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

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RICHLAND FIVE-YEAR

02 R&D PROGRAM

NUCLEAR SAFETY PROGRAM

**RICHLAND OPERATIONS OFFICE
DOUGLAS UNITED NUCLEAR, INC.
GENERAL ELECTRIC COMPANY - HAPD
ISOCHEM INC.
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RICHLAND FIVE - YEAR

02 R & D PROGRAM

NUCLEAR SAFETY PROGRAM

June 1, 1966

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RICHLAND OPERATIONS OFFICE

DOUGLAS UNITED NUCLEAR, INC.

GENERAL ELECTRIC COMPANY - HAPD

ISOCHEM INC.

BATTELLE MEMORIAL INSTITUTE

By Authority of D. S. Lewis

CG-NMP-1, 8-9-94

By J. E. Savely 10-4-94

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R I C H L A N D F I V E - Y E A R
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RICHLAND FIVE-YEAR
02 R & D PROGRAM

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PART I

NUCLEAR SAFETY, MISSION NO. 13 RL SUMMARY

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Nuclear Safety, Mission No. 13 RL

1. Statistical Summary Schedule

Dollars (in Thousands)

General Electric (N-Reactor)
Douglas United Nuclear
Isochem
Pacific Northwest Lab

Total

Man Years *

General Electric (N-Reactor)
Douglas United Nuclear
Isochem
Pacific Northwest Lab

Total

Equipment*

General Electric (N-Reactor)
Douglas United Nuclear
Isochem
Pacific Northwest Lab

Total

1966	1967	1968	1969	1970	1971	5 Year Total
61	96	188	285	289	289	
30	55	50	60	70	100	
2	3	6	10	10	10	
84	191	376	500	516	526	
177	345	620	855	885	925	3630
1.5	2.6	5.0				
1.0	1.0	1.0				
0.0	0.0	0.0				
1.5	4.9	8.0				
4.0	8.5	14	18	18	18	
	70	140				
	12	8				
	13	8				
	150	101				
	245	257	205	151	111	

*These numbers may not agree with the 189 submissions.
They are, however, necessary for effective prosecution
of the Nuclear Safety Program.

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Introduction

It has long been recognized at Hanford that extreme precautions to avoid nuclear accidents are justified. The potential consequences of such accidents are too well known to require statement here, but the very location of the Hanford reactors and separations plants was decisively influenced by nuclear safety considerations. The Hanford site selection was strongly influenced by its high degree of isolation and by the other site characteristics required for the atomic energy project, coupled with the military urgency of the project. These factors, combined with the high order of design safety against accidents built into the reactors and into the separations plants made it permissible to build the Hanford reactors without containment features.

The R&D program here proposed has as its principal objective to improve the evaluation and control of nuclear accidents and their consequences at Hanford. Out of this program it may be expected that considerable areas of needless conservatism will be identified and corrected. The initial nuclear safety analyses of Hanford facilities are usually made on the basis of broad assumptions which are demonstrably conservative, and which upon closer examination turn out to have considerably more margin of safety than could be demonstrated initially. In this way it is quite possible that it will be found that the Hanford plants are now in compliance with the intent of the evertightening regulations which are being placed on commercial reactors and nuclear facilities. Another result of this examination may be to permit relaxation of present rigid operating procedures where they are found to be needlessly restrictive. It is also possible that one result of this work in some cases may be to show that plant modifications are necessary if the plants are to be brought into compliance with the regulations currently applicable to other segments of the nuclear industry.

It is a further objective of this program, therefore, in these cases to devise means of making such modifications at minimum cost to the Commission.

A second and very important result of this program would be the maintenance of an effective nuclear safety staff in the production operations at Hanford. It is only with such a staff that it will be possible to deal with nuclear safety problems which may arise in the future, and to supply to the Atomic Energy Commission the needed technical support for carrying out the Commission's production mission at reasonable cost and with acceptable standards of nuclear safety.

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The technical scope of this program includes the evaluation and control of serious nuclear accidents in the Hanford production facilities. Problems which may be expected to arise as a result of normal operations such as control of environmental contamination, in-plant criticality safety, improvement of safety equipment for better or more economical operation, are considered in other programs and will not be considered here.

It is well recognized that the Atomic Energy Commission is sponsoring a large and active nuclear safety program and in view of this fact it may well be questioned why any additional work is necessary. The general answer to this question is twofold:

1. The existing AEC programs are almost entirely in support of the commercial nuclear power industry and of space applications of nuclear energy. Characteristically, the reactors used in commercial and in aerospace applications differ markedly from the production reactors. For example, the production reactors use metallic fuel, the commercial reactors use oxide type fuel. Fission product retention, the chemical form of evolved fission products, and other characteristics are sharply influenced by this difference.
2. Even if the broad program sponsored by the Commission was more directly in support of the production reactors, it still would be necessary to perform research and development work in nuclear safety pertaining to specific reactors. It is obvious for example that steam and water flow patterns during accidents cannot be determined in a general sense but must be established for particular reactors. Local meteorology obviously is associated with specific reactors or groups of reactors. Ground disposal of liquid wastes is a function of the type of soil available at the particular locality.

The broad Commission nuclear safety program does include some work upon which the production reactor groups may draw in investigating methods of retaining fission products. However, this does not appear to be a very active part of the total Commission program, and of course it is not focused on specific reactor situations to the extent necessary.

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A considerable part of the work to be done in the presently proposed program will consist of obtaining and maintaining familiarity with those parts of the Commission's nuclear safety program assigned to other locations and other contractors. Care will be exercised not to needlessly overlap or duplicate programs being carried on in these locations such as the National Reactor Test Stations, Atomic International, Argonne National Laboratory, Oak Ridge National Laboratory, The Brookhaven National Laboratory, or the Battelle-Northwest Laboratories.

Nuclear safety studies performed under this program will be closely integrated with the work done by other contractors, where appropriate and will, to the extent feasible, be integrated with other nuclear safety studies performed in support of specific programs or processes. Similarly, nuclear safety studies performed in support of specific programs or processes will be coordinated with, and may depend upon, work done by other contractors to the AEC. For example: Nuclear safety programs in the separations area (Isochem) include aspects of the Waste Management Program and attendant subprograms. In addition, basic criticality studies are now sponsored by DRD-04 funds, and many aspects of nuclear safety are supported by Process Technology funds and operating funds particularly in areas of environmental safety, chemical safety, and radiological protection.

It should be noted that basic criticality studies are required to support U-233 programs and other programs which introduce higher enrichments of U-235. Basic criticality studies involving uranium have been assigned to ORNL and, in order to assure the development of optimum process and equipment concepts, close liaison and integration will be required between ORNL and Hanford when evaluating U-233 and low enriched U-235 programs. In addition, basic criticality data will be needed to define optimum storage and process equipment associated with high exposure plutonium programs and associated americium "milking" concepts; support in this area would be expected from the Hanford Critical Mass Laboratory (PNL) under sponsorship of DRD-04 funding.

