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LATERAL SUPPORT MACHINE SCREW TORQUE TEST

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by

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ABSTRACT

The lateral support springs are fastened to the graphite barrel by means of an aluminum bracket and two 5/16-24 aluminum machine screws. Room temperature static tests were conducted to determine the torque that should be applied to these screws during reactor assembly. The maximum allowable torque the internal graphite threads will carry is approximately 60 inch-pounds. The recommended assembly torque is 30 to 40 inch-pounds.

Tests indicated that the quality of the bolt threads has a noticeable effect on the strength of this size internal graphite threads.

INTRODUCTION AND PURPOSE

The NRX-A1 Inner Reflector utilizes threaded holes in the Graphite Barrel to contain the lateral support spring reaction. The leaf-springs are contained by a spring bracket which is bolted to the graphite barrel with two fine thread 5/16 inch machine screws. The resultant strength of this subassembly can be affected by assembly torque-down of the screws beyond some stated value. The purpose of this test is to determine this value.

Tests were conducted to determine the maximum allowable preload torque and a recommended preload torque. A noticeable difference in test data was observed from the preliminary strength data for zero preload torque as reported in a letter to R. Saccocio (EE-3027) dated March 15, 1963 (see Tables II and III). Tests were then conducted to determine the reasons for this discrepancy. Various possible reasons for this discrepancy are listed below:

1. Graphite Thread Quality - This is a known variable and is determined by visual inspection.
2. Different Parent Blocks - The specimens for this test were taken from a different parent block of HLM than those previously reported.
3. Test Setup - A different test rig was used for the preload tests than that used for the previous zero preload tests. This included a difference in the support seat diameter of the specimen.
4. Specimen Size - Previous specimens were 4" x 4" x 1" while those used in this test were 4" x 4" x 4". Specimen size can have an effect when dealing with brittle materials, although it is doubtful that this reason would cause such a discrepancy.
5. Assembly Error - This includes the possibility of instrumentation error and operator assembly errors (i.e., bolt assembled other than two diameters deep).
6. Screw Quality - Since the present test used the actual machine screws for the NRX-A1, this may cause a discrepancy from prior results which used a rod with threads cut by a die (due to the lack of 5/16-24 bolts at the time). A difference in screw material is another possible discrepancy.

TEST RESULTS

In general, individual test results were within $\pm 10\%$ of the averages for each group. Table I shows five values of preload torque which essentially stripped the graphite threads. Five values of 62 to 65 inch-pounds torque were measured. Note however, that in Table II, failure in one test initiated at 60 inch-pounds torque. Also notice that one test was conducted at 70 inch-pounds preload which did not fail during torquing.

In Table II the results are listed for 10 inch-pound increments in preload torques. This test simulated its reactor counterpart except that the load was pure tension. This was done per Reactor Mechanical Design Section's request. In the reactor the screw carries a moment from the spring bracket, also. Five values were obtained at each preload torque with the averages given for the proportional limit and the ultimate load. The proportional limit was obtained from a chart which measured load versus relative movement between the bolt and the graphite block specimen. This value can be interpreted as the load at which initiation of failure of the graphite threads occurs. The ultimate load is the maximum load the threads carried before complete failure occurred. Although results would tend to indicate an optimum preload torque of ~ 40 inch-pounds, the range of test results is comparable at each torque range (1000-2000 pounds). Since the maximum allowable torque is 60 inch-pounds, a design preload torque of 30-40 inch-pounds is a good value. Actually there is no 'optimum' preload torque between zero and maximum preload torque.

This is because we are dealing with internal threads where the load is the sum of two components (see sketch on next page). The first is the preload from the torque which is relieved as the second load, the axial load due to the bolt loading mechanism, increases. The resultant force (net sum of the two) increases as the preload is decreased. The preload on the graphite threads must be overcome before failure of the threads occurs, otherwise the threads would have failed during torque-down. Hence, the resultant net force on the threads at failure is due to the axial load of the tensile machine only. At failure the preload torque has no further effect on the strength of the graphite threads.

TEST SETUP

The test specimens were 4 inch lengths of 4" x 4" extruded HLM graphite. The 4 sides were drilled providing 4 holes perpendicular to the grain. The holes were hand tapped about 1 inch deep. Machine screws furnished by the Reactor Mechanical Design Section were used with a resultant two diameters engagement. The torque was measured by means of a torque screw driver. The load was measured by the Wiedemann-Baldwin Tensile Machine in Building 8. Chart records of test results were obtained also.

TEST SETUP

Table IV lists the test results obtained to discover the reason for the discrepancy between Table II and Table III, which were results reported March 15, 1963. The values in Table III are roughly 70% of those in Table II. Of the suggested sources of error given in the introduction, (1) and (5) were eliminated on the first test. Subsequent tests using various rigs, specimen sizes, and different bolts determined that the bolt was the variable involved. Further tests were conducted which determined that the quality of the bolt threads was the factor and not the bolt material. The effect of the quality of the bolt threads can be observed by scanning Table IV. Note that Table III values were obtained with a steel rod of poor quality threads made by a thread cutting die also. Note that the results of various commercial 5/16-24 bolts are still somewhat below those of the aluminum lateral support screws. Most of these tests were conducted with the hole parallel to the grain in Table IV while all results in Tables I, II, and III are for the hole perpendicular to the grain. However, for HLM (H4LM) the strength values are not very different with the grain as across the grain.

