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**Chemical Technology Division
Progress Report
for the Period January 1, 1993, to
September 30, 1995**

MANAGED AND OPERATED BY
LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL-27 (3-96)

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for the Period January 1, 1993,
to September 30, 1995**

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Chemical Technology Division

Date Published: September 1996

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PREFACE

At the beginning of this reporting period, Oak Ridge National Laboratory was managed by Martin Marietta Energy Systems, Inc., for the U.S. Department of Energy. As a result of a corporate merger, Lockheed Martin Energy Systems, Inc. (LMES), became the operating contractor in May 1995. The latter name and its abbreviated form are used throughout the text of this report.

In January 1996 a new organization—Lockheed Martin Energy Research Corporation (LMER)—was created to manage Oak Ridge National Laboratory. Both the cover and the title page of this report reflect the correct name of the managing contractor at the time the report was printed.

ABSTRACT

This progress report presents a summary of the missions and activities of the various sections and administrative groups within the Chemical Technology Division for the period January 1, 1993, through September 30, 1995. Specific projects in areas such as energy research, waste and environmental programs, and radiochemical processing are highlighted, and special programmatic activities conducted by the division are identified and described. The administrative summary portion of the report features information about publications and presentations of Chemical Technology Division staff, as well as a listing of patents awarded to division personnel during the reporting period.

Overview and Section Summaries

OVERVIEW

The Chemical Technology Division (CTD) has outstanding personnel capabilities and facilities in chemical engineering and chemistry, as well as significant competence in several other engineering and scientific disciplines. The division plays a major role in a broad spectrum of Oak Ridge National Laboratory (ORNL) programs for which chemical processing is a critical element. Research and development (R&D) activities include basic and applied research and engineering, engineering developments and assessments, and operation of various pilot plants and specialized facilities. The majority of CTD research programs are funded by the U.S. Department of Energy (DOE), although significant projects are carried out for other governmental agencies and industrial sources.

The primary mission of CTD is to perform energy R&D of importance to DOE, other federal agencies, Lockheed Martin Energy Systems, Inc. (LMES), and the private sector in areas involving chemical, radiochemical, and biochemical engineering processes and related phenomena. In support of its primary mission, CTD operates special radiochemical facilities and manages selected programs in areas in which it has special competence. As it performs these activities and operates these facilities, the division strives to create an environment in which environmental, safety, and health issues are recognized and properly managed at all levels of the organization.

Major strategic goals of CTD include the following:

- maintain and be recognized for world-class capabilities and performance in chemical engineering R&D, including biochemical and radiochemical engineering, and in supporting research in process chemistry and applied biotechnology;
- provide expertise in developing, demonstrating, and evaluating integrated technology at the unit operation, pilot plant, and larger-scale levels;
- support core programs and develop new processing programs for transuranic elements and radioactive and stable isotopes;
- develop and implement research, development, and demonstration (RD&D) programs of national significance in the areas of environmental restoration and waste management;
- develop computer-based systems for modeling chemical/physical processes and for evaluating waste management and other methodologies;
- provide technical and managerial support for the development of packaging and transportation safety programs; and
- participate in RD&D programs of significance to national energy efficiency initiatives.

These and other significant objectives are achieved by activities conducted within six CTD R&D sections, with support from a seventh section, which provides technical and administrative support

services to R&D staff. An additional group of CTD staff members is on special assignment, involved with the initiation and management of programs that affect multiple organizations. The organizational structure of CTD is shown in Fig. 1. More detailed descriptions of the activities of these groups are found in the sections that follow.

Fig. 1. Organization chart for the Chemical Technology Division.

CHEMICAL DEVELOPMENT SECTION

The primary mission of the Chemical Development Section is to invent, design, develop, and test materials and processes for the treatment of radioactive and/or hazardous wastes, including chemical treatment processes for the removal/retention and/or stabilization of radionuclides and heavy metals. Research and development in a wide variety of other areas is also conducted within the section by applying expertise in the field of chemical technology to meet sponsors' needs.

Chemical Processes for Waste Management

Removal of Uranium from Mixed Wastes. The objective was to develop a process for removing uranium from aqueous pickle bath solutions so as to reduce the overall generation of mixed waste in an effort to minimize depleted uranium liquid wastes at the Y-12 Plant. A screening study was performed to determine the potential of several organic ion-exchange resins, as well as tannin, for removing uranium from aqueous acidic nitrate solutions.

Uranium Removal from Fernald Soil Leachates Using Ion Exchangers. Soils contaminated at the Fernald Site contain concentrations of uranium that exceed regulatory limits. Removal of uranium from the soil has been examined using several different leaching solutions, including a carbonate leachant. Ion exchange was studied as a means for removing the uranium from the selected leachate and allowing reuse of the leachant.

Treatment of ORNL Process and Waste Streams. Sorbents were developed and tested for separating radionuclides such as strontium and cesium from low-level liquid waste and for removing cesium and ruthenium from a simulated Cleanex raffinate solution generated at the Radiochemical Engineering Development Center. Ion exchangers were identified that can remove greater than 99% of the cesium from the raffinate. However, no sorbents were identified that removed more than 25% of the ruthenium. Strontium and cesium can be adequately removed from newly generated low-level liquid waste.

Partitioning of Sludge Components by Caustic Washing. The cost of long-term waste disposal and storage can be reduced in direct proportion to the quantity of nonradioactive components that can be removed from the waste and, therefore, will not require storage as high-level waste. The sludges generally contain mixtures of hydrated metal oxides, hydroxides, and phosphates, which have the potential of forming soluble chemical species under highly caustic conditions. If these materials could be preferentially solubilized, then the volume of the remaining radioactive waste to be treated and/or stored would be significantly reduced. As part of this study, samples of surrogate sludges, Melton Valley Storage Tank (MVST) sludges, and surrogate Hanford sludges were leached with varying concentrations of sodium hydroxide solutions. The caustic dissolution behavior of ORNL MVST W-25 sludge was measured in hot-cell tests at ambient temperature and at 95°C. Qualitatively, the results compare favorably with the data obtained from leaching tests using the surrogate sludges.

Sludge Washing and Dissolution. Acidic and caustic leaching of MVST sludge was carried out to determine the distribution of chemical species between aqueous solutions and solids and to identify potential problems due to chemical interactions that could result in process difficulties or safety concerns.

Comprehensive Supernate Treatment. DOE is faced with remediating millions of gallons of high-level and low-level radioactive waste in underground storage tanks at various sites, including Oak Ridge, Hanford, Savannah River, and Idaho. Much of the waste is in the form of liquid solution (supernate), which contains the soluble radionuclides along with high concentrations of sodium and potassium salts. The purpose of this program is to evaluate and select sorbents for removing and concentrating these radionuclides. Supernate samples retrieved from MVST W-25 and W-29 were characterized and tested for the removal of strontium, cesium, and technetium by using several ion-exchange materials.

Flow Testing of Sorbents to Remove Cesium. An experimental system was constructed in hot cell C of Building 4501 to test the ion-exchange materials in columns or modules using a single batch of supernatant from MVST W-27 as a basis for comparison. The results include cesium loading breakthrough curves, elution curves when applicable, and a summary of operational problems and observations. The results are being used to help determine the design parameters for demonstration-scale systems.

