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Division of Environmental Control Technology Program-1977

JUNE 1978

U.S. Department of Energy
Assistant Secretary for Environment
Division of Environmental Control Technology

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Division of Environmental Control Technology Program-1977

JUNE 1978

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U.S. Department of Energy
Assistant Secretary for Environment
Division of Environmental Control Technology
Washington, D.C. 20545

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P. Lee

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PREFACE

This report covers Division of Environmental Control Technology projects in progress during FY 1977 under the Energy Research and Development Administration (ERDA). For this reason, ERDA may be the agency of reference in individual project summaries. All references in subsequent editions will, of course, be to the U.S. Department of Energy.

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FOREWORD

The Division of Environmental Control Technology (ECT) supports the Assistant Secretary for Environment (EV) in discharging two primary responsibilities: the independent overview and assessment of environmental control aspects of both the U.S. Department of Energy's (DOE's) research, development, and demonstration (RD&D) programs and the Nation's energy policies and the decontamination and decommissioning (D&D) of radioactively contaminated sites that are presently owned or were formerly utilized by the Government.

ENVIRONMENTAL ENGINEERING

Rational policy decisions and effective RD&D planning for the environmental control aspects of energy technologies demand not only raw technical data on control capability, but the engineering expertise to systematically evaluate, interpret, and apply the data to the complex issues being addressed. In the Office of the Assistant Secretary for Environment, the primary source of this essential capability is ECT's Environmental Engineering program.

The philosophy guiding Environmental Engineering activities is embodied in three postulates. First, environmental controls are of great importance because they represent the mechanisms that allow energy systems to operate in the real world. Second, an organizational capability for independent, unbiased overview and assessment is required to ensure that environmental control issues receive proper emphasis for timely resolution. Third, development of environmental control hardware and systems is best conducted as an integral part of the developing energy systems themselves. In FY 1977, over \$185,000,000 (some 3.5 percent of the Department's total budget) was dedicated to environmental control activities.

An important feature of Environmental Engineering's independent overview and assessment viewpoint is that environmental control options are treated as an integral part of an overall energy-producing system. Hence, judgments on cost and control effectiveness are based on a systems orientation that reflects a host of parameters including multimedia impacts, parasitic energy demands, and potential trade-offs provided by alternative environmental controls, all of which impact on the myriad of operations within the total fuel cycle. This systems orientation is necessary to ensure that optimization of environmental control operations does not, in fact, create concomitant adverse environmental situations (for example, unacceptable by-product formation or excessive water use) in other parts of the energy cycle.

In summary, the programs supported by Environmental Engineering have nurtured the development of an environmental control assessment capability that has been used:

- To make judgments on Environmental Impact Assessments and Environmental Impact Statements (EIAs and EISs),
- To provide a sound basis for staff participation on interagency task forces,
- To impact environmental control aspects of DOE policies and Federal regulatory activities, and
- To broaden the focus of RD&D activities within other entities of DOE.

DECONTAMINATION AND DECOMMISSIONING

In the rapid pace of technical developments which have characterized the establishment of nuclear defense and energy programs, many facilities have become obsolete or otherwise rendered of no further use in their intended function. These facilities, when contaminated with radioactive material, present a unique management problem to ensure that the latent hazard of radioactivity is controlled and does not pose a threat to man nor a burden on the environment.

In many cases, the responsibility for this management has passed from programmatic sponsorship--the facilities are remnants of now defunct programs--and has become a general program in the interest of environmental stewardship, in a sense, another facet of environmental content. It is on this basis that ECT, under the Office of the Assistant Secretary for Environment, conducts the Decontamination and Decommissioning Program of the Department of Energy.

The overall objective of the decontamination and decommissioning programs is to reduce the potential environmental hazards associated with sites and facilities no longer required or used in the Nation's nuclear programs. Such facilities currently include both surplus Government-owned property and private property where nuclear activities were conducted under contract, but where the decontamination was not sufficient to allow an unrestricted alternative use or where residual radioactivity poses a potential environmental or health concern as viewed in the light of current standards. Decontamination and decommissioning actions are conducted with the goal

of minimizing potential risks and restoring sites and facilities to allow beneficial use without radiological restrictions. In the D&D process, the residual radioactive materials which remain at these facilities must be properly contained and stabilized or removed and disposed of so that all potential impacts are reduced to the lowest level practicable.

This report of work sponsored in 1977 is the first of a planned annual series. It presents a short summary of objectives, approach, progress and results, and future plans for each research, development, or assessment project within the program areas described above.

William E. Mott
Director, Division of Environmental
Control Technology
Office of the Assistant Secretary
for Environment
U.S. Department of Energy

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ENVIRONMENTAL ENGINEERING

Environmental control technology provides the bridge that allows energy systems to operate acceptably in the real world. Independent judgments on the efficacy and practicability of environmental control procedures, processes, strategies, and systems by the Division of Environmental Control Technology (ECT) provide an unbiased input to U.S. Department of Energy (DOE) policy and evaluation and serve to ensure the general public as to the objectivity of the Department on environmental control matters.

While generally DOE's energy technology programs consist of heavily funded, homogeneous programs of several years' duration, ECT projects are comparatively small, diverse, and targeted to address individual environmental control and safety issues or requirements earmarked by the energy technologies, by the Environmental Development Plans (EDPs), or by independent identification within the Office of the Assistant Secretary for Environment or ECT. In FY 1977, the Division's largest Environmental Engineering (EE) project dealt with determining the safety and control measures required for liquefied natural gas. This project had

been singled out for special attention by both the Congress and DOE. ECT activities dealing with oil spills also were directly responsible to Congressional mandate.

To achieve these EE objectives, the Division of Environmental Control Technology sponsors work at DOE laboratories and research centers, as well as at various industrial and academic facilities.

Major program areas are:

- Nonnuclear energy which examines critically the environmental control aspects of coal, petroleum and gas, oil shale, solar, and geothermal energy technologies, as well as energy conservation applications, and
- Nuclear energy, which assesses the adequacy of environmental controls for all phases of the nuclear fuel cycles including shipment of energy materials and wastes and evaluates advanced waste disposal techniques.

SURVEY OF ENVIRONMENTAL CONTROL TECHNOLOGY ACTIVITIES

ORGANIZATION AND CONTRACT NUMBER

The Aerospace Corporation
E(04-3) 1101 (PA-10); Task Order T-6

PRINCIPAL INVESTIGATORS

J. S. Dock
R. S. Frost
R. M. Kuhns

OBJECTIVES

The objective of this project is to provide support to the Division of Environmental Control Technology (ECT) in the organization, conduct, and documentation of an intra-ERDA inventory of all FY 1977 projects having environmental control technology aspects.

APPROACH

For the intra-ERDA environmental control technology inventory, a series of panels, composed of representatives from ECT, the energy technology offices, and the Office of the Controller were conducted for the purpose of identifying all of the FY 1977 projects having environmental control aspects and their associated funding. The panels were initiated by an Action Memorandum signed by the Administrator of the ERDA. Following the panel sessions, the inputs from the energy technologies were compiled, and a report was prepared and published documenting the total ERDA involvement in environmental control related activities.

PROGRESS AND RESULTS

An Action Memorandum was approved by the Administrator of ERDA, calling for a series of panel sessions to completely and concisely define the FY

1977 total of ERDA projects having environmental control technology aspects. A plan and the structure for the panel sessions, including criteria for applicability to environmental controls, schedules, structural breakdown, and guidelines, were prepared and presented to the energy technology representatives at an ECT chaired kick-off meeting. Panel sessions followed which resulted in the receipt of inputs from the energy technologies followed by resolution of all open items and final sign-off on the listing of projects having environmental control aspects. The inputs from each of the energy technologies were then compiled and integrated into a total ERDA report on all ERDA projects together with associated funding related to environmental control technology. Draft copies were reviewed and the final report master was prepared. A summary of the inputs is shown in Table 1 and the distribution of the FY 1977 funding related to environmental control activities within ERDA is depicted in Figures 1 and 2.

PLANS FOR THE NEXT PERIOD

The steps necessary to conduct and document the total Department of Energy (DOE) FY 1978 projects having environmental control aspects will be initiated.

REPORTS PUBLISHED

"Environmental Control Technology Activities of the Department of Energy in FY 1977," DOE/EV-0030, November 1977.

PROJECTED MILESTONES

- November 1977 -- Preparation for FY 1978 total DOE environmental control technology inventory completed November 1977.
- July 1978 -- Panel sessions to be completed and second annual report published

Table 1. Total DOE Environmental Control Activities Funding Allocations

Administration	FY 1977 Funding Allocation Related to Environmental Control Activities (\$ in thousands)	Portion of Total FY 1977 Budget Related to Environmental Control Activities (Percent)*
Conservation (AC)	5,984	4.8
Fossil Energy (AFE)	86,194	19.4
Nuclear Energy (ANE)	62,195	2.5
Solar, Geothermal, and Advanced Energy Systems (ASGA)	12,337	1.4
Environment and Safety (AES)	17,973	8.1
Total	184,683	3.4
TOTAL DOE FY 1977 Budget: \$5,383,932,000		

* To nearest tenth of a percent

Figure 1. Distribution of Total DOE Environmental Control Activities Related to FY 1977 Funding by Administration.

Figure 2. Distribution of Total DOE Environment Control Activities Related to FY 1977 Funding by Energy Category.

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COAL

In view of the important role coal is expected to play in the Nation's energy future, an increasingly important aspect of the Environmental Engineering program is its focus on evaluating the efficacy and practicability of environmental control options within the coal energy cycle. The need to conduct a comprehensive, unbiased evaluation is imperative to ensure that:

- The scope of DOE's planned RD&D programs includes proper emphasis on environmental control issues so that adequate environmental control options are developed in concert with emerging coal technology, and
- DOE's input to National energy policies and regulatory initiatives is based on technically sound evaluations of environmental control capabilities and costs.

A major initiative in this area has been the systematic evaluation of environmental control implications of alternative systems for generating electricity from coal. This evaluation was designed to include consideration of the economic, engineering, and environmental characteristics of conventional electric generation options (e.g., conventional combustion with either low sulfur coal, flue gas desulfurization, or precombustion physical cleaning) as well as an evaluation of near-term advanced technological alternatives such as solvent refined coal, atmospheric fluidized bed combustion, and conversion of coal to gas (medium and low Btu) with subsequent gas firing in combined power cycles. The technical understanding obtained from the component of this study dealing with first-generation flue gas desulfurization systems (lime/limestone) has allowed the Environmental Engineering program to contribute substantively to the ongoing formulation of a DOE position on the New Source Performance Standards tentatively proposed by the Environmental Protection Agency (EPA) for steam generators. Additionally, the understanding gained concerning conventional combustion with flue gas desulfurization provides DOE with a benchmark against which alternative coal electric power generation systems can be measured. Preliminary investigations of environmental control implications of

first-generation coal gasification technology have enabled Environmental Engineering outputs to impact tentative New Source Performance Standards proposed by EPA for Lurgi technology. In fact, because that assessment had suggested the need for development of a more energy/cost efficient hydrocarbon emission control system, two options were subsequently identified whose technical feasibility will be determined in the near future. Of course, consistent with EV philosophy, responsibility for development and demonstration of these options resides with the energy technology developers.

Additional Environmental Engineering accomplishments related to the coal fuel cycle include:

- Serving as a catalyst to set in place needed environmental control projects focused on water conservation, reuse, and cleanup in coal conversion systems,
- Initiating and supporting essential field investigations to identify environmental control needs and options associated with potential aquifer disruption and subsidence resulting from in situ coal gasification,
- Developing the environmental control activity components of the high priority Gasifier-in-Industry program conducted under the auspices of the Assistant Secretary for Energy Technology, and
- Contributing to and influencing the formulation of specific energy technology program plans in such a manner to ensure that environmental control aspects are adequately considered.

In addition to the specific partial list of accomplishments just delineated, it is important to state that the information generated and expertise developed in the Division of Environmental Control Technology are used, on a continuous basis, to review and comment substantively on the environmental control aspects of a host of internal and external documents, including EISs, EIAs, other agency documents, Federal regulatory initiatives, and correspondence with outside groups.

ASSESSMENT OF ENVIRONMENTAL CONTROL TECHNOLOGY FOR ELECTRIC POWER PRODUCTION FROM COAL

ORGANIZATION AND CONTRACT NUMBER

Argonne National Laboratory
W-31-109-ENG-38

PRINCIPAL INVESTIGATORS

N. R. Sather
D. E. Wilzbach

OBJECTIVES

The program is a continuing effort to provide the Division of Environmental Control Technology with comparative engineering/cost assessments of environmental control technologies for processes for generation of electric power from coal. The power generation processes to be evaluated include process options under development such as fluidized-bed combustion, coal cleaning with combustion, and coal gasification and combined power cycles, coal liquefaction (solvent refined coal), as well as conventional power plants with stack gas cleaning. All factors that affect the selection of the processes and the pollution control systems will be considered.

The program also seeks to identify unresolved issues, information gaps, and needed R&D programs pertaining to the control technologies. This effort is intended to assist the Environment staff in fulfilling its responsibility to ensure the adequacy of environmental control systems for energy extraction, conversion, and utilization technologies.

The core group of experts maintained by the program is available for consultation with the program staff as needed and can provide quick-response reviews of timely issues.

APPROACH

Information on the costs, pollution control, reliability, availability, and energy requirements of power generation processes and the associated pollution control systems are being compiled from reports and discussions with manufacturers, users, and developers of these processes and control technologies. The Argonne staff has responsibility for evaluating the information derived from its sources and for resolving discrepancies and inaccuracies that arise. The capabilities of the in-house staff are supplemented by considerable use of subcontractors and consultants with special capabilities and expertise.

A methodology for comparing alternative coal-electricity processes on the basis of their capacity for cost-effective control of environmental impacts has been made. A comparative analysis of coal-electricity options is being made during FY 1977; this analysis will be updated in subsequent years as new information from utility installations and from

process development facilities becomes available. Reports on the project are submitted semiannually. Major technology status reports are issued near the end of each calendar year. These reports are based upon the extensive subcontractor reports together with in-house investigations and evaluations. Mid-year reports present the results of comparative evaluations of the technologies based upon data from the annual status review.

PROGRESS AND RESULTS

Detailed evaluations of the status of technologies for flue gas desulfurization, particulate collection, NO_x control, and coal preparation/cleaning have been completed by various subcontractors. Subcontractor evaluations of solvent refined coal and gasification/combined cycle technologies have been initiated. An evaluation of the status of fluidized bed combustion of coal and a review of information on the health effects of combustion-derived pollutants is being made by the Argonne staff. The size of the detailed reports precludes combining the information into a single report that will provide an informed overview of the status of control technology for conventional and near-term coal-to-electricity processes. In addition to providing information on the effectiveness, performance, applicability, and costs of the various technologies, the report includes initial comparative assessments of the available control technologies for conventional coal combustion.

Follow-up program planning to update the assessments in the light of new developments will be undertaken near the end of FY 1977. It is expected that the insight developed in the review and synthesis of the subcontractor reports will be useful in identifying areas where effort is of particular importance.

An initial technology status report was issued in December 1976. This report was unique in that it was the first in-depth technical assessment of control technologies for all of the major air pollutants and the derived solid wastes. The primary emphasis was on available technologies, but appraisals of emerging control technologies under development were included.

The comprehensive nature of the project demands a highly flexible methodology for performing technology comparisons. A systems-analysis approach, utilized by a university subcontractor, represents the coal-to-electricity process as a number of modules. Each module corresponds to a mathematical model, and they may be arranged so as to form any system of interest. Further development was carried out by the Argonne staff, and a report detailing the methodology was issued in June 1977.

PLANS FOR NEXT PERIOD

Whereas emphasis in FY 1977 was on the assessment of control technologies in the light of current emission regulations, the FY 1978 assessments will be made in the light of regulations that may be promulgated under the 1977 Clean Air Act

amendments. Forced acceleration of flue gas desulfurization (FGD) deployment, maximum reduction in NO_x emissions from stationary sources, limitation of fine particulate emissions, and regulation of sulfates must all be considered. The assessments are designed to provide information on the capabilities of available control technologies to meet such challenges and on the environmental and economic consequences. Specifically, the FGD program should provide more definitive information on the reliability of lime/limestone scrubbing and on the costs and impacts of disposing of the resulting wastes; it should also provide a clearer indication, based on actual commercial performance, of the costs and potential role of regenerable FGD processes. Commercial application of combustion modification technology should establish whether NO_x emissions can be controlled in this way without adverse effects on plant reliability. The particulate control evaluation should indicate the cost effectiveness of available technologies and the potential of second-generation processes for fine particulate control. A study of U.S. coal data should yield projections of the potential quantities of U.S. coals that are available or that can be cleaned to meet specified SO_2 emission levels. The FGD program will provide the first assessment of the technology based on the actual performance of an integrated power plant at Rivesville, W.Va. Finally, the assessments of coal gasification/combined-cycle, fuel cell, and magnetohydrodynamics (MHD) technologies will provide information on the costs and availabilities of advanced power generation systems with much lower emission levels and/or greater efficiencies than are presently available.

Program planning to update ongoing assessments in the light of interim developments will be undertaken in the latter half of FY 1978. At that time also, preliminary surveys will be made of advanced processes for generation of electricity from coal for the purpose of identifying new areas for investigation. Technologies to be included in this preliminary survey are advanced steam cycles, in situ coal gasification, and energy storage systems for electric utilities.

REPORTS PUBLISHED

"Environmental Control Implications of Generating Electric Power from Coal," Technology Status Report, Argonne National Laboratory, ANL/ECT-1 (Vol. I -condensation, Vol. II -detailed information), in press.

"Environmental Control Implications of Generating Electric Power from Coal," Comparative Assessments Status Report, Argonne National Laboratory, June 1977 (draft).

PROJECTED MILESTONES

None

* * *

ASSESSMENT OF ONCE-THROUGH COOLING WATER CONTROL TECHNOLOGY

ORGANIZATION AND CONTRACT NUMBER

Argonne National Laboratory
W31-109-ENG-38

PRINCIPAL INVESTIGATOR

J. D. DiTmars

OBJECTIVES

The objectives of this study are an assessment of the efficacy of once-through cooling systems (i.e., surface and submerged discharges) for waste-heat disposal from electric power generating stations and an evaluation of statistical approaches for performance prediction and for design of once-through cooling systems.

APPROACH

The assessment of the efficacy of once-through cooling systems is primarily concerned with the satisfaction of temperature standards and guidelines for waste-heat disposal from power plants by means of surface and submerged discharge structures. The characteristics of surface and submerged discharges in the various receiving water bodies will be compared with the temperature and mixing zone standards to determine whether reasonable application of such systems can meet the standards. Thus, an array of receiving-water types, each with a range of temperature and mixing-zone standards, will be matched against an array of once-through cooling systems. Where possible, cost figures for once-through cooling systems will be gathered as an economic measure of efficacy.

The evaluation of statistical approaches to performance prediction and design of once-through cooling systems is motivated by the fact that the ambient receiving-water conditions, and thus thermal-plume behavior, have been found to vary significantly in time. Argonne has been engaged in the collection and evaluation of such data from power plant sites on the Great Lakes for several years and has extensive data sets for several sites. Those data and Argonne's experience in the evaluation of prediction techniques for thermal-plume modeling will be used to investigate the validity of statistical bases for thermal discharge performance prediction and design.

In support of the tasks related to the objectives and approaches discussed above, additional sets of thermal-plume data from a submerged multiport diffuser for cooling water discharge from a nuclear power plant will be collected to complete the characterization of that type of once-through cooling system.

PROGRESS AND RESULTS

The project was initiated in May 1977. Eight thermal-plume surveys were conducted at the J. A. FitzPatrick Nuclear Power Plant in Lycoming, N.Y., on the shore of Lake Ontario with submerged multiport diffuser discharge, with the heated water discharged in the offshore direction. This once-through cooling system is typical of the type often recommended for use in large lakes and in marine coastal waters. The performance of such systems may depend to a large extent on the effects of ambient currents and the flows induced by the high momentum discharges. In addition to measurements of the three-dimensional plume structure, 10 current meters were moored in the Lake near the diffuser to obtain current data. Data from these surveys have been reduced, processed, and combined with data collected previously at that site for interpretation concerning the behavior of "T-type" multiport diffuser systems for once-through cooling.

An initial investigation of the statistics of thermal plumes from shoreline surface discharges into large lakes included the examination of an attempt by others to predict subsurface-isotherm areas given the surface isotherm-area relations. The ambient lake conditions were broken down into general categories, and for each category, mean relationships among surface-isotherm areas, subsurface-isotherm areas, and depth were developed. An investigation of the scatter around the mean relationships indicated that little confidence could be placed in so simple a model of the depthwise variation of the plume. The scatter was particularly large for the area of the isotherm for the 3°F rise above ambient temperature, and that is the parameter often sighted in water quality standards for temperature.

PLANS FOR NEXT PERIOD

Multiport diffuser system data will be used with other predictive techniques to complete the assessment of once-through cooling system efficacy in the array of receiving-water standards versus types of once-through cooling systems. The statistics of thermal-plume behavior and ambient conditions at a surface discharge, probably the Point Beach discharge, and at a submerged discharge will be examined in detail in terms of predictability. The prototype data will also be used with models of plume behavior to investigate the validity of statistical design bases.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Reports on the assessment of efficacy of once-through cooling systems and on the application of statistical approaches to surface discharges will be

completed in the third quarter of FY 1978. A report on the application of statistical approaches to submerged discharges will be completed at the end of FY 1978.

* * *

PRELIMINARY OVERVIEW OF ENVIRONMENTAL CONTROL OPTIONS FOR CO₂

ORGANIZATION AND CONTRACT NUMBER

Brookhaven National Laboratory
EY-76-C-02-0016

PRINCIPAL INVESTIGATORS

M. Steinberg
A. S. Albanese

OBJECTIVE

The objective of this study is to assess the applicability of state-of-the-art CO₂ control processes for controlling the level of atmospheric CO₂.

APPROACH

Conceptual processing schemes for CO₂ recovery and recycle will be prepared, and exploratory studies will be performed.

PROGRESS AND RESULTS

The current literature has been reviewed, and appropriate parties contacted, to obtain data on CO₂ emissions and control processes. Several reports have been received and reviewed; others are forthcoming.

PLANS FOR NEXT PERIOD

- Assess the various sources of industrial CO₂ emissions.
- Examine the effect of alternative energy sources on limiting the emission and effects of CO₂.
- Assess the value of CO₂ recovery and recycle for such items as synthetic fuels.
- Determine the effects of other pollutant gases in typical emission mixtures on CO₂ removal and recovery on state-of-the-art control technology.
- Overall conclusions and recommendations will be made concerning various CO₂ environmental control strategies and the need for developing new control processes and for energy conversion technologies.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- October 1, 1977 -- Complete initial study.
- September 30, 1978 -- Complete literature survey, technology assessment and study on available processes and options for controlling CO₂ releases.

* * *

WASTE HEAT MANAGEMENT IN THE ELECTRIC POWER INDUSTRY: ASSESSMENT OF ENVIRONMENTAL CONTROL OPTIONS

ORGANIZATION AND CONTRACT NUMBER

Energy Laboratory, in association with the R.M. Parsons Laboratory for Water Resources and Hydrodynamics, Massachusetts Institute of Technology
E(11-1)4114 (EY-76-S-02-4114-A001)

PRINCIPAL INVESTIGATOR

D.R.F. Harleman

OBJECTIVES

The tremendous quantity of waste heat rejected by steam electric power plants represents both a substantial energy loss and a major environmental concern. The environmental impact of waste heat on natural water bodies can be greatly reduced by employing closed-cycle cooling systems such as cooling towers, ponds, or spray modules. However, these systems are generally more costly and involve greater fuel consumption than open cycle systems, due to greater capital costs, decreased net efficiency, and the requirement for greater back-up capacity. Additionally, closed-cycle systems may have other environmental impacts of their own. The objective of this project is to examine these trade-offs more closely as they relate to the choice, design, and operation of a cooling system for an individual plant and as they relate to National policies concerning fuel conservation goals, water pollution control, etc.

APPROACH

The project is divided into two complementary subtasks. Subtask 1 first involves the development of design codes to economically size open cycle systems, cooling ponds, natural and mechanical draft wet towers, and mechanical draft dry towers for use with large base load plants. Trade-offs among economics, fuel consumption, and environmental factors are

demonstrated on an individual plant level by comparing systems as they would be designed for new 1200-MW nuclear and 800-MW fossil-fueled base load plants at a hypothetical midwestern site. Trade-offs on a National level will then be evaluated by computing desirable mixes of cooling system types which might be used in the future reflecting various scenarios of future energy demand, environmental controls, fuel costs, etc.

Subtask 2 investigates the operation of supplementary cooling systems for the purpose of meeting environmental constraints on temperature increases induced in receiving waters. The Tennessee Valley Authority's (TVA's) Browns Ferry Nuclear Power Plant is used as a case study. The plant has been designed to operate in open, helper, and closed modes in order to comply with temperature standards which limit induced temperature increases in the Tennessee River. At present, the decision as to which mode to use is based on temperatures from upstream monitors which, due to spatial separation, may differ from those which would occur at the site if the plant were not operating. The research involves estimating natural temperatures based on upstream monitors and examining the effects on station operating efficiency which reflect different cooling system control (mode-change) strategies.

PROGRESS AND RESULTS

For subtask 1, a consistent set of design procedures for each cooling system has been developed. Of particular interest has been the development of a quasi-steady representation of the transient response of cooling systems with large thermal inertia (e.g., cooling ponds). This allows all cooling systems to be evaluated on the basis of a cumulative frequency distribution of the controlling meteorological parameters. The operational and construction costs of the different cooling systems have been compared for the study site, and a series of sensitivity tests is currently underway.

For subtask 2, a deterministic model has been developed to estimate differences between upstream and near-site natural temperatures based on real-time meteorological and hydrological data. A number of statistical time series models, calibrated with pre-operational upstream and near-site field data, have been developed to improve the accuracy of these estimates. Finally, an analytical model has been used to compute induced temperature increases. Initial results show that upstream and near-site temperatures differ by typically 1° to 2°F, and that operation of the plant based on computed background temperatures, rather than upstream temperatures, would reduce by approximately 20 percent the total usage of helper and closed supplementary systems.

PLANS FOR NEXT PERIOD

For subtask 1, the objective is to describe the environmental-economic trade-offs on a National level. This will involve regionalization of the

country on the basis of climatic and hydrological characteristics, anticipated growth in electrical demand, etc.; definition of energy-environmental control policies (scenarios); simulation using the design codes developed in the first year; and regional and National aggregation. Additional work will also be undertaken to improve design and predictive capabilities relative to cooling ponds and wet/dry tower combinations.

For subtask 2, the predictive-estimation models will be compared with observed river temperatures. In addition, a sensitivity study will be conducted to assess the effect on plant efficiency of temperature monitor locations, temperature standard, mode switching rule, and cooling system design.

REPORTS PUBLISHED

Quarterly Progress Reports

PROJECTED MILESTONES

FY 1978 Annual Report

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ASSESSMENT OF THE RADIOLOGICAL IMPACT OF WESTERN COAL UTILIZATION

ORGANIZATION AND CONTRACT NUMBER

Mound Laboratory
EY-76-C-04-0053

PRINCIPAL INVESTIGATOR

C.E. Styron

OBJECTIVES

Western coal, which typically possesses a low sulfur content, has been reported to contain trace uranium. The objective of this study is to delineate the scope of the potential environmental and human health problem associated with radioactivity in coals, with emphasis on Western coals.

APPROACH

A preliminary phase has been incorporated into the experimental design to identify those areas of most critical concern and to optimize research efforts for assessing potential radiological impact of increased Western coal utilization. Samples of coal from major Western mines, as well as samples of coal, ash, stack effluents, air, soil, and vegetation associated with a power plant using Western coal, were analyzed by alpha pulse height spectroscopy for uranium-234, uranium-238, polonium-210, lead-210, radium-226, and thorium-230. The data were then used in a preliminary effort to close the radionuclide balance for the power plant and to model the radiation dose to the population adjacent

to the power plant. The predicted population dose, projected future use of Western coal, and problems identified as significant but not fully addressed in the preliminary phase will be used to evaluate the need for and direction of further research.

PROGRESS AND RESULTS

Work during the past year centered on initiating development of a data base for radionuclides in coal, performing a site-oriented assessment at a coal fixed power plant, and estimating population dose commitments resulting from combustion of the coal.

Procedures were developed or modified for analysis of uranium-234, uranium-238, polonium-210, lead-210, radium-226, and thorium-230 in coal, ash, soil, vegetation, and air (airborne particulates). Major Western mines were identified, and samples were collected from the mines and at a power plant using coal from one of the mines. Samples were analyzed for uranium-234, uranium-238, polonium-210, and lead-210 with analyses for radium-226 and thorium-230 in progress. Samples of coal contained uranium-234 and uranium-238 ranging from 0.04 to 1.20 pCi/g and polonium-210 ranging from 0.12 to 2.05 pCi/g. Lead 210 in coal used at the power plant averaged 0.79 pCi/g, and lead-210 in/on vegetation in the environs of the power plant ranged from 2.23 to 5.70 pCi/g. Preliminary dose evaluations for lead-210 alone indicated that individuals whose total vegetation intake was grown in this area would receive approximately 400 mRem/year. This compares to a dose of about 125 mRem/year from natural background radiation. Additional studies of lead-210 concentrations in/on vegetation and of dose evaluations are being undertaken. It should be noted that the power plant has not been directly implicated as the major source of this radionuclide.

PLANS FOR NEXT PERIOD

Additional studies are planned to test field data on possible biomagnification of radionuclides in the food chain and to assess implications of fly ash disposal and/or utilization. Subsequent studies will also consider movement of radionuclides from ash ponds and coal cleaning refuse piles. The potential radon-222 dose to the public from use of fly ash in bricks and cement blocks for construction of homes will be evaluated. The potential release of radionuclides from any small manufacturers who have no emission controls will also be studied. Additional pathways to man and biogeochemical cycles are to be investigated. Inconsistencies in predicted versus measured environmental radionuclide concentrations are to be resolved.

REPORTS PUBLISHED

B.M. Farmer, C.E. Styron, C.A. Phillips, B. Robinson, and W.H. Westendorf, "The Assessment of the Radiological Impact of Western Coal Utilization. Phase I," Technical Interim Report, Mound Laboratory, 1977.

PROJECTED MILESTONES

- October 1977 -- Complete preliminary evaluation.
- October 1978 -- Complete evaluation of distribution and mobilization of radionuclides from coal.
- April 1979 -- Complete assessment of control technology and byproduct impact.
- October 1977 and October 1978 -- Issue quarterly progress reports and technical interim report.
- October 1979 -- Issue final report.

* * *

ASSESSMENT OF ENVIRONMENTAL CONTROL TECHNOLOGIES FOR SELECTED FIRST-GENERATION COAL GASIFIERS

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATOR

L. K. Mudge

OBJECTIVES

Data on material and energy flows in commercial plants that use either Winkler or Koppers-Totzek gasifiers to generate synthetic gas will be sought by contacting manufacturers of these gasifiers and by searching the literature. The objective of the study are: (1) to determine if environmental control technologies in commercial use are adequate relative to existing and proposed standards, (2) to identify areas where improved control technologies are needed, and (3) to rank research and development programs in terms of their potential benefit.

APPROACH

Suppliers of Koppers-Totzek and Winkler gasifiers were contacted to obtain mass and energy balances on commercial operations that employ these gasifiers. It was learned that the requested data were not available and that operating plants in foreign countries were reluctant to cooperate in gathering the data. Therefore, information from the literature was used to make the assessment.

Uniform standards specific to coal gasification plants have not been established. Standards in related industries, coke manufacture, and petroleum refineries were used in assessing the performance of commercial control technologies.

PROGRESS AND RESULTS

Review of pertinent literature and contacts with suppliers (Koppers-Totzek in Pittsburgh, Pa., and Davy Powergas in Lakeland, Fla.) have been completed. Information was obtained on the complete process for synthetic gas manufacture which involved coal preparation, coal storage, gasification, gas cooling, particulate removal, acid gas cleanup, oxygen manufacture, wastewater cleanup, and utility operation.

Processes are available for removal of sulfur compounds as required to prevent poisoning of catalysts used to convert the synthetic gas to final product forms. The sulfur compounds can be converted to elemental sulfur, an environmentally acceptable form, by the Claus process. Emissions from the Claus plant can be reduced to less than one percent of the total input sulfur by using commercially available tail gas cleanup processes.

Particulate removal is effected by use of water scrubbers (mechanical scrubbers (Theisen disintegrators), venturi scrubbers, and packed scrubbers), cyclone separators, and electrostatic precipitators. Concentration of particulates in the synthetic gas is reduced to between 0.002 and 0.005 grain/scf in venturi scrubbers used with the Koppers-Totzek gasifiers.

Commercial technology for control of environmental emissions is available and adequate to meet current standards in related industries. A major unknown is in the fate of trace elements in these processes. Very little is known about the behavior of trace elements in the Koppers-Totzek and Winkler gasification systems. Unlike power plants, the gasification processes do not have a stack emission because the product gas is cleaned for synthesis of chemicals. Airborne emissions of trace elements can occur from the utility boiler and from wind entrainment of discharged residue and stored coal. Ash components are discharged from the gasification processes with gasifier residues and gas-cleanup sludges and residues. The trace element composition of coal is geochemically similar to the makeup of the earth's crust and includes almost all of the elements of the periodic chart. The potential hazard from emissions of trace elements is mainly from long-term, low-level exposures to increased atmospheric pollution levels. Discharges from the Koppers-Totzek and Winkler processes can be expected to have very minor contributions to atmospheric pollution levels of trace elements.

Energy requirements for the different control technologies and process operations were estimated to assist in determining areas where advances could significantly improve process efficiency and thereby reduce environmental intrusion. Major energy uses were oxygen manufacture, coal drying, gas compression, and acid gas removal. These areas represent highly developed technology areas where only limited improvement in efficiency can be expected to result from research and development.

The major recommendation of this study is that a demonstration plant employing these gasification processes for the manufacture of ammonia be constructed in an area where thorough environmental monitoring can be conducted. Emissions and their effect on the environment could be accurately characterized. The information obtained would be extremely valuable in establishing standards based on environmental needs. The final draft report on this project will be submitted at the end of FY 1977.

PLANS FOR NEXT PERIOD

The study will be completed in early FY 1978 with information on other commercial entrained gasifiers (Pressurized Koppers-Totzek and Texaco) to be included.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

A final draft report will be submitted in April 1978.

* * *

STUDY OF BY-PRODUCTS AND POTENTIAL POLLUTANTS FROM HIGH-TEMPERATURE ENTRAINED-FLOW GASIFIERS

ORGANIZATION AND CONTRACT NUMBER

Brigham Young University
EE-77-S-02-4377

PRINCIPAL INVESTIGATORS

M. L. Lee
R. L. Coates

OBJECTIVES

The scope of work under this contract consists of performing a detailed characterization of pollutants associated with a high-temperature entrained-gasification process, determining the relationship between process parameters and resultant pollutants, and recommending preferred environmental control strategies.

APPROACH

Samples are being collected from gasification tests with four different coals (a high volatile, noncaking, Utah bituminous coal; a high volatile, caking, Pennsylvania bituminous coal; a North Dakota lignite; and a coal oil energy development char. Samples are collected for in-depth studies of the variation of four process parameters: coal feed

rate, reactor pressure, oxygen-to-coal ratio, and steam-to-coal ratio. These samples are taken from the cooled and water-scrubbed product gas stream, the scrubber effluent water, the gas evolved on depressurization of the scrubber water, and the particulate matter filtered from the scrubber water. The composition of these samples are determined using the analytical techniques of gas chromatography, gas chromatographic mass spectrometry, proton induced x-ray emission spectroscopy, thermometric titrimetry, ion chromatography, and atomic absorption spectroscopy.

PROGRESS AND RESULTS

The experimental gasifier studied in this report is a pressurized, entrained-flow gasifier that has a capacity of 100 pounds of coal per hour (Figure 3). This gasifier has a down flow configuration with some similarity to an entrained-flow gasifier operated by the Bureau of Mines during the period 1952-1962. It also has some similarity to the Texaco entrained-flow gasifier configuration. Throughput rates of over 1000 pounds of coal per hour per cubic foot of gasifier volume have been demonstrated with cold gas conversion efficiencies in excess of 75 percent.

Figure 3. Laboratory Scale Entrained Gasifier (Eyring Research Institute) Under Study

A diagram of the laboratory gasifier and the necessary coal feeding, gas cooling and cleaning, and ash handling equipment is presented in Figure 4. Pulverized coal is fed to the gasifier from a

Figure 4. Flow Diagram of Laboratory Scale Entrained Gasifier System

feed hopper entrained in a stream of air or recycled product gas. The coal is rapidly mixed and reacted with a mixture of superheated steam and oxygen. The reaction is carried out at pressures of 50 to 300 psig and gasifier outlet temperatures between 2300° and 2800°F. Residence times for gasification reactions are on the order of 0.1 second. The gasifier products pass downward into a quench section where they are partially cooled by mixing with a feed stream of water and/or saturated steam or simply by heat transfer to monotube boiler coils which form the walls of this section. Sufficient cooling occurs in this section to solidify the molten ash droplets.

The products then pass into a slag removal section where the slag droplets and larger fly-ash particles are separated by gravity, dropping into the lower section of this vessel that is partially filled with water. The slag is periodically discharged through a lock hopper and transported to a settling pond. The gasification products then pass through a heat exchanger and into a scrubber column.

Cleaning of soot and fly-ash particles from the gas is accomplished in the water scrubber column. Unreacted steam is also condensed in this column. A recycle water stream is pumped through a heat exchanger to remove the heat of condensation, and a feed stream of cooled water is introduced at the top of this column to provide final cooling and washing, and to suppress foaming. Approximately 6 pounds of cooled water is required per pound of coal fed.

The overflow from the scrubber passes through a fabric filter to remove the solids and the filtered liquor is discharged through a pressure reduction valve into a flash tank where dissolved gases are released and separated from the water. The composition of the product gas is mainly carbon monoxide (40%), hydrogen (35%), nitrogen (15%), carbon dioxide (10%), and methane (1%).

Recent progress has been centered on modifying the gasifier train for routine sampling and developing the analytical methodology for identification of chemical species. The flow diagram developed for

the analysis of the scrubber effluent water is given in Figure 5. In addition, the product gas and flash gas (from the scrubber water) are being analyzed by gas chromatography. Testing has begun on the first of the four coals.

PLANS FOR NEXT PERIOD

Complete testing of four coals with respect to different gasifier operating parameters is planned. Evaluation of environmental hazards of emission will be performed and environmental control strategies will be proposed.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

August 1978 -- Final Report

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Figure 5. Scrubber Quenchwater Analysis Flow Diagram

ASSESSMENT OF ENVIRONMENTAL CONTROL TECHNOLOGY FOR COAL CONVERSION WASTEWATER SYSTEMS

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge National Laboratory
W-7405-ENG-26

PRINCIPAL INVESTIGATORS

J. A. Klein
D. D. Lee

OBJECTIVES

The objectives are to (1) determine environmental control problems that will be encountered in coal hydrocarbonization (coalcon) type processes; (2) evaluate existing and developing environmental control processes and strategies for possible use in this family of processes; and (3) provide data to fill information gaps that may exist with respect to state-of-the-art and developing environmental control processes.

APPROACH

The flowsheet for the coalcon (reference hydrocarbonization) process was analyzed to determine the sources, quantities, and character of aqueous effluents. In addition, the literature on related coal conversion processes was surveyed to obtain information on the composition of coal conversion aqueous wastes. In addition, the literature on industrial wastewater treatment was surveyed to identify treatment processes applicable to coal conversion wastes. Experiments were performed to provide data necessary for the application of existing and advanced wastewater treatment processes.

PROGRESS AND RESULTS

The hydrocarbonization process flowsheets showed 15 major wastewater streams; the literature has been reviewed for information on the quantities and nature of these wastes. The most notable of these streams is the hydrocarbonization condensate, an aqueous stream of 105,000 lb/hr (based on 15,000 tons/day coal feed). This stream contains a large amount of phenolic compounds (up to 1%), a high concentration of ammonium hydroxide (0.5 to 3%), and lesser amounts of dissolved cyanide, thiocyanate, and sulfur compounds. The treatment and discharge of the hydrocarbonization condensate stream presents a difficult environmental control problem; thus, internal recycle and reuse within the process is encouraged.

Other environmental control problems which will be encountered in coal conversion processes include polynuclear aromatic hydrocarbons (PAH), which are only slightly soluble in water, but can present an environmental hazard even at small concentrations;

and dissolved trace heavy metals. Due to the design of the gas processing and ash handling systems of the reference hydrocarbonization process, all of the trace elements present in the feed coal have the potential for ultimately contaminating the wastewater. Such flow rates can be as high as 13,000 lb/day for zinc, 1600 lb/day for manganese, 850 lb/day for lead, and lesser amounts of chromium, arsenic, and mercury.

Conventional and advanced control unit operations were evaluated for the potential applicability to coal conversion wastewater. These control unit operations included biological degradation, ozonation, coagulation and flocculation, solvent extraction, absorption, and membrane processes. These processes were evaluated with respect to the following criteria: economics, raw material requirements, process compatibility, operating conditions, state of development, by-product disposal, energy requirements, reliability, environmental problems caused by the technology, and potential applicability. A survey report on the aqueous wastes in hydrocarbonization and applicable environmental control technology has been prepared.

A tapered fluidized bed bioreactor, developed at Oak Ridge National Laboratory has been used to treat representative hydrocarbonization condensate (see Figure 6). This is a high throughput reactor configuration for contacting active microorganisms which are attached to the fluidized substrate with the waste liquor. Removal rates of phenol of up to 5.0 kg/day/m³ of reactor volume have been achieved; this is a removal rate five times greater than can be achieved in conventional stirred tank activated sludge reactors.