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Incentives

By substituting facts for pessimistic estimates of maximum severity (limiting cases) this program will reduce the excessive conservatism in hazards evaluations of Hanford nuclear facilities. Thus the program results may show that the reactors are safer than heretofore considered. This would permit releasing more land for commercial use or for farming. The character of confinement systems deemed to be required for Hanford reactors will probably be changed in the direction of requiring less. Methods for further reducing the consequences of accidents in Hanford nuclear facilities will be disclosed. Very significant economies in the treatment and disposal of liquid wastes might be made possible. Future planning of land utilization, being based upon more factual information, can be done with more confidence. The service life of the Hanford production reactors may be extended.

Scope and Objectives

The Nuclear Safety Mission consists of a broad, integrated program of experimental and analytical studies designed to permit more accurate assessment of the consequences of accidents at Hanford nuclear facilities. Information obtained will assist in the design of facilities to further mitigate the consequences of accidents involving the release of radioactive materials from the Hanford nuclear reactors and chemical processing facilities.

The Safety Mission consists of seven programs described briefly below and more fully in the contractor summary sections which consider the efforts of each contractor in the programs.

Programs

13RLa A program to identify fuel element temperature transients and in particular the fraction of the fuel in the reactor which would be failed (subject to release of fission products) as a function of time after initiation of an accident.

Initial phases of the work will apply to N-Reactor but emphasis will shift to DUN reactors in later stages of the program.

An additional objective will be to characterize the temperature of reactor fuel as a function of its location in the reactor and time after initiation of a partial or complete loss of coolant to the fuel.

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13RLb A program designed to characterize the fission products released from ruptured or molten full scale fuel elements, and to develop, primarily by experimental methods, a characterization of the fractional quantities, chemical form, and rate of release of biologically significant radionuclides which would be released from metallic fuel and other target materials present in quantity in N-Reactor in a severe nuclear accident. The program is designed further to develop information on the behavior of these radioactive materials from the time of release from fuel to the time of release into the environs, i.e., effects of plate-out, rain-out, and retention on filters and collectors. The studies will be extended to include DUN fuel elements. Halogen collector efficiency is the subject of program 13DUNb.

It is expected that the fractions of key fission products released from N and K fuel for at least one temperature sequence leading to fuel failure and elements of the subsequent history of these fission products will be determined by July, 1967. The chemical form of radioactive iodine should be determined by July, 1968.

13RLc A program designed to identify methods by which noble gases can be held up or retained so as to reduce the consequences of release of radioactive noble gases from failed fuel. This program envisions exploring methods of reducing the release of noble gases to the environs in order to reduce the exclusion areas around each production reactor, which are, at present, determined by the noble gas fraction of the fission products which could be released to the environs in the event of a nuclear accident.

It is expected that the technical feasibility of reducing the release of noble gases to the environs will be established by July, 1969.

13RLd A program of local meteorological studies at N-Reactor site. This program would consist of a series of experiments and observations, using harmless aerosols (or tracer gases) released in a burst, or continuously, from the N-Reactor exhaust stack, quench basin, waste liquid disposal crib or other possible locations having a potential for the release of radioactive gases and aerosols.

An additional objective is the characterization of local meteorology, to permit comparison with generalized meteorological

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studies, define more realistic preparations for evacuation of N-Area in case of need, and to define, more accurately than can now be done, the impact of release of radioactive gases and aerosols upon the future utilization of land in the vicinity of 100-N Area. Techniques developed during this program will be applicable to other sites where release of noxious aerosols is a matter of concern.

It is expected that equipment for producing suitable aerosols and measuring dispersion will be in place by December, 1968. The experimental program at 100-N Area should be completed by December, 1970.

13RLe A program for evaluating the potential for Ground Disposal of Radioactive Liquid Wastes at 100-N Area and at other Hanford sites. This program is designed to permit characterization of ground water depth and flow direction and speed in the vicinity of actual or potential liquid waste disposal sites, and to characterize the ability of the soil to permanently retain fission products and other radioactive materials of biological significance. The program will be extended, as funds permit, to evaluation of other reactor and chemical processing sites.

The objective of this program is to determine if soil filtration is a satisfactory method of treating reactor effluent cooling water at Hanford sites. If this can be demonstrated, it may be deemed unnecessary to build evaporators, demineralizers, or large storage tanks to accommodate radioactive liquid wastes released from reactors during and following a severe accident or during normal operation.

It is expected that preliminary evaluation of soil retention characteristics, ground water flow patterns and transport rates for selected nuclides will be completed in sufficient degree to define the experimental program for 100-N site by July, 1966. The experimental work at N-site should be completed and facilities in place for testing at other sites by July, 1968.

13RLf A program to characterize the formation and release of radioactive particles and aerosols from heated nuclear materials such as plutonium and plutonium compounds. This program is designed to characterize more closely the hazards which would result from the overheating or burning of solutions and solids present in the chemical processing plants where plutonium is

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separated from irradiated uranium fuel. The objective of the program is to provide information which will permit defining and demonstrating methods for reducing the spread of plutonium in the event of fire or overheating.

13RLg A program to determine ground attenuation (or amplification) of and reactor building response to seismic shock. This program is designed to permit evaluation of the need for reinforcement of critical reactor structures.

Budget Period Plans and Expected Results Chart

Budget period plans are outlined in Table 1 which is a reproduction of the contents of the attached unclassified PERT Chart.

Specific program plans and expected results are summarized in the GE, DUN, and Isochem summaries, Section II, III and IV, respectively.

Evaluation of Progress Against Plans and Objectives

Expected progress has been made or exceeded in each program under way during FY-1966.

Significant results are:

1. Identification of a gradual release rate of noble gases from fuel elements which have failed below the uranium melting temperature.
2. Verification by crib and spring water sampling of the theoretically predicted travel time of ground water from the 1301-N crib to the Columbia River.
3. Test results indicating the feasibility of using ground disposal facilities for reactor effluent under accident conditions.

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<u>PROGRAM</u>	<u>FY-1966</u>	<u>FY-1967</u>	<u>FY-1968</u>	<u>FY-1969</u>	<u>FY-1970</u>	<u>FY-1971</u>
13RLa-(13GEa,13DUNa) Fuel Temperature Transients Under Accident Conditions	Design of experi- ments for N fuel.	Calculate spatial moderator tempera- ture transients for N-Reactor. Experimentally determine critical parameters (heat transfer coolant loss and flow) for N-Reactor. Calculate fuel and target temp. transients(family of spatial distri- bution) on loss of coolant.	Analyze steam- water flow transients upon restora- tion of cool- ant. (family of spatial distributions) for N-Reactor. Determine experimentally critical flow and heat transfer para- meters for flow restora- tion, N-Reactor.	Apply analysis to special fuel elements-N- Reactor. Report results of analysis of fuel temp. history after accidents, for N-Reactor. Report results.		
13RLb-(13GEb-13DUNb) Fission Product Release from Failed Fuel Elements	Experimentally determine prompt release of F.P. and failure temp. for N-Reactor fuel.	Experimentally determine the fractional release of biologically significant individual fission pro- ducts from full scale clad metallic uranium fuels-N-Reactor designs. Establish the re- lease rate of individual radio- nuclides from failed and from molten fuel under simulated loss of coolant conditions.	Characterize fission pro- ducts from fail- ed fuel elements as to chemical composition and particle size.	Characterize fission product release for fuel failed under delayed coolant injection con- ditions. Measure plate out of fission products on N- Reactor components subsequent to fuel failure. Measure removal efficiency of N- Reactor confina- ment system components-filters fog spray.		Prepare more realistic evaluations of the consequences of "Loss of Coolant" accidents at N,K, and other production reactors.