Glass Material Oxidation and Dissolution System. The Glass Material Oxidation and Dissolution System is a process for converting metals, oxides, and organic materials to high-level waste glass. It employs a lead borate glass to oxidize metals and dissolve oxides. The reactions of stainless steel, uranium, zirconium, aluminum, and cerium (as a surrogate for plutonium) metals, as well as carbon and sodium chloride in lead borate, have been demonstrated.

Molten Salt Oxidation of Organic and Chloro-Organic Compounds. Several experiments were performed to show that emissions of dioxin and furan from a molten-salt oxidation unit were below regulatory limits. The only significant products of incomplete combustion were chloromethane, methylene chloride, benzene, and toluene.

Nitrate to Ammonia and Ceramic Process. The Nitrate to Ammonia and Ceramic (NAC) process is an innovative technology employing denitration to convert nitrate to ammonia and ceramic, thus allowing low-level radioactive waste to be immobilized in a stable, solid ceramic matrix. The resulting sintered products confirm that cesium and strontium can be effectively immobilized in this manner. Further NAC process research for both the rheological and heat transfer properties of the products and the kinetics of the reaction in batch and continuous reactor systems was transferred by DOE to Florida International University, with oversight by the Chemical Development Section.

Acid-Mine Drainage Treatment/Heavy-Metals Removal Using Ion Exchange. Pennsylvania has many abandoned coal mines through which rainwater flows. The runoff from several square miles may drain through the ground and into these mines, where exposed pyrites and other minerals are oxidized to form soluble sulfates, such as ferrous sulfate and sulfuric acid. As the concentration of acid increases, so do the solubilities of other metals. These metals, some of which are toxic, are carried to the surface through mine shafts at low elevations. These "outfalls" then drain and pollute the river. The objective of this project is to demonstrate the ability of ion exchange, along with three other technologies, to remove heavy metals from the water.

Basic and Applied Chemical Technology

Chemical Thermodynamics of Superconducting Materials. The temperature and oxygen partial pressure dependence of oxygen content in $M_{1+z}Ba_{2-z}Cu_3O_y$, where $M = La, Nd, \text{ or } Pr$, were determined. The data from each of these systems were represented by chemical thermodynamic models. The dependence of high-temperature decomposition on temperature, oxygen, partial pressure, and z was also determined.

Fission Product Release at Severe Accident Conditions. The final two tests of a series of high-temperature tests of irradiated fuel in a vertical furnace facility were conducted. The objectives of these tests were to provide reliable data on fission product release and behavior under light-water reactor accident conditions that are needed to understand the release of radioactive fission products from fuel during severe nuclear reactor accidents.

Technical Assistance in Review of Source Term-Related Issues of Advanced Reactors.

Distribution of iodine in a nuclear reactor containment during a design-basis accident was evaluated using models in the TRENDS code. The behavior of iodine in a reactor containment depends primarily on water-pool pH. Because the pH was maintained above 7 in the sequence that was investigated, most of the iodine was in the form of iodide. Only a very small fraction was in the potentially volatile form of I_2 .

U.S. Army Field Artillery Liquid Propellant Stability Program. The primary objective of this program was to perform tests to evaluate methods for increasing the storage and handling stability of LPXM-46 liquid propellant. The technique developed to carry out this task involved the use of silicic acid gel in a peptized state to stabilize the propellant and thus prevent it from decomposing into gaseous degradation products.

ENERGY RESEARCH SECTION

The Energy Research Section performs fundamental research in chemical engineering, applied chemistry, biotechnology, and bioprocessing in support of the goals of CTD. Progress during this reporting period is summarized by the individual research groups. In addition to the efforts by these groups, the section serves as the home of the Bioprocessing Research and Development Center. Progress has also been made on the establishment of the Joint Institute for Molecular Based Engineering Science and the Center for Separation Science and Technology.

Solution Thermodynamics

The Solution Thermodynamics Group performed tasks associated with three projects: (1) "Interactions of Solvents, Solutes, and Surfaces"; (2) "Molecular-Based Study of Fluids and Amorphous Materials Using Parallel Supercomputers"; and (3) "Supercritical Water Oxidation—Technical Support." The staff completed small-angle x-ray scattering experiments of solutions and micellar suspensions of perfluoro polymers in supercritical carbon dioxide to complement ongoing small-angle neutron scattering experiments of these and related systems. The dissociation constant for sodium and chloride ions in supercritical water from molecular dynamics simulations for experimentally inaccessible states was computed and found to be in reasonable agreement with extrapolations from experimental data. New molecular simulation capabilities were developed using massively parallel supercomputers encompassing systems such as supercritical aqueous solutions, alkanes undergoing shear, polymer blends, and phase equilibrium. A useful engineering model within ASPEN Plus for electrolytes in high-temperature water was also developed.

Molecular Studies

This group was involved in four projects: (1) "Aqueous Electrolyte Solutions at Ambient and Supercritical Conditions," (2) "Theory and Molecular Simulation of Non-Equilibrium Systems," (3) "Integral Equation Theories of Molecular Fluids," and (4) "Mathematical Modeling of Bacterial Migration Through Porous Media with Application to In Situ Bioremediation." The staff also participated in the "Molecular-Based Study of Fluids and Amorphous Materials Using Parallel Supercomputers." During the review period, they developed a new intermolecular potential model for water and invested considerable effort in developing a theoretical foundation for simulation of shear-induced phase separation in complex fluids.

Chemistry Research

Fundamental discoveries were made regarding the unique behavior of uranium(IV), (V), and (VI) chloride and oxychloride species in molten salts as a function of Lewis acid/base changes and the photoreduction of uranyl in sol-gel glasses via a two-photon process.

Small-angle x-ray scattering experiments were used to observe the behavior and growth patterns of zirconium(IV) hydrous polymers in aqueous acid solution. Growth of the polymer is accomplished by stacking the commonly known tetrameric species to form a previously unknown octameric structure. Further stacking of the tetrameric species causes the formation of extensive rods with tetrameric cross sections.

In association with the Molten Salt Reactor Experiment Remediation Project, the group discovered an unusual amount of radiolytically generated fluorine and uranium hexafluoride, as well as provided key guidance and laboratory testing in solving the explosive problems created at the Auxiliary Charcoal Bed.

Separations and Materials Synthesis

Fundamental studies were undertaken to address the use of electric and magnetic fields to enhance the efficiency of multiphase separations processes. This work has yielded several important discoveries in the areas of fluid dynamics and electrohydrodynamics, including (1) a nonlinear hysteresis phenomenon was observed in the forced oscillations of pendant drops; (2) drop size and satellite droplet formation during flow from a capillary were found to be controllable with an applied electric field; (3) stretching liquid bridges were shown to be stabilized beyond the generally accepted limit through an applied axial electric field; (4) the complex effects of dynamic surface tension on spreading and deposition during the impact of drops with a solid surface were elucidated; and (5) the mechanism for an inverse electrostatic spraying method for dispersing nonconductive fluids into conductive fluids was investigated and found to be in agreement with the principles of electrohydrodynamic theory.

