guide to Niche Applications

Prepare for any electrical installation situation with trainer Harold De Loach

From the EC&M e-books library
A compilation of technical articles from *EC&M*

EC&M®

EXECUTIVE SUMMARY

THE STUFF YOU DON'T SEE EVERY DAY

Why it's important to familiarize yourself with some of the more unique applications in the NEC.

By Michael Morris, Editor

As 2024 comes to an end, we're going to close out our "Apprentice's Guide" series of training e-books with the fourth and final installment. If you're just joining us, this 2024 e-book series has highlighted some of the most popular articles from *EC&M* contributor, master electrician, electrical trainer/instructor, and founder/director of The Academy of Industrial Arts L.L.C., Harold De Loach. You can catch up on the three previous installments by visiting our e-book library available on the Members Only section of our website at ecmweb.com/ebook-library.

For this e-book, we decided to collect training articles from Harold that focus on niche applications found in the National Electrical Code (NEC). The subjects covered may not be things you see every day, but you will more than likely run into them eventually sometime in your career. Familiarizing yourself with these topics will help you be prepared for any situation you may encounter and will help you stand out from your peers.

To kick things off, this e-book begins with "The Apprentice's Guide to Special Equipment." This article covers the requirements of Chapter 6 in the NEC. As De Loach puts it, "The Articles found within this Chapter contain diverse, unique, or complex equipment system requirements." Becoming familiar with the requirements found within Chapter 6 will definitely be beneficial.

Continuing from there, the rest of the articles focus on specific applications. You can find an intro guide to motors on page 5, a guide on EV charging systems on page 8, requirements for carnivals, circuses, fairs, and similar events on page 11, mobile homes and manufactured homes on page 14, and finally, NEC requirements for audio signal processing, amplification, and reproduction equipment are on page 17.

As you can see, Harold has covered a wide range of applications found within the NEC. Depending on your area of expertise, you may run into some of these applications frequently or only a handful of times throughout your career. Either way, it's important to be familiar with these niche NEC requirements so that you're ready for whatever situation may arise on the job site.

Note: These articles reference the 2017 NEC because the Philadelphia area—the jurisdiction where Harold De Loach teaches and works—still operates under that version of the Code.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

THE APPRENTICE'S GUIDE TO SPECIAL EQUIPMENT

How to apply NEC Chapter 6 requirements — the stuff you don't see every day

By Harold De Loach

As an electrical apprentice, to advance your basic knowledge of the National Electrical Code (NEC), I've always found it's best to word-associate the purpose of each Chapter. This handy trick will help you efficiently identify the installation guidelines you seek much faster. In the process, you'll also impress the boss, gain respect from your peers and journeymen, and help you build trust in others that depend on you.

When you think about Chapter 6, the first word that comes to mind is "special." The Articles found within this Chapter contain diverse, unique, or complex equipment system requirements that may require specialized training. Here are just a few examples:

- Art. 605 (office furnishings)
- Art. 669 (electroplating)
- Art. 660 (x-ray equipment)
- Art. 670 (industrial machinery)
- Art. 692 (fuel cell systems)
- Art. 695 (fire pumps)

In addition, the wiring methods for the equipment included in these Articles may modify requirements from Chapter 3. They supplement or amend the basics you learned in Chapters 1-4 (Figure 90.3), so be prepared to meet additional guidelines. That means don't make assumptions. Installation errors of the equipment found in these Articles can cause severe injury or death to the installer and user of this equipment. Additional measures and accuracy must be taken by electricians

31447604 © Wavebreakmedia Ltd | Dreamstime.com

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

performing these Chapter 6 installations to avoid equipment failures, ensure safety for users and consumers, and prevent voiding any equipment manufacturers' warranties.

SEEK HELP ON SPECIAL INSTALLATIONS

Chapter 6 is the second of four chapters that focuses specifically on specialized (non-typical) areas of work for electricians. Due to the technical nature (and liability associated with these installations), some electricians choose to specialize, making them experts in these niches. However, this requires in-depth knowledge of other parts of the Code as well.

For example, Art. 680 (Swimming Pools, Fountains, and Similar Installations) requires a significant understanding of Art. 240 (Overcurrent Protection), Art. 250 (Grounding and Bonding), and Art. 430 (Motors, Motor Circuits, and Controllers). Permanent pool installations require specific wiring methods, burial depths for raceways, and specific locations for receptacles and electrical equipment systems.

Electrical shock drowning, for example, can occur when lighting systems and grounding/bonding systems are improperly installed or maintained around pool areas. So be prepared to do in-depth research before starting these installations or providing repair services.

