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**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

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TITLE

RESEARCH AND DEVELOPMENT ALLOCATIONS
AND PLANT ASSISTANCE SUPPORT

FY-1969

AUTHOR

J. W. Riches

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This document consists
of 42 pages.

RESEARCH AND DEVELOPMENT ALLOCATIONS
AND PLANT ASSISTANCE SUPPORT
FY-1969

August 15, 1968

J. W. Riches

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CONFIDENTIAL)

By Authority of *intent*

11-74
By *Pop* *3/6/75*

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grading and declassification.~~

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DS Lewis, 8-19-94

By *Justin Maley 11-18-94*

Verified By *PO Roberts 12-21-94*

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RESEARCH AND DEVELOPMENT ALLOCATIONS
AND PLANT ASSISTANCE SUPPORT
FY-1969

This document describes the scope of research and development and plant assistance work required to meet the program needs for FY-1969 of Douglas United Nuclear, Inc. in the operation of the C, N and K Reactors.

The allocation of research and development funds and estimates of work order support for plant assistance work to Battelle-Northwest are consistent with the research and development funding level in FY-1969 and with the estimates described in DUN-4584, "Research and Development Allocations and Plant Assistance Support, FY-1969," C. D. Harrington to F. W. Albaugh (Confidential).

As the programs progress, or if program emphasis changes, it may be necessary to make adjustments in the funds allocated to individual programs within the total level of available funds. The distribution of funds to the various programs is summarized in the enclosed tables.

JC Fuller
for
J. W. Riches, Manager
Technology Section

TECHNOLOGY SECTION
RESEARCH AND DEVELOPMENT ALLOCATION
AND WORK ORDER SUPPORT ESTIMATE - FY-1969
(Dollars in Thousands)

<u>Mission</u>	<u>Responsible DUN Subsection</u>	<u>BNW R&D* Allocations</u>	<u>Responsible DUN Subsection Mgr.</u>	<u>Estimated Work Order Support, BNW**</u>
Mission 1	Reactor Physics Technology	\$ 70.0	G. C. Fullmer	\$ 9.0
Basic Production	Reactor Technology	20.0	R. H. Shoemaker	-
	Fuel & Target Technology	112.0	M. Lewis	35.0
	Reactor Materials Technology	160.0	P. A. Carlson	85.0
	Instrument & Automation Tech.	-	J. W. Riches (act)	35.0
		<u>\$362.0</u>		<u>\$164.0</u>
Mission 4	Reactor Physics Technology	\$ -	G. C. Fullmer	\$ 17.0
Pu-238	Fuel & Target Technology	30.0	M. Lewis	-
		<u>\$ 30.0</u>		<u>\$ 17.0</u>
Mission 5	Fuel & Target Technology	\$ 25.0	M. Lewis	\$ -
Other Isotopes		<u>\$ 25.0</u>		<u>\$ -</u>
Mission 7	Reactor Physics Technology	\$ 70.0	G. C. Fullmer	\$ 4.0
Target Space Enhancement	Reactor Technology	70.0	R. H. Shoemaker	140.0
	Fuel & Target Technology	60.0	M. Lewis	45.0
	Reactor Materials Technology	39.0	P. A. Carlson	31.0
		<u>\$239.0</u>		<u>\$220.0</u>
Mission 8	Nuclear Safety Technology	\$184.5	W. S. Nechodom	\$ 42.5
Nuclear Safety	Reactor Technology	15.0	R. H. Shoemaker	40.0
		<u>\$199.5</u>		<u>\$ 82.5</u>
Mission 10	Reactor Materials Technology	\$ 50.0	P. A. Carlson	\$ -
Columbia River		<u>\$ 50.0</u>		<u>\$ -</u>
Total		<u>\$905.5</u>		<u>\$483.5</u>

*Direct dollars; AEC contractor pool overheads to be added by sponsoring department.

**Individual work orders will be used as work progresses.

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ESTIMATE OF WORK ORDER SUPPORT
FROM OTHER SECTIONS
(Dollars in Thousands)

<u>Responsible Section</u>	<u>Responsible Section Manager</u>	<u>Estimated Work Order Support, BNW*</u>
Process and Programs	T. W. Ambrose	\$140.0
Engineering	J. S. McMahon	20.0
Fuels	W. M. Mathis	25.0
Manufacturing Engineering	R. T. Jessen	<u>7.5</u>
Total		<u>\$192.5</u>
 Total R&D Allocation, FY-1969	 <u>\$905.5</u>	
 Total Estimated Work Order Support, FY-1969:		
Technology Section	\$483.5	
Other Sections	<u>192.5</u>	
Total	<u>\$676.0</u>	

*Individual work orders will be used as
work progresses.

