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E. I. du Pont de Nemours and Co.
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SECTION I

PHYSICS EXPERIMENTS FOR CANDU LATTICES

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INTRODUCTION

Experiments have been performed at the Savannah River Laboratory (SRL) to investigate the physics behavior of burned-up fuel in the CANDU and similar heavy-water power reactors. These experiments used specially fabricated fuel assemblies containing plutonium and uranium in various isotopic compositions. All experimental work has been completed, but analysis is still in progress.

New Savannah River experiments are being prepared for the measurement of the change of η with temperature in a natural uranium lattice in the PDP. These experiments are still in the planning stages.

SUMMARY

Further analyses are being made of the PDP substitution measurements of the lattice bucklings. Temperature coefficients calculated by the HAMMER code were compared to the SE experiments, and a data reduction code has been modified to accommodate the decay of fissionable isotopes.

Candidate lattices for the $d\eta/dT$ experiments have been selected on the basis of HAMMER calculations, and bids are being solicited for the copper cladding tubes used to reduce the lattice bucklings into an acceptable range.

DISCUSSION

Results were given in the August report (DPST-66-83-8) for a source-sink (HERESY) analysis of substitution buckling measurements of the mockup burned-up fuel assemblies in natural uranium lattices in the PDP. The analysis of these buckling measurements is now being expanded to include the Persson perturbation analysis of the successive substitutions and a two-group, two-region analysis. The purpose of this extension is to provide a more rigorous comparison of the HERESY analysis with more traditional methods before accepting it for future substitution analyses.

Temperature Coefficients

The results of SE measurements on the buckling changes in uniformly heated lattices of the mockup burned-up fuel assemblies were presented in DPST-66-83-8. The fuel assemblies consisted of 19-rod clusters of aluminum-clad 0.500-inch-diameter sintered UO_2-PuO_2 pellets with an isotopic fuel composition of 0.30% ^{235}U, 0.25% ^{239}Pu, and 0.016% ^{240}Pu. The clusters were without housings at a 0.597-inch triangular pitch. HAMMER calculations have now been performed for comparison with the SE measurements. The results are shown in Figure 1. Although the HAMMER calculations differ by about ±20 μB in absolute magnitude from the measurements, the HAMMER temperature coefficients are very close to those actually measured.

Foil Activation Analysis

The data reduction code which is used to correct foil activations has been modified to permit decay corrections for foils with a multiple decay scheme. The modification involves fitting the log of the count rate, ϕ , to a polynomial of the form

$$A + Bt + Ct^2$$

where t is the time. This is equivalent to $\phi = e^{\lambda t}$ in which $\lambda = f(t)$.

The modified code has been used to correct the fission product activity of the ^{235}U and ^{239}Pu foil pairs which are being used as thermal spectrum indices (DPST-66-83-10). A comparison of these activation ratios with calculated values is in progress.

$d\eta/dT$ Measurements

One of the main uncertainties in calculating the temperature coefficient of reactivity for D_2O reactors lies in determining the temperature dependence of η, the average number of fast neutrons resulting from the capture of one thermal neutron in the fuel. It appears that experiments with full lattices of single 1-inch-diameter rods of natural uranium in the PDP offer a method for measuring $\frac{1}{\eta}\ d\eta/dT$ within ±15%. Basically the measurement would consist of buckling and migration area determinations over the range from ~20°C to ~70°C. The changes in thermal utilization and resonance capture,

$\frac{1}{f}\ df/dT$ and $\frac{1}{p}\ dp/dT$, would be calculated or measured within about

±10%, and $\frac{1}{\eta}\ d\eta/dT$ would be inferred by difference. One difficulty

in the experiments is the fact that the available single-rod lattices to be used in the measurements will have too high a reactivity in the PDP. In order to reduce this reactivity, it is proposed to load the 1-inch-diameter natural uranium slugs into copper cladding tubes.

A series of HAMMER calculations were performed to determine the required lattice pitches for the fuel and the proper wall thickness of the cladding tubes. The following pitches were considered: 4.667-inch triangular, 6.062-inch square, 7.0-inch triangular and 9.333-inch triangular; the cladding thickness was varied from 20 to 70 mils; and the calculations were made for both 20 and 60°C. The results (Figure 2) show that a cladding thickness of 34 mils provides about the required material buckling of 150 to 250 μB for a 4.667-inch triangular pitch and for a 6.062-inch square pitch. The following data were computed:

Temp., °C	Pitch	B_m^2	η
20	4.667" Δ	180	1.31850
20	6.062"	259	1.32135
60	4.667" Δ	160	1.31420
60	6.062"	240	1.31674

A full reactor load at a 4.667-inch triangular pitch will use 1487 fuel tubes. The copper tubes are being ordered to meet the scheduled date for the experiments, which will include control-rod flux shaping measurements as well as the $d\eta/dT$ measurements.

