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MONTHLY REPORT

MAY 1958

AUTHOR

John E. Faulkner

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DATE _____

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MONTHLY REPORT

MAY 1958

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Compiled by Members of the
Nuclear Physics Research
Physics and Instrument Research and Development
HANFORD LABORATORIES OPERATION

Submitted by: John E. Faulkner

June 6, 1958

HANFORD ATOMIC PRODUCTS OPERATION
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NUCLEAR PHYSICS RESEARCH OPERATION

MONTHLY REPORT - MAY 1958

FISSIONABLE MATERIALS - 2000 PROGRAM

METALLURGY

Nuclear Safety Studies for the Fuels Preparation Department - N. Ketzlach

An addition to the Nuclear Safety Specifications, Fuel Element Manufacturing Processes, HW-47013, has been made to cover the handling of 0.96 percent U^{235} enriched fuel elements in a 200 hole shipping container.

Based on a study, a Process Work Request was issued giving nuclear safety rules for unloading 3.0 percent enriched fuels from a baggage car containing 0.96 percent enriched fuels.

The study began last month on the reactivity of water-flooded arrays of 0.95 percent enriched U^{235} fuel elements encased in iron pipe is nearly complete. A separate document on this subject will be issued at the completion of this work. Several exponential experiments have been made with fuels of this enrichment encased in iron and in aluminum tubing. The experimental results are in agreement with theory and indicate that for a thickness of Fe tubing of about 0.06 inch, k_{∞} will be reduced to unity. Therefore, any larger pipe thickness will make an infinite array of such fuels safe. Applying a proper safety factor, an iron pipe thickness of 1/8 inch around individual columns of these fuel elements will ensure a system that is subcritical for all masses of fuel elements of this enrichment.

Buckling Measurements to Determine Nuclear Safety Criteria Applicable to Shipping Slightly Enriched Uranium in Iron Tubes - R. C. Lloyd

Exponential measurements were taken to determine the difference in the buckling for 0.95 percent enriched fuel elements when positioned in 49-mil, Type 3S, Al tubing and 49-mil Fe tubing. These measurements were done to check prior calculations which were made in connection with a study to determine a safe method of shipping enriched fuel elements in large quantities. The buckling was measured at three different H_2O/U volume ratios with the Al and Fe tubing; the O.D. of the Al tubing was 1.50 inches and that of the Fe tubing, 1.51 inches. In each case the fuel element diameter was 1.34 inches. The effect of replacing the Al tubing with the Fe tubing was to reduce the buckling by values which ranged from approximately 2100 - 2300 μB for those cases measured. The measured bucklings are given below:

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Buckling for 0.95 Percent Enriched Fuel Elements

<u>Separation Between Rods</u>	<u>H₂O/U (by Volume)</u>	<u>Type of Tubing</u>	<u>Buckling (10⁻⁶ cm⁻²)</u>
2.1 inches	1.46	Al	2257
2.2	1.72	Al	2115
2.4	2.28	Al	1474
2.1	1.44	Fe	168
2.2	1.70	Fe	-52
2.4	2.27	Fe	-800

The increased neutron absorption in the 49-mil Fe tubing changes k_{∞} of the order - 0.075 from the value of k_{∞} for the Al tubing cases.

REACTORSTUDIES RELATED TO PRESENT PRODUCTION FILES

Exposure and Temperature Coefficient with Synthetic Slugs - R. A. Bennett,
R. I. Smith, T. J. Oakes

Analysis of experimental data for the total temperature coefficient of k_{∞} for normal uranium and for simulated 1000 MWD/T and 2000 MWD/T slugs in a 7 1/2-inch graphite lattice is incomplete. The data have been reduced to point sets of ρ and T which will be fitted to a polynomial temperature function using a least-square polynomial approximation on the IBM-650.

Analysis of the metal temperature coefficient data for normal uranium is essentially complete. A least-square linear fit to the data yielded

$$\frac{1}{k_{\infty}} \frac{dk_{\infty}}{dT} = -2.65 \pm 0.10 \times 10^{-5}/^{\circ} \text{C.}$$

The assigned error is one standard deviation based on statistical analysis and does not include systematic errors which may be as large as 10 percent.

Work is in progress to provide an IBM-650 program for computing P.C.T.R. reactivities from raw period or rod motion data, with the eventual goal being a program which will compute k_{∞} and β from the basic data.

