



GENERAL ATOMIC

GA-A13752  
UC-77

# PROPERTIES OF UNIRRADIATED FUEL ELEMENT GRAPHITES H-451 AND TS-1240

by  
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Prepared under  
Contract E(04-3)-167  
Project Agreement No. 17  
for the San Francisco Operations Office  
U.S. Energy Research and Development Administration

GENERAL ATOMIC PROJECT 3224

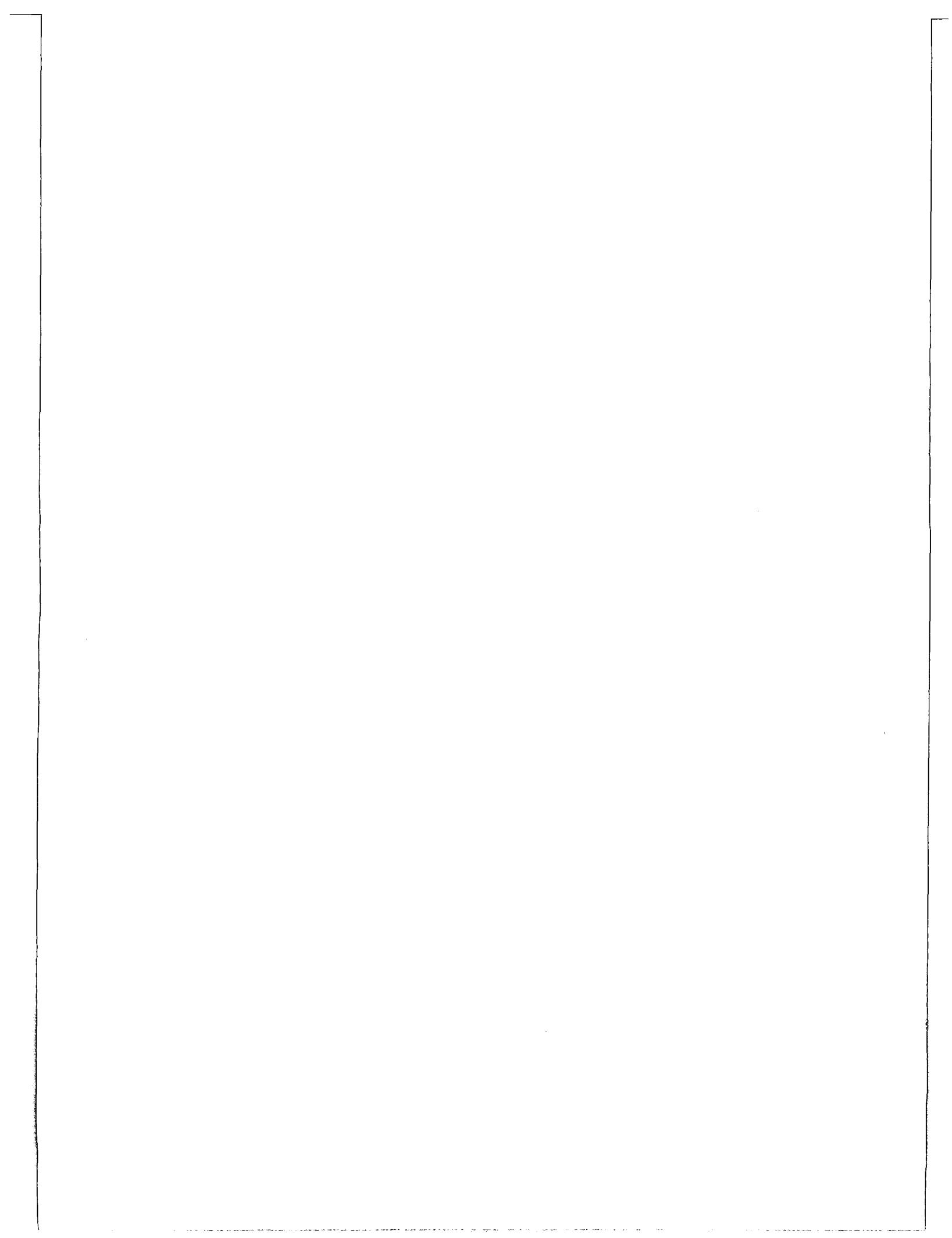
DATE PUBLISHED: JANUARY 31, 1976

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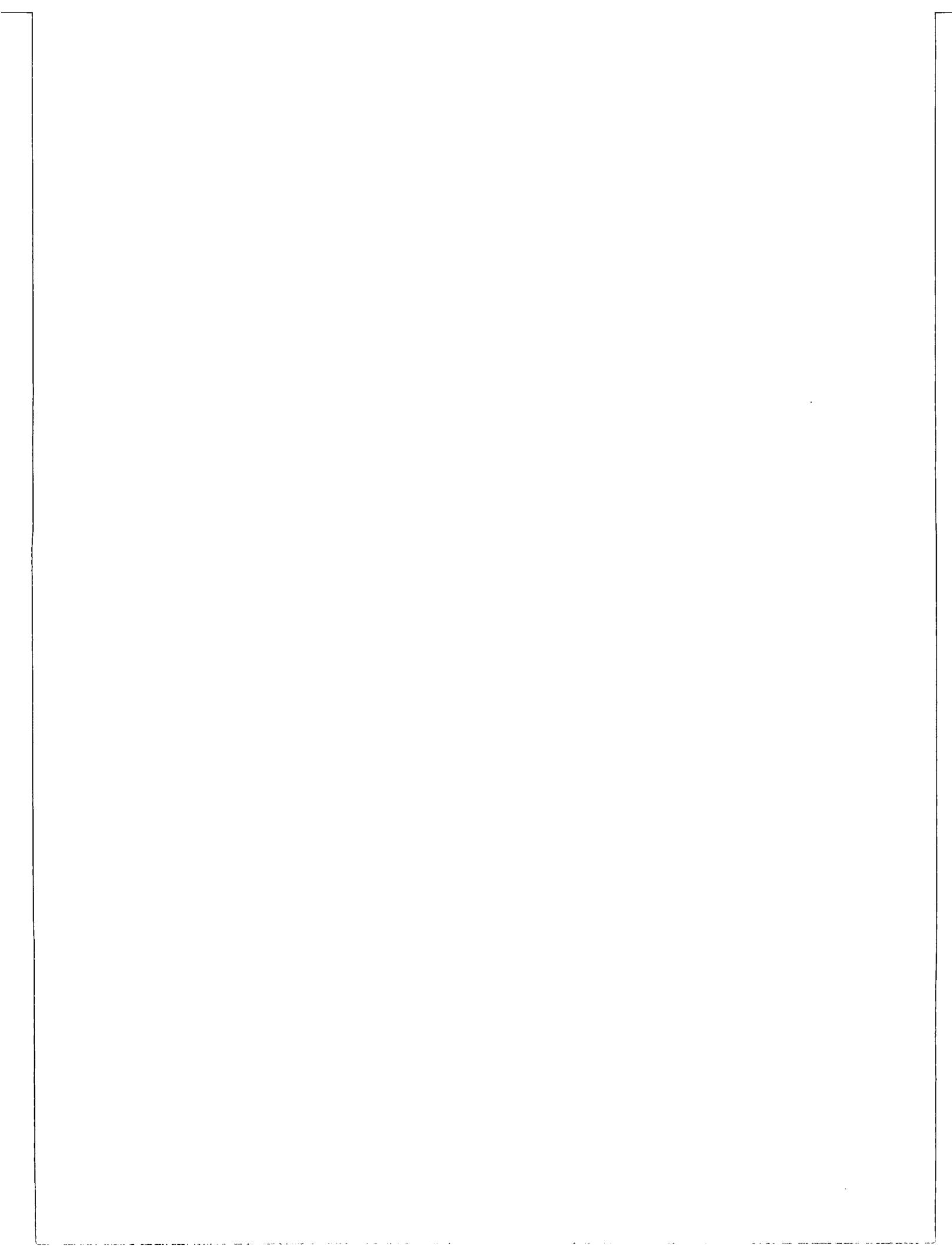
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## ABSTRACT

Nuclear graphite grades H-451 (Great Lakes Carbon Company) and TS-1240 (Union Carbide Corporation) are described and property data are presented for the unirradiated state. Properties measured included bulk density, ultimate tensile strength, modulus of elasticity, Poisson's ratio, thermal expansivity, and thermal conductivity. The data presented represent the minimum and maximum property values of the prototype full-size production logs and are indicative of property values to be expected in commercial production.



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## 1. SUMMARY

Nuclear graphite grades H-451 [Great Lakes Carbon Company (GLCC)] and TS-1240 [Carbon Products Division of Union Carbide Corporation (UCC)] are described and physical, mechanical, and chemical property data are presented on the graphites in the unirradiated state. Dimensional and property change data are given in Refs. 1 through 3.

A summary of the property data is given in Table 1-1. These data represent the minimum and maximum property values of the prototype graphites and indicate the property values to be expected in commercial production. Grade H-451 has been selected for replacement fuel and reflector elements in the Fort St. Vrain High-Temperature Gas-Cooled Reactor. Commercial production of approximately 350 logs of Grade H-451 commenced in 1975.

Grades TS-1240 and S0818 [Airco Speer Division of the Air Reduction Company (AS)] are also being evaluated for use in LHTGRs.

TABLE 1-1  
SUMMARY OF UNIRRADIATED PROPERTIES, H-451<sup>(a)</sup> AND TS-1240 GRAPHITES

Property	Mean Value $\pm$ Standard Deviation (Position In Log)			
	Axial <sup>(b)</sup>		Radial <sup>(b)</sup>	
	Minimum	Maximum	Minimum	Maximum
Log bulk density (g/cm <sup>3</sup> )				
H-451	1.707 $\pm$ 0.018	1.739 $\pm$ 0.019	--	--
TS-1240	1.800 $\pm$ 0.007	1.808 $\pm$ 0.013	--	--
Ultimate tensile strength (psi)				
H-451	1980 $\pm$ 234 (MLC)	2758 $\pm$ 269 (MLE)	1560 $\pm$ 304 (MLC)	2208 $\pm$ 326 (EE)
TS-1240	1990 $\pm$ 415 (EC)	2446 $\pm$ 368 (MLE)	1430 $\pm$ 413 (MLC)	2090 $\pm$ 263 (EE)
Modulus of elasticity ( $10^6$ psi)				
H-451	1.15 $\pm$ 0.04 (MLC)	1.26 $\pm$ 0.09 (EE)	1.00 $\pm$ 0.04 (MLC)	1.08 $\pm$ 0.06 (EE)
TS-1240	1.08 $\pm$ 0.18 (MLC)	1.17 $\pm$ 0.11 (MLE)	0.98 $\pm$ 0.11 (MLC)	1.08 $\pm$ 0.09 (EC)
Poisson's ratio				
H-451	0.110 $\pm$ 0.010 (EE)	0.127 $\pm$ 0.013 (MLC)	0.108 $\pm$ 0.008 (MLC)	0.110 $\pm$ 0.009 (MLC)
TS-1240		0.152 $\pm$ 0.010 (QLC)		0.129 $\pm$ 0.007 (QLC)
Thermal expansivity ( $10^{-6}$ °C <sup>-1</sup> )				
H-451	3.89 $\pm$ 0.16 (MLE)	4.07 $\pm$ 0.22 (EC)	4.52 $\pm$ 0.23 (MLC)	4.63 $\pm$ 0.17 (EE)
TS-1240	4.27 $\pm$ 0.39 (EC)	4.48 $\pm$ 0.25 (EE)	4.69 $\pm$ 0.28 (MLC)	4.95 $\pm$ 0.22 (EE)
Thermal conductivity, 800°C (cal/cm-sec-°C)				
H-451		0.155 $\pm$ 0.009 (MLC)		0.150 $\pm$ 0.010 (MLC)
TS-1240		0.148 $\pm$ 0.014 (MLC)		0.147 $\pm$ 0.012 (MLC)

(a) Data for lot 426 only.

(b) Direction of applied stress for Poisson's ratio.

## 2. INTRODUCTION

During the past several years nuclear graphite development for the LHTGR in the U.S. has been directed toward producing near-isotropic graphites for fuel and replaceable reflector elements. The development effort has been concentrated on the use of petroleum-based near-isotropic cokes and conventional manufacturing processes. The development of the near-isotropic graphites has progressed to the state where full-size pre-production prototype logs have been manufactured in production equipment. Three near-isotropic graphite grades, one by each of the three major U.S. graphite manufacturers, are under development; grade H-451 by GLCC, grade TS-1240 by UCC, and grade S0818 by AS. The above mentioned graphites are being evaluated by GA.

This report describes the results of property measurements on grades H-451 and TS-1240 in the unirradiated state. Irradiation data on H-451 and TS-1240 are reported elsewhere (Refs. 1 through 3). Data are presented for three prototype lots of grade H-451 and for one prototype lot of TS-1240.

### 3. MATERIALS

Prototype lots of grades H-451 and TS-1240 were manufactured by extrusion with petroleum-based near-isotropic cokes. The cokes are considered proprietary products of the respective manufacturers. Conventional manufacturing processes, similar to those used for the production of steel-furnace electrodes, were used. A description of graphites H-451 and TS-1240 is given in Table 3-1.

#### 3.1. H-451

The prototype H-451 lots were manufactured with calcined cokes from different coke sources designated A and B. A single near-isotropic coke, designated A, was used to manufacture a 6-in.-diameter pilot plant grade H-419, which was the initial development effort at GLCC leading to H-451. A description of H-419 along with property and irradiation data was reported in Ref. 1. Coke A was also used to produce the first full-size prototype (lot 266) of H-451. Subsequent H-451 lots 408 and 426 were produced with a blend of coke A and a second coke designated B. The coke sources and data are considered to be proprietary by GLCC. Three different batches of coke from source A were used in the development program (see Table 3-1). Coal-tar pitch was used as the binder and petroleum pitch as an impregnant. One additional lot, 440, is under investigation at GA, but data were not available for this report. Lot 440 was manufactured with a blend of cokes B and C. Lot 426 has been selected as the reference for future production; therefore, the data from lot 426 are of most importance in assessing H-451 and are used to describe H-451.

#### 3.2. TS-1240

Grade TS-1240 was manufactured with a single-source near-isotropic calcined petroleum coke. The details of this coke are considered

TABLE 3-1  
DESCRIPTION OF H-451 AND TS-1240 GRAPHITES

Grade	Manufacturer	Manufacturer's Identification			Log Size (in.)	Filler Coke		Binder	Impregnant	Remarks
		Lot No.	Furnace No.	Graphitization No.		Type	Designation			
H-451	GLCC	266	(a)	(a)	18 diam by 34 long	Petroleum	A <sub>1</sub>	Coal-tar pitch	Petroleum pitch	3 logs produced; 2 logs evaluated
		408	(a)	(a)			A <sub>2</sub> + B <sub>1</sub>			22 logs produced; 2 logs selected for evaluation(b)
		426	44	5698-C			A <sub>3</sub> + B <sub>1</sub>			45 logs produced
		426	77	6003-C			A <sub>3</sub> + B <sub>1</sub>			51 logs produced; 4 selected for evaluation(b)
		426	79	6399-C			A <sub>3</sub> + B <sub>1</sub>			31 logs produced
		440	79	6399-C			C <sub>1</sub> + B <sub>1</sub>			23 logs produced
TS-1240	UCC	1	--	--	17 diam x 34 long	--	--	Coal-tar pitch		48 logs produced; 5 logs selected by UCC for evaluation

(a) Unknown to authors.

(b) Logs with a whole log density (measured by the manufacturer) equal to the mean density  $\pm$  one standard deviation of the logs in a given lot were selected for evaluation.

proprietary by UCC. Coal-tar pitch was used as the binder and impregnant. A portion of the logs from the first batch of TS-1240 was graphitized as 34-in.-long logs while others were graphitized as 68-in.-long logs and halved to produce two standard 34-in.-long logs.

#### 4. EXPERIMENTAL METHODS

Details of the experimental methods are given in Appendix A.

## 5. EXPERIMENTAL RESULTS

### 5.1. SAMPLING

Commercial graphite logs of the size used for fuel and reflector elements in HTGRs (17 in. in diameter by 34 in. long) have been shown to have a nonuniform distribution of properties within a single log and from log to log within a manufactured lot (Refs. 1, 4). Therefore, the properties and impurity contents were measured as a function of location within each log tested. Properties were measured on specimens taken parallel (axial) and perpendicular (radial) to the extrusion direction and at four different locations within the log: midlength center (MLC), end center (EC), midlength edge (MLE), and end edge (EE) (see Fig. 5-1). One log of TS-1240 [5651-72 (UCC 32)] was one-half of a log that was 68 in. long during graphitization. This log was sampled at a quarter-length center (QLC) location and a quarterlength edge (QLE) location in the 68-in. log. QLC and QLE of the 68-in. log are equivalent to MLC and MLE of the 34-in. log.

### 5.2. PROPERTIES

Complete data sets of the properties measured are given in Appendix B. The data are presented in summary form in this section.

The following properties were measured on H-451 and TS-1240: (1) bulk density; (2) tensile properties including ultimate tensile strength, strain at fracture, modulus of elasticity, and Poisson's ratio; (3) thermal expansivity; (4) thermal conductivity; and (5) impurity content.

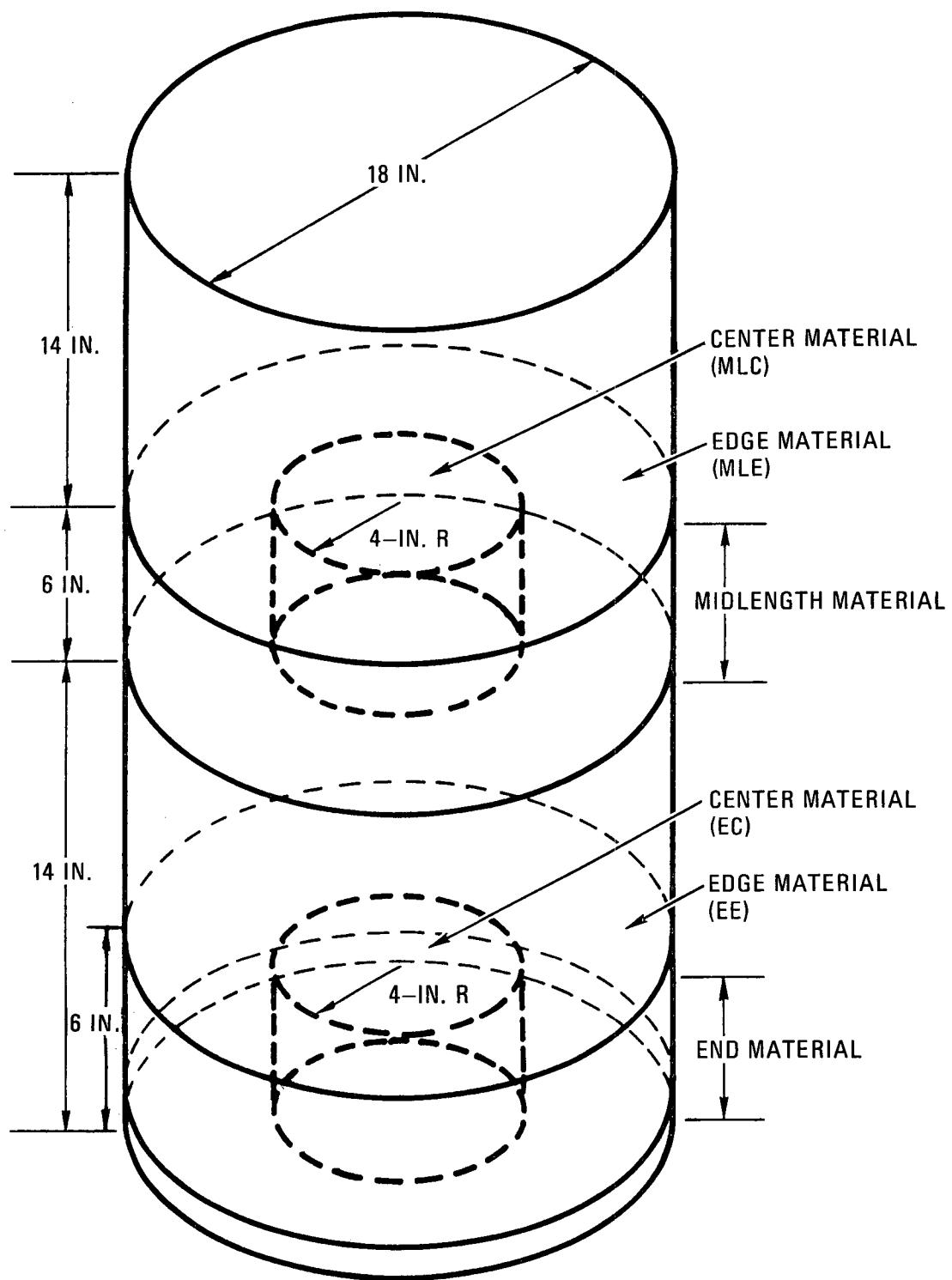


Fig. 5-1. Sampling plan of graphite log showing material designated for property measurements

### 5.2.1. Bulk Density

Bulk density measurements were made on specimens 0.505 in. in diameter by 3.0 in. long unless otherwise noted. The bulk density data are summarized in Tables 5-1 and 5-2. The tables include calculated whole log density values obtained by averaging the mean values from the center and edge specimens. Proper weight was given in the calculations to the volume of the parent log that the small specimens represented. The bulk densities measured on whole logs in the manufacturer's plant were significantly higher than those measured at GA on small specimens throughout the log. Both graphites show a small but significant increase in density from the center to the edges of the log. However, several logs had no gradient. The density was, in general, lowest at the MLC position and increased slightly near the edges and ends of the logs. Again a few exceptions were observed. The variation in density for H-451, lot 426, was 1.695 to 1.753 g/cm<sup>3</sup>. The variation for TS-1240, lot 1 (excluding log 5651-72), was 1.792 to 1.858 g/cm<sup>3</sup>.

### 5.2.2. Tensile Properties

Tensile tests were conducted in air at room temperature on 0.505-in.-diameter by 3.0-in.-long specimens or 0.25-in.-diameter by 0.90-in.-long specimens. Poisson's ratio measurements were conducted in air at room temperature on 0.50-in. by 0.50-in. by 6.0-in.-long specimens or 0.505-in.-diameter by 6.0-in.-long specimens at stresses up to 1200 psi.

#### 5.2.2.1. Ultimate Tensile Strength

The ultimate tensile strength data are summarized in Tables 5-3 and 5-4. The mean ultimate tensile strength values of the 0.505- and 0.25-in.-diameter specimens differed by only 5% in equivalent positions; therefore, the values from both sets of specimens were considered together. The tensile strength of H-451 and TS-1240 is highest in the axial direction, lowest at MLC for axial and radial specimens, and increases from the center to the edges.

TABLE 5-1  
BULK DENSITY: H-451

GA Log No.	GLCC Log No./ Lot No.	Whole Log Density(a) (g/cm <sup>3</sup> )	Mean Bulk Density, g/cm <sup>3</sup> (Standard Deviation, g/cm <sup>3</sup> ) [No. of Replicates]				Mean Log Density(b) (g/cm <sup>3</sup> )
			MLC	MLE	EC	EE	
5651-28	18/266	1.77	1.74 (0.02) [34]	1.74 (0.01) [14]			1.74
5651-58	Unknown/266	Unknown	1.73 (0.01) [19]	1.73 (0.00) [9]			1.73
Mean, lot 266			1.735 [2 logs]	1.735 [2 logs]			1.735
5651-86	52/408	1.74	1.703 (0.007) [12]	1.717 (0.004) [13]			1.713
5651-86(c)	52/408	1.74	1.697 (0.008) [20]	1.709 (0.006) [20]			1.706
5651-90	48/408	1.75	1.733 (0.005) [68]	1.739 (0.005) [96]	1.729 (0.005) [67]	1.726 (0.007) [95]	1.732
5651-90(c)	48/408	1.75	1.733 (0.006) [77]	1.738 (0.007) [96]	1.742 (0.012) [59]	1.731 (0.009) [95]	1.735
Mean, lot 408			1.716 [2 logs]	1.712 [2 logs]	1.735 [1 log]	1.729 [1 log]	1.722
6484-33	92/426	1.75	1.707 (0.008) [16]	1.737 (0.015) [16]	1.733 (0.013) [16]	1.753 (0.009) [16]	1.739
6484-34	198/426	1.73	1.711 (0.003) [16]	1.722 (0.013) [16]	1.709 (0.010) [16]	1.722 (0.004) [16]	1.719
6484-40	155/426	1.72	1.703 (0.002) [16]	1.726 (0.008) [16]	1.725 (0.007) [16]	1.717 (0.006) [16]	1.720
6484-41	184/426	1.72	1.695 (0.008) [16]	1.718 (0.013) [16]	1.685 (0.012) [16]	1.707 (0.018) [16]	1.707
Mean, lot 426			1.704 [4 logs]	1.726 [4 logs]	1.713 [4 logs]	1.725 [4 logs]	1.721

(a) Measured by GLCC.

(b) Calculated from small specimens.

(c) 0.25-in.-diameter by 0.90-in.-long specimens.

TABLE 5-2  
BULK DENSITY: TS-1240, LOT 1

GA Log No.	UCC Log No.	Whole Log Density(a) (g/cm <sup>3</sup> )	Mean Bulk Density, g/cm <sup>3</sup> (Standard Deviation, g/cm <sup>3</sup> ) [No. of Replicates]						Mean Log Density(b) (g/cm <sup>3</sup> )
			MLC	MLE	QLC	QLE	EC	EE	
5651-72	32	1.77			1.729 (0.008) [17]	1.750 (0.014) [20]	1.725 (0.013) [17]	1.741 (0.012) [18]	--
5651-73	40	1.79	1.784 (0.005) [12]	1.805 (0.006) [15]					1.800
5651-73(c)	40	1.79	1.773 (0.006) [40]	1.808 (0.007) [40]					1.800
5651-74	42	1.82	1.792 (0.004) [16]	1.803 (0.006) [16]			1.804 (0.023) [17]	1.806 (0.014) [16]	1.803
5651-75	46	1.84	1.812 (0.006) [29]	1.814 (0.006) [20]			1.815 (0.004) [16]	1.798 (0.015) [19]	1.808
6484-29	8-1S-ID-23	1.83	1.795 (0.003) [16]	1.800 (0.006) [18]			1.802 (0.004) [16]	1.804 (0.007) [19]	1.800
Mean, lot 1			1.794 [4 logs]	1.807 [4 logs]			1.807 [3 logs]	1.803 [3 logs]	1.803

(a) Measured at UCC.

(b) Calculated from small specimens.

(c) 0.25-in.-diameter by 0.90-in.-long specimens.

TABLE 5-3  
ULTIMATE TENSILE STRENGTH: H-451

GA Log No.	GLCC Log No.	GLCC Lot No.	Mean Strength, psi (Standard Deviation, psi) [No. of Replicates]											
			Axial Orientation						Radial Orientation					
			MLC	MLE	EC	EE			MLC	MLE	EC	EE		
5651-28	18	266	1914 (44) [7]	2215 (155) [7]	1889 (101) [6]				1086 (206) [3]	1151 (242) [3]	1396 (177) [3]			
5651-28 <sup>(a)</sup>	18	266	1796 (97) [7]	2246 (92) [7]	1657 (207) [7]				1558 (77) [3]	1637 (456) [3]	2051 (347) [3]			
5651-58									1338 (197) [7]	1600 (209) [7]				
Mean, lot 266		Unknown	1656 (244) [8]						1331 (235) [13]	1505 (327) [13]	1723 (435) [6]			
			1783 (187) [22]	2230 (123) [14]	1764 (200) [13]									
5651-86	52	408	2044 (82) [6]	2765 (187) [6]					1551 (240) [6]	1841 (135) [6]				
5651-86 <sup>(a)</sup>	52	408	1872 (242) [20]	2525 (219) [20]					1772 (239) [20]	2108 (243) [20]				
5651-90	48	408	2129 (153) [32]	2555 (249) [48]	2212 (254) [31]	2311 (310) [48]	1716 (160) [35]	2019 (289) [48]	1553 (245) [36]	1923 (219) [36]				
5651-90 <sup>(a)</sup>	48	408	2168 (185) [38]	2628 (243) [46]	2299 (348) [40]	2373 (288) [48]	1783 (399) [38]	2203 (260) [48]	1767 (328) [39]	1882 (278) [47]				
Mean, lot 408			2085 (215) [96]	2588 (243) [120]	2261 (311) [71]	2342 (299) [96]	1743 (294) [99]	2097 (281) [122]	1664 (308) [75]	1900 (253) [83]				
6484-33	92	426	2109 (219) [19]	2924 (338) [15]	2675 (185) [20]	2922 (227) [19]	1515 (223) [20]	2036 (366) [19]	2302 (347) [20]	2534 (177) [20]				
6484-34	198	426	2057 (108) [20]	2817 (260) [20]	2046 (134) [20]	2701 (275) [20]	1506 (300) [18]	1986 (419) [18]	1786 (432) [20]	2138 (355) [19]				
6484-40	155	426	1884 (238) [20]	2617 (165) [19]	2418 (147) [20]	2441 (157) [19]	1700 (204) [20]	2050 (231) [20]	2231 (117) [18]	2196 (150) [20]				
6484-41	184	426	1876 (178) [20]	2706 (226) [19]	1720 (120) [20]	2398 (207) [20]	1515 (417) [20]	1995 (253) [20]	1788 (294) [20]	1948 (277) [19]				
Mean, lot 426			1980 (234) [79]	2758 (269) [73]	2214 (393) [80]	2613 (303) [78]	1560 (304) [78]	2017 (318) [77]	2022 (384) [78]	2208 (326) [78]				
Mean, all logs			2009 (238) [197]	2624 (279) [207]	2199 (369) [164]	2463 (329) [174]	1640 (317) [190]	2032 (328) [212]	1846 (397) [153]	2049 (328) [161]				

(a) Specimens were 0.25 in. in diameter by 0.90 in. long.

TABLE 5-4  
ULTIMATE TENSILE STRENGTH: TS-1240, LOT 1

GA Log No.	UCC Log No.	Mean Strength, psi (Standard Deviation, psi) [No. of Replicates]											
		Axial Orientation						Radial Orientation					
		MLE	MLE	QLC	QLZ	EC	EE	MLE	MLE	QLC	QLZ	EC	EE
5651-72	32			1792 (136) [18]	1851 (287) [21]	1693 (240) [19]	1959 (137) [19]			2035 (105) [13]	2053 (151) [16]	1775 (519) [17]	2087 (110) [17]
5651-73	40	1796 (117) [6]	2290 (357) [5]					1436 (159) [6]	1837 (109) [6]				
5651-73 <sup>(a)</sup>	40	1571 (252) [20]	2315 (440) [20]			2211 (187) [20]	2271 (193) [20]	1714 (305) [17]	1744 (307) [18]			2186 (380) [15]	2090 (345) [19]
5651-74	42	2007 (131) [20]	2226 (236) [19]			1886 (278) [20]	2096 (238) [19]	1363 (683) [17]	1912 (471) [16]			2014 (688) [16]	2049 (223) [17]
5651-75	46	2696 (177) [17]	2741 (233) [19]			2345 (198) [20]	2437 (260) [17]	1301 (192) [19]	1390 (293) [19]			1954 (436) [19]	2127 (306) [20]
6484-29	8-15- ID-23	2304 (179) [19]	2571 (275) [16]										
Mean		2097 (442) [82]	2446 (368) [79]	1792 (136) [18]	1851 (287) [21]	1990 (415) [79]	2185 (272) [75]	1430 (413) [79]	1762 (395) [79]	2035 (105) [13]	2053 (151) [16]	1975 (526) [67]	2090 (263) [73]

(a) Specimens were 0.25 in. in diameter by 0.90 in. long.

The mean tensile strength of H-451, lot 426, ranged from  $1980 \pm 234$  psi at MLC to  $2758 \pm 269$  psi at MLE in the axial direction and from  $1560 \pm 304$  psi at MLC to  $2208 \pm 326$  psi at EE in the radial direction. The mean tensile strength of TS-1240, lot 1, ranged from  $2097 \pm 442$  psi at MLC to  $2446 \pm 368$  psi at MLE in the axial direction and from  $1430 \pm 413$  psi at MLC to  $2090 \pm 263$  psi at EE in the radial direction.

The mean log strengths for H-451 graphite, lot 426, calculated in the same manner as the mean log density (Section 5.2.1), were 2538 psi for the axial direction and 2032 psi for the radial direction. The corresponding values for TS-1240, lot 1, were 2247 psi for the axial direction and 1970 psi for the radial direction.

H-451 logs manufactured with a blend of cokes A and B, lots 408 and 426, had significantly higher tensile strengths at all log positions than those manufactured with coke A, lot 266 (see Table 5-3).

Standard deviations for H-451 ranged from approximately 250 to 350 psi and those for TS-1240 ranged from 300 to 400 psi. The radial strength values of TS-1240, log 5651-75, had standard deviations of about 680 psi at the MLC and EC positions. These were the highest deviations observed.

