The Soviet-designed RBMK

The four Soviet-designed RBMK reactors at the Chernobyl complex are light-water-cooled, graphite-moderated, 1,000-megawatt reactors. In the early years of nuclear power development, graphite reactors were used for research and for producing plutonium. But in the 1950s, the design was considered inappropriate by Western nuclear contractors for civilian power plant development. The Soviets began building RBMKs in the 1970s.

The RBMK is totally different from the standard light-water reactors used in the other nuclear nations. Most important, in the standard Western-style light water reactors, when the coolant is lost, the nuclear chain reaction automatically stops. This is called a *negative void coefficient.* In contrast, the RBMKs have *positive void coefficients.* This means that if the power goes up, the reactivity goes up. As the higher power boils more water, the coolant water inside the fuel channels is reduced in density, and the reactivity of the fuel is increased.

Another important difference is that RBMK reactors have no containment buildings—the standard containment structure of steel and concrete that is a final barrier against radiation releases outside the plant.

The RBMK has blocks of graphite with channels running through it for the fuel rods. The fuel elements are encased in zirconium and water-cooled both inside and out. Although graphite is a good moderator and is relatively cheap, it has a high chemical affinity for water vapor, carbon dioxide, and metals, and the energy stored in the graphite is unstable. If the stored energy is released suddenly, it causes an enormous release of thermal energy. Therefore, graphite-moderated reactors have procedures to allow for controlled and gradual periodic heating of the material so that "annealing" of radiation damage can take place in order to prevent a catastrophic temperature rise.

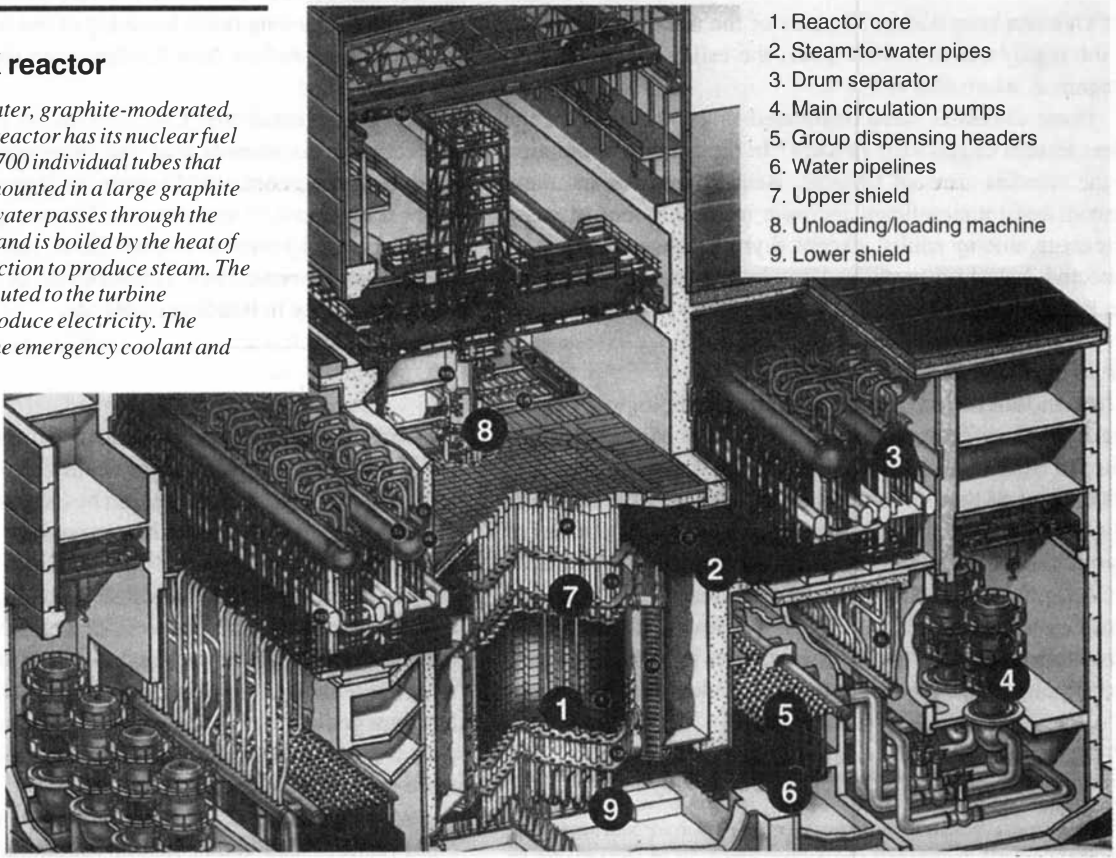
There cannot be a meltdown in a graphite reactor, because the graphite will not get hot enough. But, if the graphite catches fire, that fire is dangerous and very difficult to extinguish. And if water is poured on it, the water attacks the zirconium, opens the casings of the fuel elements, and lets out the fission products.

The Soviet-designed VVER reactor is a pressurized, light-water-cooled and -moderated reactor, more similar to Western models.

FIGURE 2

The RBMK reactor

This boiling-water, graphite-moderated, pressure-tube reactor has its nuclear fuel contained in 1,700 individual tubes that are vertically mounted in a large graphite core. Cooling water passes through the pressure tubes and is boiled by the heat of the nuclear reaction to produce steam. The steam is then routed to the turbine generator to produce electricity. The reactor lacks the emergency coolant and other safety systems found in standard light-water reactors in the West, and has no containment building.



Source: Pacific Northwest National Laboratory, Soviet-Designed Reactor Safety Program.