EMERGING INDUSTRIES REQUIRE MORE TRAINING

Article 690 (Solar Photovoltaic Systems) has provisions that require installers to have a basic understanding of inverters, direct current, charge controllers, alternating current, and storage battery systems.

As you can see, the Articles in Chapters 6-8 are more complicated in nature and structure. Figure 690.1 (B) identifies solar photovoltaic system components; this handy chart provides insight into designs and layouts for common array systems and their components. Solar or PV systems installers must be very knowledgeable of the required disconnecting means (e.g., types and locations) for individual panels and conductors throughout the system in Sec. 690.13.

Keep in mind the equipment and systems found in Chapter 6 (and their associated parts) may require you to meet additional guidelines outside of the NEC, including those set forth by third-party organizations such as Underwriters Laboratories or Nationally Recognized Testing Laboratory.

NO ONE HAS "DONE IT ALL"

Remember, all electricians aren't created or trained equally; no one has done it all! Anyone claiming to have done it all in this vast industry isn't being truthful. How many electricians have you met that install or repair pipe organs found in Art. 650, electrically driven or controlled irrigation machines (Art. 675), or cranes and hoists (Art. 610)? I'm guessing probably not an overwhelming amount. So always remember the special equipment found in these Articles may require additional safety protocols and measures when installing, repairing, or modifying any of their related systems, functions, and operation.

Harold De Loach, a master electrician and electrical trainer/instructor, is the founder of The Academy of Industrial Arts (www.taia-school.com) in Philadelphia. With more than 30 years of experience in the field, he writes regular exclusive content for EC&M and can be reached at info@taia-school.com.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

THE APPRENTICE'S INTRO GUIDE TO MOTORS

How to apply NEC Art. 430 for motors, motor circuits, and controllers in the field

By Harold De Loach

Article 430 is definitely one of the National Electrical Code's largest, most confusing, and intimidating articles because it contains complex terms and technical requirements utilized by seasoned electricians. Typically, the electricians who work within the guidelines of Art. 430 have an intermediate to mastery level of using the NEC. They are also adept in the following sectors of the electrical industry:

- Industrial (repair, construction, and maintenance)
- Commercial (repair, construction, and maintenance)
- Light commercial (repair, construction, and maintenance)

This article provides guidance on sizing the various components of a motor circuit.

SIZING CONDUCTORS

Section 430.6(A) of the 2023 NEC instructs electricians to size motor connection conductors based on the allowable ampacity tables in Table 310.16. Electricians constructing 3-phase motor circuits "in the field" use full-load current values listed in Table 430.250; they do not use the motor nameplate current. This table is used for motors running

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

at "usual" speeds for belted motors and motors with "normal" torque characteristics. The system voltage range(s) used in this table are 110V to 120V, 220V to 240V, 440V to 480V, and 550V to 600V listed rated motor voltages.

Field electricians constructing circuits for single-phase motors use the current values listed in Table 430.248, which is for 115V-, 200V-, 208V-, and 230V-rated motors. If the conductors are supplying a single motor used in a continuous-duty application, Sec. 430.22 instructs the electrician to select a wire sized not less than 125% of the motor's full-load current rating. If the conductor is supplying multiple motors, the conductor should have an ampacity not less than the sum of each of the following:

- 125% of the full-load current rating of the highest-rated motor, as determined by Sec. 430.6(A).
- The sum of the full-load current ratings of all the other motors in the group, as determined by Sec. 430.6(A).
- 100% of the noncontinuous non-motor load.
- 125% of the continuous non-motor load.

TERMINAL TEMPERATURE RATING

Another essential factor for field electricians to consider is Sec. 110.14(C). When determining the branch-circuit conductor size for a commercial motor, the temperature rating terminals of the equipment and devices matter. This Section of the Code explains that the conductor selected must be coordinated to not exceed the lowest temperature rating of any connected termination, connected conductor, or connected device; the allowable conductor ampacity must be chosen from a column that does not exceed the temperature rating of the terminations. Several steps should be considered in building motor circuits — it's not cut and dry.

CIRCUIT BREAKERS AND FUSES

Next is selecting, rating, and sizing protective devices to provide short circuit and ground fault protection for feeders and branch circuits. Motors must be protected from the following: overcurrent; low voltage; and fault currents (short circuit and ground faults).

WHEN DETERMINING THE BRANCH-CIRCUIT CONDUCTOR SIZE FOR A COMMERCIAL MOTOR, THE TEMPERATURE RATING TERMINALS OF THE EQUIPMENT AND DEVICES MATTER.

