ANNUAL REPORT

1 9 8 8

IDAHO NATIONAL ENGINEERING LABORATORY

"This past year has been a time of challenge and of great accomplishment for the Idaho National Engineering Laboratory."

The Idaho National Engineering Laboratory (INEL) is a multipurpose, defense programs laboratory. Historically a leader in the Department of Energy's (DOE) reactor technology programs and engineering projects, the INEL conducts applied research and development to support DOE's mission as well as to support the Department of Defense and other government agencies. The INEL also maintains for the federal government the capability to provide independent scientific advice, and technical verification and validation in areas of its expertise. The INEL provides use of its unique facilities for the benefit of members of the technical community, cooperates with personnel in universities and industry to aid the education of scientists and engineers, and provides technology transfer to the public and private sectors. Major facilities are located in Idaho Falls, Idaho, and on an 890-square-mile tract west of Idaho Falls.

The DOE-Idaho (DOE-ID) Operations Office has three major operating contractors at the INEL: EG&G Idaho, Incorporated; Westinghouse Idaho Nuclear Company, Incorporated (WINCO); and Rockwell-INEL. Other organizations located at the INEL include Westinghouse Electric Corporation (WEC) which operates the Naval Reactors Facility (NRF) for DOE and the U.S. Navy; Argonne National Laboratory-West (ANL-W), which operates the Experimental Breeder Reactor-II (EBR-II) and maintains research facilities; MK-Ferguson of Idaho Company (MK-FIC), provider of construction management services; and Protection Technology Idaho (PTI), Incorporated, which provides INEL security services. The DOE-ID Operations Office also operates the Radiological and Environmental Science Laboratory (RESL) at the INEL with Federal personnel.

The Idaho Operations Office manages work on projects at West Valley, New York; Three Mile Island, Pennsylvania; Denver and Grand Junction, Colorado; and Butte, Montana.

This past year has been a time of challenge and of great accomplishment for the Idaho National Engineering Laboratory. During fiscal year 1988, INEL was in the news locally and nationally more than ever before, and INEL scientists received much deserved recognition for their accomplishments, including among other honors, the winning of four R&D 100 awards for the laboratory.

Prominent in the news coverage were the Special Isotope Separation (SIS) Project and the New Production Reactor (NPR). Both are to be built at the INEL, and both are critical to our national defense. SIS will use Atomic Vapor Laser Isotope Separation technology to separate the isotopes of plutonium into concentrations required for nuclear weapons. NPR will be a modular high temperature, gas-cooled reactor. When completed, the NPR is expected to produce up to 50% of our nation's requirement for tritium, a critical ingredient for the operation of nuclear weapons. NPR will do more than that, however; besides its national defense role, it will serve as a prototype for a new generation of electrical power commercial reactors that are safer than any developed before. Also, because it uses nuclear fuel encased in ceramic pellets, spent fuel disposal problems are significantly reduced.

INEL representatives toured the state, holding hearings to receive comments and concerns regarding the projects. As expected in hearings, whose purpose was to elicit public opinion, individuals and groups opposed to the projects or concerned about reports of environmental contamination at INEL, turned out in force to voice their concerns. By the same token, many expressions of support for the projects were offered by city councils, county commissioners, and chambers of commerce. Most significantly, Governor Andrus, Senator McClure, Senator Symms, Congressman Craig, Congressman Stallings, and a number of southeastern Idaho leaders met as a group with the Secretary of Energy in the summer of 1987 expressing support for the NPR and recommending that it be built in Idaho.

We have achieved a great deal this past year in many areas. In environmental programs, INEL scientists worked with representatives from the Environmental Protection Agency in a variety of projects designed to protect and monitor the environment. INEL innovations, including removing sulfur from coal and cleaning up oil spills, show great promise for limiting damage to the environment. The Grand Junction Projects Office took the lead in exploring a national radon problem, which has captured public attention in many regions, by hosting a two-day conference on the subject. The goal of the forum was to develop cooperative efforts between DOE and the EPA to better understand radon contamination.

In the medical arena, an INEL-coordinated research project moved further along this year toward developing a treatment for a fatal form of brain cancer: glioblastoma multiform. The Boron-Neutron Capture Therapy (BNCT) project involves irradiation of boron-containing cancer cells with neutrons from the INEL Power Burst Facility. Other participants in the INEL-

A MESSAGE

managed program include Brookhaven National Laboratory, the University of Washington, Washington State University, Cornell University, Idaho State University, the University of Rochester, Mountain State Tumor Institute, and the Eastern Idaho Regional Medical Center. During the past year, project participants made solid progress toward developing the technical data they need to evaluate BNCT's feasibility for treating cancer patients. If successful, BNCT will significantly prolong the lives of patients with this particularly devastating type of cancer.

Another project we're particularly proud of is the Fuel Processing Restoration (FPR) Facility. The FPR will recover uranium from spent nuclear fuels, as existing INEL facilities have done safely for 35 years, but it will have four times the capacity of our presently operating facility. Construction began this year and is scheduled to be completed in 1993. Completion of the FPR will be the final component in a multiyear project to upgrade all facilities at the Idaho Chemical Processing Plant. The FPR, along with the other new facilities at the plant, will meet our uranium recovery needs through the year 2028.

Finally, as I mentioned at the outset, we're proud that INEL scientists won four R&D 100 awards. The awards are sponsored by Research and Development (R&D) Magazine, which recognizes the top 100 scientific or technological achievements each year. To receive four awards is quite an achievement; it's double the number of R&D 100 awards we received last year, which was double the number we received the year before. Our goal for the future is to continue the trend of the past three years by earning as many of the R&D 100 awards our INEL scientists can bring home to Idaho.

Without a doubt, fiscal year 1988 was an exciting year for the INEL. We had significant accomplishments in a wide range of areas, and we laid the foundation for even more achievements in the future. The INEL stands out as one of the finest facilities in the DOE and one of the leaders in technological innovation in the world. The work done here will help to bring a better life to millions. Equally important, our scientists and engineers support our national defense through a blend of technical expertise and patriotic dedication. I hope the citizens of Idaho are as proud to have this facility in their state as I am to be a part of it. I look forward to working with INEL employees and the people of Idaho to make 1989 another year of scientific achievement and technological progress.

Don Ofte
Manager, Idaho Operations Office
United States Department of Energy

CONTENTS

A N N U A L

COMPUTER SCIENCE

Personal Computer Program Models Ion Optics

A personal computer-based electrostatic ion optics program developed to support in-house chemistry research activities has gained wide acceptance in the mass spectrometry field.

The SIMION PC/PS2 program is a very convenient and usable tool. It was developed to support the design and analysis of charged particle beams used in basic ion processes research supported by the Division of Chemical Sciences with the Department of Energy's Office of Energy Research.

Charged particles called ions can be accelerated and focused with appropriately defined electric and/or magnetic fields. The effect is somewhat like using lenses to focus light within a camera. However, unlike lenses of shaped glass, ion optical elements are made of shaped electrodes and magnetic pole pieces.

Modeling of ion optics is typically much more difficult because electrical and magnetic fields have distributed (gradual) effect on ion trajectories rather than the edge effect (abrupt) refraction (bending) of a shaped glass lens. The mirages and distortions above hot surfaces and the atmospheric twinkling of stars illuminate optical effects of light that are similar to ion optics effects.

The field of mass spectrometry makes use of a wide variety of ion optics techniques to separate isotopes, examine the structure and composition of materials, detect trace quantities of substances like drugs, and support other important measurement and research activities. The ability to accurately and conveniently model ion optics effects is critical in the design of ion beam instruments as well as in the interpretation of experimental observations.

The SIMION PC/PS2 program models the ion optical effects of shaped electrodes. Its principal advantages are that it runs on IBM PC/PS2 class personal computers and its highly interactive graphical interface is easy to learn and operate. This type of program is an invaluable tool for those who need ion optics design and analysis capabilities, but want to avoid the complications of learning and using highly complex ion optics mainframe codes.

The rapid acceptance of SIMION PC/PS2 as a de facto standard within the mass spectrometry community has been very gratifying. The program is currently used by government facilities (e.g., Department of Energy's National Laboratories, National Aeronautics and Space Administration, Jet Propulsion Laboratory, and Naval Radiation Laboratory), industry (e.g., Finnigan Mat, Hewlett Packard, Kodak, Perkin Elmer, and IBM), and universities (e.g., Stanford, John Hopkins, Yale, Purdue, and Ohio State). As a further indication of the program's acceptance, the American Society for Mass Spectrometry sponsored a formal short course on SIMION PC/PS2 at its 1988 San Francisco meeting.

REACTOR TECHNOLOGY

Split Core Concept Adopted for Advanced Neutron Source

An Advanced Neutron Source (ANS) producing ultrahigh neutron flux intensities is being designed for materials science, isotope production, and fundamental physics research. This is part of a national effort to reestablish the United States as the leader of condensed matter research using neutrons from a state-of-the-art ultrahigh-intensity reactor source. Two reactor concepts have been proposed for the ANS. The INEL examined a split core reactor in which the fuel is uniquely configured into two "donuts" separated by a coolant plenum. Oak Ridge National Laboratory (ORNL) examined a single core reactor, which is patterned after the High Flux Isotope Reactor.

At a February 1988 meeting at ORNL, both laboratories discussed the advantages and disadvantages of each design. A split core design with involute fuel, as shown in the illustration, appears to combine some of the best features of each concept. A consensus was reached, and both laboratories recommended a modified split core design to the Department of Energy for further development.

This reactor will incorporate several features conceived at the INEL. These include the basic split-core geometry, the close-in core pressure boundary tube which creates a hospitable low temperature, low pressure pool environment for the experimental sources and beams, and the fundamental shim reactivity control concept in the central region of the core.

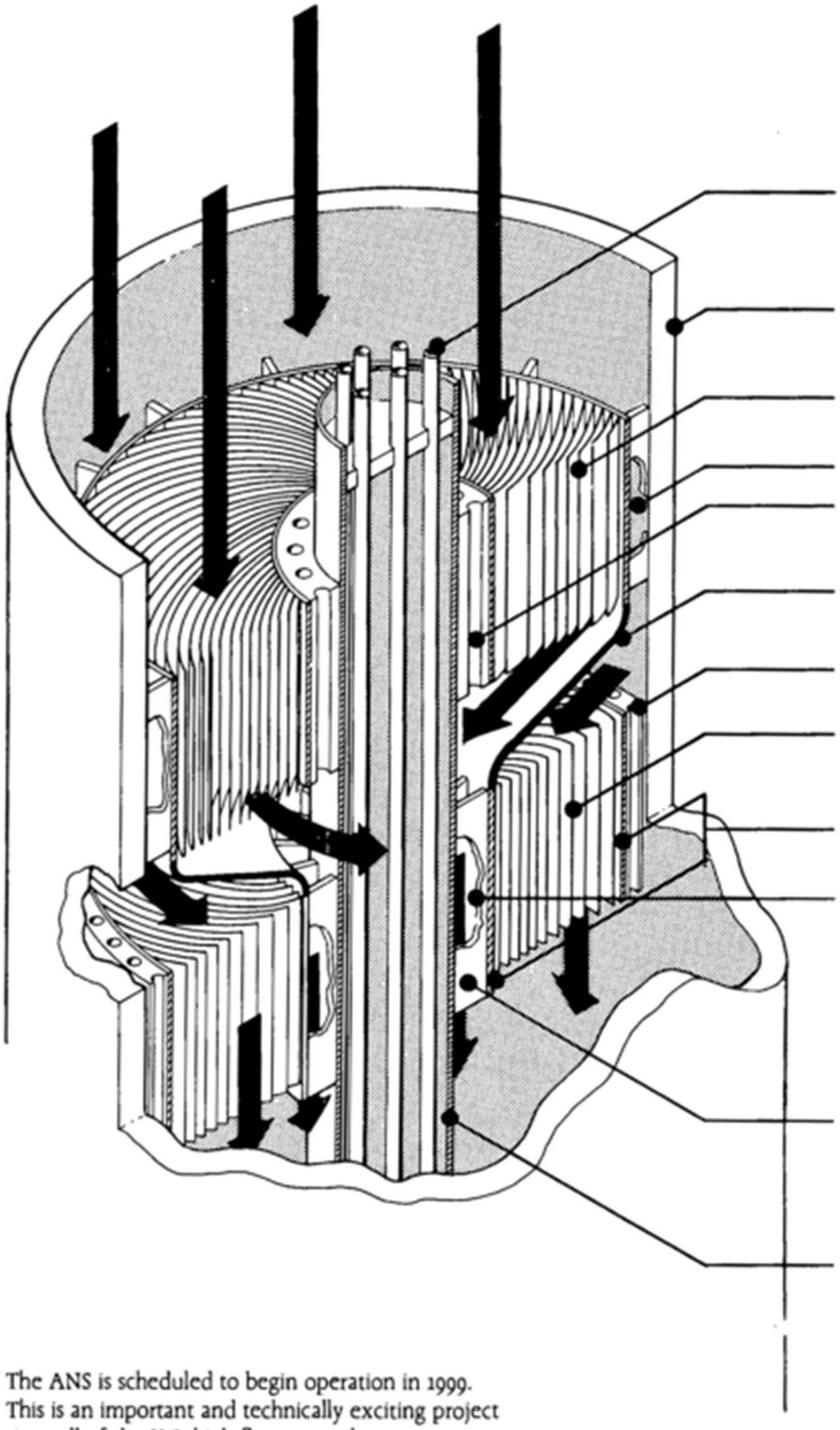
The split core features include the capability to produce thermal neutron flux levels more than 10 times higher than that in the Advanced Test Reactor (ATR), a hospitable environment for the neutron beam tubes and cold/hot sources, and flexible beam access arrangements. The core consists of two symmetric fuel donuts cooled by heavy water. The donuts are separated by a central coolant plenum. The fuel plates are highly enriched uranium silicide clad with aluminum. The thermal neutron flux peaks outside the core in a large tank of heavy water.

The central plenum mixes the coolant outlet flows from the top donut and coolant bypass ring before the coolant enters the bottom donut. This reduces the coolant temperature at the inlet to the bottom of the donut and allows the power density to be raised and produce more neutrons. If a flow diverter is added to completely separate coolant flows, as ORNL suggested, then the coolant temperature can be reduced further, and the power density can either be raised further or the safety margins can be improved.

The average power density of the split core is incredibly high (12 megawatts per liter of fuel), 325 megawatts of power generated by a reactor the size of a waste basket. This is more that 10 times the power density of the ATR and over 100 times higher than the power density in a large commercial reactor. This represents a formidable engineering challenge to cool the reactor and operate it safely.

Splitting the core also gives some neutronics advantages. The neutron efficiency is higher, so the split core produces more thermal neutrons at a lower power level. The fast neutron flux and gamma contamination in the reflector tank are lower. Experimenters want to keep these as low as possible to reduce the heat generated in the components in the reflector region and to minimize the background "noise" in the experiments.

The split core is easier to control because the worth of the hafnium control rods in the central hole is about twice as much as that in the single core design. This occurs because the central coolant plenum slows the neutrons down so they can be captured more easily in the control rods.



The Advanced Neutron Source split core with involute fuel and flow diverter.

The ANS is scheduled to begin operation in 1999. This is an important and technically exciting project since all of the U.S. high flux research reactors were built in the 1960s; and many are approaching the end of their useful lives. This reactor is the cornerstone around which the U.S. hopes to reestablish its preeminent world leadership position in neutron scattering research and condensed matter physics in the 21st century. The INEL is proud to be playing a role in the ANS development.

Experiments Continue to Show Inherent Safety of Advanced Reactor Concept

The Integral Fast Reactor (IFR), termed the flagship of the nation's advanced reactor program in the 1988 Department of Energy's (DOE's) testimony before Congress, continues to build a solid record of success in experiments that demonstrate its inherently safe design. During 1988, the IFR program achieved success in the major areas of fuel longevity and fuel reprocessing.

Experiments on IFR fuel have shown that it can operate in a reactor for as long as four years before needing replacement. Related experiments showed that a break in the stainless-steel jacket that encases the fuel need not require immediate replacement of the fuel.

Tests of a key aspect of the IFR fuel-reprocessing method have demonstrated that uranium can be routinely separated from other components of used fuel. The Hot Fuel Examination Facility-South (HFEF/S) on the INEL site is being prepared to demonstrate this process on a scale large enough to show commercial practicality.

The IFR concept is made up of three key elements. First, it is a pool-type, sodium-cooled reactor. Its core and major components sit in a pool of thousands of gallons of molten sodium. The pool provides protection against overheating in case of an accident. If an IFR-type reactor loses coolant flow or begins to overheat, natural properties inherent in materials and design will safely shut it down without human or mechanical intervention. Because of these inherent safety characteristics, an IFR-type reactor would also be less costly to build and operate than other reactors cooled by liquid metals.

Second, the IFR concept uses metal-alloy fuel. Because metal transmits heat quickly, heat buildup in the core is limited and core cooling is enhanced. Metal fuel will also elongate within the cladding if reactor power suddenly increases. This expands the core and automatically reduces reactor power.

