NASA Contractor Report 166019

STIFFNESS REDUCTIONS DURING TENSILE FATIGUE TESTING OF GRAPHITE/EPOXY ANGLE - PLY LAMINATES

(NASA-CR-166019) STIFFNESS REDUCTIONS DURING TENSILE FATIGUE TESTING OF GRAPHITE/EPOXY ANGLE-PLY LAMINATES Final Report (Wyoming Univ.) 182 p HC A09/MF A01 CSCL 11D G3/24
N83-17596
Unclas
02724

Edwin M. Odom

Donald F. Adams

Composite Materials Research Group
Mechanical Engineering Department
University of Wyoming
Laramie, Wyoming 82071

Contract No. NAS1-16557
November 1982

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665

DEPARTMENT REPORT
UWME-DR-201-105-1

STIFFNESS REDUCTIONS DURING TENSILE FATIGUE TESTING OF GRAPHITE/EPOXY ANGLE-PLY LAMINATES

EDWIN M. ODOM
DONALD F. ADAMS

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FINAL REPORT
NASA-LANGLEY RESEARCH CENTER
CONTRACT NO. NAS 1-16557

COMPOSITE MATERIALS RESEARCH GROUP
DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY OF WYOMING
LARAMIE, WYOMING 82071

PREFACE

This final report summarizes a one-year research program, initiated in January 1981, sponsored by the National Aeronautics and Space Administration under Contract No. NASA1-16557. The NASA Program Monitor was Dr. T. Kevin O'Brien, Materials Division, Fatigue and Fracture Branch.

All work during this research program was performed by the Composite Materials Research Group within the Mechanical Engineering Department at the University of Wyoming. Co-principal Investigators were Mr. Edwin M. Odom, Staff Engineer, and Dr. Donald F. Adams, Professor. Mr. Mark Walker, Staff Computer Specialist, and Mr. Raja Mohan, Graduate Student Laboratory Assistant, also made significant contributions.

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SECTION 1

INTRODUCTION AND SUMMARY

1.1 Introduction

The response of composite materials to fatigue loading has long been a topic of interest. Typically, composite materials will accumulate damage, which initially may be in the form of microcracks between the fibers of a lamina and/or between the laminae of the laminate.

During the growth of these microcracks, which eventually leads to materials failure, the response of the composite in terms of strength and stiffness is typically degraded. Of particular interest to the present program was the effect of fatigue-induced damage on composite stiffness. This effect was monitored by conducting a series of fatigue tests on $[\pm 45]_{2s}$ and $[\pm 67.5]_{2s}$ T300/5208 graphite/epoxy laminates. During the fatigue testing of these laminates, stiffness was continuously monitored, to specimen failure. The stiffness versus cycle data were then studied to determine if a correlation between loss of material stiffness and failure could be predicted.

The Composite Materials Research Group has been active in fatigue-related studies for some time. Some of the more significant studies include References [1-5]. As in some of the prior studies, the present investigation provided the special challenge of monitoring the composite stiffness as the fatigue test progressed. The challenge in monitoring the stiffness was in doing so such that the stiffness was measured with a high degree of accuracy without interrupting the fatigue test. The concern here was that continuously stopping a fatigue test to take stiffness measurements could affect the fatigue results due to time-dependent properties, or other unknown characteristics of composite materials. Therefore, the Composite Materials Research Group developed and utilized an advanced computer-aided testing facility, details of which will be presented in Section 2.

1.2 Summary

It was found that the $[\pm45]_{2s}$ laminates did experience a stiffness reduction prior to failure. However, the onset of this stiffness reduction could not be correlated to load or cycle. The $[\pm67.5]_{2s}$ laminate did not exhibit any measurable stiffness reduction prior to failure. The cyclic tension loading caused a slightly nonlinear reduction of strength with respect to the logarithmic number of cycles for the $[\pm45]_{2s}$ laminates. Using the same correlation procedures for the $[\pm67.5]_{2s}$ laminates resulted in an almost linear reduction of strength with respect to the logarithmic number of cycles.

SECTION 2

TEST PROCEDURES

2.1 Specimen Geometry

The T300/5208 graphite/epoxy test specimens for this study were supplied by NASA-Langley. The flat specimens were 12 in long, 1.5 in wide and approximately 0.04 in thick, and are one of two 8-ply laminate orientations, i.e., $[\pm 45]_{2s}$ or $[\pm 67.5]_{2s}$. A total of 30 specimens of each of these laminate orientations were provided.

2.2 Test Procedures

All static and fatigue tests were performed in an Instron Model 1321 servohydraulic testing machine. During the static testing, strain was measured utilizing three extensometers (two axial and one transverse), as indicated in Figure 1. The two axial extensometers were mounted on opposite sides of the specimen during the static tests, to monitor any bending effects.