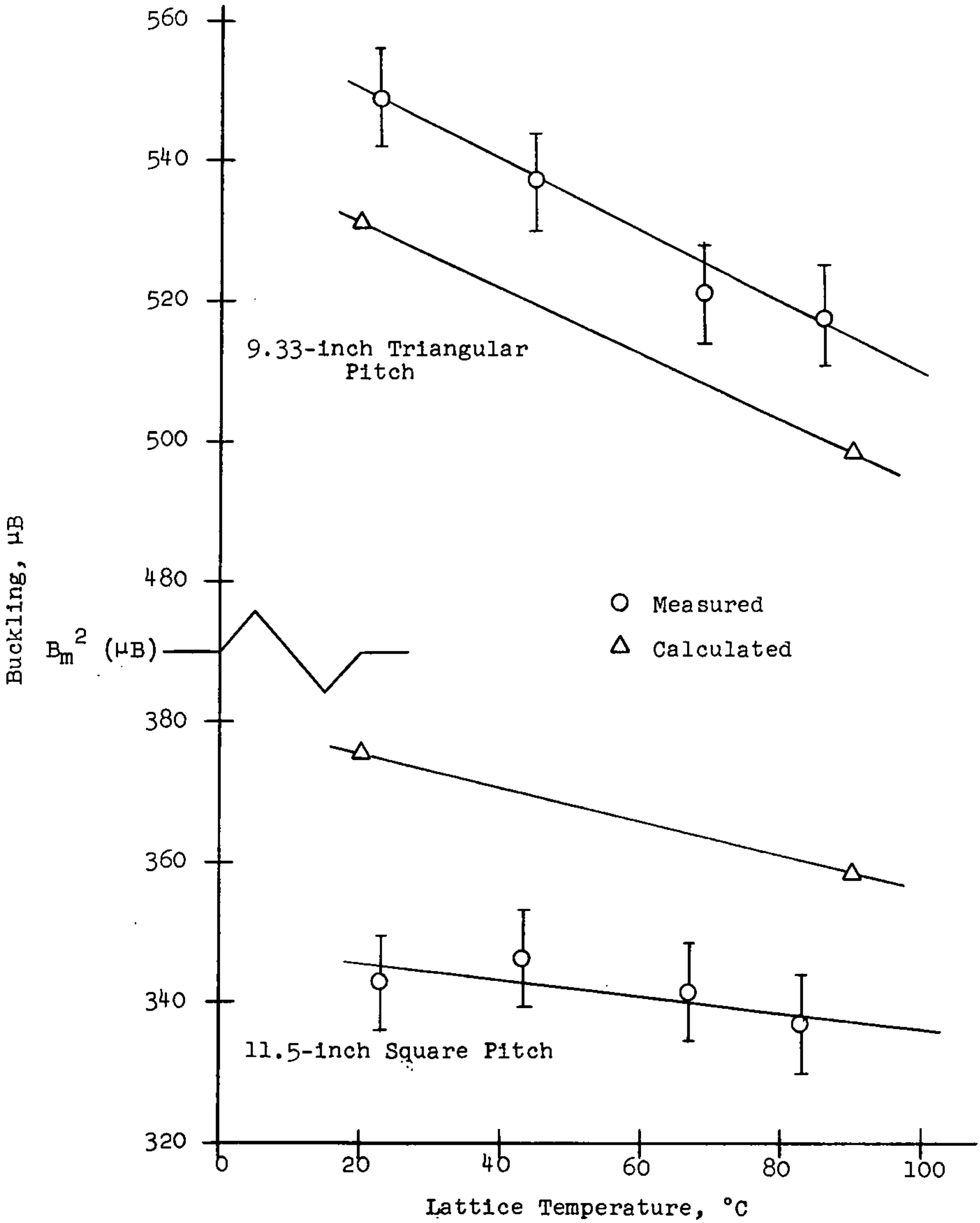

Figure 1. Measured and Calculated Temperature Coefficients in the SE 19-Rod Clusters Burned-up Fuel Mockup