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BNW: Reactor Physics (D. D. Lanning)
MISSION 1: Basic Production
FUND ALLOCATION: \$25,000 (7A4A-5T20-49P.E2)
WORK ORDER ESTIMATE: --
RESPONSIBLE DUN SUBSECTION: Reactor Physics Technology
RESPONSIBLE DUN CONTACT: G. C. Fullmer

N Fuels in Water Lattices

Funding was scheduled during FY-1968 for PCTR measurements on N Reactor fuels in geometries relevant to ex-reactor criticality analyses. The parameters derived from the pure water lattice will also aid in the understanding of the normal N Reactor lattice as on the order of half of the moderation in the N Reactor is attributed to the coolant. Testing on one of the three lattice configurations to be measured has been completed although results have not been reported to date. Completion of the PCTR tests on the other two lattices and reporting of results on all three tests are needed during FY-1969.

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BNW: Chemistry Research (W. Y. Matsumoto)
MISSION 1: Basic Production
FUND ALLOCATION: --
WORK ORDER ESTIMATE: \$9000 (7A21-5T20-422.E1)
RESPONSIBLE DUN SUBSECTION: Reactor Physics Technology
RESPONSIBLE DUN CONTACT: G. C. Fullmer

Analytical Lab Yield and Burnup Data

Analyses of individual fuel and target burnout and buildup effects are needed in support of both production and test loadings for establishing discharge goals, effects of secondary reactions on buildup of higher isotopes, and reactor conversion data.

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BNW:	Reactor Physics (R. I. Smith)
MISSION 1:	Basic Production
FUND ALLOCATION:	\$5000 (7C42-5T20-49P.E0)
WORK ORDER ESTIMATE:	--
RESPONSIBLE DUN SUBSECTION:	Reactor Physics Technology
RESPONSIBLE DUN CONTACT:	G. C. Fullmer

Gamma Scanning Development

Analytical laboratory data may be supplemented, to a considerable extent, in more detail and at lower cost, if gamma scanning techniques under study by the BNW Physics Methods Evaluation component prove out.

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BNW: Physics Research (E. D. Clayton)
MISSION 1: Basic Production
FUND ALLOCATION: \$40,000 (7C50-5T20-49P.EO)
WORK ORDER ESTIMATE: --
RESPONSIBLE DUN SUBSECTION: Reactor Physics Technology
RESPONSIBLE DUN CONTACT: G. C. Fullmer

Cross-Section Library and Development

As computer codes have become widely available on a national basis, primary emphasis has evolved to assuring their applicability to specific problems and to programming modifications minimizing their running time relative to the information desired. The service carried out by BNW of maintaining a comprehensive library of current cross-section data in a form for ready utilization in standard computer programs is valuable to DUN and worthy of support. It is important that DUN production and test irradiation calculations be based on accurate data adequately treated for energy spectrum effects. It is recommended that the allocation be equally divided between direct library work and consulting service and support of BNW fundamental cross-section studies supporting this work.

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BNW:	Reactor Engineering (F. R. Zaloudek)
MISSION 1:	Basic Production
FUND ALLOCATION:	\$20,000 (723C-5T30-49P.NO)
WORK ORDER ESTIMATE:	--
RESPONSIBLE DUN SUBSECTION:	Reactor Technology
RESPONSIBLE DUN CONTACT:	R. H. Shoemaker

Fuel Support Studies - N Reactor

An analytical program has been in progress over the past 2 years to develop fundamental technology related to hydraulic characteristics of fuel annuli and support configurations. Experimental work will be done with a two-dimensional model of an annulus with a variety of basic support configurations. Pressure profile data and flow visualization techniques will be employed in development of mathematical models for prediction of pressure drop characteristics in advanced fuel designs.

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BNW: Fuels and Materials (J. C. Tverberg)

MISSION 1: Basic Production

FUND ALLOCATION: \$25,000 (7A4C-5T40-49P.NO)
\$50,000 (7A4C-5T40-49P.SO)

WORK ORDER ESTIMATE: --

RESPONSIBLE DUN SUBSECTION: Fuel and Target Technology

RESPONSIBLE DUN CONTACT: W. C. Gallagher (NO)
R. W. Toivonen (SO)

Evaluation of Mark IV Design (49P.NO)

Assist in performance evaluations of Mark IV fuel element design including preirradiation measurements, evaluation of dimensional stability and failure mechanisms.

Special Studies and Development of Mark IV and VI Closures (49P.SO)

Perform special studies as required, for example, on alloy performance, heat treatment and new fabrication processes.

Assist in developing and evaluating a lower-cost, more reliable closure for use on Mark IV and Mark VI fuels. This work should emphasize an all-welded closure, perhaps without bonding between the end cap and the uranium. Assist in setting criteria and determining practical limits for unbonded closures.

