SAVANNAH RIVER LABORATORY
MONTHLY REPORT

February 1986

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PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC09-76SR00001

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A prototype Pu-238 waste incinerator is being tested at the TNX semiworks. Development is focusing on the feed preparation system for the process.

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NUCLEAR REACTORS AND SCIENTIFIC COMPUTATIONS

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JOSHUA System Modernization

A new JOSHUA precompiler has been installed and the GLASS and SIMULATE application modules have been converted to ANSI 77 standard FORTRAN.

Building 321-M Safety Analysis Report and Operating Safety Requirements

The revised SAR and OSR's for Building 321-M were approved by Du Pont in January. The OSR's were then provisionally approved by DOE with the stipulation that non-nuclear industrial hazards be evaluated in greater detail by the end of the fiscal year.

Reactor Materials Program

Twelve capsules containing 180 stainless steel samples have been loaded in three sparger positions in K reactor for long-term irradiation. The first capsules will be removed in 1990.

CHEMICAL PROCESSES AND ENVIRONMENTAL TECHNOLOGY

Canyon - Iodine Removal Reactor Improvements

A new conceptual design for a silver-mordenite-packed bed has been developed to improve the radioactive iodine removal from uranium fuel dissolver off-gas. The new design provides more than double the iodine reactor change cycle and a 90% reduction of personnel radiation exposure for maintenance.

Automated Online Analyzers

Automated online analyzers were developed for installation in the Separations Areas in April. These are part of the canyon process modernization program and will provide faster analyses, increased accuracy, and fewer operational errors.
Evaluation of Ground-Penetrating Radar for Waste Site Assessments

Ground-penetrating radar has been initially evaluated and shows good potential as a tool for defining the location of buried objects.

Galileo/Ulysses Safety Evaluation Report

Although the recent shuttle tragedy has forced the postponement of the Galileo/Ulysses space missions, the safety evaluation report (SER) is being completed and will be used as a basis for the final approval of the missions.

This report series informs management of SRL progress in unclassified programs.

SRL also issues a classified monthly report to inform management about progress in:

- Weapons Development Support
- Naval Reactor Fuel
- Production Support
DEFENSE WASTE AND LABORATORY OPERATIONS

Waste Glass Performance

As part of a joint program with Sandia National Laboratory, SRL has begun a program of underground tests of glass performance in the salt at the Waste Isolation Pilot Plant in New Mexico. Samples of glass, and related packaging materials, are being exposed to brine at elevated temperatures for up to five years to demonstrate the ability of glass to prevent radionuclide release even under these conditions. These tests represent the largest cooperative effort ever undertaken by the international waste management community, and include a dozen organizations from seven countries as participants.

The nuclear waste glass produced by the Defense Waste Processing Facility (DWPF) will eventually be sent to a federal repository for permanent disposal. The ability of glass to prevent the release of radioactivity even under the elevated temperatures and pressures that it will experience deep underground has been proven under controlled laboratory conditions. However, tests in actual repository environments are needed to demonstrate beyond doubt the ability of glass to prevent release.

Participants from a dozen laboratories around the world, including some in West Germany, France, Belgium, Sweden, Great Britain, Japan, Canada, and the United States are donating their abilities to perform the sophisticated analyses necessary for this project. In return, each of the laboratories has been able to include samples of its waste glasses in the tests so that the performance of a variety of compositions can be compared.

In these tests, over 50 assemblies containing nearly 2,000 samples of waste glass and other materials which might be placed in a repository will be retrieved at intervals of 6 months, one year, two years, and over five years to determine how effectively glass has withstood this aggressive environment, and to determine how the other materials have interacted with the glass. In addition, the brine will be sampled to determine how much material from the glass has actually entered the mobile aqueous solution. The first set of samples will be removed in August 1986, and a status report of the results will be issued by the end of the year.

Plutonium-238 Waste Incinerator Testing

A prototype Pu-238 waste incinerator was started up in November 1985, and is being tested at TNX. Similar equipment will eventually process combustible Pu-238 contaminated waste and will produce an ash that is amenable either to recovery of the Pu-238 or to incorporation into DWPF borosilicate glass.
Mechanical operation of the incinerator is good, but development of the continuous feed preparation system is continuing. A plug in the final feed hopper caused flame to temporarily back part way up into the feed system. Another short flameback occurred due to temporary loss of the process-induced druff. Plug points in the feed system are being streamlined by modifying the feed chutes. Air inleakage into the incinerator underneath the feed entrance also aggravates the plug problem. Inleakage points are being tracked down and sealed. Fine-tuning the draft control system will result in improved draft and temperature control.

