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.

General Electric Co.
Nucleonics Department
Hanford Works

DECLASSIFIED

✓ HW-13292

RECORD CENT COPY

- #1 - 12 J. H. Manley
- #13 G. R. Prout
- #14 H. A. Winne
- #15 C. G. Suits
- #16 Zay Jeffries
- #17 R. C. Muir
- #18 A. B. Greninger
- #19 O. H. Greager
- #20 C. H. Gross
- #21 W. K. Woods - P. F. Cast
- #22 R. H. Beaton
- #23 - 32 Extra
- #33 Pink Copy
- #34 Yellow Copy
- #35 700 File

This Document is
2 Pages No. 2
3-2 Graph. Series

May 10, 1949

TECHNICAL REPORT TO THE GENERAL ADVISORY COMMITTEE

CONTENTS

- I. Redox
- II. Higher Product Concentrations
- III. Graphite Expansion
- IV. Higher Power Levels
- V. Lattice Redesign
- VI. List of other Technical Activities

Classification Cancelled And Changed To

DECLASSIFIED

By Authority of CG-PR-2

CA Bauman 11-11-91

JE Savely 11-12-91

Verified by TL BURSTIE, 11-14-91

RECEIVED

MAY 28 1956

300 AREA
CLASSIFIED FILES

CAUTION
This document contains information which is the property of the United States Government and is loaned to you for your information only. It is not to be distributed outside your organization without the express written permission of the originating agency. Its use is limited to the purpose for which it was furnished and it is not to be used in any manner which would be prejudicial to the national defense or in any manner which would be in violation of applicable Federal laws.

MASTER

DECLASSIFIED

DISTRIBUTION RESTRICTED TO U.S. ONLY

I. REDOX**DECLASSIFIED**General

Since early 1947, the Redox program has been Hanford's major development project. Currently, over one-third of the scientific and engineering personnel in Hanford's Technical Divisions are working on Redox process development, chemistry research, and analytical research and service. Supporting research and development programs are active at Oak Ridge Laboratory, Argonne Laboratory, and Schenectady. Redox plant design is being directed by Hanford's Design Division, with Kellogg Corporation serving as architect-engineer, and with all important design features being approved by Hanford's Manufacturing and Technical Divisions.

In general, the outlook for a successful and efficient Redox plant, beginning operations by mid-1951, is very good indeed. Several major improvements to the original Redox flow sheet have been, during the past year, tested through hot semi-works and pilot-plant operation at Argonne and Oak Ridge, and process studies at all sites show that further refinements are feasible. Furthermore, a high degree of operating stability in properly controlled extraction columns has been demonstrated by Oak Ridge's pilot-plant experience and by Hanford's full plant scale "cold"-column studies. At present, major design effort is being directed toward a rescoping task, to incorporate in the Redox plant design (a) process and engineering advances, and (b) certain broadening of the Redox plant objectives, particularly the treatment of metal wastes from the BiPO_4 process in addition to treatment of current pile-discharge metal.

Process and Engineering Advances

The following is a list of recent important Redox process and engineering advances:

1. The Oak Ridge flow sheet, basic with respect to HNO_3 , shows in pilot plant runs at 30% full H.W. activity levels, reproducible 2-cycle gamma decontamination factors for uranium of 2 to 5×10^5 , with uranium and plutonium losses each less than 0.5%. Likewise, uranium decontamination from Pu exceeds the 10^6 requirement. Three cycle beta and gamma decontamination factors for plutonium are reproducible at 10^7 .
2. Studies at Schenectady, Argonne and Oak Ridge have developed a possible method for the recovery and re-use of aluminum nitrate salting agent.
3. Data from Hanford, Schenectady and Oak Ridge suggest simple processes for removing specifically certain troublesome fission products such as Ru and Zr.
4. Recent process and engineering performance at Oak Ridge, Argonne and Hanford has demonstrated the feasibility of continuous operation of the extraction column battery, as well as the possibility of considerably simplifying rework procedures for off-standard streams.

DECLASSIFIED

DECLASSIFIEDProgram

During the period October, 1948 to March, 1949, General Electric Company undertook an extensive re-examination of the Redox process objectives and status and a careful study of other possible alternative uranium recovery processes. Eleven different process schemes or combinations involving (a) Redox (b) bismuth phosphate and (c) uranyl-ammonium phosphate, were examined with regard to process, scheduling, capital cost and operating cost, and the conclusion was reached that continuation of Redox development, design and construction offered the best and most economical means of achieving uranium recovery at the earliest possible date. Accordingly, detailed recommendations were made to the Atomic Energy Commission on March 22, 1949 concerning the overall separations processes program. These recommendations, in general, are in substantial agreement with the report "Survey of the Plutonium Project", prepared by the Atomic Projects Survey Committee of the du Pont Company.

