PBMR FUEL SPHERE PRODUCTION FACILITY PROJECT PELINDABA, SOUTH AFRICA

NUKEM was contracted by PBMR (Pty) Ltd, to prepare the detail design including procurement support, installation, supervision and cold commissioning for the process equipment of the Pilot Fuel Plant (PFP) in 2005.

The South African Pebble Bed Modular Reactor company, PBMR (Pty) Ltd, was established in 1999 with the intention to develop and market high-temperature reactors both locally and internationally. The PBMR project team is based in Centurion and in Pelindaba near Pretoria, South Africa.

PBMR (Pty) Ltd's current investors are the South African Government, the electricity utility Eskom, the Industrial Development Corporation (IDC) of South Africa and Westinghouse Electric Company.

The PBMR fuel is based on a proven, high quality German fuel design consisting of 10% enriched uranium triple-coated isotropic (LEU-TRISO) particles contained in a moulded graphite sphere. A coated particle comprises a kernel of uranium dioxide surrounded by three graphitic and one ceramic layers.

A fuel sphere consists of 9 g of uranium (some 15,000 particles) and has a diameter of 60 mm; the total mass of a fuel sphere is 210 g. During normal operation the PBMR core contains a load of 456,000 fuel spheres. The Pelindaba Fuel plant is designed to produce 270,000 to 375,000 fuel spheres a year.
The pilot production plant is separated into 6 areas:

- Area K: Kernel production facility
- Area C: Coater facility
- Area M: Matrix production facility
- Area F: Fuel sphere production facility
- Area E: Effluent treatment facility
- Area R: Uranium recovery facility

In the Kernel production facility Uranium solution is cast to form micro spheres, which are gelled, dried, calcined, reduced and sintered to form Uranium Oxide Kernels, which reach nearly theoretical density.
Within the Coating facility the Kernels receive the four coatings using a chemical vapour deposition (CVD) furnace to produce the Coated Particles:

- porous Carbon,
- pyrolytic Carbon (very dense form of heat-treated Carbon),
- Silicon Carbide
- another layer of pyrolytic Carbon.

Those layers serve as barrier for retention of fission products even at temperatures far above the operational. In the fuel sphere production facility the Coated Particles are overcoated with a layer of matrix graphite powder (MGP). The matrix graphite powder is generated in the matrix production facility by mixing natural and electro Graphite powder with resins in a kneader. The overcoated particles are dosed into matrix graphite powder and pressed to the core of a fuel sphere. Then an additional 5 mm layer of matrix graphite material is added to form a “non-fuel” zone. The resulting Fuel Sphere achieves its final diameter by a machining process and is then carbonized and annealed.
The effluents from the production processes are treated in the Effluent Treatment Facility. The main purpose is to recycle process liquids. Remaining liquids are decontaminated prior to release; residual organic liquids and solids are thermally oxidized, and Uranium residues are fed to internal recycling.
The scrap material from the production process such as odd kernels, odd Coated Particles and off spec Fuel Spheres as well as other Uranium bearing materials are recycled to the Uranium Recovery Facility.

The detail design is now completed. Due to financial restrictions the procurement of equipment and the further project steps are delayed.