JUN 13 1968

GEAP-5605
APRIL, 1968

EURAEC
JOINT U.S. - EURATOM RESEARCH
AND DEVELOPMENT REPORT

2033

**POWER REACTOR
HIGH PERFORMANCE UO_2 PROGRAM
PROGRESS REPORT NUMBER 6
JANUARY 1 - MARCH 31, 1968**

COMPILED BY
S. Y. OGAWA

U.S. ATOMIC ENERGY COMMISSION
CONTRACT AT (04-3) - 189
PROJECT AGREEMENT 50

NUCLEAR FUELS DEPARTMENT
GENERAL ELECTRIC
SAN JOSE, CALIFORNIA

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

To expedite dissemination of technical information to those persons requiring it, this report has been issued without the administrative review necessary to protect the interest of the U.S. Government, the European Atomic Energy Community (Euratom) and the contractor. The recipient of this report agrees that it is passed on to him in confidence, that he will maintain that confidence and make no disclosures or publication of the contents, that would be detrimental to the interests of the U.S. Government, the European Atomic Energy Community (Euratom) and the contractor.

EURAECE
GEAP-5605
AEC Research and
Development Report
April 1968

POWER REACTOR HIGH PERFORMANCE
UO₂ PROGRAM

Progress Report Number 6
January 1 - March 31, 1968

Compiled By
S. Y. Ogawa
Project Engineer

337,9300

Approved: H. H. Klepfer
H. H. Klepfer, Manager
Fuel and Materials Development

*Printed in U.S.A. Available from the
Clearing House for Federal Scientific and Technical Information
National Bureau of Standards, U.S. Department of Commerce
Springfield, Virginia
Price: \$3.00 per copy*

U.S. Atomic Energy Commission
Contract AT(04-3)-189
Project Agreement 50

5585-NFD-15
150-wdh-4/68

NUCLEAR FUELS DEPARTMENT
GENERAL ELECTRIC
SAN JOSE, CALIFORNIA

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

leg

LEGAL NOTICE

THIS DOCUMENT WAS PREPARED UNDER THE SPONSORSHIP OF THE ATOMIC ENERGY COMMISSION PURSUANT TO THE JOINT RESEARCH AND DEVELOPMENT PROGRAM ESTABLISHED BY THE AGREEMENT FOR COOPERATION SIGNED NOVEMBER 8, 1958, BETWEEN THE GOVERNMENT OF THE UNITED STATES OF AMERICA AND THE EUROPEAN ATOMIC ENERGY COMMUNITY (EURATOM). NEITHER THE UNITED STATES, THE U.S. ATOMIC ENERGY COMMISSION, THE EUROPEAN ATOMIC ENERGY COMMUNITY, THE EURATOM COMMISSION, NOR ANY PERSON ACTING ON BEHALF OF EITHER COMMISSION:

- A. MAKES ANY WARRANTY OR REPRESENTATION, EXPRESS OR IMPLIED, WITH RESPECT TO THE ACCURACY, COMPLETENESS, OR USEFULNESS OF THE INFORMATION CONTAINED IN THIS DOCUMENT, OR THAT THE USE OF ANY INFORMATION, APPARATUS, METHOD, OR PROCESS DISCLOSED IN THIS DOCUMENT MAY NOT INFRINGE PRIVATELY OWNED RIGHTS; OR
- B. ASSUMES ANY LIABILITIES WITH RESPECT TO THE USE OF, OR FOR DAMAGES RESULTING FROM THE USE OF ANY INFORMATION, APPARATUS, METHOD OR PROCESS DISCLOSED IN THIS DOCUMENT.

AS USED IN THE ABOVE, "PERSON ACTING ON BEHALF OF EITHER COMMISSION" INCLUDES ANY EMPLOYEE OR CONTRACTOR OF EITHER COMMISSION OR EMPLOYEE OF SUCH CONTRACTOR TO THE EXTENT THAT SUCH EMPLOYEE OR CONTRACTOR OR EMPLOYEE OF SUCH CONTRACTOR PREPARES, HANDLES, DISSEMINATES, OR PROVIDES ACCESS TO, ANY INFORMATION PURSUANT TO HIS EMPLOYMENT OR CONTRACT WITH EITHER COMMISSION OR HIS EMPLOYMENT WITH SUCH CONTRACTOR.

