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MONTHLY REPORT

NOVEMBER 1958

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NUCLEAR PHYSICS RESEARCH OPERATION

MONTHLY REPORT

NOVEMBER 1958

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

Submitted by: John E. Faulkner

December 10, 1958

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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-2-

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-3-

NUCLEAR PHYSICS RESEARCH OPERATION

MONTHLY REPORT

NOVEMBER 1958

FISSIONABLE MATERIALS - 2000 PROGRAM

METALLURGY

Nuclear Safety in Processing MTR-type Fuel Elements - N. Ketzlach

At the request of CPD a study was made of the criticality problems in connection with processing MTR-type plutonium-aluminum alloy fuel elements (Pu content ≤ 15 percent by weight). A comparison of the results based on a theoretical study of heterogeneous systems of this alloy in water with that of homogeneous systems, indicates that the homogeneous systems will have a smaller critical mass. Therefore, until experimental data become available for checking the theoretical calculations, the homogeneous systems will be used as a basis for establishing the appropriate nuclear safety criteria. This study indicates that the minimum critical mass for an arbitrary loading of these type fuel elements in water is about 500 grams. This allows for bending of the fuel plates during dissolution. If it can be guaranteed that the fuel plates will remain straight during the course of dissolution (the plutonium being distributed over the 24-inch length of the plates), the minimum critical mass is about 700 grams of plutonium.

REACTOR

STUDIES RELATED TO PRESENT PRODUCTION REACTORS

Lattice Neutron Temperature Study - W. P. Stinson

Data for the ratios of the thermal fission cross sections of Pu^{239} and U^{235} have been taken at three graphite temperatures, 20°C, 80°C., and 150°C. The foils from which these data were taken were irradiated in the center of the TTR hot thermal column in a flux which has a cadmium ratio of 800 (0.040" Cd cover, 0.001" Au foil).

In addition to taking the data mentioned above, data for the ratios of the fission cross sections of Pu^{239} and U^{235} have been taken with the foils mounted inside a natural uranium slug which was irradiated in the center of the TTR hot thermal column. Two sets of data were taken at each of the three temperatures, with and without the process tube filled with cold water.

Data from which the blocking effect of coolant water is to be determined were taken at room temperature. For this run, two sets of manganese foils were irradiated, with and without water flowing through the process tube.

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-4-

The above data is being analyzed.

Figure 1 is a presentation of the data taken previously in the PCTR thermal column oven. These traverses were taken across a temperature discontinuity to determine the relaxation length for neutrons in equilibrium at one temperature to come to equilibrium at another temperature. This information will be useful in the latter part of the Lattice Neutron Temperature Study presently being conducted in the TTR hot thermal column. The errors indicated on the curves are counting statistics only.

NEUTRON THERMALIZATION

Thermal Neutron Flux in a Medium with a Temperature Discontinuity - D. A. Kottwitz and J. E. Schlosser

As reported last month, an Euler transformation of the divergent formal series expansion of the analytical solution produced a rapidly convergent series in one case. However, it was soon discovered that, for certain temperature ratios of physical interest, the new series did not converge, and a second transformation would have been required. Fortunately, this difficulty may be avoided by using a slightly different type of Euler transformation which apparently leads to a fairly rapidly convergent series in all cases of interest. The new scheme is suitable for machine computation, and it is planned, after suitable checking of convergence, to write a FORTRAN program for the IBM 709.

A large part of our interest in the aforementioned analytical solution lies in obtaining exact values against which to compare results of various approximate methods. One of these methods is the iterative solution of finite difference equations, several variants of which were carried out sometime ago. Comparison with the exact values indicates how the iterative results depend on the coarseness and extent of the finite difference mesh, on the number of iterations performed, and on the type of boundary conditions imposed. The most important conclusion from this comparison is that coarseness of the mesh was the factor limiting accuracy in the series of calculations performed.

Another method giving approximate solutions to the problem is Selengut's two thermal group approach, which leads to simple analytical functions that can be evaluated readily by machine calculation. For this purpose, an OMNICODE program has been written and debugged. Comparison of the approximate and exact results for one case is underway.