After consistent performance of the feed system can be achieved, the process will be operated for a year to verify equipment mechanical integrity and gather data that will allow choice of material of construction for the woven wire belt in the primary incinerator chamber. After the operational tests are complete, remote maintenance equipment and procedures will be developed, mocked up, and demonstrated.

Continuous Unattended Computer System Operation

A surveillance system for the SRL PDP-11/34 minicomputer is being developed by the Laboratory Services Division to monitor parameters such as temperature, humidity, and voltage levels to ensure that they are in a prescribed range. A DPU 400 computer room alert system made by Innovations in Control will be used. Each parameter being monitored by the DPU 400 has alarm and interrupt selectable thresholds. These thresholds are all user-selectable and the alarming and interrupting can be bypassed if needed.

An additional feature can delay or prevent "power-ups" following a blackout, thus negating the need for a systematic power-up required by the PDP-11/34. An emergency shutdown switch is also provided.

A Sensaphone security monitoring system will complement the computer room alert system. The Sensaphone provides direct remote two-way communications between the computer room and four other phones. The primary function of the Sensaphone is its automatic warning dial-out feature. If any parameter is detected out of range, or any alert condition is activated, the Sensaphone will automatically dial out up to four telephone numbers in sequence until the warning message is received and acknowledged. Also, at any given time, the Sensaphone may be called up to check on the status of the various parameters and alert conditions. The Sensaphone will inform the caller of its ID number, present time, temperature, electricity status, sound level status, alert condition statuses, and battery condition. Two of the external alert conditions on the Sensaphone will be coming from the DPU 400. The third alert condition will be wired to a Chemetronics Micro 1 Halon gas system. If this gas system is activated, the Sensaphone will make the appropriate warning call.
NUCLEAR REACTORS AND SCIENTIFIC COMPUTATIONS

Update Technical Standards and Technical Specifications

Savannah River Laboratory has undertaken a program to review and update the Reactor Technical Standards and Specifications. The program is coordinated by SRL, but to ensure adequate attention to operational concerns and to facilitate prompt approval of changes, SRP has been intimately involved. Cooperative effort has been ensured through a series of meetings during review of each standard and specification.

To date, two Technical Standards have received complete approvals. Two Specifications have been reviewed and found to require no change. Twelve more Standard and Specification revisions are in various stages of formal approval. Review and revision is about 50% complete for the twenty remaining Standards and seventeen remaining Specifications. The updating program will be completed during the 4th quarter of FY 86.

PRA Analysis of a Medium LOCA in the Reactor D₂O Coolant System

Work has been completed on the Phase I Probabilistic Risk Assessment (PRA) analysis of a medium-size leak in the D₂O coolant system. The specific accident postulated is a guillotine break in a "ring" supply header of the control rod coolant system. The D₂O leakage from this break would vary from an initial rate of about 7,200 gpm to a steady rate of 2,600 to 2,800 gpm with nominal operation of reactor safety systems. The progression of the accident was analyzed to the point at which fuel melting could be encountered if safety systems failed to operate properly and if remedial action were not implemented by operators.

The analysis indicates that the reliability of plant safety equipment is good for this class of D₂O leaks, and it illustrates the importance of maintaining reliable normal and emergency electrical power following such an accident. For this accident, plant safety equipment failures would render the reactor core vulnerable to damage from melting with a frequency of about 3.0 x 10⁻⁷ per year. The dominant contributor to this frequency is the independent loss of electrical power to the reactor from normal and emergency sources subsequent to the accident but prior to core discharge. Successful efforts to restore power, if completed with a timeliness based on experience, would reduce the core melt frequency by about 30%.