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Thermal Neutron Flux in a Medium with a Temperature Discontinuity - D. A. Kottwitz

A sufficiently large number of the universal constants which occur in the flux expression has been evaluated with enough accuracy to permit a reasonable guess concerning the asymptotic form of the infinite sequence. With this point decided, the analytical work on this particular problem is complete.

The ONMICODE program for numerical solution of the partial differential equation is now being debugged and will soon be ready for computations.

STUDIES RELATED TO FUTURE PRODUCTION PILES

Lattice Measurements on Cluster Fuel Elements - E. Z. Block

Several measurements have been completed in the small exponential piles using the cluster assemblies of seven 0.5-inch-diameter rods described in the previous monthly report.

The aluminum cladding of the rods is 0.504-inch I.D. x 0.046-inch wall. The aluminum process tube is 2.125-inch O.D. x 0.065-inch wall. The water capacity was measured to be 7.61 cc/cm., compared to a calculated value of 7.57 cc/cm. Four polyethylene supports, 1/4-inch thick, were distributed along a four-foot length and therefore are equivalent to about 0.16 cc/cm in the "dry" cases. The channels in the graphite are 2.137 inches in diameter.

The following table summarizes the values of material buckling thus far obtained.

<u>Lattice Spacing</u> <u>(Inches)</u>	<u>Buckling ($\mu B = 10^{-6} \text{ cm}^{-2}$)</u>	
	<u>Dry</u>	<u>Wet</u>
5 3/16	-384 μB	-209 μB
6 3/16	- 98 μB	- 58 μB

Development of Methods of Calculating Reactor Parameters

Fuel Isotopic Concentrations - J. R. Worden

In the fuel isotope problem some method of specifying the neutron temperature as a function of radius in the rod is still being sought. A solution to Boltzmann's transport equation employing a variational principle and considering the temperature as an arbitrary function of radius is being tried.

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Machine Computational Programs - D. D. Matsumoto

A program has been prepared for processing foil data taken in the P.C.T.R. With this program, raw experimental data is being analyzed and returned to the experimenter within 30 hours of the initiation of the run. Without the program, several days calculation has been required for analysis. This program represents the first example in Nuclear Physics Research of such direct use of experimental data processing.

An OMNICODE program for numerical solution of a partial differential equation encountered by D. A. Kottwitz in his thermal flux problem has been written and is being debugged. The program for evaluation of cosine weighting integrals has been completed and successfully tested.

STUDIES RELATED TO SEPARATIONS PLANTS

Measurement of k_{∞} for Uranyl Nitrate H_2O Mixtures - H. E. Handler, R. C. Lloyd

The experimental work was completed for determining k_{∞} of enriched uranyl nitrate-water mixtures in the P.C.T.R. Data were taken for uranium enrichments of 2.1 percent and 2.3 percent at H/U atomic ratios of 8 and 10, and for an enrichment of 2.2 percent at an H/U ratio of 8. When these data are analyzed and combined with previous data, it will be possible to specify the highest enrichment value which will have $k_{\infty} \leq$ unity for uranyl nitrate-water mixtures. Thus far data have been taken for enrichments of 2.1 percent and 2.3 percent at nominal H/U atomic ratios of 8, 10, 12, 14, and 16, and for an enrichment of 2.2 percent at H/U ratios of 8, 12, and 16. Although detailed calculations have not been completed, these data indicate the maximum always-safe enrichment to be about 2.1 percent.

Criticality Studies in Support of Processing Power Reactor Fuels

Experiments on Heterogeneous Systems - H. E. Handler, R. C. Lloyd, E. D. Clayton

In connection with the criticality studies for processing power reactor fuels, the stainless steel approach tank was installed adjacent to the T.T.R. in the 305-B Building. A quick dump safety system for the water moderator and reflector was installed and tested; when the dump valve was tripped, the water level in the four-foot-diameter tank dropped about 20 inches during the first three seconds. Cadmium safety and control rods were fabricated and installed. A water level indicator was installed and tested. All of the electrical and instrumentation wiring was completed for the approach tank, including the change-over wiring for the several T.T.R. safety circuits which will be used in these experiments. The first measurements, which are ready to commence, will be made with 1.6 percent enriched I. and E. fuel elements.