Slow Neutron Scattering Cross Sections - D. A. Kottwitz

Experiments performed at Chalk River indicate that under certain conditions a large component of the scattering of slow neutrons by water is similar to scattering by a free atom gas. Thus, a knowledge of the dependence of this type of inelastic scattering cross section on incident and final neutron energy, scattering angle, mass number and gas temperature may be useful in

FIGURE 1

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HW-58485

-6-

planning and interpreting experiments performed with the Hanford three-crystal spectrometer.

Accordingly, work has begun on a FORTRAN program for the IBM 709, employing a formula for the cross section given in the published literature.

Neutron Energy Spectrum in the Vicinity of a Boundary with a Temperature Discontinuity - R. A. Bennett

In order that use may be made of the multithermal-group diffusion equations proposed by Selengut for analysis of the space-and-energy dependence of thermal neutrons diffusing in a moderator having non-uniform temperatures, and experimental study has been set up to obtain the effective transfer cross section for neutrons to go from one Maxwellian energy group to another.

The experimental phase of the study is complete, and the analysis of the data is continuing. Use is being made of the IBM-650 computer and the Litton Differential Analyzer.

STUDIES RELATED TO FUTURE PRODUCTION REACTORS

Lattice Measurements for 1.92-inch Fuel Elements - G. W. R. Endres

First results from the measurement of the buckling of 1.92-inch-diameter fuel elements have been obtained. The bucklings are:

<u>Lattice Spacing</u>	<u>Buckling (10^{-6} cm.$^{-2}$)</u>	<u>Volume Ratios</u>		
		<u>H₂O/U</u>	<u>C/U</u>	<u>Al/U</u>
6 3/16 Dry	- 448	--	11.64	0.264
6 3/16 Wet	- 230	0.288	11.64	0.264

The extrapolation distance used in the calculations was 1.66 inches.

As soon as materials are available work will begin on the 2.5-inch diameter fuel elements with lattice spacings of 8 3/8, 10 3/8, 12 3/8, and 14 3/8 inches.

PCTR Measurements of k_{∞} and f for Selected Cluster Elements - E. Z. Block and R. I. Smith

The experimental work has begun in the PCTR to measure k_{∞} and f for separated seven-rod clusters of 0.926-inch-diameter natural uranium rods, air cooled, in a 10 1/2-inch graphite lattice.

The condition of zero flux spectral mismatch was approached and passed through by adjustment of the composition of the core region surrounding the nine-cell lattice array. The previously untried technique of utilizing tubes filled with D₂O placed adjacent to the PCTR driving fuel to slow down the flux spectrum incident on the core array was used satisfactorily.

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HW-58485

-7-

The "correct" (0.005" Au) cadmium ratio, corresponding to the zero mismatch condition, together with its 67 percent confidence interval, has been determined to be 3.215 ± 0.068 - 0.037 .

Measurements of the relative magnitude of the adjoint ratio at the central cell and at two surrounding buffers are currently in progress.

Coordinated Theoretical - Experimental Reactor Physics Program

A. Exponential Data Correlation - W. C. Finch and J. L. Carter

Examination of the exponential pile data for solid natural uranium rods in dry graphite lattices continues. The corrections for aluminum spacers, cladding, and tubing, as described in last month's report, have been applied to the one Al/U ratio for each rod size for which f values are given in the reference document HW-56646. At present, the accuracy of these corrections is being checked indirectly by using the same correction procedure to predict bucklings at other Al/U ratios for which buckling measurements have been made.

B. Experimental Reactor Physics Development - D. E. Wood

The IPD survey code was used to calculate 60 lattices including those where comparison between PCTR and exponential experiments can be made and measurements of I and E to solid, wet and dry buckling differences. The 1.92-inch and 2.5-inch fuel elements were included to see if the code can be used to aid in planning the experiments.

NPR Lattice Measurements - D. E. Wood

The study of a hot, pressurized exponential to support the NPR program is continuing. Nonmetallic Materials Development Operation has successfully heated a graphite tube by direct resistance heating. This tube was similar to the heating elements suitable for an exponential, so that resistance heating of the graphite may be considered feasible. It is possible to obtain an accelerator neutron source sufficiently powerful to allow activation measurements of p. However, the neutron intensity would be so large that considerable shielding would be needed.

Agreement was reached with interested parties on an exponential pile program which will lead to data on rod-and-tube and tube-and-tube type fuel geometries.