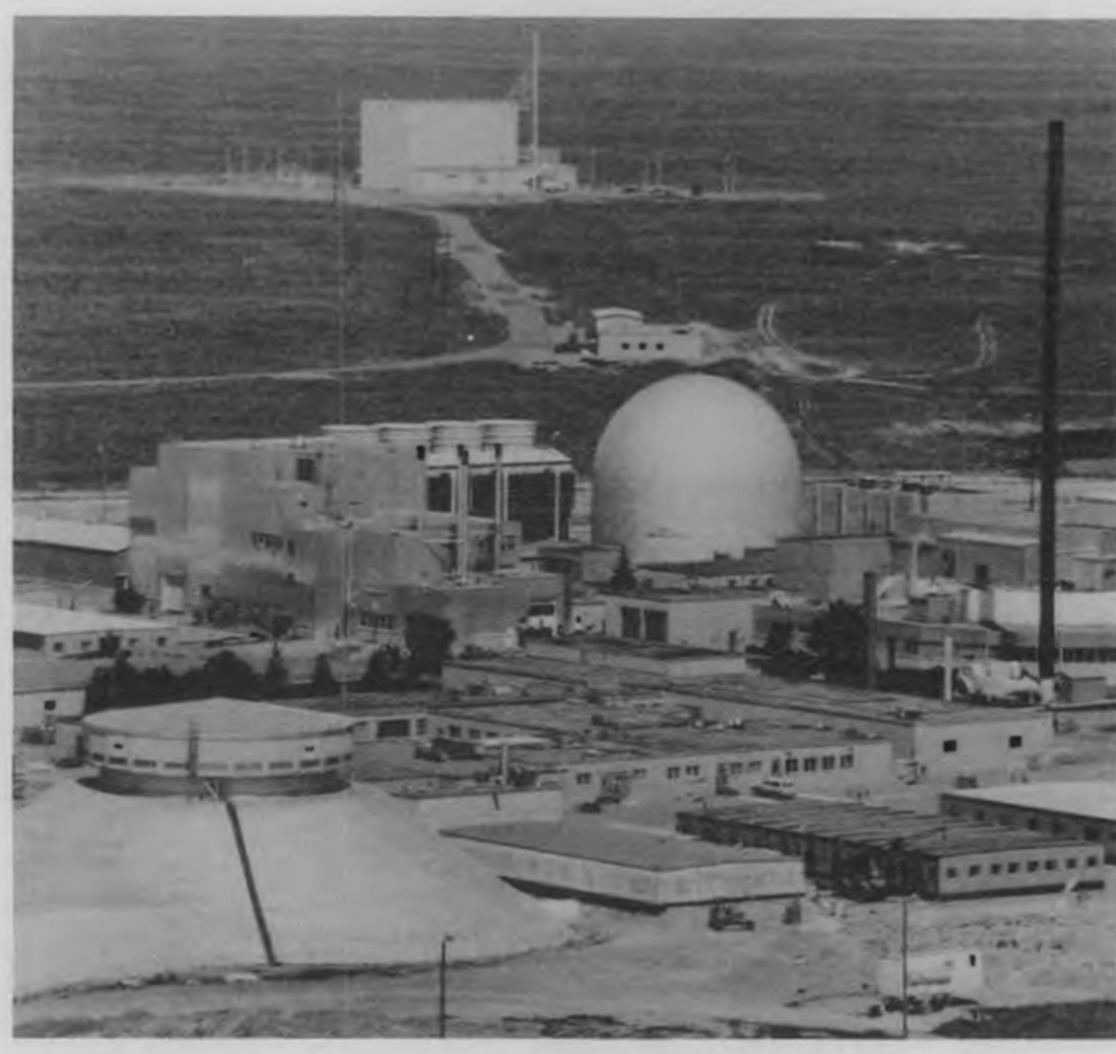
Third, the IFR uses a fuel reprocessing method that is economical, helps prevent unauthorized fuel diversion, and eliminates the need to transport radioactive material to or from the site during the reactor's operating lifetime.

The first two of these key IFR technology elements have already been demonstrated at the INEL in Argonne National Laboratory-West's Transient Reactor Test Facility (TREAT) and the Experimental Breeder Reactor II (EBR-II), the nation's only power-producing, liquid-metal-cooled reactor. Like an IFR, EBR-II is a pool-type, metal-fueled, sodium-cooled reactor.

TREAT has conducted key experiments on the inherent safety advantages of metal fuel and in the core of EBR-II. The IFR fuel has achieved a record 18 atom-percent burnup - the equivalent of three or four years in a power reactor.

Eighteen atom-percent burnup exceeds design needs for the IFR. The test fuel - an alloy of uranium, plutonium, and zirconium - was first put in the EBR-II core February 1985 and has proved so successful that the entire core of EBR-II is being loaded with it to provide a large statistical base for fully assessing the performance of IFR fuel, and to produce feed material for demonstrating the IFR fuel-reprocessing cycle.

Intentionally breached IFR fuel has also been operated in the EBR-II core for more than 200 days without widening the breach or losing fuel through the breach into the sodium coolant. This means that, if such a breach occurred in the IFR-type reactor, normal operations would not need to be disrupted to replace the fuel. Instead, replacement could wait until a normally scheduled shutdown.



Tests of the Integral Fast Reactor technology are conducted at Argonne National Laboratory-West.

In 1988, the electrorefining process to separate uranium and other fissionable material from spent nuclear fuel was successfully demonstrated on a large scale. This is a key link in the IFR fuel recycle technology and Argonne scientists now routinely separate uranium in approximately 20-pound lots at the Engineering-Scale Electrorefining Facility at Argonne's Illinois site.* The next step is to build a similar remotely operable electrorefiner for HFEF/S at the INEL to refine radioactive spent fuel from EBR-II. Modifications of the HFEF/S facility are currently under way. With completion, it will be possible to demonstrate all key elements of the IFR concept at the INEL.

*Argonne National Laboratory is operated by the University of Chicago for the U.S. Department of Energy.

Severe Accident and Source Term Research Successfully Concluded

Scientists and engineers in the Severe Accident Research Program have successfully completed detailed analysis of severe fuel damage experiments conducted in the Power Burst Facility (PBF) and the Loss-of-Fluid Test (LOFT) facility. Results from these test programs, integrated with data and analysis from the Three Mile Island (TMI) Accident Evaluation Program (also conducted at the INEL), have provided significant insight into the behavior of a nuclear reactor core during a severe accident and the resulting fission product release. An example of the insights gained during the analysis is the influence of core degradation phenomena and chemical environment on in-vessel fission product behavior.

In-vessel severe accident chemistry involves high temperature interactions between the materials present in a nuclear reactor core including fuel rods, control materials, spacer grids, and steam. The chemical form of the fission products largely dictates the degree to which they are volatile and their release and transport properties. The influence of chemistry on the release and transport of fission products has been found to be dependent on core melt progression phenomena such as fuel liquefaction, control rod failure, and molten debris relocation. The extent of fuel irradiation, the presence of control materials and spacer grids, and the amount of available steam are important factors which largely determine the chemical environment present during a severe accident. Much has been learned about the influence of chemistry and several key in-vessel phenomena on fission product release and transport.

Tests conducted at PBF and the LOFT facility culminated in very severe core conditions during the final experiment in each series, PBF SFD 1-4 and LOFT LP-FP-2. These last tests reproduced the most severe reactor accident conditions with core temperatures exceeding 3000°F. The results of these tests were compared with the results of the TMI-2 Accident Evaluation Program. Despite large differences in the LOFT, PBF, and TMI-2 reactor system conditions, a very consistent pattern of core degradation and fission product release and transport resulted.

Consistency was measured in the heatup rates, peak temperatures, hydrogen production, deformation/cladding failures, material liquefaction and relocation, core blockage, material fragmentation, and oxidation/hydrogen production. Consistency in fission product behavior was measured in the fractional release of the principal fission products, their chemical forms, and in the transport mechanisms.

The resulting database and analytical results provide the basis for a greatly strengthened understanding of the phenomena and the means for an extensive computer code validation effort. Specific results from the analysis include the timing of core flow area reduction relative to initial melting; hydrogen production and fuel rod oxidation during high temperature conditions; effects of scale and thermal hydraulic conditions on the sequence of events in a meltdown; and insights into the control of large amounts of hydrogen, released noble fission gases, and vapor and aerosol transport of cesium and iodine. In addition, the capabilities of computer codes used in the analysis of severe reactor accidents have been assessed including the ability of these codes to calculate fission product release and transport, correctly assessing the risk to the public, and assisting in the development of accident management strategies.

This analysis effort has resulted in a greatly improved understanding of severe accidents and provides a sound basis for development of future regulatory guides, advanced reactor designs, and plant evaluations.

THREE MILE ISLAND

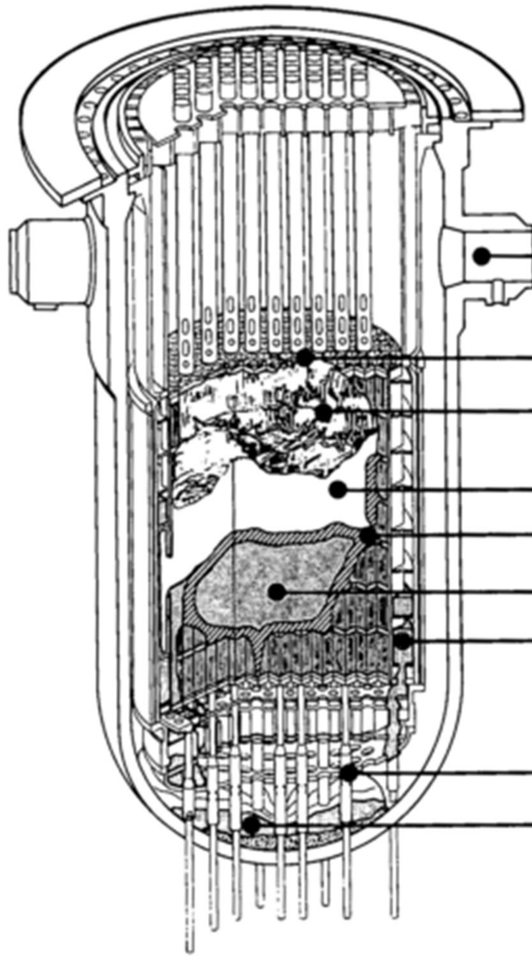
INEL Provides Estimate of TMI-2 Lower Head Thermal Response

The Three Mile Island-2 (TMI-2) accident resulted in extensive reactor core damage. Recent defueling work has confirmed that from 47 to 50% (62000 to 67000 kg) of the original core material (123000 kg) achieved melting temperatures and an estimated 15000 to 20000 kg of molten core material relocated to the lower head of the reactor vessel. Because of the extensive core damage and core material relocation, the TMI-2 accident provides a unique opportunity to extend our understanding of the physical processes controlling the latter stages of in-vessel core damage progression such as survivability of the lower head.

Because of the wide range in physical characteristics of the lower head debris (particle size, texture, composition, and in particular, the uncertainty in composition of material adjacent to the vessel wall), three assumed debris configurations were evaluated to bound the vessel thermal response.

The result of this study has provided an evaluation of the effect of the lower head debris configuration, composition, and coolability on the thermal/mechanical response of the lower head. Not all possible combinations of debris characteristics were evaluated, but the bounding cases have provided important insight relative to the most likely debris configuration and cooling characteristics.

The results show the importance of the debris configuration. For the upper bound configuration, vessel creep rupture (mechanical failure) is predicted independently from the coolability of the porous debris material. Since creep rupture of the vessel did not occur, it can be inferred that the upper bound configuration is too conservative and the consolidated material does not exist to the extent assumed. This inference emphasizes the need to better characterize the TMI-2 lower head debris material and the importance of understanding the mechanisms controlling breakup (debris formation) of the molten core material.



End-state core configuration.

The results also clearly show the importance of debris coolability. For all three assumed debris configurations, vessel creep rupture would be predicted if no cooling of the porous debris had occurred. Again, since the vessel is intact, this suggests that debris cooling was very important in limiting the vessel temperature. Since consolidated material has been observed adjacent to the vessel and the debris may have been at elevated temperatures for as long as two hours, it can be inferred that the coolability of the vessel at the consolidated material/vessel interface may be considerably greater than assumed in the calculations.

The results of this analysis provide important insight to our understanding of the latter stages of in-vessel core damage progression leading to vessel failure. Further characterization of the lower plenum debris and the vessel wall will be necessary to reduce the uncertainty in the calculated vessel temperatures and estimated vessel mechanical response.

MATERIALS RESEARCH AND ANALYSIS

Research Shows Link Between Metal Ions and Removal of Sulfur from Coal

EG&G Idaho scientists at the INEL have discovered that metal ions are an integral structural component of coal and that removal of these ions allows coal to be more readily solubilized by microbes. These metal ions, such as iron, calcium, aluminum, and magnesium, form insoluble complexes, making the solubilization of coal more difficult. Removal of these ions causes the coal to become more soluble in alkaline solutions.

The solubilization of coal is important because it can reduce the sulfur content by as much as 50% and can reduce ash content by as much a 80%. Removing such large quantities of sulfur could help significantly to ease acid rain problems associated with the burning of coal, and removing the ash helps reduce the amount of slag produced by burning coal making the coal burning process more efficient.

One method of removing metal ions is introducing a dilute mineral acid to crushed coal. The acid dissolves the ions and is later washed from the coal. After being treated with the acid, microbes are introduced to the coal, and the microbes produce an alkaline material that is responsible for coal solubilization.

Another method is using the microbes themselves to dissolve the metal ions. In this case, microbes such as Bacillus, Trametes, and Candida dissolve metal ions and raise the pH of coal slurries causing the coal to become solubilized. The effects of such treatments are most prominent with low grade coals and decrease as the grade of coal increases.

Laser Used to Inspect Space Shuttle Tiles

Scientists at EG&G Idaho have demonstrated the potential for using acoustic vibration patterns to inspect thermal protection tiles used on space shuttle orbiters. The research, being conducted for the National Aeronautics and Space Administration (NASA) Kennedy Space Center, is to develop a nondestructive testing technology for examining the tiles following space shuttle flights in order to identify loose or damaged tiles.

The average shuttle tile is 6" x 6"x 1-1/2," over 90% void, and weighs about three ounces. It has a thin black glass coating which "dumps" heat very quickly, but is also very fragile. Each tile is bonded to a thin piece of felt which in turn is bonded to the shuttle.

Each tile on the shuttle is unique and is designed for its exact placement. When a tile needs replacing, the technician must determine that tile's particular size and shape and then manufacture it.

The need for an effective method of testing the tiles is apparent when one considers that if even one tile is missing on reentry, it could jepordize the mission. Because of the complex nature of the tiles and the multilayered geometry of the tile-strain isolation pad system, conventional nondestructive examination (NDE) techniques, such as x-ray and ultrasound, have not proven feasible. The ultimate goal of the project is to develop a practical field inspection system for NASA using noncontacting laser sensors.

The noncontacting laser technique involves the use of acoustic waves to cause small vibrations on a tile. These vibrations are sensed with a laser beam that is focused on the tile surface. The very small amount of light that is reflected from the tile is used to derive a signal that follows the surface displacement. A portable computer work station then collects and analyzes these signals to detect variations in the vibrational response of the tile to identify any abnormal conditions.

Using this technique, vibrations of less than one micron (one-millionth of a meter) in wavelength can be detected. The technique is especially suited for noncontacting field inspection of materials with dark, rough surfaces such as the orbiter tiles. The presence of an "unbond" results in a different type of signature than that of a fully bonded tile. Numerous laboratory experiments have been done at the INEL on tiles identical to those on the shuttle to see how they respond to different bonding conditions. The sensitivity of the technique and problems with field implementation are currently being evaluated.

With initial success of the project, NASA funded additional work for theoretical studies and field tests to demonstrate the feasibility of field inspections. Three INEL scientists traveled to the Kennedy Space Center to perform feasibility field tests. The intent was to see how the Orbiter Processing Facility environment affected the type of measurements being made in the laboratory. Using computer, laser, and acoustic signal equipment, they measured tile movement in response to the acoustic excitation signal. The data collected are now being analyzed to determine if this method of checking for loose tiles is feasible.

Laser sensors also have other potential applications, particularly in the inspection of complex materials used in the aerospace industry.

Fusion Safety Program

International Participation

Dr. Steve Herring of the Fusion Safety Program at the INEL spent six months in West Germany working the large superconducting magnet TESPE at KfK.

International cooperation has become an increasingly important part of the Fusion Safety Program at the INEL. The United States is participating along with Japan, the European community, and the Soviet Union in the design of the next large fusion machine known as the International Tokamak Experimental Reactor (ITER). The INEL provides safety and environmental design support for the U.S. In addition to projects such as the ITER design which involves several countries, the Fusion Safety Program combined resources with individual countries to extend the resources available for fusion safety work. A safety engineer from the INEL, Dr. Steve Herring, spent six months working at the superconducting magnet safety test facility called TESPE at KfK in West Germany. The superconducting magnets in fusion devices store large amounts of electrical energy. Large off-normal forces could result from internal shorts or, if an arc developed, this stored energy could cause melting or vaporization of material.

Dr. Herring used the MSCAP computer code developed at the INEL to analyze the tests performed at this facility. This code calculates the currents and voltages resulting from such faults as shorts and arcs. These calculations can then be used to determine the off-normal forces or extent of damage from arcing. Because of the excellent agreement between these calculations and the test results, this code can now be used in safety analysis of magnet systems developed for fusion or for other applications.

In addition to these activities, fusion researchers from Canada, the Soviet Union, Italy, Holland, and France have visited the INEL in recent months. Also, the Fusion Safety Program will host a workshop on Fusion Safety sponsored by the International Atomic Energy Agency in Jackson, Wyoming, in April 1989.

Research Program Developments

In a fusion reactor, the burning fuel is at such high temperatures that it must be held away from the walls by a magnetic field. Sometimes, this burning fuel, called plasma, becomes unstable and strikes the walls. Such plasma disruptions are a safety concern since they can cause large forces and melting of the wall. The DSTAR code was developed for the Fusion Safety Program in cooperation with the Princeton Plasma Physics Laboratory to model plasma disruptions.