Engineering Science Research

A new concept in continuous fixed-bed operations was developed and tested by this group. The Continuous Ion Exchanger (CIEx) allows the performance of most fixed-bed operations continuously, without movement of the sorption medium relative to the containing annulus. The new technology was tested to determine its effectiveness for the removal of lanthanides from waste streams and for the separation of lead from other metals in another waste application. In each application, the CIEx was shown to be very successful.

Studies were conducted to elucidate the fundamentals of nucleation and growth of nanoscale particles, which are precursors for the synthesis of advanced materials. New techniques were developed that allow unparalleled monitoring of the rapid hydrolysis/condensation reactions. Key factors in the operation of the electric dispersion reactor were determined, thus enabling the controlled production of micron-sized porous spherical shells and microspheres. Studies of electrohomogenous precipitation showed the power of electric field-enhanced methods in controlling particle interactions for the formation of unique structures, such as fibrils, in ceramic materials. These results shed light on totally new ways of synthesizing fiber-reinforced advanced materials and using fine-particle suspensions.

Biotechnology Research

The Biotechnology Research Group has been investigating photosystem I (PSI) reaction center interactions with various derivatized gold surfaces and measuring the light-induced voltages from platinized, immobilized PSI reaction centers on the surface of gold in an effort to construct a PSI bioelectronic system. The study includes the selective adhesion of functional PSI biomolecules to patterned surfaces, the orientation of the immobilized PSI on various surfaces, and the identification of electronic properties of the immobilized PSI reaction centers.

Hydrolytic biocatalysts, such as cellulases and xylanases, have been developed by this group to serve as agents for enhancing the efficiency of bioconversion processes as well as for possible application in environmental biotechnology. An esterase that will be useful for cellulose ester waste reduction and recycle was discovered in lime peel.

Research activities in the area of biosorption have centered on investigations of microbial interactions with metals and radionuclides and on anaerobic degradation/dechlorination of PCBs, the development of novel uranium biosorbent materials, and the possibility of using certain bacteria to biochemically reduce and precipitate uranium. In the area of microbial PCB degradation, a unique discovery was made that allows PCB-degrading activity to be induced in an anaerobic bacterial consortium heretofore known only to dechlorinate PCBs.

The broad goals of this group are to develop and demonstrate novel and viable bioprocesses and bioreactors for (1) the production of fuels and chemicals from renewables, (2) biotreatment of fossil fuels, and (3) degradation and reuse of waste streams. A new crosscutting area is the use of biocatalysts, such as enzymes and microbes, in nonaqueous environments for new or improved transformations. This research utilizes coal synthesis gas as a carbon and energy source for fuel production and remediation fermentations. Synthesis gas can also serve as the carbon and energy source for the biological recycling of waste gypsum to elemental sulfur and calcium carbonate, thereby reducing the feed costs for both of these remediation processes. The Removal of Heteroatoms from Crude Oil Project has investigated the use of electro-spray reactors for the desulfurization of the model compound dibenzothiophene as well as actual crude oil.

A nomenclature was developed to classify nontraditional bioprocessing techniques such as the use of enzymes in organic solvents. This nomenclature was used to prepare a technology roadmap for the DOE Office of Energy Efficiency and Renewable Energy. Initial experiments relative to contacting schemes were performed in which peroxidase in toluene and cyclohexane was tested in the emulsion-phase contactor and polyphenol oxidase was tested in the vapor phase. Also, enzymatic catalysis was used in organic media for coal applications. In addition, the reducing enzyme hydrogenase was chemically modified so that it is rendered soluble and active in purely organic solvents.

ENGINEERING COORDINATION AND ANALYSIS SECTION

The Engineering Coordination and Analysis (EC&A) Section of CTD works on a wide spectrum of activities that includes performing technology assessments, providing project management and technical support, developing computer-based expert systems and artificial intelligence programs, maintaining the national Integrated Data Base (IDB), developing and demonstrating innovative mixed (i.e., radioactive and hazardous/toxic) waste management technologies, developing computer programs for the safe transportation of hazardous wastes, and providing technical and managerial support for the development of packaging and transportation safety programs. The EC&A Section serves many customers, ranging from other divisions within ORNL and LMES to several governmental agencies such as DOE, the U.S. Department of Defense (DOD), and the U.S. Department of State; the Nuclear Regulatory Commission (NRC); and the Environmental Protection Agency.

The EC&A Section is composed of six groups. The activities of each group during this reporting period are summarized in the following paragraphs.

Safety and Regulatory Technology

Experienced technical and managerial support for the hazardous materials-related transportation safety activities was provided to the Office of the Assistant Secretary for Environment, Safety, and Health in DOE through the DOE Office of Facility Safety Analysis. The group also developed documents to support the NRC in its proposed rulemaking for a new regulation under 10 CFR Part 70 and assisted the ORNL Waste Management Division in the collection and documentation of experimental data on the radioactive liquid waste tanks at ORNL.

Nuclear Waste Studies and Applications

The group maintained the IDB on the national spent nuclear fuel and radioactive waste inventories and projections for the IDB Program, which is jointly sponsored by DOE's Office of Civilian Radioactive Waste Management (OCRWM) and the Office of Environmental Management (DOE/EM; formerly the Office of Environmental Restoration and Waste Management). In addition, site-specific radiological performance assessments for the disposal of low-level radioactive wastes at DOE facilities were conducted for the ORNL Performance Assessments Group.

Pollution Prevention and Systems Analysis

Activities of the group included development of a computerized process simulator, called *FLOW*, that operates on an IBM-compatible personal computer for modeling chemical and physical processes. The group also evaluated methods for developing pollution prevention technology for use in environmental restoration activities, performed research on the compatibility of plastic materials with liquid propellants, and analyzed disposition options for reprocessed uranium from an advanced liquid-metal reactor fuel cycle.

A systems analysis methodology was developed to evaluate the treatment alternatives for managing the Oak Ridge Reservation mixed wastes in support of the site treatment plan as mandated by the

Federal Facilities Compliance Act, and a Waste Minimization Evaluation System was designed to assist persons responsible for planning and coordinating waste minimization projects.

The group also designed the Hazardous Materials Transportation Expert System for use in determining the packaging requirements for radioactive and/or hazardous materials to be transported and developed methodologies for evaluating the risks associated with the transport of hazardous and radioactive materials on-site at DOE facilities.

Advanced Technology and Assessments

A new method, called the Glass Materials Oxidation and Dissolution System (GMODS), was developed to convert surplus fissile materials, spent nuclear fuel, and other highly radioactive materials to high-level waste glass. The GMODS was developed in response to a recommendation by the U.S. National Academy of Sciences that inventories of surplus fissile materials be processed so as to prevent their rapid recovery for the manufacture of nuclear weapons.

