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RESEARCH AND DEVELOPMENT PROGRAMS

FY-1967

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FY-1967

by

R. W. Reid
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J. T. Stringer

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RESEARCH AND DEVELOPMENT PROGRAMS
FY-1967

I. INTRODUCTION

Douglas United Nuclear, Inc., has allocated to the Pacific Northwest Laboratory \$542,000 of O2 Research and Development funds and \$455,000 of Process Technology funds for FY-1967.¹ Of these, \$392,000 of O2 Research and Development funds and \$420,000 of Process Technology funds are the responsibility of the Research and Engineering Section. The balance in each case is the responsibility of the Production Fuels Section. Representatives of these Sections have met with Pacific Northwest Laboratory personnel to develop programs to be undertaken in FY-1967. This document briefly summarizes the results of the discussions and delineates the work to be accomplished.

The integrated five-year research and development program formulated in early FY-1966 identified 15 missions, each requiring research and development work. Recently, two additional missions have been added. The complete list of the missions is as follows:

<u>Number</u>	<u>Title</u>
1	Basic Production
2	Coproduct
3	Integrated Site
4	Nondefense Plutonium
5	Transplutonium
6	Pu-238
7	U-233
8	Co-60
9	Po-210
10	High Power Density Fuel
11	Reactor Modernization
12	Fundamental and General Studies
13	Nuclear Safety
14	Columbia River
15	Waste Management
16	Other Isotopes
17	Highly Enriched Fuel

¹Letter, C. D. Harrington to S. L. Fawcett, "Douglas United Nuclear, Inc., FY-1967 Sponsored Programs, Research and Development and Process Technology," dated July 6, 1966.

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The table below shows a summary of the R&D dollar allocations by mission being made to Pacific Northwest Laboratory for FY-1967. It is recognized that changes in program emphasis and/or requirements might occur as the year progresses. In that case, the funding will be revised accordingly. To facilitate charging work to the appropriate mission, the PNL end function code is also included in the table.

RESEARCH AND ENGINEERING RESPONSIBILITY

<u>Mission Number</u>	<u>Mission Title</u>	<u>PNL Allocation</u>	<u>PNL End Function Code</u>
1	Basic Production	\$ 35,000	NA
2	Coproduct	10,000	NB
5	Transplutonium	10,000	NC
6	Pu-238	10,000	ND
7	U-233	20,000	NE
10	High Power Density Fuel	95,000	NF
11	Reactor Modernization	52,000	NG
13	Nuclear Safety	40,000	NH
14	Columbia River Studies	92,000	NJ
17	Highly Enriched Fuel	<u>28,000</u>	NK
		\$392,000	

PRODUCTION FUELS RESPONSIBILITY

<u>Mission Number</u>	<u>Mission Title</u>	<u>PNL Allocation</u>	<u>PNL End Function Code</u>
1	Basic Production	\$ 75,000	NM
6	Pu-238	10,000	NN
10	High Power Density Fuel	45,000	NP
11	Reactor Modernization	<u>20,000</u>	NR
		\$150,000	

Work done on process technology funds under Research and Engineering responsibility should be charged to end function NT. Similarly, Production Fuels process technology work should be charged to end function NW.

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II. RESEARCH AND ENGINEERING RESPONSIBILITYAPPLIED PHYSICS AND ELECTRONICS DEPARTMENTQuantum ElectronicsSolid State Physics and Optics

Total Funding Level	\$ 5,000
Source of Funds	
Process Technology	\$ 5,000

The development of equipment to improve the ability to examine the internal surfaces of irradiated I&E fuel elements will be initiated. These surfaces are now being examined with the aid of a viewer designed and fabricated at the Optical Laboratory. A much more thorough examination would result if an optical probe were available which could be used under water at the end of a periscope and which could be inserted into the bore of the fuel element. Visual inspection would normally be used, but the capability to obtain a photographic record of the internal surface condition is also desired.