Commercial single-phase and 3-phase motor circuits should include protection from unexpected abnormal situations. Basic protection from these occurrences is provided by installing circuit breakers or fuses in the controller or starter at a convenient location for the operator or maintenance staff. These devices are usually selected or based on the starting current or characteristics of the motor when it's under load.

MOTOR STARTERS

In many cases, the motor manufacturer may include a recommended type and size of protection. Most motor installations provide protection through a "motor starter," which controls or regulates the electrical power for starting a commercial motor; these electrical devices are also used for stopping, reversing, and protecting electric motors. Motor overheating can cause the motor to burn out and renders the motor practically useless. To protect the motor from potential danger, overload relays can prevent these events.

Section 430.31 covers motor and branch-circuit overload protection for motor control circuits, motor controllers, and motor control centers in Part III of this Article. This section specifies sizing and selecting overload devices that protect motors, motor-control apparatus, and motor branch circuit conductors against "excessive heating" due to motor overloads and failure to start.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

IMPORTANT TERMS TO KNOW

Familiarize yourself with these important terms to become more adept in the use of Art. 430. Unique terms are typically listed in the ".2 section" of an Article — right after scope. Here are a few terms listed in Art. 100 but referenced in Art. 430 and Art. 440:

Adjustable circuit breakers. This type of circuit breaker can be set to trip at various values of current, time, or both within a predetermined range; it has small dials above or below the poles.

Setting of circuit breakers. The value of current, time, or both, at which an adjustable circuit breaker is set to trip.

Instantaneous trip circuit breakers. No delay is purposely introduced in the tripping action of this circuit breaker.

Inverse time circuit breakers. There is a delay in the tripping action of this circuit breaker purposely introduced, which delay decreases as the magnitude of the current increases.

Nonadjustable circuit breakers. This circuit breaker has no adjustments or settings for the trip time (its response time is fixed).

Hermetic refrigerant motor-compressor. A combination consisting of a compressor and motor, both of which are enclosed in the same housing, with no external shaft or shaft seals, with the motor operating in the refrigerant.

Harold De Loach, a master electrician and electrical trainer/instructor, is the founder of The Academy of Industrial Arts (www.taia-school.com) in Philadelphia. With more than 30 years of experience in the field, he writes regular exclusive content for EC&M and can be reached at info@taia-school.com.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

THE APPRENTICE'S GUIDE TO ARTICLE 625

Applying NEC requirements for electric vehicle charging systems

By Harold De Loach

Photo 279687205 © Artinun Prekmoung | Dreamstime.com

Chapter 6 of the NEC, which covers "Non-Typical or Specialized Areas of Work," is impacted or heavily influenced by changes in technology and legal legislation. Article 625 covers the installation of equipment and devices related to electric vehicle charging for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, electric motorcycles, primarily powered by an electric motor that draws current from a rechargeable storage battery, fuel cell, photovoltaic array, or other source of electric current with nominal AC system voltages of 120, 120/240, 208Y/120, 240, 480Y/277, 480, 600Y/347, 600, and 1,000 and DC system voltages of up to 1,000. It also covers electrical conductors and equipment external to an electric vehicle that connect an electric vehicle to a supply of electricity by: inductive means,conductive means, and wireless power transfer (contactless inductive charging) in the following configurations:

- Level 1 Charger: 120VAC 15A
- Level 2 Charger: 120-240VAC 60A
- Level 3 Charger: 480 VAC 125A or 600 VDC 550A
- Level 4 Charger: DC ultra-fast chargers

IMPORTANT TERMS TO KNOW

The definitions in Sec. 625.2 (2017 edition of the NEC) have several essential terms you should familiarize yourself with as you begin to perform installations in this fledging section of the electrical industry; you should also understand brand/model-specific installation requirements and best practices. Always read the installer's guide provided by the equipment manufacturer; the NEC is a supplement to the installer's guide provided with the charging equipment. It's vital that you learn how to identify each part of an EV charging system. Show the boss and your

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

peers that you invested time and resources to understand these definitions and installation requirements.

INVEST IN YOURSELF

If you can get "certified" as an installer, do it! Most Level 1 and Level 2 EV charging manufacturers offer free training courses on their websites. Most of these courses are virtual, and you can take them from the comfort of your home. In some cases, to be certified as a Level 3 and Level 4 installer, you might be required to complete 20 hours of training and pass an exam to obtain certification — the requirements vary based on the manufacturer or organization hosting the program. Some of these higher-level courses might require you to be licensed as an electrical contractor or a certified electrician; they may require documentation of a minimum of 8,000 hours of hands-on electrical construction experience. Please do your research; it'll pay off for decades.

DON'T GET CREATIVE!

