URANIUM-WATER LATTICE COMPILATION PART I, BNL EXPONENTIAL ASSEMBLIES

GLENN A. PRICE

December 30, 1966

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UPTON, NEW YORK 11973**

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TABLE OF CONTENTS

	<u>Page No.</u>
I. Introduction	1
II. Cadmium Ratios and Initial Conversion Ratios	2
III. Thermal Disadvantage Factor, ζ_{Dy}	7
IV. Fast-to-Thermal Fission Ratio, δ_{25}^{28}	8
V. Buckling	10
VI. Acknowledgements	16
VII. Bibliography	17
 Table I. (Cd Ratio) $_{28}^a$ and ρ_{28}^a	 26
II. (Cd Ratio) $_{25}^f$ and ρ_{25}^f	28
III. (Cd Ratio) $_{Au}^a$	30
IV. Initial Conversion Ratio, ICR	31
V. Thermal Disadvantage Factor, ζ^{Dy}	32
VI. Fast Disadvantage Factor, ζ^{02}	35
VII. Fast-to-Thermal Fission Ratio, δ_{25}^{28}	36
VIII. Isotopic Compositions.	39
IX. Synopsis of Lattice Data Sheets.	40
 <u>Lattice Data Sheets</u>	 41

Table of Contents -2

	<u>Page No.</u>
Appendix A. " ρ_{28} Measurements," by R. Sher and E. V. Weinstock. (47)	216
Appendix B. " ρ_{28} Measurements of Light Water Lattices with Natural Uranium Foils," by H. R. Lutz and Y. Hachiya. (65)	222
Appendix C. "Dysprosium Disadvantage Factor, 1.143% Enriched 0.387 in. Diameter Uranium Metal in Light Water," by W. Tunney. (70)	227
Appendix D. "The Experimental Determination of Fast Fission Factor in Light Water-Moderated, Slightly Enriched Uranium Rod Lattices," by Enis Erdik. (44)	242
Appendix E. "Variable Loading Analysis of the 3% $U^{233}O_2$ - ThO_2 Lattices for Material Buckling," by Henry Windsor. (94)	263

I. Introduction

Numerous exponential experiments with uniform uranium-water lattices have been performed which provide a basis for the evaluation and improvement of theoretical techniques and integral neutron cross sections. The data from these experiments have appeared variously in informal memos, BNL reports, technical journals, ANS transactions, AEC publications, IAEA proceedings, and United Nations conferences. According to the fashion of the time they have been compared with the four factor formula, single, few and multigroup theories, age and age-diffusion theories, and other models which require the use of high speed computing machines. In some cases the experimental data have been interpreted in terms of a particular theoretical model and reported in such a manner that it is difficult to compare with other models. The purpose of this compilation is to present all the basic data from the BNL exponential experiments with the lattice specifications in a concise and uniform manner. In this form they should be more readily amenable to the further development of theoretical models and neutron cross section libraries which are essential for the design of power reactors.

The careful reader may detect discrepancies between some of the data in this compilation and the corresponding data in earlier reports. For the most part, these differences reflect a re-evaluation of the original data. In the author's opinion, the data

in this compilation are the best which are available from those experiments, and should take precedence over previously published values.

The bibliography includes reports with "RP-" numbers, which are catalogue numbers in the files of the Experimental Reactor Physics Group. Although the informal memoranda were not intended for general distribution, they are available upon request to anyone who desires them. In many cases the data have been published in several reports; however, it is not feasible to indicate the source of each data point in the compilation. Consequently, only typical references are indicated in the tables and data sheets, while a complete list of references is included in the bibliography.

A few of the original reports have been attached as appendices to this report. They describe in some detail the techniques used in measuring the various parameters, thus avoiding distortion or error by a re-write in this compilation.

II. Cadmium Ratios and Initial Conversion Ratios

Measurements of $(\text{Cd Ratio})_{28}^a$, $(\text{Cd Ratio})_{25}^f$, and $(\text{Cd Ratio})_{\text{Au}}^a$ are especially important in evaluating the conversion ratio in a reactor, or the rate at which Pu-239 atoms are formed in comparison to the rate at which U-235 atoms are destroyed. The superscripts "a" and "f" refer to absorption and fission, respectively, while subscripts "28", "25", and "Au" refer to the detecting

isotopes U-238, U-235, and gold. In addition, cadmium ratios can be interpreted as spectral indices, since they are sensitive to the ratio of total to epi-cadmium neutron fluxes.

It is sometimes convenient to consider the ratio of epi-cadmium to sub-cadmium reaction rates, in which case the symbol ρ is used. Thus, ρ_{28}^a is defined as the ratio of epi-cadmium to sub-cadmium absorption rates in U-238, and ρ_{25}^f is the ratio of epi-cadmium to sub-cadmium fission rates in U-235. (In other reports the symbol δ_{25} is frequently used to denote the later quantity.)

The nature of resonance capture in heterogeneous assemblies presents more obstacles to precise measurements than do any other standard neutronic measurements. Consequently, many different techniques have been developed, and variations on variations have been tried to improve the state of our knowledge in this area. The data tabulated in Tables I, IV, V, and VI represents the accumulated effort of many researchers at BNL using different techniques on an assortment of uranium-water lattices. In general, the probable errors in these data reflect random errors such as counting statistics, etc., and are not indicative of systematic errors which may be introduced by specific techniques. A few comments on the measurements will be made here, but the interested reader is encouraged to read the references in the tables and bibliography to get more detailed information. Two references are included as appendices to this report for convenience.

FIG. 1 ARRANGEMENT FOR THE CR_{28} MEASUREMENTS

All of the data in Table I were obtained by the so-called cadmium pill box method. A typical experimental set-up in Fig. (1) shows two adjacent fuel rods in a lattice each with uranium foils for the detection of neutron captures in uranium-238, one rod incorporating a cadmium pill box while the other rod does not. The uranium foil may be either natural or depleted, and if the fuel is an oxide, it may be a UO_2 pellet. After exposure for an appropriate time in a lattice, the uranium foils are removed and the intensity of either the U-239 or Np-239 is measured by beta or gamma detectors. From the observed $(Cd\ Ratio)_{28}^a$, one can obtain ρ_{28}^a from the relationship.

$$\rho_{28}^a = \frac{1}{(Cd\ Ratio)_{28}^a - 1}$$

Experience has showed that some of the factors which may discompose the measurement are: 1) spatial and spectral distortion of the neutron flux by cadmium pill box; 2) mis-alignment of the uranium foils and fuel rods or buttons; 3) moderation of neutrons by the fuel buttons; 4) contamination of U-239 or Np-239 activities by fission product activity; 5) neutron streaming through the aluminum catchers; and 6) preferential counting of either surface or volume induced activity in the uranium foil. In addition, there appears to be a considerable uncertainty in the actual thickness of cadmium used since the quoted values in some cases contain large uncertainties and in other cases no value is available.

Appendix A summarizes some of ρ_{28}^a measurements. In addition to those measurements by the cadmium pill box technique, it includes two cases in which the thermal activation technique is utilized. Uranium-238 and dysprosium activations are done in a lattice and in a thermal neutron flux to obtain a value of ρ_{28}^a which by-passes the necessity of using cadmium in the lattice. The comparison of results by the two methods in Table III of Appendix A indicates the two methods to be comparable, although it has been found that the thermal activation method is preferable in those cases where the cadmium ratio approaches unity. The BNL lattices are, for the most part, well moderated, having values of $(\text{Cd Ratio})_{28}^a$ high enough so that the cadmium pill box method

is generally preferable, despite its inherent disadvantages.

Lutz, in Appendix B, shows a variation in observed ρ_{28}^a values which is correlated with whether or not the uranium foil is dissolved before counting. The implication of these results is that preferential counting of the surface-induced activity of the uranium foil may adversely affect the observed value of ρ_{28}^a .

Tassan^(41, 66), Girard⁽³⁹⁾, and Kouts and Sher⁽³²⁾ have showed that the initial conversion ratio, ICR, can be deduced from ρ_{28}^2 , ρ_{25}^f , ρ_{25}^a , and ρ_{Au}^a . Table VI gives their results for 20 lattices. In all cases the cadmium pill box technique was used to measure the ρ 's, and certain assumptions about ν_{25} , σ_{28} , α_{25} , and η_{25} were required to compute the initial conversion ratio. No attempt will be made at this time to compare the relative merits of initial conversion ratio measurements.

In conclusion, the resonance capture measurements in lattices appear to be the least well-defined of the microscopic parameters. There are a large variety of techniques which have been developed for this purpose. However, because of the sensitivity to many small effects, there have not yet been definitive measurements on all of the lattices of interest. Since these measurements are related directly to conversion ratios and breeding gains, and because of wide-spread interest in these areas, a comprehensive review of resonance capture techniques and measurements would be desirable.

III. Thermal Disadvantage Factor ζ^{Dy}

The thermal disadvantage factor ζ^{Dy} , is defined as the ratio of the average neutron absorption rate of Dy in the moderator to that in the fuel, averages being taken over a typical cell region. Measurements are accomplished by irradiating small dysprosium foils in the fuel rod and in the water. From the foil activations, appropriate averages are computed to yield the values of ζ^{Dy} which are given in Table II. Plots of detailed activation rates are usually given in the original references, whereas it was expedient to omit them from this compilation.

Details of the techniques involved in measuring ζ^{Dy} are given in Appendix C. This particular series of measurements is undoubtedly superior to the others, since especial care was taken to avoid systematic errors such as foil irregularities, fission product contamination, Dy half-life, and flux perturbations due to support structure. Early experiments at BNL used mixtures of dysprosium oxide and polyethylene. However, it was found that foils of aluminum-dysprosium alloy (5% Dy) were much more durable and uniform, and consequently have been used in all measurements since 1959.

The first measurements on 0.600" diameter rods made use of aluminum plates in the water to support the foils. That series was repeated, using Lucite support plates, when it was found that

aluminum plates distorted the neutron flux distribution appreciably. As a result, values ζ^{DY} published in the 1955 Geneva Conference Proceedings⁽²⁷⁾ should be disregarded.

Tunney, in Appendix C, shows that even thin lucite support plates distort the neutron flux somewhat. Their effect is eliminated, however, by a series of measurements with varying thicknesses of Lucite and ultimately extrapolating the data to zero thickness of Lucite.

The fast disadvantage factor ζ_f^{02} , is similar to the thermal disadvantage factor, except that it is an indication of the ratio of fast neutron fluxes in the moderator and in the fuel. Table VI gives the result of a single case in which fission rates in thorium foils were used to detect the fast neutron flux. A single circular foil in the fuel rod and a sector foil in the water were used to obtain average fission rates in the two regions. It is interesting to note that ζ_f^{02} is less than unity, indicating that the fast neutron flux is a maximum in the fuel rod and is a minimum in the moderator.

IV. Fast-to-Thermal Fission Ratio, δ_{25}^{28}

The term, "fast-to-thermal fission ratio," is somewhat misleading since δ_{25}^{28} is actually the ratio of fissions in U-238 to fission in U-235. Nevertheless, since U-238 is fissioned only by

fast neutrons, and U-235 in these lattices is fissioned predominately by thermal neutrons the nomenclature has been adopted with some reservations. Values of δ_{25}^{28} are of particular interest to reactor designers because they represent the direct utilization of uranium-238 by fission. They have frequently been used to compute fast fission effects, ϵ , in the four factor formula. However, values of ϵ have not been included in this compilation since their interpretation is model dependent.

A fission catcher technique has been used at BNL to measure δ_{25}^{28} , usually in the "miniature lattice" facility where the neutron spectrum should approximate the spectrum of a larger assembly. A lattice approximately 1 ft. in diameter and 18 in. high is irradiated by neutron flux in a tunnel which runs under the Brookhaven Graphite Reactor. The details are described in Appendix D. Aluminum foils adjacent to sections of a central fuel rod and to a depleted U-238 foil catch fission fragments emitted from the surface of the uranium. By counting the β activity of the fission products one can deduce the ratio of U-238 fissions to U-235 fissions.

Since the distribution of fission products from the two isotopes is not the same, it is necessary to relate fission product activity ratios to fission ratios. This procedure has been done by means of a double fission counter described in Appendix D. It should be noted that fission product activities depend upon

irradiation time, decay time, and mode of counting. Consequently, the correlation factor, $K(t)$, must be determined with the same timing and counting techniques that are used for the lattice exposures.

Values of δ_{25}^{28} are tabulated in Table VI. In addition to lattice measurements there are several single rod measurements in which isolated rods were irradiated in the reflector of the Brookhaven Graphite Reactor.

V. Buckling

Material buckling is a unique parameter because it is characteristic of infinite medium conditions and it also establishes the critical size of a reactor. Exponential experiments are predicated upon the premise that the Laplacian, or buckling, of the steady state neutron flux is independent of the size of the assembly. Although there may be exceptions to this premise for very small assemblies with high leakage probabilities, it is reasonably valid in the range of bucklings which includes most of the lattices in this compilation.

A. Flux Shape

In exponential experiments the buckling, B_m^2 can be found by measuring the Laplacian of the neutron flux along the principle axes of a sub-critical assembly, using an external source of

neutrons. If an internal neutron source exists, such as spontaneous fission, γ -n and γ -f reactions, its effect on the buckling measurement can be eliminated by a subtraction technique. This is usually done by means of a cadmium or boron shutter between the assembly and the external neutron source.

Although the presence of spurious sources has long been recognized in heavy water experiments, they have usually been ignored in light water experiments. However, in the BNL experiment with UO_2 rods in light water, some anomalies in the results at short relaxation lengths revealed the presence of a spurious neutron source. Although of quite weak intensity, it was sufficient to increase the apparent buckling by as much as 5 m^{-2} when the relaxation length along the "z" axis was less than $\sim 10 \text{ cm}$. This spurious source is attributed to high energy gammas which originate in the thermal column and surrounding shield walls. These gammas have sufficient energy ($>8 \text{ mev}$) to generate neutrons in the uranium of the lattice by either γ -n or γ -f reactions. Some probing with gold foils, using the $\text{Au} (\gamma, \text{n})$ reaction, has substantiated this hypothesis. Gold foils were used because the thresholds and cross sections for photoneutron reactions in gold and uranium are comparable. A bismuth filter was subsequently installed in the thermal column to reduce the gamma radiation, and a cadmium shutter was installed so that the remaining spurious

source could be eliminated by the usual subtraction technique. In this technique, indium foils are activated in the assembly first with the shutter in and then out. The difference in the foil activations is attributed to thermal neutrons entering the assembly from the graphite thermal column. In addition, the minimum relaxation length which is suitable for buckling determination was set at 10 cm. in order to minimize the spurious source effect. Although the data in this compilation includes some lattices with relaxation lengths less than 10 cm., those data were not included in computing the quoted bucklings.

B. Variable Loading

A second method for measuring the material buckling in an exponential assembly is known as the "variable loading" method, and is described in detail in Appendix E. The data consists of measured relaxation lengths, ℓ , as a function of the core radius, r . If two or more such data points are available, it is possible to solve for the material buckling, B_m^2 , and reflector savings, λ , from the following equation for buckling in cylindrical geometry:

$$B_m^2 = \left(\frac{2.4048}{r+\lambda} \right)^2 - \frac{1}{\ell^2}$$

There is considerable evidence from both theoretical and experimental considerations that the reflector savings should vary with the axial component of buckling, B_z^2 .⁽⁹⁴⁾ Consequently,

Windsor has analyzed some of the data in terms of a variable reflector savings of the form,

$$\lambda = \frac{\lambda_0}{\left(1 + M^2 B_z^2\right)^{\frac{1}{2}}} \frac{K_0 \left[\left(\frac{1}{M^2} + B_z^2 \right)^{\frac{1}{2}} r \right]}{K_1 \left[\left(\frac{1}{M^2} + B_z^2 \right)^{\frac{1}{2}} r \right]} + \Delta\lambda$$

where K_0 and K_1 are Bessel functions, λ_0 and M^2 are constants to be determined from the "variable loading" fit, and $\Delta\lambda$ is a small correction for having assumed a linear extrapolation of the flux at the core boundary.

There appears to be considerable improvement in the interpretation of the data when it is fitted to a variable reflector savings. Unfortunately, the range of l and r in some cases is not sufficiently large to allow a good fit to a variable reflector savings. In those cases a constant reflector savings is assumed, i.e. independent of core radius and relaxation length.

C. Boundary Effects

A mis-match between the flux shape of the neutron thermal column and the fundamental mode of the exponential assembly can generate spatial harmonics which could distort the evaluation of the basic buckling data. Calculations of higher harmonics in the BNL water lattices indicate that they have a negligible effect at distances greater than 30 cm. from the assembly-thermal column interface. Consequently, all relaxation length measurements were

done at distances greater than 30 cm. from the bottom of the lattice. Occasional experimental checks have shown this criteria to be valid.

In addition to spatial harmonics, there are also spectral distortions, or energy harmonics, which are encountered in exponential as well as critical experiments. These spectral distortions originate at the boundary of the core and reflector where there is an extreme change in neutron properties. R. L. Hellens⁽⁷⁴⁾ has shown that the transient effects on the neutron spectrum in some typical cases may exist for as far as 8 cm. into the core region. Inspection of quite a few radial flux traverses, using bare indium foils, verifies the fact that reflector effects can be observed at distances up to 8 cm. from the reflector. Therefore, as a general rule, radial flux traverses are limited to regions which are greater than 8 cm. from the reflector in order to minimize spectral distortions. The reflector savings, λ , is defined as the difference between the end point of the extrapolated neutron flux and the effective radius of the loaded core region, r . The latter can be computed from the formula,

$$R = A_0 \sqrt{N}$$

where N is the number of fuel rods and A_0 is a constant related to the lattice pitch such that πA_0^2 is the area of a single cell.

Some of the lattices in Table VIII-Lattice Data Sheets contain data which have been interpreted by both the "flux shape" and the "variable loading" techniques. Although efforts were taken to minimize spectral distortions, it may be that the spectrum in the central region of the assembly was not characteristic of the infinite medium spectrum. Such an effect might explain the differences in material buckling as determined by the two techniques.

VI. Acknowledgements

The author is particularly grateful to Herb Kouts who initiated the uranium-water lattice program at Brookhaven in 1951 and supervised the subsequent experiments. Credit for the conduct of the many measurements goes to the members of the Experimental Reactor Physics Group as well as numerous visitors from abroad.

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$$(\text{Cd Ratio})_{28}^a \text{ and } \rho_{28}^a$$
[illegible]

TABLE I Continued

Metal/ Oxide	Enrich- ment	Fuel Diameter (in.)	Fuel Density	Clad		Lattice Pitch (in.)	$\frac{V_{H_2O}}{V_{fuel}}$	(Cd Ratio) ₂₈ ^a	ρ_{28}^a	Cd Button	Cd Sleeve	Reference
				Material	O.D. (in.)	Thickness (in.)						
Th Metal	1.938% U-235	0.387"	11.70	Al	0.453	0.028	0.5674	1	2.08*	0.93**	(?)	(28)
							0.6244	1.5	2.33*	0.75**		
							0.6767	2	2.79*	0.56**		
							0.7706	3	3.50*	0.40**		
							0.8542	4	4.45*	0.29**		
Th Oxide	2.6343%	0.430"	6.836	Zirc.-2	0.499	0.0345	0.6269	1.0	1.725*	1.380**	.026"	***
							0.6767	1.4	2.078*	0.928**		
							0.7163	1.7	2.323*	0.754**		
							0.7706	2.2	2.647*	0.607**		
							0.8542	3.0	3.299*	0.435**		
							1.1720	6.8	5.887*	0.218**		
							1.3346	9.3	6.882*	0.170**		

* (Cd Ratio)₀₂^a

** ρ_{02}^a

*** Private Communication, Wm. Tunney to G. Price, 12/9/66.

TABLE II
(Cd Ratio)₂₅^f and ρ_{25} ^f

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad		Lattice Pitch (in.)	$\frac{V_{H_2O}}{V_{fuel}}$	(Cd Ratio) ₂₅ ^f	ρ_{25} ^f	Cd Button	Cd Sleeve	Reference	
				Material	O.D. (in.)								Thickness (in.)
Metal Rods <div>↓</div>	1.016%	0.600"	18.898	Al	0.666	0.028	0.8537	1	6.94	0.168	.017"-.025"	.015-.020	(32)
							0.9444	1.5	8.62	0.131			
							1.0273	2	12.82	0.085			
							1.1754	3	22.22	0.047			
							1.3070	4	31.25	0.033			
	1.143%	0.600"	18.920	Al	0.666	0.028	0.8537	1	5.75	0.211	↓	↓	↓
							0.9444	1.5	9.52	0.117			
							1.0273	2	12.20	0.089			
							1.1754	3	18.52	0.057			
							1.3070	4	25.00	0.042			
	1.299%	0.600"	18.898	Al	0.666	0.028	0.8537	1	4.83	0.261	↓	↓	↓
							0.9444	1.5	6.45	0.183			
							1.0273	2	8.55	0.132			
							1.1754	3	16.13	0.066			
							1.3070	4	20.83	0.050			
	1.016%	0.387"	18.898	Al	0.453	0.028	0.5674	1	5.17	0.24	(?)	(?)	(35)
							0.6244	1.5	11.42	0.096			
							0.7706	3	19.87	0.053			
							0.8542	4	28.03	0.037			
	1.143%	0.387"	18.920	Al	0.453	0.028	0.5674	1	5.55	0.22	↓	↓	↓
							0.6244	1.5	7.67	0.15			
							0.6767	2	11.00	0.10			
							0.7706	3	12.24	0.089			

TABLE II Continued

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad			Lattice Pitch (in.)	$\frac{V_{H_2O}}{V_{fuel}}$	(Cd Ratio) $_{25}^f$	ρ_{25}^f	Cd Button	Cd Sleeve	Reference
				Material	O.D. (in.)	Thickness							
Metal Rods <div>↓</div>	1.299%	0.387"	18.898	Al	0.453	0.028	0.5674	1	5.17	0.24	(?)	(?)	(35)
							0.6244	1.5	6.88	0.17			
							0.6767	2	9.33	0.12			
							0.7706	3	14.70	0.073			
							0.8542	4	20.23	0.052			
	1.016%	0.250"	18.898	Al	0.316	0.031	0.4190	1.5	8.14	0.14	.025"	.020"	(66)
							0.4516	2	11.53	0.095			
							0.5105	3	18.86	0.056			
							0.5633	4	21.00	0.050			
Metal Slabs	1.250%	0.122"	18.900	None	-	-	0.255	1.09	4.87	0.258±.001	(?)	(?)	(67)
							0.318	1.61	6.88	0.170			
							0.380	2.12	8.63	0.131			
							0.505	3.14	12.49	0.087			
							0.630	4.16	16.38	0.065			

TABLE III

Gold Cd Ratio, R

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad		Lattice Pitch (in.)	$\frac{V_{H_2O}}{V_{fuel}}$	R .0005"	R_o	Cd Button	Cd Sleeve	References	
				Material	O.D. (in.)								Thickness (in.)
Metal Rods <div>↓</div>	1.016%	0.600"	18.898	Al	0.666	0.028	0.8537	1	1.42	1.18	.017"-.022"	.015"	(32)
							0.9444	1.5	1.56	1.24			
							1.0273	2	1.74	1.32			
							1.1754	3	2.09	1.47			
							1.3070	4	2.28	1.55			
	1.016%	0.387"	18.898	Al	0.453	0.028	0.5674	1	1.35	1.15	~.020"	.015"	(35)
							0.6244	1.5	1.53	1.23			
							0.6767	2	1.72	1.31			
							0.7706	3	2.00	1.43			
							0.8542	4	2.76	1.76			
	1.143%	0.387"	18.920	Al	0.453	0.028	0.5674	1	1.42	1.21	0.020"	.015"	Data Book (35)
	1.016%	0.250"	18.898	Al	0.316	0.031	0.4516	2	1.63	1.27			
							0.5105	3	1.93	1.40			
							0.5633	4	2.37	1.59			
UO ₂ Rods	3.006%	0.441"	9.28	SS	0.499	0.029	0.6767	1.319	1.40±.01	1.20±.01	.023"	.015"	(53)
							0.7163	1.632	1.45±.01	1.23±.01			
							0.7706	2.091	1.63±.02	1.32±.01			
							0.8542	2.863	1.82±.02	1.41±.02			
							0.9707	4.071	2.07±.02	1.54±.02			

TABLE IV

Initial Conversion Ratio, ICR

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad			Lattice Pitch (in.)	V_{H_2O}/V_{Fuel}	ICR (32)	ICR (39)	ICR (66)
				Material	O.D. (in.)	Thickness					
Metal ↓	1.016%	0.600	18.898	Al	0.666	0.028	0.8537	1	1.012		0.965
							0.9444	1.5			0.750
							1.0273	2	0.730		0.709
							1.1754	3	0.674		0.651
							1.3070	4	0.610		0.592
	1.143%	0.600	18.920	Al	0.666	0.028	1.0273	2	0.715	0.51±.01	
							1.1754	3	0.646		
	1.299%	0.600	18.898	Al	0.666	0.028	0.9444	1.5	0.736		
							1.0273	2	0.616		
							1.1754	3	0.551		
							1.3070	4			
	1.299%	0.387	18.898	Al	0.453	0.028	0.5674	1			
							0.6244	1.5			
							0.6767	2			
							0.7706	3			
							0.8542	4			
	1.016%	0.250	18.898	Al	0.316	0.031	0.4190	1.5			1.14
							0.4516	2			1.06
							0.5105	3			0.83
							0.5633	4			0.75