Demonstration and Technology Support

During this reporting period, the group completed a wide range of important tasks. Necessary items for safety documentation, which included Hazards Screening Documents and Operating Safety Requirements, were prepared for several Radiochemical Engineering Development Center and isotope facilities at ORNL. In addition, project guidance and support were provided for the Portsmouth Gaseous Diffusion Plant X-231B Biodegradation Study, the LMES Waste Management Organization's waste-treatment activities as required by the Federal Facilities Compliance Act, the management of Appendix B wastes so as to meet Land Disposal Restrictions, the ORNL Out-of-Tank Evaporation Study, the LMES-managed Y-12 Plant Lower East Fork Poplar Creek Remediation Project, and the DOE Transportable Vitrification System demonstration at the K-25 Site.

Technical support was also provided to (1) the ORNL Energy Division in the preparation of the environmental impact statement for the DOD Chemical Weapons Demilitarization Program, (2) the DOE Rocky Flats Residue Elimination Project, (3) the K-25 Site Toxic Substances Control Act Incinerator Emissions Study, and (4) the Paducah Gaseous Diffusion Plant and the K-25 Site Emergency Operations Centers in the preparation of safety analyses.

Special projects included providing expertise, both technical and managerial, for the remediation of the hazardous wastes in the sludge lagoon of the DOD's Robins Air Force Base in Georgia; conducting assessments and evaluations to address the infrastructure issues of building hydrogen fuel dispensing stations (similar to present-day gasoline stations) for fueling light-duty vehicles; and developing (along with others) the waste management technology logic diagrams for ORNL and the Alpha-4 Facility at the Y-12 Plant.

Transportation Technologies

The group provided support to DOE/EM's Transportation Management Division in developing and implementing a safe, comprehensive, and cost-effective program for the transportation of radioactive and/or hazardous materials across the nation. This was accomplished principally through the development and application of several computer-based knowledge systems, such as the

Transportation Information Network, the Shipment Mobility/Accountability Collection, and the Hazardous Materials Transportation Expert System. As part of this effort, a Regulatory Facility Guide was developed to provide detailed compilations of international, federal, tribal, and state transportation-related regulations that are applicable to shipments to and from DOE facilities. The group also prepared 66 Site and Facility Waste Transportation Services Planning Documents for DOE's OCRWM for use by both utility and OCRWM operations planners in the shipment of spent nuclear fuel between facilities.

ENGINEERING DEVELOPMENT SECTION

The Engineering Development Section (EDS) performs applied research and development in chemistry, chemical engineering, and bioprocessing. Projects during this reporting period were mainly in the areas of environmental control and remediation technology development. Other activities included technical support of the ORNL wastewater treatment facilities, technology demonstrations, strategic planning for waste management, and program management.

ERWM Program Support

EDS provides programmatic and technical support for several DOE-wide and Oak Ridge Environmental Restoration and Waste Management (ERWM) programs. The purpose is to define process modifications for improved treatment and disposal of wastes as well as to develop waste treatment strategies and long-range plans for upgrading ORNL's waste treatment systems.

LMES Waste Management Program Support. Program management was provided for LMES mixed waste treatment as required by the Federal Facilities Compliance Act. This included coordination of activities associated with the characterization of mixed waste streams, technical evaluations to determine if the wastes can be treated in existing treatment facilities, and development of treatment and stabilization processes to meet Land Disposal Restrictions. The technology development and testing activities fell into three categories: (1) stabilization of wastes and treatment residues (final waste forms); (2) thermal desorption; and (3) studies of technologies for treatment of aqueous wastes, organic wastes, and wastes requiring decontamination.

Similar support was provided for the ORNL liquid waste collection, treatment, storage, and disposal programs. This effort included coordination of R&D activities to support construction or upgrade of the process wastewater and liquid low-level waste (LLLW) treatment facilities and development of waste acceptance criteria for the wastewater treatment plants and waste certification policies for generators. The program is a cornerstone for the National Pollutant Discharge Elimination System (NPDES) permit for process waste and certification of LLLW for disposal at the Nevada Test Site. A data base and model of the ORNL LLLW system are being developed for use as a planning and certification tool, and engineering and process support is being provided for ORNL's radioactive liquid waste treatment facilities. EDS assisted in the startup of the Nonradiological Wastewater Treatment Plant and in the evaluation of potential upgrade options.

DOE Technology Development Program Support. The Mixed Waste Integrated Program (MWIP) was formed to develop, demonstrate, and deliver technologies and systems to treat and dispose of DOE mixed low-level and mixed transuranic wastes within the DOE complex. CTD began coordinating and implementing the MWIP in April 1992 and accomplished its significant objective by the end of FY 1995: to conduct, over a three-year period, three pilot-scale demonstrations treating actual mixed waste and to develop a technology that would ultimately be capable of treating 90% of the DOE mixed low-level waste inventory. The creation of the Mixed Waste Focus Area has transferred these efforts to the DOE Idaho Operations Office.

Programmatic support was provided to implement DOE ERWM's new approach to technology development at LMES. This involved fully integrating technology development activities for the DOE complex to solve waste management problems. A Site Technology Coordination Group,

which includes EDS personnel, was established at Oak Ridge to identify and prioritize technology development activities for ERWM users and to act as the interface with DOE-wide programs in mixed waste and tank waste (high-level liquid waste and LLLW).

Chemical/Physical Waste Treatment Projects

Uranium Leaching from Contaminated Soils and Effluent Treatment. In support of the Uranium in Soils Integrated Demonstration Program, members of EDS and the Environmental Sciences Division jointly conducted bench-scale studies and supported pilot-scale tests on the leaching of uranium from soils. EDS assisted with pilot-scale tests to implement the ORNL process that were performed at the Fernald Environmental Management Project site to develop data on the efficiency and operability of the soil decontamination process. A related task was undertaken to develop methods of removing uranium from the effluent after the soil had been chemically washed.

SWSA-5 Groundwater Seep Treatment. Groundwater discharges from a free-flowing stream that emerges in a narrow valley below the former radioactive waste disposal trenches in SWSA-5 account for about 25% of the ^{90}Sr released by ORNL. A successful pilot-scale demonstration of a passive-flow treatment system that will remove a major fraction of the ^{90}Sr and reduce the cost for the groundwater treatment project was completed. The full-scale system consists of eight 55-gal drums modified for downflow treatment of the seep water with zeolite at a maximum total flow of 5 gal/min and will require zeolite reloading only once per year.

Process Waste Treatment Plant Upgrade. Processes are continuing to be developed for improved treatment of process wastewaters generated at ORNL, focusing on flowsheet design to minimize secondary waste generation and improve effluent water quality. EDS personnel performed bench-scale scoping studies to define treatment options and engineering/pilot-scale studies to obtain design data needed for a capital project upgrade, which is expected to result in significant cost savings.

Liquid Low-Level Waste and Transuranic Sludge Treatment. EDS is conducting R&D to support design of treatment facilities for the ORNL LLLW system. This includes retrieval and treatment studies for legacy sludges and treatment processes for newly generated waste.

During this reporting period, methods were evaluated for mixing and mobilizing sludge in ORNL LLLW tanks and for transporting the slurries to processing facilities. Surrogate sludges were used to demonstrate the feasibility of mobilizing sludge in horizontal cylindrical tanks via submerged jets, with subsequent studies conducted to support design of a pipeline system for slurry transport to a treatment facility. Nonradioactive simulated slurries were tested to determine the minimum transport velocity for mobilized sludge, and slurry rheological properties were analyzed to develop correlations for predicting flow parameters.

