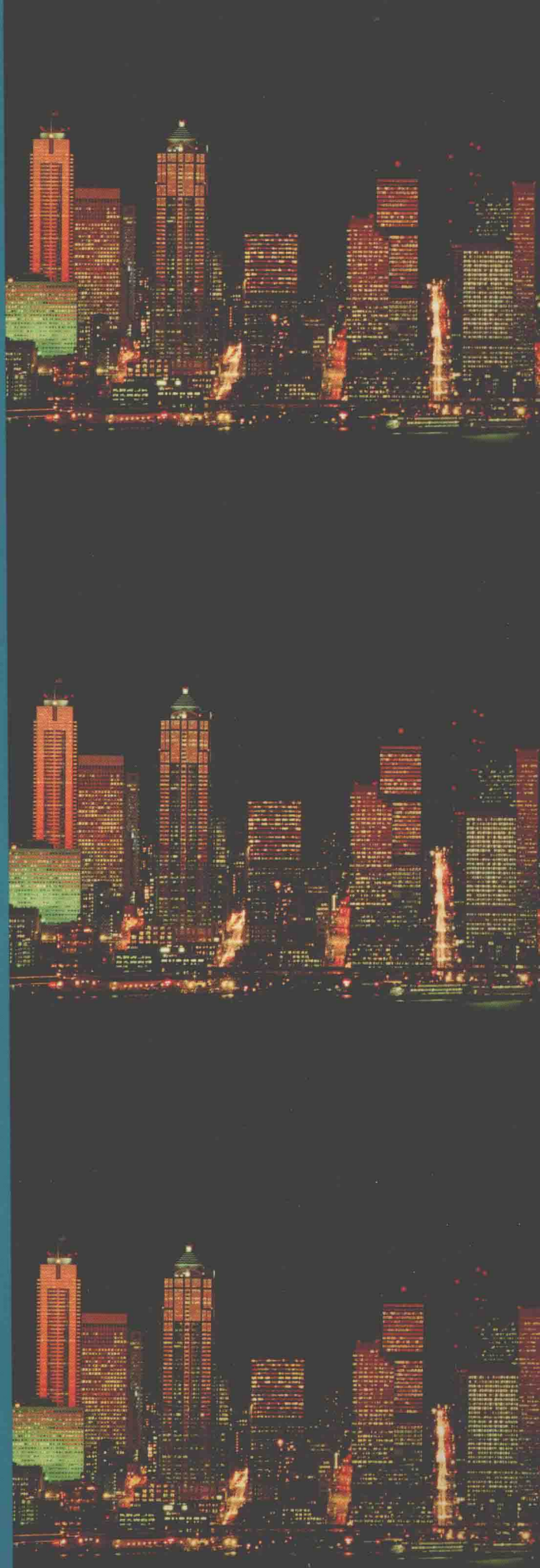


Electrical Wiring Commercial

10th Edition

Based on the
1999
National
Electrical
Code®

Ray C. Mullin
Robert L. Smith



***Based on the 1999
NATIONAL ELECTRICAL CODE®***

Electrical Wiring Commercial

Tenth Edition

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PREFACE

INTRODUCTION

The tenth edition of **ELECTRICAL WIRING — COMMERCIAL** is based on the 1999 *National Electrical Code*.^{*} The new edition thoroughly and clearly explains the *NEC*[®] changes that relate to commercial wiring.

The *National Electrical Code*[®] is used as the basic standard for the layout and construction of electrical systems. To gain the greatest benefit from this text, the learner must use the *National Electrical Code*[®] on a continuing basis.

State and local codes may contain modifications of the *National Electrical Code*[®] to meet local requirements. The instructor is encouraged to furnish students with any variations from the *NEC*[®] as they affect this commercial installation in a specific area.

This text takes the learner through the essential minimum requirements as set forth in the *National Electrical Code*[®] for commercial installations. In addition to Code minimums, the reader will find such information above and beyond the minimum requirements.

The commercial electrician is required to work in three common situations: where the work is planned in advance; where there is no advance planning; and where repairs are needed. The first situation exists when the work is designed by a consulting engineer. In this case, the electrician must know the installation procedures, must be able to read plans, and must be able to understand and interpret specifications. The second situation occurs either during or after construction when changes or remodeling are required. The third situation arises any time after a system is installed. Whenever a problem occurs with an installation, the electrician must understand the operation of all equipment included in the installation in order to solve the problem.

When the electrician is working on the initial installation or is modifying an existing installation, the circuit loads must be determined. Thorough explanations and numerous examples of calculating these loads help prepare the reader for similar problems on the job. The text and assignments make frequent reference to the commercial building drawings at the back of the text.