Large log-to-log variations in mean strength were observed for a given position in both graphites. A maximum variation of 1125 psi in the mean strengths of the logs of TS-1240 was observed at the MLC position in the axial direction. The maximum variation for H-451, lot 426, was 955 psi at EC in the axial direction. No systematic variations in strength were observed from position to position within a log for either graphite grade.

#### 5.2.2.2. Modulus of Elasticity

The modulus of elasticity data are summarized in Tables 5-5 and 5-6. The modulus of elasticity of H-451 and TS-1240 varied with position and orientation in a log in the same manner as tensile strength.

TABLE 5-5  
MODULUS OF ELASTICITY: H-451

GA Log No.	GLCC Log No.	GLCC Lot No.	Mean Modulus $\times 10^{-6}$ , psi (Standard Deviation $\times 10^{-6}$ psi) [No. of Replicates]							
			Axial Orientation				Radial Orientation			
			MLC	MLE	EC	EE	MLC	MLE	EC	EE
5651-28(a)	18	266	1.26 (0.09) [7]	1.28 (0.10) [7]	1.22 (0.12) [6]		0.94 (0.07) [3]	0.93 (0.00) [3]	0.96 (0.04) [3]	
5651-28(b)	18	266	1.12 (0.12) [7]	1.11 (0.07) [7]	1.05 (0.11) [5]		0.87 (0.07) [3]	0.95 (0.05) [3]	1.05 (0.19) [3]	
5651-58(a)	Unknown	266	1.20 (0.13) [8]				0.93 (0.14) [7]	0.95 (0.03) [7]		
Mean, lot 266			1.19 (0.12) [22]	1.20 (0.12) [14]	1.14 (0.14) [11]		0.92 (0.11) [13]	0.95 (0.03) [13]	1.01 (0.13) [6]	
5651-86	52	408	1.11 (0.13) [6]	1.32 (0.07) [6]			1.02 (0.05) [6]	1.01 (0.07) [6]		
5651-86(c)	52	408	1.08 (0.10) [19]	1.21 (0.11) [20]			1.04 (0.11) [20]	1.03 (0.11) [20]		
Mean, lot 408			1.09 (0.11) [25]	1.24 (0.11) [26]			1.04 (0.10) [26]	1.03 (0.10) [26]		
6484-33	92	426	1.18 (0.03) [8]	1.31 (0.04) [8]	1.22 (0.03) [8]	1.31 (0.03) [8]	0.98 (0.03) [8]	1.05 (0.06) [8]	1.13 (0.03) [8]	1.11 (0.03) [8]
6484-34	198	426	1.19 (0.02) [8]	1.31 (0.03) [8]	1.18 (0.03) [8]	1.27 (0.08) [8]	0.99 (0.05) [8]	1.12 (0.11) [8]	1.09 (0.07) [8]	1.10 (0.04) [8]
6484-40	155	426	1.14 (0.03) [8]	1.26 (0.03) [8]	1.24 (0.01) [8]	1.30 (0.11) [8]	1.02 (0.02) [8]	1.06 (0.03) [8]	1.08 (0.03) [8]	1.09 (0.05) [8]
6484-41	184	426	1.10 (0.02) [8]	1.25 (0.03) [8]	1.06 (0.03) [8]	1.16 (0.07) [8]	1.00 (0.02) [5]	1.04 (0.04) [8]	0.99 (0.03) [8]	1.02 (0.05) [9]
Mean, lot 426			1.15 (0.04) [32]	1.28 (0.04) [32]	1.18 (0.10) [32]	1.26 (0.09) [32]	1.00 (0.04) [29]	1.07 (0.07) [32]	1.07 (0.07) [32]	1.08 (0.06) [33]
Mean, all logs			1.14 (0.10) [79]	1.25 (0.09) [72]	1.17 (0.11) [43]	1.26 (0.09) [32]	1.00 (0.09) [68]	1.03 (0.09) [71]	1.06 (0.08) [38]	1.08 (0.06) [33]

(a) Modulus of elasticity taken as chord modulus between 250 and 500 psi on 0.505-in.-diameter by 4.0-in.-long specimens but tested to failure without cycling.

(b) Same as (a) except specimens were 0.25 in. in diameter by 0.90 in. long.

(c) Specimens were 0.25 in. in diameter by 0.90 in. long.

No.	DCC	Mean Modulus $\times 10^{-6}$ , psi (Standard Deviation $\times 10^{-6}$ , psi) [No. of Replicates]											
		10G	10E	q1G	q1E	EC	EE	10G	10E	q1G	q1E		
TABLE 5-6 MODULUS OF ELASTICITY: TS-1220, Lot 1													
5651-72	32	1.02 (0.04) [6]	1.16 (0.07) [8]	1.06 (0.08) [10]	0.93 (0.09) [8]	1.05 (0.05) [8]	1.04 (0.10) [5]	1.05 (0.07) [6]	0.97 (0.05) [9]	0.99 (0.04) [10]	0.97 (0.06) [9]	0.97 (0.05) [9]	
5651-73	40	0.90 (0.10) [20]	1.06 (0.09) [19]	1.02 (0.07) [8]	1.16 (0.07) [8]	1.05 (0.08) [10]	1.04 (0.10) [5]	1.05 (0.07) [6]	0.97 (0.05) [9]	0.99 (0.04) [10]	0.97 (0.06) [9]	0.97 (0.05) [9]	
5651-74	42	1.08 (0.03) [8]	1.13 (0.03) [8]	1.18 (0.03) [8]	1.25 (0.03) [8]	1.13 (0.05) [8]	1.02 (0.02) [8]	1.03 (0.03) [6]	1.11 (0.04) [6]	1.16 (0.04) [6]	1.08 (0.07) [8]	1.07 (0.03) [8]	
5651-75	46	1.30 (0.09) [16]	1.29 (0.07) [12]	1.18 (0.03) [8]	1.25 (0.03) [8]	1.13 (0.05) [8]	1.02 (0.02) [8]	1.03 (0.03) [6]	1.11 (0.04) [6]	1.16 (0.04) [6]	1.11 (0.05) [8]	1.08 (0.05) [9]	
5651-76	42	1.08 (0.03) [8]	1.13 (0.03) [8]	1.18 (0.03) [8]	1.25 (0.03) [8]	1.13 (0.05) [8]	1.02 (0.02) [8]	1.03 (0.03) [6]	1.11 (0.04) [6]	1.16 (0.04) [6]	1.08 (0.07) [8]	1.07 (0.03) [8]	
5651-77	40	1.22 (0.06) [8]	1.25 (0.05) [10]	1.22 (0.03) [8]	1.25 (0.03) [8]	1.22 (0.04) [11]	1.23 (0.04) [7]	1.23 (0.04) [7]	1.23 (0.04) [7]	1.23 (0.04) [7]	1.22 (0.05) [7]	1.22 (0.05) [8]	
5651-78	42	1.22 (0.06) [8]	1.25 (0.05) [10]	1.22 (0.03) [8]	1.25 (0.03) [8]	1.22 (0.04) [11]	1.23 (0.04) [7]	1.23 (0.04) [7]	1.23 (0.04) [7]	1.23 (0.04) [7]	1.22 (0.05) [7]	1.22 (0.05) [8]	
5651-79	46	1.22 (0.06) [8]	1.25 (0.05) [10]	1.22 (0.03) [8]	1.25 (0.03) [8]	1.22 (0.04) [11]	1.23 (0.04) [7]	1.23 (0.04) [7]	1.23 (0.04) [7]	1.23 (0.04) [7]	1.22 (0.05) [7]	1.22 (0.05) [8]	
5651-80	40	1.08 (0.18) [56]	1.17 (0.11) [55]	1.05 (0.07) [8]	1.05 (0.08) [10]	1.15 (0.14) [32]	1.14 (0.10) [42]	0.98 (0.11) [42]	1.04 (0.10) [49]	0.97 (0.05) [9]	0.99 (0.04) [10]	1.08 (0.09) [33]	1.06 (0.07) [34]

(a) Specimens were 0.25 in. in diameter by 0.90 in. long.

The mean modulus of H-451, lot 426, ranged from  $1.15 \times 10^6$  psi at MLC to  $1.28 \times 10^6$  psi at MLE in the axial direction and from  $1.00 \times 10^6$  psi at MLC to  $1.08 \times 10^6$  psi at EE in the radial direction. The mean modulus of TS-1240, lot 1, ranged from  $1.08 \times 10^6$  psi at MLC to  $1.17 \times 10^6$  psi at MLE in the axial direction and from  $0.98 \times 10^6$  psi at MLC to  $1.08 \times 10^6$  psi at EC in the radial direction.

The standard deviations of the moduli for H-451, lot 426, ranged from  $0.04 \times 10^6$  psi to  $0.10 \times 10^6$  psi and those for TS-1240, lot 1, ranged from  $0.07 \times 10^6$  psi to  $0.18 \times 10^6$  psi.

The mean log moduli for H-451 graphite, lot 426, calculated in the same manner as the mean log density (Section 5.2.1) were  $1.24 \times 10^6$  psi for the axial direction and  $1.07 \times 10^6$  psi for the radial direction. The corresponding values for TS-1240, lot 1, were  $1.15 \times 10^6$  psi for the axial direction and  $1.05 \times 10^6$  psi for the radial direction.

Significant log-to-log variations in mean modulus were observed for a given position for both graphites. For TS-1240, variations observed in the axial direction ranged from  $0.18 \times 10^6$  psi at EE to  $0.40 \times 10^6$  psi at MLC and in the radial direction from  $0.11 \times 10^6$  psi at EE to  $0.21 \times 10^6$  psi at MLC. For H-451, lot 426, the variations ranged from  $0.06 \times 10^6$  psi at MLE to  $0.18 \times 10^6$  psi at EC in the axial direction and from  $0.04 \times 10^6$  psi at MLC to  $0.14 \times 10^6$  psi at EC in the radial direction. The variations in modulus of both graphites at a given position were largest in the axial direction.

#### 5.2.2.3. Strain at Fracture

The data for strain at fracture are given in Appendix B in Tables B-1 through B-17.

The strain at fracture for H-451 and TS-1240 was in the range 0.25 to 0.35%. The strain at fracture was lowest for both axial and radial specimens at the MLC of all logs and increased from the center to the edges.

For TS-1240 the strain at fracture was generally greater in the axial direction than in the radial direction at MLC and MLE, whereas it was greater in the radial direction at EC and EE. A systematic variation in the strain at fracture from log-to-log or lot-to-lot was not observed in H-451.

#### 5.2.2.4. Poisson's Ratio

The Poisson's ratio data are summarized in Table 5-7. The Poisson's ratio values,  $\bar{\nu}_{ij}$ , are identified in standard tensor notation (Ref. 5) according to the orthogonal axes within a log as shown in Fig. 5-2.

Poisson's ratio was measured on H-451 and TS-1240 in the axial and radial directions at several locations in a log. Poisson's ratio decreased with increasing stress during initial loading and reached a constant value, independent of stress, after two or three loadings.

When stresses were applied in a radial direction ( $\sigma_1$  or  $\sigma_2$ ) to H-451 MLC specimens,  $\bar{\nu}_{13} = \bar{\nu}_{23} = 0.110 \pm 0.009$  and  $\bar{\nu}_{12} = \bar{\nu}_{21} = 0.108 \pm 0.008$ . When stresses were applied in the axial direction ( $\sigma_3$ ) to H-451 MLC specimens,  $\bar{\nu}_{31} = \bar{\nu}_{32} = 0.127 \pm 0.013$ . When stresses were applied in the axial direction ( $\sigma_3$ ) to H-451 MLE specimens,  $\bar{\nu}_{32} = 0.121 \pm 0.005$  and  $\bar{\nu}_{31} = 0.114 \pm 0.006$ . When stresses were applied in the axial direction ( $\sigma_3$ ) to H-451 EE specimens,  $\bar{\nu}_{32} = 0.110 \pm 0.010$  and  $\bar{\nu}_{31} = 0.117 \pm 0.006$ .

When stresses were applied in the radial direction ( $\sigma_1$  or  $\sigma_2$ ) to TS-1240 QLC specimens,  $\bar{\nu}_{31} = \bar{\nu}_{32} = 0.129 \pm 0.007$ . When stresses were applied in the axial direction ( $\sigma_3$ ) to TS-1240 QLC specimens, a Poisson's ratio (unknown orientation of transverse strain) of  $0.129 \pm 0.007$  was obtained.

#### 5.2.3. Thermal Expansivity

Thermal expansivity data are summarized in Tables 5-8 and 5-9. The mean thermal expansivity of H-451, lot 426, ranged from  $3.89 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$  to

TABLE 5-7  
POISSON'S RATIO: H-451 AND TS-1240

GA Specimen No./Log No.	Manufacturer's Log No./ Lot No.	Sample Location in Log	Direction of Stress	Direction of Transverse Strain	Poisson's Ratio (Standard Deviation) [No. of Measurements]					
					$\nu_{13} = \nu_{23}$	$\nu_{12} = \nu_{21}$	$\nu_{31} = \nu_{32}$	$\nu_{32}$	$\nu_{31}$	$\nu_{12} = \nu_{21}/\nu_{13} = \nu_{23}$ (a)
H-451 (GLCC)										
5947-102-1/ 5651-63	22/266	MLC	Radial	Axial Radial	0.120 (0.001) [3]	0.137 (0.001) [3]				
5947-102-2/ 5651-63	22/266	MLC	Radial	Axial Radial	0.096 (0.019) [10]	0.104 (0.011) [10]				
6399-8-D/ 5651-63	22/266	MLC	Radial	Axial Radial	0.112 (0.002) [64]	0.107 (0.006) [64]				
Mean				Axial Radial	0.110 (0.009) [77]	0.108 (0.008) [77]				
5947-102-4/ 5651-63	22/266	MLC	Axial	Radial			0.125 (0.009) [6]			
5947-5/ 5651-28	18/266	MLC	Axial	Radial			0.130 (0.019) [24]			
6399-8-B/ 5651-63	22/266	MLC	Axial	Radial			0.125 (0.008) [48]			
Mean				Radial			0.127 (0.013) [78]			
5651-28-133/ 5651-28	18/266	MLE	Axial	Radial Chord(b)			0.123 (0.009) [12]			0.113 (0.007) [12]
6399-8-C/ 5651-63	22/266	MLE	Axial	Radial Chord(b)			0.121 (0.003) [64]			0.114 (0.006) [64]
Mean				Radial Chord(b)			0.121 (0.005) [76]			0.114 (0.006) [76]
6399-8-A/ 5651-63	22/266	EE	Axial	Radial Chord(b)			0.110 (0.010) [40]			0.117 (0.006) [40]
TS-1240 (UCC)										
5651-72-3B -L063/5651-72	32/1	QLC	Axial	Radial			0.152 (0.010) [30]			
5651-72-3B -L095/5651-72	32/1	QLC	Radial	Unknown						0.129 (0.007) [54]

(a) Orientation of sample in log with respect to directions of measured transverse strains was unknown. Poisson's ratio represents "mean" of various components indicated.

(b) Perpendicular to radius in radial plane.

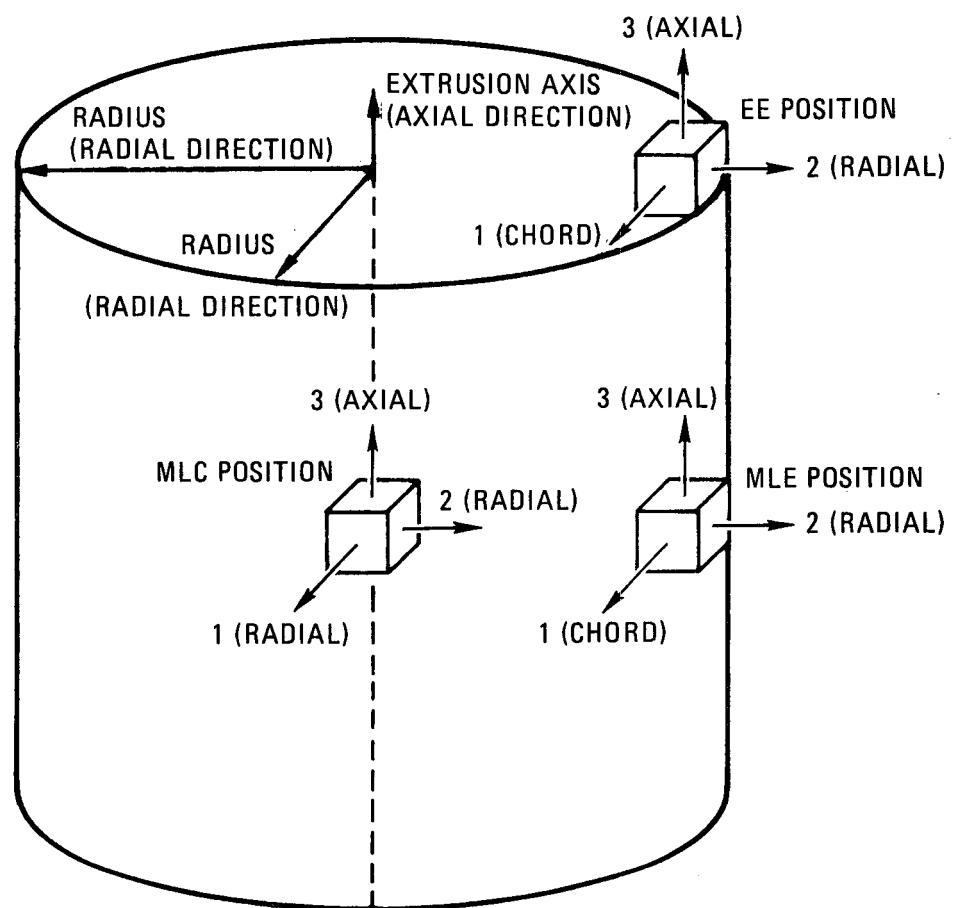


Fig. 5-2. Orientation of orthogonal axes for definition of Poisson's ratio

TABLE 5-8  
THERMAL EXPANSIVITY: H-451

GA Log No.	GLCC Log No.	GLCC Lot No.	Mean Thermal Expansivity $\times 10^6 \text{ } ^\circ\text{C}^{-1}$ (Standard Deviation $\times 10^6 \text{ } ^\circ\text{C}^{-1}$ ) [No. of Replicates]								
			Axial				Radial				
			MLC	MLE	EC	EE	MLC	MLE	EC	EE	
5651-28	18	266	3.45 (0.03) [5]	3.45 (0.06) [6]			4.41 (0.13) [6]	4.49 (0.16) [6]			
5651-86	52	408	4.18 (0.15) [8]	4.19 (0.11) [10]			4.63 (0.17) [10]	4.57 (0.21) [12]			
6484-33	92	426	4.08 (0.14) [8]	3.86 (0.20) [8]	4.00 (0.18) [8]	3.88 (0.09) [8]	4.51 (0.29) [8]	4.65 (0.13) [8]	4.70 (0.14) [8]	4.70 (0.21) [8]	
6484-34	198	426	4.10 (0.10) [8]	3.92 (0.19) [8]	4.31 (0.08) [8]	4.13 (0.12) [8]	4.63 (0.20) [8]	4.66 (0.25) [8]	4.55 (0.27) [8]	4.59 (0.10) [8]	
6484-41	184	426	3.92 (0.07) [8]	3.90 (0.09) [8]	3.90 (0.13) [8]	3.89 (0.09) [8]	4.42 (0.18) [8]	4.50 (0.18) [8]	4.43 (0.16) [8]	4.59 (0.18) [8]	
Mean, lot 426			4.03 (0.13) [24]	3.89 (0.16) [24]	4.07 (0.22) [24]	3.97 (0.15) [24]	4.52 (0.23) [24]	4.60 (0.20) [24]	4.56 (0.22) [24]	4.63 (0.17) [24]	
Mean, all logs			3.98 (0.25) [37]	3.90 (0.27) [40]	4.07 (0.22) [24]	3.97 (0.15) [24]	4.53 (0.21) [40]	4.58 (0.20) [42]	4.56 (0.22) [24]	4.63 (0.17) [24]	

TABLE 5-9  
THERMAL EXPANSIVITY: TS-1240, LOT 1

GA Log No.	UCC Log No.	Mean Thermal Expansivity $\times 10^6 \text{ } ^\circ\text{C}^{-1}$ (Standard Deviation $\times 10^6 \text{ } ^\circ\text{C}^{-1}$ ) [No. of Replicates]											
		Axial						Radial					
		MLC	MLE	QLC	QLE	EC	EE	MLC	MLE	QLC	QLE	EC	EE
5651-72	32	4.26 (0.22) [8]	4.28 (0.25) [11]	4.05 (0.21) [8]	4.12 (0.16) [8]	4.48 (0.10) [8]	4.49 (0.32) [8]	4.50 (0.11) [8]	4.68 (0.20) [8]	4.84 (0.24) [8]	4.96 (0.36) [8]		
5651-73	40	4.33 (0.06) [8]	4.26 (0.07) [8]			4.29 (0.16) [8]	4.28 (0.19) [8]	4.57 (0.18) [8]	4.62 (0.12) [8]			4.63 (0.11) [8]	4.84 (0.11) [8]
5651-74	42	3.90 (0.09) [8]	4.18 (0.13) [8]			3.69 (0.15) [8]	4.44 (0.15) [8]	4.36 (0.14) [8]	4.70 (0.11) [8]			4.27 (0.19) [8]	4.95 (0.17) [8]
5651-75	46	4.63 (0.17) [8]	4.59 (0.14) [8]			4.61 (0.21) [8]	4.69 (0.15) [8]	5.00 (0.12) [8]	5.18 (0.20) [8]			5.39 (0.30) [8]	5.03 (0.12) [8]
6484-29	8-15- ID-23												
Mean		4.28 (0.30) [32]	4.32 (0.22) [35]	4.05 (0.21) [8]	4.12 (0.16) [8]	4.27 (0.39) [32]	4.48 (0.25) [32]	4.69 (0.28) [32]	4.80 (0.27) [36]	4.50 (0.11) [8]	4.68 (0.20) [8]	4.78 (0.46) [32]	4.95 (0.22) [32]

$4.07 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$  in the axial direction and  $4.52 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$  to  $4.63 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$  in the radial direction. The mean thermal expansivity of TS-1240, lot 1, ranged from  $4.05 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$  to  $4.48 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$  in the axial direction and  $4.5 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$  to  $4.95 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$  in the radial direction. There was no significant variation of thermal expansivity as a function of specimen location in a log for either material.

#### 5.2.4. Thermal Conductivity

The thermal conductivity data are summarized in Tables 5-10 and 5-11. The mean thermal conductivity of H-451, lot 426, was  $0.155 \pm 0.009 \text{ cal/cm-sec-}^\circ\text{C}$  at  $800^\circ\text{C}$  in the axial direction and  $0.150 \pm 0.010 \text{ cal/cm-sec-}^\circ\text{C}$  in the radial direction. The mean thermal conductivity of TS-1240 was  $0.148 \pm 0.014 \text{ cal/cm-sec-}^\circ\text{C}$  at  $800^\circ\text{C}$  in the axial direction and  $0.147 \pm 0.012 \text{ cal/cm-sec-}^\circ\text{C}$  in the radial direction.

#### 5.2.5. Impurity Content

##### 5.2.5.1. Neutronic Absorbtion Impurities

Two types of neutron absorbing impurity elements, burnable and non-burnable, are of importance to the neutronic design and operation of an LHTGR. The impurity data are summarized in Table B-37. The upper bound nonburnable boron equivalent value was 0.9486 ppm for H-451 and 0.7839 ppm for TS-1240. The upper bound burnable boron equivalent value was 3.2922 ppm for H-451 and 1.8560 ppm for TS-1240. In most cases, the upper bound boron equivalent values reflect the lower limits of detection of the analytical methods used to detect the various elements.

##### 5.2.5.2. Ash and Other Important Impurities

The contents of ash and other important impurities are summarized in Table 5-12.

TABLE 5-10  
THERMAL CONDUCTIVITY: H-451

GA Log No.	GLCC Log No.	GLCC Lot No.	Location in Log	Orientation	Mean Thermal Conductivity, cal/cm-sec-°C (Standard Deviation, cal/cm-sec-°C) [No. of Replicates]				
					22°C	200°C	400°C	600°C	800°C
5651-28	18	266	MLC	Axial	0.347 (0.003) [12]	0.302 (0.005) [12]	0.246 (0.013) [12]	0.206 (0.005) [12]	0.174 (0.006) [12]
5651-28	18	266	MLC	Radial	0.295 (0.018) [12]	0.262 (0.011) [12]	0.222 (0.009) [12]	0.185 (0.009) [12]	0.158 (0.008) [12]
5651-86	52	408	MLC	Axial	0.253 (0.015) [8]	0.238 (0.018) [8]	0.207 (0.017) [8]	0.176 (0.010) [8]	0.152 (0.011) [8]
5651-86	52	408	MLC	Radial	0.251 (0.007) [8]	0.228 (0.007) [8]	0.196 (0.008) [8]	0.166 (0.007) [8]	0.145 (0.006) [8]
6484-34	198	426	MLC	Axial	0.325 (0.041) [8]	0.288 (0.065) [8]	0.221 (0.017) [8]	0.179 (0.011) [8]	0.155 (0.011) [8]
6484-34	198	426	MLC	Radial	0.308 (0.024) [8]	0.275 (0.014) [8]	0.211 (0.015) [8]	0.175 (0.015) [8]	0.150 (0.011) [8]
6484-41	184	426	MLC	Axial	0.351 (0.041) [7]	0.298 (0.033) [7]	0.220 (0.009) [7]	0.183 (0.013) [7]	0.154 (0.007) [7]
6484-41	184	426	MLC	Radial	0.333 (0.032) [7]	0.268 (0.017) [7]	0.211 (0.009) [7]	0.176 (0.011) [7]	0.150 (0.010) [7]
Mean, lot 426			MLC	Axial	0.337 (0.042) [15]	0.293 (0.051) [15]	0.221 (0.015) [15]	0.181 (0.012) [15]	0.155 (0.009) [15]
				Radial	0.320 (0.030) [15]	0.272 (0.015) [15]	0.211 (0.012) [15]	0.175 (0.015) [15]	0.150 (0.010) [15]
Mean, all logs			MLC	Axial	0.321 (0.048) [35]	0.283 (0.042) [35]	0.226 (0.021) [35]	0.188 (0.016) [35]	0.161 (0.013) [35]
				Radial	0.296 (0.035) [35]	0.259 (0.021) [35]	0.216 (0.015) [35]	0.176 (0.013) [35]	0.152 (0.010) [35]

TABLE 5-11  
THERMAL CONDUCTIVITY: TS-1240, LOT 1

GA Log No.	UCC Log No.	Location in Log	Orientation	Mean Thermal Conductivity, cal/cm-sec-°C (Standard Deviation, cal/cm-sec-°C) [No. of Replicates]							
				22°C		200°C		400°C		600°C	
5651-72	32	QLC	Axial	0.245 (0.017)	[8]	0.222 (0.013)	[8]	0.193 (0.010)	[8]	0.157 (0.006)	[8]
5651-72	32	QLC	Radial	0.235 (0.011)	[8]	0.213 (0.010)	[8]	0.183 (0.007)	[8]	0.160 (0.011)	[8]
5651-73	40	MLC	Axial	0.234 (0.020)	[8]	0.223 (0.014)	[8]	0.192 (0.014)	[8]	0.165 (0.008)	[8]
5651-73	40	MLC	Radial	0.247 (0.010)	[8]	0.231 (0.006)	[8]	0.195 (0.008)	[8]	0.167 (0.006)	[8]
5651-75	46	MLC	Axial	0.261 (0.026)	[8]	0.245 (0.014)	[8]	0.222 (0.008)	[8]	0.190 (0.011)	[8]
5651-75	46	MLC	Radial	0.254 (0.012)	[8]	0.254 (0.006)	[8]	0.209 (0.006)	[8]	0.183 (0.004)	[8]
Mean		MLC/QLC	Axial	0.247 (0.023)	[24]	0.230 (0.017)	[24]	0.202 (0.018)	[24]	0.171 (0.017)	[24]
		MLC/QLC	Radial	0.245 (0.013)	[24]	0.233 (0.019)	[24]	0.196 (0.013)	[24]	0.170 (0.012)	[24]
										0.148 (0.014)	[24]
										0.147 (0.012)	[24]

TABLE 5-12  
IMPURITY CONTENT  
[in ppm<sup>(a)</sup>]

Graphite	Ash	B	Fe	V	Ti	S	Al	Ca	Si	Na	Mg	Pb	Ba	Ni
H-451 (lot 426)	45	2.5	3.2	0.5	1.3	1.5	4.3	21.9	21.3	10.3	0.9	7.1	--	--
TS-1240	78.7	0.7	11.1	18.9	16.0	9.4	4.1	22.5	14.9	10.4	1.0	6.0	2.9	4.6

(a) Less than value given.

## 6. DISCUSSION AND CONCLUSIONS

### 6.1. DISCUSSION

#### 6.1.1. H-451

The initial lots of grade H-451 were manufactured with a blend of petroleum-based near-isotropic calcined cokes from two sources. The objective of the development program by GLCC was to optimize the properties and irradiation behavior of H-451 graphite for LHTGR design by choosing a blend of two calcined petroleum cokes for the filler. Great Lakes Carbon Co. foresees uncertainties in the procurement of petroleum coke over the long term with changing feedstocks and changing sources of coke. Therefore, the objective of their internal program is to establish coke technology that will permit them to purchase coke for future H-451 production from different sources that will reproduce the structure and properties of the prototype material currently under evaluation. Lot 426, produced from a blend of cokes A and B, has been selected as the prototype lot for future production of commercial H-451.

The mean property values of prototype lot 426 are given in Section 5.2. These data, except density, characterize grade H-451 which will be manufactured for Fort St. Vrain reload fuel and replaceable reflector elements. Commercial H-451 will be manufactured to a mean lot density value of  $1.74 \text{ g/cm}^3$  and a minimum log value of  $1.69 \text{ g/cm}^3$ .

Lot 440, manufactured with a blend of cokes B and C, is currently under evaluation. Lot 440 was manufactured with a mean density of approximately  $1.77 \pm 0.01 \text{ g/cm}^3$ . Comparisons of property and irradiation data will be made between lots 426 and 440 to assess the effect of the different

coke blends and densities. Several logs from the manufacturing run for Fort St. Vrain reload segment 9 will be evaluated to assess how well the commercial product matches the prototype lots 426 and 440.

#### 6.1.2. TS-1240

The initial lot of TS-1240 was manufactured with a single-source near-isotropic calcined petroleum coke. The objective of the development program at UCC was to produce a full-size prototype grade for evaluation. The mean property values of lot 1 are given in Section 5.2. These data are representative of grade TS-1240 in its present stage of development. One additional experimental lot of TS-1240 is being manufactured. The objectives of this further development are: (1) to reproduce the properties and irradiation behavior of the first lot, and (2) to improve the product.

#### 6.2. CONCLUSIONS

Grade H-451 has been developed to the stage where a commercial order has been placed for use as reload elements in segment 9 of the Fort St. Vrain reactor. The demonstrated superior irradiation behavior and properties of H-451 over the original Fort St. Vrain needle-coke graphite (H-327) should improve the fuel element performance.

#### ACKNOWLEDGMENTS

The authors wish to express their thanks to L. Bailey, C. H. Richards, Jr., J. R. Whaley, M. G. Dunlap, F. Hogan, H. H. Evans, and D. W. Stevens for performing the laboratory work.

L. H. Juel and R. F. Peters of Great Lakes Carbon Company and A. E. Goldman of Union Carbide Corporation are acknowledged with thanks for their cooperation in furnishing materials and their helpful comments during the course of work.

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APPENDIX A  
EXPERIMENTAL METHODS

A.1. DENSITY

Bulk densities were measured according to ASTM Standard Test C-559.

A.2. TENSILE PROPERTIES

A.2.1. Stress-Strain Curves

Tensile stress-strain curves were obtained in air at room temperature on unirradiated samples using an Instron tensile machine. Tensile tests were conducted on standard (0.505-in. diameter by 3 to 4 in. long) and subsize (0.250-in. diameter by 0.9 in. long) samples using a crosshead speed of 0.005 to 0.01 in./min. Strains were measured for subsize samples using a 0.5-in. gage length nonaveraging clip-on extensometer. A 2.0-in. gage length averaging extensometer was used on the standard samples. The samples were fixed to metal end pieces with high-strength epoxy cement, and the load was applied through roller-link chains to maintain uniaxial alignment during testing.

All samples were tested using a cyclic loading method. Each sample was loaded to 1000 psi and the crosshead reversed. After unloading to ~100 psi, the crosshead was again reversed, and the sample was loaded until fracture occurred. A typical stress-strain curve obtained by this method is shown in Fig. A-1.