A vertical wiped-film evaporator was evaluated for processing Melton Valley Storage Tank transuranic sludges for disposal at the Waste Isolation Pilot Plant (WIPP). The results showed that the unit can be used to concentrate sodium nitrate waste into a product that meets current WIPP criteria. In addition, it can be operated for extended periods with only routine maintenance.

Newly Generated Liquid Low-Level Waste Treatment. Work is in progress to develop improved processes for centralized treatment of LLLW at ORNL. The treatment operations could potentially be applied to treat Melton Valley Storage Tank supernatant and newly generated LLLW

(NGLLLW), or a blend of both, for disposal on the Oak Ridge Reservation. Bench-scale scoping tests using nonradioactive surrogate wastes are under way to remove Cs, Sr, Tc, and Ru from the waste prior to solidification/stabilization for on-site disposal. The treatment methods for Cs and Sr involve chemical precipitation and ion-exchange operations, while ^{90}Sr is removed by coprecipitation with stable strontium. The need for technetium removal from NGLLLW has been evaluated and potential treatment options identified or studied.

Bioremediation Projects

Microbial Degradation of PCBs in Contaminated Soil. EDS researchers are conducting studies on microbial degradation of polychlorinated biphenyls (PCBs) in solid matrices such as soils, sediments, sludges, and artificial carriers (e.g., sand). The emphasis of the work is on adaptation of organisms extracted from river sediments (e.g., the Hudson River) for use on the other matrices, and several schemes to enhance dechlorination rates have been tested.

Kwajalein Bioremediation Demonstration. The U.S. Army Kwajalein Atoll (USAKA) Base, located in the Republic of the Marshall Islands, has significant petroleum hydrocarbon contamination resulting from years of military activities. USAKA requested that a project, which required the efforts of EDS staff, be conducted to evaluate the feasibility of bioremediation for the environmental restoration of soils contaminated with petroleum hydrocarbon. A field investigation identified a contaminated site that contained low levels of petroleum hydrocarbons, and laboratory column studies demonstrated the feasibility of bioremediation using indigenous microbes. The column studies were followed by a ten-month in situ field demonstration system, which indicated that approximately three years would be required to remediate the demonstration site.

Cometabolic Biotreatment of Chlorinated Solvents. A three-year demonstration of cometabolic biotreatment of chlorinated solvents in a landfill leachate has been successfully completed at the Oak Ridge K-25 Site. The demonstration involved installation of the pilot-scale bioreactor and equipment, operation and waste disposal, analyses of liquid and gas samples to measure performance, and decommissioning of the site. Removal efficiencies of 50 to >90% were obtained.

Waste Stabilization Projects

Waste Stabilization Studies. Bench-scale grout and vitrification studies were performed to support privatization and design of LMES facilities for treating the inventory of LMES mixed waste in order to meet Resource Conservation and Recovery Act (RCRA) Land Disposal Restriction standards, as required by the Federal Facilities Compliance Agreement. A pilot-scale vitrification demonstration during FY 1995–1996 will provide design data for treatment systems across the DOE complex.

TIDE Stabilization Studies. A process developed by the Technology Innovative Development Engineering (TIDE) Company to create formed products for construction or to encapsulate toxic waste products using fly ash was tested for its applicability in solidifying certain wastes (e.g., pond sludge and incinerator ash). Useful data were obtained on compression strength and Toxicity Characteristic Leaching Procedure (TCLP) performance for this process, and the results indicated that its use to solidify/stabilize such wastes would be feasible.

ISOTOPE TECHNOLOGY SECTION

Major programs within the Isotope Technology Section include (1) the Transuranium Element Processing Program, sponsored by the DOE Office of Energy Research (Office of Basic Energy Sciences, Chemical Sciences); (2) the ^{252}Cf Industrial Sales/Loans Program and (3) the Mark 42 Processing Program, both sponsored by the DOE Office of Defense Programs (Office of Weapons and Materials Planning, Materials Planning Division); and (4) the Isotope Production and Distribution Program, sponsored by the DOE Office of Nuclear Energy (Office of Isotope Production and Distribution). Major facilities operated by the section include the Radiochemical Engineering Development Center, or REDC (hot cells and laboratories)—which is located in Buildings 7920 and 7930, adjacent to the High Flux Isotope Reactor (HFIR) at the X-10 site—and the Isotope Enrichment Facility (calutron mass separators, chemical and materials laboratories, and the Isotope Distribution Office)—which is located in Building 9204-3 at the Y-12 site. All activities at the Isotope Enrichment Facility are sponsored by the Isotope Production and Distribution Program. In contrast, activities at the REDC are sponsored, in part, by all of the four major programs described above. Although the DOE Office of Energy Research (DOE/ER) is the major sponsor and “owner” of the REDC facilities, regulatory activities are under the direction of the DOE Office of Nuclear Energy.

Transuranium Element Processing Program

Transuranium elements 96–100 (curium through fermium) are recovered from irradiated targets in the REDC, which is the distribution center for the DOE heavy-element research program. Target rods are fabricated at the REDC, irradiated in the HFIR, and processed at the REDC for separation, recovery, and purification of the heavy actinides through ^{257}Fm . Highly purified transuranium-element products containing ^{252}Cf , ^{249}Bk , and ^{253}Cf are stored and reprocessed at appropriate intervals to recover their radioactive-decay daughters— ^{248}Cm , ^{249}Cf , and ^{253}Es —in high isotopic purity. Also, 30 types of rare isotopes, or transuranium-element materials of special isotopic or chemical purity, are produced in small quantities to satisfy the needs of individual researchers for specific experiments. Since their construction in the mid-1960s, the REDC and the HFIR have provided the western world's supply of elements beyond curium, either by direct means or by furnishing starting materials for further nuclear-synthesis reactions. The transuranium-element isotopes recovered at the REDC are used both nationally and internationally to study the basic physics and chemistry of the transuranium elements. They are also being used in research and development programs relating to environmental effects, biological effects, and waste isolation.

Activities during this report period included the recovery of curium from Campaign 68, the fabrication of 25 targets from the recovered curium and from makeup stock ^{244}Cm produced at the Savannah River Site, irradiation of the targets in the HFIR, and a chemical separations processing campaign (Campaign 69) during early FY 1995. Products from Campaign 69 included 453 mg of ^{252}Cf , 44 mg of ^{249}Bk , 5 mg of ^{249}Cf , 721 μg of ^{253}Es (mixed isotopes), 100 μg of pure ^{253}Es , and ~ 0.05 pg of ^{257}Fm . These products were delivered to heavy-element research program participants at Livermore National Laboratory, Argonne National Laboratory, and ORNL. In addition, ~ 95 g of curium (mixed isotopes) was recovered for recycle.

