4.3.2 Pressurized water reactors (PWRs)

The majority of light water reactors (LWRs) in operation in the world are known as *pressurized water reactors* (PWRs) because water is used to remove the heat from the core and because the primary coolant loop is pressurized in order to suppress boiling. In 2013 there were about 270 of these in commercial operation worldwide. An acceptably large thermodynamic efficiency is only achieved by having a primary cooling system that operates at a high maximum temperature, and these high temperatures would result in boiling unless that primary coolant loop were pressurized. The alternative would be to allow boiling and to remove most of the heat from the core in the form of latent heat; that alternative strategy is followed in the other major design, namely the boiling water reactors (or BWRs) that are covered in the section that follows.

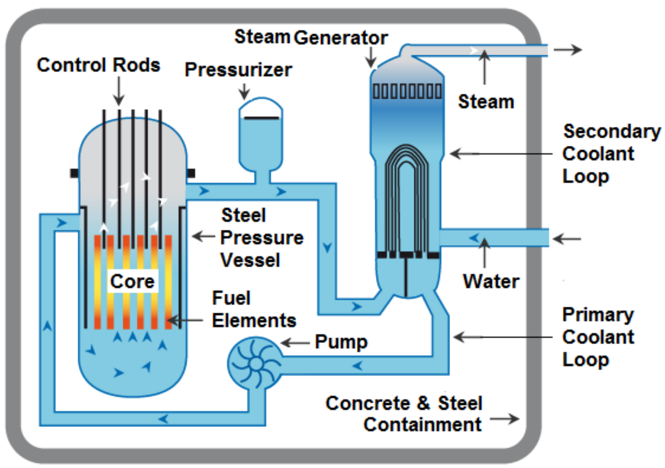

Figure 1: Schematic of a typical PWR. Adapted from WNA (2015b).

A schematic of the typical PWR is illustrated in figure 1 and includes a reactor vessel such as that cross-sectioned in figure 3 equipped with a primary coolant system like that of figure 4. All of this and more is contained in a containment building such as that shown in figure 2 and described later in section 7.5.1 (see also USNRC 1975). The primary coolant inlet and outlet temperatures (from the reactor vessel) are about $300°C$ and $330°C$ respectively but with the high specific heat of water this modest temperature difference is adequate to transport the heat at reasonable water flow rates of the order of $65 \times 10^6\ kg/hr$. However to avoid boiling at these temperatures the pressure in the primary coolant loop is 155 atm; this is maintained by pressurizers (see figure 4) contained within the containment structure (figure 2). The high pressure makes for a compact reactor with a high power density. However, the high pressure is also a liability in an accident scenario and therefore this primary coolant loop is secured inside a heavy and strong containment building. A secondary

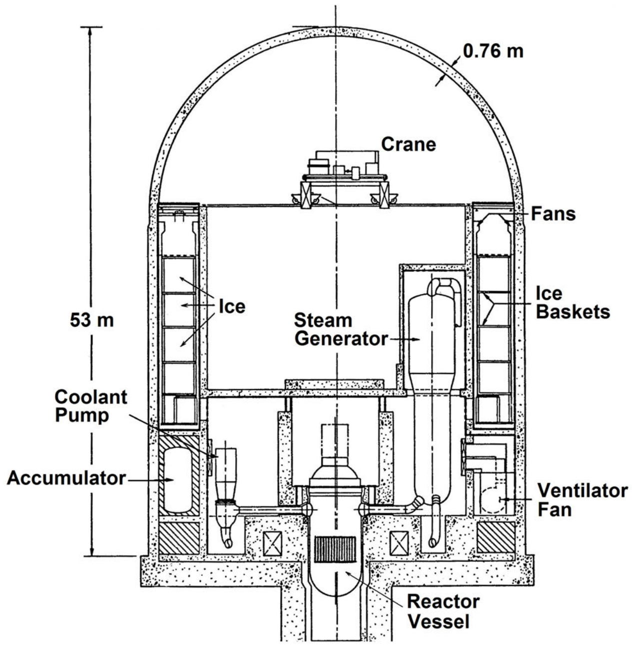

Figure 2: Typical PWR primary coolant loop and containment system. Adapted from USAEC (1973).

coolant loop that operates at much lower pressure and is less susceptible to radioactive contamination communicates thermally with the primary loop in a heat exchanger and steam generator (figures 4 and 2) within the containment building. The steam thus generated moves the heat outside of that building and is used to drive the steam turbines and electrical generators.

While this double coolant loop system involves some thermal inefficiency and some added equipment it has the advantage of confining the high pressure coolant water (and the radioactivity it contains) within the containment building. The building also houses extensive safety equipment that is described later in section 7.4.