Notification was received that the entire quantity of three percent enriched uranium for the experiments was shipped and in transit. This includes uranium

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rods of three different diameters, 0.3 inch, 0.6 inch, and 0.925 inch. A special pencil-type Ra-Be neutron source was received for use in the near critical approaches with the three percent enriched uranium.

Experiments on Homogeneous Systems - J. A. Berberet, V. I. Neeley

Preparations for the determination of the maximum k_{∞} of a homogeneous three percent enriched UO_3 - H_2O system are nearing completion. For these experiments it is planned to use boron to poison the test cell and buffer region instead of the usual copper foils. The boron will be dispersed in polyethylene film. Some difficulties are being experienced in obtaining a uniform dispersion of the boron, however, and different techniques, including ultrasonic mixing, are being tried to improve the dispersion.

The first of these measurements are scheduled for the P.C.T.R. starting the week of June 9. The major items on the agenda are: (1) a comparison of the cross section of boron with that of copper; (2) the measurement of k_{∞} at an H/U ratio of three; (3) a study of the dependence of k_{∞} on the neutron spectra; (4) a study to determine the feasibility of using polyethylene (CH_2) as a replacement for water in these experiments.

Plutonium Critical Mass Laboratory - J. A. Berberet, E. D. Clayton

Authorization was received (A.E.C. Directive No. HW-455 dated May 12, 1958) to proceed with the design of a plutonium critical mass laboratory defined as Stage I in Project Proposal No. CG-731, Revision No. 1. The fund authorized for the design work is \$175,000. The work scheduling is to be planned for completion of Stage I construction by October 1959.

Criteria for the proposed facility have been reviewed and revised, with the replacement of the control trailer by a surplus army mess hall being noted as the major change.

Several studies requested by the A.E.C. which related to this facility have been initiated with C.E.O. The purpose of the studies is to compare the economics of the currently proposed facility, in both Stage I and Stage II versions, with comparable facilities employing the type of construction used in the Oak Ridge Critical Mass Laboratory.

Buckling Measurement for Mixed 0.925-Inch and 1.66-inch Slugs - R. C. Lloyd

The buckling was measured for one lattice with 1.007 percent enriched uranium consisting of alternate rods with diameters of 0.925 inch and 1.66 inches. The separation between the rods was 1.80 inches, corresponding to an $\text{H}_2\text{O}/\text{U}$ volume ratio of 0.863. The measured buckling for the combination lattice was 1396 μB . Previous measurements had been taken with $\text{H}_2\text{O}/\text{U}$ volume ratios of 1.20, 1.45, and 1.84⁽¹⁾. An error was found in the buckling calculation for the $\text{H}_2\text{O}/\text{U}$ ratio of 1.20, which changed the earlier value from 2692 μB to 2524 μB .

(1) Gast, P. F., Physics and Instrument Research and Development Operation - Monthly Report - February 1958, HW-55162 B

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The measured bucklings for the combination lattices are less than those for the 1.66-inch fuel elements separately at the same H_2O/U ratios and also less than those for the 0.926-inch fuel elements except at small H_2O/U ratios. These measurements provide additional information about the buckling for fuel elements in mixed or random arrays.

Nuclear Safety, Critical Mass Consultations - N. Ketzlach

Nuclear Safety in 234-5 Building Processing

A study has been made of the nuclear safety in the design and handling of containers for plutonium fluoride powders in Hood 9-B (Continuous Task I-II). Recommendations were presented to Research and Engineering (C.P.D.) to insure nuclear safety of this operation.

Nuclear safety aspects of the liquid de-entrainment trap proposed for installation in Recuplex have been reviewed. Recommendations for the design and installation of such a trap have been presented to Research and Engineering (C.P.D.).

Nuclear Safety in Purex Processing

The design of a IWW recovery prototype ion exchange column and its associated equipment has been reviewed for nuclear safety. This design and positioning of the equipment in the Purex canyon meets the criteria for nuclear safety given to Facilities Engineering (C.P.D.).

Neutron Age Measurements - D. G. Foster, Jr.

Work continued on the modifications to be incorporated in the second run of these measurements. The errors in source and foil positioning have been evaluated. A method of spot welding the foil sandwiches is being studied.

