GENERAL REACTOR DESIGN

Nuclear Reactors are powered by fission. Fission was first discovered by Hahn and Strassmann in Germany by bombarding the uranium nucleaus with neutrons. It would follow that if there were neutrons among the products of fission, then they could produce additional fissions and a chain-reaction might result. Fermi, the leading nuclear physicist of the time decided to look into the matter. It was found (by Bohr & Wheeler) that U235 produced fission more readily than U238. The hard part in getting the pile to work is what is called the reproductive factor. A chain reaction can only occur if the number of neutrons emmited in fission is greater than one. If the number was one, then no chain reaction would occur. If two were emitted, then a geometric progression could be created that would lead to a "chain-reaction". Now this is complicated by the fact that when the neutrons leave the nucleus, they are moving very fast. In order to promote fission, it is necessary to have slow moving neutrons. So we get back to the hard part: It is necessary to have a reproductive factor that after slowing, is greater than one. Obviously, the larger the reproductive factor, the larger the reaction (very large reproduction factors will cause a rather large boom). To complicate matters, the "free path" of the neutron, or the average distance it travels before being absorbed by the nucleus, is long and if you can't keep the neutron from escaping the uranium, then no reaction. To overcome the problem, a lattice of uranium cells could be "piled" on top of one another in order to promote the reaction. (Hence: Chain-Reacting Pile) The pile consists of slugs of pure Uranium arranged in a space lattice embedded in a matrix of graphite. The slugs could be referred to as "fuel rods". The Graphite is used to slow the nuetrons down, and something like boron steel (control rods) is capable of being inserted to help control the neutron flux. Boron steel & cadmium both absorb neutrons.

The amount of energy that any neutron gets in the reaction is a matter of chance, and a due to technical problems, the game of slowing down and catching neutrons can be very tricky. If the neutron is moving too fast to be captured by the uranium nucleus, then it just bounces off in what is known as an "inelastic collision". In this event essentially no speed is lost. But if the neutron strikes a material of small atomic weight, such as carbon (graphite), then an "elastic colision" occurs where the graphite particle absorbs energy, and the neutron slows down. It takes about 15 collisions with carbon to slow the neutron down by a factor of 10. This would mean that about 110 such collisions are needed in order to bring a 1,000,000-volt neutron down to "thermal energy" or about 1/40 of a volt.

The "collision cross section" for cadmium is about 10E-24 centimeters, or one barn. This is very large in atomic terms and makes hitting the cadmium as easy as "hitting a barn". The collision cross section for carbon is only about one five thousandths of a barn. Now the De Broglie wavelength of a particle gets bigger as its speed gets smaller, so as the neutron gets smaller, it sort of spreads out and has a greater chance of hitting the nuclei. (or one might say that its capture cross section gets larger as its velocity decreases. Of course nuetrons can get lost, be absorbed by the carbon, or mutate the uranium into another isotope (resonance absorbsion). The losses must be taken into consideration when calculating the reproductive factor. The proportions of carbon and uranium must be precisely controlled in order to get a chain reaction.

If you have a homogenous mixture, then on the average every second nuclei will be a uranium one and the neutrons will never slow down enough and be lost due to reasonance absorbtion. To get around this, a "lumpy" mixture is used in the pile. A neutron has to get through a lump of carbon (slowing it down) and if one doesn't hit enough carbon, it will mutate only the outer layer of the U235 lump, leaving the rest O.K.

Anyway, take a lattice cell (cube) of 8.25 inches per side. (composed of U metal and UO2 imbedded in graphite. Pile them in approximately a flattened rotational ellipsoid with a polar radius of 121 inches, and an equatorial radius of 153 inches. Support the bugger with a wooden frame, (oh, you'll need about six tons for this, a small pile. Larger piles yield larger reproduction factors.) and you have it. You should have a reproduction factor of about 1.067. Each metal lump should weigh about six lbs. (available from Westinghouse, Metal Hydrides, and Ames) Lumps of about seven or eight pounds would give a better reprodution factor, but would increase the amount of U metal needed. Each lump UO2 should weigh about 4.71 lbs. Diferent piles can be mixed together, but put your best materials near the middle. Layer the graphite bearing Uranium alternating it with graphite. Ordinary wood working machines can be used to to shape & smooth the graphite to specs. (Graphite can be obtained from Nat'l Carbon, Speer Graphite, U.S. Graphite, I would suggest about 14 tons, or 40,000 bricks) In order to press the uranium dioxide lumps, any good hydrolic press will do. Make sure that the die is made from a good quality tool steel, hardened and polished. Stearic acid can be used as a lubricant (0.5% diluted in acetone) with ethylene glycol added as a wetting agent. You'll need about 150 to 175lbs of pressure. As long as you are careful you can use different forms of uranium and graphite and still get a good pile. I'd suggest surrounding the entire thing with a neutron absorbing material such as cadmium. Once you get it up, pull out all of the control rods but one (one is all you need on a small pile anyway). Remove the last one slowly till it is about halfway out. check your neutron detectors and pull it out slowly (a geometric reaction starts slow, buts will pick up speed), until you get the output that you wish.