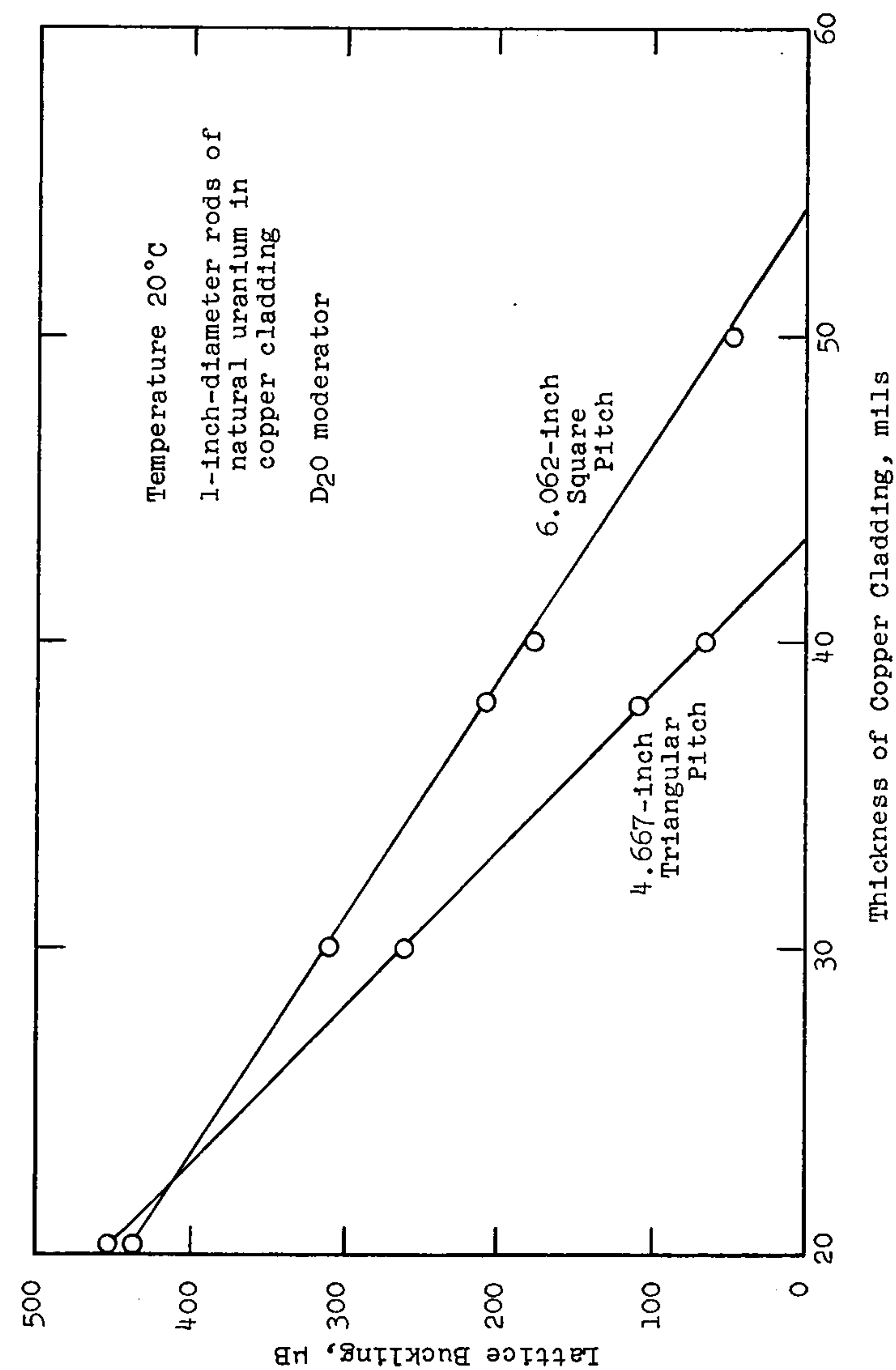

Figure 2. Calculated Buckling

SECTION II

AECL IN-CORE FLUX MONITORS

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An irradiation test of in-core flux monitors is being made in one of the Savannah River Plant reactors to determine the life characteristics of a selection of flux detectors and of the mineral insulation used in their construction. Self-powered flux detectors are relatively new; therefore, confidence in their use hinges to a great extent on proven performance at large integrated exposures. The chief points of interest are 1) integrity of the conductors and sheath during life, 2) life of insulation, and 3) sensitivity. The higher flux density available at SRP (vis-à-vis Chalk River) will shorten the irradiation time for a given exposure and should also show whether or not any new high intensity effects appear.

Fabrication and installation of the detector rod in the reactor has been completed and testing is in progress. There were no special tests in November. The data being collected will be reported in a separate topical report at the conclusion of the tests.

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