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BNW: Chemistry Research (R. L. Dillon)

MISSION 1: Basic Production

FUND ALLOCATION: \$25,000 (7A2B-5T40-49P.DO) 37
\$12,000 (7A2B-5T40-49P.NO)

WORK ORDER ESTIMATE: \$15,000 (7A2B-5T40-422.DO) 15

RESPONSIBLE DUN SUBSECTION: Fuel and Target Technology

RESPONSIBLE DUN CONTACT: D. O. Sheppard

Develop methods of applying protective coatings to fuel elements to greatly extend their useful lifetime. Perform experimental parametric studies of processes such as electrolytic or electroless plating and flame spraying of nickel, copper, chromium or combinations of these and similar metals. The goal of this work will be to eliminate those cladding performance phenomena, such as ledge and groove corrosion, that prevent single-pass reactor fuel elements from attaining very high exposures. Emphasis will be on those processes which significantly improve fuel cycle costs, not only by increasing exposure capability, but also lowering total fuel fabrication cost or by increasing the amount of uranium in the reactors.

Perform corrosion studies as required in support of fuel performance evaluations. Help define corrosion mechanisms that contribute to fuel failures and suggest methods of removing or alleviating the cause of such corrosion. Assist DUN engineers in staying abreast of the latest developments in corrosion technology.

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BNW:	Fuels and Materials (D. C. Lehfeldt)
MISSION 1:	Basic Production
FUND ALLOCATION:	--
WORK ORDER ESTIMATE:	\$20,000 (7ABO-5T40-423.NO)
RESPONSIBLE DUN SUBSECTION:	Fuel and Target Technology
RESPONSIBLE DUN CONTACT:	W. C. Gallagher

Provide radiometallurgical services as required to evaluate fuel performance especially as related to new or developmental fuel elements.

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BNW: Metallurgical Research (A. L. Bement)
MISSION 1: Basic Production
FUND ALLOCATION: \$20,000 (7A10-5T50-49P.J2)
WORK ORDER ESTIMATE: \$15,000 (7A10-5T50-422.J2)
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

N Reactor Zircaloy Process Tube Studies

The allocated funds will be used to continue programs to characterize the future behavior of hydrided and unhydrided N Reactor Zircaloy process tubes and to study the effects of irradiation in the N Reactor environment on the mechanical properties of the process tubes. The fracture testing specimens will be prefatigue cracked prior to testing to evaluate the effect of hydrogen content and the length of sharp cracks on the failure stress. The temperature dependence on critical crack length will also be determined.

The examination of process tube 2455 will be continued to evaluate the effects of irradiation damage and the reactor environment on the mechanical properties of the N Reactor process tubes. The evaluation will include crack propagation tests, burst tests and stress rupture tests to determine if increased irradiation has altered the life expectancy of the N process tubes.

The effect of creep on the future characteristics of irradiated process tubes will be performed by running crack-propagation tests on stress-rupture specimens from tubes 1756 and 2455.

Work order funds will be used for supplementary evaluations of pressure tubes, including radiometallurgy studies, as required.

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BNW: Metallurgical Research (A. L. Bement)
MISSION 1: Basic Production
FUND ALLOCATION: \$10,000 (7A10-5T50-49P.J1)
WORK ORDER ESTIMATE: \$13,000 (7A10-5T50-422.J1)
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

K Reactor Process Tube Studies

Fatigue tests will be performed on hydrided Zircaloy process tubes removed from the K Reactors to characterize potential failure modes of the tubes. The testing method should provide conditions prototypic of reactor service at the downstream gunbarrel location. If the testing program shows promise of providing meaningful failure data, additional funds will be provided, as available, to determine the effect of hydrogen content on the K Reactor Zircaloy tube failure characteristics.

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BNW: Ceramics (R. E. Nightingale)
MISSION 1: Basic Production
FUND ALLOCATION: --
WORK ORDER ESTIMATE: \$ 3,500 (7A30-5T50-422.J1)
\$23,500 (7A30-5T50-422.J2)
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

Graphite Oxidation Monitoring (J1)

Work order funds will be provided as required for continuance of the oxidation monitoring of small samples irradiated in the C, KE, KW and N Reactors. Seven analyses are planned for the year.

N Reactor Irradiations (J2)

Work order funds will be provided as required to monitor graphite samples being irradiated in ball channel 60 and rod channel 74. The program is being performed to determine the differences in contraction between large graphite blocks and small samples.

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BNW: Ceramics (R. E. Nightingale)
MISSION 1: Basic Production
FUND ALLOCATION: --
WORK ORDER ESTIMATE: \$10,000 (7A30-5T50-422.J1)
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

Radiolysis Studies

Work order funds will be provided as available for a study of the radiolysis of N_2 -He- H_2O -C mixtures. The reason for the rapid increase and decrease in NH_3 concentrations observed in FY-1968 studies will be examined in more detail. The time-temperature dependence of the NH_3 reaction will be studied and the possible occurrence of cyanides and cyanogens identified if funds are available.

