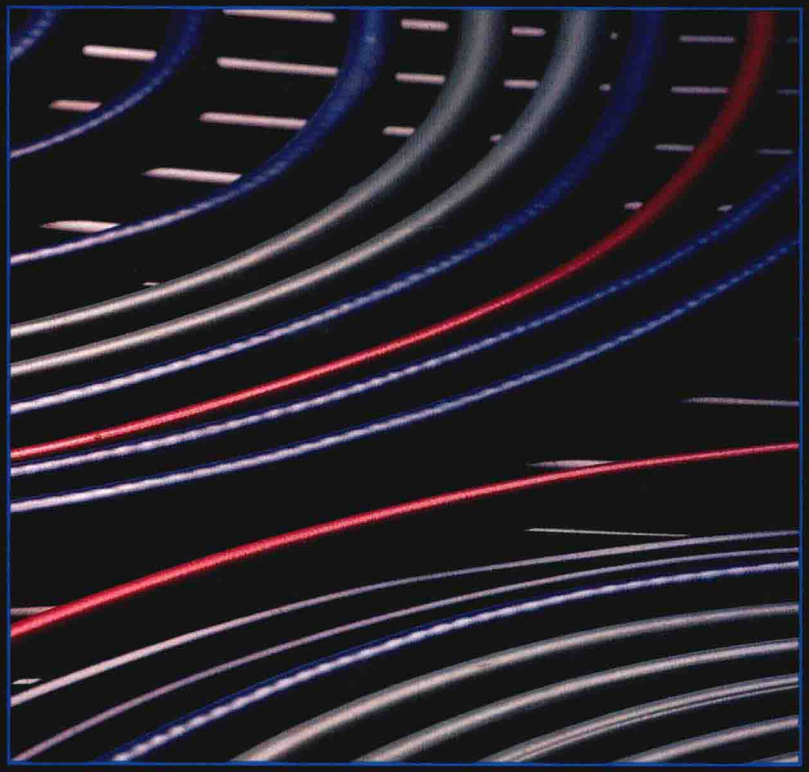
Industrial Electrical Wiring

Design, Installation, and Maintenance



John E. Traister

INDUSTRIAL ELECTRICAL WIRING

Design, Installation, and Maintenance

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INDUSTRIAL ELECTRICAL WIRING

Preface

Texts covering industrial electrical wiring have normally included page after page of electrical theory, mathematical calculations, and equations with very little material geared directly toward practical applications. *Industrial Electrical Wiring* is designed to change this; that is, with the scores of texts available covering theory, the author chose to concentrate mainly on the practical applications of industrial wiring — utilizing his more than 35 years' experience to cover practically every conceivable application from small textile mills to huge petroleum refineries.

This book begins with an overview of industrial electrical systems, touches briefly on essentials such as codes, standards, and print reading, then quickly jumps into practical categories such as the design and implementation of actual installations.

The plant engineer and electrical maintenance personnel, obviously, cannot afford to be without this book, but others in the electrical industry will also benefit:

- Consulting engineers
- Electricians who work on industrial electrical systems — either new construction or maintenance
- Apprentice electricians
- Manufacturers' representatives
- Electrical inspectors

In fact, anyone involved in the electrical industry — in any capacity — will find helpful information in this book that will be of use on a daily basis, especially those technicians involved with manufacturing processes.

John E. Traister

Contents

Chapter 1

Introduction

Industrial wiring installations include systems for all types of industrial plants, factories, refineries, and similar facilities. The basic principles of wiring for industrial installations are very similar to other types of electrical installations except that in most cases the currents used in industrial electrical systems will be larger — requiring larger wire and conduit sizes; higher voltage will normally be used in industrial wiring systems; three-phase in addition to single-phase systems will be in use, and different types of materials and equipment may be involved.

Factors to Consider

Factors affecting the planning of an electrical installation for an industrial plant include the following:

1. New structure or modernization of an existing one.

2. Type of general building construction; for example, masonry, reinforced concrete, structural steel frame, etc.

3. Type of floor, ceiling, partitions, roof, and so on.

4. Type and voltage of service entrance, transformer connections, and whether service is underground or overhead.

Figure 1-1: The type of general building construction is one factor to consider when planning an industrial electrical installation.

