# Loads, Service, and Overcurrent Protection

Lesson 2

This next lesson in your program covers three chapters in the textbook and some of the most-used content in the *NEC*. Assignment 3 will cover *load calculations* for different types of dwellings. Many of us don't like math, but the calculations you'll learn in this part of your course are critical to your use and application of the *NEC*. If you're interested in or are preparing for a journeyman examination, or perhaps a state or local licensing exam, your text estimates that at least a quarter of the questions will require load calculations.

Once you master load calculations, you'll move onto the portions of the *NEC* that deal with the *service.* This is where electrical power enters the building—and also where the jurisdiction of the Code begins. The final assignment for this lesson and Chapter 5 in your textbook cover the many types of conductors used in electrical installations, their ratings, and appropriate applications. Chapter 5 also covers the methods used to protect conductors from overcurrent conditions, mainly in the form of overcurrent protection devices (OCPD), and predominantly circuit breakers and fuses.

When you complete this lesson, you'll be able to

- Calculate load requirements for one-family and multifamily dwellings
- Apply demand factors to general lighting loads
- Understand the requirements for installing service conductors and equipment in various occupancies
- Understand the importance of the construction and installation of conductors to the integrity of an electrical system
- Define ampacity and apply the concept to the safe installation of equipment and outlets
- Understand the importance of overcurrent protection and list the common overcurrent protection devices employed to address overcurrent conditions

# ASSIGNMENT 3

**Read this introduction to Assignment 3. Then, study pages 76–105 in your textbook.**

## Chapter 3—Dwelling Load Calculations

As you've just read, the ability to perform load calculations is one of the most important skills you'll learn in this course. There are many formats for gathering the required data and performing and listing the results of the calculations: paper forms, spreadsheets, and smartphone apps. Some of the paper forms look like income tax forms, and that's a good way to look at this calculation process. If you prepare your own taxes, you know that the math isn't that difficult. What's hard is locating and arranging the data and knowing what rules to apply. As you work through the examples in this chapter, you'll find that once you know how to determine the numbers that go into the formulas, the rest is pretty easy.

Here are some tips that might be helpful as you prepare to learn this material:

- You might need to determine distances to calculate square footage. So if you're working off a scaled drawing, an architect's scale might be handy to determine the size of parts of a drawing that aren't dimensioned. Just make sure you know the scale of the drawing and use the correct portion of your architect's scale.
- Simple square footage calculations are just the room's length times its width.
- If you're multiplying by a percentage and you don't have a percent key on your calculator, remember to convert to decimals before you multiply (0.70 for 70 percent, 1.15 for 115 percent, and so on).

In addition to performing the calculations, you'll also learn about the basic interpretations of Article 220. Article 220, titled *Branch Circuit, Feeder, and Service Calculations,* is a very popular article, and working electricians refer to it often. The article is divided into multiple parts:

- General (Part I)
- Branch-Circuit Load Calculations (Part II)
- Feeder and Service Load Calculations (Part III)
- Optional Feeder and Service Load Calculations (Part IV)
- Farm Load Calculations (Part V)

Part I of Article 220 provides a general overview of nominal voltage levels, specifications for computing residential and nonresidential loads, and rules for calculating additions to existing installations. As an electrician, the voltage levels that you'll commonly refer to are nominal voltage levels, such as 208Y/120 or 480Y/277. *Nominal voltage values* indicate voltage levels under ideal conditions. Actual voltages measured with voltmeters may fall either below or above these nominal voltages. However, they're still referred to by the nominal value unless the measurement is part of a troubleshooting process sensitive to actual voltage levels.

Part II of Article 220 contains Table 220.12, which lists the unit load per square foot used in calculating general lighting loads for most types of structures. The phrase *unit load per square foot* refers to the number of volt-amperes (watts) per square foot of occupied floor space. Garages, porches, and unfinished basements aren't included as part of the floor space in residences. Electricians refer to Table 220.12 often, especially during the bidding or estimating part of an electrical project.

Once the general lighting load is calculated according to the rules, refer to Part III of Article 220. Part III helps you determine the demand factors that apply to that load so the service and feeder ratings can be calculated. Table 220.42 in the *NEC* lists these demand factors. For example, the first 3000 VA (watts) of general lighting load is calculated at 100 percent, and the next 117,000 VA is calculated at 35 percent. (Remember that the general lighting load includes lights and general-purpose receptacles in a home.) After the readjusted general lighting load is calculated and the demand factors are applied, specialty circuits such as clothes dryers, ranges, and ovens are added according to the information in the tables in

Part III of Article 220. From this calculation, an electrician can determine feeder and service sizes, including the neutral load as determined by Section 220.61.

Part IV of Article 220 summarizes an optional method for calculating feeder and service loads. This method is based on percentages of the general calculated load, including general lighting and appliances, with a percentage of the heating or air conditioning loads added to the results. This is a quicker method for determining residential loads, and the results of this calculation should closely correspond to the results found in the calculation method described in Part III of the article.

**After you've read pages 76–105 in the textbook carefully and completed the Review Questions on pages 107 and 108, check your answers against those provided in the back of this study guide. When you're sure you completely understand the material from Assignment 3, move on to Assignment 4.**

# ASSIGNMENT 4

**Read this introduction to Assignment 4. Then, study pages 112–143 in your textbook.**

## Chapter 4—Services

We now move from load calculations to a review of Article 230—*Services.* The service provides the connection from the electrical utility to the building or structure that ultimately consumes the energy. Chapter 4 of your textbook helps you understand the applications of the requirements of Article 230 for common and simple 100 A one-family dwellings through 3000 A service for industrial settings.