TABLE V

Thermal Disadvantage Factor, ζ_{Dy}

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad			Lattice Pitch (in.)	$\frac{V_{H_2O}}{V_{Fuel}}$	ζ_{Dy}	References
				Material	O.D. (in.)	Thickness (in.)				
Metal Rods ↓	0.714%	1.100"		Al	1.25	0.035	1.779	1.488	1.718	(61)
	1.027%	0.750"	18.898	Al	0.810	0.030	1.1293 1.2371 1.4285 1.5977	1.334 1.834 2.834 3.834	1.505 1.566 1.573 1.701	(78)
	1.016%	0.600"	18.898	Al	0.666	0.028	0.8537 0.9444 1.0273 1.754 1.3070	1 1.5 2 3 4	1.278 1.321 1.355 1.447 1.519	(32)
	1.143%	0.600"	18.920	Al	0.666	0.028	0.8537 0.9444 1.0273 1.1754 1.3070	1 1.5 2 3 4	1.270 1.289 1.383 1.449 1.514	
	1.299%	0.600"	18.898	Al	0.666	0.028	0.8537 0.9444 1.0273 1.1754 1.3070	1 1.5 2 3 4	1.285 1.354 1.427 1.482 1.582	
	1.016%	0.387"	18.898	Al	0.453	0.028	0.5674 0.6244 0.6767 0.7706 0.8542	1 1.5 2 3 4	1.101 1.149 1.183 1.249 1.251	(61)

TABLE V Continued

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad			Lattice Pitch (in.)	$\frac{V_{H_2O}}{V_{Fuel}}$	ζDy	References
				Material	O.D. (in.)	Thickness (in.)				
Metal Rods ↓	1.143%	0.387"	18.920	Al	0.453	0.028	0.5674	1	1.205	(70)
							0.6244	1.5	1.209	
							0.6767	2	1.243	
							0.7706	3	1.274	
							0.8542	4	1.306	
	1.299%	0.387"	18.898	Al	0.453	0.028	0.5674	1	1.150	(61)
							0.6244	1.5	1.174	
							0.6767	2	1.222	
							0.7706	3	1.258	
							0.8542	4	1.303	
	1.016%	0.250"	18.898	Al	0.316	0.031	0.4190	1.5	1.105	↓
							0.4516	2	1.091	
							0.5105	3	1.114	
							0.5633	4	1.132	
	1.143%	0.250"	18.920	Al	0.316	0.031	0.4190	1.5	1.083	
							0.4516	2	1.087	
							0.5105	3	1.128	
							0.5633	4	1.146	
Metal Slabs	1.25%	0.122"	18.900	None	-	-	0.255	1.09	1.108	
							0.318	1.61	1.135	
							0.380	2.12	1.150	
							0.505	3.14	1.211	
							0.630	4.16	1.258	
UO ₂ Rods	3.006%	0.441"	9.28	SS	0.499	0.029	0.6767	1.319	1.213	(53)
							0.7163	1.632	1.249	
							0.7706	2.091	1.278	
							0.8542	2.863	1.326	
							0.9707	4.071	1.357	

TABLE V Continued

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad			Lattice Pitch (in.)	$\frac{V_{H_2O}}{V_{Fuel}}$	ζDy	References
				Material	O.D. (in.)	Thickness (in.)				
Th Metal Rods	1.938% U-235	0.387"	11.70	Al	0.453	0.028	0.5674	1	1.154	Th data book
							0.6244	1.5	1.206	
							0.6767	2	1.233	
							0.7706	3	1.214	
							0.8542	4	1.324	
Th Oxide Rods	2.6343% U-233	0.430"	6.836	Zirc.-2	0.499	0.0345	0.6269	1.0	1.219	(84)
							0.6767	1.4	1.257	
							0.7163	1.7	1.270	
							0.7706	2.2	1.302	
							0.8542	3.0	1.325	
							0.9707	4.3	1.379	
							1.1720	6.8	1.430	
							1.3346	9.3	1.447	
U Metal Rods	1.00% Pu	0.387"	18.9	Al	0.453	0.028	0.5674	1	1.258	Pu data
							0.6244	1.5	1.321	
							0.6767	2	1.306	
							0.7706	3	1.372	
							0.8542	4	1.398	

TABLE VI

Fast Disadvantage Factor, ϵ_f^{02}

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad			Lattice Pitch (in.)	V _{H₂O} /V _{fuel}	V _M ⁰² _f	References
				Material	O.D. (in.)	Thickness (in.)				
U Metal Rods	1.299%	0.600"	18.898	Al	0.666	0.028	1.3070	4	0.780	(75)

TABLE VII

Fast to Thermal Fission Ratio, δ_{25}^{28}

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad		Lattice Pitch (in.)	V _{H₂O} /V _{fuel}	δ ₂₅ ²⁸	References
				Material	O.D. (in.)				
Metal Rods <									

TABLE VII continued

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad			Lattice Pitch (in.)	V_{H_2O}/V_{fuel}	δ_{25}^{28}	References
				Material	O.D. (in.)	Thickness				
Metal Rods ↓	1.299%	0.387"	18.898	Al	0.453	0.028	0.5674	1	0.176	(44)
							0.6244	1.5	0.127	
							0.6767	2	0.108	
							0.7706	3	0.077	
							0.8542	4	0.066	
	1.016%	0.250"	18.898	Al	0.316	0.031	0.4190	1.5	0.129	(44)
							0.4516	2	0.102	
							0.5105	3	0.077	
							0.5633	4	0.066	
	1.143%	0.250"	18.920	Al	0.316	0.031	0.4190	1.5	0.126	(44)
							0.4516	2	0.103	
							0.5105	3	0.077	
							0.5633	4	0.061	
Metal Slabs	1.250%	0.122"	18.900	None	-	-	0.255	1.09	0.163	(67)
							0.318	1.61	0.128	
							0.380	2.12	0.102	
							0.505	3.14	0.077	
							0.630	4.16	0.064	
UO ₂ Rods	3.006%	0.441"	9.28	SS	0.499	0.029	0.6767	1.319	0.065	(53)
							0.7163	1.632	0.056	
							0.7706	2.091	0.048	
							0.8542	2.863	0.037	
							0.9707	4.071	0.031	
Th Metal Rods	2% U-235	0.387"	11.70	Al	0.453	0.028	0.5674	1	0.036	Th Data book
							0.6244	1.5	0.043	
							0.6767	2	0.026	
							0.7706	3	0.022	
							0.8542	4	0.012	

TABLE VII continued

Metal/Oxide	Enrichment	Fuel Diameter (in.)	Fuel Density	Clad			Lattice Pitch (in.)	V_{H_2O}/V_{fuel}	δ_{25}^{28}	References
				Material	O.D. (in.)	Thicknesses				
Metal Rods	1.027%	0.750"	18.898	Al	0.810	0.030	—	Single Rod Fast Effect	0.044	(42)
	1.016%	0.600"	18.898	Al	0.666	0.028			0.036	
	"	0.387"	18.898	Al	0.453	0.028			0.021	
	"	0.250"	18.898	Al	0.316	0.031			0.012	
	Nat. U	1.100"	18.79	Al	1.300	0.050			0.062	
	"	1.345"	18.92	Al	1.500	0.065			0.077	
	"	1.938"	18.92	Al	2.075	0.065			0.095	
	"	2.898"	18.92	Al	3.040	0.065			0.128	
	"	3.636"	18.92	SS	3.775	0.065			0.145	

TABLE VIII
Isotopic Compositions

Fuel	Rod Size (in.)	Weight Per Cent						O ₂	B	Pu
		Th	U-233	U-234	U-235	U-236	U-238			
U Metal	1.1			.0057	0.71		99.28			
"	.250 } .357 } .600 }			.0072	1.016	.0064	98.9704			
"	.750			.0072	1.027	.0064	98.9594		<.00004	
"	.250 } .387 } .600 }			.0077	1.143	.0002	98.8491			
"	.122"slab			.0073	1.2554	.0165	98.7208			
"	.387 } .600 }			.0084	1.299		98.6926			
U-Th Metal	.387	97.92		.0206	1.9383	.0081	.1129			
UO ₂	0.4441			.017	2.649	.017	85.41	11.9		
U ²³³ O ₂ -ThO ₂	0.430	85.1764	2.6343	.0394	.0012		.0289	12.1197	.00044	
U-Pu Metal	0.387				0.38		98.62			1.00

304 Stainless Steel

<u>Element</u>	<u>Wt. %</u>
Ni	10.21
Fe	69.80
Cr	18.07
Co	.0856
Mn	1.02

Zircaloy -2

<u>Element</u>	<u>Wt. %</u>
Zr	98.27
Sn	1.45
Cr	0.10
Fe	0.13
Ni	0.05

TABLE IX

Synopsis of Lattice Data Sheets

Enrichment	Rod Diameter	V_{H_2O}/V_{Fuel}	Pages
0.71% U-235 Metal	1.1 in.	1.5	26
1.016% "	0.250	1.5-4.0	27-42
1.016% "	0.387	1.0-4.0	43-47
1.016% "	0.600	1.0-4.0	48-52
1.027% "	0.750	1.3-3.8	53-70
1.143% "	0.250	1.5-4.0	71-88
1.143% "	0.387	1.0-4.0	89-109
1.143% "	0.600	1.0-4.0	110-124
1.25% "	0.122 in. slab	1.0-4.1	125-129
1.299% "	0.387	1.0-4.0	130-134
1.299% "	0.600	0.17-4.0	135-149
3.0% Oxide	0.444	1.3-4.0	150-169
2.6% $U^{233}O_2-ThO_2$	0.430	1.0-9.2	170-191
2.6% $U^{233}O_2-ThO_2$	0.430	3.0-120.4 (D_2O)	192-199

Exponential Experiment - Rod Lattice

Fuel <u>Nat. U metal</u>	Clad material <u>Al</u>
Enrichment <u>0.71%</u>	Clad O.D. (in.) <u>1.300</u>
Diameter (in.) <u>1.1"</u>	Clad thick. (in.) <u>.050</u>
Pitch (in.) <u>1.779</u>	Clad density <u>2.7</u>
A _o (cm.) <u>2.372</u>	Fuel density <u>18.7</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-25A</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(no. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
157	15.243		
187	16.382		
211	17.214		
241	17.984		
259	18.501		
284	19.242		
313	19.759		
337	20.567		
361	20.982		
385	21.674		
397	22.187	7.88 ± 0.23	-1.82 ± 0.30

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	-1.66 ± 0.28	
λ_o	(cm)	7.71 ± 0.28	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel _____	U metal	Clad material _____	Al
Enrichment _____	1.016%	Clad O.D. (in.) _____	0.316
Diameter (in.) _____	0.250"	Clad thick. (in.) _____	0.031
Pitch (in.) _____	0.4190	Clad density _____	2.7
A _o (cm.) _____	0.5588	Fuel density _____	18.898
V _{mod} /V _{fuel} _____	1.5	Moderator _____	H ₂ O
H ₃ BO ₃ (mg/ml) _____	0	Geometry _____	triangle
B ₂ O ₃ (mg/ml) _____	0	Reference _____	RP-188

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(no. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
793	10.568		
859	10.858		
913	11.084		
979	11.456		
1039	11.868		
1111	12.031		
1177	12.256		
1237	12.374		
1303	12.852		
1369	13.166		
1495	13.537		
1561	13.938		
1627	14.285		
1687	14.509		
1789	14.939	8.19 ± 0.12	12.29 ± 0.58

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	12.14 ± 1.03	
λ_o (cm)	8.05 ± 0.19	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4190</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.5588</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.442</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.249</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(no. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
835	10.606		
877	10.748		
925	10.858		
967	11.101		
1003	11.316		
1045	11.333		
1087	11.624		
1135	11.789		
1177	11.988		
1213	12.064		
1261	12.165		
1303	12.323		
1345	12.495		
1381	12.716		
1429	12.903		
1555	13.506		
1597	13.581		
1639	13.724		

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	7.54 ± 0.97	
λ _o	(cm)	8.15 ± 0.18	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4190</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.5588</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.822</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.463</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(no. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
763	9.977		
811	10.211		
859	10.341		
913	10.585		
955	10.898		
1003	11.089		
1057	11.175		
1099	11.537		
1147	11.591		
1201	11.720		
1249	11.888		
1297	12.184		
1345	12.343		
1393	12.614		
1441	12.494		
1483	12.700		
1573	13.025		
1627	13.252		
1675	13.507		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	5.23 ± 0.95	
λ _o (cm)	7.99 ± 0.17	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.016%	Clad O.D. (in.)	0.316
Diameter (in.)	0.250"	Clad thick. (in.)	0.031
Pitch (in.)	0.4190"	Clad density	2.7
A _o (cm.)	0.5588	Fuel density	18.898
V _{mod} /V _{fuel}	1.5	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	1.462	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.823	Reference	RP-188

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(no. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
931	10.339		
1003	10.730		
1039	10.703		
1075	10.764		
1111	10.977		
1147	11.166		
1189	11.176		
1225	11.340		
1261	11.466		
1297	11.669		
1333	11.693		
1369	11.888		
1471	12.037		
1507	12.120		
1543	12.441		
1585	12.478		
1615	12.638		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	-0.63 ± 1.36	
λ _o (cm)	7.89 ± 0.25	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4516</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.6023</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(no. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
913	12.396		
955	12.780		
991	12.956		
1027	13.245		
1069	13.427		
1099	13.540		
1135	14.023		
1177	14.040		
1213	14.307		
1261	14.574		
1297	14.741		
1333	14.797		
1357	14.937		
1405	15.218		
1441	15.428		
1483	15.674		
1519	15.884		
1555	16.095		
1597	16.342		
1639	16.589		
1675	16.801		
1711	17.014		
1777	17.407		
1825		7.46 ± .05	

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	19.95 ± 0.47	
λ _o (cm)	8.02 ± 0.11	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4516</u>	Clad density <u>2.7</u>
A _O (cm.) <u>0.6023</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.852</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.480</u>	Reference <u>RP-188</u>

N (no. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector savings, cm.)	B _m ² (flux shape) (Buckling, m ⁻²)
757	10.680		
805	11.011		
859	11.294		
901	11.533		
955	11.599		
1003	12.043		
1045	12.268		
1099	12.434		
1147	12.754		
1189	12.938		
1237	13.187		
1285	13.431		
1331	13.662		
1381	13.743		
1429	14.036		
1483	14.149		
1531	14.502		
1573	14.732		
1627	14.828		
1675	15.023		

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	11.15 ± 0.45	
λ _O	(cm)	7.77 ± 0.10	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4516</u>	Clad density <u>2.7</u>
A _O (cm.) <u>0.6023</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.302</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.733</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of Rods)	(relax. length)	(reflector savings, cm.)	(Buckling, m ⁻²)
823	10.755		
871	10.951		
913	11.134		
955	11.402		
991	11.546		
1039	11.763		
1123	12.145		
1165	12.128		
1201	12.482		
1249	12.746		
1285	13.027		
1333	13.136		
1369	13.180		
1417	13.317		
1459	13.667		
1495	13.789		
1543	13.747		
1585	14.016		
1627	14.357		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	8.69 ± 0.92	
λ _O (cm)	7.31 ± 0.18	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4516</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.6023</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.877</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.057</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(Buckling, m ⁻²)
847	10.575		
889	10.753		
931	10.921		
967	11.147		
1045	11.476		
1087	11.498		
1123	11.624		
1165	11.863		
1213	11.923		
1249	12.075		
1285	12.219		
1333	12.278		
1369	12.637		
1453	12.909		
1495	13.105		
1531	13.208		
1573	13.301		
1609	13.313		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	0.87 ± 0.99	
λ_o (cm)	7.75 ± 0.21	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel _____	U metal	Clad material _____	Al
Enrichment _____	1.016%	Clad O.D. (in.) _____	0.316
Diameter (in.) _____	0.250"	Clad thick. (in.) _____	0.031
Pitch (in.) _____	0.5105	Clad density _____	2.7
A _o (cm.) _____	0.6808	Fuel density _____	18.898
V _{mod} /V _{fuel} _____	3.0	Moderator _____	H ₂ O
H ₃ BO ₃ (mg/ml) _____	0	Geometry _____	triangle
B ₂ O ₃ (mg/ml) _____	0	Reference _____	RP-188

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav-	(buckling, m ⁻²)
661	12.166	ings, cm.)	
715	12.736		
769	13.065		
823	13.625		
877	14.151		
925	14.499		
979	14.875		
1039	15.359		
1087	15.903		
1135	16.278		
1189	16.800		
1249	17.260		
1297	17.796		
1357	18.405		
1405	18.788		
1459	19.479		
1507	19.916		
1561	20.813		
1615	21.245		
1675	21.724		
1723	22.212		
1765	22.612		
1789	22.983	7.76 ± .06	24.348 ± 0.19

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	25.15 ± 0.27	
λ_o (cm)	7.46 ± 0.08	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel _____	U metal	Clad material _____	Al
Enrichment _____	1.016%	Clad O.D. (in.) _____	0.316
Diameter (in.) _____	0.250"	Clad thick. (in.) _____	0.031
Pitch (in.) _____	0.5105	Clad density _____	2.7
A ₀ (cm.) _____	0.6808	Fuel density _____	18.898
V _{mod} /V _{fuel} _____	3.0	Moderator _____	H ₂ O
H ₃ BO ₃ (mg/ml) _____	0.667	Geometry _____	triangle
B ₂ O ₃ (mg/ml) _____	0.376	Reference _____	RP-188

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
571	10.471		
637	11.015		
691	11.376		
746	11.886		
805	12.224		
859	12.538		
925	13.014		
979	13.259		
1039	13.675		
1099	14.160		
1159	14.455		
1213	14.906		
1261	15.157		
1321	15.527		
1381	16.085		
1441	16.370		
1507	16.868		
1561	17.055		
1615	17.511		
1675	17.662		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	16.04 ± 0.32	
λ_0 (cm)	7.02 ± 0.08	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5105</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.6808</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.204</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.678</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(Buckling, m ⁻²)
625	10.399		
685	10.783		
733	11.069		
793	11.432		
847	11.839		
901	12.182		
1003	12.618		
1057	13.134		
1111	13.251		
1165	13.399		
1225	13.773		
1285	14.060		
1333	14.404		
1381	14.627		
1441	14.932		
1483	15.096		
1543	15.446		
1597	15.824		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	9.31 ± 0.49	
λ _o (cm)	6.84 ± 0.11	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5105</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.6808</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.825</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.028</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of Rods)	(relax. length)	(reflector savings, cm.)	(Buckling, m ⁻²)
673	10.224		
733	10.519		
781	10.747		
835	11.147		
889	11.274		
943	11.599		
991	11.602		
1045	12.089		
1099	12.265		
1147	12.418		
1201	12.662		
1249	12.723		
1303	13.161		
1357	13.393		
1405	13.567		
1459	13.754		
1507	13.972		
1561	14.233		
1615	14.439		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	1.57 ± 0.68	
λ_o (cm)	6.61 ± 0.15	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5633</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.7512</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(Buckling, m ⁻²)
640	12.685		
688	13.236		
748	13.650		
796	14.193		
850	14.675		
904	15.383		
958	15.736		
1006	16.255		
1060	16.827		
1114	17.475		
1168	17.949		
1216	18.238		
1264	18.847		
1324	19.640		
1383	20.325		
1431	20.700		
1484	21.240		
1532	21.890		
1586	22.442		
1640	23.022		
1687	23.872		
1747	24.283	7.98 ± 0.20	20.34 ± 0.43

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	22.07 ± 0.21	
λ_o (cm)	7.25 ± 0.07	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5633</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>0.7512</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.445</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.251</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of Rods)	(relax. length)	(reflector savings, cm.)	(Buckling, m ⁻²)
421	9.976		
487	10.515		
547	11.082		
613	11.592		
685	12.226		
745	12.554		
805	13.105		
871	13.657		
931	14.118		
1003	14.664		
1073	15.141		
1123	15.528		
1189	15.939		
1261	16.374		
1320	16.940		
1381	17.384		
1453	17.906		
1507	18.283		
1573	18.725		
1639	19.134		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	14.26 ± 0.16	
λ ₀ (cm)	6.98 ± 0.05	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5633</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.7512</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.919</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.518</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of Rods)	(relax. length)	(reflector savings, cm.)	(Buckling, m ⁻²)
523	10.330		
583	10.723		
649	11.189		
703	11.569		
769	11.885		
823	12.350		
889	12.567		
943	13.104		
1003	13.384		
1069	13.755		
1123	14.010		
1189	14.363		
1249	14.889		
1303	14.975		
1369	15.428		
1429	15.727		
1483	15.920		
1543	16.461		
1609	16.731		
1663	16.827		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	6.44 ± 0.35	
λ_o (cm)	6.71 ± 0.10	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.016%	Clad O.D. (in.)	0.316
Diameter (in.)	0.250"	Clad thick. (in.)	0.031
Pitch (in.)	0.5633	Clad density	2.7
A _o (cm.)	0.7512	Fuel density	18.898
V _{mod} /V _{fuel}	4.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	1.207	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.680	Reference	RP-188

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of Rods)	(relax. length)	(reflector savings, cm.)	(Buckling, m ⁻²)
625	10.709		
685	11.080		
733	11.333		
793	11.657		
901	12.290		
955	12.598		
1003	12.809		
1057	13.029		
1111	13.365		
1165	13.528		
1285	14.198		
1333	14.374		
1381	14.641		
1441	14.806		
1495	15.088		
1543	15.350		
1597	15.562		
1651	15.724		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	1.35 ± 0.23	
λ _o (cm)	6.70 ± 0.07	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.016%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.5674	Clad density	2.7
A ₀ (cm.)	0.7567	Fuel density	18.898
V _{mod} /V _{fuel}	1.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-64

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of Rods)	(relax. length)	(reflector savings, cm.)	(Buckling, m^{-2})
1039	14.162	8.61 $\pm$ 0.16	3.23 $\pm$ 0.80

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.6244</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.8327</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.50</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-64</u>

N (No. of Rods)	L (cm) (relax. length)	λ (flux shape) (reflector savings, cm.)	B_m^2 (flux shape) (Buckling, m ⁻²)
1045	18.994	8.00 $\pm$ 0.12	19.70 $\pm$ 0.34

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ_o (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.016%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.6767	Clad density	2.7
A ₀ (cm.)	0.9024	Fuel density	18.898
V _{mod} /V _{fuel}	2.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-64

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
1045	26.346	7.32 ± 0.12	29.02 ± 0.34

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.7706</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.0277</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-64</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
853	30.376		
1045	45.942	6.88 ± 0.12	31.39 ± 0.19

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_0 (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.016%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.8542	Clad density	2.7
A ₀ (cm.)	1.1392	Fuel density	18.898
V _{mod} /V _{fuel}	4.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-64

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
745	25.590		
1045	43.101	6.39 ± 0.20	25.68 ± 0.24

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.016%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	0.8537	Clad density	2.7
A _o (cm.)	1.1385	Fuel density	18.898
V _{mod} /V _{fuel}	1.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-14

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
463	15.272	8.76 ± 0.15	9.90 ± 0.54

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.016%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	0.9444	Clad density	2.7
A _o (cm.)	1.2594	Fuel density	18.898
V _{mod} /V _{fuel}	1.5	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-14

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
439	21.925	7.47 ± 0.133	29.63 ± 0.42

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.016%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	1.0273	Clad density	2.7
A ₀ (cm.)	1.370	Fuel density	18.898
V _{mod} /V _{fuel}	2.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-14

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
439	$33.014 \pm .121$	7.04 ± 0.15	36.07 ± 0.39

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.016%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	1.1754	Clad density	2.7
A _o (cm.)	1.5675	Fuel density	18.898
V _{mod} /V _{fuel}	3.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-14

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
439	$48.934 \pm .340$	6.51 ± 0.16	33.15 ± 0.31

Variable Loading Analysis		
	constant λ	variable λ
B_m^{-2} (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.016%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.3070</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.743</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-14</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
439	31.094	6.46 $\pm$ 0.17	20.96 $\pm$ 0.26

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_0 (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.027%	Clad O.D. (in.)	0.810
Diameter (in.)	0.750"	Clad thick. (in.)	0.030
Pitch (in.)	1.1293	Clad density	2.7
A ₀ (cm.)	1.506	Fuel density	18.898
V _{mod} /V _{fuel}	1.334	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-3

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
55	8.801		
73	9.665		
91	10.435		
109	11.282		
127	12.265		
145	13.164		
163	14.070		
181	15.011		
199	15.803		
217	16.728		
235	17.722		
253	18.612		
271	19.676		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	28.9 ± 0.5	
λ ₀ (cm)	7.71 ± 0.14	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.027%	Clad O.D. (in.)	0.810
Diameter (in.)	0.750"	Clad thick. (in.)	0.030
Pitch (in.)	1.1293	Clad density	2.7
A ₀ (cm.)	1.506	Fuel density	18.898
V _{mod} /V _{fuel}	1.334	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0.742	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.418	Reference	RP-3

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
121	11.430		
157	12.735		
193	14.213		
229	15.686		
262	16.898		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	21.64 ± 0.82	
λ ₀ (cm)	7.61 ± 0.18	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.1293</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.506</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.334</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.932</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.088</u>	Reference <u>RP-3</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
121	10.828		
157	11.710		
193	12.823		
229	13.879		
263	14.960		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	11.07 ± 2.17	
λ_o (cm)	7.61 ± 0.46	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.1293</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.506</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.334</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.952</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.662</u>	Reference <u>RP-3</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
175	11.710		
193	12.121		
211	12.538		
229	12.976		
263	13.677		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	2.43 ± 0.50	
λ ₀ (cm)	7.75 ± 0.12	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.027%	Clad O.D. (in.)	0.810
Diameter (in.)	0.750"	Clad thick. (in.)	0.030
Pitch (in.)	1.183	Clad density	2.7
A _o (cm.)	1.5776	Fuel density	18.898
V _{mod} /V _{fuel}	1.584	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-3

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
73	10.021		
91	11.052		
109	12.102		
127	13.090		
145	14.230		
163	15.226		
181	16.454		
199	17.705		
217	18.784		
235	20.339		
253	22.051		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	34.70 ± 0.30	
λ _o (cm)	7.16 ± 0.10	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.2371</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.6498</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.834</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-3</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
109	13.028		
127	14.329		
145	15.007		
163	16.781		
169	16.815		
181	18.252		
199	19.621		
217	21.530		
235	23.685		
253	26.247		
265	27.297		
271	29.087		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	37.5 ± 0.8	
λ_{O} (cm)	6.94 ± 0.23	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.027%	Clad O.D. (in.)	0.810
Diameter (in.)	0.750"	Clad thick. (in.)	0.030
Pitch (in.)	1.2371	Clad density	2.7
A _o (cm.)	1.6498	Fuel density	18.898
V _{mod} /V _{fuel}	1.834	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	1.232	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.694	Reference	RP-3

