PWR pressurized light water reactors

The vast majority of reactors in operation and almost all reactors under construction at the end of 2015 use ordinary water as heat transfer medium (the fluid that extracts heat from the reactor). This family of reactors includes two systems: Boiling Water Reactors, BWRs, in which the steam produced in the core is sent directly to the turbine, and Pressurized Water Reactors, PWRs, by far the most widespread and which we will describe (Figure A).

The 58 reactors that EDF operates in France are all of the PWR type. Initially, this type of reactor was designed to propel the submarines of the American fleet because their large compactness made it possible to accommodate them inside the hull. It was only in the second phase that this submarine boiler was extrapolated to a power plant: the first PWR was commissioned in Shippingport, Pennsylvania in 1957.

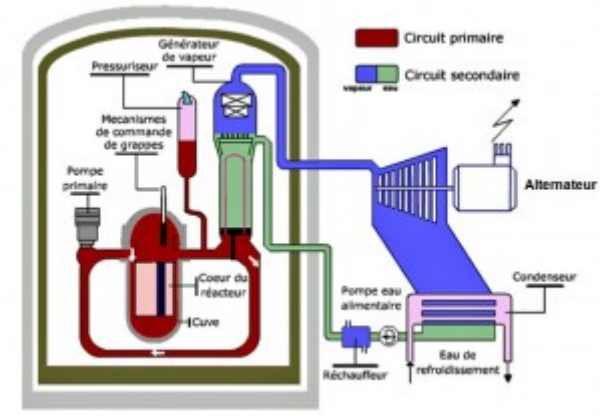

Figure 1. Diagram of a PWR reactor [Source: AREVA]

The PWR is an **indirect cycle** reactor. The core heats the ordinary water, maintained in a liquid state under high pressure (150 atmospheres) in a thick steel **primary circuit** (see Figure). It is this same water whose hydrogen nuclei ensure the **moderation** (slowing down) of neutrons. Water flows vertically and from bottom to top through the heart. At nominal power, the water enters at 290°C and exits at 315°C. The entire primary circuit is sealed and closed on itself inside the reactor. It transmits its heat to a **secondary circuit** in **steam generators**.

The primary circuit consists of a cylindrical **tank** with a thick steel spherical bottom coated with stainless steel that contains the core and a number of internal equipment. This tank is closed by a **cover** on which are mounted the mechanisms that ensure the rise and fall of the **control clusters** (which regulate the nuclear reaction by absorbing neutrons). The tank and lid are made of thick steel with an inner layer of stainless steel.

A certain number (from 2 to 4) of **primary loops** are connected to the tank**.** Each loop is equipped with a **primary pump** that circulates the primary water, a **steam generator**, and pipes connecting these components to the tank. The primary pump, driven by a motor with several MW of power, is equipped with a heavy flywheel.

A **pressurizer** is connected to the hot branch of one of the loops of the primary circuit**,** a large steel tank in which a steam bubble maintains the primary pressure at the desired level. Electric heating rods allow the pressure to rise, and a sprinkler system, similar to a shower, to lower it.

The steam generator is a large, almost cylindrical, thick steel container, placed vertically on supports. Its lower part consists of a water box divided into two compartments by a vertical wall and surmounted by a very thick plate pierced with vertical holes, the **tubular plate.** This plate is traversed by a **tube bundle** composed of several thousand U-shaped tubes connecting the two compartments of the water box. This beam is bathed by water from the secondary circuit inside the steam generator envelope.

At the outlet of the core, water from a primary loop enters the hot compartment of a steam generator's water box and flows through the tube bundle, from where it exits into the "cold" compartment of the water box to be pumped back to the tank.

Through the exchange surface of the tubes of the bundle, the primary water transfers its calories to the water of **the secondary circuit**, which it boils under a pressure of 70 atmospheres. At the beam outlet, the steam is freed of its water droplets by passing through separators and dryers before leaving the top of the steam generator through a steam pipe that leads it to the engine room at the inlet of the high-pressure turbine casing. The secondary water that remains in the liquid phase is recirculated in an annular space against the outer shell of the generator.

After expanding in the turbine bodies and condensing in the condenser, the secondary water is returned by secondary pumps to the steam generators. There are as many secondary loops as there are primary loops, and the secondary circuit is also sealed and closed on itself.