TABLE OF CONTENTS

	<u>Page</u>
FORWARD	iv
ABSTRACT	1
SECTION I INTRODUCTION	1
SECTION II SUMMARY OF THE CENTERMELT FUEL DESIGN	2
2.1 Statement of Work	2
2.2 Description of the Fuel	2
2.3 Planned Operation of the Fuel	5
SECTION III BUNDLE ASSEMBLY AT THE SITE	5
SECTION IV IRRADIATION STARTUP	7
SECTION V FUEL DESIGN AND FABRICATION	9
5.1 Segmented Fuel Design	9
5.2 Centermelt Fuel Fabrication Report	9
ACKNOWLEDGMENT	10
DISTRIBUTION	10

LEGAL NOTICE

This document was prepared under the sponsorship of the United States Atomic Energy Commission pursuant to the Joint Research and Development Program established by the Agreement for Cooperation signed November 8, 1958 between the Government of the United States of America and the European Atomic Energy Community (Euratom). Neither the United States, the U. S. Atomic Energy Commission, the European Atomic Energy Community, the Euratom Commission, nor any person acting on behalf of either Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this document, or that the use of any information, apparatus, method, or process disclosed in this document may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method or process disclosed in this document.

As used in the above, "person acting on behalf of either Commission" includes any employee or contractor of either Commission or employee of such contractor to the extent that such employee or contractor or employee of such contractor prepares, handles, disseminates, or provides access to, any information pursuant to his employment or contract with either Commission or his employment with such contractor.

FOREWORD

The United States and the European Atomic Energy Community (EURATOM) on May 29, and June 18, 1958, signed an agreement which provides a basis for cooperation in programs for the advancement of the peaceful applications of atomic energy. This agreement, in part, provides for the establishment of a joint U.S.-EURATOM research and development program which is aimed at reactors to be constructed in Europe under the Joint Program.

The work described in this report represents the Joint U.S.-EURATOM effort which is in keeping with the spirit of cooperation in contributing to the common good by the sharing of scientific and technical information and minimizing the duplication of effort by the limited pool of technical talent available in Western Europe and the United States.

ABSTRACT

The irradiation of the six centermelt fuel assemblies was started on March 15, in the Consumer Power Company's Big Rock Point Reactor. The first 12 days of operation was at a relatively low power (53% of plant rated). On March 28, the reactor power level was raised to about 73% of plant rating. At this level, the advanced performance (0.700-inch-diameter rods) compacted powder fuel is operating with central melting to about 8% of the cross-sectional area. The reactor power level that must be attained for this cycle in order for central melting to occur in all the centermelt bundles has been calculated to be 87% of the reactor rated power. One of the two recirculation pumps malfunctioned on startup, and therefore, the reactor is being operated with one pump. Further increases in reactor power beyond the present 175 MWt will not be made until the inoperative pump is repaired. Repair parts are expected to arrive during the first week in April.

SECTION I

INTRODUCTION

A research and development program was initiated on September 1, 1966, under Project Agreement 50 of Contract AT(04-3)-189 to irradiate a significant number of Zircaloy-2-clad UO_2 fuel rods to varying degrees of central melting in an operating power reactor. This is a cooperative program involving the AEC, Euratom, Consumers Power Company, and the General Electric Company. The program can be thought of as an extension of an earlier AEC-Euratom high-performance UO_2 program (Contract AT(04-3)-189, Project Agreement 17), which demonstrated that there is no intrinsic life-limiting mechanism that will prevent the attainment of high burnup in fuel rods operating with central melting. The AEC-Euratom portion of the program covers the detailed fuel design, including safeguards analysis and reactor license changes necessary to their irradiation, indirect fabrication supervision, irradiation following, and post-irradiation examination and reporting.