5. Type and voltage of distribution system for power and lighting.

6. Type of required service equipment, such as unit substation or transformer bank.

7. Type of distribution system, including step-down transformers.

8. Who is responsible for furnishing the service-entrance and distribution equipment, the power company or plant?

9. Wiring methods, types of raceways, special raceways, busways, and the like.

10. Types of power-control equipment and extent of the worker's responsibility for connection to it.

11. Furnishing of motor starters, controls, and disconnects.

12. Extent of wiring to be installed on machine tools.

13. Extent of wiring connections to electric cranes and similar apparatus.

14. Type and construction of lighting fixtures, hangers and supports, and the like.

15. Extent of floodlighting. Type and dimensions of floodlighting supporting poles and mounting brackets.

16. Extent of signal and communication systems.

17. Ground conditions affecting the installation of underground wiring.

18. The size, type, and condition of existing wiring systems and services for modernization projects.

19. Whether the plant will be in use during the electrical installation.

20. Allowable working hours when an occupied building is being rewired.

Figure 1-2: Furnishing power to electric cranes is an item to consider in industrial wiring.

Items 1 through 3 can be determined by studying the architectural drawings of the facility or, in the case of a modernization project, by a job site investigation.

Item 4 is usually worked out between the engineers and the local utility company, while items 5 through 10 are determined from the electrical drawings and specifications.

The electrical drawings as well as the mechanical drawings should be consulted to determine the condition of items 10 and 11. Also consult the special equipment section of the written specifications. In most cases, it is the responsibility of the trade furnishing motor-driven equipment to also furnish the starters and controls. The electrical contractor then provides an adequate circuit to each.

Item 12 can be determined by consulting the special equipment section in the written specifications and also

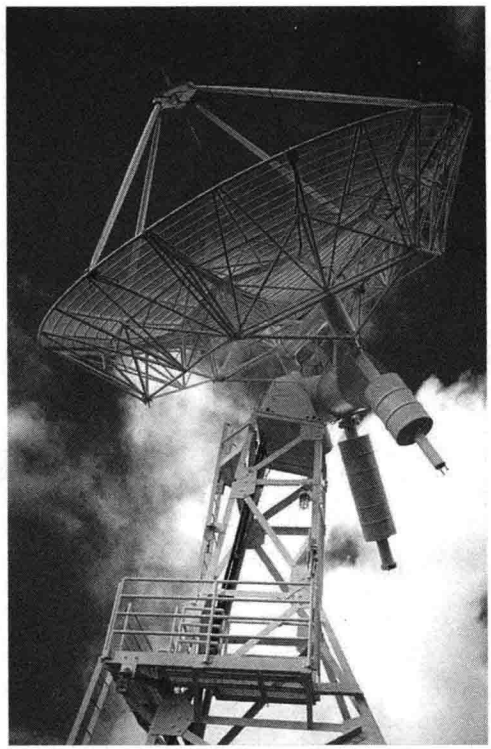

Figure 1-3: The extent of signal and communication systems must be considered.

by referring to the shop drawings supplied by the trade furnishing the equipment. It may be necessary to contact the manufacturer of the equipment in some cases.

On most projects, crane installation is a specialized category and installed by specialists in this field. All control work for the crane is normally done by the contractor who furnishes the crane. However, electrical workers will be required to furnish a feeder circuit from the main distribution panel to supply power for motors and controls to operate the crane. The extent of this work should be carefully coordinated between the trades involved.

Items 14 through 16 can be determined by consulting the electrical drawings and specifications for the project.

While items 17 through 19 might be covered to a certain extent in the project specifications, in most cases this information is obtained by a job site investigation.

Item 20 should be called out in the general specifications, but it may be necessary to hold a conference with the owners to determine the exact conditions. Item 21 is determined by referring to the local labor agreement, by contacting the local labor organization, or from past experience.

Planning and Coordination

Even with carefully engineered drawings, the person in charge of the electrical installation in an industrial occupancy must still do much planning and coordination to carry out the work in the allotted amount of time. One problem that has existed in the past has been a variation of interpretation of the code requirements by two or more inspection authorities having coinciding jurisdiction over the same job. Therefore, at the planning stage, the superintendent or foreman should meet with all inspection authorities having jurisdiction to settle any problems at the outset.

