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Gulf General Atomic Incorporated

P.O. Box 608, San Diego, California 92112

MASTER

INFORMAL AEC RESEARCH
AND DEVELOPMENT REPORT

GAMD-8738

EMPIRICAL CORRELATIONS OF PROPERTIES OF GRAPHITES

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SUMMARY

Property data on grades of graphites studied for PSC applications have been examined for parametric correlations. Those in which such relationships were found have been reported herein as a guide to assist design groups in making engineering estimates of the properties of graphites in general.

1. INTRODUCTION

Various mechanical, thermal and physical properties of candidate graphites for PSC applications have been measured at room temperature⁽¹⁻³⁾ or have been gleaned from the manufacturers' literature. With the accumulation of sufficient data on individual parameters, it is now possible and desirable to examine these empirically for correlations which can be utilized for engineering design estimates.

The parameters that were examined are listed in Table 1, with the abbreviation utilized in this report and with the units pertinent to the data. Parametric values for all sample orientations tested have been included. For example, for graphite stock in the form of a circular prism, values for the parallel (PL), or axial, direction and the perpendicular (PR), or radial, direction were reported; for graphite stock in the form of a rectangular prism, values for the parallel (PL), or axial, direction and the two perpendicular (PR1 and PR2), or transverse, directions were reported.

In general, the PL direction has been taken as the longest dimension of the manufactured graphite prism, and the PR directions have been taken as all those perpendicular to the PL direction. Since the largest fraction of the grades compared were molded graphites, the molding direction has been selected as the PL direction subsequently specified in the data points. As a result of this selection, it was necessary to plot all PL data for extruded graphites along with PR data for molded graphites (and vice versa) so that each group of data plotted would describe similar preferred orientations with the sample stock.*

*The molding process produces a preferred orientation of coke grains with their largest surfaces aligned normal to the molding direction. The extrusion process produces a preferred orientation 90° away from the molded texture; i.e., the largest surfaces of the coke grains are aligned parallel to the extrusion direction.

2. RESULTS AND DISCUSSION

The data were examined for correlative relationships, and those manifesting such relationships have been compiled by parametric pairs in Tables 2(a), 2(b), through 9(a), 9(b) and plotted in Figs. 1(a), 1(b) through 8(a), 8(b) as follows: BDN versus UTS in Tables 2(a), 2(b) and Figs. 1(a), 1(b); UTS versus STF in Tables 3(a), 3(b) and Figs. 2(a), 2(b); SMD versus UTS in Tables 4(a), 4(b) and Figs. 3(a), 3(b); SMD versus TMD in Tables 5(a), 5(b) and Figs. 4(a), 4(b); UTS versus RMD in Tables 6(a), 6(b) and Figs. 5(a), 5(b); (UTS/TMD) versus STF in Tables 7(a), 7(b) and Figs. 6(a), 6(b); (UTS/TMD) versus CTE in Tables 8(a), 8(b) and Figs. 7(a), 7(b); and (RMD/FMD) versus CTE in Tables 9(a), 9(b) and Figs. 8(a), 8(b).

The data points for each graphite have been plotted in the figures as "G's" to distinguish them from those plotted for ungraphitized carbon ("C") and from a graphite "alloy", grade TS-835, ("A"). Only the "G" symbols were considered, however, during the fitting of a curve through the data by the least-squares method. At the bottom of each of the following tables have been printed the coefficients required for fitting with straight lines with the relation

$$y = b + mx , \quad (1)$$

where y is the vertical parameter in each plot and x is the horizontal parameter.

The parametric combinations plotted in Figs. 6(a), 6(b) through 8(a), 8(b) result in unitless parameters. The combination tested in Figs. 6(a), 6(b) was based on a general relationship found to empirically represent the mechanical behavior of metals in tension; namely,

$$\ln \epsilon = A + BJ , \quad (2)$$

where ϵ is the instantaneous tensile strain and J is the associated tensile stress developed. Since a reasonable correlation resulted with this combination, similar tests were made in Figs. 7(a), 7(b) and 8(a), 8(b). In all of the figures, upper and lower limits of data scatter have been outlined with dashed lines. The widths of the scatter bands vary from figure to figure, representing variations in degree of correlation; however, in every case, at the very least, a general trend is apparent in the data plotted.