PLANS FOR NEXT PERIOD

The interim and final reports on aqueous wastes in the hydrocarbonization process will be completed. Additional screening and confirmative experiments will be made on candidate environmental control technology which will include further studies on the tapered fluidized bed bioreactor, the use of coal derived materials (e.g., char) for sorption of pollutants, and studies on the fate of PAH and trace elements in wastewater treatment processes.

REPORTS PUBLISHED

J. A. Klein and R. E. Barker, "Assessment of Environmental Control Technology for Hydrocarbonization," presented at The Second Pacific Chemical Engineering Conference, August 29 - September 2, 1977, Denver, Colorado.

R. E. Barker and J. A. Klein, "Assessment of Environmental Control Technology for Hydrocarbonization," interim and final reports, (first draft).

PROJECTED MILESTONES

The interim/final report on assessment will be published in the first quarter of FY 1978, with

Figure 6. Oak Ridge National Laboratory Tapered Fluidized Bed Bioreactor -- Capable of Removing 99.9+ percent Phenolic Components from Coal Conversion Wastewaters

additional topical reports and open literature publications published as appropriate.

* * *

A STUDY OF EFFLUENT CONTROL TECHNOLOGIES FOR HYDROCARBON AND CARBON MONOXIDE EMISSIONS FROM FIRST-GENERATION GASIFIERS

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge National Laboratory
W-7405-ENG-26

PRINCIPAL INVESTIGATORS

J. R. McWherter
J. V. Fisher

OBJECTIVES

The objective of this project is to provide a technical and economic comparison of processes available for the control of gaseous hydrocarbon (HC) and carbon monoxide (CO) emissions. The Lurgi coal gasification process and the H-Coal coal liquefaction process will be considered as reference source systems, and comparisons of control technologies will consider incineration as the reference control system.

APPROACH

The following tasks are being performed during this study: (1) develop information concerning sources of emissions from reference source systems; (2) identify Environmental Protection Agency emission allowances for HC and CO; (3) examine industrial and developmental stage processes for HC and CO removal, recovery or destruction; and (4) develop cost estimates and assess the efficiencies for each process.

PROGRESS AND RESULTS

Processes examined for HC and CO control included incineration, catalytic incineration, cryogenic separations, acid gas absorption, selective absorption, diffusion through permselective membranes and CO absorption using cuproammonium liquors.

Catalytic oxidation appears to be the most economic means of decontaminating the gas stream. A commercial catalytic system which may meet all the foreseeable requirements has recently come on the market. The catalytic system will be experimentally confirmed in the proposed service with emphasis on the amount of SO_2 which might be formed from the burning of the sulfur compounds.

Incineration in the coal fired boiler is an economic alternate. However, the CO_2 flow is such that the boiler gas throughput will be increased by 50 percent. The radiant zone of the coal fired boiler may have to be redesigned to handle the large inert flow. An engineering study by a boiler manufacturer to resolve this uncertainty will be supported.

PLANS FOR NEXT PERIOD

A detailed study of the more promising alternatives for HC and CO control will be conducted.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

The initial phase of the project will be completed in early 1978 and a report will be published. A request has been made by DOE to conduct studies on specific aspects of the alternatives.

* * *

EVALUATION OF LURGI GASIFIER TWO-STAGE QUENCH FOR WATER POLLUTION CONTROL

ORGANIZATION AND CONTRACT NUMBER

Arthur G. McKee & Company
EE-77-C02-4375

PRINCIPAL INVESTIGATOR

W. A. Parsons

OBJECTIVES

The objective of the study is the evaluation of controlled two-stage quenching of process gases as a means of improving water management of coal conversion processes. The first stage quench will separate ammonium chloride and strong acid gases as a low-volume aqueous purge from the main gas flow. Subsequent condensates will be amenable to steam stripping of volatile weak electrolytes and biooxidation of organic contaminants to yield water suitable for makeup in reuse circuits. The concept of two-stage quenching is potentially applicable to all coal conversion processes that cool the gases below the dew point.

APPROACH

The study will compare the technical and economic practicality of two-stage quenching with single-stage quenching for a hypothetical 1500-ton/day fixed-bed gasifier plant operating in conjunction with appropriate effluent regulations (see Figures 7 and 8). The plant will consist of six 250-ton/day gasifiers modeled after the pressurized, stirred, fixed-bed gasifier of the Morgantown Energy Research Center. The study will include air-blown and oxygen-blown gasification of a high halide Eastern coal and a low halide Western coal.

The volume of condensate extracted in the first-stage quench will be varied to establish optimum conditions for water management. An engineering concept will be prepared for the treatment and disposal of the primary condensate and other purges with a high salt content. An engineering concept will be prepared for the treatment and reuse of subsequent condensates. Cost estimates will be prepared to enable assessment of the practicality of meeting effluent limits with single-stage and two-stage quenching. Process water requirements will also be evaluated.

PROGRESS AND RESULTS

The study was in a preliminary stage in FY 1977. A program work plan delineating a detailed approach to the study was prepared and submitted to the Division of Environmental Control Technology.

A data file was compiled that provides an operational collection of technical resource materials. The data file includes technical literature, computer programs, and solicitations.

Figure 7. Preliminary Absorption Gas Cleaning with Two-Stage Quench

PLANS FOR NEXT PERIOD

A visit by project staff to the Morgantown Energy Research Center is planned to improve perspective relative to process operations associated with the pilot plant facility. The study is scheduled for completion in August 1978. The study will involve thermodynamic analysis for estimation of gas and condensate characteristics and the preparation of engineering concepts relative to the gas train, to water circuits, to water treatment, and to wastewater disposal. Cost estimates of alternative systems will also be prepared.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

The following events are considered as project milestones.

- January 31, 1978 -- Completion of engineering concepts for water circuits. This accomplishment will indicate the prospects for water conservation by application of two-stage quenching.

- July 31, 1978 -- Delivery of draft of final report.
- August 31, 1978 -- Delivery of final report.

* * *

TREATMENT OF SYNTHANE GASIFICATION WASTEWATERS

ORGANIZATION AND CONTRACT NUMBER

Pittsburgh Energy Research Center
00238

PRINCIPAL INVESTIGATOR

W. P. Haynes

OBJECTIVES

The objective of this project is to characterize SYNTHANE process wastewaters, to evaluate

Figure 8. Conventional Gas Cleaning with Single-Stage Quench

concentrations of effluents in relation to established standards, and to devise treatment methods capable of meeting such legally established or proposed regulations.

APPROACH

Aerobic biological treatment studies will be conducted with emphasis on lowered detention times for treatment of both diluted wastewaters and undiluted condensates. The necessity for expensive waste pretreatment steps for oil and tar separation will also be evaluated in the aerobic treatment units. Kinetic studies will provide the data necessary for design of larger units.

A study of aerobic biological removal of cyanide and cyanogen compounds will be initiated under contract with a university. Anaerobic biological treatment studies will be conducted (see Figures 9 and 10). Initial work on this phase has been very encouraging and the prospect of producing a valuable fuel (methane) from wastewater by-products of coal gasification could be very rewarding.

Studies of oil and tar separation and recovery will continue, including evaluation of the use of lime instead of sodium hydroxide for pH adjustment and evaluation of the use of alum and other chemicals used for oil and tar separation for removal of total organic carbon, phenolics, and organic compounds.

When representative by-product water is available from the sampling system of the 72-ton/day pilot plant, treatability studies will be made to verify that treatment methods being used with the waters from the process development unit (PDU) are also applicable to the pilot plant by product waters.

Absorption tests with char generated in the SYNTHANE PDU and pilot plant gasifier will be continued. Both absorption isotherms and column breakthrough data will be collected to evaluate this unit operation for either a polishing operation after biological treatment or as a primary treatment step for the removal of organic compounds. Biological treatment of char column effluents will continue to be investigated.

During this year, a continuous treatment system will be designed, process equipment will be ordered, and construction initiated.

Figure 9. Continuous Aerobic Biological Reactors Treating SYNTHANE Wastewater at Pittsburgh Energy Research Center

Figure 10. Continuous Anaerobic Biological Reactors at Pittsburgh Energy Research Center

PROGRESS AND RESULTS

During the year, activities included characterization and correlation of SYNTHANE process by-product water, investigation of the treatability of by-product water using various biological and physicochemical processes, the continuation of char

sorption studies, and the initiation of a program to construct and operate an integrated wastewater treatment system.

Characterization of coal gasification condensates both before and after treatment included: analyses of the condensates produced from each gasification run for total organic carbon (TOC), chemical oxygen demand (COD), biochemical oxygen demand (BOD), phenols, cyanogens, chlorine, total dissolved solids, oils, grease and tars, sulfur, sulfide, and ammonia concentrations. Heavy metal and trace organic component characterization of the treated and untreated condensates was conducted. The component effluent production was correlated with various fundamental parameters of gasification.

Treatability studies conducted this year included an investigation of using acids for oil and tar removal by depressing the pH into the 2 to 5 region, both with and without the addition of organic and inorganic agents to assist in flocculation. Flocculating agents used were aluminum sulfate, ferric chlorides, and various polyelectrolytes. Preliminary investigation of dissolved air flotation was conducted.

The biological kinetics of both aerobic and anaerobic systems were studied using both diluted and undiluted condensates. Kinetic and equilibrium information was gathered for use of chars as a tertiary effluent polishing technique. The ability to remove sulfur from the by-product water while stripping free ammonia was studied.

Char sorption studies were made with raw condensate water to determine the removals of COD, TOC, phenols, organic acids, metals, cyanides and thiocyanates, the effect of pH on sorption, the filtration effect, and the biodegradability of char treated effluents. The initial design and procurement for an integrated wastewater treatment system consisting of modules of various treatment steps was begun.

PLANS FOR NEXT PERIOD

Investigation of aerobic biological treatment of coal gasification wastewaters will continue. The addition of char or activated carbon to the bioreactors will be studied in order to improve biokinetics. Organic compounds refractory to biological treatment will be determined by combined gas chromatography/mass spectrometry methods. A trace element balance around the bioreactor will be made using improved analytical techniques. Wastewater pretreatment and its relation to biological treatability will continue to be investigated.

The study of aerobic biological removal of cyanide and cyanogen compound removal will continue under a university contract. Anaerobic treatment studies will continue. An "anaerobic filter" will be tested for removal of high-level phenolics.

Char adsorption studies will continue with an effort to separately identify individual organic and

trace element adsorption characteristics. Adsorption isotherms for commercial activated carbon will be determined and compared to char isotherms. This is particularly necessary for coal gasification schemes that do not generate char. Studies of the biological treatability of char treated water will continue.

Major emphasis will be placed on operation of the continuous treatment unit with wastewater trucked from the SYNTHANE pilot plant. A solvent extraction step will be added and operated. Automatic instrumentation will be incorporated to reduce the load on the analytical laboratories. Sludges produced in the various units will be investigated to determine trace elements and best disposal techniques.

A simulated cooling tower system will be constructed to simulate reuse of treated water in the plant cooling system. This is an important step in a "zero discharge" plant. Organic and trace element concentrations in the tower drift will be determined.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

See Figure 11 for the projected milestones.

* * *

△ BEGIN MILESTONE

▽ END MILESTONE

○ BEGIN KEY TASK

□ END KEY TASK

Figure 11. Projected Milestones

EVALUATION OF POLLUTANTS FROM FLASH HYDROLYSIS

ORGANIZATION AND CONTRACT NUMBER

Brookhaven National Laboratory
EY-76-C-02-0016

PRINCIPAL INVESTIGATORS

M. Steinberg
A. S. Albanese

OBJECTIVES

The objective of this project is to assess the environmental factors and the control technologies involved in the flash hydrolysis (FHP) of coal for the production of gaseous and liquid hydrocarbon fuels and feedstocks.

APPROACH

Laboratory analyses will be conducted on samples obtained from Brookhaven National Laboratory's (BNL's) experimental FHP unit. Based on the experimental data, conceptual flow diagrams are prepared, including mass and energy balances, of full-scale FHP-chemical and FHP-refinery complexes.

A survey of the literature will be conducted to determine available environmental control technology, assess available technology, and identify the areas in which new technology is required.

PROGRESS AND RESULTS

Gaseous, liquid, and solid samples obtained from the experimental FHP unit were analyzed for a Dakota lignite feed. The gaseous product is principally composed of methane, ethane, and carbon monoxide. The liquid product consists of benzenes, toluenes, and xylenes (BTXs); a wide variety of polyaromatic compounds; and water. Trace elements (Si, Cu, Fe, Ni, Mg, and Al) have also been identified in the liquid product. Residual solids (char) contain about 75 percent carbon, 20 percent ash, 3 percent hydrogen, 1 percent nitrogen, less than 1 percent sulfur, and less than 1 percent moisture by weight. Nominally, 20 percent of the carbon feed is converted to liquid products and 40 percent to gaseous products (after a two-stage condensation at 55°F and -22°F, respectively).

A preliminary flow plan and a preliminary environmental analysis of an FHP-chemical complex have been prepared, and potential pollutants and source streams have been identified.

PLANS FOR NEXT PERIOD

- Prepare a conceptual flow plan and mass balance on a FHP-refinery complex. Identify potential pollutants (sulfur, nitrogen, organics, and trace elements) and source streams.

- Conduct laboratory analyses on samples obtained from BNL's experimental FHP unit to further identify and quantify process effluents.
- Refine FHP-chemical complex and FHP-refining complex flow plans as required based on the experimental results of the analyses.
- Survey literature to determine available environmental control technologies as related to the FHP process.
- Assess available technology for adequacy and for applicability to the FHP process, and identify areas in which new technology is required.

REPORTS PUBLISHED

Quarterly Progress Report No. 1, June 20 to September 30, 1977 (in press).

PROJECTED MILESTONES

- October 1, 1977 -- Complete preliminary conceptual flow diagram of FHP-chemical complex. Identify potential pollutants and source streams.
- September 30, 1978 -- Complete conceptual flow diagrams of FHP-chemical and FHP-refinery complexes based on the data obtained from BNL's experimental unit. Complete literature survey and technology assessment.

* * *

ENVIRONMENTAL CONTROL ASPECTS OF IN SITU COAL GASIFICATION: GROUNDWATER QUALITY CHANGES AND SUBSIDENCE EFFECTS

ORGANIZATION AND CONTRACT NUMBER

Lawrence Livermore Laboratory
W-7405-ENG-48

PRINCIPAL INVESTIGATOR

S. W. Mead

OBJECTIVES

Two important environmental concerns associated with in situ coal gasification are (1) the possibility of groundwater contamination by reaction products that remain underground after gasification and (2) ground subsidence. The intermediate objectives of this project include measurements and

assessments of changes in groundwater quality and subsidence effects in the vicinity of in situ gasification experiments, and the development of a predictive capability with regard to these effects that is applicable to commercial-scale, in situ coal gasification. The ultimate objective is the identification of appropriate control technologies.

APPROACH

The investigation of groundwater quality effects of in situ coal gasification includes groundwater sampling and analysis before, during, and after in situ coal gasification experiments, laboratory studies of ash-leaching and of contaminant sorption by coal, and computer modeling of the evolving plume of contaminated groundwater.

The subsidence studies involve field investigations carried out in conjunction with in situ coal gasification experiments and the application and validation of a 3-D finite element computer code for subsidence prediction. The field investigations include strength measurements of overburden cores and both surface and subsurface ground deformation measurements.

PROGRESS AND RESULTS

The effects of in situ coal gasification on groundwater quality have been investigated during the past year by means of a groundwater monitoring program, a series of laboratory experiments, and computer modeling. The groundwater monitoring program was carried out in conjunction with an in situ coal gasification experiment conducted in northeast Wyoming by the Lawrence Livermore Laboratory (LLL). The gasification experiment (Hoe Creek I), conducted during October 1976, involved the gasification of 130 tons of coal in the Felix II seam at a depth of 125 feet. Fourteen wells, located at distances up to 100 feet from the gasified coal, have been monitored before, during, and up to nine months after gasification. Sample analysis was carried out in the field and in the laboratories of LLL, the U.S. Geological Survey, and the Research Triangle Institute. A broad range of analytical techniques was used, including gas chromatographic/mass spectrometry analysis of volatile and semivolatile organics. The post-gasification data show a large increase in the concentration of phenolic materials (maximum level: 450 mg/l) just outside the burn zone (Figure 12), and a variety of inorganic species issuing from within the residual ash bed. All contaminants decrease rapidly with distance, although above-background levels of some species were detected 100 feet from the burn zone. Several important contaminants, including phenols and cyanide, showed a large decrease in concentration with time, possibly the result of absorption. The data are beginning to provide a picture of the nature and distribution of the underground contaminant source resulting from in situ coal gasification. Source definition is an important intermediate objective of this project. Current data suggest a

Figure 12. Concentration of Phenolic Material as a Function of Distance From the Burn Boundary for Water Samples Taken 3 (Δ), 83 (●) and 132 (○) Days Following Gasification

two-part source: (1) the ash bed within the gasification zone, whose leachate is modified and redistributed by chemical reactions, and perhaps by convective mixing, and (2) a thin shell-like source of organic materials, deposited just outside the burn zone.

A laboratory facility for the study of coal gasification contaminants has been set up during the past year, and ash leaching and coal sorption studies are underway. A 1-D code has been developed that

successfully predicts the transport of phenolic materials through a laboratory coal column.

Efforts to assess the environmental significance of subsidence associated with in situ coal gasification, and to develop a reliable predictive capability, have included strength measurements of overburden cores and preparations for measurements of ground movement resulting from an underground gasification experiment. Computer calculations of the subsidence expected for a projected gasification experiment (Hoe Creek II, October 1977) indicate maximum surface ground movement of approximately 1 inch (vertical) and 0.4 inch (horizontal).

PLANS FOR NEXT PERIOD

All phases of the current program will be continued during FY 1978. Groundwater monitoring near the October 1976 gasification experiment will be supplemented by a groundwater monitoring program near a larger in situ gasification experiment (Hoe Creek II) scheduled for October 1977. Laboratory investigations of coal gasification contaminants and modeling studies of the contaminated groundwater plume will continue.

Both surface and subsurface measurements of ground deformation (subsidence) will be made in conjunction with the Hoe Creek II gasification experiment. Additional measurements of overburden cores will be conducted, and predictive modeling calculations will be extended to larger gasification geometries.

REPORTS PUBLISHED

S. Warren Mead, John H. Campbell, and Douglas R. Stephens, "Ground-Water Quality Effects of an Underground Coal Gasification Experiment," Lawrence Livermore Laboratory, UCRL-79867, 1977 (preprint).

PROJECTED MILESTONES

- October 1977 -- Annual Report
- October 1978 -- Annual report
- October 1979 -- Final Report

* * *

ASSESSMENT OF UNDERGROUND COAL GASIFICATION ON GROUNDWATER QUALITY

ORGANIZATION AND CONTRACT NUMBER

Laramie Energy Research Center

PRINCIPAL INVESTIGATORS

D. D. Fischer
R. M. Boyd
C. F. Brandenburg

OBJECTIVES

Determine necessary environmental control technology required to mitigate impacts of underground coal gasification on groundwater quality.

APPROACH

The work will consist of collection and analyses of pre- and post-test water samples to quantify changes in groundwater quality as a result of underground coal gasification. These data will be compared with proposed and existent standards for groundwater quality to first determine whether a need exists for control technology to mitigate impacts of the technology. In addition, the data will be input to existent hydrologic models to estimate long term impacts under different hydrologic conditions than exist at the Laramie Energy Research Center's field site in Hanna, Wyoming. The effects of coal sorption of organic and inorganic constituents in the groundwater exiting the gasification zone after test completion will also be determined.

PROGRESS AND RESULTS

The well pattern for the Hanna III test was drilled and completed early in FY 1977. Pretest characterization of both the Hanna I coal seam (a water-saturated system) and an aquifer located 15 feet above the coal seam was completed including pump tests, interference tests, and recovery monitoring during March and April 1977. Pretest sample collection and analyses to establish background water quality were completed in May and June. Both the characterization and analyses showed the two water-bearing zones to be isolated from each other prior to the Hanna III test. The Hanna III underground coal gasification test was conducted from June 6 through July 29 with approximately 2850 tons of coal gasified leaving a void volume of approximately 66,000 cubic feet.

PLANS FOR NEXT PERIOD

During FY 1978, monthly sample collection and analysis program will continue to quantify changes in groundwater quality in both water-bearing zones as leached materials move downstream away from the gasified area. Determination of needed control technology and recommendations for specific control approaches will also be available.

REPORTS PUBLISHED

R. Michael Boyd, Harold L. Hutchinson and Dennis D. Fischer, "Hydrologic Characterization for Hanna III," Proceedings of the Third Annual Underground Coal Gasification Symposium, Fallen Leaf Lake, California, June 6-9, 1977 (in press).

PROJECTED MILESTONES

- June 1979 -- Completion of post-test sampling and analyses

- Quarterly -- Interim reports on project status
- October 1979 -- Final report on project results

* * *

ASSESSMENT OF ENVIRONMENTAL CONTROL TECHNOLOGY FOR LURGI GASIFIERS

ORGANIZATION AND CONTRACT NUMBER

University of North Dakota
76-S-02-4035.A001

PRINCIPAL INVESTIGATORS

M. H. Somerville
J. L. Elder

OBJECTIVES

The purpose of the work performed at the University of North Dakota is to identify and categorize the effluents from and control methods utilized in four proposed gasification facilities: (1) Transwestern Coal Gasification Co., (2) El Paso Natural Gas Co., (3) ANG Coal Gasification Co., and (4) Natural Gas Pipeline Company of America.

APPROACH

Each plant design will be evaluated with respect to existing and probable environmental regulations and best available technology. The design reliability of projected effluent levels is to be identified. The report will delineate the environmental control options, the economic and energy costs of those controls, the reliability of the design-controlled effluent levels, and the current status of gasification effluent regulations.

PROGRESS AND RESULTS

The project is nearly completed. The available design data describing the plant's effluents been gathered, checked, and collated. Additional design data have been generated describing the effluent characteristics and the design control equipment.

Specifically, the effluent levels from each of the four plants have been identified and classified by internal plant division. The economic and energy cost of control of those effluents has been identified where Federal or state regulations require their control. The water treatment and reuse schemes within each plant have been analyzed, and the characteristics of the water added to the solid wastes have been identified. The solid waste disposal plans within each facility have been reviewed and the quantities identified. A computer

program allowing analysis of the above data and comparative tables to be generated was written and debugged; it is operational. The data from the four facilities have been entered into the data file.

Sulfur Removal

The major effluent control question at the start of this project was concerned with the control and removal of hydrogen sulfide from high CO₂ content streams. At that time there were few data which indicated that the removal of H₂S from streams containing high CO₂ (1 percent H₂S, 95 percent CO₂) had been accomplished on a commercial scale. Operating data were generated at the South African Coal, Oil, and Gas Corporation and in a number of other large commercial installations indicating that this technology exists and has been successfully demonstrated.

Wastewater Treatment

The gas liquor streams are the major wastewater streams which have a high potential for reuse within the plant. Characterization of phenosolvan plant input streams indicate they contain high concentrations of phenolics and fatty acids. The available data sources were generally lacking in detailed descriptions of internal water treatment facilities. Design criteria for coke plants were used to generate some of the missing data. Capital costs for the wastewater treatment systems proposed were found to vary from \$6.7 to \$9.9 million, while operating costs were found to vary from \$1.5 to \$2.33 million (1973 dollars).

Solid Wastes

The primary method of solid waste disposal in the proposed plants is by mine burial, usually at depths of 50 feet (or somewhat less) to 100 feet or more below the surface of the reclaimed mine land area. The dry solid wastes will generally be accompanied by 15 to 20 percent of reuse water introduced by handling and dust suppression procedures. The quantity of dry solid waste will vary from about 1 million to 3 million tons/year and is primarily dependent on the ash content of the coal feedstock. Two major questions need to be addressed with respect to solid waste disposal:

1. Will the burial solids have any appreciable negative effect on the quality of ground-water percolating through the buried solids and ultimately reaching surface water systems at more distant points of lower elevation?
2. Will the buried solids have a negative effect on plant life growing on reclaimed mine land areas by root system uptake of trace and major elements leached by water percolating through buried solids and replaced overburden?

All of the plant complexes plan on applying mine burial procedures for solid waste disposal and at the same time geologically isolating the buried wastes as much as possible from the adjacent groundwater system. Utilities have used rather similar systems for disposal of combustion solid wastes with reasonably good results. It is our belief the negative effects from (1) will be minimal.

Those responsible for the four tentatively planned complexes have recognized the possible negative effects of groundwater percolation through buried waste solids on the quality of the water. They have conducted and sponsored surveys and test programs designed to increase knowledge of these effects. The following test procedures are planned or have been conducted and should be encouraged.

1. Establish monitoring wells beyond the perimeter of waste burial areas and intercept and monitor groundwater quality regularly over extended periods of time.
2. Monitor surface water quality periodically at selected points somewhat distant from the area perimeter of buried solid wastes.
3. Make several laboratory leaching studies of waste solids to determine "worst case" leaching effect.
4. Make column (simulated replaced overburden and buried waste) leaching studies to estimate leaching effects more nearly approaching field conditions.
5. Conduct plant growth studies on reclaimed land to determine root system uptake as a result of leaching of replaced overburden and wastes.

Economic Evaluation of Effluent Control

Each plant was divided into 19 units and the effluents emitted into the surroundings were identified from the design data provided for by each plant's Federal Power Commission (FPC) or EIS statement. Processes for control of emission of pollutants into the environment (e.g., ash, sludges, H_2S , SO_2 , particulates, hydrocarbons, CO) were identified, and the fixed capital investment and the direct operating cost for each pollutant controlling process were calculated for 1973 costs. Table 2 gives the summary costs of control of the effluents for three proposed coal gasification plants. The cost information for various plants was obtained from the El Paso FPC filings, from EPA sources, and from published cost data. The energy requirement for operating each of these processes was also calculated. The process effluent controls studied were: Claus, Stretford, and the Shell ADIP processes for H_2S control, flue gas desulfurization process for SO_2 , electrostatic precipitator for particulates, ash dewatering and transfer for ashes and sludges, incineration for HC, and CO control.

Trace Metals

The emission of trace metals from a gasification facility has been an environmental concern for a number of years. There are currently no Federal or state point source standards dealing with emission of trace metals from coal gasification plants for solid, liquid, or gaseous effluents. The health effects dealing with trace metal emissions from gasification facilities have not been established. In our opinion, these effects are likely to be minimal or nonexistent based upon the extremely low trace metal effluent levels relative to power plant emissions. A need for basic research to understand the role of trace metals in the environment is required.

Table 2. Fixed Capital Investment (FIC) and Direct Operating Costs (DOC) For Control of Emissions of Major Pollutants from Three Proposed Coal Gasification Plants (\$ millions -- 1973 Dollars)

Effluents	El Paso		Wesco		Natural	
	FIC	DOC	FIC	DOC	FIC	DOC
Ash & Sludge	12.100	1.960	7.956	1.330	4.657	0.963
Coal Dust & Particulates	0.347	0.698	6.915	0.950	7.470	0.982
H_2S	8.612	5.950	15.293	2.153	16.980	2.369
SO_2	-	-	78.243	4.866	27.100	2.250
Hydrocarbons	1.545	0.234	-	-	1.286	0.120

prior to the setting of standards (if any) or the development of goals for environmental control technology.

PLANS FOR THE NEXT PERIOD

The only work remaining is to issue the final report of the above work.

REPORTS PUBLISHED

"A Comparative Analysis of Effluents from Four Proposed Dry Ash Lurgi Gasification Facilities," Progress Report: for the period June 1, 1976 - February 28, 1977, University of North Dakota, Report No. C00-4035-1, March 1977.

PROJECTED MILESTONES

Publish final report in early 1978.

* * *

ASSESSMENT OF SOLVENT EXTRACTION FOR TREATMENT OF COAL GASIFIER WASTEWATER

ORGANIZATION AND CONTRACT NUMBER

University of Missouri-Columbia
E(11-1)-4034

PRINCIPAL INVESTIGATOR

R. H. Luecke

OBJECTIVES

The objective of this research is to evaluate the feasibility of solvent extraction for the removal of contaminants from wastewater in coal gasification processes.

APPROACH

Investigate the distribution between aqueous and solvent phases of various phenols, naphthols, and pyridines which constitute the principal contaminants in coal gasification wastewaters. Judicious choice of solvents will facilitate selection of future solvents based on chemical structure. Simultaneous studies will be conducted on the capability, efficiency, and cost of solvent extraction processes for removing these compounds from coal gasification wastewater.

PROGRESS AND RESULTS

Measurement of distribution coefficients for a wide range of phenols and solvents has been completed (see Figure 13). Table 3 lists the combinations of contaminants and solvents for which distribution data as a function of contaminant concentration are now available, either from this study or

Figure 13. Water Samples Containing Phenolic Compounds Commonly Contaminating Coal Gasifier Wastewater are Contacted with Candidate Organic Extraction Solvents

from other sources. The distribution is most favorable in the solvents having a ketone structure; least favorable in the nonpolar solvents.

A preliminary study has also been completed assessing the economic feasibility of solvent extraction for coal gasifier wastewater treatment.

A dual extraction process is proposed in which an extraction with an efficient but partly water-soluble polar solvent is followed by a second extraction with an insoluble nonpolar solvent. This study shows very favorable economics; wastewater contaminants have a market value of about \$45.00 per 1000 gallon of water while treatment costs are about \$1.00 to \$3.00 per 1000 gallon (Table 4).

PLANS FOR NEXT PERIOD

Several tasks need to be completed for the distribution coefficient study

- Fill in some (although not all) of the blanks in Table 3.

Table 3. Solutes and Solvents for which Distribution Coefficients are Available; 0 - this research, X - other sources.

Solutes \ Solvents	Solvents												
	Isobutane	N-Hexane	n-Heptane	Cyclohexane	Isobutylene	Benzene	Methyl ethyl ketone	3-Heptanone	2-Octanone	Octanol-1	Di-isopropyl ether	n-Butyl acetate	Chloroform
Phenol	X		X		X	X	X	X	O	O	X	X	
Hydroquinone		O				O		O	O	O	O	O	
Resorcinol		O		O		O	X	O	O	O	O	O	O
Catechol		O		O		O		O	O	O	O	O	O
O-Cresol		O				O		O	O	O	O	O	O
M-Cresol		X				X	X					X	
P-Cresol													
Pyrogallic Acid						O		O	O	O		O	
β -Naphthol						O							

Table 4. Total Capital Investments and Annual Operating Cost/1000 gal for Dual Extraction Process (8000 hr/yr). Major Equipment Costs Include Installation, Piping, Instrumentation, etc.

Cost Items	Distribution Coefficient (KD)			
	KD = 300		KD = 25	
	100 gal/min (\$1000/yr)	1000 gal/min (\$1000/yr)	100 gal/min (\$1000/yr)	1000 gal/min (\$1000/yr)
Investment Costs				
Extractors (2)	50	182	135	320
Distillation (2)	48	134	48	134
Heat Exchange (5)	41	128	41	128
Pumps (8)	14	28	14	28
Tanks (2)	15	57	15	57
TOTAL	168	400	253	528
Operating Costs				
Chemicals	18	180	18	180
Utilities	15	150	15	150
Capital Equipment	44	104	66	127
Labor, lab, etc.	40	80	40	80
TOTAL	117	514	139	537
Charges	(\$/1000 gal)	(\$/1000 gal)	(\$/1000 gal)	(\$/1000 gal)
Charges per 1000 gal	2.44	1.07	2.90	1.14
Charges for 25% return on invest- ment	610.00	270.00	720.00	290.00

- Add several other compounds to Table 3. Pyridine is one example.
- Convert distribution data to activity coefficients and correlate with chemical structure.
- Investigate mixed solvents which have been reported to be more efficient than the individual pure solvents.
- Investigate mixed contaminants which react to form a more soluble product, e.g., pyridine and phenol.

In addition, studies will continue on the design of a total process. It would appear that a third-stage extraction may be justified. A small semi-works project is under consideration.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Completion of measurement of distribution coefficients for the phenolic compounds and correlation of these data will constitute a major milestone for this project. The estimated completion date is June 1978.

* * *

ENVIRONMENTAL CONTROL TECHNOLOGY SURVEY OF SELECTED U.S. STRIP MINING SITES

ORGANIZATION AND CONTRACT NUMBER

Argonne National Laboratory
W-31-109-ENG-38

PRINCIPAL INVESTIGATORS

E. J. Croke
R. P. Carter
D. O. Johnson

OBJECTIVES

The objectives are (1) to identify sites east of the 100th meridian where coal surface mining is expected to increase over the next 20 years; (2) to intensively study these sites to obtain a data base from which to assess potential health and environmental impacts of increased coal surface mining; (3) to assess the effectiveness of the control technologies utilized and examine alternatives; (4) to recommend control technologies for new and expanding mines to allow those mined to operate in an environmentally safe manner; and (5) to recom-

mend future R&D needs and priorities in environmental control technology.

Priority Pollutants Subproject

The objective of the subproject is to report on the occurrence and level of concentration for the coal mining and processing industry of 110 organic compounds or classes of compounds and 14 metals/minerals designated as "Priority Pollutants" in the EPA/U.S. District Court consent decree of June 9, 1976, covering 21 industries that may introduce toxic chemicals into the environment.

APPROACH

The future coal production areas will be surveyed, and case study sites will be selected.

The following samples and analyses activities will be completed: biweekly sampling and chemical analyses of sites effluents; sampling and analyses of coal, overburden, and treatment sludges; collection and analysis of climatic, hydrologic, and geologic data. Site impacts will be projected and extrapolated for coal regions.

Argonne will examine the efficiency and economics of control technologies including waste product(s) disposal/utilization; matrix site characteristics, control technology practices, and treatment effectiveness; and make recommendations for alternatives to existing technologies and future R&D needs.

Priority Pollutants Subproject

Seven current mines have been studied, five in the Appalachian area and two in the Midwest. Pre- and post-treatment effluent was sampled and analyzed, as was effluent from coal processing plants. Samples were analyzed by gas chromatography/mass spectrometry (GC/MS) for pesticides, semivolatile and volatile organics, and by conventional methods for phenol, TOC, COD, BOD, total suspended solids (TSS), total dissolved solids (TDS), cyanide, and metals. Sampling and analysis procedures for priority pollutants described in a March 1977 EPA publication were followed. The final report will include the analytical data, an evaluation of the data, the effectiveness of each site's control technology, and recommendations for control technology research.

PROGRESS AND RESULTS

Coal production scenarios have been developed for each state which estimated production levels through the year 2000 based on industry's announced plans for new mine openings and expansions to existing mines.

A series of maps has been produced showing each state's coal fields, active mines producing over 200,000 tons/year, and proposed new mine openings. A series of computer drawn maps of each state's coal reserves has been completed. These maps show total, surface, and deep minable reserves for each county where data are available.

Surveys of the existing technologies for coal and overburden removal and water quality control, plus coal extraction and transportation equipment trends have been completed. Governmental agencies, private research organizations, and university researchers were contacted to determine their ongoing research and 20-year perspective for technology development in the areas of surface mining and mine discharge treatment.

An intensive sampling program has been completed at 21 surface mines. Samples were obtained twice a month and analyzed for the following:

Temperature	Total dissolved solids
Conductivity	Suspended solids
pH	Calcium (Ca)
Dissolved oxygen	Total iron
Acidity/alkalinity	Sodium (Na)
Manganese (Mn)	Chloride (Cl)
Aluminum (Al)	Fluoride (F)
Copper (Cu)	Strontium (Sr)
Zinc (Zn)	Magnesium (Mg)
Sulfate (SO ₄)	Ammonia (as N)

Trace element analysis was performed every three months. Elements analyzed included:

Mercury (Hg)	Chromium (Cr)
Cadmium (Cd)	Vanadium (V)
Cobalt (Co)	Molybdenum (Mo)
Nickel (Ni)	Lead (Pb)
Potassium (K)	

The overburden was sampled and analyzed for major, minor, and trace elements and forms of sulfur. The coal or coals were sampled, and the samples underwent proximate and ultimate analyses in addition to the same types of analyses performed on the overburden. Acid potential as derived from pyritic sulfur and total neutralization potential were also determined.

Shown in Figure 14 is a mine site in Oklahoma. Figure 15 shows sampling of a creek in Oklahoma for mine effluents.

Argonne is analyzing the sample data and will assess the health and environmental impacts and pollution potential for each site. This assessment coupled with the information relative to increased coal production and technology trends will provide the baseline data for a report on the 20-year projection of volumes and characteristics of mine effluents and their potential health and environmental impacts.

Priority Pollutants Subproject

A manual of field and laboratory procedures for the determination of priority pollutants has been developed.

The field sampling portion of the program has been completed. Organic extractions are being performed on sample splits prior to GC/MS analysis;

of the remaining parameters, Argonne and EPA are analyzing the metals and a commercial laboratory is performing the rest.

Figure 14. Oklahoma Mine Site -- Peabody Coal Mine

Figure 15. Sampling at Madden Creek

PLANS FOR NEXT PERIOD

Argonne will analyze the sample data and assess the health and environmental impacts and pollution potential for each site. This assessment coupled with the information relative to increased coal production and technology trends will provide the baseline data for a report on the 20-year projection of volumes and characteristics of mine effluents and their potential health and environmental impacts. A management system for computer storage of the data generated under this program will be developed.

Mine effluent will be examined before and after treatment to provide a measure of the effectiveness of the treatment process. Cost data will be obtained whenever possible and cost-effective assessments of alternate control technologies will be

completed. Process waste products will be identified and characterized, and the economics of their disposal/reclamation will be considered. Potential waste produce utilization will be surveyed. The economics/effectiveness of alternative processes will be compared with the currently utilized process. The environmental impacts of the waste products generated by each site's treatment process and selected alternative processes will be identified and evaluated.

The mine effluent analytical data will be examined in relation to the recently established effluent limitation guidelines and new source performance standards for the coal mining point source category. The applicability of the guidelines and standards on a National scale versus state or regional scales will be analyzed. The data from this program will be used to assess the validity of the guidelines in general and in relation to current and future technology. Conferences will be held with agencies involved with coal development in several of the states participating in the study to exchange information regarding guidelines applicability, monitoring, and enforcement. Each state's input to the program will be consolidated, as will the input from industry. Recommendations for modifying or implementing the guidelines will be developed.

Priority Pollutants Subproject

Argonne will evaluate the analytical data and will prepare a final report including lists of organic compounds, classes of compounds and metals identified, organic spectral data, estimated organic concentrations, levels of metals, and other related data. Also included will be an assessment of each site's control technology effectiveness and recommendations for control technology research.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- March 1978 -- Report on 20-year projection of potential and environmental impacts related to increased surface mining based on effluent volume and characteristics data collected at case study sites.
- June 1978 -- Report on effluent control technology effectiveness, economics, and waste products; report on alternative processes, including availability and economics; develop computer storage information system.
- September 1978 -- Report on comparison and evaluation of program data with effluent limitations guidelines. Hold conferences with participating states regarding guidelines applicability and validity.

- March 1979 -- Final report including matrix to recommend effluent control technologies for existing or expanding mines. Report on control technology research and development needs and priorities.

* * *

ENVIRONMENTAL CONTROL IMPLICATIONS OF COAL PREPARATION PLANTS

ORGANIZATION AND CONTRACT NUMBER

Environmental Protection Agency
EE-77-A-28-3236

PRINCIPAL INVESTIGATOR

J. Kilgroe

OBJECTIVES

The objective of this program is (1) to evaluate the practicability of a commercial scale advanced physical coal cleaning (coal washing) plant to remove sulfur from Appalachian coals and (2) to assess the environmental control technology requirements for the mitigation of impacts from the emissions and effluents from the coal preparation plant.

APPROACH

The interest in coal cleaning as a pollution control method to reduce sulfur emissions from coal-fired power plants has been emphasized in recent years. The ability to remove pyritic sulfur from coal by physical coal cleaning techniques has been long recognized; however, in many instances the sulfur reduction has not been sufficient to meet New Source Performance Standards emission levels. This coal cleaning demonstration plant, which will process 1200 tons/hour, is being constructed by General Public Utilities (GPU) at the Homer City Generating Station of a subsidiary company -- Pennsylvania Electric Company (Penelec). Participants in the program are EPA, ERDA, GPU and Electric Power Research Institute (EPRI).

Pennsylvania's large, stationary source, sulfur oxide emission regulations for existing sources of air basins permit a maximum emission level of 4.0 pounds of SO₂ per million Btu (MBtu). Normal run of mine coal from dedicated mines cannot meet this requirement. New source performance standards, applicable to the new unit, are more restrictive and limit emissions to 1.2 pounds of SO₂/MBtu.

Indigenous coal deposits in the Penelec service territory have been recognized for their susceptibility to desulfurization by physical coal cleaning. This is a consequence of both a relatively low percentage of chemically bound organic sulfur and

high but relatively free inorganic sulfur in the pyrite form. Recognizing these inherent characteristics, GPU's R&D efforts are focused on developing advanced coal cleaning methods.

PROGRESS AND RESULTS

Based on the findings of the R&D efforts, it was concluded that a coal cleaning facility that features high gravity, heavy, medium-cyclone circuits designed to desulfurize and recover a maximum amount of Btu from the raw coal feedstock and that prepares multiple streams of varying sulfur content coal, was capable of processing coal into compliant fuel without supplemental flue gas desulfurization.

The coal cleaning system includes a number of innovative applications and extensions of existing technology to multistream coal processing. These innovations relate to:

- Extending the range of heavy, medium-cyclone equipment to smaller sized coal fractions (100-mesh from the usual 28-mesh bottom size),
- Substitution of full stream, electromagnetic separators for drain and rinse screens in the 9-mesh x 100-mesh coal circuit for recovering magnetite,
- Extending the range of operating specific gravity of heavy medium cyclones to 1.8 at the upper end and 1.3 at the lower end, and
- Development of a novel control system for control of the specific gravity of operation in the nominal 1.3 specific gravity circuit operating on fine size coal.