Per Sec. 625.15 (Markings (A) General), all equipment shall be marked by the manufacturer as follows:

FOR USE WITH ELECTRIC VEHICLES

Only use equipment and devices that are specifically designed for electric vehicles. Use equipment that is listed and labeled for such use. 625.16 (Means of Coupling) Attachment plugs, electric vehicle connectors, and electric vehicle inlets shall be listed or labeled for the purpose.

The means of coupling to the electric vehicle shall be conductive, inductive, or wireless power transfer. All these requirements affect the automobile manufacturer's:

- Vehicle charging times
- Information exchange to vehicle
- Amount of power transfer to vehicle
- Vehicle charging performance integrity specifications

CORD AND CABLES FEEDING EVS

Per Sec. 625.17 (A), power supply cord and portable power cable for connected equipment shall be listed for exposure to oil, damp, and wet locations (where required) shall be hard service cord or junior hard service cord. As noted in Sec. 625.17 (B), the output cable to the electric vehicle shall be Type EV, EVJ, EVE, EVJE, EVT, or EVJT flexible cable. The overall usable length shall not exceed 25 ft unless equipped with a cable management system that is part of the listed electric vehicle supply equipment in Sec. 625.17 (C).

IF YOU CAN GET "CERTIFIED" AS AN INSTALLER, DO IT! MOST LEVEL 1 AND LEVEL 2 EV CHARGING MANUFACTURERS OFFER FREE TRAINING COURSES ON THEIR WEBSITES.

FASTENED IN PLACE OR NOT FASTENED IN PLACE

Where the electric vehicle supply equipment or charging system is not fastened in place, the cord-exposed usable length shall be measured from the face of the attachment plug to the face of the electric vehicle connector, as noted in Sec. 625.17 (C)(1). Where the electric vehicle supply equipment or charging system is fastened in place, the usable length of the output cable shall be measured from the cable exit of the electric vehicle supply equipment or charging system to the face of the electric vehicle connector per Sec. 625.17 (C)(2).

ELECTRIC VEHICLE BRANCH CIRCUIT AND OVERCURRENT PROTECTION REQUIREMENTS

Each outlet installed for charging electric vehicles shall be supplied by an individual branch circuit; each circuit shall have no other outlets. Overcurrent protection for feeders and branch circuits supplying equipment shall be sized for continuous duty

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

and shall have a rating of not less than "125% of the maximum load" where noncontinuous loads are supplied from the same overcurrent device shall have a rating of not less than the sum of the noncontinuous loads plus "125% of the continuous loads" as required in Part III Installation of Secs. 625.40 and 625.41.

EV CHARGING EQUIPMENT RATING AND DISCONNECTING MEANS

Electric vehicle charging loads shall be considered "continuous loads." Equipment shall have a sufficient rating to supply the load served. Where an automatic load management system is used, the maximum equipment load on a service and feeder shall be the maximum load permitted by the automatic load management system. For equipment rated at more than 60A or more than 150V to ground, the disconnecting means shall be provided and installed in a "readily accessible" location (Secs. 625.42 and 625.43). This is a term found in Chapter One of the NEC [Article 100 Definition]: "Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to take actions such as to use tools (other than keys), to climb over or under, to remove obstacles, or to resort to portable ladders, and so forth." The disconnecting means shall be lockable "open" (Sec. 110.25); it shall be capable of being locked in the open position. Locking provisions shall remain in place "with" or "without" the lock installed with one exception — locking provisions for a cord-and-plug connection "shall" not be required to remain in place without the lock installed.

Harold De Loach, a master electrician and electrical trainer/instructor, is the founder of The Academy of Industrial Arts (www.taia-school.com) in Philadelphia. With more than 30 years of experience in the field, he writes regular exclusive content for EC&M and can be reached at info@taia-school.com.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

THE APPRENTICE'S GUIDE TO ARTICLE 525

Applying NEC requirements in amusement venues such as carnivals, circuses, fairs, and similar events

By Harold De Loach

Electricians power every industry within our modern economy — from the hospitality sector to the medical research industry to amusement and entertainment venues. Electricians are needed to power the motors, lighting, and controls in permanent amusement parks and mobile carnivals throughout the country. This article will provide a few tips and shortcuts on how to find the guidelines for installing portable wiring and equipment for carnivals, circuses, fairs, and similar functions. Use this handy guide for installing and repairing wiring in or on units designed to be moved (Portable Structures), as described in Sec. 525.2, which includes but is not limited to amusement rides, attractions, concessions, tents, trailers, trucks, and similar amusement structures/units.