Full Scale PCTR - H. L. Henry and P. F. Nichols

Rough drafts of the Plant and Equipment Analysis Report and of the Project Proposal were turned over to Laboratories Auxiliaries Operation for preparation of the formal documents.

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HW-58485

-8-

STUDIES RELATED TO SEPARATIONS PLANTS

Criticality Studies in Support of Processing Power Reactor Fuels

A. Experiments with Heterogeneous Systems - R. B. Smith, R. C. Lloyd, and E. D. Clayton

In reference to criticality studies for reprocessing power reactor fuels, further critical mass data were obtained with 3.063 percent enriched uranium rods of 0.925-inch diameter. Multiplication measurements were completed with the 0.925-inch rods in a 1.95-inch hexagonal lattice for each of two different fuel column lengths, 16 inches and 24 inches, respectively. These data are summarized below

<u>Lattice Spacing</u>	<u>H₂O/U (by volume)</u>	<u>Length of Fuel Column</u>	<u>Critical No. of Rods</u>	<u>Critical Mass</u>
1.95 inches	3.89	16 inches	60.4	445 lbs.
		24 inches	48.6	537 lbs.

From these data and previous measurements, the minimum critical mass can be determined for the 3.063 percent enriched rods of 0.925-inch diameter; this minimum mass (assuming spherical geometry and water tamping) is 394 pounds of uranium and occurs at an H₂O/U volume ratio of about 3.3.

Following the completion of the critical approach measurements the critical buckling was determined for the above lattice by means of the exponential pile method. In this case a sufficient number of rods were removed from the reactor to insure that the reactor would remain subcritical for any height. The buckling was then determined from flux measurements in the usual sense along the axis of the pile; measurements were made for two different fuel length columns, which were 24 inches and 32 inches, respectively. The critical buckling from the exponential pile measurements was in excellent agreement with the buckling obtained from the critical approach technique.

The material buckling was calculated from the critical mass measurements by using the data on reflector savings as given in BNL-C-7592. Then with these values for reflector savings, the maximum buckling for the 3.063 percent enriched uranium rods of 0.925-inch diameter is given as $13,330 \times 10^{-6} \text{cm}^{-2}$, which occurs at an H₂O/U volume ratio of about 2.3. Note that the minimum mass occurs at a higher ratio (about 3.3). This is consistent with previous measurements made with other rod sizes and enrichments.

The largest buckling specifies the smallest critical size for a given geometry, but not the smallest mass which can be made critical if a larger size is permitted, i. e., the safe critical size could contain more than a critical mass if the fuel were to be distributed properly in a larger container.

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HW-58485

-9-

B. Experiments with Homogeneous Systems - J. A. Berberet and V. I. Neeley

Experiments were completed in the PCTR for determining k_{∞} of three percent enriched $\text{UO}_3\text{-H}_2\text{O}$ mixtures having an H/U ratio of six for several different methods of moderation; in one case water was used, and in the second case, polyethylene (in the form of small pellets mixed uniformly with the UO_3 powder). These data are now being analyzed.

These measurements are being taken to determine the maximum k_{∞} and to establish the nuclearly safe H/U ratios or dilution values, (H/U ratios for which $k_{\infty} \leq \text{unity}$) for the three percent enriched $\text{UO}_3\text{-H}_2\text{O}$ mixtures. The initial measurements of this series were made with an H/U atom ratio of 3.4.

Plutonium Critical Mass Laboratory - J. A. Berberet, R. B. Smith and E. D. Clayton

Technical liaison in support of the design of the Plutonium Critical Mass Laboratory was continued. Major items considered were:

1. criteria for the safety and interlock systems;
2. liquid level measuring instrumentation;
3. shock and blast wave effects resulting from possible critical excursions.

The detailed design of the laboratory is now about 69 percent complete, as compared with a scheduled completion of 72 percent for this time.

Criticality Studies in Support of Processing Uranium in the Range 1.0 to 1.8 Percent U^{235} - R. C. Lloyd

A series of exponential experiments was begun with 1.25 percent enriched I and E type fuel elements (1.336-inch O.D., 0.500-inch I.D.). In addition to the void of the core, these fuel elements, which are eight inches in length, contain small indentations at each end for canning. The fuel elements were positioned in aluminum tubes of 1.422-inch O.D., with a 0.028-inch wall thickness; small aluminum tubes containing water were positioned in the core of the elements; these inner tubes were 0.492-inch in O.D., with a 0.020-inch wall thickness.

