

NASA Grant NsG - 533/49-01-001

Fund 863109454J

Final Report

on

DEVELOPMENT OF CONSTITUTIVE
EQUATIONS FOR NUCLEAR GRADE
GRAPHITE FOR SPACE APPLICATIONS I

NASA-6-65

by

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December 1966

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ABSTRACT

The object of this work was to determine and measure the significant parameters of the room temperature mechanical behavior of various commercial and experimental graphites. A series of 189 flexure and 108 uniaxial compression two-cycle uniform load-rate tests was conducted. Using resistance-type strain gages, continuous axial and poisson strain versus load curves were recorded. From these curves were obtained values for the ultimate nominal stress, ultimate strains, second-cycle elastic modulus, poisson ratio, and the strain damage at 80 percent nominal ultimate stress. The data were tabulated in a manner to reflect their dependence on the orientation, location, and graphite sub-type. Finally, since the recorded data were continuous two-cycle load versus strain curves, a computerized procedure was developed for converting this load-strain flexure data to stress-strain data. These new stress-strain data were then compared with the nominal stress-strain data.

NOMENCLATURE

σ_{ult}	ultimate nominal stress
ϵ_{ult}	ultimate axial strain
ϵ_{ultp}	ultimate poisson strain
ν	poisson ratio
ϵ_{ra}	axial strain damage at 80% ultimate nominal stress
ϵ_{rp}	poisson strain damage at 80% ultimate nominal stress
E	second-cycle elastic modulus
M	bending moment
I	second moment of area
P	load
a	cross sectional area
E_1, E_2, E_3	modulus in 1, 2, and 3 directions, respectively
ν_{ij}	poisson ratio for loading in i direction and strain in j direction
$\sigma_1, \sigma_2, \sigma_3$	ultimate stress in 1, 2, and 3 directions, respectively
$\epsilon_1, \epsilon_2, \epsilon_3$	ultimate strain in 1, 2, and 3 directions, respectively
d_1, d_2, d_3	axial strain damage in 1, 2, and 3 directions, respectively
R	radius of curvature
d	distance along neutral axis
h	height of beam
b	width of beam
τ	actual flexure stress
k	proportionality constant

DEVELOPMENT OF CONSTITUTIVE
EQUATIONS FOR NUCLEAR GRADE
GRAPHITE FOR SPACE APPLICATIONS I

1. Introduction

One of the major problems of the space industry is that of finding materials which retain their structural integrity under extreme temperature conditions. Graphite is a material whose strength actually increases with temperature up to about 4000° F. and retains structural capability up to 5500° F. This, combined with its electrical and chemical properties, makes it a highly useful material in nuclear reactors, nose cones, and other unique applications.

From a mechanical point of view, graphite is a non-Hookean anisotropic material which exhibits elastic, plastic, and viscoelastic temperature dependent characteristics. The degree to which it exhibits these characteristics depends on its composition, fabrication procedure, and the history of its loading and temperature environments. For this reason much of the quantitative experimental data that has heretofore been obtained for graphite is of relatively little use in developing constitutive equations or mechanical theories of failure. This has greatly hindered the design engineer in making efficient and effective use of graphite as a structural material.

2.1 Purpose of Investigation.

From the previous comments it is easily seen that graphite is a material which exhibits such a multitude of interrelated phenomenological responses so that a qualitative, let alone a quantitative, analysis of its mechanical characteristics is extremely difficult. Many of the attempts along this line amount to nothing more than polynomial curve fitting of uniaxial load-strain data. While such re-

sults are useful and do fulfill a purpose, they contribute little to the development of a constitutive equation theory for graphite.

The purpose of this investigation is to develop a constitutive theory and the associated constitutive equations for the room temperature mechanical response of graphite. It is felt that if such a theory and the appropriate equations can be developed for room temperature response, then this can serve as a sound basis for attacking the more formidable problem of the temperature dependent responses observed at elevated temperatures.

2.2. Scope of Report.

This report covers the room temperature testing program which was conducted in an effort to establish the significant qualitative and quantitative parameters characterizing the mechanical response of graphite.

A series of 189 flexure and 108 uniaxial compression two-cycle uniform load-rate tests was conducted on several commercial graphite types. Continuous axial and poisson strain versus load curves were recorded and the data tabulated in a manner to reflect their dependence on the sample orientation, location, and graphite sub-type. The graphite types were classified in three broad categories denoted in the following manner:

Experiment D-110: HALM graphite samples cut from a large molded cylinder. 42 compression samples, 72 flexure samples.

Experiment D-111: Four different ATJ-based materials cut from molded blocks. 48 compression samples, 72 flexure samples.

Experiment D-112: Seven types of less common graphites which might be candidates for structural applications, 18 compression samples, 45 flexure samples.

A more detailed breakdown of material and sample selection is given in the section of this report devoted to the respective experiment.

In addition to this testing program, a limited attempt was made to conduct some uniaxial tensile tests on flat bars of ATJ graphite. The results of these tests are inconclusive and further work is needed to improve the reliability of the test data and procedure. However, a discussion of this work will be appended to a subsequent report.

Finally, since the recorded data were actually continuous non-linear two-cycle load versus strain curves, a computerized procedure was developed for converting this load-strain flexure data to stress-strain data. A comparison of these data is then made.

2. Experimental Procedure

The carefully machined samples were supplied by the Los Alamos Scientific Laboratory. Immediately after arriving at the West Virginia University Laboratory, the samples were unpacked and stored in desiccators to prevent undue moisture absorption. The samples were removed from the desiccators only for short periods necessary for weighing, measuring, and instrumenting.

2.1. Weighing and Measuring.

All samples were weighed on an analytical balance with a scale accuracy of 1/10,000 gram. The length of each sample was measured with a micrometer to within an accuracy of ± 0.0005 inch, while the transverse dimensions were measured with a vernier micrometer to within an accuracy of ± 0.0001 inch. When necessary due to uneven machining, the average of three or more measurements was taken as the dimension in question.

2.2. Instrumentation of Samples.

All samples were instrumented with two 1/8 inch, 120 ohm, 90° rosette-type epoxy-backed foil strain gages diametrically opposite on the compression samples and on opposite flat faces on the flexure samples. After considerable effort, the following technique for applying the gages was developed.

a. Preparation of Samples. As previously mentioned, the samples were stored in a desiccator prior to instrumenting. The samples were first scribed with gage alignment lines and then brushed lightly with a fiber glass brush. The samples were then cleaned with a cotton swab dampened with alcohol, the alcohol acting as both a solvent and a moisture evaporator.

Scotch tape was applied and removed three times to open the pores of the graphite sample. Finally the surface was once again cleaned with alcohol to remove any of the residue from the scotch tape.

b. Preparation of Gages and Soldering Tabs. The gages and soldering tabs were first trimmed to a suitable size. Manufacturer claims to the contrary, it was found advisable to clean the back of the gages and tabs with acetone. After the gages and tabs had thoroughly dried, Eastman 910 accelator was carefully applied to the back and also permitted to dry for approximately three minutes. The gages and tabs were then turned over onto a clean surface and were positioned and lifted by use of transparent mylar tape and held in readiness.

c. Bonding of Gages. The prepared sample was placed in a small vise and the taped gage and tab held over the specimen and aligned. One end of the tape was stuck to the sample and the other end held aloft. A small quantity of Eastman 910 Contact Cement was deposited at the crease joining the tape and sample. Pressure was then rolled along the tape starting at this crease, thus spreading the cement under the gage and tab in a fairly uniform manner without creating bubbles between the gage and sample. This pressure was maintained for approximately 15 seconds. The sample was then permitted to set for about five minutes before removal of the tape to check the bond. An instrumented, though fractured, flexure sample is shown in Figure 4.

Although this entire bonding procedure was perhaps more elaborate than necessary under other conditions, this procedure was able to maintain a loss rate of less than two percent and, therefore, was well worthwhile.

2.3. Readout Circuit.

All readout data were recorded on one Moseley X-YY and two Moseley X-Y recorders in conjunction with Daytronic strain gage signal amplifiers.

a. Flexure Tests. For these tests, individual data from each of the four gages was required. Therefore, a full four-arm external bridge employing three additional dummy gages was constructed for each active gage, thus obtaining proper temperature compensation. Initial calibration was done in accordance with the procedure supplied by the manufacturer of the recording equipment used. Final calibration for each recorded output was performed immediately prior to loading by means of shunting the known resistance of the appropriate arm of the external bridge with two or more previously calibrated fixed resistances. These calibration curves are displayed on each recorded output sheet. Data from the compression side of the flexure specimen are displayed on the X-YY recordings while data from the tension side of the specimen are displayed individually on X-Y recordings.

b. Compression Tests. For these samples, the gages were instrumented in such a way as to cancel bending effects for both the axial and poisson strain output. Therefore, two full four-arm external bridges were used, each employing two active gages in opposite arms and two dummy temperature compensating gages in the other arms. Initial calibration was done in accordance with the procedure supplied by the manufacturer of the recording equipment used. Final calibration for each recorded output was performed immediately prior to loading by means of shunting the known resistance of the appropriate arm of the external bridge with two or more previously calibrated fixed resistances. These calibration curves are displayed on each recorded output sheet. The data for axial and poisson outputs are displayed on one X-YY recording.

2.4. Testing.

The overall testing facilities are shown in Figures 1 and 2. The load was applied to the sample by means of a closed loop hydraulic servo-system manufactured by Research Incorporated. Factory designation for this system is as follows:

Entire System: Model 900.86 structural testing
machine

Control Console: Model 480.48

Hydraulic Power Supply: Model 501.01

Hydraulic Actuator: 3,000 lb capacity
10,000 lb capacity

The load was applied at a uniform load rate of approximately 2000 psi nominal stress per minute up to 80 percent nominal ultimate stress, returned to zero at the same rate and then reloaded at this rate to failure. This loading program was achieved by means of a diode circuit in conjunction with a triangle wave from a function generator.

Note: Because the ultimate load was not initially known, the first test for a given family of samples often contained three or more cycles and in a few cases the specimen failed on the first cycle. These occurrences are indicated in the data.

The load cell output was calibrated prior to each day's testing. For the flexure tests, this calibrating was done by dead weights since the ultimate loads seldom exceeded 500 lbs. For the compression tests, whose ultimate loads often exceeded 5000 lbs, load calibrating was done by utilizing the load measuring system of a BLH hydraulic testing machine. This system had been officially calibrated the day before the compression testing began. Each day's calibration curves are displayed on a recording for each recorder employed.

The flexure samples were about 0.75 inch square by 4.50 inches long rectangular prisms. These specimens were loaded in the ASTM "thirds-point" (four point) manner over a 4.00 inch span by use of the jig shown in Figures 2 and 3. All flexure samples except one faulty flexure sample exhibited a brittle tensile-type of failure typified by that shown in Figure 4. Also, almost all samples fractured within the loading edges of the upper half of the jig; that is, inside the region of pure bending.

The compression samples were about 0.75 inch diameter by 1.50 inch long cylinders. These were loaded in a rigid Tinius Olsen sub-press with matched parallel anvils. The samples were fitted to the anvils by means of a rotating, lapping technique using fine emery paper. Most of the compression samples exhibited a sudden catastrophic failure in which the sample was completely destroyed. In those few samples which were not completely destroyed, a definite brittle-type fracture was clearly evident.



Figure 1

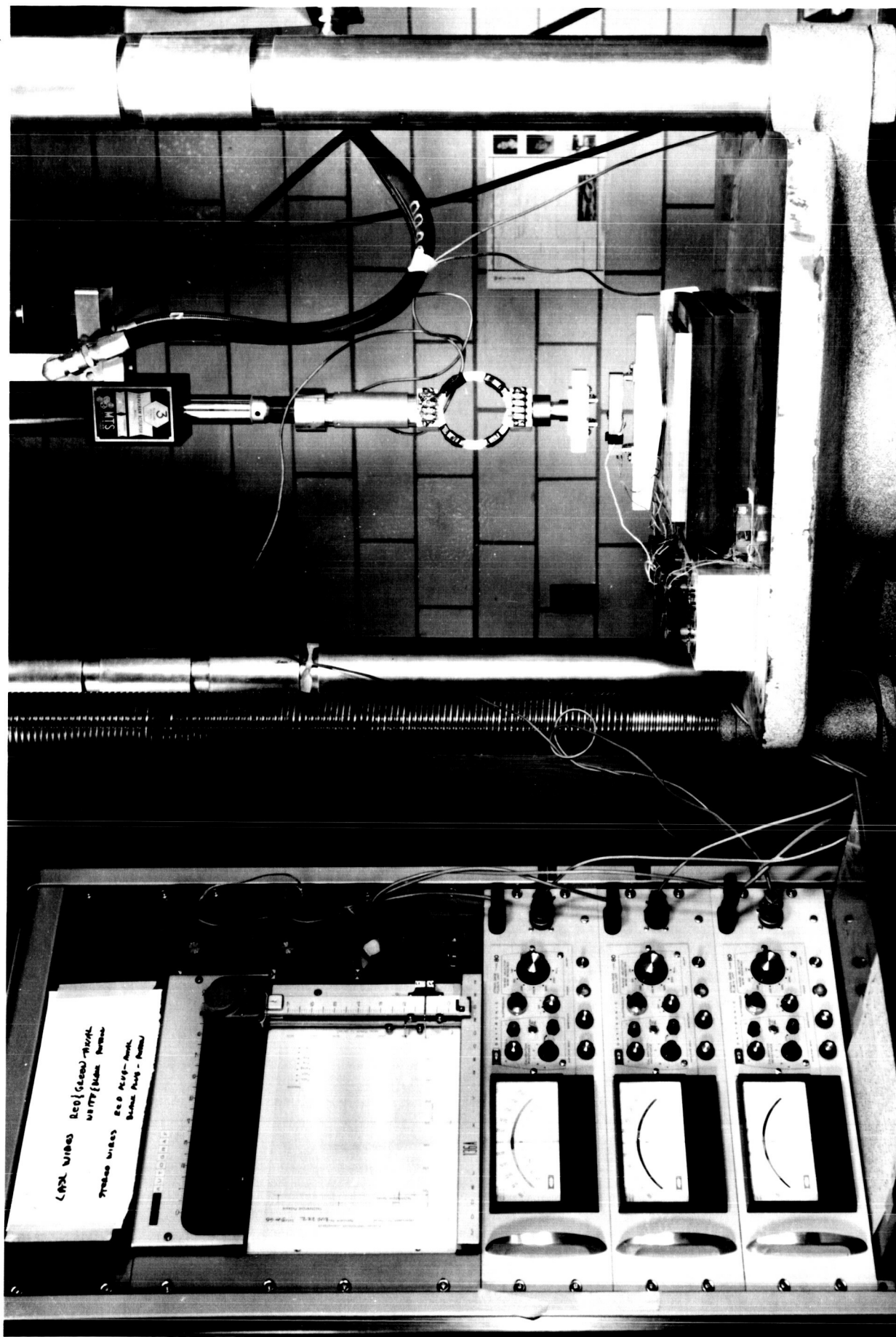


Figure 2

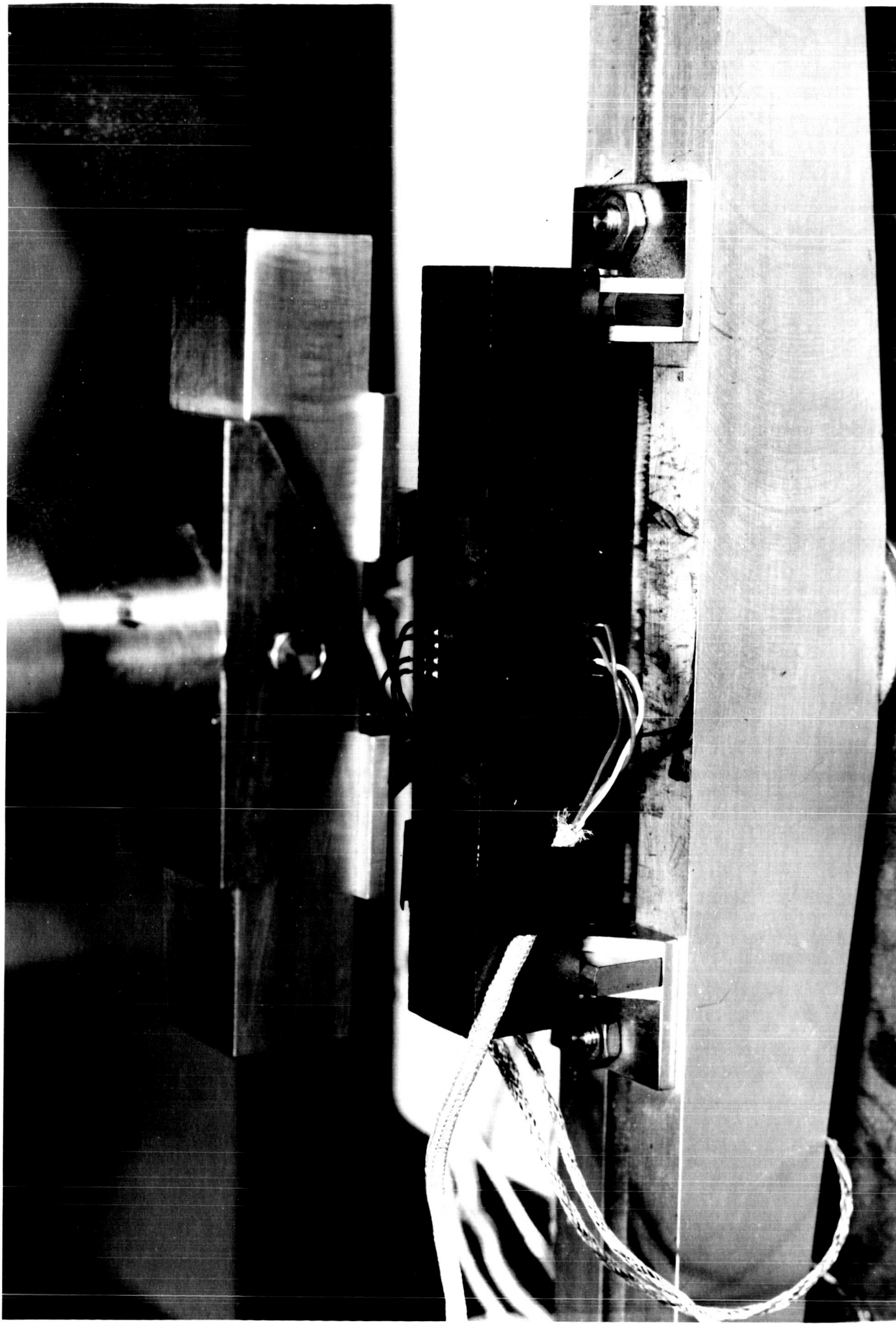


Figure 3

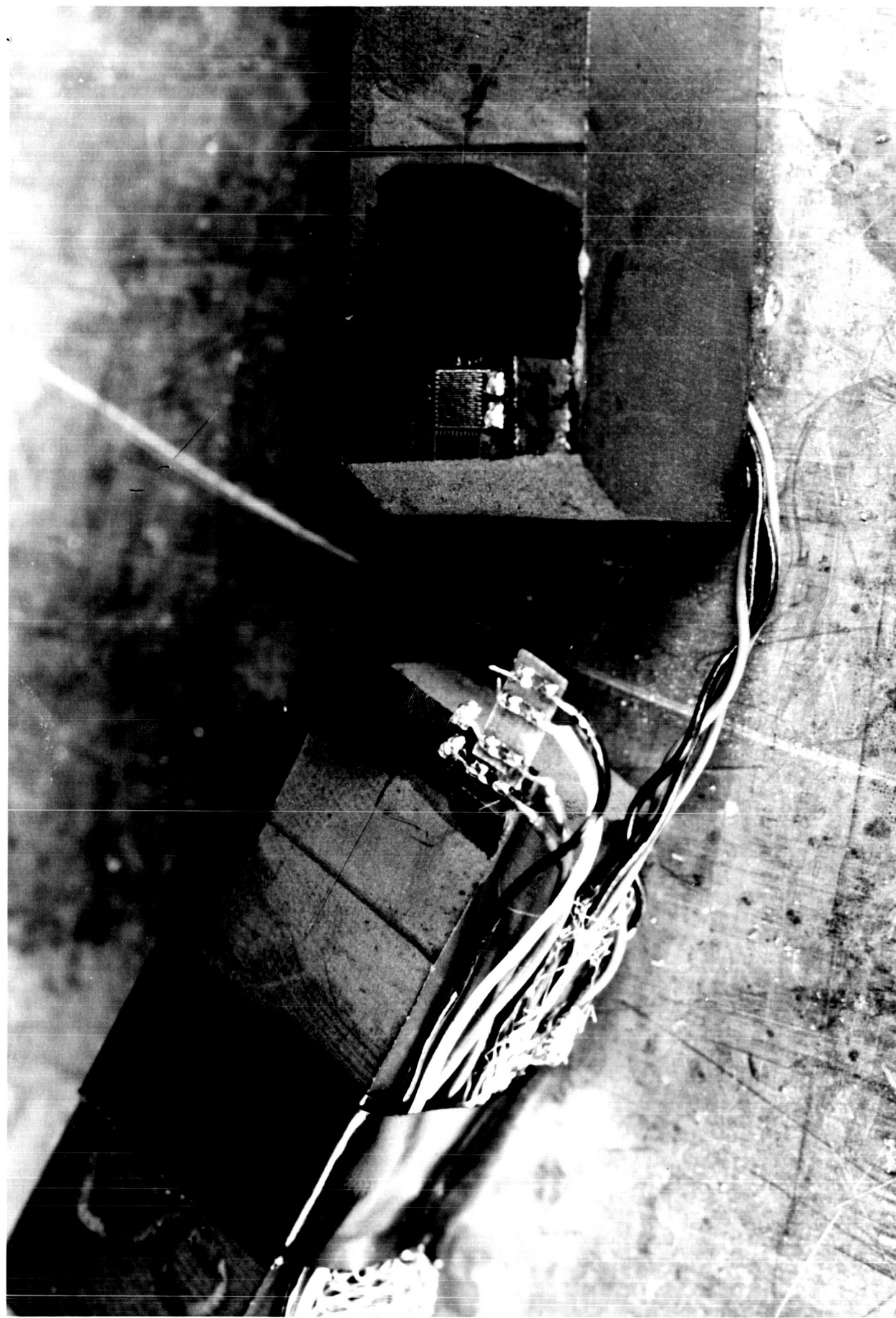


Figure 4

3. Data Reduction

The corresponding data for all of the samples in each of the experiments D-110, D-111, and D-112 were handled in the manner described below.