THE ELECTRICIAN'S DUTY

Your role as an electrician is to keep the "operator" safe; this is the individual responsible for starting, stopping,

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

and controlling an amusement ride or supervising a concession. However, keep in mind the other parties you must keep safe. They include but are not limited to:

- Patrons/thrill seekers
- Park and event personnel
- City and county inspectors
- Teammates of the operator

Your role as an electrician is to prevent:

- Electrocution (death may occur)
- Electrical shocks (minor to major injuries)
- Preventable accidents (usually caused by the lack of maintenance)
- Equipment failure and malfunction (death or serious injury may occur)

REMEMBER THESE GUIDELINES FIRST

1. When the requirements of other articles in the Code and Art. 525 differ, the requirements of Art. 525 shall take precedence and be applied to all portable wiring and equipment, as noted in Sec. 525.3(A).

2. Wiring in "Permanent Structures" shall apply to Art. 518 (Assembly Occupancies) and Art. 520 (Theaters, Audience Areas of Motion Picture and Television Studios, Performance Areas, and Similar Locations), as noted in Sec. 525.3(B).

3. Article 640 shall apply to the wiring and installation of audio signal processing, amplification, and reproduction equipment that specifically covers these installations, as noted in Sec. 525.3(C). Read one of my past articles on Art. 640 here.

4. Attractions utilizing pools, fountains, and similar installations with contained volumes of water shall be installed to comply with the applicable requirements of Art. 680 (Swimming Pools, Fountains, and Similar Installations), as noted in Sec. 525.3(D).

KEEP 'EM UP HIGH!

Wiring and conductors installed outside of tents and concessions shall have a vertical "overhead" clearance to ground in accordance with Sec. 225.18 (Clearance for Overhead Conductors and Cables) found in Chapter 2 (Wiring and Protection), as noted in Sec. 525.5(A). The clearance to ground for overhead conductors operating at 600V or less for portable structures shall be maintained not less than 15 ft in any direction [Sec. 525.5(B)(1)], except for the conductors supplying the portable structure. Portable structures included in Sec. 525.3(D) shall comply with Table 680.9(A) outlining overhead conductor clearances in swimming pools, fountains, and similar installations. Portable structures shall not be located under or within a space that is located 15 ft horizontally and extending vertically to grade of conductors operating more than 600V per Sec. 525.5(B)(2).

PROTECT ALL ELECTRICAL EQUIPMENT

Wiring methods and electrical equipment in or on units designed to be moved (portable structures) for tents, trucks, trailers, attractions, concession, and amusement rides shall be provided with mechanical protection where such equipment or wiring methods are subject to physical damage at (but not limited to) fairs, circuses, carnivals, and similar functions.

Follow the guidelines set in Art. 110 (Requirements for Electrical installations), which covers general requirements for the examination and approval, installation and use, access to, and spaces about electrical conductors and equipment; enclosures intended for personnel entry; and tunnel installations. It will explicitly guide you in the most important rules to follow.

REFER TO CHAPTER 4 "EQUIPMENT FOR GENERAL USE" TABLE 400.4

Chapter 4 covers general requirements, applications, and construction specifications for flexible cords and flexible cables that are typically used for these installations. Use Table 400.4 (Flexible Cords and Flexible Cables) as your guide. For example, where flexible cords or cables are used, they shall be listed for extra-hard usage. Where

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M
From the *EC&M* e-books library
A compilation of technical articles from *EC&M*

flexible cords or cables are used and are not subject to physical damage, they shall be permitted to be listed for hard usage. Where used outdoors, flexible cords and cables shall also be listed for wet locations and shall be sunlight resistant. Extra-hard usage flexible cords or cables shall be permitted for use as permanent wiring on portable amusement rides and attractions where not subject to physical damage. Review Sec. 525.20 for more information.

A FEW MORE RULES ABOUT WIRING

1. The minimum size single-conductor cable shall be size 2 AWG or larger [Sec. 525.20(B)].

2. Per Sec. 525.20(C), open conductors shall be prohibited except as part of a listed assembly or festoon lighting installed in accordance with Art. 225.

3. No cable splices! Flexible cords or cables shall be continuous without splice or tap between boxes or fittings [Sec. 525.20(D)].

4. Cord connectors shall not be laid on the ground unless listed for wet locations. Connectors and cable connections shall not be placed in audience traffic paths or within areas accessible to the public unless guarded, as noted in Sec. 525.20(E).

5. Wiring for an amusement ride, attraction, tent, or similar structure shall not be supported by any other ride or structure unless specifically designed for the purpose per Sec. 525.20(F).

6. Per Sec. 525.20(G), flexible cords or cables accessible to the public shall be arranged to minimize the tripping hazard and shall be permitted to be covered with nonconductive matting, provided that the matting does not constitute a greater tripping hazard than the uncovered cables. It shall be permitted to bury cables. Note: The requirements of Sec. 300.5 shall not apply.