PLANS FOR NEXT PERIOD

- Characterize pollutant stream emitted from the preparation and power plants.
- Determine if a need exists for development of improved pollution control technology.
- Determine the fate of potentially hazardous minor and trace pollutants contained within the coal used at the preparation and power plants.
- Evaluate the effectiveness of planned residue disposal techniques.
- Evaluate other equipment of coal cleaning circuits as needed to demonstrate the viability of the Homer City Plant for clean coal to meet SO₂ emission regulations.
- Determine capital and operation costs of the preparation and power plants; i.e., the costs of using physical coal cleaning to meet SO₂ emission regulations.

- Determine the variability of sulfur and other pollutants in the coal which is fed to the coal cleaning plant.
- Determine the performance of equipment used for the separation of coal and liberated pyrite.
- Determine the capability of the plant process controls in maintaining the coal product streams within sulfur, ash, and Btu specifications.
- Evaluate the effects of using clean coal on the performance of the boilers and electrostatic precipitators at the power plant.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

A comprehensive test program to meet the stated objectives will be completed in early 1978. Initial runs of the coal cleaning plant are expected in early 1978. Data will be collected during the shake down period as well as during normal operations. Characterization of pollutants from the various emissions and effluents will be completed during 1978. Environmental control technology assessments, identification of potential problem areas, and identification of RD&D needs in pollution control technology will be identified in FY 1979.

* * *

EVALUATION OF THE EFFECT OF COAL CLEANING ON FUGITIVE ELEMENTS

ORGANIZATION AND CONTRACT NUMBER

Bituminous Coal Research, Inc.
EE-77-S-02-4427

PRINCIPAL INVESTIGATORS

J. F. Boyer, Jr.
C. T. Ford

OBJECTIVES

By virtue of its origin, coal has been found to contain nearly every naturally occurring element. During coal mining, preparation, and utilization, these elements may be released to the environment.

The primary objective of this project is to assess the effect of controlled coal cleaning on fugitive elements present in run-of-mine coal. The results of this study should allow some conclusions to be drawn concerning the potential for coal cleaning as a strategy for controlling trace elements that otherwise may become an environmental problem during subsequent utilization of a particular coal.

The second project objective is to prepare a comprehensive state-of-the-art report on the effect of coal mining, preparation, transportation, and utilization on the trace elements found in coal.

The third objective is to provide a description of accurate analytical methods that can be used by coal industry and commercial laboratories for determining the concentration of selected trace elements in a variety of coals.

APPROACH

To complete the state-of-the-art study, all available, pertinent information on trace elements as they relate to the coal producing and utilizing industries will be secured and reviewed. On-going coal-related trace element studies will be evaluated. Input on future needs will be solicited from the many organizations involved in studying the problem (see Figure 16).

The effect of coal cleaning on fugitive elements will be evaluated by exhaustively studying 20 samples of run-of-mine (ROM) coal obtained from various geographic locations throughout the United States. All ROM samples will be subjected to controlled coal cleaning at the Bituminous Coal Research, Inc., laboratory. Each coal will be crushed to a 1½-inch tosize, sampled, and then screened into 1½ x ¾-inch, ¾-inch x 30-mesh, and minus 30-mesh fractions, which are typical of

present cleaning plant circuitry. The 1½ x ¾-inch and the ¾-inch x 30-mesh fractions will be gravity separated at the following gravities: 1.35, 1.55, and 1.80. The minus 30-mesh material will be separated into four distinct fractions, using a hydraulic classifier.

Samples of eight of the ROM coals also will be reduced in size to one lot which is predominately minus 30 mesh and a second lot which is predominately minus 100 mesh. Each will be screened, using the standard sieve series, down to 270 mesh. The minus 30-mesh lot should yield eight size fractions, and the minus 100-mesh lot should yield four size fractions. The size fractions will then be hydraulically classified to produce as near as possible a pure coal fraction, a pure shale fraction, and a pure pyrite fraction.

Each fraction produced by the coal cleaning task will be characterized by general chemical and trace element analysis, as well as petrographic analyses where appropriate, and the data will be evaluated to determine the trace element concentrations in the various clean coal and reject fractions. Those fugitive elements chosen for study include the trace elements antimony, arsenic, beryllium, cadmium, lead, mercury, selenium, chromium, copper, fluorine, manganese, nickel, vanadium, and zinc, along with the more prevalent constituents such as sulfur and nitrogen.

Figure 16. Effect of Coal Mining, Preparation, Transportation, and Utilization on Fugitive Elements

PROGRESS AND RESULTS

The state-of-the-art review of the effect of coal mining, transportation, preparation, and utilization on fugitive elements began in March 1977 and will be completed in June 1978. Initial activity has been reviewing the available reports, discussing related projects with EPA, and gathering information for the Trace Element Bibliography. The library collection now contains nearly 400 references.

Work on the coal cleaning phase began in February 1977. The first coal sampled was a mixture of the Upper and Lower Freeport Seams. This sample has been cleaned, and the various clean coal and refuse fractions are currently being analyzed.

The second coal to be studied in this project was received in May 1977. This sample is from the Illinois No. 6 Seam, and fractions are currently being prepared for analysis.

PLANS FOR NEXT PERIOD

During FY 1978, the state-of-the-art review will be completed, the remaining coals to be studied will be obtained, coal cleaning will be 85 percent completed, and the analytical phase will be 70 percent completed. Analytical data will be evaluated to determine mass balances for each of the fugitive elements studied. Potential relationships of the fugitive elements to the clean coal, shale, and pyrite fractions will be identified. Preliminary effects of various coal cleaning strategies on the fugitive elements in the coal will be determined.

During this period, the scope of work will continually be reevaluated in light of the results being obtained from the coal cleaning studies and from the state-of-the-art review. Modifications could include, but would not be limited to, adding elements, adding or deleting sampling sites, limiting or expanding the degree of coal cleaning, etc.

Analytical techniques will be refined or developed if necessary as new equipment is introduced and as additional elements are added to the study.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- July 1978 -- State-of-the-Art Review
- July 1979 -- Analytical Procedure Report
- July 1979 -- Final Report on the Effect of Coal on Fugitive Elements

* * *

TRACE ELEMENT CHARACTERIZATION AND REMOVAL RECOVERY FROM COAL AND COAL PREPARATION WASTES

ORGANIZATION AND CONTRACT NUMBER

Los Alamos Scientific Laboratory
IAG-D5-E681

PRINCIPAL INVESTIGATOR

E. M. Wewerka

OBJECTIVES

The major objectives of this research program are to assess the nature and magnitude of the trace elements in the drainage from coal preparation wastes and stored coals, to identify the trace elements of greatest environmental concern in these materials, and to recommend required pollution control technology or necessary research, development, or demonstration programs.

APPROACH

Experimentally, this program is divided into several activities. The initial efforts include studies of the structure and weathering and leaching behaviors of the trace elements in selected samples of refuse and coal. These investigations will establish the overall potential of these materials to cause trace element contamination and reveal the identities of the specific trace elements of concern in the refuse and coal pile effluents. The information gathered on refuse and coal structure and environmental behavior provides the basis for the latter stages of the program, which involve assessment or development of control technology to lessen the environmental impact of trace element pollution of coal or refuse associated waters.

RESULTS AND PROGRESS

Early in FY 1977, Los Alamos Scientific Laboratory (LASL) completed the analyses of the trace elements and major minerals in bulk refuse and coal samples from the Illinois Basin. This activity was followed at midyear by studies to elucidate the structural relationships and associations among the trace elements in these materials. Concurrent with these efforts, and continuing throughout most of the year, LASL conducted several series of weathering and leaching experiments to define the environmental behavior of the trace elements in the refuse and coal samples under various environmental conditions. These investigations resulted in the identification of the trace elements of most environmental concern in typical Illinois Basin refuse and coal. During the latter part of the year, LASL conducted a limited investigation of the effectiveness of alkaline neutralization for removing trace elements from refuse drainage. Figure 17 shows freshly dumped coal cleaning waste, Figure 18 shows the

eroded face of an 8-year old refuse pile, while Figure 19 shows a drainage channel between two refuse pile banks.

Two of the three objectives of this program were achieved in FY 1977 for high sulfur refuse and coal materials from the Illinois Basin. LASL succeeded in defining the nature and magnitude of the trace element releases into the aqueous drainages from these materials, and the laboratory identified the trace elements of greatest environmental concern in this type of refuse and coal. In addition, during the year, work was begun on the last objective of the program -- to assess or define environmental control technology for trace element pollution of refuse dump and coal pile drainage or

runoff. Trace elements of environmental concern in Illinois Basin coal refuse are given in Table 5.

PLANS FOR NEXT PERIOD

The main component of our programmatic activities for FY 1978 will be to continue to assess the technology options or needs to control or prevent trace element contamination of the drainage from high sulfur refuse or coal. In addition, we will begin studies to identify the trace elements of greatest environmental concern in the aqueous effluents from typical refuse and coal from the Appalachian Region, again with the aim of delineating suitable pollution control technology or research, development, or demonstration programs.

Figure 17. Freshly Dumped Coal Cleaning Waste

Figure 18. The Eroded Face of an 8-year Old Coal Refuse Pile

Figure 19. Water-filled Drainage Channel Between Two Coal Refuse Banks

Table 5. Trace Elements of Environmental Concern
in Illinois Basin Coal Refuse

Element	Labile Mineral	Static Leaching	Dynamic Leaching	Typical Leachate Concentration (g/ml)
F	X			
Al		X	X	1,630
Mn	X	X	X	75
Fe	X	X	X	22,100
Co		X	X	50
Ni		X	X	76
Cu			X	13
Zn		X	X	96
Cd		X	X	

REPORTS PUBLISHED

"Environmental Contamination from Trace Elements in Coal Preparation Wastes: A Literature Review and Assessment," Interagency Energy-Environment Research and Development Program Report, EPA-600/7-76-007, August 1976.

"Trace Element Characterization and Removal/Recovery from Raw Coal and Coal Preparation Wastes," Quarterly Progress Reports Nos. 5, 6, and 7, March 1977, April 1977, and July 1977, respectively.

"Trace Element Characterization and Removal/Recovery from Raw Coal and Coal Preparation Wastes," Annual Progress Report for FY 77, October 1977.

PROJECTED MILESTONES

During FY 78 in connection with this program, LASL will produce three quarterly progress reports and an annual report. Also, in the last quarter of the year, an additional treatise will be written defining the various options that are now or soon will be available to prevent or control trace element releases in the effluents from refuse and coal storage areas; this document will also define where additional research, development, or demonstration work needs to be done to effect adequate control of the trace element emissions from these materials.

* * *

ENVIRONMENTAL CONTROL ASPECTS OF COAL SLURRY TRANSPORTATION

ORGANIZATION AND CONTRACT NUMBER

University of California, Los Angeles
EY-76-5-03-0034

PRINCIPAL INVESTIGATOR

O. L. Anderson

OBJECTIVES

- Identify and determine the significance of all potential interactions between coal slurry and/or recovered slurry water and the environment;
- Assess water pollution control and water treatment strategies used for existing and proposed coal slurry pipeline systems;
- Assess current and developing technologies for control of suspended particles, trace elements and trace organics in waste-waters; and
- Determine the feasibility of using saline water or partially treated sewage effluent as the carrier medium, and the resulting interactions between the liquid and solid phases.

APPROACH

These objectives will be accomplished through:

- A literature review of coal water chemistry and water pollution control technology; and
- Analyses of actual or laboratory-prepared coal slurries for:
  - Transfer of inorganic species (including trace metals) from solid to liquid phase,
  - Leaching of organic species; analysis will be by gas chromatography/mass spectrometry, and
  - Effects of slurry exposure upon waste-water characteristics -- analysis will include determination of biochemical oxygen demand and coliform bacteria.

PROGRESS AND RESULTS

The project began October 1, 1977. The literature review has been started.

PLANS FOR NEXT PERIOD

The project will be completed during FY 1978.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- February 1978 -- Laboratory Results
- March 15, 1978 -- Final Report

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ENVIRONMENTAL IMPLICATIONS OF ACID MINE DRAINAGE

ORGANIZATION AND CONTRACT NUMBER

West Virginia University
E(40-1)-5261

PRINCIPAL INVESTIGATORS

A. W. Pappano
D. L. Gochenour, Jr.

OBJECTIVES

To develop a measurement of the secondary impacts to be expected from the wide scale acceptance and utilization of lime neutralization as an acid mine drainage (AMD) abatement procedure on the Monongahela River.

APPROACH

1. Establishment of mathematical models to effectively predict the effluent concentrations from an AMD lime neutralization plant for cases where the influent data are complete or only partially available.
2. Establishment of a technique to determine the lime requirements of a neutralization system where influent data are complete or only partially available.
3. Development of a computerized data base for storing and retrieving river flow characteristics, river quality, and waste-load characteristics on the river basin.
4. Development and use of a river flow simulation model to examine the effects, including secondary, on river quality of various AMD abatement scenarios.

A description of the lime neutralization model can be visualized by realizing that a typical AMD is characterized by concentrations of calcium, magnesium, iron, aluminum, manganese, and sodium usually in conjunction with sulfate anions and at a low pH. The basis of the mathematical model is to consider the reactor employed in the neutralization process to be completely mixed and to assume the aqueous reactions to occur very rapidly. In this manner, it is reasonable to assume that all chemical species will attain an equilibrium state and thus the adoption of the name Ionic Equilibrium Model. In this model, the Davies relationship has been used to compute the coefficient relating the molal concentration of the particular ion with its ionic reactive activity. It is also assumed that the activity coefficients for all single valence ions are equal, the activity coefficients for the nonionized dissolved molecules are unity, and the lime (CaOH_2) is added dry to the process.

The data base and simulation model are being programmed in FORTRAN because that language is very common and relatively easy to use. It also ensures that the format of the results are compatible with related work being done by other state and Federal agencies. Because the simulation model is designed to provide dynamic conditions of the river basin, the data base contains (and retrieves for the simulator) such information as river mile identification codes, hydraulic data for the river basin, and waste-load data. Information from the data base will be translated and edited prior to entering the simulator. Results from such treatments can be quickly viewed and evaluated without actually incurring the time and expense of doing the work in the field.

PROGRESS AND RESULTS

Results of the lime neutralization model under development in Approach-1 above are seen in Table 6 which illustrates measured and predicted calcium concentrations from published neutralization research plants.

Table 6. Effluent Calcium Concentration (moles/l)

	Measured	Predicted
Kefover Plant	0.75×10^{-2}	0.94×10^{-2}
Thompson Plant	1.95×10^{-2}	1.34×10^{-2}
Crown Plant	0.14×10^{-1}	0.67×10^{-2}

The computerized data base has been developed and is being tested for the 571 miles of river in the study area. QUAL II has been selected as the simulation model to be used for identifying river quality and the secondary impacts of various AMD abatement scenarios. Limited testing has been conducted with the data base developed for the river basin study area.

PLANS FOR NEXT PERIOD

The accomplishment of the original objectives of this project will be attained through the performance of the following tasks:

1. The assessment of projected quantitative and qualitative effects on various regions due to lime neutralization;
2. The identification of regions in which the projected secondary economic impacts from lime neutralized discharges warrant the application of other abatement technologies;
3. The determination of other potential techniques for treating AMD, other than lime;
4. The identification of levels of hardness associated with the use of various combinations of treatment schemes;
5. For the regions identified in (2), the determination of the projected impacts anticipated from the use of the treatment processes identified in (3) above;
6. For the regions identified in (2), the analysis and comparison of hardness levels and projected secondary economic impacts associated with the use of various combinations of treatment schemes; and
7. Publication of the final report.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

FY 1978 -- Final report

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PRELIMINARY ASSESSMENT OF ENVIRONMENTAL CONTROL OPTIONS FOR NOISE

ORGANIZATION AND CONTRACT NUMBER

Bolt Beranek and Newman Inc.
EE-77-C-U2-4389

PRINCIPAL INVESTIGATOR

D. N. Keast

OBJECTIVES

The objective of this study is to survey the developing energy technologies to determine the existing and/or anticipated environmental control needs for noise control. This survey will identify

practical noise-control procedures and/or process modifications to mitigate the impact of noise where appropriate. Essential products of the survey are the identification of areas where existing environmental noise control is inadequate and the development of recommendations for a program to address such inadequacies.

APPROACH

Noise control experts in the various applicable technologies (e.g., mining, transportation, electric power generation) will review the literature on the emerging energy technologies for information on potential noise problems. Some selected field measurements may also be performed. The results of these surveys and measurements will be assessed to identify and rank any potential noise problems in order of:

- Technical difficulty to control or suppress the noise,
- Importance to the timely development of the pertinent energy technology, and
- Urgency for developing control measures.

Those potential noise problems that cannot be fully assessed due to uncertainty in the data or lack thereof will be identified. In such instances, noise-research programs being conducted by other Government agencies and/or by the industrial-educational sector shall be screened to determine if they have a bearing on the particular problem area. Where necessary, a program of future noise control research will be suggested.

PROGRESS AND RESULTS

This project began in the last quarter of FY 1977 and will be completed early in the second quarter of FY 1978. As of this writing, the literature search has been instituted and some potential problem areas have been identified. However, the assessment and rank-ordering of these problems has not yet begun.

PLANS FOR NEXT PERIOD

The project will be completed early in FY 1978 with the publication of a final report.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

The major interim milestone in this brief study will be an oral review, with DOE, of the results achieved approximately midway through the contract. This review has been scheduled for early October 1977.

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PETROLEUM AND GAS

Under Section 6(b)(3)(Q) of the Federal Non-nuclear Energy and Research and Development Act of 1974, ERDA, and hence DOE, is authorized and directed to establish program elements and activities "...to improve methods for the prevention and cleanup of marine oil spills." The Environmental Engineering Program conducts assessments in areas not already adequately covered by the Environmental Protection Agency (EPA), the U.S. Coast Guard (USCG), or other public and private efforts. At the present time, these efforts are focused on spill control through the use of chemical dispersants and cleanup by mechanical means.

As a result of preliminary investigations sponsored by the Division of Environmental Control Technology, the merits of utilizing chemical dispersants in the control and cleanup of marine oil spills is being reevaluated. Investigations at the University of Rhode Island are designed to assess the efficacy, practicability, and environmental consequences of using chemical dispersants and other agents. Preliminary results indicate that some chemical dispersants may, in fact, be effective under certain circumstances without excessive or long-lasting harm to the environment. EPA and USCG serve in advisory roles for these projects.

In FY 1977, Environmental Engineering completed the evaluation of selected harbor and offshore oil spill containment and cleanup equipment. This work was performed at the Oil and Hazardous Materials Simulated Environmental Test Tank at EPA's site in Leonardo, New Jersey. The testing was sponsored jointly by EPA, USCG, and the Department of the Navy. As a result of discussions with many persons in Government, industry, and academia who are experts in various phases of liquefied natural gas (LNG) technology, the need has been identified for a

comprehensive integrated program of research, development, and demonstration to resolve LNG safety and control issues. A major FY 1977 accomplishment was the beginning of an assessment of the safety and environmental control research implications of transporting, storing, and handling LNG. The report will identify the need for R&D and will outline a program of research aimed at providing answers to those questions requiring resolution before LNG's full potential can be realized. In addition, the Environmental Engineering Program will continue sponsorship of spill tests on water together with the supporting theoretical work. Wherever practical, experimental research will be used to support the mathematical model assessment/development.

Enhanced oil and gas recovery methods, by which additional amounts of oil and gas may be extracted from producing fields, usually have associated waters contaminated by oil and gas residues. Increased understanding of systems is needed for separating the organic wastes and for disposing of the brackish waters in order to realize the full potential of such techniques. In FY 1977, preliminary results are expected from an assessment of membrane technology for cleaning up such produced waters. Crude oil refining also creates contaminated water that needs treatment before reuse or discharge to streams. Laboratory studies assessing the efficacy and practicability of activated sludge treatment for removing refractory organic compounds from refinery wastewaters were initiated in FY 1977.

In FY 1977, research directed toward the safety aspects of shipping hydrogen under conditions of large-scale usage was established. This includes a preliminary assessment of problems and needed safety and environmental research for use of liquid, gaseous, and hydride forms of hydrogen.

ASSESSMENT OF TREATED VERSUS UNTREATED OIL SPILLS

ORGANIZATION AND CONTRACT NUMBER

University of Rhode Island
EY-76-5-02-4047

PRINCIPAL INVESTIGATOR

M. P. Wilson, Jr.

OBJECTIVES

The objective of this study is to determine the practicability and feasibility of treating oil spills with dispersants.

APPROACH

The approach has been to conduct mathematical, laboratory-scale meso-scale and in situ experiments to compare treated and untreated oil spills. The effectiveness of several existing dispersants will be assessed.

PROGRESS AND RESULTS

This project was started in September 1977. Thus far, the literature search and background study have been completed.

PLANS FOR NEXT PERIOD

The mathematical and laboratory-scale analyses will be continued. The meso-scale test program will be conducted. Plans will be developed for in situ tests.

REPORTS PUBLISHED

"The Spreading, Retention and Cleanup of Oil Spills," University of Rhode Island, NTIS.

PROJECTED MILESTONES

June 1978 -- Complete meso-scale tests

* * *

FIELD TESTS OF OIL SPILL CLEANUP EQUIPMENT

ORGANIZATION AND CONTRACT NUMBER

Environmental Protection Agency
Interagency Agreement ERDA-EE-77-A-28-3235

PRINCIPAL INVESTIGATORS

R. D. Maxwell, ERDA
J. S. Farlow, EPA
J. Getman, USCG
J. E. Wilson, USN

OBJECTIVES

The objective of this study is to achieve participation with other Government agencies as a Joint Committee to acquire objective knowledge of oil spill control devices available.

APPROACH

The Joint Committee selected four devices for testing and evaluation at the Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT), combining manpower and dollar resources, standardizing testing and procedures, and effecting the savings of united efforts.

PROGRESS AND RESULTS

Three of the four devices completed testing at OHMSETT. Each was tested for two weeks beginning in April and concluding in August and September. The last skimmer will be tested in late October, the total program requiring eight weeks of tank time.

The first skimmer tested, Oil Mop Inc., is a rotating sorbent rope system mounted on a self-propelled hull, advancing at zero relative velocity to the oil slick. Throughput efficiency in calm water was 80 percent at 2 knots, falling to 40 percent at 5 knots. Performance in moderate wave conditions was similar. Recovery efficiency was generally lower than throughput efficiency at all conditions.

The second skimmer, Cyclonet 050, is a twin unit mounted on a Zodiac boat as a system and is normally self-propelled. The device penalizes itself in overall performance measurements by discounting oil passing under the boat hull. Its maximum efficiencies were at 1½ knots in calm water. The Cyclonet operates on the principle of oil water separation in a rotating cyclone. Throughput efficiency was 37 percent, recovery efficiency 26 percent, and oil recovery rate 57 liters per minute.

The third system, CLOWSOR, is floatable and normally attached to a barge. It consists of an extendable/retractable boom, a continuous loom multipaddle conveyor scoop, and an integral self-contained sump pump. The maximum performance was 99-percent throughput efficiency, 94-percent recovery efficiency, and 364 liters per minute.

The fourth system, Bennett Mark 3B, is a combination weir-conveyor absorption belt and self-propelled skimmer. The oil is to be directed into the inter-hull area with a vee containment boom configuration. The device will be tested at OHMSETT beginning 17 October using several wave conditions, ASTM oils, and various tow speeds.

The detailed performance of the four tested devices will be given in the final report that will also describe the physical characteristics indicating the differences in equipment mobility, deployment logistics, and sea keeping.

PLANS FOR NEXT PERIOD

Testing of the Bennett and preparation of the final report will be completed during the next period.

The Joint Committee will determine needs for future efforts based on the final report and new developments in the oil spill cleanup technology.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- October 31, 1977 -- Bennett testing completed
- January 1978 -- Report by the Joint Committee Project Engineer
- February 1978 -- Proposal for future study recommendations

* * *

DEVELOPMENT OF OIL SPILL TRAINING SCHOOL

ORGANIZATION AND NUMBER

National Spill Control School
Corpus Christi State University
EY-76-S-05-4995

PRINCIPAL INVESTIGATOR

R. E. Gilchrist

OBJECTIVES

The overall objective of this program is to provide a trained manpower base to respond to the needs of the Nation in controlling the problems created by oil spills. In order to reach this objective, the past year's work has centered on the detailed planning of an oil spill training school that will provide instruction and experience to key personnel of companies, organizations, and government units to effectively and adequately contend with an oil spill emergency.

APPROACH

The program has been directed toward oil spill cleanup rather than prevention. However, the subject of prevention will prevail throughout the topical presentations, because it is believed that this is the foundation of any spill program.

PROGRESS AND RESULTS

During the past year, we have built on previous research performed under this Contract and completed training aids and instructional materials detailing the various areas of knowledge available in the subject of oil spill prevention and control. This material represents in concise form the library of printed matter, audiovisual programs, and physical

samples compiled by the investigator. The instructional materials present the information in a nontechnical, easily assimilated manner for a broad spectrum audience.

Finally, a staff has been assembled to present this material in a classroom on the Contractor's campus and in the field at the Corpus Christi Area Oil Spill Control Association's facility where practical application can be demonstrated. Lesson plans have been prepared for the classes, and a practice class has been held.

PLANS FOR THE NEXT PERIOD

An additional practice class with local participants will be held at the beginning of the period. Knowledgeable persons from appropriate Federal agencies, local government, and industry will then be brought to Corpus Christi for a preview test class. The criticism provided in these practice and test classes will then be weighed and appropriate modification made to the curriculum to ensure that the whole and the parts are a viable program to meet the objective.

Finally, a series of 14 actual classes will be presented during the remainder of the period. These classes will be of 1-week duration with 20 students per class. In future periods, the school will be supported entirely by student fees and will average 20 classes per year with up to 30 students per class.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

None

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EVALUATION OF STATE-OF-THE-ART HARBOR OFFSHORE OIL SPILLS CLEANUP CAPABILITY

ORGANIZATION AND CONTRACT NUMBER

Environmental Protection Agency
Interagency Agreement ERDA-EE-77-28-3241

PRINCIPAL INVESTIGATORS

R. D. Maxwell, ERDA
J. S. Farlow, EPA

OBJECTIVES

The objective of this study is to conduct a performance evaluation of skimmers for controlling and removing oil spilled in the marine environment and in simulated offshore conditions, using the Oil and Hazardous Materials Simulated Environment Test Tank (OHMSETT).

APPROACH

Three offshore skimming devices were selected as typical of equipment being developed and marketed in the United States. These devices were tested and evaluated at OHMSETT to understand the methodology and phenomenology of controlling and collecting spilled oil products.

PROGRESS AND RESULTS

The three devices were selected by recommendations from Federal agencies, including the USN, EPA, USCG, and ERDA in March. The devices were delivered to OHMSETT and tested during portions of June, July, and August for a total of 9 weeks' tank time.

The operating principle of device number one, the Cyclonet 100, is that water and oil forced into the device through a tangential opening, rotates and is separated with the lighter oil moving inward and upward to be pumped off. The heavier water flows downward and is discharged through the bottom. Tests indicated this device to be effective in removing a maximum of 83 percent of Circo XX Heavy Oil encountered at a tow speed of 2 knots in calm water. Both regular waves and confused sea conditions caused efficiencies less than 10 percent.

The second device, the MARCO Class V Oil Recovery Vessel, operates with an absorption belt and an induction pump to relieve headwave buildup. The belt rotates upward, lifting the oil to a squeezer where it is discharged into a collection well. Tests indicated that effective removal (throughput efficiency) maximized at 95 percent in calm water at a

tow speed of 1 knot. Confused sea conditions showed a general decrease in performance to 30 percent with an average wave height of 4 feet.

The final device, the Offshore Devices High Seas Skimmer and Barrier, consists of a U.S. Coast Guard high seas prototype boom that is modified with weir slots and weir boxes mounted on the boom. Oil that flows over these weirs is subsequently off-loaded by a hydraulically operated pumping system. Maximum oil recovery rate (475 gpm) occurred at a tow speed of 1 knot in clam water with Circo XX Heavy Oil. Regular waves and confused seas produced oil recovery rates from 350 to 475 gpm at 0.5 to 1.0 knot with the heavier oil. This device is shown operating in the OHMSETT test tank in Figure 20. The data are currently being transformed into a draft report for publication.

PLANS FOR NEXT PERIOD

Determine the need for future efforts based on the final report and the performance limitation observed in currently available offshore skimming devices.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- October FY 1977 -- Draft EPA final report
- January 1978 -- Proposal for future study recommendation

Figure 20. Coast Guard Skimmer Barrier Collecting Heavy Oil (155-mm thick) at Forward Speed of 1.0 knot in Calm Water

ANALYSIS OF LNG STORAGE AND TRANSPORTATION CHARACTERISTICS

ORGANIZATION AND CONTRACT NUMBER

Institute of Gas Technology
EE-77-S-02-4234

PRINCIPAL INVESTIGATOR

P. J. Anderson

OBJECTIVES

The objective of this study is to provide an analysis of LNG storage facilities and transportation units. The data to be compiled will include, as appropriate, owner/operator, location, construction/start-up date, storage tank description, containment description, services description, primary jurisdiction, population density, and points of cargo loading and discharge. Data will be tabulated, aggregated, and analyzed for time trends.

APPROACH

Surveys of LNG companies will provide updating information for existing records. Past experience of the Institute of Gas Technology (IGT) staff will guide the analysis of the data.

PROGRESS AND RESULTS

In addition to tables that describe the LNG industry today in the United States, projections are made of the numbers and capacity for case-load import terminals and LNG vessels. During the 1976-1977 winter heating season, LNG accounted for about 12 percent of total peak-shaving supplies for the gas industry. (The balance of 88 percent came from underground storage.) In New England, LNG provided 9 percent of total peak-shaving supplies for 11 companies during the winter heating season.

PLANS FOR NEXT PERIOD

None

REPORTS PUBLISHED

Final Report "LNG Industry: Past, Present, and Future," submitted in August 1977.

PROJECTED MILESTONES

- May 1977 -- Project initiated
- August 1977 -- Project completed

* * *

SCALE EFFECTS IN LNG HAZARD ANALYSIS AND TESTING

ORGANIZATION AND CONTRACT NUMBER

Department of Mechanical Engineering
Massachusetts Institute of Technology
EE-77-S-02-4204

PRINCIPAL INVESTIGATOR

J. A. Fay

OBJECTIVES

The objectives of this study are to review existing analytical and experimental information on the properties of LNG spills on water and land (vapor generation, dispersion, and fire), and to compare predicted or extrapolated characteristics for very large spill sizes. Significant discrepancies will be discussed and an assessment made of the possibility of resolving disagreements with the limited measurements which might become available from a few large tests. An analytical framework will be developed for deciding what measurements should be made to answer certain key questions.

APPROACH

The volume of spilled LNG is considered the major variable defining the size of a spill. The description of the complete history of an unignited spill is a necessary prelude to understanding the full range of possible fire hazards. Other physical properties (e.g., thermal or mechanical properties of soil or water, storage vessel shape, wind speed, atmospheric stability) are considered parameters which affect the extent of the hazard but which need not necessarily be taken into account explicitly in determining the effects of scale.

PROGRESS AND RESULTS

Preliminary results for unconfined water spills, unconfined land spills, and confined land spills show that thermal radiation intensity and vapor concentration vary nearly in proportion to the spill volume, but that the time scale on which the spill events proceed increases only slightly with spill size. A striking result of the analysis is that many of the effects or observable quantities vary as a small fractional power of the spill volume (e.g., evaporation time, fireball burnup time, critical wind speed for plume formation). A special note should be made of the effect of wind speed on the nature of the cloud dispersion process. The distinction between low and high wind speed, as it affects plume shape or mixing, is practically independent of spill size. Thus, field tests of spills should be carried out for a range of wind speeds and atmospheric stabilities independent of

spill size. Extrapolation can then be made for fixed meteorological states.

PLANS FOR NEXT PERIOD

None

REPORTS PUBLISHED

A preliminary report is included as Appendix F, in "An Approach to Liquefied Natural Gas (LNG) Safety and Environmental Control Research," DOE/EV-0002.

PROJECTED MILESTONES

None

* * *

INTEGRATED LNG SAFETY AND CONTROL PROGRAM

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATORS

R. J. Hall
M. G. Patrick

OBJECTIVES

The overall objective of this task is to assist the Environmental Control Technology (ECT) Division in the development and implementation of a comprehensive integrated program of RD&D in liquefied natural gas (LNG) safety and control.

The specific objectives are to verify predictive capabilities and verify control methods. The development and validation of the analytical models is necessary to adequately describe, from a safety and environmental control viewpoint, the behavior of LNG systems and the possible effects of LNG releases to the environment. The investigation and validation of the effects of release prevention and control methods is necessary in order to study the likelihood, type, and magnitude of environmental consequence from LNG release.

APPROACH

The approach taken in this program was to identify any unresolved questions of LNG safety control using input from a broad collection of sources, to determine the information required to develop the answers, to formulate a plan to provide the needed information, and to initiate the required work. The following needs and constraints were

considered in preparation of the plan: (1) prevention, understanding of effects, and control of undesirable effects are all important factors in safety; (2) both public safety and operational safety are important; (3) a current acute need exists for the information; (4) an integrated approach is necessary to achieve the maximum meaningful results in the minimum time; and (5) resources are limited (e.g., funds, facilities, qualified personnel, supply of LNG for experiments).

PROGRESS AND RESULTS

In December 1976, assistance was provided to ECT in the planning and conduct of a workshop on LNG safety and control. The participants selected represented a cross section from regulatory agencies, industry, research organizations, and other individuals familiar with the current status, technology, and issues in the LNG safety and control area. A summary of the workshop recommendations were a major input to the identification of unresolved LNG safety and control questions.

The state-of-the-art of LNG safety and control research was reviewed in order to define a starting point for the RD&D program. A program plan was assembled with the purpose of developing, in a timely manner, additional pertinent LNG safety and control information for use by industry, regulatory agencies, and the general public.

Activities in six technical elements were identified as necessary to achieve these objectives: Vapor Generation and Dispersion, Fire and Radiation Hazards, Flame Propagation, Release Prevention and Control, Instrumentation and Technique Development, and Scale Effects Experiments. A method for implementation of the program has also been developed.

PLANS FOR NEXT PERIOD

Begin implementation of selected portions of the program plan.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

End of FY 1978 -- PNL Interim Report

* * *

LNG SPILL TESTS

ORGANIZATION AND CONTRACT NUMBER

U.S. Naval Weapons Center
Interagency Agreement

PRINCIPAL INVESTIGATOR

C. D. Lind

OBJECTIVES

The objective of this program is to provide background analyses and planning assistance for conducting field tests of LNG spills to determine the hazard extent of vapor clouds, pool fires, and vapor cloud fires resulting from release of LNG on both land and water.

APPROACH

The approach employed is to utilize existing or improved mathematical models to design the experiments, estimate data needs, predict experimental results (e.g., extent of vapor cloud travel). Appropriate field experiments have been performed and analyzed results compared with mathematical model prediction(s). Characteristics of flame propagation have been identified to aid in determining if deflagration or detonation occurs.

PROGRESS AND RESULTS

Initial planning and site selection activities for the test program have begun. Conceptual design studies for the experiments have been initiated.

PLANS FOR NEXT PERIOD

During the next period, we will determine final site location, complete conceptual design, complete final design, continue background analyses, and begin test facility preparation.

REPORTS PUBLISHED

None

PROJECT MILESTONES

- May 1978 -- Begin preparation of test facility
- June 1979 -- Conduct medium-scale LNG tests

* * *

ATMOSPHERIC METHANE DETECTION

ORGANIZATION AND CONTRACT NUMBER

Department of Mechanical Engineering
Massachusetts Institute of Technology
800221

PRINCIPAL INVESTIGATOR

C. F. Dewey

OBJECTIVES

The objective of this study is to assess three different measurement concepts for an inexpensive, accurate, reliable, and rapidly responding instrument for measuring the atmospheric concentration of methane. For each of the concepts, quantitative data will be obtained on the response times, accuracy, and concentration ranges over which the technique is useful. Emphasis will be placed on conditions representative of those which would be encountered in field tests of the dispersion of vapors from LNG spills.

APPROACH

The approach has involved building breadboard models of several feasible systems and measuring the response parameters as they are affected by various factors in the laboratory so that credible extrapolations may be made for field use.

PROGRESS AND RESULTS

Concept development and preliminary layout sketches of designs have been completed. The assembly of these designs for breadboard models has been initiated.

PLANS FOR NEXT PERIOD

Laboratory and field tests will be conducted and designs will be modified, as required, based on the test results.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- March 1978 -- Begin simulated field tests
- June 1978 -- Final report

* * *

DESIGN FOR MEDIUM-SCALE LNG SPILL TESTS

ORGANIZATION AND CONTRACT NUMBER

Holmes and Narver, Inc.
EY-76-C-08-0020

PRINCIPAL INVESTIGATOR

W. H. Jones

OBJECTIVES

The objective of this study is to evaluate feasibility and cost analyses related to the siting of future work associated with the LNG Spill Test Program.

APPROACH

The contractor is using criteria provided by ERDA, test experience gathered from the U.S. Naval Weapons Center during "small spill test" programs, commercial equipment that exhibits the latest state of the art, and unique equipment located at the Nevada Test Site in the development of facility designs, estimating costs, and construction completion schedules.

PROGRESS AND RESULTS

All work will be complete by October 30, 1977. A final report consisting of design drawings, operational concepts, cost, and schedule estimates will be presented in November 1977.

PLANS FOR NEXT PERIOD

Follow-on work has not yet been committed; it will be dependent on acceptability of FY 1977 effort.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- October 30, 1977 -- Field work completed
- November 30, 1977 -- Final Report

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ASSESSMENT OF HAZARDS AND CONTROL OF LNG ON WATER

ORGANIZATION AND CONTRACT NUMBER

U.S. Coast Guard
Office of Research and Development
Interagency Agreement

PRINCIPAL INVESTIGATOR

M. W. Taylor

OBJECTIVES

The objectives of this study are to determine the extent of hazard of 5.7-m³ LNG released on water and to perform experimental releases of LNG at various discharge rates to determine characteristics of vapor clouds, pool fires, and vapor cloud fires.

APPROACH

The approach has involved several tasks. Existing mathematical models were used to design the experiments and estimate data needs. Experimental results (e.g., extent of vapor cloud travel) were

predicted; appropriate field experiments were performed; and analyzed results were compared with mathematical model predictions. Characteristics of flame propagation were determined as well as the occurrence of deflagration or detonation.

PROGRESS AND RESULTS

The pool fire experiments were completed in November 1976. Vapor cloud and vapor cloud fire experiments were completed in June 1977.

PLANS FOR NEXT PERIOD

We will continue cooperative effort in conjunction with the integrated LNG safety and environmental control program.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- October 1977 -- Final report, Phase II
- December 1977 -- Final report, Phase III

* * *

LNG SCALE EFFECTS EXPERIMENTS

ORGANIZATION AND CONTRACT NUMBER

Lawrence Livermore Laboratory
W-7405-ENG-48

PRINCIPAL INVESTIGATOR

W. J. Hogan

OBJECTIVES

The overall objective involves considering such factors as safety, supply of LNG, humidity, terrain grade, and meteorological conditions to develop criteria for a site at which to conduct LNG scale effects experiments. Characteristics of promising experiments are to be prepared. Appropriate analytical and background studies will be conducted and an experimental facility will be designed. In addition, we have instituted plans to prepare test site, conduct tests, analyze data, and prepare final report.

APPROACH

The approach taken focuses on extensive assessment of current capability to predict the characteristics of LNG hazards by collecting and conducting an in-depth evaluation of existing applicable experimental information and mathematical models. Results of this assessment will be used to determine the criteria of a site suitable for the LNG field tests.

PROGRESS AND RESULTS

To date we have completed internal review of Integrated Safety and Environmental Control Program Plan and the preliminary development of test site criteria. We have begun preliminary evaluation of characteristics of potential test sites.

PLANS FOR NEXT PERIOD

Plans for the coming period involve completing development of test site criteria, completing evaluation of potential test sites, and preparing a recommendation for selection of testings site. In addition, we will begin appropriate background studies and analyses for preparation of test program.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- February 1978 -- Complete development of test site criteria
- February 1978 -- Complete evaluation of potential test sites
- April 1978 -- Recommendation for selection of test site

* * *

PRELIMINARY ASSESSMENT OF SITE CRITERIA FOR LNG

ORGANIZATION AND CONTRACT NUMBER

R & D Associates
EE-77-C-03-1364

PRINCIPAL INVESTIGATOR

H. J. Carpenter

OBJECTIVES

The objectives are to compile and assess pertinent existing data about LNG fires; to review thoroughly the capabilities, deficiencies, characteristics, and costs of various devices used to measure pertinent parameters of LNG tests (e.g., liquid depth, gas concentration, temperature, radiation); to prepare a list of criteria for use in selecting sites of future LNG experiments; to assess the usefulness of wind tunnel modeling studies in evaluating the effects on vapor dispersion of facility-control measures and terrain.

APPROACH

The approach used to obtain objectives is to survey available records and current research to obtain data, then to draw on expertise within R&D Associates for analysis and assessment.

PROGRESS AND RESULTS

A significant data base exists only for pool fires on confined land areas; some data are becoming available on pool fires on water. Radiosity is dependent upon vertical position within the flame. Desirable properties of a test site, in addition to nearness of LNG supply, are a relatively level area where both land and water spills can be studied and a range of wind speeds, temperatures, and humidity can be determined. Wind tunnel modeling of gravitational effects of LNG clouds is well established as an economical and convenient technique (see Figures 21 and 22).

A major limitation to existing meteorological wind tunnels is the smallness of the working areas. Wind tunnels can be useful in planning instrumentation layouts. Flow visualization tests show that simulated LNG vapor can flow significant distances upwind down a 2-percent slope; in the presence of a slope, the vapor cloud structure shows large variability. No available methane concentration sensors have the required time resolution and insensitivity to atmospheric water vapor, water droplets, and dust needed for field tests. A dual-film aspirated probe appears likely to satisfy technical test requirements. Infrared analyzers, Raman scattering devices, and thermocouples all show promise as concentration sensors, but require further investigation to define their capabilities and costs. No adequate testing apparatus suitable for establishing the dynamic response of sensors in an LNG vapor environment are known to exist.