Table 1

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<u>PROGRAM</u>	<u>FY-1966</u>	<u>FY-1967</u>	<u>FY-1968</u>	<u>FY-1969</u>	<u>FY-1970</u>	<u>FY-1971</u>
13RLc-(13GEc) Control of Noble Gases		Design experi- mental program.	Experimentally investigate methods for reducing noble gas release from water pools.	Develop best candidate sys- tem through pilot stage. Determine possibility.	Develop process and design specifications for N-Reactor plant facility, and issue report.	Initiate action to reduce consequences of noble gas release.
			Investigate con- cepts and sys- tems for con- fining noble gases and con- trolling re- lease.			
13RLd-(13GEd) Local Meteorology		Perform small scale smoke release tests.	Develop Tech- nology for dispersion measurements. Install meteorological measurement equipment.	Conduct field tests of dis- persion for ground level and elevated releases of unradioactive materials for stable, neutral and unstable atmospheric conditions at N-Reactor site. Derive equations relating dis- persion to meteorological parameters.	Evaluate effects on local turbu- lence caused by reactor build- ings. Relate previous experiments to K,B,D sites and analytically evaluate dis- persion and its effects on environmental hazards.	Define and effect im- proved techniques for protecting and evacuating personnel at reactor sites under accident con- ditions.

Table 1

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<u>PROGRAM</u>	<u>FY-1966</u>	<u>FY-1967</u>	<u>FY-1968</u>	<u>FY-1969</u>	<u>FY-1970</u>	<u>FY-1971</u>
13RLe-(13GEe) Ground Disposal of Radioactive Wastes		Evaluate soil transport and retention (Sr and Cs and other isotopes) N-Reactor site and laboratory.	Experimentally evaluate effects of chemical form and particle size of rupture debris on soil trans- port and retention. N- Reactor site & laboratory. Drill test wells at N,K, B,D and con- struct test retention basins at (N-site).	Develop integrated characterization of ground water flow patterns and soil retention and transport characteristics at N-Reactor site. Evaluate soil transport and retention characteristics at K,B and D sites.	Prepare and plant field plots to evaluate ecology of growing plants in contaminated and heated soil, at N-site, if acceptable. Develop inte- grated characteristics of ground water flow patterns and soil reten- tion and trans- port character- istics for K,B, and D sites. Experimentally evaluate per- manent reten- tion character- istics of soil at CPD storage sites.	Define long range requirements for disposal of radioactive liquids at Hanford sites, except as may be affected by ecological studies. Continue ecological studies.

Table 1

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<u>PROGRAM</u>	<u>FY-1966</u>	<u>FY-1967</u>	<u>FY-1968</u>	<u>FY-1969</u>	<u>FY-1970</u>	<u>FY-1971</u>
13RLf-(13ISOf) Particles and Aerosols from Burning Materials		Design experi- ments for Pu, and flammable materials.	Experimentally evaluate particulate and aerosol releases from Pu and flammable materials.	Analyze conse- quences of Pu releases under accident con- ditions. Design and pre- pare experi- ments using substitute for plutonium.	Analyze conse- quences of Pu releases under accident con- ditions. Conduct field test using substitute for plu- tonium.	Define appropriate control measures and develop criteria for application.
13RLg-(13DUNG) Seismic Measure- ments		Evaluate seismic coupling of Han- ford soils and measure vibration response of reactor facility components. Establish a permanent seismic station.		Develop mathematical correlations for coupling and response characteristics.		Report results of measurements and correlation.

Table 1

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PART II

NUCLEAR SAFETY, MISSION NO. 13 GE

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U. S. ATOMIC ENERGY COMMISSION

RICHLAND
OPERATIONS OFFICE

RESEARCH AND DEVELOPMENT STATISTICAL SUMMARY
02 PROGRAM

1. MISSION NO. AND TITLE <u>Nuclear Safety Mission #13 - GE</u> MISSION SUB-PROGRAM TITLE <u>GE Summary</u>		2. BUDGET ACTIVITY NO. _____	
3. CONTRACTOR AND A. <u>General Electric</u> CONTRACTOR B. _____ NUMBER C. _____		4. PERSON IN CHARGE: _____ INVESTIGATOR: _____ INVESTIGATOR: _____	

FIVE YEAR FORECAST

	CURRENT BUDGET YEARS					
	FY 19 66	FY 19 67	FY 19 68	FY 19 69	FY 19 70	FY 1971
5. MAN-YEARS						
A) SCIENTIFIC AND TECHNICAL	1.1	1.9	3.6			
B) OTHER	.4	.7	1.4			
TOTAL	1.5	2.6	5.0			
6. COSTS (\$000'S)	\$	\$	\$	\$	\$	\$
A) DIRECT LABOR (INCL. COST OF SERV.)	42	64				
B) MATERIALS, TECH. SERV., SUB CONTRACTS	58	104	212	320	326	326
C) SPONSORED WITH BNW						
TOTAL DIRECT	100	168				
D) INDIRECT EXPENSES	19	32				
TOTAL OPERATING COSTS	119	200	400	605	615	615
E) EQUIPMENT*(NEW)	--	152	197	167	117	76
F) IRRADIATION UNIT COSTS						

7. COMMENTS:

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*Includes prorated portion of equipment
requirements for PNL

PREPARED BY _____

DATE _____

NUCLEAR SAFETY PROGRAM, MISSION 13GE SUMMARY

GE Scope and Objectives

The general objectives of the GE-Nuclear Safety Mission are (1) To more accurately characterize the potential release of fission products and other radioactive materials from the N-Plant nuclear safety facility under accident conditions, and (2) to more closely describe the consequences of such releases in terms of radiation dose rates and area contamination. These studies will yield information which will permit designing better methods for mitigating the consequences of accidents which result in the release of radioactive materials from metallic fuel elements in the active zone of a reactor. These studies will benefit the DUN reactors and the nuclear industry as well as N-Reactor.

The GE Nuclear Safety Mission is identifiable as sub-programs as follows:

- 13GEa: Fuel Temperature Transients Under Accident Conditions
- 13GEb: Fission Product Release Rates from Failed Fuel Elements
- 13GEc: Control of Noble Gases
- 13GED: Local Meteorology
- 13GEE: Ground Disposal of Radioactive Wastes

The scope and objectives of each of these sub-programs is discussed in detail later in this section under the individual sub-programs.

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Progress During Report Period

Computer programs used to calculate fuel temperature transients were refined and used in the Mark I and Mark II fuel design.