Six assemblies are planned for irradiation in the Consumers Big Rock Point reactor to an average exposure of 15,000 MWd/T. Two of the assemblies have been designated Intermediate Performance Fuel, and will operate with incipient melting in the central region of the UO_2 at rated power conditions. These assemblies might be considered the next step toward the elimination of the central melt criterion used as a limit in current fuel design practice. The remaining four assemblies have been designated Advanced Performance Fuel, and will operate with definite but moderate central melting at

rated power conditions. These advanced performance assemblies represent a further step in reactor technology wherein the hottest fuel rods in the core are operating with moderate amounts of the UO_2 in the molten state at rated power conditions.

This is the sixth progress report and covers a 3-months' period from January 1 through March 31, 1968. In this issue are included a description of the bundle assembly operation at the reactor site, and reactor startup activities.

Prior reports issued to the Commission under this contract have included the following:

1. GEAP-5402, December 1966: Progress Report Number 1, July 1 through October 31, 1966, Arlt, W. H., et al.
2. GEAP-5431, February 1967: Progress Report Number 2, November 1 through December 31, 1966, E. A. Lees
3. GEAP-5487, April 1967: Progress Report Number 3, January 1, 1967 through March 31, 1967, E. A. Lees
4. GEAP-5521, July 1967: Progress Report Number 4, April 1 through June 30, 1967, E. A. Lees
5. GEAP-5585, January 1968: Progress Report Number 5, July 1 - December 31, 1967, compiled by S. Y. Ogawa*
6. GEAP-5591, January 1968: Fuel Design Summary and Program Status, S. Y. Ogawa, E. A. Lees, M. F. Lyons*

* Awaiting EURATOM approval.

SECTION II

SUMMARY OF THE CENTERMELT FUEL DESIGN

2.1 STATEMENT OF WORK

The Power Reactor High Performance UO₂ Program encompasses activities in the design, the fabrication, the irradiation, and the evaluation of the performance of fuel rods operated in a power-producing BWR at high specific power levels to achieve various degrees of melting in the central regions of the UO₂ fuel. The objectives of the program are to demonstrate the feasibility of applying this mode of fuel operation sustained over a large percentage of the fuel lifetime to several full-size BWR fuel assemblies, to determine the condition of the fuel, and to evaluate its performance by obtaining specific data from post-irradiation examinations, both non-destructive and destructive, of selected rods at interim exposures and at end-of-life.

2.2 DESCRIPTION OF THE FUEL

Six fuel assemblies have been designed and fabricated for irradiation in the Consumers Big Rock Point reactor. A summary of the main characteristics of these assemblies is shown in Table 1. Detailed design of the fuel was described in the previous four progress reports listed as part of the introduction to this report. The two levels of central melting in the UO₂ for which the fuel rods were designed separate the assemblies into two groups as follows:

1. Intermediate Performance Fuel

The two Intermediate Performance Fuel assemblies are designed for operation with incipient central melting of the UO₂ at rated power. Each assembly has 64 rods in an 8x8 array; of these, 36 rods are power producing; the other 28 rods, containing vibratorily compacted depleted UO₂, are essentially

non-power producing and are used for achieving specific thermal-hydraulic conditions in the assembly design. The power-producing rods in one assembly contain cold pressed and sintered pellets, and those in the other assembly, vibratorily compacted powder. The power rods in each assembly are designed to run at nearly the same relative power levels. Three U-235 enrichments (4.3, 5.0, and 5.6 percent) are used to achieve their power flattening. The distribution of the rods within an assembly is shown in Figure 1a, according to the fuel enrichment and beginning of life relative power.

The rods in these two assemblies are all clad with 0.570-inch-o.d. x 0.035-inch-wall Zircaloy-2 tubing. A depleted UO₂ sintered insulator pellet is placed at each end of the active fuel column to minimize temperature effects at the lower end plug region and on the spring used in the gas plenum at the upper end of the rod.

