176
4/4/79

MASTER

DR. 2399

**GA-A15116
UC-77**

**PROPERTIES OF UNIRRADIATED
PRODUCTION GRADE H-451;
LOT 478**

by

~~L. A. BEAVAN~~

Prepared under
Contract EY-76-C-03-0167
Project Agreement No. 65
for the San Francisco Operations Office
Department of Energy

DATE PUBLISHED: JANUARY 1979

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

GENERAL ATOMIC COMPANY

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Price: Printed Copy \$5.25; Microfiche \$3.00

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

**GA-A15116
UC-77**

PROPERTIES OF UNIRRADIATED PRODUCTION GRADE H-451; LOT 478

**by
L. A. BEAVAN**

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

**Prepared under
Contract EY-76-C-03-0167
Project Agreement No. 65
for the San Francisco Operations Office
Department of Energy**

GENERAL ATOMIC PROJECT 6422

DATE PUBLISHED: JANUARY 1979

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

GENERAL ATOMIC COMPANY

ABSTRACT

Three logs were selected from the first 98-log production lot of H-451 graphite. The three logs were characterized for density, mechanical properties under tensile, compressive, and flexural loads, thermal expansivity, thermal conductivity, and chemical impurity content.

Bulk density, thermal conductivity, and mechanical property values observed in the production-grade H-451 were equal to or slightly (up to 5%) higher than comparable property values measured in preproduction grade H-451, lot 426. Thermal expansivity of the production H-451 was as much as 10% lower than in preproduction material. Although chemical impurity content of the production grade logs was noticeably higher, the impurity levels remain within specified limits.

The weakest portion of the graphite log under axial stress was found to be the end center rather than the midlength center.

CONTENTS

ABSTRACT	iii
1. INTRODUCTION.	1
2. MATERIALS	4
3. EXPERIMENTAL METHODS.	8
4. EXPERIMENTAL RESULTS	10
4.1. Bulk Density	10
4.2. Mechanical Properties	10
4.2.1. Strength	13
4.2.2. Elastic Modulus	16
4.2.3. Poisson's Ratio	16
4.3. Thermal Properties	18
4.3.1. Thermal Expansivity	18
4.3.2. Thermal Conductivity	18
4.4. Chemical Purity	18
5. DISCUSSION AND CONCLUSIONS.	22
ACKNOWLEDGMENTS	24
REFERENCES	25
APPENDIX A: SAMPLING PLAN - MOT-007	A-1
APPENDIX B: INDIVIDUAL SPECIMEN DATA.	B-1

FIGURES

1. Acceptance test core and characterization slabs for production grade H-451 graphite	6
2. Poisson's ratio specimen geometry	9
3. Rank of properties versus location in log	15

TABLES

1. Properties of production grade H-451 graphite	3
2. H-451 characterization logs	5
3. Summary of property data: H-451, Lot 478	11
4. Distribution of tensile strength in log 7194-52	14
5. Poisson's ratios in H-451 graphite.	17
6. Thermal conductivity of H-451 graphite.	19
7. H-451 impurity content, Lot 478	20
8. Comparison of properties of production and preproduction H-451 graphite	23

1. INTRODUCTION

Grade H-451 graphite has been developed by Great Lakes Carbon Co. (GLCC) for use as fuel elements and replaceable reflector elements in the high-temperature gas-cooled reactor (HTGR). Since development of production grade H-451 from the first prototype grade H-429 graphite has already been well documented by Engle (Ref. 1), it will be only briefly reviewed here.

GLCC developed two similar families of near-isotropic petroleum cokes, designated A and C, as filler material for near-isotropic nuclear graphite. A prototype near-isotropic graphite, grade H-429, was first prepared from an A coke for preliminary irradiation experiments (Ref. 2). Subsequently, cokes A and C were separately blended with a regular production coke (B) to produce preproduction lots of grade H-451 graphite, which were characterized by General Atomic (GA) for unirradiated properties (Refs. 3 and 4) and evaluated for irradiation performance (Refs. 5 and 6). Preproduction lot No. 426, manufactured with cokes A₃ and B₂, was selected as the basis for production of H-451.

Production grade H-451 graphite, made with cokes A₃ and B₂, was manufactured by GLCC in 1976 for use in the Fort St. Vrain reactor. Ninety-eight H-451 logs were graphitized from three extrusion lots as part of an order for 354 logs. The balance of the 354 logs were processed through the bake stage and stored for future demand.

All 98 production H-451 graphite logs were sampled along the log centerline and tested for ultimate tensile strength (UTS) by GLCC and GA (Ref. 7). The same study (Ref. 7) also measured the UTS in a 25-mm-thick slab at the end of each log. The observed strength values and the deviations from log to log and lot to lot were used to evaluate acceptance criteria for H-451 production.

The 98 production logs were dispersed to GA, Oak Ridge National Laboratory (ORNL), and Brookhaven National Laboratory (BNL) for experimental purposes. Three logs were selected at GA for characterization of physical and chemical properties. The logs selected possessed nearly average density, slightly above-average tensile strength, and average to high ash (chemical impurity) content. This report presents the results of the characterization program and discusses these results in comparison to the strength acceptance testing (Ref. 7) and the characterization of preproduction H-451 (Refs. 3 and 4). Table 1 summarizes the properties of production grade H-451 graphite.

TABLE 1
PROPERTIES OF PRODUCTION GRADE H-451 GRAPHITE

Property ^(a)	Units	Axial	Radial
Bulk density	(Mg/m ³)	1.74	--
Mechanical properties at midlength center of log			
Ultimate tensile strength	(MPa)	15.1	11.1
Modulus in tension	(GPa)	9.2	7.6
Flexural strength	(MPa)	23.5	18.7
Ultimate compressive strength	(MPa)	51.9	49.6
Modulus in compression	(GPa)	6.4	5.0
Poisson's ratios			
ν_{12}			0.150
ν_{13}			0.117
$\nu_{31} = \nu_{32}$		0.130	
Thermal conductivity			
@ 1073 K	(W/m-K)	64	59
Mean coefficient of thermal expansion (293 K - 773 K)	(10 ⁻⁶ K ⁻¹)	3.70	4.40
Impurity content			
Ash	(ppm)	230	--
Boron	(ppm)	3	--
Iron	(ppm)	30	--

(a) Based upon complete characterization of three H-451 logs.

2. MATERIALS

Production grade H-451 graphite was extruded as 432-mm (17-in.) diam by 864-mm (34-in.) long solid cylinders using conventional extrusion techniques. Near-isotropic petroleum cokes A₃ and B₂ were used as filler with coal-tar pitch binder and petroleum pitch impregnant. All 98 production logs were graphitized in one furnace run, although the green logs came from extrusion lots 472, 478, and 482.

The three production logs selected for characterization studies were taken from extrusion lot 478. Properties measured by GLCC on each log are presented in Table 2 with the GLCC serial number, GLCC log number, and the GA assigned log number. Throughout this report, the GA log number will be used to identify the graphite logs (7194-49, 7194-52, 7194-87).

A 16-mm (0.63-in.) diam, 356-mm (14-in.) long rod was taken along the axial centerline of each log for acceptance strength testing studies (Fig. 1) (Ref. 7). The acceptance strength data reported by Engle and Price (Ref. 7) are included in Table 2.

Characterization specimens were taken from the three logs described in Table 2 following the sampling plan given in Appendix A. Each log was sampled at four locations: end edge (EE) and end center (EC) (slab 1, Figs. 1 and A-1), midlength edge (MLE) and midlength center (MLC) (slab 3, Figs. 1 and A-2). Log 7194-52 was also sampled at the other end (slab 5, Fig. A-3) for mechanical property specimens. All specimens were taken as cylindrical cores and machined to appropriate specimen geometries.

The end slab taken for characterization work (slab 1, Fig. 1) was arbitrarily selected to be the opposite end from the location of the acceptance test core. Therefore, material from slabs 1 and 3 were tested

TABLE 2
H-451 CHARACTERIZATION LOGS

GA Log No.	GLCC Serial No.	GLCC Lot/Log No.	Properties Measured by GLCC					GA UTS ^(b) (MPa)
			Density (Mg/m ³)	Ash (ppm)	Fe (ppm)	V (ppm)	UTS ^(a) (MPa)	
7194-49	10084	478/15	1.75	65	--	--	17.0	14.2
7194-52	10086	478/72	1.73	115	11	7.5	13.4	16.1
7194-87	10145	478/35	1.74	436	15	159	16.2	16.8
Mean of 98 production logs			1.736				13.4	12.8

(a) One specimen per log. Near axial EC.

(b) Four specimens per log. Near axial MLC (Ref. 7).

Fig. 1. Acceptance test core and characterization slabs for production grade H-451 graphite

in the characterization program while the acceptance test core penetrated slabs 4 and 5. In the acceptance testing (Ref. 7), the GLCC test specimen was taken from slab 5 material while the GA replicates were taken at the very end of the test core in slab 4, adjacent to slab 3. In previous characterizations of preproduction grade H-451, slab 1 was designated at the same end as the acceptance test core (Refs. 3, 4).

3. EXPERIMENTAL METHODS

Experimental methods used for determining bulk density, tensile properties, thermal expansivity and conductivity, and chemical impurity content are given in Ref. 3. Poisson's ratio in tension was measured by the strain gage method of Ref. 3 using square cross section test specimens machined to retain identification of orthogonal material axes, as shown in Fig. 2.

Compressive properties were measured in accordance with ASTM C695, using a well-characterized loading train for determination of modulus and stress-strain values. Flexural strengths were measured by four-point loading of 6.35-mm-diam, >51-mm-long solid cylinders. The outside load edges were spaced 38.1 mm apart. Flexural strength was calculated from modulus of rupture by accounting for the deviation from linear elasticity of the graphite.

Fig. 2. Poisson's ratio specimen geometry

4. EXPERIMENTAL RESULTS

Data for individual specimens are given in Appendix B.

4.1. BULK DENSITY

The mean bulk density ranged from 1.724 Mg/m^3 at the MLC of log 7194-52 to 1.757 Mg/m^3 at the EE of log 7194-87, as summarized in Table 3. The average bulk density, measured over all three logs, was 1.740 Mg/m^3 , which compares well to the 1.74 Mg/m^3 reported by GLCC (Table 2) and the mean of 1.736 Mg/m^3 for all 98 H-451 production logs. The mean bulk density increased from center to edge of logs 7194-52 and -87. However, log 7194-49 displayed no density gradient from center to edge at the end of the log.

The MLC position was a low-density region in the three logs tested. In log 7194-49, the EC position was also a low-density region, whereas in the other two logs, the mean EC bulk density values were 0.010 Mg/m^3 (7194-52) and 0.016 Mg/m^3 (7194-87) higher than the MLC densities.

Deviation in bulk density between logs (S_{LL}) was approximately 0.010 Mg/m^3 , while the pooled estimate of deviation within the sample from any given location in the log [S_{WL} (pooled)] was 0.0045 Mg/m^3 .

4.2. MECHANICAL PROPERTIES

Results of tests for mechanical properties are included in the summary of property data, Table 3.

TABLE 3
SUMMARY OF PROPERTY DATA: H-451 LOT 478

Direction	Location in Log	GA Log No.	Bulk Density (Mg/m ³)		Tensile Strength (MPa)		Tensile Modulus (GPa)		Flexural Strength (MPa)		Compressive Strength (MPa)		Compressive Modulus (GPa)		Coefficient of Thermal Expansion (295-773K) (10 ⁻⁶ K ⁻¹)		Thermal Conductivity (W/m-K)		Ash Content (ppm)
			($\bar{X}$)	(S _{WL} /N) ^(a)	($\bar{X}$)	(S _{WL} /N) ^(a)	($\bar{X}$)	(S _{WL} /N) ^(a)	($\bar{X}$)	(S _{WL} /N) ^(a)	($\bar{X}$)	(S _{WL} /N) ^(a)	($\bar{X}$)	(S _{WL} /N) ^(a)	($\bar{X}$)	(S _{WL} /N) ^(a)	at 1073K ($\bar{X}$)	(S _{WL} /N) ^(a)	
Axial	EC	7194-49	1.735	0.003/8	13.4	1.5/20	8.5	0.6/8	20.7	3.3/19	49.2	2.3/8	6.2	0.5/8	3.78	0.12/8			175
		-52	1.734	0.002/8	12.8	1.5/20	8.9	0.2/8	22.2	2.8/20	50.0	2.3/8	6.0	0.4/8					88
		-87	1.751	0.004/8	13.9	2.1/20	9.1	0.4/8	24.2	2.4/20	53.6	1.2/8	6.9	0.6/8					460
	EE	7194-49	1.734	0.009/8	16.1	2.2/20	9.2	0.5/8	24.0	2.0/20	55.2	4.0/8	6.9	0.4/8	3.78	0.03/4	62.8	5.8/8	170
		-52	1.741	0.005/8	18.8	0.8/20	10.4	0.3/8	27.2	1.8/20	58.3	2.3/8	6.8	0.7/8	3.99	0.30/8			132
		-87	1.757	0.003/8	19.7	1.1/20	9.8	0.3/8	27.3	1.6/20	62.9	2.3/8	7.7	0.4/8					180
	MLC	7194-49	1.736	0.004/8	14.1	1.3/20	8.8	0.2/8	22.0	2.2/20	50.3	2.3/8	6.3	0.2/7	3.72	0.08/4	62.8	5.8/8	205
		-52	1.724	0.004/8	15.5	0.9/20	9.7	0.2/8	24.5	1.8/20	51.8	2.4/8	6.4	0.4/8	3.62	0.15/8			96
		-87	1.735	0.003/8	15.6	0.9/20	9.2	0.2/8	24.0	2.1/20	53.7	1.0/8	6.6	0.5/8					660
	MLE	7194-49	1.743	0.006/8	18.6	1.3/20	9.8	0.4/8	27.4	1.6/20	58.9	1.8/8	6.8	0.5/8	3.73	0.07/8	65.0	3.5/8	147
		-52	1.739	0.004/8	18.6	1.5/20	10.3	0.3/8	27.7	1.9/20	58.9	1.5/8	6.7	0.3/8					160
		-87	1.749	0.004/8	20.0	0.9/20	9.9	0.2/8	28.4	1.3/20	60.5	1.3/8	7.3	0.2/8					255
Radial	EC	7194-49	1.737	0.003/8	12.4	1.4/20	7.8	0.2/8	21.4	1.9/20	49.4	1.9/8	5.4	0.3/8	4.46	0.10/8			
		-52	1.732	0.003/8	11.9	2.6/20	8.2	0.4/8	22.2	2.3/20	52.2	2.1/8	5.4	0.2/8					
		-87	1.748	0.003/8	12.6	2.1/20	7.9	0.3/8	24.1	1.8/20	53.1	2.8/8	5.7	0.5/8					
	EE	7194-49	1.735	0.006/8	15.5	1.5/20	8.0	0.2/8	23.7	1.5/20	55.9	1.9/8	5.7	0.4/8	4.52	0.07/4	60.2	6.0/5	
		-52	1.740	0.003/8	15.9	2.4/20	8.8	0.2/8	25.1	1.7/20	57.8	1.7/8	5.5	0.2/8	4.70	0.19/8			
		-87	1.756	0.003/8	16.7	1.4/20	8.5	0.3/8	26.1	1.1/20	56.1	2.0/8	6.1	0.4/8					
	MLC	7194-49	1.736	0.004/8	11.7	1.6/20	7.7	0.2/8	19.2	1.8/20	52.4	0.9/8	5.2	0.2/8	4.27	0.10/4	58.3	4.9/8	
		-52	1.725	0.003/8	10.7	2.5/20	7.8	0.6/8	18.1	3.4/20	48.3	1.0/8	4.7	0.3/8	4.35	0.12/8			
		-87	1.733	0.003/8	10.9	1.2/20	7.4	0.3/8	18.9	1.9/20	48.2	1.7/8	5.0	0.5/8					
	MLE	7194-49	1.743	0.006/8	14.6	1.3/20	8.1	0.2/8	22.2	1.9/20	54.6	1.8/8	5.4	0.3/8	4.32	0.31/8	59.4	5.3/8	
		-52	1.739	0.005/8	14.3	2.6/20	8.8	0.3/7	24.2	1.2/20	54.5	1.6/8	5.2	0.3/8					
		-87	1.748	0.002/8	15.0	1.4/20	8.3	0.1/8	24.0	1.2/20	50.3	1.7/8	5.4	0.3/8					

(a)_N = number of replicate specimens.

4.2.1. Strength

Tensile strengths were highest at the edge of the logs. Lowest mean strengths were observed at the MLC for the radial orientation, but mean axial tensile strength was lowest at the EC. Mean axial UTS at EC ranged from 12.8 MPa in log 7194-52 to 13.9 MPa for log 7194-87. Maximum mean axial UTS occurred at the MLE of the logs, ranging from 18.6 to 20.0 MPa over the three logs. The radial UTS averaged 10.7 MPa in log 7194-52 to 11.7 MPa in log 7194-49 at MLC. Highest radial UTS values occurred at EE, averaging 15.5 to 16.7 MPa.

S_{WL} (pooled) was 1.44 MPa for the axial direction and 1.96 MPa in the radial orientation. S_{LL} (pooled) in UTS was 1.39 MPa axially and 0.58 MPa radially.

Log 7194-52 was sampled at both ends (slabs 1 and 5) for tensile strength, and both ends displayed lower axial UTS than the MLC. The distribution of UTS in log 7192-52 is given in Table 4.

Flexural strength and ultimate compressive strength (UCS) followed the same spatial relationships observed in tensile strength. Figure 3 presents the rank of each log position for UTS, flexural strength, UCS, and density for axial and radial orientations.