Results of this analysis, and of similar analyses of other accidents currently in progress, will be reviewed carefully for improvements to safety equipment and operating procedures that would benefit reactor safety significantly.
Alternative Degreasers for Raw Materials Area

SRL and the Raw Materials Engineering and Technology Department of SRP are conducting a degreaser study in the 300 Area. The study is assessing the impact of changing from the currently used 1,1,1-trichloroethane (TCE) to either "Freon" TF or a biodegradable detergent (Magnu-Spray 205). Tests have confirmed that both alternative materials perform well in service. No economic benefit appears to result from switching to "Freon" TF, even though vapor losses and waste generation would be reduced, since the purchase price of "Freon" TF is three times that of TCE. Economic benefit (on the order of $100,000 annually) appears obtainable by changing to a biodegradable detergent. If the change to a biodegradable product is made, waste streams currently handled separately would be discharged to the 300-Area liquid effluent treatment facility. This elimination or reduction of the separate solvent waste streams is environmentally attractive, but compatibility of the new waste streams must be proven, and the capital equipment costs associated with the change must be better defined. In-plant testing is planned pending approval of waste control measures by the South Carolina Department of Health and Environmental Control.

JOSHUA System Modernization

A new JOSHUA precompiler has been installed on the IBM, VAX, and LANL CRAY. A basic set of utility routines that serves as precursor to a new JOSHUA terminal system has been completed. In addition, two families of JOSHUA application modules, GLASS and SIMULATE, have been converted to ANSI 77 standard FORTRAN and the associated benchmarks executed on the IBM and VAX computers.

The JOSHUA system is being modernized to provide compatibility with future compiler upgrades and computer systems, to improve system documentation, and to enhance the ease of interfacing JOSHUA data with standard commercial software packages. The modernization calls for development of a new JOSHUA system and conversion of all pertinent JOSHUA application modules. Over 200 JOSHUA application modules are currently in use for solving problems in the areas of reactor charge design, reactor limits, reactor safety analyses, criticality safety, shielding analyses, and other applications. This twenty-man-year effort is designed to upgrade the JOSHUA system for use through the mid 1990's.

A set of utility routines that serves as a precursor to a new JOSHUA terminal system has been developed. These routines, written in standard FORTRAN, provide an interim capability for examining and creating JOSHUA data records, using a standard text editor and simplified templates. The routines have been integrated with and linked to the JOSHUA database routines on the VAX and IBM computers.
The new JOSHUA terminal system is being designed. As currently envisioned, the new system would involve the use of remote and local processors. All terminal I/O would be performed by the local processor, supported by utilities written in largely standard FORTRAN executing on a remote worker machine. A prototype of this terminal system is being tested, using the SRL VAX as the local processor and a LANL CRAY as the remote worker machine.

In parallel with the JOSHUA system development, JOSHUA application modules are being benchmarked and converted to ANSI 77 standard FORTRAN. SIMULATE and thirty-three GLASS modules have been converted. The SIMULATE benchmarks and eight of the nine GLASS benchmarks have been run successfully with the new JOSHUA system on the VAX. Benchmarks executed on the IBM and VAX computers give equivalent results.

**Building 321-M Safety Analysis Report and Operating Safety Requirements**

Reactor fuel tubes are fabricated in Building 321-M using process steps that include casting, machining, extrusion, and cold drawing. All operations in this facility are reviewed and updated every five years with respect to the hazards impacting facility personnel, the public, and the environment. The review has as objectives the identification of the hazards inherent in the operation of the facility, analysis of the adequacy of the measures taken to eliminate, control, or mitigate their hazards, and analysis of potential accidents and their associated risks. The review is documented in the facility Safety Analysis Report (SAR). The revised SAR for Building 321-M was approved by Du Pont in January. In summary, the SAR concludes that the building can be operated without unreasonable risk to operating personnel, the general public, or the environment.

Since the fabrication of fuel tubes requires the handling, storage, and processing of nuclear materials, additional documentation is required to define the conditions, safe boundaries, and management controls required to ensure the safe operation of Building 321-M. This documentation is contained in the Building 321-M Operational Safety Requirements (OSR's) documents. The OSR's covering Building 321-M were provisionally approved by Du Pont and DOE-SR in January. It was agreed that non-nuclear industrial hazards would not be included in the OSR's at this time, provided that additional analyses would be done to quantify the risks associated with these hazards. These analyses will be completed by the end of the fiscal year.
Reactor Materials Program

The Reactor Materials Program is an experimental and analytical program to evaluate the current condition and expected life of the reactor tanks, moderator piping, and thermal shields. The goals of the program are to provide the technical bases to predict and extend reactor service life and to improve reactor safety. Emphasis is on control of moderator chemistry to mitigate stress corrosion cracking, qualification of repair methods for piping and tanks, assessment of safety margins for potential cracks in the reactor tanks and pipes, and surveillance of irradiation effects on reactor tank walls.