The accommodation of the phase change volume expansion of the UO₂ upon melting is by a dish in one end of each pellet, providing a void volume of 5 percent. The powder fuel, compacted to a bulk density of 85 percent of theoretical, will have a 15 percent distributed void volume, which is adequate to accommodate the volume expansion which will occur upon melting in these rods.

2. Advanced Performance Fuel

The Advanced Performance Fuel is designed for operation with definite, but moderate, central melting of the UO₂ at rated power. There are four assemblies in this group. Each assembly has 49 rods in a 7 x 7 array; of these, 29 rods are power producing; the other 20 rods, containing vibratorily compacted depleted UO₂, are essentially non-power producing, and are also

TABLE 1
SUMMARY OF
CENTERMELT FUEL DESIGN DETAILS AND OPERATING CONDITIONS

Fuel Assembly	Type	UO ₂ Fuel		Number of Rods	Cladding Zircaloy-2, Tube Reduction Process)		Condition
		% TD	% U-235		Outside Diameter (inch)	Wall Thickness (inch)	
Group A							
D-50	Pellet	95	4.3	12	0.570	0.035	Cold Worked and Stress Relieved
(8×8 Lattice)	Pellet	95	5.0	16			
	Pellet	95	5.6	8			
	Powder	85	0.22	28			
D-51	Powder	85	4.3	12	0.570	0.035	Cold Worked and Stress Relieved
(8×8 Lattice)	Powder	85	5.0	16			
	Powder	85	5.6	8			
	Powder	85	0.22	28			
Group B							
D-52	Pellet	95	4.3	12	0.700	0.040	Cold Worked and Stress Relieved
and	Pellet*	95	5.0	12			
D-53	Pellet	95	5.6	5			
(7×7 Lattice)	Powder	85	0.22	20			
D-54	Powder	85	4.3	12	0.700	0.040	Cold Worked and Stress Relieved
and	Powder*	85	5.0	12			
D-55	Powder	85	5.0	5			
(7×7 Lattice)	Powder	85	0.22	20			

<u>UO₂ Fuel</u>		<u>Design Burnup (MWd/TU)</u>	<u>Design Heat Flux (Btu/h-ft²)</u>		<u>Fuel Rod Power (kW/ft)</u>	
			<u>Normal</u>	<u>Overpower</u>	<u>Normal</u>	<u>Overpower</u>
<u>Group A 8×8</u>						
Cold Press and Sinter	Standard Dished	20,000	450,000 ±50,000	550,000	19.65 ±2.18	24.0
Dynapak	Vibratory Compaction	20,000	450,000 ±50,000	550,000	19.65 ±2.18	24.0
<u>Group B 7×7</u>						
Cold Press and Sinter	Standard, 0.100-inch Central Hole	20,000	450,000 ±50,000	550,000	24.15 ±2.68	29.6
Dynapak	Vibratory Compaction	20,000	450,000 ±50,000	550,000	24.15 ±2.68	29.6

* Four rods of this enrichment in each bundle will be replaced with rods containing tungsten wafers, after the first cycle of operation.

GEAP-5605

D 0.13	A 1.65	B 1.75	B 1.73	B 1.73	B 1.74	A 1.63	D 0.13
A 1.65	A 1.53	D 0.10	D 0.10	D 0.10	D 0.10	A 1.49	A 1.63
B 1.75	D 0.10	D 0.10	C 1.79	D 0.10	C 1.81	D 0.10	B 1.74
B 1.73	D 0.10	C 1.79	D 0.09	C 1.72	D 0.10	D 0.10	B 1.73
B 1.73	D 0.10	D 0.10	C 1.72	D 0.09	C 1.79	D 0.10	B 1.73
B 1.74	D 0.10	C 1.81	D 0.10	C 1.79	D 0.10	D 0.10	B 1.75
A 1.63	A 1.49	D 0.10	D 0.10	D 0.10	D 0.10	A 1.53	A 1.65
D 0.13	A 1.63	B 1.74	B 1.73	B 1.73	B 1.75	A 1.65	D 0.13