Article 230 covers the rules that apply to building electrical service entrance systems and installing equipment including panels, subpanels, and panelboards. This phase of the electrical work provides the interface of the electrical supply with

the structure. It also safely establishes an electrical base from which the branch circuit system can extend. Because Article 230 is so extensive, it is divided into eight parts.

Part I of Article 230 stipulates that only one service may supply a building unless special conditions exist that meet the exceptions to Section 230.2. These conditions may include services needed for emergency equipment, multiple occupancies, excessive electrical load requirements, or services of different voltages. According to Section 230.3, you may not run service conductors through the interior of another building, but you may run them *outside* of another building (as defined by Article 230.6). Included in this article is Section 230.7, which states that you may not run branch circuit conductors or any other conductors (except grounding conductors) in the same raceway with the service conductors.

Service conductors that supply the service entrance equipment are run either overhead or underground. The term for an overhead service conductor is *service drop.* An underground service conductor is called a *service lateral* or *lateral feed.* Article 230 addresses the installation of each type of service conductor. Sections 230.22 through 230.29 in Part II cover ampacities, clearances, and attachment techniques for overhead service conductors. Sections 230.30 through 230.33 of Part III cover the rules for service lateral conductors.

Normally, the local utility company (not the electrician) is responsible for installing service drops or lateral feeds, and the electrician is responsible for installing the rest of the electrical system (including the service entrance conductors). *Service entrance conductors* connect the service drop or lateral feed through the metering device and the main disconnect to the line terminals of the main panelboard. Because the conductors are installed at an accessible level (directly or indirectly attached to the structure) and must safely support the total electrical load of the building, many rules govern their installation. The rules are found in Sections 230.40 through 230.56 in Part IV of Article 230. These rules cover the sizing, splicing, termination, protection, and securing of service entrance conductors. All electricians

should be very familiar with the content in these sections so that they can ensure the safe and compliant installation of service entrance conductors.

Part V of Article 230 reminds the electrician that all service equipment that holds energized parts must be enclosed, guarded, and (if over 600 volts) marked as suitable for service equipment. *Note:* The *meter socket* or *base* isn't considered service equipment.

Once the service entrance conductors are installed, the ungrounded conductors must have a means of disconnection and overcurrent protection from the load. Part VI of Article 230 covers the rules associated with the installation of disconnecting means for service conductors. Sections 230.71 through 230.82 cover such topics as the maximum number of disconnects allowed per service, the grouping of these disconnects, and the methods that may be used to disconnect for a service disconnect in a one-family dwelling.

Part VII of Article 230 discusses how ungrounded service entrance conductors must be protected against overcurrent. Sections 230.90 through 230.95 cover the rules associated with this protection, including which conductors must be protected, exceptions to this protection, the conductors, and the rating of these disconnects. One particularly important part of Section 230.79(C) states the minimum rating and location of the overcurrent devices. All concerns relating to the overcurrent protection of service conductors should be first addressed by reviewing Part VII of Article 230.

Once a service is installed according to the rules in Articles 110 and 230, it must be properly *bonded* and *grounded* in accordance with Article 250. This assignment summarizes the proper grounding methods of the electrical service and equipment, but you'll cover grounding and Article 250 in more detail later in your studies.

**After you've read pages 112–143 in the textbook carefully and completed the Review Questions on pages 145–148, check your answers against those provided in the back of this study guide. When you're sure you completely understand the material from Assignment 4, move on to Assignment 5.**

# ASSIGNMENT 5

**Read this introduction to Assignment 5. Then, study pages 152–189 in your textbook.**

## Chapter 5—Conductors and Overcurrent Protection

The final assignment for this lesson covers Chapter 5 in your textbook and, for the most part, *NEC* Article 240—Overcurrent Protection. To fully understand the section on overcurrent protection, you'll first refer back to Article 100 for clear definition of conductors, and then jump forward to Article 310, which covers the requirements for all conductors used for general wiring. All conductors installed in a service and any associated equipment must be rated at an ampacity that can carry the calculated load and governed by Article 310. You should review Article 310 any time conductors are installed in any electrical system, including services.

When you have a working knowledge of conductors and their applications and ratings, you can then appreciate the need to provide circuit protection to prevent current conditions that could damage conductors or their insulation. Article 240 covers the required means for overcurrent protection. *Overcurrents* are currents that exceed the rating of the conductor or equipment. Your textbook reviews the three conditions that generate overcurrents: overloads, short circuits, and ground faults.

There are nine sections in Article 240, and Chapter 5 of your textbook covers sections I through VII. These seven sections address the most common forms of overcurrent protection, fuses and circuit breakers (CBs), their ratings, and their

required locations within circuits. You'll also study the specific rules for protecting ungrounded and grounded conductors and the various tap rules and feeder tap rules for overcurrent protection. Location and access within a premise is an important discussion covered in 240.24.

This chapter concludes with detailed descriptions and illustrations of fuses and circuit breakers, including data on their operation, ratings, marking, and specific applications.

**After you've read pages 152–189 in the textbook carefully and completed the Review Questions on pages 191–194, check your answers against those provided in the back of this study guide. When you're sure you completely understand the material from this lesson, complete the Lesson 2 Examination.**