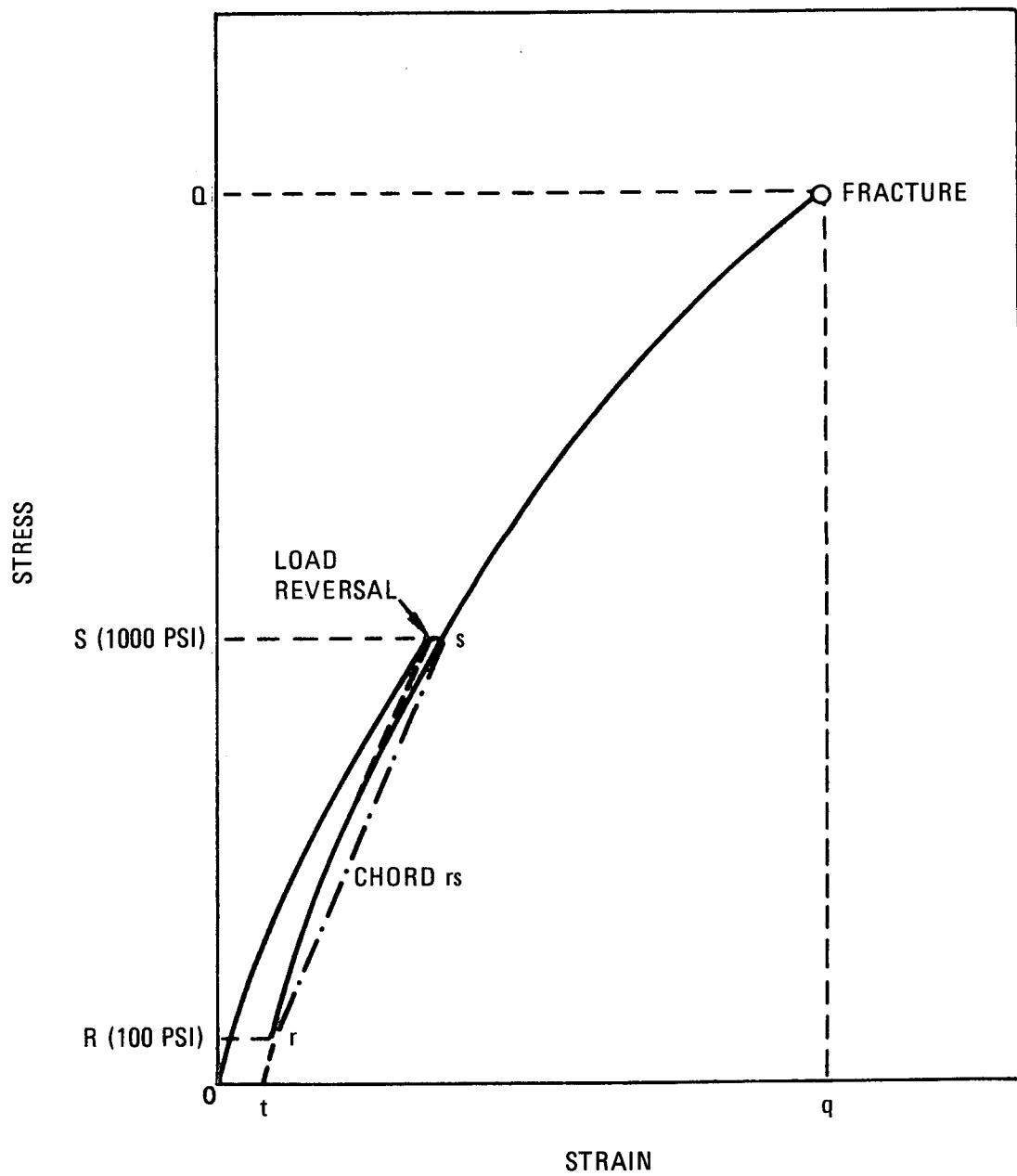


Fig. A-1. Cyclic stress-strain curve for graphite

Because of the inelastic component in the deformation of graphite, the unloading curve does not retrace the initial loading curve but reaches zero load with a positive "permanent set." The second loading curve generally superimposes on the unloading curve, and beyond the first strain reversal point it forms a continuation of the initial loading curve.

#### A.2.2. Tensile Strength

Samples tested for ultimate tensile strength only (no stress-strain curve) were loaded to failure without crosshead reversal. The tensile strength of all samples was calculated by dividing the load at fracture (stress corresponding to point Q on stress-strain curve, Fig. A-1) by the original cross-sectional area of the specimen.

#### A.2.3. Modulus of Elasticity

The modulus of elasticity of each specimen was calculated from its stress-strain curve as the slope of the chord (chord modulus) drawn between points on the second loading portion of the curve corresponding to stresses of 100 and 1000 psi (chord rs, Fig. A-1). This chord modulus represents the effective modulus of a graphite component after its first stress excursion.

#### A.2.4. Strain at Fracture

The strain at fracture for all samples was taken as the maximum strain as indicated on the stress-strain curve (strain corresponding to point q, Fig. A-1).

#### A.2.5. Permanent Set

The permanent set (residual strain) remaining in the sample after load reversal was obtained from the stress-strain curve as the value of strain extrapolated from the load reversal curve to zero stress (strain corresponding to point t, Fig. A-1).

#### A.2.6. Poisson's Ratio

Poisson's ratio was obtained on samples 0.505-in. in diameter by 5 in. long and 0.5 in. by 0.5 in. by 5 in. long using a strain gage method. Multiple (two to four) biaxial strain gages, equidistant around the cross section, were aligned with the longitudinal and transverse directions of each specimen and attached in position with an epoxy cement. The samples were fixed to end pieces with a high-strength epoxy cement and were loaded in tension in steps to stresses as high as 1200 psi while recording the strains from each gage. The load was applied through roller-link chains to maintain uniaxial alignment during testing. The transverse and longitudinal strains for each gage were measured at each load using a digital strain indicator. Poisson's ratio was calculated from the ratio of transverse and longitudinal strains for each biaxial gage after first correcting each strain for transverse sensitivity.

#### A.3. THERMAL CONDUCTIVITY

Thermal diffusivity measurements were made on disc samples, 0.45 in. in diameter by 0.050 in. thick, by the heat pulse method (ASTM Standard Test Method C-741). The thermal conductivity was calculated from the following equation:

$$k = \alpha C_p \rho ,$$

where  $\alpha$  = thermal diffusivity

$C_p$  = heat capacity

$\rho$  = density

Specimens were measured at 100°C intervals from room temperature to 800°C.

#### A.4. THERMAL EXPANSIVITY

Thermal expansivity was measured according to ASTM Standard Test Method E-228 except measurements were made on cylindrical samples, 0.25 in. in diameter by 0.9 in. long, using a silica dilatometer. Measurements were made between room temperature and 1000°C.

#### A.5. CHEMICAL IMPURITIES

The graphites were analyzed for ash for all major burnable\* and nonburnable\*\* impurities except oxygen and nitrogen. The analytical methods used are given below.

##### A.5.1. Ash

Analyses for ash were conducted by burning 10-g samples to constant weight in a covered crucible in still air (waffle furnace) at 900° to 1000°C.

##### A.5.2. Standard Emmission Spectroscopy

Procedures for analysis by emission spectroscopy on unconcentrated and preconcentrated (ashed) samples are described in Ref. A-1.

Determinations of the effects of preconcentration (by ashing) on impurity levels in graphite were made by analyzing ashed, doped standards. Samples were prepared by doping a high-purity spectrographic carbon with

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\* Burnable impurities are those elements whose cross-section and isotopic distribution are such that their neutronic poisoning effects are virtually eliminated by neutron absorption during the cycle. The major burnable impurities are B, Cd, Eu, Gd, Sm, and Li.

\*\* Nonburnable impurities are those impurities which retain a considerable fraction of their poisoning effect after a full-power year of operation. The significant nonburnable impurities are Ag, Al, Ba, Ca, Cl, Co, Cr, Cs, Cu, Dy, Er, Fe, Hf, Ho, In, K, La, Sn, Lu, Mg, Mo, Mn, Na, Nd, Ni, Pr, S, Sb, Sc, Si, Ta, Tb, Ti, Tm, V, W, Yb, P, Pb, Rb, Tl, Zn, Zr, Bi, Nb, N, O, Sr, Ce, and Be.

1 ppm each of all primary nonburnable and burnable elements in the form of salts. Procedures for ashing and emission spectrographic analysis are described in Ref. A-1.

Results obtained were used to determine losses that occurred from ashing. These results are shown in Table A-1.

#### A.5.3. Spark Source Mass Spectrometry (Accu-Labs Research, Inc.)

Semiquantitative analyses by spark source mass spectrometry (Geomascan Analysis) were conducted by Accu-Labs Research, Inc., Wheat Ridge, Colorado. Samples were graphite electrodes, 0.1 in. in diameter by 0.5 in. long (~225 mg). A description of this technique is given in Ref. A-2.

#### A.5.4. Sulfur Analysis

Analyses for sulfur were conducted by iodometric titration as follows. One-gram samples of graphite were burned in oxygen to convert sulfur to sulfur dioxide. The sulfur dioxide was passed through a potassium iodide - starch solution and was titrated with potassium iodate solution. The potassium iodate solution is standardized against samples of known sulfur content.

#### A.5.5. Isotope Dilution Spark Source Mass Spectrometry (ORNL)

Analyses by spark source mass spectrometry employing isotope dilution were conducted at ORNL. The spark source mass spectrometry technique is described in Ref. A-1. The method of isotope dilution is described in Ref. A-3.

TABLE A-1  
LOSSES RESULTING FROM ASHING

Element	Percent Loss	Element	Percent Loss
Ag	80	Mn	20
Al	0	Mo	20
B	95	Na	20
Ba	0	Nb	0
Be	0	Nd	0
Bi	40	Ni	20
Ca	0	P	20
Cd	80	Pb	20
Ce	0	Pr	0
Co	20	Rb	20
Cr	20	Sb	20
Cs	50	Sc	0
Cu	0	Si	20
Dy	0	Sm	0
Er	0	Sn	20
Eu	0	Sr	0
Fe	20	Ta	0
Gd	0	Tb	0
Hf	0	Ti	0
Ho	0	Tl	100
In	20	Tm	0
K	20	V	80
La	0	W	20
Li	50	Yb	0
Lu	0	Zn	40
Mg	0	Zr	0

#### A.5.6. Atomic Absorption Analysis for Lithium

Analyses for lithium by atomic absorption were conducted as follows. Ten-gram samples of graphite were oxidized (dissolved) in a mixture of fuming nitric acid and perchloric acid under reflux. The resultant solution was then analyzed for lithium on an atomic absorption spectrophotometer. Lithium was determined by comparison of the absorbance of the sample solution with the absorbance of standard lithium solutions.

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APPENDIX B  
TABULATED DATA

Appendix B contains complete sets of data for density and tensile properties, Poisson's ratio, thermal expansivity, thermal conductivity, and impurity content on H-451 and TS-1240 graphites.

TABLE B-1  
 DENSITY AND TENSILE PROPERTIES OF H-451, LOT 266<sub>3</sub>, (a)  
 [Log 5651-28 (GLCC 18), whole log density = 1.77 g/cm<sup>3</sup>,  
 0.505-in.-diameter by 4.0-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Strain at Fracture (%)	Ultimate Strength (psi)	Modulus of Elasticity <sup>(b)</sup> × 10 <sup>-6</sup> (psi)
5651-28-201	MLC, axial	1.70			
-202		1.74			
-203		1.74			
-204		1.75			
-205		1.75			
-206		1.74			
-207		1.74			
-208		1.73			
-209		1.73			
-210		1.75			
-211		1.74			
-212		1.74			
-221		1.75			
-222		1.75			
-223		1.74			
-226		1.69			
-227		1.75			
-228		1.73			
-231		1.75			
-232		1.75			
-233		1.74			
-236		1.65			
-237		1.75			
-238		1.74			
-241		1.77			
-242		1.74			
-243		1.72			
-246		1.75			
-247		1.75			
-248		1.75			
-251		1.72			
-252		1.74			
-253		1.75			
-256		<u>1.73</u>			
5651-28-10014			0.214	1910	1.32
-10015			0.206	1874	1.19
-10016			0.173	1849	1.39
-10017			0.194	1900	1.25
-10018			0.204	1935	1.19
-10019			0.200	1976	1.32
-10020			<u>0.216</u>	<u>1951</u>	<u>1.14</u>
Mean		1.74	0.201	1914	1.26
Std. Dev.		0.02	0.015	44	0.09
5651-28-10011	MLC, radial		0.180	1324	1.00
-10012			0.120	952	0.86
-10013			<u>0.093</u>	<u>983</u>	<u>0.96</u>
Mean			0.131	1086	0.94
Std. Dev.			0.045	206	0.07

TABLE B-1 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Strain at Fracture (%)	Ultimate Strength (psi)	Modulus of Elasticity(b) x 10 <sup>-6</sup> (psi)
5651-28-224	MLE, axial	1.72			
-225		1.75			
-229		1.74			
-230		1.75			
-234		1.74			
-235		1.74			
-239		1.74			
-240		1.76			
-244		1.75			
-245		1.75			
-249		1.73			
-250		1.75			
-254		1.74			
-255		<u>1.72</u>			
5651-28-10024			0.256	2251	1.19
-10025			0.237	2190	1.19
-10026			0.216	2215	1.47
-10027			0.193	1920	1.25
-10028			0.240	2231	1.25
-10029			0.244	2256	1.32
-10030			<u>0.271</u>	<u>2245</u>	<u>1.32</u>
Mean		1.74	0.237	2215	1.28
Std. Dev.		0.01	0.026	155	0.10
5651-28-10021	MLE, radial		0.147	1243	0.93
-10022			0.165	1334	0.93
-10023			<u>0.092</u>	<u>876</u>	<u>0.93</u>
Mean			0.135	1151	0.93
Std. Dev.			0.038	242	0.00
5651-28-10005	EC, axial		0.198	1910	1.25
-10006			0.158	1706	1.32
-10007			0.216	2012	1.25
-10008			0.182	1910	1.32
-10009			0.195	1920	1.19
-10010			<u>0.229</u>	<u>1874</u>	<u>1.00</u>
Mean			0.196	1889	1.22
Std. Dev.			0.025	101	0.12
5651-28-10001	EC, radial		0.210	1564	0.96
-10002			0.176	1411	0.93
-10003			<u>0.132</u>	<u>1212</u>	<u>1.00</u>
Mean			0.173	1396	0.96
Std. Dev.			0.039	177	0.04

(a) Measured at GLCC.

(b) Chord modulus between 250 and 500 psi.

TABLE B-2  
 TENSILE PROPERTIES OF H-451, LOT 266  
 [Log 5651-28 (GLCC 18), whole log density = 1.77 g/cm<sup>3</sup>(a)  
 0.250-in.-diameter by 0.90-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Strain at Fracture (%)	Ultimate Strength (psi)	Modulus of Elasticity(b) x 10 <sup>-6</sup> (psi)
5651-28-10042	MLC, axial	0.202	1681	
-10043		0.225	1752	1.00
-10044		0.206	1803	1.11
-10045		0.238	1966	1.18
-10046		0.225	1772	1.00
-10047		0.220	1874	1.05
-10048		0.154	1721	1.33
Mean		0.210	1796	1.18
Std. Dev.		0.028	97	0.12
5651-28-10039	MLC, radial	0.206	1487	
-10040		0.240	1548	0.83
-10041		0.245	1640	0.83
Mean		0.230	1558	0.95
Std. Dev.		0.021	77	0.07
5651-28-10052	MLE, axial	0.294	2322	
-10053		0.253	2118	1.11
-10054		0.272	2220	1.05
-10055		0.280	2220	1.18
-10056		0.272	2200	1.11
-10057		0.276	2241	1.00
-10058		0.303	2404	1.18
Mean		0.279	2246	1.11
Std. Dev.		0.016	92	0.07
5651-28-10049	MLE, radial	0.312	2037	
-10050		0.125	1141	0.91
-10051		0.247	1732	0.95
Mean		0.228	1637	1.00
Std. Dev.		0.095	456	0.05
5651-28-10034	EC, axial	0.233	1691	
-10035		0.231	1670	1.00
-10036		0.179	1732	1.25
-10037		0.163	1548	1.00
-10038		0.257	1966	1.00
-10059		0.171	1283	N.A.
-10060		0.212	1711	N.A.
Mean		0.207	1657	1.05
Std. Dev.		0.036	207	0.11
5651-28-10031	EC, radial	0.348	2384	
-10032		0.225	2078	1.25
-10033		0.235	1691	1.00
Mean		0.269	2051	0.87
Std. Dev.		0.068	347	1.05

(a) Measured at GLCC.

(b) Chord modulus between 250 and 500 psi.

TABLE B-3  
DENSITY AND TENSILE PROPERTIES OF H-451, LOT 266  
[Log 5651-58 (GLCC unknown), 0.505-in.-diameter by  
4.0-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Strain at Fracture (%)	Ultimate Strength (psi)	Modulus of Elasticity(a) × 10 <sup>-6</sup> (psi)
5651-58-1	MLC, axial	1.73			
-2		1.73			
-3		1.73			
-4		1.72			
-5		1.72			
-6		1.72			
-7		1.73			
-8		1.73			
-9		1.74			
-10		1.73			
-11		1.73			
-12		1.74			
-13		1.73			
-14		1.73			
-15		1.73			
-16		1.73			
-17		1.73			
-18		1.73			
-19		1.73			
5651-58-10061			0.191	1681	1.14
-10062			0.168	1477	1.09
-10063			0.174	1630	1.25
-10064			0.166	1630	1.19
-10065			0.172	1620	1.09
-10066			0.130	1263	1.14
-10067			0.204	1859	1.25
-10068			0.200	2088	1.47
Mean		1.73	0.176	1656	1.20
Std. Dev.		0.01	0.024	244	0.13
5651-58-10069	MLC, radial		0.171	1289	0.96
-10070			0.155	1273	0.96
-10071			0.120	1146	1.04
-10072			0.137	1070	0.64
-10073			0.185	1462	0.93
-10074			0.205	1589	1.04
-10075			0.220	1538	0.93
Mean			0.170	1338	0.93
Std. Dev.			0.036	197	0.14
5651-58-21	MLE, axial	1.73			
-22		1.73			
-23		1.73			
-24		1.73			
-25		1.73			
-26		1.73			
-27		1.73			
-28		1.73			
-29		1.73			
Mean		1.73			
Std. Dev.		0.00			
5651-58-10076	MLE, radial		0.221	1716	0.93
-10077			0.150	1304	0.96
-10078			0.160	1401	0.93
-10079			0.190	1492	0.93
-10080			0.250	1905	1.00
-10081			0.225	1716	0.96
-10082			0.210	1665	0.96
Mean			0.210	1600	0.95
Std. Dev.			0.036	209	0.03

(a) Chord modulus between 250 and 500 psi.

TABLE B-4  
 DENSITY AND TENSILE STRENGTH OF H-451, LOT 408  
 [Log 5651-90 (GLCC 48), whole log density = 1.75 g/cm<sup>3</sup><sup>(a)</sup>,  
 0.250-in.-diameter by 0.9-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
2AC-300-A1	MLC, radial	1.742	2212
2AC-301-A1		1.734	1418
2AC-302-A1		1.735	1862
2AC-303-A1		1.741	2245
2AC-304-A1		1.732	1603
2AC-305-A1		1.736	2065
2AC-306-A1		1.730	2048
2AC-307-A1		1.736	1219
2AC-308-A1		1.731	1076
2AC-309-A1		1.726	1018
2AC-310-A1		1.735	1792
2AC-311-A1		1.736	1424
2AC-312-A1		1.731	1589
2AC-313-A1		1.734	1365
2AC-314-A1		1.741	1813
2AC-315-A1		1.739	1877
2AC-316-A1		1.744	2283
2AC-317-A1		1.738	816
2BC-300-A1		1.734	1381
2BC-301-A1		1.735	1951
2BC-302-A1		1.733	2131
2BC-303-A1		1.727	1095
2BC-304-A1		1.732	2028
2BC-305-A1		1.724	1721
2BC-306-A1		1.730	1583
2BC-307-A1		1.726	1865
2BC-308-A1		1.726	1786
2BC-309-A1		1.734	1803
2BC-310-A1		1.730	2193
2BC-311-A1		1.736	2453
2BC-312-A1		1.741	2234
2BC-313-A1		1.730	2249
2BC-314-A1		1.731	2310
2BC-315-A1		1.732	2045
2BC-316-A1		1.735	1823
2BC-317-A1		1.735	2026
2BC-318-A1		1.729	1619
2BC-319-A1		1.736	2006
Mean		1.734	1783
Std. Dev.		0.005	399

TABLE B-4 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
2AC-1-A1	MLG, axial	1.733	1344
2AC-1-A2		1.742	2132
2AC-2-A1		1.735	2073
2AC-2-A2		1.727	2153
2AC-3-A1		1.737	2417
2AC-3-A2		1.729	2297
2AC-4-A1		1.733	2341
2AC-4-A2		1.730	1914
2AC-5-A1		1.726	2073
2AC-5-A2		1.725	2186
2AC-6-A1		1.717	2188
2AC-6-A2		1.728	1747
2AC-7-A1		1.730	1943
2AC-7-A2		1.741	2205
2AC-8-A1		1.729	2147
2AC-8-A2		1.722	2230
2AC-9-A1		1.727	2208
2AC-9-A2	No core	--	
2AC-10-A1		1.720	2194
2AC-10-A2		1.724	1806
2BC-1-A1		1.740	2490
2BC-1-A2		1.727	2245
2BC-2-A1		1.737	2451
2BC-2-A2		1.732	2208
2BC-3-A1		1.738	2249
2BC-3-A2		1.734	2193
2BC-4-A1		1.731	2109
2BC-4-A2		1.738	2267
2BC-5-A1		1.716	1828
2BC-5-A2		1.723	2171
2BC-6-A1		1.738	2075
2BC-6-A2		1.731	2169
2BC-7-A1		1.728	1847
2BC-7-A2		1.731	2111
2BC-8-A1		1.736	2374
2BC-8-A2		1.735	2334
2BC-9-A1		1.736	2147
2BC-9-A2		1.739	2271
2BC-10-A1		1.742	2600
2BC-10-A2		1.744	2358
Mean		1.732	2168
Std. Dev.		0.007	185

TABLE B-4 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
2AE-300-A1	MLE, radial	1.740	2565
2AE-301-A1		1.730	2164
2AE-302-A1		1.744	2613
2AE-303-A1		1.733	1764
2AE-304-A1		1.738	2212
2AE-305-A1		1.738	2132
2AE-306-A1		1.737	2411
2AE-307-A1		1.740	2537
2AE-308-A1		1.740	2374
2AE-309-A1		1.735	2559
2AE-310-A1		1.732	2796
2AE-311-A1		1.735	2573
2AE-312-A1		1.736	2029
2AE-313-A1		1.735	2129
2AE-314-A1		1.734	2223
2AE-315-A1		1.738	2534
2AE-316-A1		1.729	1909
2AE-317-A1		1.738	2173
2AE-318-A1		1.739	1851
2AE-319-A1		1.732	2195
2AE-320-A1		1.738	2356
2AE-321-A1		1.739	1604
2AE-322-A1		1.727	1768
2AE-323-A1		1.736	1607
2BE-300-A1		1.739	2065
2BE-301-A1		1.741	1867
2BE-302-A1		1.751	2370
2BE-303-A1		1.736	2524
2BE-304-A1		1.710	2232
2BE-305-A1		1.744	2229
2BE-306-A1		1.749	2431
2BE-307-A1		1.745	2065
2BE-308-A1		1.749	2427
2BE-309-A1		1.744	2184
2BE-310-A1		1.749	2308
2BE-311-A1		1.743	2109
2BE-312-A1		1.736	2267
2BE-313-A1		1.731	2112
2BE-314-A1		1.739	2254
2BE-315-A1		1.733	2193
2BE-316-A1		1.737	2170
2BE-317-A1		1.733	2252
2BE-318-A1		1.741	2232
2BE-319-A1		1.734	2087
2BE-320-A1		1.742	1763
2BE-321-A1		1.737	2330
2BE-322-A1		1.739	2271
2BE-323-A1		1.730	2313
Mean		1.737	2203
Std. Dev.		0.007	260

TABLE B-4 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
2AE-1-A1	MLE, axial	1.732	2502
2AE-1-A2		1.739	2782
2AE-2-A1		1.734	2435
2AE-2-A2		1.732	2417
2AE-3-A1		1.739	2443
2AE-3-A2		1.750	2802
2AE-4-A1		1.738	2839
2AE-4-A2		1.734	2577
2AE-5-A1		1.739	2396
2AE-5-A2		1.735	1970
2AE-6-A1		1.736	2223
2AE-6-A2		1.734	2405
2AE-7-A1		1.737	2526
2AE-7-A2		1.729	2567
2AE-8-A1		1.730	2330
2AE-8-A2		1.735	2284
2AE-9-A1		1.741	2618
2AE-9-A2		1.737	2365
2AE-10-A1		1.744	2611
2AE-10-A2		1.742	2683
2AE-11-A1		1.732	2376
2AE-12-A1		1.738	2724
2BE-1-A1		1.748	3095
2BE-2-A1		1.745	3054
2BE-3-A1		1.743	2586
2BE-4-A1		1.748	2843
2BE-5-A1		1.748	3084
2BE-6-A1		1.753	2938
2BE-7-A1		1.738	2663
2BE-8-A1		1.752	2807
2BE-9-A1		1.739	2832
2BE-10-A1		1.745	2791
2BE-11-A1		1.745	2929
2BE-12-A1		1.744	2884
2BE-13-A1		1.745	2642
2BE-14-A1		1.738	2579
2BE-15-A1		1.751	2681
2BE-16-A1		1.736	2618
2BE-17-A1		1.736	2841
2BE-18-A1		1.740	2575
2BE-19-A1		1.731	2695
2BE-20-A1		1.743	2998
2BE-21-A1		1.732	2431
2BE-22-A1		1.732	2571
2BE-23-A1		1.735	2368
2BE-24-A1		1.731	3019
Mean		1.739	2628
Std. Dev.		0.006	243

TABLE B-4 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
C-300-A1	EC, radial	1.715	1609
C-301-A1		1.737	2404
C-302-A1		1.729	1548
C-303-A1		1.726	1467
C-304-A1		1.730	1406
C-305-A1		1.725	774
C-306-A1		1.711	1446
C-307-A1		1.736	1365
C-308-A1		1.720	1508
C-309-A1		1.728	1589
C-310-A1		1.735	1630
C-311-A1		1.737	2078
C-312-A1		1.742	1691
C-313-A1		1.742	1446
C-314-A1		1.746	1670
C-315-A1		1.749	1732
C-317-A1		1.742	1691
C-318-A1		1.743	1263
C-319-A1		1.743	1161
300-A1		1.752	1711
301-A1		1.748	2139
302-A1		1.751	1691
303-A1		1.759	1772
304-A1		1.755	1833
305-A1		1.754	2282
306-A1		1.742	1304
307-A1		1.737	2159
308-A1		1.727	2292
309-A1		1.732	2098
310-A1		1.756	2261
311-A1		1.732	1895
312-A1		1.749	1996
313-A1		1.744	2037
314-A1		1.750	1365
315-A1		1.746	1589
316-A1		1.744	1813
317-A1		1.745	1772
318-A1		1.745	2221
319-A1		1.740	2221
Mean		1.740	1767
Std. Dev.		0.011	328

TABLE B-4 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
C-1-A1	EC, axial	Not Determined	1935
C-1-A2			2587
C-2-A1			1895
C-2-A2			2811
C-3-A1			2404
C-3-A2			1996
C-4-A1			2669
C-4-A2			2587
C-5-A1			2383
C-5-A2			2241
C-6-A1			2628
C-6-A2			2200
C-7-A1			2404
C-7-A2			2770
C-8-A1			2424
C-8-A2			2832
C-9-A1			1650
C-9-A2			2384
C-10-A1			2445
C-10-A2			1569
1-A1		1.754	2078
1-A2		1.760	2139
2-A1		1.753	2444
2-A2		1.750	2485
3-A1		1.742	2546
3-A2		1.759	2587
4-A1		1.759	1996
4-A2		1.753	2281
5-A1		1.756	1874
5-A2		1.748	1772
6-A1		1.752	2669
6-A2		1.751	2078
7-A1		1.762	1711
7-A2		1.749	2139
8-A1		1.749	2444
8-A2		1.755	3015
9-A1		1.754	2098
9-A2		1.751	1833
10-A1		1.752	2404
10-A2		<u>1.755</u>	<u>2545</u>
Mean		1.744	2299
Std. Dev.		0.012	348

TABLE B-4 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
E-300-A1	EE, radial	1.738	1691
E-301-A1		1.731	1304
E-302-A1		1.718	1100
E-303-A1		1.724	1182
E-304-A1		1.718	1426
E-305-A1		1.718	1813
E-306-A1		1.733	1793
E-307-A1		1.743	1956
E-308-A1		1.739	1670
E-309-A1		1.743	2058
E-310-A1		1.745	1569
E-311-A1		1.748	1670
E-312-A1		1.733	1956
E-313-A1		1.732	1914
E-314-A1		1.724	1793
E-315-A1		1.732	1895
E-316-A1		1.733	1813
E-317-A1		1.724	1426
E-318-A1		1.737	2037
E-319-A1		1.738	2220
E-320-A1		1.730	1976
E-321-A1		1.737	2017
E-322-A1		1.723	2037
E-323-A1		1.720	1976
300-A1		1.734	1787
301-A1		1.744	1723
302-A1		1.742	1833
303-A1		1.743	1729
304-A1		1.725	2051
305-A1		1.740	1995
306-A1		1.751	1893
307-A1		1.749	1687
308-A1		1.745	2230
309-A1		1.742	2127
310-A1		1.746	2029
311-A1		1.732	1943
312-A1		1.733	2124
313-A1		1.725	2023
314-A1		1.725	2162
315-A1		1.723	2361
316-A1		1.723	2037
317-A1		1.723	2116
318-A1		1.732	2082
319-A1		1.723	2254
320-A1		--	--
321-A1		1.726	2188
322-A1		1.726	2283
323-A1		1.721	1958
Mean		1.733	1882
Std. Dev.		0.009	278

TABLE B-4 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
E-1-A1	EE, axial	1.738	2057
E-2-A1		1.725	2404
E-3-A1		1.719	2118
E-4-A1		1.734	2444
E-5-A1		1.735	2139
E-6-A1		1.728	2261
E-7-A1		1.740	2302
E-8-A1		1.714	1874
E-9-A1		1.741	2322
E-10-A1		1.741	1996
E-11-A1		1.730	2567
E-12-A1		1.738	2689
E-13-A1		1.705	1792
E-14-A1		1.731	2628
E-15-A1		1.731	2485
E-16-A1		1.732	2485
E-17-A1		1.734	2465
E-18-A1		1.746	2180
E-19-A1		1.736	2506
E-20-A1		1.733	2302
E-21-A1		1.738	2322
E-22-A1		1.723	1833
E-23-A1		1.728	2546
E-24-A1		1.729	2546
1-A1		1.715	2412
2-A1		1.713	2383
3-A1		1.725	2518
4-A1		1.744	2845
5-A1		1.732	2601
6-A1		1.729	2324
7-A1		1.728	2485
8-A1		1.723	2674
9-A1		1.728	2576
10-A1		1.734	2377
11-A1		1.739	2597
12-A1		1.731	2270
13-A1		1.725	2703
14-A1		1.726	2579
15-A1		1.731	2408
16-A1		1.724	2139
17-A1		1.723	1987
18-A1		1.718	2101
19-A1		1.730	2973
20-A1		1.726	2379
21-A1		1.700	1616
22-A1		1.723	2874
23-A1		1.732	2643
24-A1		1.720	2782
Mean		1.728	2373
Std. Dev.		0.009	288

(a) Measured at GLCC.

