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Astronuclear Laboratory

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GAP MEASUREMENT BETWEEN ELEMENTS OF A NINE INCH CORE

(Title Unclassified)

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ABSTRACT

This report is part of an overall effort to determine the size of gaps which exist between elements in a full reactor core built to current specifications and assembled in a normal (not selective) manner. Included in this report are a listing of "across flats" hex dimensional data for two sectors of the core, gap measurements between elements in a 9-inch core, diameter variation of a full-length core as bundling pressure is increased, and the influence of various vibrational level loadings upon gap sizes.

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I. INTRODUCTION

This report tabulates both the "across flat" dimensions of hexagonal elements and the gap measurements between elements in a full 9-inch long core of the KIWI-B4 type. In addition, the diameter variations of a full-length KIWI-B4A core subjected to increased bundling pressure are also reported. This data was taken from LASL information gathered from analyses made at the Nevada Test Site.

The 9-inch core is a transverse slice of a longer full-length core. In this instance, the hex flat measurements were made with a micrometer, while the gap measurements between elements were made with feeler gage and shim stock. Any gaps into which a 0.0010-inch shim could not be inserted were recorded as 0.0000 inch.

Gaps of two 60-degree sectors of the 9-inch core were first measured with steel bands supplying an equivalent inward radial loading of approximately 2.5 psi, and were then measured with the core in a lateral support system with a radial loading of 3.2 psi. The average gap was less when the core was in the lateral support system than it was when the core was steel banded. Vibrating did not significantly change the gap sizes between elements.

Gap distributions were as follows:

<u>Condition</u>	<u>Core Steel Banded</u> <u>(2.5 psi radial)</u>		<u>Core in Support System</u> <u>(3.2 psi radial)</u>	
	<u>Sector 1</u>	<u>Sector 2</u>	<u>Sector 1</u>	<u>Sector 2</u>
Average gap over entire sector (in.)	0.00052	0.00062	0.00033	0.00049
Percentage of gaps recorded as 0.0010 and 0.0000 inches	74.2	71.3	84.1	77.2
Percentage of gaps recorded as 0.0015 inches	17.4	17.7	10.2	14.4

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The 9-inch core was vibrated through a series of load levels, with a small area being gap-checked after each loading. Loadings as low as 10 cps at 1g and as high as 2000 cps at 20g were exerted. There were no changes in gap because of these varying vibrational loadings.

A layout showing the leakage flow path sizes was made. Analysis of the layout showed that there were no continuous paths of larger size gaps from the central area to the periphery of the core.

Tests conducted on the full-length KIWI-B4A core at the Nevada Test Site showed that the core diameter decreased as much as 0.150 inches when bundling pressure was increased from 0 to 3.75 psi. A circumferential tape was used for these measurements.

Across flat hex measurements indicated a distribution about a peak of 0.7532 inches, whereas mean drawing dimension is 0.7530 inches.

A pneumatically banded, full-length core is being prepared for further gap measurements. All elements of this core will be inspected for bow, twist, and hex dimensions. Full-length core measurements will indicate the effect of bow and twist upon gap sizes. In addition, bundling pressures can readily be varied to further check their effect upon gap sizes.

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II. MEASUREMENT RESULTS

Table I shows gap sizes and frequency tabulations for two 60-degree sectors of the 9-inch core. Any gaps into which a 0.0010-inch shim could not be inserted were recorded as 0.0000 inches. Gaps were measured at one end of the core only. Zoning of core sectors is shown in Figure 1.