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BNW: Chemistry Research (R. L. Dillon)
MISSION 1: Basic Production
FUND ALLOCATION: \$70,000 (7A2B-5T50-49P.J1)
WORK ORDER ESTIMATE: --
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

Zircaloy Process Tube Hydriding

The use of anodized aluminum spacers has apparently not completely eliminated the Zircaloy process tube hydriding problem since recent data indicate base metal hydriding is continuing. The most critical aspect of the FY-1969 program will be to determine the source of the hydrogen which is continuing to build up in the base metal and the mechanisms responsible for its movement. It will be necessary to determine under what conditions gaseous hydrogen, which is present in the coolant, can be absorbed by the presently hydrided surface. It will also be necessary to determine if there is a mechanism by which the existing case layer can be induced to diffuse into the base metal.

The early phases of these studies are now in progress in the laboratory. As soon as meaningful results are obtained, attempts will be made to duplicate them in-reactor. These in-reactor tests will involve electrical measurements, coolant composition control, coolant velocity variation, Zircaloy surface condition, and the use of cathodic spacers in hydrided tubes.

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BNW: Chemistry Research (R. L. Dillon)
MISSION 1: Basic Production
FUND ALLOCATION: \$15,000 (7A2B-5T50-49P.J2) 15
WORK ORDER ESTIMATE: \$ 5,000 (7A2B-5T50-422.J1) 5
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

Decontamination Studies

N Reactor (J2)

Conventional N Reactor primary system decontamination techniques employ relatively concentrated solutions of potentially corrosive materials and generate large volumes of radioactive waste. The development of an intermittent process employing very dilute solutions of complexing agents and reducing agents applied to the reactor continuously during operation, or intermittently during normal outages, could allow the reduction of waste volumes, savings in the purchase of decontaminants and avoidance of potentially corrosive material.

Preliminary laboratory studies using EDTA and hydrazine mixtures appeared promising but problems of redeposition and incomplete film stripping showed the process needed optimization. Studies of the pH, temperature and reducing agent on the thermal and radiation stability and film dissolving characteristics of the solution are just starting. Continuing studies in FY-1969 should examine the properties of other complexing materials such as TTHA, DTPA, HEDTA and DHEG. The thermal and radiation stability of these chelating agents or their coordination compounds with Fe, Cr, and Mn should be determined. Continued work to optimize the pH and temperature for any of the solutions that show promise will be necessary.

Single-Pass Reactors (J1)

Some development work, corrosion studies and consultation will be required to support the through-reactor decontamination of the single-pass reactors scheduled for FY-1969.

BNW: Chemistry Research (R. L. Dillon)
 MISSION 1: Basic Production
 FUND ALLOCATION: \$25,000 (7A2B-5T50-49P.J2)
 \$20,000 (7A2B-5T50-49P.J1)
 WORK ORDER ESTIMATE: \$ 3,500 (7A2B-5T50-422.J1)
 \$11,500 (7A2B-5T50-422.J2)
 RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
 RESPONSIBLE DUN CONTACT: P. A. Carlson

Corrosion Studies

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N Reactor

Inconel-600 Steam Generator Tubes (J2 - \$15,000) ^{RM}

Although no failures have occurred in normal industrial practice, evidence is gradually accumulating that stress corrosion cracking of Inconel-600 can occur in high-temperature, high-purity water at certain conditions of stress and geometry in the absence of lead or other obvious contaminants. A program will be started to evaluate the potential for stress cracking Inconel-600 steam generator tubes and to determine the operating conditions necessary to produce and to prevent such cracking.

Crud Studies (J2 - \$10,000) ^{RM}

*WOA 40754 for 5K
 received 1-23-69 for continuation*

The mechanisms of corrosion product formation, transport, activation, and deposition are inadequately understood. Most of the crud control measures applied to recirculating pressurized water reactors have been developed empirically without sound theoretical models of the mechanisms involved. This program will support, in part, fundamental work in developing a model of crud formation.

Single-Pass Reactors (J1 - \$20,000) ^{NT}

A laboratory technique to investigate localized aluminum corrosion phenomena should be developed. This should have sufficient fidelity with reactor conditions to permit investigation of process water, reactor, and fuel parameters as they relate to frequency and severity of attack.

In addition, current programs of corrosion probe monitoring of carbon steel piping, the evaluation of sodium sulfite inhibitor, inhibitor concentration effects in the steam plants, effect of irradiation on the in-reactor corrosion of aluminum and other metals and evaluation of postulated mechanisms of groove pitting should continue.

Plant Support (J1 - \$3500; J2 - \$11,500)

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 testing, evaluate component failures and evaluate the corrosive effects of decontaminations. These studies will be work order funded and will cover the C, KW, KW and N Reactors.

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BNW: Control and Instrument (G. E. Driver)

MISSION 1: Basic Production

FUND ALLOCATION: --

WORK ORDER ESTIMATE: \$35,000 (7M30-5T60-420.R2)

RESPONSIBLE DUN SUBSECTION: Instrument and Automation Technology

RESPONSIBLE DUN CONTACT: C. F. Poor

Provide simulation services utilizing hybrid computer technology to determine the feasibility of different analog and digital control modes of operation for N Reactor.