The first buckling measurement was completed and preliminary calculations give a value of about $4650 \times 10^{-6} \text{ cm}^{-2}$ for the 2.2-inch hexagonal lattice ($\text{H}_2\text{O}/\text{U}$ volume ratio of 2.29).

For these measurements the buckling is being determined by the exponential pile method. The neutron flux is being monitored during the pile loadings but only as a nuclear safety precaution since the loadings will be restricted to less than 0.7 of the critical mass; the measurements are being conducted in the 326 Building.

Status of Critical Mass Experiment for E-Metal Dissolver - E. D. Clayton

To date personnel of the Oak Ridge Critical Mass Laboratory have made measurements both with the 0.95 percent enriched uranium in a random array and in a uniform array.

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HW-58485

-10-

The experiments with the random array were conducted with about twelve tons of uranium in a mockup of a Hanford dissolver. From these measurements in critical mass was estimated to be in excess of 16 tons; the "dissolver" was not close enough to criticality to obtain an accurate estimate of the critical mass for the random array. The results of these measurements and the considerations which must be given in applying these data to the problem of safely processing E-metal in existing Hanford dissolvers are discussed in detail in the monthly report for August.

Pending the acquisition of the additional uranium needed for extending the critical mass measurements in random arrays, measurements were then made with the fuel elements in a hexagonal lattice (two-inch spacing between fuel tubes); the H_2O/U volume ratio was 1.69 with the fuel cores containing water. The critical mass was determined for cylindrical geometry at each of four different cylinder heights. The smallest critical mass was obtained for a height of 36 inches with an equivalent cylinder diameter of about 37 inches; for this case the critical mass in the cylindrical array was about five tons; the critical mass in optimum geometry (spherical shape) will be somewhat less. The initial results of the measurements in the uniform arrays are summarized in the following table.

A lattice framework has now been made for a second measurement in the uniform array. The H_2O/U volume ratio for this lattice will be 1.11 which was the H_2O/U volume ratio of the fuel elements when in the random array.

Plans are to next measure the critical mass in the uniform array at this H_2O/U volume ratio and then to continue the studies with the random array (following the first studies with the random array, additional 0.95 percent enriched uranium was sent to Oak Ridge and Dr. Callihan now has about 17 tons on hand).

The Oak Ridge Critical Mass Laboratory is currently conducting some needed critical mass experiments for the K-25 and Y-12 plants. Because of these experiments it may be a month before any new data become available on the E-Metal Dissolver experiments for Hanford.

Offsite Meetings Pertaining to Nuclear Safety

A. United Kingdom - U. S. Criticality Discussions - N. Ketzlach

Discussions on critical mass problems were held at Oak Ridge on November 12 - 14 by ten members of the United Kingdom; staff members from ORNL, Y-12, K-25; and HAPO. Those attending from HAPO were: Dr. P. F. Gast and N. Ketzlach of the Physics and Instrument Research and Development Operation, HLO, and R. L. Stevenson of the Research and Engineering Operation, CPD. The criteria for establishing the bases for nuclear safety in plant operations, administration of nuclear safety, and the Oak Ridge radiation excursion at Y-12 were discussed. Theoretical and experimental programs needed to establish reactor physics parameters where present day knowledge is lacking were also discussed.

INITIAL RESULTS OF CRITICAL MASS MEASUREMENTS WITH 2.0-INCH LATTICE*

0.95 Percent Uranium-235 by Weight, 6-inch Long Hanford (hollow) Slugs

$$\begin{array}{l} \text{O.D.} = 1.370 \text{ in.} \\ \text{I.D.} = 0.485 \text{ in.} \end{array} \quad \frac{V_{\text{water}}}{V_{\text{metal}}} = 1.69$$

Average Weight per Slug = 2384 g (5.256 lbs.)