Mean flexural strengths in the axial direction ranged from 20.7 MPa at EC of lot 7194-49 to 28.4 MPa at MLE of log 7194-87. Mean radial flexural strength varied from 18.1 MPa (MLC, 7194-52) to 26.1 MPa (EE, 7194-87). UCS averaged from 48.2 MPa (MLC, radial) to 62.9 MPa (EE, axial). The deviations in flexural strength were S_{WL} (pooled) = 2.18 MPa axially and 1.95 MPa radially; S_{LL} (pooled) = 1.80 MPa axially and 1.36 MPa radially. UCS deviations were estimated to be 2.35 and 1.95 MPa for S_{WL} (pooled) and 3.02 and 2.49 MPa for S_{LL} (pooled) in the axial and radial directions, respectively.

TABLE 4
DISTRIBUTION OF TENSILE STRENGTH IN
LOG 7194-52

Slab	Center Location		Edge Location	
	UTS (MPa)		UTS (MPa)	
	Axial	Radial	Axial	Radial
1	12.8	11.9	18.8	15.9
3	15.5	10.7	18.6	14.3
5	13.8	12.0	19.1	13.5

LEGEND

A = AVERAGE OF UTS RANK FOR THREE LOGS IN DIRECTION INDICATED ($\longleftrightarrow$ = RADIAL, $\updownarrow$ = AXIAL).
 B = RANK OF THREE LOG AVERAGE FOR PROPERTY GIVEN AND ORIENTATION INDICATED AT TOP OF COLUMN.
 RANK: HIGHEST MEAN VALUE = 1, LOWEST MEAN VALUE = 4.

Fig. 3. Rank of properties versus location in log

Flexural strength averaged 53% higher than UTS in the axial direction and 67% higher radially. The ratio of UCS to UTS was 3.4 axially and 4.0 radially.

The greatest anisotropy in strength between axial and radial directions was observed at MLC where axial UTS was 65% higher than radial UTS. Anisotropy in tensile strengths varied from 5% to 20% at the ends of the log and averaged 30% at MLE.

4.2.2. Elastic Modulus

The elastic modulus in tension was measured as a chord modulus between 0 and 6.9 MPa during the second loading of the test specimens. Compressive modulus was determined in a like manner, but over the stress range of 0 to 27.6 MPa. The elastic modulus in tension averaged 8.5 to 10.4 GPa in the axial specimens and 7.4 to 8.8 GPa in the radial specimens. Compressive modulus values were somewhat lower due to the larger deviation from linear elasticity at high stress levels. Modulus values in compression varied from 6.0 to 7.7 GPa axially and from 4.7 to 6.1 GPa radially.

S_{WL} (pooled) was approximately 0.4 GPa for both tensile and compressive moduli. S_{LL} (pooled) was 0.3 GPa for compressive modulus and 0.4 GPa for tensile modulus.

4.2.3. Poisson's Ratio

Poisson's ratios (ν_{ij}) were measured from H-451 graphite log 7194-52, slab 1, EE. ν_{ij} is reported as the negative ratio of strain along the j axis to strain along the i axis when stress is applied along the i axis. In this work, the radial direction was taken as axis No. 1, the chord perpendicular to the log radius as direction No. 2, and the cylindrical axis of the graphite log as axis No. 3. Poisson's ratios were measured for specimens stressed along axes 1 and 3. Results are summarized in Table 5. Poisson's ratios of $\nu_{13} = 0.117$, $\nu_{12} = 0.150$, and $\nu_{31} = \nu_{32} = 0.130$ were measured for H-451 graphite.

TABLE 5
POISSON'S RATIOS IN H-451 GRAPHITE

Log	Location	Specimen	Gauge	ν_{12}	ν_{13}	ν_{31}	ν_{32}
7194-52	EE	P1	TG100	0.140	0.117		
			TM62	0.079	0.064		
		P2	TG100			0.140	0.132
			TM62			0.113	0.102
		P3	TG100	0.153	0.118		
			TM62	0.146	0.112		
		P4	TG100			0.123	0.139
			TM62			0.130	0.140

4.3. THERMAL PROPERTIES

Thermal properties are summarized in Table 3.

4.3.1. Thermal Expansivity

The mean coefficient of thermal expansion between room temperature and 773K ($\bar{\alpha}_{295-773K}$) ranged from 3.62 to $3.99 \times 10^{-6} \text{ K}^{-1}$ in the axial direction. In the radial direction, $\bar{\alpha}_{295-773K}$ varied from 4.27 to $4.70 \times 10^{-6} \text{ K}^{-1}$ with the highest expansivity occurring at EE, as in the axial direction. The lowest mean values of $\bar{\alpha}_{295-773K}$ were found at MLC for both axial and radial directions. The anisotropy ratio of $\bar{\alpha}_{295-773K} \text{ (radial)}/\bar{\alpha}_{295-773K} \text{ (axial)}$ was 1.18 at the end of log 7194-52, 1.20 at MLC, and 1.16 at MLE. Anisotropy ratios in log 7194-49 were 1.20 at EE and 1.15 at MLC.

4.3.2. Thermal Conductivity

Thermal conductivity versus measurement temperature is given in Table 6. Conductivity was measured at the MLC and MLE of logs 7194-52 and 7194-49. A slight anisotropy in conductivity was noted with axial specimens averaging 7% higher conductivity than the radial specimens. At a measurement temperature of 1073K, axial conductivity averaged 62.8 and 65.0 W/m-K and radial thermal conductivity 59.3 and 60.0 W/m-K at MLC and MLE, respectively.

4.4. CHEMICAL PURITY

The principal impurity elements and their concentrations in production grade H-451 are listed in Table 7. Total ash content ranged from 90 ppm in the center of log 7194-52 to 660 ppm at MLC of log 7194-87. Boron content, as measured by emission spectroscopy, varied from 2 to 4 ppm in all logs. The iron impurity level was lowest (5 to 15 ppm) in the high-ash log 7194-87 and highest (40 to 60 ppm) in log 7194-49 whose ash content was $\sim 180 \text{ ppm}$.

TABLE 6
THERMAL CONDUCTIVITY OF H-451 GRAPHITE

Log	Location	Orientation	Thermal Conductivity (W/m-K)				
			295K	473K	673K	873K	1073K
7194-52	MLC	Axial	134.0	116.8	93.6	75.4	62.8
		Radial	119.6	102.7	81.2	68.0	58.3
	MLE	Axial	132.9	117.3	95.1	75.2	65.0
		Radial	124.8	107.4	85.0	69.8	60.7
7194-49	MLC	Radial	116.5	103.6	82.4	66.2	60.2
	MLE	Radial	122.8	106.4	86.2	68.3	59.4

TABLE 7
H-451 IMPURITY CONTENT, LOT 478

Log	Location	Impurity Content (ppm)									Nonburnable Boron Equivalent (ppm)
		Ash	B	Fe	V	Ti	Ni	Al	Si	Mg	
7194-49	EC	175	2	40	6	6	10	10	60	2	0.08
	EE	170	3	40	6	6	10	10	90	2	0.08
	MLC	205	4	60	60	40	<4	30	60	15	0.23
	MLE	147	4	60	15	15	<4	30	80	30	0.13
7194-52	EC	88	4	20	20	10	<4	20	60	10	0.08
	EE	132	4	40	2	2	<4	10	80	4	0.06
	MLC	97	3	10	4	4	<4	5	70	4	0.05
	MLE	160	3	10	4	4	<4	4	70	4	0.05
7194-87	EC	460	2	15	30	30	<4	<1	60	3	0.13
	EE	180	2	10	14	24	<4	<1	70	4	0.10
	MLC	660	2	10	80	60	<4	<1	80	6	0.25
	MLE	255	2	5	45	35	<4	<1	80	4	0.15

The high ash content graphite appeared to contain high levels of vanadium, titanium, and silicon, as given in Table 7. The only other elements detected by emission spectroscopy were occasional reports of potassium (10 ppm), copper (10-20 ppm), and lithium (1 ppm). However, due to uncertainties in this method, the lithium values are suspect.

The boron equivalent of nonburnable elements detectable by GA standard emission spectroscopy methods ranged between 0.05 and 0.25 ppm for all three graphite logs. Certain other elements, mainly burnable elements, have relatively high limits of detection with this method and so contribute to the total calculated boron equivalence of the graphite. However, more sensitive analyses done in past H-451 samples indicate that most elements not detected by standard emission spectroscopy are either present in very low concentrations, or have very low boron equivalence factors, and therefore contribute little to the actual nonburnable boron equivalent.

5. DISCUSSION AND CONCLUSIONS

The three logs characterized displayed property values typical of near-isotropic fuel element graphite. The bulk density, UTS, flexural strength, UCS, thermal conductivity, and thermal expansivity values were comparable to the values measured in preproduction grade H-451, lot 426 (Ref. 4). As shown in Table 8, the bulk density and UTS at MLC were slightly higher in the production grade (lot 478) H-451. Although elastic modulus values were slightly higher than in preproduction H-451, their effect will be tempered by the higher strengths and lower thermal expansivities reported in lot 478. Thermal conductivity remained virtually unchanged from preproduction to production material.

Impurity levels in three production grade H-451 logs were noticeably higher than observed in lot 426 (Table 8); however, all major impurities were within specified limits. No relationship between ash content and iron content could be established. High ash graphite apparently consisted principally of silicon, vanadium, and titanium impurities. Analysis for the most commonly occurring impurity elements in graphite by spark mass spectrometry detected impurity element concentrations equivalent to 0.05 to 0.25 ppm boron for nonburnable impurities.

The axial tensile strength of the production H-451 was lower at EC than at MLC of the logs. Previous data on H-451 graphite logs (Refs. 1, 3, and 4) showed MLC to be the weakest location.

The production H-451 graphite is as good or better product than the preproduction precursors of H-451. The property values derived from tests on preproduction H-451 graphite remain valid within $\pm 5\%$ error for most properties of production grade H-451 graphite. The characterization data reported above, when combined with preproduction characterization data, provide a consistent data base for design with unirradiated H-451 graphite.

TABLE 8
COMPARISON OF PROPERTIES OF PRODUCTION AND PREPRODUCTION H-451 GRAPHITE

Lot	Log	Bulk Density (Mg/m ³)	UTS		Modulus Axial MLC (GPa)	$\bar{\alpha}$ (295-773K)		Thermal Conductivity at 1073K		Ash (ppm)	Iron (ppm)
			Axial MLC (MPa)	Radial MLC (MPa)		Axial MLC (10 ⁻⁶ K ⁻¹)	Radial MLC (10 ⁻⁶ K ⁻¹)	Axial MLC (W/m-K)	Radial MLC (W/m-K)		
478 (Production)	7194-49	1.738	14.1	11.7	8.8	3.72	4.27	--	60.2	175	50
	7194-52	1.735	15.5	10.7	9.7	3.62	4.35	62.8	58.3	120	20
	7194-87	1.748	15.6	10.9	9.2	--	--	--	--	400	10
426 (Preproduction)	6484-33	1.739	14.5	10.4	8.1	4.08	4.51	--	--	<25	3.5
	6484-34	1.719	14.2	10.4	8.2	4.10	4.63	64.9	62.8	<25	7.5
	6484-40	1.720	13.0	11.7	7.9	--	--	--	--	89	<1
	6484-41	1.707	12.9	10.4	7.6	3.92	4.42	64.4	62.8	41	<1

ACKNOWLEDGMENTS

The author gratefully acknowledges the guidance and many helpful discussions of G. B. Engle and Dr. R. J. Price. Thanks are extended to C. H. Richards, J. R. Whaley, F. Hogan, M. G. Dunlap, G. L. Campbell, C. Chaney, M. Denny, and W. Baugh for their able assistance and excellent laboratory work.

REFERENCES

1. Engle, G. B., "Assessment of Grade H-451 Graphite for Replaceable Fuel and Reflector Elements in HTGR," DOE Report GA-A14690, General Atomic Company, December 1977.
2. Price, R. J., and L. A. Beavan, "Final Report on Graphite Irradiation Test OG-1," USAEC Report GA-A13089, General Atomic Company, August 1, 1974.
3. Johnson, W. R., and G. B. Engle, "Properties of Unirradiated Fuel Element Graphites H-451 and TS1240," ERDA Report GA-A13752, General Atomic Company, January 31, 1976.
4. Engle, G. B., and W. R. Johnson, "Properties of Unirradiated Fuel Element Graphites H-451 and SO818," ERDA Report GA-A14068, General Atomic Company, October 8, 1976.
5. Price, R. J., and L. A. Beavan, "Final Report on Graphite Irradiation Test OG-2," ERDA Report GA-A13556, General Atomic Company, December 15, 1975.
6. Price, R. J., and L. A. Beavan, "Final Report on Graphite Irradiation Test OG-3," ERDA Report GA-A14211, General Atomic Company, January 1977.
7. Engle, G. B., and R. J. Price, "Strength Testing of Production Grade H-451 Graphite; Lots 472, 478, and 482," ERDA Report GA-A14269, General Atomic Company, March 1977.

APPENDIX A
SAMPLING PLAN - MOT-007

Fig. A-1. Slab diagram - replaceable hexagonal fuel element and reflector blocks: graphite log H-451 (sheet 1 of 5)

Fig. A-1. Edge Section 1AE (sheet 2 of 5)

Fig. A-1. Edge Section 1BE (sheet 3 of 5)

A-7

Fig. A-1. Center Section 1BC (sheet 5 of 5)

Fig. A-2. Edge Section 3AE (sheet 1 of 4)

Fig. A-2. Edge Section 3BE (sheet 2 of 4)

A-10

Fig. A-2. Center Section 3AC (sheet 3 of 4)

A-11

Fig. A-3. Edge Section 5AE (sheet 1 of 4)

Fig. A-3. Edge Section 5BE (sheet 2 of 4)

A-14

E
S19
E
S21
E
S23
E
S25
E
S27
E
S29
E
S31
E
S33
E
S35

E
S01
E
S03
E
S05
E
S07
E
S09
E
S11
E
S13
E
S15
E
S17

Fig. A-3. Center Section 5AC (sheet 3 of 4)

A-15

Fig. A-3. Center Section 5BC (sheet 4 of 4)

APPENDIX B
INDIVIDUAL SPECIMEN DATA

TABLE B-1

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION		LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
1AC-E	4A	AX	EC	1.736	8.4	.009	.192	12.2
-	14A	AX	EC	1.738	8.9	.030	.231	13.7
-	14B	AX	EC	1.731	9.2	.012	.227	14.7
-	18B	AX	EC	1.732	8.6	.017	.221	13.5
-	2B	AX	EC					14.0
-	4B	AX	EC					14.3
-	16A	AX	EC					15.8
-	16B	AX	EC					14.4
-	18A	AX	EC					14.7
-	20B	AX	EC					11.5
1BC-E	26A	AX	EC	1.733	7.8	.017	.212	12.7
-	36A	AX	EC	1.739	7.5	.018	.184	10.7
-	36B	AX	EC	1.732	8.9	.015	.234	14.6
-	40B	AX	EC	1.737	9.0	.015	.169	11.7
-	24B	AX	EC					15.7
-	26B	AX	EC					13.9
-	34A	AX	EC					12.7
-	34B	AX	EC					12.7
-	40A	AX	EC					10.6
-	42B	AX	EC					14.5
MEAN				1.735	8.5	.017	.209	13.4
					(1.24 MPsi)			(1946.Psi)
STD. DEV.				.003	.6	.006	.024	1.5
					(.09 MPsi)			(222.Psi)

TABLE B-1 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
1AC-E 9	RAD	EC	1.740	7.9	.032	.203	10.4
- 13	RAD	EC	1.738	7.6	.020	.176	10.3
- 27	RAD	EC	1.737	7.9	.015	.179	11.0
- 31	RAD	EC	1.736	7.9	.015	.230	12.9
- 7	RAD	EC					13.2
- 11	RAD	EC					10.8
- 15	RAD	EC					11.7
- 25	RAD	EC					13.7
- 29	RAD	EC					12.7
- 33	RAD	EC					14.1
1BC-E 45	RAD	EC	1.738	7.9	.025	.206	11.8
- 49	RAD	EC	1.734	7.9	.019	.213	12.3
- 63	RAD	EC	1.738	7.6	.020	.197	11.1
- 67	RAD	EC	1.732	7.6	.010	.225	12.7
- 43	RAD	EC					14.6
- 47	RAD	EC					14.6
- 51	RAD	EC					14.2
- 61	RAD	EC					11.3
- 65	RAD	EC					11.8
- 69	RAD	EC					12.1
MEAN			1.737	7.8 (1.14 MPsi)	.019	.204	12.4 (1794.PSI)
STD. DEV.			.003	.2 (.02 MPsi)	.007	.019	1.4 (199.PSI)

TABLE B-1 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
1AE-E	50A	AX	EE	1.731	9.0	.011	.255	16.2
-	54B	AX	EE	1.743	9.5	.009	.259	18.1
-	66A	AX	EE	1.741	9.8	.011	.261	17.5
-	74B	AX	EE	1.740	9.5	.013	.260	17.5
-	50B	AX	EE					16.9
-	54A	AX	EE					17.2
-	62A	AX	EE					17.5
-	62B	AX	EE					15.9
-	66B	AX	EE					20.0
-	74A	AX	EE					18.5
1BE-	80A	AX	EE	1.738	9.4	.015	.249	16.2
-	84B	AX	EE	1.737	9.2	.012	.272	17.2
-	96A	AX	EE	1.717	8.1	.016	.223	13.2
-	104B	AX	EE	1.725	8.7	.016	.230	13.9
-	80B	AX	EE					17.2
-	84A	AX	EE					16.1
-	92A	AX	EE					12.6
-	92B	AX	EE					12.4
-	96B	AX	EE					16.2
-	104A	AX	EE					12.2
MEAN			1.734	9.2	.013	.251	16.1	
				(1.33 MPsi)			(2339.Psi)	
STD. DEV.			.009	.5	.003	.017	2.2	
				(.08 MPsi)			(313.Psi)	

