CHAPTER 1

Electrical Plan Design

Chapter Outline

Objectives

- Identify the steps in the electrical design process.
- Determine the scope of an electrical design project.
- Interpret the various components of an electrical plan, including general and specialized loads, lighting systems, and distribution systems.
- Recognize the symbols used in electrical plan design.
- Identify the standards and regulations that guide the electrical design process.

Introduction

For all building construction or remodeling building projects, the owner or occupant must first have a concept for the new design, and then the architect or designer can produce a set of building plans. These plans convey all the required information to the local inspection authority and associated building trades so that the construction or remodeling can take place. Because commercial and industrial buildings contain a number of electrical systems, these plans include specific electrical designs and additional documentation to verify that the design conforms to all required building codes.

The Design Process

An electrical design goes through several important stages of development. First, the designer must understand the scope of the project. Then, the designer defines and designs each component (such as general office areas, specialized machinery, and power distribution equipment) to recognized industry standards. Finally, these individual components are compiled to form the final presentation for the design.

Understanding the Project Scope

Every electrical design has unique requirements, depending on the scope of the project. The project scope is determined by the customers' requirements and the type of structure that the customer will occupy. For example, if the project requires new electrical systems for an existing building, then the electrical designer works to incorporate all the new electrical wiring into the existing system. The designer must evaluate the existing electrical system to ensure that existing electrical systems can accommodate new additional electrical loads that will be imposed on them. When the design is for a new proposed facility, then the scope of the project is much greater. Electrical designs for these types of projects require an entirely new electrical system design.

Defining Parts of the Electrical Plan

Depending on the overall scope of the project, a design can include the following components:

- General electrical requirements (e.g., general purpose receptacles)
- Specialized electrical requirements (e.g., specialized office equipment or machinery)
- Lighting systems
- Electrical distribution systems

General Electrical Requirements

General electrical requirements should be defined first on any electrical design project. General electrical requirements are items such as the 120-volt general purpose receptacle outlets located throughout the commercial or industrial building. These receptacles are usually not specified to serve any particular load but rather are for general purpose use such as for desktop devices, standard wall receptacles, and desktop computer equipment with no special electrical requirements.

Specialized Electrical Requirements

Certain projects may include specialized electrical equipment that requires separate or dedicated electrical circuitry that serves only the specialized equipment (see **FIGURE 1-1**). This equipment may be of the following types:

- Computers and/or network servers
- Photocopiers
- Microwave ovens and other lunchroom appliances
- Vending machines

Because of their electrical load requirements, as per the manufacturer's requirements, these pieces of equipment may require individual circuitry and special grounding methods (see Chapter 3).

FIGURE 1-1 Some commercial electrical equipment may have specialized electrical requirements.

Lighting Systems

Because of their complexity, lighting systems are the part of the design process that generally requires the greatest amount of time to develop (see **FIGURE 1-2**). These systems include all the lighting fixtures and their controls. Lighting systems have very detailed requirements as per the *NEC* and require documentation showing that the system incorporates all required energy-saving technologies (see Chapter 4).

Distribution System

An electrical distribution system is the installed equipment that provides for the distribution of electrical wiring throughout the facility (see **FIGURE 1-3**). It includes the main switchboard, which receives the power source from the serving utility, and all the associated components such as panelboards that distribute all the required branch circuits throughout the facility (see Chapter 5). Part of the process of designing the distribution system is calculating the facility's amperage load and short-circuit values; these calculations determine the total electrical demand requirements of the facility based on the individual parts of the electrical distribution system (see Chapter 6).

FIGURE 1-2 Lighting systems are the most complex part of an electrical design.

FIGURE 1-3 An electrical distribution system provides power to the entire facility.

Determining Applicable Standards

Once each part of the design plan has been defined, the next stage is to design each part to industry-recognized standards as well as any additional standards set forth by the local jurisdiction for commercial or industrial occupancies. The primary industry standard is the **National Electrical Code (NEC)**, published by the National Fire Protection Association (NFPA). The *NEC* (commonly referred to as "the *Code*") is revised every three years and results in the publication of a new edition (e.g., the 2005 *NEC* or the 2008 *NEC*). Although the *Code* is applied on a national level, some local jurisdictions may have additional standards that exceed the requirements of the *NEC* or they may use a previous edition of the *Code*.