PLANS FOR NEXT PERIOD

None

REPORTS PUBLISHED

Final report August 1977.

PROJECTED MILESTONES

- January 1977 -- Project began
- April 1977 -- Draft final report
- August 1977 -- Final report

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Figures 21 and 22. Study in Wind Tunnel of Plume Dispersion for a Simulated LNG Spill from a Storage Tank Surrounded by a Close High Dike. The model is about 6 inches in diameter (1/400th real size). The Simulated Wind Speed is about 16 mph and the Boil-Off Rate is about $2.5 \text{ m}^3/\text{sec}$.

BOILING OF LIQUEFIED PETROLEUM GAS ON WATER

ORGANIZATION AND CONTRACT NUMBER

Department of Chemical Engineering
Massachusetts Institute of Technology
800225

PRINCIPAL INVESTIGATOR

R. C. Reid

OBJECTIVES

The objectives of this project are to (1) measure boiling rates of liquefied petroleum gas on water; (2) measure vapor fractionation occurring, and (3) compare with theory.

APPROACH

The approach used is to conduct laboratory-scale experiments, develop analytical models and compare with present theory.

PROGRESS AND RESULTS

This project was initiated in September 1977. The research team has been assembled at this time.

PLANS FOR NEXT PERIOD

Continue experimental program.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- August 1978 -- Conduct program and LPG Spill Tests
- September 1979 -- Final Report

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IDENTIFICATION OF REFRACTORY ORGANIC COMPOUNDS IN TREATED REFINERY WASTEWATERS

ORGANIZATION AND CONTRACT NUMBER

Argonne National Laboratory
W-31-109-ENG-38

PRINCIPAL INVESTIGATOR

Dr. L. A. Raphaelian

OBJECTIVES

The objectives are to determine (at four oil refineries presently using activated sludge for wastewater treatment): (1) the effectiveness of their present wastewater treatment; (2) the usefulness of a secondary treatment consisting of activated carbon as outlined in EPA's "Refining Guidelines Document," the standard for 1983 "Best Available Treatment Economically Achievable (BATEA)."

APPROACH

The approach used is gas chromatography/mass spectrometry. Each specific organic and its concentration will be determined at the following sampling points: (1) the influent of the activated sludge treatment plant, (2) the effluent of the activated sludge treatment plant, and (3) the effluent of the activated carbon treatment.

PROGRESS AND RESULTS

It is expected that many of the organics present in the influent to the activated sludge treatment will be broken down and missing from the effluent and certain new organics will have been produced. Many of the organics in the effluent of the activated sludge will be eliminated by the activated carbon filter. From the data generated, the effectiveness of activated sludge and activated sludge/activated carbon wastewater treatment can be evaluated.

PLANS FOR NEXT PERIOD

Continue sampling and analyzing data; schedule will slip somewhat due to also looking at organics on "consent decree" list.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Analysis is continuing; sampling and analysis to continue until June 1978.

- September 1978 -- Final Report

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ASSESSMENT OF ENVIRONMENTAL CONTROL ASPECTS OF TREATMENT OF ENHANCED OIL RECOVERY WASTEWATER CLEANUP

ORGANIZATION AND CONTRACT NUMBER

Department of Chemical Engineering
University of Tulsa
80029

PRINCIPAL INVESTIGATOR

R. Thompson

OBJECTIVES

The objective is to assess the efficiency and practicability of membrane processes for treatment

of wastewaters produced by tertiary oil recovery techniques.

APPROACH

The objective will be met in part by an experimental study to determine the effectiveness of the membrane ultrafiltration process in the concentration and removal of sulfonates and crude oil from wastewaters produced by the micellar flooding technique. By experimentally defining the conditions under which stable and characteristic wastewater samples can be prepared for membrane process evaluation, and by developing the effects upon filtrate flux of process variables, information will become available that will permit operating and capital costs for full sized units to be estimated.

PROGRESS AND RESULTS

This project was started in September 1977; therefore, there is no progress to report.

PLANS FOR NEXT YEAR

Study solute rejection and membrane fouling as a function of composition and operating parameters.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

September 1978 -- First annual report

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OIL SHALE

The recent trend in oil shale processing RD&D is away from surface retorting and toward in situ or modified in situ retorting. Environmental Engineering Program studies to date have suggested that wastewater control and management for in situ processing is more demanding than for surface retorting. In 1977, the Division of Environmental Control Technology (ECT) initiated a laboratory study designed to screen the technological feasibility and economics associated with in situ oil shale wastewater control and management. Uncertainties to be

examined include control of particulates from surface retorts, management of spent shale, groundwater and aquifer contamination, and land subsidence and gaseous emissions from retorting operations. Site specificity is emphasized, because environmental control needs are intimately related to the nonuniform nature of oil shale deposits and the surrounding environment. Where possible, collaborative studies will be promoted with the primary energy developers within DOE to ensure that site-specific issues can be addressed.

ASSESSMENT OF ENVIRONMENTAL CONTROL FOR WASTEWATERS IN IN SITU OIL SHALE RETORTING

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATORS

G. W. Dawson
B. W. Mercer

OBJECTIVES

Commercial development of the enormous energy resources of domestic oil shale is a vital part of the National plan for energy self-sufficiency. Several different shale oil extraction methods have been piloted and demonstrated, and additional methods are under investigation. This study is designed to assess the capabilities of current technology for treatment and disposal of shale oil development related wastewaters in an environmentally acceptable fashion. Experimental studies will be conducted to evaluate current treatment technology on actual retort water produced by ongoing pilot and demonstration operations for shale oil recovery.

APPROACH

A comprehensive review of the literature disclosed that shale oil retort water, the principal wastewater generated by the pyrolysis recovery process, is heavily polluted with both organic and inorganic constituents and is produced in approximately the same volume as that of oil recovered in in situ operations. Further, in situ recovery methods produce an excess of this wastewater which cannot be used for moisturizing and compacting spent shale as is the case for above-ground retorts. Shale oil retort water differs substantially from other industrial wastewaters but is similar in some respects to wastewaters generated by petroleum refineries and coal conversion and coking plants. Shale oil retort water is generally much higher in dissolved organics than these wastes and tends to have a greater aliphatic/aromatic ratio than coal-derived wastewaters.

The processes selected for bench scale experimental studies are essentially patterned after those used to treat petroleum refinery wastewater. The first steps in the processing sequence involve removal of suspended solids, oils, and greases by gravity sedimentation and dissolved air flotation. These steps are followed by steam stripping to reduce the high ammonia content and remove hydrogen sulfide. The waste stream is then treated biologically to remove degradable organics and is clarified by chemical coagulation and filtration prior to removal of refractory organics by activated carbon sorption. A demineralization step, such as reverse osmosis, may

also be included to remove excessive dissolved mineral matter.

Initial bench scale studies on biological and activated carbon treatment will be conducted continuously at flow rates of 1 to 3 gallons per day. The remaining processes will be investigated at flow rates to 20 gallons per day on an intermittent basis. Larger scale studies are planned as greater volumes of retort water become available. The biological treatment studies involve anaerobic digestion, trickling filters, and activated sludge.

Additional studies are also being performed on treatment of mine water for sodium bicarbonate recovery and fluoride removal. Disposal options undergoing investigation include land disposal and deep well injection.

PROGRESS AND RESULTS

The performance of a bench-scale trickling filter in combination with an activated sludge unit was evaluated with simulated retort water containing a high proportion of readily degradable organic matter (acetic and octanoic acids). These units operated quite effectively together in removing 95 percent of the organic carbon from the simulated retort water; however, the trickling filter removed between 10 and 50 percent. Although high organic removal was attained by biological treatment alone on the simulated waste, this may not be sufficient to meet discharge criteria because of the unusually high concentrations of organics in retort water. Supplementary treatment such as activated carbon sorption is expected to be required to achieve environmentally acceptable organic residuals for discharge to surface receiving streams.

Ammonia removal studies were initiated with a steam stripping column 2 inches in diameter packed to a depth of 36 inches with 1/4-inch saddles. A 5-gallon sample of retort water from the 6000-kg simulated in situ retort at the Lawrence Livermore Laboratory was fed to the top of the stripping column and countercurrently contacted with steam at a ratio of 1.5 pound of steam to 1 gallon of wastewater. The overheads (condensate) from the stripping column were recycled continuously to the feed in order to generate a gaseous ammonia stream and keep volatile organics in the aqueous liquid stream. Preliminary results indicate 99-percent removal of ammonia without addition of caustic. This removal is sufficient to reduce the ammonia below toxicity levels for biological treatment.

Studies on land treatment and disposal of retort water have been completed, and it was concluded that wastewater characteristics and climate are not generally favorable for this disposal method in the oil shale regions of Colorado, Utah, and Wyoming. The high concentrations of dissolved salts typically found in retort water are deleterious to vegetation growth and the quality of groundwater beneath a disposal site. The long winters in these regions would require large basins to store the wastewater during freezing weather when land disposal is not possible.

PLANS FOR NEXT PERIOD

Quantitative levels for pollutant removal will be established for surface and subsurface wastewater discharges. These will reflect current EPA standards and probable future limitations on oil shale facilities. Bench-scale studies will continue to evaluate the treatability of several representative retort waters because the quality of these vary considerably under different operating conditions. Studies on fluoride removal will be conducted when groundwater samples from the Debeque area of Colorado become available.

REPORTS PUBLISHED

Interim Report on Phase I, literature review.

PROJECTED MILESTONES

A draft report on land disposal and deep well injection of shale oil wastewaters is scheduled for completion by December 1977. Results of initial bench scale treatability studies will be presented in an interim report scheduled for April 1, 1978. Results of studies of a sodium bicarbonate removal process for alkaline mine waters will be documented in a topical report scheduled for February 1, 1978.

* * *

ENVIRONMENTAL CONTROL IMPLICATIONS OF OIL SHALE DEVELOPMENT ON WATER QUALITY

ORGANIZATION AND CONTRACT NUMBER

Denver Research Institute
Interagency-supported program ERDA, EPA,
FEA and NSF (RANN) with NSF (RANN) acting
as the granting agency
Grant No.: NSF (RANN) No. ENV-75-00175-A01

PRINCIPAL INVESTIGATOR

J. J. Schmidt-Collerus

OBJECTIVES

General Objectives

These general objectives apply to both above-ground oil shale retorting and in situ type retorting.

- Determination of the amount and kind of organic components in both the carbonaceous spent shale and the process water from retorting operations.
- Isolation and identification of the structure and composition of those compounds that are of known or suspected blastogenic activity.

- Investigation of the changes that compounds may undergo in large storage sites and of the impact of these changes on environmental quality including solubilization and leaching by ground and runoff water, volatilization or potential air pollutants, identification of POM present in airborne carbonaceous particulate matter from oil shale processing operations, and effect of possible auto-oxidation on volatilization or organic compounds from the waste and their transfer into air.
- Translocation of trace organic compounds from the carbonaceous residue to aquatic-life higher plants, german to the environment, are planned to be used for revegetation.

Specific Objectives

Specific objectives of some part of DOE's interest are concerned with in situ (more concisely modified in situ) type retorting.

- Isolation, separation, and analytical characterization of classes of organic and/or organometallic compounds and individual components. Some of these compounds have already been identified; however, a large number, still need to be isolated and identified.
- Observation of reactions and interactions of these components and their mixtures with the constituents of their matrix source during weathering. Oxidation of BaP to the corresponding diones have already been established; however, other components are still under investigation.
- Assessment of potential interaction of the original and possible intermediate and end products of these potential contaminants. Thus, orthodiones may easily form complexes with a variety of trace elements which can thus be mobilized since the diones are usually water soluble.
- Investigation of the influence of organic matter on salt movement, chemistry, and soil mechanics in the spent shale deposits (surface and underground).
- Formulation of recommendations for minimization of potentially harmful impact and/or physical changes in spent shale storage regions on environmental quality.
- Determination of possible modes of transport and fate of the trace organic matter leached from shale residue in surface storage and in situ process regions.

APPROACH

The approach to the problem was carried out in several phases.

Phase I included the sampling of soil, plant, water (runoff and groundwater) and air (particulate) material and the analysis for the presence of organic load, leaching, and potentially active trace organic material.

Phase II involved investigating solid liquid and particulate waste material from various above-ground retorting processes (e.g., TOSCO, Paraho, Union Oil, Superior Oil) for total organic load leachable material (in particular organic trace compounds) and their possible interaction with the environment.

The measurement of effluents and residues of an operating semiworks plants (Paraho) and the evaluation of possibilities for control of these effluents will take place during Phase III.

Phase IV will include studies of the potential type and loci of emissions and effluents of modified in situ processes and design of a comprehensive and logical strategy for experimental investigations.

Phase V consists of the design of a strategy of controls for various modified in situ oil shale operations to minimize potential environmental and health hazards.

PROGRESS AND RESULTS

To date most of the objectives of Phases I through IV have been investigated, and the results will be published in the 2nd and 3rd Annual Reports. The main findings can be summarized as follows.

- Using the pristine environmental data as a basis, the organic load from above-ground disposal of carbonaceous spent shale can reach (depending on the type of retort) values up to two orders of magnitude higher than the original pristine area.
- Short-term leaching can be strongly reduced by compaction and confinement. Long-term leaching is still a potential both for inorganic salts and organic trace elements into runoff water and groundwater.
- Particulate emissions can be minimized by wetting and compaction but not eliminated.
- Bad organic actors of the POM type in the carbonaceous spent shale can be (again depending on the type of retorting process) up to 5-fold higher in concentration than the pristine background.
- Translocation of organic material into aquatic biota and higher plants and bioamplification is possible.

- Autooxidation of large stockpiles of unretorted shale and carbonaceous retorted shale is a realistic possibility. Leaching of salts and some organic acids from stockpiled unretorted oil shale is realistic and is proportional to the particle size of the crushed shale.
- Similar considerations may apply to in situ operations. However, this aspect of the program (Phase IV) is being initiated at the present time for more intensive study.

PLANS FOR NEXT PERIOD

The plans for the next period call for completion of Phase IV (i.e., establishment of a strategy for the experimental measurement of effluents from the modified in situ processes under consideration and/or in pilot plant operations). As a follow up and based on the results of Phase IV, an experimental monitoring program shall be set up and measurements made on available sites. Based on these results, Phase V (i.e., the planning and development of control methods) can be established and policies established.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- September 1978 -- Second and Third Annual Reports
- Completion of Phase IV -- Final Report
- Initiation of Phase IV follow-up program, (a separate DOE program) -- Quarterly Reports
- Completion of Phase V (the extended DOE program) -- Final Report

* * *

ANALYSIS OF THE ENVIRONMENTAL CONTROL FOR OIL SHALE DEVELOPMENT

ORGANIZATION AND CONTRACT NUMBER

University of Utah
EY-76-S-02-4043 Mod M001

PRINCIPAL INVESTIGATORS

N. N. de Nevers
D. W. Eckhoff
B. Glenne
S. R. Swanson
F. Wagner

OBJECTIVES

The objective is to analyze the environmental control technology envisaged in the Detailed Development Plans for three oil shale tracts in the Federal Prototype Leasing Program and all other active oil shale projects. From an integrated analysis of all the control technology, we hope to learn which parts of the environmental plans are based on certain knowledge, and which are based on extrapolations. The areas where further analysis and/or laboratory work are needed will be sought and programs suggested for developing the needed knowledge.

APPROACH

By a thorough review and analysis of the available literature and test calculations and discussions among the principal investigators, we will seek to find the areas of greatest need for further work.

PROGRESS AND RESULTS

A detailed rough draft of the final report was submitted as a progress report in the fall of 1976.

This was reviewed by ERDA and the comments returned to the principal investigators. The final report is near completion, taking into account the comments received by the reviewers on the earlier report.

PLANS FOR NEXT PERIOD

A renewal request has been submitted for FY 1978. During this period, we propose to conduct a similar investigation on tar sand development and to revise and update the oil shale report as dictated by future changes in the oil shale industry and by the comments received upon our final report.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

September 30, 1977 -- Final Report submitted to DOE

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SOLAR, GEOTHERMAL, AND ENERGY CONSERVATION

Environmental control assessment activities for solar energy, geothermal energy, and energy conservation continue to have an important place in the Environmental Engineering Program.

In FY 1977, a high priority was placed on assessing environmental problems associated with materials used in Solar Heating and Cooling (SHAC). With the objective of developing a document describing the flammability, toxicity, and environmental impacts of various materials utilized in solar heating and cooling. The intent of this document will be to assist both DOE in evaluating SHAC designs submitted for Government support and homeowners in selecting suitable materials for particular applications. Another high priority activity is the assessment of environmental controls needed for the "inexhaustible" energy resource of biomass. In FY 1977, a preliminary survey identifying control needs for the biomass options (bioconversion, bio-production, and agricultural waste utilization) was initiated.

Geothermal energy, although not uniformly available throughout the United States, can represent a significant energy resource for specific regions. The major objective of the Environmental Engineering Geothermal Program is to identify potential gaps in

environmental control capabilities and to foster the timely development of control options through joint programs with the DOE Division of Geothermal Energy. Studies are being conducted on state-of-the-art liquid waste control systems and gaseous cleanup systems. The efficacy and practicability of environmental controls used in the Imperial Valley Geothermal Project are also being evaluated.

Additionally, Environmental Engineering will perform independent assessments of environmental controls identified within the Geothermal Loan Guaranty Program to help ensure prevention of default because of violations of environmental regulations.

In keeping with the National Energy Plan (NEP), evaluation of near- to mid-term energy conservation options has been initiated. Accomplishments to date include (a) an evaluation of 14,000 pages of testimony submitted for licensing a New York State high voltage transmission line as an initial assessment of environmental controls for this and similarly planned lines, (b) the demonstration of the feasibility of an active noise abatement system for transformers, and (c) the compilation of environmental regulations for siting high voltage transmission lines.

ENVIRONMENTAL AND FIRE HAZARDS OF MATERIALS USED FOR SOLAR HEATING AND COOLING

ORGANIZATION AND CONTRACT NUMBER

Sandia Laboratories
E(29-1)-789

PRINCIPAL INVESTIGATOR:

J. Q. Searcy

OBJECTIVES

The primary objective of this project is to compile a list of Solar Heating and Cooling (SHAC) materials (e.g., working fluids, storage media, insulations) and to examine them from the viewpoints of toxicity, fire safety, economics, and physical properties. This list is to be suitable for distribution to the public so that the homeowner may use it as a guide for selecting, using, and disposition of SHAC materials. This list can also be used by DOE in evaluating proposed SHAC designs in response to Government-sponsored grants.

APPROACH

The general approach for this project will be to use a literature search and manufacturer's survey or, as a last resort, to perform a preliminary chemical analysis to determine the composition of the working fluids, storage media, and solid materials. This project will be performed in two phases. Phase I involves the preparation of a document listing the materials and properties based upon a minimum of analysis and will include, for comparative purposes, commonly used household materials with similar properties. For Phase II, those materials not immediately found to be of minimal environmental consequences and requiring further detailed analysis will be investigated.

PROGRESS AND RESULTS

During the past 4 months, lists of heat transfer fluids, storage media, insulations, seal and sealant materials, and other solid materials used in solar heating and cooling systems have been compiled. The materials on the lists are identified generically; specific, commercially available examples are also given. Data, such as maximum recommended operating temperatures and other physical and chemical properties for generic types of solid material, were specified.

Chemical analyses of specific heat transfer fluids were performed to aid in the identification of additives and possible toxic materials. Commercially available examples of urethane, isocyanurate, polystyrene and fiberglass insulations were examined in the temperature range of 93° to 204°C (200° to 400°F) for their outgassing properties. Similar analyses are now in progress for the different rubbers used as sealants and seals.

A survey of existing building codes and guidelines directed at solar installations was made. The two most complete sets of guidelines are the National Bureau of Standards' "Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings" and the U.S. Department of Housing and Urban Development's "Intermediate Minimum Property Standards Supplement - Solar Heating and Domestic Hot Water Systems." For completeness, the guidelines for insuring buildings with foam insulations were obtained from a major insurance company.

PLANS FOR NEXT PERIOD

The data compiled in FY 1977 will be presented in a written report to DOE for issuance to the general public. The language used in the report will be understandable to the average homeowner and permit him to select materials for his particular applications. Those materials for which insufficient composition and toxicity data are available will be studied further by appropriate experimental means, to be done by others.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- February 1, 1978 -- Initiation of Phase II: More detailed investigation of hazardous and potentially troublesome SHAC materials.
- February 15, 1978 -- Submission of draft report on Phase I for DOE review.
- March 31, 1978 -- Phase I report published for general distribution.

* * *

ASSESSMENT OF ENVIRONMENTAL CONTROLS FOR ENERGY PRODUCTION FACILITIES USING SOLAR-DERIVED FUELS

ORGANIZATION AND CONTRACT NUMBER

Ames Laboratory
W-7405-ENG-82

PRINCIPAL INVESTIGATOR

T. A. Austin

OBJECTIVES

The general objectives of this project are to perform independent assessments of the environmental controls needed for biomass options (bioconversion, bioproduction, and agricultural waste utilization) and to identify and foster development of novel solutions to environmental control problems.

APPROACH

The general approach for this project will be first to perform a preliminary assessment of all controls and then to undertake more detailed assessment work which is in concert with and will complement activities sponsored by other environmental groups. This project will be performed in three phases. For Phase I, an extensive literature review of the state-of-the-art of biomass conversion processes and required controls will be undertaken. For Phase II, actual data, necessary to evaluate the efficacy and practicability of currently available environmental control techniques will be collected where justified. For Phase III, laboratory and field evaluation studies on novel environmental control technologies will be performed.

PROGRESS AND RESULTS

This project began in June 1977. No specific achievement of objectives can be reported at this time.

PLANS FOR NEXT PERIOD

In FY 1978, Phase II will be undertaken to collect data necessary to evaluate the effectiveness of currently available environmental control technologies. Existing data will be supplemented where information necessary for evaluation of control processes do not exist; all activities will be coordinated with other parts of DOE and with EPA.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- October 30, 1977 -- Complete state-of-the-art literature review
- October 30, 1978 -- Complete environmental control technology data collection

* * *

IMPERIAL VALLEY ENVIRONMENTAL PROGRAM: ASSESSMENT OF ENVIRONMENTAL CONTROL TECHNOLOGIES

ORGANIZATION AND CONTRACT NUMBER

Lawrence Livermore Laboratory
W-7405-Eng-48

PRINCIPAL INVESTIGATOR

D.F. Snoeberger

OBJECTIVES

The objectives of this project are to identify and describe the environmental control technologies used in the Imperial Valley Environmental Program (IVEP) for Government supported facilities (electric and nonelectric) for utilization of geothermal resources, to assess these control measures with respect to their intended use, and to evaluate their operational performance for verification of performance criteria.

APPROACH

Geothermal energy is an important new energy source. Conversion technology is being developed for the hydrothermal resources of the Imperial Valley, California, and significant progress is being made toward commercial utilization. Equally important control technologies are being developed and applications planned for mitigation of environmental impacts from this and other resource utilization. The problems of greatest concern are hydrogen sulfide abatement, liquid waste control, and management of induced land subsidence and seismicity.

The environmental control technologies are identified from the IVEP studies, project planning activities for the Imperial Valley, appraisals of available control technology, developments at other geothermal sites, and R&D program results. Descriptions are drawn from these sources and from visits to test and operational facilities.

Assessments are based primarily on state-of-the-art appraisals, demonstrated merits in development testing, and the experience accumulating with control systems in the field. Operational assessments will draw on results of operational surveillance (monitoring) and operators' appraisals.

Emphasis is placed on access to expertise through consulting arrangements and on development of good working relationships with R&D organizations, developers, utility companies, well field operators, regulators, and planners.

PROGRESS AND RESULTS

Tentative identification of environmental control technologies for the Imperial Valley has been made. A description of these technologies is underway. Information has been assembled to initiate assessment.

PLANS FOR NEXT PERIOD

In FY 1978, identification and assessment effort will be completed on environmental control technologies useful in the near term in the Imperial Valley. Work will begin on assessment of operational performance of these control measures for verification of performance criteria.

Extension of assessment activities to other geothermal resource areas is expected.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- February 28, 1978 -- Interim report describing environmental control technologies for the Imperial Valley
- June 30, 1978 -- Final report assessing these control measures.

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GEOTHERMAL LOAN GUARANTY PROGRAM: ASSESSMENT OF ENVIRONMENTAL CONTROLS

ORGANIZATION AND CONTRACT NUMBER

Lawrence Livermore Laboratory
W-7405-Eng-48

PRINCIPAL INVESTIGATOR

D. F. Snoeberger

OBJECTIVES

The primary objectives of this project are to review Geothermal Loan Guaranty Program (GLGP) environmental analyses, to identify environmental control technologies, and to independently assess their efficacy and practicability. A secondary objective is to review environmental reports and monitor data on operating control systems in order to expand the knowledge of environmental control technologies.

APPROACH

A Federal geothermal loan guaranty program was established by PL 93-410, Geothermal Energy Research, Development, and Demonstration Act of 1974. The Division of Environmental Control Technology has responsibility for independently ensuring the adequacy of environmental controls identified as part of EIA and EIS and used by the applicants in order to help prevent default in the event of noncompliance with environmental regulations. To discharge this responsibility, liaison is maintained with the Loan Guaranty Program Office and the Environmental and Safety Division of the DOE San Francisco Operations Office. Knowledge of relevant Federal and local laws and regulations and environmental quality standards is developed by site as the need arises. Also, information relevant to assessment of environmental control systems or measures is drawn largely from the related project "IVEP: Assessment of Environmental Control Technologies." On-demand reviews and assessments are made as required.

PROGRESS AND RESULTS

Cursory reviews have been made of the loan program applications submitted in FY 1977 through August. These are summarized in Table 7.

The principal activity this year was the review of the following environmental impact assessments for three loan guaranty applications.

- The East Mesa Development Project, Imperial Valley, California, on Federal land, Republic Geothermal, Inc. "Environmental Analysis" (USGS EA #67), December 15, 1976, and "Supplement to the Environmental Analysis #67," May 1977.
- Food Dehydration, Brady's Hot Springs, Churchill County, Nevada, on private land, Geothermal Food Processors, Inc.; "Environmental Impact Assessment for Geothermal Food Processors Inc. Application for Geothermal Loan Guaranty," June 1977.
- The CU 1 Venture, South Brawley, Imperial Valley, California, and Beryl and Lund, Utah, on private land, McCulloch Geothermal Corp.; "Draft Environmental Impact Assessment for CU 1 Venture Application for Geothermal Loan Guaranty," June 1977, and "Draft Environmental Impact Assessment for CU 1 Venture Application for Geothermal Loan Guaranty (Beryl and Lund, Utah)."

An annual report on these activities is being prepared.

PLANS FOR NEXT PERIOD

This effort will continue during FY 1978 as applications are submitted and approval considerations require. The level of effort is expected to increase slightly.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- March 31, 1978 -- Annual report for FY 1978.

* * *

Table 7. Applications List FY 1977

Approval Goal or Status	Applicant	Project/Location	Goal	Loan \$ millions
Hold (added preliminary exploratory drilling)	Dry Creek Exploration, Inc., (Subsidiary of Geothermal Resources International)	Dry Creek Prospect: Explore, evaluate and develop field/ Lake County (Geysers), California	165 MWe	7.5 (Bank of America)
Hold	Geothermal California Partners	Honey Lake: Elec. and Non-elec. (agri./aqua.) Explore and evaluate field/ Honey Lake, Lassen County, California	55 MWe	2.3 (Bank of Montreal)
Approved, but EIS requirement added	Republic Geothermal, Inc.	E. Mesa Development Project: Evaluate and develop field/ E. Mesa, Imperial Valley, California	48 MWe	10.0 (Bank of America)
Hold (separate applications)	McCulloch Geothermal Corp.	CU 1 Venture: Explore and evaluate fields/ Brawley, California; Beryl and Lund, Utah	110 MWe 55 MWe 50 MWe	6.3 (Bank of Montreal)
Hold	Southern California Public Energy Corp. (City of Burbank)	Site selection appraisals/ Roosevelt Hot Springs, Utah	50 MWe to 200 MWe	25.0 (Dean Witter and Co.)
Approved	Geothermal Food Processors	Food Dehydration: Rehab. existing wells; Design and build dehydrator plant/ Brady's Hot Springs, Churchill County, Nevada	(Non-elec.)	3.5 (Nevada National Bank)
Hold	Diablo Exploration, Inc.	Select site, explore evaluate, and develop field/ Rio Grande Rift Valley, New Mexico	50 MWe	21.8 (Kidder, Peabody, Inc.)
Initial review	Resource Funding Ltd. (Northern California Power Assoc., a consortium of cities)	Explore, evaluate, develop field/ Cob Valley, Lake County (Geysers), California	66 MWe	14.5

RESEARCH PROGRAM PLAN FOR GEOTHERMAL LIQUID WASTE DISPOSAL

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATOR

L. J. Defferding

OBJECTIVES

The objectives of this program are to review the state-of-the-art for disposing of liquid wastes from geothermal (electric and nonelectric) installations and to develop a research program plan for developing commercially viable techniques for waste disposal.

APPROACH

A review team was assembled from within the Pacific Northwest Laboratory. This team reviewed the available literature and evaluated the existing methods for disposal of liquid wastes from geothermal facilities. The techniques were evaluated from legal, technical, environmental, safety, and economic standpoints. During this evaluation, research needs were identified. The results of the evaluation will constitute a state-of-the-art review of disposal methods for geothermal liquid wastes. A research program plan will be written to develop the required technology on information that was identified as lacking during the review task. This program plan will be reviewed by a task force of recognized experts in the geothermal or disposal fields. DOE Division of Geothermal Energy will assume responsibility for development of disposal methods.

PROGRESS AND RESULTS

The literature search has been completed, written, and is being edited for publication.

PLANS FOR NEXT PERIOD

The project will be completed in FY 1978. The State-of-the-Art Report and the Research Program Plan will be published.

REPORTS PUBLISHED:

None

PROJECTED MILESTONES

- November 30, 1977 -- Draft State-of-the-Art Report to DOE for review
- February 15, 1978 -- Draft Program Plan to DOE for review
- March 15, 1978 -- Project completion

* * *

EVALUATION OF H₂S CONTROL TECHNOLOGY FOR GEOTHERMAL ENERGY SOURCES

ORGANIZATION AND CONTRACT NUMBER

Midwest Research Institute
EE-77-C-02-4255

PRINCIPAL INVESTIGATOR

J. B. Galeski

OBJECTIVES

The objectives of this project are to identify and evaluate technologies for control of H₂S emissions from existing and several planned geothermal energy developments; to prepare a state-of-the-art report describing all previous and ongoing attempts to control H₂S emissions from geothermal energy systems; and to identify potentially applicable H₂S removal technologies which are available, or could be developed within a commensurate time frame to control H₂S emissions from several planned geothermal development projects.

APPROACH

The study will emphasize H₂S removal technology for existing and planned geothermal energy developments. This work will be performed concurrently for approximately the duration of the project. The project has formally been divided into three tasks. Task 1 is a literature search to provide data inputs. Task 2 is a state-of-the-art review of operating systems and will include site visits to operating geothermal regions. Task 3 will involve data acquisition, selection of geothermal energy projects, and identification of potentially feasible technology.

A systematic evaluation procedure will be used to evaluate alternative technologies for geothermal development projects. Requisite information to be used for evaluation of control technology for both existing and proposed facilities will include: uncontrolled emission rates of H₂S and other contaminants; description of conversion processes, emission points, flow rates, and steam compositions; and description of candidate H₂S control technologies including performance data, investment and annualized costs for given efficiency levels, energy requirements, secondary environmental impacts (sludges, etc.), development status, and, for add-on control technologies, vendor/developer capabilities to provide equipment, support services and guarantee performance is requisite information.

PROGRESS AND RESULTS

The program was initiated late in FY 1977. The initial task, begun August 15, 1977, involves an extensive review of the literature to identify ongoing and planned geothermal developments and potentially applicable H₂S control technology. Contacts are also being made with individuals and agencies involved

with the development of H₂S control technology for geothermal applications. Information obtained will be used initially to prepare comprehensive, descriptive listings of geothermal energy programs and potentially applicable H₂S control technology. Selected development programs and control systems will be evaluated in more detail in subsequent Tasks 2 and 3. Task 2 efforts performed in FY 1977 will chiefly involve acquisition of performance test data, operating data, and other information for H₂S removal systems on geothermal effluents. Task 3 efforts performed in FY 1977 will involve data acquisition, selection of geothermal energy projects, and identification of potentially feasible technology. Part of the initial efforts in Task 3 will involve the development of "first level" evaluation methodology for given combinations of source classification (e.g., dry steam, hot brine, dry hot rock, geopressure) and energy conversion technology.

PLANS FOR NEXT PERIOD

Program activities for FY 1978 will include the preparation of a state-of-the-art review of H₂S emission control technology for geothermal sources and the detailed evaluation of selected potentially applicable H₂S control systems for planned geothermal applications.

REPORTS PUBLISHED

None

PROJECT MILESTONES

- September 1, 1977 -- Completion of Task 1
- January 15, 1978 -- Completion of Task 2 and 3
- April 9, 1978 -- Submission of draft copies of state-of-the art report and final report to DOE

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ASSESSMENT OF ENVIRONMENTAL CONTROL TECHNOLOGIES FOR HIGH MAGNETIC FIELDS

ORGANIZATION AND CONTRACT NUMBER

Los Alamos Scientific Laboratory
A985

PRINCIPAL INVESTIGATOR

W. V. Hassenzahl

OBJECTIVES

The objective of this program is to assess the relative efficiency of various means of reducing

magnetic field strengths, both within and beyond the site boundaries for nuclear fusion, using magnetic confinement, magnetohydrodynamics (MHD) for power generation, and by superconducting magnets for energy storage (SMES), and anticipating official or unofficial standards of ambient magnetic field strengths.

APPROACH

The magnets associated with the above technologies are unshielded and produce magnetic fields on the order of 10 tesla (1 tesla = 10,000 Gauss). Strong magnetic fields may have adverse effects on the health of workers in facilities employing magnetic technologies. Even relatively weak fields (down to a few Gauss) existing near these devices may have environmental effects on a biological or nonbiological nature. (For comparison, the earth's natural magnetic field is about 0.5 Gauss.)

Four computing facilities at Los Alamos Scientific Laboratory (LASL) will be used to calculate magnetic field levels as a function of distance from various energy related devices including SMES magnets, MHD power sources, and fusion reactors. In addition, the parameters of shield coils required to reduce ambient magnetic field strengths to below given levels will be calculated. The various means of controlling magnetic field strengths (e.g., site location and orientation, fence placement, ferromagnetic material placement, shield coils) will be compared as to effectiveness and cost.

PROGRESS AND RESULTS

Preliminary calculations have been made to test the proposed computational technique and acquire some typical data for one of the magnetic devices of interest. Figure 23 shows the total magnetic flux intensity produced by a superconducting magnetic energy storage magnet 150 meters below the earth's surface, with a shield coil. Curves for different heights above the surface of the earth are given as a function of the distance from ground zero. The effectiveness of the shield coil in reducing the magnetic field beyond the shield radius is evident. Calculations like this will form the basis for the proposed cost-effectiveness studies of magnetic field control.

PLANS FOR NEXT PERIOD

During FY 1978, the final report will be completed.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- February 1, 1978 -- Submission of draft final report to DOE

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Figure 23. Magnetic Field Strength above a Superconducting Magnet and a 800-m-radius Shield (Coil)

COMPRESSED AIR ENERGY STORAGE: ENVIRONMENTAL CONTROL CONCERNS

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATOR

W. V. Loscutoff

OBJECTIVES

The objectives of this study are to identify the significant technological environmental control concerns associated with implementation of compressed air energy storage plants and to provide a management program plan for eliminating or mitigating these concerns through control technology and/or procedure development.

APPROACH

The approach used in this study is to identify the major environmental concerns; to assess all past, present, and planned research related to the concerns; and to propose a program plan that is required

to meet DOE protocol and directives on environmental issues.

PROGRESS AND RESULTS

The major output of this study in FY 1977 is the Preparation of a management program plan that will be used by ECT in establishing its R&D technology program for assuring adequate environmental controls for compressed air storage systems.

PLANS FOR NEXT PERIOD

Upon completion of a satisfactory program plan, ECT may request that Pacific Northwest Laboratory (PNL) serve as lead program manager of the plan. The lead program manager's duties may include any of the following activities:

- Preparation of solicitations, review of proposals, and selection of contractors for projects identified in the plan;
- Technical management of contracts;
- Oversight of technical development of the plan; and

- Publication and distribution of technical findings of the program.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- December 25, 1977 -- Submission of draft of Management Program Plan to DOE

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ENVIRONMENTAL CONTROL REQUIREMENTS IN SOLID WASTE PROCESSING AND ENERGY RECOVERY FACILITIES: WATER POLLUTION

ORGANIZATION AND CONTRACT NUMBER

Iowa State University
W-7405-ENG-82

PRINCIPAL INVESTIGATOR

J. C. Young

OBJECTIVES

The general objectives of this project are to perform independent assessments of the environmental controls needed for urban waste utilization and to identify and foster development of novel solutions to environmental control problems.

APPROACH

The general approach for this project will be first to perform a preliminary assessment of controls needed for air and water pollution, and then to undertake more detailed assessment work which is in concert with and will complement activities sponsored by other environmental groups.

The project consists of three phases. Phase I (Oct. 1976 through Sept. 1977) involves surveying existing technology through literature reviews, site visits, and working with design engineering and manufacturing firms. This survey will help identify points of water use and wastewater production and document available information. In addition, it will serve as a basis for developing follow-up procedures for collecting additional data needed to accomplish the objectives of the evaluation program. Phase II and III (Oct. 1977 and following) will involve detailed follow-up studies to determine the treatability of wastewaters produced, to evaluate the availability and suitability of water pollution control technology to treat these wastewaters, and to identify possible ways to reduce water use and wastewater production.

PROGRESS AND RESULTS

Phase I (FY 1977) has shown that water is used at solid waste processing/energy recovery facilities for scrubbing off-gasses from burning operations, quenching incinerator residues, sluicing ash from incinerators and air pollution control devices, cooling, lubricating, fire fighting, and miscellaneous housekeeping. There has been essentially no documentation of the volume of water used for or wastewater produced by these purposes. In most cases, no measurements of wastewater quantities have been made and very little data are available on the quality of wastewaters, and wastewater streams are discharged to sanitary sewers without regard to their treatability or impact on municipal wastewater treatment systems.

PLANS FOR NEXT PERIOD

For Phase II (FY 1978), this project will emphasize the following objectives:

- Documentation of the rates and volumes of water use and wastewater production of various points of use within operating facilities, and
- Analysis of the major wastewater streams produced to determine their treatability and/or impact on municipal wastewater treatment systems or other systems receiving these wastewaters.

First efforts will be directed at those plants having the greatest need for wastewater treatment or greatest potential for causing water pollution or other water-related environmental impacts. Where possible, project activities will be interfaced with studies now being conducted by other investigators at various facilities.

Phase III (FY 1979) will involve a continuation of Phase II activities if needed, but will be designed specifically to identify the status of pollution control technology available or needed to treat these wastewaters.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Reports will be completed according to the following schedule:

- September 1, 1977 -- Phase I Interim Report
- September 1, 1978 -- Phase II Interim Report
- October 1979 -- Phase III Final Report.

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FEASIBILITY STUDY ON TRANSFORMER NOISE REDUCTION SYSTEM

ORGANIZATION AND CONTRACT NUMBER

Westinghouse Electric Corporation
EE-77-C-02-4376

PRINCIPAL INVESTIGATOR

D. A. Yannucci

OBJECTIVES

The objectives of this project are to demonstrate the feasibility of reducing audible noise for a scale model power transformer using an active sound reduction system and to compare estimated cost of this system with other sound reduction techniques. The design goal is to demonstrate sound reduction of 20 decibels over the audible noise spectrum of 120 to 360 Hz.

APPROACH

Because of the recent and anticipated emphasis on noise pollution control, transformer noise is becoming increasingly important. To verify the feasibility of an active noise abatement system which is shown schematically by Figure 24, two engineering prototype sound cancellation units will be designed and constructed that will be suitable for reducing low frequency sound from a small model of a full scale transformer. The model transformer will consist of a stacked, mitered, electrically oriented steel core with a winding wound over the core. It will be oil filled, and the core operating flux density will be approximately 1.7 teslas. Modifications to the transformer container by the addition of sound barriers will be necessary to provide an acoustic frequency spectrum more similar to an actual size transformer. Both "A" weighted and "C" weighted scale decibel measurements will be made.

The reduction system uses an active control system that requires speakers to produce a volume flow of air nearly out of phase with that of the sound producing surface at all frequencies of interest. Air thus flows back and forth between the speakers and surface leaving only a small residual net outward flow which manifests itself as sound. The system includes a closed loop control that will compensate for environmental changes and for changes in the transformer core due to a varying applied voltage. To verify that transformers are designed to the correct sound level, units are tested in an anechoic chamber. Inside the concrete walls is a separate wooden room with a lining of glass fiber wedges. The A-weighted attenuation of sound from the outside of the main door to the inside of the room is 60 decibels. The

sound instrumentation uses multiple condenser microphones, with arrangements for switching. Octave-band, one-third octave-band, and narrow-band analyzers are used for analysis, and graphic and magnetic tape recorders can be used for recording. Figure 25 shows the layout of the anechoic chamber.

An economic analysis is being made by comparing the cost ratios of reducing the sound level of a 30-MVA, 115-kV power transformer by 10, 15, and 20 decibels on the A-weighted scale with the cost of placing the sound reduction system on a standard sound level transformer. Cost ratios with sound barriers are also being investigated.