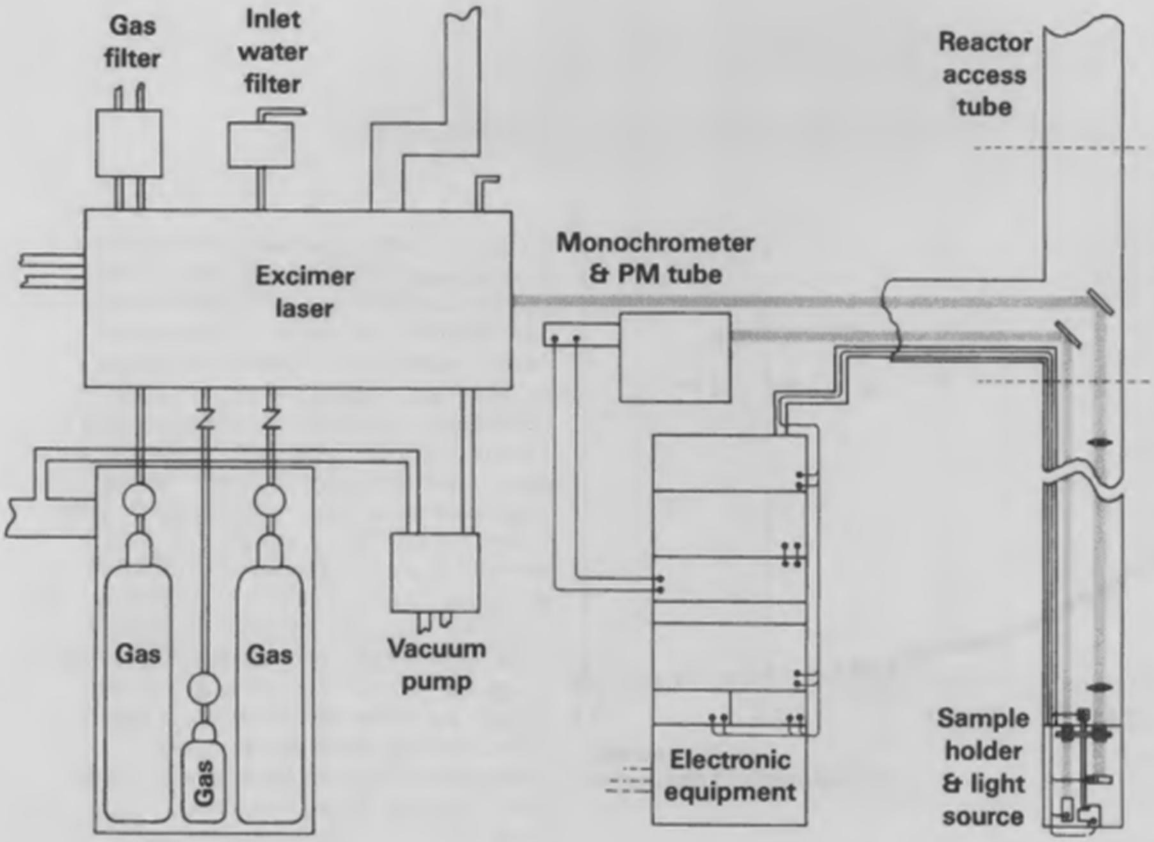
This code has been successfully validated using data from the largest U.S. fusion device, the Tokamak Fusion Test Reactor (TFTR), which is located at Princeton. A comparison of the predicted current flowing in the plasma during the disruption with measured values contributed to a better understanding of the plasma.

Radiation Damage Studies of Optical Components

The development of laser weapons systems, and in particular, nuclear-pumped laser systems will require a knowledge of the effects of nuclear irradiation on many types of optical components. Materials such as silica, magnesium fluoride, and barium fluoride used in laser designs will be subjected to irradiation doses that range from the relatively low fields of space background to the very high fluxes encountered near operating nuclear reactors and/or bomb bursts. The dielectric substrates and thin-film coatings used as reflectors or concentrators of radiative output from laser devices are also susceptible to nuclear radiation damage. Generally, the radiation-induced absorption, luminescence, and refractive index changes known to occur in optical materials when placed in radiation fields may seriously degrade the performance of a laser weapon.

Of particular importance to laser weapons is a database describing the response of optical components placed in high-flux, high-dose nuclear environments, and in addition, simultaneously exposed to temperature extremes and intense photon fluxes from laser sources. Each of these phenomena (i.e., nuclear radiation, temperature fluctuations, and laser light) is known to induce defects in optical materials, and it is highly probable that in a scenario combining these mechanisms additional synergistic effects may occur. The primary objective of the Optical Damage Studies of Optical Components Task, funded through the Department of Energy San Francisco SDI Innovative Concepts program, was to evaluate the net effect of competing damage mechanisms on optical components of interest to military programs.

Consider the following example: a laser weapon device is placed in orbit where for several years it is exposed to the cosmic radiation and low temperatures of space. It now becomes necessary to activate the weapon; the components are suddenly

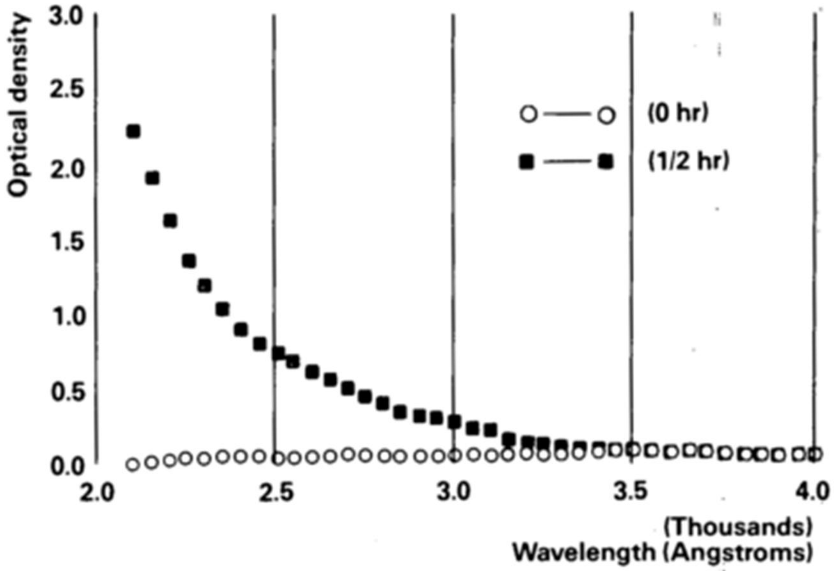


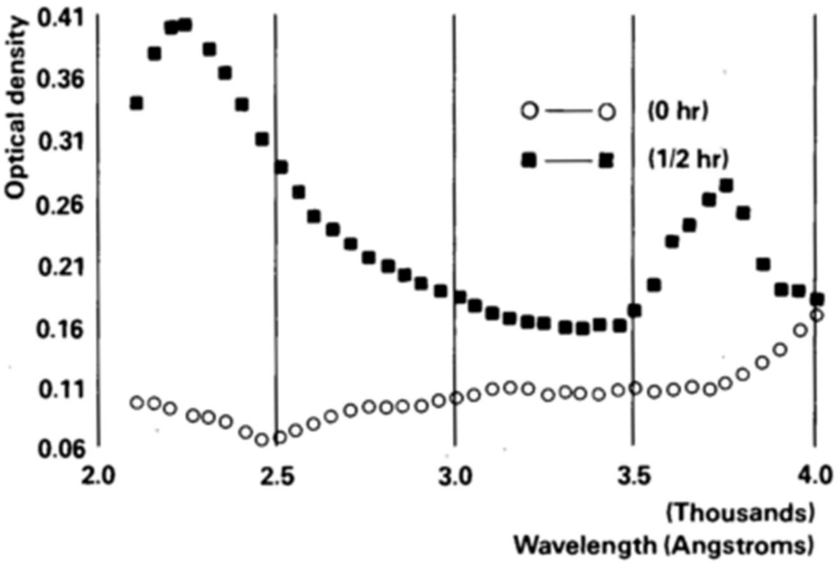
Laser and nuclear irradiation test setup.

exposed to a high nuclear radiation pulse from the nuclear pump followed by an intense burst of photon flux as the device lases. How will this device respond? Is it possible that the defects induced in the optical components by the background irradiation at low temperatures will be aggregated with the defects induced by the neutron pump and laser pulse in such a manner that the weapon will not function?

In order to investigate these effects, a series of damage experiments were performed in INEL's Advanced Reactivity Measurement Facility (ARMF). The experiments measured the radiation-induced absorption in the ultraviolet and visible regions of the spectrum of a number of optical components including window materials, coating optics, and filters. A second series of tests added the effect of high energy excimer irradiation to the effect of nuclear irradiation. Changes in the optical performance were monitored in situ throughout the test duration. (See the schematic of the experimental setup.) Testing has been performed at both ambient and low ($-150°C$) temperature. The specially designed liquid nitrogen-cooled optical fixture for the low temperature irradiation tests is shown. Samples were exposed to fast neutron fluences of approximately 4×10^{22} neutrons/cm^2, gamma doses of 5×10^6 R/hr, and excimer photon fluences of approximately 3.8×10^4J/cm^2 during the tests.

Cryogenic optical test fixture.





Comparison of radiation-induced change in optical density for quartz sample after exposure to nuclear irradiation (top) and after exposure to laser and nuclear irradiation (bottom).

A number of optical materials including quartz (Corning 7940), fused silica, magnesium fluoride, sapphire, barium fluoride, sodium chloride as well as some dielectric-coated silica components were chosen for study. The samples showed varying degrees of nuclear radiation-resistance, with the radiation-induced absorption coefficient varying from a low of approximately 0.2 cm^{-1} in the coated optical materials to a high of 2.0 cm^{-1} in the sapphire sample, at the laser wavelength of 248 nm. Evidence of laser damage was apparent at the surface of most of the samples when recovered from the reactor. The magnesium fluoride sample was the most laser-damage resistant, while the sapphire sample showed considerable damage. The net effect of simultaneously exposing the samples to both excimer and nuclear radiation appeared to be a general improvement in the transmission characteristics of the samples in the region of the laser wavelength. This is possibly due to photobleaching and/or increased localized temperature in the sample. An unexplained absorption band also appeared in the blue region of several samples, as illustrated in the data from the quartz sample shown in the figure.

The conclusion of this study is that while considerable radiation damage occurs when components are placed in high dose nuclear and excimer radiation fields, no additional detrimental effects occur when the two are combined. In fact, nuclear radiation-induced absorption may be reduced by the presence of high fluxes of photons.

GammaSnake - Health Physics and Plumbing Solve A Problem

Approximately 4,000 residential properties in Grand Junction, Colorado, are thought to be contaminated with uranium milling residues, called tailings. To qualify for remedial action under the Department of Energy's (DOE's) Uranium Mill Tailings Remedial Action (UMTRA) program, each of these properties has or will be radiologically surveyed to assess the extent of the contamination. For buried residues, the standard protocol when surface gamma-ray measurements are inconclusive is to auger a few holes in tailings-suspected areas and take soil samples. There are many instances where tailings were used as backfill for sewer lines.

To solve the problem of ensuring tailings contamination without the undesired drilling into sewer lines, UMTRA called upon the Grand Junction Projects Office (GJPO) Technical Measurements Center (TMC). The TMC was established in 1982 by the DOE's Division of Remedial Action Projects (now the Office of Remedial Action and Waste Technology). The scope of the TMC's activities includes providing calibration facilities and reference materials; evaluating instruments, methods for their use, and the results of measurements; developing field and laboratory measurement methods; and trouble-shooting technical problems.

The TMC's evaluation of the problem suggested that if a way could be found to measure the tailings outside the sewer line from within the line, the potential problem of drilling into sewers would be solved. Using technical knowledge and home plumbing repair techniques, the GammaSnake was born. After a false start using CsI crystal coupled with a photoavalanche diode (a trendy, state-of-the-art approach), the TMC researchers located a commercially-available miniature photomultiplier and coupled it with a 0.5-inch diameter by 0.5-inch long NaI crystal. The waterproof gamma detector package is 5-inches long by 1-inch in diameter and is connected to a 55-foot long flexible tether that can negotiate 90-degree bends in 3-inch diameter lines. Laboratory design measurements indicate that a 100-foot electrical cable within the flexible tether is possible using off-the-shelf scaler/high voltage power supplies.

Today, the UNC Geotech radiological survey crews can routinely do sewer catheterizations using the GammaSnake and in the process have found additional uses for the tool. Calibration of the GammaSnake at the GJPO's borehole models for radium allows it to be used for boreholes too shallow for a logging vehicle and too deep for typical hand portable units. And, instead of coring through concrete slabs, the soil beneath the slab is augered and the GammaSnake runs under the slab. So far, experience in the field has been satisfactory - the GammaSnake has easily located tailings surrounding sewer lines.

Fabrication of an aluminum (Al_2O_3) coating.

Thermal Spray Coatings

The INEL continues to investigate the use of thermal plasmas for materials processing. Most recently, a new thermal spray deposition research and development activity has been established at the INEL. This research has generated significant national interest by using the synergistic approach, involving government, industry, universities, and the INEL.

Thermal spraying is one of the most versatile methods of applying coatings. The process combines particle melting, quenching, and consolidation into a single operation, and is particularly suitable for the formation of coating for various industrial functions including wear resistance, heat and oxidation resistance, atmospheric and sea corrosion resistance, electrical or thermal conductivity or resistivity, restoration of dimension, abradability (for seal and clearance coatings), and chemical corrosion resistance. With more than 50 process parameters controlling the quality of the coating, it is always difficult to find the optimum process conditions. As coating property requirements become more stringent and restrictive, a better basic knowledge of these phenomena is necessary for improved process control and coating quality. Problem areas that need to be addressed relative to thermal spraying include deposition efficiency, uniformity, coating density, porosity, coating-surface interface, coating adhesion to substrate, particle-to-particle cohesion, contamination, oxidation, and degraded nonuniform microstructures.

The goal of the INEL coatings research is to develop the technological basis for modifying thermal spray torch designs and spray processes for coating optimization. The focus of the coatings research involves parametric testing, plasma and particle diagnostics, coating characterization, analytical modeling, and performance evaluation. The following powder systems are currently under investigation at the INEL: pure metals (Al), metallic alloys and composites (NiAl, WC-Co, Cr_3C_2), ceramics (l1203, ZrO_2), and superconducting materials ($YBa_2Cu_3O_x$ –). This research results in a conservation of national resources and enhances the competitiveness of the United States government and industry in the world market. For example, experts assume that the losses caused by wear and corrosion every year are approximately 3% of the gross national product. Optimization of the thermally sprayed coatings depends on the knowledge of the plasma physics and plasma-particle interaction in the process.

An analytical effort at the INEL is being conducted to establish comprehensive mathematical models for full description of the physics, particle dynamics, thermochemistry, and coating morphology in the thermal spray experiments. Diagnostic evaluation of the plasma plume or particle morphology relies on optical examination with laser techniques, since physical contact cannot be made without distorting the plasma properties. Also, the INEL is currently identifying and developing real time in-process sensing and control techniques for the thermal spray process. Of primary interest is the measurement and control of the thickness and uniformity and/or the amount of porosity incorporated during film disposition. Complete physical characterization of coatings is accomplished at the INEL Research Center where high-powered equipment is available. Current capabilities include an optical microscopy and x-ray diffraction laboratory, a scanning transmission electron microscope, a scanning electron microscope, and an Auger electron microscope. Finally, performance evaluation of the coatings allows the determination of the quality of the coatings.

WASTE MANAGEMENT

EG&G Idaho Scientist Adapts Device to Efficiently Separate Oil and Water

An oil spill in a Pennsylvania river caught the attention of the media and of EG&G Idaho scientist, Dave Meikrantz, who found it difficult to believe that there was not a technology for cleaning up the spill.

There was a device available, one that Meikrantz was familiar with through his work in fast radiochemical research. It consisted of annular centrifugal contactors, which until recently, were used primarily in nuclear fuel reprocessing. Meikrantz saw the potential for using a contactor in environmental cleanup work to rapidly and efficiently separate oil and water. He presented the idea to EG&G Idaho's Innovative Waste Technology and received initial research funding.

Meikrantz demonstrated the device in a bench-scale system and will now test a larger device. The contactor used centrifugal force to separate mixtures of oil and water, which have different densities. The separated liquids are then channeled out of the device. In full-scale operation, the water could be returned to the body of water from which the mixture was taken while the oil is captured in containers. The bench-scale system has achieved about 99% separation so the recovered oil would be pure enough for some reuses without any additional processing. Engineers at Oak Ridge National Laboratory, who used contactors in nuclear fuel reprocessing work, feel a full-scale device would process some 400 gallons per minute with the same or better separation rates. Currently, contactors used in nuclear fuel reprocessing handle flow rates up to 10 gallons per minute.

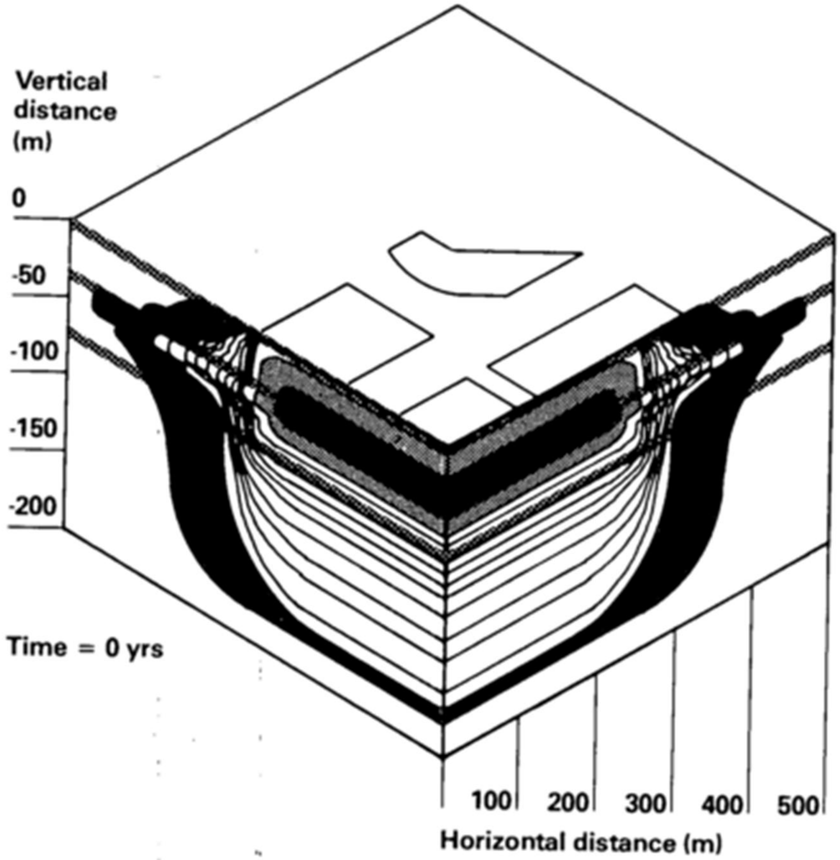
Meikrantz believes that if the contactors prove successful in adapting to oil and water separation, the device might be applied in areas such as extraction of heavy metals from contaminated waters and selective complexation (forming complex compounds) removal processes.

