



Nuclear Power: Volume II - Nuclear Power Plants

An Online Continuing Education Course for Engineers

Course Number: R-4003

Credit: 4 Hours / 4 PDH / 4 CPD

Nuclear Power



Volume II

Nuclear Power Plants

Table of Contents

<u>Section</u>	<u>Page</u>
Preface	3
Introduction	4
Chapter 1. Types of Nuclear Reactors	5
Chapter 2. Pressure Water Reactors	11
Chapter 3. Boiling Water Reactors	21
Chapter 4. Pressurized Heavy Water Reactor	30
Chapter 5. High Power Channel Reactor	35
Chapter 6. Gas Cooled Reactor	42
Chapter 7. Fast Breeder Reactor	45
Summary	50

Cover photograph: Courtesy U.S. Nuclear Regulatory Commission (NRC).

Preface

This is the second in a series of three courses about the nuclear power industry. The series covers the nuclear industry from the physics of nuclear reactions to the types of plants in operation today as well as the potential of the next generation of nuclear power plants that are likely to appear in the first half of the 21st century.

The complete series includes three courses:

1. Volume I – The Nuclear Power Industry
2. Volume II – Nuclear Power Plants
3. Volume III – The Future of Nuclear Power

The first course, *Volume I – The Nuclear Power Industry*, gives a broad overview of the nuclear power industry. This course goes into the details of nuclear reactions and the physics of nuclear power. The prime fuel source, uranium, is covered too.

The second course, *Volume II – Nuclear Power Plants*, reviews the classifications of nuclear power plants and the basic components of a nuclear power plant. The course covers the design and operation of the current generation of nuclear power plants in operation today.

The third course, *Volume III – The Future of Nuclear Power*, gives an overview of the types of plants that are being considered for the next generation of power plants. Some of the designs covered are already operating in experimental stages, some are modifications of current designs, and others are radical new concepts that have not been commercially validated.

It is not necessary to take the courses in sequence. However, for the best comprehensive it is suggested that the courses be taken in the order presented.

Introduction

The world demand for electricity continues to grow. The current electrical energy consumption for the entire planet is approximately 1,517 gigawatts (GW) of continuous power.

Approximately 16% of this electric demand is served from 439 nuclear power plants with a capacity of 371 GW. The United States produces the most nuclear energy, with nuclear power providing 19% of the electricity it consumes, while France produces the highest percentage of its electrical energy from nuclear reactors—77% as of 2006. It is quite possible to utilize nuclear power to provide the vast majority of an entire country's need for electricity.

From a *capacity* standpoint, nuclear is only about 10% of the total electrical generation in the U.S. From a consumption – or *energy* - standpoint, nuclear power is responsible for approximately 19% of the electrical energy in the United States. The total generation is approximately 3,800 thousand GWH. For comparison purposes, nuclear generation accounts for the following of the total electrical production in some other countries: 77% in France, 46% in Sweden, 43% in Ukraine, 39% in South Korea, 30% in Germany, and 30% in Japan. There are currently 104 licensed commercial nuclear power plants in the United States.

Unlike the coal and oil plants that supply most of the electrical power in the United States, a nuclear power plant, like the one shown on the right, releases virtually no pollution or greenhouse gases into the Earth's atmosphere, and therefore doesn't contribute to global warming. Although nuclear power plants generate long-lived nuclear waste, this waste arguably poses much less of a threat to the biosphere than greenhouse gases would.



Photo Credit: Nuclear Regulatory Commission

This course is the second in a series about the use of nuclear energy to generate electricity. Volume I in this series included an overview of the nuclear industry and covered the basics of nuclear physics and uranium as a fuel source. While it is not necessary to read Volume I first, it will help understand the concepts and terms presented in Volume II.

Volume II delves into the specific types of nuclear reactors in use around the world today. We will begin with a broad overview of the different types of reactors and how they are classified. Then we will look at each type of nuclear reactor that is currently in commercial operation.

Chapter 1

Types of Nuclear Reactors

A nuclear reactor is a device to initiate, control, and sustain a nuclear chain reaction. This is accomplished by using heat from the nuclear reaction to power steam turbines. In a nuclear reaction, the energy released from continuous fission of the atoms in the fuel as heat is used to make steam. The steam is used to drive the turbines which produce electricity, which is clean and virtually free of greenhouse gas emissions.

In this chapter we will look at the components of a nuclear reactor, how nuclear reactors are used to generate electricity, and an overview of the different types of nuclear reactors.

Using a common design, a reactor core is housed in long thin tubes that are put together and immediately cooled. The tubes emit neutrons and heat. The water becomes steam in a steam generator. The water in the steam generator prevents them from overheating. The water also slows down the uranium tubes. The process just described is the basic principle of a nuclear reactor. Other reactors use different fuels, but all work on the same basic principle.

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Reactor Fuel Assembly Photo Credit: NRC

Components

The following is an overview of the major components of a nuclear power plant.

1. Fuel

The fuel is used to generate heat. The reactor core generates heat in a number of ways including: The kinetic energy of fission products which is converted to thermal energy when these nuclei collide with nearby atoms, gamma rays produced during fission being absorbed by the reactor causing their energy to be converted into heat, and heat produced by the radioactive decay of fission products and materials that have been activated by neutron absorption.