TABLE B-5  
 DENSITY AND TENSILE STRENGTH OF H-451, LOT 408  
 [Log 5651-90 (GLCC 48), whole log density = 1.75 g/cm<sup>3</sup><sup>(a)</sup>,  
 0.505-in.-diameter by 3.0-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
2AE-500	MLE, radial	1.741	2491
-501		1.736	2193
-502		1.738	2415
-503		1.739	2070
-504		1.740	2317
-505		1.738	2366
-506		1.737	2447
-507		1.738	2327
-508		1.738	1979
-509		1.738	2111
-510		1.740	2358
-511		1.735	2236
-512		1.739	2300
-513		1.735	1589
-514		1.737	1793
-515		1.738	1664
-516		1.735	1663
-517		1.733	1792
-518		1.730	1846
-519		1.733	1773
-520		1.737	1885
-521		1.736	1606
-522		1.737	1474
-523		1.735	1687
2BE-500		1.747	2018
-501		1.745	1417
-502		1.744	1832
-503		1.739	1838
-504		1.749	1873
-505		1.744	2027
-506		1.748	1625
-507		1.745	1849
-508		1.743	1539
-509		1.748	1985
-510		1.749	1810
-511		1.744	1838
-512		1.734	2319
-513		1.737	2239
-514		1.736	2188
-515		1.737	2088
-516		1.737	2046
-517		1.736	2001
-518		1.732	2290
-519		1.735	2144
-520		1.737	2341
-521		1.738	2417
-522		1.730	2242
-523		1.737	2336
Mean		1.739	2019
Std. Dev.		0.005	289

TABLE B-5 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
2AE-200	MLE, axial	1.736	2630
-201		1.737	2362
-202		1.739	2529
-203		1.741	2591
-204		1.741	2489
-205		1.743	2417
-206		1.742	2371
-207		1.736	2540
-208		1.739	2623
-209		1.740	2351
-210		1.740	2270
-211		1.739	2607
-212		1.733	2070
-213		1.738	2230
-214		1.741	2571
-215		1.733	2292
-216		1.733	2635
-217		1.733	2480
-218		1.740	2550
-219		1.738	2618
-220		1.737	2519
-221		1.736	2225
-222		1.732	2374
-223		1.738	2360
2BE-200		1.748	3142
-201		1.748	3042
-202		1.743	2820
-203		1.741	3030
-204		1.748	2904
-205		1.742	2838
-206		1.741	2683
-207		1.744	2758
-208		1.739	2672
-209		1.750	2739
-210		1.745	2670
-211		1.746	2502
-212		1.745	2789
-213		1.742	2589
-214		1.745	2608
-215		1.735	2600
-216		1.751	2894
-217		1.733	2662
-218		1.735	2479
-219		1.732	2614
-220		1.729	2446
-221		1.737	1771
-222		1.729	2338
-223		1.737	2225
Mean		1.739	2555
Std. Dev.		0.005	249

TABLE B-5 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
2AC-500	MLC, radial	1.730	1731
-501		1.733	1632
-502		1.730	1912
-503		1.729	1847
-504		1.732	1848
-505		1.733	1789
-506		1.733	1621
-507		1.736	718
-508		1.731	1616
-509		1.732	1486
-510		1.733	1484
-511		1.736	1765
-512		1.733	1732
-413		1.733	1745
-514		1.734	1790
-515		1.734	1550
-516		1.732	1606
-517		1.734	1810
2BC-500		1.744	2108
-501		1.738	1794
-502		1.724	1658
-503		1.737	1779
-504		1.735	1694
-505		1.738	1594
-506		1.737	1946
-507		1.738	1678
-508		1.735	1660
-509		1.729	2042
-510		1.716	1936
-511		1.719	1664
-512		1.727	1755
-513		1.723	1684
-514		1.725	1426
-515		1.729	1613
-516		1.729	1343
-517		1.727	1593
Mean		1.732	1716
Std. Dev.		0.006	160

TABLE B-5 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
2AC-200	MLC, axial	1.735	2108
-201		1.730	2181
-202		1.734	2077
-203		1.734	2073
-204		1.736	1989
-205		1.733	1961
-206		1.731	1992
-207		1.730	2348
-208		1.731	2094
-209		1.730	2116
-210		1.730	2216
-211		1.733	2196
-212		1.735	1908
-213		1.733	2235
-214		1.736	2344
-215		1.730	2284
2BC-200		1.733	2200
-201		1.741	2170
-202		1.730	2199
-203		1.729	2095
-204		1.735	2159
-205		1.739	2172
-206		1.729	1618
-207		1.729	1911
-208		1.735	2314
-209		1.739	2226
-210		1.736	2322
-211		1.741	2193
-212		1.730	2214
-213		1.728	2185
-214		1.730	2124
-215		1.725	1865
Mean		1.733	2129
Std. Dev.		0.004	153

TABLE B-5 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
1A-E-500	EE, radial	1.727	1043
-501		1.725	1192
-502		1.721	1094
-503		1.720	1315
-504		1.716	1370
-505		1.710	1440
-506		1.701	1538
-507		1.713	1419
-508		1.725	1336
-509		1.720	931
-510		1.727	1196
-511		1.730	1310
-512		1.732	2100
-513		1.732	2200
-514		1.731	1780
-515		1.722	1908
-516		1.718	1982
-517		1.711	1651
-518		1.736	2365
-519		1.722	1678
-510		1.732	2232
-521		1.726	1684
-522		1.726	2230
-523		1.717	1251
1B-E-500		1.734	1887
-501		1.734	1978
-502		1.733	1903
-503		1.732	1928
-504		1.728	1847
-505		1.728	1726
-506		1.739	1893
-507		1.738	1925
-508		1.735	2090
-509		1.731	2040
-510		1.332	2045
-511		1.730	1908
-512		1.728	2015
-513		1.727	2017
-514		1.728	1959
-515		1.724	2067
-516		1.722	1912
-517		1.729	1658
-518		1.729	2052
-519		1.726	2106
-520		1.727	1975
-521		1.722	2014
-522		1.718	1927
-523		1.717	1377
Mean		1.726	1923
Std. Dev.		0.008	219

TABLE B-5 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
1A-E-200			
-201	EE, axial	1.728	2425
-202		1.731	2141
-203		1.734	2272
-204		1.728	2327
-205		1.731	2282
-206		1.733	2481
-207		1.732	2477
-208		1.734	2455
-209		1.727	2239
-210		1.728	2079
-211		1.733	2603
-212		1.736	2373
-213		1.722	2347
-214		1.722	2413
-215		1.718	2462
-216		1.718	2454
-217		1.717	2302
-218		1.724	2567
-219		1.726	2160
-220		1.729	2229
-221		1.721	1355
-222		1.730	1959
-223		1.726	1981
		1.725	1934
1B-E-200			
-201		1.734	2704
-202		1.734	2787
-203		1.731	2871
-204		1.733	2394
-205		1.729	2594
-206		1.733	2623
-207		1.725	2630
-208		1.730	2611
-209		1.728	2585
-210		1.729	2520
-211		1.721	2475
-212		1.724	2461
-213		1.725	1694
-214		1.721	2369
-215		1.722	2125
-216		1.720	1781
-217		1.720	1706
-218		1.708	1667
-219		1.719	2295
-220		1.722	2284
-221		1.716	2328
-222		1.713	2073
-223		1.722	2398
Mean		1.726	2311
Std. Dev.		0.006	310

TABLE B-5 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
C-500	EC, radial	1.730	1532
-501		1.729	1136
-502		1.724	1368
-503		1.729	1027
-504		1.733	1476
-505		1.726	1256
-506		1.729	1206
-507		1.732	1627
-508		1.722	1630
-509		1.735	1435
-510		1.731	1197
-511		1.719	1814
-512		1.736	1249
-513		1.730	1352
-514		1.731	1671
-515		1.731	1426
-516		1.730	1835
-517		1.721	1880
BC-500		1.734	1875
-501		1.733	2000
-502		1.725	1716
-503		1.735	1434
-504		1.733	1404
-505		1.730	1612
-506		1.731	1502
-507		1.728	1805
-508		1.725	1272
-509		1.731	1606
-510		1.730	1926
-511		1.718	1656
-512		1.735	1363
-513		1.732	1729
-514		1.727	1734
-515		1.728	1705
-516		1.729	1815
-517		1.726	1693
Mean		1.729	1553
Std. Dev.		0.004	245

TABLE B-5 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Ultimate Strength (psi)
C-200	EC, axial	1.718	2594
-201		1.728	2487
-202		1.731	2191
-203		1.731	2280
-204		1.722	2141
-205		1.727	2030
-206		1.724	2403
-208		1.718	1861
-209		1.725	2026
-210		1.724	2058
-211		1.727	1958
-212		1.733	2054
-213		1.732	2278
-214		1.732	2098
-215		1.730	2113
1BC-200		1.732	1980
-201		1.731	2271
-202		1.737	2455
-203		1.728	2440
-204		1.719	1907
-205		1.729	2323
-206		1.731	2422
-207		1.734	2514
-208		1.737	2358
-209		1.728	2158
-210		1.732	2138
-211		1.728	2436
-212		1.729	1330
-213		1.728	2535
-214		1.726	2328
-215		1.730	2361
Mean		1.728	2212
Std. Dev.		0.005	254

(a) Measured at GLCC.

TABLE B-6  
 DENSITY AND TENSILE PROPERTIES OF H-451, LOT 408  
 [Log 5651-86 (GLCC 52), whole log density = 1.74 g/cm<sup>3</sup><sup>(a)</sup>,  
 0.505-in.-diameter by 3.0-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> <sup>(b)</sup> (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-86-3A-L002A	MLC, axial	1.702	1.13	0.010	0.250	1965
-L002B		1.710	1.14	0.010	0.275	2163
-L003A		1.711	1.25	0.008	0.245	2129
-L003B		1.703	1.23	0.010	0.225	2009
-3B-L002A		1.699	0.97	0.022	0.268	2014
-L002B		1.686	0.93	0.014	0.265	1984
Mean		1.702	1.11	0.012	0.254	2044
Std. Dev.		0.009	0.132	0.005	0.018	82
5651-86-3A-L005	MLC, radial	1.712	1.07	0.013	0.204	1648
-L006		1.707	1.06	0.013	0.255	1862
-L007		1.707	1.02	0.012	0.145	1135
-L008B		1.698	1.06	0.013	0.205	1623
-3B-L005		1.702	0.99	0.018	0.215	1551
-L007		1.700	0.94	0.022	0.210	1488
Mean		1.704	1.02	0.015	0.206	1551
Std. Dev.		0.005	0.051	0.004	0.035	240
5651-86-3A-L009A	MLE, axial	1.720	1.32	0.011	0.315	2857
-L009B		1.712	1.32	0.011	0.315	2774
-L010A		1.720	1.38	0.007	0.301	2789
-L010B		1.723	1.36	0.000	0.335	3038
-3B-L009A		1.714	1.18	0.017	0.310	2486
-L009B		1.713	1.17	0.018	(c)	(c)
-L012		1.718	1.34	0.020	0.310	2646
Mean		1.717	1.30	0.012	0.314	1765
Std. Dev.		0.004	0.085	0.007	0.011	187
5651-86-3A-L013	MLE, radial	1.712	1.10	0.012	0.255	1956
-L014		1.718	1.09	0.010	0.220	1882
-L015		1.716	0.94	0.006	0.195	1629
-3B-L013		1.715	1.00	0.018	0.285	1961
-L014		1.713	0.97	0.022	0.285	1893
-L015		1.720	0.96	0.025	0.245	1724
Mean		1.716	1.01	0.015	0.247	1841
Std. Dev.		0.003	0.069	0.007	0.036	135

(a) Measured at GLCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Bond failure.

TABLE B-7  
 DENSITY AND TENSILE PROPERTIES OF H-451, LOT 408  
 [Log 5651-86 (GLCC 52), whole log density = 1.74 g/cm<sup>3</sup>(a),  
 0.25-in.-diameter by 0.90-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-86-3A-006B	MLC, axial	1.700	1.06	0.020	0.280	2095
		1.686	1.125	0.020	0.260	1993
		1.715	1.125	0.035	0.325	2199
		1.700	(c)	(c)	0.360	1789
		1.702	0.86	0.030	0.295	1710
		1.707	1.06	0.025	0.325	2192
		1.701	0.90	0.030	0.325	2075
		1.693	1.06	0.020	0.185	1486
		1.701	1.06	0.015	0.375	2153
		1.690	1.00	0.026	0.190	1564
3B-006B		1.685	1.15	0.025	0.210	1587
		1.701	1.29	0.027	0.300	2034
		1.700	1.125	0.030	0.370	1931
		1.691	1.125	0.030	0.250	1671
		1.701	0.98	0.030	0.265	1626
		1.688	1.20	0.025	0.285	1585
		1.706	1.125	0.017	0.295	2138
		1.710	1.20	0.020	0.255	2092
		1.695	1.125	0.010	0.280	1730
		1.686	1.00	0.020	0.250	1787
Mean		1.698	1.08	0.024	0.279	1872
Std. Dev.		0.008	0.104	0.006	0.047	242
-86-3A-036B	MLC, radial	1.687	1.06	0.030	0.255	1730
		1.680	1.02	0.027	0.295	1889
		1.700	1.10	0.020	0.280	2034
		1.697	1.10	0.025	0.275	1953
		1.693	0.95	0.020	0.225	1588
		1.694	1.00	0.015	0.230	1711
		1.692	0.95	0.025	0.305	1909
		1.695	0.90	0.035	0.320	2029
		1.698	1.00	0.020	0.205	1671
		1.700	1.20	0.025	0.175	1361
-3B-036B		1.692	1.125	0.025	0.225	1564
		1.679	1.125	0.025	0.295	1603
		1.715	0.86	0.040	0.350	1915
		1.699	0.82	0.040	0.265	2015
		1.697	1.29	0.020	0.285	2162
		1.701	1.06	0.030	0.200	1858
		1.710	1.125	0.020	0.225	1565
		1.692	1.00	0.035	0.245	1221
		1.696	1.125	0.030	0.240	1810
		1.687	1.06	0.020	0.285	1848
Mean		1.695	1.04	0.026	0.259	1772
Std. Dev.		0.008	0.114	0.007	0.044	239

TABLE B-7 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-86-3A-106B	MLE, axial	1.705	1.38	0.030	0.255	2215
-107B		1.706	1.29	0.030	0.375	2825
-112B		1.698	1.20	0.020	0.365	2647
-113B		1.706	1.15	0.030	0.300	2339
-118B		1.707	1.20	0.017	0.305	2541
-119B		1.707	1.29	0.021	0.320	2545
-124B		1.713	1.00	0.025	0.325	2461
-125B		1.711	1.125	0.040	0.370	2604
-127B		1.692	1.125	0.030	0.315	2276
-128B		1.714	1.125	0.035	0.335	2524
3B-106B		1.715	1.20	0.007	0.285	2520
-107B		1.706	1.20	0.015	0.350	2805
-112B		1.710	1.20	0.020	0.310	2504
-113B		1.715	1.125	0.025	0.335	2524
-118B		1.704	1.29	0.020	0.240	2117
-119B		1.699	1.50	0.020	0.320	2620
-124B		1.703	1.20	0.035	0.400	2746
-125B		1.709	1.20	0.025	0.360	2782
-127B		1.696	1.29	0.025	0.350	2785
-128B		1.704	1.20	0.027	0.240	2114
Mean		1.706	1.21	0.025	0.323	2525
Std. Dev.		0.006	0.106	0.008	0.044	219
5651-86-3A-136B	MLE, radial	1.717	1.125	0.030	0.335	2271
-137B		1.714	1.06	0.035	0.345	2256
-142B		1.714	1.08	0.050	0.395	2343
-143B		1.704	1.00	0.020	0.245	1648
-148B		1.715	1.00	0.037	0.310	2073
-149B		1.710	1.08	0.030	0.305	2132
-154B		1.720	0.82	0.025	0.295	1560
-155B		1.714	1.06	0.030	0.260	1865
-160A		1.716	0.86	0.025	0.295	1732
-160B		1.713	1.06	0.032	0.295	2138
3B-136B		1.714	1.00	0.025	0.335	2313
-137B		1.714	1.00	0.030	0.370	2099
-142B		1.705	1.125	0.030	0.320	2439
-143B		1.703	1.125	0.020	0.240	2012
-148B		1.706	0.82	0.040	0.450	2285
-149B		1.703	0.86	0.025	0.345	2040
-154B		1.710	1.06	0.015	0.300	2339
-155B		1.709	1.06	0.030	0.340	2234
-160A		1.713	1.125	0.020	0.260	2091
-160B		1.713	1.20	0.015	0.340	2293
Mean		1.711	1.03	0.028	0.319	2108
Std. Dev.		0.005	0.108	0.008	0.051	243

(a) Measured at GLCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Specimen not cycled.

TABLE B-8  
 DENSITY AND TENSILE PROPERTIES OF H-451, LOT 426  
 [Log 6484-33 (GLCC 92), whole log density = 1.75 g/cm<sup>3</sup><sup>(a)</sup>,  
 0.505-in.-diameter by 3.00-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-33-1A-L001	EC, axial	1.720	1.19	0.013	0.338	2700
-L004		1.730	1.27	0.015	0.350	2846
-L005		1.737	1.21	0.015	0.339	2802
-L009		1.728	1.23	0.016	0.354	2833
-1B-L011		1.724	1.23	0.011	0.327	2686
-L014		1.722	1.23	0.014	0.328	2661
-L015		1.716	1.20	0.015	0.329	2666
-L019		1.710	1.20	0.015	0.318	2544
-1A-L002A						2844
-L002B						2687
-L006A						2948
-L006B						2387
-L007A						2774
-L007B						2738
-1B-L012A						2770
-L012B						2619
-L016A						2623
-L016B						2645
-L017A						2088
-L017B						2647
Mean		1.723	1.22	0.014	0.337	2675
Std. dev.		0.008	0.03	0.002	0.013	185
-1A-L025	EC, radial	1.753	1.10	0.016	0.341	2491
-L026		1.743	1.13	0.016	0.367	2747
-L027		1.741	1.12	0.015	0.333	2449
-L030		1.753	1.16	0.012	0.364	2746
-1B-L037		1.743	1.14	0.016	0.380	2741
-L038		1.738	1.08	0.011	0.312	2310
-L039		1.730	1.19	0.018	0.325	2288
-L042		1.749	1.13	0.015	0.359	2611
-1A-L028						2130
-L029						2347
-L031						2455
-L032						2396
-L033						2220
-L034						1921
-1B-L040						2057
-L041						1408
-L043						2520
-L044						2496
-L045						1787
-L046						1946
Mean		1.744	1.13	0.015	0.348	2302
Std. dev.		0.008	0.03	0.002	0.023	347

TABLE B-8 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-33-1A-L101	EE, axial	1.756	1.32	0.011	0.352	3017
-L103		1.751	1.34	0.014	0.372	3180
-L105		1.756	1.30	0.009	0.337	2906
-L107		1.755	1.34	0.013	0.339	2946
-1B-L111		1.755	1.32	0.010	0.314	2825
-L112		1.750	1.28	0.013	0.339	2917
-L114		1.752	1.32	0.009	0.221	2194
-L116		1.753	1.27	0.011	0.364	3070
-1A-L102A						2934
-L102B						2863
-L104A						3223
-L104B						3135
-L109A						2877
-L109B						(c)
-L110A						2931
-L110B						3033
-1B-L119A						2717
-L119B						2740
-L120A						2856
-L120B						3157
Mean		1.753	1.31	0.011	0.330	2922
Std. dev.		0.002	0.03	0.002	0.047	227
-1A-L125	EE, radial	1.767	1.14	0.015	0.373	2722
-L126		1.757	1.14	0.017	0.376	2701
-L129		1.764	1.10	0.015	0.350	2577
-L130		1.759	1.13	0.014	0.358	2620
-1B-L142		1.736	1.08	0.015	0.346	2249
-L143		1.728	1.06	0.019	0.338	2380
-L146		1.756	1.12	0.015	0.352	2544
-L147		1.754	1.12	0.013	0.337	2499
-1A-L127						2736
-L128						2731
-L131						2612
-L132						2646
-L133						2595
-L134						2674
-1B-L140						2642
-L141						2559
-L144						2239
-L145						2124
-L148						2446
-L149						2386
Mean		1.753	1.11	0.015	0.354	2534
Std. dev.		0.014	0.03	0.002	0.014	177

TABLE B-8 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-33-3A-L050	MLC, axial	1.697	1.15	0.015	0.255	2093
-L053		1.700	1.17	0.016	0.280	2201
-L054		1.694	1.20	0.015	0.243	1961
-L058		1.711	1.14	0.011	0.219	1854
-3B-L061		1.712	1.17	0.013	0.210	1837
-L064		1.719	1.24	0.010	0.312	2625
-L065		1.717	1.17	0.016	0.250	2083
-L069		<u>1.707</u>	<u>1.20</u>	<u>0.017</u>	(c)	(c)
-3A-L051A						2196
-L051B						1898
-L055A						2071
-L055B						1987
-L056A						2271
-L056B						2615
-3B-L062A						2125
-L062B						2057
-L066A						1872
-L066B						2000
-L067A						2142
-L067B						2184
Mean		1.707	1.18	0.14	0.252	2109
Std. dev.		0.010	0.03	0.02	0.035	219
-3A-L075	MLC, radial	1.709	1.05	0.017	0.156	1455
-L076		1.710	0.97	0.010	0.131	1179
-L077		1.712	0.97	0.010	0.222	1640
-L080		1.708	(d)	(d)	(d)	884
-3B-L087		1.698	0.96	0.018	0.229	1625
-L088		1.703	0.99	0.016	0.248	1748
-L089		1.706	0.96	0.016	0.199	1421
-L092		<u>1.700</u>	<u>0.95</u>	<u>0.020</u>	<u>0.252</u>	1699
-3A-L078						1809
-L079						1708
-L081						1389
-L082						1398
-L083						1539
-L084						1399
-L090						1429
-3B-L091						1339
-L093						1598
-L094						1648
-L095						1623
-L096						1773
Mean		1.706	0.98	0.015	0.205	1515
Std. dev.		0.005	0.03	0.004	0.046	223

TABLE B-8 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-33-3A-L151	MLE, axial	1.747	1.30	0.008	(c)	(c)
-L153		1.745	1.32	0.009	0.364	3092
-L155		1.739	1.28	0.015	0.324	2808
-L157		1.726	1.23	0.008	0.346	2888
-3B-L161		1.738	1.30	0.010	0.328	2903
-L162		1.749	1.37	0.013	0.374	3187
-L164		1.761	1.36	0.007	0.349	3167
-L166		1.755	1.30	0.011	0.387	3282
-3A-L154A						(c)
-L154B						2902
-L160A						2142
-L160B						2315
-3B-L163A						3207
-L163B						3187
-L165A						3092
-L169A						3095
-L169B						2593
Mean		1.745	1.31	0.010	0.353	2924
Std. dev.		0.012	0.04	0.003	0.023	338
-3A-L175	MLE, radial	1.702	0.95	0.018	0.204	1449
-L176		1.710	0.97	0.015	0.195	1474
-L179		1.741	1.09	0.016	0.341	2448
-L180		1.739	1.08	0.017	0.309	2272
-3B-L193		1.729	1.09	0.013	0.282	2146
-L194		1.743	1.08	0.011	0.353	2499
-L197		1.740	1.10	0.014	0.277	2107
-L198		1.729	1.03	0.019	0.248	1823
-3A-L177						1597
-L178						1926
-L181						2351
-L182						2295
-L184						1511
-3B-L191						2435
-L192						2325
-L195						2290
-L196						2237
-L199						1960
-L200						1531
Mean		1.729	1.05	0.015	0.272	2036
Std. dev.		0.015	0.06	0.003	0.059	366

(a) Measured at GLCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress, and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Bond failure.

(d) Specimen broke during first loading cycle.

TABLE B-9  
 DENSITY AND TENSILE PROPERTIES OF H-451, LOT 426  
 [Log 6484-34 (GLCC 198), whole log density = 1.73 g/cm<sup>3</sup><sup>(a)</sup>,  
 0.505-in.-diameter by 3.00-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> <sup>(b)</sup> (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-34-1A-L001	EC, axial	1.701	1.19	0.014	0.268	2025
-L004		1.700	1.16	0.016	0.253	1996
-L005		1.709	1.20	0.015	0.240	2019
-L009		1.715	1.25	0.010	0.256	2368
-1B-L011		1.698	1.17	0.014	0.238	1962
-L014		1.703	1.17	0.013	0.221	1862
-L015		1.709	1.17	0.013	0.229	1911
-L019		1.711	1.16	0.006	0.256	2198
-1A-L002A						2138
-L002B						2090
-L006A						1945
-L006B						2076
-L007A						2045
-L007B						2079
-1B-L012A						1940
-L012B						1748
-L016A						2140
-L016B						2082
-L017A						2160
-L017B						2137
Mean		1.706	1.18	0.013	0.245	2046
Std. Dev.		0.006	0.03	0.003	0.016	134
-1A-L025	EC, radial	1.731	1.12	0.010	0.327	2507
-L026		1.716	1.12	0.011	0.311	2282
-L027		1.705	1.01	0.011	0.186	1450
-L030		1.693	1.07	0.012	0.286	2094
-1B-L037		1.727	1.16	0.012	0.360	2647
-L038		1.705	1.13	0.019	0.239	1742
-L039		1.698	0.97	0.017	0.212	1515
-L042		1.721	1.13	0.016	0.357	2544
-1A-L028						1192
-L029						1216
-L031						1842
-L032						1581
-L033						1646
-L034						1629
-1B-L040						1441
-L041						1301
-L043						1970
-L044						1681
-L045						1676
-L046						1766
Mean		1.712	1.09	0.014	0.285	1786
Std. Dev.		0.014	0.07	0.003	0.066	432

TABLE B-9 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-34-1A-L101	EE, axial	1.715	1.14	0.007	0.354	2953
-L103		1.715	1.39	0.004	0.345	2924
-L105		1.724	1.27	0.010	0.369	3040
-L107		1.726	1.32	0.007	0.348	2949
-1B-L111		1.713	1.24	0.008	0.341	2861
-L112		1.716	1.25	0.007	0.312	2715
-L114		1.722	1.25	0.010	0.355	2941
-L116		1.721	1.34	0.009	0.287	2821
-1A-L102A						2090
-L102B						2088
-L104A						2543
-L104B						2495
-L108A						2996
-L108B						2884
-1B-L113A						2549
-L113B						2581
-L119A						2695
-L119B						2777
-L120A						2440
-L120B						2686
Mean		1.719	1.27	0.008	0.339	2701
Std. Dev.		0.005	0.08	0.002	0.026	275
-1A-L125	EE, radial	1.749	1.14	0.015	0.344	2548
-L126		1.737	1.14	0.013	0.319	2429
-L129		1.705	1.06	0.012	0.290	2107
-L130		1.744	1.14	0.014	0.304	2315
-1B-L142		1.692	1.02	0.012	0.218	1638
-L143		1.733	1.08	0.016	0.389	2516
-L146		1.726	1.08	0.014	(c)	(c)
-L147		1.714	1.12	0.011	0.267	2077
-1A-L127						2534
-L128						2671
-L131						1851
-L132						1648
-L133						1613
-L134						2677
-1B-L140						1752
-L141						2244
-L144						1998
-L145						2086
-L148						1896
-L149						2021
Mean		1.725	1.10	0.013	0.304	2138
Std. Dev.		0.002	0.04	0.002	0.055	355

TABLE B-9 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-34-3A-L050	MLC, axial	1.711	1.16	0.011	0.239	2019
-L053		1.713	1.16	0.006	0.231	2032
-L054		1.716	1.19	0.011	0.245	2033
-L058		1.704	1.16	0.014	0.262	2171
-3B-L061		1.713	1.20	0.011	0.265	2158
-L064		1.716	1.23	0.014	0.265	2229
-L065		1.718	1.20	0.008	0.243	2102
-L069		1.711	1.19	0.013	0.279	2191
-3A-L051A						2033
-L053B						2028
-L054B						2120
-L055A						2071
-3B-L061B						2053
-L062A						1808
-L064B						2095
-L065B						1949
-L066A						2148
-L068A						2005
-L068B						1823
-L069B						2070
Mean		1.712	1.19	0.011	0.254	2057
Std. Dev.		0.004	0.02	0.003	0.016	108
-3A-L075	MLC, radial	1.709	1.00	0.016	0.225	1624
-L076		1.711	1.01	0.014	0.222	1580
-L077		1.710	1.03	0.018	0.235	1675
-L080		1.707	0.87	0.025	0.162	1040
-3B-L087		1.710	1.00	0.015	0.156	1235
-L088		1.713	1.00	0.017	0.226	1566
-L089		1.711	1.01	0.020	0.219	1575
-L092		1.713	1.04	0.018	0.290	1969
-3A-L078A						1977
-L079A						1278
-L081A						1188
-L082A						940
-L084A						1373
-3B-L090A						1385
-L091A						1608
-L093A						1873
-L094A						1811
-L096A						1418
Mean		1.710	0.99	0.018	0.217	1506
Std. Dev.		0.002	0.05	0.003	0.042	300

TABLE B-9 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-34-3A-L151	MLE, axial	1.740	1.30	0.011	0.358	3120
-L153		1.725	1.36	0.010	0.336	2854
-L155		1.730	1.30	0.010	0.356	2994
-L157		1.740	1.32	0.011	0.394	3282
-3B-L161		1.725	1.27	0.010	0.333	2812
-L162		1.726	1.28	0.009	0.327	2881
-L164		1.743	1.34	0.012	0.337	3000
-L166		1.733	1.32	0.011	0.371	3094
-3A-L154A						2446
-L154B						2243
-L155B						3039
-L156B						2841
-L157B						3077
-L160A						2926
-L160B						2696
-3B-L163A						2580
-L163B						2597
-L165A						2715
-L169A						2680
-L169B						2520
Mean		1.733	1.31	0.010	0.351	2817
Std. Dev.		0.007	0.03	0.001	0.023	260
-3A-L175	MLE, radial	1.712	1.36	0.013	0.335	2430
-L176		1.723	1.10	0.013	0.345	2494
-L181A		1.702	0.99	0.014	0.261	1870
-L180		1.710	1.06	0.013	0.237	1823
-3B-L193		1.718	1.10	0.017	0.283	2154
-L194		1.708	1.19	0.014	0.199	1570
-L197		1.707	1.08	0.011	0.294	2190
-L198		1.709	1.09	0.012	0.244	1903
-3A-L178A						2499
-L179						1332
-L182A						1287
-L183A						1436
-L184A						2145
-3B-L191A						2617
-L192A						2262
-L196A						1599
-L199A						2292
-L200A						1845
Mean		1.712	1.12	0.013	0.275	1986
Std. Dev.		0.006	0.11	0.002	0.050	419

(a) Measured at GLCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress, and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Bond failure.