3.1. Calculations.

a. Bulk Density. The bulk density of each sample was determined by dividing the weight by the measured volume.

b. The ultimate loads and ultimate strains were read directly from the recorded curves as the uppermost and rightmost points on the curve, respectively. See Figures 5(a), (b), (c), and (d). In almost all cases these points coincided with the failure point for the test.

c. Nominal Stresses. For the flexure data, the nominal ultimate stress was determined by use of the formula

$$\sigma = \frac{Mc}{I}$$

where M is the applied bending moment, c is half the height of the cross section, and I is the second moment of area based on the original dimensions of the sample.

For the compression data, the nominal ultimate stress was calculated using

$$\sigma = \frac{P}{a}$$

where P is the load and a the cross sectional area of the sample based on original dimensions.

Because of the uniformity in the dimensions of the samples for each family, the mean dimensions of the family population was used in calculating the nominal stresses for that particular family.

d. Second-Cycle Modulus. By definition the second-cycle modulus was taken to be the slope of the linear portion of the re-load cycle of the load vs axial strain curve measured in psi. In the flexure tests, Figures 5(a) and (b), the re-load curve had a high degree of apparent linearity and thus the modulus was fairly well defined. In fact, in the several tests in which three or more load cycles were run, it was observed that the linear portion for each re-load curve had approximately the same slope.

On the other hand, in the compression tests the load, unload, and re-load curves exhibited little or no degree of linearity, thus the second-cycle modulus was defined as the slope of the initial tangent of the re-load cycle of the load vs axial strain curve. This quantity was somewhat more difficult to measure uniquely than was the corresponding value for the flexure data. Figure 5(d) illustrates the fact that the initial tangent to the load and all subsequent re-load curves was approximately the same.

e. Poisson Ratio. The poisson ratio was defined as the ratio of the slope of the second-cycle load vs axial strain curve (as determined in d) to the slope of the corresponding second cycle of the load vs poisson strain curve. However, it should be observed in Figures 5(a) and (c) that the second-cycle poisson curves had a slight "S" shape and thus the apparent linear portion usually appeared well above zero loading. The slope of this linear portion was used in determining the poisson ratio.

f. Apparent Strain Damage. The value of the apparent strain damage was meant to reflect the degree to which the material was permanently deformed when loaded up to 80 percent of the failure load and then unloaded. This value could be obtained by loading the sample to 80 percent ultimate load, unloading, and then measuring the residual strain. However, since the

ultimate load for each sample could not be known au priori, the following procedure was used to determine the value of the strain damage. Eighty percent of the ultimate load was determined after the fact. From this point on the load-strain curve a straight line parallel to the second-cycle modulus line (see d) [or second-cycle poisson line (see e)] was drawn down to intersect the strain axis. The strain corresponding to this intersection was taken as the value of the strain damage for 80 percent ultimate stress. This value is indicated in Figures 5(a), (b), (c), and (d) by ϵ_{ra} for residual axial strain and ϵ_{rp} for residual poisson strain.

It should be pointed out that in the flexure data the value obtained from this procedure and the value that would be obtained directly from the unloading curve do not differ significantly in most cases because of the apparent linearity of the re-load curve, Figures 5(a), (b), and (c). However, for the compression data these two values usually differ considerably due to the obvious nonlinearity of the unloading and re-loading curves, Figure 5(d). Therefore, for the sake of consistency, the value obtained by the procedure described in the preceding paragraph was taken as the apparent strain damage. Finally it should be observed that the flexure tension poisson curve, Figure 5(c), behaved unusually in that the loading strain was positive (contraction), while the residual strain usually was negative (extension). This behavior is indicated in the tabulated results with a minus sign.

3.2. Tabulation of Data.

All data was tabulated in a manner to reflect their dependence on the location, orientation, and graphite sub-type of the samples. To this end, averages were obtained on the basis of a rational selection of sample family

population determined by a review of the data. However, the relatively small family population did not permit further statistical evaluations. The tabulated data are displayed in table form in Appendixes A, B, and C pertaining to Experiments D-110, D-111, and D-112, respectively.

3.3. Tabulation of Results.

While all of the data pertaining to the calculations of Section 3.1 are displayed in the appendixes, it was felt that some of the data are more significant than others. Explanation of this remark follows.

In the flexure data, the ultimate tensile stress and the ultimate and residual tensile strains are felt to be significant values whereas the compression values are not. This is because all flexure samples, except one faulty flexure sample, exhibited a brittle tensile-type of failure typified by that shown in Figure 4. However, significant ultimate and residual compression values were obtained from the data on the compression tests although the ultimate axial strains might be questioned on the grounds that their values (in the neighborhood of 30,000 μ in/in) possibly exceed the range of reliability of the gage and bonding material.

On the other hand, because of the difficulty in determining a unique value for the tangents to the compressive load-strain curves (see Section 3.2d) and, because of the consistent nature of the behavior of the flexure specimens, it was felt that the flexure data indicated a more realistic value for the second-cycle moduli and poisson ratios in tension and compression. Therefore, these flexure values are thought to be more significant than those from the compression tests.

Those values, which in the judgment of the writer are thought to be most indicative of the mechanical behavior of the material, are tabulated

in the next section of this report, which is devoted to the individual Experiments D-110, D-111, and D-112.

FLEXURE COMPRESSION LOAD-STRAIN

Experiment No. D-111

Specimen No.

Date

Calibration Poisson

Calibration Axial

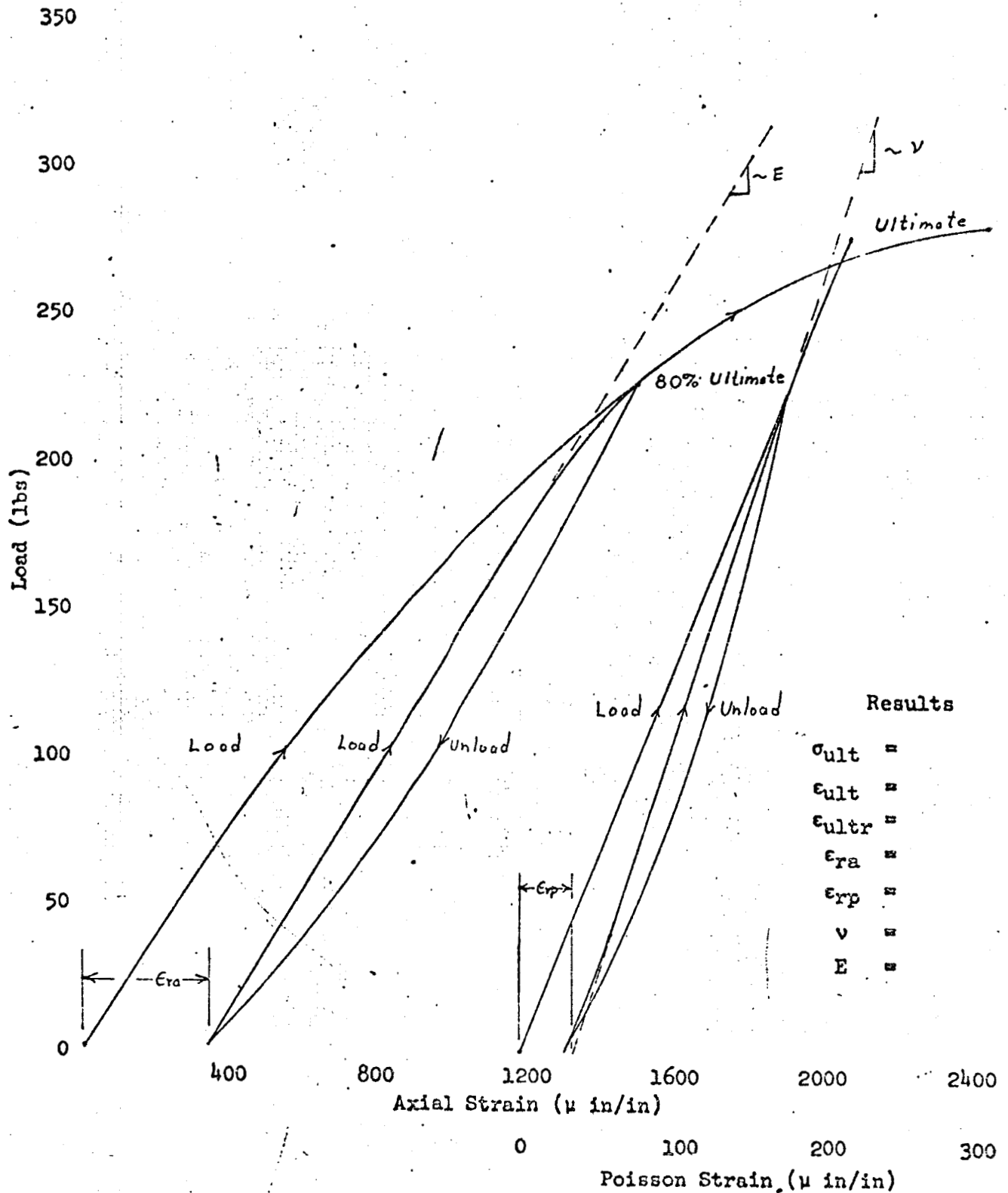


Figure 5(a)

FLEXURE TENSION LOAD-STRAIN

Experiment No. D-110

Specimen No.

Date

Calibration Poisson

Calibration Axial

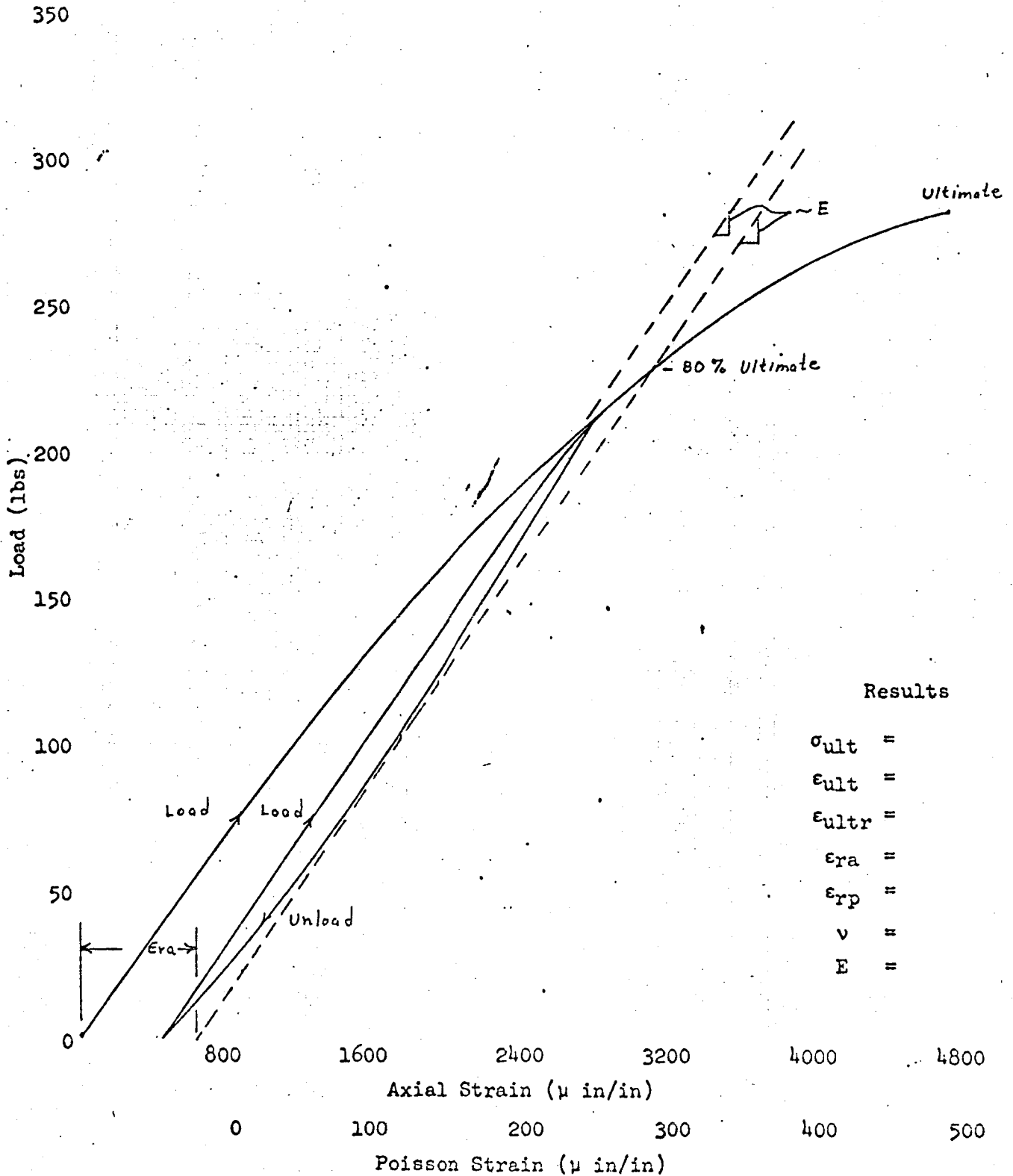


Figure 5(b)

FLEXURE TENSION LOAD-STRAIN

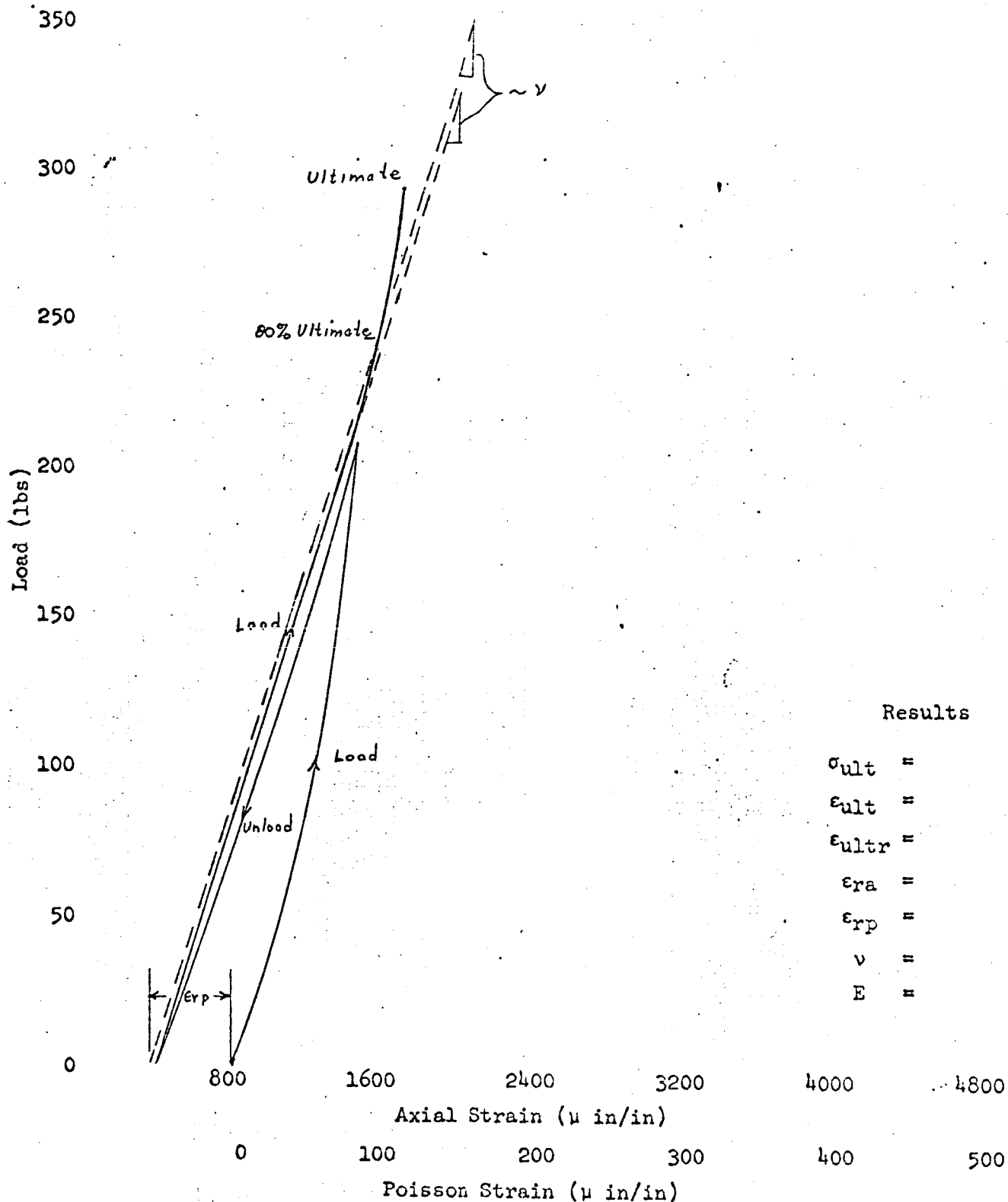
Experiment No. D-110

Specimen No.

Date

Calibration Poisson

Calibration Axial



Results

σ_{ult} =
 ϵ_{ult} =
 ϵ_{ultr} =
 ϵ_{ra} =
 ϵ_{rp} =
 ν =
 E =

Figure 5(c)

COMPRESSION LOAD-STRAIN

Experiment No. D-110

Specimen No.

Date

Calibration Poisson

Calibration Axial

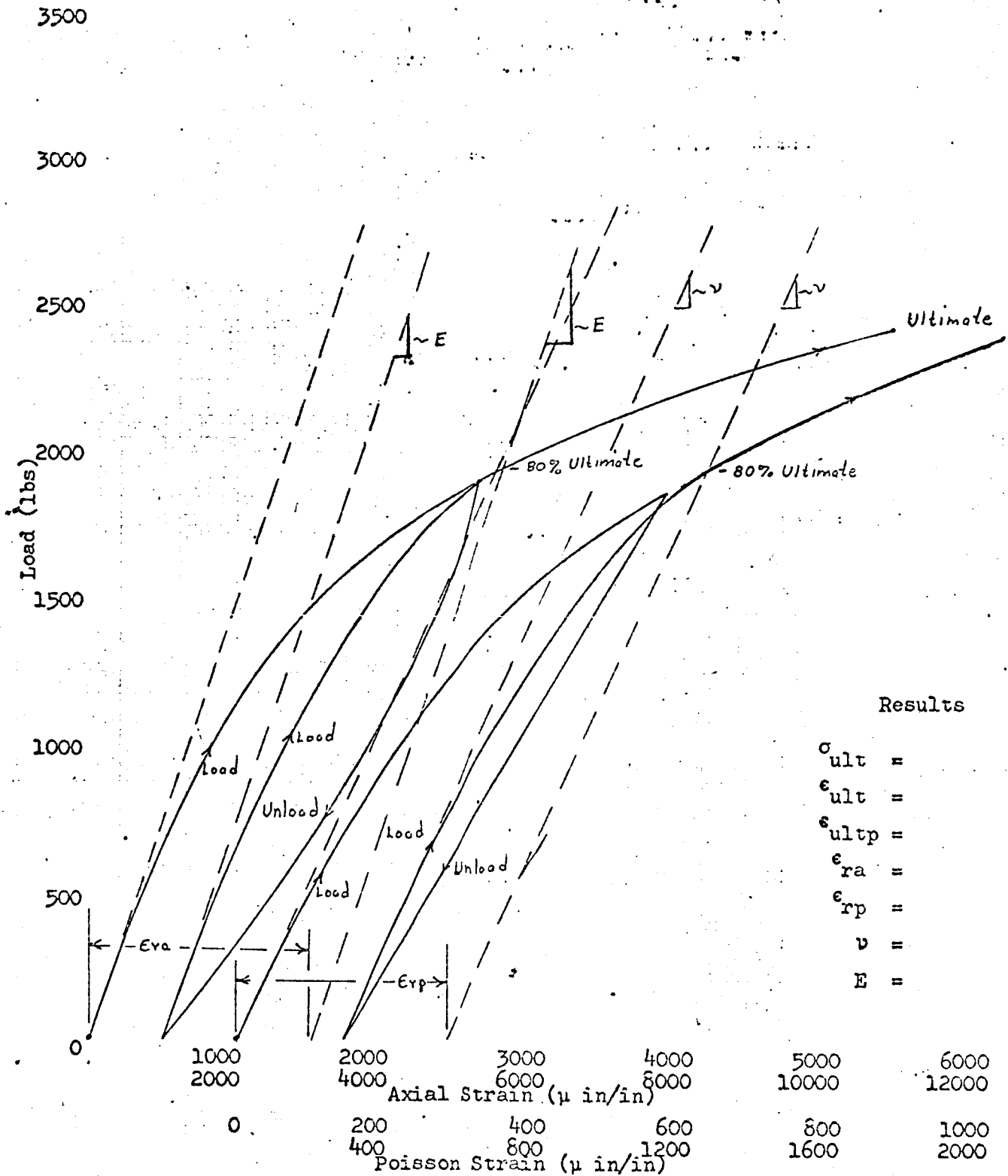


Figure 5(d)

4. Results

All tabulated data are displayed in Appendixes A, B, and C for Experiments D-110, D-111, and D-112, respectively.

4.1. Experiment D-110 - H4LM Stress-Strain Study.

These samples are cut from horizontal (slabs A, B, C) and vertical (slabs E, F, G) slabs representing four different azimuthal locations (0° , 90° , 180° , 270°) in a large molded graphite cylinder of interest. See Figures 6 and 7. Each slab has been cut into strips labeled 1 through 4, and a rectangular flexure sample was machined longitudinally from each of strips 1, 3, and 4, while strip 2 was machined into two longitudinal compressive samples (2-1 and 2-2). In the horizontal slabs A and C, the strips are approximately tangential to the molded cylinder, numbered along an increased radius, while the strips from slab B are roughly parallel to the radius of the original cylinder. In the vertical slabs E and G, the strips are parallel to the axis of the cylinder, numbered along an increased radius, while the strips from slab F were cut radially, numbered from top to bottom. This scheme provided representation for every typical orientation and location with minimum redundancy. Samples were identified in the following manner: H4LM-090-A-2-2, which retains the type, slab, strip, and sample identity, respectively.

