Idaho National Engineering Lab: forty years of nuclear research

by Marjorie Mazel Hecht

Forty years ago, on May 18, 1949, the U.S. Atomic Energy Commission began operations in Idaho Falls to set up the national laboratory that became known as Idaho National Engineering Laboratory or INEL. Later that month, construction began on the lab's first major facility, the Experimental Breeder Reactor I or EBR-I. It was this reactor that on Dec. 20, 1951, became the first in the world to produce electricity. Two years later, in June 1953, the EBR-I demonstrated the principle of breeding—that a nuclear reactor can produce more fuel than it consumes. In the Atoms for Peace days, this was one of the main goals of the still-young nuclear community: to provide a clean, efficient source of energy whose fuel would be self-perpetuating, providing energy and producing more fuel at the same time.

Since then both the EBR-I as well as the other facilities at the Idaho National Engineering Lab have accomplished many other "firsts." The 40th anniversary of the laboratory is a perfect occasion to recount the story of some of these firsts and remind Americans that this nation pioneered the frontiers of nuclear technology *and could do it again—provided the political will is there*.

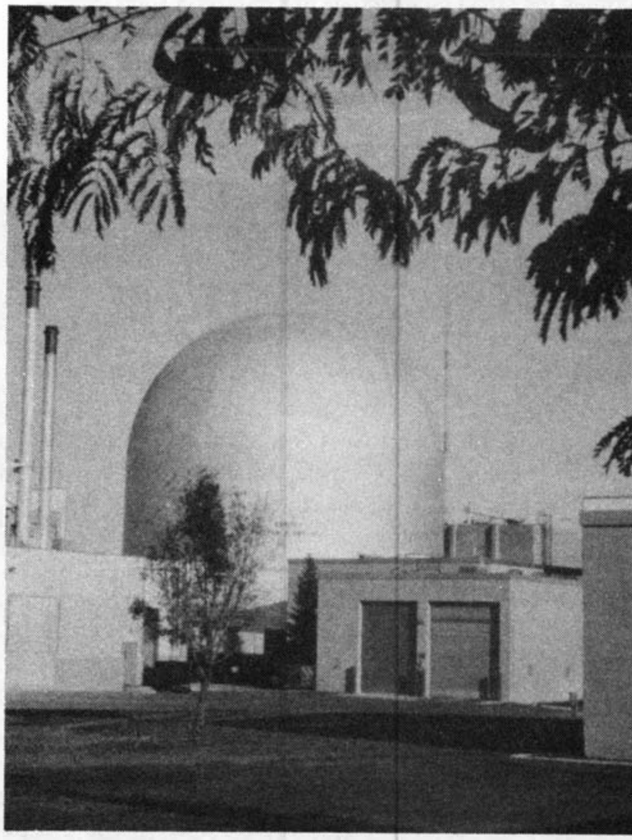
INEL, like the other national laboratories, is administered by the Department of Energy, the successor to the Atomic Energy Commission. It has three major operating contractors: EG&G Idaho, Westinghouse Idaho Nuclear Company, and Rockwell-INEL. In addition, Westinghouse Electric Corporation operates the Naval Reactors Facility at the lab, and Argonne National Laboratory West operates the Experimental Breeder Reactor. About 10,000 workers are employed at the lab.

Birthplace of the Nuclear Navy

Some of the best known facilities at INEL are the naval reactor prototypes, and it was here that the Nuclear Navy was born. The Submarine Thermal Reactor achieved its first successful power run on May 31, 1953 in the *USS Nautilus* prototype. Next came a simulated nonstop voyage of the *Nautilus* prototype, submerged and at full power, from Newfoundland to Ireland. It was this "trip" that proved that nuclear propulsion of submarines was feasible and that such submarines would be able to subnavigate the polar cap, from the Pacific to the Atlantic.