REFERENCES

1. Meyers, C., and K. Koyama, "Evaluation of Candidate Graphites (and Carbon) for PSC Core-Support Applications," USAEC Informal Report GAMD-8371, Gulf General Atomic, February 6, 1968.
2. Meyers, C., "Evaluation of GLCC Grade H-327 Graphite Logs," USAEC Informal Report GAMD-8689, Gulf General Atomic, June 21, 1968.
3. Meyers, C., "Evaluation of UCC Grade TS-814 (AGOT-NP) Graphite," USAEC Informal Report GAMD-8737, Gulf General Atomic, July 9, 1968.

Table 1
DESCRIPTION OF PARAMETERS EXAMINED

Parameter	Abbreviation	Measurement Unit
Coefficient of thermal expansion	CTE	in./in.-°C or °C ⁻¹
Thermal conductivity	TCY	cal.-cm/cm ² -sec-°C or cal/cm-sec-°C
Bulk density	BDN	gms/cm ³
Sonic modulus of elasticity	SMD	psi
Flexural modulus of elasticity	FMD	psi
Tensile modulus of elasticity	TMD	psi
Ultimate tensile strength (stress)	UTS	psi
Strain at fracture (elastic and plastic)	STF	in./in. or dimensionless
Ultimate compressive strength (stress)	UCS	psi

Table 2(a)

COMPARISON-BDN WITH UTS FOR GRAPHITES

(PARALLEL)

BULK DENSITY (BDN)		GRADE	ULTIMATE TENSILE STRESS (UTS)		YFIT
.188500+01	(A)	TS835	.144000+04	(A)	
.151800+01	(C)	B205	.239000+04	(C)	
.160000+01	(G)	CSF	.126000+04	(G)	.284959+03
.171000+01	(G)	CBN	.224000+04	(G)	.114911+04
.171500+01	(G)	RC-4	.113000+04	(G)	.123553+04
.172000+01	(G)	EGCR(e)	.734000+03	(G)	.132194+04
.172000+01	(G)	PGA	.100000+04	(G)	.132194+04
.172200+01	(G)	9567(N2)	.132400+04	(G)	.135651+04
.174200+01	(G)	9567(N3)	.132400+04	(G)	.170217+04
.174700+01	(G)	H205	.326000+04	(G)	.178859+04
.176500+01	(G)	ATJ-2	.332000+04	(G)	.209968+04
.176700+01	(G)	H-327 ^(u)	.773000+03	(G)	.213425+04
.177300+01	(G)	PGX	.169000+04	(G)	.223795+04
.178000+01	(G)	H-328	.250000+04	(G)	.235893+04
.178400+01	(G)	ATJ-1	.182000+04	(G)	.242806+04
.179500+01	(G)	H-327 ^(e)	.961000+03	(G)	.261818+04
.180200+01	(G)	H-327 ^(a)	.100000+04	(G)	.273916+04
.181600+01	(G)	MHLM	.128000+04	(G)	.298112+04
.184000+01	(G)	H-207-85	.646500+04	(G)	.339592+04
.185000+01	(G)	CHN	.467000+04	(G)	.356875+04
.187600+01	(G)	H249	.190000+04	(G)	.401811+04
.189000+01	(G)	711-TS	.491000+04	(G)	.426007+04
.189000+01	(G)	780-S	.570000+04	(G)	.426007+04

STANDARD DEVIATION OF LINEAR FIT= .129507+04

-.284050+05 + .172831+05 X

Table 2(b)

COMPARISON-BUN WITH UTS FOR GRAPHITES

(PERPENDICULAR)