Readers should be aware that many of the electrical loads used as *examples in the text* were contrived in order to create Code problems. The authors' purpose in putting this building together is to demonstrate, and thus enhance learning, as many Code problems as possible. As an example, there is a single-phase feeder to the Doctor's office. This could have been a three-phase feeder similar to those in the other occupancies. However, using the single-phase feeder allows us to demonstrate many additional Code applications.

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This is not a typical or an ideal design for a commercial building. It is a composite to demonstrate a range of Code applications. The authors also carry many calculations to a higher level of accuracy as compared to the accuracy required in many actual job situations. This is done to demonstrate the correct method. Then, if the reader wants to back off from this level, based upon installation requirements, it can be done intelligently.

THE TENTH EDITION

The unchanging goal of this text is to explain and demonstrate how, why, and where the *National Electrical Code*® is applied to the wiring of a commercial type building. Three completely rewritten units provide an expanded and simplified insight into the planning of an electrical installation, carefully demonstrating how the load requirements are converted into branch circuits, then into the feeders and finally into the building service. New tables and drawings enhance this progression. This edition totally reflects the reorganization of the 1999 *National Electrical Code*®. The authors believe that these changes will result in a Code that will be recognized as a document that is easier to interpret and apply. Every Code reference in tenth edition of *Electrical Wiring Commercial* is the result of carefully comparing the past Code references with the 1999 *NEC*®.

CHANGES FOR THIS EDITION AS A RESULT OF CHANGES IN THE 1999 NATIONAL ELECTRICAL CODE®

- Over 1,000 *NEC*® references have been reviewed and updated as dictated by the revision and reorganization of the 1999 *NEC*®.
- An expansion of Unit 2 to include working drawing review of the entry level occupancies.
- A complete rewrite of Unit 4 to clarify and simplify the creation of branch circuits. Included is a worksheet that facilitates the selection of branch circuit overcurrent protection and conductors.
- A completely new Unit 8 explains and demonstrates each step necessary in the selection of feeder phase and neutral conductors and feeder overcurrent protection.
- Unit 10 has been revised to include all three of the upper level occupancies, including an extended discussion of the merits of 3-wire single-phase and 4-wire three-phase feeders.
- A major modification of Unit 13 incorporates an entirely new procedure for making decisions related to the service entrance equipment.
- Several branch circuits have been revised and rerouted to provide more examples of *NEC*® requirements.
- An updating of the sizing of neutrals where there is significant nonlinear loading.

ABOUT THE AUTHORS

This text was prepared by Ray C. Mullin and Robert L. Smith. Mr. Mullin is a former electrical circuit instructor for the Electrical Trades, Wisconsin Schools of Vocational, Technical and Adult Education. A former member of the International Brotherhood of Electrical Workers, Mr. Mullin is presently a member of the International Association of Electrical Inspectors, the Institute of Electrical and Electronic Engineers, and the National Fire Protection Association, Electrical Section. He served on Code Making Panel 4 for the *National Electrical Code*®, *NFPA-70* for the National Fire Protection Association.

Mr. Mullin completed his apprenticeship training and has worked as a journeyman and

supervisor. He has taught both day and night electrical apprentice and journeyman courses and has conducted engineering seminars. Mr. Mullin has contributed to and assisted other authors in their writing of texts and articles relating to overcurrent protection and conductor withstand ratings. He has had many articles relating to overcurrent protection published in various trade magazines.

Mr. Mullin attended the University of Wisconsin, Colorado State University, and Milwaukee School of Engineering.

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Mr. Mullin is past Director, Technical Liaison, and Code Coordinator for a large electrical manufacturer.

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Professor Smith has been affiliated with a number of professional organizations, including the Illinois Society of Professional Engineers, the International Association of Electrical Inspectors, and the National Academy of Code Administration. He is a life-long honorary member of the International Brotherhood of Electrical Workers. He gives frequent public lectures on the application of the *National Electrical Code*® and was a regular presenter at the University of Wisconsin Extension.

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UNIT 1

Commercial Building Plans and Specifications

OBJECTIVES

After studying this unit, the student will be able to

- understand the basic safety rules for working on electrical systems.
 - define the project requirements from the contract documents.
 - demonstrate the application of building plans and specification.
 - locate specific information on the building plans.
 - obtain information from industry-related organizations.
 - apply and interchange SI and English measurements.
-

SAFETY IN THE WORKPLACE

Before we get started on our venture into the wiring of a typical commercial building, let us talk about safety.