TIP

Always contact local building inspection authorities during the design process to determine whether any local standards have been adopted and which edition of the *NEC* is being enforced.

For projects based on a national template (such as is often the case with retail outlets and fast-food chains), any requirements or adjustments that are necessary to conform to local code requirements should be documented in the final plan in a general notes section. Please note that only officially documented standards may be enforced, not widespread, unofficial community practices.

Some projects will also have additional requirements based on their specific components, such as those including specialized electrical equipment. An electrical designer should always consider manufacturer guidelines for specialized equipment and use the appropriate electrical equipment standards set forth by the manufacturer for overcurrent protection sizes, specialized grounding requirements, and so forth. These specialized requirements may require that additional specialized wiring practices be observed; when this is the case, these specialized requirements must be documented on the plan.

Designers must also consider the standards of the **National Electrical Manufacturers Association (NEMA)**, which includes standards for motor lead identification, transformer terminal markings, plug and receptacle devices, and amperage ratings, and the **Electrical Apparatus and Service Association (EASA)**, which provides current and updated information for motors and controls. Designs that include lighting systems must conform to national or state-mandated energy-saving requirements. Designers should consult the **Illuminating and Engineering Society of North America (IESNA)** standards for lights and lighting products and properly document the design to ensure that it meets all the required criteria (see Chapter 4).

For projects that include new or upgraded parts of distribution systems served from a local utility, designers must consider any requirements set forth by the serving utility. These requirements may dictate the wiring methods and equipment required for the proper distribution from the serving utility to the customer (see Chapter 5). Calculated load values must reference manufacturer guidelines to ensure that distribution systems will support these loads (see Chapter 6).

In all cases, designers must have not only solid electrical knowledge and a thorough understanding of the electrical calculations and their necessity but also awareness of the application of all relevant codes and standards utilized within the electrical industry.

Creating the Electrical Plan

Once the various parts and applicable standards have been determined, the designer begins compiling those parts to form the electrical design and complete a set of plans.

Historically, these plans took the form of hand-drawn blueprints (see **FIGURE 1-4**), but today most plans are created digitally using **computer-aided design (CAD)** software tools. Digitized plans are easier to revise and transmit than those drawn with pen and pencil. When printed, digital plans are typically produced on standard sized architectural plan sheets; the most common size sheets are architectural D sheets which are 24 in. × 36 in. and architectural E sheets which are 36 in. × 48 in.

On the plans, each device should be referenced using the appropriate electrical symbol. Electrical symbols allow for universal recognition of each part by the many persons who will be working on the project so that they can estimate costs appropriately and construct the project to the specifications. The standardized electrical symbols used for building plans are provided by the **American National Standards Institute (ANSI)** (see **FIGURE 1-5**).

Not all symbols are used on every project, so the specific symbols used on a particular project

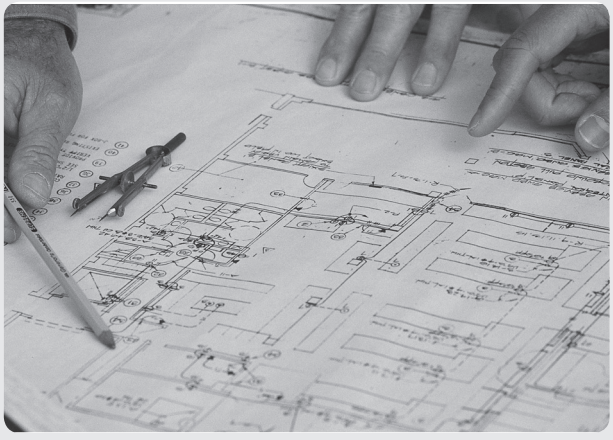

FIGURE 1-4 Traditional hand-drawn blueprints are no longer common because most designers use CAD design tools.

FIGURE 1-5 Electrical symbols are used to indicate the parts of an electrical design.

should be included in a symbols list and attached to the final design. Occasionally the need may arise for a symbol that has not been developed (such as a symbol for a newer energy-saving or energy management device). In this case, the designer may create a new symbol for the electrical design plan, as long as it is added to the symbols list included with the plan.

