2.6.2 Reactor shielding

Clearly the nuclear reactor surroundings must be shielded from the intense radiation emerging from the reactor core. Man and his natural surroundings must obviously be protected from damage, but, in addition, the material of the plant must be shielded in order to minimize both heat damage and undesirable changes in the properties of the material such as embrittlement (see, for example, Foster and Wright 1977). Moreover, shielding is not only necessary for the core and the equipment enclosed in the primary reactor vessel but also for other components of the primary coolant loop such as the pumps and heat exchangers.

In a water-cooled reactor the first level of protection is the primary cooling water surrounding the core; this water slows down the fast neutrons and provides attenuation of the gamma radiation. To supplement this many reactor cores (including PWR cores) are surrounded by a *thermal shield*, a $3-7$ *cm* thick steel (usually stainless steel) barrel that reduces the neutron and gamma radiation impacting the inside surface of the primary pressure vessel. Incoming cooling water usually flows up the outside of the thermal shield and then down the inside before turning to flow up through the core. The steel walls of the primary pressure vessel, more than 20 *cm* thick, provide yet another layer of protection against the neutron and gamma radiation so that inside the concrete secondary containment structure the radiation levels are very low. That thick, reinforced concrete building ensures that the levels of radiation outside are normally very low indeed. To quantify the attenuation provided by each of these barriers, one needs to know the attenuation distances for each of the materials used and each of the proton energies. Typical data of this kind is shown in figure 1.

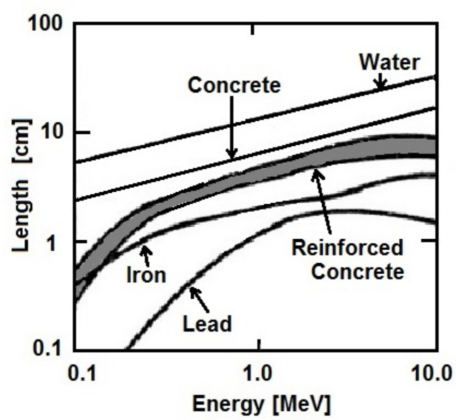

Figure 1: Typical distances required for a tenfold decrease in gamma radiation in various shielding materials as a function of the energy. Adapted from Harrison (1958).

Note also that the primary coolant water flowing through the core of a reactor carries some radioactivity out of the primary containment vessel mainly because of the radioactive nuclides, ^{16}N and ^{19}O, formed when water is irradiated. These isotopes, ^{16}N and ^{19}O, have half-lives of only 7 *sec* and 29 *sec* respectively though they produce gamma radiation during decay (Gregg King 1964). Thus, for example, access to secondary containment structures is restricted during reactor operation.