The flexure samples were instrumented with Micro-Measurements foil-type 90° rosette gages EA-03-125TM, while the compression samples were instrumented with Budd encapsulated stacked rosette gages EC3-121-R2TS, lot A7-FIJ-2 (leadless).

The samples were instrumented in the following manner.

Sample A	gaged on top surface			
" B	"	"	top	"
" C	"	"	front	"
" E	"	"	front	"
" F	"	"	top	"
" G	"	"	surface adjacent to front surface	

Hence, with this cutting and instrumenting pattern and denoting the longitudinal, tangential, and radial direction with 1, 2, and 3, respectively, the data from each of the samples can be related to the axes of the cylinder in the following manner.

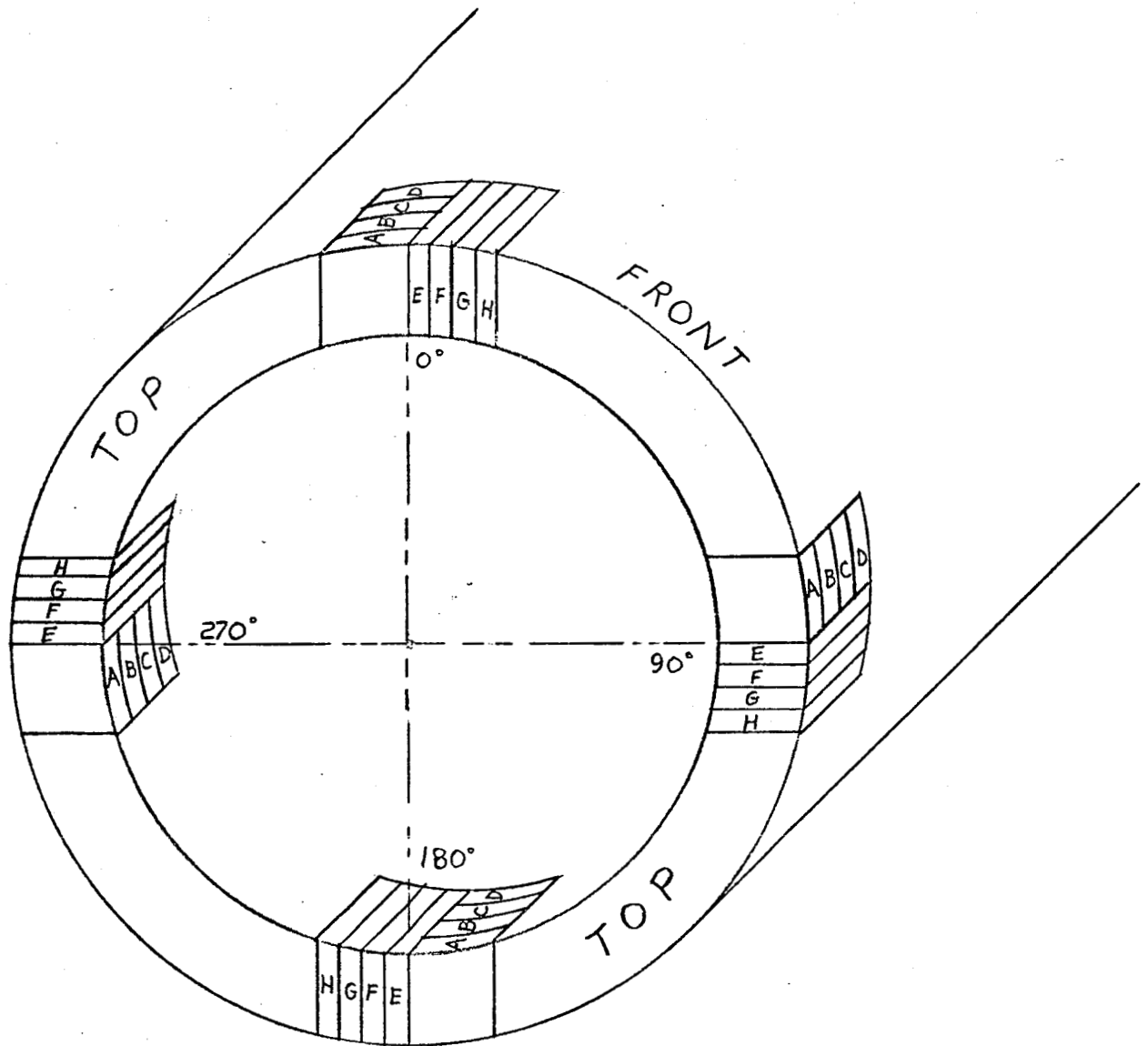
<u>Samples</u>	<u>Axial</u>	<u>Poisson</u>
A	2	3
B	3	2
C	2	1
E	1	2
F	3	2
G	1	3

Note that samples A and C, samples B and F, and samples E and G give substantially the same axial data and hence are grouped together in that manner in the tabulated results of Appendix A. Furthermore, samples B and F give substantially the same poisson data, which could have been avoided had sample B or F been instrumented on its surface adjacent to the top surface rather than on its top surface, thus yielding "1" poisson data.

By a rational evaluation of the data based on sample family population, the H4LM may be said to exhibit the mechanical properties listed in Table 1a and Table 1b, in which d indicates the strain damage as defined earlier.

In general, one can conclude that the graphite is more than twice as strong in compression as tension, is weakest in the longitudinal direction of the cylinder, and that the transverse plane is a plane of isotropy. Further, the longitudinal modulus is slightly higher than the transverse modulus and there are three distinct poisson ratios (ν_{12} or ν_{13} , ν_{21} or ν_{31} , and ν_{23} or ν_{32}). Thus one could conclude that the H4LM graphite exhibited properties of a transversely isotropic material.

H4LM GRAPHITE
SAMPLE SELECTION



Top surface refers to the transverse plane of the cylinder and the front refers to the outside surface.

Figure 6

H4LM GRAPHITE
SAMPLE SELECTION

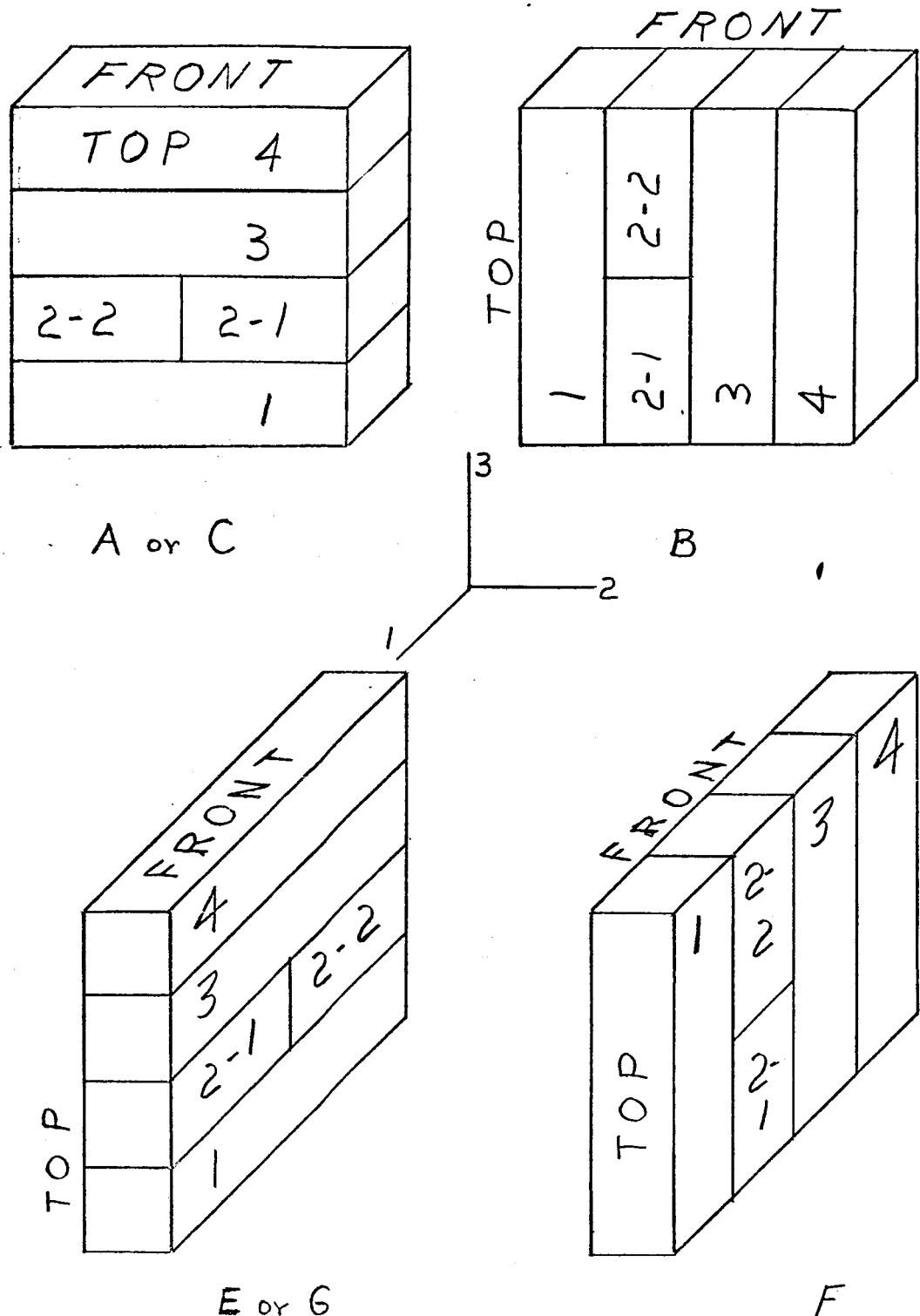


Figure 7

Table Ia
Mechanical Properties

Experiment D-110

Flexure Tension

Material: H4LM

Property	Orientation			
	000°	090°	180°	270°
E_1 psi	1.33	1.32	1.19	1.16
E_2 psi	1.10	1.23	1.23	1.22
E_3 psi	1.09	1.10	1.19	1.22
ν_{13}, ν_{12}	0.135	0.111	0.120	0.101
ν_{23}	0.126	0.133	0.160	0.117
ν_{21}	0.097	0.091	0.116	0.086
ν_{32}	0.120	0.109	0.140	0.099
σ_1 psi	2400	1950	1750	1950
σ_2 psi	2350	2700	2850	2850
σ_3 psi	2700	2550	2500	2800
ϵ_1 μ in/in	2250	1800	1800	2100
ϵ_2 μ in/in	2850	2900	3000	3350
ϵ_3 μ in/in	3300	2950	2650	2850
d_1 μ in/in	315	195	235	240
d_2 μ in/in	375	405	390	450
d_3 μ in/in	475	440	340	350

Table 1b
Mechanical Properties

Experiment D-110

Flexure Compression

Material: H4LM

Property	Orientation			
	000°	090°	180°	270°
E ₁ psi	1.36	1.41	1.21	1.19
E ₂ psi	1.14	1.26	1.25	1.31
E ₃ psi	1.17	1.08	1.23	1.21
ν_{13}, ν_{12}	0.127	0.117	0.130	0.103
ν_{23}	0.129	0.137	0.157	0.126
ν_{21}	0.113	0.096	0.115	0.116
ν_{32}	0.115	0.108	0.148	0.118

Uniaxial Compression

σ_1 psi	5750	4850	5500	5400
σ_2 psi		6200	6600	6650
σ_3 psi	6800	5550	6150	5900
ϵ_1 μ in/in	20500	14700	17450	19550
ϵ_2 μ in/in		19050	19800	21500
ϵ_3 μ in/in	21600	17650	18500	17600
d_1 μ in/in	3800	3460	3950	4775
d_2 μ in/in		4700	5100	5350
d_3 μ in/in	6050	4750	4550	4425

4.2. Experiment D-III - ATJ Stress-Strain Study.

These samples were selected in a manner quite similar to those for D-II0; however, they represent four different ATJ-based materials. Thirty samples of each type of material (18 flexural and 12 compressive) were provided for evaluation. These are identified as the following:

- | | |
|--------|---|
| Type 1 | HT-ATJ-LX-08028-1
Older material, known to be radiographically sound, heat treated one hour at 2500°C. |
| Type 2 | HT-ATJ-LX-09029-1
Material obtained approximately one year ago, radiographically unsound, heat treated one hour at 2500°C. |
| Type 3 | HT-ATJ - Air Mail
A very recently obtained improved lot, heat treated one hour at 2500°C. |
| Type 4 | NHT-ATJ - Air Mail
Type 3, but not heat treated. |

Identification was by a standard sample number, similar to D-II0; e.g., ATJ-1, A-2-2 designates the second compressive sample cut from strip 2 of slab A from ATJ type 1 block. See Figures 8 and 9.

The flexure samples were instrumented with Micro-Measurements foil-type 90° rosette gages EA-03-125TM, while the compressive samples were instrumented with Budd encapsulated stacked rosette gages EC3-121-R2TS, lot A19-FDJ-1 (factory installed leads). The samples were instrumented in the following manner.

Sample A		gaged on top surface			
"	B	"	"	top	"
"	C	"	"	front	"
"	E	"	"	front	"
"	F	"	"	top	"
"	G	"	"	surface adjacent to front surface	

Hence, with this cutting and instrumenting pattern, the data from each sample can be related to the 1, 2, and 3 axes of Figures 8 and 9 in the following manner.

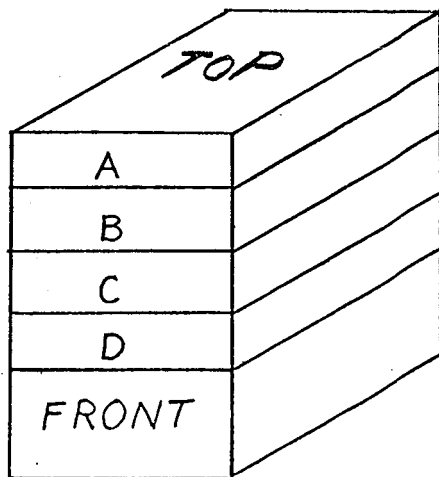
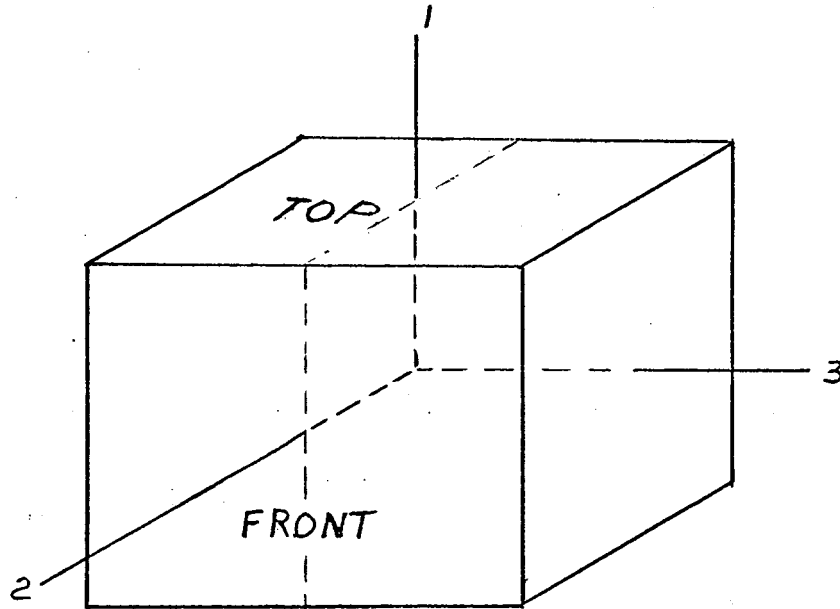
<u>Samples</u>	<u>Axial</u>	<u>Poisson</u>
A	3	2
B	2	3
C	3	1
E	1	3
F	2	3
G	1	2

Note that samples A and C, samples B and F, and samples E and G give substantially the same axial data and hence are grouped together in that manner in the tabulated results of Appendix B. Furthermore, samples B and F give substantially the same poisson data, which could have been avoided had samples B or F been instrumented on its surface adjacent to the top surface rather than on its top surface, thus yielding "1" poisson data.

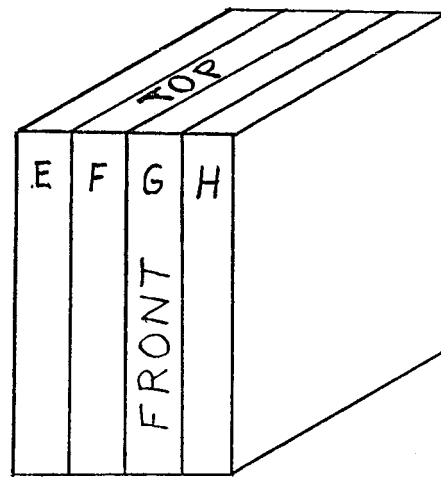
By a rational evaluation of the data based on sample family population, the ATJ graphites may be said to exhibit the mechanical properties listed in Table IIa and Table IIb, in which d indicates the strain damage as defined earlier.

In general, one concludes that type 3 is the strongest of the graphites and that all of them are weakest in the direction normal to the plane parallel to the grain of the material. Further, they tended to exhibit two distinct moduli and three distinct poisson ratios although in type 3 the poisson ratios tended to lose distinction. All of the types were obviously weaker in tension than compression.

ATJ GRAPHITE
SAMPLE SELECTION



LEFT



RIGHT

Top surface refers to the upper plane
parallel to the grain of the material.

Figure 8

ATJ GRAPHITE
SAMPLE SELECTION

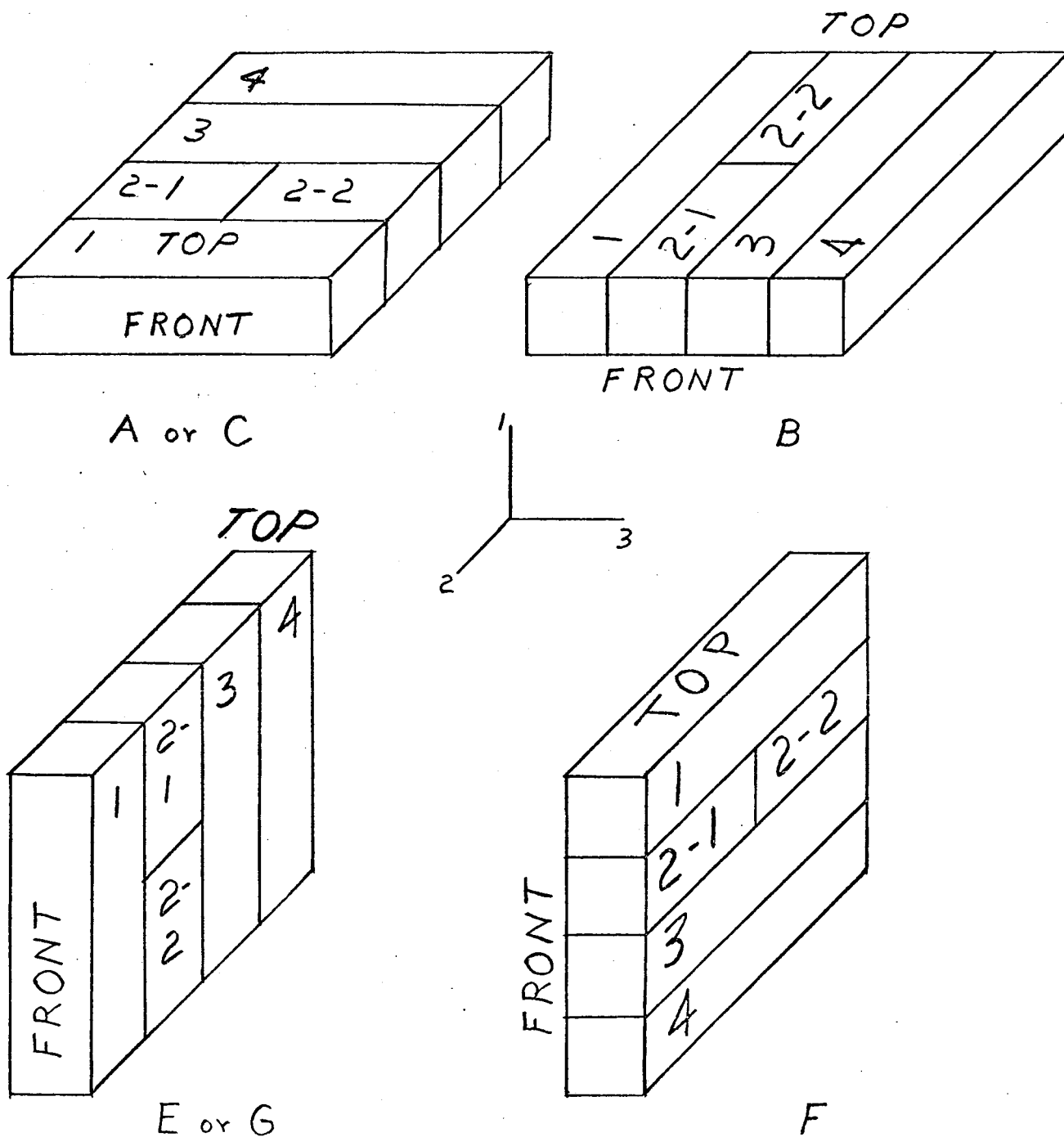


Figure 9

Table 11a
Mechanical Properties

Experiment D-III

Flexure Tension

Material: ATJ

Property	Type			
	1	2	3	4
E_1 psi	1.08	1.02	1.26	1.16
E_2 psi	1.60	1.51	1.71	1.68
E_3 psi	1.51	1.58	1.58	1.53
ν_{13}, ν_{12}	0.104	0.084	0.094	0.098
ν_{23}	0.086	0.086	0.105	0.088
ν_{32}	0.077	0.095	0.078	0.082
ν_{31}	0.132	0.148	0.083	0.134
σ_1 psi	3300	3000	3700	3450
σ_2 psi	4250	4350	5200	4850
σ_3 psi	4200	4450	4750	4450
ϵ_1 μ in/in	3800	3650	3700	3700
ϵ_2 μ in/in	3250	3450	3775	3600
ϵ_3 μ in/in	3300	3400	3675	3500
d_1 μ in/in	500	475	515	510
d_2 μ in/in	270	360	475	430
d_3 μ in/in	310	385	440	445

Table 11b
Mechanical Properties

Experiment D-III

Flexure Compression

Material: ATJ

Property	Type			
	1	2	3	4
E_1 psi	1.10	1.09	1.27	1.15
E_2 psi	1.59	1.54	1.68	1.69
E_3 psi	1.53	1.66	1.61	1.62
ν_{13}, ν_{12}	0.109	0.090	0.099	0.100
ν_{23}	0.084	0.088	0.103	0.090
ν_{32}	0.077	0.096	0.075	0.089
ν_{31}	0.138	0.156	0.087	0.142

Uniaxial Compression

σ_1 psi	9000	10550	10700	9900
σ_2 psi	9500	10000	10800	10200
σ_3 psi	9350	10400	10400	9900
ϵ_1 μ in/in	33000	34400	36600	34000
ϵ_2 μ in/in	24200	25500	25500	25700
ϵ_3 μ in/in	22100	25300	23900	25300
d_1 μ in/in	10700	10100	9800	9850
d_2 μ in/in	7000	6550	6800	6650
d_3 μ in/in	6300	6850	6000	6650

4.3. Experiment D-112 - Experimental Graphite Evaluation.

This represented a limited scouting study of some less common graphites which are candidates for structural applications. There are seven materials (all heat treated for an hour at 2500°) of interest; and, while the original intent was to obtain flexural samples from each of the mutually orthogonal directions, billet size did not always permit this and so compressive samples were provided instead. As a result, all compressive specimens had a "transverse" orientation, while most of the flexural samples were "longitudinal"; that is, their major axis was parallel to the greatest dimension and/or the layered planes of the original billets. Identification is by the graphite type, suffixed with a one, two, or three digit serial number as in P03B175-2-111. The series I through 3 indicates a transverse orientation, while II through 33 and III through 333 are longitudinal specimens. Flexural samples, identified by the two digit series, were identical to those of the three digit series; however, the three digit samples were instrumented and tested in a manner to provide a 90° rotational relationship with respect to the one and two digit samples.

