General Electric Systems Technology Manual

Chapter 1.2

Water Cooled Reactors

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1.2 WATER COOLED REACTORS

Water is generally used as both a coolant and a moderator for power reactors. Initially it was believed that water could not be permitted to boil in a reactor vessel because of the possibility of cladding burnout. This resulted in the early development of pressurized water reactors. The first pressurized water reactor went critical in 1953 at the AEC National Reactor Testing Station in Idaho.

A different type of water-cooled and water-moderated reactor was started in 1953 with the first experiment to test the theory of boiling water in a reactor vessel and making steam directly. Successive experiments established the principle that boiling was not only acceptable but even advantageous for certain purposes.

It is only natural that water became the preferred primary reactor coolant. Reliability is a key factor and water has many important advantages that do not require extensive experimental programs. Water is a known quantity. It is cheap, and it was readily available when the reactor program was started. It has good heat transfer characteristics which can be extended beyond its normal narrow temperature range by pressurizing the water to inhibit boiling. Furthermore, water does not become significantly activated if kept pure. The induced radioactivity of the coolant is short lived so that maintenance is not hampered greatly.

The corrosive quality of water is known, and the pressurizing intensifies the corrosive action. An important inducement is that water serves as moderator to slow down the neutrons. Its tendency to absorb neutrons can be overcome by enriching the fuel.

The disadvantages of using water as a moderator are: water must be highly pressurized to achieve reasonably high temperatures; pure hot water is highly corrosive and requires that the primary coolant system be constructed of special materials; water at high pressure and saturation temperature will flash to steam if the pressure is rapidly reduced, as in a rupture of the primary loop; and water can chemically react violently under certain temperature conditions with uranium, thorium, and structural materials.

The fundamental similarity in nuclear characteristics of water-moderated reactors is determined basically by the nuclear and thermal properties of light water. Briefly, these similarities can be summarized as follows:

Enriched fuel is required
Relatively low moderator-to-fuel ratios are employed
Relatively high excess reactivity is provided
Conversion ratios for existing types are low, but this is not an inherent characteristic
Power densities are comparatively high