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CHEMISTRY DEPARTMENTCoolant and Corrosion ChemistryWater Reactor Corrosion and Chemistry1. Zircaloy Process Tube Hydriding

Total Funding Level	\$80,000
Source of Funds	
Process Technology	\$80,000

a. Hydrogen Migration Studies

A critical part of the program will be to determine whether the existing case layer of hydrogen will diffuse into the base metal after further hydrogen pickup has been eliminated by the use of different spacer materials. Hydrided coupons, characterized by both metallographic and chemical methods to establish the hydrogen concentration gradient prior to charging, will be exposed in both stainless steel and aluminum coupon holders. Periodically, samples will be reexamined to determine the movement of hydrogen. In addition, sample rings have been cut and the hydrogen gradient established for in-service process tubes. These process tubes will operate with different spacers to study hydrogen migration as a function of spacer material based on the gradient established in the sample rings.

b. Spacer Evaluation

It has been demonstrated that the use of spacer materials that are cathodic to the process tube or electrically insulated from the tube will prevent hydrogen pickup during reactor operations. Current spacers are being replaced with aluminum spacers anodized by an oxalic process which has been proven but is more costly than other anodizing methods. Nickel coatings on aluminum have also been shown to prevent hydrogen pickup. The evaluation of these coating processes on spacers will continue and will consider the following factors;

- (1) Effectiveness in reducing hydrogen absorption by Zircaloy.
- (2) Durability of the coating including such factors as abrasion resistance, ease of decontamination, resistance to chemical decontamination, cost of recoating, and corrosion resistance of coating.
- (3) Interactions with the downstream elements of the fuel charge.

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- (4) Interactions with the Van Stone gasket and nozzle.
- (5) Effect of smeared aluminum on tube behavior.
- (6) Optimization of spacer design for plating or anodization.

c. Fundamental Studies

There are a number of variables which might affect the hydriding process which have not been evaluated and certain features of the mechanism of the hydriding attack which should be explained before we consider our understanding of the process adequate. Of particular concern is the effect of radiation which appears to inhibit the hydriding process. Other variables of interest include temperature, variations in Zircaloy process tube material, case thickness, and residual stresses. These studies are important to insure that our recommended courses of action will protect the reactor and not lead to additional problems.

2. Columbia River Studies

Total Funding Level	\$92,000
Source of Funds	
R and D Mission 14	\$92,000

Film inventory studies will continue and expand such that the radio and parent isotope inventories will be determined as a function of exposure in reactor, position in reactor, and surface. The results from the studies will be used to determine the kinetics of parent isotope adsorption and radioisotope release. Deionized water in the single-pass tubes will be used to investigate the effect of changing the relative salt concentrations in the coolant. In this manner the mechanisms by which film characteristics are changed upon the adsorption of ions can be deduced. The selection of additives or conditions which optimize potential reductions in effluent activity can be intelligently made. The deionized water tests will also provide useful information on the kinetics of the adsorption-desorption process.

Previous data obtained using Zircaloy fuel and tubes with deionized water as the coolant indicate that effective reductions in effluent water radioisotopes if more inert surfaces able to withstand conditions in the flux zone. Testing on a small scale using Zircaloy fuel cladding in process water will be undertaken. If application proves feasible at Oak Ridge, fuel coated with copper, nickel, and tungsten will also be tested to determine the effect on effluent radio-activity.

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Investigations correlating the zeta potential of the floc with pH, flocculant feed rate, and effluent radioactivity will continue in the water treatment pilot plant. Alternate flocculating agents and acidulating will be studied.

The relative concentrations of radioisotopes in the reactor effluent are found to vary as the concentrations of salts in the incoming water vary. In some cases it is possible to reduce the concentration of a given radioisotope by increasing the concentration of a seemingly unrelated ion. Investigations will be carried out to determine the factors involved in the interplay of water salts with the expectation of discovering additives which will result in significant effluent activity reductions. Both inorganic as well as organic materials will be tested.

