More

Safety Issues of Fission Reactors

There has been heated debate concerning the safety of fission reactors, beginning with the Windscale accident in Great Britain in 1957, but particularly since the disastrous accident at Chernobyl in Ukraine (then U.S.S.R.) in 1986 and the less serious accident at the Three Mile Island generating station in the United States in 1979. A common concern is that a reactor might blow up as a uranium bomb, although that is virtually impossible. Even in light-water reactors, the enriched uranium contains only 1 to 4 percent ^{235}U, whereas a uranium bomb typically requires uranium enriched to 90 percent ^{235}U. Another concern is *meltdown*, the melting of the fuel core because of the heat produced by the radioactive decay of the fission fragments that occurs even after the reactor is shut down. If the cooling system fails, even though the loss of the coolant/moderator in light-water reactors halts fission, it is possible that the core would melt and, in a worst-case scenario, melt its way through the floor of the containment building into the ground. Meltdown did not occur at Chernobyl; however, about 40 percent of the core melted at Three Mile Island, and a partial meltdown occurred at the Enrico Fermi reactor near Detroit in 1966. In neither case was the reactor containment breached.

A more serious problem is that radioactive material may be released into the atmosphere, as did occur at Chernobyl. The reactor at Chernobyl was a graphite-moderated reactor designed to produce plutonium for weapons as well as electrical power. At the time of the accident, it was running at low power but with the separate cooling system partially disabled. The heat developed by the continuing fission was sufficient to ignite the graphite, which in turn ignited the uranium fuel itself. There are no comparable dual-purpose reactors outside Ukraine and Russia that are op-

Densities of deposition of cesium-137, a fission product, after the 1986 accident in unit 4 at the Chernobyl nuclear power station sent radioactive fallout across the countryside. Regions shaded black have densities over 40 Ci/km^2; dark gray regions, 15 to 40 Ci/km^2; light gray regions, 5 to 15 Ci/km^2; and white regions, 1 to 5 Ci/km^2. Circle indicates evacuation zone around the reactor.

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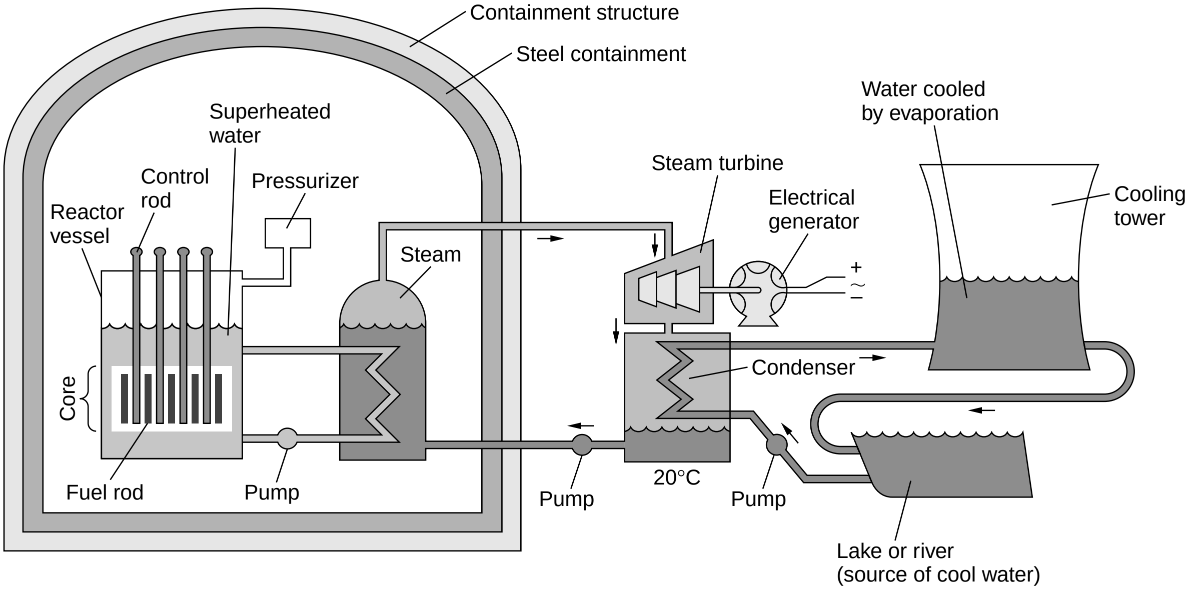

Fig. 12-16 Simplified drawing of a pressurized-water reactor (PWR). The water in contact with the reactor core serves as both the moderator and the heat-transfer material. It is isolated from the water used to produce the steam that drives the turbines. Many features, such as the backup cooling mechanisms, are not shown here. A second type of power reactor, not shown here, is the boiling-water reactor (BWR). In this system steam produced from boiling water in the core is circulated directly to the turbine without using the isolation loop.

erated in this way. A similar accident with water-cooled and -moderated reactors is probably not possible. Furthermore, a common safety feature, not used at Chernobyl, is a containment building with walls of concrete and steel at least 1 m thick. (See Figure 12-16.)

With any type of fission reactor, there is the problem of storage of the long-lived radioactive waste products produced. Despite the fact that elaborate storage methods are used, their long-term efficacy is always open to question. Nuclear fuel reprocessing raises a number of additional safety questions. Among these are the proper means for safe, long-term (thousands of years) storage of high-level wastes from the process; the potential for clandestine diversion of reprocessed fuel, particularly ^{239}Pu, to weapons use; and the release of airborne radioisotopes from reprocessing facilities. Widely accepted solutions to many of these questions are not yet in hand.