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TEST REPORT

WESTINGHOUSE ASTRONUCLEAR LABORATORY

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This report concerns tests conducted on simulated support blocks for evaluating various support block design variables.

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ABSTRACT

The strength of the graphite support blocks that support the fuel elements can be affected by three design variables. This test was conducted to determine what noticeable effects, if any, can be observed by:

1. Increasing the length (or height) of the support block from 2 to $2\frac{1}{2}$ inches.
2. Decreasing the depth of the cup seat in the support block from $\frac{3}{4}$ to $\frac{1}{2}$ inch.
3. Tapering the cup seat slightly.

Results indicated no increase in strength by increasing the support block length to $2\frac{1}{2}$ inches. Also no strengthening effect results by using a $\frac{1}{2}$ inch deep cup-washer seat instead of a $\frac{3}{4}$ inch seat. And, finally, negligible effects result from adding a slight taper to the cup seat in the block. In the actual block, the pyrolytic cup and washer were shown to fail first. This failure can be alleviated by increasing the bearing area of the cup. This can be done by:

1. Increasing the physical dimensions of the cup and cup seat, or
2. Increasing the bearing area of the cup and washer by
 - a. obtaining the maximum bearing area from given design
 - b. tapering the cup-washer and seat, or
 - c. using a pyro-washer between the pyrolytic cup and the support block.

In this series of tests method (1) had provided such an increase in load capacity that method (2-b) was not effectively evaluated.

INTRODUCTION

The strength of the graphite support blocks for the NRVA reactor can be affected by various design dimensional variables. These tests were conducted to determine what effect, if any, the following design changes may have on the strength of the support block.

1. Increasing the support block height from 2 to $2\frac{1}{2}$ inches
2. Effect of depth of pyro-cup seat, $\frac{1}{2}$ inch depth vs. $\frac{3}{4}$ inch depth
3. Effect of tapering the pyro-cup seat.

Simulated support blocks were tested instead of actual support blocks because a simplified design could be machined much faster and was conducive to completing the test in a minimum amount of time and expense. The simulated block and pyrolytic washer design was furnished by W. Brussalis of Design Section and is shown at the end of this report. The pyrolytic cup and washer were simulated by a 0.10 inch thick pyrolytic washer which is also shown. The bearing area of the cup seat was increased in the simulated blocks so that the pyrolytic washer would not fail. In the actual support block the pyrolytic cup is the weakest component (See WANL-TMI-359). Tapering the support block seat is a method of increasing the bearing area but weakens the support block due to tangential stresses caused by the radial component of the load.

TEST RESULTS

Two series of tests were conducted with a total of 21 simulated blocks tested. The test results are listed in a table at the end of this report. All blocks were loaded until total failure occurred. The cylindrical blocks were loaded on the pyro-washer with a mating simulated cone support and on the opposite side with seven individually loaded simulated fuel elements. No lateral support was used.

Test series A consisted of five simulated support blocks with the outside diameter of the cylinder of 1.80 inches. Pyrolytic graphite sleeves were not used for this series. For this series, there were not sufficient samples to make any conclusions as to the effect of block height and cup seat depth. The cup seat had tapers of 0, 10, 15 and 20 degrees with the intent of determining the strengthening effect this had on the pyrolytic washer. However, the bearing area was sufficiently large that the pyrolytic washer never failed. A general weakening effect on the blocks can be observed with increasing tapers. In all tests the washer seat (that area of the block under the pyrolytic washer) initiated the failure of the block. If this bearing area was insufficient, the pyrolytic washer would have been the first failure observed. However, crushing of the graphite (ATJ) seat under the pyrolytic washer was the initial failure as in the actual support blocks.

Test series B consisted of four different sets of blocks with four specimens per group. The outside diameter was increased to 1.9 inches and pyrolytic graphite sleeves were used with this series. As in series A, initial drops in load and crushing sounds indicated the initial failure of the washer seat. The loading was continued until complete failure of the blocks occurred. Occasionally, separate load values for seat and block failure could not be distinguished.

This is due to almost simultaneous failure of the block once crack propagation begins in the seat or perhaps the initiation of the seat failure went undetected (i.e.; no observable damage, no drop in load on the tensile machine, and no crunching noise from the loudspeaker). Failure of the pyrolytic tube usually accompanied the failure of the seat. The sleeve or tube furnished additional strength as in the case of the actual support block.