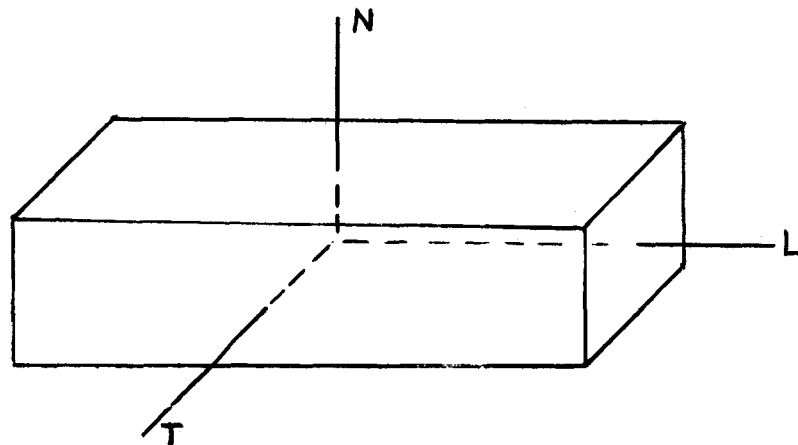


Figure 10

In Figure 10, the T,L plane (T,L denoting transverse and longitudinal, respectively) is parallel to layered planes of the original billet. Hence the data from each sample can be related to the T, L, and N directions in the following manner.

<u>Sample</u>	<u>Axial</u>	<u>Poisson</u>
I,2,3	T	L
II,22,33	L	T
III,222,333	L	N

Although the amount of data is too limited to draw any definite conclusions, the data indicate that the graphites exhibit the mechanical properties listed in Tables IIIa, b, c, d, e, f, and g. In general, the P03B175-2 and B2691 types appeared to be the strongest, while the EPI92-C4 was clearly the weakest.

Table IIIa
Mechanical Properties

Experiment D-112

Material: P03B175-2

Property	Flexure Tension	Flexure Compression
E_L psi	2.07	2.05
E_T psi	1.80	1.76
ν_{LT}	0.174	0.165
ν_{LN}	0.143	0.136
ν_{TL}	0.142	0.133
σ_L psi	6600	
σ_T psi	6100	
ϵ_L μ in/in	3500	
ϵ_T μ in/in	3750	
d_L μ in/in	265	
d_T μ in/in	250	

Table IIIb
Mechanical Properties

Experiment D-112

Material: E-24-554F-2

Property	Flexure Tension	Flexure Compression	Uniaxial Compression
E_L psi	1.21	1.23	
E_T psi			1.01
ν_{LT}	0.226	0.234	
ν_{LN}	0.253	0.243	
ν_{TL}			0.241
σ_L psi	3600		
σ_T psi			10600
ϵ_L μ in/in	3250		
ϵ_T μ in/in			13200
d_L μ in/in	150		
d_T μ in/in			1600

Table IIIc
Mechanical Properties

Experiment D-112

Material: B269I

Property	Flexure Tension	Flexure Compression	Uniaxial Compression
E_L psi	1.98	2.12	1.34
E_T psi			
ν_{LT}	0.156	0.175	
ν_{LN}	0.158	0.180	0.183
ν_{TL}			
σ_L psi	6550		
σ_T psi			18300
ϵ_L μ in/in	4050		27450
ϵ_T μ in/in			
d_L μ in/in	485		
d_T μ in/in			6000

Table IIId
Mechanical Properties

Experiment D-112

Material: RVC

Property	Flexure Tension	Tension Compression	Uniaxial Compression
E_L psi	1.99	1.97	
E_T psi			0.73
ν_{LT}	0.138	0.134	
ν_{LN}	0.079	0.079	
ν_{TL}			0.098
σ_L psi	4550		
σ_T psi			11500
ϵ_L μ in/in	2800		
ϵ_T μ in/in			31900
d_L μ in/in	353		
d_T μ in/in			10050

Table IIIe
Mechanical Properties

Experiment D-112

Material: SX4-2

Property	Flexure Tension	Flexure Compression	Uniaxial Compression
E_L psi	1.34	1.35	
E_T psi			0.59
ν_{LT}	0.115	0.148	
ν_{LN}	0.163	0.173	
ν_{TL}			0.146
σ_L psi	3800		
σ_T psi			6950
ϵ_L μ in/in	3700		
ϵ_T μ in/in			26300
d_L μ in/in	510		
d_T μ in/in			7090

Table III f
Mechanical Properties

Experiment D-112

Material: EPI92-3

Property	Flexure Tension	Flexure Compression	Uniaxial Compression
E_L psi	1.40	1.48	
E_T psi			1.29
ν_{LT}	0.232	0.260	
ν_{LN}	0.239	0.256	
ν_{TL}			0.288
σ_L psi	4750		
σ_T psi			14350
ϵ_L μ in/in	3900		
ϵ_T μ in/in			33400
d_L μ in/in	285		
d_T μ in/in			4625

Table IIIg
Mechanical Properties

Experiment D-112

Material: EP192-C4

Property	Flexure Tension	Flexure Compression	Uniaxial Compression
E_L psi	0.882	0.910	
E_T psi			0.78
ν_{LT}	0.208	0.232	
ν_{LN}	0.206	0.217	
ν_{TL}			0.210
σ_L psi	1900		
σ_T psi			8150
ϵ_L μ in/in	2200		
ϵ_T μ in/in			26450
d_L μ in/in	69		
d_T μ in/in			4200

5. Conversion of Load-Strain Flexure Data to Stress-Strain Data

Recall that the recorded data were actually non-linear load versus strain curves for two loading cycles and that the stresses referred to in Sections 3 and 4 were in reality nominal stresses directly proportional to the load. For the uni-axial compression data the nominal stress differs from the true stress only by an amount proportional to the reduction in cross sectional area which is of negligible importance. However, for the flexure data, because of the non-linearity of the load-strain curves, the nominal stress and the actual flexure stress could differ by a significant amount. Thus, for the sake of completeness, a computerized procedure was developed for determining the flexure stresses from the load-strain data. Since original undeformed sample dimensions are used in the calculations, the stress computed herein is sometimes referred to as the engineering stress.

5.1 Non-Linear Flexure.

The load-stress relationship for flexure can be obtained solely on the basis of geometry and equilibrium considerations. Consider a portion of an initially straight beam subjected to pure bending, see Figure 11. Then

$$2\phi = \frac{d}{R} \quad \text{and} \quad \epsilon = \frac{y}{R} \quad (1)$$

where R is the instantaneous radius of curvature of the neutral axis, d is the distance along the neutral axis, and ϵ is the axial strain at a distance y from the neutral axis.

From equilibrium

$$\int_{\text{area}} \tau \, da = 0 \quad \text{and} \quad M = - \int_{\text{area}} y \, \tau \, da$$

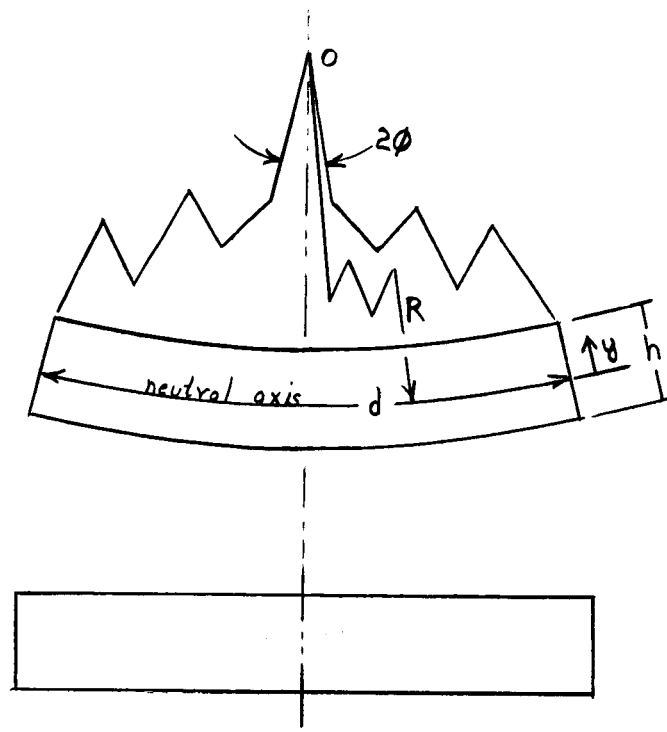


Figure 11

when τ is the flexure stress and the integrals are taken over the cross section of the beam. Then assuming a general single-valued stress-strain relation of the form $\tau = f(\epsilon)$ these become

$$\int_{\epsilon_t}^{-\epsilon_c} f(\epsilon) d\epsilon = 0 \quad M = \int_{-\epsilon_c}^{\epsilon_t} f(\epsilon) R^2 \epsilon b d\epsilon \quad (2)$$

where b is the width of the beam and the subscripts t and c denote maximum tensile and compression values at the outer surfaces. Now

$$2\phi = \frac{(\epsilon_c + \epsilon_t)d}{h} \quad (3)$$

so that from (2) we have

$$-f(\epsilon_c) \frac{d\epsilon_c}{d\phi} - f(\epsilon_t) \frac{d\epsilon_t}{d\phi} = 0$$

or

$$\frac{\tau_c}{\tau_t} = \frac{d\epsilon_t}{d\epsilon_c} = k$$

and

$$M = \frac{h^2 b}{(\epsilon_c + \epsilon_t)^2} \int_{-\epsilon_c}^{\epsilon_t} f(\epsilon) \epsilon d\epsilon \quad (4)$$

or

$$M\phi^2 = \frac{bd^2}{4} \int_{-\epsilon_c}^{\epsilon_t} f(\epsilon) \epsilon d\epsilon \quad (5)$$

Differentiating (5) we have

$$\begin{aligned} \frac{d}{d\phi} (M\phi^2) &= \frac{bd^2}{4} \left[f(\epsilon_t) \epsilon_t \frac{d\epsilon_t}{d\phi} + f(-\epsilon_c) (-\epsilon_c) \frac{d\epsilon_t}{d\phi} \right] \\ &= \frac{bd^2}{4} \left(\tau_t \epsilon_t \frac{d\epsilon_t}{d\phi} + \tau_c \epsilon_c \frac{d\epsilon_t}{d\phi} \right) \end{aligned} \quad (6)$$

Combining (3), (4) and (6) we obtain

$$\frac{bh^2 \tau_t \tau_c}{\tau_t + \tau_c} = \frac{1}{\phi} \frac{d}{d\phi} (M\phi^2)$$

so that finally we have

$$\begin{aligned} \tau_t &= \frac{k + 1}{bh^2 k} \left[\phi \frac{dm}{d\phi} + 2M \right] \\ \tau_c &= k\tau_t \end{aligned} \quad (7)$$

which, in conjunction with (3) and (4), are the desired relations between the flexure stresses and the bending moment M .

5.2 Computation of Flexure Stresses.

The previous derivation was based on the assumption of a single-valued stress-strain relation $\tau = f(\epsilon)$ which does not exist for graphite except if the loading is monotonic increasing which, of course, was not true in the experiments described in this report. However, this difficulty was satisfactorily circumvented by dividing the continuously recorded loadstrain curves into three distinct portions:

the initial first cycle loading, the unloading, and the second-cycle reloading; and treating each of these portions individually. For the first cycle loading the raw data from the curves was used directly in the computations. For the second loading cycle the origin of this portion was effectively shifted by subtracting the residual strain value from all subsequent strain values on that portion of the curve. For the unloading portion, a linear modification of the data was made by subtracting nothing at the juncture with the first load cycle portion and subtracting the residual value of the strain at its juncture with the second loading cycle, and subtracting a proportional amount from the strain values in between. These corrections of the strain values are illustrated in Figure 12. It was felt that these modifications of the data were quite reasonable in view of the testing procedure.

Since the computational procedure was primarily a finite difference technique, the selection of the starting point and increment of the data points of the curve was found to be extremely critical to the success of the program. It was found that the increment had to be large enough to eliminate meaningless results and scatter but small enough to provide a satisfactory number of points.

5.3 Comparison of Nominal and Flexure Stresses.

Data points were taken and the computer program developed. Computations were made only for the ATJ-3 graphite of Experiment D-III which was taken to be representative of the data reported herein. The computer output data were plotted as the stress-strain curves for the flexure tests. From these constructed stress-strain curves the parameters analogous to those discussed in Sections 3 and 4 were determined, namely the ultimate stress, ultimate strain, second cycle modulus, and 80% strain damage. The results are shown in Tables IV and V. Also, the sample curves of Figure 13 show that the nominal stresses were generally of the order of

10% higher than the actual flexure stresses while the nominal second cycle modulus was of the order of 5% higher than the actual modulus. Both of these results were anticipated from the nature of the original data.

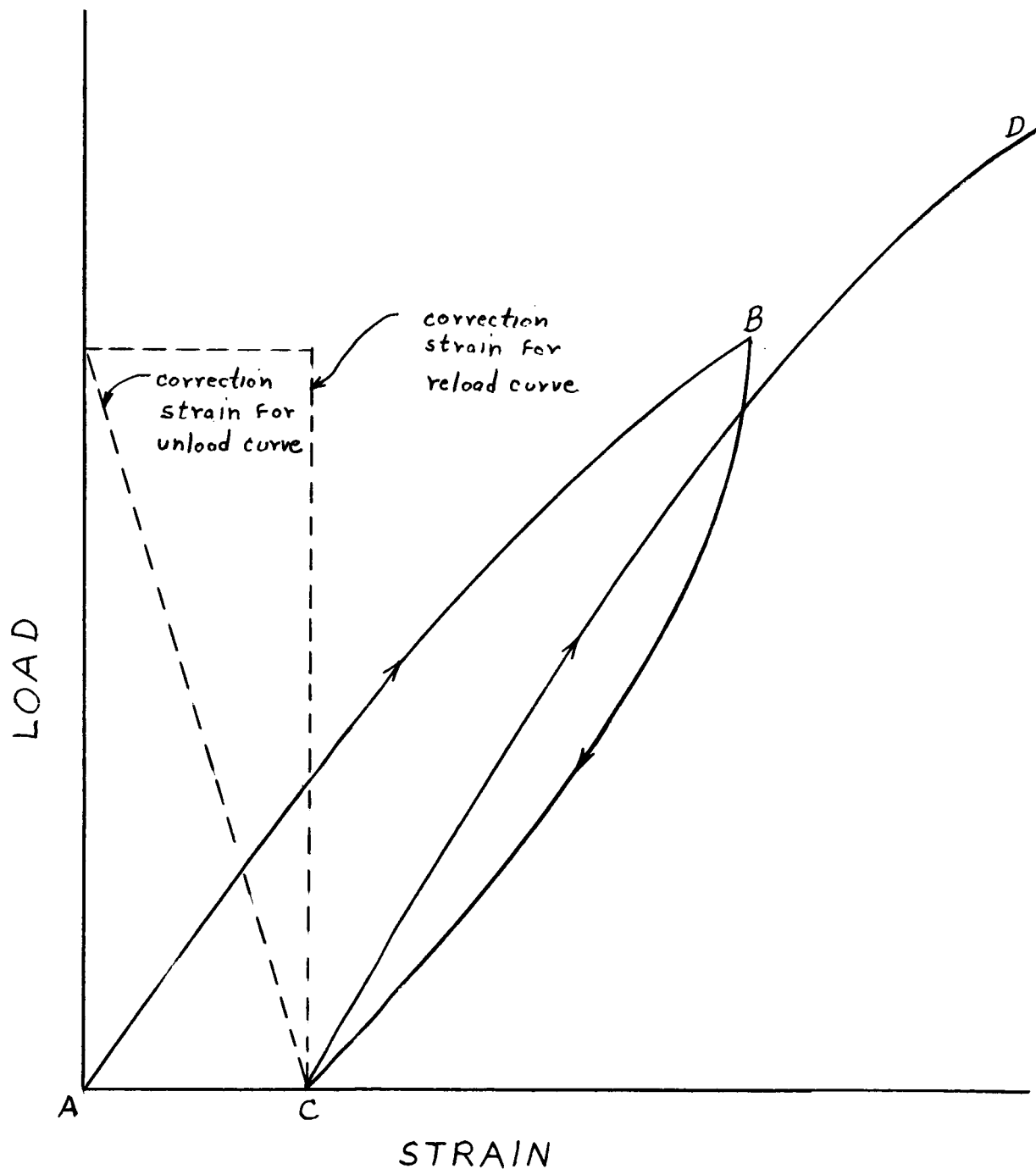


Figure 12

TABLE IVa
CHARACTERISTIC PARAMETERS

FLEXURE TENSION
(Based on Stress-Strain Curves)

Test No.	Ult.Stress (psi)	Ult.Strain (Microin./inch)	Second Cycle Modulus $\times 10^6$ psi	80% Strain Damage
3-A-1	4300	4270	1.372	640
3-A-3	3950	3600	1.556	560
3-A-4	4250	3860	1.463	620
MEAN		3910		
3-C-1	4100	3350	1.586	400
3-C-3	3750	3100	1.479	400
3-C-4	5400	3830	1.802	640
MEAN	4292	3427	1.543	545
3-E-1	3450	3700	1.244	560
3-E-3	3400	3560	1.206	480
3-E-4	3600	3880	1.253	560
3-G-1	3150	3080	1.141	120*
3-G-3	3100	3660	1.150	480
3-G-4	3250	3840	1.056	440
MEAN	3350	3620	1.175	440
3-B-1	5050	3780	1.764	520
3-B-3	4550	3880	1.382	520
3-B-4	4700	3640	1.710	400
3-F-1	4100	3860	1.539	520
3-F-3	4800	3600	1.941	560
3-F-4	4600	3960	1.244	600
MEAN	4633	3787	1.597	520

*Specimen 3-G-1 had a zero residual strain.