PROGRESS AND RESULTS

The model transformer and sound reduction system design phases have been completed. Both are currently in the building phases. A "Tabletop Demonstration" of the system was made with the following results for abatement in decibels for two different applied voltages:

<u>Voltage</u>	<u>120 Hz</u>	<u>240 Hz</u>	<u>360 Hz</u>
120	21	37	19
130	20	25	13

PLANS FOR NEXT PERIOD

Assuming that the demonstration phase is successful, acoustic measurements and acceleration data acquisition will be performed on full-scale transformers. The data will be analyzed, and a system simulation designed. A small number of sound reduction units (greater than 10) will be built and tested on a small transformer. Environmental tests and design optimization of the electronic circuits will be performed. After design optimization, a large number of units (greater than 100) will be built and applied to a power transformer. Anechoic chamber testing, field testing, and monitoring will be performed.

REPORTS PUBLISHED

A. R. Davidson, "Active Reduction of Low Frequency Sound from Large Vibrating Surfaces," School of Engineering and Applied Science, George Washington University, August 1975, Doctoral Dissertation.

PROJECTED MILESTONE

- January 4, 1978 -- Demonstration at Westinghouse Anechoic Chamber in Sharon, Pennsylvania
- March 15, 1978 -- Final Report

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Figure 24. Active Sound Cancellation Block Diagram

ENVIRONMENTAL CONTROL TECHNOLOGY REQUIREMENTS FOR FUTURE AC, HIGH- VOLTAGE OVERHEAD TRANSMISSION FACILITIES

ORGANIZATION AND CONTRACT NUMBER

SRI International
EY-76-C-03 0115
Project Agreement No. 120

PRINCIPAL INVESTIGATOR

B. L. Walton

OBJECTIVES

The main objective of this program is to provide ECT with an overview of current understanding about environmental impacts of high-voltage transmission lines by assessing testimony recently submitted for licensing a 765-kilovolt line.

APPROACH

Overhead power transmission lines are the principal means of transmitting large blocks of energy over long distances. The addition of 70,000 circuit miles of overhead high-voltage transmission lines is scheduled during 1976-81, along with 7000 line terminals. In terms of capacity, the yearly additions may average 5000 to 6000 GW-miles. DOE is concerned about the potential environmental effects resulting from additions. This project will provide DOE with an overview of current understanding and aid in defining needed environmental control technologies to mitigate significant effects of high-voltage transmission.

Figure 25. Westinghouse Anechoic Chamber at Sharon, Pennsylvania

SRI is employing a multidisciplinary team to review the potential environmental impacts of overhead high-voltage transmission and to recommend research on environmental impacts and environmental control technology when appropriate. SRI is conducting the following work:

- Task I: Review DOE requirements for new AC overhead high-voltage transmission facilities.
- Task II: Review recent documentation to determine environmental impacts.
- Task III: Describe environmental impacts.
- Task IV: Assess environmental control technology.
- Task V: Evaluate the ability of environmental control technology to meet known environmental needs.
- Task VI: Determine needed research and development beyond that which DOE currently is considering.

PROGRESS AND RESULTS

Because this project began in late FY 1977, no detailed results have yet been published. A review of

ongoing DOE programs for developing the technology and the environmental controls for overhead high-voltage transmission has been completed. The detailed assessment of the testimony has been initiated. Figure 26 shows the ECT and Division of Electrical Energy Systems program managers packing the 14,000 pages of prepared testimony before shipment to SRI.

PLANS FOR NEXT PERIOD

This project is scheduled for completion in FY 1978.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- March 15, 1978 -- Completion of the Draft Final Report
- May 15, 1978 -- Publication of the Final Report

* * *

PHOTOGRAPH NOT AVAILABLE

Figure 26.

ASSESSMENT OF ENERGY CONSERVING INDUSTRIAL WASTE TREATMENT TECHNOLOGY

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATOR

H. E. McGuire

OBJECTIVE

The objectives of this project are to provide an overview of current industrial pollution control practices, to assess DOE activities in this area, and to prepare a plan on recommended alternative possibilities of energy conserving industrial waste treatment processes.

APPROACH

Pacific Northwest Laboratory (PNL) is currently conducting a thorough literature review to establish an industry priority list, develop industrial process diagrams, determine industrial pollutant discharges,

and identify current study areas. PNL will use published data and information or data collected from industrial trade groups to develop the necessary data base. PNL will then recommend possible industrial waste treatment areas where additional research into energy conserving processes is needed.

PROGRESS AND RESULTS

A tentative priority list of industries has been compiled.

PLANS FOR NEXT PERIOD

The study will be completed in the first six months of FY 1978.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

March 15, 1978 -- Submission of draft of interim report.

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NUCLEAR ENERGY

Nuclear energy studies supported under Environmental Engineering in FY 1977 consisted of:

- Assessment of the environmental aspects of alternative nuclear fuel cycles,
- Assessments of long-term waste management concepts including investigation of the environmental feasibility of deep ocean bed disposal, and
- Development of methods for assessing the adequacy of environmental protection afforded by DOE nuclear energy material shipping container systems.

The objective of the nuclear fuel cycle studies is to provide an environmentally sensitive assessment of the effluent control systems utilized in the fuel cycle of current and proposed nuclear energy systems. Recommendations will be made for development or application to ensure that systems are available to meet environmental standards and policies.

During FY 1977, the major effort has been concentrated on generic light water reactor (LWR) fuel cycle facilities. An environmental control analysis of the alternative fuel cycles for near-term LWRs was begun. The alternative fuel cycles assessment has been limited to those areas related to the nonproliferation issues in terms of options for the standard LWR. Options to be considered in FY 1977 and continuing into FY 1978 included nonreprocessing of uranium reference fuel with stowaway or throw-away (disposal) alternatives, coprocessing of uranium and plutonium (with removal of fission product waste only), coprocessing of uranium and plutonium with spiked fuel, and thorium utilization in the LWRs.

The near-term objective of the ocean disposal studies is to assess the environmental and technical feasibility of providing isolation of high-level radioactive waste beneath the deep ocean floor in a geologically stable and biologically inactive region and to maintain the capability of assessing ocean disposal programs developed by other countries.

During FY 1977, detailed assessments of the vertical consistency of the deep ocean sediments were begun by examination of sediment core specimens. Initial assessment of the properties barring migration of selected radionuclides through sediment materials was initiated for red clay and calcareous sediments, and the characterization of the deep ocean and bottom dwelling biological communities was continued to determine biological effects and possible biological concentration mechanisms and transport pathways.

The assessment of ocean bed disposal has international implications in terms of the potential for contribution to solving the waste management

problem on a worldwide scale and in terms of the sensitivities and restrictions established by international treaties for any acts that pollute the world oceans. These implications are continually addressed in the assessment program and information is provided to various joint programs as well as to conferences and discussions of international policies affecting the seas.

The Environmental Engineering analysis and testing program, which is designed to assess the adequacy of environmental control provided by nuclear fuel and waste shipping container systems used in the fuel cycle, was continued in FY 1977. This program is performed by developing experimental and analytical tools as well as needed test data. Pertinent aspects of commercial transportation systems, within which the nuclear shipments must operate, are also considered. Such data and analysis benefit the safety of all nuclear shipment systems.

FY 1977 accomplishments include continuation of the development and experimental verification of a computer code to predict end-on impact response of shipping containers, the incorporation of newly developed material behavior descriptions in such codes, and scale model impact tests of containers. The first phase of a project to predict behavior for arbitrary impact orientations was initiated.

Analytical results and test data that have been accumulated to date were obtained from testing full-scale casks at impacts of up to 80 mph in order to determine the validity of some of the modeling techniques developed under this program. Development of analytical and experimental techniques for assessing the adequacy of these transportation systems will continue in FY 1977. Structural and thermal analysis methods were developed to be verified by future scale model and prototype experiments. The efficiency and accuracy of dynamic computer codes were enhanced by incorporation of the most modern material behavior descriptions. Additionally, the response of fuel and waste container systems under conditions of simulated malevolent attack were analyzed.

Work was continued to develop and maintain a nuclear transportation accident data bank for use by Government agencies and the public (a continuing program begun in FY 1976); to collect and publish statistics and data on DOE's own transportation operations program; and to develop films, booklets, and exhibits about the environmental and safety aspects of the transportation of fuels and wastes. This activity incorporates data, technical information, and visual aid material derived from all related projects to demonstrate the assessment by the Office of the Assistant Secretary for Environment of these environmental control systems. The output of these efforts are included in DOE's information and technical information exchange programs.

ANALYSIS OF NUCLEAR FUEL CYCLES

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATORS

T. J. Kabele
E. C. Watson
C. M. Heeb

OBJECTIVES

The goal of this program is to provide an independent overview of environmental control technology development for nuclear fuel cycles to ensure that environmental control technologies will not limit the implementation of these cycles. The objective of the project is to recommend where R&D will improve effluent control on a cost-effective basis.

APPROACH

The technical approach selected to meet the program objective is to (1) identify effluents and release rates from each facility in the fuel cycle, (2) rank these effluents according to impact, (3) identify the alternative control technologies, (4) estimate the costs for control technologies -- both applied and alternative, (5) evaluate the cost effectiveness of alternative technologies, and (6) recommend where improvements are needed. The analysis presently focuses on light water reactor (LWR) fuel cycles with some attention given to nonproliferation fuel cycles, advanced reactor fuel cycles (liquid metal fast breeder reactors), and fusion energy cycles. The cycle includes all process steps from mining of raw materials to the operation(s) of waste disposal.

PROGRESS AND RESULTS

Methodologies Developed

Environmental Assessment

There are hundreds of toxic nonradioactive and radioactive materials in nuclear fuel cycle facilities. A methodology which is summarized below and described in detail in "Environmental Assessment Methodologies for Nuclear Fuel Cycles" (BNWL-2219), was developed to assign priorities for controlling these effluents.

Radioactive Effluents -- For a given nuclear electric energy generation scenario, the following calculations are made for each isotope from each facility and for each year in the scenario:

- Maximum individual dose for a 50-year dose commitment for a 1-year exposure according to the organ affected;

- Population dose for a 50-year dose commitment from a 1-year exposure according to the organ affected; and
- Annual dose rate for the maximally exposed individual.

The relative contribution of a specific nuclide and source to the total dose for any time period in the scenario provides a method of ranking the nuclides, which in turn identifies the sources that should receive the greatest control in the future. These results are used in subsequent tasks to assess the environmental impact of the total nuclear fuel cycle.

The major pathways by which human beings can be exposed to radiation from a nuclear facility are illustrated in Figure 27. Exposure pathways are grouped into those associated with gaseous effluents, those associated with liquid effluents, and those associated with exposure to direct radiation from the facility or from transportation of radioactive materials to or from the facility. Calculations for each pathway are then made for those selected organs which could potentially receive the highest radiation dose.

Nonradioactive (Chemical) Effluents -- Non-radioactive toxic species are generally referred to as chemical effluents. Chemical dose was not used as a basis for evaluating and ranking chemical effluents because appropriate pathway calculation models are not available. As shown in Figure 28, an approach using environmental standards was selected. The assessment methodology is shown in the flow diagram in Figure 29.

First, effluent standards are compared with the estimated emission rates. This direct comparison provides a simple method for calculating the degree of control required. If effluent standards are not available, a second approach using ambient standards is used. If neither effluent nor ambient standards exist for a chemical, toxicological data are used to estimate acceptable ambient limits using threshold limit values (TLVs) and oral lethal dose concentrations (LD₅₀s) for rats.

As the source/chemical analysis is completed, each facility is studied to evaluate the combined effect of multiple chemical pollutants and to set priorities for the environmental control technology needs.

Cost Estimating -- Capital and operating costs for applied and available systems to control effluent releases must be prepared for each of the fuel cycle facilities. Standard estimating procedures and assumptions were developed to ensure that the results were consistent and could be compared to determine cost variations of alternatives. A topical report, "Procedures for Estimating Nuclear Fuel Cycle Costs" (BNWL-2210), was issued which describes these procedures and assumptions.

Figure 27. Exposure Pathways to Human Beings

Fuel Cycle Effluents -- A computer code system, ENFORM, was developed to calculate the fuel cycle mass flows as a function of time. As shown in Figure 30, the inputs for the calculation are release fractions by facility, radiological dose coefficients by nuclide for each facility, unit costs for each process, and a growth scenario for nuclear power. The output of the computer calculation is a ranking of each effluent for the whole fuel cycle and for each plant in the cycle and the contribution to the total power costs from each fuel cycle component. The ranking of radiological effluents is based on dose to the general population. Because there is no established dose equivalent for nonradiological effluents, a methodology for ranking these effluents was developed based on existing standards. The computer system is capable of accounting for roughly 175 radionuclides and about 250 chemically toxic species. The

ENFORM system provides the tool for evaluating the impact of different fuel cycle strategies and growth scenarios on fuel cycle effluents and control technology costs for radionuclides and chemicals. This code is described in "ENFORM: An Energy Information System" (BNWL-2195).

Analysis

Descriptions of the generic LWR fuel cycle facilities are complete. The types of facilities analyzed include:

- Uranium Mines, surface and underground
- Uranium Mill, acid leach process
- Conversion Plant

Figure 28. Environmental Considerations

Figure 29. Methodology for Source/Chemical Analysis

NUCLEAR POWER GROWTH

Figure 30. Fuel Cycle Calculation Method

- Gaseous Diffusion Enrichment Plants
- UO_2 Fuel Fabrication Plant
- MOX Fuel Fabrication Plant
- Pressurized Water Reactor
- Boiling Water Reactor
- Fuel Reprocessing Plant

In addition, descriptions of liquid metal fast breeder reactor (LMFBR) fuel cycle facilities, initiated during the FY 1976 Transition Period, were completed in the third quarter of FY 1977. These facilities included an LMFBR and associated fuel fabrication and reprocessing plants for oxide, carbide, and nitride advanced fuels.

Alternative nonproliferation fuel cycles are being studied. The initial reference fuel cycle uses a once-through uranium fuel with stowaway of unprocessed fuel as shown in Figure 31. At the end of FY 1977, analysis of the reference LWR fuel cycle will be completed for the latest DOE projection in nuclear growth.

Figure 31. The Nuclear Fuel Cycle

PLANS FOR NEXT PERIOD

The efforts in FY 1978 will be to extend and refine the analyses for LWR uranium fuel cycles and to focus on alternative nonproliferation fuel cycles such as high temperature gas reactors (HTGRs). The LWR fuel cycle work includes analysis of advanced fuel cycle operations (e.g., centrifuge enrichment, solution mining, packaging spent unprocessed fuel) and detailed engineering evaluations of control technologies for those effluents appearing at the top of the ranking list. The major effort, however, will be evaluating environmental control technology of alternative fuel cycles. These include the various near-term alternatives for uranium/plutonium cycles (e.g., coprocessed and/or spiked U/Pu) and mid-to far-term alternatives of thorium utilization and denatured uranium cycles in LWRs, HTGRs, and LMFBs. Also, a preliminary analysis will be made to identify potential troublesome effluents in fusion fuel cycles.

These alternative and advanced power generation technologies are currently being defined. Lacking definition of processes and facilities in these cycles, the technical approach for this project has to be modified from that described in the Approach section of this report. The modified approach, as currently envisioned, includes developing functional process descriptions, establishing equilibrium material flows (or a range of potential flows), identifying the toxic constituents and performing comparative analyses to identify applicable control technologies, and making recommendations where development of new control technologies is needed.

REPORTS PUBLISHED

J. K. Soldat, "Methodology for Calculation of Radioactive Doses in the Environs from Nuclear Fuel Cycle Facilities," BNWL-2075, August 1976.

C. M. Heeb, et al., "ENFORM: An ENergy InFORMation System," BNWL-2195, March 1977.

J. R. Young, "Procedures for Estimating Nuclear Fuel Cycle Costs," BNWL-2210, March 1977.

D. L. Brenchley, et al., "Environmental Assessment Methodologies for Nuclear Fuel Cycles," BNWL-2219, July 1977.

K. J. Schneider, et al., "Analysis of LWR Fuel Cycle Facilities," BNWL-2286 (to be published).

T. J. Kabele, et al., "Data Book on Effluents in LWR Fuel Cycles," BNWL-2287 (to be published).

PROJECTED MILESTONES

None

* * *

SEABED DISPOSAL PROGRAM

ORGANIZATION AND CONTRACT NUMBER

Sandia Laboratories
AT(29-1)-789

PRINCIPAL INVESTIGATORS

D. M. Talbert
D. R. Anderson

OBJECTIVES

The objectives of the program are (1) to determine the environmental and technical feasibility of disposing high-level radioactive wastes into the deep ocean floor in geologically stable and biologically inactive sediments and (2) to develop and maintain a capability for assessing the ocean radioactive waste disposal programs of other nations.

APPROACH

The approach of the program is to first assess and define an entire disposal system and to determine the feasibility of seabed disposal from firm scientific and technical information. The safety and environmental effects of such a system are then to be determined, and the requirements to carry out seabed disposal defined, based on the findings of the program as above and subject to considerations of both the feasibility and safety of the system. The final step is to prove system capability by a combination of tests and demonstrations.

PROGRESS AND RESULTS

In FY 1977, the activities described in the following paragraphs were accomplished.

A 24.38-m-long core was recovered from a central North Pacific study area. This core was obtained using a giant piston corer. This core represents the longest sediment core ever obtained from the North Pacific and the longest undisturbed record of continuous sedimentation, from the present, ever recovered from the deep sea.

A parachute retardation system was developed, tested, and used to eliminate the tension and, thus, the rope rebound problem long associated with the deployment of piston corers for oceanographic investigations.

Initial analyses of data obtained from the long sediment core shows no evidence of any significant past erosional effects or inconformities nor does it reveal any evidence for significant changes in the ocean floor environment of this region that would have altered the area's suitability as a repository. The sediment at the bottom of the core was estimated to be deposited approximately 65 to 70 million years ago.

Development and testing of a free-fall, deep conductivity-temperature-depth (CTD) instrument was completed. This CTD was developed to provide

extremely sensitive measurements as part of the program to measure the diffusive properties of the deep ocean at abyssal depths.

A high resolution (~1-m), high powered (10-kW), 3.5-kHz seismic reflection profiling system deployed in a surface towed fish was designed, developed, tested, and used. Full penetration to acoustic basement (lithified chert or basalt) was achieved everywhere the system was deployed, and its vertical resolution was consistently less than 1 m (achieved in nearly 20,000 ft of water).

Thermally driven velocity field estimates were developed for idealized heat sources (point and lines) in sediments.

A thermal conduction model was derived and verified for a heated vertical cylinder in sediments.

The temperature/sorption relationships for selected ions in the range of 5° to 85° C in red clay sediments were established.

A literature survey and compilation of available sorption data for fall-out nuclides and deep-sea sediments in contact with seawater was accomplished.

Near-bottom deep-water faunal samples were successfully recovered using a modification to "Deep Tow," as the technique was developed to relate biology and ion transport from the benthic region to the water column.

Mobile, scavenging amphipods were identified as a likely subset of deep-water organisms for concentrated studies to evaluate typical transport of radioactive ions by the benthic communities.

Deep-water (~5000 m) benthic organisms were recovered successfully alive for laboratory studies of metabolism and radionuclide uptake.

PLANS FOR NEXT PERIOD

Some of the specific milestones expected to be accomplished in FY 1978 include those described below.

1. An operational computer model concerned with the thermal interaction between a waste canister and the sediments will exist.
2. A predictive environmental model for the central North Pacific sediments (10⁶ to 10⁷ years) will be completed.
3. A computer model of the sediment column response to the quasi-static emplacement of a heat generating waste container will be operational.
4. An initial assessment of the quality of a vertical red clay sediment column as a barrier to the migration of selected ions will be completed.
5. An initial barrier assessment of bulk hemipelagic sediments for selected single ions will be completed.

6. A theoretical assessment study of the rates of thermally induced pore water movement will be completed.
7. Planning for an in situ heat transfer experiment will be initiated.
8. An initial assessment of the supercritical property changes of the sediments driven by radiogenic heat will be completed.
9. An analysis will be completed for economic potential of the ferromanganese nodules of the central North Pacific.
10. A synthesis of existing western North Atlantic geological and geophysical data will be completed.
11. The detailed assessment of the vertical consistency of the sediment column recovered from the central North Pacific will be completed.
12. Long-term (2 to 5 years) laboratory corrosion tests of economically feasible container materials will be initiated.
13. An initial assessment of glass waste from leaching phenomenon in heated seawater will be made.
14. A number of sampling devices and instruments for the recovery of deep biological specimens will be developed to enable populations to be determined and allow further laboratory studies to be carried out.

REPORTS PUBLISHED

V. T. Bonen, M. D. Livingston, and J. C. Burke, "Distributions of Transuranium Nuclides in Sediment and Biota of the North Atlantic Ocean," Transuranium Nuclides in the Environment, International Atomic Energy Agency, 1976.

D. A. Masse, "Seabed Emplacement and Political Reality," in Oceanus, Vol. 20, No. 1, Winter 1977.

G. R. Heath, "Barriers to Radioactive Waste Migration," in Oceanus, Vol. 20, No. 1, Winter 1977.

R. R. Messler and P. A. Jumars, "Abyssal Communities and Radioactive Waste Disposal," in Oceanus, Vol. 20, No. 1, Winter 1977.

C. E. Hickox, H. A. Watts, "Study Thermal Convection From a Concentrated Source in a Porous Medium," SAND 76-0502, Sandia Laboratories, November 1976.

C. D. Hollister, "The Seabed Option," in Oceanus, Vol. 20, No. 1, Winter 1977.

A. J. Silva, "Physical Processes in Deep-Sea Clays," in Oceanus, Vol. 20, No. 1, Winter 1977.

A. J. Silva and D. I. Calnan, "Geotechnical Aspects of Subsurface Seabed Disposal of High Level Radioactive Wastes," Annual Progress Report No. 3, University of Rhode Island, February 1977.

K. L. Smith, et al., "A Free Vehicle for Measuring Benthic Community Metabolism," Limnology and Oceanography, 21, 1976.

W. H. Smyrl, L. L. Stephenson, J. W. Braithwaite, "Behavior of Candidate Canister Materials in Deep Ocean Environments," SAND 77-0243, Sandia Laboratories, April 1977.

D. M. Talbert, "Seabed Disposal Program Annual Report, January-December 1976," SAND 77-1270, Sandia Laboratories, September 1977.

PROJECTED MILESTONES

- FY 1980 (Approximately) -- The second assessment of the seabed disposal option using newly developed mass transport models and new essential oceanographic and effects data will be completed. Detailed engineering plans will be started and studies addressing environment and safety will be initiated.
- FY 1985 (Approximately) -- The main oceanographic and effects data will be collected. The third of four feasibility assessments will be made from a sound engineering base. A final choice of the optimum site with the appropriate qualities will be made.
- FY 1990 (Approximately) -- The final assessment of the concept will be made from an ongoing demonstration plant.

* * *

REVIEW AND ASSESSMENT OF HYDROGEN ENERGY ECONOMY TRANSPORTATION SAFETY PROBLEMS

ORGANIZATION AND CONTRACT NUMBER

Los Alamos Scientific Laboratory
W-7405-ENG-36

PRINCIPAL INVESTIGATOR

F. J. Edeskuty

OBJECTIVES

The objectives of this project are to define thoroughly the potential safety problems associated with large-scale transportation of hydrogen and to recommend analytical and experimental studies that will lead to satisfactory solutions.

APPROACH

To achieve the project objectives, the following approaches will be followed.

A review of existing Government and safety regulations for the production of transportation equipment and for the transportation of natural gas,

liquefied natural gas (LNG), hydrogen gas, and liquid hydrogen (LH₂) will be performed. Important subjects for study include the problems that existing regulations address, their applicability to large-scale handling of hydrogen, and areas where further regulations are required.

A review and evaluation of the research and development work sponsored by Government and industry that is pertinent to hydrogen transportation problems will be made.

The most probable modes for hydrogen transportation will be defined, and a detailed safety or risk analysis of each mode will be performed.

Based on the above evaluations, Los Alamos Scientific Laboratory's technical expertise, and input from appropriate consultants, potential problems will be defined and possible solutions to these problems will be suggested.

PROGRESS AND RESULTS

Using information obtained from contacts with experts in the field of hydrogen safety and a detailed assessment of literature on existing hydrogen and natural gas work, the most probable transportation modes between suppliers and users have been chosen. The most probable scenarios can be derived by following the appropriate paths shown in Figure 32.

The least costly method is to transfer high pressure hydrogen gas through converted natural gas pipelines. Similar lines have given decades of continuous service for high hydrogen content producer gas in this country, Europe, and Japan.

Shipment of LH₂ is less attractive economically because of liquefaction cost and the capital costs of insulated containers. However, when the user requires hydrogen in this form, or when pipeline transport is not available between the producer and the user, some form of liquid transport becomes the preferred method. In spite of the liquefaction cost, LH₂ shipment by tank truck and tank car already constitute an important segment of current merchant hydrogen transport. This transportation method will probably be important for some time, because no conversions of natural gas pipelines are presently planned.

The metal hydride system of transportation had been included in this study for the sake of completeness. Presently, this technology is far from being developed as a useful bulk transportation method, although it has numerous proponents and could become a useful method in the future. Research on this subject is continuing.

To date, we have identified four transportation methods to which studies of safety hazards, existing safety regulations, and proposed safety standards should be addressed. These are, in decreasing order of priority:

- Pipeline hydrogen gas;
- Tank truck LH₂;
- Rail tanker LH₂; and
- High pressure tube trailer.

Figure 32. Future Hydrogen Transportation Scenarios

While LH_2 is different from LNG or gasoline, considerable insight can be gained from evaluating available studies on the transportation safety aspects of these fossil fuels.

A detailed safety analysis of LH_2 shipment by tank truck is being undertaken. Studies of transportation accidents for trucks transporting LH_2 have been obtained. Although some explicit data on accidents involving LH_2 transport exist, these data are limited. Therefore, shipment of other hazardous material by truck transport, such as gasoline and LNG, has been included. Because the importation of LNG is already underway, several safety studies and risk analyses for these systems have been analyzed for their relevance to LH_2 shipment.

An examination of accumulated data is being made to determine their suitability in a risk analysis. If appropriate, a risk analysis will be included in next year's program.

National regulation and standards on transportation and storage of bulk hydrogen have been accumulated and are being evaluated. Generally, most of

these cover flammable gases so that examination for pertinence to hydrogen is necessary. Presently we are accumulating in-house standards on hydrogen system design and operation that might be useful in improving existing regulations and in developing National standards.

The major materials problems of interest to hydrogen usage are hydrogen embrittlement and cold embrittlement. The latter problem is well understood, but the former needs further experimental and theoretical work. Contacts and visits with personnel working in this area have been made.

PLANS FOR NEXT PERIOD

The safety analysis will continue on LH_2 transportation by cryogenic trailer and gaseous hydrogen by pipeline. Review of existing regulations and in-house standards for application to hydrogen usage will also continue, as well as studies of hydrogen embrittlement. Solutions or recommendations for further studies will be made for potential problems identified in all of the above studies.

REPORTS PUBLISHED

F. J. Edeskuty, "Hydrogen Safety," in Transmission and Storage of Hydrogen, Hydrogen, Its Technology and Implications, Vol. II, Cox and Williamson, ed. (to be published).

PROJECTED MILESTONES

- March 31, 1977 -- Completion of initial liaison with Government and commercial contacts
- September 30, 1977 -- Identification of major technological problem areas
- October 1977 -- First annual report
- September 30, 1978 -- Analysis of specific problem areas and recommendations for solutions; commencement of analytical and experimental studies leading to effective solutions
- October 1978 -- Second annual report

* * *

ENERGY MATERIAL TRANSPORT, NOW THROUGH YEAR 2000: SYSTEM CHARACTERISTICS AND POTENTIAL PROBLEMS

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATORS

J. G. DeSteele
G. W. Dawson
P. L. Hendrickson
R. I. Smith

OBJECTIVES

The overall objectives of this project are to provide advanced warning of potential problems which may inhibit the safe and environmentally acceptable development of nuclear and fossil energy material transportation systems in the period now to year 2000 and to recommend research, development, and other necessary action to mitigate the potential adverse impact of these problems. The FY 1977 efforts address potential problems in nuclear, coal, petroleum, and natural gas transportation.

APPROACH

Information sources, including literature research, personal contact with experts, and participation in workshops and seminars are used as the basis

for characterizing energy material transportation systems and identifying issues. Issue analysis, along with the identification of system trends and change scenarios, leads to the identification of potential problems that could affect the transportation of energy materials. These problems are separated into two categories:

- Those which will probably be solved with the input of related program effort and
- Those which are not totally addressed by related program effort and which require additional attention.

Priorities will be suggested and recommendations for needed action will be made for problems in the second category.

PROGRESS AND RESULTS

Progress is reported in each task of this project. Effort in FY 1977 has resulted in the achievement of the following project objectives:

- An overview characterization to the year 2000 of energy material transportation for nuclear and fossil fuel systems;
- The identification of potential problems based on system characteristics and trends and the most probable scenarios of growth or change;
- The identification and assessment of Government and Industry programs which address the solution of the above potential problems; and
- The recommendation of additional research, development, and other necessary actions to address potential problems identified as needing attention.

PLANS FOR NEXT PERIOD

Plans for FY 1978 include the continuation of the basic task of this year's project and two new tasks addressing potential problems of transporting future fuel forms. An update effort is planned to continue nuclear, coal, petroleum, and natural gas studies with emphasis on changing system characteristics and multiple growth/change scenario development.

A new task is planned to review and identify potential problems in the anticipated future transportation of synfuels. An additional task will address potential transport problems associated with secondary materials such as reactants and treatment agents used in the primary fuel systems. Cross impact analysis of potential problems across commodity and modal lines is planned to identify the consequences.

REPORTS PUBLISHED

R. E. Rhoads, "An Overview of Transportation in the Nuclear Fuel Cycle," BNWL-2066, Battelle, Pacific Northwest Laboratories, May 1977.

PROJECTED MILESTONES

- A revised draft of the nuclear task report containing a section with concern packages and recommendations
- September 1977 -- Drafts of the milestone fiscal year summary reports for coal, petroleum, and natural gas transportation systems

* * *

ASSESSMENT AND APPLICATION OF ENDOCHRONIC PLASTICITY FOR THE DYNAMIC ANALYSIS OF ENERGY MATERIALS SHIPPING CONTAINERS

ORGANIZATION AND CONTRACT NUMBER

Argonne National Laboratory
W-31-109-ENG-38

PRINCIPAL INVESTIGATORS

R. A. Valentin
H. C. Lin

OBJECTIVES

The major objective of this project is to evaluate the suitability of the endochronic theory of plasticity for use in the design and risk assessment of energy materials shipping containers. This evaluation will determine whether an endochronic description of the dynamic response of structural materials can improve the accuracy and efficiency of predictions of the dynamic response of energy material shipping containers subjected to high transient loads. A positive assessment will be followed by development of detailed design methods and their testing and validation in terms of existing experimental evidence on shipping container response.

APPROACH

The evaluation phase of this program will be performed using an existing finite element computer program, suitably modified to accept a material description in terms of endochronic plasticity theory. The resulting small-strain, large displacement shell code will be applied to a series of reference problems which, when compared to available experimental evidence and to comparable solutions based on classical plasticity, will form the basis for evaluation. To ensure that this evaluation is relevant to current design practice and is consistent with existing

knowledge on the response of energy materials shipping containers, contact will be maintained with ongoing DOE programs on analysis and model and prototype testing of such containers.

PROGRESS AND RESULTS

This activity was initiated in the last quarter of FY 1977 and, hence, only the very start of the indicated evaluation phase is complete. Preliminary modifications of the finite element shell code have been tested and a small number of comparison problems have been examined. Early results indicate that the endochronic theory, when compared to classical plasticity, appears to give somewhat "softer" dynamic response in that the predicted dynamic displacements are slightly larger.

PLANS FOR NEXT PERIOD

The initial activity of the next fiscal year will be completion of the modified endochronic plasticity finite element code and its verification against experimental data and existing exact solutions in dynamic plasticity. This will be followed by calculations using the geometry and loading conditions typical of those encountered in the design and analysis of shipping containers. Sufficient data should then be available to complete the evaluation of endochronic plasticity theory and provide quantitative evidence of its advantages and disadvantages in typical application.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

The major milestone for the next fiscal year will be preparation and issue of an evaluation report giving in detail the results of the various calculations, comparisons with experiment, and conclusions concerning the utility of endochronic plasticity for predicting the dynamic response of shipping containers. This evaluation report will be completed by September 1978.

* * *

DEVELOPMENT OF ANALYTICAL METHODS FOR ACCIDENT DAMAGE ANALYSIS OF TYPE B PACKAGES

ORGANIZATION AND CONTRACT NUMBER

Los Alamos Scientific Laboratory
W-7405-ENG-36

PRINCIPAL INVESTIGATOR

T. A. Butler

OBJECTIVES

The objective of this overview and assessment is to develop analytical methods that will efficiently and accurately predict the response of nuclear energy material shipping containers to impact accident conditions.

APPROACH

Theoretically exact solution techniques for container accident problems do not exist, primarily because of difficulties in mathematically modeling the container geometric configurations and the non-linear behavior of the container materials under the accident conditions. The Los Alamos Scientific Laboratory approach is to use approximate analytical methods utilizing computer programs to provide realistic, yet inexpensive predictions of container response.

PROGRESS AND RESULTS

A two-dimensional mathematical model that predicts container response to end-on impact accident conditions has been developed during the past year. The computer program that solves the equations of motion is designed to be economical and easy to use while yielding accurate results. Thus it meets the needs of Government and industry as a tool with which to perform parametric and sensitivity studies on variables influencing container response to impact conditions.

The finite element method is used to develop the mass and nonlinear stiffness matrices for the basic container component (Figure 33). An eight-node isoparametric element formulation is used to simulate the shielding, impact limiter, and target. A three-node isoparametric element is used to simulate the cylindrical shells and circular end plates. Non-linear springs simulate a "stick-slip" interface be-

Figure 33. Basic Shipping Container Components

tween the shielding and shell components. A preprocessor automatically creates the finite element mesh with the appropriate interfaces between the shielding material and other container components.

Strain data from a series of tests performed by Battelle Columbus Laboratory have been used to ensure that all important phenomena are accounted for in the model. The same test data are being used to verify the model accuracy.

In a related task, the response of a container mounted on a railcar has been analytically determined for several cases of the railcar striking a stationary train. Computer tie-down loads were also determined. The responses were computed for various tie-down stiffnesses, impact velocities, and container weights.

The mathematical model used to compute container response allows (1) for elastic longitudinal motion of the railcar and container and (2) for rigid body vertical translation and pitch of the container relative to the railcar. The tie-down system is represented by a nonlinear spring. Viscous damping is included for the tie-down members and the railcar coupler.

Results to date, some of which are shown in Figure 34, indicate that vertical acceleration of the container and the overturning moment acting on it are important parameters in designing tie-downs. Also, forces acting on the containers are significant, and further studies should be performed to determine the effects on the container itself.

Figure 34. Railcar and Container Response to High-Speed Coupling

PLANS FOR NEXT PERIOD

To make the two-dimensional, end-on container model more accurate for a wider range of containers, several features will be added. These will include the ability to consider liquid coolants, axisymmetric stiffening rings, and state-of-the-art material consti-

tutive equations. A parametric study will be performed to determine container response when striking realistic impact targets using the two-dimensional model coupled with deformable targets.

To study response of containers striking targets at various orientations, a simplified three-dimensional container model will be developed. Response will be determined for both initial and secondary impacts. The response of an actual container to exposure to a 1475°F fire for 30 minutes will be computed.

An extensive literature assessment will be performed to determine methods currently available to evaluate container resistance to puncture. This will include the container response to projectiles of various geometries striking with varying amounts of kinetic energy.

REPORTS PUBLISHED

The following reports were written by J. Counts and J. B. Payne and published by Los Alamos Scientific Laboratory, January 1977:

- "Evaluation of Analysis Methods for Type B Shipping Container Impact Problems," Report No. LA-6642-MS.
- "Comparison of Predicted and Measured Drop Test Responses of Type B Shipping Containers," Report No. LA-6642-MS.
- "IMPAC2-A Lumped-Mass Nonlinear Spring Computer Program to Analyze Type B Shipping Container Impact Problems," Report No. LA-6643-MS.

PROJECTED MILESTONES

- October 1977 -- "CRASHC -- A Two-Dimensional Code to Compute the Response of Axisymmetric Containers to End-On Impact"
- October 1977 -- "Cargo Response to Railcar Impact and Tie-down Loads Analysis"
- October 1978 -- Final Report on "CRASHC..." (see above)
- October 1978 -- "Response of a Two-Dimensional Shipping Container Model Couples with Deformable Targets"
- October 1978 -- "Response of a Shipping Container During Initial and Secondary Impact When Striking Targets at Arbitrary Orientations"

* * *

REVIEW CRITERIA FOR NUCLEAR CRITICALITY SAFETY EVALUATION FOR TRANSPORTATION OF FISSILE MATERIALS

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge National Laboratory
W-7405-ENG-26

PRINCIPAL INVESTIGATOR

J. T. Thomas

OBJECTIVES

The objectives of this project are to examine the margin of subcriticality of arrays of packages as utilized in transportation of fissile materials and to determine the magnitude of reactivity associated with changes in (1) mass and form of fissile material contained in packages, (2) array reflector from water to concrete, and (3) geometric shape of the arrays. In addition, the reactivity change will be related or expressed in terms of common factors of safety, e.g., number of packages and/or mass loading per package. The factors of safety inherent in the transportation criteria will be defined and determined.

APPROACH

Margins of subcriticality will be established by calculational methods satisfying the requirements of the American National Standard Validation of Calculational Methods for Nuclear Criticality Safety, N 16.9-1975. Critical experiments with various types of insulating materials performed at the Oak Ridge Critical Experiments Facility and reported in 1972 will be used as benchmark experiments in the validation procedure.

PROGRESS AND RESULTS

Calculation of the benchmark experiments were performed with KENO IV, an Improved Monte Carlo Criticality Program. The Hansen-Roach sixteen group neutron cross section sets were used. The results are in good agreement with the experimental data.

Department of Transportation Specification 6 M packaging criteria were used to describe container material parameters and configurations. The cane fiberboard insulating material Celotex was initially studied. Uranium metal containing 93.2 wt percent uranium-235 was utilized as the fissile material in the form of right circular cylinders. The mass loading required to establish criticality was determined as a function of container volume and number of packages in arrays reflected by water and by concrete. The reactivity associated with the addition of insulating material, introduced alone, increases the array reactivity while the successive addition of the inner container of steel and then the outer container of iron cause a decrease in the array reactivity. The effect of concrete as a reflector substituted for water is to increase the reactivity by about 18

percent in k_{eff} for uncontained fissile material and by about 6 percent for packaged fissile materials. Further, the reflector effect diminishes as the number of packages in the array increases and ultimately, under the constraint of criticality, a mass loading can be specified that results in a class I package for these container materials.

Preliminary calculations characterizing the introduction of Foamglas into arrays of air-spaced units have been completed. Neutron coupling of packages with this material as an insulator is greater and results in smaller mass loadings than is the case with Celotex of the same thickness. The reflector effect on arrays of these packages will be greater than observed for the Celotex packages, but not as great as with arrays of uncontained fissile materials.

PLANS FOR NEXT PERIOD

Complete the characterization of the influence of packaging materials on the criticality of arrays reflected by water and by concrete. Examine the effect of different fissile materials on the array reactivity. Apply the nuclear criticality safety criteria of 10 CFR 71 and determine the magnitudes of reactivity associated with both explicit and implicit safety factors contained in the evaluation procedure.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- November 1977 -- Calculations performed with Celotex container will be reported at the Meeting of the American Nuclear Society.
- May 1978 -- A preliminary report of the results of the study will be made at the Fifth International Symposium of Packaging and Transportation of Radioactive Materials
- End FY 1978 -- Final report on study findings and recommendations will be published

* * *

TESTING OF LARGE OBSOLETE CASKS

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge National Laboratory
W-7405-ENG-26

PRINCIPAL INVESTIGATORS

R. D. Seagren	J. H. Evans
W. D. Box	R. C. Muller

OBJECTIVES

Current Federal regulations require DOE's large radioactive materials shipping containers (casks) to survive a 30-foot (9-meter) drop onto an essentially unyielding surface in the orientation for which the most damage is expected. The objectives of this overview and assessment task are (1) to experimentally determine if casks can satisfy these regulations without sustaining damage that would release radioactivity to the environment and (2) to demonstrate that scale model tests and analytical techniques developed by other Environmental Control Technology overview and assessment contractors can be confidently used in place of expensive full-scale drop tests.

APPROACH

Retired casks that are reasonably similar in materials and construction to modern shipping containers are available at modest cost. Drop tests of instrumented casks provide records of strain history and experimental information on damage to seal and closure designs as well as an indication of the type (e.g., gas, liquid) and amounts of activity that might be released if loss of containment should occur.

The tests provide engineering data on the behavior of these casks under severe accident conditions and consequently provide information necessary to substantiate mathematical models for predicting cask damage and, more importantly, potential survivability. Release of radioactive materials to the environment which might occur in an extremely severe accident is most likely through the seal area of the cask. This program provides experimental information on the advantages and/or disadvantages of particular seal and closure designs as well as an indication of the type (e.g., gas, liquids) of activity and amount which might be released if loss of containment should occur.

PROGRESS AND RESULTS

Construction of the new drop test pad (see Figure 35) at the Tower Shielding Facility (TSF) was started in April and completed in July. This is the "essentially unyielding surface" for use in the 9-meter drop tests in the Obsolete Cask Testing Program. The reinforced-concrete, armor-plate structure is in the shape of a truncated Aztec pyramid. There are 550 metric tons of concrete and 64 metric tons of armor plate in the structure. The TSF hoisting equipment can lift loads up to 100 metric tons to a height of 9 meters. This is the largest installation of its kind in the free world that complies with International Atomic Energy Agency (IAEA) testing requirements.