²⁵²Cf Sales/Loans Program

One of the transuranium-element isotopes, ²⁵²Cf, has found many applications in service to industry and medicine in addition to its use in basic science investigations. As a portable neutron source, ²⁵²Cf is unique in providing a highly concentrated and extremely reliable neutron spectrum from a very small assembly. Over the past several years, it has been found to have many beneficial uses in areas such as cancer therapy, neutron radiography of objects ranging from flowers to entire aircraft, startup sources for nuclear reactors, and fission activation for quality assurance of all commercial nuclear fuel. The extensive exploitation of this highly specialized product has been made possible through ²⁵²Cf sales/loan programs sponsored by the DOE Office of Defense Programs. Since the Transuranium Element Processing Program supplies ²⁵²Cf to the entire western world, the industrial and medical neutron source products can be regarded as a spin-off from DOE/ER research efforts.

The largest neutron sources are used for neutron radiography, particularly in the U.S. Department of Defense-sponsored and other related programs. During this reporting period, the demand for ²⁵²Cf exceeded the inventory until additional material from Campaign 69 became available. The total amount of ²⁵²Cf shipped was approximately 200 mg/year, whereas the amount sold in bulk to commercial source fabricators was in the range of 20 to 30 mg/year. Many neutron sources of varying size were loaned to industrial and academic institutions and then returned to inventory for reloan.

Twelve medical neutron sources, containing a total of ~280 µg of ²⁵²Cf, were prepared for use in areas such as cancer treatment and neutron brachytherapy research. Surplus medical source fabrication equipment was obtained from the Savannah River Site (SRS) and was modified to produce small wire-form neutron "seed" sources for various medical applications.

Plans were made for a ²⁵²Cf Users' Workshop, which was held in April 1995, bringing together ~100 scientists involved in researching various applications of ²⁵²Cf neutron science.

Mark 42 Processing Program

This project consists of the chemical processing, separation, and recovery of ²⁴²Pu, ²⁴³Am, and ²⁴⁴Cm for use in programs involving weapons diagnostics. These transuranium-element isotopes were produced in ten Mark 42 target assemblies, which were irradiated at the SRS.

The major activity accomplished during this report period was the transportation of the assemblies (each was originally ~14 ft long) from the SRS to a hot cell located at the Pacific Northwest National Laboratory (PNNL), where each target was segmented into eight pieces (sized to fit the REDC dissolver tank). The segmented targets were encapsulated at PNNL and sent to ORNL for storage and eventual processing. A dry storage facility and shielded transfer cask were designed, fabricated, and installed at the REDC to enable storage of the Mark 42 assemblies. Portions of several assemblies were processed to recover the product isotopes and shipped to users at the Los Alamos National Laboratory.

Radiochemical Separations Demonstration Projects

The radiochemical separations capabilities necessary for the recovery of radioisotopes, particularly those produced by the fission process, are closely related to nuclear fuel reprocessing and

radioactive waste treatment R&D. The isotope hot-cell facilities and specialized technical staff at the REDC are often used for coprogram development and demonstration of separations processes for these related program elements.

During this reporting period, a multistage solvent extraction demonstration was carried out to evaluate and validate computer codes describing the transuranium extraction (TRUEX) process (developed at Argonne National Laboratory), and an ion-exchange process was demonstrated for the removal of radiocesium from alkaline waste liquids, using a resorcinol-formaldehyde resin developed at the Savannah River Technology Center.

Isotope Enrichment Program

A major accomplishment of the section staff was the successful restart of the calutrons at the Y-12 site to produce enriched stable isotopes. Market demands and a new long-term commercial contract negotiated primarily by the Isotope Technology staff made restart of the calutrons necessary by the end of 1994. The restart effort involved restaffing and training of new personnel, conducting technical preparations, and achieving full compliance with rigorous DOE facility restart requirements (all within a few months). These tasks were complicated by the Y-12 standdown, which began in September 1994, and by the tight restrictions on acquiring new operations personnel due to the special retirement incentive program. Dedicated startup, review, and approval teams were assembled from ORNL, Y-12, and DOE Oak Ridge Operations staff. In spite of numerous barriers, the technical preparations, together with 77 restart requirement activities, were completed on time, and the calutrons were restarted on January 3, 1995. The rapid restart and the assembly of a relatively inexperienced operating staff led to an expectation of low product quality during initial operations. However, because of the dedication and capabilities of the diverse staff, high-quality products that met the necessary customer requirements became immediately available. All material produced (^{203}Th) during the first two months of operation met the 95 atom % contract specification; 34% of the material produced during the first four months met a 97 atom % specification. Altogether, the calutron restart was an outstanding achievement which brought well-deserved praise to ORNL by the news media and DOE.

RADIOCHEMICAL TECHNOLOGY SECTION

The Radiochemical Technology Section (RTS) operates facilities for conducting radiochemical processing and providing safe storage of radioisotopes. These operations cover a wide spectrum of activities that include (but are not limited to) the following:

- development of radiochemical processes,
- development of decontamination techniques,
- development of remote inspection techniques,
- setup of radiochemical experiments and evaluation of results,
- chemical conversion of radioisotopes,
- preparation of radioisotopes for medical applications,
- design of radiochemical systems,
- management of radiochemical facilities,
- characterization and management of radioactive wastes, and
- deactivation of radiochemical facilities.

Although the major RTS customer is DOE, the section serves many other customers as well—including other divisions at ORNL and within LMES; other governmental agencies, such as the U.S. Nuclear Regulatory Commission; and nongovernmental agencies.

During this period, RTS improved both the general technical makeup of its staff and the conduct of its facility operations. A summary of specific accomplishments can be organized into four programs or areas of emphasis: Isotopes Facilities Deactivation Project, Storage and Distribution of ^{233}U , Molten Salt Reactor Experiment (MSRE) Remediation, and Engineering and Support Services.

Isotopes Facilities Deactivation Project

RTS manages 16 facilities for the LMES Environmental Restoration Program that are being stabilized and deactivated in accordance with the direction of the DOE Office of Environmental Management (EM)-60 Facility Transition Program. During this period, significant radioactive inventory reductions were accomplished; approximately 87,000 Ci of tritium in radioluminescent lights was packaged and shipped to Canada for tritium recovery, and 58 ^{60}Co sources were packaged and shipped to retrievable storage on-site. Major improvements in safety documentation were made by the deactivation of Safety Analysis Reports/Operational Safety Requirements for Buildings 3026C, 3026D, and 3029 and the submittal of the Basis for Interim Operations (BIO) documents for Buildings 3026C, 3038, 3047, and 3517 to DOE Oak Ridge Operations (DOE-ORO) for approval. Deactivation of Buildings 3033A, 3028, 3030, 3031, and 3036 was completed, with ownership of Building 3036 being returned to the ORNL Radioactive Packaging and Shipping Organization. Other major accomplishments during the period included the inventory removal and decontamination of Building 3038 (Alpha Handling Facility) and the decontamination and general operations improvements at Building 3517.