TABLE IVb
CHARACTERISTIC PARAMETERS

FLEXURE TENSION
(Based on Load-Strain Curves)

Specimen No.	Ult.Stress (psi)	Ult.Strain (microin./Inch)	Second Cycle Modulus $\times 10^6$ psi	80% Strain Damage
3-A-1	4909	4270	1.4464	550
3-A-3	4578	3600	1.5637	420
3-A-4	4786	3860	1.5325	480
MEAN		3910		
3-C-1	4578	3360	1.6337	360
3-C-3	4238	3120	1.6016	320
3-C-4	5392	3830	1.7028	520
MEAN	4747	3437	1.5801	442
3-E-1	3793	3720	1.3225	530
3-E-3	3755	3570	1.3462	480
3-E-4	4020	3880	1.3168	520
3-G-1	3311	3060	1.1598	470
3-G-3	3523	3640	1.2317	480
3-G-4	3708	3840	1.2071	620
MEAN	3685	3618	1.2640	516
3-B-1	5505	3770	1.8097	460
3-B-3	5259	3880	1.7274	530
3-B-4	5146	3640	1.7340	440
3-F-1	4843	3840	1.6082	440
3-F-3	5297	3650	1.7898	480
3-F-4	5127	3960	1.6006	480
MEAN	5196	3790	1.7116	472

TABLE Va
CHARACTERISTIC PARAMETERS
FLEXURE COMPRESSION
(Based on Stress-Strain Curves)

Test No.	Ult.Stress (psi)	Ult.Strain (microin./inch)	Second Cycle Modulus $\times 10^6$ psi	80% Strain Damage
3-A-1	4250	4020	1.534	520
3-A-3	4350	3420	1.588	440
3-A-4	4700	3620	1.600	440
MEAN		3687		
3-C-1	4300	3250	1.693	440
3-C-3	4100	2800	1.865	400
3-C-4	5100	3780	2.066*	660*
MEAN	4466	3482	1.724	483
3-E-1	3550	3720	1.204	480
3-E-3	3250	3540	1.244	480
3-E-4	3750	3920	1.222	440
3-G-1	3300	2900	1.306	80**
3-G-3	3350	3460	1.244	480
3-G-4	2900	3680	1.282	440
MEAN	3350	3537	1.250	400
3-B-1	5050	3850	1.621	400
3-B-3	4550	3860	1.692	480
3-B-4	4350	3640	1.671	500
3-F-1	4350	3860	1.556	440
3-F-3	5000	3760	1.585	400
3-F-4	4700	3760	1.555	420
MEAN	4667	3758	1.613	440

* Test 3-C-4 recycled 3 times

** Specimen 3-G-1 had a zero offset strain

TABLE Vb
CHARACTERISTIC PARAMETERS
FLEXURE COMPRESSION
(Based on load-strain curves)

Specimen No.	Ult. Stress (psi)	Ult. Strain (Microin./inch)	Second Cycle Modulus $\times 10^6$ psi	80% Strain Damage
3-A-1	4909	4010	1.5250	500
3-A-3	4635	3490	1.6214	400
3-A-4	4758	3640	1.3045	390
MEAN		3713		
3-C-1	4569	3250	1.6943	360
3-C-3	4219	2800	1.7681	280
3-C-4	5430	3800	1.7463	520
MEAN	4753	3283	1.6099	408
3-E-1	3876	3720	1.2629	480
3-E-3	3821	3610	1.3083	400
3-E-4	4096	3920	1.3055	450
3-G-1	3334	2920	1.2062	400
3-G-3	3566	3480	1.2610	400
3-G-4	3736	3670	1.2752	510
MEAN	3738	3554	1.2698	440
3-B-1	5467	3840	1.7681	460
3-B-3	5184	3860	1.7028	510
3-B-4	4938	3650	1.6943	460
3-F-1	4843	3680	1.6167	410
3-F-3	5307	3770	1.6706	420
3-F-4	5061	3740	1.6422	400
MEAN	5133	3757	1.6824	445

FLEXURE TENSION STRESS-STRAIN

Specimen No. 3-A-1

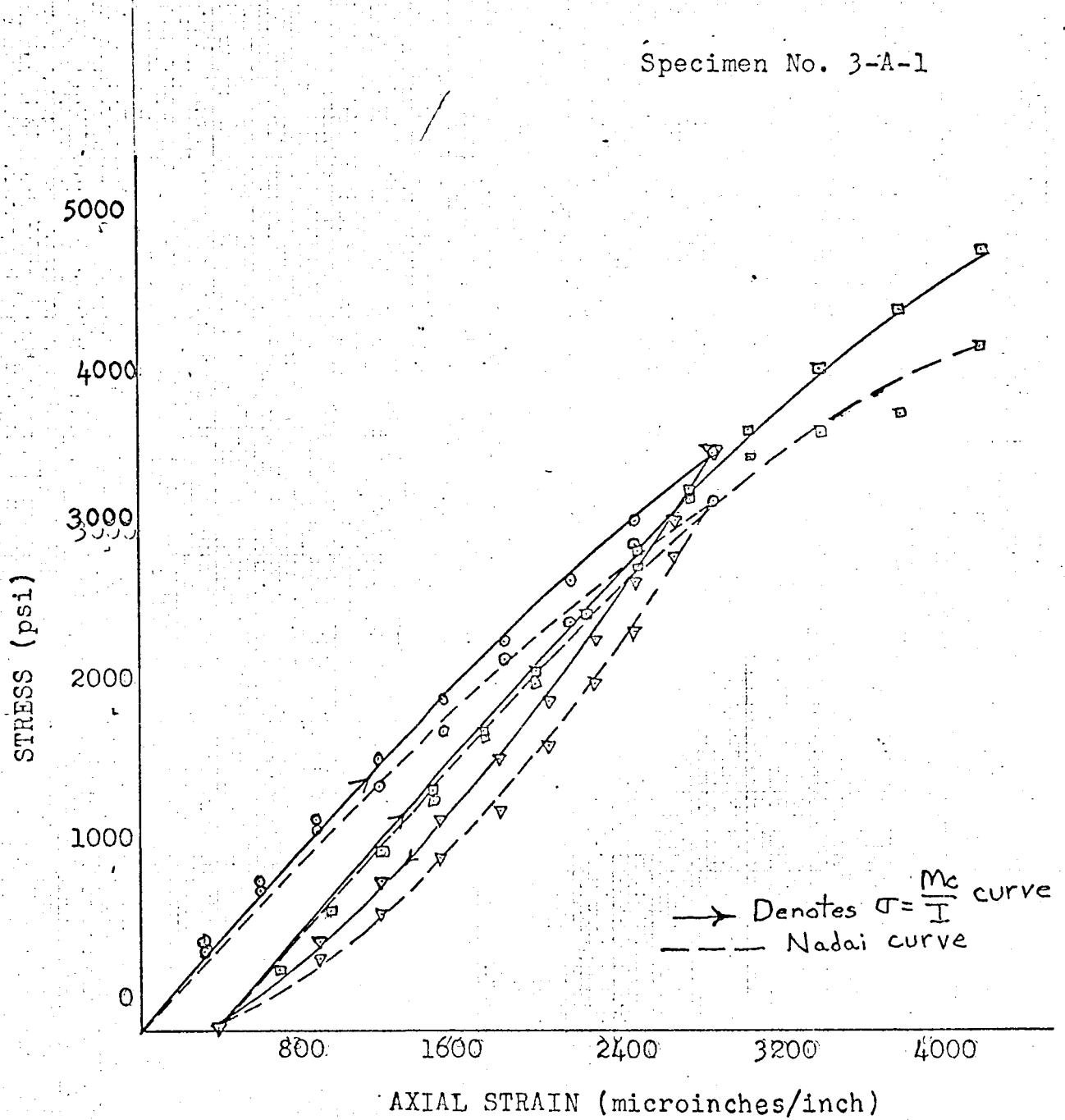


FIGURE 13

6. Concluding Remarks

Overall, the experimental technique appeared to be consistent and reliable. Some signal noise and balancing problems were encountered which were eventually eliminated by replacing the Model 300C Daytronic amplifiers with the older Model 800. Also, considerable shorting problems were encountered in the poisson arm of the leadless Budd stacked rosette gages. These difficulties disappeared with the use of the Budd gages with factory installed leads.

Insofar as the data itself is concerned, the continuous two-cycle load vs strain curves provide a wealth of interesting information, of which only a very small portion has been tabulated and discussed in this report. There can be little doubt that the graphites exhibited brittle behavior under the room temperature experimental conditions and that the ultimate nominal stresses calculated in the manner discussed in Section 3.1 are quite indicative of the ultimate true stresses of the materials. However, no claims can be made that this data establishes any failure criteria or failure mechanism for graphite.

Also, it is clear that the manufacturing and heat treating processes play an important role in influencing the properties and anisotropy of the graphite. This fact implies that meaningful data for graphite can only be obtained if its manufacture, heat treating, machining, and testing are all carefully controlled and recorded. In this regard the two-cycle testing program played a very important role. The first cycle loading actually served as a history-establishing device so that for the second loading cycle the most significant immediate history of the graphite was definitely known. This improved the credibility of the data and considerably reduced the scatter usually inherent in graphite testing.

It was the intent of this investigation to determine and measure parameters of the test behavior of the material which are indicative of its structural

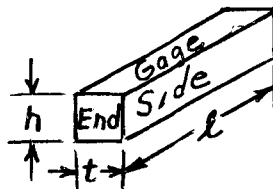
capabilities. To this end, the tabulated results of this report represent a definite contribution.

Finally, one of the most interesting aspects of the data was the history dependent characteristic of the behavior of the graphite. In a subsequent investigation efforts will be made to develop a history-type of constitutive equation for graphite in general which could incorporate parameters representative of such factors as grain size, manufacture and heat treating processes, loading history, temperature, etc. Such a broad attack on graphite might well lead to more fruitful results than have thus far been obtained with much more narrow, intensive efforts.

APPENDIX A
Experiment D-110

FLEXURE SAMPLES

Experiment D-110



Material: H4LM-000

Instrumented 3-10-66

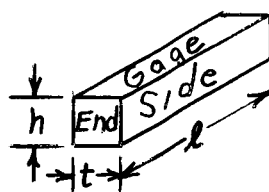
Specimen Number	Surface G S E	Dimensions			Weight** Grams	Density Grams/cm ³	Test Remarks
		h in.	t in.	l in.			
A-1	T* F*	0.7515	0.7515	4.494	72.7599	1.7489	OK
-3	T F	0.7510	0.7510	4.496	72.3045	1.7407	OK
-4	T F	0.7510	0.7510	4.496	72.2955	1.7405	Bad data Adjusted
B-1	T F	0.7520	0.7510	4.495	72.5646	1.7438	OK
-3	T F	0.7520	0.7520	4.496	72.5226	1.7403	Noisy poisson tension
-4	T F	0.7520	0.7515	4.496	72.5641	1.7425	OK
C-1	F T	0.7510	0.7510	4.496	72.3492	1.7418	OK
-3	F T	0.7510	0.7510	4.495	72.2882	1.7403	OK
-4	F T	0.7520	0.7525	4.495	72.6055	1.7415	OK
E-1	F T	0.7510	0.7510	4.496	72.6764	1.7497	3 cycle Bad 1st cycle
-3	F T	0.7505	0.7495	4.496	72.0312	1.7313	OK
-4	F T	0.7510	0.7515	4.496	72.2505	1.7360	Preloaded
F-1	T F	0.7520	0.7515	4.496	72.5004	1.7398	OK
-3	T F	0.7505	0.7500	4.495	72.2051	1.7436	OK
-4	T F	0.7505	0.7500	4.496	72.2994	1.7430	OK
G-1	F T	0.7500	0.7500	4.495	72.3129	1.7449	OK
-3	F T	0.7500	0.7500	4.496	72.1021	1.7394	5 cycle
-4	F T	0.7500	0.7500	4.496	72.0828	1.7390	Noisy poisson tension
Mean		0.7510	0.7508	4.4956	72.3730	1.74150	

*T,F - Designates top and front surfaces of slab.

**Scale accuracy 1/10,000 grams.

FLEXURE SAMPLES

Experiment D-110



Material: H4LM-090

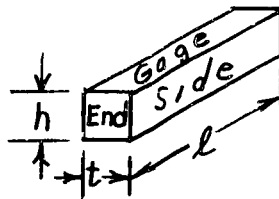
Instrumented 3-10-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
A-1	T*	F*		0.7510	0.7510	4.498	72.4154	1.7416	OK
-3	T	F		0.7510	0.7510	4.496	72.2424	1.7392	OK
-4	T	F		0.7505	0.7505	4.496	72.1702	1.7388	Bad poisson tension
B-1	T		F	0.7510	0.7510	4.496	72.4029	1.7431	OK
-3	T		F	0.7510	0.7510	4.497	72.2624	1.7383	Bad poisson tension
-4	T		F	0.7500	0.7500	4.497	72.1315	1.7398	OK
C-1	F	T		0.7510	0.7510	4.498	72.2318	1.7372	OK
-3	F	T		0.7505	0.7510	4.497	72.2826	1.7400	OK
-4	F	T		0.7500	0.7500	4.497	72.0477	1.7378	Noisy poisson tension
E-1	F		T	0.7510	0.7510	4.496	72.5165	1.7458	OK
-3	F		T	0.7510	0.7510	4.496	72.2859	1.7403	OK
-4	F		T	0.7510	0.7510	4.497	72.3215	1.7397	OK
F-1	T		F	0.7510	0.7510	4.496	72.3709	1.7423	OK
-3	T		F	0.7510	0.7510	4.495	72.3483	1.7425	OK
-4	T		F	0.7510	0.7510	4.496	72.3035	1.7407	OK
G-1		F	T	0.7500	0.7490	4.496	72.1757	1.7434	OK
-3		F	T	0.7500	0.7500	4.496	72.1152	1.7397	OK
-4		F	T	0.7500	0.7505	4.497	72.0403	1.7363	Noisy poisson tension
Mean				0.7506	0.7506	4.4965	72.2590	1.7403	

*T,F - Designates top and front surfaces of slab.

FLEXURE SAMPLES

Experiment D-110



Material: H4LM-180
Instrumented 3-11-66

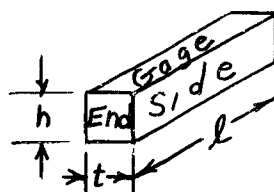
Specimen Number	Surface G S E	Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
		h in.	t in.	l in.			
A-1	T* F*	0.7512	0.7513	4.497**	72.682**	1.7471	OK
-3	T F	0.7515	0.7512	4.500	72.477	1.7451	Noisy poisson tension
-4	T F	0.7516	0.7512	4.498	72.393	1.7392	OK
B-1	T F	0.7507	0.7503	4.500	72.383	1.7425	OK
-3	T F	0.7510	0.7507	4.500	72.480	1.7430	OK
-4	T F	0.7510	0.7509	4.498	72.520	1.7444	OK
C-1	F T	0.7516	0.7516	4.503	72.452	1.7378	OK
-3	F T	0.7513	0.7511	4.497	72.422	1.7412	Noisy poisson tension
-4	F T	0.7512	0.7510	4.497	72.480	1.7429	Noisy poisson tension
E-1	F T	0.7508	0.7505	4.501	72.642	1.7474	Bad poisson tension
-3	F T	0.7518	0.7521	4.502	72.684	1.7422	OK
-4	F T	0.7516	0.7519	4.499	72.593	1.7415	OK
F-1	T F	0.7513	0.7510	4.499	72.628	1.7457	OK
-3	T F	0.7514	0.7513	4.500	72.571	1.7340	OK
-4	T F	0.7505	0.7506	4.498	72.376	1.7428	OK
G-1	F T	0.7516	0.7509	4.498	72.890	1.7519	Broke first cycle
-3	F T	0.7510	0.7505	4.501	72.336	1.7397	Faulty sample
-4	F T	0.7503	0.7508	4.501	72.446	1.7445	OK
Mean		0.7511	0.7511	4.4993	72.591	1.7440	

*T_oF - Designates top and front surfaces of slab.

**LASL data.

FLEXURE SAMPLES

Experiment D-110



Material: H4LM-270

Instrumented 3-11-66

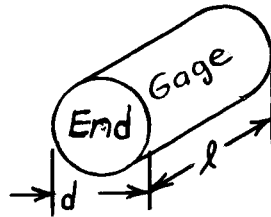
Specimen Number	Surface G S E	Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
		h in.	t in.	l in.			
A-1	T* F*	0.7502	0.7500	4.499	73.023**	1.7602	Noisy poisson tension
-3	T F	0.7505	0.7500	4.500	72.720	1.7516	OK
-4	T F	0.7520	0.7520	4.499	73.151	1.7542	OK
B-1	T F	0.7510	0.7503	4.501	72.989	1.7558	OK
-3	T F	0.7504	0.7501	4.500	72.999	1.7583	OK
-4	T F	0.7508	0.7508	4.499	73.033	1.7570	Noisy poisson tension
C-1	F T	0.7513	0.7512	4.501	73.331	1.7611	Noisy poisson tension
-3	F T	0.7512	0.7510	4.500	73.085	1.7563	OK
-4	F T	0.7511	0.7514	4.501	73.070	1.7549	OK
E-1	F T	0.7515	0.7508	4.502	73.342	1.7617	OK
-3	F T	0.7508	0.7508	4.500	73.028	1.7565	OK
-4	F T	0.7508	0.7510	4.503	73.003	1.7544	Bad poisson tension
F-1	T F	0.7512	0.7510	4.502	73.075	1.7553	OK
-3	T F	0.7503	0.7511	4.500	72.866	1.7529	OK
-4	T F	0.7505	0.7515	4.500	73.151	1.7585	Noisy poisson tension
G-1	F T	0.7517	0.7508	4.500	73.307	1.7610	OK
-3	F T	0.7510	0.7508	4.499	72.979	1.7554	OK
-4	F T	0.7513	0.7509	4.500	72.996	1.7541	OK
Mean		0.7508	0.7509	4.5003	73.0367	1.7566	

*T,F - Designates top and front surfaces of slab.

**LASL data.

COMPRESSION SAMPLES

Experiment D-110



Material: H4LM-000
Instrumented 6-6-66

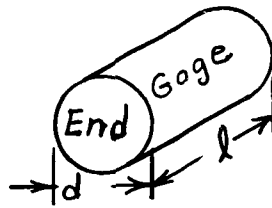
Specimen Number	Surface G E	Dimensions d in. l in.	Weight Grams	Density Grams/cm ³	Test Remarks
A-2-1	T**	0.7505* 1.501*	18.871*	1.7431*	Tested by LASL
A-2-2	T	0.7510 1.501	18.973	1.7409	"
B-2-1	T F	0.7504 1.502	18.995	1.7446	"
B-2-2	T F	0.7507 1.501	18.946	1.7397	"
C-2-1	F	0.7510 1.501	18.924	1.7364	"
C-2-2	F	0.7508 1.502	18.985	1.7418	"
E-2-1	F T	0.7500 1.502	18.935	1.7430	OK
E-2-2	F T	0.7504 1.501	18.979	1.7443	3 cycle. OK
F-2-1	T F	0.7506 1.501	18.934	1.7392	OK
F-2-2	T F	0.7499 1.502	18.974	1.7449	OK
G-2-1	F T	0.7502 1.502	18.953	1.7417	Bad poisson
G-2-2	F T	0.7504 1.502	18.942	1.7397	Noisy poisson
Mean		0.7504 1.502	18.959	1.7416	

*LASL data.

**T,F - Designates arbitrary top and front of specimen slab.

COMPRESSION SAMPLES

Experiment D-110



Material: H4LM-090

Instrumented - LASL

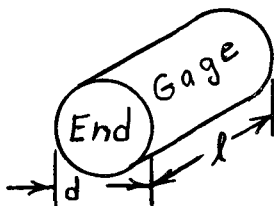
Specimen Number	Surface G E	Dimensions d in. l in.		Weight Grams	Density Grams/cm ³	Test Remarks
A-2-1	T**	0.7501*	1.502*	18.859*	1.7337	OK
A-2-2	T	0.7507	1.501	18.978	1.7426	OK
B-2-1	T F	0.7498	1.502	18.902	1.7389	OK
B-2-2	T F	0.7504	1.501	18.923	1.7392	OK
C-2-1	F	0.7508	1.501	18.890	1.7343	OK
C-2-2	F	0.7509	1.501	18.954	1.7396	OK
E-2-1	F T	0.7505	1.502	18.934	1.7388	OK
E-2-2	F T	0.7508	1.500	18.947	1.7406	OK
F-2-1	T F	0.7502	1.502	18.975	1.7438	OK
F-2-2	T F	0.7510	1.501	18.984	1.7419	OK
G-2-1	F T	0.7504	1.501	18.953	1.7420	OK
G-2-2	F T	0.7508	1.501	18.970	1.7417	OK
Mean		0.7507	1.501	18.939	1.7397	

*LASL data.

**T,F - Designates arbitrary top and front of specimen slab.

COMPRESSION SAMPLES

Experiment D-110



Material: H4LM-180
Instrumented 6-6-66

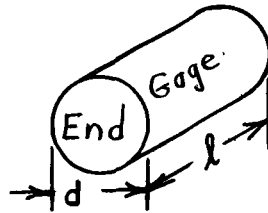
Specimen Number	Surface G E	Dimensions d in. l in.		Weight Grams	Density Grams/cm ³	Test Remarks
A-2-1	T**	0.7502*	1.500*	18.930*	1.7419	3 cycle. OK
A-2-2	T	0.7505	1.500	19.008	1.7478	OK
B-2-1	T F	0.7509	1.499	19.015	1.7479	3 cycle. Ad-justed poisson
B-2-2	T F	0.7516	1.496	18.936	1.7404	OK
C-2-1	F	0.7501	1.500	18.949	1.7453	Noisy poisson OK
C-2-2	F	0.7509	1.500	18.998	1.7449	OK
E-2-1	F T	0.7497	1.501	18.977	1.7475	OK
E-2-2	F T	0.7511	1.502	19.012	1.7428	OK
F-2-1	T F	0.7502	1.501	19.027	1.7496	OK
F-2-2	T F	0.7509	1.501	18.986	1.7427	OK
G-2-1	F T	0.7495	1.502	18.988	1.7481	OK
G-2-2	F T	0.7508	1.502	18.947	1.7383	Adjusted poisson
Mean		0.7505	1.500	18.981	1.7455	

*LASL data.

**T,F - Designates arbitrary top and front of specimen slab.

COMPRESSION SAMPLES

Experiment D-110



Material: H4LM-270
Instrumented 6-7-66

Specimen Number	Surface G E	Dimensions d in. l in.		Weight Grams	Density Grams/cm ³	Test Remarks
A-2-1	T**	0.7498*	1.500*	19.065*	1.7562	OK
A-2-2	T	0.7504	1.499	19.147	1.7621	OK
B-2-1	T F	0.7506	1.499	19.223	1.7682	Adjusted noisy poisson
B-2-2	T F	0.7513	1.499	19.142	1.7577	Noisy poisson OK
C-2-1	F	0.7502	1.500	19.118	1.7592	OK
C-2-2	F	0.7507	1.500	19.195	1.7638	Noisy poisson OK
E-2-1	F T	0.7504	1.500	19.123	1.7588	OK
E-2-2	F T	0.7508	1.499	19.187	1.7639	OK
F-2-1	T F	0.7500	1.500	19.161	1.7640	Adjusted noisy poisson
F-2-2	T F	0.7509	1.499	19.110	1.7566	Bad 1st cycle poisson
G-2-1	F T	0.7501	1.501	19.109	1.7577	OK
G-2-2	F T	0.7509	1.499	19.174	1.7625	Damaged poisson gage
Mean		0.7505	1.500	19.146	1.7608	

*LASL data.