INEL's Naval Reactors Facility also developed a prototype propulsion system for surface ships, the A1W, pioneering the use of two reactors to power one turbine. This is a dual pressurized water reactor plant built within a steel hull. Both the aircraft carrier *USS Enterprise* and the missile cruiser *USS Long Beach* used A1W-type systems, and a later model A1W is used on the newer aircraft carriers, the *USS Nimitz*, the *USS Eisenhower*, and the *USS Vinson*. Many naval officers and enlisted men get their training at the INEL site.

Today, the *Nautilus* prototype plant still operates as a test



Credit: All photos are courtesy of INEL

The Experimental Breeder Reactor-II, which replaced the EBR-I, started up in 1961. Today it is the key U.S. facility for advanced reactor concepts with a fast breeder reactor. It has also produced almost 2 million megawatt-hours of electricity for INEL's use.

bed for advanced design equipment for new nuclear projects, but it will begin decommission operations this year. The latest model of the A1W uses two different kinds of reactor designs that operate independently to power one ship propeller shaft.

Other naval facilities include the S5G pressurized water reactor, which can operate using natural circulation cooling flow, instead of pumps, and the Expended Core Facility, which prepares the used reactor cores for reprocessing of the spent fuel.

INEL was also the site in the 1950s for work on the first prototype nuclear power plant for aircraft propulsion. This was called the Aircraft Nuclear Propulsion Project and was geared to produce a nuclear-powered engine that would keep an airplane going for very long periods. A presidential order canceled this program in 1961, however, before any reactor was flight tested on an actual plane.

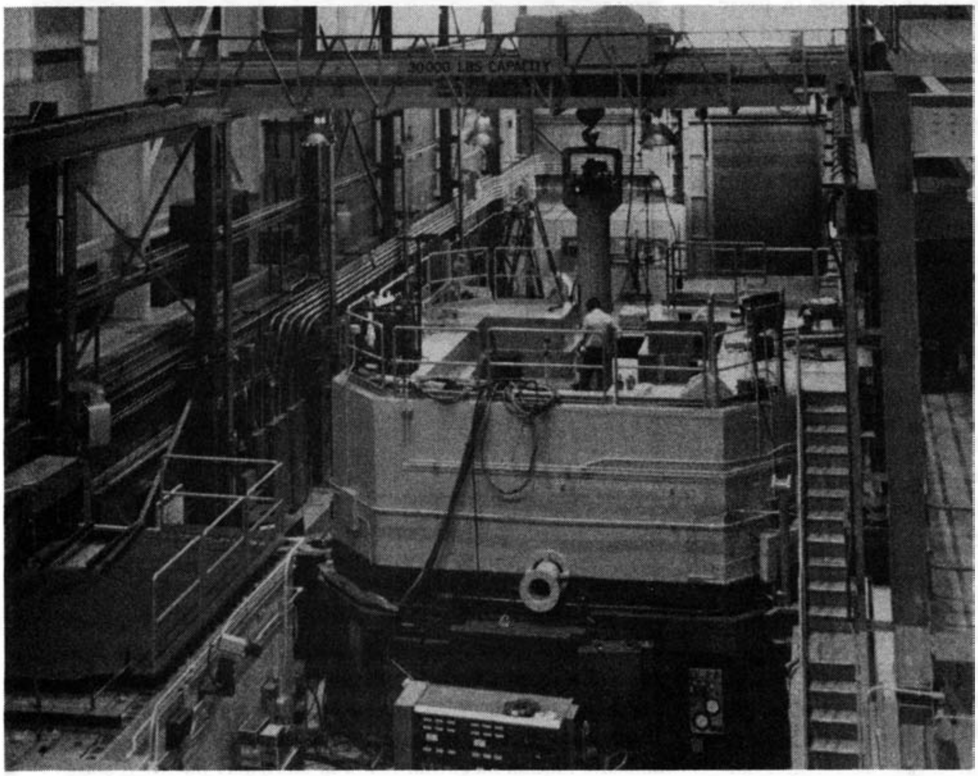
Test reactors

INEL boasts the world's largest test reactor, the Advanced Test Reactor, which began operating in 1969. Its mission is to study the effects of radiation on materials, simulating a reactor test environment. Because it produces such a high neutron flux, the Advanced Test Reactor can determine the effect on materials in a relatively short time—weeks and months—compared to the years it would take to accumulate such results on regular working reactors.