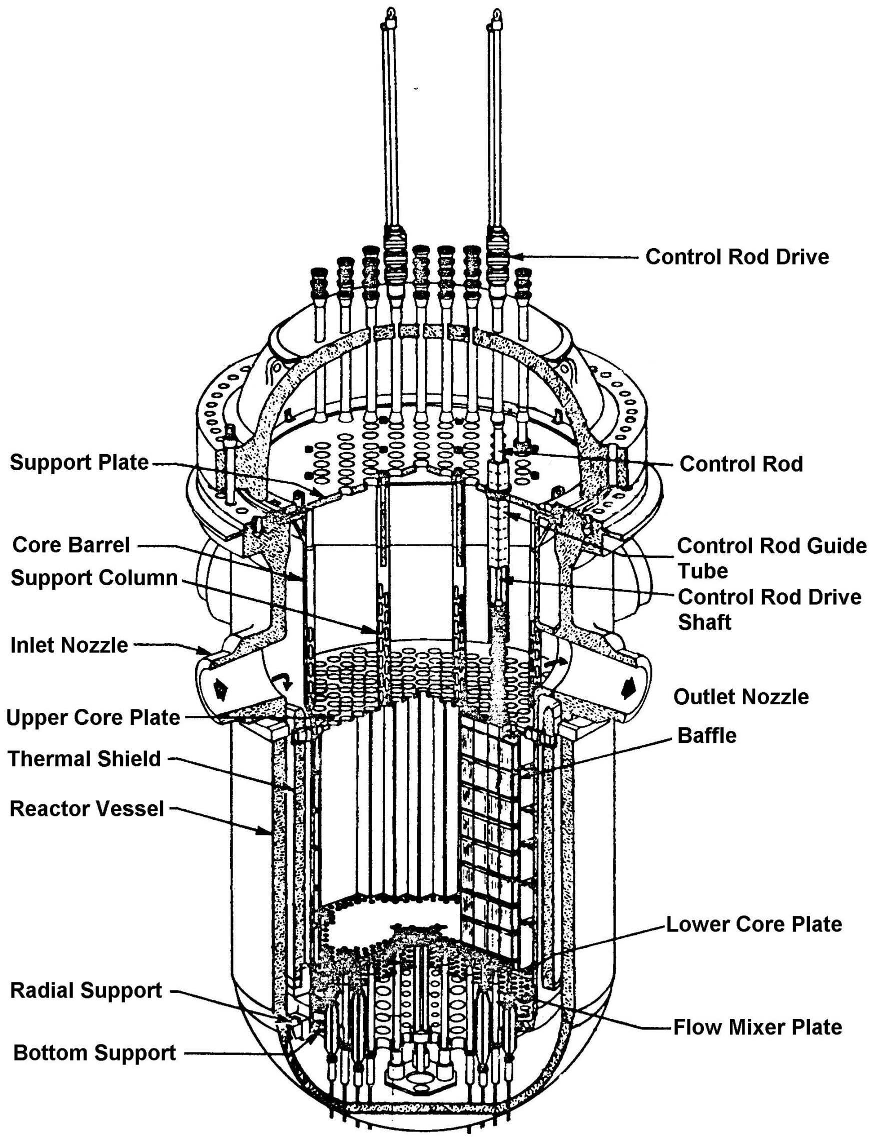

Figure 3: Internals of a typical PWR reactor vessel. Adapted from USAEC (1973).

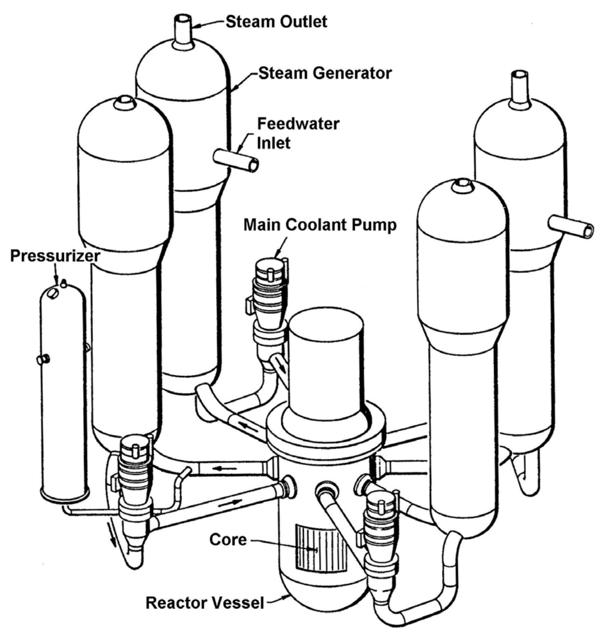

Figure 4: PWR coolant system. Adapted from USAEC (1973).