**T,F - Designates arbitrary top and front of specimen slab.

TABULATED RESULTS

Experiment D-110

Flexure Tension

Material: H4LM-000

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.1528	0.1032	2292	2635	135	400	-50
A-3	1.1651	0.1211	2476	2735	225	350	-32.5
A-4	1.2264	0.1548	2490	2650	285	395	-40
Mean		0.1263			215		-41
C-1	1.0104	0.0982	2452	3675	190	575	-30
C-3	1.1085	0.1026	2198	2675	160	390	-30
C-4	0.9330	0.0913	2146	2620	190	160	-20
Mean	1.0993	0.0973	2341	2831	180	378	-40
E-1	1.3292	0.1318	2103	2000	162	275	-35
E-3	1.2377	0.1141	2367	2475	160	325	-45
E-4	1.5538	0.1921	2377	1945	225	260	-32
G-1	1.1792	0.1145	2500	2480	175	400	-35
G-3	1.2972	0.1245	2603	2360	223	300	-40
G-4	1.3755	0.1354	2429	2280	105	330	-88
Mean	1.3287	0.1354	2386	2257	175	315	-46
B-1	1.1792	0.1204	2858	3160	220	475	-45
B-3	1.0311	0.1006	2500	3010	175	360	-57
B-4	1.1226	0.1375	2896	3410	218	530	-105
F-1	1.1113	0.1250	2783	3700	203	630	-120
F-3	1.0311	0.1257	2584	3080	234	430	-55
F-4	1.0623	0.1084	2716	3310	168	490	-72
Mean	1.0896	0.1196	2723	3278	203	478	-76

TABULATED RESULTS

Experiment D-110 Flexure Compression Material: H4LM-000

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.1142	0.1181	2276	2525	272	260	30
A-3	1.1142	0.1418	2471	2710	370	275	45
A-4	1.1792	0.1275	2490	2630	337	325	45
Mean		0.1291			326		40
C-1	1.1679	0.1114	2452	2625	280	300	32.5
C-3	1.1679	0.1179	2193	2325	245	275	20
C-4	1.0915	0.1107	2146	2440	252	160	20
Mean	1.1391	0.1133	2338	2547	259	266	24
E-1	1.3019	0.1042	2122	2175	222	200	25
E-3	1.4151	0.1518	2396	2090	290	220	37
E-4	1.4340	0.1280	2492	2127	276	300	48
G-1	1.4151	0.1304	2377	2180	260	270	26
G-3	1.3057	0.1014	2603	2440	280	320	40
G-4	1.2924	0.1484	2510	2480	356	300	41
Mean	1.3607	0.1274	2417	2248	281	269	38
B-1	1.2632	0.1074	2858	2800	330	320	45
B-3	1.1792	0.1125	2509	2500	275	270	27
B-4	1.0802	0.9060	2877	3360	287	380	35
F-1	1.2264	0.1312	2783	2870	352	350	35
F-3	1.1198	0.1187	2523	2760	330	320	55
F-4	1.1491	0.1294	2716	2930	385	360	50
Mean	1.1696	0.1149	2711	2870	326	333	41

TABULATED RESULTS

Experiment D-110

Flexure Tension

Material: H4LM-090

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.2830	0.1440	2952	3180	290	435	-30
A-3	1.2453	0.1242	2877	2935	188	375	-65
A-4	1.2755	0.1314	2712	2920	230	475	-35
Mean		0.1332			236		-43
C-1	1.1576	0.0856	2382	2795	135	435	-27
C-3	1.2972	0.1083	2584	2520	168	350	-30
C-4	1.1038	0.0795	2603	3025	138	360	-12
Mean	1.2270	0.0911	2685	2895	147	405	-23
E-1	1.2434	0.0900	1981	2025	130	240	-16
E-3	1.4509	0.1305	2084	1830	155	245	-20
E-4	1.3924	0.1230	2000	1760	161	210	-5
G-1	1.2208	0.1109	1745	1070	122	130	-20
G-3	1.2972	0.1031	1839	1730	95	175	-30
G-4	1.3755	0.1075	1981	1725	140	160	-20
Mean	1.3225	0.1108	1938	1790	134	193	-18
B-1	1.1566	0.1045	2759	3120	107	480	-87
B-3	1.1019	0.1201	2476	2730	233	370	-22
B-4	1.1557	0.1127	2509	2830	185	430	-36
F-1	1.0717	0.1136	2575	3200	227	520	-25
F-3	1.0755	0.0969	2339	2680	170	450	-43
F-4	1.0104	0.1038	2556	3090	215	400	-20
Mean	1.0953	0.1085	2536	2941	190	442	-39

TABULATED RESULTS

Experiment D-110 Flexure Compression Material: H4LM-090

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.1528	0.1187	2943	3475	377	390	65
A-3	1.2028	0.1299	2858	2900	372	350	52
A-4	1.2972	0.1625	2707	2690	418	345	32
Mean		0.1370			389		50
C-1	1.3358	0.0945	2367	2420	226	310	28
C-3	1.2406	0.0838	2566	2525	251	300	45
C-4	1.3085	0.1109	2603	2520	270	300	32
Mean	1.2562	0.0964	2674	2805	259	332	35
E-1	1.4151	0.1230	1981	1770	200	325	18
E-3	1.4576	0.1385	2113	1825	241	250	30
E-4	1.2576	0.0803	2028	1925	152	225	18
G-1	1.3472	0.1156	1858	1650	185	140	15
G-3	1.5198	0.1396	1849	1395	150	100	0
G-4	1.4340	0.1040	1990	1660	186	150	15
Mean	1.4052	0.1168	1970	1704	186	198	16
B-1	1.0377	0.1133	2707	3250	350	360	35
B-3	1.0858	0.1137	2452	2730	312	320	50
B-4	1.1198	0.1187	2500	2740	355	280	42
F-1	1.1047	0.1134	2594	2800	333	280	58
F-3	1.0745	0.1025	2339	2640	270	360	42
F-4	1.0396	0.0847	2537	3010	282	320	45
Mean	1.0770	0.1077	2522	2861	317	320	45

TABULATED RESULTS

Experiment D-110

Flexure Tension

Material: H4LM-180

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.1981	0.1512	2452	2586	310	300	0
A-3	1.3274	0.1608	2660	2480	269	295	-36
A-4	1.1123	0.1665	2995	3675	430	585	-42
Mean		0.1595			336		-26
C-1	1.3142	0.1222	2877	2695	225	310	-22
C-3	1.1528	0.1128	3000	3290	224	335	-45
C-4	1.2698	0.1130	3084	3250	176	500	-68
Mean	1.2291	0.1160	2845	2996	208	388	-45
E-1	0.9481	0.1005	1254	1520	105	160	-30
E-3	1.2481	0.1125	1962	1940	154	200	-16
E-4	1.2264	0.1516	1981	2320	185	260	-48
G-1	1.1349	0.0760	1566	1520	75		
G-3			Faulty Sample				
G-4	1.3991	0.1571	2037	1750	238	320	5
Mean	1.1913	0.1195	1760	1810	151	235	-23
B-1	1.0877	0.1166	2537	3000	200	380	-55
B-3	1.1962	0.1199	2481	2610	162	320	-52
B-4	1.2377	0.1584	2669	2680	315	350	-18
F-1	1.2113	0.1588	2311	2420	260	350	-20
F-3	1.2972	0.1598	2476	2270	295	280	-5
F-4	1.0802	0.1292	2510	2920	248	360	-40
Mean	1.1850	0.1404	2497	2650	247	340	-32

TABULATED RESULTS

Experiment D-110 Flexure Compression Material: H4LM-180

No.	2nd Cycle Modulus x 10 ⁶ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.2311	0.1242	2433	2495	364	310	55
A-3	1.2472	0.1667	2632	2590	418	310	55
A-4	1.2472	0.1807	2948	3050	515	360	62
Mean		0.1572			432		57
C-1	1.1585	0.1179	2858	2990	353	325	50
C-3	1.2783	0.1061	2995	2880	332	330	60
C-4	1.3519	0.1200	3080	2815	341	350	52
Mean	1.2523	0.1146	2824	2803	342	331	54
E-1	0.9906	0.1200	1320	1520	175	120	10
E-3	1.2472	0.1013	1981	1910	198	300	26
E-4	1.2264	0.1375	1952	2240	306	210	57
G-1	1.0802	0.1167	1650	1520	177		
G-3			Faulty Sample				
G-4	1.4868	0.1752 *	2473	1635	270	270	18
Mean	1.2062	0.1301	1875	1765	225	225	28
B-1	1.6151	0.1944	2518	2610	368	250	45
B-3	1.1585	0.1335	2481	2540	358	260	60
B-4	1.0906	0.1252	2660	2840	361	280	45
F-1	1.1491	0.1265	2311	2380	293	270	35
F-3	1.1792	0.1500	2476	2570	387	280	60
F-4	1.2066	0.1571	2566	2520	398	240	55
Mean	1.2331	0.1477	2502	2571	361	263	50

TABULATED RESULTS

Experiment D-110

Flexure Tension

Material: H4LM-270

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.2698	0.1252	2801	2875	226	360	-44
A-3	1.2472	0.1202	2867	2885	207	325	-45
A-4	1.2028	0.1063	3009	3335	192	475	-45
Mean		0.1171			208		-45
C-1	1.1858	0.0727	2858	4200	0	660	-105
C-3	1.2670	0.1021	2688	2570	158	275	-65
C-4	1.1453	0.0842	2933	3775	93	600	-82
Mean	1.2196	0.0863	2860	3273	126	449	-84
E-1	1.2226	0.1140	1839	1800	155	160	-12
E-3	1.1038	0.0873	2066	2475	90	305	-24
E-4	1.2000	0.1018	2311	2585	150	405	-22
G-1	1.0915	0.1180	1367	1535	185	75	-10
G-3	1.0453	0.0867	1792	1940	110	200	-21
G-4	1.2972	0.0975	2198	2200	105	290	-37
Mean	1.1600	0.1008	1930	2089	132	240	-21
B-1	1.2066	0.1151	2566	2650	178	290	-40
B-3	1.1887	0.0823	3056	3150	110	430	-65
B-4	1.2132	0.1102	2783	2840	222	310	-24
F-1	1.2840	0.0850	2858	2880	132	420	-30
F-3	1.2113	0.0991	2754	2800	175	325	-34
F-4	1.2057	0.1022	2669	2800	163	360	-52
Mean	1.2182	0.0989	2781	2853	163	356	-41

TABULATED RESULTS

Experiment D-110

Flexure Compression

Material: H4LM-270

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.3085	0.1419	2806	2550	379	225	54
A-3	1.2972	0.1306	2858	2790	363	375	63
A-4	1.2293	0.1042	2995	3060	336	300	59
Mean		0.1255			359		59
C-1	1.4604	0.1295	2867	2870	262	325	10
C-3	1.2679	0.1026	2641	2490	260	275	40
C-4	1.2830	0.1145	2933	3350	359	575	70
Mean	1.3077	0.1155	2850	2851	294	346	40
E-1	1.1792	0.1000	1863	1840	178	145	17
E-3	1.1264	0.1036	2066	2295	220	250	20
E-4	1.1679	0.0863	2339	2475	190	275	15
G-1	0.9670	0.1118	1367	1900	185	75	0
G-3	1.3651	0.1240	1886	1670	217	16	33
G-4	1.3208	0.0948	2198	1995	185	300	22
Mean	1.1877	0.1034	1953	2029	196	177	18
B-1	1.2557	0.1245	2566	2450	310	240	45
B-3	1.2349	0.1274	2933	2950	390	315	69
B-4	1.0142	0.1044	2783	3300	340	320	57
F-1	1.1481	0.1135	2849	3120	345	385	50
F-3	1.3094	0.1084	2735	2530	288	280	45
F-4	1.3094	0.1287	2665	2490	270	280	37
Mean	1.2119	0.1178	2755	2806	324	303	51

TABULATED RESULTS

Experiment D-110

Uniaxial Compression

Material: H4LM-000

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
E-2-1	0.9745	0.1344	5912	20975	2640	4600	875
E-2-2	1.0000	0.1415	5630	22250	3360	3510	700
G-2-1	0.9891		5675	18562		3800	
G-2-2	0.9420	0.0696	5743	20250	4100	3300	600
Mean	0.9764	0.1151	5740	20509	3366	3801	725
F-2-1	0.8050	0.1242	6806	23850	5520	6300	1155
F-2-2	1.2042	0.1680	6840	19350	3460	5800	1015
Mean	1.0046	0.1461	6823	21600	4490	6050	1085

TABULATED RESULTS

Experiment D-110

Uniaxial Compression

Material: H4LM-090

No.	2nd Cycle Modulus x 10 ⁶ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-2-1	0.8803	0.1443	6303	20125	3740	4460	1015
A-2-2	0.8254	0.1558	6314	22475	4840	5100	1335
C-2-1	0.8905	0.1524	6099	17125	3480	5160	1085
C-2-2	0.9655	0.1619	6043	16500	3140	4070	1025
Mean	0.8904	0.1536	6189	19056	3800	4698	1115
E-2-1	0.9542	0.1571	4891	18000	2240	3420	620
E-2-2	0.8994	0.1423	4800	13550	2570	3250	760
G-2-1	1.0391	0.1380	4631	14975	2140	3800	675
G-2-2	1.0426	0.1356	5083	12280	2056	3400	640
Mean	0.9838	0.1432	4851	14701	2251	3467	674
B-2-1	0.7320	0.1445	5354	15375	2600	4200	825
B-2-2	0.7482	0.1366	5726	19250	3520	4860	1050
F-2-1	0.6698	0.1290	5580	19900	2920	5080	1020
F-2-2	0.7530	0.1287	5534	16075	2420	4820	935
Mean	0.7257	0.1347	5548	17650	2865	4740	957

TABULATED RESULTS

Experiment D-110

Uniaxial Compression

Material: H4LM-180

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-2-1	1.0136	0.1614	6441	18500	3380	4800	860
A-2-2	0.9841	0.1299	6780	20125	2660	5490	1035
C-2-1	0.8398	0.1294	6486	21825	2965	5500	820
C-2-2	1.0110	0.1307	6791	18700	2740	4590	920
Mean	0.9621	0.1378	6624	19787	2868	5095	908
E-2-1	0.9650	0.1490	5661	17100	2815	4110	740
E-2-2	0.8318	0.1273	5447	18675	2920	4450	805
G-2-1	0.9625	0.1419	5808	19250	2770	4000	740
G-2-2	0.9605	0.0996	5062	14750	2440	3210	565
Mean	0.9299	0.1294	5494	17443	2736	3942	712
B-2-1	1.0388	0.1246	6294	17250	2600	4550	940
B-2-2	0.7810	0.1223	5989	19750	2880	4810	910
F-2-1	0.9139	0.1305	6328	20125	3320	4760	795
F-2-2	0.8475	0.1363	5932	16600	2680	4080	840
Mean	0.8953	0.1284	6135	18431	2870	4550	871

TABULATED RESULTS

Experiment D-110

Uniaxial Compression

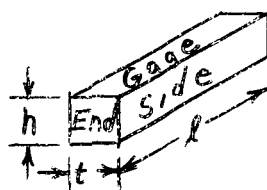
Material: H4LM-270

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-2-1	0.9004	0.1332	6599	20875	3240	5180	855
A-2-2	0.9887	0.1385	6916	22500	3820	5700	1135
C-2-1	0.8982	0.1175	6577	23250	3120	5410	890
C-2-2	0.9981	0.1261	6498	19500	2900	5100	920
Mean	0.9463	0.1287	6647	21531	3270	5347	950
E-2-1	0.9259	0.1251	5368	17000	2420	4700	1230
E-2-2	0.8071	0.0952	5616	23750	3720	6330	1055
G-2-1	0.8710	0.0895	5198	14275	1500	3070	412
G-2-2	0.7472	0.1058	5379	23250		5000	
Mean	0.8378	0.1039	5390	19568	2546	4775	899
B-2-1	0.9534	0.1377	6351	16925	3400	4830	960
B-2-2	0.8089	0.1333	5876	20625	2920	4820	942
F-2-1	0.9351	0.1222	5616	15000	2800	3640	505
F-2-2	0.8731	0.1011	5786	17750		4420	
Mean	0.8926	0.1235	5907	17575	3040	4427	802

APPENDIX B
Experiment D-III

FLEXURE SAMPLES

Experiment D-III



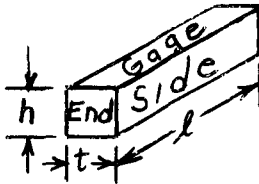
Material: ATJ-1
Instrumented 3-9-66

Specimen Number	Surface G S E	Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
		h in.	t in.	l in.			
I-A-1	T* F*	0.7500	0.7500	4.498	72.6130	1.7510	Questionable poisson
-3	T F	0.7500	0.7500	4.499	72.0232	1.7364	OK
-4	T F	0.7500	0.7500	4.499	72.1052	1.7383	OK
I-B-1	T F	0.7505	0.7500	4.498	73.5609	1.7739	Questionable poisson ten.
-3	T F	0.7500	0.7500	4.499	71.7139	1.7289	OK
-4	T F	0.7500	0.7500	4.498	71.2752	1.7187	Questionable poisson ten.
I-C-1	F T	0.7500	0.7500	4.498	71.6284	1.7273	OK
-3	F T	0.7505	0.7505	4.498	71.5237	1.7225	OK
-4	F T	0.7505	0.7500	4.499	71.4031	1.7202	Poor poisson
I-E-1	F T	0.7495	0.7500	4.500	72.3786	1.7459	OK
-3	F T	0.7500	0.7500	4.498	71.2382	1.7179	First test
-4	F T	0.7500	0.7505	4.498	70.7618	1.7057	OK
I-F-1	T F	0.7490	0.7490	4.498	73.1712	1.7691	OK
-3	T F	0.7495	0.7495	4.499	70.9265	1.7130	OK
-4	T F	0.7505	0.7500	4.499	70.6640	1.7019	Broke on first cycle
I-G-1	F T	0.7500	0.7495	4.498	72.4052	1.7472	Load cell trouble
-3	F T	0.7500	0.7500	4.499	71.1364	1.7150	OK
-4	F T	0.7500	0.7500	4.498	70.7210	1.7054	OK
Mean		0.7500	0.7499	4.499	71.7349	1.7299	

*T,F - Designates top and front surfaces of slab.

FLEXURE SAMPLES

Experiment D-III



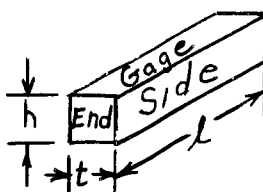
Material: ATJ-2
Instrumented 3-9-66

Specimen Number	Surface G S E	Dimensions h in. t in. l in.			Weight Grams	Density Grams/cm ³	Test Remarks
2-A-1	T* F*	0.7500	0.7500	4.498	73.7100	1.7775	OK
-3	T F	0.7500	0.7500	4.499	73.4130	1.7699	OK
-4	T F	0.7500	0.7500	4.498	72.9866	1.7600	OK
2-B-1	T F	0.7500	0.7500	4.497	71.2583	1.7187	Load Noise OK
-3	T F	0.7505	0.7505	4.498	71.2524	1.7160	OK
-4	T F	0.7500	0.7500	4.500	71.3131	1.7189	OK
2-C-1	F T	0.7505	0.7510	4.497	72.1041	1.7357	OK. Ran off poisson scale
-3	F T	0.7495	0.7500	4.498	70.4715	1.7000	OK
-4	F T	0.7500	0.7500	4.496	70.3025	1.6960	OK
2-E-1	F T	0.7500	0.7500	4.498	70.6199	1.7029	OK
-3	F T	0.7500	0.7505	4.498	70.3944	1.6963	OK
-4	F T	0.7500	0.7500	4.497	70.2506	1.6944	OK
2-F-1	T F	0.7505	0.7505	4.499	70.5763	1.6994	OK
-3	T F	0.7505	0.7500	4.497	70.1630	1.6910	OK
-4	T F	0.7500	0.7500	4.498	70.0722	1.6897	OK
2-G-1	F T	0.7500	0.7500	4.498	70.5065	1.7002	OK
-3	F T	0.7500	0.7500	4.497	69.9217	1.6864	OK
-4	F T	0.7500	0.7500	4.498	69.7154	1.6811	OK
Mean		0.7501	0.7501	4.498	71.0543	1.7130	

*T,F - Designates top and front surfaces of slab.

FLEXURE SAMPLES

Experiment D-III



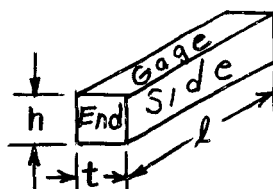
Material: ATJ-3
Instrumented 3-2-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
3-A-1	T*	F*		0.7510	0.7510	4.499	72.9109	1.7531	OK
-3	T	F		0.7510	0.7510	4.499	73.3063	1.7626	OK
-4	T	F		0.7500	0.7510	4.492	73.7467	1.7785	Poor poisson
3-B-1	T		F	0.7500	0.7510	4.497	74.2753	1.7892	OK
-3	T		F	0.7510	0.7510	4.497	74.1127	1.7829	OK
-4	T		F	0.7500	0.7505	4.497	74.0177	1.7840	OK
3-C-1	F	T		0.7505	0.7495	4.498	73.5244	1.7730	OK
-3	F	T		0.7505	0.7510	4.497	73.2821	1.7641	OK
-4	F	T		0.7510	0.7505	4.497	73.3372	1.7654	3 cycle
3-E-1	F		T	0.7505	0.7505	4.498	71.9247	1.7326	OK
-3	F		T	0.7480	0.7500	4.499	72.2499	1.7465	OK
-4	F		T	0.7475	0.7520	4.500	73.0652	1.7624	OK
3-F-1	T		F	0.7505	0.7500	4.498	72.6925	1.7513	Load fluctuation. OK
-3	T		F	0.7505	0.7500	4.497	72.4992	1.7474	Load fluctuation. OK
-4	T		F	0.7500	0.7505	4.497	72.2641	1.7417	3 cycle. OK
3-G-1		F	T	0.7450	0.7510	4.497	71.2723	1.7282	Strain hardened
-3		F	T	0.7515	0.7500	4.497	72.4576	1.7442	OK
-4		F	T	0.7510	0.7510	4.497	73.3191	1.7637	OK with jump
Mean				0.7500	0.7506	4.497	73.0143	1.7594	

*T, F - Designates top and front surfaces of slab.