3. Corrosion Studies

Total Funding Level	\$50,000
Source of Funds	
Process Technology	\$50,000

a. Continuation of Present Programs

Present programs such as the corrosion probe monitoring of the carbon steel piping system should be continued. Laboratory studies and/or assistance on reactor testing on the downstream pitting of aluminum process tubes are required until resolution of the problem. The evaluation of sodium sulfite addition as a corrosion inhibitor should be completed. The effects of irradiation on the in-reactor corrosion of aluminum has been partially defined. More fundamental knowledge of irradiation effects should be obtained both for aluminum and for metals other than aluminum.

b. Process Technology Activities

From time to time apparently unusual corrosion phenomena are observed. A need is anticipated for consultation and possibly laboratory tests to define or resolve such situations. Continued support is expected to evaluate corrosion effects during in-reactor water quality testing.

Analytical Chemistry

Total Funding Level	\$20,000
Source of Funds	
R&D Mission 7	\$20,000

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The continued irradiation of target materials will require analytical effort to define product yield and purity. Although funds for the anticipated work are assigned to R&D Mission 7, U-233, a wide variety of analyses will be requested; many of which cannot be identified at this time.

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ENGINEERING DEVELOPMENT DEPARTMENTReactor Engineering

Total Funding Level	\$180,000
Source of Funds	
R&D Mission 1	\$ 35,000
R&D Mission 10	\$ 40,000
R&D Mission 11	\$ 25,000
Process Technology	\$ 80,000

1. Rod-in-Tube Fuel Heat Transfer Studies

A full-scale model of a process tube assembly similar to those to be used in a reactor with the channels enlarged by one inch will be used to study the thermal hydraulic behavior of rod-in-tube fuel elements. Both the steady-state and transient heat transfer characteristics of the system will be studied at tube power levels up to 200 percent of the basic level. Transient tests will include studies of flow-loss and power-surge accidents. The experimental program will be designed to provide sufficient data to establish heat transfer limits for the operation of a reactor with rod-in-tube fuel elements in enlarged process channels. All hardware, including a Zircaloy process tube, will be provided for the mockup with the exception of the heater rod(s).

2. Burnout Heat Flux Program

A program to define more closely burnout heat flux conditions in the present reactor fuel geometries under present and possible future operating conditions is planned. The results of the tests will be used to establish burnout limits for the various modes of reactor operation and for hazards analyses. The program was scheduled to begin in FY-1966, but did not get under way because of competition for funds from higher priority programs. It is expected that sufficient support will be given to this program in FY-1967 to complete an evaluation of the burnout heat flux for the inner surface of the I&E fuel element and that experimental data will also be compiled to provide a preliminary evaluation with respect to the outer or annular surface.

3. Process Tube Coolant Boilout Studies

Experiments will be performed to define the rates of coolant loss from process tubes following a complete loss-of-coolant accident. Data will be obtained at tube power levels up to 200 percent of basic levels using present process tube geometries. A correlation will be developed from the experimental data so that the data may be factored into

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reactor safety analyses. As funds permit, the conditions required to restore coolant flow to a process tube after coolant boilout will be investigated.

4. Fog Spray Cooling Studies

The heat transfer coefficients obtained during fog cooling of fuel elements will be determined to provide data for the evaluation of reactor fog spray systems. The effect of sprays of about 0.1 to 0.5 inches per minute will be studied.

5. Hydraulics Laboratory

Support will be provided to the Thermal Hydraulics Laboratory to obtain flow tests as required to evaluate process tube hardware and fuel element design changes and to support current reactor operations.