Mass Spectrometer for Plutonium Analyses - C. R. Lagergren, W. J. Friesen

The mechanical portions of the spectrometer are essentially complete except for the finishing work on the cabinet and frame. The electrical instrumentation work has been delayed because of late delivery of some commercial components. The 10-megacycle amplifier which was ordered was found to not meet purchase specifications and was returned. Substitute amplifiers have been ordered. The spectrometer and basic instrumentation components are scheduled for installation during June.

REACTOR DEVELOPMENT - 4000 PROGRAM

STUDIES RELATED TO THE PLUTONIUM RECYCLE PROGRAM

D_2O - UO_2 and PuAl Lattice Measurements - J. R. Lilley, F. C. Engesser

The calandria with a nine-inch lattice spacing has been installed in the P.C.T.R. and experiments are in progress to determine k_{∞} and f for four cases of 19-rod

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clusters of 1/2-inch-diameter fuel rods; 19 rods of UO_2 with air coolant and with D_2O coolant; 16 rods of UO_2 and three rods of PuAl with air coolant and with D_2O coolant.

Comparisons of manganese, gold and BF_3 cadmium ratios are being made to determine the corrections necessary to obtain relative "1/v" fluxes from relative manganese activities and to check the linearity of the curve of gold (CdR-1) versus BF_3 (CdR-1).

An IBM-650 program has been written for processing foil activation data. Relative activities are computed in the case of thermal flux traverses. In the case of cadmium ratios, the (CdR-1), the epicadmium and the subcadmium fluxes are computed at each foil activation point, together with the differences in these quantities at each point relative to some reference point.

Resonance Escape Theory - R. H. Meichle

The values of p as obtained from H. Neumann's formulation of resonance escape probability have been compared with those deduced by C. R. Richey from exponential data, using the classical formulation. The comparison was made as $(1-p_{\text{theor}})/(1-p_{\text{expon}})$ for a given rod size with different lattice spacings.

For the 1.727 cm radius rod the ratio is fairly constant over the different lattice spacings of interest. The ratios obtained are about 0.70; this value is interpreted as indicating that 70 percent of the total neutron captures are contributed by the 18 resolved resonances. The constancy of the ratio appears to indicate that the assumption of spatial flatness of the flux in the moderator is valid.

From H. Neumann's formulation of p we obtain a value $p = 1$ for a rod with an infinite lattice spacing which is obviously incorrect. C. R. Richey has obtained a p_{∞} to correct the p obtained from exponential data. An attempt is being made to find a corresponding correction to the theoretical p 's; this involves the calculation of the age of resonance neutrons.

Theoretical P.C.T.R. Studies - M. T. Lee

Further work has been done on the formulation for resonance escape probability in an infinite lattice of supercells, a problem of importance in connection with recent P.C.T.R. measurements. Expressions have been developed for evaluating two of the parameters involved in this study. The first of these, the ratio of the relative resonance capture probabilities of neutrons in neighboring fuel elements to those in the fuel element of the same type in which they originated, has been found by use of a very approximate method. A more accurate method gives values which differ by only about ten percent for the geometry of interest. A method of approximating the second parameter, the relative resonance capture probabilities of two fuel elements of different material, has been outlined. The third parameter, the relative number of fission occurring in the elements of different material in a particular lattice is still to be evaluated.

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Nuclear Safety Studies for the Plutonium Recycle Program - N. Ketzlach

A study has been made of the nuclear safety criteria for the dissolution of the plutonium-aluminum alloy P.R.T.R. fuel elements containing 1.8 percent Pu by weight. When enough fuel elements of this type are available, a few lattice measurements should be made to verify the theory used in this study. This is especially necessary since there exists no experimental data on light water lattices of plutonium-aluminum alloys of any Pu enrichment.

Nuclear safety in the processing of these fuel elements in large dissolvers depends on the presence of three mols of nitrate per mol of aluminum (as in ANN). A plutonium-aluminum water "solution" of the enrichment studied can be made critical in the absence of nitrate in solution. If the proper amount of nitrate can be guaranteed, the maximum safe number of fuel element in the proposed E-metal dissolver is 6.6; each fuel element consists of 19 rods about 0.50 inch in diameter by seven feet four inches in length and contains 270 grams of Pu. It is believed that there is a safety factor greater than two in this limit for double batch protection. The maximum safe batch size in an arbitrary dissolver under the same processing conditions is 3.29 fuel elements. The diameter of a cylindrical dissolver which is safe by geometry cannot exceed 12 inches, and the always safe slab thickness of a slab type dissolver cannot exceed six inches.