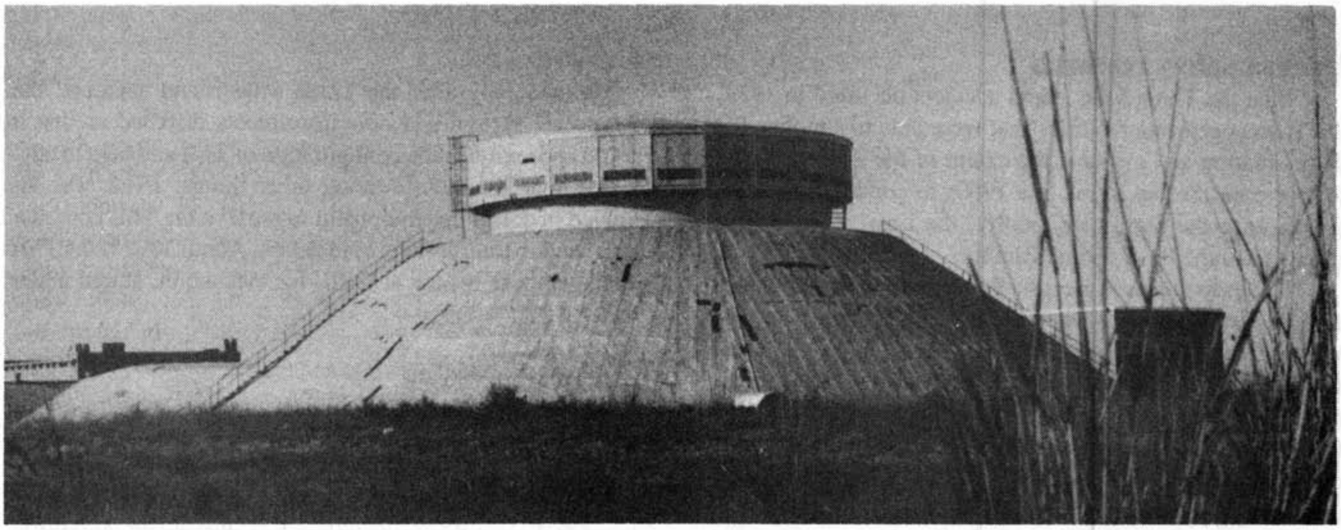
Argonne West (the main Argonne National Laboratory is located in Illinois) operates several test reactors and research programs at INEL, including the Experimental Breeder Reactor-II, the Transient Reactor Test Facility, the Zero Power Physics Reactor, and the Hot Fuel Examination Facility.

The Experimental Breeder Reactor-I became a Registered National Historic Landmark in 1966 and is open every day for public tours. Its successor, the EBR-II, is a pool-type sodium-cooled breeder reactor that produces 19 megawatts of power. After the first demonstrations of operation with reprocessing on site, the EBR-II switched after 1969 to irradiation testing of fuels and materials for larger breeder reactors. Its core can accommodate up to 65 experimental fuel subassemblies and it is frequently used to test fuel assemblies for fusion and space reactor programs.