Preliminary tests were completed in which six irradiated full scale fuel elements were failed under simulated loss of coolant conditions to determine fission product release fractions.

Noble gas release rates were calculated for static and maximum turbulence conditions for gases in aqueous solution to estimate consequences of a sudden release under certain accident conditions.

Portable equipment was used to measure surface meteorological conditions at N-Reactor to determine the degree of short term correlation between N-site and 200 Area plateau wind speeds and direction.

1300-N crib, test well, and riverbank spring samples were measured to determine the concentrations of biologically significant radio-nuclides.

Laboratory tests were conducted using 100-N Area soil which indicated rapid migration of iodine in ground water but slow migration of elemental cesium and strontium.

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Budget Period Plans and Expected Results

Initiate laboratory studies that will aid in defining fuel temperatures during a blowdown transient. Upgrade computer programs used in calculating the graphite temperatures spatial distribution.

FY-1967

Determine from tests on full scale fuel elements the fractional release and fractional release rate of biologically significant fission products. Tests will be conducted under simulated loss of coolant conditions.

Initiate tests to measure the release rate of noble gases from solutions. Release rates obtained will be used in a more accurate assessment of possible accidents where noble gases are dissolved in primary coolant then suddenly depressurized.

Conduct small scale smoke release tests to obtain semi-quantitative estimates of potential 100-N onsite radiation hazards during postulated incidents.

Research will begin on the degree of removal by soil of particulate and soluble radionuclides from reactor coolant. Initial studies will use 100-N Area soil and emphasize removal of cesium, strontium, ruthenium and iodine.

FY-1968-1971

Plans and expected results are described under the five individual programs which comprise the 13GE effort.

Reference Reports Issued

Ben Hajek, "The Migration and Dispersion of Strontium and Cesium in N-Area Soil", BNWL-CC-208, July 1965.

M. M. Hendrickson, "Eolus, A Computer Programmed Solution for Estimating the Dispersion of Airborne Particles and Gases", RL-NRD-454.

M. M. Hendrickson, R. L. Engle and J. Greenborg, "Isoshield, A Computer Code for General Purpose Isotope Shielding Analysis", BNWL-236, April 1966.

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Equipment Needed

Yearly expenditures for equipment needed are summarized below.

Equipment Requirements Each Fiscal Year: Dollars in thousands.
13GE Dollars only. (Subprograms show GE and PNL dollars needed.)

<u>Program</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>
13GEa	10	20	--	--	--
13GEb	20	20	20	20	--
13GEc	10	10	50	50	--
13GED	10	60	30	--	--
13GEE	<u>20</u>	<u>30</u>	<u>20</u>	<u>--</u>	<u>--</u>
FY Total Expenses	70	140	120	70	--

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13GEa: Fuel Temperature Transients Under Accident ConditionsScope and Objectives

This program is designed to generate a description of the approach to fuel failure conditions as a function of location in the reactor and time after loss of adequate cooling. This program will involve experimental and analytical evaluation of the heat transfer and coolant fluid flow as a function of location in the reactor and time after initiation of the accident. The end results will be identification of the fraction of fuel in the reactor which will be subject to release of fission products as a function of time after initiation of an accident. This information combined with the characterization of the release of fission products from ruptured or molten fuel (Mission GEB) will permit characterizing, more accurately than can be done now, the potential for release of radioactive materials into the N-Reactor core as the result of accidents which involve inadequate cooling. These studies will be related to fuel geometries used for production loads at N-Reactor. The techniques developed will benefit the DUN reactors as well as any other horizontal tubed reactors.

Progress During Report Period

Principal work was in refinement of computer program to calculate fuel temperature transients. Specific refinements were addition of capability to calculate self consistent reactor and fuel operating parameters (such as spatial distribution of uranium temperatures, process tube temperatures and graphite moderator temperatures) to determine initial conditions at the start of temperature transients. In addition, work was done to more satisfactorily account for heat generated during loss of cooling accident due to the exothermic reaction between zircaloy and water (or steam). Capability was generated to calculate spatial fractions of fuel reaching specific temperatures following loss of cooling accidents. This was applied to the Mark I and Mark II fuel designs to establish the fractions of fuel reaching failure temperatures following a sudden and complete loss of cooling accident.

Plans and Expected ResultsFY-1967

Work will be complete in identifying the critical postulated cooling system accidents with respect to the potential for release of fission products. Laboratory studies will aid in defining the boundary conditions for fuel temperature transient calculation, such as factors affecting distribution of coolant flow in the reactor core during a blowdown transient. In addition, computer programming will be completed for calculating the temporal and spatial distribution of temperature in the graphite moderator.

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FY-1968

Steam and water transients in the reactor core and primary piping will be analyzed in a family of spatial distributions. It is expected that some laboratory work will be required to determine critical heat transfer and fluid flow parameters for the analysis. The objective will be to properly characterize a spectrum of transients, including both fuel temperature transients and mechanisms for release of fission products from failed fuel or restoration of coolant.

FY-1969-1971

Advanced design N-Reactor fuel elements will be tested and analyzed to determine temperature transients under loss of fuel coolant conditions.

Results of analysis will be reported and applied to obtain the fuel temperature history of the core during postulated accidents.

Reference Reports Issued

None

Equipment Needed

FY-1967

System Components for flow tests.	\$10,000
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FY-1968

System components and temperature and coolant flow measurement devices.	\$20,000
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13GEb: Fission Product Release From Ruptured or Molten Full Scale
Fuel Elements

Scope and Objectives

This program is designed to develop, primarily by experimental methods, a characterization of the fractional quantities and fractional release rates of biologically significant radioisotopes which would be released from full size metallic fuel and other target materials present in quantity in the N-Reactor core as a function of time after reaching temperature conditions which would, by failure of cladding or melting of contents, permit the release of radioisotopes. The program will also involve characterization, to the maximum practicable degree, of the behavior of biologically significant radioisotopes under condition where plate-out on hot or cold surfaces, rain-out by fog sprays and retention on filters or collectors can occur. The results of this program will permit more realistic evaluation of the consequences of rupturing or melting a given quantity of fuel or target material in a reactor core. Combined with the results from the DUNb program for evaluation of the efficiency of charcoal halogen collectors, this program will permit characterization of the release of biologically significant radioisotopes to the environs as the result of accidents involving inadequate cooling of the heat generating core of the reactor.

Progress During Report Period

Six full-scale fuel failure tests under simulated loss of coolant conditions were completed. These tests were the first to be conducted using full size, clad, irradiated fuel. Previous tests at Hanford and other sites have used small unclad samples of metallic or oxide fuel which were oxidized or melted to determine the fractional fission product release. The test indicated:

1. The fraction of fission products released from fully clad, full size, irradiated fuel elements is substantially different from that observed for small unclad samples. It appears to be much lower for full-size elements.
2. Fuel failure would appear to be largely temperature rather than time-temperature dependent during a heating transient following loss of reactor coolant.
3. Fuel elements which fail below the melting temperature appear to release noble gases gradually during heating after failure. The maximum observed rate was about one per cent/minute.