Storage and Distribution of ^{233}U

The Radiochemical Development Facility (RDF)—the Building 3019 complex—is a national repository for ^{233}U and is sponsored by the DOE Office of Defense Programs. Major improvements

in the conduct of operations have been accomplished at the RDF with upgrades of operating procedures, the training program, and safety documentation. The facility's BIO was submitted to DOE-ORO on September 1995; upon approval it will constitute a greatly improved Facility Authorization Basis. A strategy was developed for the facility, and options for final disposition of the stored ^{233}U were developed through the DOE Fissile Materials Disposition Program. Plans were developed for repackaging the inventory, and procurement of modular hot cells was initiated to facilitate material handling. Many decontamination and maintenance items greatly improved the general condition of the facility. A maintenance structure was constructed over the 3108 filter house north of Building 3019 to facilitate filter changes.

Significant interest developed during this period in the radioisotope ^{229}Th , which is a daughter of ^{233}U and is present in relatively large quantities in the stored ^{233}U inventory. Daughters of ^{229}Th (^{225}Ac and ^{213}Bi) are being proposed for alpha radioimmunotherapy used in cancer treatment. Residues containing ^{229}Th were recovered and shipped to the Institute for Transuranium Elements in Karlsruhe, Germany, for preparation of a ^{213}Bi generator for cancer therapy research. A Laboratory Director's R&D proposal has been funded to pursue recovery of ^{229}Th , purification of ^{225}Ac , development of a ^{213}Bi generator, and alpha therapy on mice tumors.

Molten Salt Reactor Experiment Remediation

RTS personnel have also assumed significant responsibilities in the remediation of the MSRE, which had been shut down since 1969, with subsequent storage of the solidified ^{233}U spent fuel in the system drain tanks. Because of elevated radiation readings in the system, gas samples were taken from the off-gas piping system in March 1994. These samples revealed unexpectedly high concentrations of F_2 and UF_6 in the system. Additional investigation located a significant deposit of uranium in the auxiliary charcoal bed (ACB) in the off-gas system. The discovery of ^{233}U migration by the RTS and other CTD support sections resulted in an intense interim corrective action program to reduce the risk of the as-found condition and remediate the reactor.

During this period, the water was drained from the ACB cell, thus eliminating the potential for accidental criticality due to inleakage of water into the dry ^{233}U deposit in the ACB. Other water sources in the MSRE were removed to eliminate the potential for accidental criticality by inleakage of water via multiple failures into the drain tanks. Most importantly, the failed valve (V561) that allowed continued migration of UF_6 and fluorine to the ACB was remotely repaired and closed. The closure of V561, led by RTS personnel, eliminated a major ORNL vulnerability associated with potential rapid reaction with F_2 and unstable carbon-fluorine components present in the ACB.

At the end of this reporting period, the risk of a potential environmental release at the MSRE was greatly reduced.

Engineering and Support Services

RTS engineering and support services played a major role in all activities performed by the section and also provided assistance to other divisions at ORNL.

Engineering support for the MSRE remediation project and the failed ^{192}Ir target recovery project was the most noteworthy accomplishment during this period, although numerous other important engineering design projects were performed. The MSRE remediation project presented many

as-found conditions that required special fixtures to be designed for remote application. These one-of-a-kind designs reduced radiation exposure and allowed major risk reductions, such as the closure of V561 at MSRE, to be accomplished.

The failed ^{192}Ir target recovery also provided major as-found design challenges. The engineering support provided to this project included special mechanical assemblies to handle the massive cask with the uncontained failed capsule inside and to disassemble the cask remotely in an existing unequipped hot cell. The special fixture designs were major contributions to the success of the ^{192}Ir recovery project conducted at Building 3047 for the Isotope Production and Distribution Program.

Other support activities included the development of decontamination and video inspection technologies. Building 3503 was established as the decontamination services facility base, and a versatile inventory of decontamination equipment and systems was assembled. The inventory of decontamination equipment and systems at the end of FY 1995 included the following: mechanical scabblers; superheated, high-pressure, and ultrahigh-pressure (35,000-psi) water systems; strippable-coating airless sprayers; high-efficiency particulate air (HEPA) ventilation systems; and HEPA-filtered vacuum systems. During the reporting period, three decontamination demonstrations were completed to show the effectiveness of crystalline ice blasting, CO_2 blasting, and fluorocarbon surfactant surface cleaning. A video inspection technology effort was initiated to develop innovative means for performing remote industrial video inspections, identifying the methods and equipment that can be utilized to provide maximum effect during an inspection process, and creating a service program that will address the needs of both ORNL and other RTS customers. This new area of support has already proven to be very useful in accomplishing RTS objectives and in providing vital services to other ORNL divisions as well.

RESOURCE SYSTEMS MANAGEMENT SECTION

Administrative and Service Functions

During this reporting period, the Resource Systems Management Section (RSMS) provided support to CTD research and development objectives and performed a broad range of essential administrative service functions. The primary objectives of RSMS involved interpreting and coordinating proper application of company policy and procedures, while maintaining efficient work flow, by providing services in the following areas: staffing and performance and promotion planning, computer security coordination, capital facility development, editorial support, drafting resources, procurement and special services, finance and budget resources, training coordination, and document management. During the period, the scope of the section also expanded to include the Office of Safety and Operational Readiness.

Employment and Training of Division Personnel. The Personnel Resources function continued to ensure that CTD employment requirements were satisfied in a timely manner, administered the student co-op program within the division, and assisted in the implementation of CTD Work Force Diversity programs. To oversee the compliance-related and other training needs of division personnel, the CTD Training Office facilitated the scheduling and documentation of training activities.

Finance and Procurement Services. As part of their task to provide financial support to CTD research staff and division management, Finance Office staff met with CTD staff to complete requirements for budget submission prior to the beginning of each fiscal year within the reporting period and performed essential close-out activities at the end of each fiscal year. The Procurement function within RSMS not only helped to expedite the processing of purchase requisitions but also continued to coordinate a variety of services for the division, including those in the areas of property transfer, telecommunications services, space allocation, inventory of precious metals, and requests for keys and locks.

Publications Services and Drafting Resources. Publications Services staff continued to provide editorial and publications-related assistance to division staff and management, including activities such as coordinating document clearances and printing activities. In editing and proofreading materials prior to publication, Publications Services staff worked closely with the members of the Drafting Resources Group to produce high-quality visuals for CTD staff. The period was one of transition for the latter group, as new computer software was installed and steps were taken to achieve greater computer utilization in areas such as poster production.

Procedures Development and Records Management. Significant administrative efforts of RSMS involved the areas of procedures development and records management. The CTD procedures coordinator coordinated and directed the preparation, review, approval, and controlled distribution of division procedures and facilitated CTD review of procedures generated outside the division. The procedures coordinator worked closely with records management staff, especially those in the CTD Administrative Document Management Center, which maintains records of procedure review. Additional document centers—supporting the Radiochemical Engineering Technology Center, the Radiochemical Technology Section, and various DOE programmatic initiatives—provided other essential information retrieval services for CTD staff.

Facilities Development and Engineering Resources. The Facilities Development and Engineering Resources (FDER) Group continued to play a significant role in division operations. The group maintained oversight of the majority of the expense and capital projects that affected CTD facilities in such a manner that environmental, safety, and health (ES&H) regulations were satisfied; DOE specifications were met; and the operational capabilities of the various CTD facilities were consistent with the programmatic objectives and missions of the division. Activities during the reporting period included radiochemical and process waste treatment projects as well as management and oversight of the capital and expense projects, with the group's waste certification official continuing to ensure that CTD's capital projects were in compliance with the regulations of the Waste Management and Remedial Action and Environmental Restoration divisions.