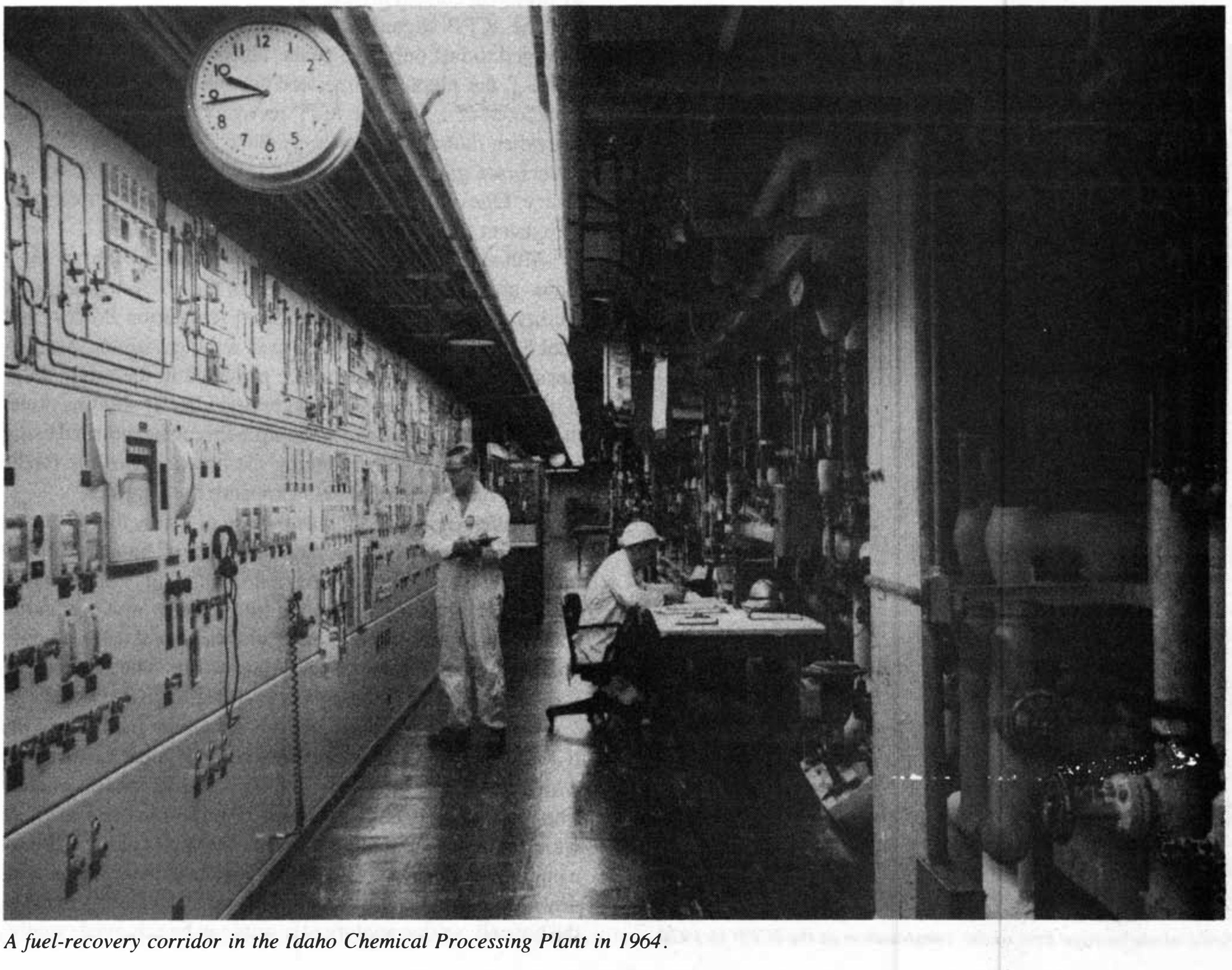
One of Argonne's new projects is the Integral Fast Reactor, which uses metallic fuel instead of the usual ceramic fuel. The advantage of metallic fuel is that it can be reprocessed in what's called a melt-refining system that is much simpler than the current chemical reprocessing. Because it can be done right on the reactor site, no transportation of radioactive spent fuel is necessary. And because the fuel remains highly radioactive at all times, Argonne argues that it is a system safe from thieves who want to steal nuclear materials for weapons production. The EBR-II is now conducting tests on the special fuel, a metallic uranium-plutonium-zirconium alloy. The next step, if these tests go well, is to build a prototype Integral Fast Reactor—a sodium-cooled, liquid metal breeder.



The Transient Reactor Test Facility, operated by Argonne West, is a uranium-oxide-fueled, graphite-moderated, air-cooled reactor with the purpose of simulating accident conditions that lead to fuel damage.