Provide noise and vibration analysis consultation for DUN boiling burnout experiments.

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BNW: Chemistry Research (W. Y. Matsumoto)
MISSION 4: Pu-238
FUND ALLOCATION: --
WORK ORDER ESTIMATE: \$17,000 (7A21-5T20-422.YO)
RESPONSIBLE DUN SUBSECTION Reactor Physics Technology
RESPONSIBLE DUN CONTACT: G. C. Fullmer

Analytical Lab Yield and Burnup Data

Analyses of individual fuel and target burnout and buildup effects are needed in support of both production and test loadings for establishing discharge goals, effects of secondary reactions on buildup of higher isotopes, and reactor conversion data.

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BNW: Chemistry Research (R. L. Dillon)
MISSION 4: Pu-238
FUND ALLOCATION: \$5000 (7A2B-5T40-49P.YO)
WORK ORDER ESTIMATE: --
RESPONSIBLE DUN SUBSECTION: Fuel and Target Technology
RESPONSIBLE DUN CONTACT: D. Wilson

Analyze the feasibility of using occlusion electroplating to fabricate neptunium target elements to produce Pu-238 on a large scale. It is important that the element be designed to minimize high gamma-n and n-2n reactions on Np-237 (because these produce a Pu-236 impurity). To this end, the neptunium should be in a thin layer over an inert substrate with a minimum of aluminum present. If occlusion electroplating appears feasible, funds may be provided for more detailed experimental studies.

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BNW: Fuels and Materials (W. L. Hampson)
MISSION 4: Pu-238
FUND ALLOCATION: \$25,000 (7A41-5T40-49P.YO)
WORK ORDER ESTIMATE: --
RESPONSIBLE DUN SUBSECTION: Fuel and Target Technology
RESPONSIBLE DUN CONTACT: D. Wilson

Develop fabrication methods for alloy, ceramic, cermet target elements containing neptunium or Americium or other hazardous or difficult-to-handle isotopes. Fabricate small numbers of such target elements as needed for test irradiations. Assist in developing criteria and specifications for specific fuel or target elements.

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BNW:	Fuels and Materials (W. L. Hampson)
MISSION 5:	Other Isotopes
FUND ALLOCATION:	\$25,000 (7A41-5T40-49P.30)
WORK ORDER ESTIMATE:	--
RESPONSIBLE DUN SUBSECTION	Fuel and Target Technology
RESPONSIBLE DUN CONTACT:	D. Wilson/J. C. Nosler

Develop fabrication methods for alloy, ceramic, cermet target elements containing plutonium or other hazardous or difficult-to-handle isotopes. Fabricate small numbers of such target elements as needed for test irradiations. Assist in developing criteria and specifications for specific fuel or target elements.

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BNW: Reactor Physics (D. D. Lanning)
MISSION 7: Target Space Enhancement
FUND ALLOCATION: \$70,000 (7A4A-5T20-49P.WO)
WORK ORDER ESTIMATE: --
RESPONSIBLE DUN SUBSECTION: Reactor Physics Technology
RESPONSIBLE DUN CONTACT: G. C. Fullmer

Oralloy Spiking Tests

As normalizing cases from minimal to maximum use of oralloys as drivers, physics parameters for the wet and dry lattices of two K super-cell configurations are to be established in PCTR tests. The first is a fuel and driver configuration in which all the drivers are of oralloy and the second configuration is one in which the oralloy and 95 metal combination will be comparable in product split to the maximum enriched uranium lattice tested to date, namely 210 metal. PCTR test work was initiated in the latter part of FY-1968. Funds are allocated for the completion of the present two experiments and possible refinements suggested by their results.

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BNW: Chemistry Research (W. Y. Matsumoto)
MISSION 7: Target Space Enhancement
FUND ALLOCATION: --
WORK ORDER ESTIMATE: \$4000 (7A21-5T20-422.MO)
RESPONSIBLE DUN SUBSECTION: Reactor Physics Technology
RESPONSIBLE DUN CONTACT: G. C. Fullmer

Analytical Lab Yield and Burnup Data

Analyses of individual fuel and target burnout and buildup effects are needed in support of test loadings for establishing discharge goals, effects of secondary reactions on buildup of higher isotopes and conversion data from the C overbore zone.

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BNW: Reactor Engineering (F. R. Zaloudek)
MISSION 7: Target Space Enhancement
FUND ALLOCATION: \$70,000 (7C23-5T30-49P.P0)
WORK ORDER ESTIMATE: --
RESPONSIBLE DUN SUBSECTION: Reactor Technology
RESPONSIBLE DUN CONTACT: R. H. Shoemaker

Mark IV Boiling Pressure Drop Experiments - N Reactor

Experiments are required to determine steady-state boiling pressure drop characteristics of the individual subchannels of a Mark IV fuel column. Results of these experiments will be used as a basis in formulating process tube outlet temperature limits for avoidance of operating conditions that would lead to boiling burnout of the fuel. This phase of the work will involve design and construction of full-scale cosine-heated models of the three subchannels of the fuel column.

