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PRELIMINARY RESULTS OF HIGH-TEMPERATURE
BARE U²³⁵ -C CRITICAL ASSEMBLY
MEASUREMENTS

LIVERMORE SITE

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ABSTRACT

The influence of temperature upon the critical buckling of bare graphite assemblies with various carbon-to-uranium-235 molar ratios has been measured. A range of C/U^{235} ratio from 1185:1 to 21,690:1 was covered, for temperatures between 45°F and 1205°F.

Preliminary results indicate that the fractional rate of change of critical buckling with core temperature varies monotonically with C/U^{235} ratio by a factor of five over the factor-of-eighteen range in gross C/U^{235} ratio. This quantity appears to approach asymptotically a value near 2%/100°F at very high C/U^{235} ratios.

PRELIMINARY RESULTS OF HIGH-TEMPERATURE BARE U^{235} -C CRITICAL ASSEMBLY MEASUREMENTS

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A survey has been completed of the influence of temperature upon the critical buckling of bare-graphite/enriched-uranium assemblies in the Lawrence Radiation Laboratory's HOT BOX high-temperature critical facility.¹ The survey covered the whole range of carbon-to-uranium-235 molar ratio available in HOT BOX, for temperatures between 45°F and 1205°F. The lowest ratio, 1185:1, required more than 90% of the total inventory of both 4-mil and 2-mil fuel elements,² and the highest ratio, 21,690:1 (18 times the lowest), involved the largest assembly that can presently be stacked on the low-mass table. Preliminary results of the survey are given in Table I.

The C/ U^{235} ratios are taken from the amount of graphite per lattice unit and the amount of U^{235} present in the associated foils; no corrections have been made for foil self-shielding or flux depression. All dimensions are room-temperature measurements, and the heights include 2.5 in. for the contribution of the base layer, low-mass table, and floor. The poison of the neutron source container³ was present in the center of the assembly for all criticality determinations. The volume-average density of the graphite, including flow passages and control voids, was 1.48 g/cm³. The graphite contained 5 ppm boron equivalent moderator poison. The measured thermal expansion of HOT BOX graphite (grade CS-312) in the vertical and horizontal directions is shown in Fig. 1. Room-temperature critical heights and the critical temperature of overstacked assemblies were determined by means of standard HOT BOX experimental procedures.³

The numbers in the table, while of preliminary nature and subject to minor revision, are of sufficient accuracy to allow comparison with machine calculations of the differential effect of temperature. A difference in buckling between the assembly critical at room temperature and the assembly critical at an elevated temperature for each C/ U^{235} ratio has been calculated from the room temperature dimensions given in the table. The fractional change in buckling and the associated change in temperature give the fractional rate of change of buckling with temperature for each

experiment. This quantity is plotted in Fig. 2 against the median temperature between room temperature and the elevated critical temperature in each case. It is seen that for the two C/U^{235} ratios where two high temperature experiments were done, the absolute value of $\frac{\Delta B^2/B^2}{\Delta T}$ decreases with $\bar{T}$. Using this information on the variation of this quantity with temperature, we can evaluate it at one temperature for all values of the C/U^{235} ratio. Figure 3 is a plot of the value of $\frac{\Delta B^2/B^2}{\Delta T}$ at 500°F vs C/U^{235} ratio. (The experimental results are not pertinent to homogeneous systems until corrected for foil self-shielding and the often ignored variation in foil self-shielding with temperature.)

A series of ZOOM-code⁴ calculations for the actual HOT BOX experiments will be undertaken soon. A more complete description and analysis of the experiments will be issued in a later report.

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Table I. Preliminary Results of HOT BOX Bare Graphite Assembly Survey.

Uncorrected C/U ²³⁵	T _c (°F)	H (in. at R. T.)	L × W (ft at R. T.)	Fuel element lattice	(Top view)	
1185	60	50.3	4 × 5	4-mil foils - 2-in. spacing	4 4 2 2 4	Location of foil thicknesses
1185	850	52.5	4 × 5	2-mil foils - 1-in. spacing	4 4 2 2 4	
					4 4 2 2 4	
					4 4 2 2 4	
2370	45	59.2	4 × 5	4-mil foils - 4-in. spacing		
2370	950	65.5	4 × 5			
2370	1620*	69.5	4 × 5			
					(Top view)	
					8 8 8 8 8 8	
					4 4 4 4 4 4	
7150	85	61.0†	6 × 6	2-mil foils - { 4-in. spacing 8-in. spacing	8 8 8 8 8 8	Location of foil spacings
7150	1110	72.5†	6 × 6		8 8 8 8 8 8	
					4 4 4 4 4 4	
					8 8 8 8 8 8	
8940	50	62.0	6 × 6	2-mil foils - { 5-in. spacing (where 4 above) 10-in. spacing (where 8 above)		
8940	880	74.5	6 × 6			
14440	79	61.5	8 × 8	2-mil foils - 12-in. spacing		
14440	723	69.5	8 × 8			
14440	1060	73.5	8 × 8			
16850	52	68.8	8 × 8	2-mil foils - 14-in. spacing		
16850	961	84.5	8 × 8			
21690	46	78.8	8 × 10	2-mil foils - 18-in. spacing		
21690	557	89.5	8 × 10			

Average 2-mil foil wt = 123 g or alloy (93.2% U²³⁵) with 105 g SS-347 cladding.

Average 4-mil foil wt = 246 g or alloy (93.2% U²³⁵) with 105 g SS-347 cladding.

Average graphite density = 1.48 g/cm³; a 12- × 24-in. graphite area is associated with each foil.

*Extrapolated from a 1205°F experiment.

†This experiment had, in effect, an extra 2.41 kg of SS-304 per kg of or alloy, not in the or alloy flux depression.

Fig. 1. Linear thermal expansion of HOT BOX graphite in horizontal direction (l to extrusion axis) as measured by LRL autographic dilatometer.

Fig. 2. Auxiliary plot of measured values of $\frac{\Delta B^2}{B^2}$ vs temperature at center of measured range (to obtain value at 500°F). $\Delta T = T_c - T_o$, $\bar{T} = \frac{T_c + T_o}{2}$.

Fig. 3. Variation of $\frac{\Delta B^2/B^2}{\Delta T}$ at 500°F vs C/U^{235} ratio.

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