7. A box or fitting shall be installed at each connection point, outlet, switch point, or junction point, as noted in Sec. 525.20(H).

A FINAL NOTE ON THE "DISCONNECTING MEANS" FOR RIDES, TENTS, AND CONCESSIONS

A means to disconnect each portable structure from all ungrounded conductors shall be provided. The disconnecting means shall be located "within sight of" (this is an Art. 100 definition) and within 6 ft of the operator's station. The disconnecting means shall be "readily accessible" to the operator (also an Art. 100 definition), including when the ride is in operation. Where accessible to unqualified persons, the disconnecting means shall be lockable.

A shunt trip device that opens the fused disconnect or circuit breaker when a switch located in the ride operator's console is closed shall be a permissible method of opening the circuit per Sec. 525.21 (A), which discusses disconnecting means.

Harold De Loach, a master electrician and electrical trainer/instructor, is the founder of The Academy of Industrial Arts (www.taia-school.com) in Philadelphia. With more than 30 years of experience in the field, he writes regular exclusive content for EC&M and can be reached at info@taia-school.com.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

THE APPRENTICE'S GUIDE TO ART. 550

Applying NEC requirements for mobile homes, manufactured homes, and mobile home parks

By Harold De Loach

This handy Article covers the electrical conductors, equipment, and appurtenances installed "within" or "on" mobile and manufactured homes. A mobile home is a factory-assembled structure or structures that's transportable in one or more sections, "built" on a permanent chassis, and designed to be used as a dwelling without a permanent foundation connected to necessary utilities that include heating, plumbing, appliances, air-conditioning, lighting "luminaires," and electrically powered accessories. It also covers "transportable" manufactured homes that are in one or more sections, 8 ft or more in width or 40 ft or more in length in traveling mode, built on a permanent chassis when erected on a site of 320 ft2 or more, and designed to be used as a dwelling unit "with or without" a permanent foundation.

The guidelines within this Article also cover the conductors and electrical equipment that connect mobile and manufactured homes to a "supply" of electricity within a mobile home park "up to" the mobile home service-entrance conductors — the mobile home service equipment for connecting to a 3-wire, 120/240VAC system with a grounded neutral conductor.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

FAMILIARIZE YOURSELF WITH THESE TERMS!

Following are some unique terms you should know that apply to Art. 500.

Feeder Assembly. The overhead or under-chassis feeder conductors, including the grounding conductor, together with the necessary fittings and equipment or a power-supply cord listed for mobile home use, identified for the delivery of energy from the source of electrical supply to the panelboard within the mobile home.

Mobile Home Accessory Building or Structure. Any awning, cabana, ramada, storage cabinet, carport, fence, windbreak, or porch established for the use of the occupant of the mobile home on a mobile home lot.

Mobile Home Lot. A designated portion of a mobile home park designed for the accommodation of one mobile home and its accessory buildings or structures for the exclusive use of its occupants.

Mobile Home Park. A contiguous parcel of land that is used for the accommodation of occupied mobile homes.

Mobile Home Service Equipment. The equipment containing the disconnecting means, overcurrent protective devices, and receptacles or other means for connecting a mobile home feeder assembly.

Park Electrical Wiring Systems. All of the electrical wiring, luminaires, equipment, and appurtenances related to electrical installations within a mobile home park, including the mobile home service equipment.

MOBILE AND MANUFACTURED HOME POWER IS SUPPLIED BY A "FEEDER"

The mobile home power supply shall be a feeder "assembly" consisting of not more than one listed 50A mobile home power-supply cord or a permanently installed feeder 550.10 (A). If the mobile home has a power-supply cord, it shall be permanently attached to the panelboard or to a junction box permanently connected to the panelboard with the free end terminating in an attachment plug cap, as noted in Sec. 550.10(B). The Art. 100 definition for an attachment plug (plug cap or plug) is a device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. The attachment plug cap shall be 125/250V, 3-pole, 4-wire, grounding type rated at 50A.

THE MOBILE HOME POWER SUPPLY SHALL BE A FEEDER "ASSEMBLY" CONSISTING OF NOT MORE THAN ONE LISTED 50A MOBILE HOME POWER-SUPPLY CORD OR A PERMANENTLY INSTALLED FEEDER 550.10 (A).

The configuration must match Figure 550.10(C). It shall be listed, by itself or as part of a power-supply cord assembly, for the purpose and shall be molded to or installed on the flexible cord so that it is secured tightly to the cord at the point where the cord enters the attachment plug cap. If a right-angle cap is used, the configuration shall be oriented so that the grounding member is farthest from the cord.