Figure 1 Zoning of Core Sectors

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TABLE 1

Gap Sizes and Frequency Tabulation for Two 60-Degree Sections of the 9-Inch Core

Gap Measured (in)	Core Steel-Banded (2.5 psi radial)				Core In Support System Before Vibration (3.2 psi radial)				Core In Support System After Vibration (3.2 psi radial)			
	Sector I		Sector II		Sector I		Sector II		Sector I		Sector II	
	No. of Occurrences	% of Occurrences	No. of Occurrences	% of Occurrences	No. of Occurrences	% of Occurrences	No. of Occurrences	% of Occurrences	No. of Occurrences	% of Occurrences	No. of Occurrences	% of Occurrences
<u>Zone I</u>												
0.0000	102	75.00	88	63.40	109	78.45	98	70.50	114	32.00	101	72.65
0.0010	2	1.47	3	2.16								
0.0015	21	15.43	19	13.68	18	12.96	25	18.00	15	10.80	15	10.80
0.0020	5	3.68	12	8.63	10	7.20	7	5.04	4	2.88	14	10.08
0.0025			4	2.88	1	0.72	6	4.32				
0.0030	4	2.94	8	5.75	1	0.72	3	2.16	5	3.60	7	5.04
0.0040	1	0.74	4	2.88							2	1.44
0.0050	1	0.74	1	0.72					1	0.72		
Total No. of Gaps Measured	136		139		139		139		139		139	
Average Gap	0.00042		0.00080		0.00038		0.00054		0.00036		0.00057	
<u>Zone II</u>												
0.0000	167	73.25	153	67.10	212	93.00	186	81.50	192	84.20	193	84.60
0.0010	1	0.44	4	1.76								

TABLE 1 (Continued)

Gap Sizes and Frequency Tabulation for Two 60-Degree Sections of the 9-Inch Core

Gap Measured (in)	Core Steel-Banded (2.5 psi radial)				Core In Support System Before Vibration (3.2 psi radial)				Core In Support System After Vibration (3.2 psi radial)			
	Sector I		Sector II		Sector I		Sector II		Sector I		Sector II	
	No. of	% of Occurrences	No. of	% of Occurrences	No. of	% of Occurrences	No. of	% of Occurrences	No. of	% of Occurrences	No. of	% of Occurrences
Zone II (contd)												
0.0015	49	21.50	50	21.96	14	6.15	32	14.04	28	12.29	27	11.84
0.0020	8	3.51	14	6.14	1	0.44	5	2.20	7	3.07	3	1.32
0.0025	2	0.88	1	0.44			1	0.44				
0.0030	1	0.44	3	1.32	1	0.44	2	0.88	1	0.44	3	1.32
0.0040			3	1.32			2	0.88			2	0.88
Total No. of Gaps Measured	228		228		228		228		228		228	
Average Gap	0.00043		0.00057		0.00011		0.00033		0.00026		0.00028	
Zone III												
0.0000	257	76.50	236	70.20	303	90.10	283	84.25	298	88.70	262	78.00
0.0010	11	3.28	9	2.68								
0.0015	45	13.41	62	18.48	24	7.15	37	11.02	27	8.05	50	14.90
0.0020	13	3.87	12	3.58	7	2.08	4	1.19	7	2.08	7	2.08
0.0025	5	1.49	7	2.08	1	0.30	5	1.49				
0.0030	3	0.89	6	1.79	1	0.30	5	1.49	2	0.60	9	2.68
0.0040	1	0.30	3	0.89			2	0.60	2	0.60	8	2.38
0.0050	1	0.30	1	0.30								

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TABLE 1 (Continued)

Gap Sizes and Frequency Tabulation for Two 60-Degree Sections of the 9-Inch Core

Gap Measured (in)	Core Steel-Banded (2.5 psi radial)				Core In Support System Before Vibration (3.2 psi radial)				Core In Support System After Vibration (3.2 psi radial)			
	Sector I		Sector II		Sector I		Sector II		Sector I		Sector II	
	No. of	% of Occurrences	No. of	% of Occurrences	No. of	% of Occurrences	No. of	% of Occurrences	No. of	% of Occurrences	No. of	% of Occurrences
Zone III (contd)												
Total No. of Gaps Measured	336		336		336		336		336		336	
Average Gap	0.00041		0.00053		0.00017		0.00029		0.00020		0.00044	
Zone IV												
0.0000	247	68.50	254	70.15	272	75.10	255	70.50	245	72.70	224	67.05
0.0010	3	0.83	12	3.32								
0.0015	70	19.40	57	15.76	53	14.65	59	16.31	60	17.82	64	19.19
0.0020	11	3.04	14	3.87	14	3.86	14	3.87	11	3.26	15	4.50
0.0025	5	1.39	4	1.11			4	1.11				
0.0030	8	2.22	4	1.11	9	2.48	9	2.48	5	1.49	8	2.40
0.0040	4	1.11	4	1.11	3	0.83	4	1.11	11	3.26	12	3.60
0.0050	10	2.77	9	2.48	5	1.38	7	1.94	3	0.89	3	0.90
0.0060					4	1.11	7	1.94	1	0.30	5	1.50
0.0065			1	0.28								
0.0070	1	0.28	1	0.28	1	0.28					2	0.60
0.0075							1	0.28				
0.0080							1	0.28				
0.0100			1	0.28							1	0.30