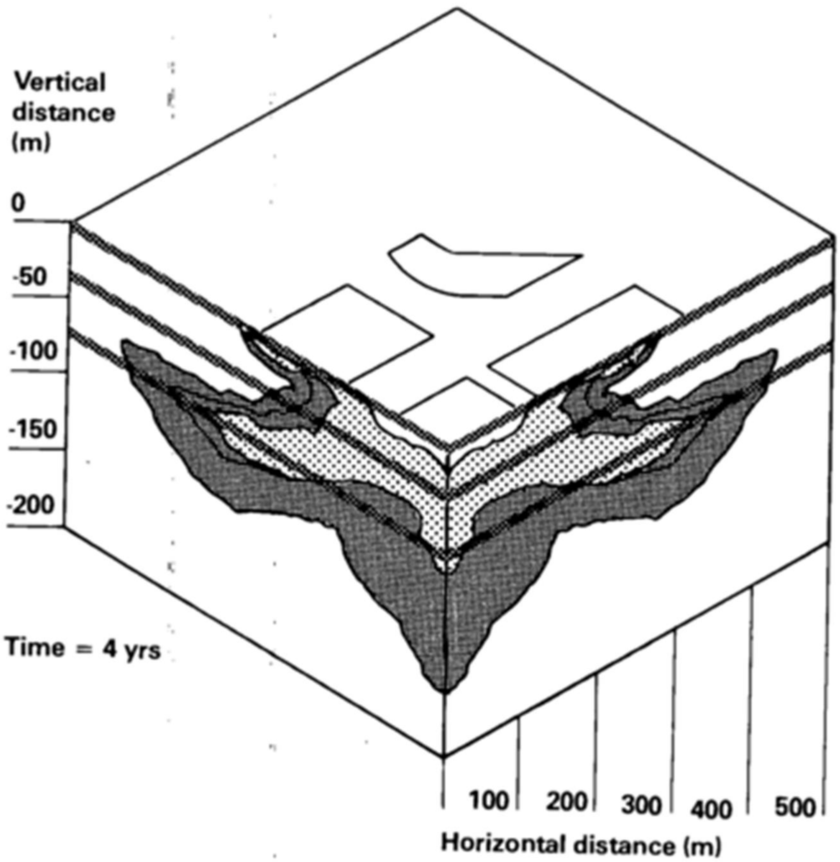
Models Used to Evaluate Remedial Actions for Waste Sites

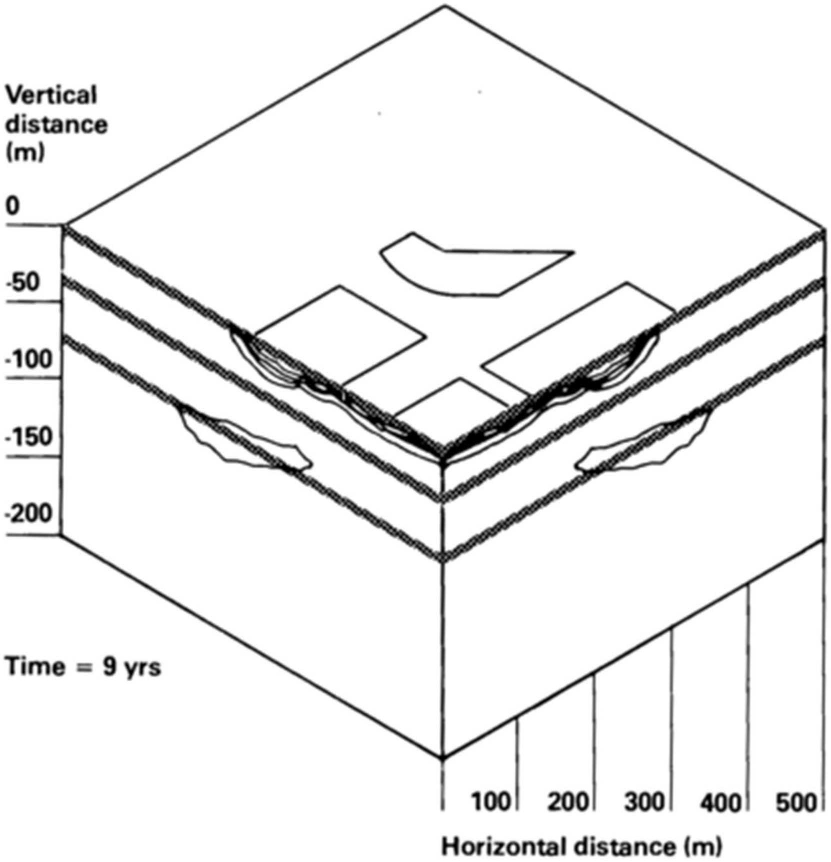
Geoscientists at the INEL have developed a suite of computer models for use in predicting the migration of contaminants from mixed-waste disposal sites. The computer models simulate the release and transport of radioactive and organic contaminants through the vadose zone (unsaturated zone) and ground water; these codes were developed for the INEL's Buried Waste Program. The computer models are installed on the INEL's CRAY X-MP 24 computer and are capable of simulating contaminant migration in complex, three-dimensional geologic environments. The models are interfaced with graphics software that produces three-dimensional visualizations of the contaminant plume.

Recently, the computer models were applied to assess the organic vapor migration occurring at the Radioactive Waste Management Complex (RWMC). Soil-gas sampling at the RWMC indicates that organic vapors are currently being emitted by various disposal sites. Ground water sampling in wells surrounding the RWMC shows minute concentrations indicating that vapors have migrated downward to the aquifer. A preliminary modeling study was performed to develop an understanding of the release mechanisms and transport processes and evaluate the effectiveness of possible remedial actions.

Computer simulations of the organic vapor releases from the pit and transport through the subsurface indicate that a relatively large plume has formed over the past twenty years. These simulations agree with recent field measurements of organic vapor concentrations. Peak concentrations in the subsurface are predicted to have occurred about five years after the burial of organic waste in 1966. The models also predict that ground water concentrations will not peak for another twenty years or more, which will allow sufficient time for implementation of remedial actions.







Computer simulation of vacuum vapor.

Various remedial actions such as organic waste retrieval, soil cover enhancement, and vacuum vapor extraction have been considered. Computer simulations of these remedial actions indicate that vacuum extraction (i.e., subsurface gas pumping) will produce the most effective and fastest clean-up of the subsurface environment. Moreover, the models predict that the remedial action will eliminate further transport of vapors to the aquifer. The computer models are currently being applied to design the optimum gas pumping configuration for the RWMC. Computer simulations of vacuum vapor, illustrate the removal of the subsurface plume as a function of time. A field demonstration of the vacuum vapor extraction is planned for FY-89.

EG&G Idaho Scientists Help Solve Waste Problems Associated with Solvents

At Air Force Logistics Command Centers located worldwide, toxic wastes that are generated by aircraft refurbishing and refinishing processes are a problem of major concern. Helping to solve this waste problem are EG&G Idaho scientists at the INEL Research Center who have identified a number of biodegradable solvents that can replace chlorinated hydrocarbon solvents.

Chlorinated hydrocarbons, such as 1,1,1-trichloroethane and P-D-680 are currently used for degreasing aircraft engine parts. These compounds are not biodegradable and cannot be treated in Industrial Waste Treatment Plants (IWTPs) that use biological processes for organic removal. Such wastes must be placed in drums and shipped to hazardous waste disposal sites. Other solvents, such as chlorofluorocarbon-113, are being placed under strict control of the Environmental Protection Agency for their ozone depleting effects.

EG&G Idaho scientists screened approximately 200 solvents for biodegradability, cleaning efficiency, and corrosiveness. Of those 200 solvents, scientists identified nine that are easily biodegradable and minimally corrosive yet clean as well as the currently used toxic solvents.

Biodegradable solvents can be treated in IWTPs in which microorganisms "eat" the solvents and produce CO_2, a harmless gas. In addition to helping protect the environment, using these solvents should be cost effective. Currently, toxic solvents, in the form of liquid, have to be solidified, put in drums, and transported to disposal sites. Using the solvents identified by EG&G Idaho scientists, solidification and transportation costs will be eliminated.

A Fast Thorium-230 Field Determination

In the uranium milling process, uranium is removed leaving radioactive daughters of uranium as residues or tailings. The Department of Energy is removing tons of tailings residues as part of the Uranium Mill Tailings Remedial Action (UMTRA) Projects. The milling process created a biased distribution of products. Some of the thorium-230, a radioactive decay product of uranium and the parent of the radium-226 in the tailings, was concentrated in one direction in the milling process while the radium was concentrated in another. The problem with this disequilibrium between thorium-230 and radium-226 is that radium radioactive decay products are easy to measure, but thorium-230 radioactivity is not. It decays by emitting an alpha particle which is of such low energy that it cannot pass through a paper barrier or soil. Thorium will eventually decay into radium-226, so the ability to detect it and to ensure that it is removed, as well as the radium, is essential to tailings remedial action.

Natural thorium is all thorium-232 and is easily detected by the gamma-ray emissions from the daughters of thorium-232. Thorium-230 is usually measured in the laboratory from soil samples brought back from the field site. In the laboratory, the soil samples are carefully prepared so that the thorium-230 can be chemically extracted and its alpha radioactivity measured. However, waiting for the analysis results with heavy earth moving equipment standing by is expensive, so there existed a need for an on-site method of determining thorium rapidly with reasonable accuracy and precision.

A number of groups around the country are working on this problem, the Technical Measurements Center (TMC) among them. The TMC, at the Grand Junction Projects Office, has come up with a method which they believe to be the fastest practical method yet developed. It takes less than one hour per thorium-230 determination which is much faster then sending samples to the laboratory and waiting for the results. Simply stated, the TMC method is a hybrid developed by deleting certain parts of the standard laboratory method and abridging other parts.

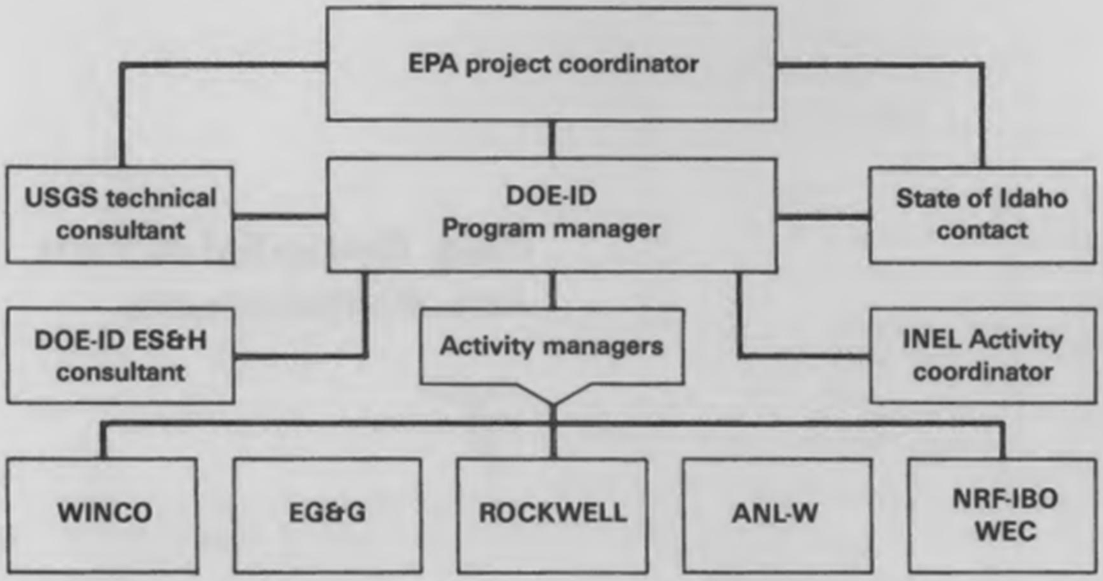
The consequence of this shortcut is that the abridged chemical part of the method does not extract all the thorium-230 in the samples. Field testing at various mill tailings sites and an Environmental Protection Agency (EPA) Superfund radium cleanup site demonstrated convincingly that the extraction efficiency is fairly constant for a site although it may vary from site to site. Many measurements on samples from five different sites, including the EPA Superfund site, indicated that with a confidence of 95%, the expected precision for any single measurement will vary from 22% to 57% - the exact number is site specific. The 41% precision at the Superfund site has convinced the EPA of the method's usefulness. The EPA plans to use the TMC thorium-230 method on the Denver Radium Superfund Project.

INEL Remedial Action Accomplishments

Through the Department of Energy's (DOE's) Environmental Restoration Program, the INEL is actively identifying and pursuing solutions to problems generated from past waste management activities. Although early activities were initiated pursuant to requirements of a DOE Order, the controlling requirement has now become the implementation of a signed agreement between Region X of the Environmental Protection Agency (EPA), U.S. Geological Survey (USGS), and the DOE-Idaho Operations Office (DOE-ID). This first-of-the-kind document, signed into effect in July 1987, is in the form of a Consent Order and Compliance Agreement (COCA) and lays out how the signatories will work together to achieve compliance with the Resource Conservation and Recovery Act (RCRA) at the INEL. The major emphasis of the COCA is to address actual or potential releases of hazardous constituents to the environment from past waste management units.

The number of solid waste management units identified at the INEL thus far is approximately 350. These units must now be worked through one or more of the several action paths described in COCA. The appropriate paths are based upon factors such as when the waste went to the unit, whether hazardous constituents are expected to be present, how serious the potential is for contaminant release, etc. The number of units to be investigated is large, but the number expected to require significant remedial action is only a fraction of the total. This is because the COCA calls for the INEL to identify all units where waste has been managed, including those places such as construction rubble piles and septic tank and drainage field systems where no hazardous constituents are expected to be present.

The COCA is not only a unique and trend-setting agreement in the relationship between the EPA and DOE, but has also presented an opportunity for DOE to establish and promote new avenues of internal coordination at the INEL. The COCA is signed and



DOE-ID management plan for implementation of EPA agreement.

Sampling of the Test Support Facility injection well.

managed by DOE-ID, but encompasses all INEL activities, including those controlled by other DOE offices. The Naval Reactors Facility (NRF) and Argonne National Laboratory-West (ANL-W), operated through the Pittsburgh Naval Reactors Office and DOE-Chicago, respectively, have agreed to implement the COCA through a DOE-ID focal point. EG&G Idaho has been asked to play a coordinating role for DOE-ID, but each of the INEL's prime operating contractors (EG&G Idaho, WINCO, Rockwell, ANL-W, and WEC) play full participating roles.

Sampling of the Test Support Facility paint shop floor drain leach field.

Carrying out the remedial action activities at the INEL has been a multidisciplinary team approach. The contractor's efforts have normally been managed from within environmental programs' and waste managements' offices, but support in completing individual tasks has come from numerous areas. Geoscience personnel have worked on preparing and implementing sampling and characterization plans and on interpreting the subsequent results. Engineering personnel have developed a computerized data management system for storing, validating, and analyzing incoming data from analytical laboratories. Chemical science support has been used to ensure quality of analytical results, supplemental to the computerized validation efforts.

Engineering organizations have also performed record and process reviews to provide initial characterization of sites, provided project engineering support, and along with science and technology programs, have worked on the development of potential treatment processes for remedial actions. The remedial action activities have made use of many existing areas of expertise at the INEL and have resulted in the INEL developing expertise in others.

The result of the INEL remedial activities will be compliance with the COCA and environmental regulations. But, more importantly, it will ensure protection of public health and safety and the environment. The federal government (in this case DOE) is accountable for its past waste management activities as is general industry. As generally acceptable waste management practices evolve and improve with time, knowledge gained must be applied to past activities if a threat or potential threat exists. An additional benefit from this work is the maintenance of a good neighbor relationship between the INEL and surrounding communities; a must for maintaining the INEL as a viable alternative for future DOE projects.

Denver Remedial Action Activities

Denver Radium Site

The Denver Radium Site Program is conducted through interagency agreements between the Environmental Protection Agency (EPA) and the Department of Energy (DOE). Under these agreements, DOE's Grand Junction Projects Office (GJPO) conducts remedial design and action at 11 groups of properties included in the Denver Radium Superfund Site. These properties contain radioactive residues from the radium refining process, conducted between 1914 and 1924, which were discarded or left on site.

Exemplary performance on the Denver Radium Site resulted in significantly increased EPA funding from $300,000 at the beginning of FY-88 to a year-end level of $6,700,000. Additional scope of work includes characterization of unexpected hazardous wastes, ground water investigations, development of action plans for the disposition of contaminated material, and provision of technical oversight for the remedial investigation/feasibility study of one of the operable units under the direction of the State of Colorado.

Surplus Facilities Management Program

Support for Surplus Facilities Management Program (SFMP) activity is provided through the Monticello (Utah) Vicinity Properties project (MVP) and the Monticello Millsite Remedial Action Project (MRAP). Defense Decontamination and Decommission Program support is provided through GJPO. These projects involve all aspects of the remedial action process for contaminated vicinity properties and a major uranium millsite in Utah, and for the uranium pilot plant formerly operated on the premises of DOE's GJPO facility.

A Federal Facilities Agreement is being negotiated between the Environmental Protection Agency (EPA) and the DOE to cover the on-going work on the SFMP projects since both projects are on the National Priority List. The result of a series of meetings and presentations with the Colorado Department of Health supported the DOE approach to the remedial action and sanction of the disposal of the GJPO tailings in the UMTRA respository.

