NUCLEAR FUEL

Developing New Processes

During World War II, Oak Ridge's Graphite Reactor was operated as a pilot plant to demonstrate plutonium production. ORNL researchers developed chemical processes to separate plutonium from spent uranium fuel and fission products. They designed and applied processes using precipitation to extract plutonium from spent fuel dissolved in nitric acid.

Subsequently, research by John Swartout and Frank Steahly had a profound impact on reprocessing. They favored the more efficient solvent-extraction technique being developed at ORNL. It used nitric acid and tri-butyl phosphate dissolved in an organic liquid to extract uranium and plutonium and separate them from fission products. This technique became the Purex (Plutonium/URanium EXtraction) process, still used worldwide to recover uranium and plutonium from spent fuel reactor fuels.

In the ensuing decades, ORNL teams headed by Floyd Culler, Frank Bruce, Raymond Wymer, William Unger, and others set the pace in designing and piloting nuclear fuel reprocessing plants using the Purex process. The designs became the basis for immense reprocessing plants built at Idaho Falls, Hanford, Savannah River, and elsewhere throughout the world.

During the late 1970s and 1980s ORNL advanced nuclear fuel reprocessing technology by developing more efficient equipment for dissolving spent fuels, controlling hazardous gaseous effluents, and performing solvent-extraction operations. Although ORNL's plans for recovering plutonium from the never-built Clinch River Breeder Reactor were canceled in the mid-1980s, many of its advanced techniques were employed in Europe and Japan.

ORNL-developed processes have been used worldwide to extract uranium from ores for electricity production. In the 1950s and 1960s a team led by Keith Brown developed methods for recovering uranium from ore. In the early 1980s Fred Hurst devised a method for extracting uranium from phosphoric acid. These techniques are the standard methods for recovering uranium for use in nuclear power plants.

Remote manipulation technology was initially developed at ORNL for nuclear fuel reprocessing.

International Software

SCALE is an easy-to-use computer software system for determining whether designs of nuclear facilities and transportation or storage packages meet nuclear safety standards. This ORNL-developed system is used worldwide to answer nuclear safety questions. Examples: Do storage casks containing spent nuclear fuel have enough shielding to protect employees from hazardous radiation levels? Will the cask design or arrangement of casks on a flatbed truck or railroad car prevent a criticality accident involving an uncontrolled release of energy and radiation?

In 1980 when the Standardized Computer Analyses for Licensing Evaluation code system was released, it was used to assess the safety of transporting nuclear material in casks. Since then, SCALE has been applied to questions about criticality safety and radiation shielding in a variety of nuclear facilities and containers for fissile and radioactive materials.

SCALE incorporates well-known computer codes, such as the KENO Monte Carlo code developed at ORNL in 1966 for criticality safety assessments. Experiments at ORNL's Critical Experiments Laboratory, led by Dixon Callihan and Joe Thomas, provided benchmark data against which the computer code calculations could be checked. Significant code enhancements and additional validation have continued.

SCALE was used to assure criticality safety in the recovery effort after fuel partially melted during the 1979 accident at the Three Mile Island nuclear power plant. SCALE is used on every continent except Antarctica. ORNL researchers conducted SCALE training for users in the United States, Europe, Japan, and Latin America. Users include the Department of Energy and Nuclear Regulatory Commission (both of which support SCALE development), as well as cask designers, fuel fabricators, reactor fuel vendors, and nuclear power plant utilities. SCALE 5, scheduled for release in 2003, will continue the tradition of providing state-of-the-art computational tools for nuclear-fuel-cycle safety analyses.

1950

Oak Ridge School of Reactor Technology established

Low Intensity Test Reactor first operated

1951

Startup of Bulk Shielding Reactor

Neutron's half-life measured

5-MW Van de Graaff accelerator installed

1952

ORNL's first heavy-ion cyclotron built

Based on irradiated mouse embryo studies, ORNL advises against x-raying possibly pregnant women

Homogeneous Reactor Experiment first run