BULK DENSITY (BUN)		GRADE	ULTIMATE TENSILE STRESS (UTS)		YFIT
.188500+01	(A)	TS835	.167000+04	(A)	
.188500+01	(A)	TS835	.820000+03	(A)	
.151800+01	(C)	B205	.264000+04	(C)	
.168000+01	(G)	CSF	.140000+04	(G)	.621225+03
.171000+01	(G)	CBN	.308000+04	(G)	.151630+04
.171500+01	(G)	RC-4	.203000+04	(G)	.160581+04
.172000+01	(G)	EGCR ^(e)	.138500+04	(G)	.169532+04
.172000+01	(G)	PGA	.150000+04	(G)	.169532+04
.172200+01	(G)	9567(N2)	.166700+04	(G)	.173112+04
.174200+01	(G)	9567(N3)	.166700+04	(G)	.208915+04
.174700+01	(G)	H205	.363000+04	(G)	.217866+04
.176500+01	(G)	ATJ-2	.238000+04	(G)	.250089+04
.176500+01	(G)	ATJ-2	.239000+04	(G)	.250089+04
.176700+01	(G)	H-327 ^(d)	.135100+04	(G)	.253669+04
.177300+01	(G)	PGX	.162000+04	(G)	.264410+04
.178400+01	(G)	ATJ-1	.296000+04	(G)	.284102+04
.179500+01	(G)	H-327 ^(c)	.221800+04	(G)	.303793+04
.180200+01	(G)	H-327 ^(a)	.117300+04	(G)	.316324+04
.181000+01	(G)	H-205-85	.350000+04	(G)	.330646+04
.181600+01	(G)	MHLM	.149000+04	(G)	.341386+04
.183000+01	(G)	HLM-85	.200000+04	(G)	.366449+04
.184000+01	(G)	H-207-85	.619400+04	(G)	.384350+04
.185000+01	(G)	CHN	.614500+04	(G)	.402252+04
.187600+01	(G)	H249	.279000+04	(G)	.448796+04
.189000+01	(G)	111-TS	.726500+04	(G)	.473858+04

STANDARD DEVIATION OF LINEAR FIT= .132440+04
 -.290953+05 + .179015+05 X

Table 3(a)

COMPARISON-UTS WITH STF FOR GRAPHITES(PARALLEL)ULTIMATE TENSILE STRESS (UTS)STRAIN TO FRACTURE (STF)YFIT

.144000+04	(A)	.145000-02	(A)	
.239000+04	(C)	.176000-02	(C)	
<u>.734000+03</u>	(G)	<u>.167000-02</u>	(G)	.194276-02
.777000+03	(G)	.167000-02	(G)	.196419-02
.961000+03	(G)	.211000-02	(G)	.205588-02
.100000+04	(G)	.217000-02	(G)	.207532-02
.113000+04	(G)	.125000-02	(G)	.214010-02
.128000+04	(G)	.135000-02	(G)	.221486-02
.132400+04	(G)	.300000-02	(G)	.223678-02
.132400+04	(G)	.310000-02	(G)	.223678-02
.169000+04	(G)	.281000-02	(G)	.241918-02
.182000+04	(G)	.258000-02	(G)	.248397-02
.190000+04	(G)	.313000-02	(G)	.252383-02
.224000+04	(G)	.264000-02	(G)	.269327-02
.326000+04	(G)	.302000-02	(G)	.320159-02
<u>.332000+04</u>	(G)	<u>.292000-02</u>	(G)	.323149-02

STANDARD DEVIATION OF LINEAR FIT= .514294-03
.157697-02 + .498350-06 X

Table 3(b)

COMPARISON-UTS WITH STF FOR GRAPHITES AND A CARBON (PERPENDICULAR)

<u>ULTIMATE TENSILE STRESS (UTS)</u>		<u>STRAIN TO FRACTURE (STF)</u>	<u>YFIT</u>
.167000+04	(A)	.170000-02	(A)
.820000+03	(A)	.146000-02	(A)
.264000+04	(C)	.177000-02	(C)
.117300+04	(G)	.780000-03	(G) .117937-02
.135100+04	(G)	.100000-02	(G) .133286-02
.138500+04	(G)	.138000-02	(G) .136218-02
.149000+04	(G)	.244000-02	(G) .145272-02
.162000+04	(G)	.206000-02	(G) .156482-02
.166700+04	(G)	.130000-02	(G) .160535-02
.166700+04	(G)	.130000-02	(G) .160535-02
.203000+04	(G)	.194000-02	(G) .191837-02
.221800+04	(G)	.141000-02	(G) .208048-02
.238000+04	(G)	.366000-02	(G) .222017-02
.239000+04	(G)	.261000-02	(G) .222880-02
.250000+04	(G)	.126000-02	(G) .232365-02
.279000+04	(G)	.270000-02	(G) .257372-02
.296000+04	(G)	.241000-02	(G) .272031-02
.308000+04	(G)	.234000-02	(G) .282379-02
.363000+04	(G)	.370000-02	(G) .329806-02

STANDARD DEVIATION OF LINEAR FIT= .611588-03
 .167877-03 + .862310-06 X

(PARALLEL)

