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FINAL REPORT

EML-54

FATIGUE STRENGTH OF GLUE JOINTS
ON WAFER-END ELEMENTS AT AMBIENT TEMPERATURE

(Title Unclassified)

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1.0 INTRODUCTION

1.1 Problems associated with end coating of fueled elements led to a design utilizing an unfueled wafer cemented on the end of the fuel element. Preliminary mechanical strength tests by the Materials Section showed that the bond joint was of adequate strength, and the adherence of the end coating was good. A fatigue test of a quantity of typical element joints was set up to insure that the elements would stand up under repeated vibration. The test was intended to establish an S-N curve of the joint strength; however, fuel element material problems prevented fabrication of an adequate number of specimens. The test provided data to bracket the endurance limit but did not result in an S-N curve due to the limited sample quantity.

2.0 PURPOSE

- 2.1 The purpose of this test was to establish a room temperature fatigue strength of a fueled element - unfueled element cement joint.
- 2.2 The objective was to conduct sufficient fatigue tests to permit plotting an S-N curve for the cemented joint.

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3.0 DISCUSSION

3.1 Ten wafer-end cement joint specimens were fabricated by the Materials Laboratory. One specimen was damaged during a machining operation required for the test setup (see Figure 2). Two other specimens were fractured during transportation between the Materials Laboratory and the Engineering Mechanics Laboratory despite the use of aluminum element tubes. The remaining seven specimens were tested in completely reversed cantilever fatigue on a Sonntag SF-2 constant speed-constant load fatigue machine shown in Figure 1. Standard procedures were followed in all tests. The data obtained was sufficient to bracket the endurance limit but was not adequate to permit plotting of an S-N curve.

3.2 Data obtained from the test is shown on Table I. Note that all specimens stressed above 885 psi failed at a low number of fatigue cycles but that one of the specimens stressed to 885 psi went to 4.8×10^6 cycles, while another failed at only 3600 cycles. This data implies an endurance limit of 880 psi for 2×10^6 cycles; however, this can only be regarded as preliminary data because of the limited quantity of samples tested.

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4.0 CONCLUSIONS AND RECOMMENDATIONS

- 4.1 The endurance limit of 880 psi, achieved with seven specimens, should be verified with a larger quantity of specimens, preferably specimens obtained directly from the production line.
- 4.2 The cement joint tested should be adequate for wafer-end designs if a suitable quality control program is maintained to eliminate poor cement bonds.
- 4.3 Any fuel element design utilizing a cement bond joint should be tested under reactor environmental conditions to ascertain that safe stress levels are not exceeded.

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TABLE I
DATA SHEET - WAFER END ELEMENT FATIGUE TEST

DATE	SPECIMEN NUMBER	LOAD lb P	MOMENT ARM in. l	EXTREME FIBER DISTANCE in. c	MOMENT OF INERTIA in. ⁴ I*	FATIGUE STRESS psi σ **	FATIGUE CYCLES Cycles x 10 ³ n	REMARKS
8-17-64	AG-1	11.05	3.75	.3935	.018	905	7.0	Specimen Fractured
8-19-64	AG-6	10.40	3.75	.3935	.018	805	2400.0	No Failure
8-20-64	AG-9	10.85	3.75	.3935	.018	895	3.8	Specimen Fractured
8-20-64	AG-10	10.8	3.75	.3935	.018	885	3.6	Specimen Fractured
8-20-64	AG-5	10.6	3.75	.3935	.018	850	2400.0	No Failure
8-24-64	AG-7	10.72	3.75	.3935	.018	870	2635	No Failure
8-26-64	AG-4	10.8	3.75	.3935	.018	885	4843	No Failure

All fractures occurred across the cement joint.

Note: *Specimens were fabricated without the final machining process, hence the I shown is slightly higher than that of the finished element.

**The stress is calculated from $\sigma = \frac{Mc}{I} = \frac{Plc}{I}$

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FIGURE 1

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FIGURE 2
APPROXIMATE TEST SPECIMEN DIMENSIONS

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