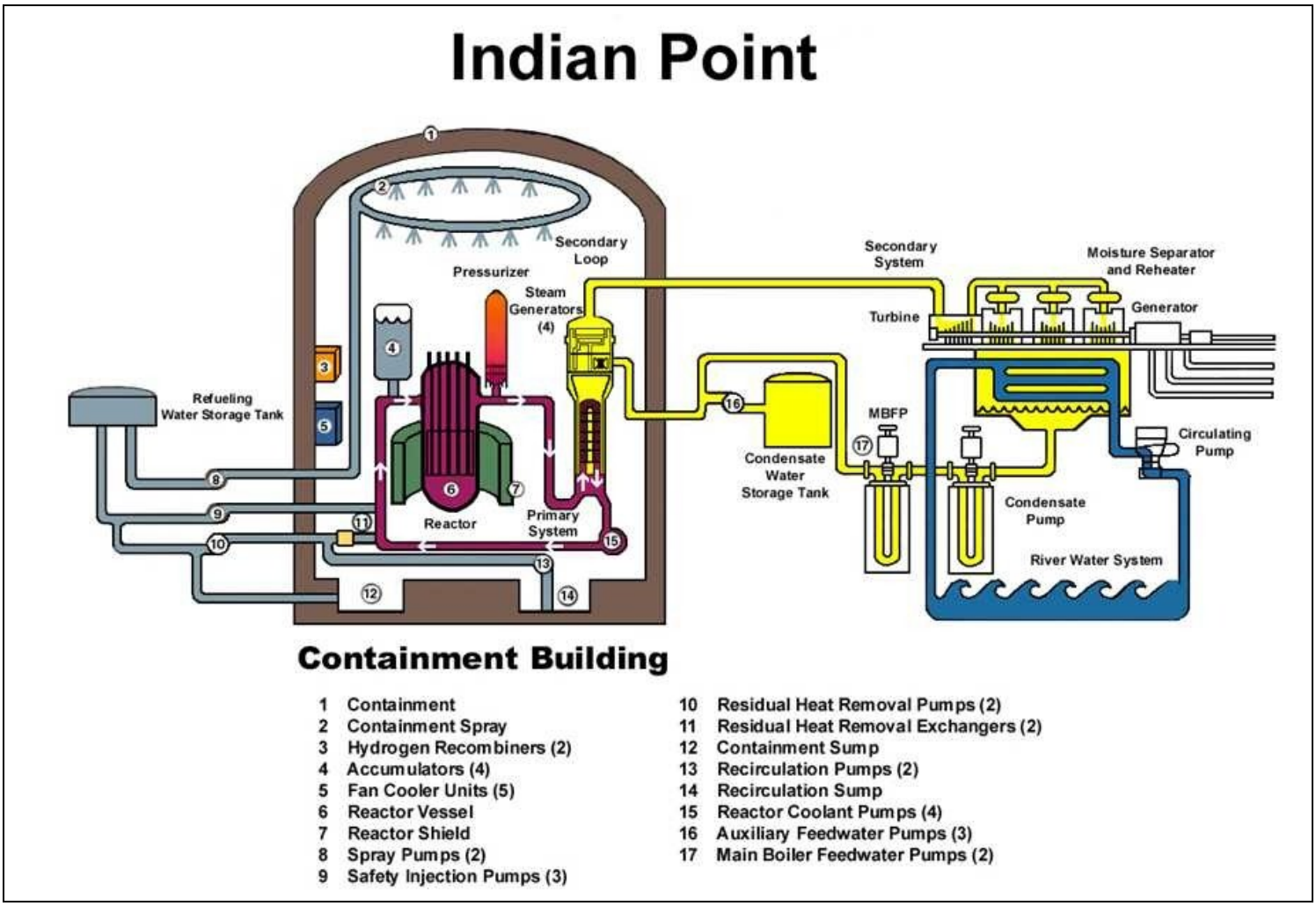
Basic Reactor Operation and Safety Systems



The design of the Indian Point reactors are pressurized water reactors. Heat generated by the fission process within the reactor- fuel core produces steam in a second water system in four steam generators which then turns the turbine, spins the generator, and produces electricity. The design includes three independent water cooling loops and five independent barriers to confine radioactive materials given off by the reactor fuel as it heats the water.