Argonne West's Zero Power Physics Reactor is a national facility designed to test the physics properties of advanced fast-spectrum reactors, including large breeder reactors and space reactors. The test reactors are assembled in a matrix that is at the center of a 50-foot-diameter concrete cylinder buried under a mound of earth, a construction similar to that used to test weapons. Although the power level may be only one-millionth of the particular reactor design being tested, the physics properties—such as the critical mass of the fuel or the effectiveness of the control rods—are almost the same as those in the reactor design being tested.



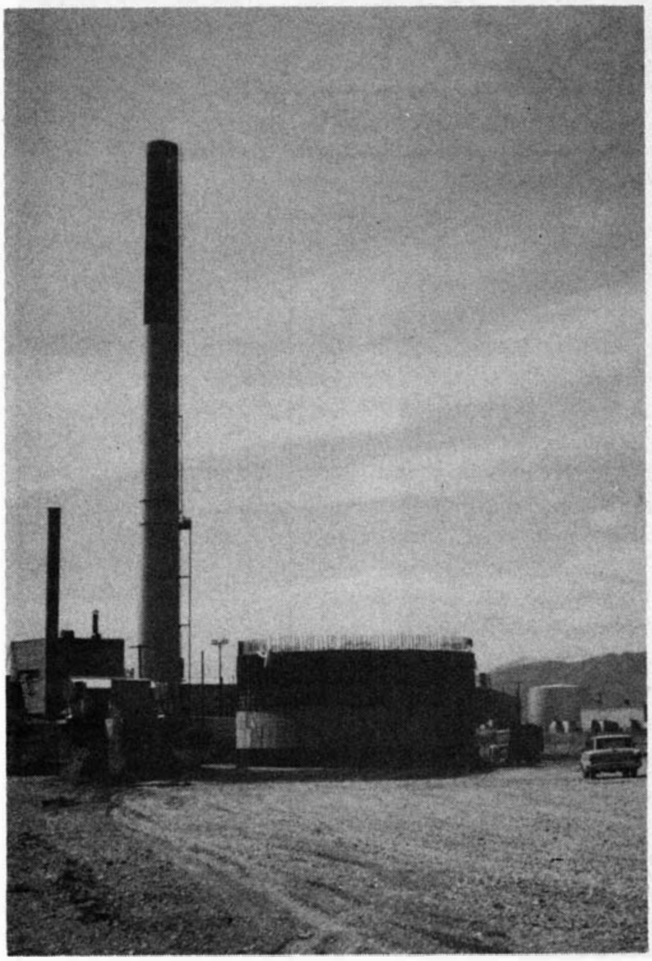
A fuel-recovery corridor in the Idaho Chemical Processing Plant in 1964.

Nuclear safety research

When the Three Mile Island accident occurred in 1979, INEL had operating facilities that were able to simulate the TMI situation and evaluate the extent of the damage to the reactor core. Set up in the late 1960s to conduct safety research were the Semiscale facility, the Loss of Fluid Test reactor, and the Power Burst Facility.

The Semiscale used electrically heated rods to simulate a reactor core's behavior when there was a break in the system's piping. The Loss of Fluid Test reactor, as the name implied, could simulate several different accidents that might occur in civilian nuclear plants, including the worst possible type of loss of coolant accident—a big break in the reactor's main coolant pipe. The 38th and final test on this reactor was a core meltdown conducted in July 1985.

The Power Burst Facility was designed to examine what happens when fuel rods burst, and its initial mission was to conduct 40 experiments that would provide data on nuclear fuel safety.



Solid waste storage bins under construction at the ICPP in 1970.

Immediately after the Three Mile Island accident, the Semiscale system had new instruments installed so that it could approximate the configuration of TMI and help in analyzing that situation. Among other things, INEL was involved in designing equipment to retrieve the TMI core material and to transport the core debris. About 70% of the TMI damaged core is now at INEL for evaluation, stored under water.