Electricity is dangerous! Working on electrical equipment with the power turned on can result in death or serious injury, either as a direct result of electricity or from an indirect secondary reaction such as falling off a ladder or falling into moving parts of equipment. Dropping a metal tool onto live parts or allowing metal shavings from a drilling operation to fall onto live parts of electrical equipment generally results in an *arc blast* that can cause deadly burns. The heat of an electrical arc has been determined to be hotter than the sun. Pressures developed during an arc blast can blow a person clear across the room. Dirt, debris, and moisture can also set the stage for catastrophic equipment failures and personal injury. Neatness and cleanliness in the workplace are a must.

The Federal Regulations in the Occupational

Safety and Health Act (OSHA) Number 29, Subpart S, in Part 1910.332 discusses the training needed for those who face a risk of electrical injury. Proper training means “trained in and familiar with the safety-related work practices required by paragraphs 1910.331 through 1910.335.” Numerous texts are available that delve into the OSHA requirements in great detail.

The *National Electrical Code*® defines a *qualified person* as “one familiar with the construction and operation of the equipment and the hazards involved.” Merely telling someone or being told “be careful” does not meet the definition of proper training, and does not make the person qualified.

Only qualified persons are permitted to work on or near exposed energized equipment. To become qualified, a person must have the skill and technique necessary to distinguish exposed live parts from other parts of electrical equipment, be able to determine the voltage of exposed live parts, and be trained in the use of special precautionary

techniques such as personal protective equipment, insulations, shielding material, and insulated tools.

In Subpart S, paragraph 1910.333 requires that safety-related work practices shall be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contact. Live parts to which an employee may be exposed shall be de-energized before the employee works on or near them, unless the employer can demonstrate that de-energizing introduces additional or increased hazards.

Working on equipment “live” is acceptable only if there would be a greater hazard if the system were de-energized. Examples of this would be life support systems, some alarm systems, certain ventilation systems in hazardous locations, and the power for critical illumination circuits. Working on energized equipment requires properly insulated tools, proper nonflammable clothing, rubber gloves, protective shields and goggles, and in some cases, rubber blankets.

OSHA regulations allow only qualified personnel to work on or near electrical circuits or equipment that has not been de-energized. The OSHA regulations provide rules regarding “lockout and tagging” to make sure that the electrical equipment being worked on will not inadvertently be turned on while someone is working on the supposedly “dead” equipment. As the OSHA regulations state, “a lock and a tag shall be placed on each disconnecting means used to de-energize circuits and equipment. . . .”

Some electricians’ contractual agreements require that as a safety measure, two or more qualified electricians must work together when working on energized circuits. They do not allow untrained apprentices to work on “live” equipment, but do allow apprentices to stand back and observe.

The National Fire Protection Association’s publications *Safety Related Work Practices* NFPA 70E and *Electrical Equipment Maintenance* NFPA 70B present much of the same material regarding electrical safety as do the OSHA regulations.

Safety cannot be compromised.

Follow this rule: turn off and lock off the power, then properly tag the disconnect with a description as to exactly what that particular disconnect controls.

With safety the utmost concern in our minds, let us begin our course on the wiring of a typical commercial building.

COMMERCIAL BUILDING SPECIFICATIONS

When a building project contract is awarded, the electrical contractor is given the plans and specifications for the building. These two contract documents govern the construction of the building. It is very important that the electrical contractor and the electricians employed by the contractor to perform the electrical construction follow the specifications exactly. The electrical contractor will be held responsible for any deviations from the specifications and may be required to correct such deviations or variations at personal expense. Thus, it is important that any changes or deviations be verified — in writing. Avoid verbal change orders.

It is suggested that the electrician assigned to a new project first read the specifications carefully. These documents provide the detailed information that will simplify the task of studying the plans. The specifications are usually prepared in book form and may consist of a few pages to as many as several hundred pages covering all phases of the construction. This text presents in detail only that portion of the specifications that directly affects the electrician; however, summaries of the other specification sections are presented to acquaint the electrician with the full scope of the document.

The specification is a book of rules governing all of the material to be used and the work to be performed on a construction project. The specification is usually divided into several sections.

GENERAL CLAUSES AND CONDITIONS

The first section of the specification, titled *General Clauses and Conditions*, deals with the legal requirements of the project. The index to this section may include the following headings:

- Notice to Bidders
- Schedule of Drawings
- Instruction to Bidders
- Proposal
- Agreement
- General Conditions

Some of these items will affect the electrician on the job and others will be of primary concern to the electrical contractor. The following paragraphs give a brief, general description of each item and how it affects either the electrician on the job or the contractor.