Array Height (in.)	Equivalent Cylinder Dia. (cm)	Critical No. Rods	Critical Mass U (kg)	K ex (cents)	Description of Array	Critical Number Slugs
48	87	266	5073	1.4	5 Corners off, 9 ring Hex.	2128
48		267	5092	5.3	5 Corners off, 1 added to center of one face	2136
48		267 - C rod	5111	7.5	5 Corners off, 1 + control added to centers of 2 faces	2144
48		271	5168	11.4	This is completed Hex. (9 ring)	2168
42	90	284	4739	1	9 Ring Hex. with 5 corners off + 3 rods in center of each face	1988
42		285	4756	0.0	9 Ring Hex. plus 2 rods in center of 4 faces and 3 rods in center of 2 faces	1995
36	95	320	4577	2	9 Ring Hex. + 8 rods in 5 faces + 9 rods in 1 face	1920
36		321	4591	3.5	9 Ring Hex. + 8 rods in 4 faces + 9 rods in 2 faces opposite	1926
36		322	4605	6	9 Ring Hex. + 8 rods in 3 faces + 9 rods in 3 faces	1932
30	105	389	4636	0.0	3 Rods removed from each apex of 11th ring + 2 on 4 faces + 1 on 2 faces	1945
30		391	4660	2.3	3 Rods removed from each apex of 11th ring + 2 on all 6 faces	1955
30		397	4732		1 Rod removed from each apex of 11th ring + 1 in center of each face - Critical with 2.8 cm top reflector	1985
30		391	4660		2 Rods removed from each apex of 11th ring + 1 rod in center of each face - Critical with 3.9 cm of top reflector	1955

*These experiments are being conducted at Oak Ridge by members of the Oak Ridge Critical Mass Laboratory (by Dr. John Fox et al) under the direction of Dr. A. D. Callihan who is in charge of this laboratory.

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-11-

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HW-58485

-12-

Members of the United Kingdom commented on a proposed plutonium critical mass facility along the lines of that being considered for HAPO in order to help supply the very badly needed experimental data for plutonium-water systems. A keen interest was expressed in the exchange of experimental data from the two facilities.

The following is a tabulation of the general types of experiments planned for 1959-1961 in the United Kingdom:

1. Critical mass measurements of large disks of uranium containing 45 percent U^{235} (no moderator).
2. Critical volumes (with different geometries) for uranium containing 5, 15, and 40 percent U^{235} when the hydrogen-to-total uranium atomic ratio is 1, 2, 5, and 20; this will require the production of solid compacts of uranium compounds and hydrogen compounds.
3. Critical volumes of uranium containing 5, 15, and 40 percent U^{235} when the hydrogen-to-total uranium atomic ratio is greater than 20; the fuel mixture will consist of solutions in water and the measurements will be carried out in cylindrical geometry.
4. Measurements of the effectiveness of lattices of absorbing rods in changing critical sizes.
5. Extension of available data on low-enriched uranium in water, including UO_2 in beryllium and uranium with a plutonium content.
6. Extension of available data on water solutions of plutonium isotopes to other geometries and isotopic compositions.
7. Measurements of the extent of interaction between subcritical cylinders with and without moderator-absorber materials interposed.

B. Report on Meeting at the Oak Ridge Gaseous Diffusion Plant to Discuss Shipment of UO_3 - E. D. Clayton

A meeting was held at Oak Ridge on November 20 to discuss pending shipments of nominally 0.95 percent enriched UO_3 to Oak Ridge. Those persons attending this meeting from Hanford were: E. D. Clayton, L. M. Knights, and D. D. Deming (AEC).

The greatest part of the meeting was devoted to discussions on the criticality aspects of slightly enriched homogeneous UO_3 mixtures and the restrictions imposed by the "Guide to Shipment of U^{235} Enriched Uranium Materials" as compiled and edited by Dr. H. F. Henry of Oak Ridge. It was pointed out that the critical mass limits for uranium solutions as given in this guide contained safety factors of 2.3 for double batching, i. e., the actual critical mass of the material in question was 2.3 times larger than the values given in the guide; since the shipping containers for the 0.95 percent

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HW-58485

-13-

UO₃ would hold less than these amounts when filled to capacity, double batching could not logically be considered in determining the criticality of an individual container; members of the K-25 Nuclear Safety Group were in agreement on this point. The discussions and decisions reached pertaining to nuclear safety are summarized below:

