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**DOE FUNDAMENTALS
ELECTRICAL SCIENCE
INTRODUCTION**



ABSTRACT

Electrical Science Fundamentals was developed to assist nuclear facility operating contractors provide operators, maintenance personnel, and the technical staff with the necessary fundamentals training to ensure a basic understanding of electrical theory, terminology, and application. The text includes information on alternating current (AC) and direct current (DC) theory, circuits, motors, and generators; AC power and reactive components; batteries; AC and DC voltage regulators; transformers; and electrical test instruments and measuring devices. This information will provide personnel with a foundation for understanding the basic operation of various types of DOE nuclear facility electrical equipment.

Key Words: Training Material, Magnetism, DC Theory, DC Circuits, Batteries, DC Generators, DC Motors, AC Theory, AC Power, AC Generators, Voltage Regulators, AC Motors, Transformers, Test Instruments, Electrical Distribution

FOREWORD

The *Department of Energy (DOE) Fundamentals* consist of ten academic subjects, which include Mathematics; Classical Physics; Thermodynamics, Heat Transfer, and Fluid Flow; Instrumentation and Control; Electrical Science; Material Science; Mechanical Science; Chemistry; Engineering Symbology, Prints, and Drawings; and Nuclear Physics and Reactor Theory. The texts are provided as an aid to DOE nuclear facility contractors.

These handbooks were first published as Reactor Operator Fundamentals Manuals in 1985 for use by DOE category A reactors. The subject areas, subject matter content, and level of detail of the Reactor Operator Fundamentals Manuals were determined from several sources. DOE Category A reactor training managers determined which materials should be included, and served as a primary reference in the initial development phase. Training guidelines from the commercial nuclear power industry, results of job and task analyses, and independent input from contractors and operations-oriented personnel were all considered and included to some degree in developing the text material and learning objectives.

DOE Fundamentals represent the needs of various DOE nuclear facilities' fundamental training requirements. To increase their applicability to nonreactor nuclear facilities, the Reactor Operator Fundamentals Manual learning objectives were distributed to the Nuclear Facility Training Coordination Program Steering Committee for review and comment. To update their reactor-specific content, DOE Category A reactor training managers also reviewed and commented on the content. On the basis of feedback from these sources, information that applied to two or more DOE nuclear facilities was considered generic and was included. The final draft of each of the handbooks was then reviewed by these two groups. This approach has resulted in revised modular handbooks that contain sufficient detail such that each facility may adjust the content to fit their specific needs.

Each book contains an abstract, a foreword, an overview, learning objectives, and text material, and is divided into modules so that content and order may be modified by individual DOE contractors to suit their specific training needs. Each subject area is supported by a separate examination bank with an answer key.

OVERVIEW

Electrical Science was prepared as an information resource for personnel who are responsible for the operation of the Department's nuclear facilities. A basic understanding of electricity and electrical systems is necessary for DOE nuclear facility operators, maintenance personnel, and the technical staff to safely operate and maintain the facility and facility support systems. The information in the text is presented to provide a foundation for applying engineering concepts to the job. This knowledge will help personnel more fully understand the impact that their actions may have on the safe and reliable operation of facility components and systems.

Electrical Science consists of fifteen modules. The following is a brief description of the information presented in each module of the handbook.

Module 1 - Basic Electrical Theory

This module describes basic electrical concepts and introduces electrical terminology.

Module 2 - Basic DC Theory

This module describes the basic concepts of direct current (DC) electrical circuits and discusses the associated terminology.

Module 3 - DC Circuits

This module introduces the rules associated with the reactive components of inductance and capacitance and how they affect DC circuits.

Module 4 - Batteries

This module introduces batteries and describes the types of cells used, circuit arrangements, and associated hazards.

Module 5 - DC Generators

This module describes the types of DC generators and their application in terms of voltage production and load characteristics.

Module 6 - DC Motors

This module describes the types of DC motors and includes discussions of speed control, applications, and load characteristics.

Module 7 - Basic AC Theory

This module describes the basic concepts of alternating current (AC) electrical circuits and discusses the associated terminology.

Module 8 - AC Reactive Components

This module describes inductance and capacitance and their effects on AC circuits.

Module 9 - AC Power

This module presents power calculations for single-phase and three-phase AC circuits and includes the power triangle concept.

Module 10 - AC Generators

This module describes the operating characteristics of AC generators and includes terminology, methods of voltage production, and methods of paralleling AC generation sources.

Module 11 - Voltage Regulators

This module describes the basic operation and application of voltage regulators.

Module 12 - AC Motors

This module explains the theory of operation of AC motors and discusses the various types of AC motors and their application.

Module 13 - Transformers

This module introduces transformer theory and includes the types of transformers, voltage/current relationships, and application.

Module 14 - Test Instruments and Measuring Devices

This module describes electrical measuring and test equipment and includes the parameters measured and the principles of operation of common instruments.

Module 15 - Electrical Distribution Systems

This module describes basic electrical distribution systems and includes characteristics of system design to ensure personnel and equipment safety.

The information contained in this handbook is by no means all encompassing. An attempt to present the entire subject of electrical science would be impractical. However, *Electrical Science* does present enough information to provide the reader with a fundamental knowledge level sufficient to understand the advanced theoretical concepts presented in other subject areas, and to better understand basic system and equipment operations.