TABLE B-1 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
1AE-E 79	RAD	EE	1.736	7.8	.021	.296	15.9
- 83	RAD	EE	1.739	8.2	.020	.287	15.4
- 99	RAD	EE	1.738	7.7	.016	.278	15.2
- 103	RAD	EE	1.742	8.3	.015	.286	15.6
- 77	RAD	EE					15.3
- 81	RAD	EE					16.6
- 85	RAD	EE					20.1
- 97	RAD	EE					15.3
- 101	RAD	EE					15.5
- 105	RAD	EE					15.4
18E-E 115	RAD	EE	1.736	8.3	.015	.295	16.2
- 119	RAD	EE	1.736	8.2	.017	.303	16.5
- 133	RAD	EE	1.725	7.8	.016	.244	13.8
- 137	RAD	EE	1.727	7.7	.015	.241	13.3
- 113	RAD	EE					16.6
- 117	RAD	EE					14.1
- 121	RAD	EE					14.1
- 131	RAD	EE					15.5
- 135	RAD	EE					16.0
- 139	RAD	EE					13.8
MEAN			1.735	8.0 (1.16 MPsi)	.017	.279	15.5 (2249.Psi)
STD. DEV.			.006	.2 (.04 MPsi)	.002	.024	1.5 (211.Psi)

TABLE B-1 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION		LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
3AC-M	4A	AX	MLC	1.737	8.6	.009	.201	13.3
-	14A	AX	MLC	1.731	8.7	.010	.210	13.1
-	14B	AX	MLC	1.734	8.8	.015	.222	13.8
-	18B	AX	MLC	1.733	8.8	.014	.196	12.7
-	2E	AX	MLC					13.4
-	4R	AX	MLC					14.7
-	12A	AX	MLC					11.5
-	12B	AX	MLC					13.1
-	18A	AX	MLC					12.9
-	20B	AX	MLC					13.6
3BC-M	26A	AX	MLC	1.735	8.6	.010	.220	14.0
-	36A	AX	MLC	1.739	8.9	.011	.243	15.4
-	36B	AX	MLC	1.742	9.0	.014	.234	14.9
-	40B	AX	MLC	1.741	9.2	.012	.232	15.2
-	24B	AX	MLC					14.3
-	26B	AX	MLC					14.3
-	38A	AX	MLC					15.2
-	38B	AX	MLC					15.2
-	40A	AX	MLC					14.5
-	42B	AX	MLC					17.4
MEAN				1.736	8.8 (1.28 MPsi)	.012	.220	14.1 (2045.PSI)
STD. DEV.				.004	.2 (.03 MPsi)	.002	.017	1.3 (186.PSI)

TABLE B-1 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
3AC-M	9	RAD	MLC	1.738	7.9	.015	.230	13.1
-	13	RAD	MLC	1.737	7.7	.016	.217	12.0
-	27	RAD	MLC	1.728	7.7	.020	.182	10.3
-	31	RAD	MLC	1.730	7.3	.021	.124	7.2
-	7	RAD	MLC					13.2
-	11	RAD	MLC					13.0
-	15	RAD	MLC					10.7
-	25	RAD	MLC					12.1
-	29	RAD	MLC					10.6
-	33	RAD	MLC					12.0
3BC-M	45	RAD	MLC	1.739	7.7	.021	.183	10.2
-	49	RAD	MLC	1.739	7.6	.014	.186	10.9
-	57	RAD	MLC	1.737	7.7	.012	.240	13.1
-	61	RAD	MLC	1.740	7.6	.017	.231	12.7
-	43	RAD	MLC					12.7
-	47	RAD	MLC					12.6
-	51	RAD	MLC					10.9
-	55	RAD	MLC					13.6
-	59	RAD	MLC					13.0
-	63	RAD	MLC					10.3
MEAN			1.736	7.7 (1.11 MPsi)	.017	.199	11.7 (1698.PSi)	
STD. DEV.			.004	.2 (.03 MPsi)	.003	.038	1.6 (227.PSi)	

TABLE B-1 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
3AE-M	50A	AX	MLE	1.745	10.0	.013	.290	19.1
-	54B	AX	MLE	1.743	10.0	.016	.275	18.5
-	66A	AX	MLE	1.739	9.6	.024	.273	17.8
-	74B	AX	MLE	1.733	9.4	.010	.274	18.0
-	50B	AX	MLE					19.6
-	54A	AX	MLE					17.6
-	62A	AX	MLE					15.9
-	62B	AX	MLE					17.3
-	66B	AX	MLE					16.1
-	74A	AX	MLE					18.8
3BE-	80A	AX	MLE	1.742	10.0	.015	.258	17.6
-	86B	AX	MLE	1.749	10.0	.011	.289	19.4
-	96A	AX	MLE	1.754	10.0	.009	.296	20.2
-	104B	AX	MLE	1.741	9.1	.010	.274	18.7
-	80B	AX	MLE					19.9
-	84A	AX	MLE					18.7
-	92A	AX	MLE					20.4
-	92B	AX	MLE					18.8
-	96B	AX	MLE					20.6
-	104A	AX	MLE					19.0
MEAN			1.743	9.8 (1.41 MPsi)	.013	.279	18.6 (2698.Psi)	
STD. DEV.			.006	.4 (.05 MPsi)	.005	.012	1.3 (187.Psi)	

TABLE B-1 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
3AE-M 75	RAD	MLE	1.742	8.2	.015	.228	13.4
- 79	RAD	MLE	1.743	8.5	.015	.250	14.5
- 93	RAD	MLE	1.734	8.0	.012	.245	14.0
- 97	RAD	MLE	1.735	7.9	.014	.180	10.6
- 73	RAD	MLE					15.9
- 77	RAD	MLE					14.4
- 81	RAD	MLE					15.5
- 91	RAD	MLE					14.3
- 95	RAD	MLE					14.5
- 99	RAD	MLE					15.8
3BE-M 111	RAD	MLE	1.747	8.4	.015	.247	14.5
- 115	RAD	MLE	1.749	8.3	.016	.282	15.9
- 129	RAD	MLE	1.747	7.8	.018	.262	14.1
- 133	RAD	MLE	1.748	7.9	.020	.265	14.6
- 109	RAD	MLE					12.4
- 113	RAD	MLE					15.8
- 117	RAD	MLE					15.2
- 127	RAD	MLE					14.8
- 131	RAD	MLE					15.8
- 135	RAD	MLE					15.6
MEAN			1.743	8.1 (1.18 MPsi)	.016	.245	14.6 (2114.PSI)
STD. DEV.			.006	.2 (.03 MPsi)	.002	.031	1.3 (192.PSI)

TABLE B-2

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-52 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION		LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
1AC-E	4A	AX	EC	1.735	8.8	.016	.191	12.0
	14A	AX	EC	1.736	8.5	.018	.179	11.1
	14B	AX	EC	1.735	8.8	.016	.179	11.7
	18B	AX	EC	1.735	9.1	.015	.208	13.4
	2B	AX	EC					14.1
	4B	AX	EC					14.3
	16A	AX	EC					12.4
	16B	AX	EC					12.2
	18A	AX	EC					11.8
	20B	AX	EC					10.1
1BC-E	26A	AX	EC	1.732	9.1	.015	.223	14.4
	36A	AX	EC	1.735	8.9	.016	.215	13.9
	36B	AX	EC	1.733	9.1	.011	.150	10.9
	40B	AX	EC	1.730	8.6	.012	.195	12.7
	24B	AX	EC					12.0
	26B	AX	EC					13.4
	34A	AX	EC					15.4
	34B	AX	EC					15.1
	40A	AX	EC					13.6
	42B	AX	EC					10.3
MEAN				1.734	8.9	.015	.192	12.8
					(1.29 MPsi)			(1849.Psi)
STD. DEV.				.002	.2	.002	.023	1.5
					(.03 MPsi)			(223.Psi)

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-52 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION		LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
1AC-E	9	RAD	EC	1.735	8.0	.019	.254	14.4
	13	RAD	EC	1.736	7.9	.019	.200	11.7
	27	RAD	EC	1.734	7.7	.021	.190	10.5
	31	RAD	EC	1.729	8.6	.023	.225	13.7
	7	RAD	EC					15.2
	11	RAD	EC					12.7
	15	RAD	EC					14.1
	25	RAD	EC					8.5
	29	RAD	EC					7.6
	33	RAD	EC					6.1
1BC-E	45	RAD	EC	1.734	8.3	.019	.175	10.9
	49	RAD	EC	1.731	7.6	.025	.190	9.9
	63	RAD	EC	1.730	8.1	.015	.163	9.9
	67	RAD	EC	1.728	9.0	.020	.245	14.8
	43	RAD	EC					11.3
	47	RAD	EC					11.3
	51	RAD	EC					11.0
	61	RAD	EC					14.1
	65	RAD	EC					14.5
	69	RAD	EC					14.8
MEAN				1.732	8.2 (1.18 MPsi)	.020	.205	11.9 (1719.PSI)
STD. DEV.				.003	.4 (.06 MPsi)	.003	.033	2.6 (378.PSI)

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-52 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
1AE-E	50A	AX	EE	1.740	10.0	.015	.274	18.9
	54B	AX	EE	1.738	10.7	.010	.246	18.2
	66A	AX	EE	1.748	10.7	.010	.261	19.3
	74B	AX	EE	1.742	10.7	.011	.261	19.2
	50B	AX	EE					19.0
	54A	AX	EE					18.9
	62A	AX	EE					18.5
	62B	AX	EE					17.0
	66B	AX	EE					19.4
	74A	AX	EE					19.1
1BE-E	80A	AX	EE	1.741	10.3	.009	.239	18.2
	84B	AX	EE	1.747	10.5	.010	.252	18.9
	96A	AX	EE	1.742	10.5	.012	.269	18.9
	104B	AX	EE	1.733	10.1	.010	.273	19.3
	80B	AX	EE					17.8
	84A	AX	EE					18.7
	92A	AX	EE					18.4
	92B	AX	EE					20.3
	96B	AX	EE					19.9
	104A	AX	EE					17.4
MEAN			1.741	10.4	.011	.259	18.8	
				(1.51 MPsi)			(2721.PSI)	
STD. DEV.			.005	.3	.002	.013	.8	
				(.04 MPsi)			(112.PSI)	

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-52 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
1AE-E 79	RAD	EE	1.740	9.0	.021	.280	16.6
83	RAD	EE	1.737	8.8	.013	.286	17.1
99	RAD	EE	1.740	8.5	.019	.180	11.7
103	RAD	EE	1.741	8.6	.015	.124	8.9
77	RAD	EE					16.8
81	RAD	EE					17.0
85	RAD	EE					16.8
97	RAD	EE					17.6
101	RAD	EE					13.5
105	RAD	EE					13.6
1BE-E 115	RAD	EE	1.744	9.0	.015	.294	17.6
119	RAD	EE	1.742	8.8	.014	.256	15.7
133	RAD	EE	1.738	8.8	.015	.320	18.6
137	RAD	EE	1.736			.321	18.7
113	RAD	EE					16.6
117	RAD	EE					16.8
121	RAD	EE					14.7
131	RAD	EE					16.0
135	RAD	EE					15.3
139	RAD	EE					17.8
MEAN			1.740	8.8 (1.28 MPsi)	.016	.258	15.9 (2303.PSI)
STD. DEV.			.003	.2 (.03 MPsi)	.003	.070	2.4 (350.PSI)

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-52 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
3AC-M	4A	AX	MLC	1.731	10.0	.015	.244	16.7
	14A	AX	MLC	1.726	9.8	.011	.189	13.7
	14B	AX	MLC	1.720	9.4	.010	.215	15.1
	18B	AX	MLC	1.718	9.8	.016	.222	15.5
	2B	AX	MLC					17.5
	4B	AX	MLC					16.4
	12A	AX	MLC					15.8
	12B	AX	MLC					14.9
	18A	AX	MLC					15.4
	20B	AX	MLC					15.0
3BC-M	26A	AX	MLC	1.729	9.7	.010	.229	15.5
	36A	AX	MLC	1.724	10.0	.015	.223	15.1
	36B	AX	MLC	1.722	9.5	.009	.205	14.7
	40B	AX	MLC	1.723	9.4	.011	.241	16.2
	24B	AX	MLC					14.2
	26B	AX	MLC					14.8
	38A	AX	MLC					15.9
	38B	AX	MLC					15.8
	40A	AX	MLC					15.8
	42B	AX	MLC					16.1
MEAN			1.724	9.7 (1.41 MPsi)	.012	.221	15.5 (2248.Psi)	
STD. DEV.			.004	.2 (.04 MPsi)	.003	.018	.9 (126.Psi)	

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478
 LOG NO. 7194-52
 LOG DENSITY MG/M**3
 SPEC. DIA. 12.8 MM
 SPEC. LENGTH 70. MM

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
3AC-M	9	RAD	MLC	1.727	7.6	.015	.156	9.4
-	13	RAD	MLC	1.730	7.7	.019	.141	8.7
-	27	RAD	MLC	1.721	7.6	.020	.158	8.9
-	31	RAD	MLC	1.721	7.0	.021	.159	8.9
-	7	RAD	MLC					9.2
-	11	RAD	MLC					8.1
-	15	RAD	MLC					13.9
-	25	RAD	MLC					10.2
-	29	RAD	MLC					8.9
-	33	RAD	MLC					8.7
3BC-M	45	RAD	MLC	1.725	7.6	.019	.188	10.3
-	49	RAD	MLC	1.723	7.5	.019	.150	8.9
-	57	RAD	MLC	1.726	8.7	.015	.224	14.1
-	61	RAD	MLC	1.725	8.7	.015	.221	13.5
-	43	RAD	MLC					8.4
-	47	RAD	MLC					8.9
-	51	RAD	MLC					10.1
-	55	RAD	MLC					14.1
-	59	RAD	MLC					15.4
-	63	RAD	MLC					14.8
MEAN			1.725	7.8 (1.13 MPsi)	.018	.175	10.7 (1547.PSI)	
STD. DEV.			.003	.6 (.09 MPsi)	.002	.032	2.5 (366.PSI)	

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-52 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION		LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
3AE-M	50A	AX	MLE	1.740	10.3	.012	.274	19.7
	54B	AX	MLE	1.743	10.5	.012	.261	19.2
	66A	AX	MLE	1.742	9.8	.010	.251	18.4
	74B	AX	MLE	1.741	10.2	.014	.252	17.8
	50B	AX	MLE					18.6
	54A	AX	MLE					19.0
	62A	AX	MLE					17.5
	62B	AX	MLE					18.1
	66B	AX	MLE					16.0
	74A	AX	MLE					17.4
3BE-M	80A	AX	MLE	1.738	10.2	.008	.280	20.1
	86B	AX	MLE	1.734	10.3	.011	.255	18.6
	96A	AX	MLE	1.741	10.9	.008	.251	19.1
	104B	AX	MLE	1.732	10.5	.010	.260	18.9
	80B	AX	MLE					14.8
	84A	AX	MLE					19.6
	92A	AX	MLE					18.2
	92B	AX	MLE					19.3
	96B	AX	MLE					21.9
	104A	AX	MLE					20.2
MEAN				1.739	10.3 (1.50 MPsi)	.011	.260	18.6 (2699.Psi)
STD. DEV.				.004	.3 (.04 MPsi)	.002	.011	1.5 (221.Psi)

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478
 LOG NO. 7194-52
 LOG DENSITY MG/M**3
 SPEC. DIA. 12.8 MM
 SPEC. LENGTH 70. MM

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
3AE-M 75	RAD	MLE	1.740	8.4	.012	.196	12.6
79	RAD	MLE	1.741	8.6	.015	.157	10.1
93	RAD	MLE	1.741			.095	6.5
97	RAD	MLE	1.744	9.2	.015	.171	11.4
73	RAD	MLE					14.2
77	RAD	MLE					16.4
81	RAD	MLE					15.0
91	RAD	MLE					15.5
95	RAD	MLE					15.2
99	RAD	MLE					16.5
3BE-M 111	RAD	MLE	1.741	8.8	.015	.197	12.9
115	RAD	MLE	1.743	9.1	.015	.251	15.5
129	PAD	MLF	1.731	8.8	.024	.259	16.0
133	RAD	MLE	1.732	8.8	.016	.269	16.4
109	RAD	MLF					16.5
113	RAD	MLE					16.5
117	RAD	MLE					13.2
127	RAD	MLF					17.0
131	RAD	MLE					14.0
135	PAD	MLE					14.9
MEAN			1.739	8.8 (1.28 MPsi)	.016	.199	14.3 (2076.PSI)
STD. DEV.			.005	.3 (.04 MPsi)	.004	.059	2.6 (380.PSI)

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. SPEC. DIA. 12.8 MM
 LOG NO. 478 7194-52 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
5AE-504A	AX	EC	1.726	9.1	.014	.221	14.2
-514A	AX	EC	1.720	9.1	.013	.215	14.3
-514B	AX	EC	1.730	9.0	.014	.200	13.1
-518B	AX	EC	1.725	8.8	.014	.175	11.6
5BL-526A	AX	EC	1.723	9.1	.011	.193	12.9
-536A	AX	EC	1.720	8.8	.014	.190	12.5
-536B	AX	EC	1.724	9.0	.010	.187	12.4
-540B	AX	EC	1.725	9.1	.015	.172	11.3
5AE-502B	AX	EC					15.2
-504B	AX	EC					15.8
-516A	AX	EC					15.8
-516B	AX	EC					16.6
-518A	AX	EC					15.0
-520B	AX	EC					15.0
5BL-524B	AX	EC					12.4
-526B	AX	EC					14.0
-534A	AX	EC					14.2
-534B	AX	EC					10.8
5BL-540A	AX	EC					15.4
-542B	AX	EC					12.9
MEAN			1.724	9.0 (1.31 MPsi)	.013	.194	13.8 (1998.PSI)
STD. DEV.			.003	.1 (.02 MPsi)	.002	.017	1.6 (237.PSI)