1. Oak Ridge will accept shipment of the UO₃ hoppers provided that these hoppers do not contain more than 13,400 pounds of UO₃. Since these hoppers normally contain only about 12,000 to 12,500 pounds of UO₃ when full, it will not be necessary to ship partially filled hoppers; the hoppers may be shipped full of material.
2. Concerning the transit of UO₃ to Oak Ridge, the recommendation of Dr. Henry is that the UO₃ hoppers be spaced for shipment, however, the method of spacing or loading the rail cars is a local matter to be decided between Hanford and the AEC. If Hanford does not choose to space the hoppers during shipment, then on arrival at Oak Ridge the hoppers will be spaced when unloaded from the rail cars. Critical Mass Physics at Hanford does not recommend that spacing be used to insure nuclear safety in transit since the Hanford PCTR measurements show that 0.95 percent enriched UO₃ cannot be made critical even in infinite amounts under conditions of optimum moderation. The enriched UO₃ (nominally 0.95 percent and actually about 0.85 - 0.88 percent after pile exposure and subsequent processing) can be handled in the same manner as natural or depleted UO₃ shipments.
3. Personnel at Oak Ridge believe that the Hanford PCTR measurements, which show the limiting safe enrichment for homogeneous systems to be 1.02 ± 0.02 percent, are probably correct and that the limiting safe enrichment is close to this measured value. However, before accepting these data for inclusion in their shipping guide they would like to have some kind of additional confirmation; they feel that the k_{∞} measurements are indirect measurements and are not as straightforward as critical mass experiments.

In order to obtain the critical mass from k_{∞} values it is necessary to calculate the migration area or neutron leakage, except for those cases where $k_{\infty} \leq \text{unity}$ in which case the critical mass is infinite. On the other hand, the critical mass cannot be measured for k_{∞} near unity since a prohibitively large amount of uranium would be required. In other words, in order to determine the limiting safe enrichment, critical mass measurements must be done at higher enrichment values and the results extrapolated to obtain the enrichment value for which $k_{\infty} \leq \text{unity}$ for any degree of moderation; however, k_{∞} measurements in the PCTR are most precise for the values of k_{∞} near unity.

Dr. A. D. Callihan has recently made some critical mass determinations with two percent enriched uranium (UF₄ mixed in paraffin). If Hanford were to measure the multiplication constant (k_{∞}) of this material in the PCTR this would provide the additional confirmation requested by the Oak Ridge personnel. Further, if the k_{∞} , as measured in the PCTR for this material, is in agreement with the value derived from the critical mass measurements then Oak Ridge will consider the appropriate changes in their safety guide which pertain to slightly enriched uranium

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HW-58485

-14-

solutions. They will continue to space the shipping hoppers in storage and handling pending the outcome of the above proposed measurement.

Critical Mass Physics had planned to make the above type measurement in the latter part of fiscal year 1959 when this uranium was expected to become available. Because of the importance of this experiment and its bearing on nuclear safety, it was agreed to carry out the k_{∞} measurements with the "paraffin blocks" as soon as feasible. Dr. Callihan of Oak Ridge will ship about 3,000 pounds of his two percent material to Hanford within the next three weeks; the H/U ratio of the material being sent is about four, and a preliminary value of k_{∞} from the critical mass measurements is given as 1.18. Commencing about December 15 or shortly thereafter the k_{∞} measurements will be undertaken in the PCTR by members of Critical Mass Physics. The final results of these measurements are expected to be forthcoming about seven weeks after initiation of the measurements, or sometime during February.

The results of these measurements will be very useful for comparing the PCTR k_{∞} values with a "known" high value of k_{∞} ; k_{∞} is tentatively given as 1.18. The "known" k_{∞} value from the critical mass measurements depends on a calculated or measured migration area since the critical mass measurements do not give a k_{∞} value directly.

Critical Mass Studies - B. C. Clark and J. L. Carter

The investigation of the solutions of pile kinetic equations with linear time variation of reactivity has been completed. A document, HW-32346, by J. R. Triplett was found which discusses these solutions along lines similar to those being investigated. The forms of his solutions, with minor modifications, are appropriate for the present purposes.

At the present time, variational principle solutions to the critical equation for a system of similar interacting fissionable regions are being studied.

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

The age measurement facility has been dismantled and removed from the 325 Building. The counting equipment has been set up in the 326 Building for the weight standardizations of the indium foils by irradiations in the standard pile. The standardization of the final set of foils has been completed and the relative efficiencies of the proportional counters have been determined. An earlier set of indium foils is being recalibrated in an attempt to recover some data taken during the time that the foils were damaged.