TABLE B-10  
 DENSITY AND TENSILE PROPERTIES OF H-451, LOT 426  
 [Log 6484-40 (GLCC 155), whole log density = 1.72 g/cm<sup>3</sup><sup>(a)</sup>,  
 0.505-in.-diameter by 3.00-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> <sup>(b)</sup> (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-40-1A-L002A	EC, axial	1.713	1.18	0.019	0.296	2390
-L002B						2332
-L003B						2590
-L005A		1.718	1.23	0.015	0.297	2471
-L005B						2425
-L006A		1.721	1.20	0.016	0.293	2430
-L006B						2681
-L008A		1.711	1.18	0.021	0.344	2625
-L008B						2386
-L009B						2643
-1B-L002A		1.710	1.47	0.010	0.221	2394
-L002B						2394
-L003B						2434
-L005A		1.710	1.15	0.014	0.300	2346
-L005B						2389
-L006A		1.715	1.22	0.022	0.294	2336
-L006B						2107
-L008A		1.722	1.27	0.023	0.260	2217
-L008B						2545
-L009B						2219
Mean		1.715	1.24	0.017	0.288	2418
Std. Dev.		0.005	0.01	0.004	0.035	147
-1A-L011	EC, radial	1.724	1.06	0.022	0.333	2354
-L012						2339
-L013		1.723	1.11	0.015	0.288	2165
-L014						2270
-L015						1990
-L017						2086
-L018		1.724	1.06	0.014	0.290	2127
-L019						2350
-L020		1.720	1.06	0.016	0.331	2329
-L021						2295
-1B-L011		1.724	1.10	0.023	(c)	(c)
-L012						2299
-L013		1.712	1.10	0.015	(c)	(c)
-L014						2219
-L015						2075
-L017						2384
-L018		1.714	1.11	0.014	0.308	2314
-L019						2279
-L020		1.710	1.05	0.015	0.310	2200
-L021						2091
Mean		1.719	1.08	0.017	0.310	2231
Std. Dev.		0.006	0.03	0.004	0.019	117

TABLE B-10 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-40-1A-L031A	EE, axial	1.739	1.47	0.017	0.280	2450
-L031B		1.720	1.41	0.015	0.300	2580
-L034A		1.728	1.23	0.010	0.299	2638
-L034B		1.725	1.36	0.021	0.289	2375
-L035A		1.735	1.32	0.013	0.297	2546
-L035B		1.719	1.18	0.015	0.282	2207
-L038A		1.722	1.15	0.014	0.264	2349
-L038B		1.720	1.25	0.014	0.302	2512
-L039A						2385
-L039B						2650
-1B-L031A		1.726	1.30	0.015	0.289	2606
-L031B		0.007	0.11	0.003	0.013	2236
-L034A		1.719	1.18	0.015	0.282	2274
-L034B		1.722	1.15	0.014	0.264	2421
-L035A		1.720	1.25	0.014	0.302	2151
-L035B						2335
-L038A						2470
-L039A						2665
-L039B						2539
Mean Std. Dev.						2441
						157
-1A-L041	EE, radial	1.726	1.07	0.019	0.231	1784
-L042		1.726	1.18	0.031	0.268	2120
-L043						2003
-L044						2191
-L045						2165
-L047						2196
-L048		1.722	1.15	0.023	0.304	2249
-L049		1.731	1.10	0.015	0.317	2355
-L050		1.732	1.05	0.020	0.296	2273
-L051		1.725	1.05	0.019	0.316	2419
-1B-L041		1.724	1.09	0.016	0.291	2074
-L042		0.007	0.05	0.007	0.029	2135
-L043						2218
-L044						2360
-L045						2454
-L047						2219
-L048						2249
-L049						2096
-L050						2139
-L051						2231
Mean Std. Dev.						2196
						150

TABLE B-10 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-40-3A-L031A	MLE, axial	1.737	1.28	0.010	0.319	2747
-L031B		1.735	1.28	0.014	0.308	2606
-L034A		1.738	1.27	0.011	0.312	2701
-L034B		1.732	1.27	0.014	0.328	2693
-L035A		1.721	1.28	0.011	0.281	2661
-L035B		1.725	1.22	0.012	0.254	2475
-L038A		1.718	1.25	0.012	0.291	2774
-L038B		1.716	1.22	0.010	0.270	2600
-L039A						2560
-L039B						2680
-3B-L031A						2545
-L031B						2788
-L034A						2292
-L034B						2390
-L035A						2510
-L035B						(c)
-L038A						2390
-L038B						2536
-L039A						2853
-L039B						2919
Mean		1.728	1.26	0.012	0.295	2617
Std. Dev.		0.009	0.03	0.002	0.026	165
-3A-L041	MLE, radial	1.729	1.10	0.018	0.241	1895
-L042		1.717	1.05	0.015	0.275	2323
-L043						2070
-L044						2173
-L045						2248
-L047						2192
-L048		1.729	1.07	0.019	0.299	2203
-L049		1.728	1.06	0.016	0.304	2223
-L050		1.726	1.07	0.016	0.294	2222
-L051		1.726	1.08	0.016	0.228	2333
-3B-L041						2198
-L042						2072
-L043						2108
-L044						2047
-L045						2052
-L047						1393
-L048		1.718	1.02	0.021	0.245	1827
-L049		1.716	1.02	0.015	0.237	1788
-L050		1.724	1.06	0.017	0.272	1801
-L051		0.006	0.03	0.002	0.027	1845
Mean						2050
Std. Dev.						231

TABLE B-10 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-40-3A-L002A	MLC, axial	1.703	1.18	0.012	0.276	2268
-L002B		1.706	1.10	0.015	0.217	2391
-L003B		1.705	1.18	0.018	0.260	1997
-L005A		1.704	1.15	0.017	0.248	1764
-L005B		1.702	1.14	0.018	0.222	2237
-L006A		1.703	1.10	0.012	0.211	2073
-L006B		1.703	1.11	0.022	0.192	2097
-L008A		1.702	1.15	0.016	0.265	1974
-L008B		1.703	1.11	0.016	0.237	1847
-L009B		1.702	1.15	0.016	0.265	2057
-3B-L002A		1.703	1.14	0.018	0.222	1758
-L002B		1.703	1.10	0.012	0.211	1767
-L003B		1.703	1.11	0.022	0.192	1737
-L005A		1.703	1.10	0.012	0.211	1727
-L005B		1.703	1.11	0.022	0.192	1438
-L006A		1.702	1.15	0.016	0.265	1568
-L006B		1.702	1.15	0.016	0.265	1662
-L008A		1.702	1.15	0.016	0.265	2137
-L008B		1.703	1.11	0.016	0.265	1887
-L009B		1.703	1.14	0.016	0.236	1288
Mean Std. Dev.		1.703 0.001	1.14 0.03	0.016 0.003	0.236 0.030	1884 238
-3A-L011	MLC, radial	1.703	1.01	0.024	0.220	1565
-L012		1.702	0.99	0.025	0.168	1687
-L013		1.706	1.05	0.023	0.239	1229
-L014		1.702	1.02	0.015	0.266	1757
-L015		1.700	1.05	0.019	0.268	1638
-L017		1.704	1.03	0.019	0.206	1847
-L018		1.704	1.01	0.019	0.249	1750
-L019		1.706	1.01	0.018	0.250	1697
-L020		1.706	1.01	0.018	0.250	1969
-L021		1.703	1.02	0.015	0.266	1957
-3B-L011		1.700	1.05	0.019	0.268	1901
-L012		1.704	1.03	0.019	0.206	1767
-L013		1.704	1.03	0.019	0.206	1608
-L014		1.704	1.03	0.019	0.206	2017
-L015		1.704	1.01	0.019	0.249	1372
-L017		1.704	1.01	0.019	0.249	1383
-L018		1.706	1.01	0.019	0.249	1763
-L019		1.706	1.01	0.018	0.250	1737
-L020		1.706	1.01	0.018	0.250	1767
-L021		1.706	1.01	0.018	0.250	1588
Mean Std. Dev.		1.703 0.002	1.02 0.02	0.020 0.003	0.233 0.034	1700 204

(a) Measured at GLCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress, and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Bond failure.

TABLE B-11  
 DENSITY AND TENSILE PROPERTIES OF H-451, LOT 426  
 [Log 6484-41 (GLCC 184), whole log density = 1.72 g/cm<sup>3</sup>(a),  
 0.505-in.-diameter by 3.00-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-41-1A-L002A	EC, axial	1.694	1.08	0.012	0.250	1994
-L002B						1663
-L003A		1.668	1.02	0.019	0.235	1643
-L005A						1758
-L005B						1842
-L006A		1.697	1.06	0.017	0.211	1699
-L006B						1528
-L008A		1.689	1.08	0.016	0.235	1795
-L008B						1742
-L009A						1717
-1B-L002A		1.685	1.00	0.021	0.247	1720
-L002B						1757
-L003A						1493
-L005A		1.681	1.08	0.020	0.249	1860
-L005B						1643
-L006A		1.686	1.10	0.019	0.246	1887
-L006B						1573
-L008A		1.681	1.07	0.018	0.229	1696
-L008B						1727
-L009A						1667
Mean		1.685	1.06	0.018	0.238	1720
Std. Dev.		0.009	0.03	0.003	0.013	120
-1A-L011	EC, radial	1.699	1.03	0.016	0.312	2170
-L012						1638
-L013		1.664	0.98	0.024	0.256	1680
-L014						1737
-L015						1378
-L017						2042
-L018		1.667	0.98	0.024	0.295	1939
-L019						1677
-L020		1.684	0.94	0.016	0.219	1595
-L021						2055
-1B-L011		1.702	1.04	0.017	0.329	2290
-L012						2007
-L013		1.678	0.98	0.016	0.194	1428
-L014						1168
-L015						1742
-L017						2277
-L018		1.694	0.97	0.020	0.239	1680
-L019						1817
-L020		1.686	0.99	0.018	0.275	1692
-L021						1747
Mean		1.684	0.99	0.019	0.265	1788
Std. Dev.		0.014	0.03	0.003	0.047	294

TABLE B-11 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-41-1A-L031A	EE, axial	1.728	1.20	0.011	0.261	2239
-L031B		1.692	1.10	0.009	0.274	2403
-L034A		1.714	1.14	0.012	0.304	2171
-L034B		1.710	1.22	0.010	0.320	2289
-L035A						2323
-L035B						2440
-L038A						2535
-L038B						2390
-L039A						2383
-L039B						2278
-1B-L031A		1.718	1.25	0.011	0.316	2501
-L031B		1.679	1.02	0.017	0.244	2616
-L034A		1.718	1.18	0.011	0.299	1742
-L034B		1.706	1.20	0.021	0.320	2640
-L035A						2438
-L035B						2507
-L038A						2465
-L038B						2396
-L039A						2745
-L039B						2455
Mean		1.708	1.16	0.013	0.292	2398
Std. Dev.		0.016	0.07	0.004	0.029	207
-1A-L041	EE, radial	1.732	1.05	0.015	0.334	2294
-L042		1.711	1.07	0.019	0.294	2132
-L043		1.703	1.06	0.019	0.267	2091
-L044						2046
-L045						1995
-L047						(c)
-L048		1.685	1.00	0.019	0.308	2082
-L049		1.675	1.00	0.023	0.319	2000
-L050		1.697	0.93	0.019	0.229	2099
-L051		1.724	1.05	0.019	0.332	2185
-1B-L041		1.716	1.06	0.017	0.295	2248
-L042		1.675	0.93	0.027	0.251	1773
-L043		1.697	0.93	0.020	0.292	2131
-L044						1692
-L045						2197
-L047						1982
-L048						1568
-L049						1568
-L050						1658
-L051						1283
Mean		1.705	1.02	0.020	0.292	1948
Std. Dev.		0.019	0.05	0.003	0.036	277

TABLE B-11 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-41-3A-L031A	MLE, axial	1.745	1.28	0.012	0.349	2868
-L031B		1.709	1.20	0.016	0.312	2747
-L034A		1.734	1.28	0.012	0.320	2547
-L034B		1.722	1.27	0.017	0.342	2509
-L035A		1.724	1.25	0.011	0.328	2743
-L035B		1.699	1.23	0.021	0.293	2822
-L038A		1.722	1.23	0.016	0.327	2774
-L038B		1.722	1.23	0.017	0.354	2880
-L039A		1.722	1.23			2845
-L039B		1.722	1.23			2782
-3B-L031A		1.722	1.25	0.011	0.328	2746
-L031B		1.699	1.23	0.021	0.293	2794
-L034A		1.722	1.23	0.016	0.327	2270
-L034B		1.722	1.23	0.017	0.354	2017
-L035A		1.722	1.23			2696
-L035B		1.722	1.23			2852
-L038A		1.722	1.23			2876
-L038B		1.722	1.23			2789
-L039A		1.722	1.23			(c)
-L039B		1.722	1.23			<u>2864</u>
Mean		<u>1.722</u>	<u>1.25</u>	<u>0.015</u>	<u>0.328</u>	<u>2706</u>
Std. Dev.		0.014	0.03	0.003	0.020	226
-3A-L041	MLE, radial	1.735	1.10	0.016	0.328	2346
-L042		1.713	1.07	0.015	0.211	1691
-L043		1.710	1.03	0.021	0.310	1687
-L044		1.708	1.05	0.023	0.308	2304
-L045		1.704	1.01	0.021	0.223	2249
-L047		1.730	1.03	0.018	0.251	2224
-L048		1.700	0.99	0.020	0.249	2115
-L049		1.714	1.01	0.025	0.282	1950
-L050		1.714	1.01			2139
-L051		1.714	1.01			2340
-3B-L041		1.704	1.01	0.021	0.223	1644
-L042		1.730	1.03	0.018	0.251	1998
-L043		1.700	0.99	0.020	0.249	1931
-L044		1.714	1.01	0.025	0.282	2391
-L045		1.714	1.01			1858
-L047		1.714	1.01			1911
-L048		1.714	1.01			1705
-L049		1.714	1.01			1766
-L050		1.714	1.01			1965
-L051		1.714	1.01			<u>1697</u>
Mean		<u>1.714</u>	<u>1.04</u>	<u>0.020</u>	<u>0.270</u>	<u>1995</u>
Std. Dev.		0.012	0.04	0.003	0.043	253

TABLE B-11 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-41-3A-L002A	MLC, axial	1.680	1.10	0.017	0.255	1966
-L002B						1882
-L003A						1912
-L005A		1.696	1.10	0.019	0.233	1808
-L005B						2092
-L006A		1.690	1.10	0.017	0.274	2090
-L006B						1648
-L008A		1.707	1.14	0.019	0.243	1920
-L008B						1752
-L009A						1792
-3B-L002A		1.696	1.09	0.016	0.193	1547
-L002B						1952
-L003A						1992
-L005A		1.695	1.06	0.020	0.190	1503
-L005B						1837
-L006A		1.702	1.12	0.020	0.272	2096
-L006B						1887
-L008A		1.683	1.07	0.018	0.232	1771
-L008B						1887
-L009A						2182
Mean		1.694	1.10	0.018	0.236	1876
Std. Dev.		0.009	0.02	0.001	0.032	178
-3A-L011	MLC, radial	1.689				838
-L012						1573
-L013		1.694				718
-L014						759
-L015						1623
-L017						1638
-L018		1.696	1.01	0.020	0.299	2001
-L019						1862
-L020		1.706	1.02	0.022	0.285	1977
-L021						2047
-3B-L011		1.694				844
-L012						1338
-L013		1.692	0.97	0.021	0.240	1621
-L014						1792
-L015						1642
-L017						1548
-L018		1.696	0.98	0.024	0.184	1382
-L019						1832
-L020		1.704	1.00	0.013	0.195	1546
-L021						1722
Mean		1.696	1.00	0.020	0.241	1515
Std. Dev.		0.006	0.02	0.004	0.052	417

(a) Measured at GLCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress, and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Bond failure.

TABLE B-12  
 DENSITY AND TENSILE PROPERTIES OF TS-1240, LOT 1<sup>(a)</sup>,  
 [Log 5651-72 (UCC 32), whole log density = 1.77 g/cm<sup>3</sup><sup>(a)</sup>,  
 0.505-in.-diameter by 3.0-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-72-1A-L001	EC, axial	1.736	1.07	--	0.260	1980
-L004		1.721	0.94	--	0.170	1443
-L005		1.700	0.82	--	0.156	1210
-L009		1.732	0.92	--	0.304	1941
-1B-L011		1.727	0.99	--	0.234	1742
-L014		1.719	1.00	--	0.176	1454
-L015		1.711	0.80	--	0.266	1618
-L019		1.734	0.93	--	0.227	1661
-1A-L002A						1347
-L003A						1302
-L003B						1429
-L006A						1203
-L006B						1152
-1B-L012A						1538
-L012B						1756
-L016A						1401
-L016B						1554
-L017A						1350
-L017B						<u>1293</u>
Mean		1.722	0.93	--	0.224	1493
Std. Dev.		0.012	0.090	--	0.053	240
5651-72-1A-L028	EC, radial	1.706	0.84	0.030	0.363	1909
-L026		1.744	1.02	--	0.308	2179
-L027		1.722	0.95	--	0.326	2079
-L030		1.724	1.05	--	0.200	1776
-1B-L037		1.731	0.96	--	0.312	1979
-L038		1.723	0.95	--	0.295	1964
-L039		1.726	1.02	--	0.288	2127
-L042		1.722	0.98	--	0.310	2071
-1A-L025		1.753	1.01	--	(c)	(c)
-L029						1920
-L032						1892
-L033						1581
-L034						1609
-1B-L040						2077
-L041						249
-L044						1936
-L045						728
-L046						<u>2104</u>
Mean		1.728	0.97	--	0.300	1775
Std. Dev.		0.014	0.062	--	0.046	519

TABLE B-12 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-72-1A-L101	EE, axial	1.738	1.03	--	0.295	2044
-L103		1.750	1.05	--	0.282	2057
-L105		1.738	1.00	--	0.314	2083
-L107		1.767	1.07	--	0.310	2240
-1B-L111		1.749	1.10	--	0.264	1996
-L112		1.745	1.07	--	0.249	1931
-L114		1.732	1.12	--	0.260	2000
-L116		1.711	0.99	--	0.228	1712
-1A-L102A						2082
-L102B						2094
-L104A						1947
-L108A						2104
-L108B						1777
-1B-L117A						1910
-L117B						1806
-L119A						1776
-L119B						1905
-L120A						1948
-L120B						1792
Mean		1.741	1.05	--	0.275	1959
Std. Dev.		0.016	0.046	--	0.030	137
5651-72-1A-L128	EE, radial	1.753	0.92	0.032	0.361	2050
-L126		1.745	1.01	--	0.354	2294
-L129		1.753	1.05	--	0.323	2242
-L130		1.748	0.96	--	0.330	2050
-1B-L144		1.727	0.88	0.020	0.370	2089
-L143		1.729	0.94	--	0.330	2070
-L146		1.742	1.00	--	0.324	2165
-L147		1.730	0.97	--	0.305	2027
-1A-L127						1930
-L131						2080
-L132						2080
-L133						2125
-L125		1.737	0.99			(c)
-1B-L140						1943
-L141						2227
-L145						2014
-L148						1905
-L149						2183
-L142						(c)
Mean		1.738	1.00	--	0.337	2087
Std. Dev.		1.740	0.97	--	0.022	110
		0.010	0.049			

TABLE B-12 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain in Fracture (%)	Ultimate Strength (psi)
5651-72-3A-L050	QLC, axial	1.719	1.02	0.024	0.252	1718
-L053		1.718	0.95	0.013	0.287	1906
-L054A		1.718	0.95	0.028	0.275	1734
-L058		1.741	1.11	0.026	0.320	2078
-3B-L061A		1.737	1.11	0.034	0.292	1969
-L064A		1.725	1.12	0.023	0.236	1753
-L065		1.721	1.11	0.031	0.236	1694
-L069		1.732	1.03	0.023	0.240	1643
-3A-L051A						1546
-L054B						1845
-L055A						1890
-L055B						1830
-3B-L061B						1917
-L062A						1841
-L062B						1593
-L064B						1737
-L066A						1709
-L066B						1846
Mean		1.726	1.05	0.025	0.267	1792
Std. Dev.		0.009	0.073	0.006	0.031	136
5651-72-3A-L079	QLC, radial	1.744	0.98	0.013	0.356	2098
-L078		1.731	0.88	0.030	0.350	1997
-L077		1.734	0.98	0.017	0.307	1943
-L080		1.727	1.05	0.016	0.337	2035
-3B-L087		1.722	0.99	0.018	0.355	2150
-L088		1.731	1.01	0.028	0.345	2138
-L089		1.726	0.89	0.016	0.370	2073
-L092		1.727	0.96	0.021	0.320	1997
-3A-L076		1.734	0.96	0.023	(c)	(c)
-L081						2191
-L084						2048
-3B-L090						1965
-L093						1786
-L096						2040
Mean		1.731	0.97	0.019	0.342	2035
Std. Dev.		0.006	0.054	0.007	0.020	105

TABLE B-12 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain in Fracture (%)	Ultimate Strength (psi)
5651-72-3A-L152	QLE, axial	1.748	0.96	0.025	0.305	1893
-L153		1.758	1.10	0.031	0.276	2010
-L155		1.768	1.08	0.016	0.315	2167
-L157		1.773	1.22	0.016	0.268	2019
-3B-L170		1.761	1.01	0.020	0.288	1912
-L162		1.725	1.00	0.024	0.286	1866
-L164		1.749	1.02	0.017	0.240	1762
-L166		1.742	1.05	0.020	0.220	1624
-3A-L151		1.730	0.97	0.030	(c)	(c)
-L154A						1527
-L154B						1891
-L156A						2299
-L157A						2130
-L158A						1988
-L160A						1868
-L160B						1940
-3B-L163A						1559
-L163B						1000
-L167A						1543
-L167B						1742
-L169A						2126
-L169B						2011
-L161		1.758	1.15	0.030	(c)	(c)
Mean		1.751	1.06	0.021	0.275	1851
Std. Dev.		0.016	0.081	0.008	0.032	287
5651-72-3A-L178	QLE, radial	1.770	1.05	0.025	0.328	2113
-L181		1.755	0.96	0.031	0.400	2241
-L179		1.745	0.096	0.006	0.304	1978
-L180		1.745	0.95	0.010	0.298	1918
-3B-L193		1.731	0.096	0.010	0.284	1870
-L194		1.726	0.99	0.022	0.358	2145
-L197		1.753	1.07	0.017	0.353	2261
-L198		1.754	0.99	0.010	0.320	2153
-3A-L175		1.759	1.00	0.020	(c)	(c)
-L176		1.755	0.99	0.023	(c)	(c)
-L182						2259
-L183						2086
-L184						1805
-3B-L191						1811
-L192						1961
-L196						2142
-L199						2095
-L200						2016
Mean		1.749	0.99	0.014	0.330	2053
Std. Dev.		0.013	0.040	0.008	0.038	151

(a) Measured at UCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress, and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Bond failure.

TABLE B-13  
 DENSITY AND TENSILE PROPERTIES OF TS-1240, LOT 1<sup>(a)</sup>  
 [Log 5651-73 (UCC 40), whole log density = 1.79 g/cm<sup>3</sup>,  
 0.505-in.-diameter by 3.0-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-73-3A-L002A	MLC, axial	1.783	0.97	0.009	0.242	1837
-L002B		1.782	1.00	0.008	0.255	1873
-L003A		1.777	1.00	0.007	0.230	1658
-L003B		1.779	1.02	0.010	0.230	1724
-3B-L002A		1.784	1.03	0.010	0.231	1714
-L002B		<u>1.791</u>	<u>1.10</u>	<u>0.012</u>	<u>0.258</u>	<u>1969</u>
Mean		1.783	1.02	0.009	0.241	1796
Std. Dev.		0.005	0.044	0.002	0.013	117
5651-73-3A-L005	MLC, radial	1.788	1.00	0.000	0.185	1452
-L006		1.789	0.97	0.005	0.227	1665
-L007		1.783	(c)	(c)	(c)	1316
-L008		1.779	1.00	0.017	0.158	1233
-3B-L005		1.786	1.22	0.020	0.208	1560
-L007		<u>1.789</u>	<u>1.02</u>	<u>0.017</u>	<u>0.192</u>	<u>1388</u>
Mean		1.786	1.04	0.012	0.194	1436
Std. Dev.		0.004	0.101	0.009	0.026	159
5651-73-3A-L009A	MLE, axial	1.814	1.18	0.018	0.342	2583
-L011A		1.800	1.12	0.030	0.317	2287
-L010A		1.814	1.15	0.015	0.365	2684
-L009B		1.795	(c)	(c)	(c,d)	(d)
-L010B		1.815	(c)	(c)	(c,d)	(d)
-3B-L011A		1.808	1.10	0.031	(d)	(d)
-L011B		1.810	1.34	0.030	(d)	(d)
-L009A		1.806	1.17	0.016	0.255	2204
-L009B		<u>1.800</u>	<u>1.15</u>	<u>0.014</u>	<u>0.345</u>	<u>2498</u>
Mean		1.807	1.17	0.022	0.327	2290
Std. Dev.		0.007	0.079	0.008	0.049	357
5651-73-3A-L013	MLE, radial	1.808	0.99	0.015	0.292	2004
-L014		1.801	1.01	0.019	0.257	1730
-L015		1.804	1.02	0.016	0.255	1755
-3B-L013		1.799	1.03	0.019	0.285	1939
-L014		1.804	1.07	0.012	0.248	1790
-L015		<u>1.804</u>	<u>1.18</u>	<u>0.016</u>	<u>0.260</u>	<u>1805</u>
Mean		1.803	1.05	0.016	0.266	1837
Std. Dev.		0.003	0.069	0.003	0.018	109

(a) Measured at UCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Specimen tested without extensometer and not load cycled.

(d) Bond failure.

TABLE B-14  
 DENSITY AND TENSILE PROPERTIES OF TS-1240, LOT 1<sup>a</sup>  
 [Log 5651-73 (UCC 40), whole log density = 1.79 g/cm<sup>3</sup>(a),  
 0.25-in.-diameter by 0.9-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-73-3A-106B	MLE, axial	1.812	1.06	0.020	0.440	2789
-107B		1.811	1.02	0.006	0.365	2569
-112B		1.813	1.06	0.017	0.383	2400
-113B		1.796	1.03	0.007	0.318	2262
-118B		1.813	1.06	0.022	0.315	2120
-119B		1.798	0.98	0.032	0.375	2267
-124B		1.803	0.97	0.020	0.375	2244
-125B		1.801	0.99	0.010	0.355	2347
-127B		1.798	0.98	0.025	0.365	2183
-128B		1.801	1.01	0.030	0.356	2042
-3B-106B		1.803	0.95	0.070	0.260	1540
-107B		1.801	1.00	0.035	0.290	2082
-112B		1.817	1.12	0.035	0.350	2526
-113B		1.809	1.20	0.015	0.390	2648
-118B		1.805	1.20	0.020	0.360	2588
-119B		1.800	1.06	0.030	0.410	2648
-124B		1.817	1.06	0.040	0.410	2699
-125B		1.820	1.06	0.030	0.380	2608
-127B		1.811	(c)	(c)	0.130	971
-128B		1.820	1.29	0.010	0.370	2777
Mean		1.807	1.06	0.025	0.350	2315
Std. Dev.		0.008	0.089	0.014	0.066	440
5651-73-3A-136B	MLE, radial	1.794	1.38	0.020	0.190	1608
-137B		1.804	0.82	0.035	0.275	1524
-142B		1.812	1.12	0.015	0.290	2061
-143B		1.812	0.95	0.040	0.420	2397
-148B		1.820	1.00	0.005	0.355	2302
-149B		1.807	1.06	0.015	0.320	1884
-154B		1.808	1.00	0.040	0.260	1711
-155B		1.806	0.82	0.030	0.325	1732
-160A		1.799	0.90	0.030	0.250	1671
-160B		1.813	1.00	0.015	0.350	2486
-3B-136B		1.814	1.06	0.030	0.320	2119
-137B		1.815	1.00	0.040	0.340	2040
-142B		1.805	0.95	0.030	0.310	1992
-143B		1.808	0.95	0.045	0.390	2207
-148B		1.808	1.00	0.035	0.390	2322
-149B		1.801	1.00	0.020	0.310	2207
-154B		1.814	1.12	0.020	0.240	1848
-155B		1.809	0.90	0.030	0.290	1788
-160A		1.809	0.95	0.035	0.290	1714
-160B		1.808	0.95	0.020	0.320	2205
Mean		1.808	1.00	0.027	0.312	1991
Std. Dev.		0.006	0.121	0.011	0.055	285

TABLE B-14 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-73-3A-006B	MLC, axial	1.774	0.90	0.015	0.210	1427
-007B		1.767	0.95	0.030	0.270	1711
-012B		1.766	1.00	0.025	0.310	2015
-013B		1.776	0.90	0.025	0.320	1896
-018B		1.775	0.86	0.020	0.200	1469
-019B		1.765	0.69	0.015	0.285	1406
-024B		1.775	0.95	0.010	0.275	1796
-025B		1.776	1.00	0.020	0.250	1691
-027B		1.770	0.86	0.010	0.245	1449
-028B		1.777	0.90	0.020	0.265	1672
-3B-006B		1.767	1.00	0.017	0.323	1976
-007B		1.765	1.00	0.025	0.245	1670
-012B		1.780	1.00	0.010	0.185	1438
-013B		1.767	0.95	0.030	0.145	1141
-018B		1.769	0.60	0.030	0.240	1080
-019B		1.778	0.86	0.022	0.190	1283
-024B		1.765	0.88	0.020	0.215	1487
-025B		1.766	0.90	0.030	0.295	1569
-027B		1.764	0.86	0.015	0.275	1507
-028B		1.763	0.86	0.027	0.335	1731
Mean		1.770	0.90	0.021	0.254	1571
Std. Dev.		0.005	0.102	0.007	0.051	252
5651-73-3A-036B	MLC, radial	1.766	-	-	0.140	957
-037B		1.775	0.95	0.025	0.220	1428
-042B		1.781	1.00	0.035	0.205	1367
-043B		1.771	0.78	0.030	0.300	1266
-048B		1.781	0.72	0.030	0.245	1388
-049B		1.782	1.00	0.020	0.130	1120
-054B		1.778	0.90	0.015	0.210	1450
-055B		1.771	0.95	0.020	0.250	1531
-060A		1.767	1.06	0.040	0.350	2400
-060B		1.781	0.90	0.010	0.175	1170
-3B-036B		1.776	0.75	0.035	0.330	1448
-037B		1.773	(c)	(c)	0.165	958
-042B		1.779	0.95	0.030	0.210	1428
-043B		1.776	0.88	0.025	0.195	1287
-048B		1.785	0.90	0.030	0.252	1594
-049B		1.778	0.95	0.017	0.255	1491
-054B		1.777	1.00	0.047	0.205	1384
-055B		1.783	0.91	0.030	0.233	1428
-060A		1.770	0.83	0.025	0.295	1428
-060B		1.769	0.68	0.015	0.255	1144
Mean		1.776	0.90	0.027	0.231	1383
Std. Dev.		0.006	0.105	0.009	0.058	298

(a) Measured at UCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress, and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Specimen broke during first loading cycle.

TABLE B-15  
 DENSITY AND TENSILE PROPERTIES OF TS-1240, LOT 1<sup>1</sup>(a),  
 [Log 5651-74 (UCC 42), whole log density = 1.82 g/cm<sup>3</sup>,  
 0.505-in.-diameter by 3.00-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-74-3A-L051A	MLC, axial					2028
-L057A						1987
-L057B						2035
-L054B						2038
-L055A						1895
-L058B						2137
-3B-L068B						2175
-L062A						1918
-L062B						2035
-L064B						2150
-L067A						1986
-L067B						1970
-3A-L050		1.797	1.10	0.018	0.306	2238
-L053		1.798	1.12	0.014	0.285	2186
-L054A		1.795	1.08	0.021	0.275	2010
-L058A		1.798	1.11	0.019	0.260	1914
-3B-L061		1.793	1.06	0.020	0.221	1661
-L064A		1.791	1.10	0.025	0.271	1890
-L065		1.784	1.05	0.024	0.286	1943
-L069		1.789	1.06	0.024	0.284	1944
Mean		1.793	1.08	0.021	0.273	2007
Std. Dev.		0.005	0.026	0.004	0.025	131
5651-74-3A-L079	MLC, radial					1588
-L081						1642
-L082						1672
-L084						1641
-3B-L090						2120
-L091						2409
-L093						1621
-L094						1692
-L096						1237
-3A-L075		1.785	0.97	0.045	0.206	1445
-L076		1.791	1.02	0.024	0.250	1692
-L077		1.790	1.02	0.026	0.260	1749
-L080		1.792	1.03	0.028	0.265	1505
-3B-L087		1.791	1.03	0.026	0.261	1835
-L088		1.795	1.05	0.022	0.335	2284
-L089		1.793	1.03	0.022	0.221	1630
-L092		1.789	1.01	0.021	0.189	1372
Mean		1.791	1.02	0.027	0.248	1714
Std. Dev.		0.003	0.023	0.008	0.045	305

TABLE B-15 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-74-1A-L002A	EC, axial					2140
-L002B						2135
-L003A						2088
-L003B						2391
-L006A						2196
-L006B						1959
-1B-L012A						2520
-L012B						2444
-L016A						2238
-L016B						1842
-L017A						2142
-L017B						2143
-1A-L001		1.800	1.15	0.018	0.250	1944
-L004		1.814	1.20	0.028	0.333	2418
-L005		1.802	1.18	0.013	0.310	2344
-L009		1.797	1.18	0.019	0.330	2404
-1B-L011		1.807	1.23	0.025	0.295	2256
-LC14		1.802	1.14	0.020	0.265	1987
-L015		1.798	1.15	0.023	0.320	2298
-L019		1.815	1.18	0.023	0.315	2342
Mean		1.804	1.18	0.021	0.302	2211
Std. Dev.		0.007	0.030	0.005	0.030	187
5651-74-1A-L028	EC, radial					1633
-L032						2077
-L033						1818
-L034						1942
-1B-L040						2171
-L041						1992
-L045						1932
-L037		1.824				(c)
-1A-L025		1.816	1.17	0.032	0.365	2462
-L026		1.811	1.10	0.023	0.310	2145
-L027		1.807	1.02	0.025	0.280	1948
-L030		1.823	1.14	0.024	0.450	2980
-1B-L044		1.720	0.94	0.020	0.260	1946
-L038		1.815	1.11	0.029	0.378	2534
-L039		1.808	1.07	0.030	0.360	2369
-L042		1.812	1.05	0.025	0.450	2843
Mean		1.804	1.08	0.026	0.363	2186
Std. Dev.		0.032	0.073	0.004	0.063	380

TABLE B-15 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-74-1A-L102A -L102B -L104A -L104B -L108A -L108B -1B-L117A -L117B -L119A -L119B -L120A -L120B -1A-L101 -L103 -L105 -L107 -1B-L111 -L112 -L114 -L116	EE, axial					2290 2203 2284 2569 2115 2135 2199 2469 2384 2368 2241 2139 2369 2666 2494 2110 1794 2148 2197 2244
Mean		1.808	1.18	0.018	0.308	2271
Std. Dev.		1.813	1.18	0.016	0.350	193
1.815	1.18	0.022	0.335			
1.802	1.10	0.020	0.295			
1.788	1.12	0.018	0.230			
1.786	1.08	0.023	0.306			
1.777	1.07	0.023	0.325			
1.792	1.11	0.027	0.318			
1.798	1.13	0.021	0.308			
0.014	0.046	0.004	0.036			
5651-74-1A-L127 -L131 -L132 -L133 -L134 -1B-L140 -L141 -L145 -L148 -L149 -L144 -1A-L125 -L126 -L129 -L130 -1B-L142 -L143 -L146 -L147	EE, radial					1547 2196 2197 1886 1717 2022 1596 2132 1926 1551 1831 2544 2150 2510 2300 2760 2406 2247 2185
Mean		1.822	1.08	0.016	0.372	2090
Std. Dev.		1.818	1.07	0.025	0.314	345
1.822	1.08	0.019	0.366			
1.813	1.08	0.024	0.327			
1.820	1.11	0.021	0.410			
1.810	1.08	0.021	0.354			
1.806	1.01	0.022	0.337			
1.798	1.06	0.017	0.325			
1.814	1.07	0.021	0.351			
0.009	0.028	0.003	0.031			

TABLE B-15 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-74-3A-L154A	MLE, axial					(c)
-L154B						2539
-L156B						2384
-L157B						2340
-L158A						2197
-L158B						2160
-3B-L163A						2097
-L163B						2055
-L167A						2189
-L167B						2026
-L169A						2324
-L169B						2424
-3A-L151		1.809	1.18	0.020	0.336	2489
-L153		1.809	1.18	0.022	0.356	2586
-L155		1.793	1.12	0.020	0.301	2157
-L157A		1.808	1.12	0.016	0.275	2064
-3B-L161		1.792	1.10	0.024	0.292	1995
-L162		1.797	1.10	0.020	0.253	1603
-L164		1.799	1.10	0.021	0.305	2199
-L166		1.809	1.15	0.030	0.332	2458
Mean		1.802	1.13	0.022	0.306	2226
Std. Dev.		0.007	0.034	0.004	0.034	236
5651-74-3A-L178	MLE, radial					2037
-L181						1906
-L182						1802
-L183						1687
-L184						2001
-3B-L191						2092
-L192						1138
-L196						1970
-L199						1372
-L200						1371
-3A-L175		1.805	1.02	0.023	0.300	2004
-L176		1.805	1.03	0.020	0.291	1981
-L179		1.810	1.06	0.029	0.259	1785
-L180		1.804	1.05	0.030	0.275	1861
-3B-L193		1.804	1.06	0.026	0.262	1796
-L194		1.805	1.06	0.020	0.292	1987
-L197		1.796	0.98	0.021	0.179	1248
-L198		1.794	0.98	0.025	0.196	1347
Mean		1.803	1.03	0.024	0.257	1744
Std. Dev.		0.005	0.034	0.004	0.045	307

(a) Measured at UCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress, and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Bond failure.