TABLE B-2 (Continued)
TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. SPEC. DIA. 12.8 MM
LOG NO. 478 7194-52 SPEC. LENGTH 70. MM
LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
5AE-550A	AX	EE	1.726	9.8	.011	.281	18.9
-554B	AX	EE	1.736	10.3	.009	.281	19.3
-566A	AX	EE	1.740	10.3	.010	.331	22.3
-574B	AX	EE	1.729	9.5	.006	.273	18.4
5BE-580A	AX	EE	1.736	10.3	.011	.260	18.2
-584B	AX	EE	1.735	10.2	.010	.295	19.6
-596A	AX	EE	1.735	10.5	.010	.281	19.6
-604B	AX	EE	1.727	9.4	.011	.250	16.8
5AE-550B	AX	EE					19.1
-554A	AX	EE					19.6
-562A	AX	EE					18.7
-562B	AX	EE					17.7
-566B	AX	EE					19.3
-574A	AX	EE					19.2
5BE-580B	AX	EE					16.7
-584B	AX	EE					18.7
-590A	AX	EE					19.2
-590B	AX	EE					21.0
-596B	AX	EE					20.4
-604A	AX	EE					19.6
MEAN			1.733	10.1 (1.46 MPsi)	.010	.281	19.1 (2773.PSI)
STD. DEV.			.005	.4 (.06 MPsi)	.002	.024	1.3 (187.PSI)

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. SPEC. DIA. 12.8 MM
 LOG NO. 478 7194-52 SPEC. LENGTH 70. MM
 LOC DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
-509	RAD	EC	1.727	8.4	.019	.186	11.2
-513	RAD	EC	1.729	7.7	.015	.220	11.8
-527	RAD	EC	1.719	6.7	.023	.150	7.8
-531	RAD	EC	1.724	7.2	.022	.170	8.9
-545	RAD	EC	1.719	7.7	.017	.201	11.2
-549	RAD	EC	1.718	7.6	.017	.209	11.6
-563	RAD	EC	1.718	8.0	.019	.249	13.9
-567	RAD	EC	1.721	8.4	.020	.242	13.8
-507	RAD	EC					11.0
-511	RAD	EC					12.0
-515	RAD	EC					10.3
-525	RAD	EC					8.6
-529	RAD	EC					8.9
-533	RAD	EC					10.6
-543	RAD	EC					12.7
-547	RAD	EC					10.9
-551	RAD	EC					11.6
-561	RAD	EC					14.4
-565	RAD	EC					13.7
-569	RAD	EC					14.2
MEAN			1.722	7.7 (1.12 MPsi)	.019	.203	11.5 (1662.PSI)
STD. DEV.			.004	.6 (.08 MPsi)	.003	.034	1.9 (280.PSI)

TABLE B-2 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. SPEC. DIA. 12.8 MM
 LOG NO. 478 7194-52 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
-579	RAD	EE	1.729	8.5	.015	.225	13.5
-583	RAD	EE	1.727	7.9	.016	.238	13.5
-599	RAD	EE	1.726	7.8	.027	.192	10.6
-603	RAD	EE	1.723	7.3	.017	.220	11.4
-615	RAD	EE	1.728	8.3	.014	.239	13.8
-619	RAD	EE	1.725	8.4	.014	.245	14.1
-633	RAD	EE	1.722	8.3	.017	.310	16.9
-637	RAD	EE	1.723	8.1	.010	.280	16.0
-577	RAD	EE					15.3
-581	RAD	EE					10.9
-585	RAD	EE					13.2
-597	RAD	EE					9.1
-601	RAD	EE					9.9
-605	RAD	EE					8.6
-613	RAD	EE					15.9
-617	RAD	EE					13.8
5BL-621	RAD	EE					17.2
-631	RAD	EE					16.5
-635	RAD	EE					16.6
-639	RAD	EE					14.4
MEAN			1.725	8.1 (1.17 MPsi)	.016	.244	13.5 (1965.PSI)
STD. DEV.			.003	.4 (.06 MPsi)	.005	.037	2.7 (389.PSI)

TABLE B-3

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-87 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
1AC-E	4A	AX	EC	1.755	9.5	.015	.217	14.8
-	14A	AX	EC	1.749	9.1	.015	.194	13.6
-	14B	AX	EC	1.755	9.5	.012	.176	12.6
-	18B	AX	EC	1.746	8.8	.013	.174	11.0
-	2B	AX	EC					17.7
-	4B	AX	EC					17.0
-	16A	AX	EC					15.6
-	16B	AX	EC					14.2
-	18A	AX	EC					12.1
-	20B	AX	EC					13.8
1BC-E	26A	AX	EC	1.749	8.3	.011	.167	11.0
-	36A	AX	EC	1.753	9.4	.014	.167	12.3
-	36B	AX	EC	1.747	9.1	.014	.159	11.6
-	40B	AX	EC	1.755	9.4	.011	.221	15.3
-	24B	AX	EC					11.5
-	26B	AX	EC					12.9
-	34A	AX	EC					17.2
-	34B	AX	EC					15.8
-	40A	AX	EC					14.4
-	42B	AX	EC					14.3
MEAN			1.751	9.1	.013	.184	13.9	
				(1.33 MPa)			(2020.PSI)	
STD. DEV.			.004	.4	.002	.024	2.1	
				(.06 MPa)			(300.PSI)	

TABLE B-3 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-87 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
1AC-E	9	RAD	EC	1.751	7.5	.023	.200	10.7
-	13	RAD	EC	1.751	7.7	.022	.160	9.7
-	27	RAD	EC	1.748	8.4	.014	.247	14.8
-	31	RAD	EC	1.748	8.0	.015	.208	12.2
-	7	RAD	EC					13.7
-	11	RAD	EC					8.0
-	15	RAD	EC					10.4
-	25	RAD	EC					16.2
-	29	RAD	EC					13.4
-	33	RAD	EC					12.0
1BC-E	45	RAD	EC	1.744	8.0	.019	.257	14.7
-	49	RAD	EC	1.745	7.6	.019	.177	10.6
-	63	RAD	EC	1.749	7.7	.020	.185	11.0
-	67	RAD	EC	1.748	8.3	.015	.239	13.8
-	43	RAD	EC					15.1
-	47	RAD	EC					12.9
-	51	RAD	EC					11.9
-	61	RAD	EC					12.9
-	65	RAD	EC					13.8
-	69	RAD	EC					14.5
MEAN			1.748	7.9 (1.15 MPsi)	.018	.209	12.6 (1830.Psi)	
STD. DEV.			.003	.3 (.05 MPsi)	.003	.035	2.1 (303.Psi)	

TABLE B-3 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-87 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PFRM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
1AE-E	50A	AX	EE	1.757	9.8	.014	.291	19.6
-	54B	AX	EE	1.761	10.0	.013	.286	19.9
-	66A	AX	EE	1.759	9.5	.013	.258	18.7
-	74B	AX	EE	1.755	9.4	.011	.272	18.6
-	50B	AX	EE					19.9
-	54A	AX	EE					21.4
-	62A	AX	EE					20.2
-	62B	AX	EE					19.3
-	66B	AX	EE					21.3
-	74A	AX	EE					20.0
1BE-E	80A	AX	EE	1.751	9.5	.009	.308	20.5
-	84B	AX	EE	1.756	9.8	.014	.301	20.3
-	96A	AX	EE	1.759	10.2	.008	.230	17.3
-	104B	AX	EE	1.759	9.7	.010	.280	19.2
-	80B	AX	EE					22.0
-	84A	AX	EE					18.9
-	92A	AX	EE					19.0
-	92B	AX	EE					19.6
-	96B	AX	EE					18.6
-	104A	AX	EE					19.8
MEAN			1.757	9.8	.011	.278	19.7	
				(1.41 MPsi)			(2858.Psi)	
STD. DEV.			.003	.3	.002	.025	1.1	
				(.04 MPsi)			(159.Psi)	

TABLE B-3 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-87 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
1AE-E 79	RAD	EE	1.757	8.7	.014	.251	15.8
- 83	RAD	EE	1.755	8.5	.015	.251	15.3
- 99	RAD	EE	1.753	8.4	.016	.239	14.4
- 103	RAD	EE	1.751	8.9	.010	.215	14.0
- 77	RAD	EE					16.4
- 81	RAD	EE					16.9
- 85	RAD	EE					15.8
- 97	RAD	EE					18.5
- 101	RAD	EE					17.7
- 105	RAD	EE					16.1
1BE-E 115	RAD	EE	1.756	8.7	.010	.319	18.8
- 119	RAD	EE	1.756	8.7	.011	.312	18.4
- 133	RAD	EE	1.757	8.3	.018	.268	15.9
- 137	RAD	EE	1.758	8.1	.014	.306	17.7
- 113	RAD	EE					17.1
- 117	RAD	EE					16.5
- 121	RAD	EE					17.2
- 131	RAD	EE					16.1
- 135	RAD	EE					17.3
- 139	RAD	EE					18.6
MEAN			1.756	8.5 (1.24 MPsi)	.013	.270	16.7 (2425.PSI)
STD. DEV.			.002	.3 (.04 MPsi)	.003	.038	1.4 (196.PSI)

TABLE B-3 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOC NO. 7194-87 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION		LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
3AC-M	4A	AX	MLC	1.733	9.4	.007	.235	15.9
-	14A	AX	MLC	1.735	9.2	.010	.225	15.5
-	14B	AX	MLC	1.731	9.0	.012	.245	15.6
-	18B	AX	MLC	1.736	9.1	.015	.246	16.5
-	2B	AX	MLC					17.2
-	4B	AX	MLC					13.7
-	12A	AX	MLC					14.8
-	12B	AX	MLC					16.2
-	18A	AX	MLC					14.6
-	20B	AX	MLC					15.5
3BC-M	26A	AX	MLC	1.736	9.2	.010	.258	17.0
-	36A	AX	MLC	1.740	9.4	.015	.222	14.8
-	36B	AX	MLC	1.737	9.4	.013	.244	16.3
-	40B	AX	MLC	1.729	9.1	.007	.235	15.9
-	24B	AX	MLC					15.7
-	26B	AX	MLC					15.1
-	38A	AX	MLC					14.5
-	38B	AX	MLC					15.1
-	40A	AX	MLC					16.1
-	42B	AX	MLC					16.5
MEAN				1.735	9.2	.011	.239	15.6
					(1.34 MPaSI)			(2266.PSI)
STD. DEV.				.003	.2	.003	.012	.9
					(.02 MPaSI)			(129.PSI)

TABLE B-3 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-87 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)
3AC-M 9	RAD	MLC	1.733	7.3	.014	.166	9.0
- 13	RAD	MLC	1.731	7.4	.019	.181	10.2
- 27	RAD	MLC	1.731	7.8	.025	.190	11.3
- 31	RAD	MLC	1.732	7.5	.021	.239	12.9
- 7	RAD	MLC					11.3
- 11	RAD	MLC					9.9
- 15	RAD	MLC					10.0
- 25	RAD	MLC					12.4
- 29	RAD	MLC					10.8
- 33	RAD	MLC					12.0
3BC-M 45	RAD	MLC	1.731	7.0	.025	.158	8.6
- 49	RAD	MLC	1.733	7.2	.011	.197	10.8
- 57	RAD	MLC	1.737	7.6	.020	.231	12.2
- 61	RAD	MLC	1.738	7.0	.024	.216	11.7
- 43	RAD	MLC					10.7
- 47	RAD	MLC					10.0
- 51	RAD	MLC					10.4
- 55	RAD	MLC					9.2
- 59	RAD	MLC					11.8
- 63	RAD	MLC					12.5
MEAN			1.733	7.4 (1.07 MPsi)	.020	.197	10.9 (1580.PSI)
STD. DEV.			.003	.3 (.04 MPsi)	.005	.029	1.2 (178.PSI)

TABLE B-3 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-87 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
3AE-M	50A	AX	MLE	1.745	9.7	.014	.300	20.2
-	54B	AX	MLE	1.755	10.1	.012	.294	20.6
-	66A	AX	MLF	1.753	9.8	.011	.292	20.3
-	74B	AX	MLE	1.748	9.8	.014		19.9
-	50B	AX	MLE					18.6
-	54A	AX	MLE					19.7
-	62A	AX	MLE					20.4
-	62B	AX	MLE					19.3
-	66B	AX	MLE					19.9
-	74A	AX	MLF					19.6
3BE-M	80A	AX	MLE	1.748	10.0	.005	.294	20.6
-	86B	AX	MLE	1.746	9.7	.013	.308	20.7
-	96A	AX	MLF	1.749	9.8	.011	.263	18.8
-	104B	AX	MLE	1.747	10.0	.009	.299	20.5
-	80B	AX	MLF					17.5
-	84A	AX	MLE					19.8
-	92A	AX	MLE					21.3
-	92B	AX	MLF					21.1
-	96B	AX	MLE					19.4
-	104A	AX	MLF					21.0
MEAN			1.749	9.9 (1.43 MPsi)	.011	.293	20.0 (2896.PSI)	
STD. DEV.			.004	.2 (.02 MPsi)	.003	.014	.9 (133.PSI)	

TABLE B-3 (Continued)

TENSILE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOC NO. 7194-87 SPEC. LENGTH 70. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	TENSILE STRENGTH (MPA)	
3AE-M	75	RAD	MLE	1.748	8.4	.021	.256	15.4
-	79	RAD	MLE	1.746	8.3	.014	.287	16.7
-	93	RAD	MLE	1.748	8.5	.015	.245	14.9
-	97	RAD	MLE	1.746	8.1	.020	.267	15.4
-	73	RAD	MLE					13.1
-	77	RAD	MLE					14.4
-	81	RAD	MLE					14.4
-	91	RAD	MLE					13.8
-	95	RAD	MLE					15.8
-	99	RAD	MLE					17.4
3BE-M	111	RAD	MLE	1.750	8.3	.015	.230	14.1
-	115	RAD	MLE	1.750	8.4	.011	.249	14.9
-	129	RAD	MLE	1.749	8.1	.015	.276	16.1
-	133	RAD	MLE	1.747	8.3	.016	.289	16.5
-	109	RAD	MLE					15.6
-	113	RAD	MLF					12.5
-	117	RAD	MLF					15.2
-	127	RAD	MLE					14.5
-	131	RAD	MLE					12.8
-	135	RAD	MLE					17.2
MEAN			1.748	8.3 (1.20 MPsi)	.016	.262	15.0 (2182.Psi)	
STD. DEV.			.002	.1 (.02 MPsi)	.003	.021	1.4 (201.Psi)	

TABLE B-4
FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO. SPEC. DIA. 6.4 MM
LOG NO. 7194-49 SPEC. LENGTH 0. MM
LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- TION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AC	2A	AX	EC	22.9	20.1
	4A	AX	EC	27.2	23.2
	4B	AX	EC	31.8	26.1
	14A	AX	EC	29.7	24.8
	14B	AX	EC	23.9	20.8
	20A	AX	EC	23.2	20.3
	20B	AX	EC	19.7	17.7
	26A	AX	EC	26.9	23.0
	26B	AX	EC	27.0	23.0
	28A	AX	EC	25.6	22.1
1BC	32A	AX	EC	23.6	20.6
	36A	AX	EC	23.1	20.3
	42A	AX	EC	23.2	20.3
	42B	AX	EC	25.5	22.0
	52A	AX	EC	19.4	17.4
	52B	AX	EC	20.4	18.2
	54A	AX	EC	27.9	23.6
	54B	AX	EC	21.7	19.2
	58A	AX	EC	11.6	10.9
MEAN				23.9 MPA (3468. PSI)	20.7 MPA (3005. PSI)
STD. DEV.				4.5 MPA (647. PSI)	3.3 MPA (483. PSI)

TABLE B-4 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.		6.4 MM	
LOG NO.		7194-49		SPEC. LENGTH	
LOG DENSITY		MG/M**3		0. MM	
SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AC	1 RAD	EC		28.7	23.6
1AC	5 RAD	EC		24.2	20.7
	7 RAD	EC		22.3	19.4
	11 RAD	EC		23.9	20.5
	13 RAD	EC		21.4	18.8
	23 RAD	EC		23.7	20.4
	25 RAD	EC		24.9	21.2
	29 RAD	EC		23.7	20.4
	31 RAD	EC		23.4	20.2
	35 RAD	EC		23.2	20.0
1HC	41 RAD	EC		29.6	24.2
	45 RAD	EC		28.9	23.8
	47 RAD	EC		29.2	24.0
	51 RAD	EC		22.8	19.7
	53 RAD	EC		25.4	21.5
	63 RAD	EC		29.6	24.2
	65 RAD	EC		29.2	23.9
	69 RAD	EC		24.4	20.9
	71 RAD	EC		25.4	21.6
	75 RAD	EC		20.4	18.0
MEAN				25.2 MPA (3658. PSI)	21.4 MPA (3098. PSI)
STD. DEV.				2.9 MPA (425. PSI)	1.9 MPA (280. PSI)

TABLE B-4 (Continued)
FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO. SPEC. DIA. 6.4 MM
LOG NO. 7194-49 SPEC. LENGTH 0. MM
LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LUCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AE	64A	AX	EE	28.7	24.5
1AE	64H	AX	EE	27.3	23.5
	66A	AX	EE	29.8	25.3
	66H	AX	EE	31.1	26.1
	70A	AX	EE	27.8	23.9
	70H	AX	EE	28.3	24.3
	76A	AX	EE	27.1	23.4
	76H	AX	EE	29.3	24.9
	78A	AX	EE	28.1	24.1
	78H	AX	EE	32.3	26.8
1HE	84A	AX	EE	27.9	24.0
	84H	AX	EE	34.1	27.9
	86A	AX	EE	28.9	24.7
	86H	AX	EE	31.0	26.0
	90A	AX	EE	25.7	22.4
	90H	AX	EE	23.6	20.8
	96A	AX	EE	20.9	18.8
	96H	AX	EE	26.4	22.9
	98A	AX	EE	25.3	22.1
	98H	AX	EE	27.9	23.9
MEAN				28.1 MPA (4072. PSI)	24.0 MPA (3485. PSI)
STD. DEV.				3.0 MPA (428. PSI)	2.0 MPA (297. PSI)