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Plans and Expected ResultsFY-1967

Research to be undertaken will be a systematic study of the release of fission products from fully irradiated, full-size uranium fuel elements. The fuel elements will be inductively heated at rates expected in reactor loss of coolant incidents to various goal temperatures, including the melting point. The time in which fuel elements are held at goal temperature will be sufficient to ensure that fission product release is complete or that the rate of release has reached a constant value. In these experiments particular attention will be given to the rate at which biologically significant radionuclides are released. The forms of iodine and cesium in the atmosphere leaving the fuel piece will be investigated. Data to date suggests that the form of iodine released is dependent upon the temperature and the time at temperature during release. The release form also appears to be dependent on the presence of uranium and other fission products. Little is known of the effects of temperature and cladding on cesium release.

FY-1968

Particular emphasis will be placed at the characterization of fission products as to physical form and chemical composition. Some experiments will be conducted having the dual objective of measuring release characteristics of fission products from the fuel and the subsequent deposition characteristics. Other data expected to be generated are the influence of cladding, the influence of atmosphere, degree of oxidation, and the importance of radiation level on release. The latter is known to be important up to 10-20 nvt. Irradiation level effect on fraction and rate of release at higher levels is yet to be shown.

Other experimental work will develop information in two areas in which there are currently only meager data which can be confidently applied in reactor accident analysis. (1) The deposition and transport of fission products and fuel channels and related piping in the pathway from the overheated fuel elements to the reactor confinement space, and (2) the efficiency of currently favored confinement features and new concepts for retaining fission products actually released from fuels overheated to the point of melting.

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The experimental arrangement will essentially be a mock-up of a section of an N-Reactor fuel channel at the inlet end of which the clad uranium specimen will be heated to a goal temperature. The downstream section will be a reasonable facsimile of a process tube containing electrically heated rods simulating the fuel pieces near the rear face of the reactor. The process tube may also require controlled heating in these experiments. Further downstream will be exit hardware representing the remaining pathway to a break point. Fission products escaping this point will pass through filters and charcoal traps representative of the N-Reactor confinement system. A measurement of the penetration of fission products to each section of this path will be made.

FY-1969-71

Fuel failure caused by delayed injection of cooling will be studied. The fission product release rate subsequent to failure will be determined. Attention will be given to the plate-out of fission products on N-Reactor core components under conditions simulating accident conditions as nearly as feasible. The physical nature and chemical composition of released fission products will be identified where pertinent and temperature effects on chemical form will be noted. Tests will be continued on N-Reactor fuel to provide enough data to be of statistical significance. Concurrent experiments will be planned to test systems designed to mitigate the consequences of radioactive noble gas release.

Reference Reports Issued

None

Equipment Needed

FY-1967

Sampling Equipment	\$20,000
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FY-1969-1970

Systems and equipment for measurements of rain-out, plate-out, etc. of radioactive nuclides.	\$60,000
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DECLASSIFIED

Mission 13GEc: Control of Noble Gases

Scope and Objectives

At the present time no techniques have been developed specifically to retain noble gases released from metallic fuel after a loss of coolant accident. The noble gas release determines the exclusion boundary and the low population zone boundary calculated in accordance to 10CFR 100 for the N-Reactor. Depletion of the noble gas cloud by holdup or retention would significantly reduce the exclusion area required by N and the DUN reactors and would potentially free additional land for industrial development or farming.

This program envisions exploring methods of reducing the release of noble gases such as:

1. Mechanical retention (as in a gas holder)
2. Absorption in liquids
3. Absorption on solids
4. Immobilization of precursors of the noble gases
5. Chemical combination of noble gases (for example the Clathrate compounds)

Progress During Report Period

The rate of noble gas release from an aqueous solution was calculated. The release rate was, as expected, found to be largely dependent on the turbulence of the solution. The release being almost instantaneous for highly turbulent solutions but very slow (over a period of days) for static solutions.

Plans and Expected Results in FY-1967

The research will include a comprehensive literature search to collect and assimilate available data on the behavior of the noble gases, particularly their solubility and partition between air and liquid under all conditions. Physical properties, chemical reactivity, and suggested and demonstrated methods for trapping noble gases will be studied. Although some reviews are available, there is to our knowledge no up-to-date review of this area of work.

Surface renewal and the liquid film mass transfer coefficients are known to be of controlling importance in the release rate of a dissolved gas. Only meager information is available on the release of noble

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gases from the surface of a system as a function of mixing and turbulence in the body of the fluid. Initial experiments will be designed and carried out to permit the transfer in the liquid and the release to be measured. Initially, the experiments will be carried out in tanks of size to permit some generalizations to be firmed up regarding the release rate as a function of turbulent mixing. In subsequent experiments the systems envisaged for N-Reactor emergency water disposal will be simulated to study the influence of entrance geometry and velocity, temperature gradients, and sweep air velocity over the surface.

FY-1968

Further definition of the transfer mechanisms of noble gases into and out of liquid systems will result from continued experiments. From the body of information developed, possible ways to limit (or enhance, in some cases) the release of noble gases will be suggested for study. Promising methods will be tried using techniques and equipment developed in earlier studies. Some of the suggested methods include immiscible liquid films (including monolayers) and floating solids such as membranes or pellets.

FY-1969-71

Based on facts brought out in previous study, a selection would be made of the more promising methods and detailed studies performed to identify the engineering feasibility of the application. Systems promoting retention in water pools may require supplementing with improved and novel methods for gas retention. Absorption on various beds, foam encapsulation, and trapping in organic liquids will be studied. Application of conventional gas holders or inflatable envelopes may be considered.

Experiments visualized will require design and construction of a model basin in which flow conditions can be varied over a range of mixing conditions and entrance conditions. Other controllable variables will be sweep velocity of air across the surface, liquid depth, flow rate of liquid through the basin and temperature.

Although a radioactive tracer, likely Kr⁸⁵, is anticipated for this work, equivalent data may be obtained more easily with other inert gases. These possibilities will be explored. Oxygen appears to be promising.

Research in these years is expected to permit selection and engineering of the best system for retention of noble gases, both through the route

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of water leaving the reactor confinement structure or through gaseous effluents. The research will be devoted to developing the necessary design criteria to insure optimum performance of the selected system.

Special Equipment Requirements

FY-1967

Kr ⁸⁵ measurement instrumentation	\$12,000
Other instruments -- flow and temperature sensors and recorders	8,000
	<u>\$20,000</u>

FY-1968

Oxygen or other gas analyzer instrumentation	\$ 6,000
Other equipment -- flow generator, sensors, recorders	20,000
	<u>\$26,000</u>

FY-1969

Flow sensors, recorders, and related equipment	\$12,000
Temperature control and recording instrumentation	6,000
Unspecified miscellaneous laboratory equipment	5,000
Prototype equipment for noble gas control	50,000
	<u>\$73,000</u>

FY-1970

Equipment and prototype systems for noble gas control	\$50,000
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Reference Reports

None

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13GE1: Local Meteorology

Scope and Objectives

This program contemplates a series of experiments involving release of harmless gases or aerosols at N-Reactor and other reactors in order to characterize the path, size and dilution of the cloud as a function of weather conditions. Such studies will, as a minimum, permit more realistic preparations for evaluation of an area in the event of an accident. They may have significant impact on the future utilization of land in the vicinity of the Hanford reservation.