STANDARD DEVIATION OF LINEAR FIT= .397994+03
.199318+02 + .158014-02 X

COMPARISON SMD WITH UTS FOR GRAPHITES

(PERPENDICULAR)

SONIC MODULUS OF ELASTICITY (SMD)		ULTIMATE TENSILE STRESS (UTS)		YFIT
.162000+07	(A)	GRADE	.167000+04	(A)
.710000+06	(A)	TS 835	.820000+03	(A)
.163000+07	(C)	TS 835	.264000+04	(C)
.100000-29	(G)	B205	.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.100000-29	(G)		.100000-29	(G)
.108000+07	(G)	MHLM	.149000+04	(G)
.123000+07	(G)	ATJ-2	.238000+04	(G)
.123000+07	(G)	PGX	.162000+04	(G)
.141000+07	(G)	ATJ-2	.239000+04	(G)
.156000+07	(G)	H205	.363000+04	(G)
.162700+07	(G)	RC-4	.203000+04	(G)
.170000+07	(G)	HLM-85	.200000+04	(G)
.170000+07	(G)	H-205-85	.350000+04	(G)
.181800+07	(G)	9567(N2)	.166700+04	(G)
.181800+07	(G)	9567(N3)	.166700+04	(G)
.186000+07	(G)	CBN	.308000+04	(G)
.187000+07	(G)	ATJ-1	.296000+04	(G)
.204000+07	(G)	H249	.279000+04	(G)

STANDARD DEVIATION OF LINEAR FIT= .484195+03

$$.278704+02 \quad + \quad .145668-02 \quad \times$$

(PARALLEL)

$$\frac{\text{STANDARD DEVIATION OF LINEAR FIT} = .111582+06}{.179632+05 \quad + \quad .879470-00 \quad X}$$

Table 5(b)

COMPARISON-SMD WITH TMD FOR GRAPHITES(PERPENDICULAR)

<u>SONIC MODULUS OF ELASTICITY (SMD)</u>			<u>TENSILE MODULUS OF ELASTICITY (TMD)</u>	<u>YFIT</u>
		<u>GRADE</u>		
.162000+07	(A)	TS835	.129000+07	(A)
.710000+06	(A)	TS835	.630000+06	(A)
.163000+07	(C)	B205	.158000+07	(C)
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.100000-29	(G)		.100000-29	(G) -.603011+04
.108000+07	(G)	MHLM	.810000+06	(G) .942575+06
.123000+07	(G)	ATJ-2	.950000+06	(G) .107433+07
.123000+07	(G)	PGX	.119000+07	(G) .107433+07
.141000+07	(G)	ATJ-2	.121000+07	(G) .123243+07
.156000+07	(G)	H205	.124000+07	(G) .136418+07
.162700+07	(G)	RC-4	.124000+07	(G) .142303+07
.181800+07	(G)	9567(N2)	.192000+07	(G) .159079+07
.181800+07	(G)	9567(N3)	.192000+07	(G) .159079+07
.186000+07	(G)	QBN	.170000+07	(G) .162768+07
.187000+07	(G)	ATJ-1	.150000+07	(G) .163646+07
.204000+07	(G)	H249	.159000+07	(G) .178578+07

STANDARD DEVIATION OF LINEAR FIT= .127725+06
 -.603011+04 + .878339-00 X

Table 6(a)

COMPARISON-UTS WITH RMD FOR GRAPHITES		(PARALLEL)	MODULUS OF RUPTURE (RMD)		YFIT
ULTIMATE TENSILE STRESS (UTS)					
.239000+04	(C)	GRADE B205	.446000+04	(C)	
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000-29	(G)		.100000-29	(G)	.794641+02
.100000+04	(G)	PGA	.150000+04	(G)	.203644+04
.115000+04	(G)	RC-4	.280000+04	(G)	.229085+04
.128000+04	(G)	MHLM	.370000+04	(G)	.258440+04
.182000+04	(G)	ATJ-1	.472000+04	(G)	.364117+04
.190000+04	(G)	H249	.339000+04	(G)	.379772+04
.326000+04	(G)	H205	.613000+04	(G)	.645922+04
.332000+04	(G)	ATJ-2	.610000+04	(G)	.657663+04

$$\frac{\text{STANDARD DEVIATION OF LINEAR FIT} = .431218+03}{.794641+02 + .195098+01 \lambda}$$