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
121	12.085		
157	13.597		
193	15.288		
229	16.750		
265	18.744		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	20.45 ± 0.26	
λ _o (cm)	7.45 ± 0.67	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.2371</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.6498</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.834</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.025</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.140</u>	Reference <u>RP-3</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
121	11.205		
157	12.568		
193	13.899		
229	14.867		
265	16.367		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	12.72 ± 3.14	
λ ₀ (cm)	7.11 ± 0.78	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.027%	Clad O.D. (in.)	0.810
Diameter (in.)	0.750"	Clad thick. (in.)	0.030
Pitch (in.)	1.2371	Clad density	2.7
A ₀ (cm.)	1.6498	Fuel density	18.898
V _{mod} /V _{fuel}	1.834	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	2.829	Geometry	triangle
B ₂ O ₃ (mg/ml)	1.593	Reference	RP-3

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
121	10.850		
157	11.848		
193	12.862		
229	13.902		
265	14.700		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	3.26 ± 0.94	
λ ₀ (cm)	7.32 ± 0.22	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.027%	Clad O.D. (in.)	0.810
Diameter (in.)	0.750"	Clad thick. (in.)	0.030
Pitch (in.)	1.336	Clad density	2.7
A _o (cm.)	1.7817	Fuel density	18.898
V _{mod} /V _{fuel}	2.334	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-3

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
73	11.088		
91	12.370		
109	13.862		
127	15.232		
145	16.908		
163	18.602		
181	20.509		
199	22.824		
217	24.899		
235	27.945		
245	30.246		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	36.73 ± 0.48	
λ_o (cm)	6.90 ± 0.16	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.4285</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.9050</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.834</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-3</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
55	9.933		
91	13.006		
127	15.918		
145	17.482		
163	19.492		
181	21.498		
199	23.711		
217	26.224		
235	29.454		
253	33.514		
265	36.710	6.65 ± 0.50	33.35 ± 1.13

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	32.88 ± 0.18	
λ_0 (cm)	6.95 ± 0.11	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.4285</u>	Clad density <u>2.7</u>
A _O (cm.) <u>1.9050</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.834</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.597</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.336</u>	Reference <u>RP-3</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav-ings, cm.)	(buckling, m ⁻²)
121	13.579		
157	15.767		
193	17.794		
229	19.978		
263	22.519		

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	20.86 ± 0.52	
λ _O	(cm)	6.79 ± 0.20	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.4285</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.905</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.834</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.185</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.667</u>	Reference <u>RP-3</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
121	12.225		
157	13.910		
193	15.467		
229	16.825		
263	18.128		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	11.37 ± 0.57	
λ_o (cm)	6.37 ± 0.19	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.027%	Clad O.D. (in.)	0.810
Diameter (in.)	0.750"	Clad thick. (in.)	0.030
Pitch (in.)	1.4285	Clad density	2.7
A _o (cm.)	1.9050	Fuel density	18.898
V _{mod} /V _{fuel}	2.834	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	1.758	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.990	Reference	RP-3

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector savings, cm.)	B_m^2 (flux shape) (buckling, m^{-2})
121	11.582		
157	12.794		
193	13.874		
229	14.856		
263	15.659		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	0.19 $\pm$ 0.49	
λ_o (cm)	6.59 $\pm$ 0.17	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.5977</u>	Clad density <u>2.7</u>
A _o (cm.) <u>2.1307</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.834</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-3</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
109	13.936		
145	16.126		
163	16.950		
181	18.799		
199	20.246		
217	21.352		
235	22.717		
253	23.845		
267	25.183		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	18.6 ± 0.60	
λ_o (cm)	6.42 ± 0.22	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.5977</u>	Clad density <u>2.7</u>
A _o (cm.) <u>2.1307</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.834</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.254</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.143</u>	Reference <u>RP-3</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
121	13.939		
157	16.010		
193	17.790		
265	21.287		

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	11.03 ± 0.50	
λ_o	(cm)	7.16 ± 0.24	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.5977</u>	Clad density <u>2.7</u>
A _o (cm.) <u>2.1307</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.834</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.501</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.282</u>	Reference <u>RP-3</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
121	13.202		
157	14.571		
193	16.203		
229	17.624		
265	18.895		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	5.96 ± 0.67	
λ_o (cm)	6.60 ± 0.30	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.027%</u>	Clad O.D. (in.) <u>0.810</u>
Diameter (in.) <u>0.750"</u>	Clad thick. (in.) <u>0.030</u>
Pitch (in.) <u>1.5977</u>	Clad density <u>2.7</u>
A _o (cm.) <u>2.1307</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.834</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.748</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.421</u>	Reference <u>RP-3</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
121	12.595		
157	13.745		
193	15.045		
229	16.187		
265	17.097		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	0.54 ± 0.70	
λ_o (cm)	6.81 ± 0.32	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.316
Diameter (in.)	0.250"	Clad thick. (in.)	0.031
Pitch (in.)	0.4190	Clad density	2.7
A _o (cm.)	0.5588	Fuel density	18.898
V _{mod} /V _{fuel}	1.5	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-188

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
913	11.8607		
967	12.298		
1015	12.428		
1057	12.749		
1111	12.986		
1159	13.315		
1201	13.452		
1249	13.841		
1297	14.351		
1345	14.264		
1393	14.479		
1441	14.744		
1495	15.140		
1543	15.493		
1682	16.176		
1969	17.948	8.488 $\pm$ 0.09	21.16 $\pm$ 0.38

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	19.93 $\pm$ 0.94	
λ_o (cm)	8.49 $\pm$ 0.18	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.316
Diameter (in.)	0.250"	Clad thick. (in.)	0.031
Pitch (in.)	0.4190	Clad density	2.7
A _o (cm.)	0.5558	Fuel density	18.898
V _{mod} /V _{fuel}	1.5	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	1.115	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.628	Reference	RP-188

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
943	11.102		
1015	11.594		
1087	12.011		
1159	12.405		
1225	12.594		
1297	12.799		
1369	13.178		
1441	13.613		
1507	13.850		
1585	14.021		
1651	14.362		
1723	14.683		
1801	14.851		
1855	15.230		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	15.90 ± 0.91	
λ_o (cm)	7.41 ± 0.17	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel _____	U metal	Clad material _____	Al
Enrichment _____	1.143%	Clad O.D. (in.) _____	0.316
Diameter (in.) _____	0.250"	Clad thick. (in.) _____	0.031
Pitch (in.) _____	0.4190	Clad density _____	2.7
A _o (cm.) _____	0.5588	Fuel density _____	18.898
V _{mod} /V _{fuel} _____	1.5	Moderator _____	H ₂ O
H ₃ BO ₃ (mg/ml) _____	1.912	Geometry _____	triangle
B ₂ O ₃ (mg/ml) _____	1.077	Reference _____	RP-188

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
943	10.754		
991	10.932		
1027	11.137		
1075	11.364		
1165	11.548		
1213	11.730		
1261	12.028		
1393	12.657		
1441	12.703		
1495	13.053		
1543	13.238		
1585	13.452		
1629	13.604		
1675	13.723		
1721	13.802		
1768	14.069		
1813	14.213		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	10.43 ± 0.67	
λ_o (cm)	7.25 ± 0.13	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4190</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.5588</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>3.564</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.007</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
1057	10.444		
1135	10.769		
1201	11.137		
1261	11.180		
1345	11.426		
1405	11.769		
1483	12.021		
1555	12.076		
1615	12.319		
1687	12.757		
1759	12.961		
1831	13.111		

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	5.34 ± 1.72	
λ_o	(cm)	6.30 ± 0.31	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4516</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.6023</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
733	12.263		
769	12.513		
817	12.745		
859	13.140		
901	13.510		
943	13.880		
979	14.253		
1027	14.687		
1069	14.914		
1111	15.263		
1147	15.626		
1189	15.908		
1237	16.428		
1261	16.623		
1321	17.139		
1357	17.524		
1405	17.810		
1441	18.199		
1483	18.871		
1531	19.160		
1573	19.388		
1609	19.872		
1993	24.801	7.80 ± 0.13	31.80 ± 0.41

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	31.07 ± 0.37	
λ_o (cm)	7.93 ± 0.08	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4516</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>0.6023</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.805</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.453</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
715	11.231		
781	11.637		
835	12.012		
901	12.513		
967	12.834		
1027	13.402		
1087	13.794		
1147	14.172		
1213	14.719		
1285	15.294		
1345	15.702		
1405	15.989		
1471	16.429		
1531	16.511		
1597	17.087		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	24.44 ± 0.89	
λ_0 (cm)	7.50 ± 0.18	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4516</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.6023</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.631</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.919</u>	Reference <u>RP-188</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
805	11.078		
859	11.393		
913	11.707		
967	12.153		
1027	12.329		
1075	12.699		
1135	12.960		
1189	13.314		
1249	13.631		
1303	13.998		
1357	14.154		
1417	14.463		
1471	14.947		
1531	15.034		
1584	15.376		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	18.35 ± 0.59	
λ_o (cm)	6.98 ± 0.11	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.316
Diameter (in.)	0.250"	Clad thick. (in.)	0.031
Pitch (in.)	0.4516	Clad density	2.7
A _o (cm.)	0.6023	Fuel density	18.898
V _{mod} /V _{fuel}	2.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	3.496	Geometry	triangle
B ₂ O ₃ (mg/ml)	1.969	Reference	RP-188

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
991	10.766		
1045	11.040		
1159	11.491		
1213	11.648		
1261	11.811		
1333	12.236		
1381	12.215		
1441	12.567		
1495	12.796		
1555	12.857		
1609	12.980		
1663	13.150		
1723	13.475		
1777	13.704		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	3.12 ± 1.14	
λ _o (cm)	6.51 ± 0.24	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.4516</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>0.6023</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>3.601</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.028</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
979	10.717		
1057	11.157		
1213	11.674		
1285	11.946		
1441	12.698		
1519	12.871		
1598	13.100		
1675	13.313		
1759	13.704		
1831	13.836		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	4.22 ± 0.67	
λ_o (cm)	6.31 ± 0.14	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5105</u>	Clad density <u>2.7</u>
A _O (cm.) <u>0.6808</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
535	11.952		
583	12.467		
637	13.120		
691	13.842		
745	14.536		
793	14.972		
847	15.841		
901	16.544		
955	17.374		
1003	18.020		
1057	18.755		
1111	19.810		
1159	20.568		
1213	21.569		
1261	22.336		
1309	23.631		
1369	24.791		
1417	26.269		
1471	27.536		
1519	28.610		
1573	31.188		
1615	30.717		
1543	30.664	7.38 ± 0.07	39.05 ± 0.32

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	38.41 ± 0.18	
λ _O (cm)	7.35 ± 0.05	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.316
Diameter (in.)	0.250"	Clad thick. (in.)	0.031
Pitch (in.)	0.5105	Clad density	2.7
A _o (cm.)	0.6808	Fuel density	18.898
V _{mod} /V _{fuel}	3.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0.636	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.358	Reference	RP-188

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
595	11.825		
649	12.222		
691	12.610		
745	13.170		
793	13.654		
835	14.152		
889	14.667		
931	14.953		
979	15.599		
1027	16.226		
1075	16.581		
1123	17.080		
1177	17.662		
1225	18.129		
1261	18.722		
1321	19.307		
1369	19.931		
1417	20.721		
1459	20.929		
1507	21.613		
1561	22.381		
1597	23.014		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	30.05 ± 0.24	
λ_o (cm)	7.16 ± 0.06	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5105</u>	Clad density <u>2.7</u>
A _O (cm.) <u>0.6808</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.302</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.733</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
733	12.165		
781	12.343		
823	12.753		
871	13.079		
913	13.423		
955	13.946		
1003	14.288		
1045	14.283		
1087	14.717		
1135	15.325		
1177	15.382		
1225	15.966		
1261	16.153		
1309	16.421		
1357	16.861		
1405	17.516		
1453	17.952		
1495	18.095		
1543	18.405		
1585	18.799		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	22.28 ± 0.58	
λ_o (cm)	6.75 ± 0.14	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5105</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.6808</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.926</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.085</u>	Reference <u>RP-188</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
745	11.470		
805	11.853		
871	12.220		
925	12.550		
991	13.036		
1045	13.410		
1111	13.797		
1165	14.124		
1225	14.525		
1285	14.888		
1345	15.121		
1405	15.546		
1471	15.943		
1531	16.359		
1585	16.715		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	15.04 ± 0.32	
λ_o (cm)	6.54 ± 0.07	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5105</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.6808</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.810</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.583</u>	Reference <u>RP-188</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
847	11.281		
925	11.756		
991	12.057		
1057	12.350		
1135	12.862		
1201	13.101		
1261	13.414		
1345	13.604		
1423	13.857		
1483	14.323		
1555	14.517		
1615	14.922		
1687	15.132		
1759	15.384		
1825	15.648		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	4.32 ± 0.59	
λ _o (cm)	6.71 ± 0.16	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5633</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.7512</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-188</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
453	11.918		
512	12.668		
560	13.278		
626	14.145		
674	14.829		
734	15.726		
782	16.544		
848	17.330		
902	18.546		
956	19.628		
1016	20.556		
1070	21.636		
1124	22.975		
1178	24.865		
1238	25.727		
1298	27.639		
1346	29.476		
1406	31.609		
1460	34.093		
1519	37.507		
1573	41.188		
1615	43.302		
1507	37.287	7.41 ± 0.06	36.05 ± 0.19

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	36.31 ± 0.18	
λ _o (cm)	7.17 ± 0.07	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.316
Diameter (in.)	0.250"	Clad thick. (in.)	0.031
Pitch (in.)	0.5633	Clad density	2.7
A ₀ (cm.)	0.7512	Fuel density	18.898
V _{mod} /V _{fuel}	4.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0.530	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.298	Reference	RP-188

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
475	11.383		
535	11.989		
583	12.652		
637	13.026		
691	13.825		
745	14.302		
805	14.925		
859	15.536		
913	16.276		
967	16.896		
1016	17.477		
1075	18.187		
1123	18.760		
1177	19.518		
1237	20.112		
1285	21.103		
1345	21.973		
1393	22.760		
1453	23.464		
1507	24.412		
1561	25.361		
1615	26.372		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	27.27 ± 0.17	
λ ₀ (cm)	7.08 ± 0.05	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5633</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.7512</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.004</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.565</u>	Reference <u>RP-188</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
547	11.218		
595	11.731		
649	12.157		
691	12.617		
745	13.021		
793	13.424		
847	14.096		
889	14.444		
943	14.807		
991	15.121		
1045	15.743		
1099	16.126		
1147	16.647		
1189	16.866		
1249	17.365		
1297	17.848		
1345	18.304		
1393	18.860		
1453	19.288		
1495	19.659		
1543	20.404		
1585	20.806		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	19.87 ± 0.26	
λ_o (cm)	6.63 ± 0.07	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.316</u>
Diameter (in.) <u>0.250"</u>	Clad thick. (in.) <u>0.031</u>
Pitch (in.) <u>0.5633</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.7512</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.622</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.914</u>	Reference <u>RP-188</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
613	11.154		
661	11.424		
715	11.936		
757	12.176		
805	12.413		
847	12.652		
901	13.118		
943	13.437		
991	13.772		
1027	13.993		
1075	14.282		
1123	14.569		
1177	14.937		
1213	15.207		
1261	15.492		
1309	15.709		
1357	16.033		
1405	16.330		
1453	16.515		
1495	16.724		
1543	17.028		
1585	17.178		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	9.91 ± 0.30	
λ _o (cm)	6.66 ± 0.08	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.5674</u>	Clad density <u>2.7</u>
A _O (cm.) <u>0.7567</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>1.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-64</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
595	12.498	8.60 $\pm$ 0.13	12.03 $\pm$ 0.91
637	12.278		
679	12.527		
715	13.397		
757	13.681		
793	13.865		
823	14.027		
871	14.507		
901	14.517		
931	14.742		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.5674	Clad density	2.7
A _o (cm.)	0.7567	Fuel density	18.92
V _{mod} /V _{fuel}	1.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	1.133	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.638*	Reference	RP-64

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
643	11.696	7.99 ± .14	5.40 ± 0.89
679	12.056		
715	12.239		
745	11.964		
775	12.780		
805	12.486		
835	13.156		
859	13.207		
883	13.149		
907	13.536		
931	13.677		

*Note change in boron concentration. Value quoted in RP-64 is in error.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	7.05 ± 1.28	
λ _o (cm)	7.36 ± 1.33	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.5674	Clad density	2.7
A _o (cm.)	0.7567	Fuel density	18.92
V _{mod} /V _{fuel}	1.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	1.987	Geometry	triangle
B ₂ O ₃ (mg/ml)	1.119	Reference	RP-64

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
662	11.543		
692	11.849		
722	11.955		
752	12.052		
782	12.093		
812	12.763		
842	12.691		
872	12.916		
902	13.185		
932	12.910		
962	13.299	7.67 ± 0.31	3.64 ± 1.57

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	1.83 ± 3.59	
λ_o (cm)	8.05 ± 0.79	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.5674</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.7567</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>1.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.644</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.489</u>	Reference <u>data book</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
661	11.248	6.81 ± 0.24	3.88 ± 1.27
691	11.446		
721	11.689		
751	11.817		
781	11.837		
811	12.111		
841	12.286		
871	12.474		
901	12.516		
931	12.713		
961	13.012		

Variable Loading Analysis			
		constant λ	variable λ
B_m^2	(m ⁻²)	-0.52 ± 1.79	
λ_o	(cm)	7.71 ± 0.38	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.5674	Clad density	2.7
A _o (cm.)	0.7567	Fuel density	18.92
V _{mod} /V _{fuel}	1.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	4.007	Geometry	triangle
B ₂ O ₃ (mg/ml)	2.256	Reference	data book

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
769	11.465	7.62 ± 0.24	-7.44 ± 1.21
787	11.585		
805	11.517		
823	11.620		
841	11.654		
859	11.557		
877	11.567		
901	11.852		
919	12.045		
955	12.206		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	-17.93 ± 7.65	
λ_o (cm)	10.31 ± 2.13	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.6244</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.8327</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-64</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
989	23.351		
990	23.225		
991	(23.099) *	7.81 ± 0.11	31.21 ± 0.35

*extrapolated value

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ_o (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.6244	Clad density	2.7
A _o (cm.)	0.8327	Fuel density	18.92
V _{mod} /V _{fuel}	1.5	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	1.408	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.793	Reference	RP-64

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
571	12.992		
613	13.779		
655	14.286		
697	14.483		
739	15.067		
781	15.600		
817	16.173		
853	16.606		
889	16.888		
925	17.312		
961	17.635	6.54 ± 0.18	24.15 ± 0.90

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	20.85 ± 1.23	
λ_o (cm)	7.31 ± 0.30	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.6244</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.8327</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.652</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.493</u>	Reference <u>RP-64</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
619	12.484		
703	13.077		
787	13.985		
859	14.610		
931	15.102		
955	15.559	6.65 ± 0.22	12.87 ± 1.02

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	14.49 ± 1.83	
λ_o	(cm)	6.27 ± 0.42	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.6244</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.8327</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>5.204</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.930</u>	Reference <u>RP-64</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
757	11.976		
775	12.081		
793	12.184		
811	12.252		
829	12.529		
847	12.458		
865	12.702		
883	12.631		
901	12.846		
919	13.108		
937	13.036	6.03 $\pm$ 0.14	-0.50 $\pm$ 0.54

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	1.86 $\pm$ 3.08	
λ_o (cm)	5.48 $\pm$ 0.69	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.6767	Clad density	2.7
A _o (cm.)	0.9024	Fuel density	18.92
V _{mod} /V _{fuel}	2.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-64

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m^{-2})
835	31.285	7.12 ± 0.15	42.26 ± 0.51

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.6767</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.9024</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.408</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.793</u>	Reference <u>RP-64</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
421	12.512		
511	14.021		
547	14.463		
583	14.961		
619	15.810		
655	16.507		
691	17.226		
727	17.421		
799	18.934		
835	19.478		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	28.17 ± 1.00	
λ_o (cm)	6.58 ± 0.22	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.6767</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.9024</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.652</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.493</u>	Reference <u>RP-64 & data book</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
493	12.383		
529	12.698		
565	13.146		
601	13.568		
637	13.972		
673	14.154		
709	14.727		
745	15.112		
775	15.409		
805	15.782		
835	15.643	6.28 ± 0.10	16.36 ± 0.56

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	12.97 ± 1.32	
λ_o (cm)	7.13 ± 0.32	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel _____	U metal	Clad material _____	Al
Enrichment _____	1.143%	Clad O.D. (in.) _____	0.453
Diameter (in.) _____	0.387"	Clad thick. (in.) _____	0.028
Pitch (in.) _____	0.6767	Clad density _____	2.7
A _o (cm.) _____	0.9024	Fuel density _____	18.92
V _{mod} /V _{fuel} _____	2.0	Moderator _____	H ₂ O
H ₃ BO ₃ (mg/ml) _____	6.500	Geometry _____	triangle
B ₂ O ₃ (mg/ml) _____	3.660	Reference _____	RP-64 & data book

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
655	10.906		
673	11.173		
691	11.128		
709	11.483		
727	11.256		
745	11.422		
763	11.425		
781	11.830		
799	11.568		
817	11.664		
835	11.874	5.77 ± 0.13	-13.85 ± 0.71

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	-18.45 ± 5.93	
λ_o (cm)	6.93 ± 1.54	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.7706	Clad density	2.7
A _o (cm.)	1.0277	Fuel density	18.92
V _{mod} /V _{fuel}	3.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-64

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
649	37.944	6.81 ± 0.11	46.18 ± 0.37

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.7706</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.0277</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.408</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.793</u>	Reference <u>RP-64</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
313	11.981		
385	13.067		
421	14.021		
457	14.577		
493	15.353		
529	15.949		
565	16.762		
601	17.265		
625	17.429		
648	17.989		
649	18.163	6.02 ± 0.18	26.43 ± 1.01

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	22.70 ± 1.08	
λ_o (cm)	6.77 ± 0.26	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.7706</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.0277</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.662</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.499</u>	Reference <u>RP-64</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
469	12.365	6.15 ± 0.11	7.31 ± 0.54
487	12.624		
505	13.034		
523	13.057		
541	13.227		
559	13.536		
577	13.760		
595	13.733		
613	14.110		
631	14.316		
649	14.369		

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	7.87 ± 1.94	
λ_o	(cm)	6.01 ± 0.46	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.7706</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.0277</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>3.991</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.247</u>	Reference <u>RP-64</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
469	11.117		
487	11.422		
505	11.435		
523	11.674		
541	11.786		
559	11.900		
577	11.911		
595	12.142		
613	12.093		
631	12.452		
649	12.528	5.78 ± 0.14	-6.97 ± 0.67

Variable Loading Analysis			
		constant λ	variable λ
B_m^2	(m ⁻²)	-10.25 ± 2.50	
λ_o	(cm)	6.57 ± 0.61	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.1392</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-64</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
247	13.420		
283	14.804		
319	16.119		
355	17.651		
367	18.141		
379	18.840		
391	19.243		
403	19.564		
415	20.238		
427	21.198		
445	22.095		
463	23.139		
481	24.124		
499	25.444		
517	26.770		
535	28.255		
553	29.931		
571	31.731		
589	33.853		
601	35.607		
607	37.081		
613	37.608	6.66 ± 0.26	40.50 ± 0.70

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	40.14 ± 0.17	
λ_0	(cm)	6.80 ± 0.05	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.8542	Clad density	2.7
A _o (cm.)	1.1392	Fuel density	18.92
V _{mod} /V _{fuel}	4.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0.636	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.358	Reference	RP-64

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m^{-2})
614	22.750	6.20 ± 0.17	29.47 ± 0.52

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.1392</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>1.408</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.793</u>	Reference <u>RP-64</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
313	12.051		
349	12.618		
385	13.144		
457	14.399		
493	15.025		
517	15.380		
541	15.866		
565	16.482		
589	16.726		
613	16.465		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	15.76±0.85	
λ_o (cm)	5.83±0.21	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.1392</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>2.666</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.501</u>	Reference <u>RP-64</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
433	11.690		
451	11.810		
469	12.153		
487	12.166		
505	12.239		
523	12.317		
542	12.573		
560	12.730		
578	12.927		
596	12.948		
614	13.094	6.34±0.11	-9.50±0.46

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	-11.68±1.75	
λ_o (cm)	6.85±0.53	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	0.8537	Clad density	2.7
A _o (cm.)	1.1385	Fuel density	18.92
V _{mod} /V _{fuel}	1.00	Moderator	H2O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-10

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
487	17.943	8.10 ± 0.12	21.33 ± 0.41

Variable Loading Analysis		
	constant λ	variable λ
B_m^{-2} (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.8537</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.1385</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>1.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>5.292</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.98</u>	Reference <u>RP-51 + data book</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
217	9.635		
265	10.236		
289	10.484		
313	11.018		
337	11.193		
361	11.793		
385	11.667		
409	11.850		
433	12.262		
457	12.201	6.21±0.24	-5.20±1.12

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	-2.54±0.58	
λ_o (cm)	6.16±0.15	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	0.8537	Clad density	2.7
A _o (cm.)	1.1385	Fuel density	18.92
V _{mod} /V _{fuel}	1.0	Moderator	H2O
H ₃ BO ₃ (mg/ml)	5.909	Geometry	triangle
B ₂ O ₃ (mg/ml)	3.327	Reference	RP-51 + date book

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
499	12.449	6.29 ± 0.20	$-6.44 \pm .46$

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.9444</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.2594</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-10 + date book</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
187	13.664		
199	14.025		
211	14.673		
223	15.144		
235	15.794		
247	16.196		
259	17.037		
271	17.533		
283	18.216		
295	18.927		
307	19.706		
319	20.478		
331	21.194		
343	21.923		
355	22.717		
367	23.896		
379	25.001		
391	25.881		
403	27.156		
415	28.597		
427	30.127		
439	31.057	7.81±0.17	38.73±0.82

