

General Electric Systems Technology Manual

Chapter 1.1

Commercial Nuclear Power Plants

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1.1 COMMERCIAL NUCLEAR POWER PLANTS

1.1.1 Introduction

To understand the BWR power plant, a basic knowledge of the major components and their functions is needed.

1.1.2 Nuclear Power Plants

A nuclear power plant is an arrangement of components and systems used to generate heat. The heat is used to make steam which is converted to electrical power. The principal components of a nuclear power plant are the:

- nuclear fuel and moderator,
- heat removal system,
- control systems, and
- power conversion systems.

1.1.3 Nuclear Fuel and Moderator

Nuclear fuel consists of a mixture of fissile, fissionable, and fertile materials. The essential ingredient is a fissile material, which readily undergoes nuclear fission when struck by neutrons. The only naturally available fissile material is Uranium-235 (U^{235}), an isotope of uranium which is less than 1% of all the Uranium found in nature. There are two synthetic fissile materials, Plutonium-239 (Pu^{239}) and Uranium-233 (U^{233}). When high energy neutrons strike Uranium-238 (U^{238}) fission can possibly occur, hence U^{238} is fissionable. If the neutrons are not of high enough energy then they will most likely be absorbed. This absorption leads to the formation of Pu^{239} . For this reason U^{238} is called a "fertile" material. An isotope of thorium (Th^{232}) is also a fertile material, forming U^{233} after neutron absorption.

The three basic fissile materials may be used separately or with one of the fertile materials as fuel for a nuclear reactor.

The most commonly used fuel is uranium, either natural, or enriched in the U^{235} isotope.

Fuels may be solid or fluid and they may be used in different material forms: metals, alloys, oxides, or salts. A variety of solid fuel physical shapes is used, including rods, plates, tubes, and other shapes, along with various methods for containing (cladding) the fuel.

A moderator is a substance used in a reactor to slow down neutrons from high to low energy levels. Slowing down the neutrons increases the probability of continued fission. Moderators commonly used include ordinary water, heavy water, and graphite. Water moderators can also serve as the coolant.

1.1.4 Heat Removal System

The heat removal system or cycle removes heat which is generated by the fission process in the reactor core. Heat removal system arrangements include single, double, and triple heat transfer cycles. An example of the single cycle system is the direct cycle boiling water reactor delivering steam to a turbine. Pressurized water reactors use two cycles, with the primary water transferring heat in a steam generator to produce steam for the turbine cycle.

1.1.5 Control Systems

In the general sense of the term, there are numerous control systems on modern reactors. The specific control system of concern here is reactivity control, which is the method by which the reactor core fission process is regulated. The basic method of accomplishing this regulation is to insert a neutron poisoning or absorbing material into the reactor core, thereby preventing those neutrons absorbed in the poison from causing fission in the fuel. There are other methods, some of which are specific to the BWR, which are discussed later in this text.

1.1.6 Power Conversion Systems

In modern reactor power plants, steam turbine generators are used to convert the energy of the steam into electrical power.