Many industrial plants will have one or more wiring installations in hazardous locations. Therefore, those in charge should frequently consult the *National Electrical Code*® (*NEC*®) to ascertain that all wiring is

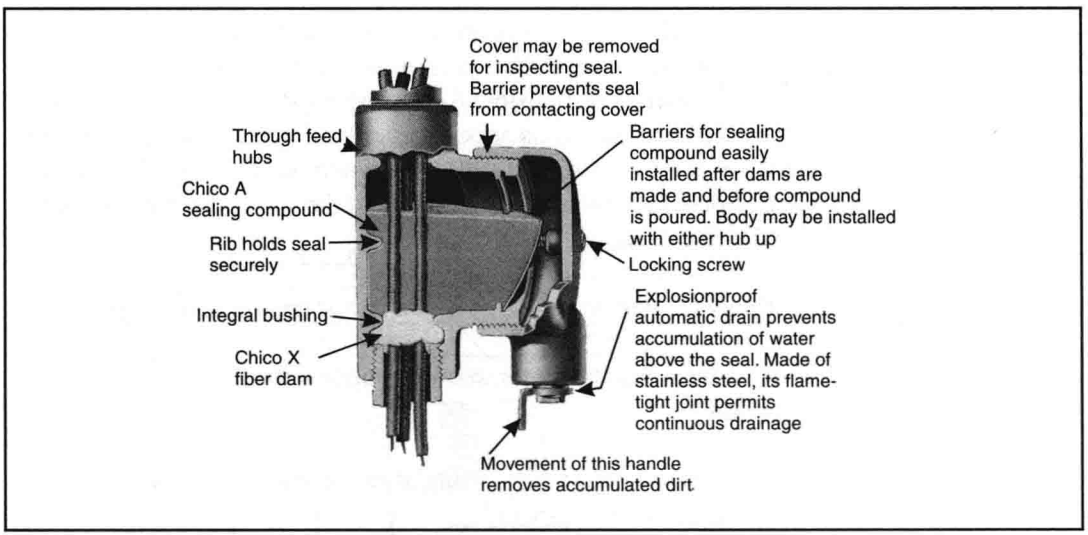

Figure 1-4: Cross-sectional view of a seal, used in wiring systems for some hazardous locations.

installed in a safe manner. Provisions must also be made to isolate the hazardous areas from those not considered hazardous.

Drawings from consulting engineers will vary in quality, and in most cases the wiring layout for a hazardous area is little different than the layout for a nonhazardous area. Usually the only distinction is a note on the drawing or in the specifications stating that the wiring in a given area or room shall conform to the *NEC* requirements for hazardous locations. Rarely do the working drawings contain much detail of the system, leaving much of the design to the workers on the job. Therefore, the electrical foreman must study these areas very carefully, and consult the *NEC* and other references, to determine exactly what is required.

Sometimes electrical contractors will have drafters prepare special drawings for use by their personnel in installing systems in such areas. If time permits, this is probably the best approach as it will save money plus much time in the field once the project has begun. In either case, whether preparing drawings or determining the requirements at the job site, considerable damage can be done to life and property if the system installed is faulty. Explosionproof boxes, fittings, and equipment are very expensive and vary in cost for different types, sizes, and hub entrances, and require considerably more labor than nonhazardous installations.

For other than very simple systems, it is advisable to make detailed wiring layouts of all wiring systems in hazardous locations, even if it is only in the form of sketches and rough notes.

The typical plant wiring system will entail the connection of a power supply to many motors of different sizes and types. Sometimes the electrical contractor will be responsible for furnishing these motors, but in most cases they will be handled on special order from the motor manufacturers and will be purchased directly by the owners or by special equipment suppliers. Some factors involved in planning the wiring for electric motors include the following:

1. The type, size, and voltage of the motor and related equipment.
2. Who furnishes the motor, starter, control stations, and disconnecting means?
3. Is the motor separately mounted or an integral part of a piece of machinery or equipment?
4. Type and size of junction box or connection chamber on the motor.
5. The extent of control wiring required.
6. The type of wiring method of the wiring system to which the motor is to be connected, that is, conduit and wire, bus duct, trolley duct. Is the motor located in a hazardous area? If so, what provisions have been made to ensure that it will be wired according to the *NEC*?
7. Who mounts the motor?
8. The physical shape and weight of the motor.

Obtaining all of the above information will facilitate the installation of all electric motors on the job by ensuring that proper materials will be available for the wiring and that no conflicts will arise between trades.