Mass Spectrometry - C. R. Lagergren and W. J. Friesen

The progress toward putting the mass spectrometer for this program into operation has been confined to debugging the electronic instrumentation. A new kovar to glass seal is being fabricated in the glass shop and work on the source vacuum lock has been suspended until this seal is finished.

DECLASSIFIED

HW-58485

-15-

CROSS SECTION PROGRAM

Slow Neutron Scattering Cross Sections - J. H. McCrary and B. R. Leonard, Jr.

Water

An energy analysis has been made of the quasi-elastic scattering component of 0.096 ev incident neutrons scattered at angles of 5, 10, and 20 degrees from a room temperature water sample. No structure of this component was measurable. The scattering of 0.24 ev neutrons was also studied at several scattering angles. The neutrons scattered from the 0.20 ev molecular vibrational level could not be detected. In addition, the quasi-elastic component could not be clearly distinguished from background.

Zr Hydride

Several attempts were made to find the neutrons scattered from the optical level at about 0.12 ev in Zr hydride. The cross section for scattering from this level was apparently below the present detectable limit of the spectrometer.

Subthreshold Fission - B. R. Leonard, Jr. and S. J. Friesenhahn

Data have been taken with improved precision through the 0.3 ev fission resonance in Am^{241} . The analysis of these data is incomplete at present. The Be crystal was realigned on the $[1011]$ planes so that data could be taken at energies below 0.1 ev with order corrections. The accumulation of these data is about fifty percent complete.

Fast Neutron Cross Sections - J. T. Russell

A study was made of several 6810A multiplier phototubes to select the best tubes for use. Different types of optical coupling and light reflectors were also studied. An improvement in pulse height of about thirty percent was achieved from these tests. No difference was detectable between the performance of two phosphor types, "Scintillion" and "Pilot B", with the multipliers used.

The new R. F. generator to supply a higher charged particle beam sweeping voltage has been completed and installed at the Van de Graaff accelerator. The adjustment of the generator has not been completed.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Correlation of Data on Heavy Water Moderated Cluster Lattices - J. R. Lilley

In order to define the effects of the central cell containing can on the measurements of k_{∞} in the PCFR, work was done to look at the problem of

DECLASSIFIED

HW-58485

-16-

running a core flux distribution with VALPROD, an IBM-650 program. Although many AEC sites have had good success in duplicating experimental traverses and critical conditions using three neutron group methods, no tables of cross sections have been found. A table of cross sections has now been compiled from the work of others and from fundamental data.

Nuclear Safety in Processing PRTR Fuel Elements - N. Ketzlach

A study was made of the nuclear safety considerations in loading chopped up PRTR fuel elements (Pu-Al alloy containing 1.8 percent Pu by weight) in the present slug buckets. The study was made in the same manner as that for the MTR fuel elements. For the case of the 1.8 percent Pu-Al alloy, the critical masses for the homogeneous cases are also less than the heterogeneous cases.

It is felt that the results of the homogeneous study should be used at the present time. This study indicates that a single slug bucket (16" x 16" x 17") will be subcritical when filled with 1.8 percent Pu-Al fuel elements. However, an array of these buckets will be safe under water when separated by at least 12 inches of water. In air a single plane array of these buckets will be safe with a 48-inch spacing between buckets. Before a decision is made as to the amount of fuel that can be placed in these buckets, a study should be made to determine the type and size of dissolver to be used. Needless to say, there is no point in filling the buckets if the amount of fuel will not be safe in the dissolver. When a sufficient number of fuel elements become available, plans are to measure the critical mass by means of multiplication measurements to verify the theory used.

Gas Cooled Reactor Program - T. J. Oakes

Working drawings were presented to Tech Shops and estimates were made for fabricating the PCTR core loading. Tech Shops is scheduled to begin work during the first week in December and the presently accepted delivery time of the completed core assembly is March 1, 1959. Further planning for the experimental portion of this program will continue. Assuming that we receive all materials from ACF by January 15, 1959, the first phase of the experimental program could begin, on or about, March 15, 1959.

Theoretical PCTR Studies In Support of the Gas Cooled Reactor Experiment - J. R. Worden and J. L. Carter

The small source theory analysis of the control rod worth in the GCR lattice is continuing. The lattice sums of exponential integrals have been examined and have proved more complicated than the corresponding K_0 sums. The method to be used in handling these sums in the future cumbersome manipulations is still undecided.