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	40.23±0.30	
λ_0 (cm)	7.50±0.08	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	0.9444	Clad density	2.7
A _o (cm.)	1.2594	Fuel density	18.92
V _{mod} /V _{fuel}	1.5	Moderator	H2O
H ₃ BO ₃ (mg/ml)	3.591	Geometry	triangle
B ₂ O ₃ (mg/ml)	2.022	Reference	RP-22

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods) 439	(relax. length) 15.734	(reflector sav- ings, cm.) 6.47 $\pm$ 0.10	(buckling, m ⁻²) 13.70 $\pm$ 0.43

Variable Loading Analysis		
	constant λ	variable λ
B_m^{-2} (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.9444</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.2594</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>6.973</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>3.926</u>	Reference <u>RP-22</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
439	12.486	5.757±0.093	-8.18±0.40

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_0 (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.0273</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.370</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-10</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
157	14.108		
169	14.795		
181	15.849		
193	16.635		
205	17.521		
217	18.287		
229	19.633		
241	20.356		
253	21.737		
265	23.004		
277	24.768		
283	25.548		
289	26.613		
295	27.572		
301	28.194		
307	29.464		
313	29.929		
319	30.328		
325	32.084		
331	33.669		
337	34.529		
343	38.731		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	48.22±0.31	
λ_o (cm)	7.10±0.08	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	1.0273	Clad density	2.7
A _o (cm.)	1.370	Fuel density	18.92
V _{mod} /V _{fuel}	2.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	3.394	Geometry	triangle
B ₂ O ₃ (mg/ml)	1.911	Reference	RP-22

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
438	17.065	6.52 $\pm$ 0.17	12.36 $\pm$ 0.62

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.0273</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.370</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>5.328</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>3.00</u>	Reference <u>RP-22 + data book</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
121	8.755	5.91±0.10	-5.44±0.62
157	9.432		
193	10.171		
229	10.704		
265	11.274		
301	11.889		
325	12.153		
349	12.477		
373	12.651		
409	13.336		
433	13.549		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	-5.96±1.00	
λ_0 (cm)	5.95±0.10	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.1754</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.5675</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-10</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
103	12.303		
115	13.263		
127	13.999		
139	15.136		
151	15.878		
163	17.755		
175	18.133		
187	19.656		
199	21.240		
211	22.745		
223	24.682		
235	26.935		
241	27.458		
247	29.231		
253	30.766		
259	32.269		
265	33.972		
271	34.855		
277	37.920		
283	41.012		
289	45.429		
295	49.230		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	47.12±0.33	
λ_o (cm)	6.68±0.10	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	1.1754	Clad density	2.7
A _o (cm.)	1.5675	Fuel density	18.92
V _{mod} /V _{fuel}	3.0	Moderator	H2O
H ₃ BO ₃ (mg/ml)	2.323	Geometry	triangle
B ₂ O ₃ (mg/ml)	1.308	Reference	RP-51

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m^{-2})
313	15.343	6.22 $\pm$ 0.18	7.70 $\pm$ 0.58

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.3070</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.743</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-10</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
127	14.304		
139	15.314		
151	16.115		
163	17.044		
175	17.888		
187	19.278		
199	20.402		
211	21.563		
223	22.964		
235	24.602		
245	26.048		
253	27.473		
259	27.975		
265	29.171		
271	30.441		
277	31.558		
283	32.781		
289	34.910		
295	36.126		
301	37.554		
307	40.305		
313	42.153		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	36.03±0.16	
λ_o (cm)	6.43±0.06	
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	1.3070	Clad density	2.7
A ₀ (cm.)	1.743	Fuel density	18.92
V _{mod} /V _{fuel}	4.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0.611	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.344	Reference	RP-51

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods) 337	(relax. length) 24.152	(reflector sav- ings, cm.) 6.36 ± 0.16	(buckling, m^{-2}) 22.16 ± 0.36

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.143%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	1.3070	Clad density	2.7
A ₀ (cm.)	1.743	Fuel density	18.92
V _{mod} /V _{fuel}	4.0	Moderator	H2O
H ₃ BO ₃ (mg/ml)	1.325	Geometry	triangle
B ₂ O ₃ (mg/ml)	0.746	Reference	RP-51

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods) 337	(relax. length) 17.442	(reflector sav- ings, cm.) 6.78 ± 0.24	(buckling, m^{-2}) 5.58 ± 0.48

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.143%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.3070</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.743</u>	Fuel density <u>18.92</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>2.309</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.300</u>	Reference <u>RP-51</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
337	13.797	6.53 $\pm$ 0.21	-13.57 $\pm$ 0.46

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_0 (cm)		
M^2 (cm ²)		

Exponential Experiment - Slab Lattice

Fuel _____ U metal _____	Fuel Density _____ 18.825 _____
Enrichment _____ 1.25% _____	Clad material _____ None _____
Thickness (in.) _____ 0.122 ± .002 _____	Moderator _____ H ₂ O _____
Pitch (in.) _____ 0.255 _____	Geometry _____ par. plate _____
V_{mod}/V_{fuel} _____ 1.09 _____	Reference _____ RP-201 _____

x (in.)*	y (in.)	L (cm.)	λ_x (cm.)	λ_y (cm.)	B_m^2 (m ⁻²)
22.065	11.475	14.464			
20.050	11.475	14.033			
18.053	11.475	13.488			
16.050	11.475	12.928			
14.052	11.475	12.322			
12.036	11.475	11.531			
10.024	11.475	10.707			
18.055	18.615	17.739	7.20±0.07		21.41±0.30
16.055	18.615	16.512			
14.046	18.615	15.219			
14.046	18.105	15.123			
14.046	17.595	14.932			
14.046	17.085	14.714			
14.046	16.575	14.492			
14.046	16.065	14.325			
14.046	15.555	14.141			
14.046	14.535	13.652			
14.046	14.025	13.414			
14.046	13.515	13.135			
14.046	13.005	12.966			
14.046	12.495	12.744			
14.046	11.985	12.477			
14.046	11.475	12.230			
14.046	10.965	11.942			
14.046	10.455	11.718			
14.046	9.945	11.381			
14.046	9.435	11.108			
14.046	8.925	10.896			
14.046	8.415	10.562			
14.046	7.905	10.270			

*Fuel slabs parallel to x axis.

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	19.63 ± 1.0	19.3 ± 1.0
λ_0 (cm)	7.86 ± 0.15	8.2 ± 0.1
M ² (cm ²)	-	40 ± 5

Exponential Experiment - Slab Lattice

Fuel	U metal	Fuel Density	18.825
Enrichment	1.25%	Clad material	None
Thickness (in.)	0.122 ± .002	Moderator	H ₂ O
Pitch (in.)	0.3180	Geometry	par. plate
V _{mod} /V _{fuel}	1.61	Reference	RP-201

x (in.)*	y (in.)	L (cm.)	λ_x (cm.)	λ_y (cm.)	B _m ² (m ⁻²)
20.040	18.444	38.163	6.95±0.10	6.91±0.11	43.62±0.34
22.044	16.536	35.249			
24.048	15.264	32.349			
18.036	20.352	38.111			
18.036	19.716	35.268			
18.036	19.080	32.525			
18.036	18.444	30.556			
18.036	17.808	28.270			
18.036	17.172	27.368			
18.036	16.536	25.806			
18.036	15.900	24.041			
18.036	15.264	23.101			
18.036	13.992	20.637			
18.036	13.356	19.533			
18.036	12.720	18.504			
18.036	12.084	17.602			
18.036	11.448	16.726			

*Fuel slabs parallel to x axis.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	41.96 ± 0.61	42.6 ± 0.7
λ_0 (cm)	7.46 ± 0.18	7.9 ± 0.1
M ² (cm ²)	-	40 ± 5

Exponential Experiment - Slab Lattice

Fuel <u>U metal</u>	Fuel Density <u>18.825</u>
Enrichment <u>1.25%</u>	Clad material <u>None</u>
Thickness (in.) <u>0.122 ± .002</u>	Moderator <u>H₂O</u>
Pitch (in.) <u>0.380</u>	Geometry <u>par. plate</u>
$V_{\text{mod}}/V_{\text{fuel}}$ <u>2.12</u>	Reference <u>RP-201</u>

x (in.)*	y (in.)	L (cm.)	λ_x (cm.)	λ_y (cm.)	B_m^2 (m ⁻²)
16.032	18.240	37.954	6.86±0.15	6.64±0.15	54.13±0.33
14.028	20.900	33.853			
14.028	20.520	32.677			
14.028	20.140	31.775			
14.028	19.760	30.429			
14.028	19.380	29.426			
14.028	19.000	28.473			
14.028	18.620	27.584			
14.028	18.240	27.026			
14.028	17.860	25.984			
14.028	17.480	24.816			
14.028	16.720	24.346			
14.028	16.340	23.216			
14.028	15.580	21.971			
14.028	14.820	20.904			
14.028	14.060	19.456			
14.028	13.300	18.364			
14.028	12.540	17.323			
14.028	11.780	16.307			
14.028	11.020	15.265			
22.044	13.300	30.844	6.71±0.15	6.74±0.15	53.72±0.33
20.040	14.440	33.167		6.83±0.12	

*Fuel slabs parallel to x axis.

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	52.57 ± 0.61	53.3 ± 1.0
λ_0 (cm)	7.15 ± 0.13	7.75 ± 0.10
M ² (cm ²)	-	61 ± 15

Exponential Experiment - Slab Lattice

Fuel <u>U metal</u>	Fuel Density <u>18.825</u>
Enrichment <u>1.25%</u>	Clad material <u>None</u>
Thickness (in.) <u>0.122 ± .002</u>	Moderator <u>H₂O</u>
Pitch (in.) <u>0.504</u>	Geometry <u>par. plate</u>
V_{mod}/V_{fuel} <u>3.14</u>	Reference <u>RP-201</u>

x (in.) *	y (in.)	L (cm.)	λ_x (cm.)	λ_y (cm.)	B_m^2 (m ⁻²)
14.045	20.696	39.702			
14.045	20.163	36.794			
14.045	19.652	34.466			
14.045	19.127	32.232			
14.045	18.653	30.793			
14.045	18.148	29.404			
14.045	17.615	27.900			
14.045	17.112	26.418			
14.045	16.611	25.169			
14.045	16.106	24.101			
14.045	15.599	22.856			
14.045	15.101	22.003			
14.045	14.599	21.150			
14.045	14.093	20.272			
14.045	13.582	19.437			
14.045	13.077	18.653			
14.045	12.571	17.771			
14.045	12.083	17.011			
14.045	11.577	16.318			
14.045	11.089	15.716			
14.045	10.071	14.380			
14.045	10.572	14.973			
14.045	9.556	13.718			
14.045	9.054	13.168			
14.045	8.559	12.596			
14.045	8.057	12.016			
22.051	13.581	40.448	6.39±0.06	6.33±0.05	58.78±0.26
20.054	13.581	31.901			
18.037	13.581	26.959			
16.041	13.581	19.328			
12.027	13.581	16.484			
10.029	13.581	14.026			
8.019	13.581	11.813			
6.024	13.581	9.918			
18.022	15.685	40.663			

*Fuel slabs parallel to x axis.

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	56.65 ± 0.55	58.14 ± 0.5
λ_0 (cm)	6.82 ± 0.08	7.2 ± 0.1
M ² (cm ²)	-	43 ± 5

Exponential Experiment - Slab Lattice

Fuel <u>U metal</u>	Fuel Density <u>18.825</u>
Enrichment <u>1.25%</u>	Clad material <u>None</u>
Thickness (in.) <u>0.122 ± .002</u>	Moderator <u>H₂O</u>
Pitch (in.) <u>0.630</u>	Geometry <u>par. plate</u>
V_{mod}/V_{fuel} <u>4.16</u>	Reference <u>RP-201</u>

x (in.) *	y (in.)	L (cm.)	λ_x (cm.)	λ_y (cm.)	B_m^2 (m ⁻²)
18.036	17.640	38.532	6.51±0.05	6.25±0.13	51.97±0.50
18.036	17.010	34.097			
18.036	16.380	30.899			
16.032	16.380	25.009			
16.032	15.750	23.520			
16.032	15.120	22.146			
16.032	14.490	21.016			
14.028	14.490	18.202			
14.028	13.860	17.465			
14.028	13.230	16.695			
14.028	12.600	15.964			
12.024	12.600	14.399			
12.024	11.970	13.774			
12.024	11.340	13.338			
12.024	10.710	12.888			
10.020	10.710	11.565			
10.020	10.080	11.227			
10.020	9.45	10.836			
10.020	8.82	10.457			

*Fuel slabs parallel to x axis.

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	50.10 ± 0.41	51.9 ± 1.0
λ_0 (cm)	6.73 ± 0.06	6.7 ± 0.1
M ² (cm ²)	-	49 ± 15

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.299%	Clad O.D. (in.)	0.453
Diameter (in.)	0.387"	Clad thick. (in.)	0.028
Pitch (in.)	0.5674	Clad density	2.7
A _o (cm.)	0.7567	Fuel density	18.898
V _{mod} /V _{fuel}	1.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-64

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
559	12.763		
583	12.866		
607	13.092		
631	13.577		
655	13.618		
679	13.950		
703	14.118		
727	14.720		
751	14.566		
775	14.952		
799	15.177		
823	15.558		
847	15.752		
871	16.004		
919	16.295		
943	16.701		
967	16.867		
991	16.996		
1015	17.221		
1033	17.398		

Variable Loading Analysis			
		constant λ	variable λ
B_m^2	(m ⁻²)	20.98 ± 0.46	
λ_o	(cm)	8.56 ± 0.11	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel _____	U metal	Clad material _____	Al
Enrichment _____	1.299%	Clad O.D. (in.) _____	0.453
Diameter (in.) _____	0.387"	Clad thick. (in.) _____	0.028
Pitch (in.) _____	0.6244	Clad density _____	2.7
A ₀ (cm.) _____	0.8327	Fuel density _____	18.898
V _{mod} /V _{fuel} _____	1.5	Moderator _____	H ₂ O
H ₃ BO ₃ (mg/ml) _____	0	Geometry _____	triangle
B ₂ O ₃ (mg/ml) _____	0	Reference _____	RP-64

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
547	16.706		
571	17.220		
595	17.947		
619	18.361		
643	19.198		
667	19.692		
691	20.393		
715	21.189		
739	21.957		
763	22.449		
787	23.462		
805	24.311		
823	25.278		
841	25.588		
859	26.701		
877	27.344		
895	27.895		
913	29.136		
931	30.342		
941	30.918		
985	33.126		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	40.51 $\pm$ 0.30	
λ_0 (cm)	8.07 $\pm$ 0.09	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.6767</u>	Clad density <u>2.7</u>
A _o (cm.) <u>0.9024</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-64</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
319	14.099		
337	14.529		
355	15.003		
373	15.607		
391	16.422		
409	16.939		
427	17.594		
445	18.535		
463	19.136		
481	19.979		
499	20.884		
517	21.630		
535	23.013		
553	23.749		
571	25.862		
589	26.151		
607	27.275		
625	29.268		
643	30.895		
661	33.196		
679	35.995		
697	39.584		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	52.19 ± 0.36	
λ_o (cm)	7.56 ± 0.08	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.7706</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.0276</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-64</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
295	16.788		
307	16.967		
319	17.950		
331	18.616		
343	19.333		
355	20.148		
367	21.320		
379	22.344		
391	23.397		
403	24.498		
415	25.640		
421	26.487		
427	27.099		
433	27.721		
439	28.803		
445	29.363		
451	30.613		
457	31.859		
463	32.881		
469	34.214		
475	35.268		
481	37.277		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	59.25 ± 0.33	
λ_o (cm)	6.94 ± 0.07	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.453</u>
Diameter (in.) <u>0.387"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.1391</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-64</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
343	22.631		
355	23.632		
367	25.859		
379	26.569		
391	27.723		
403	29.805		
415	32.440		
421	33.312		
427	35.301		
433	36.674		
439	38.908		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	54.69 ± 0.36	
λ ₀ (cm)	6.81 ± 0.08	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.299%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	0.6786	Clad density	2.7
A _O (cm.)	0.9050	Fuel density	18.898
V _{mod} /V _{fuel}	0.1784	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	data book

N *	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m^{-2})
91	7.260		
138	8.199		
186	8.336		
240	8.817		
288	9.230		

*1 fuel rod removed from center for BF_3 counter.

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	-35.23 $\pm$ 8.86	
λ_o (cm)	11.1 $\pm$ 0.32	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.8537</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.1384</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-22, RP-10</u>

N *	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
162	11.023		
174	11.316		
186	11.887		
198	12.261		
210	12.604		
222	12.937		
234	13.196		
246	13.657		
258	14.055		
270	14.438		
282	14.895		
294	15.096		
306	15.464		
318	15.953		
330	16.432		
342	16.581		
354	17.073		
366	17.439		
378	17.817		
390	18.131		
402	18.836		

*1 fuel rod missing from center

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	32.11 ± 0.54	
λ ₀	(cm)	7.94 ± 0.10	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.8537</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.1385</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>4.594</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.587</u>	Reference <u>RP-51</u>

N* (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
288	11.393		
300	11.640		
312	11.947		
336	12.257		
348	12.419		
360	12.681		
372	12.853		
384	12.926		
396	13.158		
408	13.408		

*1 fuel rod missing from center of lattice

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	10.67 ± 1.48	
λ _o (cm)	6.32 ± 0.27	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	<u>U metal</u>	Clad material	<u>Al</u>
Enrichment	<u>1.299%</u>	Clad O.D. (in.)	<u>0.666</u>
Diameter (in.)	<u>0.600"</u>	Clad thick. (in.)	<u>0.028</u>
Pitch (in.)	<u>0.9444</u>	Clad density	<u>2.7</u>
A _o (cm.)	<u>1.2594</u>	Fuel density	<u>18.898</u>
V _{mod} /V _{fuel}	<u>1.5</u>	Moderator	<u>H₂O</u>
H ₃ BO ₃ (mg/ml)	<u>0</u>	Geometry	<u>triangle</u>
B ₂ O ₃ (mg/ml)	<u>0</u>	Reference	<u>RP-51</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
247	19.449		
253	20.205		
259	20.716		
265	21.200		
271	21.939		
277	22.517		
283	23.261		
289	23.895		
295	25.101		
301	25.493		
307	26.115		
313	27.248		
319	27.873		
325	29.165		
331	29.487		
337	31.007		
343	32.852		
349	34.595		
355	35.580		
361	38.986		
367	40.942		
373	42.744		

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	51.87 ± 0.50	
λ _o	(cm)	7.44 ± 0.10	
M ²	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel _____	U metal	Clad material _____	Al
Enrichment _____	1.299%	Clad O.D. (in.) _____	0.666
Diameter (in.) _____	0.600"	Clad thick. (in.) _____	0.028
Pitch (in.) _____	0.9444	Clad density _____	2.7
A ₀ (cm.) _____	1.2594	Fuel density _____	18.898
V _{mod} /V _{fuel} _____	1.5	Moderator _____	H ₂ O
H ₃ BO ₃ (mg/ml) _____	1.845	Geometry _____	triangle
B ₂ O ₃ (mg/ml) _____	1.039	Reference _____	

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
313	18.164		
319	18.308		
325	18.607		
331	18.812		
337	19.214		
343	19.433		
349	19.891		
355	20.254		
361	20.605		
367	20.989		
373	21.425		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	38.63 $\pm$ 1.13	
λ_0 (cm)	6.56 $\pm$ 0.26	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	<u>U metal</u>	Clad material	<u>Al</u>
Enrichment	<u>1.299%</u>	Clad O.D. (in.)	<u>0.666</u>
Diameter (in.)	<u>0.600"</u>	Clad thick. (in.)	<u>0.028</u>
Pitch (in.)	<u>0.9444</u>	Clad density	<u>2.7</u>
A ₀ (cm.)	<u>1.2594</u>	Fuel density	<u>18.898</u>
V _{mod} /V _{fuel}	<u>1.5</u>	Moderator	<u>H₂O</u>
H ₃ BO ₃ (mg/ml)	<u>3.966</u>	Geometry	<u>triangle</u>
B ₂ O ₃ (mg/ml)	<u>2.233</u>	Reference	<u>data book</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
313	14.633		
319	14.785		
325	14.694		
331	14.834		
337	15.108		
343	15.284		
349	15.339		
355	15.510		
361	15.671		
367	15.882		
373	15.994		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	17.96 ± 2.24	
λ ₀ (cm)	7.47 ± 0.56	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>0.9444</u>	Clad density <u>2.7</u>
A _O (cm.) <u>1.2594</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>1.5</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>6.131</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>3.452</u>	Reference <u>RP-51</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m ⁻²)
253	11.545		
265	11.677		
277	11.906		
289	12.222		
301	12.445		
313	12.755		
325	12.845		
337	13.147		
349	13.638		
361	13.534		
373	13.733		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	10.84 ± 1.22	
λ_o (cm)	5.82 ± 0.24	
M^2 (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.0273</u>	Clad density <u>2.7</u>
A _O (cm.) <u>1.370</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>2.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-7</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
133	14.308		
139	14.885		
145	15.301		
151	15.702		
157	16.218		
163	16.844		
169	17.208		
175	18.303		
181	18.869		
187	19.685		
193	20.224		
199	21.418		
205	22.044		
211	23.177		
217	23.924		
223	25.657		
229	26.944		
235	28.340		
241	30.071		
247	32.466		
253	34.066		
259	37.526		
265	40.293		
271	43.399		
277	51.116		
283	61.589		

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	61.08 ± 0.32	
λ_0	(cm)	7.04 ± 0.06	
M ₂	(cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.299%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	1.0273	Clad density	2.7
A ₀ (cm.)	1.370	Fuel density	18.898
V _{mod} /V _{fuel}	2.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	4.594	Geometry	triangle
B ₂ O ₃ (mg/ml)	2.587	Reference	

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
163	10.436		
175	10.811		
187	11.177		
199	11.695		
211	11.820		
223	12.143		
235	12.517		
247	12.688		
259	13.130		
271	13.344		
283	13.739		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	16.38 ± 0.34	
λ ₀ (cm)	5.90 ± 0.10	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel _____	U metal _____	Clad material _____	Al _____
Enrichment _____	1.299% _____	Clad O.D. (in.) _____	0.666 _____
Diameter (in.) _____	0.600" _____	Clad thick. (in.) _____	0.028 _____
Pitch (in.) _____	1.1754 _____	Clad density _____	2.7 _____
A _o (cm.) _____	1.5675 _____	Fuel density _____	18.898 _____
V _{mod} /V _{fuel} _____	3.0 _____	Moderator _____	H ₂ O _____
H ₃ BO ₃ (mg/ml) _____	0 _____	Geometry _____	triangle _____
B ₂ O ₃ (mg/ml) _____	0 _____	Reference _____	RP-7 _____

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
85	12.177		
91	12.654		
97	13.418		
103	14.021		
109	14.403		
115	15.116		
121	15.644		
127	16.472		
133	17.342		
139	18.041		
145	18.969		
151	19.955		
157	21.382		
163	22.350		
169	23.387		
175	25.072		
181	26.835		
187	29.026		
193	31.127		
199	34.025		
205	37.255		
211	42.496		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	60.99 ± 0.26	
λ_o (cm)	6.70 ± 0.05	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.1754</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.5675</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>3.0</u>	Moderator <u>H2O</u>
H ₃ BO ₃ (mg/ml) <u>3.062</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.724</u>	Reference <u>RP-51</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
91	9.160		
103	9.720		
115	10.116		
127	10.524		
139	11.053		
151	11.465		
163	11.702		
175	12.107		
187	12.583		
199	12.902		
211	13.289		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	12.87 ± 0.83	
λ_o (cm)	6.08 ± 0.12	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel	U metal	Clad material	Al
Enrichment	1.299%	Clad O.D. (in.)	0.666
Diameter (in.)	0.600"	Clad thick. (in.)	0.028
Pitch (in.)	1.3070	Clad density	2.7
A _o (cm.)	1.743	Fuel density	18.898
V _{mod} /V _{fuel}	4.0	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-7

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
91	13.368		
97	14.001		
103	14.539		
109	15.224		
115	15.895		
121	16.500		
127	17.200		
133	17.982		
139	18.910		
145	19.957		
151	20.563		
157	21.796		
163	23.185		
169	23.879		
175	25.958		
181	27.087		
187	29.109		
193	31.410		
199	34.209		
205	35.892		
211	40.515		
217	44.287		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	50.38 ± 0.27	
λ _o (cm)	6.64 ± 0.07	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.3070</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.743</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.888</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.500</u>	Reference <u>RP-51</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
91	11.168		
103	12.042		
115	12.896		
127	13.489		
139	14.152		
151	14.954		
163	16.108		
175	16.668		
187	17.673		
199	18.537		
211	19.575		
217	20.040		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	33.21 ± 0.81	
λ_o (cm)	5.90 ± 0.16	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.3070</u>	Clad density <u>2.7</u>
A _o (cm.) <u>1.743</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.518</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.855</u>	Reference _____

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
97	10.836		
109	11.388		
121	11.971		
133	12.560		
145	13.142		
157	13.480		
169	14.229		
181	14.489		
193	14.903		
205	15.811		
217	16.137		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	16.93 ± 1.00	
λ_o (cm)	6.65 ± 0.23	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>U metal</u>	Clad material <u>Al</u>
Enrichment <u>1.299%</u>	Clad O.D. (in.) <u>0.666</u>
Diameter (in.) <u>0.600"</u>	Clad thick. (in.) <u>0.028</u>
Pitch (in.) <u>1.3070</u>	Clad density <u>2.7</u>
A ₀ (cm.) <u>1.743</u>	Fuel density <u>18.898</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.881</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.059</u>	Reference <u>RP-51</u>

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
97	10.446		
109	10.825		
121	11.304		
133	11.731		
145	12.050		
157	12.588		
169	13.315		
181	13.661		
193	13.925		
205	14.362		
217	14.952		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)	10.97 ± 1.30	
λ_o (cm)	6.31 ± 0.25	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.6767</u>	Clad density <u>7.942</u>
A _O (cm.) <u>0.9024</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>1.319</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
163	10.004		
169	10.247		
181	10.544		
199	11.022		
211	11.3115		
223	11.6774		
235	12.133		
253	12.633		
265	12.978		
283	13.551		
301	14.163		
325	14.971		
349	15.903		
379	16.868		
409	18.249		
451	20.143		
511	23.625		
583	29.651		
649	39.837	(7.33) *	56.6
361		7.38 ± 0.11	
439		7.20 ± 0.06	
523		7.39 ± 0.08	
607		7.36 ± 0.04	