(PERPENDICULAR)

(PERPENDICULAR)

$$\frac{\text{STANDARD DEVIATION OF LINEAR FIT} = .591872+03}{.511181+02 \quad + \quad .181555+01 \quad X}$$

(PARALLEL)

(PÉRPENDICULAR)

STANDARD DEVIATION OF LINEAR FIT= .174274-03
.678312-04 + .132552+01 X

Table 8(a)

COMPARISON-UTS/TMD WITH CTE FOR GRAPHITES(PARALLEL)

<u>TENSILE STRESS/TENSILE MODULUS OF ELASTICITY (UTS/TMD)</u>		<u>COEFFICIENT OF THERMAL EXPANSION (CTE)</u>		<u>YFIT</u>	
		<u>GRADE</u>			
.113400-02	(A)	75835	.394000-05	(A)	-
.167100-02	(C)	B205	.692000-05	(C)	-
.770000-03	(G)	EGCP (e)	.397500-05	(G)	.405939-05
.106000-02	(G)	RC-4	.544700-05	(G)	.426002-05
.111300-02	(G)	MHLM	.312000-05	(G)	.429669-05
.121000-02	(G)	H327 (e)	.385800-05	(G)	.436380-05
.132000-02	(G)	H327 (u)	.428200-05	(G)	.443991-05
.142000-02	(G)	9567 (N3)	.437800-05	(G)	.450909-05
.142000-02	(G)	9567 (N2)	.402100-05	(G)	.450909-05
.172300-02	(G)	CBN	.599000-05	(G)	.471872-05
.187600-02	(G)	ATJ-1	.486000-05	(G)	.482457-05
.195000-02	(G)	H328	.650000-05	(G)	.487577-05
.204900-02	(G)	ATJ-2	.357000-05	(G)	.494426-05
.216700-02	(G)	PGX	.396000-05	(G)	.502590-05
.228000-02	(G)	H205	.686000-05	(G)	.510408-05
.279400-02	(G)	H249	.457000-05	(G)	.545969-05

STANDARD DEVIATION OF LINEAR FIT= .101742-05
 .352666-05 + .691850-03 X

Table 8(b)

<u>COMPARISON-UIS/TMD WITH CTE FOR GRAPHITES</u>			<u>(PERPENDICULAR)</u>			
<u>TENSILE STRESS/TENSILE MODULUS OF ELASTICITY</u>	<u>(UTS/TMD)</u>		<u>COEFFICIENT OF THERMAL EXPANSION</u>	<u>(CTE)</u>		<u>YFIT</u>
			<u>GRADE</u>			
.129500-02	(A)		TS835	.332000-05	(A)	
.130200-02	(A)		TS835	.814000-05	(A)	
.167100-02	(C)		B205	.625000-05	(C)	
.450000-03	(G)		H327 (A)	.207200-05	(G)	.167153-05
.560000-03	(G)		H327 (b)	.227000-05	(G)	.186109-05
.690000-03	(G)		H327 (c)	.209800-05	(G)	.208511-05
.800000-03	(G)		EGCR (c)	.201900-05	(G)	.227467-05
.870000-03	(G)		9567 (N3)	.209000-05	(G)	.239530-05
.870000-03	(G)		9567 (N2)	.186500-05	(G)	.239530-05
.136100-02	(G)		PGX	.344000-05	(G)	.324142-05
.164000-02	(G)		RC-4	.452700-05	(G)	.372222-05
.175500-02	(G)		H249	.341000-05	(G)	.392039-05
.181200-02	(G)		CBN	.421000-05	(G)	.401862-05
.184000-02	(G)		MHLM	.462000-05	(G)	.406687-05
.197300-02	(G)		ATJ-1	.376000-05	(G)	.429606-05
.197500-02	(G)		ATJ-2	.363000-05	(G)	.429951-05
.250500-02	(G)		ATJ-2	.488000-05	(G)	.521284-05
.292700-02	(G)		H205	.651000-05	(G)	.594006-05

STANDARD DEVIATION OF LINEAR FIT= .463966-06
.696058-06 + .172327-02 X

Table 9(a)