The first two groups of Series B had identical dimensions except for the support block length or height. Group 1 had a length of 2 inches with the average failure load of the block equal to 5,455 pounds total axial load on the block. Group 2 had a length of $2\frac{1}{2}$ inches with an average failure load of 5,140 pounds. Group 4 differed from group 3 by having a 10 degree taper in the support block seat. The bearing area of the pyrolytic washer for groups 1, 2, and 3 was 0.318 square inches and for group 4 was 0.287 square inches due to the 45° taper on the outside diameter.

Tested specimens may be observed in the Engineering Mechanics Laboratory, Building 8.

CONCLUSIONS

The test results tended to overlap in the various groups for the range of support block dimensions used. While the results do not vary greatly from the averages; the selected dimensions that were varied (in the selected ranges) do not have significant effects on the design.

In general, the following may be concluded from this test.

1. A $2\frac{1}{2}$ inch support block does not exhibit greater strength than a 2 inch block.
2. A seat depth of $\frac{3}{4}$ inch is not detrimental compared to a shallower seat depth.
3. Using a small taper in the cup-washer seat does not provide any noticeable advantage.

TESTS OF SIMULATED SUPPORT BLOCKS

SERIES A

Support Block O. D. = 1.8", Pyro-tubes Not Used

	<u>Length, l</u>	<u>Seat Depth, d</u>	<u>Seat Taper, Θ</u>	<u>Failure of</u>	<u>Load, lb.</u>
I	2	1/2	0°	Seat Block	4610 3375
II	2-1/2	3/4	0	Seat & Block	4385
III	2-1/2	3/4	10	Seat Block	4170 4340
IV	2-1/2	3/4	15	Seat Block	4015 4215
V	2-1/2	3/4	20	Seat Block	3400 4485

The washers remained intact after all tests.

SERIES B

Support Block O.D. = 1.9", Pyro-tubes Used

	<u>Length, l</u>	<u>Seat Depth, d</u>	<u>Seat Taper, Θ</u>	<u>Failure of</u>	<u>Load, lb.</u>
I					
a.	2	1/2	0°	Seat Block	5400 5655
b.	2	1/2	0	Seat & Block	5675
c.	2	1/2	0	Seat Block	4780 5130
c.	2	1/2	0	Seat Block	5010 5360
Average Maximum Load					5455

The Pyro-tube was damaged in all four tests, but not the Pyrowasher.

SERIES B, Continued

	<u>Length, l</u>	<u>Seat Depth, d</u>	<u>Seat Taper, Θ</u>	<u>Failure of</u>	<u>Load, lb.</u>
II					
a.	2-1/2	1/2	0	Seat Block	5125 5205
b.	2-1/2	1/2	0	Seat & Block	4920
c.	2-1/2	1/2	0	Seat Block	4805 5690
d.	2-1/2	1/2	0	Seat Block	4700 4745
Average Maximum Load					5140
All tests but (d) damaged the Pyro-tube; the Pyro-washer remained unchanged.					

III					
a.	2-1/2	3/4	0	Seat Block	5225 5250
b.	2-1/2	3/4	0	Seat & Block	5360
c.	2-1/2	3/4	0	Seat Block	5050 5210
d.	2-1/2	3/4	0	Seat Block	5180 5560
Average Maximum Load					5345

The Pyro-tube was damaged in all four tests, but not the Pyro-washer.

IV					
a.	2-1/2	3/4	10	Seat Block	4750 4950
b.	2-1/2	3/4	10	Seat & Block	5100
c.	2-1/2	3/4	10	Seat & Block	4960
d.	2-1/2	3/4	10	Seat & Block	4810
Average Maximum Load					4955

The Pyro-tube was damaged in all four tests, but not the Pyro-washer.

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SIMULATED SUPPORT BLOCK

$$\left. \begin{array}{l} l = 2.5'' \\ d = .75'' \end{array} \right\} \theta = 0^\circ, 10^\circ, 15^\circ, 20^\circ$$

$$\left. \begin{array}{l} l = 2.0'' \\ d = .50'' \end{array} \right\} \theta = 0^\circ$$

$$\left. \begin{array}{l} l = 2.5'' \\ d = 0.50'' \end{array} \right\} \theta = 0^\circ$$

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PYROLYTIC WASHER *

$\theta = 0^\circ, 10^\circ, 15^\circ \& 20^\circ$

- * For simulating actual pyrolytic cup & washer.
Washer is loaded on surface S by simulated
cone & tie rod support.