*Extrapolated value.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	54.41 ± 0.10	54.2 ± 0.7
λ _O (cm)	7.87 ± 0.02	8.5
M ² (cm ²)	-	33.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .000155</u>
Pitch (in.) <u>0.6767</u>	Clad density <u>7.942</u>
A ₀ (cm.) <u>0.9024</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>1.319</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>3.826</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.154</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
241	10.095		
253	10.272		
271	10.571		
283	10.794		
301	11.113		
337	11.776	6.42 ± 0.13	37.35 ± 1.25
349	11.973		
379	12.492		
397	12.905		
433	13.551		
463	14.145	6.10 ± 0.10	38.84 ± 0.70
511	15.092		
547	15.814		
607	17.052		
661	18.245		
733	20.087	5.94 ± 0.10	37.91 ± 0.42
817	22.493		
925	26.260		
1027	31.011		
1147	39.506	6.06 ± 0.08	36.71 ± 0.20

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	35.34 ± 0.09	36.1 ± 0.7
λ ₀ (cm)	6.63 ± 0.03	6.58
M ² (cm ²)	-	35.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.6767</u>	Clad density <u>7.942</u>
A _O (cm.) <u>0.9024</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>1.319</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>7.8000</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>4.391</u>	Reference <u>RP-270</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
301	9.873		
325	10.147		
349	10.443		
379	10.871	5.76 ± 0.22	21.65 ± 2.00
397	11.187		
433	11.558		
463	11.942		
511	12.468	5.59 ± 0.16	21.29 ± 2.35
547	12.856		
607	13.587		
661	14.171		
733	15.156	5.81 ± 0.10	19.70 ± 0.42
817	15.994		
925	17.336		
1045	18.726		
1225	20.838	5.84 ± 0.06	18.26 ± 0.23

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	17.48 ± 0.19	18.9 ± 0.7
λ _O	(cm)	6.23 ± 0.04	6.80
M ²	(cm ²)	-	39.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.7163</u>	Clad density <u>7.942</u>
A _o (cm.) <u>0.9553</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>1.632</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
253	14.187	7.15 ± 0.10	66.14 ± 1.17
265	14.675		
271	15.019		
283	15.460		
295	16.064		
301	16.325		
313	16.925		
325	17.636	6.99 ± 0.23	66.50 ± 1.95
337	18.347		
349	19.165		
361	19.868		
367	20.292		
379	21.148		
385	21.743		
397	22.682		
409	23.627	6.85 ± 0.15	66.53 ± 1.01
421	24.930		
433	26.280		
439	26.845		
451	28.237		
463	30.592		
475	32.371		
487	34.787		
499	37.469	6.82 ± 0.09	65.81 ± 0.52

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	62.45 ± 0.18	64.6 ± 0.7
λ _o (cm)	7.52 ± 0.03	7.80
M ² (cm ²)	-	45.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.7163</u>	Clad density <u>7.942</u>
A _o (cm.) <u>0.9553</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>1.632</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.690</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.514</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (1) (relax. length)	λ (flux shape) (2) (reflector sav- ings, cm.)	B _m ² (flux shape) (3) (buckling, m ⁻²)
223	10.708		
235	10.954		
241	11.055		
253	11.375		
265	11.621		
271	11.870		
283	12.134		
295	12.399		
301	12.519		
313	12.894		
325	13.141		
337	13.451		
349	13.740		
361	14.097		
367	14.229		
379	14.564		
385	14.600		
397	15.067	6.25 ± 0.05	46.41 ± 0.45
409	15.315		
421	15.699		
433	16.068		
439	16.395		
451	16.596		
463	16.960		
475	17.353		

(continued on next page)

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	43.56 ± 0.07	44.5 ± 0.7
λ _o (cm)	6.65 ± 0.02	6.70
M ² (cm ²)	-	34.

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 + .0013</u>	Clad thick. (in.) <u>0.02743+.00015</u>
Pitch (in.) <u>0.7163</u>	Clad density <u>7.942</u>
A _O (cm.) <u>0.9553</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>1.632</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.690</u>	Geometry <u>Triangle</u>
B ₂ O ₃ (mg/ml) <u>1.514</u>	Reference <u>RP-270</u>

N	(1) L (cm)	(2) λ (flux shape)	(3) B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
487	17.788		
499	18.193		
511	18.578		
535	19.339		
559	20.335		
583	21.197		
595	21.943	6.23 ± 0.06	45.23 ± 0.10
613	22.801		
637	23.790		
661	25.197		
691	27.010		
703	27.908		
721	28.756		
745	30.983		
769	33.117		
793	35.992		
817	39.083	6.19 ± 0.06	45.00 ± 0.24

- (1) Indium foils in Lucite rod.
(2) Indium foils on fuel rods.
(3) "λ+L" at one fuel loading.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	43.56 ± 0.07	44.5 ± 0.7
λ _O (cm)	6.65 ± 0.02	6.70
M ² (cm ²)	-	34.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.7163</u>	Clad density <u>7.942</u>
A _o (cm.) <u>0.9553</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>1.632</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>5.680</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>3.198</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
271	10.318		
283	10.538		
295	10.777		
301	10.838		
313	10.968		
325	11.243		
337	11.398		
361	11.816		
379	12.088		
397	12.400		
421	12.763		
439	13.097	6.03 ± 0.07	26.95 ± 0.61
463	13.527	5.93 ± 0.08	27.79 ± 0.65
487	13.917		
499	14.092		
517	14.309		
547	14.819		
583	15.489		
625	16.245		
661	16.884		
715	17.795		
769	18.724		
835	20.031		
901	21.253		
991	23.274	5.91 ± 0.05	26.20 ± 0.17

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	25.33 ± 0.11	26.0 ± 0.7
λ _o (cm)	6.29 ± 0.02	6.2
M ² (cm ²)	-	25.0

Exponential Experiment - Rod Lattice

Fuel <u> </u>	<u>UO₂</u>	Clad material <u> </u>	<u>304 SS</u>
Enrichment <u> </u>	<u>3.006%</u>	Clad O.D. (in.) <u> </u>	<u>0.499</u>
Diameter (in.) <u> </u>	<u>0.4441 ± .0013</u>	Clad thick. (in.) <u> </u>	<u>0.02743 ± .00015</u>
Pitch (in.) <u> </u>	<u>0.7163</u>	Clad density <u> </u>	<u>7.942</u>
A _O (cm.) <u> </u>	<u>0.9553</u>	Fuel density <u> </u>	<u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u> </u>	<u>1.632</u>	Moderator <u> </u>	<u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u> </u>	<u>7.700</u>	Geometry <u> </u>	<u>triangle</u>
B ₂ O ₃ (mg/ml) <u> </u>	<u>4.335</u>	Reference <u> </u>	<u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
337	10.548		
349	10.711		
361	10.940		
379	11.140		
397	11.306		
409	11.402		
421	11.560		
439	11.864		
463	12.187		
487	12.523	5.71 ± 0.06	16.80 ± 0.51
499	12.593		
511	12.705		
535	13.009		
559	13.301		
595	13.719		
625	14.077		
661	14.473		
703	14.944		
745	15.423		
781	15.898		
847	16.550	5.83 ± 0.06	14.62 ± 0.28
913	17.275		
991	18.134		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	13.94 ± 0.20	14.5 ± 0.7
λ _O (cm)	6.07 ± 0.04	5.9
M ² (cm ²)	-	24.0

Exponential Experiment - Rod Lattice

Fuel	UO ₂	Clad material	304 SS
Enrichment	3.006%	Clad O.D. (in.)	0.499
Diameter (in.)	0.4441 ± .0013	Clad thick. (in.)	0.02743 ± .00015
Pitch (in.)	0.7706	Clad density	7.942
A _o (cm.)	1.0276	Fuel density	9.299 ± .047
V _{mod} /V _{fuel}	2.091	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	0	Geometry	triangle
B ₂ O ₃ (mg/ml)	0	Reference	RP-270

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
187	12.918		
199	13.491		
211	14.086		
223	14.908	6.53 ± 0.15	75.86 ± 1.79
235	15.462		
241	15.821		
253	16.530		
265	17.328		
271	17.940		
283	18.824	6.55 ± 0.13	73.56 ± 1.20
295	19.829		
301	20.356		
313	21.496		
325	22.849		
337	24.093		
349	25.980	6.77 ± 0.13	70.95 ± 0.90
379	31.495		
409	41.522	6.75 ± 0.10	70.49 ± 0.60

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	68.03 ± 0.15	69.6 ± 0.7
λ _o (cm)	7.21 ± 0.02	7.58
M ² (cm ²)	-	36.0

Exponential Experiment - Rod Lattice

Fuel	UO ₂	Clad material	304 SS
Enrichment	3.006%	Clad O.D. (in.)	0.499
Diameter (in.)	0.4441 ± .0013	Clad thick. (in.)	0.02743 ± .00015
Pitch (in.)	0.7706	Clad density	7.942
A _O (cm.)	1.0276	Fuel density	9.299 ± .047
V _{mod} /V _{fuel}	2.091	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	2.460	Geometry	triangle
B ₂ O ₃ (mg/ml)	1.385	Reference	RP-270

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
169	10.026		
181	10.334		
187	10.414		
199	10.824	6.00 ± 0.25	52.31 ± 3.45
211	11.156		
223	11.487		
241	11.970	5.68 ± 0.46	53.79 ± 5.25
253	12.320		
271	12.854		
295	13.590	6.00 ± 0.26	49.25 ± 2.38
313	14.092		
337	14.883		
361	15.715	6.00 ± 0.08	48.28 ± 0.66
397	16.940		
433	18.352		
475	20.212		
517	22.242	5.90 ± 0.06	47.31 ± 0.33
571	25.485		
637	30.696		
703	40.765	5.99 ± 0.12	46.34 ± 0.43

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	44.42 ± 0.12	45.35 ± 0.7
λ _O (cm)	6.57 ± 0.03	6.60
M ² (cm ²)	-	33.0

Exponential Experiment - Rod Lattice

Fuel	UO ₂	Clad material	304 SS
Enrichment	3.006%	Clad O.D. (in.)	0.499
Diameter (in.)	0.4441 ± .0013	Clad thick. (in.)	0.02743 ± .00015
Pitch (in.)	0.7706	Clad density	7.942
A _O (cm.)	1.0276	Fuel density	9.299 ± .047
V _{mod} /V _{fuel}	2.091	Moderator	H ₂ O
H ₃ BO ₃ (mg/ml)	4.600	Geometry	triangle
B ₂ O ₃ (mg/ml)	2.590	Reference	RP-270

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
223	10.171		
235	10.373		
241	10.503		
265	10.957	5.57 ± 0.14	33.02 ± 1.60
271	11.120		
295	11.594		
313	11.924	5.84 ± 0.09	29.90 ± 0.90
337	12.389		
367	12.946		
397	13.520	5.68 ± 0.07	29.83 ± 0.60
433	14.196		
475	15.016		
517	15.905	5.90 ± 0.03	27.99 ± 0.23
559	16.768		
625	18.186		
685	19.606	5.88 ± 0.08	27.82 ± 0.36
769	21.805		
871	24.604		
1045	31.363	5.86 ± 0.01	27.70 ± 0.07

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	26.98 ± 0.10	27.9 ± 0.7
λ _O (cm)	6.18 ± 0.03	5.95
M ² (cm ²)	-	37.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.7706</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.0276</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>2.091</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>6.530</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>3.676</u>	Reference <u>RP-270</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
253	9.880		
271	10.137		
295	10.483		
313	10.818	6.12 ± 0.10	12.49 ± 0.95
337	11.107		
367	11.566		
397	11.999		
433	12.405	5.65 ± 0.06	14.15 ± 0.50
463	12.873		
511	13.534		
559	14.108		
625	14.988	5.79 ± 0.06	13.84 ± 0.37
703	15.937		
805	17.280		
913	18.545		
1045	20.090	5.940 ± 0.04	12.94 ± 0.13

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	13.03 ± 0.14	13.6 ± 0.7
λ _O (cm)	5.98 ± 0.03	5.80
M ² (cm ²)	-	23.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 + .0013</u>	Clad thick. (in.) <u>0.02743+.00015</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.1391</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>2.863</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-270</u>

N	L (cm) ⁽¹⁾	λ (flux shape) ⁽²⁾	B _m ² (flux shape) ⁽³⁾
(No. of rods)	(relax. length)	(reflector sav-ings, cm.)	(buckling, m ⁻²)
97	9.767		
109	10.363		
121	11.028		
127	11.296		
137	12.063	6.74 ± 0.08	74.81 ± 1.29
151	12.689		
163	13.479		
169	13.892		
181	14.488		
187	15.001		
199	15.817	6.69 ± 0.08	71.67 ± 0.89
211	16.757		
223	17.867		
235	18.688		
241	19.529		
253	20.938		
265	22.095	6.45 ± 0.08	72.10 ± 0.64
271	23.096		
283	25.008		
295	26.982		
301	28.665		
313	31.346		
325	35.450		
337	41.942	6.69 ± 0.09	70.22 ± 0.55

(1) Indium foils in Lucite rod.

(2) Indium foils in fuel rods.

(3) "λ+L" at one fuel loading.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	67.98 ± 0.20	69.4 ± 0.7
λ _O (cm)	7.08 ± 0.03	7.45
M ₂ ² (cm ²)	-	41.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441</u> ± .0013	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.1391</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>2.863</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.650</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.929</u>	Reference <u>RP-270</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
127	9.718		
139	10.116		
151	10.561		
169	11.123		
181	11.530		
187	11.769		
199	12.070		
211	12.630		
223	13.062		
241	13.825		
265	14.722	6.05 ± 0.17	49.48 ± 1.47
295	15.942		
313	16.779	6.09 ± 0.04	48.46 ± 0.36
337	17.857		
349	18.522		
385	20.649		
421	23.007		
451	25.428	6.12 ± 0.05	47.48 ± 0.26
499	30.879		
541	38.014	6.07 ± 0.04	47.61 ± 0.18
379		6.12 ± 0.03	

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	46.04 ± 0.15	47.3 ± 0.7
λ _O (cm)	6.52 ± 0.04	6.5
M ² (cm ²)	-	33.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.1391</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>2.863</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>3.449</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.942</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
181	10.109		
187	10.298		
199	10.584		
211	10.748		
223	11.047		
241	11.491		
265	12.027	5.91 ± 0.08	27.58 ± 0.78
283	12.413		
301	12.880		
325	13.352		
361	14.221		
385	14.743		
421	15.559	5.89 ± 0.08	26.23 ± 0.47
463	16.660		
517	17.919		
583	19.838	5.84 ± 0.07	26.61 ± 0.32
661	22.040		
757	25.146	5.98 ± 0.05	25.71 ± 0.16
889	30.673		
1045	40.494	6.15 ± 0.05	25.22 ± 0.12

Variable Loading Analysis			
	constant λ	variable λ	
B _m ² (m ⁻²)	25.05 ± 0.08	25.68 ± 0.7	
λ _O (cm)	6.27 ± 0.03	6.10	
M ² (cm ²)	-	33.0	

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.1391</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>2.863</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>4.410</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.483</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
223	10.386		
235	10.622		
253	10.981		
271	11.274		
295	11.744	5.56 ± 0.11	19.11 ± 0.95
313	12.101		
337	12.443		
367	12.944		
397	13.488	5.72 ± 0.04	16.65 ± 0.35
433	14.139		
475	14.809		
535	15.749		
595	16.729	5.88 ± 0.05	15.29 ± 0.25
685	18.232		
793	20.148	5.95 ± 0.05	15.36 ± 0.16
931	22.543		
1045	24.798	6.15 ± 0.29	15.05 ± 0.48

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	14.94 ± 0.11	15.5 ± 0.7
λ _O (cm)	6.11 ± 0.03	5.87
M ² (cm ²)	-	34.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.9707</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.2945</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>4.071</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
85	9.655		
91	10.005		
97	10.423		
109	11.063		
121	11.764		
127	12.188		
139	12.945	6.71 ± 0.20	60.12 ± 2.33
151	13.773		
163	14.554		
169	15.067		
181	15.938	6.51 ± 0.10	61.66 ± 0.95
187	16.405		
199	17.466		
211	18.635		
223	19.936		
235	21.246		
241	22.023	6.40 ± 0.20	61.76 ± 1.29
253	23.926		
265	25.833		
271	26.971		
283	29.676		
295	33.179		
301	35.290		
313	41.003	6.33 ± 0.10	61.73 ± 0.51

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	59.98 ± 0.07	60.23 ± 0.7
λ _O (cm)	6.71 ± 0.01	7.05
M ² (cm ²)	-	27.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.9707</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.2945</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0.999</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.557</u>	Reference <u>RP-270</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
139	11.111		
151	11.560		
163	12.096		
169	12.329		
181	12.856		
187	13.054		
199	13.579		
211	14.177		
223	14.654		
235	15.517		
241	15.567		
253	16.145		
265	16.723		
271	17.024		
283	17.765		
295	18.431		
301	18.832		
313	19.435		
325	20.201		
337	21.080		
349	21.932		
361	22.703		
367	23.286		
379	24.182	6.30 ± 0.10	41.18 ± 0.42

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	40.40 ± 0.18	41.09 ± 0.7
λ _O (cm)	6.51 ± 0.04	6.57
M ² (cm ²)	-	23.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743±.00015</u>
Pitch (in.) <u>0.9707</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.2945</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>4.071</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.487</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.837</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
151	10.965		
163	11.380		
169	11.587		
181	12.006		
187	12.215		
199	12.593		
211	13.113		
223	13.449		
235	13.940		
241	14.092		
253	14.542		
265	14.952		
271	15.209		
283	15.658		
295	16.084		
301	16.425		
313	16.806	6.30 ± 0.10	32.41 ± 0.56

Variable Loading Analysis			
		constant λ	variable λ
B _m ²	(m ⁻²)	31.26 ± 0.24	32.3 ± 0.7
λ _O	(cm)	6.56 ± 0.04	6.45
M ²	(cm ²)	-	29.0

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.9707</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.2945</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.2307</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.256</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
151	10.229		
163	10.488		
169	10.668		
181	10.971		
187	11.143		
199	11.475		
211	11.848		
223	12.171		
235	12.451		
241	12.641		
253	12.912		
265	13.287		
271	13.346		
283	13.712		
295	13.906		
301	14.207		
313	14.397	6.10 ± 0.10	20.51 ± 0.62

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	19.31 ± 0.45	
λ _O (cm)	6.42 ± 0.07	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel <u>UO₂</u>	Clad material <u>304 SS</u>
Enrichment <u>3.006%</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.4441 ± .0013</u>	Clad thick. (in.) <u>0.02743 ± .00015</u>
Pitch (in.) <u>0.9707</u>	Clad density <u>7.942</u>
A _O (cm.) <u>1.2945</u>	Fuel density <u>9.299 ± .047</u>
V _{mod} /V _{fuel} <u>4.0</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>3.085</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.737</u>	Reference <u>RP-270</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
187	10.264		
199	10.521		
211	10.839		
223	11.042		
235	11.261		
241	11.421		
253	11.664		
265	11.908		
271	12.008		
283	12.181		
295	12.484		
301	12.530		
313	12.722		
325	12.908		
337	13.073		
349	13.288		
361	13.458		
367	13.585		
379	13.762	6.15 ± 0.10	6.04 ± 0.53

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)	5.18 ± 0.44	
λ _O (cm)	6.45 ± 0.09	
M ² (cm ²)	-	

Exponential Experiment - Rod Lattice

Fuel $U^{233}O_2-ThO_2$	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>.0345</u>
Pitch (in.) <u>0.6269</u>	Clad density <u>6.8365</u>
A_o (cm.) <u>0.8360</u>	Fuel density <u>8.9618</u>
V_{mod}/V_{fuel} <u>1.0</u>	Moderator <u>H₂O</u>
H_3BO_3 (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B_2O_3 (mg/ml) <u>0</u>	Reference <u>RP-359</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m^{-2})
163	10.509	6.88 ± 0.33	86.2 ± 4.0
181	11.208		
199	11.651		
223	12.621		
241	13.232		
265	14.200		
283	15.076		
301	15.754		
325	17.032		
349	18.180		
367	19.432		
385	20.754		
409	22.463		
433	24.948		
451	26.989		
463	29.002		
475	31.200		
487	33.515	7.11 ± 0.11	79.01 ± 0.73
499	36.664		
511	39.297		

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m^{-2})		75.04 ± 0.7
λ_o (cm)		8.80 ± 0.1
M_o^2 (cm^2)		51 ± 5

Exponential Experiment - Rod Lattice

Fuel $U^{235}O_2-ThO_2$	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.6269</u>	Clad density <u>6.8365</u>
A_o (cm.) <u>0.8360</u>	Fuel density <u>8.9618</u>
V_{mod}/V_{fuel} <u>1.0</u>	Moderator <u>H2O</u>
H_3BO_3 (mg/ml) <u>13.299</u>	Geometry <u>triangle</u>
B_2O_3 (mg/ml) <u>7.487</u>	Reference <u>RP-359</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m^{-2})
313	10.370		
361	11.111		
421	12.102		
487	13.271		
583	14.924		
673	16.645		
781	18.905		
889	21.683	5.26 ± 0.05	42.2 ± 0.3

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m^{-2})		
λ_o (cm)		
M^2 (cm^2)		

Exponential Experiment - Rod Lattice

Fuel $U^{233}O_2-ThO_2$	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.6269</u>	Clad density <u>6.8265</u>
A_O (cm.) <u>0.8360</u>	Fuel density <u>8.9618</u>
V_{mod}/V_{fuel} <u>1.0</u>	Moderator <u>H2O</u>
H_3BO_3 (mg/ml) <u>25.020</u>	Geometry <u>triangle</u>
B_2O_3 (mg/ml) <u>14.086</u>	Reference <u>RP-359</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B_m^2 (flux shape) (buckling, m^{-2})
409	10.281		
463	10.828		
511	11.335		
583	12.028		
661	12.784		
769	13.714		
889	14.872	5.12 ± 0.11	18.85 ± 0.6

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m^{-2})		15.9 ± 0.7
λ_O (cm)		5.8 ± 0.1
M^2 (cm^2)		29 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>.0345</u>
Pitch (in.) <u>0.6767</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>0.9024</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>1.38</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>R.P. - 359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
No. of Rods	(relax. Length)	(reflector sav- ings, cm.)	(buckling m ⁻²)
19	5.950		
31	6.414		
37	6.633		
43	6.923		
55	7.348		
61	7.584		
73	8.061		
85	8.523		
91	8.720		
97	8.994		
109	9.454		
121	10.010		
127	10.235		
139	10.729		
151	11.245		
163	11.784		
181	12.572		
199	13.421		
211	14.111		
223	14.703		
235	15.510		
253	16.735		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ _O (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel _____	Clad material _____
Enrichment _____	Clad O.D. (in.) _____
Diameter (in.) _____	Clad thick. (in.) _____
Pitch (in.) _____	Clad density _____
A _o (cm.) _____	Fuel density _____
V _{mod} /V _{fuel} _____	Moderator _____
H ₃ BO ₃ (mg/ml) _____	Geometry _____
B ₂ O ₃ (mg/ml) _____	Reference _____

Continued

N	L (cm)	λ (flux shape)	B_m^2 (flux shape)
265	17.370	6.95 ± 0.35	88.2 ± 2.6
283	19.128		
295	20.169		
313	21.996		
325	23.524		
337	25.558		
349	27.787		
361	30.367		
379	35.060		
397	45.370		

Variable Loading Analysis			
		constant λ	variable λ
B_m^2	(m ⁻²)		85.43 ± 0.7
λ_o	(cm)		8.4 ± 0.1
M^2	(cm ²)		52 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.6767</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>0.9024</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>1.38</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>7.823</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>4.404</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
241	10.457	5.44 ± 0.05	51.06 ± 0.23
295	11.663		
367	13.295		
475	16.191		
649	22.631		
859	41.472		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		50.14 ± 0.7
λ _O (cm)		6.1 ± 0.1
M ² (cm ²)		39 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.6767</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>0.9024</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>1.38</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>22.893</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>12.889</u>	Reference <u>RP-359</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
397	10.044		
463	10.642		
517	11.101		
595	11.772		
661	12.245		
769	13.013		
889	13.786	5.13 ± 0.06	3.73 ± 0.36

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ _O (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.7163</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>0.9553</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>1.71</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
109	9.988		
127	10.817		
139	11.379		
151	12.023		
169	13.055		
181	13.744		
187	14.112		
199	14.863		
211	15.668		
223	16.735		
235	17.688		
253	19.552		
265	21.029		
271	21.670		
283	23.483		
301	27.087		
313	29.704		
325	34.432		
337	39.785	6.50 ± 0.14	93.8 ± 1.2
343	44.575		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		87.6 ± 0.7
λ _O (cm)		8.3 ± 0.1
M ² (cm ²)		45 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.7163</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>0.9553</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>1.71</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>4.740</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.669</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
187	10.280	5.65 ± 0.07	60.2 ± 0.4
211	10.979		
265	12.517		
337	15.106		
451	20.125		
625	40.514		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		60.7 ± 0.7
λ _O (cm)		6.1 ± 0.1
M ² (cm ²)		44 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.7163</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>0.9553</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>1.71</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>18.876</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>10.627</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
337	9.696		
385	10.136		
439	10.628		
499	11.121		
595	11.848		
703	12.614		
889	13.787	5.25 ± 0.06	-1.79 ± 0.33

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		-3.3 ± 0.7
λ _O (cm)		5.55 ± 0.1
M ² (cm ²)		38 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.7706</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.0276</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>2.19</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
19	5.881		
31	6.506		
37	6.798		
43	7.173		
55	7.722		
61	7.984		
73	8.663		
85	9.208		
91	9.524		
97	9.987		
109	10.547		
121	11.264		
127	11.545		
139	12.354		
151	13.031		
169	14.352		
187	15.843		
199	16.845		
211	18.065		
223	19.526		
241	22.025		
265	27.072		
283	33.891		
301	44.813	6.55 ± 0.16	92.3 ± 1.4