The specimens selected for the SRP reactor irradiation program were cut from 8 pipe sections removed from R-reactor process piping. A total of 180 mechanical test specimens — Charpy V-notch, tensile, compact tensile, and wedge opening loaded — were assembled into twelve capsules and, along with fifteen dosimetry tubes, were loaded into three sparjet assemblies. These assemblies were inserted during the long shutdown prior to the start of subcycle K-12.1. The first specimens are scheduled for removal from the reactor in 1990. Accumulated neutron exposure of the removed specimens will match tank wall maxima of P and K reactors. Other specimen withdrawals will take place in 4- to 5-year increments. These specimens will have neutron exposures corresponding to as much as 70 years of additional reactor operation. Neutron dosimetry wires are loaded into each specimen capsule to allow validation of preirradiation predictions.

The neutron dosimetry tubes for fluence measurement are provided by ORNL and are identical to sets used in offsite irradiations in the high flux isotope reactor. Elemental components of the dosimetry tubes include Co(0.1 wt %) — Al, Cu, and Fe flux wires. Postirradiation analysis of the activated wires will yield a fluence spectrum history for the specimen capsule of interest. The major fluence components directly measurable from these postirradiation studies are: (1) thermal (energy <0.63 eV) from Co-59 (n,γ) Co-60 and Cu-63 (n,γ) Cu-64 reactions; (2) epithermal (energy >0.63 eV) from cadmium-shielded Co-59 and Cu-63 (n,γ) reactions, and (3) fast (energy >2.2 MeV) from Fe-54 (n,p) Mn-54 reactions.
Canyon - Iodine Removal Reactor Improvements

A new conceptual design for a silver-mordenite-packed bed has been developed to improve the radioactive iodine removal from uranium fuel dissolver off-gas. The new design provides more than double the iodine reactor change cycle and a 90% reduction of personnel radiation exposure for maintenance.

Uranium fuel slug dissolution releases volatile iodine fission products. The iodine exiting with the dissolver off-gas passes through an iodine absorption reactor containing silver-nitrate-coated ceramic Berl saddles. In that reactor, the iodine combines with silver and is immobilized for later disposal in solid form. Although the H-Area reactor performs well with an average bed life of more than five years, the necessary use of caustic in the F-Area slug decladding process reduces the average F-Area iodine reactor change cycle to only 10 months. The shorter life has been attributed to a combination of caustic carryover and localized overheating in the reactor. These factors cause packing deterioration, silver nitrate melting and washoff, and a gradual solids buildup along with loss of iodine removal efficiency or decontamination factor. The frequent reactor maintenance increases personnel radiation exposure and reduces canyon process availability.

A new conceptual design has been developed for an improved iodine reactor. The Berl saddles would be replaced by silver mordenite extrudates. Silver mordenite, a commercially available molecular sieve material, withstands high temperatures better than the present material. It also provides a decontamination factor a hundredfold to a thousandfold higher than the coated ceramic. It is highly resistant to acid, but disintegrates in heated caustic. To overcome the problem with caustic, a 10-inch-deep bed will replace the present 96-inch bed and it will be raised to the top of the iodine reactor. The bottom 7 feet of reactor cartridge will be filled with stainless steel Pall rings to demist and provide a surge volume to catch carryover. Even with the shallower bed, the higher decontamination factor of mordenite will reduce the total F-Area iodine release by 80%. A two-year reactor change cycle will reduce personnel radiation exposure for reactor maintenance by 90%. Packaging the mordenite in small disposable cartridges will reduce required canyon crane time by 60%. One-time fixed costs for engineering detailing and procurement of the new reactor cartridge will be about $135,000, and the annual savings in reactor operating costs will be $15,000.

SRP is pursuing design and fabrication of a new iodine reactor cartridge for a plant test of the silver mordenite.
Automated Online Analyzers

Automated online analyzers were developed for installation in the Separations Areas in April. They are part of the canyon process modernization program and will provide faster analyses, increased accuracy, and fewer operational errors. The first two online systems will be installed in Building 221-F.

The two samplers chosen for the initial installation will analyze feed solutions for the second plutonium cycle. One of them, position 12.5, will be installed at the sample point that has the highest sampling frequency in the entire process. The 12.5 sampler will replace a manual color test by monitoring the sample oxidation state, online, using a REDOX electrode. The second sampler, at position 12.6, will measure total plutonium in the sample stream using a gamma peak height analyzer and detector.

