How Nuclear Plants Work

Reactor forms and materials

Currently, two types of commercial reactors are widely used in this country: the boiling water reactor (BWR) and the pressurized water reactor (PWR).

Both are called light water reactors (LWRs) because their coolant or medium to transfer heat is ordinary water, incorporating the light isotope of hydrogen.

BWRs and PWRs use essentially the same fuel and operate on basically the same principles.

The fuel is an oxide containing two kinds, or isotopes, of uranium atoms, designated by their differing weights. U-235 is the fissionable isotope, which constitutes less than one per cent of natural uranium. U-238 is practically non-fissionable but makes up all the rest of the element as it is found in nature.

The uranium in the fuel has passed through an enriching process that increases the concentration of U-235 to three or four per cent. This allows the reactor to be smaller than it would be if fueled with natural uranium and allows ordinary water to be used for cooling instead of a more expensive and less convenient fluid.

But the concentration of U-235 is still so low that a bomb-like nuclear explosion is impossible.

Safety built in

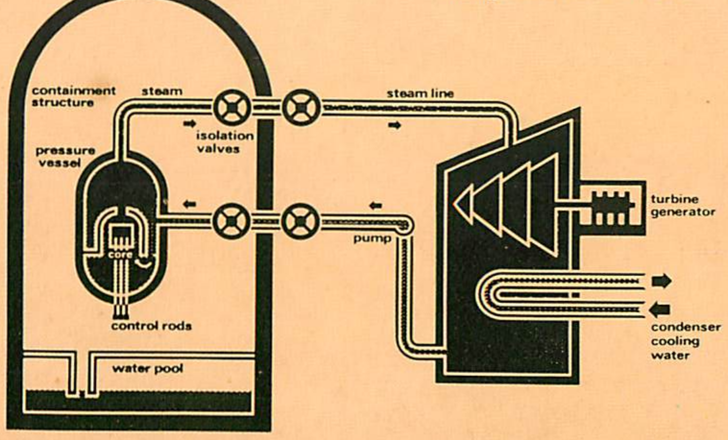
Pre-fired as a ceramic, the fuel resists the effects of high temperature and corrosion during reactor operation. And the dilute mixture of U-235 with other, non-fissionable, materials in the pellet is one of the reactor's natural safety features because it tends to slow down the chain reaction as it gets hotter.

The pellets are stacked end-to-end in 12-foot long tubes made of zirconium alloy. These fuel rods are then precisely arranged as bundles within the reactor, with spaces between them for control rods. Water flowing up through the bundles removes the heat and puts it to work.

The water serves also as a "moderator," slowing down the neutrons to increase the probability of fission. Rather than "clobbering" the nucleus, the neutron must combine with it momentarily. Thus the neutron must go fast enough to combine with the nucleus but not so fast as to skip over it — like a ball putted toward the hole in golf.

This moderating effect of the water adds another natural safety feature, since an accident that would cause a loss of water would also stop the chain reaction.

Boiling water reactor (BWR)



Reprinted with permission from:

ATOMIC INDUSTRIAL FORUM, INC.
Public Affairs and Information Program
7101 Wisconsin Avenue
Bethesda, MD 20814

Fuel replaced, recycled

Certain changes take place in the fuel pellets during their time in the reactor. Rather than causing fissions in U-235, some neutrons hit atoms of U-238 and turn them into plutonium, another fissionable element. Some of this plutonium is subsequently fissioned in place by other neutrons, contributing to the production of heat. Because it can breed these fissionable atoms, U-238 is known as a "fertile" isotope.

Most of the fragments of fission are radioactive, and during the life of the fuel enough of them collect within the pellets to contribute substantially to the heat through radioactive decay — the spontaneous emission of particles and gamma rays.

The fuel remains in a reactor for three or four years before these trapped fission products reduce the efficiency of the chain reaction — like ashes smothering a fire. All the fuel is not removed at once; from one-fourth to one-third of the rods are discharged and replaced each year.

Enough unfissioned uranium and newly generated plutonium remain to make recovery worthwhile, so this spent fuel is saved for reprocessing and eventual recycling of the fissionable materials.

Harnessing the energy

The cooling system is a main link in the chain that converts fission energy to electrical energy.

Here is the chief difference between boiling water reactors and pressurized water reactors.

In BWRs, made by General Electric Company, the water boils to steam directly in the reactor vessel.

In PWRs, made by The Babcock & Wilcox Company, Combustion Engineering, Inc. and Westinghouse Electric Corporation, the reactor water is pressurized so as not to boil. Instead it is pumped through a heat exchanger, where a separate supply of water is heated to produce steam.

At both types of plant, this steam is then used to make electricity in exactly the same way as at a plant burning fossil fuel — by spinning the turbine which drives an electric generator. This equipment is essentially the same at all thermal power plants. The product, electricity, is identical.

A nuclear power plant, then, is nothing more than a steam-electric generating station in which a nuclear reactor takes the place of a furnace, and the heat comes from the fissioning of uranium fuel rather than from the burning of fossil fuel.

Pressurized water reactor (PWR)