TABLE B-16  
 DENSITY AND TENSILE PROPERTIES OF TS-1240, LOT 1  
 [Log 5651-75 (UCC 46), whole log density = 1.84 g/cm<sup>3</sup>(a),  
 0.505-in.-diameter by 3.00-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-75-3A-L050B	MLC, axial					2781
-L053B						2643
-L054B						2317
-L056A						2594
-L056B						2570
-L058B						2685
-3B-L061B						2826
-L064B						2949
-L065B						2921
-L068B						2937
-L069B						2681
-3A-L050		1.808	1.30	0.000	(c)	(c)
-L054		1.807	1.36	0.006	(c)	(c)
-3B-L061		1.810	1.34	0.013	(c)	(c)
-L064		1.809	1.45	0.013	(c)	(c)
-L065		1.805	1.27	0.016	(c)	(c)
-L069		1.810	1.36	0.012	(c)	(c)
-3A-L051		1.822	1.23	0.013	0.325	2590
-L053		1.806	1.47	0.005	0.305	2592
-L055		1.819	1.27	0.020	(c)	(c)
-L058		1.810	1.41	0.013	0.314	2605
-3B-L062		1.820	1.25	0.025	0.378	2836
-L066		1.817	1.23	0.012	0.335	2851
-L067		1.820	1.25	0.023	(c)	(c)
-L068		1.824	1.27	0.015	0.327	2450
Mean		1.813	1.30	0.016	0.323	2696
Std. Dev.		0.007	0.091	0.006	0.029	177
5651-75-3A-L079	MLC, radial					1197
-L081						1511
-L082						1302
-L078		1.812				803
-L079		1.812				817
-L084		1.814				1762
-3B-L090		1.816				920
-L093		1.813				(c)
-L094		1.816				2327
-L091X <sup>(d)</sup>		1.812				666
-3A-L075		1.807	(e)	(e)	0.108	996
-L076		1.804	(e)	(e)	0.150	596
-L077		1.807	(e)	(e)	0.130	865
-L080		1.806	1.15	0.016	0.235	1821
-3B-L087		1.809	1.03	0.020	0.140	1056
-L096		1.809	1.14	0.008	0.360	2666
-L089		1.807	(e)	(e)	0.084	833
-L092		1.808	1.14	0.007	0.390	2696
Mean		1.810	1.11	0.013	0.199	1343
Std. Dev.		0.004	0.057	0.006	0.117	683

TABLE B-16 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-75-1A-L101						
-L104A						(c)
-L104B						1925
-L108A						1930
-L108B						1895
-1B-L113A						2123
-L113B						1717
-L117A						2235
-L117B						2330
-L119A						2255
-L119B						2092
-L120A						2090
-L120B						2264
-L114		1.788	1.12	0.020	(c)	(c)
-1A-L102		1.821	1.14	0.018	0.270	2050
-L103		1.786	1.16	0.017	0.308	2339
-L105		1.777	1.13	0.020	0.260	1994
-L107		1.778	1.08	0.016	0.183	1467
-1B-L111		1.779	1.11	0.018	0.335	2335
-L112		1.788	1.10	0.020	0.320	2353
-L118		1.802	1.05	0.017	0.335	2341
-L116		1.781	1.10	0.017	0.277	2089
Mean		1.788	1.11	0.018	0.286	2096
Std. Dev.		0.013	0.035	0.001	0.051	238
5651-75-1A-L127	EE, radial					1786
-L128						1670
-L130						(c)
-L132						2258
-L133						2186
-L134						1596
-1B-L140						2046
-L141						2021
-L145						2038
-L148						1995
-L149						1787
-1A-L125		1.810	1.07	0.017	0.335	2301
-L126		1.800	1.07	0.022	0.290	2037
-L129		1.811	1.14	0.009	0.310	2300
-L131		1.816	1.14	0.017	(c)	(c)
-1B-L142		1.818	1.00	0.018	0.308	2208
-L143		1.810	1.03	0.020	0.330	2113
-L146		1.807	1.07	0.020	0.340	2310
-L147		1.808	1.05	0.018	0.290	2175
Mean		1.809	1.08	0.018	0.315	2049
Std. Dev.		0.005	0.051	0.004	0.021	223

TABLE B-16 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-75-1A-L002A	EC, axial					1752
-L002B						1788
-L003A						1208
-L006A						2021
-L008A						2035
-L008B						1611
-1B-L012A						1858
-L012B						1975
-L016A						1775
-L016B						2161
-L017A						1774
-L017B						1318
-1A-L001		1.815	1.22	0.020	0.270	2060
-L004		1.815	1.23	0.014	0.222	1920
-L005		1.815	1.23	0.012	0.200	1770
-L009		1.817	1.30	0.012	0.230	2007
-1B-L011		1.815	1.30	0.015	0.290	2338
-L014		1.823	1.25	0.015	0.272	2190
-L015		1.815	1.20	0.016	0.270	2130
-L019		1.816	1.30	0.020	0.245	2038
Mean		1.816	1.25	0.015	0.250	1886
Std. Dev.		0.003	0.041	0.003	0.031	278
5651-75-1A-L028	EC, radial					801
-L029						689
-L032						2217
-L033						2223
-L034						(c)
-1B-L040						1728
-L041						1425
-L045						2894
-L046						2909
-1A-L025		1.814	1.22	0.008	0.323	2390
-L026		1.811	1.08	0.022	0.280	2007
-L027		1.811	1.07	0.020	0.155	1235
-L030		1.808	1.12	0.019	0.320	2319
-1B-L037		1.821	1.11	0.020	0.387	2600
-L038		1.817	1.08	0.020	0.278	1996
-L039		1.813	1.07	0.023	0.288	1997
-L042		1.812	1.11	0.016	0.397	2793
Mean		1.813	1.11	0.018	0.303	2014
Std. Dev.		0.004	0.049	0.005	0.075	688

TABLE B-16 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
5651-75-3A-L151	MLE, axial					2824
-L152A						2689
-L152B						2623
-L153B					(c)	
-L154A						2743
-L154B						2399
-L156B						2240
-L157B						2688
-3B-L163A						3012
-L163B						2794
-L170A						3032
-L170B						3037
-3A-L155		1.804	1.32	0.013	(c)	(c)
-L157A		1.804	1.34	0.014	(c)	(c)
-3B-L164		1.812	1.45	0.006	(c)	(c)
-3B-L166		1.815	1.32	0.010	(c)	(c)
-3A-L151A		1.808	1.27	0.013	0.356	2828
-L153		1.807	1.34	0.015	0.340	2703
-L158		1.818	1.17	0.017	0.345	2597
-L160		1.827	1.22	0.019	0.360	2752
-3B-L161		1.828	1.27	0.016	0.400	3152
-L162		1.826	1.29	0.015	0.365	2928
-L167		1.825	1.27	0.015	0.295	2569
-L169		1.826	1.27	0.009	0.295	2578
Mean		1.817	1.29	0.013	0.344	2741
Std. Dev.		0.009	0.07	0.004	0.035	233
5651-75-3A-L182	MLE, radial					1756
-L183						1857
-L184						1961
-3B-L191						1961
-L192						2619
-L196						1237
-L199						2741
-L200						1766
-3A-L175		1.809	1.20	0.009	0.215	1740
-L176		1.812	1.10	0.024	0.255	1884
-L179		1.808	1.12	0.015	0.216	1692
-L180		1.808	1.12	0.016	0.196	1615
-3B-L193		1.809	1.12	0.022	0.150	1315
-L194		1.811	1.12	0.010	0.165	1497
-L197		1.816	1.15	0.020	0.367	2571
-L198		1.813	1.20	0.010	0.360	2600
Mean		1.811	1.14	0.016	0.240	1912
Std. Dev.		0.003	0.039	0.006	0.082	471

(a) Measured at UCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress, and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Bond failure.

(d) Specimen machined from extra core taken adjacent to core L091.

(e) Specimen broke during first loading cycle.

TABLE B-17  
 DENSITY AND TENSILE PROPERTIES OF TS-1240, Lot 1  
 [Log 6484-29 (UCC 8-1S-ID-23) whole log density = 1.83 g/cm<sup>3</sup>(a),  
 0.505-in.-diameter by 3.00-in.-long specimens]

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-29-1A-L102A	EE, axial	1.798	1.22	0.010	0.228	2095
-L102B						2378
-L104A						2524
-L104B						2703
-L109A						2320
-L109B						2314
-L110A		1.804	1.23	0.011	0.254	2149
-L110B						1921
-1B-L119A		1.801	1.25	0.017	0.294	2460
-L119B						2338
-L120A						2411
-L118A						2685
-L118B						3049
-1A-L101		1.804	1.27	0.015	(c)	(c)
-L103		1.807	1.27	0.020	(c)	(c)
-L105		1.807	1.23	0.020	(c)	(c)
-L107		1.807	1.25	0.011	0.311	2440
-1B-L111		1.793	1.17	0.017	0.330	2545
-L112		1.785	1.16	0.017	0.320	2435
-L114		1.791	1.20	0.022	(c)	(c)
-L116		1.809	1.25	0.013	0.314	2655
Mean		1.800	1.23	0.016	0.293	2437
Std. Dev.		0.008	0.04	0.004	0.038	260
6484-29-1A-L127	EE, radial					2202
-L128						2057
-L131						2007
-L132						2244
-L133						1896
-L134						2443
-1B-L140						2047
-L141						1698
-L144						2258
-L145						2257
-L148						1538
-L149						1483
-1A-L125		1.820	1.12	0.020	0.355	2566
-L126		1.809	1.08	0.023	0.329	2323
-L129		1.811	1.13	0.020	0.323	2327
-L130		1.806	1.12	0.029	0.339	2471
-1B-L142		1.809	1.13	0.021	0.331	2421
-L143		1.805	1.12	0.019	0.316	2383
-L146		1.813	1.16	0.024	0.254	1997
-L147		1.800	1.08	0.019	0.266	1927
Mean		1.808	1.12	0.022	0.314	2127
Std. Dev.		0.006	0.03	0.003	0.035	306

TABLE B-17 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-29-1A-L002A -L002B -L006A -L006B -L007A -L007B -1B-L012A -L012B -L016A -L016B -L017A -L017B	EC, axial					2186 1989 2220 2421 2264 2557 2177 2045 2358 2491 2486 2133
6484-29-1A-L001 -L004 -L005 -L009 -1B-L011 -L014 -L015 -L019		1.796 1.802 1.804 1.799 1.798 1.794 1.795 <u>1.802</u>	1.17 1.22 1.22 1.19 1.23 1.27 1.23 <u>1.23</u>	0.018 0.020 0.014 0.015 0.017 0.021 0.018 <u>0.019</u>	0.265 0.314 0.288 0.299 0.319 0.325 0.325 <u>0.304</u>	2041 2527 2381 2441 2565 2585 2603 <u>2425</u>
Mean Std. Dev.		1.799 0.004	1.22 0.03	0.018 0.002	0.305 0.021	2345 198
6484-29-1A-L028 -L029 -L031 -L032 -L033 -L034 -1B-L040 -L043 -L044 -L045 -L046 -1A-L025 -L026 -L027 -L030 -1B-L037 -L038 -L039 -L042	EC, radial					1254 1553 2238 2032 1653 1597 1018 2551 1771 1962 2057 2500 2191 1808 2596 2575 1887 1875 <u>2007</u>
Mean Std. Dev.		1.804 0.004	1.13 1.14 1.09 1.19 1.19 1.14 1.17 <u>1.20</u>	0.025 0.019 0.018 0.018 0.016 0.018 0.022 <u>0.017</u>	0.350 0.289 0.234 0.342 0.333 1.241 0.239 <u>0.239</u>	1954 436

TABLE B-17 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-29-3A-L051A -L051B -L055A -L055B -L056A -L056B -3B-L062A -L062B -L066A -L066B -L067A -L067B -3A-L050 -L053 -L054 -L058 -3B-L061 -L064 -L065 -L069	MLC, axial					2519 2186 2517 2426 2111 2328 2119 2338 2079 2248 2243 2339 2596 2390 2651 2116 2338 2152 2072  Mean Std. Dev.
		1.794 1.798 1.798 1.795 1.797 1.792 1.792 1.792	1.34 1.22 1.27 1.14 1.19 1.22 1.17 1.20	0.009 0.016 0.014 0.016 0.022 0.017 0.106 0.016	0.312 0.291 0.324 0.261 0.302 0.259 0.252 (c) 0.286	2304  1144 1189 1338 1368 1244 1389 1374 1290 1658 1439 1633 1235 1240 1229 1563 (d) 894 1054 1108 0.156 0.155
6484-29-3A-L078 -L079 -L081 -L083 -L084 -3B-L090 -L091 -L093 -L094 -L095 -L096 -3A-L075 -L076 -L077 -L080 -3B-L087 -L088 -L089 -L092	MLC, radial					1189 1338 1368 1244 1389 1374 1290 1658 1439 1633 1235 1240 1229 1563 0.017 0.145 0.023 0.019 0.020 0.155 0.023
Mean Std. Dev.		1.794 0.003	1.02 1.02 1.02 1.04 (d) 0.94 0.07 1.08	0.022 0.020 0.026 0.014 (d) 0.200 0.023 0.019	0.147 0.160 0.164 0.200 (d) 0.145 0.134 0.156 0.155	1301  192

TABLE B-17 (Continued)

GA Specimen No.	Location in Log and Orientation	Density (g/cm <sup>3</sup> )	Modulus of Elasticity x 10 <sup>-6</sup> (b) (psi)	Permanent Set After First Loading (%)	Strain at Fracture (%)	Ultimate Strength (psi)
6484-29-3A-L154A	MLE, axial					(c)
-L154B		1.795	1.23	0.013	0.320	2742
-L156B						2665
-L160A						2733
-L160B						2582
-3B-L163A						2489
-L163B						1863
-L165B		1.800	1.22	0.015	0.223	1995
-L166A						2700
-L166B						2837
-L169A						2490
-L169B						(c)
-3A-L151		1.804	1.27	0.021	0.335	2743
-L153		1.803	1.34	0.016	(c)	(c)
-L155		1.807	1.32	0.019	(c)	(c)
-L157		1.805	1.23	0.018	0.354	2753
-3B-L161		1.800	1.22	0.018	0.365	2804
-L162		1.792	1.20	0.014	0.302	2467
-L164		1.797	1.27	0.020	0.336	2665
-L165		1.797	1.23	0.014	0.316	2605
Mean		1.800	1.25	0.017	0.319	2571
Std. Dev.		0.005	0.05	0.003	0.044	275
6484-29-3A-L177	MLE, radial					1349
-L178						1419
-L181						1649
-L182						1732
-L184						1104
-3B-L191						1507
-L192						1018
-L195						1408
-L196						1437
-L199						948
-L200						1013
-3A-L175		1.807	1.09	0.019	0.192	1549
-L176		1.807	1.10	0.025	0.241	1758
-L179		1.802	1.09	0.022	0.251	1844
-L180		1.803	1.08	0.024	0.229	1724
-3B-L193		1.802	1.09	0.020	0.189	1543
-L194		1.799	1.09	0.024	0.170	1394
-L197		1.793	0.97	0.026	0.136	1023
-L198		1.791	(d)	(d)	0.136	998
Mean		1.800	1.07	0.023	0.201	1390
Std. Dev.		0.006	0.05	0.003	0.041	293

(a) Measured at UCC.

(b) Specimens were loaded to 1000 psi, unloaded to zero stress and reloaded to failure while recording the stress-strain curve. Modulus of elasticity = chord modulus between 100 and 1000 psi on second loading.

(c) Bond failure.

(d) Specimen broke during first loading cycle.

TABLE B-18  
POISSON'S RATIO: H-451

GA Specimen No./Log No. (GLCC Log No./Lot No.)	Specimen Size (in.)	No. of Biaxial Gages	Location In Log	Direction of Stress	Direction of Transverse Strain (Poisson's Ratio Tensor Designation)	Loading	Poisson's Ratio (Standard Deviation)								
							200 psi	250 psi	400 psi	500 psi	600 psi	750 psi	800 psi	1000 psi	1200 psi
5947-102-1/ 5651-63 (22 / 266)	0.5 x 0.5 x 6 long	2 (90° apart)	MLC	Radial	Axial ( $\nu_{13} = \nu_{23}$ )	1	0.125		0.121				0.112	0.108	0.105
						2	0.109		<u>0.119</u>				0.117	0.115	0.115
						3			<u>0.119</u>				0.121	0.119	<u>0.119</u>
						Mean							0.121		0.119
					Radial ( $\nu_{12} = \nu_{21}$ )	1	0.140		0.139				0.127		0.118
	0.5 x 0.5 x 6 long	4 (90° apart)	MLC	Radial	Axial ( $\nu_{13} = \nu_{23}$ )	2	0.119		<u>0.138</u>				0.134		0.134
						3			<u>0.138</u>				0.136		<u>0.136</u>
						Mean							0.136		0.136
					Radial ( $\nu_{12} = \nu_{21}$ )	1	0.089 (0.027)		0.096 (0.032)						
						2	0.066 (0.015)		0.096 (0.023)						
5947-102-2/ 5651-63 (22 / 266)	0.5 x 0.5 x 6 long	4 (90° apart)	MLC	Radial	Axial ( $\nu_{13} = \nu_{23}$ )	3	0.086 (0.024)		0.096 (0.024)				0.093 (0.028)		
						4			0.102 (0.021)						
						5									
						6									
						7									
						8									
						9									
						10									
						Mean	0.094 (0.021)		0.098 (0.021)						
						1	0.098 (0.014)		0.102 (0.013)						
5947-102-4/ 5651-63 (22 / 266)	0.5 x 0.5 x 6 long	2 (90° apart)	MLC	Axial	Radial ( $\nu_{31} = \nu_{32}$ )	2	0.067 (0.004)		0.105 (0.018)						
						3	0.095 (0.011)		0.106 (0.013)						
						4							0.098 (0.010)		
						5							0.104 (0.011)		
						6							0.103 (0.011)		
5947-5/ 5651-28 (18 / 266)	0.505 diameter x 6 long	3 (120° apart)	MLC	Axial	Radial ( $\nu_{31} = \nu_{32}$ )	7									
						8									
						9									
						10									
						Mean	0.104 (0.014)		0.104 (0.010)						
						1	0.137 (0.004)		0.131 (0.007)				0.128 (0.008)		
						2	0.134 (0.008)		<u>0.124 (0.013)</u>				0.130 (0.011)	0.119 (0.010)	0.114 (0.011)

TABLE B-18 (Continued)

GA Specimen No./Log No. (GLCC Log No./Lot No.)	Specimen Size (in.)	No. of Biaxial Gages	Location in Log	Direction of Stress	Direction of Transverse Strain (Poisson's Ratio Tensor Designation)	Loading	Poisson's Ratio (Standard Deviation)							
							200 psi	250 psi	400 psi	500 psi	600 psi	750 psi	800 psi	1000 psi
5651-28-133/ 5651-28 (18 / 266)	0.5 x 0.5 x 6 long	4 (90° apart)	MLE	Axial	Radial ( $\nu_{32}$ )	6			0.124 (0.009) 0.124 (0.010)					
						7					0.122 (0.012) 0.126 (0.011)			
						8								
						12								
						13								
					Perpendicular to radius in radial plane ( $\nu_{31}$ )	Mean			0.124 (0.008)					
						6			0.117 (0.006) 0.117 (0.006)					
						7					0.115 (0.006) 0.115 (0.004)			
						8								
						12								
						13								
6399-8-C/ 5651-63 (22 / 266)	0.5 x 0.5 x 6 long	4 (90° apart)	MLE	Axial	Perpendicular to radius in radial plane ( $\nu_{31}$ )	Mean			0.117 (0.005)					
						1	0.112 (0.014)		0.111 (0.010)					
						2	0.114 (0.018)		0.117 (0.012)					
						3	0.107 (0.014)		0.111 (0.009)					
						4	0.101 (0.007)		0.109 (0.009)					
						5	0.112 (0.001)		0.114 (0.001)					
						6	0.115 (0.010)		0.115 (0.006)					
						7	0.114 (0.010)		0.116 (0.011)					
						8	0.118 (0.004)		0.117 (0.004)					
						9	0.109 (0.004)		0.113 (0.006)					
						10	0.115 (0.005)		0.115 (0.006)					
						Mean	0.112 (0.008)		0.114 (0.006)					
					Radial ( $\nu_{32}$ )	1	0.115 (0.009)		0.116 (0.002)					
						2	0.120 (0.007)		0.123 (0.006)					
						3	0.114 (0.001)		0.118 (0.001)					
						4	0.113 (0.004)		0.116 (0.001)					
						5	0.120 (0.004)		0.124 (0.001)					
						6	0.118 (0.004)		0.121 (0.003)					
						7	0.117 (0.005)		0.123 (0.002)					
						8	0.122 (0.002)		0.124 (0.003)					
						9	0.117 (0.004)		0.119 (0.001)					
						10	0.120 (0.004)		0.122 (0.001)					
						Mean	0.118 (0.004)		0.121 (0.003)					

TABLE B-18 (Continued)

GA Specimen No./Log No. (GLCC Log No./Lot No.)	Specimen Size (in.)	No. of Biaxial Gages	Location in Log	Direction of Stress	Direction of Transverse Strain (Poisson's Ratio Tensor Designation)	Loading	Poisson's Ratio (Standard Deviation)								
							200 psi	250 psi	400 psi	500 psi	600 psi	750 psi	800 psi	1000 psi	1200 psi
6399-8-D/ 5651-63 (22 / 266)	0.5 x 0.5 x 6 long	4 (90° apart)	MLC	Radial $(v_{12} = v_{21})$	Radial $(v_{12} = v_{21})$	1	0.119 (0.008)		0.114 (0.008)		0.109 (0.010)		0.106 (0.006)		
						2	0.125 (0.020)		0.118 (0.011)		0.113 (0.011)		0.111 (0.009)		
						3	0.103 (0.009)		0.106 (0.011)		0.106 (0.008)		0.106 (0.008)		
						4	0.102 (0.010)		0.105 (0.008)		0.107 (0.007)		0.107 (0.008)		
						5	0.103 (0.011)		0.106 (0.009)		0.106 (0.008)		0.106 (0.008)		
						6	0.100 (0.006)		0.105 (0.011)		0.106 (0.010)		0.105 (0.008)		
						7	0.098 (0.010)		0.106 (0.013)		0.107 (0.011)		0.107 (0.010)		
						8	0.111 (0.007)		0.108 (0.007)		0.108 (0.006)		0.107 (0.006)		
						9	0.109 (0.000)		0.108 (0.004)		0.108 (0.004)		0.106 (0.005)		
						10	<u>0.109 (0.000)</u>		<u>0.108 (0.004)</u>		<u>0.108 (0.002)</u>		<u>0.108 (0.006)</u>		
						Mean	0.105 (0.007)		0.107 (0.007)		0.107 (0.006)		0.107 (0.006)		
				Axial $(v_{13} = v_{23})$	Axial $(v_{13} = v_{23})$	1	0.127 (0.004)		0.121 (0.003)		0.113 (0.001)		0.117 (0.001)		
						2	0.133 (0.004)		0.123 (0.001)		0.119 (0.001)		0.117 (0.001)		
						3	0.112 (0.004)		0.114 (0.001)		0.113 (0.001)		0.113 (0.000)		
						4	0.112 (0.004)		0.112 (0.002)		0.113 (0.003)		0.112 (0.001)		
						5	0.110 (0.001)		0.112 (0.002)		0.112 (0.003)		0.110 (0.001)		
						6	0.106 (0.005)		0.111 (0.000)		0.112 (0.001)		0.110 (0.001)		
						7	0.108 (0.002)		0.113 (0.001)		0.113 (0.000)		0.113 (0.000)		
						8	0.111 (0.004)		0.113 (0.004)		0.112 (0.002)		0.112 (0.002)		
						9	0.111 (0.001)		0.112 (0.002)		0.111 (0.002)		0.111 (0.002)		
						10	<u>0.112 (0.000)</u>		<u>0.113 (0.002)</u>		<u>0.112 (0.002)</u>		<u>0.112 (0.003)</u>		
						Mean	0.110 (0.003)		0.113 (0.002)		0.113 (0.002)		0.112 (0.001)		
6399-8-A/ 5651-63 (22/266)	0.5 x 0.5 x 6 long	4 (90° apart)	EE	Axial Perpendicular to radius in radial plane $(v_{31})$	Perpendicular to radius in radial plane $(v_{31})$	1	0.112 (0.004)		0.112 (0.005)		0.111 (0.008)		0.111 (0.015)		
						2	0.104 (0.004)		0.112 (0.007)		0.113 (0.012)		0.119 (0.008)		
						3	0.118 (0.000)		0.119 (0.006)		0.119 (0.008)		0.119 (0.008)		
						4	0.118 (0.008)		0.121 (0.012)		0.121 (0.011)		0.119 (0.011)		
						5	0.114 (0.007)		0.116 (0.012)		0.117 (0.008)		0.117 (0.009)		
						6	0.108 (0.006)		0.117 (0.006)		0.118 (0.007)		0.119 (0.007)		
						7	<u>0.108 (0.004)</u>		<u>0.117 (0.006)</u>		<u>0.118 (0.007)</u>		<u>0.120 (0.007)</u>		
				Radial $(v_{32})$	Radial $(v_{32})$	Mean	0.113 (0.005)		0.118 (0.007)		0.119 (0.006)		0.119 (0.006)		
						1	0.105 (0.011)		0.102 (0.007)		0.103 (0.008)		0.106 (0.014)		
						2	0.098 (0.023)		0.106 (0.020)		0.106 (0.017)		0.110 (0.015)		
						3	0.108 (0.011)		0.108 (0.016)		0.111 (0.014)		0.111 (0.016)		
						4	0.103 (0.014)		0.108 (0.017)		0.111 (0.014)		0.111 (0.016)		
						5	0.105 (0.011)		0.107 (0.015)		0.110 (0.013)		0.110 (0.017)		
						6	0.107 (0.011)		0.112 (0.013)		0.112 (0.014)		0.111 (0.016)		
						7	<u>0.107 (0.006)</u>		<u>0.111 (0.013)</u>		<u>0.113 (0.013)</u>		<u>0.114 (0.014)</u>		
						Mean	0.106 (0.008)		0.109 (0.011)		0.112 (0.010)		0.111 (0.011)		

TABLE B-18 (Continued)

GA Specimen No./Log No. (GLCC Log No./Lot No.)	Specimen Size (in.)	No. of Biaxial Gages	Location in Log	Direction of Stress	Direction of Transverse Strain (Poisson's Ratio Tensor Designation)	Loading	Poisson's Ratio (Standard Deviation)								
							200 psi	250 psi	400 psi	500 psi	600 psi	750 psi	800 psi	1000 psi	1200 psi
6399-8-B/ 5651-63 (22/266)	0.5 x 0.5 x 6 long	4 (90° apart)	MLC	Axial	Radial ( $\nu_{31} = \nu_{32}$ )	1 2 3 4 5 6 7 8 Mean	0.120 (0.009) 0.118 (0.008) 0.115 (0.010) 0.125 (0.007) 0.121 (0.005) 0.131 (0.003) 0.123 (0.011) 0.123 (0.009) 0.123 (0.009)		0.123 (0.008) 0.124 (0.010) 0.122 (0.009) 0.125 (0.008) 0.124 (0.008) 0.127 (0.006) 0.125 (0.007) 0.125 (0.009) 0.125 (0.008)		0.123 (0.008) 0.125 (0.009) 0.124 (0.009) 0.125 (0.008) 0.125 (0.009) 0.125 (0.008) 0.126 (0.009) 0.126 (0.008) 0.126 (0.008)		0.121 (0.008) 0.125 (0.008) 0.125 (0.009) 0.126 (0.008) 0.125 (0.008) 0.128 (0.008) 0.125 (0.009) 0.126 (0.008) 0.126 (0.007)		

TABLE B-19  
POISSON'S RATIO: TS-1240

GA Specimen No./Log No. (GLCC Log No./Lot No.)	Specimen Size (in.)	No. of Biaxial Gages	Location in Log	Direction of Stress	Direction of Transverse Strain (Poisson's Ratio Tensor Designation)	Loading	Poisson's Ratio (Standard Deviation)			
							250 psi	500 psi	750 psi	1000 psi
5651-72-3B-L063/ 5651-72 (30 / 1)	0.505 diameter x 6 long	3 (120° apart)	MLC	Axial	Radial ( $\nu_{31} = \nu_{32}$ )	1 2 3 4 11 Mean	0.142 (0.015) 0.150 (0.016) 0.152 (0.010) 0.149 (0.011) 0.160 (0.008) 0.154 (0.010)	0.134 (0.012) 0.147 (0.015) 0.152 (0.011) 0.151 (0.011) 0.153 (0.012) 0.152 (0.010)	0.119 (0.014) 0.145 (0.016) 0.151 (0.012) 0.150 (0.012) 0.154 (0.012) 0.150 (0.010)	0.151 (0.012) 0.151 (0.012)
5651-72-3B-L095/ 5651-72 (30 / 1)	0.505 diameter x 6 long	3 (120° apart)	MLC	Radial	Unknown ( $\nu_{12} = \nu_{21}$ / $\nu_{13} = \nu_{23}$ ) <sup>(a)</sup>	1 2 3 4 5 6 7 8 Mean	0.122 (0.007) 0.128 (0.010) 0.132 (0.008) 0.126 (0.007) 0.131 (0.008) 0.132 (0.007) 0.129 (0.009) 0.128 (0.012) 0.130 (0.008)	0.115 (0.009) 0.128 (0.008) 0.130 (0.007) 0.127 (0.008) 0.126 (0.004) 0.129 (0.007) 0.128 (0.008) 0.130 (0.008) 0.130 (0.006)	0.103 (0.009) 0.123 (0.005) 0.129 (0.007) 0.127 (0.007) 0.128 (0.008) 0.129 (0.008) 0.128 (0.009) 0.127 (0.008) 0.128 (0.007)	

(a) Orientation of sample in log with respect to directions of measured transverse strains was unknown. Poisson's ratio values shown represent mean of various components ( $\nu_{12}$ ,  $\nu_{21}$ ,  $\nu_{13}$ ,  $\nu_{23}$ ) indicated.

TABLE B-20  
 THERMAL EXPANSIVITY OF H-451, LOT 266  
 [Log 6484-28 (GLCC 18), whole log density = 1.77 g/cm<sup>3</sup><sup>(a)</sup>]

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6$ °C <sup>-1</sup> (22° - 500°C)
KO 353	MLC, axial	3.44
354		3.44
355		3.49
356		3.42
357		<u>3.46</u>
Mean		3.45
Std. Dev.		0.03
KO 341	MLC, radial	4.43
342		4.36
343		4.40
344		4.20
345		4.60
346		<u>4.45</u>
Mean		4.41
Std. Dev.		0.13
KO 359	MLE, axial	3.36
360		3.52
361		3.51
362		3.43
363		3.48
364		<u>3.41</u>
Mean		3.45
Std. Dev.		0.06
KO 347	MLE, radial	4.34
348		4.58
349		4.61
350		4.63
351		4.53
352		<u>4.25</u>
Mean		4.49
Std. Dev.		0.16

(a) Measured at GLCC.

TABLE B-21  
THERMAL EXPANSIVITY OF H-451, LOT 408  
[Log 5651-86 (GLCC 52), whole log density = 1.74 g/cm<sup>3</sup>(a)]

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, (b) $\alpha \times 10^6$ °C <sup>-1</sup> (22° - 500°C)
5651-86-3A-001B -002B -010B -011B -3B-001B -002B -010B -011B	MLC, axial	4.00 (4.36) 4.35 (4.26) 4.41 4.14 4.08 (4.44) 4.27 (4.35) 4.04 4.16
Mean		4.18
Std. Dev.		0.15
5651-86-3A-031B -032B -040B -041B -3B-031B -032B -040B -041B -031A -041A	MLC, radial	4.53 (4.73) 4.81 (4.77) 4.62 4.82 4.37 (4.66) 4.47 (4.44) 4.72 4.64 4.83 4.46
Mean		4.63
Std. Dev.		0.17
5651-86-3A-101B -102B -110B -111B -3B-101A -101B -111A -111B -102B -110B	MLE, axial	4.20 (4.39) 4.36 4.21 4.11 (4.19) 4.10 4.11 (4.31) 4.10 4.05 (4.31) 4.34 4.28
Mean		4.19
Std. Dev.		0.11
5651-86-3A-131A -131B -141A -141B -132B -140B 3B-131A -131B -141A -141B -132B -140B	MLE, radial	4.62 4.16 (4.40) 4.80 4.35 (4.64) 4.66 4.62 4.84 4.65 (4.77) 4.69 4.27 (4.40) 4.72 4.43
Mean		4.57
Std. Dev.		0.21

(a) Measured at GLCC.