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		87.4 ± 0.7
λ _O (cm)		8.1 ± 0.1
M ² (cm ²)		41 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.7706</u>	Clad density <u>6.8365</u>
A _o (cm.) <u>1.0276</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>2.19</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>4.708</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.651</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
187	10.467		
253	12.376		
295	13.763		
361	15.954		
475	21.201		
661	42.185	5.70 ± 0.07	50.4 ± 0.3

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		50.6 ± 0.7
λ _o (cm)		6.05 ± 0.1
M ² (cm ²)		38 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.7706</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.0276</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>2.19</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>13.327</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>7.503</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
349	10.334		
409	10.982		
487	11.734		
595	12.625		
745	13.836		
889	14.635	5.45 ± 0.04	-2.28 ± 0.15

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ _O (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.1391</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>3.00</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-359</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
19	6.562		
31	7.032		
37	7.257		
43	7.579		
55	8.174		
61	8.530		
73	9.184		
85	9.859		
91	10.239		
97	10.643		
109	11.288		
121	12.119		
127	12.480		
139	13.427		
151	14.335		
163	15.374		
169	15.981		
181	17.189		
187	17.881		
199	19.463		
211	21.282		
223	23.401		
235	26.171		
253	32.569		
271	46.304	6.42 ± 0.16	86.61 ± 1.2

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		85.3 ± 0.7
λ _O (cm)		7.4 ± 0.1
M ² (cm ²)		45 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.1391</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>3.00</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>4.987</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.808</u>	Reference <u>RP-359</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
181	10.123		
223	11.147		
271	12.229		
379	14.734		
547	18.926		
889	31.410	5.69 ± 0.05	26.64 ± 0.14

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		26.3 ± 0.7
λ _O (cm)		6.1 ± 0.1
M ₂ (cm ²)		33 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.1391</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>3.00</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>7.822</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>4.404</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav-ings, cm.)	(buckling, m ⁻²)
271	10.445	5.77 ± 0.05	1.92 ± 0.19
325	11.162		
397	12.105		
487	13.084		
637	14.578		
889	16.973		

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		2.06 ± 0.7
λ _O (cm)		5.5 ± 0.1
M ² (cm ²)		44 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499"</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.9707</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.2945</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>4.27</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
85	10.341		
91	10.622		
97	11.115		
109	11.856		
121	12.672		
127	13.133		
139	14.105		
151	15.165		
169	16.754		
187	18.662		
199	20.256		
211	22.171		
223	24.178		
241	28.799		
253	33.111		
265	38.933	6.27 ± 0.07	70.75 ± 0.44

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		68.7 ± 0.7
λ _O (cm)		7.17 ± 0.1
M ² (cm ²)		40 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.9707</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.2945</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>4.27</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>2.676</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>1.507</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
139	10.023		
163	10.701		
181	11.226		
211	12.007		
235	12.748		
271	13.664		
337	15.427	5.82 ± 0.24	24.1 ± 1.2
409	17.420		
535	21.282		
721	28.481	5.88 ± 0.08	22.69 ± 0.19

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		22.5 ± 0.7
λ _O (cm)		6.2 ± 0.1
M ² (cm ²)		38 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt %²U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.9707</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.2945</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>4.27</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>4.959</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>2.792</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
211	10.023		
241	10.518		
271	10.930		
301	11.296		
337	11.736		
385	12.298		
439	12.867		
517	13.596		
607	14.350		
721	15.318	6.01 ± 0.06	-7.82 ± 0.20

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		-7.6 ± 0.7
λ _O (cm)		5.6 ± 0.1
M _O ² (cm ²)		44 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>1.1720</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.5630</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>6.84</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-359</u>

N (No. of rods)	L (cm) (relax. length)	λ (flux shape) (reflector sav- ings, cm.)	B _m ² (flux shape) (buckling, m ⁻²)
85	10.187		
91	10.502		
97	10.818		
109	11.398		
121	11.976		
127	12.262		
139	12.879		
151	13.552		
163	14.081		
181	14.942		
199	16.010	6.44 ± 0.08	32.2 ± 0.5
223	17.306		
241	18.567		
271	20.451		
313	23.641		
349	27.059		
397	33.183		
433	39.884	6.23 ± 0.05	32.22 ± 0.15
433	42.251 ± .70	(upside-down axial)	32.90 ± 0.28

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		32.3 ± 0.7
λ _O (cm)		6.5 ± 0.1
M ² (cm ²)		44 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zurcaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>1.1720</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.5630</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>6.84</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>1.700</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0.9571</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
151	10.128		
163	10.354		
181	10.689		
199	11.036		
223	11.437		
241	11.731		
265	12.125		
283	12.367		
301	12.595		
325	12.930		
349	13.273		
367	13.524		
385	13.724		
409	14.012		
433	14.342	6.96 ± 0.16	-11.52 ± 0.45

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		-10.8 ± 0.7
λ _O (cm)		5.9 ± 0.1
M _O ² (cm ²)		36 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt % U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430"</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>1.3346</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>1.7798</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>9.27</u>	Moderator <u>H₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>triangle</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>RP-359</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav-ings, cm.)	(buckling, m ⁻²)
97	10.101		
109	10.513		
121	10.980		
139	11.505		
151	11.853		
169	12.351		
187	12.827		
199	13.088	6.83 ± 0.16	-1.68 ± 0.72
211	13.570		
223	13.718		
235	14.077		
253	14.455		
265	14.741		
283	15.096		
295	15.410		
313	15.655		
325	16.021		
337	16.151		
349	16.271	6.60 ± 0.06	-1.58 ± 0.18

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		-0.56 ± 0.7
λ _O (cm)		6.5 ± 0.1
M ² (cm ²)		32 ± 5

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt% U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430</u>	Clad thick. (in.) <u>0.0345</u>
Pitch (in.) <u>0.8542</u>	Clad density <u>6.8365</u>
A ₀ (cm.) <u>1.1392</u>	Fuel density <u>8.9518</u>
V _{mod} /V _{fuel} <u>3.004</u>	Moderator <u>99.25 mole % D₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>Triangular</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>pvt. com. - H. Windsor</u>

N	L (cm)	λ^* (cm flux shape)	B_m^2 (m ⁻² flux shape)
(No. of rods)	(relax. length)	(reflector savings, cm.)	(buckling, m ⁻²)
871	28.15 ± .1	4.06 ± .1 (cm)	20.54 ± .2 (m ⁻²)

*The measurements were performed in a partially loaded, boral clad, paraffin shielded 75.405 cm I.D. tank; λ was taken as one-half of the flux extrapolated width minus the tank I.D.

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_0 (cm)		
M^2 (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt% U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430</u>	Clad thick. (in.) <u>0.345</u>
Pitch (in.) <u>1.4795</u>	Clad density <u>6.8365</u>
A _o (cm.) <u>1.9731</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>11.698</u>	Moderator <u>99.26 mole % D₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>Triangular</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>pvt. com. - H. Windsor</u>

N	L (cm)	λ^* ^{cm.} (flux shape)	B_m^2 ^{m⁻²} (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
349	47.75 $\pm$.4	3.40 $\pm$.05 (cm.)	29.85 $\pm$.12 (m ⁻²)

*The measurements were performed in a boral clad, paraffin shielded 75.405 cm. I.D. tank; λ was taken as one-half of the flux extrapolated width minus the tank I.D.

Variable Loading Analysis		
	constant λ	variable λ
B_m^2 (m ⁻²)		
λ_o (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt% U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430</u>	Clad thick. (in.) <u>0.345</u>
Pitch (in.) <u>1.708</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>2.2783</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>16.050</u>	Moderator <u>99.30 mole % D₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>Triangular</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>pvt. com. - H. Windsor</u>

N	L (cm)	* λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
253	41.30 ± .5	3.24 ± .1 (cm.)	28.64 ± .29 (m ⁻²)

*The measurements were performed in a boral clad, paraffin shielded 75.405 cm. I.D. tank; λ was taken as one-half of the flux extrapolated width minus the tank I.D.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ _O (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt% U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430</u>	Clad thick. (in.) <u>0.345</u>
Pitch (in.) <u>2.259</u>	Clad density <u>6.8365</u>
A _O (cm.) <u>3.0139</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>29.086</u>	Moderator <u>99.33 mole % D₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>Triangular</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>pvt. com. - H. Windsor</u>

N	L (cm)	* λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
151	31.92 ± .2	3.06 ± .05 (cm.)	25.00 ± .16 (m ⁻²)

*The measurements were performed in a boron clad, paraffin shielded 75.405 cm. I.D. tank; λ was taken as one-half of the flux extrapolated width minus the tank I.D.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ _O (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt% U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430</u>	Clad thick. (in.) <u>0.345</u>
Pitch (in.) <u>2.562</u>	Clad density <u>6.8365</u>
A _o (cm.) <u>3.4175</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>37.797</u>	Moderator <u>99.33 mole % D₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>Triangular</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>pvt. com. - H. Windsor</u>

N	L (cm)	λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
121	28.04 ± .15	3.20 ± .10 (cm.)	21.85 ± .20 (m ⁻²)

*The measurements were performed in a boron clad, paraffin shielded 75.405 cm. I.D. tank; λ was taken as one-half of the flux extrapolated width minus the tank I.D.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ_o (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt% U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430</u>	Clad thick. (in.) <u>0.345</u>
Pitch (in.) <u>3.079</u>	Clad density <u>6.8365</u>
A _o (cm.) <u>4.1073</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>55.19</u>	Moderator <u>99.34 mole % D₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>Triangular</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>pvt. com. - H. Windsor</u>

N	L (cm)	* λ (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
85	24.77 ± .07	2.70 ± .15 (cm.)	19.13 ± .27 (m ⁻²)

*The measurements were performed in a boron clad, paraffin shielded 75.405 cm. I.D. tank; λ was taken as one-half of the flux extrapolated width minus the tank I.D.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ _o (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt% U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430</u>	Clad thick. (in.) <u>0.345</u>
Pitch (in.) <u>3.725</u>	Clad density <u>6.8365</u>
A _o (cm.) <u>4.964</u>	Fuel density <u>8.9518</u>
V _{mod} /V _{fuel} <u>81.31</u>	Moderator <u>98.95 mole % D₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>Triangular</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>pvt. com. - H. Windsor</u>

N	L (cm)	λ^* (flux shape)	B _m ² (flux shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
55	22.35 ± .07	3.12 ± .2 (cm.)	14.67 ± .37 (m ⁻²)

*The measurements were performed in a boron clad, paraffin shielded 75.405 cm. I.D. tank; λ was taken as one-half of the flux extrapolated width minus the tank I.D.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ_o (cm)		
M ² (cm ²)		

Exponential Experiment - Rod Lattice

Fuel <u>U²³³O₂-ThO₂</u>	Clad material <u>Zircaloy-2</u>
Enrichment <u>2.6343 wt% U-233</u>	Clad O.D. (in.) <u>0.499</u>
Diameter (in.) <u>0.430</u>	Clad thick. (in.) <u>0.345</u>
Pitch (in.) <u>4.520</u>	Clad density <u>6.8365</u>
A _o (cm.) <u>6.0279</u>	Fuel density <u>8.9618</u>
V _{mod} /V _{fuel} <u>120.49</u>	Moderator <u>99.30 mole % D₂O</u>
H ₃ BO ₃ (mg/ml) <u>0</u>	Geometry <u>Triangular</u>
B ₂ O ₃ (mg/ml) <u>0</u>	Reference <u>pvt. com. - H. Windsor</u>

N	L (cm)	λ^* (flux ^{cm.} shape)	B _m ² (flux ^{m⁻²} shape)
(No. of rods)	(relax. length)	(reflector sav- ings, cm.)	(buckling, m ⁻²)
37	20.41 ± .1	2.61 ± .25 (cm.)	11.70 ± .56 (m ⁻²)

*The measurements were performed in a boron clad, paraffin shielded 75.405 cm. I.D. tank; λ was taken as one-half of the flux extrapolated width minus the tank I.D.

Variable Loading Analysis		
	constant λ	variable λ
B _m ² (m ⁻²)		
λ_o (cm)		
M ² (cm ²)		

APPENDIX A

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: August 7, 1961

TO: R. Hellens

FROM: R. Sher and E. V. Weinstock

SUBJECT: ρ_{28} Measurements

Measurements of ρ_{28} in .600", .387", and .250" lattices were made several years ago. Recently a few of these were repeated. The techniques will be described and the results summarized in this memo.

All the measurements were done on 1% enriched, light water moderated miniature lattices, irradiated in the animal tunnel. Irradiation times were usually of the order of 40 min. Miniature lattices are about 1 ft. in diameter by 2 ft high.

The spectral equilibrium in similar (slab) lattices was checked (much latter) by measurement of Cd ratio (indium detectors) as a function of position. The results of this measurement indicated that over the central regions of the lattice the Cd ratio was constant and equal to the Cd ratio in a full size lattice. This measurement was done on only one volume ratio, 4 to 1.

The first set of measurements, covering all the 1% lattices, were done by the U^{239} β - counting technique. The heights of the bare and Cd covered foils were carefully chosen to be the same, and the rods were assumed to be in flux-symmetric positions, though the actual flux equality was not checked. Natural uranium or depleted uranium detectors were used.

The thickness of the Cd sleeve was about .014" or .015". The end cover discs were about .020" thick. (Klein at Bettis has shown that the Cd ratios do not vary with Cd thickness at these values.)

The sodium uranyl acetate method was employed to separate uranium from its daughter and fission products. The separation was carried out on both foils simultaneously. The final sodium uranyl acetate precipitate was dissolved in water and then evaporated onto aluminum planchets. The deposits were often non-uniform, although the average thickness of deposit was of the order of 1 mg/cm². Several such samples were prepared from each

of the detector foils, and these were counted in end-window Geiger counters. Standard corrections for background and dead-time were made. Because of the growth of Np^{239} , the decay curves were not exponential, but they fit the calculated shape quite well.

There was some indication on some of the runs that some fission product activity was present in the bare foil samples; this would have the effect of making the cadmium ratios too high and ρ_{28} too low. For a cadmium ratio of 1.75, 2% fission activity would make ρ_{28} too low by about 5%.

The cadmium ratio is given by

$$\frac{A_{\text{bare}}}{N_{\text{bare}}^{28}} \bigg/ \frac{A_{\text{Cd}}}{N_{\text{Cd}}^{28}}$$

where A is the count rate corrected to some standard time after separation, and N^{28} is the number of U^{238} atoms in the sample being counted.

N^{28} was determined in three ways: weighing the sodium uranyl acetate; counting the U^{238} daughter activity several weeks later (when all Np^{239} has decayed out); and by quantitative chemical analysis. These methods often disagreed by as much as 5%, but in an apparently random fashion.

The results of these measurements are given in Table I.

A second technique was employed on the 0.250" lattices. This involved the counting of γ - γ coincidences between the 285 keV γ ray in the Np^{239} decay and the combination of 106 keV γ ray and 103 keV X ray (due to internal conversion processes). Depleted (5 ppm) uranium foils were used and were counted by two sodium iodide scintillation crystals. One crystal fed a single channel analyzer which picked out 285 keV γ rays; the other crystal fed a multi-channel analyzer which displayed the spectrum in coincidence with the single channel analyzer output. This spectrum has a prominent peak in the neighborhood of 105 keV, and the relative peak intensities yielded the cadmium ratios, when corrected for the weights of the foils. These results are given in Table II.

Two 0.387" lattices were done recently in order to try out a method which avoids the use of Cd. In this method, the ratio of the activation of a bare U^{238} foil to the activation of a Dy foil is determined in the lattice and in a thermal flux. Because of the extremely high Cd ratio of dysprosium, the ratio of these ratios indirectly yields the value of ρ_{28} in the lattice, when certain corrections are included. These corrections assume that the lattice spectrum is Maxwellian at energies up to 5 kT, and is dE/E above 5 kT. The Cd ratio was also determined in the usual way by singles counting of the 105 kev Np^{239} peak, corrected for fission product background. The fission product background was obtained by examination of the fission product γ -ray activity from aluminum catcher foils which were irradiated next to depleted uranium foils in separate irradiations. The results of these measurements are given in Table III.

Table I

U^{239} β^- Results

Date (1956)	Rod Size	Volume Ratio	C. R. (weights)	C. R. (daughter activity)	C. R. (chemical analysis)	Average C. R.
4-3	.600"	4:1	2.82	2.78	2.80	2.66 $\pm$ 0.13
4-4	"	"	2.60	2.50	2.46	
4-8	"	3:1	2.32	2.25	2.29	2.26 $\pm$ 0.03
4-9	"	"	2.18	2.28	2.24	
2-24	"	2:1	1.80	1.81	1.75	1.95 $\pm$.11
2-28	"	"	1.99	1.93	1.96	
3-2	"	"	2.06	2.00	2.10	
3-14	"	1.5:1	1.91	1.84	1.82	1.95 $\pm$.08 not used
4-11	"	"	1.53	1.72	1.81	
4-18	"	"	1.89	1.90	2.04	
4-16	"	1:1	1.56	1.55	1.50	1.50 $\pm$.05
5-2	"	"	1.44	1.44	1.43	

Table I - continued

<u>Date</u> (1955)	<u>Rod</u> <u>Size</u>	<u>Volume</u> <u>Ratio</u>	<u>C. R.</u> (weights)	<u>C. R.</u> (daughter activity)	<u>C. R.</u> (chemical analysis)	<u>Average C. R.</u>
8-17	.387"	4:1	2.50		2.50	
9-9	"	"	2.34	2.33		2.37 $\pm$.06
(1956)						
1-27	"	3:1	2.17	2.03	2.05	
4-19	"	"	2.19	1.99	2.04	2.07 $\pm$.03
11-10 ('55)	"	2:1	1.86	1.64	1.70	
4-17	"	"	2.17	2.06	2.12 (not used*)	1.74
5-4	"	"	1.74	1.72	1.79	$\pm$.03
1-12	"	1.5:1	1.62	1.53	1.56	
1-19	"	"	1.74	1.55	1.52	1.62 $\pm$.04
4-10	"	1:1	1.45	1.38	1.42	
4-12	"	"	1.34	1.44	1.41	1.41 $\pm$.02
(1957)						
2-6	.250"	4:1	-	1.59	1.63 (not used)	
2-12	"	"	-	1.87	1.88	
2-25	"	"	-	1.93	1.98	1.98 $\pm$.03
4-15	"	"	-	2.00	2.05	
4-17	"	"	-	2.05	2.05	
2-5	"	3:1	-	1.79	1.78	
2-14	"	"	-	1.66	1.68	
3-26	"	"	-	1.98	1.90	1.79 $\pm$.03
4-4	"	"	-	1.84	1.81	
4-5	"	"	-	1.71	1.77	

* Decay curve did not match expected curve.

Table I - continued

<u>Date</u> (1957)	<u>Rod</u> <u>Size</u>	<u>Volume</u> <u>Ratio</u>	<u>C. R.</u> (weights)	<u>C. R.</u> (daughter activity)	<u>C. R.</u> (chemical analysis)	<u>Average C. R.</u>
1-14	"	2:1	-	1.42	1.44	1.50 $\pm$.04
1-15	"	"	-	1.61	1.65	
2-26	"	"	-	1.35	1.30	
3-27	"	"	-	1.56	1.46	
4-18	"	"	-	1.40	1.49	
4-19	"	"	-	1.62	-	
1-10	"	1.5:1	-	1.45	1.48	1.43 $\pm$.02
2-19	"	"	-	1.40	1.39	
4-23	"	"	-	1.38	1.56	
4-24	"	"	-	1.41	1.34	

Table II

Np²³⁹ γ - γ Coincidence Technique

<u>Date</u> (1959)	<u>Rod</u> <u>Size</u>	<u>Volume</u> <u>Ratio</u>	<u>C. R.</u>	
10-28	.250"	4:1	1.95	1.98 $\pm$.07
11-12	"	"	2.19	
11-30	"	"	1.92	
12-4	"	"	2.06	
10-6	"	3:1	1.60	1.76 $\pm$.02
10-20	"	"	1.79	
10-23	"	"	1.78	
12-16	"	"	1.72	
9-29	"	2:1	1.61	1.56 $\pm$.02
9-30	"	"	1.55	
11-25	"	"	1.59	
11-19	"	1.5:1	1.30	1.39 $\pm$.03
11-20	"	"	1.40	
11-24	"	"	1.43	

Table III

U-Dy Results

<u>Rod Size</u>	<u>Volume Ratio</u>	<u>ρ_{28} (U-Dy)</u>	<u>C. R. (Singles Counting of Np γ-ray)</u>
.387"	3:1	-	1.962
		1.000	2.013
		1.023	2.038
		1.027	1.969
		.974	2.020
		.987	-
		.980	
		Av. .998 [*] $\pm$.015	2.000 $\pm$.015

* Implies C. R. = 2.002

.387"	1:1	2.855	-
		2.883	1.347
		2.848	-
		2.822	1.369
		-	1.332
		Av. 2.855 ⁺ $\pm$.013	1.349 $\pm$.010

⁺ Implies C. R. = 1.351

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APPENDIX B

ρ_{28} Measurements of Tight Water Lattices
with Natural Uranium Foils¹

by

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¹Work done under the auspices of the U. S. A. E. C.

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Early measurements of ρ_{28} in 0.250 in. diameter uranium metal rod lattices performed at BNL⁽¹⁾ showed unusually poor agreement with the theoretical calculations. Two later measurements^(2,3) of the tightest lattice (water-to-uranium = 1.5:1) gave somewhat better agreement, but quite large scatter from one experiment to another remained. In the measurements reported here, an attempt has been made to reduce the errors suspected in the earlier measurements.

Special attention has been given to the following three points, which were considered as the probable sources of the previously observed scatter and discrepancy.

1. Perfect alignment of the foils with the rods.
2. The influence of foil geometry on the γ -activity measurement (by using the initial foil or a dissolved sample).
3. Fission product contamination.

The activation of the two 0.015 in. thick natural uranium foils was done at flux symmetric positions in a miniature lattice containing 373 1% enriched rods in an inner zone surrounded by an outer zone of 246 1.15% enriched rods. The thicknesses of the Cd sleeve around the fuel and the Cd disks above and below the foil were 0.020 in. and 0.028 in., respectively.

The bare and Cd covered foil activities were alternately observed by the γ - γ coincidence counting method proposed by Sher⁽⁴⁾. The foils were either dissolved in nitric acid or were counted in their original shape.

To correct for the fission product contamination, we used a technique similar to that reported by Antunez⁽⁵⁾. A natural U and a U-Al foil (14.8 weight % U of 93.5% U²³⁵) were activated one above the other in the bare and Cd covered rod. After a slight correction for the flux gradient in the lattice, the two coincidence activities are given by the following equations:

$$A_{\text{nat}} = BN_{28}^{\text{nat}} + CN_{25}^{\text{nat}} + \delta_{28} N_{25}^{\text{lattice}} / N_{25}^{\text{nat}} \cdot N_{28}^{\text{nat}} / N_{28}^{\text{lattice}} CN_{25}^{\text{nat}}$$

$$= BN_{28}^{\text{nat}} + (1 + a^{\text{nat}}) CN_{25}^{\text{nat}}$$

$$A_{\text{enr}} = BN_{28}^{\text{enr}} + (1 + a^{\text{enr}}) CN_{25}^{\text{enr}}$$

with $\delta_{28} = \text{fission rate of U}^{238} / \text{fission rate of U}^{235}$.

The fraction F of coincidences due to fission products in the bare foil can then be written as

$$F_{\text{bare}} = \frac{1}{1 + (B/C) \cdot (1/1+a^{\text{nat}}) \cdot (N_{28}^{\text{nat}}/N_{25}^{\text{nat}})}$$

In the expression for the Cd covered foils $1 + a^{\text{nat}}$ has to be replaced by $1 + R_{25}a^{\text{nat}}$ (where R_{25} denotes the Cd ratio of U^{235} in the lattice measured.

Figure 1 shows the Cd ratio of undissolved foils as a function of time with and without correction for fission products. In Figure 2 the same quantities for the dissolved foils are represented. Taking the average values for R_{28} in intervals from 40 to 140 hours we get the two values for ρ_{28} listed in Table I.

Table I.

ρ_{28} Values of 0.250 in. Lattice, 1% Enriched
1.5:1 Water-to-Uranium Ratio Measured at BNL

<u>Authors</u>	<u>Technique</u>	<u>Detectors</u>	<u>ρ_{28}</u>	<u>Scatter in R_{28}</u>
Sher and Weinstock	γ - γ coincidence	depleted U not diss.	2.56 ± 0.18	10%
Ricabarra	chemical separation β -counting	natural U	2.00 ± 0.04	3.5%
Arcipiani	γ - γ coincidence	depleted U diss.	2.05 ± 0.06	4%
Present Authors	γ - γ coincidence	natural U	2.08 ± 0.03	2%
		diss.	2.08 ± 0.03	2%
		not diss.	2.53 ± 0.04	

As a conclusion one can say the following:

1. The proper alignment improved the reproducibility by a factor of 2.
2. Dissolving the foils changes ρ_{28} by as much as 25%.
3. The minimal fission product correction (around 90 hrs after the end of activation) is about 6% on ρ_{28} .
4. There is still a remaining discrepancy between theory and experiment; the theoretical value being 1.941.

References

- (1) R. Sher and E. V. Weinstock, ρ_{28} Measurements, BNL Memorandum (1961).
- (2) D. and G. Ricabarra, Comparison of Experimental Techniques Used to Obtain ρ_{28} , BNL Memorandum (1962).
- (3) B. Arcipiani, Measurement of U^{238} -Cd Ratio by Coincidence Technique, BNL Memorandum (1962).
- (4) R. Sher, γ - γ Coincidence Method for Measuring Resonance Escape Probability in U^{238} Lattices, Nuc. Sci. & Eng. 7, (1960) p. 479.
- (5) A. Antunez, Determination of Fission Product Background in the γ - γ Coincidence Technique for U^{238} Activation Measurements, Nuc. Sci. & Eng. 14, (1962), p. 8-10.