Uranium Mill Tailing Remedial Action Project

Support for the Department of Energy (DOE) Uranium Mill Tailing Remedial Action (UMTRA) project is provided through three constituent projects: Grand Junction Vicinity Properties, Edgemont (South Dakota) Vicinity Properties, and Site Characterization. The vicinity properties projects involve all aspects of the remedial action process for an estimated 4,000 contaminated vicinity properties in two locales, including land survey, radiologic characterization, engineering design, subcontracted construction, verification survey, and closeout. The Site Characterization Project encompasses radiologic characterization for engineering purposes and provision of analytical-laboratory support to other DOE subcontractors at 24 uranium millsites throughout the United States.

Despite the severe winter weather in Grand Junction for the last nine years, the vicinity properties work in Grand Junction exceeded all major milestones while achieving a substantial budget savings of $4.3 million that were reinvested in added program scope.

Added program scope accomplished during the year included work on three ground water tasks. These tasks were to provide an assessment of vicinity properties whose remedial action may be affected by compliance with the proposed Environmental Protection Agency (EPA) ground water standards; evaluate the current legal means to prevent the use of contaminated ground water (i.e., institutional controls) in the affected states and tribal lands; and, support DOE-Albuquerque in an independent review of budget assumptions and cost requirements to carry our potential ground water cleanup/protection measures.

In September 1988, cleanup began on the 2000th vicinity property. This marked the halfway point for removal of mill tailing in the Grand Junction Projects Office's largest project. In South Dakota, the city of Edgemont sewage lagoon was completed ahead of schedule, and the city was able to meet new sewage requirements and avoid potential EPA fines.

FACILITY OPERATIONS

Effective Alarm Filtering

A new approach to alarm filtering and prioritization has been developed, implemented, and fielded by INEL engineers. This new approach, known as the Alarm Filtering System (AFS), dynamically prioritizes alarms according to the process state. The approach utilizes relationships between alarms as a basis for determining relative priorities. These relationships were the result of understanding and modeling how operators respond to alarms. The approach has been patented by the Department of Energy and has been licensed to commercial vendors.

Dan Corsberg, an INEL engineer, invented and implemented the Alarm Filtering System.

The AFS was originally developed three years ago as a prototype for the Advanced Test Reactor (ATR), a research reactor at the INEL. ATR engineers were interested in operator aids to address the information overload problem. Based on the prototype, a decision was made to plan on incorporating AFS into the upcoming control room upgrade. Since that decision, AFS has been ported to the computers of the ATR simulator. Working with the ATR training simulator, AFS is being used and evaluated by operators as they train for the new control room. Plans are to include AFS in the actual control room upgrade in early 1989.

At ATR, AFS performed well, responding to a typical alarm activation (or deactivation) within 15-25 milliseconds. A key issue in the successful use of AFS by operators has been the displays. While the current displays are adequate, operators have made many suggestions for added capabilities. Once these enhancements are implemented, the displays will evolve into a very simple, concise, and effective operator aid.

While work was progressing at ATR, a chemical processing plant (FAST) at the INEL was also experiencing problems. Just as the processes are different at ATR and FAST, so too were the alarm problems. The various systems at ATR are interrelated, meaning that a transient in one system would ripple through many other systems. This caused the on-rush of alarms that ATR experienced. At FAST, systems were not so interrelated, but they were experiencing a steady stream of alarm messages. In analyzing the messages, it was found that many were expected because of the process state or plant evolutions.

Using the same approach and relationships that were developed for ATR, many of the alarm problems at FAST were addressed. One major point of difference was that FAST allowed AFS to inhibit the display of some messages. This allows AFS to reduce alarm message traffic by over 90%. Messages that are not inhibited are further prioritized to ensure that the most significant ones are always displayed on the screen. Currently, AFS is installed at FAST and has been used for several months in the control room.

Advanced Test Reactor simulator.

The AFS offers solutions to alarm problems in real control room environments. While it does not solve all the problems faced by the operator, it is a step towards more effective operator-control room interfaces. The approach itself is applicable to a wide variety of processes, as evidenced by the fact that both FAST and ATR are using the same source code for determining priorities. The prioritized information that AFS produces can be displayed in whatever manner is appropriate. Finally, AFS is easily maintained, since changing relationships or adding alarms is simply a matter of changing records in a database. No modifications to the source code need to be made. The ATR recently added six new alarms to the system. Defining the new relationships and setting up the associated paperwork took about four hours. The changes to AFS took 20 minutes to enter and check. As process facilities evolve and change, AFS can support those modifications with minimal effort.

Waste Calcining Facility

The Department of Energy (DOE) and Westinghouse Idaho Nuclear Company (WINCO) marked the 25th anniversary of solidifying liquid high-level radioactive waste on July 1 with a ceremony at the Idaho Chemical Processing Plant (ICPP), operated for DOE by WINCO. Many veteran INEL employees who contributed to the success of the fluidized-bed calcining process were honored at the ceremony. Officials from DOE and WINCO, as well as Idaho Governor Cecil Andrus, attended the ceremony held at ICPP's New Waste Calcining Facility (NWCF).

The original Waste Calcining Facility (WCF) was designed as a demonstration plant to prove the feasibility of using a new fluidized-bed calcination process conceived earlier at Argonne National Laboratory (ANL) to solidify highly radioactive liquid waste solutions. The fluidized-bed process uses air flow to make solid particles behave like a liquid during conversion. Pioneering development work on this process began in 1955. The results were encouraging, and a proposal to demonstrate the concept on a large scale was accepted by the U.S. Atomic Energy Commission in 1956. The original waste calciner and the first bins for storing solid wastes were designed and built at an approximate cost of $6 million. Construction began in 1958 and was completed in 1961.

The WCF began solidifying radioactive liquid waste on December 8, 1963. After a successful demonstration run, WCF operated routinely as a production facility for 18 years. About 3.9 million gallons of liquid waste were solidified before WCF was shut down in 1981 at the end of its useful life.

The New Waste Calcining Facility at the Idaho Chemical Processing Plant.

Design for the NWCF began in 1974 and construction started in 1976. The $92-million facility incorporated the latest advances in fluidized-bed calcination, off-gas cleanup, remote operations and maintenance, and decontamination processes. The remote capabilities installed at NWCF are some of the finest in the world. They were tested in a full-scale mock-up facility at the INEL. As a result, high-failure-prone equipment in the NWCF was identified and positioned for easy removal and replacement without lengthy facility shutdowns or high radiation exposures to operating personnel.

Calcine veteran Bert Wheeler, right, receives a plaque commemorating 25 years of calcining at the ICPP from Don Ofte, Manager of the DOE-ID Operations Office, left, and Idaho Governor Cecil Andrus.

After opening in 1982, NWCF calcined about 1.6 million gallons of waste before shutting down for maintenance and modifications in March 1984, when all available liquid waste was processed. During the maintenance period, a sophisticated Distributive Control System was installed which replaced the original control system. The new computers gave NWCF operators the ability to constantly monitor and control every plant function through computer screens.

The NWCF was restarted in September 1987 and has already calcined more than 800,000 gallons of liquid waste. The NWCF is the only plant in the nation being used to solidify government-owned high-level liquid radioactive waste. It continues to employ the same process technology demonstrated with the original WCF. Solid calcined wastes are now safely stored at ICPP in bins with a design life of more than 500 years. The wastes will eventually be converted to an even more stable form, probably ceramic logs, and will be shipped offsite to a permanent federal repository.

Two bin sets for storing calcined high-level radioactive waste at the ICPP. The plant celebrated 25 years of calcining in 1988.

COOPERATIVE STUDIES

University Cooperative Program Active At GJPO

Significant progress was achieved during the year with the acceptance of the Grand Junction Projects Office (GJPO) as a cooperating laboratory by the Associated Western Universities, Inc., which has 37 member institutions. A graduate student from Vanderbilt University, working with the GJPO Technical Measurements Center, completed his research project, resulting in an article, "The Half-life of Polonium-218" for publication in the *Health Physics* journal. Seven undergraduate students worked with the Uranium Mill Tailings Remedial Action Program during the summer. The students represented six different colleges and universities - the University of Colorado, Colorado State University, Mesa State College, Western State College, the University of South Carolina, and Wabash College, Indiana.

Double Beta-Decay: A Nuclear Physics Experiment In An Idaho Silver Mine

In collaboration with scientists from Lawrence Berkeley Laboratory, Mount Holyoke College, and the University of New Mexico, INEL scientists conducted a search for the rare nuclear process double beta-decay in a silver mine near Kellogg, Idaho.

The research takes place in the Consolidated Silver Mine, 4,000 feet below the Earth's surface, in order to shield the sensitive experiment from cosmic rays. Designed to measure processes with half-lives 10^{18} years or longer (10^{18} years is a billion billion years; the age of the universe is thought to be 10^{10} years), it is one of the most sensitive nuclear physics experiments ever performed.

The INEL has the responsibility of purification and fabrication of the molybdenum-100 (^{100}Mo) sources crucial to the experiment. The required 10 parts-per-billion purity required will be assayed by activation analysis in the INEL's Advanced Test Reactor. INEL physicists also assisted with the operation of the underground experiment.

Joint INEL/Fish and Wildlife Service Program Develop Contaminant Monitoring Plans

Expertise developed at the INEL by the Center for Environmental Monitoring and Assessment (CEMA) and the Environmental Sciences and Engineering unit is being applied in a multiyear project to determine if pollutants pose a threat to fish and wildlife resources in the United States.

The Fish and Wildlife Service has entered into an agreement with the INEL to develop a contaminant monitoring plan to identify where, why, how, and when to collect samples at an National Wildlife Refuge (NWR). This plan uses an integrated ecosystem approach that looks at all parts of the environment. Using this comprehensive technique allows the manager of the NWR to consider all sources of contaminants, how they interact with the environment, and the most probable impacted receptor. The program will help managers improve their sampling and monitoring techniques to detect refuge contamination, provide a consistent set of sampling methods, and detect trends so that potential problems can be forecasted.

In addition to the wildlife refuge plan, EG&G Idaho's CEMA is also using its numerous years of experience in designing environmental monitoring systems to develop a long-term national contaminant monitoring strategy to determine the presence of pollutants in fish and wildlife resources across the country. This program will require coordination with many other federal agencies since many of the fish and wildlife use lands are managed by these agencies including nesting, wintering, and feeding areas (i.e., Department of Energy National Laboratory System, Bureau of Land Management, Park Service, and U.S. Forest Service).

This long-term national contaminant monitoring strategy will use many of the techniques being developed for the NWR monitoring plan and integrate it with environmental monitoring activities conducted by other agencies. The objective of this effort is to establish a consistent strategy for sampling and data collection procedures that will provide the Fish and Wildlife Service with a larger database to assess the status, trends, and the impact of man's activities on the fish and wildlife resources in the U.S.

Denver Support Office Participates in Electri-Cycle Project

The Denver Support Office, Public Service Company, and Colorado Office of Energy Conservation have joined together to build an "Electri-cycle." This joint effort is intended to educate people about the cost and effect of electricity and the need to conserve energy. The Electri-cycle is connected to a computer and read-out meters which visually display how much electricity the rider is actually producing as he rides. The computer then translates the amount of electricity produced into a variety of everyday comparisons to give the rider a sense of what it takes to run electric appliances, lights, etc. The Electri-cycle is built on a mobile trailer which Public Service will be displaying around the state over the next month.

Tunnel Neutralization Team Support Program

Through an interagency agreement between the Department of Energy (DOE) and the Department of the Army's Belvoir Research Development and Engineering Center, DOE-Grand Junction Projects Office (GJPO) and UNC Geotech supported the Eighth U.S. Army and the South Korean Army as part of the Tunnel Neutralization Team (TNT) Support Program. The GJPO became involved in the program in 1985 because of its geotechnical and engineering expertise.

The present role of the GJPO is to provide technical and administrative support to TNT. Technical support includes field operations, data processing, and procurement/development of state-of-the-art instrumentation, equipment, data processing software, and interpretive techniques for implementation in Korea.

National Low-Level Waste Management Program

EG&G Idaho, as lead laboratory for the Department of Energy (DOE) Low-Level Radioactive Waste Management Program, provides management and technical assistance to support the disposal of low-level radioactive waste. Established in 1979, the National Low-Level Waste Management Program divides its activities into two areas: Defense Program and Nuclear Energy Program. The Defense Program supports waste management operations at DOE facilities; the Nuclear Energy Program supports development of new commercial low-level waste disposal capacity.

Defense Program

The Defense Program provides a central organization to identify DOE-wide needs, coordinates technology development activities to meet those needs, and promotes the use of improved technology at DOE facilities. As an independent organization, the program develops and recommends criteria and guidance for DOE low-level waste management activities. Specific program objectives are to identify, develop, and recommend improved waste management technologies and practices, and assist with transfer of these technologies to DOE operations; develop and recommend an integrated systems approach for managing all DOE low-level and mixed wastes; identify and develop a consistent DOE system-wide approach for disposal facility performance assessment; and provide guidance for, and assist with, the implementation of DOE's low-level waste management, DOE Order 5820.2A, Chapter III, at DOE facilities.

Nuclear Energy Program

The Low-Level Radioactive Waste Policy Amendments of 1985 charges the U.S. DOE to assist the states and compact regions in fulfulling their responsibilities to provide for disposal of low-level radioactive waste generated within their borders.

The Nuclear Energy Low-Level Waste Management Program assists states in developing an effective nation-wide low-level waste management system by providing technical assistance, maintaining a national low-level waste management information system, and preparing Congressionally mandated reports.

The program assists states and regions by developing and distributing technical information; developing and demonstrating treatment and disposal technology; collecting, analyzing, and reporting waste management information; providing computer analysis tools; and providing direct technical assistance to states and regions for meeting their responsibilities to provide for new low-level waste disposal. Some of the technology development projects include the Mobile Incinerator, Dresden Power Plant, Morris, Illinois; Disposal Site Monitoring, Savannah River Plant, Aiken, South Carolina; and the Grouting Demonstration task at Maxey Flats, Kentucky.

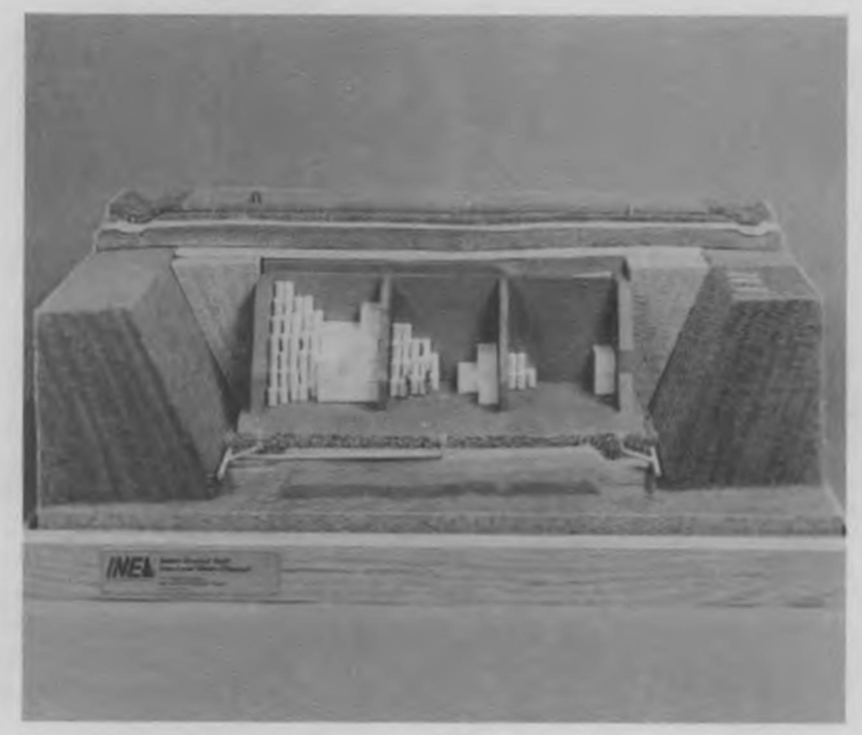
Past activities of the program have supported the development and implementation of regional compacts for the disposal of commercial low-level waste. As a result, in part, of program efforts, Congress has ratified eight regional compacts.

Waste Information Systems

The National Information Management System is a combination of database information, models, and project management systems that have wide-spread applicability. The shipment monitoring and communication systems, while of no less importance, have a more focused applicability to specific region, state, or user's group needs.

Some specific information that can be extracted from these services is monthly updated low-level waste volume information on waste disposed of at the three commercial disposal sites. These data can be retrieved by compact or state, any month or sequence of months. The system also maintains cumulative totals of volumes disposed of from each commercial power reactor, allowing the sited states and utility managers to monitor reactor allocations.

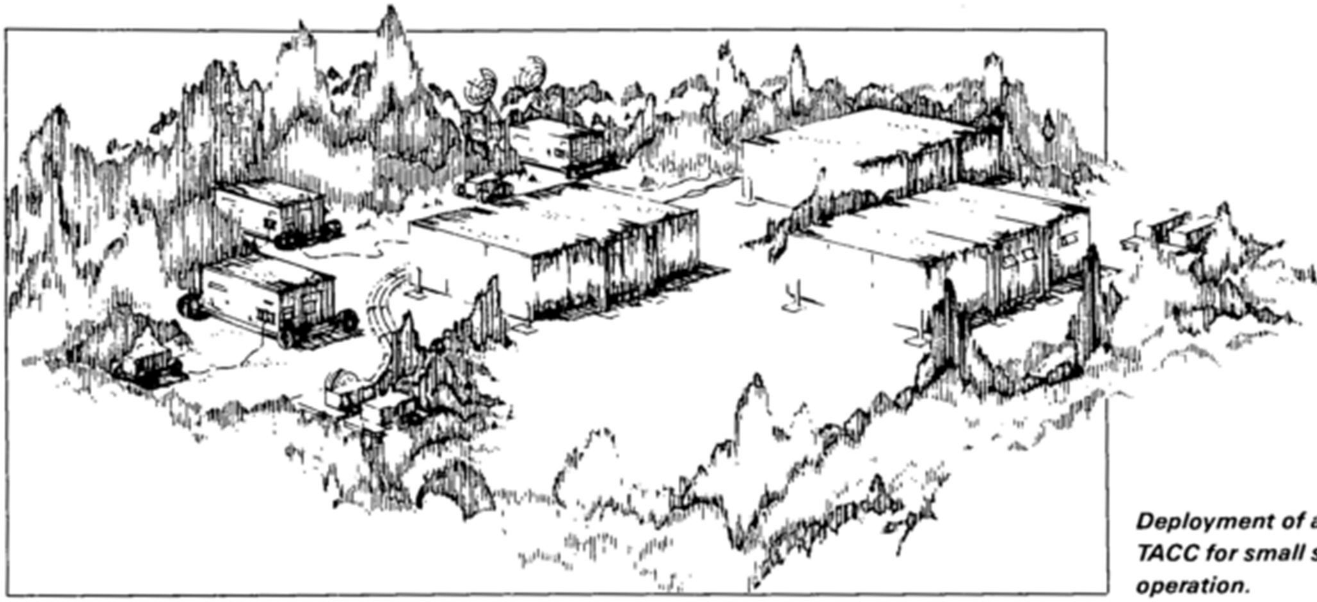
The newest database in the production environment is the Records Inventory Management System (RIMS), a repository for state, compact, and Federal documents concerning low-level radioactive waste.



