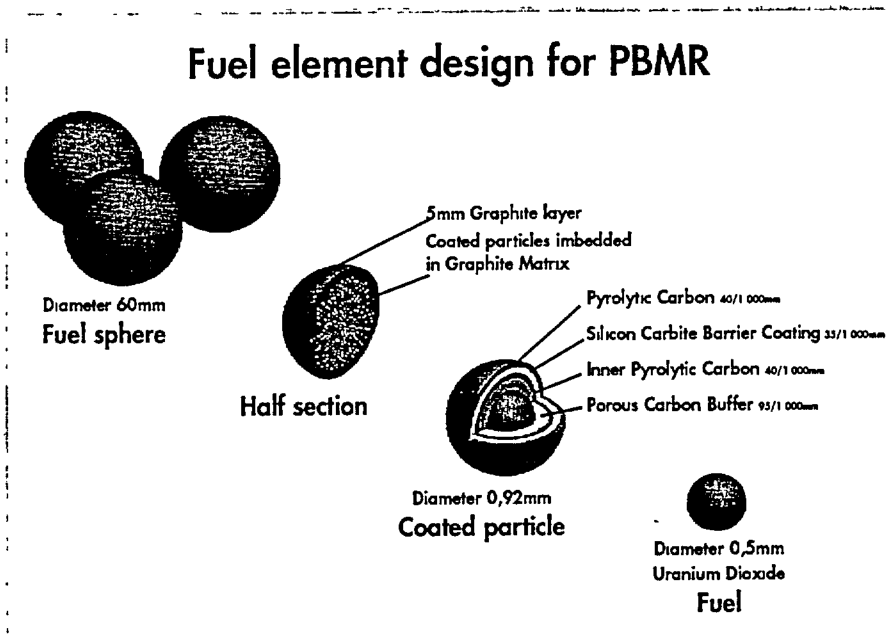
PBMR

HOW THE PBMR FUEL WORKS



The PBMR fuel is based on proven high quality German moulded graphite sphere and triple coated particles (TRISO). Essentially, the fuel elements are multi-layer spheres consisting of enriched uranium and various forms of carbon.

In the fabrication process, tiny beads of enriched UO_2 are dropped to form microspheres, which are then gelled and calcined (baked at high temperature) to produce uranium fuel "kernels". The kernels are then run through a Chemical Vapor Deposition (CVD) machine – typically using an argon environment at a temperature of 1 000°C – in which layers of specific chemicals can be added with extreme precision

For the PBMR fuel, the first layer deposited on the kernels is porous carbon, which allows fission products to collect without over-pressurising the coated fuel particle This is followed by a thin coating of pyrolitic carbon (a very dense form of heat-treated carbon), followed by a layer of silicon carbide (a strong refractory material), followed by another layer of pyrolitic carbon.

The porous carbon accommodates any mechanical deformation that the uranium oxide particle may undergo during the lifetime of the fuel. The pyrolytic carbon and silicon carbide layers provide an impenetrable barrier designed to contain the fuel and the radioactive decay products resulting from the nuclear reactions

Some 15 000 of these fuel particles, now about a millimeter in diameter, are then mixed with a graphite phenol powder and pressed into the shape of 50mm diameter balls. A 5mm thick layer of highly pure carbon is then added to form a "non-fuel" zone, and the resulting spheres are then pressed, sintered and annealed to make them hard and durable.

Finally, the fuel elements are machined to a uniform thickness of 60mm, about the size of a tennis ball.

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Each fuel sphere contains 9g of uranium, which means that the total uranium in one fuel load is 2,79 tons. The total mass of a fuel sphere is 210g

During normal operation, the PBMR core contains a load of 440 000 spheres, 310 000 of which are fuel spheres The balance are solid nuclear grade graphite and serve the function of an additional nuclear moderator Graphite is used in nuclear applications because of its structural characteristics and its ability to slow down neutrons to the speed required for the nuclear reaction to take place.

The graphite spheres are located in the centre of the core and the fuel spheres in the annulus around it This geometry limits the peak temperature in the fuel following a loss of cooling

In order to have a self-sustaining or "chain" reaction, the uranium in the PBMR pebbles is enriched, on average to 8 percent This is the isotope of uranium which undergoes the fission reaction in the core U-235 occurs in natural uranium in a concentration of 0,7 percent

The reactor will be continuously replenished with fresh or re-useable fuel from the top, while used fuel is removed from the bottom. The fuel pebbles are measured to determine the amount of fissionable material left. If the pebble still contains a usable amount of the fissile material, it is returned to the rector at the top for a further cycle. Each cycle is about three months.

When a fuel sphere has reached a burn-up of 80 000MWd/T of uranium metal, it is removed and sent to [illegible]t fuel storage facility. Each fuel pebble passes through the reactor about 10 times and a reactor will [illegible] to 15 total fuel loads in its design lifetime A fuel sphere will last about three years and a graphite sphere about 12 years.

The extent to which the enriched uranium is used to depletion (called the extent of "burn-up") is much greater in the PBMR than in conventional power reactors There is therefore minimal fissile material that could be extracted from depleted PBMR fuel. This, coupled with the level of technology and cost required to break down the barriers surrounding the spent fuel particles, protects the PBMR fuel against the possibility of nuclear proliferation or other covert use.

The spent fuel storage facility in a PBMR is situated in the reactor building The fuel is transported to the spent fuel storage by means of a pneumatic fuel handling system The spent fuel storage consists of 10 tanks, each with a diameter of 3,2m and a height of 14m. One tank can store 330 000 spheres

The South African Nuclear Energy Corporation (NECSA), where fuel rods for Eskom's Koeberg nuclear reactor near Cape Town were manufactured in the past, is currently under contract from the PBMR project team to develop the fuel manufacturing capability using the technology established in Germany