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BUCKLING OF LIGHT-WATER MODERATED LATTICES OF .387″ DIAMETER, 1.027% ENRICHED URANIUM RODS

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Abstract: Experimental values of the buckling of lattices of .387" diameter, 1.027% enriched uranium rods in light-water are reported. The measurements were made in an exponential experiment, as part of a continuing program of study of ordinary water, slightly enriched uranium systems. A brief description of the method of measurement is reported. The results are compared with previous ones involving the same rod enrichment but other rod diameters.

Introduction: We have reported in earlier papers (1) the results of buckling measurements with 1.027% enriched rods of .750" and .600" diameter, with light-water moderator, and also similar results obtained with 1.3% and 1.15% rods of .600" diameter.(2) Still to be completed under the scheduled program are buckling measurements with .387" diameter, 1.3% and 1.15% enriched rods, and measurements with .250" diameter rods of all three enrichments.

The results given and discussed in the following apply to lattices of .387" diameter, 1.027% enriched uranium rods, with water-to-uranium volume ratios from 1:1 to 4:1. The rods are clad with .028" aluminum, and have a .005" air gap between the fuel and the clad.

Methods: The procedure used to obtain the material buckling of these assemblies was that of the standard exponential experiment. Cylindrical loadings of the fuel were placed vertically in the water tank on top of the Brookhaven reactor, with a thermal column under the tank supplying the source neutrons for excitation of the assemblies. Rod spacings were maintained by aluminum locating plates at the top and bottom of the rods, and by two lucite spacer plates at equal intervals between.

Vertical and horizontal flux distributions were measured throughout the assemblies. The relaxation lengths L of thermal neutrons in the lattices were obtained from the vertical (axial) flux traverses, and the effective radii R were obtained from the horizontal (radial) flux distributions. Then the buckling was calculated as

$$B^2 = \left(\frac{2.4048}{R}\right)^2 - \frac{1}{L^2}$$

The axial flux distributions were measured by means of activation of bare indium foils. Thus the relaxation lengths observed represented some combination of thermal and indium resonance neutrons. However, the low energy neutron spectrum does not vary appreciably throughout most of the lattice, and as a result the relaxation lengths are well descriptive of thermal neutrons alone.

For the four lattices with volume ratios greater than 1:1, the foils for relaxation length measurement were located in a lucite rod placed in the center of a lattice cell. The 1:1 volume ratio lattice was too tightly packed for this procedure, and in this case the foils were placed between sections of a cut-up fuel rod.

The radial flux traverses were made by means of a fission chamber inside a fuel rod. This element was placed at successive positions along radii, and counts were taken in each instance. Simultaneously, counts were taken with a monitor detector (a second fission chamber), and the relative fluxes were thus derived as the ratio of the count rates of the two detectors.

Generally the outer points on a radial flux plot showed the effect of the flux increase at the core-reflector interface. Therefore these points were eliminated from the analysis, and the remainder of the relative flux values were fitted to

$$A\ J_o\ (2.4048\ \frac{r}{R}\ )$$

This procedure led to determination of the effective radii R, and also to the reflector savings.

<u>Results</u>: The measured values of buckling and reflector savings are given in table I. The errors indicated are derived solely from the standard deviations from least squares fits to the measured radial fluxes and from reproducibility of axial traverses; however, experience from previous measurements indicates that these do indeed generally represent the over-all accuracy of the measurments themselves.

The buckling results are plotted in figure 1. Also given there are the bucklings measured with larger rods of the same enrichment. It is apparent that decreasing the rod size in this range flattens the buckling curve, decreases its maximum value, and shifts the maximum to larger volume ratios. These effects of course result from the combined increase of thermal utilization and decrease of resonance escape probability as the rod size is diminished.

It is interesting to note that the three buckling curves cross near the 3:1 volume ratio. At this point, then, (supposing ε and η are independent of rod size) the logarithmic derivatives of f and p are equal and opposite in sign.

<u>References</u>:

(1) BNL Log No. C-6687, Exponential Experiments on Light-Water Moderated, 1 percent U-235 Lattices, November 28, 1952.

BNL Log No. C-7915, Buckling of Light-Water Lattices, .600" Diameter Rods, 1.027% 25, March 17, 1954.

(2) BNL Log No. C-7592, Buckling of Light-Water Lattices (.600" Diameter Rods, 1.3% and 1.15% 25), November 5, 1953.

Table I

Buckling and Reflector Savings, Lattices of 1.027% Enriched, .3[illegible]7" Diameter Uranium Rods in Ordinary Water.

Volume Water / Volume Uranium	Buckling ($cm^{-2} \times 10^4$)	Reflector Savings (cm)
1	3.15 ± .83	8.52 ± .17
1.5	19.31 ± .54	7.93 ± .17
2	28.82 ± .63	7.30 ± .25
3	31.31 ± .27	6.84 ± .14
4	25.76 ± .59	6.40 ± .26

FIGURE 1

B² VS VOLUME RATIO

1.027 % ENRICHED URANIUM RODS IN LIGHT WATER