TABLE B-4 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.		6.4 MM	
LOG NO.		7194-49		SPEC. LENGTH	
LOG DENSITY		MG/M**3		0. MM	
SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1A6	81 RAD	EE		25.3	21.6
1A6	85 RAD	EE		29.6	24.3
	87 RAD	EE		29.3	24.1
	91 RAD	EE		26.5	22.3
	93 RAD	EE		28.8	23.8
	103 RAD	EE		28.3	23.5
	105 RAD	EE		28.4	23.6
	109 RAD	EE		30.2	24.6
	111 RAD	EE		24.7	21.2
	115 RAD	EE		29.1	24.0
1B6	121 RAD	EE		32.9	26.1
	125 RAD	EE		32.8	26.0
	127 RAD	EE		32.7	26.0
	131 RAD	EE		30.2	24.6
	133 RAD	EE		25.5	21.7
	143 RAD	EE		28.0	23.3
	145 RAD	EE		29.7	24.4
	149 RAD	EE		25.2	21.5
	151 RAD	EE		28.1	23.4
	155 RAD	EE		27.5	23.0
MEAN				28.6 MPA (4155. PSI)	23.7 MPA (3432. PSI)
STD. DEV.				2.5 MPA (356. PSI)	1.5 MPA (215. PSI)

TABLE B-4 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-49	SPEC. LENGTH	0. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AC	102A	AX	MLC	24.4	21.3
	106A	AX	MLC	24.7	21.5
	106H	AX	MLC	19.5	17.6
	112A	AX	MLC	23.8	20.9
	112H	AX	MLC	26.2	22.6
	120A	AX	MLC	21.8	19.4
	120H	AX	MLC	25.1	21.8
	124A	AX	MLC	28.0	23.9
	124H	AX	MLC	21.7	19.3
	128A	AX	MLC	26.9	23.1
3BC	132A	AX	MLC	22.6	20.0
	136A	AX	MLC	25.2	21.9
	136H	AX	MLC	26.7	22.9
	142A	AX	MLC	29.2	24.6
	142H	AX	MLC	23.6	20.8
	152A	AX	MLC	23.0	20.3
	152H	AX	MLC	32.6	26.7
	154A	AX	MLC	25.8	22.3
	154H	AX	MLC	29.9	25.1
	158A	AX	MLC	26.5	22.8
MEAN				25.4 MPA (3678. PSI)	22.0 MPA (3184. PSI)
STD. DEV.				3.1 MPA (447. PSI)	2.2 MPA (314. PSI)

TABLE B-4 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-49	SPEC. LENGTH	0. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AC	161 RAD	MLC		26.7	22.3
	165 RAD	MLC		19.0	16.9
	167 RAD	MLC		23.3	20.0
	171 RAD	MLC		21.9	19.1
	173 RAD	MLC		21.2	18.5
	183 RAD	MLC		17.7	15.9
	185 RAD	MLC		22.2	19.2
	189 RAD	MLC		22.8	19.7
	191 RAD	MLC		22.5	19.5
	195 RAD	MLC		21.4	18.7
3BC	201 RAD	MLC		20.6	18.1
	205 RAD	MLC		20.0	17.6
	207 RAD	MLC		20.5	18.0
	211 RAD	MLC		25.6	21.5
	213 RAD	MLC		21.9	19.0
	223 RAD	MLC		25.4	21.4
	225 RAD	MLC		19.2	17.0
	229 RAD	MLC		27.2	22.6
	231 RAD	MLC		22.2	19.2
	235 RAD	MLC		21.9	19.1
MEAN				22.2 MPA (3216. PSI)	19.2 MPA (2781. PSI)
STD. DEV.				2.5 MPA (367. PSI)	1.8 MPA (256. PSI)

TABLE B-4 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-49	SPEC. LENGTH	0. MM
LOG DENSITY	46/M ³		

SPECIMEN NUMBER	ORIENTATION	LOCATION	DENSITY (MG/M ³)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AE	164A	AX	MLE	33.6	28.1
	164B	AX	MLF	34.8	28.8
	166A	AX	NLE	31.1	26.4
	166B	AX	MLF	32.4	27.3
	170A	AX	NLE	33.9	28.3
	170B	AX	MLE	29.2	25.1
	176A	AX	MLF	32.9	27.6
	176B	AX	NLE	32.0	27.1
	178A	AX	MLE	30.3	25.9
	178B	AX	MLF	27.2	23.8
3PE	184A	AX	MLF	35.7	29.4
	184B	AX	NLE	30.4	25.9
	186A	AX	MLE	31.5	26.7
	186B	AX	MLE	35.0	29.0
	190A	AX	MLE	30.1	25.8
	190B	AX	MLF	37.5	30.4
	192A	AX	MLE	35.2	29.1
	192B	AX	MLF	33.8	28.2
	198A	AX	MLE	34.1	28.4
	198B	AX	MLE	32.3	27.2
MEAN				32.7 MPA (4737. PSI)	27.4 MPA (3977. PSI)
STD. DEV.				2.5 MPA (362. PSI)	1.6 MPA (235. PSI)

TABLE B-4 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.		6.4 MM	
LOG NO.		7194-49		SPEC. LENGTH	
LOG DENSITY		MG/M**3		0. MM	
SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AE	241 RAD	MLE		22.8	19.9
	245 RAD	MLE		30.9	25.2
	247 RAD	MLE		28.1	23.5
	251 RAD	MLE		26.9	22.7
	253 RAD	MLE		26.8	22.6
	263 RAD	MLE		22.3	19.5
	267 RAD	MLE		25.3	21.6
	269 RAD	MLE		21.5	18.9
	273 RAD	MLE		24.4	21.0
	275 RAD	MLE		23.3	20.2
	281 RAD	MLE		28.8	23.9
	285 RAD	MLE		28.0	23.4
	287 RAD	MLE		29.3	24.3
	291 RAD	MLE		25.6	21.8
	293 RAD	MLE		30.2	24.8
3BE	303 RAD	MLE		23.4	20.4
	305 RAD	MLE		28.7	23.9
	309 RAD	MLE		27.1	22.8
	311 RAD	MLE		23.9	20.7
	315 RAD	MLE		28.4	23.7
MEAN				26.3 MPA (3813. PSI)	22.2 MPA (3226. PSI)
STD. DEV.				2.8 MPA (407. PSI)	1.9 MPA (270. PSI)

TABLE B-5
FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO. SPEC. DIA. 6.4 MM
LOG NO. 7194-52 SPEC. LENGTH 0. MM
LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AC	2A	AX	EC	25.9	22.4
	4A	AX	EC	27.5	23.6
	4R	AX	EC	28.0	23.9
	14A	AX	EC	16.0	14.8
	14H	AX	EC	25.4	22.1
	20A	AX	EC	20.1	18.1
	20H	AX	EC	25.4	22.1
	26A	AX	EC	24.7	21.6
	26B	AX	EC	28.2	24.1
	28A	AX	EC	30.4	25.5
1BC	32A	AX	EC	26.4	22.8
	36A	AX	EC	28.8	24.4
	36B	AX	EC	19.1	17.3
	42A	AX	EC	24.8	21.6
	42B	AX	EC	29.1	24.6
	52A	AX	EC	29.4	24.8
	52B	AX	EC	27.1	23.3
	54A	AX	EC	23.2	20.4
	54B	AX	EC	23.5	20.7
	58A	AX	EC	29.6	24.9
MEAN				25.6 MPA (3718. PSI)	22.2 MPA (3213. PSI)
STD. DEV.				3.8 MPA (548. PSI)	2.8 MPA (404. PSI)

TABLE B-5 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-52	SPEC. LENGTH	0. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AC	1 RAD	EC		30.5	24.9
	5 RAD	EC		30.1	24.7
	7 RAD	EC		28.4	23.7
	11 RAD	FC		25.0	21.4
	13 RAD	EC		23.0	20.0
	23 RAD	EC		26.9	22.7
	25 RAD	FC		27.5	23.1
	29 RAD	EC		26.2	22.3
	31 RAD	EC		21.6	19.0
	35 RAD	EC		21.5	18.9
1AC	41 RAD	EC		30.3	24.8
	45 RAD	EC		30.2	24.8
	47 RAD	EC		30.1	24.7
	51 RAD	FC		19.9	17.7
	53 RAD	EC		22.9	19.9
	63 RAD	EC		25.1	21.5
	65 RAD	EC		27.3	23.0
	69 RAD	FC		22.4	19.6
	71 RAD	EC		27.8	23.3
	75 RAD	EC		30.2	24.8
MEAN				26.3 MPA (3821. PSI)	22.2 MPA (3225. PSI)
STD. DEV.				3.5 MPA (506. PSI)	2.3 MPA (340. PSI)

TABLE B-5 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO. SPEC. DIA. 6.4 MM
 LOG NO. 7194-52 SPEC. LENGTH 0. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AE	64A	AX	EE	31.2	26.9
	64B	AX	EE	25.7	22.8
	66A	AX	EE	28.3	24.8
	66B	AX	EE	34.5	29.1
	70A	AX	EE	30.2	26.2
	70B	AX	EE	33.3	28.3
	76A	AX	EE	32.3	27.6
	76B	AX	EE	29.8	25.9
	78A	AX	EE	34.3	28.9
	78B	AX	EE	33.5	28.4
1BE	84A	AX	EE	33.7	28.6
	84B	AX	EE	36.0	30.1
	86A	AX	EE	33.0	28.1
	86B	AX	EE	31.2	26.9
	90A	AX	EE	31.4	27.0
	90B	AX	EE	30.1	26.1
	96A	AX	EE	27.1	23.9
	96B	AX	EE	32.6	27.8
	98A	AX	EE	31.6	27.2
	98B	AX	EE	34.2	28.9
MEAN				31.7 MPA (4596. PSI)	27.2 MPA (3942. PSI)
STD. DEV.				2.6 MPA (380. PSI)	1.8 MPA (266. PSI)

TABLE B-5 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-52	SPEC. LENGTH	0. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AE	81 RAD	EE		32.0	26.4
	85 RAD	EE		28.5	24.2
	87 RAD	EE		32.1	26.5
	91 RAD	EE		29.5	24.8
	93 RAD	EE		28.9	24.4
	103 RAD	EE		26.5	22.8
	105 RAD	EE		30.8	25.6
	109 RAD	EE		30.4	25.4
	111 RAD	EE		31.2	25.9
	115 RAD	EE		29.8	25.0
1HE	121 RAD	EE		34.7	28.0
	125 RAD	EE		32.6	26.8
	127 RAD	EE		23.1	20.4
	131 RAD	EE		28.9	24.4
	133 RAD	EE		26.0	22.5
	143 RAD	EE		28.8	24.4
	145 RAD	EE		32.2	26.5
	149 RAD	EE		32.1	26.5
	151 RAD	EE		30.1	25.2
	155 RAD	EE		30.8	25.7
MEAN				29.9 MPA (4343. PSI)	25.1 MPA (3636. PSI)
STD. DEV.				2.6 MPA (381. PSI)	1.7 MPA (250. PSI)

TABLE B-5 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-52	SPEC. LENGTH	0. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AC	102A	AX	MLC	26.3	23.1
	106A	AX	MLC	28.7	24.8
	106H	AX	MLC	31.9	26.9
	112A	AX	MLC	21.7	19.5
	112H	AX	MLC	24.7	21.8
	120A	AX	MLC	27.1	23.7
	120H	AX	MLC	28.0	24.3
	124A	AX	MLC	29.7	25.5
	124H	AX	MLC	30.0	25.7
	128A	AX	MLC	28.1	24.4
3HC	132A	AX	MLC	27.6	24.1
	136A	AX	MLC	32.4	27.3
	136H	AX	MLC	27.2	23.7
	142A	AX	MLC	28.4	24.6
	142H	AX	MLC	31.1	26.4
	152A	AX	MLC	28.2	24.5
	152H	AX	MLC	31.0	26.4
	154A	AX	MLC	27.8	24.1
	154H	AX	MLC	26.2	23.0
	158A	AX	MLC	29.6	25.4
MEAN				28.3 MPA (4102. PSI)	24.5 MPA (3548. PSI)
STD. DEV.				2.5 MPA (365. PSI)	1.8 MPA (262. PSI)

TABLE B-5 (Continued)
FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.		5.4 MM	
LOG NO.		7194-52		SPEC. LENGTH	
LOG DENSITY		MG/M**3		0. MM	
SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AC	161	RAD	MLC	20.1	17.8
	165	RAD	MLC	23.3	20.1
	167	RAD	MLC	22.5	19.6
	171	RAD	MLC	21.5	18.8
	173	RAD	MLC	22.5	19.5
	183	RAD	MLC	17.4	15.6
	185	RAD	MLC	11.9	11.2
	189	RAD	MLC	21.2	18.6
	191	RAD	MLC	9.0	8.5
	195	RAD	MLC	20.1	17.7
3BC	201	RAD	MLC	16.8	15.2
	205	RAD	MLC	21.9	19.1
	207	RAD	MLC	20.7	18.2
	211	RAD	MLC	20.2	17.8
	213	RAD	MLC	20.1	17.8
	223	RAD	MLC	22.8	19.8
	225	RAD	MLC	22.5	19.6
	229	RAD	MLC	24.5	20.9
	231	RAD	MLC	26.8	22.4
	235	RAD	MLC	28.4	23.4
MEAN				20.7 MPA (3003. PSI)	18.1 MPA (2621. PSI)
STD. DEV.				4.4 MPA (645. PSI)	3.4 MPA (498. PSI)

TABLE B-5 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-52	SPEC. LENGTH	0. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LUCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AE	164A	AX	MLE	37.3	30.8
	164B	AX	MLE	29.5	25.7
	166A	AX	MLE	31.7	27.2
	166B	AX	MLE	30.4	26.3
	170A	AX	MLE	31.9	27.3
	170B	AX	MLE	30.2	26.1
	176A	AX	MLE	32.2	27.6
	176B	AX	MLE	24.4	21.8
	178A	AX	MLE	32.6	27.8
	178B	AX	MLE	31.0	26.7
3HE	184A	AX	MLE	34.8	29.2
	184B	AX	MLE	35.1	29.4
	186A	AX	MLE	32.4	27.7
	186B	AX	MLE	34.2	28.8
	190A	AX	MLE	37.0	30.7
	190B	AX	MLE	33.6	28.5
	192A	AX	MLE	33.6	28.5
	192B	AX	MLE	34.0	28.7
	198A	AX	MLE	32.6	27.8
	198B	AX	MLE	32.5	27.8
MEAN				32.6 MPA (4721. PSI)	27.7 MPA (4021. PSI)
STD. DEV.				2.8 MPA (408. PSI)	1.9 MPA (282. PSI)

TABLE B-5 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.		6.4 MM	
LOG NO.		7194-52		SPEC. LENGTH	
LOG DENSITY		MG/M**3		0. MM	
SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
34E	241 RAD	MLE		29.0	24.5
	245 RAD	MLE		26.5	22.8
	247 RAD	MLE		25.1	21.8
	251 RAD	MLF		27.2	23.3
	253 RAD	MLE		28.2	24.0
	263 RAD	MLE		29.9	25.1
	267 RAD	MLE		28.1	23.9
	269 RAD	MLE		28.7	24.3
	273 RAD	MLE		29.9	25.1
	275 RAD	MLE		29.4	24.8
34E	281 RAD	MLE		27.6	23.6
	285 RAD	MLE		30.3	25.3
	287 RAD	MLE		29.3	24.7
	291 RAD	MLE		31.1	25.9
	293 RAD	MLE		29.9	25.1
	303 RAD	MLE		29.4	24.8
	305 RAD	MLE		29.4	24.8
	309 RAD	MLE		31.0	25.8
	311 RAD	MLE		25.5	22.1
	315 RAD	MLE		25.8	22.3
MEAN				28.6 MPA (4142. PSI)	24.2 MPA (3509. PSI)
STD. DEV.				1.8 MPA (258. PSI)	1.2 MPA (172. PSI)

TABLE B-6

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-87	SPEC. LENGTH	51. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AC	2A	AX	EC	27.4	23.6
	4A	AX	EC	32.5	27.0
	4B	AX	EC	33.2	27.4
	14A	AX	EC	31.9	26.6
	14B	AX	EC	28.0	24.0
	20A	AX	EC	28.1	24.1
	20B	AX	EC	26.4	22.9
	26A	AX	EC	26.6	23.1
	26B	AX	EC	25.2	22.0
	28A	AX	EC	27.9	24.0
18C	32A	AX	EC	27.0	23.4
	36A	AX	EC	27.7	23.9
	36B	AX	EC	18.0	16.4
	42A	AX	EC	32.0	26.7
	42B	AX	EC	28.3	24.3
	52A	AX	EC	29.3	24.9
	52B	AX	EC	28.4	24.3
	54A	AX	EC	30.2	25.5
	54B	AX	EC	32.4	26.9
	58A	AX	FC	27.1	23.4
MEAN				28.4 MPA (4117. PSI)	24.2 MPA (3514. PSI)
STD. DEV.				3.4 MPA (492. PSI)	2.4 MPA (349. PSI)