Electrical design plans may be included as a separate document within a complete set of building plans. To identify the electrical plans, each page of the electrical design plan is labeled and numbered: E_1, E_2, E_3, and so forth. Please note that these electrical sheets (often called "E sheets") are not ***architectural*** E sheets, which denote a standard size paper. Electrical sheets are generally presented in the following order:

- Exterior electrical site plan
- Interior electrical power plan
- Interior lighting plan
- Documentation (such as panel schedules, electrical calculations, single line diagrams, and lighting system energy requirements)

The number of electrical sheets required for a project varies based on the amount of required information that each project requires and how much of that information can fit on one page and still provide for a clear, concise understandable set of prints.

Wrap Up

Master Concepts

- When designing an electrical plan, the designer must understand the scope of the project, define each required part, and then design them to recognized industry standards.
- The major parts of an electrical plan include general and specialized electrical requirements, lighting systems, and the electrical distribution system.
- Every electrical plan must be designed to recognized industry standards, use appropriate electrical symbols, and conform to all applicable codes.
- Once the various parts and applicable standards have been determined, the designer creates a complete a set of plans.

Charged Terms

American National Standards Institute (ANSI) An organization that oversees the development of standards created by manufacturers throughout the industry to promote safety and other standards.

computer-aided design (CAD) The use of computers and design software to aid in the design of drawings, objects, shapes, and other items.

Electrical Apparatus and Service Association (EASA) An organization that provides information and education about sales, service, and maintenance materials for motors, generators, and other electromechanical equipment.

Illuminating and Engineering Society of North America (IESNA) An organization that works with manufacturers, designers, architects, consultants, electrical and building contractors, and suppliers with regard to lighting systems.

***National Electrical Code* (*NEC*)** Regulatory code published by the National Fire Protection Association (NFPA); also known as NFPA 70.

National Electrical Manufacturers Association (NEMA) A trade association that provides standards for the electrical manufacturing industry including the generation, transmission and distribution, control, and end use of electricity.

Check Your Knowledge

1. Which of the following parts are included in an electrical design?
   - **A.** General and specialized equipment loads
   - **B.** Lighting systems
   - **C.** Distribution system
   - **D.** All of the above
2. The standardized electrical symbol list utilized in the electrical industry is provided by:
   - **A.** the International Electrical Symbol Association.
   - **B.** the Institute of Electrical and Electronics Engineers.

C. the *National Electrical Code*.
D. the Association of Electrical Designers.

3. Receptacles that are installed to serve wall outlets are those that will serve:
A. specialty equipment.
B. general purpose loads.
C. appliance loads.
D. special equipment loads.

4. Dedicated electrical circuitry is installed to serve:
A. computers.
B. photocopiers.
C. vending machines.
D. All of the above

5. The primary industry standard used in electrical design is:
A. IESNA.
B. EASA.
C. *NEC*.
D. NEMA.

You are the Designer

Apply the knowledge you have gained to your electrical design. In this section, you will:

- Begin the first steps in developing an electrical design for a commercial building.
- Define the scope for your project.
- Develop a project folder for your design project.

■ About the Project

To complete your task, you must know the following general details about your project:

- The scope of the plan, including the following:
  - Power plan with general and specialized equipment components
  - A lighting plan including lighting fixtures and controls
  - A distribution system including a main switchboard and panelboards
- Applicable standards from the *NEC* and National Electrical Manufacturers Association (NEMA)

■ Resources

To develop this part of the design, you need the following resources:

- The following documents from the Student Resource CD-ROM:
  - Plan sheet E_1: Interior building power
  - Plan sheet E_2: Building interior lighting
  - Plan sheet E_3: Single line diagram, developed panel schedules, load and short-circuit calculations
  - Electrical symbol list
- Three-ring binder with section dividers

■ Get to Work

At the onset of your project, you need to define the scope for your project. Begin by examining plan sheets E_1, E_2, and E_3 on the Student Resource CD-ROM and note all the required parts of the plan: general and specialized electrical requirements, lighting system, and distribution system. Next, make a section for each component in a three-ring binder and add a section for general notes. Print out a copy of the electrical symbol list from the Student Resource CD-ROM as well and add this to the binder. The binder helps organize the documents you will gather, create, and reference throughout your design project. It also serves as a useful resource throughout the design process and helps you organize and compile the final design plan quickly and accurately.