A major item in General Electric's recommendations calls for the design of a dual-purpose Redox plant for both current metal waste recovery and recovery of metal from bismuth phosphate wastes. Thus, in addition to continued process improvement studies on the solvent extraction process, it will be necessary to develop chemical coupling steps for preparing a solvent extraction feed from the BiPO_4 unneutralized waste and from buried waste. Because of inadequate laboratory and development facilities, Hanford must count on continued research and development assistance in this program from the national laboratories and from Schenectady.

II. HIGHER PRODUCT CONCENTRATIONSPhysics

At present the ratio of Pu^{240} to Pu^{239} is limited by Los Alamos specification to that resulting from an average product concentration of 360 grams Pu per ton of uranium metal, or from 400 MWD/ton operation. The effect of any future recycling of depleted metal will have negligible effect on the $\text{Pu}^{240}/\text{Pu}^{239}$ ratio for a given exposure. Diversion of plutonium as a fuel for power piles would remove the above restriction and permit higher product concentrations subject to the economic factors involved in plutonium burn-out. An increase in product concentration results in an important increase in pile reactivity. Basic information is listed below:

	Operating levels, MWD/Ton		
	200	400	600
Grams Pu/MWD	.93	.90	.87
Grams Pu^{240} /ton	2	9	19
Grams $\text{Pu}^{239+240}$ /grams U^{235}	.824	.820	.816
Inhour gain per pile	0	100	~ 200
Metal Consumption tons per year			
B, D, & F at 350 MW)			
H at 400 MW) ----	~ 2000	~ 1000	~ 650
Operating Eff. 75%)			

DECLASSIFIEDMetallurgy

Uranium metal extruded in the gamma phase exhibits large grains that are randomly oriented and shows a marked surface distortion after pile irradiation. Uranium rolled in the alpha phase has a much smaller grain size and is completely free of local surface distortion after irradiation; however, slugs made from this metal, after irradiation, show troublesome amounts of diameter and length changes and warp. Dilatometric and x-ray diffraction studies show this metal to have a high degree of preferred orientation and this preferredness is reflected in an overall dimensional change during pile exposure. These observations on the behavior of uranium metal during pile exposure correlated with laboratory structure studies have firmed the original hypothesis that the distortion is a direct result of the anisotropic nature of the metal and that the ultimate solution lies in obtaining fine grains which are randomly oriented. Metal currently being charged into the piles is a compromise of these two conditions. Alpha-rolled metal is heated into the beta phase during canning; this effects a degree of randomness to the structure but enlarges the grains to an intermediate size so that only moderate surface distortion and a slight overall expansion is obtained during pile exposure. Current production of this metal is yielding slugs which probably can be irradiated to 400 MWD/ton with little danger of encountering difficulty during discharge. Fifty tons of 400 MWD/ton metal will be discharged from the piles by July 20, 1949 and 100 tons by August 31, 1949.

To achieve a much greater factor of safety even with extreme exposures, effort is being made to obtain the optimum in grain size and orientation. These efforts involve studies of different fabrication procedures which include different working conditions and heat treatments as well as the addition of alloying elements in small amounts to serve as grain growth inhibitors. Temporary facilities for the metallurgical examination of irradiated uranium to aid in determining the mechanism of deformation are nearing completion.

Engineering

Equipment for partial discharge of tubes in the pile has been developed to a useful but not perfect stage. If most of the slugs in a tube are discharged but about 25% of the slugs from the upstream end of the tube are retained in the downstream end for an additional period of irradiation, several important benefits are obtainable. Such "segmented discharge" will permit increasing the product concentration by about 10% above that obtained in conventional discharge for a given amount of Pu^{240} contamination in the product. The procedure also permits all slugs to be discharged with a reasonably constant amount of product, in contrast to the ten-fold variation obtained during conventional discharge. Disadvantages include loss of pile reactivity and reduced operating efficiency; the overall efficiency of the system has not been completely evaluated.

Chemical Separations

There are no factors present in either existing or planned separation facilities which will preclude operation with metal containing higher product concentrations. Major cost reductions in construction of new facilities could be made if it were known that higher product concentrations would be reached.

-5-

III. GRAPHITE EXPANSION

DECLASSIFIED

Experimental addition of carbon dioxide gas to the circulating helium atmosphere in D Pile beginning in January, 1948, has been accompanied by a complete cessation of the overall expansion of the pile. Accordingly, gas containing 40% carbon dioxide has been adopted for all piles. The effects of higher carbon dioxide concentrations are being studied experimentally in F Pile.

This development has obtained some additional life for the piles and encourages the prospect for an extended life. It is conceivable that the higher ambient temperatures in the pile resulting from the use of carbon dioxide have caused a partial annealing; if so, the expansion may start again after a lapse of time, and expansion of the cooler fringes of the piles may be continuing. It is hoped that the effect is attributable to a selective oxidation of displaced atoms in the graphite.