FLEXURE SAMPLES

Experiment D-III



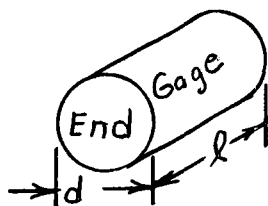
Material: ATJ-4
Instrumented 3-8-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
4-A-1	T*	F*		0.7510	0.7510	4.494	72.4158	1.7431	OK
-3	T	F		0.7510	0.7520	4.494	72.6682	1.7468	OK
-4	T	F		0.7500	0.7510	4.494	72.6705	1.7518	OK
4-B-1	T		F	0.7510	0.7500	4.494	73.7489	1.7778	OK
-3	T		F	0.7510	0.7510	4.495	72.1825	1.7371	OK
-4	T		F	0.7510	0.7510	4.495	71.9874	1.7324	OK
4-C-1	F	T		0.7505	0.7500	4.495	72.1509	1.7387	OK
-3	F	T		0.7505	0.7500	4.495	72.2854	1.7430	Switch load scales
-4	F	T		0.7525	0.7520	4.495	72.8045	1.7462	Poor poisson
4-E-1	F		T	0.7515	0.7510	4.494	71.4718	1.7268	Bad poisson tension gage
-3	F		T	0.7510	0.7510	4.494	71.7003	1.7259	OK
-4	F		T	0.7510	0.7510	4.495	71.7581	1.7276	OK
4-F-1	T		F	0.7520	0.7515	4.494	71.9200	1.7271	OK
-3	T		F	0.7510	0.7505	4.494	71.6735	1.7231	3 cycle. OK
-4	T		F	0.7500	0.7505	4.495	71.3041	1.7194	3 cycle
4-G-1		F	T	0.7510	0.7510	4.495	71.6264	1.7237	OK
-3		F	T	0.7510	0.7510	4.494	71.8217	1.7288	OK
-4		F	T	0.7510	0.7510	4.493	71.9070	1.7313	OK
Mean				0.7510	0.7509	4.494	72.1180	1.7361	

*T,F - Designates top and front surfaces of slab.

COMPRESSION SAMPLES

Experiment D-III



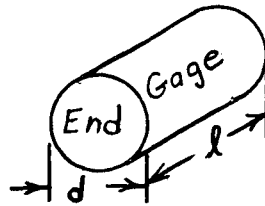
Material: ATJ-1
Instrumented 6-2-66

Specimen Number	Surface G E	Dimensions d in. l in.		Weight Grams	Density Grams/cm ³	Test Remarks
A-2-1	T*	0.7505	1.5005	19.3296	1.7827	OK
A-2-2	T	0.7507	1.5006	18.8573	1.7321	OK
B-2-1	T F	0.7506	1.5004	19.0514	1.7508	OK
B-2-2	T F	0.7510	1.5003	19.0282	1.7468	OK
C-2-1	F	0.7506	1.5002	19.0490	1.7508	OK
C-2-2	F	0.7510	1.5004	18.7367	1.7200	OK
E-2-1	F T	0.7515	1.5010	18.6069	1.7049	OK
E-2-2	F T	0.7520	1.5010	18.5439	1.6971	OK
F-2-1	T F	0.7511	1.5010	18.5534	1.7018	OK
F-2-2	T F	0.7513	1.5004	18.4467	1.6923	OK
G-2-1	F T	0.7508	1.5008	18.4736	1.6963	OK
G-2-2	F T	0.7513	1.5005	18.4213	1.6889	OK
Mean		0.7509	1.5005	18.7581	1.7220	

*T,F - Designates arbitrary top and front of specimen slab.

COMPRESSION SAMPLES

Experiment D-III



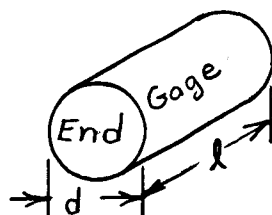
Material: ATJ-2
Instrumented 6-2-66

Specimen Number	Surface G E	Dimensions d in. l in.		Weight Grams	Density Grams/cm ³	Test Remarks
A-2-1	T*	0.7500	1.5000	19.1595	1.7639	OK
A-2-2	T	0.7505	1.5000	19.2703	1.7720	OK
B-2-1	T F	0.7502	1.5002	18.8771	1.7368	OK
B-2-2	T F	0.7510	1.5002	18.6393	1.7131	OK
C-2-1	F	0.7500	1.5000	18.5804	1.7105	OK
C-2-2	F	0.7504	1.5000	18.6327	1.7137	OK
E-2-1	F T	0.7500	1.5002	19.0614	1.7546	OK
E-2-2	F T	0.7505	1.5002	18.6214	1.7117	OK
F-2-1	T F	0.7503	1.5005	18.9332	1.7410	OK
F-2-2	T F	0.7510	1.5000	18.6652	1.7139	OK
G-2-1	F T	0.7500	1.5000	19.0854	1.7570	OK
G-2-2	F T	0.7507	1.5000	18.6537	1.7140	OK
Mean		0.7503	1.5001	18.8447	1.7335	

*T, F - Designates arbitrary top and front of specimen slab.

COMPRESSION SAMPLES

Experiment D-III



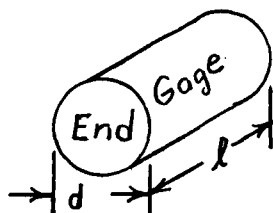
Material: ATJ-3
Instrumented 6-3-66

Specimen Number	Surface G E	Dimensions d in. l in.		Weight Grams	Density Grams/cm ³	Test Remarks
A-2-1	T*	0.7500	1.5004	19.3025	1.7766	OK
A-2-2	T	0.7508	1.5000	19.0274	1.7477	OK
B-2-1	T F	0.7503	1.5003	19.3483	1.7793	OK
B-2-2	T F	0.7506	1.5000	19.4863	1.7912	OK
C-2-1	F	0.7500	1.5004	19.3453	1.7805	OK
C-2-2	F	0.7508	1.4998	19.1874	1.7631	OK
E-2-1	F T	0.7506	1.5000	18.9407	1.7420	OK
E-2-2	F T	0.7508	1.5000	18.8826	1.7347	OK
F-2-1	T F	0.7505	1.5003	18.9093	1.7384	OK
F-2-2	T F	0.7508	1.4998	19.1002	1.7551	OK
G-2-1	F T	0.7502	1.4998	18.9477	1.7437	OK
G-2-2	F T	0.7508	1.5000	18.8603	1.7326	OK
Mean		0.7505	1.5000	19.1115	1.7510	OK

*T,F - Designates arbitrary top and front of specimen slab.

COMPRESSION SAMPLES

Experiment D-III



Material: ATJ-4
Instrumented 6-3-66

Specimen Number	Surface G E	Dimensions d in. l in.		Weight Grams	Density Grams/cm ³	Test Remarks
A-2-1	T*	0.7503	1.5003	19.2478	1.7701	OK
A-2-2	T	0.7510	1.4997	18.8621	1.7324	OK
B-2-1	T F	0.7493	1.5013	19.0088	1.7521	OK
B-2-2	T F	0.7507	1.5000	19.0690	1.7522	3 cycle. OK
C-2-1	F	0.7510	1.4997	18.8762	1.7337	OK
C-2-2	F	0.7500	1.5000	19.1270	1.7609	OK
E-2-1	F T	0.7502	1.4985	18.7299	1.7257	OK
E-2-2	F T	0.7514	1.4975	18.7188	1.7198	OK
F-2-1	T F	0.7510	1.4982	18.7795	1.7264	OK
F-2-2	T F	0.7513	1.4974	18.8327	1.7311	OK
G-2-1	F T	0.7510	1.4978	18.8059	1.7292	OK
G-2-2	F T	0.7518	1.4994	18.7975	1.7238	OK
Mean		0.7507	1.4991	18.9062	1.7322	

*T, F - Designates arbitrary top and front of specimen slab.

TABULATED RESULTS

Experiment D-III

Flexure Tension

Material: ATJ-1

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.5407	0.0777	4171	3220	126	370	-68
A-3	1.5653	0.0786	4124	3050	133	280	-43
A-4	1.4790	0.0756	4247	3400	147	400	-45
Mean		0.0773			135		-52
C-1	1.4610	0.1284	4095	3440	317	420	-40
C-3	1.5549	0.1366	4247	3130	318	210	-35
C-4	1.4610	0.1298	4418	3440	360	170	-15
Mean	1.5103	0.1316	4217	3280	332	308	-30
E-1	1.0960	0.1082	3531	4050	235	495	-76
E-3	1.0372		3128	3600		460	
E-4	1.0476	0.1105	3086	3540	230	360	-61
G-1	1.0970	0.1001	3270	3800	210	600	-59
G-3	1.0770	0.1010	3299	3840	245	480	-45
G-4	1.0970	0.1022	3375	3960	262	630	-44
Mean	1.0753	0.1044	3282	3798	236	504	-57
B-1	1.7720	0.0810	4579	3040	123	240	-60
B-3	1.5682	0.0791	4095	3120	130	280	-57
B-4	1.4942	0.0862	3944	3070	150	280	-59
F-1	1.6070	0.0919	5119	3560	223	320	-45
F-3	1.5312	0.0935	4484	3390	193	230	-55
F-4*			3308*	2570*	195*		
Mean	1.5945	0.0863	4255	3236	164	270	-55

*Not included in means.

TABULATED RESULTS

Experiment D-III Flexure Compression Material: ATJ-1

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.5975	0.0706	4133	3080	250	360	60
A-3	1.5492	0.0735	4124	3160	262	320	50
A-4	1.5407	0.0870	4247	3240	265	360	27
Mean		0.0770			259		46
C-1	1.4894	0.1353	4095	3280	445	360	55
C-3	1.5644	0.1355	4266	3190	410	250	32
C-4	1.5283	0.1426	4427	3410	500	270	70
Mean	1.5273	0.1378	4215	3226	452	320	52
E-1	1.1519	0.1147	3545	3800	460	400	77
E-3	1.0690	0.1083	3128	3600	425	400	65
E-4	1.1140	0.1144	3071	3320	395	320	60
G-1	1.1235	0.1033	3261	3760	337	580	30
G-3	1.0932	0.1019	3299	3570	415	480	85
G-4	1.1102	0.1085	3441	3740	402	480	42
Mean	1.1030	0.1085	3291	3631	406	443	60
B-1	1.7379	0.0795	4550	3140	307	300	73
B-3	1.5549	0.0800	4095	3080	252	260	35
B-4	1.4932	0.0824	3906	3100	275	275	47
F-1	1.6450	0.0843	5081	3540	331	260	55
F-3	1.5170	0.0958	4446	3380	356	210	53
F-4*			3252*	2420*	246*		
Mean	1.5896	0.0844	4222	3250	294	261	52

*Not included in means.

TABULATED RESULTS

Experiment D-III

Flexure Tension

Material: ATJ-2

No.	2nd Cycle Modulus x 10 ⁶ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.6592	0.0978	5119	3770	250	470	-38
A-3	1.6924	0.0970	3906	2720	172	320	-38
A-4	1.5549	0.0900	4133	3200	175	400	-54
Mean		0.0949			199		-43
C-1	1.5938	0.1494	5015	3800	384	360	-60
C-3	1.4610	0.1491	4446	3600	400	320	-32
C-4	1.5008	0.1433	4171	3340	353	440	-35
Mean	1.5770	0.1472	4465	3405	379	385	-42
E-1	0.9870	0.0854	2967	3620	183	320	-45
E-3	1.0192	0.0888	2844	3400	202	420	-40
E-4	1.0714	0.0857	3270	3840	179	510	-60
G-1	1.1472	0.0767	3255	3630	170	560	-40
G-3	0.9661	0.0833	2820	3640	194	480	-38
G-4	0.9434	0.0819	2820	3740	184	560	-50
Mean	1.0223	0.0836	2992	3645	185	475	-46
B-1	1.4222	0.0892	4437	3820	220	440	-38
B-3	1.6696	0.0921	5072	3760	214	450	-45
B-4	1.4582	0.0938	4114	3360	206	420	-42
F-1	1.4676	0.0844	4190	3400	157	330	-38
F-3	1.6800	0.0791	4304	2940	183	260	-10
F-4	1.3880	0.0756	4057	3370	152	270	-55
Mean	1.5142	0.0857	4362	3441	189	362	-76

TABULATED RESULTS

Experiment D-III Flexure Compression Material: ATJ-2

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.8052	0.0980	5138	3520	330	400	65
A-3	1.7066	0.0920	3906	2680	270	295	55
A-4	1.6895	0.0974	4133	2840	290	290	45
Mean		0.0958			297		55
C-1	1.6696	0.1651	5062	3720	603	400	65
C-3	1.5283	0.1478	4475	3450	492	320	45
C-4	1.5644	0.1546	4152	3190	490	360	67
Mean	1.6606	0.1558	4478	3233	528	344	59
E-1	1.0268	0.0875	2958	3440	317	320	48
E-3	1.0438	0.0984	2853	3240	327	360	45
E-4	1.1188	0.0944	3280	3640	342	470	51
G-1	1.1651	0.0857	3289	3480	280	480	36
G-3	1.0021	0.0873	2825	3720	302	480	43
G-4	0.9803	0.0868	2815	3600	297	520	39
Mean	1.0894	0.0900	3003	3520	311	437	44
B-1	1.5482	0.0918	4389	3560	362	440	78
B-3	1.6194	0.0915	5006	3700	365	370	62
B-4	1.5312	0.0959	4029	3140	330	360	65
F-1	1.5482	0.0887	4133	3170	302	320	52
F-3	1.5663	0.0758	4285	3100	287	210	62
F-4	1.4364	0.0825	4048	3350	275	320	49
Mean	1.5416	0.0877	4315	3336	320	337	61

TABULATED RESULTS

Experiment D-III

Flexure Tension

Material: ATJ-3

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.4464	0.0755	4909	4270	173	550	-60
A-3	1.5637	0.0764	4578	3600	252	420	-55
A-4	1.5325	0.0834	4786	3860	215	480	-25
Mean		0.0784			213		-47
C-1	1.6337	0.0837	4578	3360	148	360	-66
C-3	1.6016	0.0844	4238	3120	156	320	-50
C-4	1.7028	0.0818	5392	3830	183	520	-68
Mean	1.5801	0.0833	4747	3673	162	442	-61
E-1	1.3225	0.0979	3793	3720	200	530	-60
E-3	1.3462	0.1008	3755	3570	238	480	-34
E-4	1.3168	0.0971	4020	3880	240	520	-65
G-1	1.1598	0.0892	3311	3450	205	470	-64
G-3	1.2317	0.0937	3523	3640	213	480	-63
G-4	1.2071	0.0881	3708	4000	207	620	-38
Mean	1.2640	0.0944	3685	3710	217	517	-54
B-1	1.8097	0.0836	5505	3770	164	460	-66
B-3	1.7274	0.1467	5259	3880	352	530	-69
B-4	1.7340	0.1354	5146	3640	298	440	-73
F-1	1.6082	0.0885	4843	3740	185	440	-50
F-3	1.7898	0.0874	5297	3650	188	480	-65
F-4	1.6006	0.0890	5127	3960	224	480	-60
Mean	1.7116	0.1051	5196	3773	235	472	-64

TABULATED RESULTS

Experiment D-III

Flexure Compression

Material: ATJ-3

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.5250	0.0786	4909	4010	295	500	34
A-3	1.6214	0.0803	4635	3490	270	400	34
A-4	1.3045	0.0653	4758	3640	270	390	25
Mean		0.0747			278		31
C-1	1.6943	0.0876	4569	3250	270	360	30
C-3	1.7681	0.0898	4219	2800	239	280	25
C-4	1.7463	0.0833	5430	3800	294	520	32
Mean	1.6099	0.0869	4753	3498	268	408	29
E-1	1.2629	0.0991	3876	3850	342	480	25
E-3	1.3083	0.0980	3821	3610	310	400	15
E-4	1.3055	0.0974	4096	3920	328	450	15
G-1	1.2062	0.1085	3334	3290	322	400	30
G-3	1.2610	0.0930	3566	3480	305	400	35
G-4	1.2752	0.0999	3736	3670	324	510	27
Mean	1.2698	0.0993	3738	3636	322	440	24
B-1	1.7681	0.0829	5467	3840	291	460	26
B-3	1.7028	0.1442	5184	3860	510	510	26
B-4	1.6943	0.1425	4938	3650	473	460	46
F-1	1.6167	0.0796	4843	3680	280	410	35
F-3	1.6706	0.0777	5307	3770	269	420	25
F-4	1.6422	0.0914	5061	3740	309	400	23
Mean	1.6824	0.1030	5133	3756	355	443	30

TABULATED RESULTS

Experiment D-III

Flexure Tension

Material: ATJ-4

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.4742	0.0806	4460	3710	177	470	-50
A-3	1.5498	0.0836	4479	3340	176	490	-53
A-4	1.5630	0.0806	4517	3590	165	470	-53
Mean		0.0816			173		-52
C-1	1.5026	0.1248	4224	3310	283	410	-50
C-3	1.5536	0.1409	4432	3460	329	400	-68
C-4	1.5394	0.1376	4649	3650	317	420	-73
Mean	1.5304	0.1344	4460	3510	310	443	-64
E-1	1.2086	0.1112	4139	4450	278	680	-55
E-3	1.1463	0.1033	3109	3500	239	550	-38
E-4	1.1274	0.1047	3189	3580	226	490	-49
G-1	1.1671	0.0878	3231	3440	194	440	-37
G-3	1.0527	0.0891	3165	3600	212	440	-37
G-4	1.2654	0.0914	3770	3710	218	460	-37
Mean	1.1612	0.0979	3434	3713	228	510	-42
B-1	1.9798	0.0854	6199	4130	168	650	-70
B-3	1.5262	0.0880	4290	3340	188	320	-42
B-4	1.6018	0.0857	4611	3530	190	440	-38
F-1	1.7898	0.0861	5528	3820	200	440	-53
F-3	1.5611	0.0877	4517	3440	198	360	-37
F-4	1.5989	0.0969	4063	3300	174	360	-54
Mean	1.6762	0.0883	4868	3593	186	428	-49

TABULATED RESULTS

Experiment D-III Flexure Compression Material: ATJ-4

No.	2nd Cycle Modulus x 10 ⁶ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-1	1.5545	0.0860	4517	3530	308	370	46
A-3	1.6348	0.0901	4517	3390	301	440	40
A-4	1.6745	0.0895	4517	3280	293	370	40
Mean		0.0885			301		42
C-1	1.6197	0.1371	4224	3020	427	310	62
C-3	1.5583	0.1451	4479	3380	479	380	50
C-4	1.6745	0.1449	4658	3440	481	350	50
Mean	1.6193	0.1423	4485	3340	462	370	54
E-1	1.2039	0.1001	4120	4350	412	560	53
E-3	1.1066	0.1071	3118	3350	336	390	30
E-4	1.0100	0.0965	3213	3480	324	380	35
G-1	1.2068	0.1011	3250	3240	307	320	26
G-3	1.0877	0.1017	3181	3510	324	340	20
G-4	1.2918	0.0951	3770	3500	319	320	30
Mean	1.1511	0.1002	3442	3571	337	385	32
B-1	1.8399	0.0829	6123	4080	312	440	23
B-3	1.5611	0.0938	4261	3230	300	310	33
B-4	1.6906	0.0958	4611	3160	320	370	50
F-1	1.7549	0.0870	5462	3800	320	390	33
F-3	1.7095	0.0904	4432	3140	299	360	55
F-4	1.5621	0.0885	4054	3090	261	320	24
Mean	1.6863	0.0897	4824	3416	302	365	36

TABULATED RESULTS

Experiment D-III

Uniaxial Compression

Material: ATJ-1

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-2-1	1.2472	0.1521	10161	25250	4450	6700	940
A-2-2	1.1084	0.1606	8524	18000	2750	5700	790
C-2-1	1.2042	0.1752	9596	22250	3650	6200	875
C-2-2	1.0458	0.1515	9100	22750	3580	6600	870
Mean	1.1514	0.1598	9345	22062	3607	6300	868
E-2-1	0.6872	0.1067	9009	32450	3470	10750	910
E-2-2	0.6709	0.0955	8693	30600	3270	9550	920
G-2-1	0.7150	0.1096	9201	35000	4150	11750	1175
G-2-2	0.6295	0.08983	9167	33800	4000	10625	1180
Mean	0.6756	0.1025	9017	32962	3722	10668	1046
B-2-1	1.2701	0.1698	10364	24000	4130	6100	830
B-2-2	1.1654	0.1454	9935	25250	4530	5950	960
F-2-1	1.0210	0.1554	8919	24250	4220	8000	1330
F-2-2	1.0468	0.1545	8806	23250	3600	7960	1100
Mean	1.1258	0.1562	9506	24187	4120	7002	1055

TABULATED RESULTS

Experiment D-III

Uniaxial Compression

Material: ATJ-2

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-2-1	1.3566	0.1315	10151	21500	3620	6000	950
A-2-2	1.3350	0.1553	11531	30500	5550	8450	1490
C-2-1	1.0982	0.1619	10005	25450	4440	6750	1150
C-2-2	1.2152	0.1727	9835	23700	4140	6125	880
Mean	1.2512	0.1553	10380	25287	4437	6831	1117
E-2-1	0.7796	0.1003	10830	36500	4320	11100	1180
E-2-2	0.8168	0.1146	9779	30675	3640	9125	1160
G-2-1	0.8168	0.1184	11124	36500	4220	11100	1240
G-2-2	0.7796	0.1302	10457	33875	4290	9150	850
Mean	0.7982	0.1158	10547	34387	4117	10118	1107
B-2-1	1.1870	0.1693	10401	26750	5000	7100	1275
B-2-2	1.1172	0.1710	9835	26700	4850	7490	1220
F-2-1	1.2661	0.1787	9722	20950	3600	6200	910
F-2-2	1.1892	0.1733	9926	27500	5075	5400	1175
Mean	1.1898	0.1730	9971	25475	4631	6548	1145

TABULATED RESULTS

Experiment D-III

Uniaxial Compression

Material: ATJ-3

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-2-1	1.1978	0.1608	10452	24600	4000	5600	1100
A-2-2	1.1987	0.1580	9289	20575	3540	5475	780
C-2-1	1.2656	0.0887	11470	27875	2880	6500	670
C-2-2	1.3344	0.0973	10486	22450	2300	6400	680
Mean	1.2491	0.1262	10424	23875	3180	5993	807
E-2-1	0.7793	0.1034	10984	38450	4440	11250	1220
E-2-2	0.7587	0.1103	10758	37750	5100	10975	1430
G-2-1	0.7910	0.0928	10848	38500	4100	7750	675
G-2-2	0.7727	0.1065	10125	31750	3850	9200	1040
Mean	0.7754	0.1032	10678	36612	4372	9793	1091
B-2-1	1.2995	0.1955	10961	24300	4525	6525	1230
B-2-2	1.4851	0.1577	11775	27750	5040	7750	1290
F-2-1	1.2656	0.1445	10486	27550	4950	7150	1330
F-2-2	1.1894	0.1518	9944	22500	3860	5700	1100
Mean	1.3099	0.1623	10791	25525	4594	6781	1237

TABULATED RESULTS

Experiment D-III

Uniaxial Compression

Material: ATJ-4

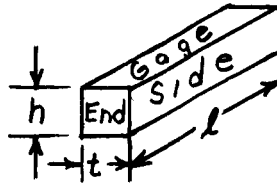
No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
A-2-1	1.3052	0.1445	9036	16250*	2860	3850*	880
A-2-2	1.1566	0.1486	10098	26225	4940	7200	1500
C-2-1	1.1832	0.1649	10301	26525	5150	6575	1270
C-2-2	1.2478	0.1079	10278	23225	2280	6125	580
Mean	1.2232	0.1414	9928	25325	3807	6633	1057
E-2-1	0.7574	0.1026	10278	36125	4080	9900	1030
E-2-2	0.7940	0.1095	9872	34550	4320	9550	1090
G-2-1	0.7870	0.1685	10030	34800	4600	10775	770
G-2-2	0.7981	0.1156	9533	30300	3880	9125	1180
Mean	0.7841	0.1240	9928	33943	4220	9837	1017
B-2-1	1.2424	0.1141	10448	25800	4370	6500	1270
B-2-2	1.1144	0.1578	10436	27500	5440	7250	1280
F-2-1	1.2602	0.1544	9940	26350	4580	6600	1140
F-2-2	1.1148	0.1475	9781	23125	3925	6250	1130
Mean	1.1829	0.1434	10151	25693	4578	6650	1205

*Not included in mean.