Fuel reprocessing

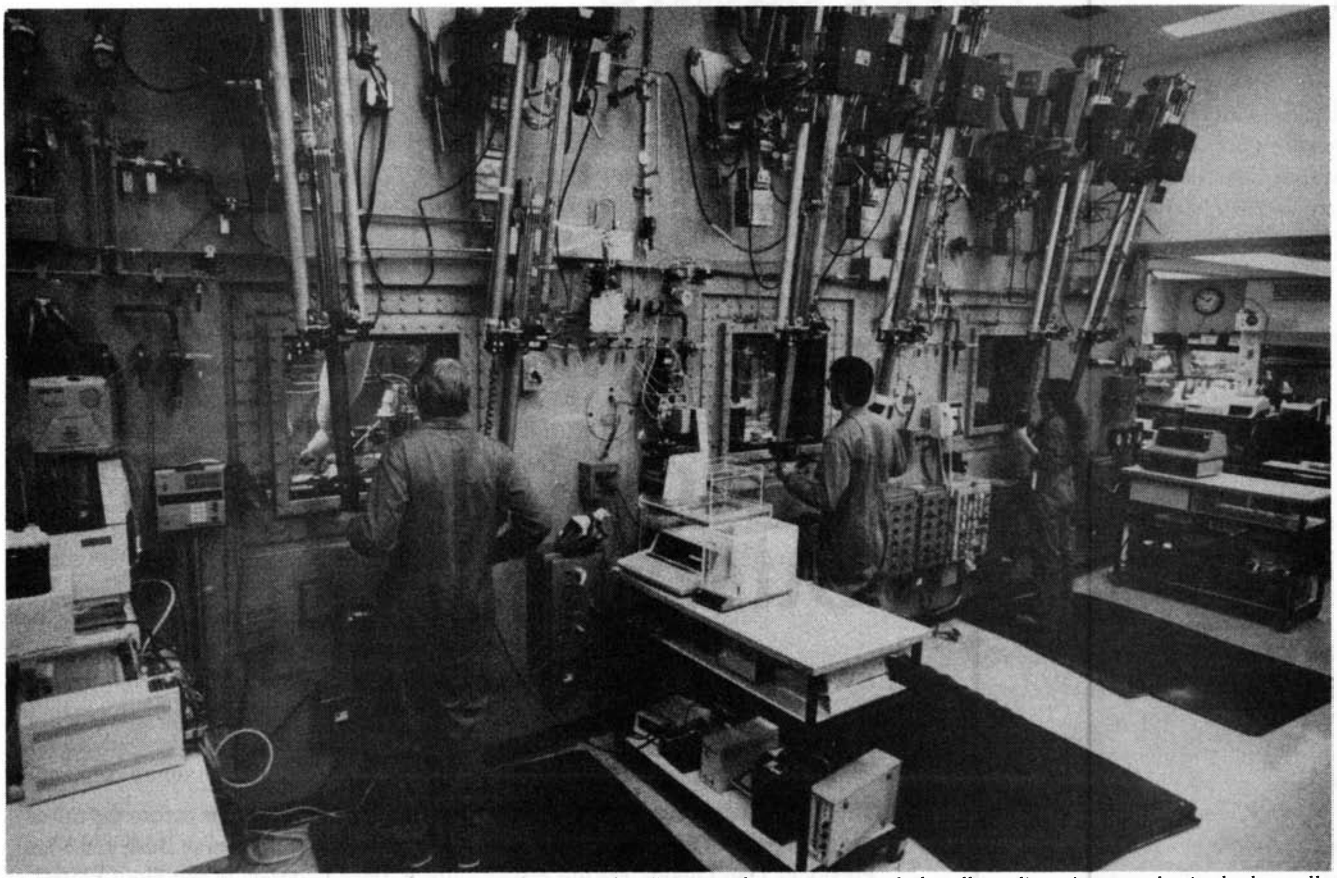
One of INEL's initial missions was to recover the usable uranium from the spent fuel rods of government nuclear plants, both experimental plants and power reactors, and it was the first facility to do this. Once separated out from the spent fuel rods, this uranium can be reprocessed and used to make new fuel elements. As INEL proudly notes, over the past 36 years, the Idaho Chemical Processing Plant (ICPP) has recovered about 24,000 kilograms of fissionable uranium (uranium-235) from this nuclear "waste," worth more than $1 billion at current prices.