Most of the data obtained at Hanford on atmospheric dispersion has been obtained on the flat plateau where the meteorology station is located. This site is ideal for such studies but unfortunately the terrain is significantly different than that at N-Reactor.

This program would establish the values of dispersion parameters specific of the N-Reactor site for use in the wind variability - dispersion model, (Simpson-Fuquay model). It would permit a more realistic estimate of required exclusion and low population zone boundaries for N-Reactor. The data obtained would have more general application and would add to the general knowledge of diffusion of aerosols in the atmosphere.

Progress During Report Period

Data were collected using portable instruments which indicated that there was no short term correlation between surface wind speeds and directions at N-Reactor and the 200 area plateau. The confirmation or absence of correlation indicates a need for meteorological measurement equipment at N-Reactor and also indicates a need for specific knowledge of values for dispersion parameters for the N-Reactor site.

Smoke release studies have given a qualitative indication of potentially severe onsite radiation exposure problems for certain types of postulated accidents involving release of fission products to the atmosphere.

Plans and Expected Results

FY-1967-1970

Hazards calculations to estimate possible onsite and offsite consequences of fission product releases to the atmosphere from reactor areas rely on dispersion models and data developed elsewhere. The 200 Area plateau

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is the site of the closest extensive measurements. Thus the meteorological phenomenon peculiar to each of the reactor sites is not well established. Lacking more detailed information the available data obtained in experiments on the 200 Area plateau have been used as the basis for estimating atmospheric dispersion of fission products following a postulated release from N-Reactor site (and the DUN reactors). This program is planned as a small scale effort in FY-1967 with increased effort in FY-1968 during which instrumentation would be installed at the N-Reactor site, and a full scale effort in FY-1969 - 1970.

During FY-1967 smoke release tests are planned to obtain a semi-quantitative estimate of potential 100-N onsite radiation hazards during postulated incidents.

During FY-1968 - FY-1969 the needed technology would be developed and field tests would be conducted to determine atmospheric dispersion for the ground level and elevated releases at the N-site. Dispersion phenomena would be studied for stable, neutral and unstable atmospheric conditions. Equations would be derived which related the measured dispersion to meteorological variables. The equations would then be used to revise previous hazards estimates.

Reports Issued

M. M. Hendrickson and R. L. Engle

"Eolus, A Computer for Estimating the Dispersion of Airborne Particles and Gases." RL-NRD-454.

Equipment Needed

<u>FY-1967</u> - Portable wind speed and Direction Measurement Sys.	\$10,000
<u>FY-1968</u> - Wind direction and wind speed measurement devices and recording equipment.	\$45,000
Installation of equipment on existing tower.	\$15,000
<u>FY-1969</u> - Aerosol generator and detecting equipment (photographic).	\$30,000

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Subprogram 13GEe (Ground Disposal of Radioactive Wastes)Scope and Objectives

This program will characterize the depth and flow of ground water in the vicinity of N-Reactor, initially, and at other reactor and chemical processing sites later, as a function of river level, and season of the year. The capacity of the soil for permanent retention of radionuclides will be determined from laboratory evaluation of core samples taken from test wells and from tracer studies in the field which will disclose the nature and rate of transport of radionuclides in the soil and ground water at selected sites. The objective of this program will be to evaluate the potential for permanent storage in the soil of radionuclides from radioactive solutions generated by normal process or accident conditions. Ground disposal of radioactive wastes if acceptable, would make unnecessary the construction of very large storage tanks for solutions generated under emergency conditions and processing plants for the treatment of routine wastes.

Progress in FY 1966

Results were derived, both experimentally and mathematically, which characterize the sorption, migration and dispersion in 100-N Area soil of Sr and Cs present in a simulated emergency waste. Actual 1301-N crib flow analysis was made based on I^{131} concentration peaks which appeared in the crib, monitoring wells and riverbank springs. Travel time calculations thus determined showed excellent correlation with those theoretically predicted earlier. Additional work now in progress will combine these results with ion-exchange data for other radionuclides of interest to determine amounts which might enter the river over prolonged periods. Also, river entry of radionuclides (distribution of concentrations as waste enters river) will be evaluated as a function of concentrations discharged to the crib.

Research will begin to determine particulate and soluble radionuclide removal from reactor coolant containing rupture debris by filtration through 100-N Area soil. Initial work will be directed toward determining the distribution of radionuclides of concern in solid and liquid phases. Solution rates associated with the solid phase, as a function of particle size and temperature, are also of interest.

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Plans and Expected Results: FY 1967

More detailed investigation will continue on the particulate-soluble research begun the previous year. Evaluations will be made of the effects of particle size on the infiltration and penetration rates of reactor coolant and associated rupture debris. Simulated coolant and particles will be used, based on results of particle-size determinations made with actual debris in coolant. Final evaluation (FY 1969) will involve hot cell tests with undiluted coolant containing actual irradiated fuel rupture debris.

FY-1968

The effects of chemical form and particle size on soil transport will be studied. Both laboratory and N-Reactor site experiments will be performed. The movement of biologically significant radionuclides, particularly I^{131} , Sr^{90} , Cs^{137} , Ru^{106} will be studied. The suitability of N-Reactor site soil for use for effluent treatment will be determined such that use of ground effluent disposal facilities can be evaluated.

The effect of additives to coolant water will be studied. Often, relatively low concentrations of non-radioactive constituents in waste waters can have a measurable effect on the efficiency with which soils remove radionuclides. In some instances the effects are beneficial and in others they are detrimental. Radionuclide ion-exchange and sorption behavior on soil as a function of reactor coolant non-radioactive chemical composition will be studied to delineate the magnitudes of the effects and to specify optimum coolant composition from the standpoint of soil removal of radioisotopes.

FY-1969

An integrated characterization of ground water flow patterns and soil retention and transport characteristics will be developed for the N-Reactor site. Test wells will be drilled and core samples will be removed for laboratory analysis and use. 130LN crib, well, and spring water samples will be taken and analyzed for radionuclide content as part of the program to determine actual radionuclide movement from discharge points. Measurements will be compared with predictions to establish a more firm design basis for effluent treatment facilities.

Hydrological analysis methods will be used at 100-N Area to determine optimum sites for emergency disposal of large volumes of cooling water. Basic information needed for this study consists of hydraulic potential and permeability measurements, and ion-exchange data. Final soil chemistry studies to complete a comprehensive model will include integration

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of previous data and demonstration of behavior with full level debris in a high level cell from fuel quench studies.

Questions often arise (e.g., from NAS Committee on Geological Aspects of Waste Disposal) relating to the migration of radionuclides beneath disposal sites after abandonment. To date, most of the evidence available is based on field measurements made over relatively short periods of time in comparison to necessary retention periods often associated with "permanent storage" concepts. The needed programs will be derived to permit determination of moisture and radionuclide distribution and movement beneath abandoned disposal sites as a function of drainage time for prolonged periods. Also evaluations will be made of the effects of rainfall on the upward and downward migration of radionuclides. Results will be applied to an actual disposal site.