APPENDIX C
Experiment D-112

FLEXURE SAMPLES

Experiment D-112



Material: P03B175-2
Instrumented 3-17-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
-1	**		***	0.7502	0.7500	4.5034*	77.529*	1.8670	OK
-2	Tr		H	0.7495	0.7503	4.5015	77.268	1.8624	OK
-3	Tr		H	0.7508	0.7506	4.5022	77.611	1.8661	OK
-11	L		H	0.7505	0.7500	4.5018	77.606	1.8685	OK
-22	L		H	0.7504	0.7498	4.5030	77.500	1.8664	OK
-33	L		H	0.7503	0.7505	4.5019	77.516	1.8656	OK
-111	L		V	0.7506	0.7508	4.5022	76.836	1.8475	4 cycle
-222	L		V	0.7502	0.7505	4.5018	77.184	1.8580	OK
-333	L		V	0.7500	0.7495	4.5013	77.435	1.8672	OK
Mean				0.7503	0.7502	4.5021	77.387	1.8631	

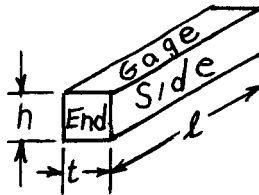
*LASL data.

**Tr, L - Designates transverse and longitudinal specimen orientations.

***H, V - Designates horizontal and vertical orientations.

FLEXURE SAMPLES

Experiment D-112



Material: E-24-554F-2

Instrumented 3-15-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
-11	**		***	0.7504	0.7500	4.5051*	66.606*	1.6027	OK
-22	L		H	0.7510	0.7510	4.5049	65.613	1.5755	OK
-33	L		H	0.7505	0.7508	4.5015	66.110	1.5901	OK
-111	L		V	0.7503	0.7503	4.5042	66.201	1.5927	6 cycle
-222	L		V	0.7502	0.7500	4.5048	66.355	1.5974	OK
-333	L		V	0.7502	0.7505	4.5046	65.802	1.5830	Noisy & bad poisson ten.
Mean				0.7504	0.7504	4.5042	66.114	1.5902	

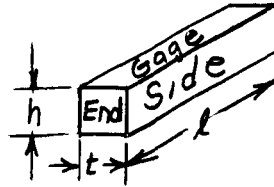
*LASL data.

**L - Designates longitudinal specimen orientation.

***H,V - Designates horizontal and vertical orientations.

FLEXURE SAMPLES

Experiment D-112



Material: B269I
Instrumented 3-15-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
-11	**		***	0.7500	0.7505	4.5044*	78.492*	1.8887	4 cycle
-22	L		H	0.7500	0.7500	4.5031	78.494	1.8906	OK
-33	L		H	0.7505	0.7505	4.5024	78.442	1.8873	Noisy axial compression
-111	L		V	0.7498	0.7500	4.5034	78.317	1.8866	Questionable poisson
-222	L		V	0.7500	0.7502	4.5022	78.314	1.8864	Noisy poisson compression
-333	L		V	0.7500	0.7498	4.5021	78.336	1.8876	OK
Mean				0.7500	0.7502	4.5029	78.399	1.8878	

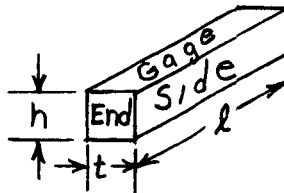
*LASL data.

**L - Designates longitudinal specimen orientation.

***H,V - Designates horizontal and vertical orientations.

FLEXURE SAMPLES

Experiment D-112



Material: RVC
Instrumented 3-17-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
-11	**		***	0.7506	0.7502	4.4872*	77.444*	1.8700	3 cycle
-22	L		H	0.7490	0.7503	4.5033	78.060	1.8818	OK
-33	L		H	0.7508	0.7500	4.5032	77.847	1.8730	Questionable poisson data
-111	L		V	0.7510	0.7510	4.5033	78.134	1.8769	Corrected load
-222	L		V	0.7510	0.7505	4.5029	77.847	1.8715	Corrected load
-333	L		V	0.7510	0.7508	4.5030	78.062	1.8759	Corrected load
Mean				0.7506	0.7504	4.5005	77.899	1.8748	

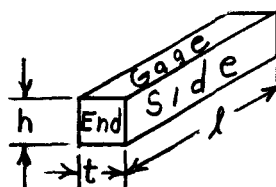
*LASL data.

**L - Designates longitudinal specimen orientation.

***H,V - Designates horizontal and vertical orientations.

FLEXURE SAMPLES

Experiment D-112



Material: SX4-2
Instrumented 3-16-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
-11	**		***	0.7505	0.7505	4.5054*	69.633*	1.6743	OK
-22	L		H	0.7507	0.7505	4.5048	69.344	1.6667	OK
-33	L		H	0.7502	0.7500	4.5045	70.635	1.7005	3 cycle
-111	L		V	0.7500	0.7503	4.5048	71.028	1.7096	3 cycle
-222	L		V	0.7505	0.7503	4.5047	69.496	1.6715	OK
-333	L		V	0.7502	0.7505	4.5049	70.785	1.7028	OK
Mean				0.7504	0.7503	4.5048	70.154	1.6875	

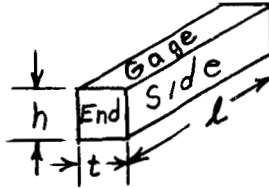
*LASL data.

**L - Designates longitudinal specimen orientation.

***H,V - Designates horizontal and vertical orientations.

FLEXURE SAMPLES

Experiment D-112



Material: EPI92-3
Instrumented 3-16-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
-11	**		***	0.7498	0.7507	4.5023*	69.870*	1.6821	OK
-22	L		H	0.7502	0.7505	4.5020	69.799	1.6801	OK
-33	L		H	0.7506	0.7508	4.5049	69.887	1.6794	OK
-111	L		V	0.7505	0.7503	4.5042	69.549	1.6730	OK
-222	L		V	0.7496	0.7498	4.5036	69.979	1.6869	OK
-333	L		V	0.7505	0.7503	4.5005	69.633	1.6764	3 cycle. Noisy axial compression
Mean				0.7502	0.7504	4.5029	69.786	1.6796	

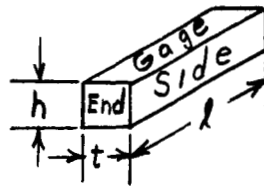
*LASL data.

**L - Designates longitudinal specimen orientation.

***H,V - Designates horizontal and vertical orientations.

Experiment D-112

FLEXURE SAMPLES



Material: EP192-C4
Instrumented 3-16-66

Specimen Number	Surface			Dimensions			Weight Grams	Density Grams/cm ³	Test Remarks
	G	S	E	h in.	t in.	l in.			
-11	**		***	0.7490	0.7500	4.5047*	64.090*	1.5451	Non-linear compression
-22	L		H	0.7502	0.7500	4.5048	63.790	1.5356	OK
-33	L		H	0.7498	0.7500	4.5043	63.713	1.5345	OK
-111	L		V	0.7505	0.7503	4.5048	64.278	1.5460	OK
-222	L		V	0.7502	0.7502	4.5047	63.767	1.5346	Broke first cycle
-333	L		V	0.7501	0.7500	4.5048	64.122	1.5436	Broke first cycle
Mean				0.7499	0.7501	4.5047	63.960	1.5399	

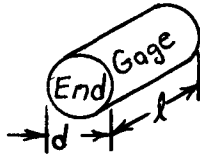
*LASL data.

**L - Designates longitudinal specimen orientation.

***H,V - Designates horizontal and vertical orientations.

COMPRESSION SAMPLES

Experiment D-112



Material: E-24-554F-2

Instrumented 6-7-66

Specimen Number	Surface G E	Dimensions d in. l in.		Weight Grams	Density Grams/cm ³	Test Remarks
1	** *** Tr H	0.7496*	1.5038*	17.332*	1.5933	OK
2	Tr H	0.7489	1.5031	17.052	1.5715	OK
3	Tr H	0.7513	1.5024	17.508	1.6038	Broke 1st cycle
Mean		0.7499	1.5031	17.297	1.5895	

Experiment D-112

Material: B2691

Instrumented 6-7-66

1	** *** Tr H	0.7494*	1.5034*	20.487*	1.8850	OK
2	Tr H	0.7496	1.5042	20.505	1.8846	4 cycle. OK
3	Tr H	0.7496	1.5052	20.449	1.8781	OK
Mean		0.7495	1.5042	20.497	1.8825	

Experiment D-112

Material: RVC

Instrumented 6-7-66

1	** *** Tr H	0.7490*	1.5063*	20.636*	1.8971	5 cycle. OK
2	Tr H	0.7492	1.5028	20.612	1.8983	Noisy poisson OK
3	Tr H	0.7488	1.5050	20.543	1.8912	Noisy poisson OK
Mean		0.7490	1.5047	20.597	1.8955	

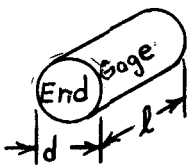
*LASL data.

**Tr - Designates transverse specimen orientation.

***H - Designates horizontal orientation.

COMPRESSION SAMPLES

Experiment D-112



Material: SX4-2
Instrumented 6-7-66

Specimen Number	Surface G E	Dimensions d in. l in.		Weight Grams	Density Grams/cm ³	Test Remarks
1	** *** Tr H	0.7518*	1.5029*	18.146*	1.6595	OK
2	Tr H	0.7490	1.5032	18.086	1.6660	OK
3	Tr H	0.7481	1.5022	17.899	1.6541	OK
Mean		0.7496	1.5027	18.044	1.6598	

Experiment D-112

Material: EP-192-3
Instrumented 6-7-66

1	** *** Tr H	0.7491*	1.5022*	18.189*	1.6761	OK
2	Tr H	0.7498	1.5023	18.200	1.6739	OK
3	Tr H	0.7497	1.5030	18.206	1.6743	4 cycle. OK
Mean		0.7495	1.5025	18.198	1.6747	

Experiment D-112

Material: EP-192-C4
instrumented 6-7-66

1	** *** Tr H	0.7496*	1.5029*	16.642*	1.5292	OK
2	Tr H	0.7493	1.4988	16.670	1.5390	3 cycle Bad poisson
3	Tr H	0.7501	1.5024	16.731	1.5377	OK
Mean		0.7496	1.5013	16.681	1.5353	

*LASL data.

**Tr - Designates transverse specimen orientation.

***H - Designates horizontal orientation.

TABULATED RESULTS

Experiment D-112

Flexure Tension

Material: P03B175-2

No.	2nd Cycle Modulus x 10 ⁶ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
-1	1.8311	0.1445	5783	3440	513	200	50
-2	1.8236	0.1428	6330	4000	578	350	60
-3	1.7434	0.1380	6179	3830	540	200	42
Mean	1.7993	0.1417	6097	3756	543	250	51
-11	2.0576	0.1789	6952	3770	665	200	50
-22	1.8868	0.1607	6962	3660	654	260	50
-33	2.2189	0.1809	6849	3650	658	350	70
Mean		0.1735			659		57
-111	1.8868	0.1250	6084	3630	470	300	40
-222	2.1736	0.1296	6452	3250	439	240	30
-333	2.2179	0.1735	6150	3040	535	240	50
Mean	2.0736	0.1427	6575	3500	481	265	40

TABULATED RESULTS

Experiment D-112

Flexure Compression

Material: P03B175-2

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
-1	1.7811	0.1336	5783	3910	352	440	- 60
-2	1.7519	0.1326	6330	4410	385	530	- 65
-3	1.7576	0.1318	6179	4170	330	430	- 90
Mean	1.7635	0.1327	6097	4163	356	467	- 72
-11	2.0434	0.1635	6952	4000	380	340	-120
-22	2.1481	0.1674	6962	3770	380	380	-112
-33	2.1481	0.1626	6849	4490	380	460	- 90
Mean		0.1645			380		-107
-111	1.7358	0.1131	6084	4070	255	450	-100
-222	2.0660	0.1184	6452	3600	260	340	- 70
-333	2.1349	0.1584	6150	3360	345	360	- 80
Mean	2.0460	0.1359	6575	3881	287	388	- 83

TABULATED RESULTS

Experiment D-112

Flexure Tension

Material: E-24-554F-2

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
-11	1.2371	0.2367	3502	3040	700	120	20
-22	1.1490	0.2115	3397	3140	660	140	25
-33	1.1528	0.2285	3464	3210	704	150	20
Mean		0.2255			688		22
-111	1.3961	0.3154	3951	3580	796	200	25
-222	1.1907	0.2132	3539	3150	726	140	20
-333	1.1519	0.2308	3634	3385	762	140	30
Mean	1.2129	0.2531	3581	3250	761	148	25

Experiment D-112

Flexure Compression

Material: E-24-554F-2

-11	1.3014	0.2322	3502	2925	689	120	30
-22	1.2011	0.2379	3397	3100	732	120	30
-33	1.2115	0.2327	3464	3040	715	120	30
Mean		0.2342			712		30
-111	1.2787	0.2500	3951	3400	865	140	40
-222	1.2617	0.2476	3539	2990	740	120	25
-333	1.1358	0.2300	3634	3250	745	120	25
Mean	1.2317	0.2425	3581	3117	783	123	30

Experiment D-112

Uniaxial Compression

Material: E-24-554F-2

-1	1.0144	0.2341	9674	11375	2775	1125	370
-2	1.0114	0.2483	11541	15000	3550	2100	545
-3			5884*	6430*	1395*		
Mean	1.0129	0.2412	10610	13185	3165	1600	460

*Not included in mean.

TABULATED RESULTS

Experiment D-112

Flexure Tension

Material: B2691

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
-11	2.0190	0.1331	6369	3775	310	440	- 90
-22	1.9716	0.1300	6891	4180	290	480	-100
-33	2.0399	0.2042	6398	3830	510	480	-100
Mean		0.1557			370		- 97
-111	1.9451	0.1389	6862	4440	345	520	- 85
-222	1.7953	0.1184	6407	4180	300	500	-100
-333	2.1067	0.2168	6635	3920	550	490	- 90
Mean	1.9796	0.1580	6561	4054	398	485	- 92

Experiment D-112

Flexure Compression

Material: B2691

-11	2.1186	0.1552	6369	3440	560	300	60
-22	2.1328	0.1534	6692	3610	576	280	70
-33	2.0901	0.2176	6398	3420	795	290	80
Mean		0.1754			644		70
-111	2.0626	0.1518	6862	3840	614	320	70
-222	2.1640	0.1649	6407	3420	578	290	65
-333	2.1660	0.2229	6635	3380	825	320	80
Mean	2.1223	0.1798	6561	3518	672	300	72

Experiment D-112

Uniaxial Compression

Material: B2691

-1	1.2715	0.1720	18557	27375	5260	5750	1680
-2	1.4143	0.1895	18534	27250	6920	6110	1900
-3	1.3403	0.1884	17878	27700	5440	6100	1850
Mean	1.3420	0.1833	18323	27441	5873	5986	1810

TABULATED RESULTS

Experiment D-112

Flexure Tension

Material: RVC

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
-11	1.9565	0.1563	4711	2990	225	420	-100
-22	1.9915	0.1851	4153	2560	300	320	- 60
-33	1.8326	0.0704	4692	3000	100	360	- 45
Mean		0.1372			208		- 68
-111	2.2044	0.0720	4923	2800	95	360	- 55
-222	1.8941	0.0803	4420	2740	140	320	- 35
-333	2.0360	0.0838	4432	2720	95	340	- 60
Mean	1.9858	0.0787	4555	2801	110	353	- 50

Experiment D-112

Flexure Compression

Material: RVC

-11	1.8922	0.1692	4711	3050	530	360	70
-22	1.8922	0.1585	4153	2580	400	240	40
-33	2.0010	0.0732	4692	2670	210	300	25
Mean		0.1336			380		45
-111	2.1713	0.0827	4923	2970	220	340	30
-222	2.0332	0.0834	4420	2640	213	280	30
-333	1.8316	0.0723	4432	2960	215	340	30
Mean	1.9702	0.0794	4555	2811	216	310	30

Experiment D-112

Uniaxial Compression

Material: RVC

-1	0.7706	0.1143	11564	31750	5600	11560	1920
-2	0.7491	0.0919	10976	29700	4440	8950	1350
-3	0.6638	0.0880	11903	34250	5750	9625	1810
Mean	0.7278	0.0980	11481	31900	5263	10045	1693

TABULATED RESULTS

Experiment D-112

Flexure Tension

Material: SX4-2

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
-11	1.3308	0.1192	4032	3950	360	520	-25
-22	1.2844	0.1056	3606	3680	510	480	5
-33	1.3639	0.1200	3814	3600	305	500	-25
Mean		0.1149			392		-18
-111	1.3800	0.1822	3502	3370	470	550	10
-222	1.3431	0.1221	3909	3800	350	490	-15
-333	1.3639	0.1845	4003	3800	550	520	0
Mean	1.3443	0.1629	3812	3700	457	510	-8

Experiment D-112

Flexure Compression

Material: SX4-2

-11	1.3469	0.1262	4032	3840	492	540	88
-22	1.3052	0.1929	3606	3460	684	440	109
-33	1.3317	0.1241	3814	3390	442	360	70
Mean		0.1477			539		89
-111	1.3904	0.1867	3502	3060	560	360	70
-222	1.3857	0.1372	3909	3520	485	400	65
-333	1.3667	0.1956	4003	3720	722	500	98
Mean	1.3544	0.1731	3812	3498	589	433	78

Experiment D-112

Uniaxial Compression

Material: SX4-2

-1	0.6171	0.1515	6959	23550	3750	5750	1070
-2	0.5818	0.1639	6913	27000	5100	7150	1370
-3	0.5715	0.1229	6936	28350	4670	8375	1160
Mean	0.5901	0.1461	6936	26300	4506	7091	1200

TABULATED RESULTS

Experiment D-112

Flexure Tension

Material: EPI92-3

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
-11	1.4208	0.2437	4764	3840	718	280	-31
-22	1.3526	0.2104	5067	4330	718	360	-30
-33	1.4208	0.2405	4508	3620	712	250	-35
Mean		0.2315			716		-32
-111	1.4312	0.2455	4887	3890	811	280	-25
-222	1.3678	0.2291	4982	3900	795	250	-35
-333	1.3772	0.2424	4413	3680	745	280	-30
Mean	1.3950	0.2390	4770	3876	784	283	-30

Experiment D-112

Flexure Compression

Material: EPI92-3

-11	1.5222	0.2623	4764	3510	920	250	80
-22	1.4966	0.2546	5067	3790	970	290	85
-33	1.4540	0.2601	4508	3330	888	180	60
Mean		0.2590			926		75
-111	1.4691	0.2486	4887	3690	930	250	80
-222	1.4568	0.2622	4982	3650	972	200	65
-333	1.4729	0.2560	4413	3310	869	230	70
Mean	1.4786	0.2556	4770	3566	924	233	72

Experiment D-112

Uniaxial Compression

Material: EPI92-3

-1	1.3246	0.2991	14710	30750	6525	4570	1380
-2	1.1866	0.2655	14710	41875	8510	4900	1840
-3	1.3578	0.3000	13572	27500	6000	4400	1830
Mean	1.2896	0.2882	14330	33375	7012	4623	1683

TABULATED RESULTS

Experiment D-112

Flexure Tension

Material: EPI92-C4

No.	2nd Cycle Modulus $\times 10^6$ psi	Poisson Ratio	Ultimate Stress psi	Ultimate Strain Axial μ in/in	Ultimate Strain Poisson μ in/in	80% Strain Damage Axial μ in/in	80% Strain Damage Poisson μ in/in
-11	0.8951	0.1988	1972	2250	428	30	-10
-22	0.8732	0.2096	1915	2295	438	75	-10
-33	0.9027	0.2164	2076	2480	478	100	-10
Mean		0.2082			448		-10
-111	0.8865	0.2084	1872	2215	439	70	-10
-222	0.8591	0.2000	1635	1875	379		
-333	0.8752	0.2093	1839	2130	428		
Mean	0.8819	0.2059	1885	2207	415	69	-10

Experiment D-112

Flexure Compression

Material: EPI92-C4

-11	1.1331	0.2427	1972	1405	450	0	0
-22	0.8989	0.2242	1915	2195	483	65	10
-33	0.9482	0.2285	2076	2340	510	60	10
Mean		0.2318			484		7
-111	0.9235	0.2198	1872	2075	458	40	10
-222	0.8344	0.2139	1635	1860	402		
-333	0.7244	0.2184	1839	2110	455		
Mean	0.9104	0.2173	1885	1997	438	41	10

Experiment D-112

Uniaxial Compression

Material: EPI92-C4

-1	0.7654	0.2093	8882	25125	5275	3900	850
-2	0.7779	0.2187	9222	27750		4520	
-3	0.7812	0.2013	7106	12750	2820	1760	630
Mean	0.7748	0.2097	8150	26440		4210	