APPENDIX C

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: 4/15/64

TO: Files

FROM: W. Tunney

SUBJECT: Dysprosium Disadvantage Factor,
1.143% Enriched, 0.387 in.
Diameter Uranium Metal in
Light Water.

Summary

The disadvantage factor of a low enrichment uranium metal lattice has been remeasured. The miniature lattice used was a hexagonal lattice of 0.387" diameter 1.143% enriched uranium. The moderator-to-fuel volume ratios measured were 1:1, 1.5:1, 2:1, 3:1, and 4:1. The purpose for the remeasurement was to determine the reason for the discrepancy between theoretical values and measured values.

Improvements in the experiment have led to values that agree within the possible errors of the measurement and the theoretical calculation.

Experimental Method

The point detector method was used in the measurements to obtain a neutron distribution across a unit cell of the lattice. The detectors are 1/16" diameter, 0.005" thick foils of an aluminum-dysprosium alloy (5% Dy). The foils were calibrated by placing them on the perimeter of a spinning wheel that is exposed to a neutron source, then counting the resulting β activity. The calibrations used were the average of several runs.

During an exposure of a lattice, these foils were positioned across a unit cell of the lattice. They were placed in a cross section of a fuel rod, in the aluminum cladding, and in the water moderator (see Fig. 1). The fuel rod has holes milled in it to hold the foils, and the ends of the rod are copper plated to a thickness of 0.001" to protect the foils from fission product

contamination. The aluminum cladding has holes milled to various depths to hold the foils. The foils in the water were held by means of a 0.015" thick Lucite plate. Care was taken to position all foils at the same height in the lattice.

After an exposure, the β activity of the foils was counted in a bank of four gas-flow proportional counters. These data were then corrected for scalar deadtime, background, and decay. The results were then corrected for foil calibration and a J_0 neutron distribution across the lattice. The points in the fuel were fitted to a parabola by the method of least squares. An integration of the parabola gives the average neutron flux in the fuel. To obtain the average neutron flux in the water, the points in the water were plotted, a smooth curve was drawn, and a numerical integration was done under the curve. The ratio of the average flux in the moderator to the average flux in the fuel is the disadvantage factor.

Improvements in Experiment

The initial measurements of disadvantage factor varied widely in value. Part of the reason was that the measurements were being done in the 1:1 lattice, but most of the fluctuation was caused by the poor foils. Investigation showed that the mixture of aluminum and dysprosium was not homogeneous. The result was that some foils showed side effects caused by the self-absorption of the β rays if the dysprosium was concentrated on one side of the foil. As much as 4% difference in count rate was observed in some foils.

Another effect that was found to be contributing to the foils having a hot side was the exponential neutron distribution in the lattice. The effect across a thin foil is small but not negligible. To correct for this, all foils are counted on the same side, i.e., the side facing the neutron source or the other side.

Better foil calibrations were obtained by running a number of wheel calibrations and taking the average of the runs. A systematic effect was noticed in the foil calibrations which suggested that the decay constant for dysprosium that was being used was in error. The value of half-life was remeasured and the new half-life value of 139.90 ± 0.20 min (1) corrected this problem.

In analyzing the data obtained from the least squares fit done on the points in the fuel rod, it was noticed in many runs that two points on one side of the rod would lie above the fit and the two

points on the opposite side would lie below the fit. This trend was caused by the failure of the halves of the intracell rod to meet squarely. This was corrected by wrapping a small piece of tape around the rod to take up the space of the air gap between the fuel and the cladding.

To obtain more accuracy in the parabolic fit in the fuel region, the number of foils was increased from nine to thirteen. These foils were added as near as possible to the edge of the rod because this is the most important region in the fuel.

In addition to foils being added to the fuel, three foils were placed at various depths in the aluminum cladding. This was done by milling holes in the cladding so that the foils were standing on end compared to the other foil in the traverse. These foils were covered with aluminum plugs and held in place with tape.

The foils in the cladding served two purposes. First, they helped to give a smooth curve connecting the points in the moderator to the points in the fuel. Second, these foils helped to show the separation of the curves in the two different directions in the moderator. This effect is strongest in the lattices of low moderator-to-fuel ratios.

Another important contribution to the experimental method was a measurement of the effect on the neutron flux of the Lucite foil holder used to position foils in the water. It has been found that the Lucite depresses the flux in the water.

The method of protecting against fission product contamination by copper plating the ends of the intracell rods (2) was used in this experiment.

Results

The results of the measurement are listed in Tables 1, 2, and 3. The errors quoted are the sum of the statistical errors, the errors in the interpretation of the flux plots, and the uncertainty in the correction factors.

The corrected disadvantage factors are compared to THERMOS calculations done by H. Honeck (3). This comparison is shown in Fig. 2. It is seen that the measured values and calculated values agree with each other to within 1.5%, within the errors quoted for both results.

The first correction considered is the correction due to the perturbation in the neutron flux caused by the Lucite used to hold the detector foils in the water. This correction was made by measuring the effect on the disadvantage factor by varying the thickness of the Lucite foil holder. For each moderator-to-fuel ratio, the disadvantage factor was measured using 0.015", 0.030", and 0.045" thick Lucite to hold the foils in the moderator. The results are shown in Fig. 3 where disadvantage factor is plotted as a function of Lucite thickness for the five different moderator-to-fuel ratios. The correction is obtained by extrapolating back to zero thickness by drawing a straight line through the three points. The point at 0.015" of Lucite is given more weight because more runs were done with this thickness. The reason for the Lucite depressing the neutron flux is not understood, but some pulsed neutron measurements of Lucite diffusion coefficient and absorption cross section may give the answer.

The second correction is for the vertical placement error of the foils in the moderator. Care was taken in initial positioning but small errors are important in the miniature lattice with its small relaxation length. Small errors were found in three of the five lattices. This was corrected for by applying the following formula:

$$\text{Corrected Activity} = \text{Observed Activity} e^{\frac{\text{Placement Error}}{\text{Relaxation Length}}}.$$

The third correction is concerned with the error associated with fitting to a parabola the points in the fuel region. It was found that the flux diverges from a parabola at the edge of the fuel rod. This was found by drawing a smooth curve through the points in the fuel, cladding and moderator (see Fig. 4). The correction was made by determining the difference in average flux between the parabola and the other curve for an average of several runs. The observed difference was then applied as a correction to each of the runs.

Finally, the data had to be corrected because of the incorrect unit cell used to facilitate the numerical integration done on the points in the moderator. A cylindrical unit cell was used instead of a triangle (see Fig. 5). The dimensions of the cylinder were chosen such that the cross section area of the cylinder would be the same as the cross section area of the triangular unit cell. The error results from the fact that the neutron flux is higher in area I than it is in area II which is substituted for area I in the approximation.

A mixup of fuel of different enrichments had been found for fuel of 1% and 1.3% enrichment. To determine that this was not the situation with the 1.143% metal, an isotopic analysis was done on the fuel.

Conclusions

Agreement has been obtained between the measured values of disadvantage factor and calculated values. It appears that the discrepancy that existed before (Table 4) was due to the sum of many small inaccuracies. Better foil calibrations, increased number of points, better counting statistics, more runs, have all gone toward improvement of the accuracy of the measurement. Protection against fission product contamination and correction for Lucite depression of flux in the moderator have resulted in values that are nearer to the calculated values.

The over-all result has been the final development of the method of measuring dysprosium disadvantage factors using small dysprosium-aluminum foils as point detectors.

The author wishes to express his appreciation to Mac Titmus for his assistance in this experiment.

References

- (1) Memo to Files, "Dy¹⁶⁵ Half-life", June 25, 1963.
- (2) Memo to Files, "Disadvantage Factor Measurements", Oct. 25, 1962.
- (3) H. Honeck, "The Calculation of the Thermal Utilization and Disadvantage Factor in Uranium-Water Lattices", BNL-7047, May, 1963.
- (4) Memo to Files, "Intracell Measurements", Nov. 28, 1962.

Table 1.

Typical Results of Different Ratios

<u>1:1 Ratio</u>		<u>1.5:1 Ratio</u>		<u>2:1 Ratio</u>		<u>3:1 Ratio</u>		<u>4:1 Ratio</u>	
R	φ	R	φ	R	φ	R	φ	R	φ
0.0018	1.0000	0.0018	1.0000	0.0018	1.0000	0.0018	1.0000	0.0018	1.0000
0.0795	1.0124	0.0795	1.0217	0.0795	1.0200	0.0795	1.0393	0.0795	1.0236
0.0798	1.0155	0.0798	1.0238	0.0798	1.0145	0.0798	1.0283	0.0798	1.0240
0.0788	0.9916	0.0788	1.0218	0.0788	1.0307	0.0788	1.0481	0.0788	1.0007
0.0788	1.0148	0.0788	1.0282	0.0788	1.0413	0.0788	1.0283	0.0788	1.0092
0.1580	1.0903	0.1580	1.0949	0.1580	1.1146	0.1580	1.1099	0.1580	1.0872
0.1583	1.1154	0.1583	1.0795	0.1583	1.1068	0.1583	1.1168	0.1583	1.0812
0.1578	1.0630	0.1578	1.0805	0.1578	1.1029	0.1578	1.0976	0.1578	1.0834
0.1583	1.0975	0.1583	1.0845	0.1583	1.1003	0.1583	1.1212	0.1583	1.0841
0.1568	1.0627	0.1568	1.0874	0.1568	1.1042	0.1568	1.1129	0.1568	1.0934
0.1583	1.0895	0.1583	1.1082	0.1583	1.1106	0.1583	1.0995	0.1583	1.1074
0.1575	1.0941	0.1575	1.0878	0.1575	1.0917	0.1575	1.1022	0.1575	1.0810
0.1583	1.0718	0.1583	1.0970	0.1583	1.0962	0.1583	1.1147	0.1583	1.0764
0.2110	1.1826	0.2110	1.2164	0.2110	1.1998	0.2110	1.2226	0.2110	1.2040
0.2150	1.2119	0.2150	1.2204	0.2150	1.2000	0.2150	1.2328	0.2150	1.2097
0.2190	1.1818	0.2190	1.2009	0.2190	1.2123	0.2190	1.2266	0.2190	1.2014
0.2690	1.2467	0.2710	1.2767	0.2650	1.3012	0.2690	1.3356	0.2720	1.3392
0.2835	1.2619	0.3500	1.2905	0.3360	1.3567	0.3450	1.4255	0.3490	1.4179
0.2685	1.2979	0.2725	1.2869	0.4080	1.2880	0.4210	1.4499	0.4260	1.4183
0.3432	1.3154	0.3515	1.2825	0.2670	1.2917	0.4965	1.3411	0.5020	1.3966
0.4170	1.3163	0.3005	1.3286	0.3380	1.3522	0.2745	1.3524	0.5790	1.3240
0.4915	1.2788	0.3810	1.3504	0.4100	1.2893	0.3500	1.4268	0.2720	1.3062
		0.4605	1.3219	0.2770	1.3205	0.4260	1.4109	0.3480	1.4112
		0.5405	1.3224	0.3550	1.3762	0.5015	1.3205	0.4250	1.4321
				0.4320	1.3728	0.2775	1.3591	0.5020	1.4042
				0.5080	1.3539	0.3560	1.4419	0.5790	1.3157
				0.5850	1.3488	0.4340	1.4700	0.2850	1.3339
						0.5130	1.4480	0.3600	1.4297
						0.5895	1.4415	0.4350	1.4431
						0.6680	1.4261	0.5100	1.4828
								0.5850	1.4589
								0.6600	1.4357
								0.7350	1.4214

Table 2.

Results of Each Run

<u>Run #</u>	<u>Vol. Mod.</u> <u>Vol. Fuel</u>	<u>Lucite</u> <u>Thickness</u>	$\bar{\phi}$ <u>Fuel</u>	$\bar{\phi}$ <u>Mod.</u>	<u>C</u>
8833	1:1	0.015	1.0831	1.2936	1.1943
8834	1:1	0.015	1.0713	1.2798	1.1946
8835	1:1	0.015	1.0736	1.2884	1.2001
8837	1:1	0.015	1.0742	1.2786	1.1903
8844	1:1	0.015	1.0799	1.2822	1.1873
8838	1:1	0.030	1.0814	1.2887	1.1917
8839	1:1	0.030	1.0739	1.2623	1.1754
8840	1:1	0.030	1.0658	1.2604	1.1826
8841	1:1	0.045	1.0787	1.2776	1.1844
8842	1:1	0.045	1.0798	1.3017	1.2055
8843	1:1	0.045	1.0801	1.2660	1.1721
8915	1.5:1	0.015	1.0667	1.2937	1.2128
8916	1.5:1	0.015	1.0723	1.2990	1.2114
8917	1.5:1	0.015	1.0685	1.2859	1.2035
8918	1.5:1	0.015	1.0758	1.3054	1.2134
8919	1.5:1	0.015	1.0728	1.3074	1.2187
8920	1.5:1	0.030	1.0797	1.3037	1.2075
8921	1.5:1	0.030	1.0690	1.2776	1.1951
8922	1.5:1	0.030	1.0636	1.2791	1.2026
8923	1.5:1	0.045	1.0642	1.2883	1.2106
8924	1.5:1	0.045	1.0673	1.2787	1.1981
8895	2:1	0.015	1.0771	1.3219	1.2273
8896	2:1	0.015	1.0711	1.3220	1.2342
8900	2:1	0.015	1.0798	1.3371	1.2383
8901	2:1	0.015	1.0726	1.3223	1.2328
8906	2:1	0.015	1.0808	1.3465	1.2458
8907	2:1	0.030	1.0745	1.3255	1.2336
8908	2:1	0.030	1.0663	1.3266	1.2441
8909	2:1	0.030	1.0691	1.3204	1.2357
8910	2:1	0.045	1.0633	1.2884	1.2117
8911	2:1	0.045	1.0756	1.3181	1.2255
8912	2:1	0.045	1.0696	1.2996	1.2150
8862	3:1	0.015	1.0726	1.3687	1.2761
8864	3:1	0.015	1.0749	1.3711	1.2756
8865	3:1	0.015	1.0774	1.3680	1.2697
8866	3:1	0.015	1.0787	1.3801	1.2794
8867	3:1	0.015	1.0759	1.3880	1.2901
8868	3:1	0.030	1.0689	1.3492	1.2622
8869	3:1	0.030	1.0705	1.3470	1.2583
8870	3:1	0.030	1.0751	1.3656	1.2702
8871	3:1	0.045	1.0785	1.3772	1.2770
8872	3:1	0.045	1.0796	1.3644	1.2638
8845	4:1	0.015	1.0726	1.3963	1.3018
8848	4:1	0.015	1.0744	1.4033	1.3061
8849	4:1	0.015	1.0709	1.4002	1.3075
8850	4:1	0.015	1.0712	1.3952	1.3025
8851	4:1	0.030	1.0752	1.4067	1.3083
8852	4:1	0.030	1.0809	1.4012	1.2963
8853	4:1	0.030	1.0768	1.3932	1.2938
8854	4:1	0.045	1.0826	1.3998	1.2930
8855	4:1	0.045	1.0776	1.4072	1.3058
8856	4:1	0.045	1.0702	1.3994	1.3076

Table 3.

Corrected Results

<u>Vol. Mod.</u> <u>Vol. Fuel</u>	<u>ζ_0</u>	<u>ζ_1</u>	<u>ζ_2</u>	<u>ζ_3</u>	<u>ζ_4</u>	<u>Error</u>	<u>Theory</u>
1:1	1.1946	1.2040	1.2040	1.2021	1.2052	± 0.0134	1.201
1.5:1	1.2107	1.2163	1.2089	1.2070	1.2086	± 0.0113	1.227
2:1	1.2356	1.2430	1.2430	1.2410	1.2425	± 0.0111	1.248
3:1	1.2751	1.2800	1.2749	1.2729	1.2738	± 0.0096	1.286
4:1	1.3041	1.3118	1.3066	1.3045	1.3056	± 0.0079	1.317

ζ_0 = uncorrected values

ζ_1 = corrected for Lucite

ζ_2 = corrected for placement error

ζ_3 = corrected for deviation from parabola fit in fuel

ζ_4 = corrected for incorrect unit cell

Table 4.

Comparison to Old Values

<u>Vol. Mod.</u> <u>Vol. Fuel</u>	<u>Old (4)</u>	<u>New</u>	<u>Theory</u>
1:1	1.142	1.205	1.201
1.5:1	1.182	1.209	1.227
2:1	1.193	1.243	1.248
3:1	1.257	1.274	1.286
3:1 ^a	1.278	1.274	1.286
4:1	1.302	1.306	1.317

^aRecent measurement by E. Sermet (see Ref. 2).

Table 5.

Lattice Dimensions

Fuel Diameter = 0.387"

Cladding O.D. = 0.453"

Cladding Thickness = 0.028"

<u>Vol. Mod.</u> <u>Vol. Fuel</u>	<u>"A" (inches)</u>	<u>"B" (inches)</u>
1:1	0.5674	0.4914
1.5:1	0.6244	0.5407
2:1	0.6767	0.5860
3:1	0.7706	0.6673
4:1	0.8542	0.7397

Figure 1.

Foil Placement in 3:1 Lattice

Figure 2.

Figure 3.

Lucite Effect

Figure 4. Divergence from Parabola in Fuel.

Figure 5.

Unit Cell

APPENDIX D

THE EXPERIMENTAL DETERMINATION OF FAST FISSION FACTOR IN LIGHT
WATER-MODERATED, SLIGHTLY ENRICHED URANIUM ROD LATTICES

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THE EXPERIMENTAL DETERMINATION OF FAST FISSION FACTOR IN LIGHT
WATER-MODERATED, SLIGHTLY ENRICHED URANIUM ROD LATTICES

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ABSTRACT

The ratio, δ_{28} , of the fission rate in U^{238} to that U^{235} was determined for various slightly enriched hexagonal miniature uranium rod lattices in light water. The experimental value of δ_{28} and ϵ for 1.0%, 1.15%, and 1.3% fuel enrichments, 1, 1.5, 2, 3, and 4 water-to-uranium volume ratios and 0.250 in., 0.387 in., and 0.600 in. rod diameters are listed in Table I, A, B, C. The measurements were carried out by comparing the β activities of Al catcher foils which were in contact with the depleted uranium foil and fuel rod sections. The effects of volume ratio, rod diameter and fuel enrichment on the δ_{28} were observed.

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INTRODUCTION

Fast neutrons in a slightly enriched uranium lattice may cause fission of U^{238} nuclei. Allowance for this effect may be made by introducing the Fast Fission Factor, ϵ .

ϵ is defined to be the number of neutrons slowing down past the U^{238} fission threshold, per neutron from thermal fission (1, 2, 3).

The fast fission factor ϵ in U^{238} can be given in terms of the measured quantities by the formula

$$\epsilon - 1 = \left(\frac{\nu_{28}}{\nu_{25}} - \frac{1 + \alpha_{28}}{\nu_{25}} \right) \delta_{28} \quad (1)$$

where ν_{28} and ν_{25} are equal to the average number of neutrons emitted per fission of U^{238} and U^{235} , respectively, and

$$\alpha_{28} = \frac{\sigma_r^{28}}{\sigma_f^{28}} = \frac{\int_{E_0}^{\infty} dE N(E) \sigma_r^{28}(E)}{\int_{E_0}^{\infty} dE N(E) \sigma_f^{28}(E)} \quad (2)$$

Where $N(E)$ is the fission neutron energy spectrum, $\sigma_r^{28}(E)$ the U^{238} radiative capture cross section, $\sigma_f^{28}(E)$ the U^{238} fission cross section, and E_0 the U^{238} fission threshold energy.

The quantity δ_{28} is equal to the ratio of the fission rate in U^{238} to that in U^{235} in the lattice.

Numerical integration of (2) leads to $\alpha_{28} = 0.107$.

If we use the recent best value of $\frac{\nu_{28}}{\nu_{25}} = 1.160$ and $\nu_{25} = 2.45$ ($\nu_{28} = 2.84$) the relationship between ϵ and δ_{28} becomes

$$\epsilon - 1 = 0.708 \times \delta_{28} \quad (3)$$

The unknown quantity to be determined is δ_{28} . Then, the experimental technique for determining ϵ consists essentially of determining δ_{28} ratio (2, 4, 5, 6).

Experimental Technique. Determination of δ_{28}

The measurement of δ_{28} is based on the fission Catcher Technique. We have used the method developed previously by H. Kouts et al. at Brookhaven National Laboratory (2, 4).

As shown schematically in Figure 1, a fuel rod is cut cross-wise into sections, and between the sections are placed uranium and aluminum foil sandwiches. The fuel rod with the two foil sandwiches is inserted in the center of a hexagonal miniature rod lattice. The whole lattice is then irradiated for 10 or 15 minutes. At the end of exposure time the rod is removed and the activities of aluminum catcher foils numbered in Figure 1 as 1, 3, 4, 6, 7, 9, 10 and 12 are measured with end-window β particle counters.

From the fission product activities of foils 1 and 6 is obtained a quantity R_1 proportional to the fission rate in the fuel rod. The fission product activities of foils 3 and 4 give a quantity R_2 proportional to the fission rate in the depleted uranium foil. Thus an experimental parameter $B(t)$ is defined more precisely by,

$$B(t) = \frac{R_2}{R_1} = \frac{\text{measured fission product } \beta \text{ activity in the depleted foil}}{\text{measured fission product } \beta \text{ activity in the fuel rod}} \quad (4)$$

The parameter $B(t)$ is related to the fast effect, δ_{28} , by the expression,

$$\delta_{28} = K(t) \frac{B(t) - n_{25}/N_{25}}{n_{28}/N_{28} - B(t)} \quad (5)$$

where N_{25} , N_{28} and n_{25} , n_{28} are the atom densities in the uranium rod and in the depleted foil, respectively. The subscripts 25 and 28 refer to U^{235} and U^{238} , respectively.

The quantity $K(t)$ is a time-dependent factor to convert the fission product β activity to the true number of fissions that occurred. An auxiliary experiment is indispensable to determine $K(t)$ (5, 7, 8, 9).

The values of n_{28}/N_{28} and n_{25}/N_{25} for the 1.3% enriched fuel rod and 3 ppm depleted uranium foil are, about, $n_{28}/N_{28} = 1.01316 \simeq 1$, $n_{25}/N_{25} = 0.0002308 \simeq 0$.

If we accept that $\frac{n_{28}}{N_{28}} \simeq 1$ and $\frac{n_{25}}{N_{25}} \simeq 0$, i.e., neglecting the slightly different atomic densities in the depleted uranium and the fuel rod, the equation (5) leads to

$$\delta_{28} = K(t) \frac{R_2}{R_1 - R_2} \quad (6)$$

If we take into account these slightly different atomic densities, equation (5) leads to

$$\delta_{28} = K(t) \frac{R_2}{1.013 R_1 - R_2} \quad (7)$$

For the natural fuel rod and 3 ppm depleted uranium foil, 1.007 is used in place of 1.013.

This is the formula adopted for the determination of δ_{28} . To do this, it is necessary to determine the correction factors $K(t)$ to convert a measured ratio of $\frac{U^{238}}{U^{235}}$ fission product β activities to a true fission rate ratio (10).

Measurement of $K(t)$. Double Fission Chamber and the Fission Counting Apparatus

The relationship between the fission rate and fission product β activity for U^{235} and U^{238} was determined by the double fission chamber experiment (5, 7, 8, 10, 11).

The double fission chamber shown in detail in Figure 2, contained on each aluminum cathode disc an accurately known amount

of uranium source in the form of a very thin layer as fissioning elements.

The uranium sources were plated on a platinum disc 0.002 inches thick and 1 inch in diameter and their exact deposited amounts were determined by α counting (12).

The amount of 3 ppm (approximately) depleted uranium source waxed to the cathode disc of chamber 1 was 217 $\mu\text{g.}$ or 96 $\mu\text{g./cm}^2$.

The amounts of natural and 1.3% enriched uranium sources waxed to the cathode disc of chamber 2 were 195 $\mu\text{g.}$ or 86 $\mu\text{g./cm}^2$, and 42.5 $\mu\text{g.}$ (or 19 $\mu\text{g./cm}^2$), respectively.

The spacing between each chamber cathode anode aluminum discs was 5/8 inches (or 1.5 cm).

Dry argon gas was passed through the two chambers at a rate of 0.20 liter/min.

The average background counting rates in the empty fission chambers were 49 counts/min. in chamber 1 and 65 counts/min. in chamber 2. These backgrounds, which were independent of discrimination setting, may be attributed to the activation of impurities and (n,p), (n,2n) and (n, α) reactions in the aluminum.

Calculation and Experimental Results

The determination of $\frac{R_2}{R_1 - R_2} = \left(\frac{\delta_{28}}{K(t)} \right)$ was carried out by foil counting.

In order to determine $K(t)$ a sandwich of depleted-natural (or enriched) uranium foils and aluminum catcher foils was placed in the small gap between the two fission chambers. The arrangement of this sandwich is shown in Figure 3. The chambers, with depleted and natural (or enriched) sources, were then exposed to the neutron flux using the same exposure time, as in the fast effect measurements. The fission rates in the two fission chambers were recorded and the catcher foils were afterwards removed and the resultant fission product β activities counted in the same way as for a fast effect measurement.

The recorded average count rates were 14,000 counts/min. in chamber 1 (depleted source), 18,134 counts/min. in the chamber 2 (enriched source) and the average value of (δ_{28}) for the chambers' sources,

$$(\delta_{28}) = \frac{\text{fissions per gram recorded in chamber containing depleted uranium source}}{\text{fissions per gram recorded in chamber containing enriched uranium source} - \text{numerator}}$$

$$(\delta_{28}) = 0.1787 \text{ (with the Cd box of 0.004 in. thick).}$$

With the fission chambers containing depleted - natural uranium sources, using the cadmium box of 0.007 inches thick, the recorded average count rates were 12,900 counts/min. in chamber 1 (depleted source), 25,454 counts/min. in chamber 2 (natural source) and the average value of $(\delta_{28}) = 0.8043$.