Reports pertaining to graphite threads pointed out the importance of the quality of the graphite threads. It may now be added that the bolt thread quality (smoothness, percentage threads, etc.) is of great importance where the failure mode is

not by removal of graphite cone (see WANL-TMI-376). The failure mode is dependent on many things, including specimen size, depth of thread engagement, size of thread, type of graphite, and type of thread (also see WANL-TMI-540). Often sizes less than 1/2 inch tend to fail in the threads as shown by previous test data.

CONCLUSIONS

From Table I it may be concluded that the maximum allowable preload torque for the lateral support machine screws is 60 inch-pounds. Table II illustrates a preload torque of approximately half that as a working value. That is, a value 30 to 40 inch-pounds provides strength yet is safely below the pullout torque value.

Of the six suggested sources of the discrepancy between Table II and Table III, the data of Table IV eliminated all but the effect of the quality of the screw threads. It has been previously reported (WANL-TMI-376) that bolt quality is insignificant when the failure mode is the removal of a conical section of graphite about the threads. However, for fine threads less than 1/2 inch size, the failure mode is generally partial thread shear-partial removal of material (see WANL-TMI-376). The screw material was not found to be a factor. It is concluded that the quality of the bolt threads can have a significant effect on the results when the failure mode is the graphite threads.

TABLE I

MAXIMUM PRELOAD TORQUE TEST
VALUES FOR THE NRX-A1 INNER
REFLECTOR GRAPHITE THREADS WITH
THE LATERAL SUPPORT BRACKET
MACHINE SCREW AN507DD524-14

<u>Preload Torque</u>	<u>Failure Of</u>
63 in-lb	Graphite Threads
63 in-lb	Graphite Threads
62 in-lb	Graphite Threads
65 in-lb	Graphite Threads
63 in-lb	Graphite Threads

Maximum Allowable Preload Torque ~ 60 in-lb.

TABLE II

STRENGTH OF UNF 5/16-24 INTERNAL GRAPHITE
THREADS VS. PRELOAD TORQUE FOR HLM GRAPHITE-
THREADED HOLE PERPENDICULAR TO THE GRAIN -
5/8 INCH THREAD ENGAGEMENT - AN507DD524-14
ALUMINUM BOLT

Preload Torque, In-Lb	Proportional Limit, Lb	Ultimate Load, Lb
10	575*	620*
	900	1000
	925	1080
	850	960
	950	1165
	Average 905	1050
20	950	1150
	700	855
	900	995
	900	1200
	925	1110
	Average 875	1060
30	1000	1160
	925	1150
	950	1160
	925	1140
	900	1020
	Average 940	1125
40	---	1365
	900	1020
	950	1100
	875	1065
	1050	1200
	Average 945	1150

* Depth of Engagement was not 5/8 inch.

TABLE II (Continued)

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Preload Torque, In-Lb	Proportional Limit, Lb	Ultimate Load, Lb
50	880	1060
	950	1220
	980	1170
	925	1080
	920	1080
	Average 930	1120
60	900	1055
	960	1200
	930	1125
	940	1100
	600**	650**
	Average 930	1120
70	800	1060

** Partial Failure Occurred During Torque-Down.

TABLE III

PRELIMINARY RESULTS OF THE STRENGTH
OF UNF 5/16-24 INTERNAL GRAPHITE
THREADS - HLM GRAPHITE - THREADED
HOLE PERPENDICULAR TO THE GRAIN -
2 DIAMETERS (5/8 INCH) BOLT ENGAGEMENT*

<u>Proportional Limit</u>		<u>Ultimate Load</u>
	620	800
	600	810
	580	780
	560	755
Average	590	790

*From letter to R. Saccocio (EE-3027) dated March 15, 1963.

TABLE IV

STRENGTH OF UNF 5/16-24 INTERNAL GRAPHITE
THREADS FOR VARIOUS BOLTS - HLM GRAPHITE -
5/8 INCH DEPTH THREAD ENGAGEMENT

Bolt	Description of Bolt Threads	Proportional Limit lb	Ultimate Load lb	Direction of Hole with Re- spect to Grain
Steel Rod	Threads made with Die Poor Quality	575	795	Parallel
		-	830	"
		600	828	"
		650	900	"
Steel Rod	Threads made with Die Fair Quality	760	880	Perpendicular
		700	835	"
Aluminum Screw	Threads made with Die Poor Quality	600	660	Parallel
		600	705	"
		630	707	"
Aluminum Screw	Threads made with Die Good Quality	850	980	Parallel
		800	913	"
Brass Screw	Threads made with Die Good Quality	800	906	Parallel
		800	955	"
Allen Screw	Commercial Threads Good Quality	900	950	Parallel
		900	1010	"
Standard Bolt	Commercial Threads Good Quality	900	1017	Parallel
		870	943	"
Standard Bolt	Commercial Threads Fair Quality	-	867	Perpendicular
		810	923	"
Reactor Screws (Aluminum)	Standard Threads Very Good Quality	900	1117	Parallel
		940	1163	"