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BNW: Reactor Engineering (F. R. Zaloudek)
MISSION 7: Target Space Enhancement
FUND ALLOCATION: --
WORK ORDER ESTIMATE: \$140,000 (7C23-5T30-422.WO)
RESPONSIBLE DUN SUBSECTION: Reactor Technology
RESPONSIBLE DUN CONTACT: R. H. Shoemaker

K Reactor Transient Experiments

The purpose of this program is to develop methods to accurately predict the rate of coolant ejection from a K Reactor process channel following a loss-of-coolant flow accident and to define the heat removal rates along the fuel during the coolant ejection. Specific application will be associated with the advanced driver development program, which will involve operation with power densities and tube powers that are considerably higher than experienced with uniform loadings. The following experimental work will be directed towards solution of potential nuclear safety problems associated with such operating conditions.

Computer Code for Transient Calculations (\$10,000)

In FY-1968, laboratory experiments were performed in which complete plugging and front inlet header rupture accidents were simulated. Work in FY-1969 will refine a computer code developed for analysis of such accidents and will verify the code by comparing its predictions to the results of the laboratory experiments. A final report will be prepared describing the analytical methods developed and defining the consequences of the accidents under study.

Additional Transient Experiments (\$35,000)

Experimental apparatus used in the previous experiments will be rebuilt to investigate additional transient conditions, the principal ones being associated with sudden reductions in front header pressure caused by ruptures of supply piping (such as front riser failure). The experiments also will determine the effect of hydraulic

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resistance of the fuel column on the rear header pressure required to prevent fuel failures. Consideration will be given to a more realistic simulation of heat transferred into the process channel from the graphite and determining its effects on the transient thermal and hydraulic characteristics of the fuel column.

Overbore Heat Transfer Experiments (\$45,000)

Experimental apparatus was constructed in FY-1968 for study of the thermal hydraulic behavior of process channels enlarged by 1 inch, such as in the block now installed in C Reactor. Both the steady-state and transient heat transfer characteristics of the system will be studied at tube powers up to 200 percent of the basic level using this apparatus. Transient tests will simulate total and partial supply plugging, coolant supply piping failures and (as possible) power surge and supply pressure reduction accidents.

Subcooled Film Boiling Experiments (\$30,000)

Work will be directed towards completion and analysis of an experimental program to determine the relationships between boiling burnout heat fluxes and local coolant conditions (mass velocity, enthalpy and pressure). The results obtained will be applied towards analysis of boiling burnout safety factors for high-powered driver elements operating with a cooling stream having from moderate to extreme magnitudes of subcooling.

Hydraulics Laboratory Experiments for Single-Pass Reactors (\$20,000)

The single-pass process tube mockup facilities in the hydraulics laboratory will be utilized as required to evaluate process tube hardware and fuel element design changes. Support in this area will be provided to evaluate incidental operational problems with process channel components at the time the problems develop.

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BNW: Chemistry Research (R. L. Dillon)
MISSION 7: Target Space Enhancement
FUND ALLOCATION: --
WORK ORDER ESTIMATE: \$15,000 (7A2B-5T40-422.MO)
RESPONSIBLE DUN SUBSECTION: Fuel and Target Technology
RESPONSIBLE DUN CONTACT: R. W. Toivonen

Develop methods of applying protective coatings to fuel elements to greatly extend their useful lifetime. Perform experimental parametric studies of processes such as electrolytic or electroless plating and flame spraying of nickel, copper, chromium or combinations of these and similar metals. The goal of this work will be to eliminate those cladding performance phenomena, such as ledge and groove corrosion, that prevent single-pass reactor fuel elements from attaining very high exposures. Emphasis will be on those processes which significantly improve fuel cycle costs, not only by increasing exposure capability, but also lowering total fuel fabrication cost or by increasing the amount of uranium in the reactors.

Perform corrosion studies as required in support of fuel performance evaluations. Help define corrosion mechanisms that contribute to fuel failures and suggest methods of removing or alleviating the cause of such corrosion. Assist DUN engineers in staying abreast of the latest developments in corrosion technology.

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BNW: Fuels and Materials (D. C. Lehfeldt
MISSION 7: Target Space Enhancement
FUND ALLOCATION: --
WORK ORDER ESTIMATE: \$30,000 (7ABO-5T40-423.WO)
RESPONSIBLE DUN SUBSECTION: Fuel and Target Technology
RESPONSIBLE DUN CONTACT: M. Lewis

Provide radiometallurgical services as required to evaluate fuel performance, especially as related to new or developmental fuel elements.