Model of a below ground vault.

Model of intermediate depth disposal.

ASSISTANCE TO THE ARMED FORCES



Deployment of a TACC for small scale operation.

The INEL Enhances Conventional Defense Capability

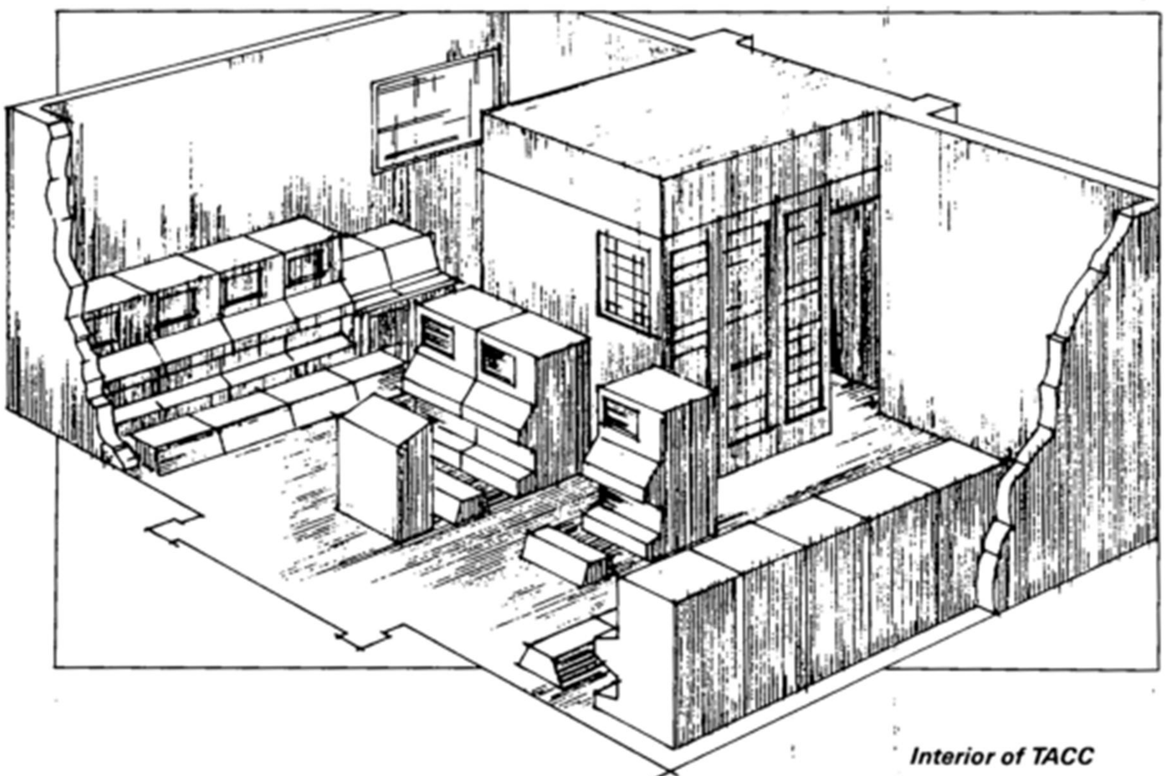
The INEL has undertaken a major effort to assist the Tactical Air Command with the modernization of the Tactical Air Control System (TACS). The TACS incorporates all of the command, control, communications, and intelligence capabilities necessary to orchestrate the employment of tactical air forces in contingency or full scale wartime engagements wherever in the world they may be deployed. Air forces are normally deployed as part of a joint task force consisting of both air and land forces, and operate under a Joint Task Force Commander. The TACS must provide the capability not only to control the air battle, but also to provide coordinated air support to ground forces in the Close Air Support mission. The overall command and control structure for offensive operations of a joint task force is illustrated in the figure. The INEL is developing prototypes of each of the command centers as a totally integrated system.

The INEL provides all the engineering required to integrate previously produced hardware and software and develops original hardware and software systems required to ensure a totally integrated system. Most of the previous hardware and software requires adaptation/modification in order to attain the acceptable compatibility for integration. The overall INEL system design incorporates an open architecture which will facilitate the continued modernization and upgrading of the system as newly developed decision aids, advances in battle management techniques, or improved communications become available. The design incorporates the latest available technologies such as fully distributed processing; relational, distributed database management systems; protection against undesirable emanation; and survivability measures.

The prototypes developed by the INEL will be field tested, and the design will then be improved as a result of field test experience. These improved designs will become the basis of a major procurement action by the Air Force to acquire the large quantities of these systems necessary to support tactical air operations. The INEL will transfer technology to industry or other government agencies for this production phase of the TACS modernizations program.

A typical deployment of the Tactical Air Command and Control TACC for small scale operations and the interior of the TACC shelter are illustrated.

The TACS Modernization Program enjoys very high priority within the Tactical Air Command as an urgently needed conventional defense capability. The need for this force modernization program has been enhanced by reductions in nuclear weapon delivery systems under the Intermediate Nuclear Forces treaty. The development of these prototypes by the INEL represents a major contribution to enhancement of the conventional defense capability of the United States.



Interior of TACC expanded shelter.

NEW PROJECTS AND CAPABILITIES

Radiological and Environmental Sciences Laboratory

The Department of Energy's (DOE's) Radiological and Environmental Sciences Laboratory (RESL) is one of only three laboratories in the DOE system operated by federal personnel. Its mission is undergoing significant change in response to increasing health and safety oversight requirements.

The Radiological and Environmental Sciences Laboratory.

The RESL has traditionally performed radiological measurements in support of worker and environmental protection for both DOE and the Nuclear Regulatory Commission (NRC). Now INEL site support activities, such as personnel dosimetry and bioassay, are being increasingly performed by INEL contractors while RESL is emphasizing its role as an oversight and standardization laboratory.

The RESL continues to provide environmental surveillance of the INEL and its environment and to conduct environmental research in cooperation with universities. A university-based independent monitoring program to complement ongoing environmental surveillance activities is being established.

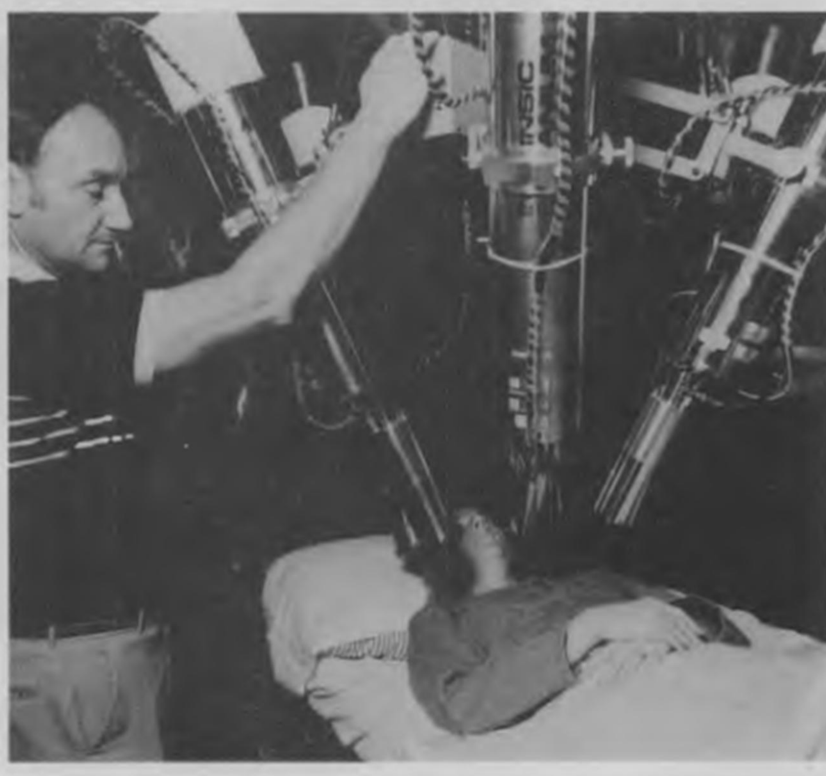
New analytical instrument employs laser technology.

The RESL now administers and conducts performance testing of all DOE and DOE-contractor personnel dosimetry programs for the mandatory DOE Laboratory Accreditation Program in personnel dosimetry. Initial work for similar programs in bioassay and whole body counting began in FY-88, and pilot studies for these programs are planned for FY-89.

The NRC recently designated RESL as its official Reference Laboratory. RESL will prepare reference standards to test the capabilities of NRC regional laboratories and NRC licensees. Additionally, RESL analyzes samples to resolve disputes between the NRC and its licensees.

Two new capabilities were acquired by RESL this year. Kinetic Phosphorescence Analysis employs laser technology to allow faster, more sensitive and more accurate analysis of certain uranium isotopes. A new lung counting system permits direct assessment of transuranic radionuclides in humans at lower levels than previously possible.

Overall, RESL continues to improve its capabilities as it shifts from analytical work in support of site programs toward oversight and standardization activities. These important new activities help DOE and NRC ensure that their contractors and licensees are capable of correctly performing the complex measurements required by health and safety programs in today's nuclear facilities.



A new lung counting system permits direct assessment of transuranic radionuclides.

New Environmental Cleanup System

Idaho Chemical Processing Plant Injection Well to be Capped

In July 1988, the Department of Energy announced that the injection well at the Idaho Chemical Processing Plant (ICPP) would be plugged and capped during 1989. The injection well has not been used for more than two years.

Capping the injection well will culminate a $5.6 million service waste upgrade project that is expected to be finished in the spring of 1989. The project involves installing five new pumps and a 90,000 gallon underground surge tank that, when completed, will eliminate the need for the injection well.

Only one pump is needed to transport waste water to the evaporation ponds under normal flow conditions. Two pumps will handle the maximum flow conditions. The three other pumps are being built as backups. In the unlikely event that all five pumps fail, the water would flow into the surge tank. ICPP officials estimate that it would take one to two hours to fill the tank - enough time to restore the pumps.

Since 1984, the injection well has been used only for emergency discharges when the pumps to evaporation ponds failed. There have been no discharges to the injection well since March 1986.

Liquid Effluent Treatment and Disposal

The ICPP generates about two million gallons of waste water each day. This liquid effluent, which is now pumped to evaporation ponds, consists of non-radioactive cooling water, steam condensate, water softener and demineralized waste water, and process waste evaporator condensate.

The process waste evaporator condensate contributes very low levels of radioactivity to the liquid effluent. Another major environmental project at ICPP, Liquid Effluent Treatment and Disposal (LET&D), will eliminate the evaporator condensate from the waste water. It is scheduled to come on-line in 1991.

NOx Abatement Project

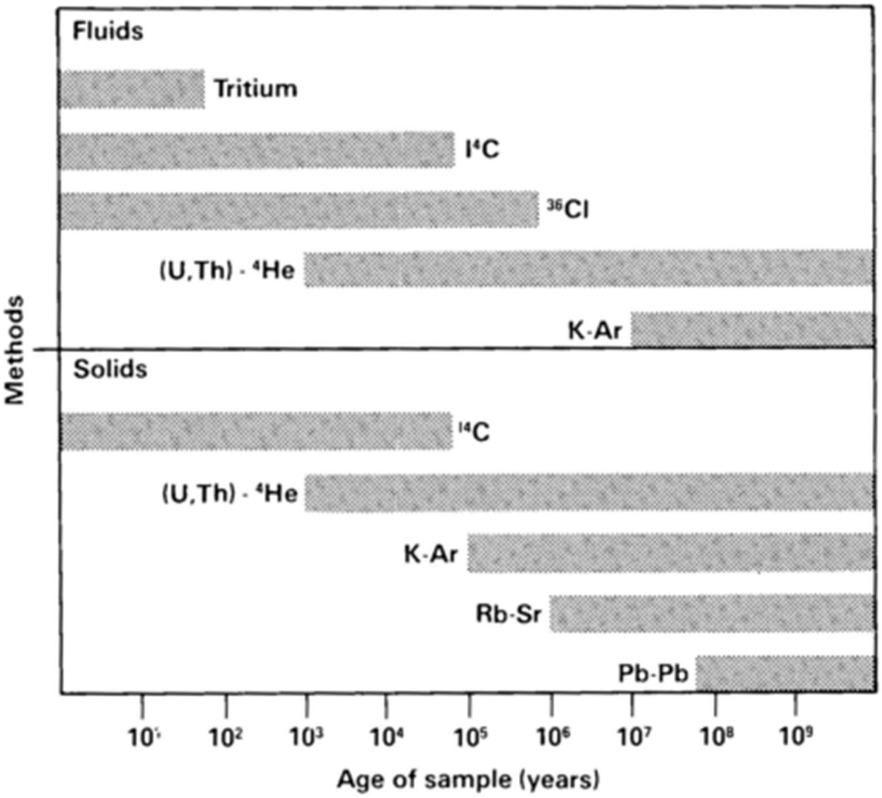
A third environmental cleanup project involves removing the orange-brown nitric oxide (NOx) emmissions from the New Waste Calcining Facility off-gas stream. The NOx Abatement Project is now in the pilot plant testing stage. Construction of the full-scale facility is projected to begin in 1992, and the plant is expected to be on line in the mid-1990's.

Component Development and Integration Facility in Butte, Montana.

New Hardware for Component Development and Integration Facility

Preparations were made for installing and operating new generation hardware at the Component Development and Integration Facility (CDIF) in Butte, Montana. The coal/seed transfer systems were upgraded to reduce operator workload and increase system reliability. A combustion diagnostics system was designed and installed, and new plant systems and interface designs were developed to support the installation of the TRW-supplied, coal-fired precombustor.

During testing at the CDIF, a record coal-fired combustor peak power of 1.77 MW_e was attained. In addition, the total hours of testing increased over the last year with fewer tests being run. Both the higher power levels and the increased test time are important contributors toward solving technical issues in the goal of commercializing magnetohydrodynamics.



Water and rock samples can be dated by various methods, each with a particular realm of application.

Isotope Mass Spectrometry Laboratory

The Isotope Mass Spectrometry Laboratory at the Grand Junction Projects Office specializes in the measurement of all five noble gases - helium, neon, argon, krypton, and xenon - including geochronology by the uranium-thorium-helium and potassium-argon dating methods using isotope dilutions. The laboratory performs neutron activation argon-argon and iodine-xenon dating. Measurements are performed using status mass-spectrometer methods at ultrahigh vacuum conditions (to 10^{-12} atmospheres).

The current principal applications of these measurements are for the study of ground water systems. From the radiogenic noble gas (helium and argon) data, estimates of the residence times of ground water movement are determined. The direction of flow can be determined when areal variations in helium are present. Limitations on the paleotemperature and original composition (salinity) of recharge waters can be obtained from the non-radiogenic noble gases.

Studies on ground water transport have been conducted at the sites proposed for storage of high-level nuclear waste and at uranium ore deposits in Wyoming. Ground water systems involving important environmental concerns, such as transport of associated contaminants, have also become an important realm of study.

The laboratory participates in numerous collective efforts with other Department of Energy facilities, universities, and private industry. Specialized water sampling equipment and written procedures for field sampling are also available.

IN BRIEF

INEL Helps Evaluate Arms Control Pact

At the December 1987 summit, the United States and Soviet Union agreed to hold talks on the reduction of strategic nuclear weapons. President Reagan insisted that any new arms control agreements must be accompanied by measures for ensuring effective verification of compliance.

In December, the Department of Energy (DOE) requested five of its national laboratories, including the INEL, to technically evaluate verification provisions of a Soviet proposal presented at the summit. The INEL response was integrated with the other laboratories, and a briefing was given by DOE to the U.S. Strategic Arms Reduction delegation on January 10, 1988. The DOE technical assessment will play an important part in the formulation of the U.S. government policy.

The team of INEL scientists and specialists produced its findings and forwarded them to DOE Headquarters. Since then, INEL has been requested to participate and assist on related technical working sessions.

The INEL technical assistance in the U.S. Strategic Arms Reduction Talks verification process is considered a milestone. Opportunities for the INEL to participate in this process not only provided DOE with top caliber technical assistance, but also provided the INEL with a clearer understanding of the government's evolving needs.

SP-100 Engineering Mockup Critical Experiments

During the last half of FY-88, Zero Power Plutonium Reactor (ZPPR) (critical assembly) tested the SP-100 space reactor design for accuracy in predicting physics parameters related to performance and safety. The goal of the SP-100 project is to build a 100 kilowatt-electric reactor that can be launched by the space shuttle and used to power a broad assortment of space missions. The principal purpose of the ZPPR-20 tests is to support the design of the reactor that will be built for the Nuclear Assembly Test. Therefore, in addition to the full-size reactor, internal and external control elements, and flight shield, the tests include mockups of the vacuum vessel and the near shield and insulation. Additional tests will be performed to address the safety issues of the effects of flooding (crashing into the ocean). Significant results to date show that the nominal design has to be adjusted 1% for fuel loading and about 15% for reactor control.