The installation of transformers and transformer vaults is another type of work that is frequently encountered in industrial wiring. A transformer vault, for example, is representative of the type of installation situation when, within a small area of the building and comprising a specialized section of the wiring system, a relatively small quantity of a number of different items of equipment and material is required. In many instances, even when working drawings and specifications are provided by consulting engineering firms, the vault will not be completely laid out to the extent that workers can perform the installation without further planning or

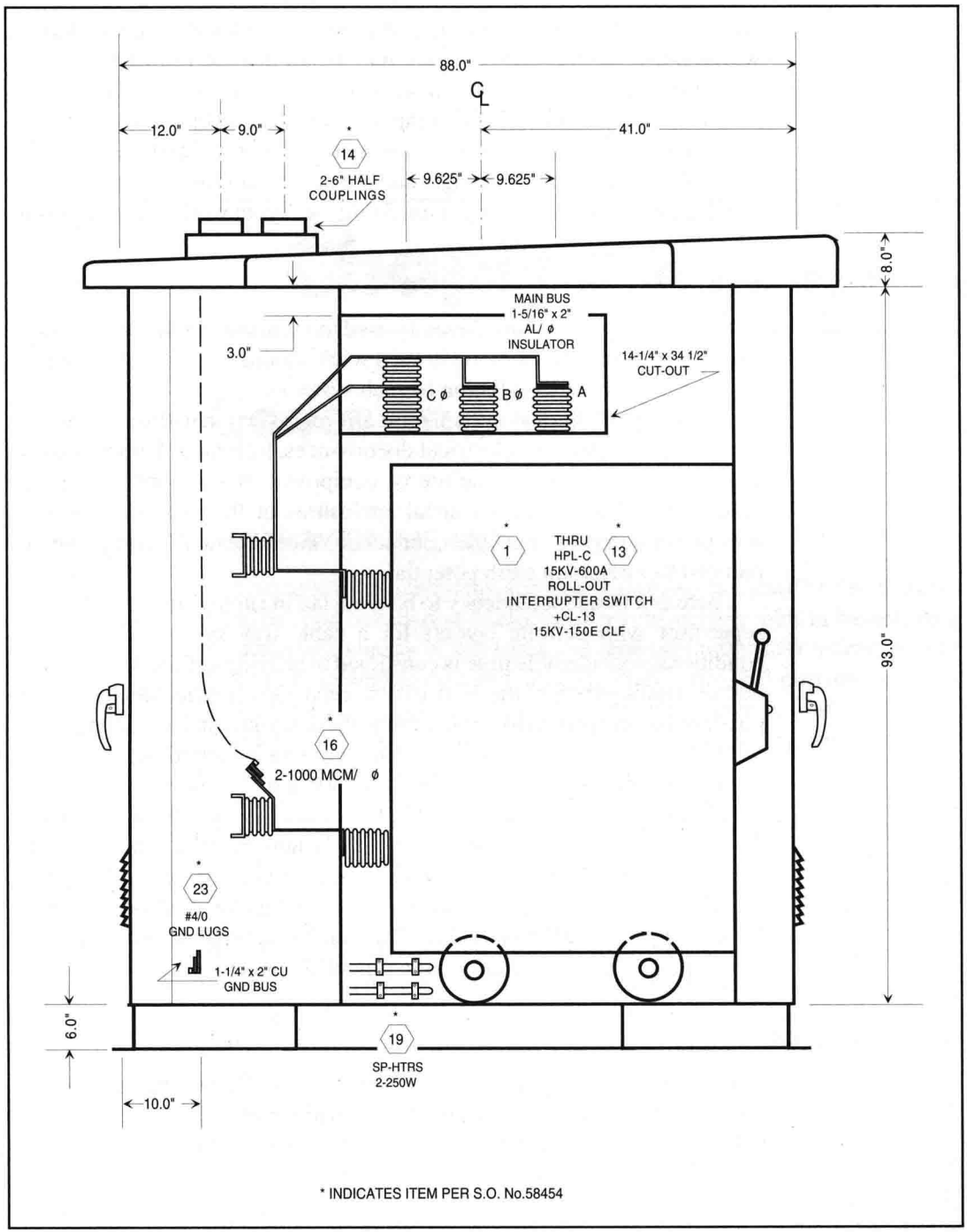

Figure 1-5: Shop drawings greatly facilitate the installation of special electrical equipment.

questions. The major transformers, disconnects, and similar devices along with a one-line schematic diagram may be all that the drawings show. In such instances, the supervisor or worker must make a rough layout of the primary and secondary, indicating the necessary supports, supporting structures, connections, controls and metering wiring, and the like. This calls for experienced knowledge, and the ability to visualize the complete installation on the part of the person doing the layout work and supervision.

