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DOE FUNDAMENTALS

NUCLEAR PHYSICS AND REACTOR THEORY



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ABSTRACT

Nuclear Physics and Reactor Theory was developed to assist nuclear facility operating contractors in providing operators, maintenance personnel, and the technical staff with the necessary fundamentals training to ensure a basic understanding of nuclear physics and reactor theory. This document includes information on atomic and nuclear physics; neutron characteristics; reactor theory and nuclear parameters; and the theory of reactor operation. This information will provide personnel with a foundation for understanding the scientific principles that are associated with various DOE nuclear facility operations and maintenance.

Key Words: Training Material, Atomic Physics, The Chart of the Nuclides, Radioactivity, Radioactive Decay, Neutron Interaction, Fission, Reactor Theory, Neutron Characteristics, Neutron Life Cycle, Reactor Kinetics

OVERVIEW

Department of Energy Fundamentals: Nuclear Physics and Reactor Theory was prepared as an information resource for personnel who are responsible for the operation of the Department's nuclear facilities. Almost all processes that take place in a nuclear facility involve the transfer of some type of energy. A basic understanding of nuclear physics and reactor theory 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 this text is presented to provide a foundation for applying engineering concepts to the job. This knowledge will help personnel understand the impact that their actions may have on the safe and reliable operation of facility components and systems.

Nuclear Physics and Reactor Theory consists of four modules. The following is a brief description of the information presented in each module.

Module 1 - Atomic and Nuclear Physics

Introduces concepts of atomic physics including the atomic nature of matter, the chart of the nuclides, radioactivity and radioactive decay, neutron interactions and fission, and the interaction of radiation with matter.

Module 2 - Reactor Theory (Nuclear Parameters)

Provides information on reactor theory and neutron characteristics. Includes topics such as neutron sources, neutron flux, neutron cross sections, reaction rates, neutron moderation, and prompt and delayed neutrons.

Module 3 - Reactor Theory (Nuclear Parameters)

Explains the nuclear parameters associated with reactor theory. Topics include the neutron life cycle, reactivity and reactivity coefficients, neutron poisons, and control rods.

Module 4 - Reactor Theory (Reactor Operations)

Introduces the reactor operations aspect of reactor theory. Topics include subcritical multiplication, reactor kinetics, and reactor operation.

The information contained in this handbook is not all-encompassing. An attempt to present the entire subject of nuclear physics and reactor theory would be impractical. However, *Nuclear Physics and Reactor Theory* presents enough information to provide the reader with the fundamental knowledge necessary to understand the advanced theoretical concepts presented in other subject areas, and to understand basic system and equipment operation.