In addition to Argonne National Laboratory-West, other participants in the ZPPR-20 program include Westinghouse, General Electric, and Los Alamos National Laboratory.

Department of Energy-Grand Junction Hosts Radon Forum

The Department of Energy (DOE) Grand Junction Projects Office (GJPO) hosted a two-day meeting in February for DOE-Headquarters and Contractor personnel at the the first Departmental Radon Forum. The forum gave participants an opportunity to exchange information about their individual programs, technical goals, current results, and future plans. Discussions covered work being done with naturally-occurring radon sources and man-made sources. Sponsored by the DOE-Headquarters Office of Environment, Safety, and Health (EH), the meeting included representatives from EH; Bonneville Power Administration; Conservation and Renewable Energy; Defense Programs; Energy Research; and Nuclear Energy. EH plans to use the forum proceedings to discuss possible cooperative efforts between DOE and the Environmental Protection Agency.

EG&G Idaho Scientists Use Chilean National Park to Study and Track Global Pollution Spread

Within a remote Chilean national park, EG&G Idaho scientists are taking a lead role in an international environmental monitoring pilot project. This work may pave the way for the INEL to participate in a premier environmental project starting in the next several years.

INEL scientist teaches Chilean rangers how to change a filter and package it for shipment to the INEL for analysis.

INEL scientists and specialists completed a nine-day data-gathering research effort in Torres del Paine National Park in April 1988. The work was done through the United Nations' Global Environmental Monitoring System (GEMS) project. The goal of GEMS is to develop and operate monitoring sites in remote locations worldwide and to develop baseline environmental data to help scientists evaluate the spread of pollutants.

The Torres del Paine GEMS site served as a locale for developing background reference levels of certain pollutants, provided a frame of reference against which changes in impacted areas can be measured, and will serve as an early warning system for changes of a global nature long before the changes become obvious in more impacted areas.

As one of the few organizations doing baseline environmental monitoring, collecting data through GEMS and similar work elsewhere, and perfecting monitoring techniques, the INEL is establishing itself as a leader in environmental baseline monitoring. This places the INEL in a good position to be included in a pending global pollution monitoring project of a grand scale.

Department of Energy Environmental Site Survey

The UNC Geotech staff supports EG&G Idaho/INEL in conducting environmental surveys at various Department of Energy (DOE) facilities. The purpose of the surveys is to identify current environmental problems and risks at the major DOE facilities. The results of the surveys will be used to prioritize these facilities for further characterization/remedial action.

During FY-88, analysis of radioactive samples from the Hanford Site in Richland, Washington, was completed, and sampling programs at the Savannah River Site in Georgia, and the Sandia National Laboratory in New Mexico, were completed. DOE-Grand Junction support consists of preparing site-specific sampling plans, collecting field samples, and providing analytical support at the UNC Geotech Chemistry Laboratory.

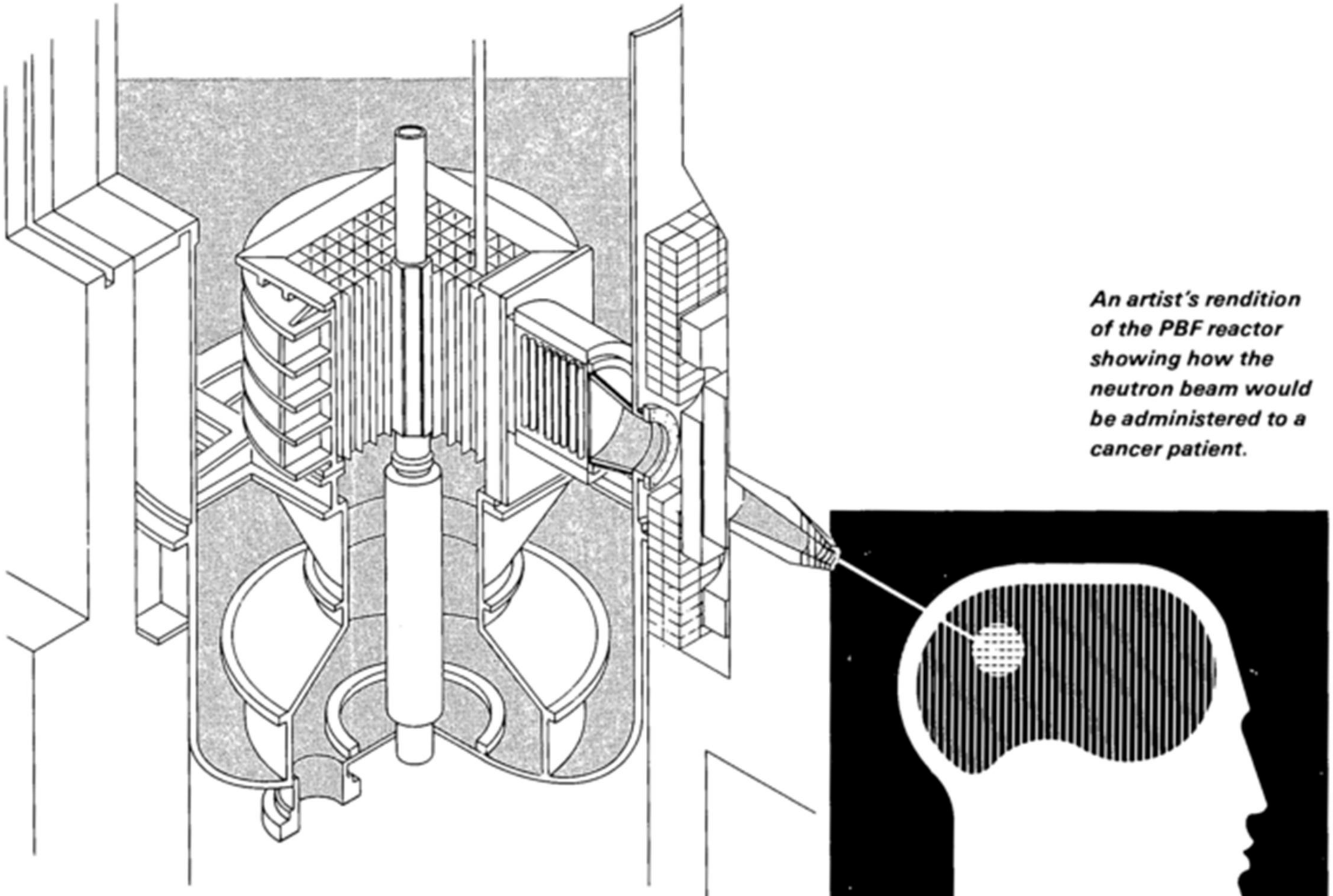
Technical support was provided to the DOE Kansas City Site Remediation Process. UNC Geotech conducted quarterly environmental monitoring and analytical support. Increased sampling activities have taken place as new monitoring wells have been completed.

Boron-Neutron Capture Therapy Project at Power Burst Facility

The goal of the proposed Boron-Neutron Capture Therapy (BNCT) project using the Power Burst Facility (PBF) is to scientifically conduct a clinical trials program to determine the viability of the process for treatment of a currently fatal form of brain cancer-glioblastoma multiforme. The objective of the EG&G Idaho BNCT program is to demonstrate that BNCT can significantly increase the quality of life for a patient relative to currently available treatment.

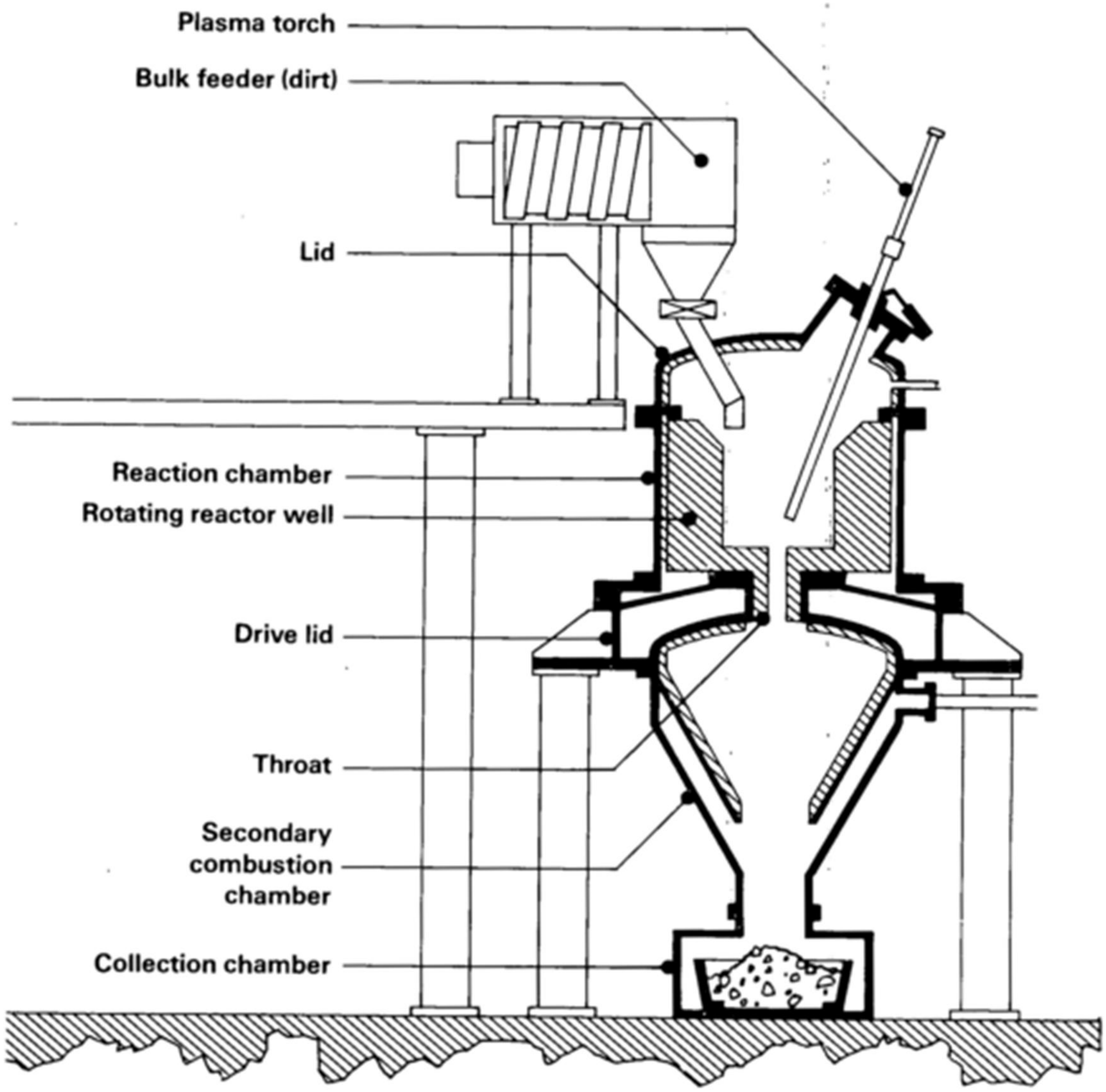
An EG&G Idaho team in nuclear engineering designed a neutron filter for regulating the velocity of the neutrons conveyed from a reactor to the patient. A filter of this type had never been built and verified. The first filter was installed at the Brookhaven Medical Research Reactor (BMRR). The BMRR is being used because it is a smaller, more accessible reactor in which the neutron beam filter can be quickly and inexpensively installed. The EG&G Idaho team measured the velocity distribution of the neutrons coming through the filter, and the measurement data was used to improve the design accuracy for the more expensive neutron filter that has be designed for use in the PBF reactor.

Researchers have agreed that to maximize the total benefit to the national BNCT effort, the same filtering material used in the BMRR will be used at PBF. The BMRR measurements provided a benchmark for the analytical tools used to design the PBF filter. The studies are helping to determine radiation dosages that audio long-term delayed necrosis, or death of healthy brain tissue, and to establish treatment limitations.



An artist's rendition of the PBF reactor showing how the neutron beam would be administered to a cancer patient.

Scientists have evaluated and are optimizing the best method for noninvasively locating and quantifying the amount of boron in the tumor and for determining microscopic boron distribution within the individual tumor cells. These techniques allow optimum treatment results with a minimum neutron dose and provide maximum protection of healthy brain tissue. Scientists are also evaluating the most desirable boron-administering procedures.



Plasma Centrifugal Reactor.

Component Development and Integration Facility Selected for Demonstration

The Component Development and Integration Facility (CDIF) in Butte, Montana, has been selected by the Environmental Protection Agency (EPA) as the site for a Superfund Innovative Technology Evaluation (SITE) demonstration of the Plasma Centrifugal Reactor. The Plasma Centrifugal Reactor destroys hazardous waste at high temperatures and has the potential for treating mixed waste. This will be the first joint Department of Energy-EPA SITE demonstration project. The SITE program was established by Congress as part of the Superfund program to encourage development of new treatment technologies.

This technology is the first non-magnetohydrodynamic program to be conducted at the CDIF. The plasma waste destruction is based on using an electric arc to heat wastes to temperatures that completely break down any organic compound into simple molecules such as carbon dioxide, water, and hydrochloric acid. This intense heat also fuses toxic metals into a nonleachable slag. The entire reaction takes place in a sealed combustion chamber under negative pressure with an exhaust gas scrubbing system that removes high vapor pressure metals, hydrochloric acid, etc., from the gas stream before discharge to the environment.

JUPITER-III Large LMFBR Cooperative Physics Program with Japan

The experimental phase of the JUPITER-III program, a cooperative effort with the Power Reactor and Nuclear Fuel Corporation of Japan, was completed in March 1988. During the last six months of the program, physics testing was done on the second largest fast-spectrum reactor ever assembled (Superphenix in France is larger). In September, sixteen Japanese scientists came to the INEL to discuss the results from the first half of the test program with reactor physicists from Argonne, General Electric, Westinghouse, and the Department of Energy. These results were the first data from a commercial-size (650 MWe), axially heterogeneous liquid-metal fast-breeder reactor (LMFBR). In an axial-heterogeneous design, a layer of breeder blanket material (depleted ^{238}U) is sandwiched between two layers of fuel in each pin over a large region of the core.

Analyses of the Zero Power Plutonium Reactor experiments generally confirmed the predictions for this type of reactor design, with calculations deviating from measured results only slightly worse than for conventional designs. However, the results were significantly more sensitive to calculational models.

Computer Applications and Technology Transfer Group Supports Work-for-Others' Efforts

The Computer Applications and Technology Transfer group supported the Information Resources Work-for-Others' efforts in providing systems modernization and micro-based conversion software for the U.S. Army Corps of Engineers and the U.S. Marine Corps.

The INEL supported the U.S. Army Corps of Engineers' systems modernization efforts through the Source Selection Evaluation Board (SSEB), prototyping, independent verification and validation, and database and systems architecture concepts with a FY-88 budget of approximately $4 million. The U.S. Marine Corps' tasks consisted of conversion and prototyping of 10 micro-based systems at U.S. Marine Corps Headquarters in Washington, D.C.; Quantico, Virginia; and Albany, Georgia, with a total FY-88 budget of $2.8 million.

The combined efforts resulted in over $6.8 million in funding for the Department of Energy-Idaho Operations Office.

MSE, Inc. Obtains Five-year Follow-on Contract

MSE was successful in obtaining the five-year follow-on contract for operating the Component Development and Integration Facility (CDIF), a major Department of Energy magnetohydrodynamic (MHD) test facility in Butte, Montana. Within the national MHD program, MSE personnel are responsible for performing integration testing of vendor-supplied MHD power train components at the CDIF to support the goal of commercialization. The contract became effective October 1, 1988.

Special Isotope Separation

The Draft Environmental Impact Statement (DEIS) for the Department of Energy's (DOE's) Special Isotope Separation (SIS) Project was released for public review on February 12, 1988. The purpose of the DEIS was to provide environmental input for a DOE decision on the proposed construction and operation of the SIS Project using the Atomic Vapor Laser Isotope Separation (AVLIS) process technology, and on the selection of a site for such a project. The DOE had previously announced that the preferred site for the project is the north end of the Idaho Chemical Processing Plant, operated by Westinghouse Idaho Nuclear Company (WINCO) for DOE.

The SIS Project would provide DOE with the capability to segregate the isotopes of DOE-owned plutonium into specific concentrations required for national defense. Before the DEIS was released, employees from DOE and WINCO were involved in a concerted effort to inform Idaho citizens about the project. These individuals spoke to community, business, and civic groups across the state and held numerous media interviews.

The DOE and WINCO stepped up public outreach activities in preparation for March public hearings on the DEIS. Originally, three hearing were scheduled, one each in Idaho Falls, Boise, and Twin Falls. Additional hearings were scheduled, one at each location, to accommodate the large number of people who signed up to testify. In all, 508 persons testified during 53 hours of testimony. Written exhibits totaled 811. A final Environmental Impact Statement and a record of decision are expected in FY-89.

Meanwhile, a team of 56 WINCO employees is stationed at Lawrence Livermore National Laboratory in California preparing to transfer SIS technology to the INEL when the project begins.

Annual Welding and Cutting Demonstration

The Annual Welding and Cutting Demonstration, sponsored by MK-Ferguson of Idaho Company (MK-FIC) in early February 1988, featured the latest state-of-the-art equipment and tools. The demonstration was very informative and extremely successful for FY-88 and resulted in procurement by several local subcontractors and the Plumber's and Pipefitter's Union, Local 648.

More that 300 individuals, representing all the INEL contractors (WINCO, EG&G Idaho, Rockwell, ANL-West, and NRF), the local subcontracting community, and representatives from labor organizations participated in the demonstrated processes. Some of the equipment demonstrated included plasma cutting systems and automatic welding and component positioning equipment.

Parameters for the automatic welding head are set using a hand-held keyboard.

SMC Manufacturing Expertise Developed

With the Specific Manufacturing Capabilities (SMC) Program at the INEL entering a fully operation mode, essential skills in manufacturing management, manufacturing automation, and production material logistics are well established.