Twenty-eight channels of FM recording equipment were installed and checked out for the next series of tests. Two retired Knapp Mills spent-fuel casks were purchased and are being decontaminated in preparation for testing.

Figure 35. Construction of New Drop Test Pad

PLANS FOR NEXT PERIOD

One of the Knapp Mills casks and the Los Alamos Scientific Laboratory uranium-shielded casks will be tested. These casks will be dropped on their closures and on other vulnerable areas such as drain plugs and thermowells. A detailed test plan will be written and tailored to each cask.

REPORTS PUBLISHED

L. B. Shappert et al., "The Obsolete Cask Program: End-On Drop Tests With and Without an Impact Limiter and the 40-Inch Puncture Test," ORNL/TM1312, Vol. 19, June 1977.

L. B. Shappert et al., "The Obsolete Cask Test Program, HWCTR Cask Oblique and Center of Gravity Drop Tests," ORNL/TM-1312, Vol. 17, September 1977.

PROJECTED MILESTONES

- Second Quarter FY 1978 -- Drop Tests and Leak-Tightness Tests of Knapp Mills Cask With Instrumented Fuel Element and With and Without Impact Limiter
- Fourth Quarter FY 1978 -- Drop Tests of LASL Uranium Shielded Cask

* * *

TRANSPORTATION SAFETY STUDIES

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATORS

R. E. Rhoads
J. F. Johnson
H. K. Elder

OBJECTIVES

In order to ensure adequate protection of man and the environment in the transport of energy material, it is necessary to understand the safety and potential environmental effects of the shipments of energy materials, both in normal transport and under accident conditions. The objective of the Transportation Safety Studies Project is to assess these potential effects in terms of risk. Risk is defined as the probability that an undesirable event will occur, multiplied by the type and degree of consequences.

APPROACH

An analysis method has been developed that can be used to systematically evaluate the risks in the shipment of various energy materials. This method can also be used to

- Provide information to assist in determining the acceptability or unacceptability of the risk,
- Identify the principal factors controlling the risk in order to provide a basis for the selection of corrective or preventive action should the risk be judged unacceptable,
- Permit comparison of overall transportation risks between different energy systems, and
- Permit comparison of the risk in energy material transport with that of other commonly shipped hazardous materials (e.g., chlorine, pesticides).

Risk assessments are performed by comprehensive investigation of all the relevant system parameters (packaging or container characteristics, transportation accident characteristics, shipment activity, etc.) using a consistent methodology. An added advantage of such an approach is that it inherently identifies areas where sufficient data are not available to fully understand the system safety, thus providing for additional studies within or outside the Transportation Branch.

PROGRESS AND RESULTS

During the past year, a number of energy material transportation risk assessments have been carried out. Work is continuing as planned in six major areas.

- Nuclear Fuel Cycle Materials Shipment Risk Assessments,
- Fossil Energy Materials Shipment Risk Assessments,
- Fusion Energy Materials Shipment Risk Assessments,
- Shipment Security Studies,
- Special Projects, and
- Analysis Methods and Computer Code Development.

Final reports on the risk assessments of shipping plutonium dioxide and plutonium nitrate by rail and plutonium dioxide by cargo aircraft were issued during the current fiscal year. These two studies complement an earlier study in this project that assessed the risk of shipping plutonium dioxide and plutonium nitrate by truck. The results of all three studies are compared in Figure 36. The studies indicate that shipping plutonium by truck and rail involve similar risks, and that shipping similar amounts of plutonium by cargo aircraft would produce a higher (although still low) risk.

A draft report on the risk assessment of the shipment of uranium hexafluoride (UF_6) by truck and rail was also completed. The results of the study are shown in Figure 37. It was found that while UF_6 is a radioactive material, the risk from accidents involving containers of UF_6 result primarily from the toxic hydrogen fluoride gas released when a spill of UF_6 reacts with water vapor in the atmosphere.

An assessment of the risk of shipping gasoline by truck was completed and released in draft form early this fiscal year. The results and risk comparison are shown in Table 8. The study showed that the use of stronger tanks, or the installation of onboard fire suppression systems on gasoline-tank trucks could reduce the risk if the current risk levels are judged unacceptable.

Two activities were carried out in the area of Special Projects. The first was a preliminary investigation of the consequences of the loss of a spent fuel cask or a plutonium shipping package at sea. A draft report was prepared and circulated for comments. Parallel work is being carried out by the Japanese, and both countries are benefiting by the sharing of information. The second special project

Figure 36. Comparison of Plutonium Shipment Risks with Other Risk Spectra

Figure 37. Comparison of UF_6 Risk Spectrum Shipment with Other Risk Spectra

Table 8. Comparison of Individual Risk from Various Accidents and Natural Disasters with Risks from Gasoline-Tank Truck Accidents

Accident Type	Total Fatalities	Individual Risk Per Year
All Accidents	115,821	1 in 2,000
Motor Vehical Accidents	55,511	1 in 4,000
All Industrial Accidents*	14,100	1 in 6,000*
Falls	16,506	1 in 13,000
Drowning	7,152	1 in 29,000
Fires	6,503	1 in 32,000
Poisoning	5,335	1 in 40,000
Airplane Crashes	1,668	1 in 130,000
Railway Accidents	789	1 in 250,000
Lightning	160	1 in 1,300,000
Tornadoes	90	1 in 2,300,000
Gasoline-Tank Truck Accidents	60	1 in 3,500,000

*Only workers included in population at risk.

was a resurvey of the receivers of plutonium shipping containers to determine the conditions of plutonium packages during transport. This project was undertaken to determine if new regulations had changed the results of a similar survey conducted in 1974 in conjunction with the risk assessment of the shipment of plutonium by truck. Preliminary results of the resurvey indicate that the number of nonstandard packages shipped has decreased as a result of the new regulations.

In addition to the studies completed and described above, a risk assessment of the shipment of spent fuel by truck was initiated during this fiscal year. This risk assessment is nearing completion. A draft report is expected to be issued for comment during the first quarter of FY 1978.

PLANS FOR NEXT PERIOD

In addition to the completion of current studies, a number of new risk assessments will be made. The risks of the shipment of spent fuel by rail will be studied, and the truck and rail shipment of propane will be analyzed. The safety issues related to the increasing number of shipments of coal by rail will also be examined. An assessment of the risk of shipping chlorine by rail will be completed as a special project.

Two new areas will be examined during the next fiscal year. Shipment security studies will consider the security aspects of the transportation of energy materials and their relationship to transportation safety. Initial efforts will concentrate on nuclear fuel cycle shipments. In addition, studies will be made to incorporate economic risks into the risk assessment model. Currently, only health effects are considered.

REPORTS PUBLISHED

R. J. Hall, "An Assessment of the Risk of Transporting Plutonium Dioxide and Liquid Plutonium Dioxide and Liquid Plutonium Nitrate by Train," BNWL-1996, Battelle, Pacific Northwest Laboratories, February 1977.

T. I. McSweeney and J. F. Johnson, "An Assessment of the Risk of Transporting Plutonium Oxide by Cargo Aircraft," BNWL-2030, Battelle, Pacific Northwest Laboratories, June 1977.

R. E. Rhoads, "An Assessment of the Risk of Transporting Gasoline by Truck," BNWL-2133, Battelle, Pacific Northwest Laboratories, November 1976 (draft).

S. W. Heaberlin, et al., "Consequences of Postulated Losses of LWR Spent Fuel and Plutonium Shipping Packages at Sea," BNWL-2093, Battelle, Pacific Northwest Laboratories, December 1976 (draft).

S. W. Heaberlin, "Evaluation of the Consequences of LWR Spent Fuel and Plutonium Shipping Package Loss at Sea," IAEA-SR-10/14.

R. J. Hall and L. D. Williams, "Risk of Transporting Plutonium Dioxide and Liquid Plutonium Nitrate by Truck and Rail," IAEA SR-10/13.

J. Mishna, "Potential Aerosol Generation Mechanisms from Damaged Shipping Packages," IAEA-SR-10/15.

R. J. Hall and J. F. Johnson, "The Usefulness of the Risk Assessment Technique in Solving Transportation Problems," BNWL-SA-5947, (Presented at the 56th Annual Meeting of the Transportation Research Board, National Academy of Sciences, Washington, D.C.), January 1977.

J. F. Johnson, "An Assessment of the Risk of Transporting Uranium Hexafluoride by Truck and Rail," BNWL-2211, Battelle, Pacific Northwest Laboratories, September 1977 (draft).

PROJECTED MILESTONES

- First quarter FY 1978 -- Issue draft report on the risk assessment of shipping spent fuel by truck
- First quarter FY 1978 -- Issue final report on the resurvey of the condition of plutonium shipping packages during transport
- First quarter of FY 1978 -- Issue final report on the risk of shipping gasoline by truck
- Second quarter FY 1978 -- Issue recommendations for future efforts in shipment security studies
- Second quarter FY 1978 -- Issue draft report on the risk of shipping chlorine by rail
- Third quarter FY 1978 -- Issue final report on the risk of shipping spent fuel by truck
- Third quarter FY 1978 -- Issue final report on the risk of shipping UF₆ by truck and rail
- Third quarter FY 1978 -- Incorporate economic risks in risk assessment model
- Fourth quarter FY 1978 -- Issue draft report on the risk of shipping spent fuel by rail
- Fourth quarter FY 1978 -- Issue draft report on the safety issues of increased coal shipments by rail
- Fourth quarter FY 1978 -- Issue draft report on the risk of shipping propane by truck and rail
- Fourth quarter FY 1978 -- Issue final report on the risk of shipping chlorine by rail

* * *

PACKAGE FAILURE FROM MALEVOLENT ATTACK

ORGANIZATION AND CONTRACT NUMBER

Sandia Laboratories
AT(29-1)-789

PRINCIPAL INVESTIGATORS

R. B. Pope   M. J. Forrestal
L. A. Suber

OBJECTIVES

This program provides a comprehensive study of the failure modes of protective packages for radioactive material subjected to malevolent attack and of the consequences to the public which may result from postulated attacks on nuclear transportation systems. Where the objective of the attack is to cause a dispersal incident, the potential of occurrence of events which would cause harm to the public can be minimized (1) by understanding cask breaching mechanisms and dispersal consequences of different attacks and (2) by rendering existing and future casks inherently more resistant to such attacks.

APPROACH

With the object of establishing modeling techniques as a workable approach to testing large shielded containers, explosives tests were conducted on both obsolete spent fuel shipping casks and models thereof. Modeling correlation was excellent for those explosive tests involving bulk charges in contact with the cask surface, large platter charges, and two large shaped charges. In the air blast tests where correlation between full scale and models was not obtained in the previous year's testing, the scaling parameters were investigated to determine the source of the discrepancy. Results indicated that the explosive was not amenable to modeling because of erratic behavior in small quantities.

PROGRESS AND RESULTS

Radioactive material packages with authorized contents in excess of strategic quantities were categorized according to structural characteristics and contents. Packages representative of the categories were identified. Adversary simulation was done to show that the only significant malevolent attacks on the packages in their transportation environment are those which involved explosives.

Possible analytical techniques for predicting the results of explosive attacks on containers were investigated and found to be inadequate for all but extremely simplified cases. Current spent fuel casks were examined and representative designs were selected for modeling and testing.

A few tests on scale models of the obsolete cask were conducted to finish the test matrix for this portion of the program. All the work through this point in the program is being reported in a final report for this phase.

PLANS FOR NEXT PERIOD

In preparation for the next phase of the effort, scale models which incorporate attack-resistant features will be designed and fabricated. The vulnerability of these different designs will be studied. Results will provide a basis for decisions on protection to be afforded various containers in transport and lend weight to suggested design upgrades to improve attack resistance of packages. The ultimate result would be an identification of methods for improving the safety of the transportation of radioactive materials.

REPORTS PUBLISHED

"Package Failure from Malevolent Attack-- Summary Report through December 1976," SAND 77-0810, Report CNSI, Sandia Laboratories, November 1977 (review draft).

PROJECTED MILESTONES

Program definition and milestones for FY 1978 are still being defined.

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STUDY OF PHYSICAL PARAMETERS OF TRANSPORTATION ACCIDENTS

ORGANIZATION AND CONTRACT NUMBER

Sandia Laboratories
AT (29-1)-789

PRINCIPAL INVESTIGATORS

R. B. Pope
T. G. Priddy
A. W. Dennis
J. T. Foley
W. F. Hartman
D. W. Larson
J. D. McClure

OBJECTIVES

The objective of this task is to extend the work reported in "Severities of Transportation Accidents" (SLA 74-0001), to describe the accident environment to which large shipping casks may be exposed and, in addition, to describe the marine transport accident environment. These basic environmental descriptions are required to determine (1) the risk of shipping radioactive material and (2) the preparation of environmental impact statements.

APPROACH

The basic approach used in this type of study has been to search historical records for the details of railroad, highway, and marine transport accidents.

From this data base, a description or profile of the various accident types can be formed. Monte Carlo methods are sometimes used to describe the multi-variable data base which described these accidents. From this type of analysis the probability of occurrence of selected environmental parameters can be determined.

PROGRESS AND RESULTS

The basic study for accident environments involving large shipping casks was completed in FY 1977. A draft report has been written and is being prepared for distribution as a review copy. Three copies of the draft report have been forwarded to the DOE Office of Environmental Control Technology.

The investigations for marine transport accidents are still being performed and a report of the results of this study is scheduled to be published at the end of the second quarter FY 1978.

PLANS FOR NEXT PERIOD

The final report for the surface transport (truck, rail) of large shipping casks (SAND 77-0001) is scheduled for completion at the end of FY 1977. Some final editing and incorporation of review comments may be required during the first quarter of FY 1978. The publication of the report on the severity of marine transport accidents (barges and freight vessels) is scheduled for mid-FY 1978. The investigation of the effects of potential and promising controlled transportation operations on the reduction of the probability of severe accidents will be commenced in FY 1978.

REPORTS PUBLISHED

"Severities of Transportation Accidents Volumes 1-4," SLA 74-0001, Sandia Laboratories, July 1976.

"Risk Assessment of ERDA Nuclear Weapons," ERDA 77/10, January 1977.

"Risk-Based Criteria for Certification of Packages for Air Shipment of Plutonium," SAND 77-1313, Sandia Laboratories, September 1977.

"Severities of Transportation Accidents Involving Large Packages," SAND 77-0001, Sandia Laboratories, April 1977 (review draft).

"Analysis of Current Qualification Test Standards Used for Licensing Radioactive Material Shipping Packages," SAND 76-0708, Sandia Laboratories, September 1977 (review draft).

PROJECTED MILESTONES

- First and second quarter 1978 -- Analysis of waterway transport environment
- Second Quarter 1978 -- Final report on waterways
- Third and Fourth Quarter 1978 -- Analysis of effect of administrative controls
- Each quarter 1978 -- Quarterly reports

* * *

FULL SCALE VEHICLE TESTING PROGRAM

ORGANIZATION AND CONTRACT NUMBER

Sandia Laboratories
AT(29-1)-789

PRINCIPAL INVESTIGATORS

R. B. Pope	C. M. Stone
H. R. Yoshimura	R. H. Nilson
M. Huerta	A. W. Dennis

OBJECTIVES

The primary objective of this destructive test program is to assess and demonstrate the validity of DOE's analytical and scale modeling techniques for assessing the safety of hazardous material packaging systems under extreme accident conditions. Secondary objectives of this program are to gain scientific knowledge of the extreme accident environment and to provide a means of demonstrating the response of full scale shipping containers and vehicular systems to extra severe transportation accident conditions. These tests are not intended to prove or disprove the validity of the present regulatory standards.

APPROACH

Sandia approached this full scale test program in three separate phases:

1. Mathematical analysis,
2. Scale model testing, and
3. Full scale tests.

Once the accident scenarios were chosen, the accident environment to which the cask transport system would be subject was analyzed by both static and dynamic structural analyses.

The second phase of the program used scaling techniques to assess the damage to the container and transport systems in 1/8 scale. Structurally adequate models of the cask and transport system were constructed and subjected to scaled crashes under existing and well-established scaling laws. Scale model test results were then correlated with the analytical studies.

Full scale confirmatory testing was the final phase of the program.

PROGRESS AND RESULTS

In January and March 1977, tests were conducted which involved full scale truck-cask systems impacting head-on into a massive concrete abutment (see Figures 38, 39, and 40) at speeds of 97 and 135 kph (60 and 84 mph, respectively). Two months later, in May, a grade-crossing test was conducted which involved a 131-kph (81-mph) impact of a locomotive into a truck-mounted cask stalled at a simulated grade crossing (see Figures 41 and 42). The

Figure 38. Full-Scale Truck Cask Test - 84 mph - Pretest Conditions

Figure 39. Full-Scale Truck Cask Test - 84 mph - Test Conditions

Figure 40. Full-Scale Truck Cask Test - 84 mph - Post-Test Conditions

Figure 41. Full Scale Grade Crossing Test - 81.5 mph - Test Conditions

Figure 42. Full-Scale Grade Crossing Test - 81.5 mph - Post-Test Cask Conditions

last test in this series, which involved the impact of a special railcar, was carried out in September 1977 (see Figures 43 and 44). This test is to be followed by a pool fire test several months later.

In reviewing the progress of the test program to date, the objectives of the program have been met successfully. It has shown that current analytical and scale modeling techniques can be used to conservatively predict vehicular and cask damage in extremely severe accident environments. In addition, there has been much data collected during the tests on the response of transport systems. Furthermore, these tests have shown that the tested spent fuel shipping casks are extremely rugged containers which can survive extremely severe accidents without failure.

PLANS FOR NEXT PERIOD

The final test of the series which involves the crashed railcar and cask in a pool fire will be conducted in early FY 1978. In addition, a proposed (propane) torching test on the rail cask is planned. This test may be conducted at Sandia or at the Department of Transportation Railroad Test Facility in Pueblo, Colorado. A comprehensive program review of the full scale tests conducted to date and future plans will be performed.

REPORTS PUBLISHED

H. R. Yoshimura, "Full Scale Vehicle Testing Program," Transportation Research Board 55th Annual Meeting, Washington, D.C., 1976.

H. R. Yoshimura and M. Huerta, "Full Scale Tests of Spent-Nuclear-Fuel Shipping Systems," Transport Packaging for Radioactive Materials, IAEA-SR-10/17, Vienna, Austria, August 1976.

M. Huerta and H. R. Yoshimura, "Impact Analysis of Nuclear Spent Fuel Shipping Casks," paper presented at the CUBE Symposium, Sandia Laboratories, August 1976.

H. R. Yoshimura, "Full Scale Tests of Spent Fuel Shipping Systems," ANS Winter Meeting, San Francisco, California, November 1976.

R. M. Jefferson, "Full Scale Transportation Test Program," Nuclear Engineering International, Vol. 22, No. 260, p. 59-61, July 1977.

PROJECTED MILESTONES

- Second quarter 1978 -- Conduct pool fire test of rail cask
- Third quarter 1978 -- Conduct torching test of rail cask (tentative)
- Fourth quarter 1978 -- Complete program review and final report

* * *

STRUCTURAL RESPONSE OF SHIPPING CONTAINERS UNDER ACCIDENT CONDITIONS

ORGANIZATION AND CONTRACT NUMBER

Battelle Memorial Institute
W-7405-ENG-92

PRINCIPAL INVESTIGATOR

R. A. Robinson

OBJECTIVES

The scope of work covered in this overview and assessment experimental scale model program is the collection of data on the structural response of spent fuel and high-level waste energy material shipping

Figure 43. Railcar Impact - Pretest Condition

Figure 44. Railcar Impact - Post-Test Condition

container systems to assess the effects of accident environments on safety and potential environmental consequences. The immediate purpose of the experimental plan is to (1) assess the effects of accident conditions on the structural response of spent fuel and high-level waste containers and (2) provide information for computer code correlation for codes being developed by other Environmental Control Technology (ECT) contractors to analyze shipping container accident conditions.

APPROACH

Transportation of nuclear energy material shipping containers has, for many years, been conducted in carefully engineered casks or shipping containers. As the size, heat rating, and complexity of these systems have increased, so have the demands on engineering design and analysis. Broadly speaking, the technical areas which must be evaluated for safety assessment are criticality, shielding, thermal, and structural. The criticality, shielding, and thermal assessments are relatively well established in terms of approaches to analysis and computer codes which have been well benchmarked. This is not yet the case for structural analysis -- particularly in the area of dynamic loading. There are no generally acceptable techniques for analysis in this area, although many data are available, and there are simplified computer codes that may be used to approximate certain types of hypothetical impact accidents.

The approach used in this program is to conduct a few carefully selected experiments for specified container accident conditions and simulated environments. The containers used in the present experiments are replica scale models of typical spent fuel and high-level waste shipping casks. These experiments are being closely coordinated with other ECT contractors to provide baseline data for correlation of the computer codes being developed there.

The tasks planned in this program to accomplish the overall objective of assessment of safety and environmental issues are the following:

- Engineering and analysis to determine relevant parameters, proper scaling criteria, and scale model design.
- Experimentation with scale models to assess dynamic accident response modes of containment shells, shielding, and radioactive contents. The models will simulate SS/Pb, SS/U, impact limiter systems, and spent fuel elements. The experiments will include effects of geometry, temperature, impact direction, thermal stresses, and containment seals. Materials property tests will be performed on conventional testing machines for certain of the selected model materials where such information is not available.
- Analyze and make pre- and post-test analyses of the scale model experiments

with sophisticated structural computer codes to allow timely experimental planning and provide an analytical comparison for the simpler and more efficient design codes being developed by other ECT contractors, when appropriate. Typical of the type of dynamic structural codes that will be used in this task of the program are MARC, ANSYS, and ADINA. All of these codes allow a 3-D, finite element, dynamic treatment of impact accidents with nonlinear material behavior and nonlinear interface/boundary conditions.

- Liaison with related Government programs to utilize Battelle Memorial Institute experimental data to corroborate computer code development, to refine risk assessment, to aid in interpretation of full-scale obsolete cask experiments, and to provide documentary film production.

PROGRESS AND RESULTS

Distorted, replica-scale models of a typical, legal-weight, spent fuel truck cask were designed in 1/8, 1/4, and 1/2 linear scale sizes. Only the primary containment vessel, lead shield, and lead containment vessel were simulated. Fabrication of the models was completed and a test matrix was developed for a series of 30-ft free fall drops at temperatures in the range of -40°C to 175°C (see Figures 45, and 46). Experiments were conducted to provide minimum coverage of the variable of interest. Figures 47 and 48 show the instrumentation package and a test in progress.

A series of 1-ft drop tests were conducted with 1/8 and 1/4 scaled containment vessel shells to determine instrumentation capability, scaling verification, and impact surface effects on induced elastic strains and to provide benchmarking data for computer code development.

PLANS FOR NEXT PERIOD

The effort in FY 1978 will continue with replica scale model design, fabrication, and testing. Depleted-uranium shielded models will be used. The experimental data obtained with the lead-shield scale models will be supplied to other ECT contractors and documented and distributed as a topical report.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- January 1978 -- Issue topical report on SS/Pb model experiments with LASL and BCL computer code predictions
- October 1978 -- Complete SS/U model experiments to obtain effects of tempera-

Figure 45. PB/SS Model (1/2 scale) Ready for 30-ft Bottom Impact at -40°C

Figure 46. PB/SS Model (1/8-Scale) Prepared for High Temperature (260°C) Dynamic Impact Test

Figure 47. PB/SS Model (1/8-Scale) with Auxiliary Instrumentation for Dynamic Impact Measurements

Figure 48. Impact Test

ture, impact angle, impact limiters, thermal induced stresses and dynamic loads and provide results to other ECT contractors

- October 1978 -- Complete complex structural computer analyses of all SS/U model data
- January 1979 -- Issue topical report on SS/U model experiments and computer code comparisons with other ECT contractors
- FY 1979 -- Conduct experiments on spent fuel rod response, containment seal leakage, puncture, and impact limiters with both SS/Pb and SS/U scale models
- January 1980 -- Issue topical reports on data obtained

* * *

TRANSPORTATION ACCIDENT ENVIRONMENTAL DATA BANK

ORGANIZATION AND CONTRACT NUMBER

Sandia Laboratories
AT(29-1)-789

PRINCIPAL INVESTIGATORS

R. B. Pope
J. T. Foley
C. A. Davidson

OBJECTIVES

Under this program, a centralized source of environmental information is provided for use by organizations engaged in risk assessment, testing, and evaluation of standards for programs involving the transportation of energy materials. Information generated is analyzed, summarized, and disseminated to potential users. Emphasis is placed on obtaining the latest information, ensuring comprehensive coverage of transportation applications, and publicizing the existence of the information. Such information is provided on a cooperative basis to other Government agencies, industry, and, when appropriate, to foreign nations.

APPROACH

The purpose of this activity is to respond to identified data needs by either collecting data available from other sources or by obtaining data not available and then to properly analyze the data for inclusion in the data store. The Environment Data Acquisition Systems developed by Sandia Laboratories, which have been used in the past at the

request of DOE/ECT, would be used to obtain new data.

The collection of needed data for different modes of transport and better methods of analyzing and summarizing the data will be emphasized.

A study of DOE transportation accident environment data needs, identification of potential sources, and recommendations concerning improvements in accident data reporting which would be required to provide useful engineering information is in progress.

Consideration will be given to sponsoring one or more workshops in the effective operation and utilization of the Transportation Environmental Data Center - bringing the information to the user and obtaining input from the user to improve the Center and its content.

PROGRESS AND RESULTS

This work is a continuation of the Environmental Engineering Information Collection/Dissemination Activity (previously known as the Environmental Data Bank) conducted under the auspices of DOE/ECT since 1975. A large collection of environmental data has been gathered, evaluated, catalogued, and placed in repository for ready access by individuals involved in engineering analyses of transportation systems. The information can be obtained by any qualified user upon request, following specified procedures. There will be a continuing effort to participate in technical symposia and to publish transportation environmental information in technical journals.

REPORTS PUBLISHED

J. T. Foley and C. A. Davidson, "Transportation Environment Data Index," SAND 75-0248, Sandia Laboratories, April 1977.

PROJECTED MILESTONES

Information collected under this program has been and is being used as the prime source for studies of normal and accident transportation environments, in truck, train, aircraft, and ship modes of transport. The index to this work is updated quarterly and information is added to the program as it becomes available.

* * *

DOE-WIDE TRANSPORTATION STATISTICS DATA BANK

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge National Laboratory
W7405-ENG-26

PRINCIPAL INVESTIGATOR

W. E. Foster

OBJECTIVES

The Division of Environmental Control Technology, DOE, requested the design, implementation, and operation of a DOE-Wide Transportation Statistics Data Bank (TSDB) following a feasibility study submitted in June 1974 by the Oak Ridge National Laboratory's Union Carbide Corporation Nuclear Division to U.S. Atomic Energy Commission. The task involves a detailed identification of the types of data that will provide the best information for DOE management and the most efficient procedures for collecting the data through review of other data bank systems. The data bank is to eventually include information concerning every movement of material to and from every DOE contractor site in the USA whether the material is moved by commercial or Government carrier systems. Some movements will not be included due to lack of adequate documentation; however, efforts will be made to use estimates, if necessary.

APPROACH

A review of the present Oak Ridge Operations (ORO) Data Bank system, which is routinely operating, has been completed to gain knowledge of problems, deficiencies, and shortcomings. Guidance from DOE concerning their needs for information was obtained. A clear understanding of material movements to be included in the DOE-Wide Bank were developed. A thorough analysis of data elements to be collected for each shipment has been accomplished to ensure that the system would provide the detailed information desired by DOE.

A simplified User's Guide and instruction manual including complete specifications and procedures for collecting data was prepared and published for the review and approval by DOE. Computer programming is now being completed for any revised data elements.

PROGRESS AND RESULTS

Procedures have been established for routine operation of the TSDB Central Bank. Data have been

collected, stored, and will be used for routine reporting and exception reports as desired by DOE. We have conducted a study for implementation of a system to collect data on movements of materials (hazardous and nonhazardous) from and to every DOE contractor site and Energy Research Center.

PLANS FOR NEXT PERIOD

Following DOE approval of the User's Guide and instruction manual, a directive will be issued to all Department of Energy Field Offices by DOE Headquarters with implementing instructions. The directive is expected to offer official guidance to contractor sites to begin collecting data as specifically outlined in the TSDB instruction manual.

It is anticipated that each contractor site will begin collecting data in accordance with a schedule established by the TSDB Central Bank in Oak Ridge. Some test runs are anticipated. Reports will be prepared and issued as deemed appropriate.

All contractor and field sites, as directed by DOE, will be participants in the data collection system. Implementation should be completed for about 15 installations by September 30, 1978.

During FY 1979, programming changes and improvements will be accomplished. All contractor site participants will be collecting data and submitting them to the Central Bank. Some items not included initially in the system due to lack of documentation, classification problems, or other reasons will be added to the system or discarded. Reports as needed by DOE will be published routinely or on an exception basis. Implementation for the remaining 20 or more contractor sites should be completed by mid-FY 1979.

REPORTS PUBLISHED

An instruction manual was published in September 1977. Progress reports to be submitted monthly.

PROJECTED MILESTONES

Projected milestones are shown in Figure 49.

Figure 49. Projected Milestone Schedule

TRANSPORTATION AND PACKAGING FILMS

ORGANIZATION AND CONTRACT NUMBER

Sandia Laboratories
AT(29-1)-789

PRINCIPAL INVESTIGATORS

R. B. Pope
R. C. Colgan
C. E. Cokelreas

OBJECTIVES

This project object is to produce an information film for use with nontechnical public audiences on the overall testing program for the various types of containers and casks used in the packaging and transportation of radioactive materials. The film will show a wide variety of tests (e.g., drop, burn, immersion, impact, etc.), how these tests are conducted, and what conditions are being simulated or duplicated. In addition, other sound and silent films on the packaging and transportation of radioactive materials and on the testing of radioactive containers will be produced as requested.

APPROACH

A Film Specification Sheet and/or Treatment is prepared for each sound film project. This states the film's purpose, content, audience, length, production analysis, and a statement of how the content will be presented. Following approval of this statement, a shooting script is prepared, animation art (if needed) is designed and rendered, a search is made for stock footage (if usable), a narration script is written (and approved prior to narration), sound is recorded, the film and sound tracks are edited, an interlock of the edited film and track is screened for approvals, final editing is completed and the original footage is conformed, an internegative and optical track are prepared, and release prints are produced.

PROGRESS AND RESULTS

The following projects have been completed: (1) 10-minute, sound film, "Testing to Reality...And Beyond," on the 1/8- and full-scale cask testing program; (2) 2-minute sound film on the 60-mph full scale truck/cask impact test; (3) 11-minute sound film, "Accident Safe?" on the cask testing program (noted above in the "Objectives" statement); (4) 3-minute sound film on the 84-mph truck/cask full scale impact test; (5) 3-1/2-minute sound film on the full-scale truck/cask and train/cask impact tests; and (6) completed six silent films on the 1/8- and full-scale cask impact tests, including a 2-minute film clip.

PLANS FOR NEXT PERIOD

During the next reporting period, a sound film will be produced on the overall cask testing program

including the full-scale railroad car/cask impact test to be conducted. This film will be the culmination and final edition of the "Testing to Reality...And Beyond" and the "Accident Safe?" films produced in FY 1977. During the next period sound and silent film clips on the railroad car/cask impact test will be produced. Other sound and silent films will be produced and will concern the packaging and transportation of radioactive materials as requested.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Milestones (e.g., film specification sheets/treatment, shooting script, photography, narration script, editing, etc.) are described in the approach section above. Dates for these milestones are established when a specific film project has been defined. For FY 1978, a defined film on the overall cask testing program should be released in December 1977.

* * *

"ATOMS ON THE MOVE" EXHIBIT

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge Associated Universities
AT (40-1)-GEN-33

PRINCIPAL INVESTIGATOR

R. G. English

OBJECTIVES

The project purpose is to prepare an exhibit which is designed primarily for conferences, meetings, and other appropriate locations. It has been designed to depict the important fact that nuclear materials are not moved until they are safely packaged.

APPROACH

This exhibit will be manned at exhibit showings by a Teacher/Demonstrator who will describe and show the various methods of handling, containing, and shielding radioactive materials.

PROGRESS AND RESULTS

During FY 1977, this exhibit, "Atoms on the Move," was displayed at nine different conferences and meetings as listed in Table 9 and has been seen by over 20,000 people, including state legislators and county Government administrators as well as chemists, engineers, and trucking industry management personnel.

Table 9. FY 1977 Summary of "Atoms On The Move" Exhibit Showings

Place Shown	Date	Attendance
ANS Meeting Washington, D. C.	November 14-17, 1976	1,500
25th Annual Physics Show Chicago, Ill.	February 7-9, 1977	1,800
Energy Technology Conference Washington, D. C.	March 14-16, 1977	1,500
5th International Confer- ence on Reactor Shielding Knoxville, Tenn.	April 19-21, 1977	100
International Trucking Show Atlanta, Ga.	May 18-20, 1977	10,000
Safety Expo '77 Philadelphia, Pa.	June 14-16, 1977	2,000
National Association of Counties Detroit, Mich.	July 24-26, 1977	1,500
National Conference of State Legislators Detroit, Mich.	August 1-4, 1977	1,000
American Chemical Society 1977 Annual Meeting Chicago, Ill.	August 28 through September 2, 1977	2,500
		<u>21,900</u>

PLANS FOR NEXT PERIOD

At the end of FY 1977 (September), this exhibit was turned over to a new contractor, Northwest College and University Association for Science. This exhibit's showings will be coordinated with a second exhibit, "Transporting Radioactive Cargoes." These exhibits will be presented at various technical conferences and transportation symposia.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Not applicable

* * *

"TRANSPORTING RADIOACTIVE CARGOES" EXHIBIT

ORGANIZATION AND CONTRACT NUMBER

Northwest College and University Association
for Science (NORCUS)
E(45-1)-2225

PRINCIPAL INVESTIGATOR

B. B. Valeth

OBJECTIVES

This exhibit will be operated throughout the western half of the U.S. It will be shown at conferences and other appropriate locations. It will show how package designs for radioactive material of various sizes are tested and used for shipments.

APPROACH

This exhibit will be manned at presentations by a Teacher/Demonstrator who will show the three film strips and the various types of nuclear material packaging.

PROGRESS AND RESULTS

The schedule began in April, and there were three presentations including a county fair in Portland, Oregon. Total attendance at the showings was estimated to be 121,000.

PLANS FOR NEXT PERIOD

A schedule of planned exhibit showings will be forwarded to DOE for approval or suggested changes. The exhibit will be displayed at heavily attended meetings and conferences.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Not applicable

* * *

NEW STANDARDS FOR PACKAGE SAFETY QUALIFICATION TESTS

ORGANIZATION AND CONTRACT NUMBER

Sandia Laboratories
AT(29-1)-789

PRINCIPAL INVESTIGATORS

R. B. Pope
J. D. McClure

OBJECTIVES

The purpose of this study is to examine the maximum or near maximum environmental stresses produced in truck, rail, and aircraft transport acci-

dents, and to compare these environmental severities with the severity of existing qualification test standards to which small radioactive material (RAM) containers are subjected under the Federal Regulations.

APPROACH

This study used the detailed description of the transport accident provided in a previous Sandia study, "Severities of Transport Accidents" (SLA 74-0001), as a data base. The basic methodology was the quantification of the severity of the accident environmental categories of impact, fire, crush, puncture, and immersion for the truck, rail, and aircraft transportation modes. These severities were compared with the severity of current qualification test criteria in order to assess the degree of protection provided by the existing regulations in the interest of public safety.

PROGRESS AND RESULTS

The results of the study are being published as a review draft of the report, "An Analysis of the Qualification Criteria for Small Radioactive Material" (SAND 76-0708), with final publication of the report scheduled for the fall of 1977.

PLANS FOR NEXT PERIOD

The publication of SAND 76-0708 will essentially complete this task for small radioactive material packages. There will be some editorial work required in the first quarter of FY 1978.

REPORTS PUBLISHED

"An Analysis of the Qualification Criteria for Small Radioactive Material Shipping Packages," SAND 76-0708, Sandia Laboratories, September 1977 (review draft).

PROJECTED MILESTONES

The project for small RAM packages will be completed with the publication of the final report, SAND 76-0708, in November 1977.

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DECONTAMINATION AND DECOMMISSIONING

Responsibilities for Decontamination and Decommissioning under the Division of Environmental Control Technology are organized into four program activities:

- Management of surplus radioactively contaminated DOE facilities;
- Remedial Action at formerly utilized Manhattan Engineer District and Atomic Energy Commission (MED/AEC) contractor sites;
- Remedial Action for inactive uranium mill tailings sites; and
- Grand Junction remedial action

MANAGEMENT OF SURPLUS RADIOACTIVELY CONTAMINATED DOE FACILITIES

ECT is responsible for planning, budgeting, and implementing the program for safe management and disposition of DOE facilities that are radioactively contaminated and have been declared surplus to programmatic needs. There are currently more than 460 of these facilities including cribs, ponds, trenches, buildings, and reactors, more than 80 percent of which are located at Hanford. By 1981, it is estimated that an additional 100 facilities will be declared surplus.

The overall plan for the management of surplus contaminated DOE-owned facilities is based on the long-term objective of eliminating potential hazards and reducing the need for perpetual surveillance and maintenance. Where practicable, however, the goal is to release property for alternative productive use without restrictions. Activities within the program include: providing surveillance and maintenance to ensure that surplus facilities remain in an environmentally safe condition; developing improved techniques for the safe and economic decontamination and disposition of radioactive facilities, equipment, materials, and land; developing plans, priorities, costs, and schedules for disposition projects; and implementing projects leading to improved safety, elimination of the expense of continuing surveillance and maintenance, and restoration of needed facilities or land areas without radiological restriction.

A part of the strategy of this program is the development of a method for establishing the relative priority for projects within the inventory and selecting the optimum D&D approach from the options (e.g., salvage for other use, continued surveillance, and maintenance, entombment, or dismantling). Complementing this approach will be the effort to develop and document the technology as more and more structures are decontaminated and decommissioned. This will not only be of value to those responsible for future disposition of surplus DOE

facilities, but it will also provide technology for this aspect of the commercial nuclear fuel cycle.

The program is developing new and improved technology for disposition of surplus nuclear facilities. For example, the decontamination of concrete, the volume reduction of process equipment, and the decontamination of metals through smelting are all being studied. Studies will be continued, and findings will be published in FY 1979 in a decommissioning handbook that will document techniques for decommissioning and assist in the selection of methods and estimation of the cost to achieve disposition criteria.

The planning activity also includes developing a system for identifying projects and assigning priorities from among the more than 460 surplus facilities currently listed in a comprehensive inventory. The priorities established will provide a rational basis for future D&D planning and budgeting activities. This system, to be called the DOE National D&D Planning System, will include an inventory and a data base for all designated surplus facilities. As additional facilities are declared surplus, they will be integrated into the system. The output from the planning system will provide a basis for developing future annual budgets, 5-year planning projections, and long-term budget requirements for disposition of surplus facilities. Emphasis will be placed on identifying and scoping individual projects and preparing a schedule that is comprehensive and compatible with National energy program needs. The effort will also identify the needs for developing supporting technology including dismantling and entombment techniques, soil cleanup and stabilization methods for burial grounds, and concrete durability studies as a guide to formulating future R&D programs. The disposition of these facilities in a way that ensures the permanent protection of mankind from harmful levels of radiation will be a massive undertaking requiring significant expenditures over several decades.

SURPLUS FACILITY SURVEILLANCE

ORGANIZATION AND CONTRACT NUMBER

Argonne National Laboratory
W-31-109-ENG-38

PRINCIPAL INVESTIGATORS

C. L. Cheever
J. F. Bartusek

OBJECTIVES

The objectives of the program are to provide radiation hazard surveillance and maintenance and power to contaminated surplus facilities.

APPROACH

The approaches being used are: to take and record periodic (Table 10) air and smear samples (for ascertaining radioactivity levels) and to provide maintenance and power for surplus Building 37/Fanhouse #1 and Building 331/EBWR reactor shell. Air and smear samples are also taken in Building 335/Juggernaut Reactor Facility.

PROGRESS AND RESULTS

During FY 1977, radiation hazard surveillance has included monthly contamination surveys in Building 37, continuous air sampling in Building 331, access control and escort service for Building 331, retention

tank sampling in Building 331, weekly air samples in Building 335, numerous consultations and special surveys for Components Technology in Building 335 as well as special surveys (both smear and direct) for other groups providing service. In addition, maintenance and power to the named facilities has been provided.

PLANS FOR NEXT PERIOD

Continued surveillance and maintenance will be provided until the facilities are properly disposed of as indicated.

PROJECTED MILESTONES

All aspects of the Radiation Hazard Surveillance Program must continue as described under the "Approach" heading until the facilities are decontaminated, demolished, or put back into service. A milestone will be reached when the facilities are no longer of a surplus nature requiring maintenance.

* * *

SURPLUS OAK RIDGE NATIONAL LABORATORY REACTOR SURVEILLANCE

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge National Laboratory
W-7405-ENG-26

Table 10. Surplus Facility Surveillance Program

Frequency	Surveillance Type	Remarks
Weekly	Radiation Survey	All occupied buildings, areas, and equipment
Monthly	Industrial and Environmental Hazards	All buildings inspected for safety and fire hazards
	Radiation Survey	All occupied buildings including radiation zones
Quarterly	Radiation Survey	Unoccupied contaminated buildings
Semi-Annual	Radiation Survey	Unoccupied uncontaminated buildings
Annual	Radiation Survey	High radiation zones in all 105 and 115 buildings
During Spring	Radiation Survey	Burial grounds, cribs, trenches, etc. surveyed during growing and windy seasons

PRINCIPAL INVESTIGATORS

R. V. McCord
S. S. Hurt, III

OBJECTIVES

The objective of this task is to provide the necessary surveillance of highly contaminated shut-down reactor facilities and associated liquid and gaseous waste services to ensure safe decontamination of the residual radioactivity pending complete decontamination and decommissioning.