Engineering Materials and Mechanics

Total Funding Level	\$20,000
Source of Funds	
Process Technology	\$20,000

Physical property tests on Zircaloy process tubes will be performed to determine the effect of hydriding on process tube integrity and to evaluate prototype tubes obtained in the reactor modernization program. It is anticipated that both flexure and burst tests will be run on hydrided Zircaloy process tubes removed from the K Reactors.

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ENVIRONMENTAL AND RADIOLOGICAL SCIENCES DEPARTMENTEarth SciencesParticulate and Gaseous Waste Research

Total Funding Level	\$15,000
Source of Funds	
R&D Mission 13	\$15,000

In order to develop information on the factors influencing the quantity and rate of fission product release from the reactors operated by Douglas United Nuclear, Inc., a program was initiated in FY-1966 to determine the release of fission products as a function of heating and maximum temperature for full-size aluminum clad, metallic uranium fuel. These experiments will be completed and the results reported in FY-1967.

Water and Wastewater Research

Total Funding Level	\$30,000
Source of Funds	
Process Technology	\$30,000

One of the important steps in water treatment is filtration. In order to determine whether changes in DUN filtration practices might reduce the amount of radioactivity in reactor effluent, laboratory scale filtration equipment was installed in FY-1966. In FY-1967 studies will be carried out to determine floc loading effects by investigating floc strength, floc concentration, polymer concentration, and floc size. The distribution of floc in the filter during normal operation will be determined by using aluminum-26. Such experiments will demonstrate the distribution of the floc at breakthrough as well as how much passes the filter prior to breakthrough.

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ENVIRONMENTAL HEALTH AND ENGINEERING DEPARTMENTNuclear Safety and Engineering

Total Funding Level	\$ 5,000
Source of Funds	
R&D Mission 13	\$ 5,000

The diversification of the reactors operated by DUN necessitates a continual review of the nuclear safety aspects of new and/or modified loadings. Of particular concern is the reactor containment status, the potential for fission product release, and the consequences of such a release. Although undefined at this time, the need for consultation and assistance is foreseen for establishing the consequences of a fission product release.

Environmental Studies

Total Funding Level	\$20,000
Source of Funds	
R&D Mission 13	\$20,000

A program has been scoped to characterize the Hanford site response to minor seismic activities in relation to measurements and observations at offsite locations and to evaluate the response at buildings and critical components to seismic excitation frequencies. During FY-1967 preliminary measurements will be made to determine seismic coupling factors between basalt formations and major plant locations. The measurements would be made with acceleration detectors capable of measuring low intensity movement at low frequencies in the range characteristics of seismic disturbances.

The establishment of a permanent seismic will be initiated.

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MATERIALS DEPARTMENTCeramics and Graphite ResearchGraphite Research and Development

Total Funding Level	\$60,000
Source of Funds	
Process Technology	\$60,000

1. Graphite Distortion Studies

Assistance in predicting future reactor graphite distortion problems will be obtained by irradiating reactor graphite samples in high flux test reactors. Graphite samples will be removed from the C and K Reactors and irradiated to approximately double their existing exposure in a high flux test reactor. Previous irradiation tests have shown that when graphite contraction stops, further irradiation results in relatively rapid growth. The objective of the irradiation tests of C and K graphite is not only to determine the point at which contraction ceases in typically irradiated Hanford reactor graphite, but also if changes in future irradiation temperature can control the subsequent expansion.

2. Graphite Oxidation Studies

Experiments will be performed to establish the thermal reaction rates between KS or KC graphite and carbon dioxide. Little or no data are available concerning the reaction between CO₂ and the type of graphite used in the B and D Reactor stacks. In the past it has been necessary to extrapolate from data obtained from tests with TSX graphite. Recent laboratory tests indicate there is a considerable difference in the behavior of the TSX graphite used in N Reactor and the KS and KC graphite used in B and D Reactors. Since the routine oxidation monitor samples used in the older reactors contain KS graphite, it is desirable to determine the behavior of KS graphite in a CO₂ atmosphere to aid in interpreting the results of reactor monitor samples. To accomplish this, laboratory tests will be conducted to determine the reaction rates between KS or KC graphite in CO₂ at temperatures of 600-900 C, CO₂ concentrations up to 100 percent, and CO concentrations up to 10 percent.