Five Independent Barriers

The Indian Point plants have five independent barriers to confine radioactive materials given off by the reactor fuel as it heats the water. Virtually all radioactivity is contained within the first two barriers.

The ceramic uranium fuel pellets provide the first barrier. Most of the fission products are either trapped or chemically bound in the fuel, where they remain. However, a few fission products that are volatile or gaseous at normal operating temperature are not held in the fuel.

The second barrier consists of zirconium alloy tubes that resist corrosion and high temperatures. The fuel pellets are contained within these tubes. There is a small gap between the fuel and the cladding in which the noble gases and other volatile radionuclides collect.

The primary coolant water system is the third barrier. Many of the fission products, including radioactive iodine, strontium and cesium are soluble and are retained in water in an ionic (electrically charged) form. These materials are removed in the purification system of the reactor. However, krypton and xenon do not readily dissolve in the coolant, particularly at high temperatures. Radioactive Krypton and Xenon collect as a gas above the coolant when the reactor coolant system water is depressurized.

The fourth barrier consists of the reactor pressure vessel and the steel piping of the primary coolant system. The reactor pressure vessel is a 44 foot high tank with steel walls about nine inches thick. It encases the reactor. The remainder of the primary coolant system includes the pressurizer, steam generators and associated piping. This system contains the radioactivity in the primary coolant.

The reactor building (or containment building) provides the fifth barrier. It has steel-lined, thick steel-reinforced concrete walls that enclose the reactor pressure vessel and the primary coolant system and a vast vacant space to absorb extreme pressures from within.

Three Independent Cooling Water Loops

The Indian Point reactors have three separate cooling water loops:

Primary System: Uranium oxide fuel— a ceramic material— is arranged in bundles, which form the reactor core. The uranium atoms split, or fission, inside the reactor releasing heat energy. Heat from the fission process is absorbed by water under high pressure in the reactor (primary system - reactor coolant) that flows from the reactor through tubes (13,040 tubes) in four steam generators and then is pumped back to the reactor to repeat the process. The pressure in the primary system prevents the water from boiling and converting to steam.

Secondary System: Water in the secondary system flows around the tubes in the steam generator where the heat is transferred from the primary system. The water in the secondary system is under less pressure than the primary system and will boil, turning to steam, which is then directed to the turbine generator to produce electricity. Steam from the turbine, collects in a condenser where it is cooled and becomes water. The secondary water is pumped back into the steam generators to be boiled again. The two water

systems are designed to remain separate, so that water in the secondary side does not mix with the water in the primary system.

Tertiary System: Water from the Hudson River cools the water in the condenser and is returned to the river. All three cooling systems are each completely separate.

Nuclear Plant Safety: Defense in Depth

Nuclear power plants are built with "defense-in-depth" safety design and construction. Numerous safety systems are incorporated into the design of the Indian Point nuclear power plants. The protection of public health and the environment is an integral part of the operation of the power plants. The systems are designed to minimize the chances, or reduce the consequences, of any event. These safety systems include:

- Diverse sources of cooling water to the reactor to prevent the fuel from overheating under normal and emergency conditions;
- A leak-tight, steel lined, steel reinforced massive concrete containment building for each reactor;
- Back up electric power supplies to operate all key components.
- The structure containing the reactor- called the containment building- is made of approximately 4-foot thick, steel-reinforce concrete. The reactor itself is housed in a massive steel vessel approximately 9 inches thick and weighing more than 300 tons.
- Redundant safety systems are designed to maintain reactor safety at all times. This redundancy ensures that every measure taken to keep a plant safe can be done in two or more ways.
- Federally licensed operators ensure safe plant operation. These highly trained professionals must requalify for their licenses every two years. NRC regulations also require operators to participate in emergency preparedness drills and exercises.