WASHINGTON DESIGNATED PROGRAM - C. R. Lagergren and W. J. Friesen

The triple filament surface emission ion source was installed in the mass spectrometer for this program. Ion currents of the order of 10^{-10} amperes

HW-58485
DECLASSIFIED

-17-

were detected at the collector from an 80 μgm sample of natural uranium. The detection efficiency of the system is expected to be of the order of 10^{-19} amperes when ion pulse counting detection is employed. The observed detection sensitivity with current detection indicates that the over-all sensitivity with ion pulse counting will be in the desired range.

Further studies were made of the shape and intensity profile of the ion beam. The beam was found to have a curvature which gave a deviation of about 0.006 inches from a straight line over a 5/8-inch wide beam. This would imply a resolving power about two thirds of the theoretical value for the slit geometry studied. The intensity profile of the beam appears to be dependent on the manner in which the sample is loaded. Variations of intensity along the width of the beam of a factor of three or four were observed.

The factors influencing the stability of the ion source potentials were studied. The AC component of the output voltage of the high power supply could be adjusted to within the tolerance required. Leakage currents across the source electrode insulators were eliminated by replacing the metal and Pyrex supports by quartz pieces. Electrical breakdowns also occur at the glass to metal seals in the source region. These have been improved by extensive cleaning and vacuum baking but have not been eliminated.

The ion counting system components were returned from the instrument fabrication shop and have again been debugged. This instrumentation is nearly ready for operation.

SERVICE ITEMS

Computational Programs and Services - D. D. Matsumoto

Experience in programming for the 709 continues to be acquired. Most of the month was spent in writing a SCAT program to translate data from a 702 tape to a 709 tape. Rewriting is still in progress. The remainder of the month was spent in writing plugboard subroutines for the 650 Simulator program and in becoming familiar with this program. This 650 Simulator program has been prepared elsewhere and is written for the 704. Thus, to run 650 programs on the 709, both the 650 Simulator and the 704 Compatibility Package must be used.

PCTR Operations - H. A. Fowler

Operation of the PCTR continued routinely during the month. There were two unscheduled shutdowns; one was due to electronic failure and the other to faulty bypassing technique. A two-day outage was taken for maintenance.

The three percent enriched $\text{UO}_2\text{-H}_2\text{O}$ k_{∞} measurements were completed during the month and the close packed natural uranium lattice experiments was started.

The 305-B annex was completed, accepted, and turned over for occupancy November 25, 1958. Benches and equipment were ordered for the new building, and a work order was issued to move furniture and equipment into the building.

-18-

DECLASSIFIED

TTR Operation - W. P. Stinson

Critical mass experiments were conducted during the first week of November.

Eight runs were made in the TTR hot thermal column for the Lattice Neutron Temperature Experiment.

Two unscheduled scrams occurred; one was due to a switching transit in Channel 3 level and the other was caused by the reactor room door limit switch.

PAPERS FOR PUBLICATIONAccepted

"High Resolution Clock Aids Fast Neutron Research" - H. W. Lefevre and J. T. Russell. For publication in Electronics.

Published

"Variation of Graphite Diffusion Length with Temperature" - R. C. Lloyd, E. D. Clayton, and C. R. Richey. Nuclear Science and Engineering, Volume 4, Number 5, November 1958.

Submitted

"Bases for Establishing Nuclear Safety Criteria" - N. Ketzlach. This paper has been tentatively accepted for presentation at the 1959 Nuclear Congress, Cleveland, Ohio, April 5 - 10, 1959.

PAPERS FOR PRESENTATIONPresented

"Criticality of Plutonium Solutions and Low U²³⁵ Enrichment Fuels" - N. Ketzlach. This paper was given at the United Kingdom Criticality Meeting at ORNL, November 12 - 14, 1958.

INFORMAL REPORTS PUBLISHED

HW-58135 "Nuclear Physics Research Operation Monthly Report - October 1958"

HW-58234 "Information on Graphite Bars Sent to France" - Letter to H. Hering from E. Z. Block, November 20, 1958.

HW-57853 "Buckling Measurements of Fuel Elements in Random Arrays" - R. C. Lloyd Unclassified.

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