3. Reactor Graphite Monitoring Program

The existing program of monitoring in-reactor graphite oxidation by routine installation of oxidation monitoring samples will be continued. A total of 10-15 charges for oxidation monitoring will be needed for the five DUN-operated reactors during FY-1967.

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Fuel Development

Total Funding Level	\$10,000
Source of Funds	
Process Technology	\$10,000

Consultation will be provided as required with respect to problems involving uranium oxide fuels, plutonium fuels, and target element fabrication and evaluation. Target elements of primary interest include thorium, neptunium-aluminum alloy, and bismuth.

Radiometallurgy Laboratory

Total Funding Level	\$70,000
Source of Funds	
Process Technology	\$70,000

Radiometallurgical examinations will be provided in support of research and development programs and reactor operations.

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MATHEMATICS DEPARTMENT

Statistics

Total Funding Level	\$ 5,000
Source of Funds	
Process Technology	\$ 5,000

Support will be provided in the design of production tests and in the correlation and evaluation of test data.

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REACTOR PHYSICS DEPARTMENTReactor Lattice PhysicsHeavy Moderator Physics1. PCTR Testing

Total Funding Level	\$67,000
Source of Funds	
R&D Mission 2	10,000
R&D Mission 10	35,000
R&D Mission 11	22,000

a. Supercells

Separate target (supercell) experiments will be continued. The 125 metal driver, thoria target system, at a 3:1 ratio has been used for experiments in FY-1966. These experiments will be analyzed and the results will be compared with calculated values. As an extension to this experiment, comparative measurements with a smaller fuel element will be performed in FY-1967. Another supercell experiment is to be made early in FY-1967 utilizing 210 metal drivers with lithium targets at a 3:1 ratio. This experiment is important since the 210 metal represents about the limit of low enrichment fuels that can reasonably be handled in the separations facilities without elaborate changes for criticality control. The lithium target at a 3:1 driver-to-target ratio represents about as concentrated an absorber as is practical for irradiation in the production reactors. Thus, the experiments give information on reactivity changes due to water loss, together with values of k_{∞} and f , to check calculational techniques over the expected operating range.

b. Overbore

An experiment in the PCTR is to be made with a typical overbore lattice containing the "standard" plutonium-producer fuel consisting of a tube and rod. Overbore, i.e., enlargement of the present process tubes, is a possible means of improving the productivity and the safety of the reactors. The larger tubes give more room for fuel and changes the reactivity effect on water loss so that loss of water will automatically reduce the reactor power. Measurements will be made of reactivity effects due to water flooding of the lattice including control strength changes. In addition, the usual experiments of k_{∞} and f will be made.

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2. Analytical Work

Total Funding Level	\$15,000
Source of Funds	
R&D Mission 5	\$ 5,000
R&D Mission 6	\$ 5,000
R&D Mission 11	\$ 5,000

In addition to the requirements for continued analytical support, there are some specific projects to be completed. For example, there are times when it would be of interest to use the cross section data from the BNW Master Cross Section Library in connection with calculations made by using the MOFDA code. Modifications can be made to allow use of the cross section library. Also, a plotting can be added to MOFDA to aid in quick analysis of survey calculations.

As faster computers become available, the ability to quickly interpret the results of a survey study is important, thus allowing several variations to be chosen and the optimum design determined in a rapid manner.

3. Enriched Fuel Operation

Total Funding Level	\$28,000
Source of Funds	
R&D Mission 17	\$28,000

The conversion of isotopes other than U-238 can be envisioned by utilizing high or fully enriched fuel. It is important to make analytical and later experimental studies on a complete reactor load of enriched fuel as well as spike enrichment to establish limits of safe operation. Such studies will involve the evaluation of k_{∞} for wet and dry lattices with target materials such as cobalt, lithium, thorium, neptunium, and possibly bismuth.