a. RELATIVE POWERS OF FUEL RODS IN 8x8 ASSEMBLY AT BEGINNING OF LIFE

D 0.13	A 1.60	B 1.68	B 1.67	B 1.68	A 1.60	D 0.13
A 1.60	A 1.42	D 0.10	D 0.10	D 0.10	A 1.42	A 1.60
B 1.68	D 0.10	C 1.71	D 0.09	C 1.71	D 0.10	B 1.68
B 1.67	D 0.10	D 0.09	C 1.65	D 0.09	D 0.10	B 1.67
B 1.68	D 0.10	C 1.71	D 0.09	C 1.71	D 0.10	B 1.68
A 1.60	A 1.42	D 0.10	D 0.10	D 0.10	A 1.42	A 1.60
D 0.13	A 1.60	B 1.68	B 1.67	B 1.68	A 1.60	D 0.13

UO₂ ENRICHMENTS

A 4.3% U-235
B 5.0% U-235
C 5.6% U-235
D 0.22% U-235

b. RELATIVE POWERS OF FUEL RODS IN 7x7 ASSEMBLY AT BEGINNING OF LIFE.

63-01373

FIGURE 1. DISTRIBUTION OF FUEL RODS IN ASSEMBLY ACCORDING TO POWER LEVELS AND UO₂ ENRICHMENTS

used for achieving specific thermal-hydraulic conditions in the assembly design.

Sintered pellet and compacted powder UO_2 fuels are used. The power-producing rods in two assemblies will have pellet fuel, and those in the other two assemblies will have compacted powder fuel. The U-235 enrichments used in these fuels are the same as those used in the Intermediate Performance Fuel. The distribution of the rods within the assembly is shown in Figure 1b.

The rods in the four assemblies are all clad with 0.700-inch o.d. $\times$ 0.040-inch-wall Zircaloy-2 tubing. A depleted UO_2 sintered insulator pellet is placed at each end of the active fuel column. The enriched pellets in the rods have a 0.100-inch-diameter hole at the center to provide a void volume for the phase change volume expansion of the UO_2 on melting. The 15 percent distributed void volume in the compacted powder fuel is adequate to accommodate the volume expansion on melting in this fuel.

A third fuel-rod design utilizes tungsten wafers placed at approximately 18-inch intervals in the fuel column for the purpose of minimizing axial movement of the molten UO_2 during rod operation. A total of eight rods of this design is planned to be fabricated and inserted into the Advanced Performance Fuel assemblies as replacement rods during an interim examination of the bundles conducted after the first cycle of operation. This feature is planned to be incorporated in both pellet-type and compacted-powder-type fuels.

2.3 PLANNED OPERATION OF THE FUEL

The fuel rods are designed so that central melting in the UO_2 occurs at a surface heat flux of $450,000 \pm 50,000 \text{ Btu/h-ft}^2$. The amount of melting that occurs depends upon the type of fuel. The calculated fractions of the fuel that will be molten over the design surface heat flux range are shown in Figure 2.

SECTION III

BUNDLE ASSEMBLY AT THE SITE

The plans for the shipment of the fuel to the reactor site were changed in late December, 1967, when it was learned that the reactor shutdown for refueling was delayed to late January - early February, 1968. Up to that time, the fully assembled bundles were in shipping containers awaiting AEC-ACRS approval to proceed with the irradiation. When the additional time became available, it was decided to ship the fuel in the disassembled form, i.e., fuel rods packed separately from the bundle cage. This change was adopted because of the possibility of damage to the rod spacers during transport of the fully assembled bundles to the reactor site, particularly with the heavy, 0.700-inch-diameter rods. Associated with this change

in the mode of shipment was the requirement for fuel bundle assembly at the reactor site.

To carry out this plan, the following steps were taken. Approval to assemble the bundles at the site was obtained from Consumers Power Company, and procedures for the operation were written and discussed with them. Two special AEC licenses were obtained on January 22, and on February 5, to permit the shipment of the disassembled bundles and to assemble them at the site.