FY-1970

The constructive use of reactor effluent will be demonstrated in a program to evaluate the use of reactor cooling water on field plots of growing plants and fruit trees. The program will have high public relations value by demonstrating the beneficial use of N-Reactor primary loop bleed water. Plants watered by the reactor effluent will be analyzed for radionuclide content to compare measured nuclide uptake and plant burden with predicted values. Early maturation of some row crops will be attempted by using the heat in reactor coolant to water and warm test plots.

Reports Issued

B. F. Hajek, "Absorption, Migration and Dispersion of Strontium and Cesium in an N-Area Soil", BNWL-CC-208, July, 1965.

Equipment Needed

FY-1967

X-ray diffraction and fluorescence instrument.	\$30,000
Test wells and on-site sampling systems.	20,000
	<u>\$50,000</u>

FY-1968

Laboratory equipment.	\$10,000
Test wells and sampling systems.	30,000
	<u>\$40,000</u>

FY-1969-1971

Laboratory equipment	\$30,000
Test wells and sampling systems.	20,000
	<u>\$50,000</u>

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PART III

NUCLEAR SAFETY, MISSION NO. 13 DUN SUMMARY

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Richland
Operations
Office

U.S. ATOMIC ENERGY COMMISSION

Research & Development Statistical Summary

02 Program

1. Mission No. & Title <u>Nuclear Safety Mission No. 13 DUN</u> Mission Sub-Program Title <u>Summary</u>		2. Budget Activity No. _____
3. Contractor & a. _____ Contract No. b. _____ c. _____		4. Person in Charge: _____ Investigator: _____ Investigator: _____

FIVE YEAR FORECAST (in Thousands of Dollars)

Current Budget Years

FY-1966 FY-1967 FY-1968 FY-1969 FY-1970 FY-1971

5. Manyears

a) Scientific & Technical

b) Other

Total

1	1	1			
--	--				
<u>1</u>	<u>1</u>	<u>1</u>			

6. Costs (\$000's)

a) Direct Labor(Incl.cost of Serv)

& b) Materials, Tech Serv, Sub Contracts

c) Sponsored with PNL

Total Direct

d) Indirect Expenses

Total Operating Costs

\$	\$	\$	\$	\$	\$
25	37				
0	40	70	90	100	110
<u>25</u>	<u>77</u>				
5	18				
<u>30</u>	<u>95</u>	<u>120</u>	<u>150</u>	<u>170</u>	<u>210</u>
--	43	27	19	15	16

e) Equipment*(New)

f) Irradiation Unit Costs

7. Comments:

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RL 2-13
Page 3

*Includes prorated portion of equipment
requirements for PNL

Prepared By: _____
Date: _____

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DUN Scope and Objectives

The objectives of the DUN-Nuclear Safety Program are: 1) To develop improved information for defining the Maximum Credible Accident for the DUN-operated reactors; 2) to develop analytical techniques to describe the sequence of events after an accident in evaluating the rate and amount of fission products released from the reactor fuel; and 3) to develop better methods for mitigating the consequences of an accident.

The program effort consists of:

Fuel Temperature Transients Under Accident Conditions

This area of work is designed to generate a description of the approach to uranium melting conditions as a function of location in the reactor and time after the loss of adequate coolant. It is parallel to a portion of the GE program except that it will generate data needed for the DUN-operated reactors. The analytical effort would use the DUN-operated reactor and fuel geometry to evaluate heat transfer and coolant flow conditions. The expected result would be the temperature rise characterization of the reactor fuel according to location in the reactor and nature of accident.

Fission Product Release from Ruptured or Molten Fuel

A characterization of the fractional quantities of biologically significant fission products which would be released from the aluminum-clad metallic reactor fuel as a function of temperature will be developed experimentally. The results of this effort when combined with results from other DUN and GE programs, which are developing information on factors influencing the quantity and rate of fission product release from the reactor and building, will permit more realistic evaluation of the release of radioisotopes to the environs as a result of an accident. A means of routinely monitoring the efficiency of the charcoal halogen collectors is needed to assure that they will effectively reduce the iodine released as a result of a reactor accident. Experimental evaluations of various means for in-place testing of the halogen collection efficiency will be made.

The expected results of the effort would be reduction of off-site dose estimates and less costly confinement system modifications for reducing the quantity of fission products released.

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Seismic Measurements

This program would characterize the Hanford site response to minor seismic activities in relation to measurements and observations at off-site locations and evaluate the response at reactor buildings and critical components to seismic excitation frequencies. The measurements are expected to provide a better basis for determining the required reactor and building modifications for given earthquake intensities. Also a seismic history will be generated for the Hanford area.

Progress During Report Period

Fuel Temperature Transients Under Accident Conditions - 13DUNa

The ALOC computer program was written to calculate the fuel temperature transient following accidental loss of coolant to a reactor. The program calculates the effect of a nuclear excursion on fuel temperature prior to shutdown and accounts for the change in heat transfer characteristics due to aluminum cladding melting. Each fuel cell is treated as an adiabatic unit. This program was used in preliminary estimates of the rate of fuel melting for the Improved Confinement Studies. (Ref.1)

Fission Product Release from Ruptured or Molten Fuel - 13DUNb

An experimental program was initiated to determine the release of fission products as a function of heating and maximum temperature for full-size, aluminum-clad, metallic-uranium fuel. The heating rates used simulate those predicted by the ALOC computer program. The maximum temperature was below the uranium melting point. These are the first tests of full-size, aluminum-clad fuel elements.

Full-size confinement system tests were conducted at a shutdown reactor using radioactive iodine and argon as tracers to evaluate plate-out factors, fog-spray effectiveness, and particulate filter tests methods. The condensation nuclei counter filter test method appeared most promising. In general the tests confirmed plate-out and filtering factors expected. The fog spray was very effective in removing iodine.

A confinement improvement study identified further heat transfer and fuel release characterization as areas for further R&D effort which could result in reducing the estimate of potential off-site consequences of a reactor accident. (Ref.1) This study also identified a release path for fission products through the effluent water to the river. This path requires further effort to develop means for diversion and storage of effluent contaminated as a result of a reactor accident

Seismic Measurements - 13DUNg

The program was scoped and equipment procurement of seismic instruments was initiated.

Plans and Expected Results

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FY-1967

Subroutines will be developed for the ALOC computer program to allow evaluation of the effect of heat flow to adjacent cooled channels for partial coolant loss accidents, such as coolant loss to a single header or to a set of risers supplying alternate crossheaders. The effort is expected to show that for present reactor conditions, no melting of metallic uranium would occur for partial coolant loss accidents.

The fission product release experiments initiated in FY-1966 will be completed and the results reported. Laboratory evaluation will be made of methods for routinely monitoring the efficiency of charcoal-halogen collectors while installed in the reactor confinement system. The use of elemental iodine, radioactive iodine (Iodine-128), and freon gas plus laboratory measurements on collector samples will be evaluated.