The effect of enlarged process tubes (overbore) is to be considered. The studies will include water flooding and fuel element melting safety considerations. The objective of the FY-1967 work is to study the problem analytically and arrive at reactor loadings that may possibly be used. In addition to safety considerations, some of the economic studies must be reviewed including conversion ratios and possibly the enhancement of Np-237 production from the utilization of enriched fuel.

Critical Mass Physics

Total Funding Level	\$10,000
Source of Funds	
Process Technology	\$10,000

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The critical mass limits of 210 metal fuel and lattices of 210 metal fuel mixed with uranium fuel or other enrichments will be measured.

Basic Cross Sections

Total Funding Level	\$30,000
Source of Funds	
R&D Mission 5	\$ 5,000
R&D Mission 6	\$ 5,000
R&D Mission 10	\$20,000

The evaluations and documentation of completed measurements of scattering cross sections in water will be finished. Consulting services will be provided for obtaining and evaluating basic cross sections, and arrangements made for procuring experimental cross section data as requested.

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III. PRODUCTION FUELS RESPONSIBILITYAPPLIED PHYSICS AND ELECTRONICS DEPARTMENTNondestructive Testing

Total Funding Level	\$25,000
Source of Funds	
R&D Mission 1	\$20,000
Process Technology	\$ 5,000

New or potentially improved nondestructive testing methods for fuel evaluation and testing methods for fuel evaluation and quality control will be developed. An immediate need exists for testing equipment capable of distinguishing between mechanical and metallurgical bonds.

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CHEMISTRY DEPARTMENTChemical Research1. Nickel Plating Studies

Total Funding Level	\$20,000
Source of Funds	
R&D Mission 1	\$20,000

Basic studies will be continued to improve the quality of electro-deposited nickel plate on uranium fuel cores for diffusion bonding by the hot-die-sizing process. This work will be oriented toward (1) reducing nickel plate porosity, (2) correlation of nickel plate quality with uranium-aluminum diffusion, and (3) laboratory scale investigations of alternate plating techniques such as pulse and particulate plating.

2. Alternate Plating Techniques

Total Funding Level	\$25,000
Source of Funds	
R&D Mission 10	\$20,000
Process Technology	\$ 5,000

The study of electrodeposition of thin coatings of zirconium on uranium will be continued to demonstrate the feasibility of depositing a nonporous, adherent plate of uniform thickness. Deposition of zirconium or other corrosion resistant metallic coatings on fuel cladding materials will also be investigated.

Coolant and Corrosion Chemistry

Total Funding Level	\$30,000
Source of Funds	
R&D Mission 1	\$ 5,000
R&D Mission 10	\$15,000
Process Technology	\$10,000

The ability to achieve the objective of the high power density fuel program for doubling current reactor tube powers will require the development of fuel cladding alloys or coatings, which are superior in corrosion resistance to the present 8001 aluminum alloy. Concurrent with the in-reactor evaluation of a potentially improved high silicon (10 wt%) aluminum alloy, a search for other candidate alloys or coatings will be extended. Particular emphasis is to be placed on a better understanding of the mechanisms of nonuniform (ledge and groove) corrosion, and cladding alloy properties needed to resist this type of corrosion.

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Work will be concluded on the development of optimum heat treating parameters for electronickel plated, 8001 alloy clad hot-die-sized fuel elements to produce an adherent plate for preliminary in-reactor corrosion testing.

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MATHEMATICS DEPARTMENTStatistics

Total Funding Level	\$20,000
Source of Funds	
R&D Mission 1	\$ 5,000
R&D Mission 10	\$ 5,000
R&D Mission 11	\$ 5,000
Process Technology	\$ 5,000

The funds are allocated for consultation and statistical assistance in the design and analysis of production tests conducted in conjunction with fuels research and development programs. As an example, continued support will be required in comparing the irradiation behavior of hot-die-sized and AlSi-bonded fuel monitor columns.