SERVICES, FEEDERS, AND ALLOWABLE DEMAND FACTORS

Part 3 (Services and Feeders) of this Article covers everything you need to know about providing power to the entire mobile park. Here are a few facts you should know:

1. Per Sec. 550.30, the secondary (side) of electrical distribution or voltage system for mobile home parks to mobile home lots "shall be" single-phase, 120/240V, nominal.

2. Transformers and secondary panelboards "shall be treated as" services, where the park service exceeds 240V, nominal. This part is important! For testing and exam purposes, always follow

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M
From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

instructions from the NEC; never use a minimum volt-ampere (load calculation per lot) less than what is required by Sec. 550.31 (Allowable Demand Factors).

Here's an example of a typical question you may see on an electrical licensing examination related to this topic:

In a mobile-home park, the computed load for each mobile home is 15,000 VA, and the park will have 25 mobile homes. The service will be a single main, 120/240V service.

The electrical service required for this mobile-home park shall be at least _____ amps.

A. 350

B. 400

C. 1,600

D. 1,700

Step 1. The fastest and most efficient approach to answer this question is to start at the rear of your Code book in the index. Your "keyword" search should start at the letter "M" until you see:

Main Topic: Mobile Home Parks

Sub-Topic: Minimum allowable demand factor, 550.31

Step 2. Confirm the NEC's minimum "calculated load" requirement.

Aha! Sec. 550.31(1) states that park electrical wiring systems shall be calculated (at 120/240V) on the larger of the following:

(1) 16,000 volt-amperes for each mobile home lot

In the question, they use a computed load of 15,000VA. Since this is below the NEC's minimum "calculated" load requirement, we must use 16,000VA to meet the minimum load requirement. Always check the NEC's requirements first — especially for anything that requires a demand factor to be applied. The exam question will typically mislead you; do not be lazy, and make assumptions. This is to test your understanding of when and how to apply the NEC'S calculated "minimum" load requirements.

These exams are designed to test your experience and knowledge on NEC application, navigation, and interpretation. Remember "calculated" electrical service feeder load(s) in a "bulk" quantity (two or more) must have a demand factor applied. For a further explanation, please refer to The Apprentice's Guide to Service Feeder Calculations.

Step 3. First, we must calculate our **GROSS LOAD**. Let's do the math:

(25) mobile homes x 16,000VA = 400,000VA

Step 4. Now apply your demand factor: According to Table 550.31 (Demand Factors for Services and Feeders), we are only required to use 24% of our calculated load.

400,000VA x .24 = 96,000VA

Step 5. Now convert your calculated load (P) power 96,000VA to (I) current or amperes

To perform this calculation, we must use the power wheel formula:

Current I Amps=Power or volt — amperes/V voltage

96,000 ÷ 240 = 400A

The correct answer is B — 400A.

Note: If you used the wrong minimum volt-amperes 15,000 listed in the question (this is also one of your answer choices), be careful. The test creator is testing your knowledge of when to apply the Code guidelines.

Harold De Loach, a master electrician and electrical trainer/instructor, is the founder of The Academy of Industrial Arts (www.taia-school.com) in Philadelphia. With more than 30 years of experience in the field, he writes regular exclusive content for EC&M and can be reached at info@taia-school.com.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

THE APPRENTICE'S GUIDE TO ARTICLE 640

Applying NEC requirements for audio signal processing, amplification, and reproduction equipment

By Harold De Loach

This column will explore what electrical apprentices need to know when it comes to Art. 640, Audio Signal Processing, Amplification, and Reproduction Equipment. Found in Chapter 6 of the National Electrical Code (Special Equipment), this Article addresses nontypical applications or specialized areas of work/installations, such as electric signs, office furnishings, pipe organs, photovoltaic systems, escalators, elevators, etc.

Art. 640 covers equipment and wiring (permanent and temporary) for:

- Public address systems
- Speech input systems
- Distribution of sound
- Electronic musical instruments
- Temporary audio system installations
- Audio signal generation, recording, processing, amplification, and reproduction

It also addresses special occupancies or locations that use both portable and permanent installations, such as restaurants, hotels, business offices, commercial and retail sales environments, churches, schools, residences, auditoriums, theaters, stadiums, movie and television studios, auditoriums, theaters, stadiums, and outdoor events (e.g., fairs, festivals, circuses, public events, and concerts).