Experimental Solid State Physics - T. I. Moran (G.E.R.L.)

Studies at G.E.R.L. were continued on electron irradiation damage to copper. Measurements were made to determine the variation of damage with total irradiation flux which indicate a nonsaturable damage. No flux rate dependence of the damage was observed. Measurements were also made to study the possible electron energy dependence of the primary annealing processes.

Cross Section Measurements Program

Subthreshold Fission - Np²³⁷ and Am²⁴¹ - E. J. Seppi, B. R. Leonard, Jr.

More data were accumulated to improve the statistical precision of the low resolution data previously reported.

Beryllium Monochromator Crystals - E. J. Seppi, J. H. McCrary, S. J. Friesenhahn

Two single beryllium crystals were received for possible use as monochromating crystals. Both crystals gave multiple reflections with neutrons. Investigation to date shows that each crystal is of roughly comparable quality to our present Be crystal and gives intensities with high resolution about an order of magnitude less than an optimum crystal.

Three Crystal Spectrometer - E. J. Seppi, J. H. McCrary, S. J. Friesenhahn

The defective beam shutter mechanism furnished on the Project CG-672 has not been replaced to date. The instrumentation for the spectrometer has not been completed and basic testing of the spectrometer has not yet been initiated.

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Time of Flight - H. W. Lefevre, J. T. Russell

The neutron detection threshold of the large (3.5-inch-diameter) detector was significantly lowered by modifying the preamplifier. The detection threshold is now about 200 to 300 Kev neutron energy. A parallel slow channel was successfully used with the vernier chronotron as a pulse height selection system to determine the neutron threshold energy.

A survey run was made of the angular distribution of $\text{Be}^9(d,n)$ neutrons.

Offsite Program - C. R. Lagergren, W. J. Friesen

The construction of the mass spectrometer for this program proceeded simultaneously with the construction of the mass spectrometer for plutonium analyses.

P.C.T.R. Operations - H. L. Henry

Operation of the P.C.T.R. continued on a two-shift basis during the month. There were seven unscheduled shutdowns during the month; one was due to faulty bypassing technique, one to a power interruption, and five were due to electronic failure.

Measurements were completed using slightly enriched UN hydrate. Measurements were nearly completed on a series of tests in the nine-inch P.R.T.R. lattice.

One improved design control rod was installed, completing the replacement of the eight control rods. Aluminum was substituted for stainless steel in the stationary tube and the moving tube was strengthened to prevent damage during emergency shutdowns. The removal of the steel increased reactivity by about one and two-thirds control rods with a full graphite core in the P.C.T.R. This is an increase of approximately \$1.15 permitting a decrease in fuel loading of 225 grams of U^{235} .

All control rods were moved from the 70 to 80 centimeter positions to improve operation with the enlarged test cavity. In this location, the value of No. 5 rod was 14.6 cents per inch compared to 18.2 cents per inch at 70 centimeters. This should reduce the fuel requirements somewhat but measurements have not been made to date.

An improved design source boat was installed to permit using a nylon cord in place of the stainless steel cable in the source drive mechanism. The stainless steel cable did not wear well going around the small pulleys in the source drive.

The bid package for the addition to the 305-B Building has been completed and a contractor may be selected during June.

Design of the test lattice graphite blocks for the proposed gas-cooled reactor experiments was completed and blueprints were prepared.

An improved core heater tank is being designed. Provisions are being made to permit removal of the resistance heaters before the reactor is made critical. Reduced fuel requirements and thus improved control rod sensitivity will result.

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T.T.R. Operations - H. L. Henry

Work was continued on normalizing the fission foils that are to be used in the lattice neutron temperature experiment.

Modification of the T.T.R. control circuits by H. E. Handler for the critical mass experiments has been completed.

There were no unscheduled scrams during the month.

Work with the fission foil equipment was continued by Experimental Nuclear Physics personnel during several periods of reactor operation.

REPORTS ISSUED

HW-55879 - Nuclear Physics Research Quarterly Report, January, February, March 1958 (Formal)

PAPERS PRESENTED

E. J. Seppi - Ternary Fission Cross Section of U^{235} - American Physical Society Meeting, Washington, D. C., May 3, 1958

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