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TABLE 1 (Continued)

Gap Sizes and Frequency Tabulation for Two 60-Degree Sections of the 9-Inch Core

Gap Measured (in)	Core Steel-Banded (2.5 psi radial)		Core In Support System Before Vibration (3.2 psi radial)		Core In Support System After Vibration (3.2 psi radial)	
	Sector I	Sector II	Sector I	Sector II	Sector I	Sector II
	No. of % of Occurrences	No. of % of Occurrences	No. of % of Occurrences	No. of % of Occurrences	No. of % of Occurrences	No. of % of Occurrences
Zone IV (contd)						
0.0110		1 0.28		1 0.28		
0.0120	1 0.28					
0.0130	1 0.28				1 0.30	
0.0140			1 0.28			
Total No. of Caps Measured	361	362	362	362	337	334
Average Gap	0.00073	0.00066	0.00060	0.00075	0.00061	0.00080
Average Gap For All Zones	0.00052	0.00062	0.00033	0.00049	0.00037	0.00053

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The 9-inch core was vibrated through the following series of load levels, and a small area of the core was gap-checked after each level. There were no changes in gap sizes.

<u>Frequency</u> <u>(cps)</u>	<u>Acceleration Load Level</u> <u>(g's)</u>
10	1
10	3
100	1
100	3
100	10
1000	1
1000	3
1000	10
2000	1
2000	3
2000	10
2000	20

In addition to the foregoing tests, the following tabulation showing the measurements across the hexagonal flat surfaces of elements in 60-degree Sectors 1 and 2 was also derived. Figure 2 compares the frequencies of occurrence by dimensions against a normal distribution curve generated as part of a statistical analysis.

<u>Measurement</u> <u>Across Flats</u> <u>(in.)</u>	<u>Frequency</u> <u>of Occurrence</u>	
	<u>Sector 1</u>	<u>Sector 2</u>
0.7517	0	1
0.7518	0	1
0.7520	0	2
0.7521	0	2
0.7522	2	6
0.7523	10	9
0.7524	6	7
0.7525	8	8
0.7526	16	9
0.7527	27	17
0.7528	40	57
0.7529	38	58
0.7530	85	101
0.7531	105	85
0.7532	168	157

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Measurement Across Flats (in.)	Frequency of Occurrence	
	Sector 1	Sector 2
0.7533	159	146
0.7534	138	127
0.7535	104	54
0.7536	36	41
0.7537	9	16
0.7538	9	18
0.7539	4	11
0.7540	0	2
0.7541	0	4
0.7542	0	4
0.7543	1	3
0.7544	1	1
0.7545	0	2
0.7546	0	1
0.7548	0	1
0.7550	0	5
0.7551	0	1
0.7562	0	1
0.7564	0	1
0.7565	0	1

The following diameter variations for the bundled KIWI-B4A core were gathered from analysis conducted at the Nevada Test Site.

Bundling Pressure (psi)	Axial Distance from Inlet (in.)				
	11	36	40	44	48
Initial	113.50	113.28	113.28	113.30	113.65
2	113.44	113.20	113.25	113.25	113.35
4	113.30	113.05	113.12	113.13	113.25
6	113.27	113.00	113.01	113.02	113.13

These measurements are based on a core with a theoretical diameter of 35.850 inches.

Figure 3 shows the diameter variation versus pressure for this tabulation.

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Figure 2 Dimensions Across Hexagonal Flats of Elements

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EFFECT OF BUNDLING PRESSURE ON CORE DIAMETER
FOR KIWI-B4 TYPE CORE

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Figure 3 Effect of Bundling Pressure on Core Diameter for
a KIWI-B4 Type Core

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III CONCLUSIONS AND RECOMMENDATIONS

Measurement of the gaps existing between elements of the 9-inch core which has been assembled in a normal manner indicates that there are no continuous paths of larger-size gaps from the center area to the periphery of the core. Furthermore, investigation indicates that the gaps do not close when this core is vibrated.

Gap sizes in a full-length core should be checked at various bundling pressure levels to determine how bow, twist and bundling affect the core. Such a core, along with its supporting fixtures, is now in preparation.

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