TABLE B-6 (Continued)
FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.		6.4 MM	
LOG NO.		7194-R7		SPEC. LENGTH	
LOG DENSITY		MG/M**3		51. MM	
SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AC	1 RAD	EC		31.5	25.3
	5 RAD	EC		27.6	23.0
	7 RAD	EC		28.8	23.8
	11 RAD	EC		26.1	22.0
	13 RAD	EC		23.0	20.0
	23 RAD	EC		29.9	24.4
	25 RAD	EC		37.0	27.8
	29 RAD	EC		32.8	26.0
	31 RAD	EC		31.5	25.3
	35 RAD	EC		30.1	24.5
	41 RAD	EC		30.8	24.9
	45 RAD	EC		31.9	25.5
	47 RAD	EC		30.6	24.8
	51 RAD	EC		27.6	23.0
1HC	53 RAD	EC		27.0	22.6
	63 RAD	EC		31.8	25.5
	65 RAD	EC		31.1	25.1
	69 RAD	EC		30.4	24.7
	71 RAD	EC		27.4	22.9
	75 RAD	EC		25.5	21.6
MEAN				29.6 MPA (4296. PSI)	24.1 MPA (3501. PSI)
STD. DEV.				3.1 MPA (448. PSI)	1.8 MPA (260. PSI)

TABLE B-6 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-87	SPEC. LENGTH	51. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AE	64A	AX	EF	35.2	29.1
	64B	AX	EE	32.0	27.1
	66A	AX	EE	33.2	27.8
	66B	AX	EE	31.5	26.7
	70A	AX	EE	35.6	29.3
	70B	AX	EE	32.9	27.6
	76A	AX	EF	33.9	28.2
	76B	AX	EE	33.4	27.9
	73A	AX	EF	33.7	28.1
	73B	AX	EE	29.7	25.5
1BE	84A	AX	EF	35.1	29.0
	84B	AX	EE	33.9	28.2
	86A	AX	EE	26.9	23.5
	86B	AX	EE	33.7	28.1
	90A	AX	EE	30.1	25.8
	90B	AX	EF	31.5	26.7
	96A	AX	EE	34.8	28.9
	96B	AX	EE	34.4	28.6
	98A	AX	EE	29.0	25.0
	98B	AX	EE	29.2	25.1
MEAN				32.5 MPA (4711. PSI)	27.3 MPA (3961. PSI)
STD. DEV.				2.4 MPA (351. PSI)	1.6 MPA (232. PSI)

TABLE B-6 (Continued)
FLEXURAL PROPERTIES OF P-451 GRAPHITE

LOT NO. SPEC. DIA. 6.4 MM
LOC NO. 7194-87 SPEC. LENGTH 51. MM
LOC DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
1AE	81 RAD	EE		33.5	27.0
	85 RAD	EE		31.4	25.8
	87 RAD	EE		29.5	24.6
	91 RAD	EE		29.7	24.8
	93 RAD	EE		32.3	26.4
	103 RAD	EE		29.0	24.3
	105 RAD	EE		30.2	25.1
	109 RAD	EE		34.1	27.4
	111 RAD	EE		34.8	27.7
	115 RAD	EE		32.6	26.5
1EE	121 RAD	EE		29.7	24.8
	125 RAD	EE		31.7	26.0
	127 RAD	EE		34.0	27.3
	131 RAD	EE		30.6	25.4
	133 RAD	EE		33.6	27.1
	143 RAD	EE		35.7	28.2
	145 RAD	EE		31.6	26.0
	149 RAD	EE		30.7	25.4
	151 RAD	EE		32.9	26.7
	155 RAD	EE		30.1	25.1
MEAN				31.9 MPA (4626. PSI)	26.1 MPA (3782. PSI)
STD. DEV.				2.0 MPA (284. PSI)	1.1 MPA (165. PSI)

TABLE B-6 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-87	SPEC. LENGTH	51. MM
LOC DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCAL TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
--------------------	------------------	---------------	----------------------	--	---

3AC	102A	AX	MLC	29.8	25.3
	106A	AX	MLC	31.1	26.1
	106B	AX	MLC	27.7	23.9
	112A	AX	MLC	27.8	23.9
	112B	AX	MLC	31.8	26.6
	120A	AX	MLC	27.0	23.4
	120B	AX	MLC	27.4	23.7
	124A	AX	MLC	30.9	26.0
	124B	AX	MLC	32.9	27.3
	128A	AX	MLC	32.4	27.0
3BC	132A	AX	MLC	23.7	21.0
	136A	AX	MLC	22.6	20.2
	136B	AX	MLC	28.4	24.4
	142A	AX	MLC	25.7	22.5
	142B	AX	MLC	27.2	23.5
	152A	AX	MLC	27.8	23.9
	152B	AX	MLC	29.8	25.3
	154A	AX	MLC	26.6	23.1
	154B	AX	MLC	23.1	20.5
	158A	AX	MLC	25.8	22.5

MEAN

28.0 MPA	24.0 MPA
(4058. PSI)	(3480. PSI)

STD. DEV.

3.0 MPA	2.1 MPA
(431. PSI)	(299. PSI)

TABLE B-6 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-87	SPEC. LENGTH	51. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AC	161 RAD	MLC		23.4	19.9
	165 RAD	MLC		21.9	18.9
	167 RAD	MLC		20.5	17.9
	171 RAD	MLC		18.7	16.6
	173 RAD	MLC		20.8	18.1
	183 RAD	MLC		25.5	21.3
	185 RAD	MLC		23.8	20.2
	189 RAD	MLC		26.3	21.8
	191 RAD	MLC		23.1	19.7
	195 RAD	MLC		22.3	19.2
3BC	201 RAD	MLC		17.4	15.6
	205 RAD	MLC		20.7	18.1
	207 RAD	MLC		18.6	16.5
	211 RAD	MLC		22.9	19.6
	213 RAD	MLC		23.8	20.2
	223 RAD	MLC		17.5	15.6
	225 RAD	MLC		24.3	20.5
	229 RAD	MLC		25.3	21.2
	231 RAD	MLC		24.0	20.3
	235 RAD	MLC		19.9	17.5
MEAN				22.0 MPA (3195. PSI)	18.9 MPA (2745. PSI)
STD. DEV.				2.7 MPA (387. PSI)	1.9 MPA (272. PSI)

TABLE B-6 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO. SPEC. DIA. 6.4 MM
 LOC NO. 7194-87 SPEC. LENGTH 51. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AE	164A	AX	MLE	31.4	26.7
	164B	AX	MLE	35.1	29.1
	166A	AX	MLF	33.5	28.1
	166B	AX	MLE	35.1	29.1
	170A	AX	MLE	37.9	30.7
	170B	AX	MLE	34.8	28.9
	176A	AX	MLE	32.7	27.6
	176B	AX	MLE	32.4	27.3
	178A	AX	MLE	37.8	30.7
	178B	AX	MLE	35.4	29.3
3BE	184A	AX	MLE	30.8	26.4
	184B	AX	MLE	34.7	28.9
	186A	AX	MLE	30.6	26.2
	186B	AX	MLE	35.6	29.4
	190A	AX	MLE	33.4	28.0
	190B	AX	MLE	34.7	28.9
	192A	AX	MLE	32.8	27.6
	192B	AX	MLE	36.0	29.7
	198A	AX	MLF	34.8	28.9
	198B	AX	MLE	31.2	26.6
MEAN				34.0 MPA (4938. PSI)	28.4 MPA (4121. PSI)
STD. DEV.				2.1 MPA (309. PSI)	1.3 MPA (195. PSI)

TABLE B-6 (Continued)

FLEXURAL PROPERTIES OF H-451 GRAPHITE

LOT NO.		SPEC. DIA.	6.4 MM
LOG NO.	7194-97	SPEC. LENGTH	51. MM
LOG DENSITY	MG/M**3		

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	MODULUS OF RUPTURE (MPA) (UNCORRECTED)	FLEXURAL STRENGTH (MPA) (CORRECTED)
3AE	241 RAD	MLF		28.7	24.0
	245 RAD	MLE		30.5	25.1
	247 RAD	MLE		30.8	25.2
	251 RAD	MLE		29.6	24.5
	253 RAD	MLE		30.1	24.8
	263 RAD	MLE		28.4	23.8
	267 RAD	MLE		30.1	24.8
	269 RAD	MLE		26.1	22.3
	273 RAD	MLE		25.4	21.8
	275 RAD	MLE		30.1	24.8
3EE	281 RAD	MLE		26.1	22.2
	285 RAD	MLE		25.7	22.0
	287 RAD	MLE		28.4	23.7
	291 RAD	MLE		31.0	25.4
	293 RAD	MLE		26.2	22.3
	303 RAD	MLE		30.6	25.1
	305 RAD	MLE		31.3	25.6
	309 RAD	MLE		28.8	24.0
	311 RAD	MLE		30.2	24.9
	315 RAD	MLE		28.4	23.8
MEAN				28.8 MPA (4183. PSI)	24.0 MPA (3482. PSI)
STD. DEV.				2.0 MPA (285. PSI)	1.2 MPA (161. PSI)

TABLE B-7

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOC NO. 7194-49 SPEC. LENGTH 25. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPR. STRENGTH (MPA)
1AE	E50C	AX	EE	7.1	.070	1.821	52.5
	E54C	AX	EE	7.1	.090	2.164	58.3
	E66C	AX	EE	7.3	.100	2.230	59.2
	E74C	AX	EE	6.9	.120	2.138	55.4
1BE	E80C	AX	EE	7.1	.110	2.153	56.3
	E84C	AX	EE	6.7	.100	2.315	58.0
	E96C	AX	EE	7.1	.100	2.037	54.9
	E104C	AX	EE	6.1	.120	1.645	47.0
MEAN				6.9 (1.00 MPaSI)	.101	2.063	55.2 (8008.PSI)
STD. DEV.				.4 (.05 MPaSI)	.016	.223	4.0 (574.PSI)
1AE	E77B	RAD	EE	5.3	.120	2.397	52.7
	E81B	RAD	EE	5.4	.070	2.375	55.4
	E85B	RAD	EE	5.9	.130	2.465	54.7
	E97B	RAD	EE	5.6	.149	2.985	57.8
1BC	E113B	RAD	EE	6.1	.100	2.578	57.3
	E117B	RAD	EE	5.3	.080	2.660	57.5
	E121B	RAD	EE	6.1	.129	2.624	57.3
	E131B	RAD	EE	6.1	.070	1.253	54.4
MEAN				5.7 (.83 MPaSI)	.106	2.417	55.9 (8107.PSI)
STD. DEV.				.4 (.05 MPaSI)	.031	.508	1.9 (272.PSI)

TABLE B-7 (Continued)

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 25. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPR. STRENGTH (MPA)
1AC	E2C	AX	EC	6.3	.110	1.910	49.9
	E4C	AX	EC	6.4	.129	1.656	46.8
	E18C	AX	EC	4.9		1.824	47.0
	E20C	AX	LC	6.1	.130	1.748	46.8
1BC	E24C	AX	EC	6.6	.140	2.141	52.5
	E26C	AX	EC	6.1	.140	1.972	48.4
	E40C	AX	LC	6.3	.130	2.012	51.6
	E42C	AX	EC	6.7	.130	1.869	50.8
MEAN				6.2 (.89 MPsi)	.130	1.891	49.2 (7139.PSI)
STD. DEV.				.5 (.08 MPsi)	.010	.153	2.3 (332.PSI)
1AC	E7B	RAD	EC	5.1	.150	2.146	46.8
	E11B	RAD	LC	4.8	.150	2.216	46.8
	E15B	RAD	EC	5.2	.149	2.361	50.3
	E25B	RAD	EC	5.2	.110	2.283	49.7
1BC	E43B	RAD	EC	5.5	.110	1.839	49.2
	E47B	RAD	EC	5.4	.110	2.209	49.9
	E51B	RAD	LC	5.9	.150	2.175	49.6
	E61B	RAD	EC	5.6	.129	2.492	52.8
MEAN				5.4 (.78 MPsi)	.132	2.215	49.4 (7164.PSI)
STD. DEV.				.3 (.05 MPsi)	.020	.189	1.9 (281.PSI)

TABLE B-7 (Continued)

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 25. MM
 LOC DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPR. STRENGTH (MPA)
3AE	M55C	AX	MLE	6.6	.110	2.340	59.6
	M54C	AX	MLE	6.4	.139	2.614	60.6
	M66C	AX	MLE	6.9	.120	2.045	56.8
	M74C	AX	MLE	6.0	.129	2.253	55.4
3BE	M80C	AX	MLE	7.1	.110	2.304	59.4
	M84C	AX	MLF	7.7	.100	2.369	60.6
	M98C	AX	MLE	6.9	.080	2.161	59.2
	M104C	AX	MLE	7.1	.090	2.147	59.9
MEAN				6.8 (.99 MPsi)	.110	2.270	58.9 (8547.PSI)
STD. DEV.				.5 (.07 MPsi)	.020	.174	1.8 (268.PSI)
3AE	M73B	RAD	MLE	5.3	.110	2.218	52.0
	M77B	RAD	MLF	5.8	.120	2.769	55.6
	M81B	RAD	MLE	5.3	.130	2.610	53.4
	M91B	RAD	MLE	5.4	.170	2.471	52.5
3BE	M109B	RAD	MLE	5.1	.149	2.642	55.4
	M113B	RAD	MLE	5.6	.130	2.608	55.2
	M117B	RAD	MLE	5.4	.130	2.515	55.6
	M127B	RAD	MLF	4.9	.110	2.943	57.3
MEAN				5.4 (.78 MPsi)	.131	2.597	54.6 (7923.PSI)
STD. DEV.				.3 (.04 MPsi)	.020	.213	1.8 (264.PSI)

TABLE B-7 (Continued)

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-49 SPEC. LENGTH 25. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPR. STRENGTH (MPA)
3AC	M2C	AX	MLC	6.0	.120	2.035	50.8
	M4C	AX	MLC	6.4	.120	1.830	51.3
	M18C	AX	MLC	3.6	.100	1.967	48.2
	M20C	AX	MLC	6.1	.140	1.883	46.5
3BC	M24C	AX	MLC	6.6	.110	2.057	54.0
	M26C	AX	MLC	6.4	.140	1.853	49.7
	M40C	AX	MLC	6.3	.119	1.887	51.3
	M42C	AX	MLC	6.3	.110	2.012	50.4
MEAN				6.0 (.87 MPsi)	.120	1.938	50.3 (7203.PSI)
STD. DEV.				1.0 (.14 MPsi)	.014	.091	2.3 (327.PSI)
3AC	M7B	RAD	MLC	5.4	.130	2.407	51.3
	M11B	RAD	MLC	5.2	.170	2.379	52.0
	M15B	RAD	MLC	5.2	.130	2.570	53.0
	M25B	RAD	MLC	5.5	.120	2.453	52.8
3BC	M43B	RAD	MLC	5.2	.170	2.549	52.0
	M47B	PAD	MLC	5.0	.169	2.474	52.8
	M51B	PAD	MLC	4.8	.190	2.537	51.1
	M55B	RAD	MLC	5.1	.140	2.714	53.9
MEAN				5.2 (.75 MPsi)	.152	2.510	52.4 (7595.PSI)
STD. DEV.				.2 (.03 MPsi)	.026	.107	.9 (136.PSI)

TABLE B-8

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-52 SPEC. LENGTH 25. MM
 LOC DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPR. STRENGTH (MPA)
1AE	E52C	AX	EE	5.4	.160	2.352	57.0
	E54C	AX	EE	7.3	.100	2.258	60.8
	E66C	AX	EE	6.9	.130	2.118	57.0
	E74C	AX	EE	6.3	.110	2.340	58.9
1BE	E80C	AX	EE	7.5	.100	2.324	59.6
	E84C	AX	EE	7.5	.100	1.925	57.0
	E96C	AX	EE	7.1	.100	2.507	61.4
	E104C	AX	EE	6.4	.120	2.040	54.6
MEAN				6.8 (.98 MPsi)	.115	2.233	58.3 (8450.PSI)
STD. DEV.				.7 (.10 MPsi)	.021	.191	2.3 (334.PSI)
1AE	E77B	RAD	EE	5.5	.119	2.717	59.0
	E81B	RAD	EE	5.5	.130	2.944	59.9
	E85B	RAD	EE	5.8	.110	2.530	56.3
	E97B	RAD	EE	5.4	.119	2.970	55.4
1BC	E113B	RAD	EE	5.2	.149	2.462	56.1
	E117B	RAD	EE	5.6	.149	2.808	59.0
	E121B	RAD	EE	5.6	.139	2.710	57.5
	E131B	RAD	EE	5.0	.149	2.772	59.4
MEAN				5.5 (.79 MPsi)	.133	2.739	57.8 (8388.PSI)
STD. DEV.				.2 (.04 MPsi)	.016	.178	1.7 (250.PSI)

TABLE B-8 (Continued)

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOT NO. 7194-52 SPEC. LENGTH 25. MM
 LOT DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (CPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPR. STRENGTH (MPA)
1AC	E2C	AX	EC	6.7	.110	2.149	53.5
	E4C	AX	EC	5.5	.110	2.061	48.5
	E18C	AX	EC	6.1	.120	1.595	47.2
	E20C	AX	EC	6.4	.120	2.005	53.0
1BC	E24C	AX	EC	6.1	.130	2.008	49.6
	E26C	AX	EC	5.6	.180	2.163	49.2
	E4JC	AX	EC	6.3	.120	1.835	50.4
	E42C	AX	EC	5.6	.150	2.077	48.2
MEAN				6.0 (.88 MPsi)	.130	1.987	50.0 (7246.Psi)
STD. DEV.				.4 (.06 MPsi)	.024	.188	2.3 (329.Psi)
1AC	E7B	RAD	EC	5.8	.120	2.352	54.4
	E11B	RAD	EC	5.5	.129	2.517	54.4
	E15B	RAD	EC	5.3	.139	2.388	53.0
	E25B	RAD	EC	5.3	.149	2.091	48.9
1BC	E43B	RAD	EC	5.2	.139	2.775	53.9
	E47B	RAD	EC	5.1	.130	2.391	50.6
	E51B	RAD	EC	5.2	.149	2.305	51.5
	E61B	RAD	EC	5.4	.170	2.260	50.6
MEAN				5.4 (.78 MPsi)	.141	2.385	52.2 (7564.Psi)
STD. DEV.				.2 (.03 MPsi)	.015	.200	2.1 (299.Psi)

TABLE B-8 (Continued)

 COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-52 SPEC. LENGTH 25. MM
 LOG DENSITY MG/M**3 --

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPR. STRENGTH (MPA)
3AE	M50C	AX	MLE	6.1	.130	2.029	57.1
	M54C	AX	MLE	6.6	.130	2.200	57.8
	M66C	AX	MLE	6.7	.120	2.242	58.3
	M74C	AX	MLE	6.9	.110	2.351	58.7
3BE	M80C	AX	MLE	6.6	.100	2.212	58.5
	M84C	AX	MLE	7.1	.120	2.403	61.1
	M98C	AX	MLE	7.3	.120	2.489	61.4
	M104C	AX	MLE	6.7	.130	2.237	58.2
MEAN				6.7 (.98 MPsi)	.120	2.270	58.9 (8544.PSI)
STD. DEV.				.3 (.05 MPsi)	.011	.142	1.5 (223.PSI)
3AE	M73B	RAD	MLE	5.0	.160	2.607	53.4
	M77B	RAD	MLE	5.4	.139	2.584	54.0
	M81B	RAD	MLE	5.5	.120	2.578	53.9
	M91B	RAD	MLE	4.9	.169	2.711	51.5
3BE	M109B	RAD	MLE	5.2	.109	2.831	55.9
	M113B	RAD	MLE	5.0	.129	2.856	55.6
	M117B	RAD	MLE	5.2	.169	2.744	56.5
	M127B	RAD	MLE	5.5	.149	2.409	54.9
MEAN				5.2 (.76 MPsi)	.143	2.665	54.5 (7898.PSI)
STD. DEV.				.3 (.04 MPsi)	.023	.149	1.6 (235.PSI)

TABLE B-8 (Continued)

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LCG NO. 7194-52 SPEC. LENGTH 25. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPP. STRENGTH (MPA)
3AC	M2C	AX	MLC	6.7	.130	2.141	54.6
	M4C	AX	MLC	6.4	.139	2.207	55.1
	M18C	AX	MLC	6.0	.090	1.777	48.9
	M20C	AX	MLC	6.4	.120	1.996	50.3
3BC	M24C	AX	MLC	6.6	.105	2.012	53.2
	M26C	AX	MLC	5.8	.085	1.657	48.7
	M40C	AX	MLC	6.0	.139	2.060	52.5
	M42C	AX	MLC	6.7	.120	1.787	50.9
MEAN				6.4 (.92 MPsi)	.116	1.956	51.8 (7508.PSI)
STD. DEV.				.4 (.05 MPsi)	.021	.195	2.4 (355.PSI)
3AC	M7B	RAD	MLC	4.8	.139	2.327	48.5
	M11B	RAD	MLC	4.5	.169	2.400	47.7
	M15B	RAD	MLC	4.8	.169	2.411	47.7
	M25B	RAD	MLC	4.3	.179	2.599	48.2
3BC	M43B	RAD	MLC	4.7	.179	2.711	49.1
	M47B	RAD	MLC	4.4	.199	2.498	47.0
	M51B	RAD	MLC	5.1	.150	2.031	47.8
	M55B	RAD	MLC	5.2	.139	2.391	50.3
MEAN				4.7 (.68 MPsi)	.166	2.421	48.3 (7002.PSI)
STD. DEV.				.3 (.05 MPsi)	.021	.201	1.0 (147.PSI)

TABLE B-9

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOC NO. 7194-87 SPEC. LENGTH 25. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNG'S MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMP. STRENGTH (MPA)
1AE	E53C	AX	EE	7.5	.100	2.793	59.4
	E54C	AX	EE	7.9	.090	2.651	65.4
	F66C	AX	EF	7.1	.110	2.687	65.2
	E74C	AX	EE	7.5	.150	2.253	60.2
1BE	E83C	AX	EF	7.3	.100	2.342	61.4
	E84C	AX	EE	8.4	.120	2.474	64.0
	E96C	AX	EE	9.1	.100	2.463	64.2
	E104C	AX	EE	7.7	.090	2.461	63.0
MEAN				7.7 (1.11 MPsi)	.107	2.431	62.9 (9118. PSI)
STD. DEV.				.4 (.70 MPsi)	.020	.198	2.3 (330. PSI)
1AE	E77B	RAD	EE	6.3	.110	2.353	55.4
	E81B	RAD	EE	6.4	.120	2.394	55.4
	E85B	RAD	EE	5.8	.120	2.027	53.4
	E97B	RAD	EE	6.3	.120	2.373	56.1
1BC	E113B	RAD	EE	5.4	.100	2.654	60.2
	E117B	RAD	EE	6.4	.100	2.222	54.9
	E121B	RAD	EE	6.3	.100	2.595	56.6
	E131B	RAD	EE	6.0	.090	2.575	56.6
MEAN				6.1 (.39 MPsi)	.107	2.399	56.1 (8135. PSI)
STD. DEV.				.4 (.75 MPsi)	.012	.210	2.0 (288. PSI)

TABLE B-9 (Continued)

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-87 SPEC. LENGTH 25. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNGS MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPR. STRENGTH (MPA)
1AC	E2C	AX	EC	6.7	.110	1.998	53.3
	E4C	AX	EC	6.3	.100	1.820	51.1
	E18C	AX	EC	8.4	.110	1.892	54.4
	E20C	AX	EC	6.9	.110	2.168	54.6
1BC	E24C	AX	EC	6.7	.110	1.960	53.9
	E26C	AX	EC	6.9	.110	1.890	52.5
	E40C	AX	EC	6.7	.100	2.117	54.6
	E42C	AX	EC	6.4	.060	2.133	54.2
MEAN				6.9 (1.00 MPsi)	.101	1.997	53.6 (7769.Psi)
STD. DEV.				.0 (.09 MPsi)	.017	.129	1.2 (176.Psi)
1AC	E7B	RAD	EC	5.9	.080	2.271	53.7
	E11B	RAD	EC	5.6	.139	2.503	52.2
	E15B	RAD	EC	5.8	.120	2.297	50.8
	E25B	RAD	EC	6.0	.100	2.678	57.8
1BC	E43B	RAD	EC	6.4	.090	2.030	53.9
	E47B	RAD	EC	5.0	.140	2.723	55.1
	E51B	RAD	EC	5.1	.110	2.456	48.7
	E61B	RAD	EC	5.9	.159	2.173	52.3
MEAN				5.7 (.83 MPsi)	.117	2.391	53.1 (7695.Psi)
STD. DEV.				.5 (.07 MPsi)	.028	.242	2.8 (400.Psi)

TABLE B-9 (Continued)

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-87 SPEC. LENGTH 25. MM
 LOG DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCAL- TION	DENSITY (MG/M**3)	YOUNG'S MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPRESSIVE STRENGTH (MPA)
3AE	M50C	AX	MLE	7.3	.110	2.461	60.9
	M54C	AX	MLE	7.3	.110	2.341	61.6
	M66C	AX	MLE	7.3	.090	2.127	59.0
	M74C	AX	MLE	7.3	.090	2.085	58.7
3EE	M80C	AX	MLE	6.9	.100	2.326	60.6
	M84C	AX	MLE	7.7	.110	2.456	62.0
	M98C	AX	MLE	7.7	.100	2.152	59.6
	M104C	AX	MLE	7.3	.110	2.596	62.0
MEAN				7.3 (1.06 MPsi)	.101	2.317	60.5 (8781.PSI)
STD. DEV.				.2 (.04 MPsi)	.008	.185	1.3 (190.PSI)
3AE	M73P	RAD	MLE	5.2	.150	2.007	46.8
	M77B	RAD	MLE	5.3	.150	2.323	50.9
	M81B	RAD	MLE	5.6	.130	2.131	49.2
	M91B	RAD	MLE	5.9	.130	1.992	51.0
3EE	M109B	RAD	MLE	5.6	.160	2.406	50.1
	M113B	RAD	MLE	4.9	.150	2.503	50.3
	M117B	RAD	MLE	5.2	.150	2.538	51.3
	M127B	RAD	MLE	5.5	.130	2.558	52.5
MEAN				5.4 (.79 MPsi)	.143	2.307	50.3 (7291.PSI)
STD. DEV.				.3 (.04 MPsi)	.012	.234	1.7 (246.PSI)

TABLE B-9 (Continued)

COMPRESSIVE PROPERTIES OF H-451 GRAPHITE

LOT NO. 478 SPEC. DIA. 12.8 MM
 LOG NO. 7194-87 SPEC. LENGTH 25. MM
 LOC DENSITY MG/M**3

SPECIMEN NUMBER	ORIENT- ATION	LOCA- TION	DENSITY (MG/M**3)	YOUNG'S MODULUS (GPA)	PERM- ANENT SET (PCT)	FRAC- TURE STRAIN (PCT)	COMPR. STRENGTH (MPA)
3AC	M20	AX	MLC	6.4	.080	1.960	53.7
	M40	AX	MLC	5.8	.060	2.002	54.4
	M180	AX	MLC	6.4	.139	2.047	52.0
	M200	AX	MLC	7.1	.090	1.879	52.7
3BC	M240	AX	MLC	6.7	.090	1.891	53.2
	M260	AX	MLC	6.9	.090	1.992	54.5
	M400	AX	MLC	7.1	.120	2.003	54.4
	M420	AX	MLC	6.1	.090	2.104	54.9
MEAN				6.6 (.95 MPsi)	.095	1.965	53.7 (7789.PSI)
STD. DEV.				.5 (.07 MPsi)	.024	.075	1.0 (147.PSI)
3AC	M7B	RAD	MLC	4.4	.160	2.547	48.4
	M11B	RAD	MLC	4.7	.160	2.284	45.1
	M15B	RAD	MLC	4.8	.140	2.475	46.8
	M25B	RAD	MLC	5.4	.139	2.014	48.2
3BC	M43B	RAD	MLC	4.8	.150	2.570	47.8
	M47B	RAD	MLC	4.7	.130	2.429	48.7
	M51B	RAD	MLC	5.2	.150	2.640	49.7
	M55B	RAD	MLC	6.0	.140	2.276	50.8
MEAN				5.0 (.72 MPsi)	.146	2.404	48.2 (6989.PSI)
STD. DEV.				.5 (.06 MPsi)	.011	.204	1.7 (253.PSI)

TABLE B-10
THERMAL EXPANSIVITY OF H-451 GRAPHITE
LOG 7194-49

Specimen Number	Orientation	Location	$\bar{\alpha}_{RT-773K}$ ($10^{-6} K^{-1}$)	$\bar{\alpha}_{RT-1173K}$ ($10^{-6} K^{-1}$)
1AE-62A	Ax	EE	3.79	4.25
-62B	Ax	EE	3.81	4.28
-72A	Ax	EE	3.75	4.24
-72B	Ax	EE	3.75	4.19
Mean			3.78	4.24
Std. dev.			0.03	0.04
2AC-108A	Ax	MLC	3.62	4.15
-108B	Ax	MLC	3.69	4.16
-118A	Ax	MLC	3.80	4.27
-118B	Ax	MLC	3.76	4.24
Mean			3.72	4.21
Std. dev.			0.08	0.06
1AE-83A	Rad	EE	4.51	4.95
-83B	Rad	EE	4.56	4.92
-107A	Rad	EE	4.57	5.03
-107B	Rad	EE	4.42	4.86
Mean			4.52	4.94
Std. dev.			0.07	0.07
3AC-169A	Rad	MLC	4.14	4.76
-169B	Rad	MLC	4.25	4.80
-187A	Rad	MLC	4.35	4.82
-187B	Rad	MLC	4.34	4.80
Mean			4.27	4.80
Std. dev.			0.10	0.03

TABLE B-11
THERMAL EXPANSIVITY OF H-451 GRAPHITE
LOG 7194-52

Specimen Number	Orientation	Location	$\bar{\alpha}_{(RT-773K)}$ ($10^{-6} K^{-1}$)	$\bar{\alpha}_{(RT-1173K)}$ ($10^{-6} K^{-1}$)
1AC-6A	Ax	EC	3.83	4.37
-6B	Ax	EC	3.80	4.35
-18A	Ax	EC	3.71	4.22
-18B	Ax	EC	3.78	4.29
1BC-34A	Ax	EC	3.84	4.27
-34B	Ax	EC	3.90	4.40
-48A	Ax	EC	3.87	4.35
-48B	Ax	EC	3.53	4.12
Mean			3.78	4.30
Std. dev.			0.12	0.09
1AE-62A	Ax	EE	3.68	4.13
-62B	Ax	EE	3.73	4.18
-72A	Ax	EE	3.87	4.20
-72B	Ax	EE	3.97	4.43
1BE-82A	Ax	EE	3.68	4.16
82B	Ax	EE	4.32	4.47
92A	Ax	EE	4.24	4.30
92B	Ax	EE	4.42	4.59
Mean			3.99	4.31
Std. dev.			0.30	0.17

TABLE B-11 (Continued)

Specimen Number	Orientation	Location	$\bar{\alpha}_{(RT-773K)}$ ($10^{-6} K^{-1}$)	$\bar{\alpha}_{(RT-1173K)}$ ($10^{-6} K^{-1}$)
3AC-108A	Ax	MLC	3.39	4.26
-108B	Ax	MLC	3.73	4.18
-118A	Ax	MLC	3.76	4.21
-118B	Ax	MLC	3.68	4.16
3BC-134A	Ax	MLC	3.63	4.19
-134B	Ax	MLC	3.80	4.26
-146A	Ax	MLC	3.51	4.14
-146B	Ax	MLC	3.49	4.11
Mean			3.62	4.19
Std. dev.			0.15	0.05
3AE-162A	Ax	MLE	3.82	4.21
-162B	Ax	MLE	3.71	4.15
-172A	Ax	MLE	3.75	4.21
-172B	Ax	MLE	3.69	4.16
3BE-182A	Ax	MLE	3.85	4.29
-182B	Ax	MLE	3.65	4.16
-192A	Ax	MLE	3.72	4.21
-192B	Ax	MLE	3.66	4.21
Mean			3.73	4.20
Std. dev.			0.07	0.05
1AC-9A	Rad	EC	4.54	4.94
-9B	Rad	EC	4.32	4.80
-27A	Rad	EC	4.42	4.90
-27B	Rad	EC	4.58	4.96
1BC-49A	Rad	EC	4.50	4.99
-49B	Rad	EC	4.40	4.90
-67A	Rad	EC	4.54	4.98
-67B	Rad	EC	4.33	4.63
Mean			4.46	4.89
Std. dev.			0.10	0.12

TABLE B-11 (Continued)

Specimen Number	Orientation	Location	$\bar{\alpha}_{(RT-773K)}$ ($10^{-6} K^{-1}$)	$\bar{\alpha}_{(RT-1173K)}$ ($10^{-6} K^{-1}$)
1AE-83A	Rad	EE	5.08	5.49
-83B	Rad	EE	4.57	5.08
-107A	Rad	EE	4.76	5.29
-107B	Rad	EE	4.54	5.08
1BE-123A	Rad	EE	4.74	5.23
-123B	Rad	EE	4.49	5.00
-147A	Rad	EE	4.74	5.27
-147B	Rad	EE	4.65	5.12
Mean			4.70	5.20
Std. dev.			0.19	0.16
3AC-169A	Rad	MLC	4.44	4.90
-169B	Rad	MLC	4.40	4.87
-187A	Rad	MLC	4.23	4.75
-187B	Rad	MLC	4.50	4.93
3BC-209A	Rad	MLC	4.34	4.83
-209B	Rad	MLC	4.13	4.66
-227A	Rad	MLC	4.38	4.86
-227B	Rad	MLC	4.40	4.83
Mean			4.35	4.83
Std. dev			0.12	0.09
3AE-249A	Rad	MLE	4.36	4.83
-249B	Rad	MLE	4.43	4.88
-265A	Rad	MLE	4.64	4.99
-265B	Rad	MLE	4.56	4.98
3BE-289A	Rad	MLE	4.54	4.99
-289B	Rad	MLE	4.31	4.85
-307A	Rad	MLE	3.77	4.65
-307B	Rad	MLE	3.95	4.92
Mean			4.32	4.89
Std. dev.			0.31	0.11

TABLE B-12

THERMAL CONDUCTIVITY OF H-451 GRAPHITE

LOT NUMBER: 478			LOG NUMBER: 7194-49				

ORIENTA- TION	LOCA- TION	SPECIMEN NUMBER	THERMAL CONDUCTIVITY (W/M-K) AT:				
			295K (22C)	473K (200C)	673K (400C)	873K (600C)	1073K (800C)

RADIAL	MLE	7194-49-M105	130.0	114.5	90.4	71.8	60.0
		7194-49-M105	119.0	104.1	82.8	70.3	59.1
		7194-49-M105	124.5	106.7	88.0	70.5	62.3
		7194-49-M105	119.5	102.2	83.2	67.8	53.9
		7194-49-M105	119.6	97.9	81.0	64.0	57.5
		7194-49-M105	131.4	113.8	99.1	75.9	68.8
		7194-49-M105	119.8	107.3	81.1	61.7	51.7
		7194-49-M105	118.9	99.4	84.0	64.6	62.1

MEAN:		122.6	106.4	86.2	68.3	59.4	

STD. DEV:		5.2	7.2	6.2	4.7	5.3	

TABLE B-12 (Continued)

THERMAL CONDUCTIVITY OF H-451 GRAPHITE

LOT NUMBER: 47E			LOG NUMBER: 7194-49				

ORIENTA- TION	LOCA- TION	SPECIMEN NUMBER	THERMAL CONDUCTIVITY (W/M-K) AT:				
			295K (22C)	473K (200C)	673K (400C)	873K (600C)	1073K (800C)

RADIAL	MLC	7194-49-M39-	114.4	102.0	80.7	62.6	54.7
		7194-49-M39-	124.9	107.1	89.6	70.7	65.9
		7194-49-M39-	122.4	107.7	86.6	68.0	67.2
		7194-49-M39-	94.9	100.8	76.9	62.8	58.2
		7194-49-M39-	120.0	100.3	78.0	66.7	55.0
MEAN:			116.5	103.6	82.4	66.2	60.2
STD. DEV:			13.2	3.5	5.5	3.5	6.0