APPROACH

Surveillance includes monitoring of critical radiation, contamination, and volumetric information; operation of gaseous, solid, and liquid waste systems; and maintenance of necessary support systems.

PROGRESS AND RESULTS

The established surveillance program has been effective in the confinement of radioactive contamination and prevention of any significant releases to the environment. The four reactors under surveillance are discussed in the following paragraphs.

For the Molten-Salt Reactor Experiment (MSRE), daily checks were made on the radiation and contamination conditions, salt temperatures, cell pressure, and the off-gas and cell ventilation systems. Additional tests and checks completed during the year were: (1) the fuel storage cell leak rate test; (2) reheating of the fuel and flush salt in the drain tank for recombination; (3) verification of the operability of standby equipment; (4) verification that annunciators and control switches in service have the proper setpoints; and (5) verification of filter efficiency.

For the Oak Ridge Graphite Reactor (OGR), daily checks were made on radiation and contamination conditions, the cell ventilation system and canal flow rate, radioactivity, and pH. Two inspections were made inside the reactor exit duct and inside the base of the stack for water accumulation, debris, and cracking. Debris which accumulated in the base of the stack had plugged the drain line. The debris, which was highly contaminated, was removed.

For the Low-Intensity Test Reactor (LITR), daily checks were made on the ventilation system and on radiation and contamination conditions.

During the Homogeneous Reactor Experiment (HRT), routine surveillance checks were made on the building radiation and contamination conditions, cell ventilation, off-gas systems, water accumulation, and radioactivity in the various sumps. The asphalt coating over the waste retention pond cracked and allowed some radioactive contamination to seep out. The crack was repaired and the asphalt resealed.

PLANS FOR NEXT PERIOD

Surveillance operations will be continued until decontamination and decommissioning operations are initiated.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

The nature of this surveillance operation is not compatible with the establishment of discrete milestones.

* * *

FSSION PRODUCT DEVELOPMENT LABORATORY SURVEILLANCE

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge National Laboratory
W-7405-ENG-26

PRINCIPAL INVESTIGATOR

R. W. Schaich

OBJECTIVES

The objective of this task is to provide the necessary surveillance of highly contaminated shielded cells and associated liquid and gaseous waste services in the Fission Product Development Laboratory (FPDL) to ensure safe containment of the residual radioactivity pending complete decontamination and decommissioning.

APPROACH

Surveillance includes monitoring of critical radiation, contamination, and volumetric information; operation of gaseous, solid, and liquid waste systems; and maintenance of necessary support systems.

PROGRESS AND RESULTS

A total of 95,000 gallons of waste was transferred to the Intermediate Level Waste system. The high efficiency particulate air (HEPA) filters in the cell ventilation and vessel off-gas systems were DOP-tested twice and were changed on the basis of radiation readings. About 70,000 gallons of process waste were collected, monitored, and discharged to the process waste system. Maintenance on the process waste monitoring station was decreased by

the installation of a new pump. The in-cell arms of several master-slave manipulators were re-booted to prevent excessive contamination of mechanical parts. About 300 smears per week were taken to monitor contamination on operating floors and surfaces, and all areas having high removable contamination were cleaned. Cells 1 and 15 were decontaminated to personnel entry levels for use in ORNL solid waste decontamination operations.

PLANS FOR NEXT PERIOD

Surveillance operations will be continued until decontamination and decommissioning operations are initiated.

PUBLISHED REPORTS

None

PROJECTED MILESTONES

The nature of this surveillance operation is not compatible with the establishment of discrete milestones.

* * *

PIQUA SURVEILLANCE

ORGANIZATION AND CONTRACT NUMBER

Battelle Memorial Institute
W-7405-ENG-92

PRINCIPAL INVESTIGATOR

J. Davis

OBJECTIVES

The objective is to provide radiation monitoring of the decommissioned reactor at Piqua, Ohio, for any changes that may affect the environment.

APPROACH

Air and sump samples are taken annually and analyzed.

PROGRESS AND RESULTS

A one-day trip was made to the decommissioned Piqua reactor. Air samples were taken as well as samples from the sump. These samples were analyzed for changes from previous samples. The results were reported to ECT.

PLANS FOR NEXT PERIOD

Continue the annual surveillance.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Milestones are not applicable to this project.

* * *

IDAHO NATIONAL ENGINEERING LABORATORY SHUTDOWN REACTORS

ORGANIZATION AND CONTRACT NUMBER

EG&G Idaho, Incorporated
1375

PRINCIPAL INVESTIGATOR

R. A. Messervy

OBJECTIVES

The objective of this project is to provide minimum surveillance and security for Idaho National Engineering Laboratory (INEL) surplus radioactively contaminated facilities to keep them in a safe condition.

APPROACH

The surveillance and security of INEL contaminated facilities will be accomplished by use of existing staffs of security, fire protection, radiation protection, and property management organizations to provide surveillance and maintenance for INEL shutdown facilities including (1) TAN Radioactive Waste Evaporation System (PM-2A), (2) Hallam Reactor Components stored at Test Area North (TAN), (3) Organic Moderated Reactor Experiment (OMRE), (4) Initial Engine Test Facility (IET), (5) Materials Test Reactor (MTR), (6) Army Reentry Vehicle Facility Site (ARVFS), (7) Auxiliary Reactor Area-IV, and (8) Borax-V Facility.

PROGRESS AND RESULTS

The surveillance has been maintained with no adverse incidents.

PLANS FOR NEXT PERIOD

Surveillance and maintenance will continue during the next reporting period.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Not applicable

* * *

SURVEILLANCE OF HANFORD 100 AREA SURPLUS FACILITIES

ORGANIZATION AND CONTRACT NUMBER

United Nuclear Industries
RL 9307A

PRINCIPAL INVESTIGATOR

R. K. Wahlen

OBJECTIVES

There are currently four production reactor facilities at Hanford that are in a retired (surplus) status. A surplus facilities surveillance program has been established to ensure that potential radiological and industrial hazards are promptly corrected and to maintain an effective property control system.

APPROACH

The surplus facility surveillance program is implemented by a system of procedures which identify periodic industrial, radiological, and environmental surveillance requirements. In addition, procedures are included for the maintenance, inspection, and testing of emergency alarm and fire protection systems. The frequency of inspections are based on several factors including:

- Facility status (e.g., occupied, partially occupied, unoccupied)
- Condition of the buildings
- Fire potential
- Potential safety and environmental hazards

Records are maintained of all inspections, showing current facility condition, actions required, and actions taken to correct potentially hazardous conditions. Table 10 (see Surplus Facility Surveillance) summarizes the surplus facility surveillance program.

PROGRESS AND RESULTS

All required inspections have been completed on schedule. Potentially hazardous conditions identified during these inspections have been corrected.

PLANS FOR NEXT PERIOD

The current surplus facility surveillance program will be continued. The surveillance program is reviewed periodically to ensure its adequacy.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Not applicable

* * *

SURVEILLANCE OF HANFORD 200 AREA SURPLUS FACILITIES

ORGANIZATION AND CONTRACT NUMBER

Rockwell Hanford Operations
EY-77-C-06-1030

PRINCIPAL INVESTIGATORS

A. W. Graves
J. A. Swenson

OBJECTIVES

Several facilities are located in the 200 Areas of the Hanford Reservation and are surplus to the Energy Research and Development Administration program and operational needs. This task involves surveillance and maintenance of these facilities, which are contaminated with radionuclides, and correction of problems which may impact upon the environment.

APPROACH

Structural facilities require periodic surveillance to determine that there has been no tampering by other personnel or destruction by natural forces. Where services such as ventilation and heating are provided to these structures, the equipment must be maintained. Abandoned subsurface repositories of radionuclide waste require periodic surveillance and corrective action. Signs and barriers must be installed or repaired as necessary; contaminated vegetation must be removed to the burial ground; loose contamination must be covered with clean soil; and cave-ins and depressions must be filled to prevent release of contamination to the environment.

PROGRESS AND RESULTS

The following structural facilities have been surveilled and maintained in a safe layaway condition.

- 202-S Redox Facility and adjoining facilities that have been abandoned;
- 271-C Semiworks Facility and adjoining facilities that have been abandoned;
- The surplus fuel storage basins in 200 North Area and the Gable Mountain storage vaults designated 213-J and 213-K; and

- The abandoned in-tank solidification units located in the 241-BY Tank Farm.

In addition, there are approximately 300 outdoor radiation zones that have been surveilled, and corrective action taken where required, as shown in Table 11.

PLANS FOR NEXT PERIOD

- Surface decontamination of the area immediately surrounding the 207-T Retention Basin in 200 West Area;
- Placement of a plastic biobarrier to preclude moisture from leaching contamination from within the site boundary at the UN-216-W-5 at the corner of 23rd and Camden Avenues in 200 West Area;
- Installation of approximately 5,000 concrete marker posts at outdoor radiation zones in 200 East, 200 West, 200 North Areas; and
- Maintenance items such as chains, signs, and posts as they become necessary.

REPORTS PUBLISHED

"Environmental Protection Section, Annual Report -- CY 1976," ARH-LD-154, June 23, 1977.

PROJECTED MILESTONES

No significant milestones are anticipated on this task.

* * *

HEAVY WATER COMPONENTS TEST REACTOR SURVEILLANCE

ORGANIZATION AND CONTRACT NUMBER

E. I. duPont de Nemours and Company, Inc.
AT(07-2)-1

PRINCIPAL INVESTIGATOR

G. F. Merz

OBJECTIVES

The objective of this surveillance is to maintain the security and safety of this heavy water components test reactor (HWCTR) facility which was shut down in 1964 and has for the past several years been "abandoned in place."

APPROACH

The surveillance of HWCTR is carried out by plant patrols through routine visual property inspection and lock check each shift. Maintenance is performed on fan, lights, etc., bimonthly. An annual safety inspection is made and recorded by ERDA Safety personnel.

PROGRESS AND RESULTS

No security or safety incidents have been reported.

PLANS FOR NEXT PERIOD

Surveillance will continue as in the past year.

Table 11. Radiation Zones (RZ) Surveilled

Site Group	Total Sites	Number of Sites in Each Condition				Acreage Released From RZ Status
		Contamination Removed	Radiation Zones Signs Replaced	Chain Barrier Repaired	Debris Removed	
216-A	46	1	7	5	1	0.25 acre
216-B	69	8	13	10	12	
216-C	10		3	3	4	
216-N	6		1	2	2	
216-S	25	1	8	8	9	3.35 acres
216-T	36	2	8	8	2	
216-U	18		7	7		
216-Z	25		3	1	2	
216-E	15		5	5	2	0.50 acre
218-W	13		7	7	2	
UN-216			1	1	2	
Misc. Sites	18	1	18	18	7	1.38 acres

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Decommissioning is planned to begin in FY 1980 if sufficient funding is made available.

* * *

GNOME SURVEILLANCE

ORGANIZATION AND CONTRACT NUMBER

Reynolds Electrical & Engineering Co., Inc.
EY-76-C-08-0410

PRINCIPAL INVESTIGATOR

P. B. Dunaway

OBJECTIVES

The Reynolds Electrical & Engineering Co. (REECo), in carrying out the surveillance of the Gnome facility, performs bimonthly reconnaissance of the site to ensure that fencing is in good repair to exclude the site as a grazing area. EPA supports the Nevada Operations Office in conducting a monitoring program of wells on and near the Gnome site and in servicing nearby communities; specifically, seven wells on/or near the site are sampled annually, along with the Pecos Pump Station No. 1 well, Carlsbad City Well No.7, and the Loving City Well No. 2 also serving Malaga.

APPROACH

REECo provides periodic inspection of the fencing to omit grazing in the area, and EPA will continue to provide the long-term hydrologic monitoring.

PROGRESS AND RESULTS

The Nevada Operations Office efforts are expected to continue until the site proves radiologically safe, is cleaned up, and is returned to the public domain.

PLANS FOR NEXT PERIOD

During the next period, bimonthly reconnaissance of the site will continue and monitoring of contamination leading to cleanup and return to public domain will be conducted.

REPORTS PUBLISHED

EPA monitoring results are reported to the Nevada Operations Office and are also published in the Annual Environmental Surveillance Report by EPA.

PROJECTED MILESTONES

The REECo and EPA efforts will continue until the site cleanup is complete.

* * *

SALVAGE OF ALPHA-CONTAMINATED METALS

ORGANIZATION AND CONTRACT NUMBER

Argonne National Laboratory
W-31-109-ENG-38

PRINCIPAL INVESTIGATORS

M. J. Steindler
M. G. Seitz
T. J. Gerding

OBJECTIVES

Nuclear operations involving direct or suspected contact with transuranium (TRU) elements generate waste streams that, because of existing and proposed regulations, require special treatment. The metals, contaminated with plutonium and americium, are generated by replacement and decommissioning of process facilities. Some transuranic contaminated metals may meet proposed Federal requirements for commercial burial with no decontamination step. However, the uncertainties associated with measuring low levels of plutonium on irregularly shaped objects precludes reliable assay. Therefore, a method to convert the material to standard homogenized forms as well as to decontaminate the material is desirable. Melt-refining techniques were selected to achieve these objectives. These techniques are feasible for the large-scale processing required to handle the quantities of presently existing contaminated metals.

PROGRESS AND RESULTS

An experimental program was undertaken to determine the chemical behavior of plutonium in melt-refining processes using different experimental conditions with various metals and slags. For most experiments, steels, plutonium oxide, and slag were loaded into an alumina crucible and heated in a tungsten mesh resistance furnace to melt the slag and metal. The metals used in these experiments were a cold-rolled mild steel, 304 stainless steel, nickel-200, and mild steel with a minor amount of copper. The plutonium oxide contained 83.81 wt % plutonium and 0.528 wt % americium-241. The slags were commercial glasses or industrial slags from steel-making processes or were constituted by fusing mixtures of metal oxides.

Prior to being loaded in the furnace, the plutonium oxide was placed in a cavity of the steel sample and retained with a metal plug to restrict its

accessibility and to simulate contamination in cracks or imbedded on wear surfaces of metals. In the experiments with mild steel, the amount of slag and its composition were varied to determine the effect on the metal.

After melting and solidification in the resistance furnace, the metals and slag were removed from the crucible for analyses or for reprocessing. The crucibles were often cracked, probably having cracked upon cooling, due to differential thermal contraction of the crucible, metal, and slag. The metal ingots have shiny surfaces, varying from smooth to pitted, and generally fragments of slag adhered to them.

Other experimental approaches were taken to determine whether (1) arc melting was also useful in decontaminating metals and (2) staged extraction (i.e., successive melt-refining steps) produced a cleaner metal product.

Chemical analyses of massive samples (~ 10 g) were used to determine the average plutonium concentrations for the slags and metals. Two additional methods were used to identify the actual association of the plutonium with the metals and slags: (1) an autoradiographic technique, sensitive to alpha particles, was used to reveal the microscopic distribution of plutonium and americium in the metals and slags and (2) a fission-track analysis technique was employed that was highly sensitive to plutonium.

The analyses of the metal from typical experiments are given in Table 12 and indicate extensive fractionation of the plutonium to the slag during melt-refining. Some of the metal samples had

plutonium concentrations below the 10 nCi/g (~0.1 ppm plutonium) level currently used to define TRU-contaminated wastes. The low plutonium levels (Table 12, column 3) were achieved without special treatments to separate slag from metal (such as trimming or electropolishing the surface of the ingot).

Analyses by alpha radiographs and fission tracks indicated that the alpha activity (plutonium and americium) was predominantly on the surface of the ingots. All ingots analyzed showed this effect. Occurrences of plutonium at the metal surface or in visible defects accounted for most (99 percent) of the plutonium associated with the metal. Plutonium, as determined from the radiographs, also occurred in the interior of some ingots; where present in concentrated form, plutonium was associated with visible defects. Only occasionally did a point source of high alpha activity appear in an area of the steel where there was no observable defect. The types of plutonium associations with metal ingots, seen from alpha radiographs and from fission-track analyses, are depicted in Figure 50.

Chemical analyses of bulk samples of slag and radiographs of slag indicate that plutonium concentrations were high in slags analyzed. It was found by analyses that the crucible walls did not contain plutonium. Therefore, most of the plutonium from the metal was presumed to be in the slags. Inhomogeneities of plutonium concentration in the slag were generally noted and precluded accurate mass balance calculations for plutonium.

Table 12. Plutonium Concentration of Typical Metal Ingots in Melt-Refining Experiments

Experiment Number	Initial Steel Contamination (ppm Pu)*	Melt-Refined Steel	
		Bulk Samples (ppm Pu)	Metal Matrix (ppb Pu)
1	450	0.5	2.4
2	420	0.2	2.4
3	430	0.04	3.5
4	400	0.2	2.0
5	410	0.001	0.4
6	430	0.01	3.0
7	0.1	0.001	0.02
8	280	0.03	0.08
9	410	--	0.6
10	8,750	--	5.9
11	13,700	--	18.0

*Concentrations are on a weight basis, i.e., ppm indicates micrograms of plutonium per gram of sample.

Figure 50. Types of Plutonium Associations Identified with Melt-Refined Metal

Apparent partitioning coefficients, K_D , of plutonium between silicate slag and metal-- (concentration in slag)/(concentration in metal) -- were calculated. For experiments with low amounts of plutonium (400 ppm), partitioning coefficients of 2×10^3 to 8×10^3 for mild steel and stainless steel and 5×10^3 for nickel were observed. In Figure 51, the plutonium concentrations in slag after melt refining were plotted against concentration in the process metal for experiments in which the plutonium loading was varied. The graph indicates efficient extraction of plutonium from metal with an initial loading of up to ~14,000 ppm plutonium and that slag of borosilicate glass extracts plutonium from metal to a greater extent than does diopsidic slag. This is one of the few indications obtained in the experiments that one slag was better than another.

Results of the experimental program indicates that staged extraction, that is, recycling processed steel through the melt-refining process, is an effective procedure for reducing the plutonium level of the product metal. Performing the second extraction by either resistance-furnace melting or arc-melting is effective. Slag adhering to the metal ingots and defects within the ingots are important contributors to plutonium retention in process metals. With control of these sources of plutonium, the melt-refining process can be used on a large scale to convert highly contaminated metals to homogeneous and compact forms suitable for assaying and containing very low residual concentrations of plutonium.

PLANS FOR NEXT PERIOD

The program was completed in FY 1977.

REPORTS PUBLISHED

Quarterly Report for the Period October-December 1976, Chemical Engineering Fuel Cycle Programs, ANL-77-36, 1977.

Quarterly Report for the Period January March 1977, Chemical Engineering Fuel Cycle Programs 1977.

T. J. Gerding, M. G. Seitz, and M. J. Steindler, "Salvage of Plutonium and Americium Contaminated Metals," Symposium of the American Institute of Chemical Engineering, November 13-17, 1977.

PROJECTED MILESTONES

None

Figure 51. Plutonium Concentrations in Slag vs Plutonium in Metal

RECYCLE OF CONTAMINATED SCRAP METALS

ORGANIZATION AND CONTRACT NUMBER

National Lead Company of Ohio
EY-76-C-05-1156

PRINCIPAL INVESTIGATOR

J. H. Cavendish

OBJECTIVES

There are two tasks involving the recycle of contaminated scrap metals. The objective for Task A is to have current Federal Regulations amended to permit unlicensed possession, sale, and use of metal contaminated with special nuclear materials (SNM) below a specified de minimis concentration. For Task B the objectives is to provide a means for decontaminating the scrap metal so that it meets our proposed de minimis concentrations for SNM.

APPROACH

Concerning Task A, present Federal Regulations (10CFR70) prohibit the possession, use, or sale of any quantity of SNM except by holders of a specific license. Because this is not practical for the sale of metal scrap homogeneously contaminated with small quantities of SNM, we are pursuing an amendment to 10CFR70 establishing a de minimis concentration for enriched uranium and technetium-99 which would allow unrestricted sale of the metal scrap. ERDA's Environmental Impact Assessment concerning the proposed amendment is currently under review by the Nuclear Regulatory Commission (NRC).

For Task B, the primary decontamination method being pursued to achieve these de minimis concentrations is that of smelting. We are preparing to submit an FY 1980 line item construction project to build a portable smelter which would be shipped from site to site and used to smelt the contaminated metal.

PROGRESS AND RESULTS

For Task A, the need for an amendment to 10CFR70 covering de minimis levels of plutonium and neptunium is being evaluated. Discussions of this matter have led to consideration of an alternative approach to the establishment of de minimis quantities. Currently being considered is the possibility of establishing an overall activity level exemption for smelted metals instead of individual exemptions for each radionuclide. A specific exemption covering the CIP/CUP scrap is also under consideration.

The contaminated scrap metal survey, part of Task B, which is designed to identify potential feeds for the portable smelter has proceeded quite satisfactorily in FY 1977. An Environmental Impact Assessment concerning the portable smelter was prepared by the National Lead Company, reviewed by ORO, and submitted to Headquarters for comment in FY 1977. Evaluation of the preliminary design of the

portable smelter is proceeding. A contract with Birdair Corporation to determine the feasibility of using an air supported enclosure for the smelter has been issued. Work on an improved decontamination process for aluminum was initiated this fiscal year.

PLANS FOR NEXT PERIOD

The plans for the next period for Task A include preparation of an EIA for the amendment establishing a de minimis concentration for plutonium and neptunium, if necessary.

For Task B, the contaminated scrap metal survey and the evaluation of the portable smelter preliminary design will be completed in early FY 1978. A Schedule 44, construction project data sheet, will be prepared and submitted for the portable smelter in April 1978. Development work will be continued on an improved decontamination process for aluminum scrap in FY 1978.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

Figure 53 shows the projected milestone schedule.

* * *

CONTAMINATED EQUIPMENT VOLUME REDUCTION

ORGANIZATION AND CONTRACT NUMBER

Rockwell Hanford Operations
EY-77-C-06-1030

PRINCIPAL INVESTIGATOR

G. A. Beitel

OBJECTIVE

The objective of this program is to develop, design, and demonstrate process equipment which will reduce the volume of contaminated equipment to a size and form suitable for terminal storage or disposal.

APPROACH

Studies during the past three years have concluded that meltdown is the optimum final step in preparing metallic waste for disposal if fume control and remote operation can be achieved. Control of fumes associated with the melting process dictates the use of a closed furnace. A vacuum furnace has been chosen as the ideal containment system.

Figure 52. Projected Milestones

A vacuum furnace capable of melting up to 400 kg of steel scrap per batch has been designed. Melting is to be accomplished by direct arc heating (from a water-cooled electrode) in a water-cooled copper crucible. Mechanical pumps will provide the requisite vacuum. The furnace was designed to maximize cleanliness and minimize complexity. Following successful operation of the vacuum furnace with uncontaminated scrap, the system will be redesigned and modified to accept radioactive scrap. Simultaneously, laboratory scale (4 kg) tests will be conducted with contaminated materials to investigate the redistribution and to determine the feasibility of slag separation of radionuclides during meltdown.

PROGRESS AND RESULTS

The following activities were accomplished during FY 1977.

- Vacuum furnace design was completed.
- The design of the facility to accept the furnace and size reduction test stand was completed. A suitable existing building was identified for this purpose and necessary modifications are being performed.
- Procurement of the vacuum furnace and accessories began. An order for a 15,000-

ampere power supply was placed and a purchase requisition written for the furnace vacuum pumps.

- Design of the size reduction test stand was completed. Acquisition, fabrication, and installation of this equipment was transferred to another program.
- A 1-kg induction furnace has been ordered for test purposes. A hot laboratory was prepared in which to conduct the proposed tests.
- A Purex dissolver was decontaminated as part of a decontamination cost benefit analysis study.

PLANS FOR NEXT PERIOD

The building required to install the furnace will be modified and equipped to accept the furnace modules. Related tasks to be completed include hazards review, safety analysis, operating procedure preparation, technician training, and preparation of a test program. Furnace fabrication will be a major project effort. In addition, laboratory studies on melting kilogram-sized contaminated samples will be initiated and conducted.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- November 1, 1977 -- Sign furnace fabrication contract
- February 15, 1978 -- Receive furnace power supplies
- November 30, 1978 -- Complete furnace fabrication

* * *

DECOMMISSIONING OF RETIRED FACILITIES AT HANFORD: TECHNOLOGY

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATORS

R. R. King
J. M. Hjalter
R. G. Sullivan
J. F. Cline
R. L. Brodzinski

OBJECTIVES

The objectives of this project are to conceive, develop, and test advanced D&D technology which will be applicable to the Hanford decommissioning effort.

APPROACH

This project is divided into four tasks.

- Concrete decontamination,
- Concrete properties/structure,
- Burial ground stabilization, and
- D&D survey instrumentation.

For concrete decontamination, two novel techniques for removal of contaminated concrete surface layers are being investigated. One is a water cannon that shoots a small jet of liquid at very high pressure against the concrete surface. The other is a tool that exerts radial pressure with expanding split wedges on the sides of a shallow cylindrical hole drilled in the concrete.

For concrete properties/structures, a program is being defined to investigate several important parameters of concrete including effect of burial; freeze/thaw cycling; chemical degradation; permeability with respect to time, stress and thermal cycling; radiation effects; and effect of additions. The program will include detailed testing of samples under rigid control including samples taken from existing Hanford facilities. Concepts for in situ containment of trenches, ponds, cribs, and other burial sites are also being evaluated.

The burial ground stabilization program is designed to test the ability of a "barrier" (a rock-gravel-sand-topsoil cover) to prevent plant and animal penetration of contaminated burial grounds. Soil mixed with lithium chloride simulates radioactive wastes. A layer of cobble is placed over the simulated wastes and covered with topsoil.

Different biological barriers are tested in a replicated plot design. Ant colonies and pocket mice are introduced to the test area. Ant carcasses and soil particles on the ant hill are analyzed for lithium content. The mice are trapped and feces sampled for lithium content. Roots from the tumbleweed plants are also analyzed.

For the D&D survey instrumentation task, a prototype field unit is being developed to measure very low levels of residual transuranic activity in structural materials and soils following decontamination. The instrument is based on the direct counting of low-energy photons from plutonium and americium isotopes using an intrinsic germanium diode.

PROGRESS AND RESULTS

The water cannon (a modified 45.8 caliber gun) technique for concrete decontamination was found to consistently spall craters 4 to 5 inches in diameter.

After 65 firings, the nozzle and gun parts exhibited no signs of wear. The rock splitter bit continued to perform very well in tests on concrete foundations. Best results have been obtained using a triangular pattern of holes drilled 6 inches apart and 1½ inches deep. An invention report has been prepared describing this latest version of the bit. The rock splitter was demonstrated for Rockwell-Hanford staff who are planning the 233-S demonstration project. They indicate the technique would be included in their plans for the project.

The concrete properties/structures program has been defined to investigate the long-term properties of concrete and to evaluate in situ containment of contaminated burial grounds.

A small plot for growing two species of plants was established for the burial ground stabilization task in the drainage finger adjoining the U-Pond in the 200-West Area. The plot is intended to test availability of the radionuclides in the soil to growing plants under field conditions. Soil was analyzed and the following radionuclides were found in quantities from 50 to 100 pCi per gram of dry soil: uranium-235, americium-241, cesium-137, europium-155, and plutonium-239. Several other radioelements were observed in very low concentrations. The plot has been tilled, fertilized, and planted to beans and barley. Plant tissue from these crops will be analyzed, throughout the growing season, for the radioisotopes shown above.

Hair and feces of mice were collected and submitted for lithium analysis to determine if the mice had dug through the barrier into the lithium spiked soil. Ants were also collected for lithium analysis.

A prototype field unit has been assembled for the D&D survey instrumentation task to measure residual transuranic activity in structural materials and soils following decontamination. A cassette tape drive and interface are used to store spectral data in the field for subsequent computer analysis. On-the-spot field information will be limited to americium-241 activity. The low energy x-ray emitting plutonium isotopes will be determined by computer data reduction.

A FORTRAN computer code has also been initiated for rapid reduction of multichannel spectral data to yield depth-corrected americium and plutonium activities. The code will also determine the average depth of the activity and will permit unfolding spectra with interfering peaks.

PLANS FOR NEXT PERIOD

In the next period we plan to:

- Design and test the tooling required to dismantle a Hanford production reactor (new task for this project),
- Develop and test new techniques for mechanical decontamination of structural concrete,

- Evaluate the use of concrete for entombment and design entombment structures for reference Hanford facilities,
- Develop and test techniques for preventing the penetration of contaminated soil zones at liquid and solid waste disposal sites by plant roots and animals, and
- Field test survey instrumentation.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

No major milestones were projected for FY 1977. Each task will be continued into FY 1978.

* * *

DOE NATIONAL DECOMMISSIONING PLANNING PROGRAM

ORGANIZATION AND CONTRACT NUMBER

Rockwell International
EY-76-C-03-0701

PRINCIPAL INVESTIGATOR

A. M. Stelle

OBJECTIVES

The objectives of the National decommissioning planning program is to prepare a Program Plan Document for disposition of surplus radioactively contaminated DOE facilities and to collect and maintain a data base of information to support the development of plans and priorities for disposition of surplus facilities.

APPROACH

In cooperation with Pacific Northwest Laboratories and United Nuclear Industries, a questionnaire will be prepared to collect data necessary to establish priorities, estimate budgets, and prepare 5-year plans for the disposition of surplus facilities. Also, a system will be developed for maintaining an updated data base.

PROGRESS AND RESULTS

During FY 1977, plans were developed for collecting characterizational data and preparing the program plan.

PLANS FOR NEXT PERIOD

During the next period, the plans are to continue compilation of the data base so that it is complete for all surplus facilities and to prepare a draft DOE National Decommissioning Program Plan Document.

PROJECTED MILESTONES

- December 22, 1977 -- Send out questionnaire to obtain characterizational data.
- February 28, 1978 -- Assemble data and forward to Pacific Northwest Laboratory and United Nuclear Industries
- April 15, 1978 -- Issue draft DOE National Decommissioning Program Plan.

* * *

PLANNING FOR DISPOSITION OF EXCESS REACTOR FACILITIES

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge National Laboratory
W-7405-ENG-26

PRINCIPAL INVESTIGATORS

C. D. Cagle
L. B. Holland
L. P. Pugh

OBJECTIVES

The objective of the task is to provide procedures, tooling requirements, and cost estimates for the disposal of shutdown research and development nuclear reactors at Oak Ridge National Laboratory (ORNL).

APPROACH

By using existing blueprints, component descriptions in publications, and the knowledge of personnel familiar with the reactors, a procedural job listing was developed for each shutdown reactor both for dismantling of all radioactive and contaminated components followed by disposal in a solid-waste storage area and for entombing all such items in concrete within the reactor containment. From the job listings, man-hour estimates and tooling requirements were identified as a basis for cost estimates. The results are published separately for each reactor.

PROGRESS AND RESULTS

Studies for the Molten-Salt Reactor Experiment (MSRE) and the TSR Space Nuclear Auxiliary Power, (SNAP) were completed in FY 1977, and the results

are being published to complete this phase of the work. The results of studies for the Low-Intensity Testing Reactor (LITR), the Oak Ridge Graphite (OGR), and the Homogeneous Reactor Experiment No. 2 (HRE-2 or HRT) were published earlier.

PLANS FOR NEXT PERIOD

New 189s are being submitted to begin actual decommissioning of the reactors subject to selection, by DOE, of the methods to be used.

REPORTS PUBLISHED

C. D. Cagle and L. P. Pugh, "Decommissioning Study for the ORNL Molten-Salt Reactor Experiment (MSRE)," ORNL/CF-77/391, August 25, 1977.

L. B. Holland, "Decommissioning of the TSR-SNAP-10 Reactor -- A Study and Cost Estimate," ORNL/CF-77/401, September 9, 1977.

PROJECTED MILESTONES:

None

* * *

CHARACTERIZATION OF HANFORD 300 AREA BURIAL GROUNDS

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATOR

S. J. Phillips

OBJECTIVES

Substantial quantities of high level, transuranic, and other nuclear materials have been disposed in solid waste burial facilities on the Hanford Reservation in Washington. The location, composition, physiochemical status and migration of waste materials and isotopes are not accurately known. The objective of this program is to develop the technologies required to conduct comprehensive geologic, geophysical, biologic, and computer model analysis of specific sites. These studies will provide analyses of the risk associated with the alternatives of designating sites for permanent storage or removal of wastes and contaminated sediments.

APPROACH

Because of the comprehensive scope of this work, specific tasks have been designated to achieve program objectives. Task activities include analysis of materials by: (1) geophysical surveys, (2) stratigraphy, (3) geochemistry, (4) soil physics, (5) atmos-

pheric and soil physics monitoring, and (6) fauna and flora surveys.

PROGRESS AND RESULTS

Geophysics instrumentation capable of effectively collecting data and real-time processing these data from burial sites has been designed, and fabrication of components is proceeding. The following systems have been utilized: (1) ground penetrating radar, (2) acoustic holography, (3) acoustic reflection and refraction, (4) magnetics, (5) ferromagnetic detection, and (6) thermal infrared inertia. Prototype development of an optimum ground penetrating radar, magnetic, and ferromagnetic detection system has produced a unique geophysics system capable of conducting surveys in high acoustic attenuation, high dielectric, partially indurated and desiccated sediments. Figure 53 illustrates such a mobile computer-based system currently being fabricated and tested.

Geochemical sediment-waste relationships partially control the flux of radionuclides in sedimentary materials. Contaminated sediment samples from radioactive waste burial sites have been collected, and evaluation of the chemical status of materials absorbed on mineral grains has been analyzed by specifically developed optical microscopy, x-ray fluorescence, neutron autoradiography, and electron microprobe techniques. Table 13 represents an example of electron microprobe analysis of the same material. The concurrence of phosphorous and uranium suggests complexing of an unstable phosphorous compound and uranium waste materials.

Fluid migration is the primary mode of transport of radioactive material in shallow land burial sites. Both fluid and vapor phase flux and mass and energy balance determinations are required to define worst case hazard scenarios. Each atmospheric and in situ transport controlling factor is being monitored by a system which will be used to collect ambient data and data from controlled field conditions simulating increased precipitation. Laboratory analyses of nonisothermal liquid and vapor flux of anisotropic heterogeneous flow systems are also being conducted under controlled conditions.

Two nonisothermal energy balance computer models have been developed to evaluate and predict factors controlling long-term stability of various waste forms.

Various plants and animals inhabit shallow land burial sites. Specific species have the potential to uncover and transport significant quantities of waste materials into the biosphere. In vivo dosimetry of burrowing rodents has been conducted to assess the in situ dose of gamma neutron emitters. Figure 54 illustrates a thermoluminescence dosimeter in vivo implant used to monitor doses to rodents inhabiting subsurface contaminated zones. Beta gamma spectroscopy analysis has delineated radionuclide

Figure 53. Generic Representation of Developed Computer-Based Geophysical System

uptake in plant tissue. Table 14 is an example of spectrographic analysis of contaminated plant tissue.

PLANS FOR NEXT PERIOD

In the next period, we plan to:

- Survey all designated burial sites and define location and composition of waste containment structures and wastes;
- Core drill all waste burial sites to determine the extent of waste migration;
- Define additional waste-sediment geochemical reactions;
- Monitor one annual cycle of field energy and mass balance parameters;
- Establish quantitative nonisothermal fluid and vapor phase flux in anisotropic heterogeneous sediments;
- Model liquid and vapor phase flow systems and develop long-term predictive scenarios;
- Assess biologic transport and define biologic waste containment alternatives; and
- Develop decontamination and decommissioning rationale alternatives.

Table 13. Electron Microprobe Analysis of Subsamples of Contaminated Sediment (weight %)

CONSTITUTENT	A	A'	C	C	C	D
SiO ₂	2.8	98.5	16.2	8.9	7.1	2.6
TiO ₂	0.1	--	--	--	--	--
Al ₂ O ₃	0.1	--	9.9	5.0	7.4	0.3
FeO	1.4	0.1	3.5	2.1	1.5	2.3
MgO	0.3	--	--	--	--	--
CaO	1.3	--	8.7	1.2	0.9	1.5
Na ₂ O	1.3	--	--	--	--	--
K ₂ O	2.9	0.06	1.4	2.8	1.7	1.4
P ₂ O ₅	22.2	0.2	21.1	25.5	27.1	27.1
UO ₂	69.1	1.3	38.7	53.8	53.4	63.1
S	0.04	--	0.6	0.7	0.8	0.1
P/U	1.2	--	2.0	1.8	1.9	1.6

Figure 54. Thermoluminescent Dosimeter In Vivo Implant in Rodent Inhabiting Waste Burial Facilities

REPORTS PUBLISHED

S. J. Phillips, A. E. Reisenauer, W. H. Richard, and G. A. Sandness, "Initial Site Characterization and Evaluation of Radionuclide Contaminated Solid Waste Burial Grounds," BNWL-2184, Battelle, Pacific Northwest Laboratories, 1977.

PROJECTED MILESTONES

Figure 55 shows the projected milestone schedule.

* * *

Table 14. Radionuclide Content of Plant Inhabiting the 300 Wye Burial Ground

Radioisotope	dpm/gm
Ce-144	54,400
Ru-106	10,000
Cs-137	7,400
Zr-95	32,400
Mn-54	7,600
Zn-65	10,000

Figure 55. Projected Milestones

PLANNING FOR DECOMMISSIONING OF RETIRED HANFORD FACILITIES

ORGANIZATION AND CONTRACT NUMBER

Pacific Northwest Laboratory
EY-76-C-06-1830

PRINCIPAL INVESTIGATORS

J. W. Litchfield
J. C. King

OBJECTIVES

The objectives of this program are to establish a plan (methods, costs, priorities, schedule) for decommissioning retired contaminated DOE facilities at Hanford; to undertake site characterization of Hanford surplus facilities, and to initiate detailed planning for future decommissioning demonstration projects at Hanford.

APPROACH

Activities central to development of long-range plans for decommissioning surplus facilities include: (1) identification of planning objectives (scenarios), (2) development of plans for achieving identified scenarios, and (3) evaluation of scenarios and plans with the objective of selecting a preferred scenario and plan. Background information required to implement the planning process described above includes facility characterization data, facility priorities for D&D, and selection and characterization of feasible D&D modes.

PROGRESS AND RESULTS

Task I: Facility Characterization

Remaining unpublished sections of the resource book, BNWL-MA-88, except Waste Management Facilities, are in draft form. It is expected that these sections will be issued by the end of FY 1977. A draft of the Waste Management Facilities section will be available by the end of FY 1977. For the 100 area facility characterization, characterization of selected production reactors through core sampling was secured in December 1976 when available funds were exhausted. Additional funds became available in August 1977 allowing the completion of this program. For the 200 Area Facility Characterization, identification and documentation of administrative, physical, functional, and radiological characteristics of the tank farms and waste transfer systems are under way. Completion of this work is anticipated by the end of FY 1977.

A model was developed for the liquid waste disposal site to predict dispersal of radionuclides from the 216-S-1&2 crib under elevated water table conditions. A report on this model is expected by the end of FY 1977.

Task II: Radiological Studies

A radiological design guide for Hanford D&D Operations has been completed and a draft was issued for review on July 1, 1977.

Task III: System Studies

Characterization of D&D activities was accomplished for the facilities listed in Table 15. Activity characteristics estimated included costs, project schedules, contaminated waste generation, and labor requirements.

The facility prioritization system was rerun incorporating refined scores for three of the four prioritization criteria. It is expected that priorities for all facilities currently considered surplus (i.e., ERDA facilities not needed as of October 1, 1976) will be developed by the end of FY 1977.

To achieve integrated planning, three prospective scenarios were identified and four preliminary plans prepared to achieve these scenarios. The plans included D&D modes for all surplus facilities, a schedule of D&D activities, and costs, in both constant and inflated dollars (Table 16). A draft report has been prepared, discussing the preliminary plans in detail. An update of this draft, incorporating all currently surplus facilities, is scheduled for the end of FY 1977.

PLANS FOR NEXT PERIOD

Major objectives, subject to the objectives of a proposed national decommissioning planning project, for FY 1978 include the following:

- Revising the preliminary scenarios and decommissioning plans,
- Completing activity characterization for remaining representative Hanford facilities,
- Estimating occupational dose and releases to the environment for feasible D&D modes on representative facilities, and
- Evaluating major implications and effects of proposed decommissioning plans, and preparing an environmental assessment for preferred decommissioning plans.

REPORTS PUBLISHED

J. W. Litchfield and J. C. King "Decommissioning and Decontamination Planning for Hanford Nuclear Facilities Using Multiattributed Decision Analysis," BNWL-SA-6007, Battelle, Pacific Northwest Laboratories, May 1977.

D. A. Waite, W. D. McCormack, J. R. Berry and P. L. Baker, "Radiological Design Guide for Hanford D&D Operations," BNWL-2187, UC-41, Battelle, Pacific Northwest Laboratories, July 1977 (working paper).

Table 15. Summary of FY 1977 Activity Characterization Work

Representative Facility		Modes Characterized			
Type	Number	Layaway	Prot. Stor.	Entomb.	Dismantle
Gas Recirculation Bldg.	115-D	+	+		+
Confinement Filter	117-D	+	+		+
Sample Bldg.	119-DR	+			+
Stack	116-D	+			+
Reprocessing Canyon	202-S				+
Production Reactor	105-D				+
Metal Storage Bldg.	103-D				+
Transuranic (TRU) Crib	216-Z-12		X		X
Mixed Fission Product (MFP)/TRU Crib	216-S-1&2		X	X	
Mixed Fission Product Trench	216-B-20		X	X	
Pond	216-S-17		X	X	
MFP/TRU Burial Ground	318-11		X		X

KEY: + Characterized by Planning-Level Estimate
 X Characterized by Computer-Based Model

Table 16. Comparison of Four Preliminary Plans

Activity	Preliminary Plan			
	Unrestricted Use Case A	Unrestricted Use Case B	Current Trend	Minimum Effort
Program Start	1980	1980	1980	1980
Program Completion	2080	2060	2000	2000
Interim Use*/Date Achieved**				
100 Areas	U/2080	U/2060	R/2000	R/2000
200 Areas	C/2080	C/2060	R/2000	R/2000
300 Areas	U/2080	U/2060	U/2000	R/2000
Ultimate Use*/Date Achieved**				
100 Areas	--	--	U/2030	D/2000
200 Areas	U/2280	U/2280	D/2080	D/2000
300 Areas	--	--	--	D/2000
Facilities Included	ECT Surplus	ECT Surplus	ECT Surplus	ECT Surplus
Budget (% Millions)				
Annual (1980)	8.2	10.0	10.4	1.1
Total (Constant)	823	823	198	24
Total (3% Inflation)	4991	3468	264	33

* Sites of ECT-Surplus Facilities Only
 ** Rounded to Nearest 5 Years

KEY: U = Unrestricted Use
 C = Conditional Use
 R = Restricted Use
 D = Additional D&D Action Required

J. W. Litchfield and J. C. King, "Planning for Decommissioning and Decontamination of Hanford Nuclear Facilities," BNWL-SA-6450, Battelle, Pacific Northwest Laboratories, August 1977.

