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 1703-D BUILDING  
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ANALYSIS OF DISTORTION DATA FROM PRODUCTION TEST IP-68-A-90-FP.  
COMPARISON OF VOID-FREE FUEL ELEMENTS WITH STANDARD PRODUCTION FUEL ELEMENTS

Eighteen charges of fuel elements were irradiated at the DR reactor in this production test, primarily to investigate the relationship between porosity or voids in the alsi braze layer of the fuel elements and hot spot corrosion of the jackets.

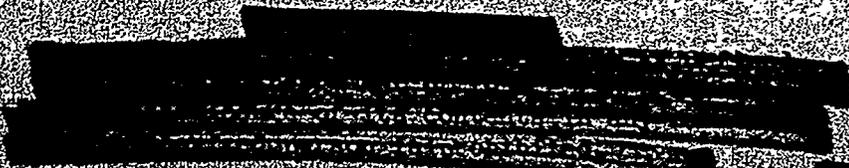
The fuel elements were chosen from three classes of slugs which were within bond specifications. These were as follows:

- 1) "barely acceptable" fuel elements were from the bottom 5% as tested by the ultrasonic bond tester,
- 2) "best acceptable" fuel elements were from the top 5%, and
- 3) "void-free" fuel elements which were obtained by subjecting normal lead-dip-canned fuel elements to a "hot pressing" operation upon completion of canning. Six charges of each class were irradiated at various exposures. This report contains an analysis of the dimensional distortion data from the 16 tubes listed in table I.

There will be a separate report which will contain an analysis of the "hot spots" data.

Conclusions

There are statistically significant differences between the three classes of slugs with respect to warp and diameter growth. However, these differences are small and it must be remembered that there were a large number of fuel



elements in the analysis and small but true differences have a high probability of being detected, whereas the uppermost consideration is probably the practical significance of the results. In other words, if the tests were repeated under similar conditions there is a high probability that similar results, such as they are, would obtain.

The "void-free" fuel elements exhibited higher warp values than "barely acceptable" or "best acceptable" fuel elements and smaller growths at the ends and center of the fuel elements. In turn the "barely acceptable" fuel elements had higher warp values and smaller diameter growths than the "best acceptable" fuel elements.

The differences between the TFC<sup>(1)</sup> values of the three classes of fuel elements were not significant statistically.

The exposure effect was not significant in any of the above-mentioned yield variables. The "void-free" fuel elements were irradiated at higher powers than the other classes of fuel element. This may, but probably does not, account for the slightly different behavior experienced by the several slug classes.

Operating Data

The following tubes were used in this production test.

TABLE I

	<u>Tube #</u>	<u>Exposure*</u>	<u>Power**</u>
"best acceptable" slugs	2182	300	920
	3277	470	920
	2782	740	930
	1686	700	870
	1668	700	870
	1968	690	860
"barely acceptable" slugs	1470	300	890
	2270	500	930
	1464	710	900
	2269	720	920
	2082	720	820
"void-free" slugs	2265	300	920
	2677	480	950
	2570	750	940
	2283	750	930
	2583	670	960

\* From R. W. Bown's Status of Special Loading Reports (Rounded Off)

\*\* Personal Communication, R. R. Bloomstrand (Rounded Off)

(1) HW-56490, "Basis for Use of Tube Filling Capacity Statistic in Analysis of Dimensional Distortion Data," J. L. Jauch, 6/23/58.

## Diameter - Slug Ends

The diameter is defined as the post-irradiation diameter minus the pre-irradiation diameter. Average diameters at the ends of the fuel elements for the individual tubes are given in table II.

TABLE II

"best acceptable"		"barely acceptable"		"void-free"	
<u>Tube #</u>	<u>Average Diameter</u>	<u>Tube #</u>	<u>Average Diameter</u>	<u>Tube #</u>	<u>Average Diameter</u>
2182	0.3	1470	-1.1	2265	-0.9
3277	0.1	2270	0.5	2677	-2.1
2782	1.8	1464	-0.3	2570	-2.6
1686	1.5	2269	0.3	2283	-3.1
1668	0.6	2082	0.7	2583	-2.4
1968	<u>-0.1</u>				
Average	0.7		0.0		-2.2

The average diameters of the "void-free" fuel elements at the slug ends are significantly smaller than the average diameters for the other two classes. Though these differences are small they are notably consistent.

## Diameters - Slug Centers

Table III contains average diameters measured at the fuel element centers.

TABLE III

"best acceptable"		"barely acceptable"		"void-free"	
<u>Tube #</u>	<u>Average Diameter</u>	<u>Tube #</u>	<u>Average Diameter</u>	<u>Tube #</u>	<u>Average Diameter</u>
2182	2.6	1470	1.1	2265	0.3
3277	2.4	2270	1.1	2677	-2.1
2782	1.3	1464	1.6	2570	-0.1
1686	1.0	2269	-0.6	2283	0.5
1668	3.8	2082	0.1	2583	-0.9
1968	2.1				
Average	2.2		0.7		-0.5

The differences between diameters at the slug centers for the three classes of slugs are statistically significant. For purposes of analysis slugs 1-3 are considered to be in section 1, slugs 4-6 in section 2, and so on. The

position effect for diameters at the slug centers is highly significant, where the diameters at the fuel element centers tend to be larger for those fuel elements in the central portion of the tube.

Average Warp

The following table gives the average warp values for the individual tubes in the analysis.

TABLE IV

"best acceptable"		"barely acceptable"		"void-free"	
<u>Tube #</u>	<u>Average Warp</u>	<u>Tube #</u>	<u>Average Warp</u>	<u>Tube #</u>	<u>Average Warp</u>
2182	8.5	1470	8.8	2265	8.9
3277	6.6	2270	7.5	2677	9.5
2782	7.8	1464	7.0	2570	9.5
1686	9.1	2269	7.8	2283	11.1
1668	6.8	2082	10.1	2583	10.9
1968	8.2				
-----					
Average	7.8		8.2		10.0

The "void-free" fuel elements exhibit larger warp values than the other two categories. Though the differences between the "void-free" slugs and both the "best acceptable" and "barely acceptable" fuel elements are small they are statistically significant. The section effect is also significant, where the larger warp values tend to be found in the central portion of the tube.

TFC

The TFC value associated with a fuel element is of great practical interest. Individual tube averages are given in Table V.

TABLE V

"best acceptable"		"barely acceptable"		"void-free"	
<u>Tube #</u>	<u>Average TFC Value</u>	<u>Tube #</u>	<u>Average TFC Value</u>	<u>Tube #</u>	<u>Average TFC Value</u>
2182	9.7	1470	9.0	2265	9.3
3277	7.2	2270	8.0	2677	7.5
2782	8.9	1464	7.4	2570	8.1
1686	10.1	2269	7.0	2283	9.3
1668	9.0	2082	9.9	2583	9.0
1968	9.1				
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Average	9.0		8.3		8.6

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The differences between the average TFC values for the three categories of slugs are not statistically significant. This result is due to a combination of effects. The "void-free" fuel elements exhibit larger average warp values but smaller average diameters at the slug centers resulting in average TFC values for the three classes of slugs which are reasonably close. The position effect is highly significant where the largest TFC values are found in the central portion of tube.

For fuel elements and irradiation conditions similar to those in this study, approximately 10% of the slugs will have TFC values greater than 20 mils, 2% greater than 30 mils, and 0.1% greater than 40 mils.

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OPERATIONS RESEARCH & SYNTHESIS

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