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BNW: Fuels and Materials (J. C. Tverberg)

MISSION 7: Target Space Enhancement

FUND ALLOCATION: \$30,000 (7A4C-5T40-49P.WO)
\$30,000 (7A4C-5T40-49P.PO)

WORK ORDER ESTIMATE: --

RESPONSIBLE DUN SUBSECTION Fuel and Target Technology

RESPONSIBLE DUN CONTACT: G. C. Sorenson (49P.WO)
W. C. Gallagher (49P.PO)

Design and Development of Driver Elements (49P.WO)

Perform conceptual design and design development studies as requested for driver elements required in future production reactor programs. It is envisioned that this work will concentrate on elements that utilize highly enriched uranium (greater than 1 percent) as their fissionable component. A specific example of current interest is an element to utilize oralloy, fully-enriched uranium. Included in the studies would be materials selection, fabrication process selection and development and cost analyses for scale-up to production. A small number of elements may be fabricated for irradiation testing. Additional funds would be provided for fabrication of any sizeable number of elements.

Develop Improved Support System (49P.PO)

Develop an improved support system for N Reactor fuel elements using the "end spider" concept. Primary criteria for the system should be (1) removal of attachments on heat transfer surfaces so as to eliminate locally impaired heat transfer as a failure cause, (2) elimination of sliding, rubbing, vibrating contacts on Zircaloy surfaces so as to minimize fretting corrosion as a failure cause. Work on this program will include design evaluation, performance testing, and assistance in process development.

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BNW: Chemistry Research (R. L. Dillon)
MISSION 7: Target Space Enhancement
FUND ALLOCATION: \$4000 (7A2B-5T50-49P.WO)
WORK ORDER ESTIMATE: --
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

Advanced Technology Corrosion Studies

Corrosion problems associated with limited boiling in the N Reactor process tubes will be evaluated in support of the Advanced Technology B program.

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BNW: Ceramics (R. E. Nightingale)
MISSION 7: Target Space Enhancement
FUND ALLOCATION: \$10,000 (7A30-5T50-49P.PO)
WORK ORDER ESTIMATE: \$15,000 (7A30-5T50-422.PO)
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

Protective Coatings on Graphite

The work to develop and evaluate protective coatings for graphite will continue. Emphasis will be placed on development of the application of adherent protective SiC coatings in the presence of radiation. The quality of the coatings will be evaluated using oxidation tests. Computer analyses will also be used to predict the behavior of coatings under various conditions.

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BNW: Ceramics (R. E. Nightingale)
MISSION 7: Target Space Enhancement
FUND ALLOCATION: \$10,000 (7A30-5T50-49P.MO)
WORK ORDER ESTIMATE: \$ 6,000 (7A30-5T50-422.WO)
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

K Reactor Graphite Irradiations

This work involves non-instrumental core irradiations in the ETR and is aimed at a determination of the exposure at which turnaround occurs as a function of irradiation temperature. Irradiation units (I.U.'s) are not included in the allocation provided and will be arranged for by DUN and transferred to BNW.

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BNW: Metallurgical Research (A. L. Bement)
MISSION 7: Target Space Enhancement
FUND ALLOCATION: \$15,000 (7A10-5T50-49P.PO)
WORK ORDER ESTIMATE: \$10,000 (7A10-5T50-422.PO)
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

N Reactor

This program will investigate the effects of the reactor atmospheres and higher temperatures expected in future N Reactor operation on the mechanical properties of as-received and hydrided Zircaloy-2 pressure tubes. Tubes will be exposed in moist helium, dry helium and hydro-carbon helium mixtures to temperatures in the range of 370 to 620 C for extended periods. The environmental effects will be evaluated using crack propagation tests, micro-structural examination, chemical analyses and other tests deemed appropriate.

Determination of the high-temperature stress-rupture properties of Zircaloy-2 pressure tubes will continue. Test temperatures will be extended to 475 C using both as-received and hydrided tubing.

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BNW: Water and Land Resources (D. E. Olesen)
MISSION 8: Nuclear Safety
FUND ALLOCATION: \$ 8,500 (7431-5T10-49P.C2)
WORK ORDER ESTIMATE: \$ 7,500 (7431-5T10-420.C2)
\$20,000 (7431-5T10-420.C1)
RESPONSIBLE DUN SUBSECTION: Nuclear Safety Technology
RESPONSIBLE DUN CONTACT: W. S. Nechodom

Determine the travel time of waste water from the N Reactor crib to riverbank springs by means of dye additions, special radionuclide tracking, and monitoring of radionuclide pulses following fuel ruptures.

Reassess current ground water flow models, and, if necessary, develop a more sophisticated model consistent with test data. Determine the need for additional development work in the areas of influencing ground water flow rates or retarding the travel of radionuclides (strontium and cesium) through pretreatment.