<u>COMPARISON-RMD/FMD WITH CTE FOR GRAPHITES</u>			<u>(PARALLEL)</u>		
<u>MODULUS OF RUPTURE/FLEXURAL MODULUS OF ELASTICITY (RMD/FMD)</u>			<u>COEFFICIENT OF THERMAL EXPANSION (CTE)</u>		<u>YFIT</u>
			<u>GRADE</u>		
.155400-02	(C)		B205	.692000-05	(C)
.156200-02	(G)		H249	.457000-05	(G) .363389-05
.221800-02	(G)		ATJ-2	.357000-05	(G) .407789-05
.230200-02	(G)		ATJ-1	.486000-05	(G) .413474-05
.305800-02	(G)		MHLM	.312000-05	(G) .464642-05
.340000-02	(G)		H-327 ^(d)	.406400-05	(G) .487789-05
.457500-02	(G)		H205	.686000-05	(G) .567316-05
<u>STANDARD DEVIATION OF LINEAR FIT= .100509-05</u>					
<u>.257670-05 + .676823-03 X</u>					

Table 9(b)

<u>COMPARISON-RMD/FMD WITH CTE FOR GRAPHITES</u>			<u>(PERPENDICULAR)</u>		
<u>MODULUS OF RUPTURE/FLEXURAL MODULUS OF ELASTICITY (RMD/FMD)</u>			<u>COEFFICIENT OF THERMAL EXPANSION (CTE)</u>		<u>YFIT</u>
			<u>GRADE</u>		
.166200-02	(C)		B205	.625000-05	(C)
.142000-02	(G)		EGGR ^(a)	.201900-05	(G) .259856-05
.187400-02	(G)		H249	.341000-05	(G) .294674-05
.229000-02	(G)		ATJ-1	.376000-05	(G) .326579-05
.250000-02	(G)		H327 ^(d)	.166800-05	(G) .342684-05
.263100-02	(G)		ATJ-2	.488000-05	(G) .352731-05
.355700-02	(G)		MHLM	.462000-05	(G) .423748-05
.480400-02	(G)		ATJ-2	.363000-05	(G) .523985-05
.488300-02	(G)		H205	.651000-05	(G) .525443-05
<u>STANDARD DEVIATION OF LINEAR FIT= .111985-05</u>					
<u>.150952-05 + .766927-03 X</u>					

ULTIMATE TENSILE STRESS (UTS)

Fig. 1(b). Comparison--BDN with UTS for graphites (perpendicular)

STRAIN TO FRACTURE (STF)

Fig. 2(a). Comparison--UTS with STF for graphites and a carbon (parallel)

STRAIN TO FRACTURE (STF)

Fig. 2(b). Comparison--UTS with STF for graphites and a carbon (perpendicular)

ULTIMATE TENSILE STRESS (UTS)

Fig. 3(a). Comparison--SMD with UTS for graphites and a carbon (parallel)

Fig. 3(b). Comparison--SMD with UTS for graphites (perpendicular)

TENSILE MODULUS OF ELASTICITY (TMD)

Fig. 4(a). Comparison--SMD with TMD for graphites (parallel)

Fig. 4(b). Comparison--SMD with TMD for graphites (perpendicular)

Fig. 5(a). Comparison--UTS with RMD for graphites (parallel)

Fig. 5(b). Comparison--UTS with RMD for graphites (perpendicular)

STRAIN TO FRACTURE (STF)

Fig. 6(a). Comparison--UTS/TMD with STF for graphites and a carbon (parallel)

STRAIN TO FRACTURE (STF)

ULTIMATE TENSILE STRESS/TENSILE MODULUS OF ELASTICITY (UTS/TMD)

Fig. 6(b). Comparison--UTS/TMD with STF for graphites and a carbon (perpendicular)

COEFFICIENT OF THERMAL EXPANSION (CTE)

ULTIMATE TENSILE STRESS/TENSILE MODULUS OF ELASTICITY (UTS/TMD)

Fig. 7(a). Comparison--UTS/TMD with CTE for graphites and a carbon (parallel)

COEFFICIENT OF THERMAL EXPANSION (CTE)

ULTIMATE TENSILE STRESS/TENSILE MODULUS OF ELASTICITY (UTS/TMD)

Fig. 7(b). Comparison--UTS/TMD with CTE for graphites and a carbon (perpendicular)

Fig. 8(a). Comparison--RMD/FMD with CTE for graphites and a carbon (parallel)

Fig. 8(b). Comparison--RMD/FMD with CTE for graphites
(perpendicular)