2.2.3 The post-reactor stages

Upon removal from a reactor, the fuel in the fuel rods is highly radioactive and is still producing decay heat as described in section 2.4.2. At the time of shutdown of the reactor the decay heat is about 6.5% of the full power level. This declines rapidly falling to about 1.5% after an hour, 0.4% after a day and 0.2% after a week. Spent fuel rods are therefore normally stored in isolated water pools near the generation site for several months not only to keep them cool but also to allow for the radioactive elements with short half-lives to decay substantially before further processing. The water absorbs the decay heat and prevents overheating of the fuel rods. They can be transferred to dry storage after about 5 years.

At the present time there are two subsequent strategies. The fuel may be reprocessed in order to recycle the useful remnants or it may remain in long term storage to await re-evaluation of its potential use or disposal in the future. Reprocessing involves separating the uranium and plutonium from the waste products by chopping up the fuel rods (cladding and all) and dissolving them in acid to separate their components (see, for example, Nero 1979). This enables the uranium and plutonium to be reused in fuel while the remaining 3% of radioactive waste is disposed of as described below. The recovered uranium is usually a little richer in ^{235}U than in nature and is reused after enrichment. The plutonium can be combined with uranium to make so-called *mixed oxide* (MOX) fuel that can be used as a substitute for enriched uranium in mixed oxide reactors.

All the waste from the nuclear cycle and fuel processing is classified according to the radiation it emits as either low-level, intermediate level or high-level waste. The high-level waste from reprocessing is reduced to powder and entombed in glass (*vitrified*) to immobilize it. The molten glass is poured into steel containers ready for long term storage. One year of high-level waste from a 1000 MW reactor produces about 5000 kg of such high-level waste. Currently there are no disposal facilities for used fuel or reprocessing waste. These are deposited in storage to await future use or treatment or for the creation of more permanent disposal facilities. The small mass of the material involved makes this wait not only feasible but wise.

Parenthetically, we note that the end of the Cold War created a new source of nuclear fuel from the Russian stockpiles of highly-enriched weapons-grade uranium. Under a US-Russian agreement, this has been diluted for use in nuclear power plants and, since then, has provided fully half of the nuclear fuel used in the USA for the generation of electricity.