Develop an analytical description of the kinetics of solution and disengagement of noble gases and iodine in and from water in order to assess the uptake of these gases in reactor coolant and fog spray water and the subsequent releases in quench tanks, cribs and retention basins. Scope and propose an experimental verification which will establish the validity of the model.

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BNW: Reactor Engineering (D. L. Reid)

MISSION 8: Nuclear Safety

FUND ALLOCATION: \$55,000 (7C25-5T10-49P.C1)
\$91,000 (7C25-5T10-49P.C2)

WORK ORDER ESTIMATE: \$10,000 (7C25-5T10-422.C2)

RESPONSIBLE DUN SUBSECTION: Nuclear Safety Technology

RESPONSIBLE DUN CONTACT: W. S. Nechodom

Studies of the metal-water reaction will be made by heating irradiated and unirradiated fuel to and past the failure temperature. Further studies will also be made to confirm release fractions of the various fission products from irradiated fuel.

During the first part of the fiscal year, the work will be carried out at the 292-T facility; later, the main emphasis of testing will shift to the 324-D facility after it has been fully equipped.

At present, estimates of the extent and consequences of metal-water reactions are based on laboratory data obtained from small, unirradiated samples of Zircaloy-2 and uranium. The tests to be conducted will be with full-diameter, unirradiated and irradiated elements and will provide a much more realistic basis for evaluating accident consequences.

The fission product release tests will continue testing previously carried out to Zircaloy-2 elements heated to element failure and will continue the investigation to temperatures up to uranium melting. Results should show the fraction of the various fission products (noble gases, halogens and volatile solids) released from overheated fuel and provide information on the chemical and physical forms of the fission products escaping from the fuel.

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BNW: Atmospheric Resources (E. C. Watson)
MISSION 8: Nuclear Safety
FUND ALLOCATION: \$30,000 (7K12-5T10-49P.C2)
WORK ORDER ESTIMATE: \$ 5,000 (7K12-5T10-420.C2)
RESPONSIBLE DUN SUBSECTION: Nuclear Safety Technology
RESPONSIBLE DUN CONTACT: W. S. Nechodom

Conduct and report results of balloon releases and release and photograph smoke plumes to determine wind trajectories from the reactor site to surrounding areas, primarily the Wahluke Slope.

Prepare diffusion experiments to test the validity of theoretical models to the N Reactor site.

Provide data from wind stations on the Wahluke Slope and from the Hanford meteorological station, which can be correlated with data taken from the N meteorological system by DUN.

Provide quarterly progress reports for incorporation into DUN safeguards studies.

Provide consulting service, including off-site exposure computations, which incorporate the results of meteorological studies at the N Reactor site as well as established Hanford climatology.

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BNW: Reactor Engineering (F. R. Zaloudek)
MISSION 8: Nuclear Safety
FUND ALLOCATION: \$15,000 (723C-5T30-49P.C2)
WORK ORDER ESTIMATE: \$40,000 (7C23-5T30-422.C2)
RESPONSIBLE DUN SUBSECTION: Reactor Technology
RESPONSIBLE DUN CONTACT: R. H. Shoemaker

Loss-of-Coolant Heat Transfer Experiments - N Reactor

Technological support of the Nuclear Safety Mission is required to substantiate analytical determinations of the radiological consequences of postulated loss-of-coolant accidents. The principal contribution in the area of thermal hydraulics is in calculation of the rate of temperature rise in various fuel types operating over a wide range of initial powers and temperatures. Results are used for two basic purposes: (1) heat-up experiments with irradiated fuel to determine failure conditions and the rate and quantity of release of fission products, and (2) calculation of spacial distributions of fuel temperature transients required for prediction of the quantity and rate of release of fission products from the reactor core. Experimental heat transfer data will determine the critical parameters controlling rate of temperature rise in the fuel as determined by power generation decay in the fuel and radiative and conductive heat removal to the graphite. The experimental apparatus will represent a single N Reactor lattice unit and will have provisions for determining the effects of Zircaloy-water reactions and oxide film thickness of fuel cladding on the radiative heat transport.

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BNW: Radiological Sciences (H. A. Kornberg)
MISSION 10: Columbia River
FUND ALLOCATION: \$50,000 (7K00-5T50-49P.B1)
WORK ORDER ESTIMATE: --
RESPONSIBLE DUN SUBSECTION: Reactor Materials Technology
RESPONSIBLE DUN CONTACT: P. A. Carlson

Columbia River Program

Deionized water and chemical additions thereto will be used in the single-pass tubes to investigate the effect of changing the relative salt concentrations in the coolant. In this manner the mechanisms by which film characteristics are changed by the adsorption of ions can be deduced. The deionized water tests also provide additional information on the kinetics of the adsorption-desorption process.

Testing will continue in the water treatment pilot plant. Modifications of the current water treatment process will be investigated as well as scouting new and novel processes. The effect of flocculating reactor effluent will also be tested.