Preliminary measurements will be made to determine seismic coupling factors between basalt formations and major plant locations. These would be made with acceleration detectors capable of measuring low intensity movement at low frequencies in the range characteristic of seismic disturbances.

Establishment of a permanent seismic station will be initiated.

FY-1968

Further analysis using results from the GE program and thermal-hydraulics experiments conducted under other DUN R&D missions will be made to refine the predicted spatial temperature transients of the fuel in the DUN-operated reactors. The expected results would be further refinement of fuel temperature profiles versus time.

The charcoal-halogen collectors efficiency monitoring evaluations will be tested under simulated and actual field conditions including the monitoring effects of humidity and nitrous oxides. Tests will be conducted to develop methods of rehabilitating the collectors having reduced efficiency due to contaminants, such as nitrous oxide.

Determination of vibration response characteristics of reactor facility building and critical components will be initiated. Seismic history recording would be continued.

FY-1969-1971

The above computer programs will be adapted to revised reactor geometry and/or target loadings to predict temperature profiles versus times. These would be combined with results from other GE and DUN R&D sub-programs to give more realistic evaluations of the consequences of loss of coolant accidents in the DUN-operated reactors.

The tests expected during this period would include evaluation of the effects of charcoal additives on the flame point of the charcoal and the effects in increasing the efficiency in collecting organic iodides under humid or other adverse conditions. Further full-size confinement system tests would be conducted to confirm laboratory findings during FY-1967 and 1968.

The seismic coupling measurements would be completed. Vibration response characteristics of reactor facility components will be completed and development of mathematical correlations will be completed by the end of FY-1971. The seismic history recording would be continued through this period.

Reference Reports Issued

1. Compiled by N.F. Fifer and J.R. Spink, "Status Report for Confinement Studies - Douglas United Nuclear Operated Reactors", DUN-200. December 30, 1965.
2. R. J. Jaske, and R.E. Brown, "Research Program to Determine the Oscillator Response Characteristics of Critical Hanford Structures and Related Geological Factors", BNWL-CC-409.

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PART IV

NUCLEAR SAFETY MISSION NO. 13 ISO SUMMARY

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U.S. ATOMIC ENERGY COMMISSION

Research & Development Statistical Summary

02 Program

1. Mission No. & Title <u>Nuclear Safety Mission #13 ISO</u> Mission Sub-Program Title _____		2. Budget Activity No. <u>025010201</u>
3. Contractor & Contract No. a. _____ b. _____ c. _____		4. Person in Charge: <u>RE Tomlinson</u> Investigator: _____ Investigator: _____

FIVE YEAR FORECAST (in Thousands of Dollars)

	Current Budget Years					
	FY-1966	FY-1967	FY-1968	FY-1969	FY-1970	FY-1971
5. Manyears						
a) Scientific & Technical	0.0	0.0	0.0			
b) Other	0.0	0.0	0.0			
Total	0.0	0.0	0.0			
6. Costs (\$000's)	\$	\$	\$	\$	\$	\$
a) Direct Labor(Incl.cost of Serv.)						
& b) Materials, Tech Serv., Sub Contracts	26	47	94	90	90	90
c) Sponsored with PNL						
Total Direct						
d) Indirect Expenses -						
Total Operating Costs	28	50	100	100	100	100
e) Equipment*(New)		50	33	19	19	19
f) Irradiation Unit Costs						
7. Comments:						

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Prepared By: _____
Date: _____

*Includes prorated portion of equipment requirements for PNL

Nuclear Safety Mission No. 13 ISO Summary

Scope and Objectives

The purpose of the Nuclear Safety Program is to determine the technological parameters associated with the accidental release of radioactive materials to the environment. Better understanding of the release mechanisms, the controlling parameters, the fraction released, and nature of the released material should assist materially in arriving at more realistic hazards assessments and help establish preventive and recovery measures. Accidents involving plutonium and its compounds in which these materials are subjected to high temperatures are of particular concern in this facet of nuclear safety research.

Progress During Report Period

The fractional release of plutonium oxide from ignited metallic plutonium was measured under several different conditions of temperature of ignition and air flow rate. Plutonium entrained ranged from 3×10^{-6} to 5×10^{-5} weight per cent when air flow velocities from 3 to 50 cm/sec were used. The particle size distribution of the entire oxide produced was measured. Particles equivalent to less than 15 microns in diameter represented as much as 0.03 weight per cent of the total oxide. The physical nature of the oxide was characterized as a function of temperature. Reasonable agreement of particle size data with that reported by others was shown. Two reports have been issued.

Budget Period Plans and Expected Results FY-1967

The fraction and nature of plutonium airborne from several compounds of plutonium subjected to several heating regimes will be studied and reported. Subsequent to investigating the releases from relatively pure compounds of plutonium experiments will be carried out to determine the nature and fraction of plutonium made airborne when plutonium and its compounds are present in combustibles which may overheat, take fire and burn. The experiments will endeavor to establish the important parameters governing the fate of plutonium in typical fire situations. The deposition characteristics of the airborne products will be investigated, and initial experiments on the effect of fire extinguishment on the release will be performed. The information developed will be applied to improved accident assessment.

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FY-1968

Several "typical" situations will be studied to determine the consequences of plutonium fires in terms of plutonium deposition. The paper studies should better define the areas of uncertainty and facilitate the design of near full-scale experiments to demonstrate the transport of material from a fire involving plutonium. A tracer technique will be developed which will use a stand-in for plutonium, such as cerium. Selection of a suitable substitute for plutonium would permit experiments to be conducted with greater output and safety. The experiments visualized will involve a room within which fires of various descriptions may be initiated and extinguished. As a result the consequences of various incidents can be evaluated in terms of fraction of plutonium transported under various circumstances as guides to hazards assessment and control.

FY-1969-1970

Further experiments realistically scaled to simulate actual fire situations will be conducted to develop better understanding of the consequences of involving plutonium in fires. Other radionuclides may also be tested under the same conditions as was plutonium in order to obtain an adequate comparison that would allow the plutonium data to be extrapolated to other radionuclides. The data developed will provide the input to better justified hazards analysis and assist in determining courses of action in recovery operations.

Reference Reports

1. J. Mishima. "A Review of Research on Plutonium Releases During Overheating and Fires", HW-83668, August, 1964
2. J. Mishima. "Plutonium Release Studies. I. Release from the Ignited Metal", BNWL-205, December, 1965.

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<u>Equipment Requirements</u>	
<u>FY-1967</u>	
Remote microscopy and photo microscopy	\$ 3,000
Particle sizing collectors (impaction devices)	3,000
Direct - counting for surface contamination and other samples	3,500
Temperature sensing and recorders	1,600
Other Equipment	1,200
	<u>\$12,300</u>
<u>FY-1968</u>	
Particle size analysis equipment	\$ 2,600
Other Equipment	5,400
	<u>\$ 8,000</u>
Other equipment	6,000

NY-1966

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