TABLE B-13

THERMAL CONDUCTIVITY OF H-451 GRAPHITE

LOT NUMBER: 478

LOG NUMBER:

7/94-52

ORIENT- TATION	LOCA- TION	SPECIMEN NUMBER	THERMAL CONDUCTIVITY (W/M-K) AT:				
			295K (22C)	473K (200C)	673K (400C)	873K (600C)	1073K (800C)
RADIAL	MLE	7194-52-M105	136.6	117.6	94.3	77.0	63.7
		7194-52-M105	126.5	108.3	82.7	70.3	61.5
		7194-52-M105	119.0	101.7	80.1	66.3	57.5
		7194-52-M105	124.5	95.6	83.6	65.1	61.5
		7194-52-M105	120.5	103.0	78.3	64.4	57.0
		7194-52-M105	125.6	107.7	87.4	71.9	59.7
		7194-52-M105	119.5	115.2	86.9	72.2	63.6
		7194-52-M105	125.9	110.6	86.4	71.3	61.9
MEAN:		124.8	107.4	85.0	69.8	60.7	
STD. DEV:		5.7	7.2	5.0	4.3	2.5	

TABLE B-13 (Continued)

THERMAL CONDUCTIVITY OF H-451 GRAPHITE

LOT NUMBER: 478

LOG NUMBER:

7194-52

ORIENT- TATION	LOCA- TION	SPECIMEN NUMBER	THERMAL CONDUCTIVITY (W/M-K) AT:				
			295K (22C)	473K (200C)	673K (400C)	873K (600C)	1073K (800C)
AXIAL	MLE	7194-52-M98-	122.3	115.4	89.7	75.6	67.3
		7194-52-M98-	142.0	124.2	103.1	80.8	63.1
		7194-52-M98-	134.2	121.7	92.7	70.9	57.6
		7194-52-M98-	128.3	106.3	92.8	65.5	66.2
		7194-52-M98-	131.1	120.1	94.2	77.5	67.4
		7194-52-M98-	131.2	115.7	97.4	77.5	66.2
		7194-52-M98-	137.3	118.3	98.7	79.2	68.5
		7194-52-M98-	136.8	116.4	92.2	74.5	63.4
MEAN:		132.9	117.3	95.1	75.2	65.0	
STD. DEV:		6.1	5.4	4.3	5.0	3.5	

TABLE B-73 (Continued)

THERMAL CONDUCTIVITY OF H-451 GRAPHITE

LOT NUMBER: 478

LOG NUMBER:

7194-52

ORIENT- TATION	LOCA- TION	SPECIMEN NUMBER	THERMAL CONDUCTIVITY (W/M-K) AT:				
			295K (22C)	473K (200C)	673K (400C)	873K (600C)	1073K (800C)
RADIAL	MLC	7194-52-M39-	125.3	106.7	87.2	74.1	63.8
		7194-52-M39-	119.9	98.1	80.1	66.7	58.6
		7194-52-M39-	104.5	87.1	73.7	57.5	47.5
		7194-52-M39-	117.3	100.2	81.1	69.4	60.5
		7194-52-M39-	128.5	109.0	80.3	68.2	58.7
		7194-52-M39-	123.1	103.0	82.7	69.8	61.9
		7194-52-M39-	116.0	99.0	78.6	66.0	56.3
		7194-52-M39-	122.1	110.6	85.6	72.2	59.3
MEAN:		119.6	102.7	81.2	68.0	58.3	
STD. DEV:		7.3	8.9	4.2	5.0	4.9	

TABLE B-13 (Continued)

THERMAL CONDUCTIVITY OF H-451 GRAPHITE

LOT NUMBER: 473

LOG NUMBER:

7194-52

ORIENT- TATION	LOCA- TION	SPECIMEN NUMBER	THERMAL CONDUCTIVITY (W/M-K) AT:				
			295K (220)	473K (2000)	673K (4000)	873K (6000)	1073K (8000)
AXIAL	MLC	7194-52-M30-	125.0	109.7	92.5	76.4	62.5
		7194-52-M30-	137.2	115.3	87.3	75.6	57.5
		7194-52-M30-	131.9	110.6	90.4	71.3	66.5
		7194-52-M30-	145.1	122.2	93.0	74.3	62.9
		7194-52-M30-	125.3	110.0	104.2	68.0	60.5
		7194-52-M30-	130.5	128.0	95.3	78.0	72.5
		7194-52-M30-	138.0	115.9	93.0	77.7	66.3
		7194-52-M30-	139.0	123.0	93.6	82.1	53.9
	MEAN:		134.0	116.0	93.6	75.4	62.8
	STD. DEV:		7.1	6.9	4.9	4.3	5.8

TABLE B-14
CHEMICAL PURITY
LOG 7194-49

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611 REPORT TO: AL BEAVAN DATE: 6-2678
SAMPLE: 7194-49 E12 PROJECT NO. 3273604200 DILUTION: 1.0000 PLATE NO. 046.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	10.00	AS	< 40.00
AU	< 6.00	B	2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	EP	< 6.00
EU	< 10.00	FE	40.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	1.00	LU	< .50
MG	2.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	10.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	60.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	6.00	TL	< 20.00
V	6.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-14 (Continued)

CHEMICAL PURITY

LOG 7194-49

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANYLAB. NO. 49611
SAMPLE: 7194-49 E38REPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	10.00	AS	< 40.00
AU	< 6.00	B	2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	40.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	1.00	LU	< .50
MG	< 2.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 10.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	60.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	< 6.00	TL	< 20.00
V	< 6.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
 > MEANS GREATER THAN
 < MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
 RESULTS ARE CORRECT WITHIN A FACTOR OF 40% (ONE STANDARD DEVIATION)

TABLE B-14 (Continued)
CHEMICAL PURITY
LOG 7194-49

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-49 E60

REPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000

DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	10.00	AS	< 40.00
AU	< 6.00	B	2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	40.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	1.00	LU	< .50
MG	< 2.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	10.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	< 80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	6.00	TL	< 20.00
V	< 6.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-14 (Continued)
CHEMICAL PURITY
LOG 7194-49

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-49 E90

REPORT TO: AL BEAVAN
PROJECT NO. 32736C4200 DILUTION: 1.0000

DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	10.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	40.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	10.00
LA	< 10.00	LI	1.00	LU	< .50
MG	2.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	10.00
P	< 100.00	PB	< 6.00	PO	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	100.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	6.00	TL	< 20.00
V	6.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	8.00

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-14 (Continued)

CHEMICAL PURITY

LOG 7194-49

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANYLAB. NO. 49611
SAMPLE: 7194-49 M16REPORT TO: AL BFAVAN
PROJECT NO. 32736C4200 DILUTION: 1.0000DATE: 6-2-78
PLATE NO. 042.0

ELEMENT CONCENTRATION, PPM

ELEMENT CONCENTRATION, PPM

ELEMENT CONCENTRATION, PPM

AG < .50
 AU < 6.00
 BE < .50
 CD < 10.00
 CR < 10.00
 EU < 10.00
 HF < 20.00
 IN < 1.00
 LA < 10.00
 MG < 20.00
 NA < 10.00
 P < 100.00
 PT < 4.00
 RU < 8.00
 SI < 80.00
 TA < 40.00
 TH < 10.00
 V < 60.00
 YB < 10.00

AL 40.00
 B 4.00
 BI < 2.00
 CE < 80.00
 CU 6.00
 FE 80.00
 HG < 10.00
 IR < 10.00
 LI < 1.00
 MN < 1.00
 NB < 6.00
 PB < 6.00
 RB < 40.00
 SB < 8.00
 SN < 6.00
 TB < 40.00
 TI 40.00
 W < 40.00
 ZN < 20.00

AS < 40.00
 BA < .50
 CA < 20.00
 CO < 4.00
 ER < 6.00
 GE < 4.00
 HO < 10.00
 K 10.00
 LU < .50
 MO < 1.00
 NI < 4.00
 PD < 4.00
 RH < 8.00
 SC < 1.00
 SR < 40.00
 TE < 20.00
 TL < 20.00
 Y < 1.00
 ZR < .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
 > MEANS GREATER THAN
 < MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
 RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

B-81

TABLE B-14 (Continued)
CHEMICAL PURITY
LOG 7194-49

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-49 M34

REPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000

DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	20.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	40.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	10.00
LA	< 10.00	LI	2.00	LU	< .50
MC	10.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PR	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	40.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	40.00	TL	< 20.00
V	60.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-14 (Continued)

CHEMICAL PURITY

LOG 7194-49

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANYLAB. NO. 49611
SAMPLE: 7194-49 M60REPORT TO: AL BEAVAN
PROJECT NO. 3273604207 DILUTION: 1.0000DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	40.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	80.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	20.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PR	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	20.00	TL	< 20.00
V	20.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
 > MEANS GREATER THAN
 < MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
 RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-14 (Continued)

CHEMICAL PURITY

LOG 7194-49

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANYLAB. NO. 49611
SAMPLE: 7194-49 M9CREPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	20.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	40.00	ER	< 6.00
EU	< 10.00	FE	40.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	40.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	10.00	TL	< 20.00
V	10.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	8.00

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
 > MEANS GREATER THAN
 < MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
 RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-15
CHEMICAL PURITY
LOG 7194-52

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-52 E12

REPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000

DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	20.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	20.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	10.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	40.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
Th	< 10.00	TI	10.00	TL	< 20.00
V	20.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-15 (Continued)
CHEMICAL PURITY
LOG 7194-52

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-52 E38

REPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000

DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	20.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	10.00	ER	< 6.00
EU	< 10.00	FE	20.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	10.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	10.00	TL	< 20.00
V	20.00	W	< 40.00	Y	< 1.00
VB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-15 (Continued)
CHEMICAL PURITY
LOG 7194-52

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-52 E60

REPORT TO: AL BEAVAN
PROJECT NO. 3273604260 DILUTION: 1.0000

DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	10.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	8.00	ER	< 6.00
EU	< 10.00	FE	40.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	4.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	PH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	2.00	TL	< 20.00
V	2.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-15 (Continued)
CHEMICAL PURITY
LOG 7194-52

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-52 E90

REPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000

DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	10.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	2.00	ER	< 6.00
EU	< 10.00	FE	40.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	4.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	2.00	TL	< 20.00
V	< .50	W	< 40.00	Y	< 1.00
VB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-15 (Continued)

CHEMICAL PURITY

LOG 7194-52

SPECTROCHEMICAL REPORT

GENERAL ATOMIC COMPANY

LAB. NO. 49611

REPORT TO: AL BEAVAN

DATE: 6-2-78

SAMPLE: 7194-52-M12

PROJECT NO. 3273604200

DILUTION: 1.0000

PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	6.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	2.00	ER	< 6.00
EU	< 10.00	FE	10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	4.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	4.00	TL	< 20.00
V	4.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT

> MEANS GREATER THAN

< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED

RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-15 (Continued)

CHEMICAL PURITY

LOG 7194-52

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611

REPORT TO: AL BEAVAN

DATE: 6-2-78

SAMPLE: 7194-52 M34

PROJECT NO. 3273604200

DILUTION: 1.0000

PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	4.00	AS	< 40.00
AU	< 6.00	B	2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	4.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	60.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	YB	< 40.00	TE	< 20.00
TH	< 10.00	TI	4.00	TL	< 20.00
V	4.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT

> MEANS GREATER THAN

< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED

RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

B-90

TABLE B-15 (Continued)

CHEMICAL PURITY

LOG 7194-52

SPECTROCHEMICAL REPORT

GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-52 M60REPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	4.00	AS	< 40.00
AU	< 6.00	B	2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	4.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	< 60.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	4.00	TL	< 20.00
V	4.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT

> MEANS GREATER THAN

< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED

RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-15 (Continued)

CHEMICAL PURITY

LOG 7194-52

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANYLAB. NO. 49611
SAMPLE: 7194-52 M90REPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	4.00	AS	< 40.00
AU	< 6.00	B	4.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	< 4.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	4.00	TL	< 20.00
V	4.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZP	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
 > MEANS GREATER THAN
 < MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
 RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-16
CHEMICAL PURITY
LOG 7194-87

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611 REPORT TO: AL BEAVAN DATE: 6-2-78
SAMPLE: 7194-87 E12 PROJECT NO. 327360420 DILUTION: 1.0000 PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	< 1.00	AS	< 40.00
AU	< 6.00	B	< 2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	< 10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	< 2.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	< 60.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	< 20.00	TL	< 20.00
V	< 20.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-16 (Continued)

CHEMICAL PURITY

LOG 7194-87

SPECTROCHEMICAL REPORT

GENERAL ATOMIC COMPANY

LAB. NO. 49611

REPORT TO: AL BEAVAN

DATE: 6-2-78

SAMPLE: 7194-87 E38

PROJECT NO. 3273604200

DILUTION: 1.0000

PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	< 1.00	AS	< 40.00
AU	< 6.00	B	< 2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	< 20.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	< 4.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	< 60.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	< 40.00	TL	< 20.00
V	< 40.00	W	< 40.00	Y	< 1.00
VB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT

> MEANS GREATER THAN

< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED

RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-16 (Continued)
CHEMICAL PURITY
LOG 7194-87

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-87 E6G

REPORT TO: AL BEAVAN
PROJECT NO. 32736042GC DILUTION: 1.DDDD

DATE: 6-2-78
PLATE NO. 042.D

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	< 1.00	AS	< 40.00
AU	< 6.00	B	< 2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 20.00	ER	< 6.00
EU	< 10.00	FE	< 10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	< 2.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	< 60.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	< 40.00	TL	< 20.00
V	< 20.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 4%, (ONE STANDARD DEVIATION)

TABLE B-16 (Continued)

CHEMICAL PURITY

LOG 7194-87

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANYLAB. NO. 49611
SAMPLE: 7194-87 E9CREPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	< 1.00	AS	< 40.00
AU	< 6.00	B	< 2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	< 10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	< 6.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	< 80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	< 8.00	TL	< 20.00
V	< 8.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT

> MEANS GREATER THAN

< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED

RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-16 (Continued)

CHEMICAL PURITY

LOG 7194-87

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANYLAB. NO. 49611
SAMPLE: 7194-87 M16REPORT TO: AL BEAVAN
PROJECT NO. 3273674200 DILUTION: 1.0000DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	< 1.00	AS	< 40.00
AU	< 6.00	9	< 2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	< 10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	< 6.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	< 80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	< 60.00	TL	< 20.00
V	< 80.00	W	< 40.00	Y	< 1.00
VF	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
 > MEANS GREATER THAN
 < MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
 RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-16 (Continued)
CHEMICAL PURITY
LOG 7194-87

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-87 M34

REPORT TO: AL BEAVAN
PROJECT NO. 3273604200 DILUTION: 1.0000

DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	< 1.00	AS	< 40.00
AU	< 6.00	B	< 2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	EP	< 6.00
EU	< 10.00	FE	< 10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IP	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	< 6.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	PH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	< 80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	< 60.00	TL	< 20.00
V	< 80.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-16 (Continued)
CHEMICAL PURITY
LOG 7194-87

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611 REPORT TO: AL BEAVAN DATE: 6-2-78
SAMPLE: 7194-87 M60 PROJECT NO. 3273604200 DILUTION: 1.0000 PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	< 1.00	AS	< 40.00
AU	< 6.00	B	< 2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CP	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	< 10.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LT	< 1.00	LU	< .50
MG	< 6.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RR	< 40.00	RH	< 8.00
RU	< 6.00	SB	< 8.00	SC	< 1.00
SI	< 80.00	SN	< 6.00	SP	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	< 60.00	TL	< 20.00
V	< 80.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZP	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)

TABLE B-16 (Continued)
CHEMICAL PURITY
LOG 7194-87

SPECTROCHEMICAL REPORT
GENERAL ATOMIC COMPANY

LAB. NO. 49611
SAMPLE: 7194-87 M9C

REPORT TO: AL BEAVAN
PROJECT NO. 32736C4200 DILUTION: 1.0000

DATE: 6-2-78
PLATE NO. 042.0

ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM	ELEMENT	CONCENTRATION, PPM
AG	< .50	AL	< 1.00	AS	< 40.00
AU	< 6.00	B	< 2.00	BA	< .50
BE	< .50	BI	< 2.00	CA	< 20.00
CD	< 10.00	CE	< 80.00	CO	< 4.00
CR	< 10.00	CU	< 1.00	ER	< 6.00
EU	< 10.00	FE	< 1.00	GE	< 4.00
HF	< 20.00	HG	< 10.00	HO	< 10.00
IN	< 1.00	IR	< 10.00	K	< 10.00
LA	< 10.00	LI	< 1.00	LU	< .50
MG	< 1.00	MN	< 1.00	MO	< 1.00
NA	< 10.00	NB	< 6.00	NI	< 4.00
P	< 100.00	PB	< 6.00	PD	< 4.00
PT	< 4.00	RB	< 40.00	RH	< 8.00
RU	< 8.00	SB	< 8.00	SC	< 1.00
SI	< 80.00	SN	< 6.00	SR	< 40.00
TA	< 40.00	TB	< 40.00	TE	< 20.00
TH	< 10.00	TI	< 10.00	TL	< 20.00
V	< 10.00	W	< 40.00	Y	< 1.00
YB	< 10.00	ZN	< 20.00	ZR	< .50

CONCENTRATION BASED ON ORIGINAL SAMPLE BEFORE DILUTION WITH DILUENT
> MEANS GREATER THAN
< MEANS LESS THAN THE SENSITIVITY OF THE SPECTROGRAPHIC PROCEDURE USED
RESULTS ARE CORRECT WITHIN A FACTOR OF 40% , (ONE STANDARD DEVIATION)