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MATERIALS DEPARTMENT

Materials Development

Total Funding Level	\$ 5,000
Source of Funds	
R&D Mission 6	\$ 5,000

Limited funding is allocated for consultation and evaluation of alternate processes (NpO_2 aluminum powder compaction and Np-Al alloy) for the fabrication of neptunium target elements to produce Pu-238. Ultimate process selection and the preparation of process criteria if justified to support project action on a target element production facility will be based on available technology in the Material Development and Plutonium Metallurgy Section of Battelle Northwest.

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METALLURGY DEPARTMENTFabrication Metallurgy1. Rod and Tube Fuel Elements

Total Funding Level	\$15,000
Source of Funds	
R&D Mission 11	\$15,000

Assistance is required in the design of suitable supports and locking hardware for the rod-in-tube fuel elements being developed for evaluation in small reactor process channels that have been enlarged one inch. The outer fuel tube will require aluminum alloy supports of sufficient strength to withstand charge-discharge forces and center the heavier fuel assemblies in the process tubes. A spring-loaded support design may be required to assure self-centering of the rod and contact with the outer fuel tube throughout the irradiation resistance time.

2. Nickel Uranium Bonding

Total Funding Level	\$10,000
Source of Funds	
R&D Mission 1	\$10,000

Studies will be conducted to characterize the aluminum-nickel-uranium diffusion bonds of hot-die-sized fuel elements. This effort will include a critical analysis of work already accomplished, and additional study as required to increase understanding and ability to specify optimum process parameters with respect to fuel element bond integrity. Identification, measurement, and characterization of the intermetallic compounds in the nickel diffusion bond layer will be required to fully evaluate the effects of process variables.

3. Process Technology Activities

Total Funding Level	\$10,000
Source of Funds	
Process Technology	\$10,000

Special uranium, cladding component, and fuel fabrication work will be performed in support of fuel development programs that cannot be accomplished in Production Fuels facilities.

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Process Metallurgy

Total Funding Level	\$20,000
Source of Funds	
R&D Mission 1	\$15,000
R&D Mission 10	\$ 5,000

Pertinent to the selection of uranium alloys and heat treatments for fuel cores is the measurement of such variables as texture, texture gradients, transformation kinetics, nature of second phase precipitation, and thermal stability, and relating these variables to irradiation behavior. Work in this area will be directed toward identifying those variables which contribute to uranium instability during irradiation. A fundamental understanding of the effects of these variables is expected to provide answers to a previously experienced diameter growth problem in hot-die-sized fuel, and to facilitate the selection of optimum uranium alloys and heat treatments for present and future reactor operating conditions.

At the higher operating temperatures imposed by the high power density fuel program, uranium fuel cores will be susceptible to swelling by grain boundary tearing rather than the current problem of irradiation growth. Further study is required to develop a definitive relationship between the composition, metallurgical properties, and external restraint of higher order uranium alloys and various heat treatments on fuel core grain boundary tearing at irradiation temperatures in the 400 to 500 C range.

Plutonium Metallurgy

Total Funding Level	\$ 5,000
Source of Funds	
R&D Mission 6	\$ 5,000

Limited funding is provided for consultation and evaluation of alternate processes for the fabrication of neptunium target elements to produce Pu-238. Technology has been developed in BNW facilities for the fabrication of neptunium target elements by two processes. One involves the blending of NpO_2 with aluminum powder and compaction to the desired density under pressure. The other consists of reducing the NpO_2 by cryolite reduction in an aluminum alloy melt and casting the alloy for subsequent canning. Essential to the program will be the selection of an optimum process and assistance in the preparation of the process criteria required to support project action on target element production facilities if justified.

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