J. C. King and J. W. Litchfield, "Preliminary Plans for Decontamination and Decommissioning at Hanford," Battelle, Pacific Northwest Laboratories, August 1977 (working paper).

PROJECTED MILESTONES

- June 1978 -- Issue update of resource book
- August 1978 -- Issue update of decommissioning plans
- August 1978 -- Issue draft environmental assessment

* * *

DECONTAMINATION OF CENTER FOR ENERGY AND ENVIRONMENTAL RESEARCH REACTOR FACILITY

ORGANIZATION AND CONTRACT NUMBER

University of Puerto Rico
EY-76-C-05-1833

PRINCIPAL INVESTIGATOR

R. Brown

OBJECTIVES

Decontamination of the Center for Energy and Environmental Research (CEER) Facilities at Mayaguez including the Reactor Facility to levels of residual radioactivity suitable for unrestricted use, or in the case of nuclear facilities to be retained by the University of Puerto Rico (UPR), to levels consistent with Nuclear Regulatory Commission (NRC) licensing requirements.

APPROACH

The facilities at Mayaguez will be decontaminated for unrestricted use, or to meet NRC licensing requirements as appropriate, in conformity with the requirements of Manual Chapter ERDAM 0524 utilizing CEER forces and/or an ERDA-approved subcontractor. A Decontamination Plan will be submitted to ERDA for approval prior to any decontamination effort involving structural integrity of the facility and its safety features. All radioactive debris and wastes, excluding permissible levels for release to the environment, will be shipped to approved radioactive waste disposal sites in the Continental United States.

PROGRESS AND RESULTS

A draft Decontamination Plan has been developed and submitted to Oak Ridge Operations (ORO) Office for review and comment. Included in the plan are the required history of past usage of the facility, a catalog of radioactive debris and other radioactive waste and materials to be removed from the facility, and a radiological survey of the facility in sufficient detail to allow development of the plan. The CEER training research and isotope production (TRIGA) reactor has been dismantled and transferred to Argonne National Laboratory-West, Idaho Falls, Idaho. Components transferred to ANL-West include the reactor console, control system, and reactor fuel. The reactor cooling system is scheduled for transfer to Argonne National Laboratory for future transfer to Korea.

PLANS FOR NEXT PERIOD

The final draft of the decontamination plan will be submitted to ERDA for review and approval on or before January 1, 1978. Radioactive debris, wastes, and other sources will be collected, packaged, and shipped to the Continental U.S. for appropriate disposal. The reactor support structure will be dismantled and disposed of as above. The reactor pool water will be decontaminated utilizing the existing hot waste system. Subsequently, a more detailed radiological survey, including core sampling of the reactor pool, will be conducted to determine more precisely the construction (demolition and restoration) effort required. Specifications for the final phase of the decontamination work toward selection of a subcontractor will be developed in late FY 1978 or FY 1979.

REPORTS PUBLISHED

"Draft Reactor Decontamination Plan for the Center for Energy and Environment Research," University of Puerto Rico, July 13, 1977.

PROJECTED MILESTONES

- January 1, 1978 -- Submit final Decontamination Plan
- March 1, 1978 -- Collect, package, and ship to Continental U.S., for appropriate disposal, existing radioactive wastes, debris, and other radioactive sources not needed by CEER
- May 31, 1978 -- Decontaminate reactor pool water and conduct detailed supplemental radiological survey of Mayaguez site
- October 1, 1978 -- Prepare specifications for final decontamination work by subcontractor

- December 1, 1978 -- Select final decontamination subcontractor
- July 1, 1979 -- Complete decontamination and restoration work
- August 15, 1979 -- Conduct final radiological survey
- December 1979 -- Transfer Mayaguez Facilities to University of Puerto Rico for unrestricted and/or NRC licensed use as appropriate

* * *

PROJECT GNOME SITE DISPOSAL

ORGANIZATION AND CONTRACT NUMBER

Reynolds Electrical & Engineering Co., Inc.
EY-76-C08-0410

EG&G, Inc.
EY-76-C-08-1183

Fenix & Scisson, Inc.
EY-76-C-08-0038

PRINCIPAL INVESTIGATOR

D. T. Schueler

OBJECTIVES

The objectives of this project are to clean up the site in accordance with approved safety and radiological guidelines and to return the property to the public domain.

APPROACH

The approach is to conduct an aerial radiological survey (gamma spectral analysis) of the entire square mile and adjacent contiguous area as may be required; survey all operational areas and areas identified by the aerial survey using a mobile radiological survey vehicle (gamma spectral analyzer) followed by a comprehensive soil sampling program to define the magnitude of the clean-up program. The holes into the Gnome cavity and its associated drifts are to be cleaned out and a slurry of contaminated soil and salt is to be injected into these underground voids. Any remaining contaminated material will be packaged and returned to the Nevada Test Site for isolation. All holes, except those to be retained for later EPA monitoring, will be plugged and the disturbed site work areas will be shaped to conform to the natural lay of the land and stabilized.

PROGRESS AND RESULTS

During FY 1977, the aerial and van surveys were conducted, a grid layout was made, an auger was tested for sampling to a depth of 12 feet, and a metal detector survey of the operational areas was completed. A map showing the site location is given in Figure 56.

PLANS FOR NEXT PERIOD

In FY 1978, it is planned to complete the ground survey and identify all the material which needs to be removed from the surface and injected into the underground voids, open the holes into the voids, and prepare the site for the down-hole operation. During FY 1979, the actual injection of identified contaminated material into the underground voids is planned. This will be followed by a confirming ground survey, site restoration, and a final report.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

- June 30, 1978 -- Site radiological survey completed
- September 30, 1978 -- Final detail planning document completed and approved
- June 30, 1979 -- Field execution of cleanup program completed
- December 1, 1979 -- Final report published

* * *

WELDON SPRING SITE SUPERVISION AND DECOMMISSIONING

ORGANIZATION AND CONTRACT NUMBER

National Lead Company of Ohio
EY-76-C-05-1156

PRINCIPAL INVESTIGATOR

A. F. Pennak

OBJECTIVES

The objective of this project is to decommission the ERDA-Weldon Spring Site and return it to unrestricted use.

Figure 56. Gnome Location

APPROACH

The site consists of four pits that contain the radioactive wastes generated from the production of uranium metal at the Weldon Spring Production Center from 1957 to 1966. ERDA also has possession of a quarry located four miles from the Weldon Spring Plant which was used for the disposal of contaminated rubble and thorium residues. The residues contained in the four pits will be removed by private contractor during FY 1978 and FY 1979. The National Lead Company of Ohio will monitor the removal of the sludges and pump any surface runoff as necessary back into the pits. After the sludges have been removed, the supernatant liquors will be discharged to the Missouri River and the site will be graded to an esthetically pleasing contour. There will also be an attempt made to seal a portion of the floor of the quarry with grouting. If this proves successful, then the quarry area will be filled, graded, and seeded.

PROGRESS AND RESULTS

We have reached substantial agreement with Cotter Corporation on the terms of a contract which calls for them to remove the wastes from the four pits over a period of two years. ERDA-ORO has solicited a nonrevokable permit from the Department of the Army which would give Cotter the use of the Army's railspur and land at Weldon Spring. We expect to receive this permit in September and consummate the contract with Cotter soon thereafter. Additional test well sampling at the quarry will be completed in FY 1977.

PLANS FOR NEXT PERIOD

It is anticipated that Cotter Corporation will begin removing the raffinate sludges early in FY 1978 and finish the work in late FY 1979. National Lead Company of Ohio will monitor Cotter's progress, conduct radiological surveys, and control excess water in the pits to facilitate removal of the sludges by Cotter.

APPROACH

The ERDA Site is primarily used as a radioactive waste storage area. No radioactive wastes were generated on the site. The wastes were shipped there from several production locations between 1944 and 1953. National Lead Company of Ohio currently provides supervision and caretaking activities on the site. National Lead will monitor the removal of the radioactive residues from the site by a private contractor beginning in FY 1979. After this has been completed, actions will be undertaken to reduce the site to a minimum area including:

- Decontamination or dismantling/removal of radioactively contaminated buildings and structures on the entire site,
- Decontamination of the excess site area by excavation and removal of all contaminated soil, and
- Consolidation of all contaminated rubble, earth, and debris within the retained ERDA area.

PROGRESS AND RESULTS

The installation of an improved groundwater sampling system will be completed in FY 1977.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

See Figure 57 for projected milestone schedule.

* * *

SUPERVISION AND DECONTAMINATION OF NIAGARA FALLS SITE

ORGANIZATION AND CONTRACT NUMBER

National Lead Company of Ohio
EY-76-C-05-1156

PRINCIPAL INVESTIGATOR

A. F. Pennak

OBJECTIVES

The objective of this project is to decontaminate 157.3 acres of the 191-acre ERDA-Niagara Falls Site and return it to unrestricted use. All contaminated rubble would be consolidated on the 33.7 remaining acres.

Figure 57. Projected Milestone Schedule

PLANS FOR NEXT PERIOD

Surveillance of the site will be continued in FY 1978 by National Lead.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

For projected milestones, see Figure 58.

* * *

NUCLEAR ROCKET DEVELOPMENT STATION FUEL AND FACILITY CLEANUP

ORGANIZATION AND CONTRACT NUMBER

Reynolds Electric Engineering Co.
EY-75-C-08-0597

PRINCIPAL INVESTIGATOR

T. K. Foglinai

OBJECTIVES

The objectives of this project are to disassemble the Tory II-C Nuclear Reactor, package and assay the nuclear fuel rods, and ship to the Idaho National

Environmental Laboratory (INEL) for eventual uranium recovery. The reactor prior to disassembling is shown in Figure 59.

APPROACH

The radioactive reactor will be remotely disassembled using the E-MAD facility at Area 25 of the Nevada Test Site (NTS). The fuel rods will be placed in approximately 650 aluminum cans, assayed by means of a Los Alamos Scientific Laboratory (LASL) device to ascertain the amount of uranium in each can, and shipped to the INEL using LASL-owned lead shielded casks.

PROGRESS AND RESULTS

Tory II-C disassembly continued following the retrieval from R-MAD in mid-December. By the end of January, Duct 5, containing the nuclear reactor, had been separated from the rest of the assembly which was then moved to the Reactor Materials Storage Facility (RMSF) for storage. Also, the Rail Handling System was removed to RMSF. The disassembly bay was partially decontaminated and equipment for Phase II, core disassembly, was installed and checked out. This disassembly operation started in mid-March, and the core was installed on the disassembly stand in mid-April.

In May, two preselected columns of fuel were removed from the core and sent to Lawrence Livermore Laboratory (LLL) for detailed examination. The Tory II-C reactor core disassembly was started in late May and was completed at the end of

Figure 58. Projected Milestone Schedule

Figure 59. Tory II-C Before Disassembly

August, and the fuel was packaged into 650 cans. The assay of uranium in each can was started in mid-September and completed in mid-October. The totals were 58,178 grams of uranium (54,173 grams of U-235 isotope). This was 4.3 percent higher than official records indicated.

During all of the core disassembly operations, neutron counting equipment was operational, and particular attention was given to the measurement of neutron multiplication during poison rod removal and exchange of poison rods to ensure nuclear safety.

The Roots Blower system (Figure 60) used for removal of fuel rods from the reactor, was modified to improve efficiency by the fabrication of a new nozzle attached to the end of the vacuum hose. An additional piece of equipment, called a "Bear Claw," was built to loosen the core assembly, thereby accelerating the pace of the disassembly operation. The core appearance at 25-percent fuel removal is shown in Figure 61.

An air operated vibrator was attached to the inclined fuel chute to assist gravity in the transfer of fuel from the vicinity of the core to the sorting station at one of the viewing windows.

Plans to crush or compact the fuel rods into the shipping cans to reduce the volume and to increase the mass of fuel in each can were found to be technically unfeasible. The fuel was inserted into the cans using master-slave manipulators, with particular care being given to the filling of each can to capacity.

During the reactor disassembly, certain items of hardware and instrumentation made of platinum were set aside. Thirty-four pounds of this material were packaged for later processing; the market value was close to \$100,000.

Fuel shipments of 25 cans each began on October 3 and, barring unforeseen delays, should be complete by the end of November. A loaded fuel shipment is shown in Figure 62.

PLANS FOR NEXT PERIOD

Shipment of the Tory II-C canned fuel to the INEL is scheduled to start in early October 1977 and should be complete by mid-November, thus completing the fuel recovery program, except for facility cleanup and decontamination.

REPORTS PUBLISHED

"Safety Analysis Report for Tory II-C Fuel Recovery, NVO-164, September 1975.

PROJECTED MILESTONES

Completion of the program is expected to take place in mid-December 1977. A final report will be published shortly thereafter.

* * *

Figure 60. (Above) Phase II Tory Disassembly -- Removing Reflector Tubes with Roots Blower

Figure 61. (Right) Phase II Tory Disassembly -- Appearance of Cove at 25% Fuel Removal

Figure 62. Truck and Cask Loaded with Tory II-C Fuel for Shipment to INEL

DECONTAMINATION AND DECOMMISSIONING OF SPACE NUCLEAR AUXILIARY POWER, KINETIC ENERGY WATER BOILER, AND RADIOACTIVE MATERIALS DISPOSAL FACILITIES

ORGANIZATION AND CONTRACT NUMBER

Atomics International
EY-76-C-03-0701

PRINCIPAL INVESTIGATORS

B. F. Ureda
A. W. Graves

OBJECTIVES

The objective of the task is to return to unrestricted use the sites or the facilities of the partially dismantled Space Nuclear Auxiliary Power (SNAP) reactor facilities (Buildings 010, 024, and 059) and the Radioactive Materials Disposal Facility (RMDF).

The other facilities, Building 003 Hot Cave, Kinetic Energy Water Boiler (KEWB) reactor, and the Shield Test Irradiation (STIR) reactor (Building 028), which were included in the original scope of the program, have now been decontaminated and the sites or facilities made available for other use. Before and after, views of the STIR reactor facility are shown in Figure 63.

APPROACH

The radioactive contamination in these facilities will be decreased to acceptable levels for unrestricted use by decontamination or direct removal of structure, equipment, and materials as necessary. Structures, soil, and equipment activated by neutrons in reactor buildings will be removed as necessary.

PROGRESS AND RESULTS

The Facility Dismantling Plan and the Activity Requirements for SNAP Building 010 have been completed and approved. Detailed Working Procedures were prepared and dismantling of the nonradioactive systems was initiated.

The radiological survey of SNAP Building 024 has been completed and the Facility Dismantling Plan has been submitted for approval. An activated vacuum chamber was removed from the facility and shipped for burial prior to the radiological survey so that data could be obtained to determine the remaining materials to be moved.

Conceptual D&D planning was performed for SNAP Building 059 during FY 1977.

An assessment was made of the contamination level of the leach field associated with RMDF. Thirty-one exploratory holes were drilled and 170 soil samples were taken for radiometric analysis. A radiation isopleth map was prepared to illustrate the extent of radioactive contamination present. The

specific activity of 20 of the 170 samples taken were above the 100-pCi/gm specific activity considered acceptable for unrestricted use. Safety precautions were instituted to secure the site and prevent the spread of the contamination pending initiation of removal operations. These data were used to establish a plan and cost estimate for removal of the soil.

PLANS FOR NEXT PERIOD

Dismantling of the radioactive systems at SNAP Building 010 will be completed. Contaminated areas will be opened, a radiological survey will be conducted, and decontamination and dismantling will proceed. All radioactive materials or components removed from the facility will be decontaminated or packaged for disposal as radioactive waste by land burial at the Beatty, Nevada, site. All activated concrete and soil will be removed until radiation is at acceptable levels. The above-grade structure will be removed, the excavation will be backfilled, and the site restored to natural grades.

A radiological survey will be conducted at SNAP Building 024 after opening contaminated areas. The results will be assessed, and decontamination and dismantling will proceed. All radioactive materials or components removed from the facility will be decontaminated or packaged for disposal as radioactive waste by land burial at Beatty, Nevada. All activated concrete and soil will be removed to acceptable radiation levels. The below-grade rooms and vaults will be partially dismantled. The radioactive waste system holding tanks will be removed and be decontaminated or shipped to burial. Excavations will be backfilled and repaired as necessary to restore to a safe condition.

The Facilities Dismantling Plan, Activities Requirements, and Detailed Working Procedures for SNAP Building 059 activities will be prepared. A radiological survey of the facility will be conducted, the results will be assessed, and decontamination initiated. Contaminated equipment will be removed and decontaminated or packaged for shipment to burial.

For RMDF, the Dismantling Plan, Activity Requirements, and Detailed Working Procedures will be prepared. Radiological surveys and assessments will be conducted in all the buildings. Building 665 (Sodium Reactor Experiment (SRE) sodium storage), Building 075 (contaminated storage), and Building 621 (accountable waste storage) will be decontaminated.

A "B" budget has been submitted to excavate the leach field, package, and ship the radioactive material for burial and restore the site to a safe condition.

REPORTS PUBLISHED

"Facilities Dismantling Plan for Building 10 (SER)," N704-FDP-990-005.

"Facilities Dismantling Plan for Building 024 (SETF)," N704-FDP-990-006.

Figure 63. "Before" and "After" Views of STIR Decommissioning

"Radiological Survey Plan, Support of D&D Program Operations T-024 (SNAP 2 and 10)," N704-TP-990-009.

"Radiological Survey Plan, Support of D&D Program Operations T024 (SNAP 2 and 10)," N704-TP-990-009.

"Facilities Dismantling Plan for Building T024, SNAP Environmental Test," N704-FDP-990-006.

PROJECTED MILESTONES

- July 1, 1978 -- Building 010: D&D Complete
- October 1, 1978 -- Building 010: Final Report
- June 1, 1978 -- Building 024: D&D Complete
- July 1, 1978 -- Building 024: D&D Complete
- February 1, 1978 -- Building 059: Task Activity Submittal
- March 1, 1978 -- Building 059: Dismantling Plan Submittal
- May 1, 1978 -- Building 059: Dismantling Initiated
- March 15, 1978 -- RMDF (Buildings 21, 22): Task Activity Submittal
- May 1, 1978 -- RMDF (Buildings 21, 22): Dismantling Plan Submittal

* * *

DECONTAMINATION AND DISPOSITION OF SODIUM REACTOR EXPERIMENT

ORGANIZATION AND CONTRACT NUMBER

Atomics International
EY-76-C-03-0701

PRINCIPAL INVESTIGATORS

B. F. Ureda
A. W. Graves

OBJECTIVES

The objective of the task is to dismantle the Sodium Reactor Experiment (SRE) Facility and to remove all significant reactor-originated radioactivity from the site, thus releasing the facility

from all requirements for radiological control, licensing, or monitoring and make the site available for other uses.

APPROACH

The approach is the complete dismantling and disposal by land burial of all activated structures or components, the dismantling or decontamination of all contaminated structures or components, and the disposal by land burial of all radioactive waste generated as part of the dismantling activity.

PROGRESS AND RESULTS

The SRE Core II fuel decladding was completed during the first quarter of FY 1977. The ERDA-escorted shipments of the repackaged fuel were initiated in the first quarter and completed in the second quarter of FY 1977. All cell cleanup and waste disposal was completed in the second quarter of FY 1977, which completed the SRE fuel declad task.

The SRE vessels were filled with water after completion of the alcohol passivation of residual sodium. The water is required as shielding for the activated stainless steel internal components. The 140-inch-diameter loading face shield plug was removed from the top of the vessels (Figure 64), wrapped, and set aside for further disassembly. All the core components were removed from the vessels, including the moderator cans and reflector cans. These cans were wrapped and packaged for burial. The bellows assemblies (two) were cut to free the 14-foot-diameter ring shield from the core tank and outer tank, and the ring shield was removed from the top of the vessels.

The thermal shields were removed from the bottom of the 140-inch diameter shield plug and the 14-foot diameter ring shield, and the plug and ring shield were wrapped with protective sheeting and shipped intact to the Beatty, Nevada, burial grounds.

The internal components from the storage and wash cells were removed, packaged, and shipped for land burial. The piping and sodium components were removed from the primary and secondary sodium service systems, completing all SRE piping removal. These components were all subjected to a sodium passivation process: steam cleaning for components with only a light film of sodium, alcohol passivation for components with sodium residual, and sodium melting and removal prior to alcohol passivation for components with sodium residual and bulk sodium residual.

The remote tooling development task was completed; the manipulator-plasma arc cutting system (Figure 65) and control console were moved to the SRE; the support remote tooling was developed, checked out, and installed in the SRE; and the SRE vessel underwater-plasma arc cutting was begun. The major support tooling included the remote oxyacetylene thermal ring cutting fixture; the remote

Figure 64. Sodium Reactor Experiment Vessel

Figure 65. Manipulator/Plasma Arc Cutting System

plasma arc pipe cutting fixture for installation in the storage pit; the containment enclosure for installation over the SRE vessels, and the manipulator; various lifting, holding, and grappling tools for vessel segment removal; and a television and lighting system.

The explosive removal of internal pipe from the SRE vessels was successfully completed in two phases. The explosive cutting had been successfully demonstrated on piping mockups the previous year.

The vessel liner and core tank were removed using the manipulator-plasma arc cutting system. Removal of the grid plate assembly by plasma arc cutting was initiated.

The radioactive liquid and gas waste tanks and piping systems were removed from the north side of the SRE complex and buried as radioactive waste. Dismantling and disposal of the fuel and moderator handling machines was begun. Prior to the initiation of D&D, the SRE complex appeared as in Figure 66. The area to the east of the SRE, where the secondary process equipment was located, was then cleared of all buried piping and all mounting pads were removed. The entire area was graded and the site repaired by asphalt paving and now appears as in Figure 67.

PLANS FOR NEXT PERIOD

The remote plasma arc cut up and removal of the reactor vessels will be completed, and the cavity liner and biological concrete shielding will be removed. The highly activated reactor vessel segments will be shipped and buried in specially designed cask

liners which fit into a commercially available licensed shipping cask. The contaminated concrete around the storage and wash cells and the hot cells will be removed. The dismantling and disposal of the fuel and moderator handling machines will be completed. The retention pond will be cleared of contamination, and associated structures will be razed or repaired. All radioactive waste packaging and disposal will be completed. Site excavations will be back-filled as necessary. The final radiation survey, final dismantling report, and all the efforts associated with the SRE dismantling will be completed.

REPORTS PUBLISHED

"Final Report -- SRE Fuel Decladding," N704-FDR-990-004.

PROJECTED MILESTONES

- January 1, 1978 -- Completion of reactor vessels removal
- July 1, 1978 -- Completion of cavity liner and biological shielding
- December 1, 1978 -- Completion of fuel and moderator handling machines disposal
- June 1, 1978 -- Completion of retention pond removal and razing or repairing all structures
- September 29, 1978 -- Completion of final dismantling report.

* * *

Figure 66. Sodium Reactor Experiment Complex prior to Decontamination and Decommissioning

Figure 67. The Sodium Reactor Experiment Complex as it Now Appears

REMEDIAL ACTIONS AT FORMERLY UTILIZED MANHATTAN ENGINEER DISTRICT/ATOMIC ENERGY COMMISSION SITES

The objective of this program is to plan and implement programs of remedial actions at approximately 30 sites that have been found to have residual radioactive contamination above currently acceptable levels for unrestricted use. The program includes a review of the files of the operating programs for Manhattan Engineer District (MED) and Atomic Energy Commission (AEC) to identify all facilities and determine the status of radiological conditions at the termination of operations. Some 150 such files were reviewed. Where the status is unclear (about 82 cases), additional steps have been taken including site visits to determine if additional survey work is needed. In 30 cases surveys were conducted to establish the degree of residual contamination; about 12 of these will require engineering studies to select the course of remedial action. The other 18 have more localized contamination that can be cleaned up with less effort.

OAK RIDGE NATIONAL LABORATORY RADIOLOGICAL SURVEY OF FORMERLY UTILIZED MED/AEC SITES

ORGANIZATION AND CONTRACT NUMBER

Oak Ridge National Laboratory
W-7405-ENG-26

PRINCIPAL INVESTIGATOR

F. F. Haywood

OBJECTIVES

The objective of this project is to determine and document the radiological status of 39 assigned sites and to evaluate the level of residual radioactivity against current radiation control guidelines.

APPROACH

The following tasks are performed for this study: (1) visit each site to make a preliminary radiation survey and evaluation and to participate with DOE in the determination of need for a formal site survey; (2) conduct formal surveys as requested by DOE to characterize the radiological condition of the site; and (3) document survey findings and provide an assessment of potential personnel radiation exposure under current and possible future occupancy and use conditions.

PROGRESS AND RESULTS

As of the close of FY 1977, visits and preliminary surveys at 33 sites have been conducted. Formal Oak Ridge National Laboratory (ORNL) radiological

assessments are required at 17 of these sites. ORNL field surveys have been completed at 14 sites and reports for 5 sites have been finalized. Six additional reports have been submitted in draft for DOE review. Based on resurvey data collected to date, 17 of the 33 sites assessed do not meet current unrestricted use guidelines and will require further evaluation.

PLANS FOR NEXT PERIOD

Funding for ORNL will provide support at the current staff level through January 1978. As of that time, final reports will be completed on the remaining 12 sites. Visits to six remaining sites for preliminary assessment and a determination of the need for formal ORNL survey will be made.

REPORTS PUBLISHED

All survey reports for sites in this program will be published as DOE documents by Headquarters.

PROJECTED MILESTONES

Documentation of the radiological assessment of the 39 assigned sites will be completed by February 1, 1978, assuming that additional sites requiring formal ORNL survey are not identified from among the six sites yet to be visited.

* * *

LOS ALAMOS SCIENTIFIC LABORATORY
RADIOLOGICAL SURVEY OF FORMERLY
UTILIZED MED/AEC SITES

ORGANIZATION AND CONTRACT NUMBER

Los Alamos Scientific Laboratory
W-7405-ENG-36

PRINCIPAL INVESTIGATOR

H. Jordon

OBJECTIVES

The objectives of this project are to determine and document the radiological status of assigned sites and to evaluate the level of residual radioactivity against current radiation control guidelines.

APPROACH

The following tasks are performed for this study: (1) visit each site to make a preliminary radiation survey and evaluation and to participate with DOE in the determination of need for a formal site survey; (2) conduct formal surveys as requested by DOE to characterize the radiological condition of the site; and (3) document survey findings and provide an assessment of potential personnel radiation exposure under current and possible future occupancy and use conditions.

PROGRESS AND RESULTS

As of the close of FY 1977, visits and preliminary surveys and radiological assessments have been completed at these sites. Draft reports are in preparation. Based on preliminary resurvey data collected to date, two of the four sites assessed do not meet current unrestricted use guidelines and will require further evaluation.

PLANS FOR NEXT PERIOD

Funding for Los Alamos Scientific Laboratory will provide support at the current staff level through FY 1978. At the end of that time, final reports will be completed on the four sites.

REPORTS PUBLISHED

All survey reports for sites in this program will be published as DOE documents by Headquarters.

PROJECTED MILESTONES

- September 30, 1978 -- Documentation of the radiological assessment of the four assigned sites will be completed.

* * *

ARGONNE NATIONAL LABORATORY
RADIOLOGICAL SURVEY OF FORMERLY
UTILIZED MED/AEC SITES

ORGANIZATION AND CONTRACT NUMBER

Argonne National Laboratory
W-31-109-N-38

PRINCIPAL INVESTIGATOR

R. A. Wynveen

OBJECTIVES

The objectives of this project is to determine and document the radiological status of 16 assigned sites and to evaluate the level of residual radioactivity against current radiation control guidelines.

APPROACH

The following tasks are performed for this study: (1) visit each site to make a preliminary radiation survey and evaluation and to participate with DOE in the determination of need for a formal site survey; (2) conduct formal surveys as requested by DOE to characterize the radiological condition of the site; and (3) document survey findings and provide an assessment of potential personnel radiation exposure under current and possible future occupancy and use conditions.

PROGRESS AND RESULTS

As of the close of FY 1977, visits and preliminary surveys at 16 sites have been conducted. Formal Argonne National Laboratory (ANL) radiological assessments were required at seven of the sites and these were completed. Draft reports are in preparation. Based on resurvey data collected to date, 7 of the sixteen sites assessed do not meet current unrestricted use guidelines and will require further evaluation.

PLANS FOR NEXT PERIOD

Funding for ANL will provide support at the current staff level through September 1978. As of that time, final reports should be completed on the remaining seven sites.

REPORTS PUBLISHED

All survey reports for sites in this program will be published as DOE documents by Headquarters.

PROJECTED MILESTONES

Documentation of the radiological assessment of the 16 assigned sites will be completed by September 30, 1978, assuming that additional sites requiring formal ANL survey are not identified.

* * *

GRAND JUNCTION REMEDIAL ACTION PROGRAM

The Grand Junction Remedial Action Program implements the legislative authority provided by the Congress in Title II of P.L. 92-314. The objective of the program is to remedy conditions of excessive radiation exposure to people as a result of the use of uranium mill tailings in construction of structures at Grand Junction, Colorado. The law specifies that the Federal Government shall provide 75 percent of the cost of a State-operated remedial program.

Approximately one-half of approximately 600 structures estimated to be eligible under the program have been completed. It is estimated that the program can be completed by FY 1981 at an accelerated rate of about 100 structures per year.

GRAND JUNCTION REMEDIAL ACTION PROGRAM

ORGANIZATION AND CONTRACT NUMBER

State of Colorado
AT(05-1)-1621
EW-76-C-23-1621

PRINCIPAL INVESTIGATOR

A. Robbins

OBJECTIVES

The objectives of this program are to reduce the radiation exposure of the public resulting from the use of tailings from the former uranium ore processing mill in Grand Junction, Colorado, as a construction material.

APPROACH

The remedial action program was authorized by Congress in 1972 under Title II of Public Law 92-314. The U.S. Surgeon General established remedial action guidelines at the request of the Colorado Department of Health. Radiation measurements are first made to determine whether structures for which owners have made application for remedial action qualify under the guidelines. The State is responsible for conducting the remedial work, most of which is carried out by an architect-engineer contractor. The State draws up remedial action plans and submits them to DOE for approval. Under the law, DOE has the final responsibility for selection of appropriate remedial action for each structure. In most instances, the remedial action method used is to remove the floor slab, excavate the tailings, replace them with clean fill, and pour a new concrete floor. In some cases, an epoxy sealant is used on the inside of concrete

surfaces to prevent radon gas generated by the radium in the tailings from diffusing into the living space.

A priority system was established under which houses and schools were given priority over industrial buildings. Priority was also given to the structures with the highest radiation levels.

PROGRESS AND RESULTS

Through FY 1977, remedial action has been carried out on a total of 280 structures, including 254 residences, 11 schools, and 15 commercial structures. Under the provisions of PL 92-314, the Federal Government pays 75 percent of the remedial program cost and the State of Colorado pays the remainder. About 64 structures were completed in FY 1977.

PLANS FOR NEXT PERIOD

Plans call for completing about 30 to 35 structures in FY 1978. This level is below that for FY 1977 due to the funding and time of application restrictions contained in the original authorizing legislation. In February 1978, new legislation (Public Law 95-236) was passed extending the time limit for owners to apply for remedial action for an additional four years and providing additional funding. Plans will be made to accelerate the program in FY 1979 and complete work on eligible structures by 1981. It is estimated that a total of about 600 structures will qualify for remedial action.

REPORTS PUBLISHED

None

PROJECTED MILESTONES

None

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REMEDIAL ACTIONS AT INACTIVE MILL TAILINGS SITES

The objective of this program is to reduce the radiological hazards from accumulations of tailings that resulted from milling of uranium to supply the needs of National Defense programs. Twenty engineering assessment reports have been completed and provide detailed information on radiation exposures, practicable remedial alternatives, and costs for 22 such mill tailings sites in 8 western states. The findings of these reports indicated that none of the sites has been adequately stabilized for long-term control of wind and water erosion and that many tailings sites are favorably located and in demand for alternate uses. In some cases, consolidation of the tailings pile areas and provision of an adequate stabilizing cover may be effective to correct the situation. In other cases, however, the present sites are unsuitable for long-term stabilization and removal to an alternate location will be necessary.

Research and development efforts conducted in FY 1977 in connection with the engineering assessment work provided some encouraging results indicating that further efforts to develop methods to control the release of radon, to improve ground sealants, and to establish cover materials could be successful in reducing environmental impact and the cost of remedial actions.

The remedial effort is estimated to require about five years to perform, largely because of the large quantities of tailings and other radioactively contaminated materials involved. On the 22 sites examined in the engineering assessment work, there are about 26,000,000 tons of tailings containing about 14,000 curies of radium, and additional large volumes of slightly contaminated materials.

PHASE II - TITLE I ENGINEERING ASSESSMENT OF INACTIVE URANIUM MILL TAILINGS SITES

ORGANIZATION AND CONTRACT NUMBER

Ford, Bacon and Davis Utah, Inc.
E(05-01)-1658
EW-76-C-13-1658

PRINCIPAL INVESTIGATOR

V. C. Rogers

OBJECTIVES

The objectives for this project are (1) to complete engineering assessments and estimates of costs for practicable alternatives for stabilization of uranium mill tailings at 22 inactive sites where uranium was formerly produced for sale to the U.S. Government and (2) to carry out a laboratory and bench scale research program to improve means of reducing radiation exposure to the public from uranium mill tailings.

APPROACH

Field studies include radiation measurements and identification of extent of contamination on and in the vicinity of each mill site. Demographic information is gathered to identify present and future population risk and future land-use potential. Practicable remedial alternatives are identified and cost estimates made. A cost/benefit analysis is performed. In the R&D work, initial efforts have been to determine importance of ambient conditions in influencing the rate of emanation of radon from tailings.

PROGRESS AND RESULTS

Four reports covering engineering assessments on inactive uranium mill tailings sites on the Navajo Indian Reservation in New Mexico, Utah, and Arizona were issued during the year. Work on the reports on the remaining 16 tailings locations were drafted and were under review by the several agencies participating in the work. The initial laboratory R&D effort was completed and the technical report was drafted.

PLANS FOR NEXT PERIOD:

During the next period the following activities are planned.

- The remaining 15 engineering assessment reports are to be issued early in the fiscal year.
- The R&D work will be continued in an effort to develop better means of tailings stabilization and radiation control at lower cost than simply providing a thick earth covering.
- Work will be initiated on preparation of environmental assessments, based largely on information already assembled in connection with the engineering assessments.
- Title II engineering involving preparation of detailed plans and specification for

remedial action may be undertaken on priority sites.

REPORTS PUBLISHED

GJT-2 Phase II - Title I Engineering Assessment of Inactive Mill Tailings, Shiprock Site, Shiprock, New Mexico.

GJT-3 Phase II - Title I Engineering Assessment of Inactive Uranium Mill Tailings, Mexican Hat Site, Mexican Hat, Utah

GJT-4 Phase II - Title I Engineering Assessment of Inactive Uranium Mill Tailings, Monument Valley Site, Monument Valley, Arizona

GJT-5 Phase II - Title I Engineering Assessment of Inactive Uranium Mill Tailings, Tuba City Site, Tuba City, Arizona

PROJECTED MILESTONES

None

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APPENDIX

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ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
AES	Assistant Administrator for Environment and Safety
AMD	acid mine drainage
ANG	Michigan - Wisconsin Pipeline Company
ANL	Argonne National Laboratory
ANS	American Nuclear Society
ARVFS	Army Reentry Vehicle Facility Site
ASTM	American Society of Testing and Materials
BATEA	best available treatment economically achievable
BCL	Battelle Columbus Laboratory (now Battelle Memorial Institute)
BCR	Bituminous Coal Research, Inc.
BNL	Brookhaven National Laboratory
BNWL	Battelle Northwest Laboratory
BOD	biochemical oxygen demand
BTX	benzene, toluene, and xylene
BYU	Brigham Young University
CEER	Center for Energy and Environment Research
CFR	Code of Federal Regulations
c.g.	center of gravity
CIP	Cascade Improvement Program
COD	chemical oxygen demand
COED	coal oil energy development (liquefaction process)
CTD	conductivity-temperature-depth (instrument)
CUP	Cascade Upgrading Program
CY	calendar year
D&D	Decontamination and Decommissioning
DGE	Division of Geothermal Energy
DOC	direct operating costs
DOE	Department of Energy
DOP	dioctyl phthalate
DOT	Department of Transportation
dpm	disintegration per minute
DRI	Denver Research Institute
EBWR	Experimental Boiling Water Reactor
ECT	Division of Environmental Control Technology
EDP	Environmental Development Plan
EE	Environmental Engineering
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
E-MAD	Engine Maintenance Assembly and Disassembly
ENFORM	An ENergy InFORMation System
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERDA	Energy Research and Development Administration
ERDAM	Energy Research and Development Administration Manual
EV	Assistant Secretary for Environment
FBC	fluidized bed combustion
FGD	flue gas desulfurization
FHP	flash hydrolysis
FIC	fixed capital investment
FPC	Federal Power Commission
FPDL	Fission Power Development Laboratory
FY	fiscal year

g	acceleration of gravity
GC/MS	gas chromatography/mass spectrometry
GPU	general public utilities
H-Coal	hydrogenated coal
HEPA	high efficiency particulate air (filter)
H&N	Holmes & Narvar, Inc.
HQ	DOE Headquarters
HRE	Homogeneous Reactor Experiment
HRT	Homogeneous Reactor Test
HTGR	High Temperature Gas Reactor
HWCTR	Heavy Water Components Test Reactor
IAEA	International Atomic Energy Agency
ICC	Interstate Commerce Commission
IET	Initial Engine Test Facility
IGT	Institute of Gas Technology
INEL	Idaho National Environmental Laboratory
IVEP	Imperial Valley Environmental Project
K _D	partitioning coefficient
k _{eff}	nuclear criticality coefficient
KD	distribution coefficient
KEWB	kinetic energy water boiler
LASL	Los Alamos Scientific Laboratory
LD	lethal dose
LERC	Laramie Energy Research Center
LITR	low intensity test reactor
LLL	Lawrence Livermore Laboratory
LMFBR	liquid metal fast breeder reactor
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LWR	light water reactor
MED	Manhattan Engineer District
MFP	mixed fissions product
MHD	magnetohydrodynamics
MIT	Massachusetts Institute of Technology
MOX	mixed oxide fuels
MRI	Midwest Research Institute
MSRE	Molten-Salt Reactor Experiment
MTR	Materials Test Reactor
NLO	National Lead Company of Ohio
NORCUS	Northwest College and University Association for Science
NOX	oxides of nitrogen
NPDES	National Pollution Discharge Elimination Permit
NRC	Nuclear Regulatory Commission
NRDS	Nuclear Rocket Development Station
NTIS	National Technical Information Service
NTS	Nevada Test Site
NV	Nevada Operations Office
NWC	Naval Weapons Center (China Lake, California)
OGR	Oak Ridge Graphite (Reactor)
OHMSETT	Oil and Hazardous Materials Simulated Environmental Test Tank
OMRE	Organic Moderated Reactor Experiment
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations

PAH	polynuclear aromatic hydrocarbons
pCi/g	picocuries per gram
PDU	Process Development Unit
Penelec	Pennsylvania Electric Company
PERC	Pittsburg Energy Research Center
pH	acidity/alkalinity concentration
PL	public law
PNL	Pacific Northwest Laboratory
POM	polyorganic material
P.S.	polar solvent
RAM	radioactive material
R&D	research and development
RDA	R and D Associates, Inc.
RD&D	research, development, and demonstration
REECO	Reynolds Electric and Engineering Company, Inc.
Rem	roentgen equivalent in man
R-MAD	reactor maintenance assembly and disassembly
RMDF	Reactor Materials Disposal Facility
RMSF	Reactor Materials Storage Facility
ROM	run-of-mine (coal)
scf	standard cubic feet
SHAC	solar heating and cooling
SLA	Sandia Laboratory
SMES	Superconducting Magnetic Energy Storage
SNAP	Space Nuclear Auxiliary Power
SNM	special nuclear materials
SRC	solvent refined coal
SRE	Sodium Reactor Experiment
SRI	Stanford Research Institute
STIR	Shield Test Irradiation
SYNTHANE	synthetic methane process
TAN	test area north
TDS	total dissolved solids
TLV	threshold limit value
TOC	total organic carbon
TOSCO	The Oil Shale Corporation (process)
TRIGA	Training Research and Isotope Production Reactors
TRU	transuranium
TSBD	Transportation Statistics Data Bank
TSF	Tower Shielding Facility
TSR	Tower Shielding Reactor
TSS	total suspended solids
TVA	Tennessee Valley Authority
UCLA	University of California at Los Angeles
UD	University of Denver
UMC	University of Missouri-Columbia
UND	University of North Dakota
UPR	University of Puerto Rico
URI	University of Rhode Island
UT	University of Tulsa
USCG	United States Coast Guard
USGS	United States Geological Survey
USN	United States Navy
UU	University of Utah
VS	volatile solvent
WESCO	Western Coal Gasification Company
WVU	West Virginia University

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