Office of Safety and Operational Readiness

Major personnel and management changes occurred within the Office of Safety and Operational Readiness (OSOR) during this reporting period. At the beginning of FY 1993, a permanent manager was appointed, and one year later the group was incorporated into RSMS. During this time of transition, OSOR continued its role of ensuring compliance with section, division, and ORNL requirements by preparing and issuing several significant procedures, directives, and management plans.

As part of its essential ES&H functions, the group was involved in a wide range of activities, including monthly reports in the Continuous Self-Improvement and Upgrade Program as well as in the areas of facility responsibility, hazardous materials control, waste handling, and environmental protection. In addition to routine participation in quarterly safety inspections, the staff conducted numerous unscheduled and preaudit walkthroughs and acted as escorts for several external audits/surveillances. Self-assessments were conducted in the areas of Nuclear Criticality Safety, Industrial Safety, Emergency Preparedness, and Radiological Protection and Configuration Management. An assessment of the Business Factors and Customer Satisfaction sections of the Malcolm Baldrige Criteria was also performed in each section. Concurrently, efforts were initiated to make improvements in the Corrective Action Tracking System, including modifications of the data base to enable tracking and trending of corrective actions.

Partly as a result of these concerted efforts, CTD enjoyed a two-year period without an environmental noncompliance and was recognized as the recipient of the ORNL Director's Award for Excellence in ES&H. Also, in order to avoid noncompliances associated with time limits imposed on treatability studies conducted within CTD, a system was established to track the receipt and current status of samples received by researchers.

During the period CTD gained the valuable services of a resident Industrial Hygiene/Industrial Safety Representative from the ORNL Office of Safety and Health Protection as an adjunct to the CTD safety program. OSOR also initiated measures to provide better interaction and communication between members of the group and section-level ES&H staff and improved communication with personnel involved in waste handling.

Special OSOR projects during this period included assisting section personnel with the preparation of various facility authorization basis documents and coordinating and conducting surveillances to ensure compliance with operational safety requirements. A Conduct of Operations matrix was

completed for all CTD facilities that are not classified as Hazard Category 2 or 3. (These require separate matrices.) In this context, a survey was conducted to verify CTD's status of compliance with Conduct of Operations.

Work also continued on the task to support the DOE Environmental Restoration and Waste Management (EM) effort to coordinate the development of significant collaborative work between EM and Taiwan governmental organizations in the field of environmental restoration and waste management.

SPECIAL ASSIGNMENTS

For several years CTD staff members on special assignment have been involved in activities related to the initiation or management of programs that affect multiple organizations, rather than concentrating on tasks identified with any single research section of the division. The following paragraphs describe the major activities of CTD staff who were on special assignment during the reporting period.

Management and Oversight of Programmatic Activities

Waste Remediation Tasks. The largest activity in this area involved the management of a program to develop the technology necessary to remediate wastes stored in underground tanks such as the Melton Valley Storage Tanks at ORNL and tanks containing similar wastes at Hanford, Savannah River, West Valley, and Idaho. DOE created the Office of Technology Development (later renamed the Office of Science and Technology) for the purpose of developing the required technology. In turn, this office established a number of programs to address major environmental management problems, such as tank wastes. Two of the most important programs were the Underground Storage Tank Integrated Demonstration, which subsequently became the Tank Focus Area, and the Efficient Separation and Processing Integrated Program, which subsequently became the Efficient Separations Crosscutting Program. The former program focused primarily on technology demonstrations, while the latter encompassed R&D activities at all stages from applied research to engineering development. Within this overall framework, the special assignment staff had responsibility for managing the national and ORNL program to demonstrate separation technologies such as filtration, ion exchange, evaporation, and solvent extraction, as well as comanaging the national program to perform R&D concerning separation technologies related to tank wastes, contaminated plumes, landfills, decontamination and decommissioning activities, and mixed wastes.

In addition to this major initiative in the area of tank waste, one staff member relocated to the Rocky Flats Environmental Test Site to provide technical expertise in the ongoing remediation at that site and to encourage joint efforts between ORNL and Rocky Flats. As a result of this activity, ORNL acquired an instrumental role in the DOE Office of Environmental Management's Mixed Waste Focus Area.

Nonnuclear Programs Related to Chemical Technology. A second important activity managed by the special assignment staff members was to initiate programs to greatly expand CTD and ORNL funding in nonnuclear programs related to chemical technology. This effort focused on targeting sponsors such as (1) DOE offices involved with fossil and renewable energy sources and conservation and (2) industries such as petroleum and industrial chemicals. As a result of these efforts, CTD was rewarded with a greatly expanded portfolio of diverse activities ranging from decentralized hydrogen production to pipeline insulation and crystal manufacture. Working relationships were established with a number of industrial firms, trade organizations, and other national laboratories, thus providing a dynamic base upon which these programs can continue to expand. Also initiated during this period was a major effort to establish a Center for Separation Science and Chemical Processing.

Molten Salt Reactor Experiment Remediation Project. Because of its expertise, CTD was called upon to help the LMES Environmental Restoration Program address safety issues related to the

Molten Salt Reactor Experiment, a facility that was managed by the Waste Management and Remedial Action Division. The reactor had achieved initial criticality in June 1965 and was shut down in December 1969. During final operation the primary fissionable material was ^{233}U —which contained a significant fraction of ^{232}U —and a surveillance and monitoring program had been implemented following shutdown. Increasing radiation levels, first noted at this facility in 1990, along with the discovery of radioactive uranium in a charcoal absorber in the off-gas system in 1994, raised concerns that the highly enriched uranium in the residual fuel salt might be migrating and collecting in a location where the probability of a criticality excursion was unacceptably high.

In 1994 CTD provided key members to a team that was formed to alleviate the immediate safety concerns and then proceed to remove and process the salt into a form suitable for long-term storage. The safety concerns were immediately addressed by the multiorganizational MSRE Remediation Project team, which reported to the Environmental Restoration Program. The initial task considered factors such as containment, criticality control, and protection against chemical reactions. CTD staff served in major roles in the team's assessment of the migration phenomenon and in the implementation of corrective measures. During the reporting period, a team including CTD staff also began work on equipment design, facility modification, and performance testing as part of the second task—to remove the radioactive gases generated by radiolysis of the stored fuel salt.

Other Technical Activities

In addition to their managerial responsibilities during the reporting period, the special assignment staff were able to maintain a significant level of technical involvement, producing publications on a wide range of subjects, such as spectroscopy, separations science, and waste repository performance. Several were involved in a variety of external activities that required expertise unique to CTD—for example, organizing the most recent Separations Science Symposium, serving on a number of National Academy of Sciences committees, chairing major committees of the National Council on Radiation Protection and the Nuclear Energy Agency, assisting in a host of ad hoc technical review groups, and extensively participating in professional society activities by holding elected and appointed positions in the societies and organizing technical activities at their meetings.

Administrative Summary

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M. R. Ally

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