The fuel rods were protected individually with plastic sleeves, and then put into steel pipes. The loaded pipes were then packed into the shipping container with the empty bundle

FIGURE 2. UO_2 MELT FRACTION VERSUS HEAT FLUX

cage in the next compartment. The fuel was shipped on February 21, 1968.

The bundle assembly operation was started on February 27, and completed on March 1. Based upon a further evaluation of the role of the dimples in the corner angle pieces of the bundle cage, it was decided to form additional ones at the site, as part of the assembly operation. A portable, manually operated device was taken to the site for this work. Three dimples were formed between spacers on each leg of the angle piece.

This distribution of the dimples is illustrated in Figure 3. The dimples were formed to give maximum assurance there would be no line contact between fuel rods and the corner angle, if rod bowing or bending of the sheet-metal angle piece occurred during bundle operation.

Extreme caution was taken to assure that the correct rods were placed into their proper locations in the bundle array. During the rod sorting and insertion into the cage, there were four separate checks on the rod serial number and enrichment designation stamped on the top end plug. A final verification of the fully loaded

bundle was made by photographing the tops of the bundle and by matching the Polaroid prints against a master chart.

Because of the excellent cooperation and help from the Big Rock Point reactor personnel, the entire assembly operation proceeded extremely smoothly, in spite of the busy outage schedule.

FIGURE 3. DISTRIBUTION OF ADDITIONAL DIMPLES FORMED IN THE CORNER ANGLES OF THE BUNDLE STRUCTURE

SECTION IV

IRRADIATION STARTUP

The core reloading was started on March 2; the six centermelt fuel assemblies were positioned in the core as shown in Figure 4. This dispersed array complies with the technical specifications of the amendment to the reactor operating license which requires that the centermelt bundle spacing be no closer than two bundles in the x-direction and one in the y-direction, and also that they are not placed in the outer row at the periphery of the core.

The operating power levels of the centermelt bundles in these positions are calculated to be well within the design range. The actual power levels that are attained will have to be calculated after the reactor is brought up to a scheduled power level with full coolant flow and run for a period of time.

The startup of the reactor occurred on March 15. A nuclear physicist from General

FIGURE 4. THE CORE POSITIONS OCCUPIED BY THE CENTERMELT EXPERIMENTAL FUEL ASSEMBLIES AT THE BEGINNING OF IRRADIATIONS

Electric was present during the startup operation. The power level was raised to 30 MWe and held at this level for about 2 days. The power was then raised to 40 MWe, which is 53.4 percent of the maximum plant rating. On March 28, the reactor power was raised to 175 MWe (73% of plant rating) and held at this level through the end of the month.

The reactor is operating with only one of the two recirculation pumps, because the other pump malfunctioned during the startup. Further increases in reactor power can not be made until the inoperative pump is repaired using parts that are expected to arrive in early April. For this short cycle, the plan is to bring the reactor power up to about 87% of rated power with two pumps operating and hold at this level for the duration of the cycle. The fuel rod surface heat fluxes in the centermelt assemblies will be within the design range (nominally 475,000 Btu/h-ft²) at this power level.

At the present 175 MWe reactor power level, the approximate surfaces heat fluxes of the assemblies are as follow

Intermediate Performance Fuel (8 × 8)

Q/A (Btu/h-ft²)

Bundles D-50 and D-51: ~377,000

Advanced Performance Fuel (7 × 7)

Bundles D-52 and D-53: ~384,000

Bundles D-54 and D-55: ~401,000

With reference to Figure 2, it can be seen that the Advanced Performance compacted powder fuel, i.e., bundles D-54 and D-55, is operating with central melting. About 8 percent of the cross-sectional area is estimated to be in the molten state.

SECTION V

FUEL DESIGN AND FABRICATION

5.1 Segmented Fuel Design

The original fuel design effort included a design for segmented fuel rods containing tungsten discs placed at intervals in the fuel column, for the purpose of localizing the axial redistribution of molten UO₂. Final calculations for heat flow and temperature distributions remain to be completed before fabrication can be started. Recent information from irradiation tests conducted at Chalk River have revealed problems resulting from the use of

discs in a similar design. Consequently, the plan for the segmented rods in this program must be re-evaluated in light of this new information, and if the outcome shows a high probability of adverse performance, the plans for fabricating and irradiating segmented rods will be dropped.