Specific technical skills developed through the INEL participation in the SMC Program include automated control of fabrication and material-handling equipment, material and product storage and handling, maintenance of total quality records including genealogy and nonconformance data, manufacturing resource planning (MRP II), machine vision inspection, statistical process control, and statistical design of experiments.

ACHIEVEMENTS, AWARDS, AND COMMUNITY INVOLVEMENT

EG&G Idaho Captures Four R&D 100 Awards

Four major technological systems and processes developed by EG&G Idaho have been named among the top 100 scientific or technological achievements this year by *Research & Development* (R&D) magazine. Winning products for the annual R&D 100 awards are selected on the basis of their importance, uniqueness, and usefulness from a technological standpoint as determined by the magazine's editorial staff advisory board as well as other selected experts.

Don Ofte, Department of Energy-Idaho Manager, accepted all four awards on behalf of the INEL at the R&D 100 awards presentations in Chicago on September 22, 1988. The awards were given for "Improved Iron-Base Alloys from Noble Gas Doping" developed by John Flinn; "Neutral Beam with Sharp Focusing" an innovation by James Delmore, Anthony Appelhans, and David Dahl; "Oxynitride Braze Method for Joining Silicon Nitride Compounds," a new method devised by Robert Nielson, Jr., Dennis Coon, Stanley Scheutz, Randy Rice, and Richard Tallman; and "Biodegradation System for Toxic Organic Waste Processing" created by James Wolfram and Robert Rogers. A description of each of the award winning processes is provided.

Improved Iron-based Alloys from Noble Gas Doping

Research at the INEL shows that a new generation of iron-based alloys, particularly stainless steels, which display high temperature microstructure stability and strengthening, can be produced with powder metallurgy. The process relies on rapid crystallization of small molten droplets and entrainment of the atomizing gases. Rapid crystallization produces a high concentration of vacancies (missing atom sites). The presence of entrained gases such as helium (noble) and oxygen (reactive) stabilizes the vacancies to form vacancy-gas clusters. A fine dispersion of the clusters strengthens the alloy. They also provide sites in the alloy where fine precipitates, such as carbides, develop during aging heat treatments. Observations show that the vacancy-gas clusters and associated precipitates form in the grain interiors with few observed on grain boundaries. This cluster-precipitate dispersion improves the high temperature strength of the alloys.

Neutral Beam with Sharp Focusing

A new device developed at the INEL allows secondary ion mass spectrometry to be applied easily in analyzing surfaces of non-conducting materials. This device allows the production of high energy beams of the negative ion of a molecule of sulfur hexafluoride, a gas commonly used in the electrical and refrigeration industries. These negative ions can be accelerated to high energy by electric fields. Shortly after acceleration, they begin to spontaneously eject the extra electron. Since the internal vibrations of the molecule cause the electron to be ejected, the beam is not defocused by this step. The remaining charged particles and electrons can be skimmed off electrically or magnetically, and the resulting beam is composed of only high energy, electrically neutral molecules.

Oxynitride Braze Method for Joining Silicon Nitride Compounds

A team of scientists at the INEL developed a new method to join silicon nitride ceramics, enabling cost-effective production of large parts with complex geometries necessary for today's high-technology applications. This oxynitride joining method relies on the use of glass brazes that are comparable in composition to the material that binds the silicon nitride grains together. The binding material forms as a result of the addition of oxide densification aids that are added to silicon nitride powders during the consolidation processes used to form the ceramic. Densification aids are necessary because of the low atomic mobility in silicon nitride, even at the high temperatures used during consolidation. The oxide densification aids interact with the silicon nitride powder during consolidation to form oxynitride phases at grain boundaries in the ceramic. Oxynitride glass braze joining is accomplished by introducing a joint interface that is similar to the grain boundary interfaces already present in the ceramic. As a result, these joints ideally can provide properties comparable to that of the silicon nitride ceramic itself.

Biodegradation System for Toxic Organic Waste Processing

Researchers at the INEL developed a biodegradation system that introduces organisms to a mixture of hazardous waste compounds called a liquid scintillation cocktail that detoxifies the cocktail at very high levels of efficiency. The system includes a bioreactor (where living cells feed on the toxic materials and produce carbon dioxide), accessory hardware, and a supply of the detoxifying microorganisms. Once installed, the system will continually bioprocess an inflow of the cocktail, rendering it safe for conventional disposal through the sewer system if the radioactivity is within prescribed limits, or as low-level radioactive waste. This eliminates the high cost of packing and transporting mixed waste to authorized disposal sites. The current allowable methods for handling the waste are incineration and long-term storage. Converting the waste on-site eliminates depending upon these methods and their associated costs.

Four technological systems and processes developed by EG&G Idaho scientists received R&D 100 awards.

AFS Developers Receive Award

Developers of the Alarm Filtering System (AFS) were the recipients of an award from the Federal Laboratory Consortium for excellence in technology transfer efforts. A patent of this technology was issued to the Department of Energy in 1987, and as a result of technology transfer efforts, a non-exclusive license has been granted to Bechtel Western Power Company. (See Effective Alarm Filtering, page 23.)

MK-Ferguson Honored for Safety Accomplishments

MK-Ferguson of Idaho Company (MK-FIC), who provides INEL Construction Management Project services, was honored for its significant safety accomplishments. A major milestone, one million manhours without a lost time injury, was achieved in February 1988. This represents an accumulation of over four years of dedicated effort by both the administrative staff and craftsmen from February 1984 to February 1988. Considering the complexity of construction activity and the dispersed work area, the record is even more impressive. With this milestone accomplishment, MK-FIC President/General Manager, Robert E. Lawrence, received his third President's Award for outstanding safety performance and supervisory direction. Also, a special award was presented to the MK-FIC employees at the INEL to commemorate this achievement.

Displaying milestone safety awards for MK-FIC, are (left to right) Jon Bell, carpenter; William Hughes, senior vice president; and Robert Lawrence, president and general manager.

EG&G Idaho Biochemical Engineer Gets Into Print

One form of professional recognition that is more toil than reward is the invitation to write review articles for professional books and journals. When a field of study becomes "hot," people who are well-known in it may suddenly find that they are outnumbered by editors looking for authoritative contributions. This recently happened in the area of reactor design for large-scale biological processes such as waste water treatment and bulk fermentation, and it engulfed Dr. Graham Andrews, a biochemical engineer who joined the INEL Biotechnology Unit this year. Despite turning down two invitations, he completed a chapter on "Fixed-Film and Fluidized-Bed Bioreactors" for Biotechnology and Genetic Engineering Reviews. He is now working on a chapter on "Aerobic Waste Water Process Models" for Volume 3 of the eight volume Biotechnology series.

INEL Security Force Accomplishments

The INEL Security Force participated in and won the Department of Energy (DOE) Secretary's Trophy and the Individual Sportsmanship Award at the DOE National Firearms Tournament. The U.S. Army Special Forces, the Federal Bureau of Investigations, and seven city and county police special weapons and tactics teams were invited to participate in Security Force training seminars and exercises at the INEL for the intent of increasing community relations within the geographic area. Additional accomplishments throughout the year include:

- Quality Improvement Program suggestions resulted in a net savings of $120,180 to DOE
- Coordinated with Equal Employment Opportunity Cultural Awareness Program for INEL security personnel
- Successfully completed security contractor transition from American Protective Services to Protection Technology Idaho
- Received satisfactory rating on all areas tested during DOE's safety and evaluation inspection
- Upgraded INEL aircraft capabilities to two fully operational Bell 222's.

The INEL security headquarters at Central Facilities Area.

Technology Transfer Award for VME Organization

Bud Albin, Senior Human Resources Specialist at Westinghouse Idaho Nuclear Company, received a 1988 Special Award for Excellence in Technology Transfer from the Federal Laboratory Consortium. He was recognized for forming a local chapter of Volunteers in Medical Engineering (VME), an organization devoted to using technology to assist disabled persons.

VME applies the engineering and professional abilities of its volunteers to provide practical, low-cost solutions to problems faced by handicapped individuals and by medical and rehabilitation services. The Idaho Falls-based chapter is made up of volunteers from all INEL contractors.

Bud Albin, Human Resources Specialist with WINCO.

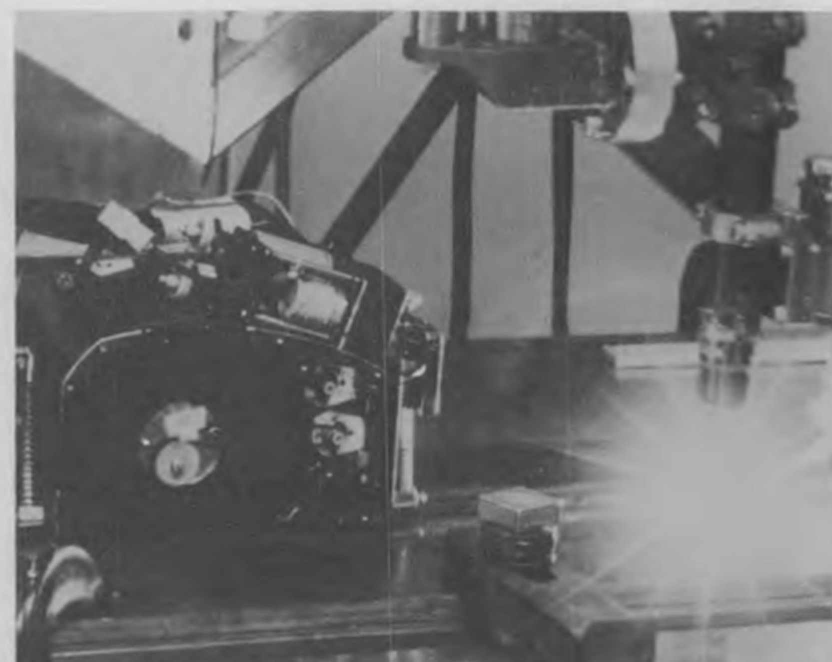
Although there is a need for the devices VME designs and builds, the market for them is typically not large. Therefore, they may never be built commercially, or if they are, they may be so costly that many who need them cannot afford them. By finding ways to eliminate material and fabrication costs, VME has been able to deliver products to clients at no charge.

Some of the projects the area VME chapter has provided include a plexiglass communication board for patients with no communication skills except eye movement; support pillows to help handicapped patients sit upright more comfortably for longer periods of time; a puff-and-sip switching device that allows children without muscle control to play with mechanical toys; and an apparatus that automatically loads paper into a computer printer for a client with spastic muscle movements.

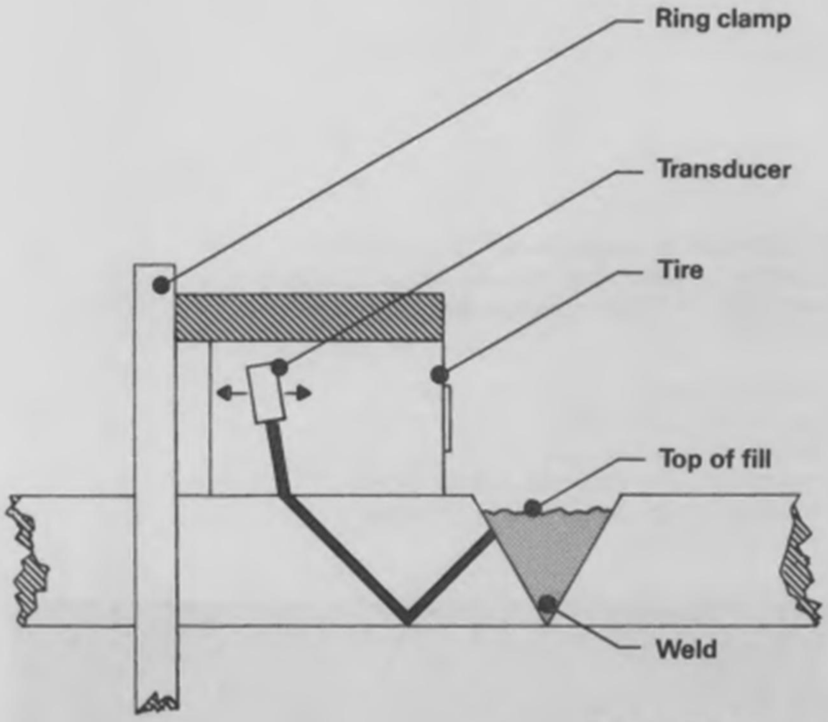
Engineers Receive Patent for Weld Examination System

A system developed by three EG&G Idaho engineers using ultrasonic sound to inspect a weld immediately after the weld is made has earned a U.S. patent. The EG&G Idaho inventors, Donald Hood, Herschel Smartt, and John Johnson, from the Materials Technology group, received a patent for the "Concurrent Ultrasonic Weld Evaluation System."

The invention has caught the interest of private industry because it can help increase productivity and save energy and money in mechanized welding operations.



Demonstration of the ultrasonic weld evaluation system.



Schematic of ultrasonic beam path in the inspection system.

The welding system consists of a mechanized welding head and a computer-controlled ultrasonic search head. When the system operates, the search head sends and receives ultrasonic sound waves as it trails behind the welding head. Computer processing of the signals reveals defects in a freshly-made weld. The ultrasonic process is similar to using sonar for detecting objects under water.

With this concept, a defect can be spotted immediately after it is made and repaired before it is covered up with additional weld material. Also, immediate weld inspection can indicate what may have caused the defect in the first place so that the problem can be solved and additional defects avoided.

The weld inspection technology has a number of potential applications in such areas as ship building and construction of energy production plants, pipelines, spacecraft, and off-shore oil rigs.

This system represents positive collaboration between two areas of research long under study at the INEL. One is the use of automated ultrasonic testing in nondestructive evaluation which was pioneered by INEL researchers, originally for nuclear facility applications. The other is the considerable research that has been done in the fundamentals of arc welding to develop advanced welding techniques.

Flinn Receives "Doc" Edgerton Award

On the basis of research findings which could create a whole new generation of alloys, John E. Flinn was awarded the "Doc" Edgerton Award. The technique Flinn developed is called "Doping with Inert Gas in Alloys for Improving Microstructure Stability and Strengthening." During the production of alloys using rapidly solidified powder technology, Dr. Flinn discovered that substantial levels of some inert gases, such as helium and argon, are captured in the alloys microstructure. The microstructures are more resistant to high temperatures. Also, mechanical properties such as tensile strength and resistance to "creep" increase greatly.

John Flinn received the second annual "Doc" Edgerton Award for his work in discovering the advantages of trapped inert gases in metal alloys.

Flinn explained that an advantage of entrapping helium within the microstructure is that helium has a strong affinity for vacancies or missing atoms in the crystalline makeup of a microstructure. It is the vacancies which allow the atoms of a microstructure to migrate and allow the grains to grow and the material to creep. The helium ties up the vacancies greatly restricting grain growth and creep.

MK-FIC Receives Award for Program Support

Plaques recognizing MK-Ferguson of Idaho Company's (MK-FIC's) effort for outstanding performance and exceptional program support for small and disadvantaged programs were presented to MK-FIC's Procurement Manager, Bernard Schroeder, at a special awards ceremony in January 1988. MK-FIC has received this prestigious award nine consecutive years for their performance in both the small and disadvantaged business programs.

Members Installed as Fellow at ANS Annual Meeting

Paul W. Dickson received the membership grade of Fellow at the June 14, 1988, annual meeting of the American Nuclear Society (ANS). Dickson was recognized for his contribution to the development of advanced and innovative nuclear designs, especially for his contribution to developing fast reactor design methods, and for his leadership in the development of the Clinch River Breeder Reactor nuclear design.

At at recent ANS/European Nuclear Society 1988 International Conference held in Washington, D.C., J. Paul Bacca, Argonne National Laboratory-West, was awarded the rank of Fellow of the ANS. At the November 1, 1988, awards ceremony, Bacca was presented with the Fellow certificate and was cited "for his technical leadership in the advancement of postirradiation handling and examination of advanced reactor fuels and materials at the Hot Fuel Examination Facility and for his exceptional service to the Remote Systems Technology Division of the American Nuclear Society." Bacca has been a member of the ANS since 1964 and the Idaho Section since 1965.

The ANS Fellow rank is the Society's highest membership grade to which a select group has been elected. Selection comes as a result of nominations by peers, careful review by the ANS Honors and Awards Committee, and election by the Society's Board of Directors.

Paul W. Dickson received membership grade of Fellow at ANS meeting.

James Murphy, winner of the 1988 silver George Westinghouse Signature of Excellence Award.

Westinghouse Corporate Awards

Two Westinghouse Idaho Nuclear Company (WINCO) employees received special recognition during FY-88 from Westinghouse Electric Corporation. Ray Frankoski, Manager of Human Resources, was presented the Westinghouse Human Resources Award, which honors outstanding achievement and excellence by human resources employees throughout the corporation. The award cited Frankoski's efforts in implementing human resources programs at WINCO and his leadership in making Westinghouse a strong, valued member of the southeastern Idaho community.

James Murphy won a silver George Westinghouse Signature of Excellence Award for designing, fabricating, and installing a remote pipette for use in the hot cell of the Idaho Chemical Processing Plant's Remote Analytical Laboratory. He was one of 30 winners selected from nominees throughout Westinghouse operations worldwide.

Ray Frankoski received Human Resources Award.

Computer Graphics Awards Won by Hatcher

Louise Nelson Hatcher was recognized for her outstanding performance as a computer graphics artist. Hatcher received two gold awards, one for her diagram of a Tokomak (prototype fusion reactor) and one for a newsletter cover in the Title and Text portion of the 1988 Integrated Software Systems Corporation competition held in Nashville, Tennessee.

Louise Hatcher received awards for her computer graphics in the 1988 competition.

R E P O R T

Idaho National Engineering Laboratory
U.S. Department of Energy
Idaho Operations Office
785 DOE Place
Idaho Falls, Idaho 83402

DOE Manager .... Don Ofte

Director of DOE Office of External Affairs .. Charles E. Gilmore

Report editor/
Jill White

Report designer/
Ray Reynolds

Prepared as a service by EG&G Idaho.

BP-527-0369-2M-T

Idaho
National
Engineering
Laboratory

MISC-054