The ICPP began in 1953 as a demonstration project, designed to last only five years. However, with several "facelifts," the plant has operated for 36 years. Now, with a workforce of 1,500, the ICPP recovers uranium, separating out other radioactive waste products. The facility also recovers rare gases like krypton-85, which is valuable for industry. One of the non-nuclear uses of krypton, for example, is to detect small defects in electronics equipment.

Although the basic process has remained the same, a major advance in fuel recovery was the 1984 opening of a facility called FAST (for Fluorinal Dissolution Process and Fuel Storage Facility), which uses remote maintenance, instead of the direct maintenance provided in the original design of the ICPP. Now, instead of periodically shutting down the facility for maintenance, equipment can be replaced using remote handling, thus reducing the downtime of the facility—and reducing the worker exposure to radiation.

Another first at ICPP was the use of a new fluidized-bed technology to convert the huge amounts of liquid waste remaining after the recovery of fissionable fuel. This involves the use of calcining to turn the liquid waste into a granular solid that is more stable than liquid waste and takes up only one-eighth the volume of the liquid waste. The New Waste Calcining Facility is the only one operating in the world.

Radioactive chemical analysis for all the facilities of the ICPP are carried out at the Remote Analytical Laboratory, which is designed to work with highly radioactive samples. The laboratory is built around a 50 × 20 foot "hot cell," to which samples are delivered from other parts of the ICPP by a pneumatic transfer system like those in drive-up bank windows. The samples travel at speeds up to 50 feet a second to the hot cell, so that analytical results can be achieved rapidly.



Technicians at the Remote Analytical Laboratory use "master-slave" manipulators to remotely handle radioactive samples in the hot cell. The leaded glass windows are oil-filled and 30 inches thick. The cell itself has three-foot concrete walls.

Special isotope separation

Looking to the future, the big new project on the INEL agenda is the construction of the Special Isotope Separation project in the 1990s, which will involve many new technologies for the lab. The SIS will use a new advanced laser process to produce plutonium for the U.S. defense use. Called AVLIS, for atomic vapor isotope separation, this process uses high-energy lasers to refine otherwise unusable stocks of fuel-grade plutonium into weapons-grade plutonium.

First, the plutonium is vaporized. Then lasers are used to ionize the undesirable plutonium isotopes and send them to charged collector plates. The remaining plutonium-239 is then recovered and processed for weapons use.

The AVLIS technology has been under development at the Lawrence Livermore National Laboratory for the past 12 years, but it has proceeded at a slow pace because of lack of funding and the Reagan administration philosophy of "privatizing" technology development. Lawrence Livermore has a full-scale development facility under construction that will test all aspects of the SIS and train its staff.

As defense production facilities were shut down by environmentalist pressures and the need for repairs, the development of the AVLIS system became more urgent. As Adm. James Watkins, head of the Department of Energy, said in his March 17 report to Congress on the SIS, "It could possibly be the nation's only such source of material prior to full implementation of the New Production Reactor" (the government's new conventional defense production reactor).

Start-up for the SIS is scheduled for 1995, and the final Environmental Impact Statement was issued in December 1988 and approved Jan. 19, 1989. However, the environmentalist groups who are concerned with forcing the United States to institute unilateral disarmament have just filed a suit to stop construction of the plant. Led by the Natural Resources Defense Council and two other regional groups, the suit alleges that the Department of Energy did not give enough consideration to "alternatives," chief among which is *not building* the plant.

In addition to the SIS, INEL is also being considered for the development of the Modular High Temperature Gas Cooled Reactor, which is one of two new designs for a defense production reactor.