5.2 Centermelt Fuel Fabrication Report

A topical report covering the details of the fuel fabrication is being prepared.

ACKNOWLEDGMENT

The following individuals have contributed to the Program this reporting period.

R. T. Bellan
M. F. Lyons
J. T. Worthington
M. D. Hassebrock

We should also like to thank Messrs W. Beckius, D. Bixel, C. Hartman, and R. DeWitt of Consumer Power Company. Big Rock Point Reactor for their help and cooperation in connection with the assembly of the six fuel bundles at the reactor site.

DISTRIBUTION

	<u>Copies</u>		<u>Copies</u>
U.S. Atomic Energy Commission San Francisco Operations Office 2111 Bancroft Way Berkeley 4, California	24	Babcock and Wilcox Company Atomic Energy Division P.O. Box 1260 Lynchburg, Virginia	1
U.S. Atomic Energy Commission Division of Reactor Development Washington 25, D.C. Attn: Office of Foreign Activities	1	USAEC Liaison Office Scientific Representative Chalk River, Ontario	1
U.S. Atomic Energy Commission Division of Reactor Development Washington 25, D.C. Attn: Fuels and Materials Development Branch - Nuclear Technology	2	Oak Ridge National Laboratory P.O. Box X Oak Ridge, Tennessee Attn: D B Tranger	1
U.S. Atomic Energy Commission Division of Reactor Development Washington 25, D.C. Attn: Water Reactors Branch Civilian Reactors	1	Combustion Engineering, Inc. Nuclear Division Prospect Hill Road Windsor, Connecticut Attn: W. P. Chernock	1
U.S. Atomic Energy Commission Chicago Operations Office 9700 South Cass Avenue Argonne, Illinois Attn: Director, Reactor Engineering Division	1	Westinghouse Electric Corporation Bettis Atomic Power Laboratory P.O. Box 79 West Mifflin, Pennsylvania 15122 Attn: Dr. R.J. Creagan	2
Argonne National Laboratory 9700 South Cass Avenue Argonne, Illinois Attn: Robert Macherey	1	Fiat Joint U.S.-Euratom Program "Swaging of Uranium Dioxide; and "Uranium Dioxide Fuel Development" Corso g-Marconi, 10/20 Torino, Italy	1

DISTRIBUTION (Continued)

	<u>Copies</u>		<u>Copies</u>
Commissariat a l'Energie Atomique Joint U.S.-Euratom Program "Sintered Uranium Oxide" Direction des Relations Exterieurs et des Programmes Boite Postale 307 Paris 7, France	1	U.S. Atomic Energy Commission Naval Reactors Branch Division of Reactor Development Washington, D.C. 20545 Attn: R. Steele	1
Battelle Memorial Institute 505 King Avenue Columbus 1, Ohio Attn: S. Paprocki	1	U.S. Atomic Energy Commission New York Operations Office 376 Hudson Street New York 14, New York Attn: J. Dissler	1
Atoms International P.O. Box 309 Canoga Park, California Attn: C. Weber	1	Westinghouse Electric Corporation Bettis Atomic Power Laboratory P.O. Box 79 West Mifflin, Pennsylvania 15122 Attn: Mrs. V. Sternberg	2
E.I. DuPont de Nemours and Co. Atomic Energy Division 2430 Nemours Bldg. Wilmington, Delaware Attn: E.E. Hayes	1	U.S. Atomic Energy Commission DTIE P.O. Box 62 Oak Ridge, Tennessee	3
United Nuclear Corporation Development Division Grasslands Road Elmsford, New York 10523 Attn: S. Strasser	1	Battelle Memorial Institute Pacific Northwest Laboratory Richland, Washington Attn: E. A. Evans	1