Cable Tray Systems

Cable tray systems are frequently used in industrial applications, and all electrical technicians involved in such work should be thoroughly familiar with the design and installation of such systems.

In general, a cable tray system must afford protection to life and property against faults caused by electrical disturbances, lightning, failures that are a part of the system, and failure of equipment that is connected to the system. For this reason, all metal enclosures of the system, as well as noncurrent-carrying or neutral conductors, should be bonded together and reduced to a common earth potential.

There is a frequent tendency to become lax in supplying the installation supervisor with definite layouts for a cable tray system. Under these conditions, considerable time is consumed in arriving at final decisions and definite routings before the work can proceed. On the other hand, it is often possible for one person to predetermine these layouts and save many hours of field erection time, provided careful planning is carried out.

For economical erection and satisfactory installation, working out the details of supports and hangers for the system is the job of the system designer and should not be left to the judgment of a field force not acquainted with the loads and forces to be encountered. Also, all types of supports and hangers should permit vertical adjustment, along with horizontal adjustment where possible. This can be accomplished by the use of channel framing, beam clamps, and threaded hanger rods.

Other Systems

Other systems that are mainly used in industrial wiring applications include high-voltage substations, heavy-load generating plants, crane and hoist systems, ac and dc standby electrical systems, and enormous electrical motor installations.

Chapter 2

Codes and Standards

PURPOSE AND HISTORY OF THE NEC

Owing to the potential fire and explosion hazards caused by the improper handling and installation of electrical wiring, certain rules in the selection of materials, quality of workmanship, and precautions for safety must be followed. To standardize and simplify these rules and provide a reliable guide for electrical construction, the *National Electrical Code (NEC)* was developed. The *NEC*, originally prepared in 1897, is frequently revised to meet changing conditions, improved equipment and materials, and new fire hazards. It is a result of the best efforts of electrical engineers, manufacturers of electrical equipment, insurance underwriters, fire fighters, and other concerned experts throughout the country.

The *NEC* is now published by the National Fire Protection Association (NFPA), Batterymarch Park, Quincy, Massachusetts 02269. It contains specific rules and regulations intended to help in the practical safeguarding of persons and property from hazards arising from the use of electricity.

Although the *NEC* itself states, "This Code is not intended as a design specification nor an instruction manual for untrained persons," it does provide a sound basis for the study of electrical installation procedures — under the proper guidance. The probable reason for the *NEC*'s self-analysis is that the Code also states, "This Code contains provisions considered necessary for safety. Compliance therewith and proper maintenance will result in an installation essentially free from hazard, but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use."

The *NEC*, however, has become the bible of the electrical construction industry, and anyone involved in electrical work, in any capacity, should obtain an up-to-date copy, keep it handy at all times, and refer to it frequently.

NEC TERMINOLOGY

There are two basic types of rules in the *NEC*: mandatory rules and advisory rules. Here is how to recognize the two types of rules and how they relate to all types of electrical systems.

- Mandatory rules — All mandatory rules have the word *shall* in them. The word "shall" means *must*. If a rule is mandatory, you must comply with it.
- Advisory rules — All advisory rules have the word *should* in them. The word "should" in this case means *recommended but not necessarily required*. If a rule is advisory, compliance is discretionary.

Be alert to local amendments to the *NEC*. Local ordinances may amend the language of the *NEC*, changing it from *should* to *shall*. This means that you must do in that county or city what may only be recommended in some other area. The office that issues building permits will either sell you a copy of the code that's enforced in that area or tell you where the code is sold. In rare instances, the electrical inspector having jurisdiction may issue these regulations verbally.

There are a few other "landmarks" that you will encounter while looking through the *NEC*. These are summarized in Figure 2-1, and a brief explanation of each follows.

Explanatory material: Explanatory material in the form of Fine Print Notes is designated (FPN). Where these appear, the FPNs normally apply to the *NEC* Section or paragraph immediately preceding the FPN.

Change bar: A change bar in the margins indicates that a change in the *NEC* has been made since the last edition. When becoming familiar with each new edition of the *NEC*, always review these changes. There are also several illustrated publications on the market that point out changes in the *NEC* with detailed explanations of each. Such publications make excellent reference material.

Bullets: A filled-in circle called a "bullet" indicates that something has been deleted from the last edition of the *NEC*. Although not absolutely necessary, many electricians like to compare the previous *NEC* edition to the most recent one when these bullets are encountered, just to see what