31447604 © Wavebreakmedia Ltd | Dreamstime.com

Within the guidance of Art. 640, pieces of equipment that are connected to sound systems can include, but are not limited to loudspeakers; headphones; pre-amplifiers; microphones and their power supplies; mixers; MIDI (musical instrument digital interface) equipment or other digital control systems; equalizers, compressors, and other audio signal processing equipment; and audio media recording and playback equipment, including turntables, tape decks and disk players (audio and multimedia), synthesizers, tone generators, and electronic organs.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

Electronic organs and synthesizers may have integral or separate amplification and loudspeakers except for amplifier outputs; virtually all such equipment is used to process signals (analog or digital techniques) that have nonhazardous voltage levels or current.

RELATED ARTICLES

When it comes to applying the requirements of Art. 640, be prepared to do your research. This Article may be modified or supplemented by the following Articles:

- Art. 518, Assembly Occupancies
- Art. 517, Health Care Facilities, Part VI
- Art. 525, Carnivals, Circuses, Fairs, and Similar Events
- Art. 530, Motion Picture and Television Studios and Similar Locations
- Art. 520, Theaters, Audience Areas of Motion Picture and Television Studios, Performance Areas, and Similar Locations

PUTTING IT ALL TOGETHER

No matter how small or large the application is, use these practices and methods wherever you work. Electricians must meet the guidelines required to protect persons and property — Art. 90.1 (A). The Code also requires us to provide the customer with a neat, organized installation; in other words, don't create a "bird's nest" of wiring. Art. 640.6, Mechanical Execution of Work, requires us to install all audio cables so that the audio distribution cables will not be damaged by everyday building use. Cables installed on an exposed surface of ceilings and sidewalls shall be supported or secured by:

- Cables
- Straps
- Staples
- Cable ties
- Hangers
- Similar fittings that will not damage the cable

SAFETY FIRST

Make safety a priority for your installation in the common and staff areas. Flexible cords and cables accessible to the public that are laid or run on the ground or floor shall be covered with approved nonconductive mats, as noted in Art. 640.45 (A), Protection of Wiring. In addition, your work should not present a tripping hazard. An accumulation of wires and cables should not prevent the removal of panels and suspended ceiling panel access, as described in Art. 640.5, Access to Electrical Equipment Behind Panels Designed to Allow Access.

NO MATTER HOW SMALL OR LARGE THE APPLICATION IS, USE THESE PRACTICES AND METHODS WHEREVER YOU WORK. ELECTRICIANS MUST MEET THE GUIDELINES REQUIRED TO PROTECT PERSONS AND PROPERTY — ART. 90.1 (A).

If your installation is by a body of water, pool, spa, hot tub, or fountain, the branch-circuit power shall not be placed horizontally within 5 ft of the inside wall or within 5 ft of the prevailing or tidal high-water mark. The equipment shall be protected by a ground-fault circuit interrupter branch-circuit, as explained in Art. 640.10, Audio Systems Near Bodies of Water.

WIRING PERMANENT INSTALLATIONS

When wiring to and between audio equipment, the same requirements of Chapters 1 through 4, except as modified by this Article, apply when wiring from a power source to and between devices connected to the building wiring systems, as noted in Art. 640.9 (1). Cables used to connect loudspeakers or to an amplifier shall comply with Art. 725, Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits. The

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*

additional listed cable types are signal, hybrid communications, and composite optical fiber cables.

Flexible cords and cables shall be permitted for permanently installed equipment racks to the premises' wiring system. The connection shall be made either by using approved plugs and receptacles or by direct connection within an approved enclosure, as noted in Art. 640.21 (B). Flexible cords and cables shall not be subjected to abuse while the rack is in use. Installation of flexible cords and cables used to connect loudspeakers or an amplifier shall be listed for portable use — either hard or extra-hard usage. The cables must comply with Part I of Art. 400 and Parts I, II, III, and IV of Art. 725 640.42 (B).

As you continue your journey to understand the NEC's layout and structure, always remember that the NEC only sets the minimum guidelines for installation — so be prepared to do more if required by your local Authority Having Jurisdiction.

Harold De Loach, a master electrician and electrical trainer/instructor, is the founder of The Academy of Industrial Arts (www.taia-school.com) in Philadelphia. With more than 30 years of experience in the field, he writes regular exclusive content for EC&M and can be reached at info@taia-school.com.

PAGE 2
The Stuff You Don't See Every Day

PAGES 3-4
The Apprentice's Guide to Special Equipment

PAGES 5-7
The Apprentice's Intro Guide to Motors

PAGES 8-10
The Apprentice's Guide to Article 625

PAGES 11-13
The Apprentice's Guide to Article 525

PAGES 14-16
The Apprentice's Guide to NEC Art. 550

PAGES 17-19
The Apprentice's Guide to Article 640

EC&M

From the *EC&M* e-books library

A compilation of technical articles from *EC&M*