(b) Values in parentheses are repeat measurements.

TABLE B-22  
 THERMAL EXPANSIVITY OF H-451, LOT 426  
 [Log 6484-33 (GLCC 92), whole log density = 1.75 g/cm<sup>3</sup><sup>(a)</sup>]

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6$ °C <sup>-1</sup> (22°-500°C)
6484-33-1A-L007A	EC, axial	4.10
-L007B		4.16
-L010A		3.81
-L010B		4.17
-1B-L032A		4.02
-L032B		4.15
-L035A		3.69
-L035B		<u>3.90</u>
Mean		4.00
Std. Dev.		0.18
-1A-L063A	EC, radial	4.66
-L063B		4.67
-L066A		4.68
-L066B		4.87
-1B-L073A		4.53
-L073B		4.74
-L076A		4.53
-L076B		<u>4.90</u>
Mean		4.70
Std. Dev.		0.14
-1A-L052A	EE, axial	3.78
-L052B		3.96
-L054A		3.75
-L054B		3.93
-1B-L057A		3.97
-L057B		3.97
-L059A		3.83
-L059B		<u>3.89</u>
Mean		3.88
Std. Dev.		0.09
-1A-L081A	EE, radial	4.58
-L081B		4.41
-L083A		5.12
-L083B		4.79
-1B-L085A		4.80
-L085B		4.60
-L087A		4.59
-L087B		<u>4.69</u>
Mean		4.70
Std. Dev.		0.21

TABLE B-22 (Continued)

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22 $^\circ$ -500 $^\circ$ C)
6484-33-3A-L107A	MLC, axial	4.19
-L107B		4.27
-L110A		4.26
-L110B		4.09
-3B-L132A		3.96
-L132B		3.90
-L135A		4.04
-L135B		3.94
Mean		4.08
Std. Dev.		0.14
-3A-L163A	MLC, radial	4.62
-L163B		4.35
-L166A		5.19
-L166B		4.37
-3B-L173A		4.37
-L173B		4.29
-L176A		4.45
-L176B		4.45
Mean		4.51
Std. Dev.		0.29
-3A-L152A	MLE, axial	3.78
-L152B		3.92
-L154A		3.81
-L154B		4.24
-3B-L157A		3.70
-L157B		3.58
-L159A		3.80
-L159B		4.03
Mean		3.86
Std. Dev.		0.20
-3A-L181A	MLE, radial	4.80
-L181B		4.61
-L183A		4.59
-L183B		4.85
-3B-L185A		4.66
-L185B		4.60
-L187A		4.65
-L187B		4.43
Mean		4.65
Std. Dev.		0.13

(a) Measured at GLCC.

TABLE B-23  
 THERMAL EXPANSIVITY OF H-451, LOT 426  
 [Log 6484-34 (GLCC 198), whole log density = 1.71 g/cm<sup>3</sup>(a)]

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6$ °C <sup>-1</sup> (22°-500°C)
6484-34-1A-L007A	EC, axial	4.24
-L007B		4.32
-L010A		4.46
-L010B		4.22
-1B-L032A		4.31
-L032B		4.40
-L035A		4.24
-L035B		<u>4.29</u>
Mean		4.31
Std. Dev.		0.08
↓		
-1A-L063A	EC, radial	5.02
-L063B		4.91
-L066A		4.50
-L066B		4.33
-1B-L073A		4.41
-L073B		4.36
-L076A		4.35
-L076B		<u>4.52</u>
Mean		4.55
Std. Dev.		0.27
↓		
-1A-L052A	EE, axial	3.88
-L052B		4.13
-L054A		4.07
-L054B		4.17
-1B-L057A		4.24
-L057B		4.19
-L059A		4.09
-L059B		<u>4.25</u>
Mean		4.13
Std. Dev.		0.12
↓		
-1A-L081A	EE, radial	4.62
-L081B		4.52
-L083A		4.66
-L083B		4.75
-1B-L085A		4.70
-L085B		4.53
-L087A		4.52
-L087B		<u>4.45</u>
Mean		4.59
Std. Dev.		0.10

TABLE B-23 (Continued)

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22°-500°C)
6484-34-3A-L107A -L107B -L110A -L110B -3B-L132A -L132B -L135A -L135B	MLC, axial	4.06 4.13 3.98 4.31 4.03 4.07 4.13 <u>4.13</u>
Mean		4.10
Std. Dev.		0.10
-3A-L163A -L163B -L166A -L166B -3B-L173A -L173B -L176A -L176B	MLC, radial	4.75 4.47 4.73 4.72 4.88 4.24 4.68 <u>4.56</u>
Mean		4.63
Std. Dev.		0.20
-3A-L152A -L152B -L154A -L154B -3B-L157A -L157B -L159A -L159B	MLE, axial	3.69 4.08 3.75 3.88 4.21 4.02 3.70 <u>4.01</u>
Mean		3.92
Std. Dev.		0.19
-3A-L181A -L181B -L183A -L183B -3B-L185A -L185B -L187A -L187B	MLE, radial	4.61 4.63 5.14 4.66 4.79 4.77 4.61 <u>4.42</u>
Mean		4.66
Std. Dev.		0.25

(a) Measured at GLCC.

TABLE B-24  
 THERMAL EXPANSIVITY OF H-451, LOT 426  
 [Log 6484-41 (GLCC 184), whole log density = 1.72 g/cm<sup>3</sup><sup>(a)</sup>]

GA Specimen No. No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6$ °C <sup>-1</sup> (22°-500°C)
6484-41-1A-004A	EC, axial	3.80
-004B		4.11
-014A		4.00
-014B		3.88
-1B-004A		4.00
-004B		3.79
-014A		3.93
-014B		<u>3.70</u>
Mean		3.90
Std. Dev.		0.13
-1A-031A	EC, radial	4.35
-031B		4.68
-044A		4.57
-044B		4.20
-1B-031A		4.44
-031B		4.26
-044A		4.48
-044B		<u>4.48</u>
Mean		4.43
Std. Dev.		0.16
-1A-053A	EE, axial	3.99
-053B		3.76
-058A		3.98
-058B		3.89
-1B-053A		3.92
-053B		3.92
-058A		3.76
-058B		<u>3.90</u>
Mean		3.89
Std. Dev.		0.09
-1A-071A	EE, radial	4.46
-071B		4.30
-084A		4.71
-084B		4.85
-1B-071A		4.50
-071B		4.59
-084A		4.80
-084B		<u>4.54</u>
Mean		4.59
Std. Dev.		0.18

TABLE B-24 (Continued)

GA Specimen No. No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22 $^\circ$ -500 $^\circ\text{C}$ )
6484-41-3A-004A	MLC, axial	3.87
-004B		4.02
-014A		3.95
-014B		4.02
-3B-004A		3.86
-004B		3.93
-014A		3.85
-014B		<u>3.84</u>
Mean		3.92
Std. Dev.		0.07
	↓	↓
-3A-031A	MLC, radial	4.57
-031B		4.68
-044A		4.18
-044B		4.31
-3B-031A		4.43
-031B		4.49
-044A		4.18
-044B		<u>4.50</u>
Mean		4.42
Std. Dev.		0.18
	↓	↓
-3A-053A	MLE, axial	3.91
-053B		3.86
-058A		3.78
-058B		3.81
-3B-053A		4.03
-053B		4.04
-058A		3.92
-058B		<u>3.88</u>
Mean		3.90
Std. Dev.		0.09
	↓	↓
-3A-071A	MLE, radial	4.48
-071B		4.63
-084A		4.82
-084B		4.25
-3B-071A		4.46
-071B		4.60
-084A		4.29
-084B		<u>4.48</u>
Mean		4.50
Std. Dev.		0.18

(a) Measured at GLCC.

TABLE B-25  
 THERMAL EXPANSIVITY OF TS-1240, LOT 1  
 [Log 5651-72 (UCC 32), whole log density = 1.77 g/cm<sup>3</sup>(a)]

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22°–500°C)
5651-72-1A-007A	EC, axial	4.51
-007B		4.43
-010A		4.60
-010B		4.45
-1B-032A		4.36
-032B		4.40
-035A		4.64
-035B		4.52
Mean		4.48
Std. Dev.		0.097
5651-72-1A-063A	EC, radial	4.70
-063B		5.08
-066A		4.75
-066B		4.61
-1B-073A		4.80
-073B		4.83
-076A		4.66
-076B		5.33
Mean		4.84
Std. Dev.		0.243
5651-72-1A-052A	EE, axial	3.96
-052B		4.45
-054A		4.32
-054B		4.75
-1B-057A		4.28
-057B		4.48
-059A		4.96
-059B		4.73
Mean		4.49
Std. Dev.		0.317
5651-72-1A-081A	EE, radial	4.77
-081B		5.57
-083A		5.07
-083B		5.04
-1B-085A		5.00
-085B		5.16
-087A		4.31
-087B		4.83
Mean		4.96
Std. Dev.		0.360

TABLE B-25 (Continued)

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22 $^\circ$ -500 $^\circ$ C)
5651-72-3A-107A	QLC, axial	4.16
-107B		4.29
-110A		4.00
-110B		4.35
-3B-132A		3.83
-132B		4.10
-135A		3.78
-135B		3.90
Mean		4.05
Std. Dev.		0.209
5651-72-3A-163A	QLC, radial	4.64
-163B		4.45
-166A		4.42
-166B		4.63
-3B-173A		4.50
-173B		4.31
-176A		4.55
-176B		4.52
Mean		4.50
Std. Dev.		0.109
5651-72-3A-152A	QLE, axial	3.99
-152B		4.02
-154A		4.45
-154B		3.92
-3B-157A		4.16
-157B		4.19
-159A		4.17
-159B		4.03
Mean		4.12
Std. Dev.		0.165
5651-72-3A-181A	QLE, radial	4.90
-181B		4.44
-183A		5.07
-183B		4.65
-3B-185A		4.65
-185B		4.50
-187A		4.65
-187B		4.63
Mean		4.68
Std. Dev.		0.205

(a) Measured at UCC.

TABLE B-26  
THERMAL EXPANSIVITY OF TS-1240, LOT 1  
[Log 5651-73 (UCC 40), whole log density = 1.80 g/cm<sup>3</sup>(a)]

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, (b) $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22°-300°C)
5651-73-3A-001B -002B -010B -011B -3B-001B -002B -010B -011B	MLC, axial	4.17 (4.04) 4.22 4.20 4.46 (4.18) 3.97 (4.22) 4.09 4.67 4.29 (3.99)
Mean Std. Dev.		4.26 0.22
5651-73-3A-031B -032B -040B -041B 3B-031B -032B -0408 -041B	MLC, radial	4.81 (4.39) 4.81 4.96 4.89 (4.55) 4.85 (4.54) 4.64 4.86 4.89 (4.57)
Mean Std. Dev.		4.84 0.09
5651-73-3A-101B -102B -111A -111B -110B 3B-101A -101B -111A -111B -102B -110B	MLE, axial	4.29 (4.12) 4.61 3.86 4.04 (4.08) 4.51 4.05 4.15 (4.02) 4.27 4.25 4.63 4.45
Mean Std. Dev.		4.28 0.25
5651-3A-131A -131B -141A -141B -132B -140B 3B-131A -131B -141A -141B -132B -140B	MLE, radial	4.28 4.78 (4.57) 4.56 4.86 (4.45) 4.70 5.15 4.53 4.83 (4.54) 4.81 4.70 (4.41) 4.80 4.78
Mean Std. Dev.		4.73 0.21

(a) Measured at UCC.

(b) Values in parentheses are repeat measurements.

TABLE B-27  
 THERMAL EXPANSIVITY OF TS-1240, LOT 1  
 [Log 5651-74 (UCC 42), whole log density = 1.82 g/cm<sup>3</sup>(a)]

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22°-500°C)
5651-74-1A-007A	EC, axial	4.25
-007B		4.09
-010A		4.28
-010B		4.49
-1B-032A		4.25
-032B		4.55
-035A		4.25
-035B		4.15
Mean		4.29
Std. Dev.		0.16
5651-74-1A-063A	EC, radial	4.45
-063B		4.52
-066A		4.75
-066B		4.75
-1B-073A		4.56
-073B		4.67
-076A		4.71
-076B		4.71
Mean		4.63
Std. Dev.		0.11
5651-74-1A-052A	EE, axial	4.45
-052B		4.68
-054A		4.23
-054B		4.16
-1B-057A		4.20
-057B		4.17
-059A		4.20
-059B		4.16
Mean		4.28
Std. Dev.		0.19
5651-74-1A-081A	EE, radial	4.75
-081B		4.86
-083A		4.94
-083B		4.65
-1B-085A		4.83
-085B		4.85
-087A		5.01
-087B		4.83
Mean		4.84
Std. Dev.		0.11

TABLE B-27 (Continued)

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22°–500°C)
5651-74-3A-107A -107B -110A -110B 3B-132A -132B -135A -135B	MLC, axial	4.38 4.22 4.39 4.27 4.33 4.33 4.31 4.41
Mean		4.33
Std. Dev.		0.06
5651-74-3A-163A -163B -166A -166B -3B-173A -173B -176A -176B	MLC, radial	4.79 4.61 4.70 4.51 4.16 4.59 4.60 4.57
Mean		4.57
Std. Dev.		0.18
5651-74-3A-152A -152B -154A -154B -3B-157A -157B -159A -159B	MLE, axial	4.33 4.27 4.28 4.13 4.22 4.27 4.34 4.24
Mean		4.26
Std. Dev.		0.07
5651-74-3A-181A -181B -183A -183B 3B-185A -185B -187A -187B	MLE, radial	4.66 4.71 4.75 4.74 4.52 4.68 4.41 4.52
Mean		4.62
Std. Dev.		0.12

(a) Measured at UCC.

TABLE B-28  
 THERMAL EXPANSIVITY OF TS-1240, LOT 1  
 [Log 5651-75 (UCC 46), whole log density = 1.84 g/cm<sup>3</sup>(a)]

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22°-500°C)
5651-75-1A-052A	EE, axial	4.59
-052B		4.38
-054A		4.40
-054B		4.27
-1B-057A		4.28
-057B		4.42
-059A		4.69
-059B		<u>4.56</u>
Mean		4.44
Std. Dev.		0.151
5651-75-1A-081A	EE, radial	5.11
-081B		4.80
-083A		5.26
-083B		4.81
-1B-085A		4.91
-085B		4.86
-087A		4.84
-087B		<u>5.03</u>
Mean		4.95
Std. Dev.		0.166
5651-75-3A-152A	MLE, axial	4.21
-152B		4.31
-154A		4.20
-154B		4.30
-3B-157A		3.94
-157B		4.09
-159A		4.31
-159B		<u>4.12</u>
Mean		4.18
Std. Dev.		0.130
5651-75-3A-181A	MLE, radial	4.68
-181B		4.67
-183A		2.58
-183B		4.72
-3B-185A		4.72
-185B		4.73
-187A		4.57
-187B		<u>4.94</u>
Mean		4.70
Std. Dev.		0.114

TABLE B-28 (Continued)

GA Specimen No.	Location in Log And Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22°-500°C)
5651-75-3A-107A -107B -110A -110B -3B-132A -132B -135A -135B	MLC, axial	3.87 3.95 3.86 3.86 3.96 3.73 4.03 3.91
Mean		3.90
Std. Dev.		0.089
5651-75-3A-163A -163B -166A -166B -3B-173A -173B -176A -176B	MLC, radial	4.41 4.33 4.12 4.31 4.26 4.42 4.61 4.45
Mean		4.36
Std. Dev.		0.145
5651-75-1A-007A -007B -010A -010B -1B-032A -032B -035A -035B	EC, axial	3.75 3.58 3.54 3.63 3.60 3.61 3.83 3.99
Mean		3.69
Std. Dev.		0.154
5651-75-1A-063A -063B -066A -066B -1B-073A -073B -076A -976B	EC, radial	4.20 4.30 4.17 4.54 4.30 4.46 4.29 3.91
Mean		4.27
Std. Dev.		0.191

(a) Measured at UCC.

TABLE B-29  
 THERMAL EXPANSIVITY OF TS-1240, LOT 1  
 [Log 6484-29 (UCC 8-1S-ID-23), whole log density = 1.83 g/cm<sup>3</sup><sup>(a)</sup>]

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ } ^\circ\text{C}^{-1}$ (22 $^\circ$ -500 $^\circ$ C)
6484-29-1A-L007A	EC, axial	4.46
-L007B		4.67
-L010A		4.63
-L010B		4.61
-1B-L032A		4.85
-L032B		4.91
-L035A		4.45
-L035B		4.29
Mean		4.61
Std. Dev.		0.21
	↓	
-1A-L063A	EC, radial	5.59
-L063B		5.40
-L066A		5.03
-L066B		5.08
-1B-L073A		5.53
-L073B		5.94
-L076A		5.30
-L076B		5.24
Mean		5.39
Std. Dev.		0.30
	↓	
-1A-L052A	EE, axial	4.63
-L052B		4.98
-L054A		4.61
-L054B		4.61
-1B-L057A		4.48
-L057B		4.72
-L059A		4.80
-L059B		4.72
Mean		4.69
Std. Dev.		0.15
	↓	
-1A-L081A	EE, radial	5.01
-L081B		5.01
-L083A		4.92
-L083B		4.88
-1B-L085A		5.17
-L085B		5.22
-L087A		4.97
-L087B		5.06
Mean		5.03
Std. Dev.		0.12

TABLE B-29 (Continued)

GA Specimen No.	Location in Log and Orientation	Mean Coefficient of Thermal Expansion, $\alpha \times 10^6 \text{ }^{\circ}\text{C}^{-1}$ (22 $^{\circ}$ -500 $^{\circ}$ C)
6484-29-3A-L107A	MLC, axial	4.45
-L107B		4.51
-L110A		4.39
-L110B		4.76
-3B-L132A		4.71
-L132B		4.81
-L135A		4.81
-L135B		4.63
Mean		4.63
Std. Dev.		0.17
-3A-L163A	MLC, radial	4.91
-L163B		4.97
-L166A		4.92
-L166B		5.02
-3B-L173A		4.93
-L173B		5.28
-L176A		4.93
-L176B		5.06
Mean		5.00
Std. Dev.		0.12
-3A-L152A	MLE, axial	4.36
-L152B		4.74
-L154A		4.80
-L154B		4.62
-3B-L157A		4.48
-L157B		4.59
-L159A		4.55
-L159B		4.61
Mean		4.59
Std. Dev.		0.14
-3A-L181A	MLE, radial	4.96
-L181B		4.97
-L183A		5.30
-L183B		5.34
-3B-L185A		5.11
-L185B		5.11
-L187A		5.53
-L187B		5.11
Mean		5.18
Std. Dev.		0.20

(a) Measured at UCC.

TABLE B-30  
 THERMAL CONDUCTIVITY OF H-451, LOT 266  
 [Log 5651-28 (GLCC 18), whole log density = 1.77 g/cm<sup>3</sup>(a)]

GA Specimen No.	Location in Log and Orientation	Thermal Conductivity (cal/cm-sec-°C)				
		22°C	200°C	400°C	600°C	800°C
L-0011	MLC, radial	0.302	0.249	0.210	0.173	0.147
0012		0.324	0.273	0.235	0.195	0.163
0013		0.315	0.277	0.225	0.186	0.160
0014		0.317	0.275	0.223	0.175	0.145
0015		0.310	0.270	0.235	0.193	0.175
0017		0.287	0.245	0.204	0.173	0.150
0028		0.283	0.265	0.225	0.190	0.155
0029		0.278	0.265	0.226	0.198	0.165
0030		0.274	0.245	0.212	0.187	0.155
0031		0.270	0.261	0.223	0.185	0.162
0033		0.295	0.264	0.224	0.188	0.162
0034		0.285	0.260	0.222	0.175	0.154
Mean		0.295	0.262	0.222	0.185	0.158
Std. Dev.		0.018	0.011	0.009	0.009	0.008
L-0137	MLC, axial	0.355	0.308	0.220	0.204	0.166
0138		0.346	0.309	0.252	0.209	0.179
0139		0.344	0.306	0.250	0.217	0.188
0140		0.345	0.307	0.257	0.210	0.174
0141		0.347	0.300	0.253	0.209	0.175
0142		0.346	0.305	0.264	0.205	0.173
0143		0.351	0.303	0.244	0.207	0.168
0144		0.343	0.297	0.257	0.210	0.173
0145		0.345	0.298	0.251	0.203	0.174
0146		0.345	0.291	0.232	0.198	0.172
0147		0.346	0.300	0.241	0.198	0.173
0148		0.348	0.301	0.232	0.203	0.171
Mean		0.347	0.302	0.246	0.206	0.174
Std. Dev.		0.003	0.005	0.013	0.005	0.006

(a) Measured at GLCC.

TABLE B-31  
 THERMAL CONDUCTIVITY OF H-451, LOT 408  
 [Log 5651-86 (GLCC 52), whole log density = 1.74 gm/cm<sup>3</sup><sup>(a)</sup>]

GA Specimen No.	Location in Log and Orientation	Thermal Conductivity (cal/cm-sec-°C)				
		22°C	200°C	400°C	600°C	800°C
5651-86-3A-L1M	MLC, axial	0.288	0.273	0.242	0.196	0.177
		0.252	0.245	0.218	0.183	0.141
		0.242	0.238	0.205	0.176	0.150
		0.244	0.236	0.203	0.174	0.155
		0.253	0.235	0.203	0.174	0.155
		0.253	0.219	0.182	0.163	0.144
		0.242	0.215	0.195	0.173	0.147
		0.248	0.246	0.209	0.173	0.151
		—	—	—	—	—
Mean		0.253	0.238	0.207	0.176	0.152
Std. Dev.		0.015	0.018	0.017	0.010	0.011
5651-86-3A-L8A	MLC, radial	0.249	0.221	0.188	0.160	0.145
		0.253	0.216	0.190	0.156	0.133
		0.242	0.234	0.201	0.173	0.144
		0.253	0.233	0.203	0.169	0.148
		0.266	0.236	0.210	0.178	0.152
		0.247	0.233	0.199	0.166	0.150
		0.251	0.228	0.192	0.166	0.147
		0.248	0.224	0.189	0.164	0.141
		—	—	—	—	—
Mean		0.251	0.228	0.196	0.166	0.145
Std. Dev.		0.007	0.007	0.008	0.007	0.006

(a) Measured at GLCC.

TABLE B-32  
THERMAL CONDUCTIVITY OF H-451, LOT 426  
[Log 6484-34 (GLCC 198), whole log density = 1.73 g/cm<sup>3</sup><sup>(a)</sup> and  
log 6484-41 (GLCC 184), whole log density = 1.72 g/cm<sup>3</sup><sup>(a)</sup>] ]

GA Specimen No.	Location in Log and Orientation	Thermal Conductivity (cal/cm-sec-°C)				
		22°C	200°C	400°C	600°C	800°C
6484-34-3A-L51A	MLC, axial	0.271	0.227	0.186	0.164	0.138
		0.327	0.268	0.211	0.162	0.147
		0.315	0.292	0.241	0.190	0.165
		0.317	0.266	0.228	0.192	0.163
		0.281	0.271	0.224	0.182	0.158
		0.382	0.442	0.231	0.180	0.163
		0.384	0.275	0.224	0.187	0.167
		<u>0.323</u>	<u>0.265</u>	<u>0.225</u>	<u>0.174</u>	<u>0.142</u>
Mean		0.325	0.288	0.221	0.179	0.155
Std. Dev.		0.041	0.065	0.017	0.011	0.011
6484-34-3A-L78A	MLC, radial	0.312	0.270	0.201	0.173	0.149
		0.310	0.273	0.200	0.144	0.141
		0.341	0.303	0.222	0.189	0.156
		0.324	0.266	0.197	0.175	0.136
		0.258	0.284	0.235	0.179	0.163
		0.308	0.259	0.199	0.170	0.142
		0.312	0.282	0.205	0.180	0.144
		<u>0.296</u>	<u>0.266</u>	<u>0.226</u>	<u>0.192</u>	<u>0.168</u>
Mean		0.308	0.275	0.211	0.175	0.150
Std. Dev.		0.024	0.014	0.015	0.015	0.011
6484-41-3A-L003A	MLC, axial	0.325	0.280	0.219	0.179	0.151
		0.341	0.272	0.215	0.157	0.150
		0.430	0.296	0.203	0.175	0.148
		0.381	0.366	0.219	0.190	0.148
		0.339	0.301	0.224	0.188	0.167
		0.328	0.306	0.232	0.198	0.158
		<u>0.312</u>	<u>0.268</u>	<u>0.228</u>	<u>0.189</u>	<u>0.157</u>
Mean		0.351	0.298	0.220	0.183	0.154
Std. Dev.		0.041	0.033	0.009	0.013	0.007
6484-41-3A-L016A	MLC, radial	0.308	0.272	0.205	0.189	0.150
		0.293	0.245	0.204	0.159	0.139
		0.340	0.286	0.221	0.178	0.138
		0.309	0.272	0.215	0.174	0.162
		0.382	0.274	0.216	0.188	0.163
		0.361	0.281	0.219	0.179	0.151
		<u>0.336</u>	<u>0.244</u>	<u>0.197</u>	<u>0.168</u>	<u>0.145</u>
Mean		0.333	0.268	0.211	0.176	0.150
Std. Dev.		0.032	0.017	0.009	0.011	0.010

(a) Measured at GLCC.

TABLE B-33  
 THERMAL CONDUCTIVITY OF TS-1240, LOT 1  
 [Log 5651-72 (UCC 32), whole log density = 1.77 g/cm<sup>3</sup>(a) and  
 log 5651-75 (UCC 46), whole log density = 1.84 g/cm<sup>3</sup>(a)]

GA Specimen No.	Position in Log and Orientation	Thermal Conductivity (cal/cm-sec-°C)				
		22°C	200°C	400°C	600°C	800°C
5651-72-3A-L51A -L51B -L55A -L55B -3B-L62A -L62B -L66A -L66B	QLC, axial	0.234	0.222	0.196	0.153	0.130
		0.242	0.236	0.190	0.162	0.139
		0.265	0.237	0.193	0.163	0.139
		0.256	0.220	0.193	0.151	0.134
		0.224	0.207	0.183	0.152	0.133
		0.231	0.205	0.182	0.156	0.129
		0.266	0.232	0.213	0.169	0.151
		0.235	0.212	0.188	0.153	0.129
		0.245	0.222	0.193	0.157	0.136
Mean		0.017	0.013	0.010	0.006	0.007
5651-72-3A-L78A -L78B -L81A -L81B -3B-L90A -L90B -L93A -L93B	QLC, radial	0.219	0.208	0.183	0.150	0.123
		0.243	0.230	0.193	0.170	0.146
		0.229	0.216	0.181	0.172	0.141
		0.247	0.219	0.186	0.150	0.130
		0.242	0.198	0.178	0.157	0.127
		0.248	0.216	0.184	0.165	0.139
		0.231	0.215	0.187	0.175	0.142
		0.222	0.201	0.170	0.145	0.125
		0.235	0.213	0.183	0.160	0.134
Mean		0.011	0.010	0.007	0.011	0.009
5651-75-3A-L51A -L51B -L55A -L55B -3B-L62A -L62B -L66A -L66B	MLC, axial	0.323	0.278	0.240	0.210	0.175
		0.246	0.244	0.214	0.169	0.151
		0.255	0.250	0.222	0.194	0.161
		0.248	0.238	0.221	0.195	0.172
		0.240	0.233	0.217	0.184	0.157
		0.266	0.245	0.223	0.189	0.168
		0.262	0.237	0.220	0.192	0.163
		0.248	0.236	0.216	0.188	0.166
		0.261	0.245	0.222	0.190	0.164
Mean		0.026	0.014	0.008	0.011	0.008
5651-75-3A-L78A -L78B -L81A -L81B -3B-L90A -L90B -L93A -L93B	MLC, radial	0.246	0.244	0.199	0.178	0.151
		0.254	0.249	0.213	0.188	0.164
		0.248	0.248	0.216	0.184	0.160
		0.262	0.244	0.204	0.177	0.156
		0.241	0.235	0.202	0.180	0.154
		0.243	0.241	0.211	0.186	0.160
		0.275	0.250	0.210	0.185	0.161
		0.265	0.255	0.214	0.189	0.165
		0.254	0.254	0.209	0.183	0.159
Mean		0.012	0.006	0.006	0.004	0.005

(a) Measured at UCC.

TABLE B-34  
 THERMAL CONDUCTIVITY OF TS-1240, LOT 1  
 [Log 5651-73 (UCC 40), whole log density = 1.80 g/cm<sup>3</sup><sup>(a)</sup>]

GA Specimen No.	Location in Log and Orientation	Thermal Conductivity (cal/cm-sec-°C)				
		22°C	200°C	400°C	600°C	800°C
5651-73-3A-L001M	MLC, axial	0.211	0.204	0.185	0.159	0.139
		0.219	0.216	0.174	0.155	0.139
		0.226	0.213	0.180	0.160	0.143
		0.230	0.221	0.199	0.164	0.143
		0.225	0.221	0.188	0.165	0.144
		0.245	0.229	0.192	0.163	0.139
		0.274	0.250	0.218	0.176	0.154
		<u>0.243</u>	<u>0.233</u>	<u>0.204</u>	<u>0.180</u>	<u>0.157</u>
Mean		0.234	0.223	0.192	0.165	0.145
Std. Dev.		0.020	0.014	0.014	0.008	0.007
5651-73-3A-L008A	MLC, radial	0.242	0.230	0.203	0.166	0.158
		0.244	0.233	0.188	0.161	0.144
		0.258	0.246	0.202	0.179	0.154
		0.230	0.224	0.184	0.161	0.141
		0.260	0.230	0.207	0.175	0.151
		0.251	0.231	0.190	0.163	0.143
		0.246	0.227	0.193	0.168	0.143
		<u>0.249</u>	<u>0.229</u>	<u>0.197</u>	<u>0.166</u>	<u>0.147</u>
Mean		0.247	0.231	0.195	0.167	0.148
Std. Dev.		0.010	0.006	0.008	0.006	0.006

(a) Measured at UCC.