Thermal annealing of the piles is still considered as a justifiable last resort to avoid complete abandonment of a pile, and experimental work is in progress. On May 3, 1949, the ratios of total MWD exposure for piles B, D, and F were 1.00, 2.09, and 1.77 respectively, and the total pile vertical expansions were 2.0, 2.8, and 3.2 inches.

IV. HIGHER POWER LEVELS

A program for experimental evaluation of higher power level at the D Pile is being initiated. It is probable that power levels of about 350 MW can be reached in the present piles.

The primary limiting factor is the necessity to restrict the ambient temperature of the pile so that the vertical aluminum thimbles will not fail in creep.

Control problems at power levels up to 400 MW have been solved by providing additional emergency controls in the form of cadmium coated splines which can be inserted into tubes from the front face without requiring access to the rear face.

Experiments have demonstrated that a 20% reduction in flow in individual tubes is not accompanied by adverse corrosion effects. It is believed that a 20% increase in heat load with the present flow rate will introduce no important corrosion problems.

The increased activity of the effluent water may become limiting, but the long-lived activity introduced into the river is independent of the number of piles used for a given total production.

A table of expected characteristics of the D Pile at various power levels is given below:

DECLASSIFIED

HW-13292

-6-

	Power Levels, M.W.		
	<u>275</u>	<u>350</u>	<u>400</u>
Increase in cooling water temperature in flat zone °C.			
Average for level operation	36	48	55
Maximum for level operation	43	57	66
Maximum during full power start up**	61	81	92
Central Graphite Temperatures in flat zone - °C.			
Average for level operation***	240	306	350
Local max. for level operation***	290	369	421
Local max. during full power start up**	328	--	--
Temperature of central uranium slugs in flat zone - °C.			
Average surface temperature, level operation	51	65	72
Max. surface temperature, level operation	60	74	81
Average axial temperature, level operation	152	182	196
Max. axial temperature, level operation	170	200	216
Thermal expansion of graphite packing in inches (from shutdown to level operation)	0.21	0.27	0.31

**Reduced level start-up required for the reason of excessive tube outlet temperatures beyond 275 MW.

***No allowance has been made for probable annealing of the graphite thermal conductivity effect at elevated temperatures.

V. LATTICE REDESIGN

The problem of improvement in the design of the lattice of a Hanford type pile is essentially one of neutron economy. Higher power levels may be achieved by consuming neutrons in an increased amount of cooling water and in fission products. Higher production of plutonium per unit of U^{235} consumed may be achieved by increased absorption of neutrons in U^{238} . Higher production of other radioisotopes may be achieved by diverting neutrons for their formation. These three objectives thus compete among themselves for the use of neutrons. Any reduction in the parasitic absorption of neutrons in the materials of the reactor makes more neutrons available for any of the three objectives. In the piles now nearing completion important improvements in the purity of graphite have been made. Gains of equal magnitude could be made in the future if it proves feasible, from an engineering standpoint, to replace the aluminum water tubes and slug jackets with magnesium.

Based on present knowledge, a slight reduction in the amount of graphite in the pile lattice would produce an increase of 2% in the plutonium produced without increasing consumption of natural uranium or other operating costs and would in addition result in a slight increase in neutrons available for other purposes. Further substantial gains in the efficiency of conversion of U^{235} to plutonium can be achieved only by reducing the neutrons available for increasing the power level or the production of other isotopes. However, it is within the realm of possibility to increase the conversion efficiency from 80% (its value in the present piles) to 90% and still maintain a daily production equal to that of

DECLASSIFIED

HW-13292

-7-

one of the present piles. If additional neutrons become available from use of magnesium or from further improvements in graphite purity the efficiency may approach 100%. Piles could be designed to operate with depleted metal at conversion efficiencies higher than at present.

On the other hand, by maintaining the conversion efficiency at its present level it would be possible to obtain from a new pile, of the same size as the present ones, a production rate two to three times as large as the present rate of one of the operating piles. The production rate of other radioisotopes would also be increased comparably. An improved design of control system makes it possible to provide the additional safety control which will be required at these higher power levels.

A program of exponential pile studies, just now being started, should provide basic information for lattice redesign in about one year.

VI. OTHER TECHNICAL ACTIVITIES

Following is a partial list of other active technical problems:

1. Measurement of plutonium critical mass
2. Tritium production
3. Third safety system for piles
4. Process for making high purity graphite
5. Measurement of property changes of irradiated graphite
6. Process for producing plutonium metal shapes
7. Reduction in amount of radioactivity discharged to the air from separations plants
8. Process for producing radio-lanthanum
9. Design of laboratory facilities.

MANAGER, TECHNICAL DIVISIONS

AB Greninger:dg

**DATE
FILMED**

4 / 7 / 94

END