These two samplers represent a universal sampler design. They are essentially identical in construction, differing only in the section of piping where the analyzer is located. Several features that improve sampler operation are built into the design. Flow rate and density measurements ensure that samples are representative of the tank contents, and larger flow passages in the sampler reduce the likelihood of pluggage. The sampling mechanism has been redesigned, replacing hazardous double needles with a more effective, safer blunt probe.

The samplers can be operated in several modes of control. Fully automated sampling can be controlled remotely or locally in the sample aisle. Two manual modes are provided: one is "semiautomatic," and operator actions are prompted in sequence, the other is manual via hardware switches.

In automatic sample analysis, the sampler automatically opens and closes the proper valves to establish sample flow, signals the analyzer to begin the analysis, gets the results from the analyzer, and passes them to the central process computer. When the analysis is complete, the sampler shuts itself down, drains and flushes itself, and returns to idle to wait the next request for analysis. This can be done from the 4th level control room in the canyon building.

In manual sampling, the sample aisle operator interacts with the control system by means of a touch-sensitive flat panel display screen, responding to simple English messages. He can stop the sampler at any time with a single touch and, with a key, regain control of its operation. The keyswitch also allows for troubleshooting and training.

A new system like this is complicated and difficult to understand; if it stops working, it can be very difficult to fix. To help the operator recognize and diagnose problems, a knowledge-based expert system for troubleshooting is being developed to deliver with the samplers.
Ground-penetrating radar (GPR), an electromagnetic geophysical technique used for studying the subsurface environment, was evaluated for its applicability as a tool for obtaining information about waste sites at SRP. The two manufacturers of GPR equipment, Geophysical Survey Systems, Inc., Hudson, NH, and Xadar Corporation, Springfield, VA, were contracted to survey selected waste sites. The location of trenches, individual objects, depths of penetration, and the perimeters of regraded waste basins and rubble pits were successfully determined by GPR surveys.

The GPR system includes a transmitter, antenna, receiver, magnetic tape recorder, and graphic display unit. Rapid, consecutive, short-time voltage pulses are generated by the transmitter and radiated into the ground by the antenna. Pulse frequencies range from 100 to 500 MHz. Continuous data are obtained as the antenna is pulled over the ground. The signal is reflected by objects and soil conditions in the ground, received by the antenna, converted to waveforms by the receiver, and recorded. The depth of penetration is calculated from the output of the graphic printer and assuming a dielectric constant of the soil.

Trenches in the burial grounds were located easily by pulling an antenna perpendicular to the trenches. The bottom of the trenches was observed in some classes. A large crane was located in one of the trenches and smaller objects were observed during lengthwise transects of other trenches. Concrete culverts and saltstone lysimeters were also detected by the radar. Eight additional waste sites including rubble pits and waste basins were surveyed for perimeter determination. Additional information about subsurface conditions, such as soil profiles and depth to water tables, was obtained during the surveys.

Overall, the technique of GPR has been found to be useful for waste site assessment. Although GPR cannot identify objects, it can be used to locate them, outline burial pits, basins and trenches, measure depth to objects, and observe soil conditions.

Opportunities for using this technique to locate power cables and reinforcement rods in construction areas will also be explored with SRP personnel.

Galileo/Ulysses Safety Evaluation Report

The space probes Galileo and Ulysses were scheduled to be launched from the space shuttle in May and June of this year. Because these two probes are powered by plutonium (Pu-238) dioxide thermal generators, an independent panel of outside experts was named to assess the risks of the two missions.
The risk assessment panel was composed of five subpanels: Launch Abort, Reentry, Biomedical, Meteorology, and Oceanography. SRL was represented on the latter two subpanels.

Each mission was broken down into five phases, ranging from prelaunch to forced reentry from orbit. Associated with each phase were hypothetical accidents and their probabilities of occurrence, including radioactive release, particle size distributions, insertion heights, etc. The risks were then examined for a "weighted average" case and a "worst" case. The process was similar to the preparation of an environmental impact statement.

The panel concluded (before the recent shuttle disaster) that the NASA Shuttle Data Book underestimates the probability of accidents for shuttle launches. In addition, the necessity of positioning the Centaur rockets of the Ulysses and Galileo space probes within the cargo bay of the shuttle greatly increases the chance of 100% release of Pu-238 during a launch pad accident. However, most of the released fuel is expected to be in the form of large particles and therefore would fall out very near the launch pad rather than being dispersed to nearby population centers.