TABLE B-35  
IMPURITY CONTENT OF H-451  
[in ppm(a)]

[GA Log No. (GLCC Log No., Lot No.)] GA Specimen No.	Location in Log	Ash	B	Fe	V	Ti	S	Al	Ca	Si	Na	Mg	Pb	
[5651-28 (18,226)]														
30434-1 -2 -3 -4 -5 -6	MLC	530	1.0	4.0	20.0	8.0	(b)	(b)	(b)	(b)	(b)	(b)	(b)	
	MLC	270	2.0	10.0	80.0	10.0	(b)	(b)	(b)	(b)	(b)	(b)	(b)	
	MLE	440	4.0	2.0	<4.0	4.0	(b)	(b)	(b)	(b)	(b)	(b)	(b)	
	MLE	490	5.0	4.0	<4.0	2.0	(b)	(b)	(b)	(b)	(b)	(b)	(b)	
	EE	230	3.0	4.0	<4.0	4.0	(b)	(b)	(b)	(b)	(b)	(b)	(b)	
	EE	360	2.0	4.0	<4.0	1.0	(b)	(b)	(b)	(b)	(b)	(b)	(b)	
Mean	Whole log	385	2.8	5.6	<19.0	4.8	(b)	(b)	(b)	(b)	(b)	(b)	(b)	
B-92 [5651-86 (52,408)]	MLC	<53	1.0	4.0	<0.5	<1.0	<1.5	<1.0	<20.0	60.0	<10.0	<0.5	<6.0	
	MLC	<72	2.0	<1.0	<0.5	<1.0	<2.0	<1.0	<20.0	60.0	<10.0	<0.5	<6.0	
	MLE	<350(c)	2.0	2.0	<0.5	<1.0	<3.0	<1.0	<20.0	40.0	<10.0	1.0	<6.0	
	MLE	<500(c)	2.0	<1.0	<0.5	<1.0	<2.0	<1.0	<20.0	20.0	<10.0	<0.5	<6.0	
	Mean	Whole log	<62	1.8	<2.0	<0.5	<1.0	<2.1	<1.0	<20.0	45.0	<10.0	<0.6	<6.0
	[6484-33 (92,426)]													
6484-33-3A-L082 -3B-L094 -3A-L156 -3B-L165 -1A-L031 -1B-L043 -1A-L106 -1B-L115	MLC	<25	2.0	<1.0	<0.5	<1.0	<2.0	2.0	<20.0	20.0	<10.0	<0.5	<6.0	
	MLC	<25	2.0	2.0	<0.5	<1.0	<2.0	2.0	<20.0	20.0	<10.0	<0.5	<6.0	
	MLE	<25	4.0	10.0	<0.5	<1.0	<2.0	2.0	<20.0	20.0	<10.0	<0.5	<6.0	
	MLE	<25	2.0	10.0	<0.5	<1.0	<2.0	8.0	<20.0	10.0	<10.0	<0.5	<6.0	
	EC	<25	8.0	<1.0	<0.5	<1.0	<2.0	8.0	<20.0	80.0	<10.0	<0.5	<6.0	
	EC	<25	2.0	<1.0	<0.5	<1.0	<2.0	4.0	<20.0	20.0	<10.0	<0.5	<6.0	
	EE	<25	2.0	<1.0	<0.5	<1.0	<2.0	4.0	<20.0	20.0	<10.0	<0.5	<6.0	
	EE	<25	2.0	<1.0	<0.5	<1.0	<2.0	2.0	<20.0	40.0	<10.0	<0.5	<6.0	
	Mean	Whole log	<25	3.0	<3.4	<0.5	<1.0	<2.0	4.0	<20.0	28.8	<10.0	<0.5	<6.0

TABLE B-35 (Continued)

[GA Log No. (GLCC Log No., Lot No.)] GA Specimen No.	Location in Log	Ash	B	Fe	V	Ti	S	Al	Ca	Si	Na	Mg	Pb	
[6484-34 (198,426)]														
6484-34-3A-L082	MLC	<25	20.0	<1.0	<0.5	<1.0	<2.0	4.0	<20.0	20.0	<10.0	<0.5	<6.0	
-3B-L094	MLC	<25	2.0	<1.0	<0.5	<1.0	<3.0	4.0	<20.0	10.0	20.0	<0.5	<6.0	
-3A-L156	MLE	<25	2.0	<1.0	<0.5	<1.0	<2.0	4.0	<20.0	40.0	<10.0	<0.5	<6.0	
-3B-L165	MLE	<25	2.0	<1.0	<0.5	<1.0	<2.0	10.0	<20.0	60.0	<10.0	<0.5	<6.0	
-1A-L031	EC	<25	2.0	10.0	<0.5	<1.0	<2.0	8.0	<20.0	40.0	<10.0	<0.5	<6.0	
-1B-L043	EC	<25	4.0	40.0	<0.5	10.0	<2.0	10.0	80.0	60.0	<10.0	<0.5	40.0	
-1A-L106	EE	<25	2.0	<1.0	<0.5	<1.0	<2.0	10.0	<20.0	20.0	10.0	1.0	<6.0	
-1B-L115	EE	<25	4.0	4.0	<0.5	<1.0	<2.0	40.0	<20.0	40.0	<10.0	1.0	<6.0	
Mean	Whole log	<25	4.8	<7.4	<0.5	<2.1	<2.1	11.3	<27.5	36.3	<11.3	<0.6	<10.3	
B-93	[6484-40 (155,426)]													
	6484-40-3A-L016	MLC	110	1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	2.0	<6.0
	-3B-L016	MLC	60	1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	2.0	<6.0
	-3A-L036	MLE	140	0.5	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	2.0	<6.0
	-3B-L036	MLE	70	<0.5	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	2.0	<6.0
	-1A-L016	EC	90	1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	4.0	<6.0
	-1B-L016	EC	50	1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	1.0	<6.0
	-1A-L036	EE	70	<0.5	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	1.0	<6.0
	-1B-L036	EE	120	0.5	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	2.0	<6.0
Mean	Whole log	89	<0.8	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	2.0	<6.0	

TABLE B-35 (Continued)

[GA Log No. (GLCC Log No., Lot No.)] GA Specimen No.	Location in Log	Ash	B	Fe	V	Ti	S	Al	Ca	Si	Na	Mg	Pb
[6484-41 (184,426)]													
6484-41-3A-L016	MLC	40	1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0
-3B-L016	MLC	40	4.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0
-3A-L036	MLE	34	1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0
-3B-L036	MLE	36	2.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0
-1A-L016	EC	55	0.5	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0
-1B-L016	EC	37	1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0
-1A-L036	EE	31	1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0
-1B-L036	EE	57	1.0	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0
Mean	Whole log	41	<1.4	<1.0	<0.5	<1.0	<1.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0
Mean	Lot 426 (4 logs)	<45	<2.5	<3.2	<0.5	<1.3	<1.5	<4.3	<21.9	<21.3	<10.3	<0.9	<7.1
Mean	All logs, lots 408 and 426 (5 logs)	<48	<2.4	<3.0	<0.5	<1.2	<1.6	<3.7	<21.5	<26.0	<10.3	<0.8	<6.9

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(a) Analyses for all elements listed except sulfur were obtained by a standard emission spectrograph technique on 20-mg samples. Other elements detected (lots 426 and 408 only) but not listed are as follows: Lu, Ba, Be, Zr, Ag <0.5 ppm; Li, Sc, Mn, Cu, Mo <1.0 ppm; Bi <2.0 ppm; Co, In, Tm, Ni <4.0 ppm; Nb, Sn, Er <6.0 ppm; Sb <8.0 ppm; K, Cr, Cd, La, Eu, Gd, Ho, Yb <10.0 ppm; Zn, Hf, Tl, Dy <20.0 ppm; Rb, Sr, Ta, W, Tb <40.0 ppm; Ce <80.0 ppm; Sm, Pr, Cs, P <100.0 ppm; Nd <200.0 ppm. The symbol < means less than the sensitivity of the spectrographic procedure used. Results for individual analysis are correct within a factor of 40% or one standard deviation.

(b) Not measured.

(c) Insufficient material for proper analysis. Values not used in mean value calculation.

TABLE B-36  
IMPURITY CONTENT OF TS-1240, LOT 1  
[in ppm(a)]

[GA Log No. (UCC Log No.)] GA Specimen No.	Location in Log	Ash	B	Fe	V	Ti	S	Al	Ca	Si	Na	Mg	Pb	Ba	Ni
[5651-72 (30)]															
5651-72-3A-L082	QLC	94	1.0	<10.0	20.0	20.0	5.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0	<0.5	<4.0
-3B-L094	QLC	120	1.0	<10.0	10.0	20.0	5.0								
-3A-L156	QLE	140	1.0	<10.0	10.0	10.0	10.0								
-3B-L165	QLE	92	1.0	<10.0	10.0	10.0	13.0								
-1A-L031	EC	68	1.0	<10.0	20.0	20.0	22.0								
-1B-L043	EC	69	1.0	<10.0	10.0	10.0	18.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0	<0.5	<4.0
-1A-L106	EE	110	<0.5	<10.0	10.0	10.0	<7.0								
-1B-L115	EE	120	<0.5	<10.0	10.0	10.0	25.0								
Mean	Whole log	89	<0.9	<10.0	12.5	13.7	<13.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0	<0.5	<4.0
[5651-73 (40)]															
5651-73-3A-L005	MLC	<98	<0.5	<1.0	10.0	10.0	<2.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0	<0.5	<4.0
-L007	MLC	<39	<0.5	4.0	10.0	10.0	<2.0	40.0	<20.0	<10.0	<10.0	2.0	<6.0	6.0	<4.0
-L009	MLE	<30	<0.5	<1.0	20.0	10.0	22.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0	0.5	<4.0
-L010	MLE	<31	<0.5	<1.0	10.0	8.0	10.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0	4.0	<4.0
Mean	ML position	<42	<0.5	<1.7	12.5	9.5	<9.0	<10.8	<20.0	<10.0	<10.0	<0.9	<6.0	<2.8	<4.0
[5651-75 (46)]															
5651-75-3A-L082	MLC	95	<0.5	<10.0	10.0	20.0	5.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0	<0.5	<4.0
-3B-L094	MLC	81	<0.5	<10.0	10.0	20.0	18.0								
-3A-L156	MLE	74	<0.5	<10.0	20.0	20.0	15.0								
-3B-L165	MLE	47	<0.5	<10.0	10.0	20.0	13.0								
-1A-L031	EC	55	<0.5	<10.0	10.0	20.0	9.0								
-1B-L043	EC	89	<0.5	<10.0	20.0	20.0	18.0	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0	<0.5	<4.0
-1A-L106	EE	58	<0.5	<10.0	10.0	10.0	17.0								
-1B-L115	EE	39	<0.5	<10.0	20.0	20.0	18.0								
Mean	Whole log	67	<0.5	<10.0	13.7	18.7	14.2	<1.0	<20.0	<10.0	<10.0	<0.5	<6.0	<0.5	<4.0

TABLE B-36 (Continued)

[GA Log No. (UCC Log No.)] GA Specimen No.	Location in Log	Ash	B	Fe	V	Ti	S	Al	Ca	Si	Na	Mg	Pb	Ba	Ni
[5651-74 (42)]															
5651-74-3A-L082	MLC	<44	<1.0	<10.0	<10.0	<10.0	<1.5	<1.0	<20.0	<10.0		<0.5	<6.0	<0.5	<4.0
-3B-L094	MLC	<28	<1.0	<10.0	60.0	40.0	<1.5	<1.0	<20.0	<10.0		<0.5	<6.0	<0.5	<4.0
-3A-L156	MLE	<35	<1.0	<10.0	40.0	20.0	5.5	<1.0	<20.0	10.0		6.0	<6.0	<0.5	<4.0
-3B-L165	MLE	<27	2.0	<10.0	<10.0	<10.0	3.5	<1.0	<20.0	<10.0		4.0	<6.0	<0.5	<4.0
-1A-L031	EC	<50	<1.0	<10.0	<10.0	<10.0	3.5	<1.0	<20.0	<10.0		2.0	<6.0	<0.5	<4.0
-1B-L043	EC	<40	<1.0	<10.0	40.0	40.0	2.5	<1.0	<20.0	<10.0		0.5	<6.0	<0.5	<4.0
-1A-L106	EE	53	<1.0	<10.0	<10.0	<10.0	3.5	<1.0	<20.0	<10.0		1.0	<6.0	<0.5	<4.0
-1B-L115	EE	<35	<1.0	<10.0	40.0	40.0	5.0	10.0	<20.0	<10.0		<0.5	<6.0	<0.5	<4.0
Mean	Whole log	<39	<1.1	<10.0	<27.5	<22.5	<3.2	<2.1	<20.0	<10.0	--	<1.9	<6.0	<0.5	<4.0
[6484-29 (8-1S-ID-23)]															
6484-29-3A-L082	MLC	250	0.5	40.0	40.0	20.0	2.0	20.0	60.0	--	<10.0	2.0	<6.0	10.0	8.0
-3B-L094	MLC	204	<0.5	40.0	40.0	20.0	4.0	<1.0	40.0	20.0	20.0	<0.5	<6.0	10.0	8.0
-3A-L156	MLE	138	<0.5	10.0	10.0	20.0	12.0	<1.0	20.0	20.0	--	<0.5	<6.0	10.0	6.0
-3B-L165	MLE	66	<0.5	40.0	40.0	20.0	8.5	<1.0	20.0	40.0	10.0	<0.5	<6.0	10.0	8.0
-1A-L031	EC	125	<0.5	20.0	20.0	20.0	12.0	<1.0	20.0	40.0	10.0	<0.5	<6.0	10.0	8.0
-1B-L043	EC	171	<0.5	10.0	8.0	8.0	8.0	<1.0	20.0	40.0	<10.0	<0.5	<6.0	10.0	4.0
-1A-L106	EE	102	<0.5	20.0	40.0	20.0	9.5	10.0	40.0	60.0	<10.0	2.0	<6.0	10.0	8.0
-1B-L115	EE	257	<0.5	10.0	20.0	10.0	5.0	10.0	40.0	20.0	<10.0	2.0	<6.0	10.0	6.0
Mean	Whole log	157	<0.5	23.7	28.5	15.7	7.6	<5.6	32.5	34.3	<11.4	<1.1	<6.0	10.0	7.0
Mean	Whole lot 1 (5 logs)	<78.8	<0.7	<11.1	<18.9	<16.0	<9.4	<4.1	<22.5	<14.9	<10.4	<1.0	<6.0	<2.9	<4.6

(a) Analyses for all elements listed except sulfur were obtained by a standard emission spectrograph technique on 20-mg samples. Other elements detected but not listed are as follows: Be, Zr, Ag <0.5 ppm; Li, Sc, Mn, Cu, Mo <1.0 ppm; Bi <2.0 ppm; Co, In, Tm <4.0 ppm; Nb, Sn, Er <6.0 ppm; Sb <8.0 ppm; K, Cr, Cd, La, Eu, Gd, Ho, Yb <10.0 ppm; Zn, Hf, Tl, Dy <20.0 ppm; Rb, Sr, Ta, W, Tb <40.0 ppm; Ce <80.0 ppm; Sm, Pr, Cs, P <100.0 ppm; Nd <200.0 ppm. The symbol < means less than the sensitivity of the spectrographic procedure used. Results for individual analyses are correct within a factor of 40% or one standard deviation.

TABLE B-37  
BURNABLE AND NONBURNABLE BORON EQUIVALENT VALUES FOR H-451 AND TS-1240

Element	Boron Equivalent	Impurity Content, Less Than Value Given (ppm)		Upper Limit of Boron Equivalent Value (ppm)		Analytical Methods(a)
		H-451	TS-1230	H-451	TS-1240	
NONBURNABLE						
Ag	0.0322	0.5	0.5	0.0161	0.0161	1
Al	0.00012	3.7	4.1	0.0004	0.0005	1
Ba	0.00042	0.5	2.9	0.0002	0.0012	1
Ca	0.00020	21.5(b)	22.5	0.0043(b)	0.0045	1
Cl	0.0136	3.0(b)	1.0	0.0408(b)	0.0136	2
Co	0.0114	4.0	4.0	0.0456	0.0456	1
Cr	0.00086	1.0	1.0	0.0009	0.0009	2
Cs	0.0127	1.0(b)	1.0	0.0127(b)	0.0127(b)	2
Cu	0.00099	0.07(b)	0.47(b)	0.0001(b)	0.0004(b)	3
Dy	0.1048	0.12	0.16	0.0126	0.0168	3
Er	0.0692	0.03	0.04	0.0021	0.0028	3
Fe	0.00068	3.0	11.1	0.0020	0.0076	1
Hf	0.0475	0.17	0.16	0.0081	0.0076	3
Ho	0.0222	0.08	0.08	0.0018	0.0018	3
In	0.135	1.0	1.0	0.5400	0.5400	2
K	0.00081	1.0	1.0	0.0008	0.0008	2
La	0.00114	0.03	1.38	0.0000	0.0016	3
Sn	0.00029	1.0	1.0	0.0003	0.0003	2
Lu	0.048	0.02	0.01	0.0010	0.0010	3
Mg	0.00005	0.8	1.0	0.0000	0.0001	1
Mo	0.0014	1.0	1.0	0.0014	0.0014	1
Mn	0.0041	1.0	1.0	0.0041	0.0041	1
Na	0.00034	10.3	10.4	0.0035	0.0035	1
Nd	0.00573	0.3	0.36	0.0017	0.0021	3
Ni	0.00114	4.0	4.6	0.0046	0.0052	1
Pr	0.00156	0.42	0.64	0.0007	0.0010	3
S	0.00029	1.6	9.4	0.0005	0.0027	4
Sb	0.0062	1.0	1.0	0.0062	0.0062	2
Sc	0.0074	0.01	0.01	0.0007	0.0007	3
Si	0.000085	26.0	14.9	0.0022	0.0013	1
Ta	0.0159	0.35	0.32	0.0056	0.0051	3
Tb	0.0137	0.20	0.26	0.0027	0.0036	3
Ti	0.00180	1.2	16.0	0.0022	0.0286	1
Tm	0.0487	0.04	0.03	0.0019	0.0015	3
V	0.00147	0.5(b)	18.9	0.0007	0.0278	1
W	0.00857	25.5(b)	1.0	0.2185(b)	0.0086	1
Yb	0.00715	0.03	0.06	0.0002	0.0004	3
P	0.00010	1.0	1.0	0.0001	0.0001	2
Pb	0.000001	6.9	6.0	0.0000	0.0000	1
Rb	0.00033	1.0	1.0	0.0003	0.0003	2
Tl	0.00043	1.0	1.0	0.0004	0.0004	2
Zn	0.00027	1.0	1.0	0.0003	0.0003	2
Zr	0.00010	0.08	0.5	0.0000	0.0001	2
Bi	0.000026	1.0	1.0	0.0000	0.0000	2
Nb	0.00088	0.05	1.74	0.0000	0.0015	3
N	0.002	--	--	--	--	--
O	0.000004	--	--	--	--	--
Sr	0.000836	0.30	0.47	0.0003	0.0004	3
Ce	0.0001	0.30	0.56	0.0000	0.0001	3
Be	0.000016	0.005	0.00	0.0000	0.0000	3
(c) Nonburnable boron equivalent value, less than value given (ppm)				0.9486	0.7839	

TABLE B-37 (Continued)

Element	Boron Equivalent	Impurity Content, Less Than Value Given (ppm)		Upper Limit of Boron Equivalent Value (ppm)		Analytical Methods(a)
		H-451	TS-1230	H-451	TS-1240	
BURNABLE						
B	1.0	2.4	0.7	2.4	0.7	1
Cd	0.855	0.5	0.5	0.4275	0.4275	5
Eu	0.459	0.04	0.06	0.0183	0.0275	3
Gd	1.57	0.05	0.08	0.0785	0.1256	3
Sm	0.941	0.39	0.61	0.3670	0.5740	3
Li	0.171	0.005	0.005	0.0009	0.0009	6
Burnable boron equivalent value, less than value given (ppm)				3.2922	1.8560	

(a) Method 1. Standard emission spectroscopy on 20-mg samples (Section A.5.2). Values represent means of approximately 40 measurements. Results are correct within a factor of approximately 40% or one standard deviation.

Method 2. Spark mass spectroscopy (Section A.5.3) (work performed by Accu-Labs Research, Inc., Wheat Ridge, Colorado). Value represents mean of two measurements. Results are correct within approximately 200 to 300%.

Method 3. Same as 1 above except samples were preconcentrated to 20 to 50 mg. Samples of 10 to 20g were preconcentrated by ashing in still air at 750°C. Value represents mean of two measurements. Results are correct within 40% or one standard deviation.

Method 4. Wet chemical analysis (Section A.5.4). Mean of approximately 40 measurements.

Method 5. Same as 1 above but on a single 50-mg sample. Results are correct within approximately 40% or one standard deviation.

Method 6. Isotopic dilution spark mass spectroscopy (Section A.5.5). Work done by Oak Ridge National Laboratory (ORNL) on 10-g samples.

(b) Actual values.

(c) Does not include boron equivalent contributions from O and N.

TABLE B-38  
IMPURITY CONTENT OF H-451 AND TS-1240  
[in ppm(a)]

Element	H-451 GA Log No. (GLCC Log No./GLCC Lot No.)			TS-1240 GA Log No. (UCC Log No./UCC Lot No.)					Mean(d)
	5651-86 (52/408)(b)	6484-34 (198/426)(c)	Mean(d)	5651-72 (30/1)(b)	5651-73 (40/1)(b)	5651-74 (42/1)(b)	5651-75 (46/1)(b)	6484-29 (8-1S-ID-23/1)(e)	
Ag(f)	0.06		--	0.01	0.30	0.30	0.22		--
Ba	7.50		7.50	5.25	3.00	4.50	1.88		3.66
Ca	6.00		6.00	>7.50	7.50	>7.50	7.50		>7.50
Co(g)	<0.03		<0.03	<0.03	3.00	0.30	3.75		<1.77
Cu	0.07		0.07	0.06	0.75	0.30	0.75		0.47
Eu	<0.07	<0.02	<0.04	<0.07	<0.07	<0.07	<0.07	<0.02	<0.06
Hf	<0.15	<0.20	<0.17	<0.15	<0.15	<0.15	<0.15	<0.20	<0.16
K(g)	3.00		3.00	1.50	1.50	0.45	3.00		1.61
Lu	<0.00	<0.04	<0.02	<0.00	<0.00	<0.00	<0.00	<0.04	<0.01
Mo(g)	<0.01		<0.01	0.15	0.75	0.45	0.15		0.38
Ni(g)	3.00		3.00	4.50	4.50	7.50	3.75		5.06
Pr	<0.75	<0.20	<0.42	<0.75	<0.75	<0.75	<0.75	<0.20	<0.64
Sc	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01		<0.01
Sn(g)	<0.04		<0.04	<0.04	0.60	<0.04	<0.04		0.18
Tb	<0.30	<0.10	<0.20	<0.30	<0.30	<0.30	<0.30	<0.10	<0.26
Tm	<0.03	<0.04	<0.04	<0.03	<0.03	<0.03	<0.03	<0.04	<0.03
Yb	<0.07	<0.00	<0.03	<0.07	<0.07	<0.07	<0.07	<0.00	<0.06
Al	1.50		1.50	1.50	7.50	3.00	6.00		4.50
Be	<0.00		<0.00	<0.00	0.02	<0.00	<0.00		<0.00
Cd(f)	0.30	<0.50(h)	<0.50	0.45	0.52	0.60	0.38	<0.50(h)	<0.50
Cr(g)	<0.07		<0.07	7.50	6.75	7.50	<0.07		<5.46
Dy	<0.15	<0.10	<0.12	<0.15	<0.15	<0.15	<0.15	0.20	<0.16
Fe(g)	7.50		7.50	7.50	>7.50	7.50	7.50		>7.50
Ho	<0.07	<0.10	<0.08	<0.07	<0.07	<0.07	<0.07	<0.10	<0.08
La	0.07	<0.00	<0.03	0.07	3.00	0.07	3.75	<0.00	<1.38
Mg	0.30		0.30	0.60	0.30	0.75	0.45		0.53
Na(g)	3.00		3.00	4.50	3.00	1.50	4.50		3.38
P(g)	<0.75		<0.75	<0.75	<0.75	<0.75	<0.75		<0.75
Rb(g)	<0.30		<0.30	<0.30	<0.30	<0.30	<0.30		<0.30
Si(g)	7.50		7.50	1.50	4.50	3.00	3.75		3.19
Sr	<0.30		<0.30	<0.30	0.52	<0.30	0.75		<0.47
Ti	3.00		3.00	>7.50	>7.50	>7.50	>7.50		>7.50
V(f)	0.75		--	7.50	>7.50	>7.50	>7.50		--
Zn(f)	0.15		--	<0.15	<0.15	<0.15	<0.15		--
B(f)	0.60		--	0.60	0.30	0.07	<0.00		--
Bi(f)	<0.02		--	<0.02	<0.02	<0.02	<0.02		--
Ce(f)	<0.60	<0.10	<0.30	<0.60	<0.60	<0.60	<0.60	0.40(h)	<0.56
Cs	<0.75	<10.00(h)	<10.00	<0.75	<0.75	<0.75	<0.75	<10.00(h)	<10.00
Er	<0.04	<0.02	<0.03	<0.04	<0.04	<0.04	<0.04	<0.02	<0.04
Gd	<0.07	<0.04	<0.05	<0.07	<0.07	<0.07	<0.07	0.10	<0.08
In(g)	<0.03		<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Li(f)	0.07		--	0.07	0.45	0.04	0.45		--
Mn(g)	0.15		0.15	0.60	0.52	0.75	0.10		0.49
Nb	<0.04	<0.06	<0.05	0.45	0.60	7.50	0.07	<0.06	<1.74
Pb(g)	0.15		0.15	<0.04	0.04	<0.04	0.10		<0.06
Sb(g)	<0.06		<0.06	<0.06	<0.06	<0.06	<0.06		<0.06
Sm	<0.75	<0.04	<0.39	<0.75	<0.75	<0.75	<0.75	<0.04	<0.61
Ta	<0.30	<0.40	<0.35	<0.30	<0.30	<0.30	<0.30	<0.40	<0.32
Tl	<0.15		--	<0.15	<0.52	<0.15	<0.52		(F)
W(g)	<0.30	<0.40	<0.35	<0.30	0.38	<0.30	<0.30		<0.32
Zr	0.15	<0.01	<0.08	7.50	7.50	7.50	7.50	0.20	6.04
Nd	<0.40	<0.20	<0.30	<0.40	<0.40	<0.40	<0.40	<0.20	<0.36

(a) Unless otherwise specified, all analyses were obtained on preconcentrated samples (20 to 50 mg) by a standard emission spectrographic technique. A 10 to 25 g sample was obtained for each log by combining cores from several different locations. Samples were preconcentrated by ashing in still air at ~750°C. The symbols < and > mean less than and greater than the sensitivity of the spectrographic procedure used. Results for individual analyses are correct within a factor of 40% or one standard deviation.

(b) Composite sample (25 g) of cores listed for specific log in Tables B-34 and B-35.

(c) Sample (35 g) taken from cores 6484-34-3A-L054, -L054, and -L058 (midlength center position).

(d) Includes only values for elements with no appreciable (<20%) losses on ashing.

(e) Sample (35 g) taken from cores 6484-29-3A-L051, -L053, -L055, and -L062 (midlength center position).

(f) Measurements on an ashed spectrographic standard indicate 40 to 100% loss of element on ashing.

(g) Measurement on an ashed spectrographic standard indicate ~20% loss of element on ashing.

(h) High resolution emission spectrographic analysis on unashed 50-mg sample.

TABLE B-39  
SPARK MASS SPECTROMETRIC IMPURITY ANALYSIS OF H-451 AND TS-1240  
[in ppm(a)]

Element	H-451 GA Log No. (GLCC Log No./GLCC Lot No.)			TS-1240 GA Log No. (UCC Log No./UCC Lot No.)		
	6484-34 (198/426)	6484-40 (155/426)	Mean	5651-72 (30/1)	5651-74 (42/1)	Mean
Ag						
Ba						
Ca	2	1	1.5	2	5	3.5
Co	7		<4.0			
Cu						
Eu						
Hf						
K	3		<2.0	3	2	2.5
Lu						
Mo						
Ni						
Pr						
Sc						
Sn						
Tb						
Tm						
Yb						
Al	1					
Be						
Cd						
Cr						
Dy						
Fe	10	3	6.5	1	1	1.0
Ho						
La						
Mg	1					
Na	6	2	4.0	6	3	4.5
P					1	
Rb					1	
Si	10	7	8.5	3		2.0
Sr					1	
Ti						
V						
Zn	1					
B	1	1	1.0	1	1	1.0
Bi						
Ce						
Cs						
Er						
Gd						
In						
Li						
Mn						
Nb						
Pb						
Sb						
Sm						
Ta						
Tl						
W	50	1	25.5	1		
Zr						
Nd	6	1	3.5	6	6	6.0
S	4	2	3.0		1	
Cl						

(a) All analyses were performed on ~225-mg samples by Accu-Labs Research, Inc., Wheat Ridge, Colorado. All elements not reported are less than (<) 1 ppm by weight. Precision of measurements is approximately  $\pm 200$  to 300%. All measurements made on composite samples (cores) taken from midlength center/end center positions in log: 6484-34-3B-001/-1A-004, 6484-40-3A-002/-1A-001, 5651-72-3A-L051/-1B-L014, and 5651-74-3A-108/-1B-028.

TABLE B-40  
SUMMARY OF LITHIUM ANALYSES FOR H-451

GA Log No. (GLCC Log No., Lot No.)	Sample (Core) No.	No. of Samples	Location in Log	Analysis Method(a)	Li Content (ppm)
5651-86 (52, 408)	5651-86 cores shown in Table B-35	4	MLC, MLE	1	<1.0 <sup>(b)</sup>
	Composite of 5651-86 cores shown in Table B-35	1	MLC/MLE	2 <sup>(c)</sup>	<0.07
	Composite of cores 5651-86-3A-L001, -3B-L011	1	MLC/MLE	3	<0.02
6484-33 (92, 426)	6484-33 cores shown in Table B-35	8	MLC, MLE, EC, EE	1	<1.0 <sup>(b)</sup>
	Composites of cores 6484-33-1A-L108, -1B-L117, 03A-L152, -3A-L158, -3B-L167, and -3B-L170(d)	2	MLE/EE	3	0.04 <sup>(b)</sup>
	Same as above <sup>(d)</sup>	2	MLE/EE	4	<0.005 <sup>(b)</sup>
6484-34 (198, 426)	6484-34 cores shown in Table B-35	8	MLC, MLE, EC, EE	1	<1.0 <sup>(b)</sup>
	Composite of cores 6484-34-1A-L108, -1B-L117, -3A-L152, -3A-L158, -3B-L167, and -3B-L170(d)	1	MLE/EE	3	0.07
	Same as above <sup>(d)</sup>	1	MLE/EE	4	<0.005
	Composite of cores 6484-34-3A-L056, -3B-L067(d)	1	MLC	3	0.074
	Same as above <sup>(d)</sup>	1	MLC	4	<0.005
	Composite of cores 6484-34-3A-L155, -3B-L164(d)	1	MLE	3	<0.01
	Same as above <sup>(d)</sup>	1	MLE	4	<0.005
	Composite of cores 6484-34-3B-001 and -1A-004	1	MLC/EC	5	<1.0
	6484-40 cores shown in Table B-35	8	MLC, MLE,	1	<1.0 <sup>(b)</sup>
6484-40 (155, 426)	6484-40-3B-L037	1	MLC	3	<0.01
	Composite of cores 6484-40-3A-002, -1A-001	1	MLC/EC	5	<1.0
	6484-41 cores shown in Table B-35	8	MLC, MLE, EC, EE	1	<1.0 <sup>(b)</sup>
6484-41 (184, 426)	6484-41-3B-L001	1	MLC	3	<0.01

- (a)
1. Standard emission spectrographic analysis on 20-mg sample.
  2. Standard emission spectrographic analysis on a preconcentrated sample (20 to 50 mg). Sample concentrated by ashing a 25-g sample in still air at ~750°C.
  3. Analysis by atomic absorption on chemically ashed 10-g sample.
  4. Isotope dilution spark mass spectrometric analysis on 10-g sample (performed at Oak Ridge National Laboratory).
  5. Spark mass spectrometric analysis on 225-mg sample (performed at Accu-Labs Research, Inc., Wheat Ridge, Colorado).

(b) All samples have this value.

(c) Analysis of ashed spectrographic standard (doped) indicates >50% loss on ashing.

(d) Companion samples.

TABLE B-41  
SUMMARY OF LITHIUM ANALYSES FOR TS-1240

GA Log No. (UCC Log No., Lot No.)	Sample (Core) No.	No. of Samples	Location in Log	Analysis Method <sup>(a)</sup>	Li Content (ppm)
5651-72 (30, 1)	5651-72-3B-L094, -1B-L043	2	MLC, EC	1	<1.0 <sup>(b)</sup>
	Composite of 5651-72 cores shown in Table B-36	1	QLC/QLE/ EC/EE	2 <sup>(c)</sup>	0.07
	5651-72-1A-L009	1	EC	3	<0.01
	Composite of cores 5651-72-3A-L051, -1B-L014	1	MLC/EC	5	<1.0
5651-73 (40, 1)	5651-73 cores shown in Table B-36	4	MLC, MLE	1	<1.0 <sup>(b)</sup>
	Composite of 5651-73 cores shown in Table B-36	1	MLC/MLE	2 <sup>(c)</sup>	0.45
	Composite of cores 5651-73-3A-L001, -3B-L011	1	MLC/MLE	3	0.02
5651-74 (42, 1)	5651-74 cores shown in Table B-36	8	MLC, MLE, EC, EE	1	<1.0 <sup>(b)</sup>
	Composite of 5651-74 cores shown in Table B-35	1	MLC/MLE/ EC/EE	2 <sup>(c)</sup>	0.04
	5651-74-3B-L065	1	MLC	3	<0.01
	Composite of cores 5651-74-3A-108, -1B-028	1	MLC/EC	5	<1.0
5651-75 (46, 1)	5651-75-3B-L094, -1B-L043	2	MLC, EC	1	<1.0 <sup>(b)</sup>
	Composite of 5651-75 cores shown in Table B-36	1	MLC, MLE, EC, EE	2 <sup>(c)</sup>	0.07
6484-29 (8-1S-ID-23, 1)	5651-75-3A-L057	1	MLC	3	<0.01
	6484-29 cores shown in Table B-36	8	MLC, MLE, EC, EE	1	<1.0 <sup>(b)</sup>
	Composite of cores 6484-29-1A-L108, -1B-L117, -3A-L152, -3A-L158, -3B-L167, and -3B-L170 (d)	1	MLE/EE	3	0.06
		1	MLE/EE	4	≤0.005

- (a) 1. Standard emission spectrographic analysis on 20-mg sample.  
 2. Standard emission spectrographic analysis on a preconcentrated sample (20 to 50 mg). Sample concentrated by ashing a 25-g sample in still air at ~750°C.  
 3. Analysis by atomic absorption on chemically ashed 10-g sample.  
 4. Isotope dilution spark mass spectrometric analysis on 10-g sample (performed at Oak Ridge National Laboratory).  
 5. Spark mass spectrometric analysis on 225-mg sample (performed at Accu-Labs Research, Inc., Wheat Ridge, Colorado).

(b) All samples have this value.

(c) Analysis of ashed spectrographic standard (doped) indicates >50% loss on ashing.

(d) Companion samples.