Finally, experiments done with the double fission chamber, in the cadmium box of 0.007 inches thick, containing depleted-enriched uranium sources, have given 13,549, 9016 counts/min. and $(\delta_{28}) = 0.4222$.

The experimental values of $K(t)$ were obtained by substituting the measured values of (δ_{28}) and the time variant $\frac{r_2}{r_1 - r_2}$ from catcher foils in the double fission chamber into an equation similar to the equation (6) or (7).

The time variant $\frac{r_2}{r_1 - r_2}$ was measured at about 12 min. intervals (counting time 10 min.) beginning approximately 40 min. after the end of exposure until 350 min. after irradiation. The variable $K(t)$ was then evaluated for all experiments taking the average of three successive measurements.

Figure 4 shows the correction factor $K(t)$ curve as a function of time after end of exposure. The vertical lines indicate the standard deviation of the three measurements.

The regular fast effect foil counting began 60 minutes after end of exposure and ended an average of 196 minutes after end of exposure. An average value of $K(t)$ over this range was determined by averaging points taken from the curve at 10 min. intervals. This average value was $K(t) = 1.00 \pm 0.03$.

The values of δ_{28} for various enrichments, rod diameters and lattice volume ratios are listed in Table I, A, B, C, with

the standard deviations. Each δ_{28} is the average of several measurements. The values of δ_{28} are plotted in Figure 5 as a function of the water-to-uranium volume ratio (w/u).

The dependence of the fast effect δ_{28} or ϵ , on the characteristics of the lattice (moderator-to-fuel volume ratio and rod diameter) and on the fuel enrichment may be deduced from the results obtained in this work as shown in Figure 5 and Table I, A, B, C.

The fast fission factor increases with decreased w/u volume ratio, i.e., in closely packed water-uranium lattices, as expected.

Although the accuracy of the experimental method is not very high, in general, as Figure 5 shows, the fast effect increases slightly with fuel rod diameter. The theoretical ϵ analysis for a single rod also shows this increase. The effect of rod diameter on the fast fission factor in the range covered by these experiments becomes increasingly clear especially for the small values of δ_{28} . Unfortunately, for the high values of δ_{28} corresponding to the low volume ratios, the observed differences are just within the experimental errors. In this region the effect of closer packed lattice dominates.

In these experiments the fuel enrichment often appears to have no significant effect on the fast fission factor. Since for these range of enrichments the observed differences are within the

experimental errors, it is difficult to establish the magnitude of this trend. Except the values for 0.600 in. diameter rod with the volumes ratios 1, 1.5 and 2. It is for this reason that an average value of δ_{28} for each volume ratio was given in Table I, A, B, C, (column 5).

Discussion

The major source of uncertainty in determining values of ϵ is the uncertainty in the value of v_{28} . The previous BNL values of ϵ have been calculated by the formula:

$$\epsilon - 1 = 0.557 \delta_{28}$$

based on the D. L. Hill's original assumption $v_{25} = v_{28} = 2.5$.

The value of $v_{28} = 2.5$ is uncertain. Our determined values of ϵ were based on the recent (13) best values of $\frac{v_{28}}{v_{25}} = 1.160 \pm 0.020$. $v_{25} = 2.45 \pm 0.03$ ($v_{28} = 2.86 \pm 0.05$) and the formula

$$\epsilon - 1 = 0.708 \times \delta_{28}$$

The indicated standard deviations in $\delta_{28} = K(t) \frac{R_2}{R_1 - R_2}$ results from combining the following experimental errors:

1. The probable errors due to counting statistics in obtaining (δ_{28}) , $\frac{r_2}{r_1 - r_2}$ and $\frac{R_2}{R_1 - R_2}$.

The limit of absolute statistical errors in $\frac{R_2}{R_1 - R_2}$ and between ± 0.0046 and ± 0.0063 .

2. 2% uncertainty in the relative counting efficiencies of the two fission counting sets and chambers.
3. 0.4% uncertainty in the counting rates of two chambers due to the neutron-induced empty chamber fission background.

In order to check the shape of the curve we have done several fast effect runs using the same exposure times, but changing the waiting time after exposure. For these types of experiments foil counting began 195 min. (on the average) after end of exposure and ended 328 min. (on the average) after end of exposure. The corresponding values of $\frac{R_2}{R_1 - R_2}$ were found to be a little smaller than the regular ones. The average ratio between these two kind of values is 1.037 for about twenty different experiments.

For this interval of time the average value of the correction factors taken from the curve were $K(t) = 1.04 \pm 0.02$.

Both results indicates that the second half of the correction factor curve increases only slightly with respect to the first half. Thus close agreement was found between the previously measured shape of the curve and the experimental results of the fast effect measurements.

Separate experiments have shown that the catcher foils technique may be handled without significant loss of activity. An average value of the fast fission factor for the fuel rod can be obtained directly from disc catcher foils irradiated between

transverse sections of the fuel rod without $K(t)$ correction factor using a suitable waiting time, on the average, 60 min., after the end of the exposure and a 10 min. counting time. Under these conditions, the average value of $K(t)$ was found equal to unity.

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In particular, I would like to thank Dr. Herbert Kouts for his kind hospitality during my stay at Brookhaven National Laboratory.

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Table I. A, B, C

Experimental Values of the Fast Effect, δ_{28} , and Fast Fission Factor, ϵ , in Light Water Moderated, Slightly Enriched Uranium Rod Lattices

A

0.250 in. Diameter Rods

Volume Ratio:	Enrichment % U ²³⁵ by Weight			Average δ_{28}	Fast Fission Factor	
	1.0	1.15	1.3		$\epsilon=1+0.557 \delta_{28}$	$\epsilon=1+0.708 \delta_{28}$
W/U						
1	-	-	-	-	-	-
1.5	0.129	0.126	-	0.128 $\pm$ 0.003	1.071	1.091
2	0.102	0.103	-	0.103 $\pm$ 0.003	1.057	1.073
3	0.077	0.077	-	0.077 $\pm$ 0.002	1.043	1.055
4	0.066	0.061	-	0.064 $\pm$ 0.002	1.036	1.045

B

0.387 in. Diameter Rods

Volume	Enrichment			Average	Fast Fission Factor	
Ratio:	% U ²³⁵ by Weight				δ_{28}	$\epsilon=1+0.557 \delta_{28}$
W/U	1.0	1.15	1.3			
1	0.187	0.177	0.176	0.180 <u>±</u> 0.003	1.100	1.127
1.5	0.136	0.138	0.127	0.134 <u>±</u> 0.002	1.075	1.095
2	0.109	0.106	0.108	0.108 <u>±</u> 0.004	1.060	1.076
3	0.081	0.081	0.077	0.080 <u>±</u> 0.003	1.045	1.057
4	0.068	0.064	0.066	0.066 <u>±</u> 0.002	1.037	1.047

C

0.600 in. Diameter Rods

Volume	Enrichment			Average	Fast Fission Factor	
Ratio:	% U ²³⁵ by Weight				$\epsilon=1+0.557 \delta_{28}$	$\epsilon=1+0.708 \delta_{28}$
W/U	1.0	1.15	1.3	δ_{28}		
1	0.180	0.179	0.177	0.179±0.002	1.100	1.127
1.5	0.144	0.142	0.126	0.137±0.003	1.076	1.097
2	0.116	0.113	0.106	0.112±0.004	1.062	1.079
3	0.081	0.086	0.084	0.084±0.002	1.047	1.059
4	0.072	0.070	0.071	0.071±0.002	1.040	1.050

Figure 1. Catcher Foil Arrangement for Determination of δ_{28} .

Negative No. 3-398-60

Figure 2. Double Fission Chamber. Negative No. 3-399-60

Figure 3. Double Fission Chamber Foil Arrangement.

Negative No. 3-397-60

Figure 4. Correction Factor $K(t)$ for Fast Fission Factor Measurement. Negative No. 3-396-60

Figure. 5. Fast Effect, δ_{28} , as a Function of W/U Volume Ratio. Negative No. 3-400-60

APPENDIX E

M E M O R A N D U M

VARIABLE LOADING ANALYSIS OF THE 3% U²³³O₂-ThO₂ LATTICES
FOR MATERIAL BUCKLING

by
Henry H. Windsor

February, 1966

VARIABLE LOADING ANALYSIS OF THE 3% $U^{233}O_2$ - ThO_2 LATTICES
FOR MATERIAL BUCKLING

Summary

An analysis of a series of 3% enriched $U^{233}O_2$ - ThO_2 lattices moderated with H_2O and H_2O solutions of H_3BO_3 was carried out utilizing a "modified variable loading" technique. A total of 18 lattices were analyzed. Comparisons were made with "flux shape" values of B_m^2 . Good agreement was obtained between the "flux shape" and "modified variable loading" material bucklings (B_m^2) for values of B_r^2 less than 50 m^{-2} , above this the "flux shape" values were systematically higher than those obtained using the "variable loading" technique.

Measurement

Exponential experiments were carried out using fuel elements of 3% enriched $U^{233}O_2$ - ThO_2 compacted to a density of 8.96 g/cc in 0.500" in diameter zircalloy-2 tubes having a .035" wall thickness. The active length of the fuel was 42-1/2". See Pgs. 268-279 for a detailed description of the fuel and lattice spacings. These elements were arranged into circularized hexagonal lattices of volume ratios of moderator-to-fuel of 9.27:1, 6.84:1, 4.27:1, 3.0:1, 2.19:1, 1.71:1, 1.38:1, and 0.997:1. The fuel was moderated and reflected with H_2O and H_2O solutions of H_3BO_3 . The concentration of H_3BO_3 used ranged from 0 to 25 mg/ml, and was chosen to reduce the buckling in each volume ratio from its clean (pure H_2O) value to approximately 0 in 2 steps.

The neutron distribution in the lattices were determined using 0.387" in diameter by 0.005" (for radials) and 0.010 thick (for axials) indium foils. For axial traverses these foils were located by use of a lucite stringer. The foils were spaced every

5.08 cm starting 50.8 cm off the bottom of the lattice up to 76.2 cm. Radial traverses were carried out by taping foils to rings milled in the clad of individual fuel elements at the height of the plane of the traverse. Two foils, one to the side of the rod facing the center of the lattice, the other to the side facing away from center, were attached to each fuel rod on the diameter of interest. Six different diameters were traversed; each one twice. The activity of the two opposing foils on each rod were averaged and the average activity was considered to be located at the center of the fuel element.

Both radial and axial traverses were done at the top or fullest loaded lattice. Loadings were limited to ones which gave a relaxation length of less than 50 cm. Axial relaxation lengths were measured for a series of about 10 radial sizes for each lattice.

The foils activated in these traverses were each counted in four gas flow counters and the resulting activities were corrected for dead time, background and decay. The corrected activities were fit to either a J_0 or $\sinh$. The J_0 fits were limited to points measured in a region between the center of the lattice and 8 cm from the core reflector interface. Calculations carried out by Hellens indicated the region was in equilibrium. Corrections were made to the axial relaxation lengths for a γ source contribution to the foil activities. To make this correction axial traverses were performed both with a normal and cadmium covered thermal column.

From analyses of these measured flux activities the "flux shape" and "variable loading" values of material buckling were determined.

Analyses

The variable loading analysis was carried out using an expression for the reflector savings that was suggested by a modified one group -2 region solution of the diffusion equation for reflector savings:

$$\lambda_z = \frac{\lambda_o}{(1+M^2 B_z^2)^{\frac{1}{2}}} \frac{K_0 \left(\frac{1}{M^2} + B_z^2 \right)^{\frac{1}{2}} r}{K_1 \left(\frac{1}{M^2} + B_z^2 \right)^{\frac{1}{2}} r} + \Delta\lambda \quad (1)$$

where λ_o and M^2 were arbitrary constants, B_z^2 was the measured value of $-\frac{1}{L^2}$ (for an exponential) and $\Delta\lambda$ was a correction for linearly extrapolating the flux at the interface rather than extrapolating the J_o .

$$\Delta\lambda = \lambda_L - \frac{J_o (B_r N)}{B_r J_1 (B_r N)} \quad (2)$$

where $\lambda_L = \lambda_z - \Delta\lambda$ and $B_r = \frac{2.4048}{(r+\lambda L)}$

The above equation was incorporated into the standard

$$B_m^2 = \frac{J_o^2}{(r+\lambda)^2} - \frac{1}{L^2} \quad (3)$$

formulation. The values of λ_o , M^2 and B_m^2 were determined by fitting a series of measured relaxation lengths that had been measured in cores of different known values of r .

Prior to fitting the model to the measured values of $\frac{1}{L^2}$ and r , the values of L were corrected for the effect of the "spurious source" (a γ -N contribution to the foil activities) and in the cases

of the poisoned lattices for variation of poison concentration during the measurements.

The "flux shape" results were analyzed using the normal procedure. The region of equilibrium was chosen as starting 8 cm in from the edge of the core reflector interface. All points in the equilibrium region were least squares fit to a J_0 function. The reflector savings were determined as the difference between the core reflector interface and where the J_0 function extrapolated to 0. The measured radial and axial flux traverses (both measured in the same core) were combined to give the material buckling using formula (3).

"Flux shaped" and "modified variable loading" values of material buckling are given in Table I. Tables II → IX list the various measured relaxation lengths as a function of a number of rods in the core.

Results

Examination of Table I shows that the "variable loading" and "flux shaped" measured bucklings are in good agreement for lattices with radial bucklings smaller than 50 m^{-2} . For lattices with higher radial bucklings the agreement is not as good. It appears that the reflector savings cannot be reliably determined using the simple "flux shape" technique in lattices with radial bucklings larger than 50 m^{-2} ; consequently the "modified variable loading" measured bucklings are considered more reliable for high buckling lattices.

$U^{233}O_2$ - ThO_2 Fuel Rod

Cladding: Zircaloy-2

Nominal Composition: Sn - 1.45%
 Cr - .10
 Fe - .13
 Ni - .05
 Zr - 98.27 (remainder)

Total 100.00%

Nominal Size: O.D. = 0.499 ± 0.002 in. = 1.26746 cm

I.D. = 0.430 ± 0.0015 in. = 1.09220 cm

Linear Density = 133 gm/60.6425 cm = 2.19318 gm/cm length

Volume Density = 6.8365 gm/cm³.

Fuel Density

# Fuel Rods	Carrier #	Av. Fuel Wt. (gms)	Av. Fuel Length (cm)	Av. Linear Density (gms/cm)	Av. Vol. Density (gm/cm ³)	
120	1	906.308	107.457	8.4341	9.0021	} Av. Density 8.9618 gm/cm ³
120	2	904.800	103.148	8.3663	8.9297	
120	3	904.100	108.318	8.3467	8.9088	
120	4	910.725	108.154	8.4206	8.9877	
120	5	909.850	108.220	8.4074	8.9736	
120	6	904.375	107.865	8.3843	8.9490	
120	7	906.100	107.890	8.3976	8.9631	
60	8	909.017	107.812	8.4315	8.9993	
200 (short rod)	9	313.130	36.9411	8.4765	9.0473	

$U^{233}O_2$ -ThO₂ Fuel Rod Composition:

Av. Density = 8.9618 gm/cm³; O.D. = 0.430 in. = 1.09220 cm.

$$U^{233}/(U^{233} + Th) \text{ wt ratio} = 0.03000$$

Isotope	Fractional Weight	Atoms/cm ³
O ¹⁶	0.121197	0.408832 x 10 ²³
Th ²³²	0.851764	0.198155 x 10 ²³
U ²³³	0.026343	0.0061021 x 10 ²³
U ²³⁴	0.000394	0.0000909 x 10 ²³
U ²³⁵	0.000012	0.0000027 x 10 ²³
U ²³⁸	0.000289	0.0000655 x 10 ²³
(9 ppm) B	0.000009	0.0000449 x 10 ²³
(2-9 ppm)	<hr/>	
$\left(\frac{\delta k}{k} \approx .005\right)$	$\Sigma = 0.999008$	

Clad Composition: Zircaloy-2, $\rho = 6.8365$ gm/cm³; O.D. = 0.499 in. = 1.26746 cm; I.D. = 0.430 in. = 1.09220 cm

Isotope	Fractional Weight	Atoms/cm ³
Zr	0.9827	0.443550 x 10 ²³
Sn	0.0145	0.005030 x 10 ²³
Cr	0.0010	0.000792 x 10 ²³
Fe	0.0013	0.000958 x 10 ²³
Ni	0.0005	0.000351 x 10 ²³

Moderator Composition: H₂O; $\rho = 0.998$ gm/cm³

H	0.111901	0.668597 x 10 ²³
O	0.888099	0.334293 x 10 ²³

Water-to-Fuel Volume Ratios

$$\text{Vol. Ratio} = \left[AB - \frac{\pi}{4}(0.499)^2 \right] / \frac{\pi}{4}(0.430)^2 = \left[AB - 0.1955649 \right] / 0.1452201.$$

$\frac{V_{H_2O}}{V_{UO_2}}$	<u>A (in.)</u>	<u>B (in.)</u>	<u>A (cm)</u>	$\frac{A_o}{\sqrt{\pi}} = \frac{A}{\sqrt{\pi}} \frac{\sqrt[4]{3}}{\sqrt{2}} = 0.525037 A$
0.9970	0.6269	0.5429	1.5923	0.8360
1.3840	0.6767	0.5860	1.7188	0.9024
1.7134	0.7163	0.6204	1.8194	0.9553
2.1943	0.7706	0.6673	1.9573	1.0276
3.0043	0.8542	0.7397	2.1697	1.1391
4.2722	0.9707	0.8406	2.4656	1.2945
6.8449	1.1720	1.0150	2.9769	1.5630
9.2747	1.3346	1.1558	3.3899	1.7798

TABLE I

 $U^{233}O_2-ThO_2$

Volume Ratio V_m/V_f	H_3BO_3 mg/ml	No. of Rods	L Top Loading cm	B_m^2 (Variable Loading) M^{-2}	B_m^2 (Flux Shape) M^{-2}	λ (Variable Loading) Top Loading cm	λ (Flux Shape) cm	λ_o cm	M^2 cm
0.9970	0	511	39.57	± 0.7		± 0.2		± 0.1	± 0.5
	13.3	889	21.68	75.04	79.10 ± 0.7	7.8	7.11	8.80	51
	25.00	889	14.9	15.9	42.04 ± 0.2		5.26		
1.3840	0	397	43.58	85.43	18.91 ± 0.4	5.85	5.12	5.80	29
	7.82	859	41.47	50.14	87.80 ± 2.6	7.37	6.95	8.4	52
	22.9	889	13.79		51.0 ± 0.20	5.8	5.44	6.10	39.4
1.7134	0	343	39.76	87.6	3.72 ± 0.3				
	4.74	625	40.51	60.7	93.76 ± 1.2	7.33	6.50	8.3	45
	18.88	889	13.79	-3.33	60.16 ± 0.3	5.75	5.65	6.1	44
2.1943	0	301	44.5	87.4	-1.78 ± 0.2	5.9	5.25	5.55	38
	4.71	661	42.34	50.60	92.26 ± 1.3	7.17	6.55	8.10	41
	13.3	889	14.8		50.47 ± 0.2	5.8	5.70	6.05	38
3.0043	0	271	45.18	85.3	-1.09 ± 0.3		5.45		
	4.99	889	31.33	26.3	86.40 ± 1.3	6.63	6.42	7.4	45
	7.82	889	16.96	2.06	26.66 ± 0.1	6.00	5.69	6.10	33
4.2722	0	265	38.04	68.7	1.85 ± 0.15	5.5	5.77	5.5	44
	2.68	721	28.67	22.46	70.45 ± 0.4	6.54	6.27	7.17	± 5
	4.96	721	15.32	-7.56	22.87 ± 0.80	6.1	5.88	6.2	38
6.8449	0	433	39.97	32.34	-7.67 ± 0.25	6.0	6.01	5.60	44
	1.70	409	14.01	-10.8	32.26 ± 0.1	6.28	6.23	6.5	44
9.2747					-	6.4	-	5.90	36
	0	337	16.32	-0.56	-1.08 ± 0.14	6.7	6.6	6.5	32

TABLE II

0.997:1 Clean and Poisoned Lattice Relaxation Lengths $A_0 = 0.8360$ cm

Poison H_3BO_3 mg/ml	0		13.30		25.00	
	No. Rods	L cm	No. Rods	L cm	No. Rods	L cm
	511	39.297	889	21.683	889	14.872
	499	36.664	781	18.905	769	13.714
	487	33.515	673	16.645	661	12.784
	475	31.200	583	14.924	583	12.028
	463	29.002	487	13.271	511	11.335
	451	26.989	421	12.102	463	10.828
	433	24.948	361	11.111	409	10.281
	409	22.463	313	10.370		
	385	20.754				
	367	19.432				
	349	18.180				
	325	17.032				
	301	15.754				
	283	15.076				
	265	14.200				
	241	13.232				
	223	12.621				
	199	11.651				
	181	11.208				
	163	10.509				

TABLE III

1.384:1 Clean and Poisoned Lattice Relaxation Lengths $A_o = 0.9024$ cm

Poison H_3BO_3 mg/ml	0		7.82		22.90	
	No. Rods	L cm	No. Rods	L cm	No. Rods	L cm
	397	45.370	859	41.472	769	13.013
	379	35.060	649	22.631	661	12.245
	361	30.367	475	16.191	595	11.772
	337	25.558	367	13.295	517	11.101
	325	23.524	295	11.663	463	10.642
	313	21.996	241	10.457	397	10.044
	295	20.169				
	283	19.128				
	265	17.370				
	253	16.735				
	235	15.510				
	223	14.703				
	211	14.111				
	199	13.421				
	181	12.572				
	163	11.784				
	151	11.245				
	139	10.729				
	127	10.235				
	121	10.010				

TABLE IV

1.7134:1 Clean and Poisoned Lattice Relaxation Lengths $A_o = 0.9553$ cm

Poison H_3BO_3 mg/ml		0		4.74		18.88	
		No. Rods	L cm	No. Rods	L cm	No. Rods	L cm
		343	44.575	625	40.514	889	13.787
		337	39.785	451	20.125	703	12.614
		325	34.432	337	15.106	595	11.848
		313	29.704	265	12.517	499	11.121
		301	27.087	211	10.979	439	10.628
		283	23.483	187	10.280	385	10.136
		271	21.670			337	9.696
		265	21.029				
		253	19.552				
		235	17.688				
		223	16.735				
		211	15.668				
		199	14.863				
		187	14.112				
		181	13.744				
		169	13.055				
		151	12.023				
		139	11.379				
		127	10.817				
		109	9.988				

TABLE V

2.1943:1 Clean and Poisoned Lattice Relaxation Lengths

Poison H_3BO_3 mg/ml	0		4.71		13.33	
	No. Rods	L cm	No. Rods	L cm	No. Rods	L cm
	301	44.813	661	42.185	745	13.836
	283	33.891	475	21.201	595	12.625
	265	27.072	361	15.954	487	11.734
	241	22.025	295	13.763	409	10.982
	223	19.526	253	12.376	349	10.334
	211	18.065	187	10.467		
	199	16.845				
	187	15.843				
	151	13.031				
	139	12.354				
	121	11.264				
	109	10.547				
	97	9.987				
	91	9.524				
	85	9.208				
	73	8.663				
	61	7.984				
	55	7.722				
	43	7.173				
	37	6.798				
	31	6.506				
	19	5.881				

TABLE VI

3.0043:1 Clean and Poisoned Lattice Relaxation Lengths $A_0 = 1.1391$ cm

Poison H_3BO_3 mg/ml		0		4.99		7.82	
No.	L	No.	L	No.	L	No.	L
Rods	cm	Rods	cm	Rods	cm	Rods	cm
271	46.304	889	31.410	889	16.973		
253	32.569	547	18.926	637	14.578		
235	26.171	379	14.734	487	13.084		
223	23.401	271	12.229	397	12.105		
211	21.282	223	11.147	325	11.162		
199	19.463	181	10.123	271	10.445		
187	17.881						
181	17.189						
169	15.981						
163	15.374						
151	14.335						
139	13.427						
127	12.480						
121	12.119						
109	11.288						
97	10.643						
91	10.239						

TABLE VII

4.2722:1 Clean and Poisoned Lattice Relaxation Lengths $A_0 = 1.2945$ cm

Poison H_3BO_3 mg/ml		0		2.68		4.96	
No. Rods	L cm	No. Rods	L cm	No. Rods	L cm	No. Rods	L cm
265	38.933	721	28.481	721	15.318		
253	33.111	535	21.282	607	14.350		
241	28.799	409	17.420	517	13.596		
223	24.178	337	15.427	439	12.867		
211	22.171	271	13.664	385	12.298		
199	20.256	235	12.748	337	11.736		
187	18.662	211	12.007	301	11.296		
169	16.754	181	11.226	271	10.930		
151	15.165	163	10.701	241	10.518		
139	14.105	139	10.023	211	10.023		
127	13.133						
121	12.672						
109	11.856						
97	11.115						
91	10.622						
85	10.341						

TABLE VIII

6.8449:1 Clean and Poisoned Lattice Relaxation Lengths $A_0 = 1.5630$ cm

Poison H_3BO_3 mg/ml		0	1.70
No. Rods	L cm	No. Rods	L cm
433	39.884	433	14.342
397	33.183	409	14.012
349	27.059	385	13.724
313	23.641	367	13.524
271	20.451	349	13.273
241	18.567	325	12.930
223	17.306	301	12.595
199	16.010	283	12.367
181	14.942	265	12.125
163	14.081	241	11.731
151	13.552	223	11.437
139	12.879	199	11.036
127	12.262	181	10.689
121	11.976	163	10.354
109	11.398	151	10.128
97	10.818		
91	10.502		
85	10.187		

TABLE IX

9.2747:1 Clean and Poisoned Lattice Relaxation Lengths $A_O = 1.7798$ cm

Poison H_3BO_3 mg/ml	0
No. Rods	L cm
337	16.151
325	16.021
313	15.655
295	15.410
283	15.096
265	14.741
253	14.455
235	14.077
223	13.718
211	13.570
199	13.088
187	12.827
169	12.351
151	11.853
139	11.505
121	10.980
109	10.513
97	10.101