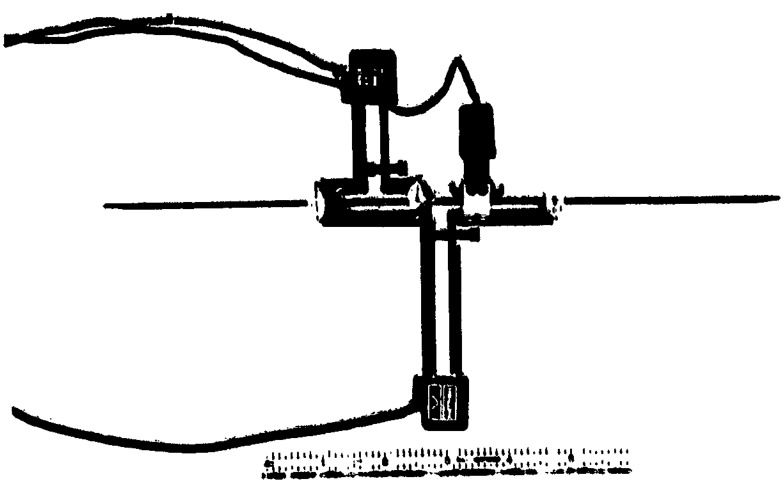

Figure 1. Extensometer Arrangement Utilized to Measure Axial and Transverse Strains

After studying the stress-strain plots and the stiffnesses calculated using each axial extensometer, it was determined that bending effects were nonexistent. Therefore, only one axial and one transverse extensometer were utilized during the fatigue testing. Stress versus strain plots of the static tests are included in Appendix A.

All static tests were conducted at a rate of 2 mm/min. Fatigue testing was conducted using a stress ratio of $R = 0.1$ and a cyclic rate of 10 Hz.

Prior to conducting a fatigue test, an initial static stiffness test was conducted to determine the precyclic stiffness of the specimen. This static test was terminated at the maximum axial tensile stress, σ_{max}, prescribed for the fatigue test. The resultant stiffness was then utilized to establish five percent increments of decreasing dynamic stiffness. Cyclic loading was interrupted after the dynamic stiffness of the specimens reached each of these increments and a static stiffness test was conducted to verify the stiffness decay.

2.3 Data Acquisition

All data acquisition for the static and fatigue testing was performed using a Hewlett Packard HP21MX-E minicomputer. For monitoring the fatigue testing, the data acquisition software combined a real time data acquisition and reduction routine and a logarithmic data storage routine. The data acquisition routine is capable of reading 8 channels of data for a fatigue test conducted at 10 cycles/sec at a sampling rate of 320 samples/sec/channel. Additionally, the data acquisition for each cycle of the test was synchronized to begin sampling at the beginning of the cycle, i.e., at σ_{min}. This allowed a very efficient data storage format for reduction purposes. After the stress and strain data were acquired for a complete cycle, the dynamic stiffness was calculated using a linear regression curve-fit. A decision based upon this value was then made to continue or interrupt the load cycling. If the calculated dynamic stiffness indicated a 5 percent increment drop of stiffness, then the test was interrupted to allow a static stiffness test to be conducted, after which the fatigue test was continued.

Data were stored using a logarithmic procedure, as indicated in Table 1. Since stiffness reduction precedes specimen failure, it would

Table 1

Data Storage Progression

Cycle Range	Cycle Increment Between Data Storage
1 to 10	2
10 to 100	10
100 to 1000	100
1000 to 10,000	1000
10,000 to 100,000	10,000
100,000 to 1,000,000	100,000

be quite possible for the specimen to start to indicate a reduction of stiffness and fail before a scheduled cycle when data were to be stored. To prevent the above condition, the dynamic modulus was checked 10 times between each data storage cycle. If the specimen had not failed at the designated storage cycle, these values were then deleted from storage and the value for the data storage cycle was stored. If the specimen failed before a designated data storage cycle, then the values were maintained in memory. This ensured that the maximum amount of data was collected for each specimen, while keeping data storage files to a reasonable size.

2.4 Modulus Calculations

The statement of work for this program requested that the dynamic secant modulus be calculated. However, during verification of the software routines before fatigue testing was initiated, it was noticed that the secant modulus calculated varied by approximately five percent from cycle to cycle. Since the increment of modulus decay needed for test interruption was five percent, this was unacceptable. It was found that the variation was caused by two problems. First, the data acquisition approach utilized by the Composite Materials Research Group entails digitizing analog stress-strain data. This entails periodically sampling the analog signals, and then converting the sample to digital form. During this process, the absolute minimum and maximum stress and strain values may not be sampled on every cycle. For the sampling rate utilized, it was calculated that the greatest difference between the absolute maximum and minimum stress and strain values and the values actually sampled would be three percent. Additionally, the samples are subject to approximately one percent electrical noise. These two uncertainties essentially explain the variation of the secant modulus from cycle to cycle. One further point is that, while studying the reasons for the dynamic secant modulus cycle-to-cycle variations, it was noted that the $[\pm 45]_{2s}$ laminates were nonlinearly elastic. Therefore, the magnitude of the dynamic secant modulus is load-dependent. In terms of relating modulus decay from specimen to specimen this behavior was considered to be unacceptable.

Thus, it was decided to utilize the tangent modulus method for calculating dynamic stiffnesses. This method is believed to have several advantages over the secant modulus method. First, a tangent modulus is calculated utilizing more data points than just the two end points utilized to calculate the secant modulus. In general, the more data points utilized to characterize a material, the better will be the characterization. Second, by utilizing a linear regression fit, slight anomalies in material behavior or data scatter due to electrical noise can be averaged out. As can be seen in the data generated during the fatigue testing position of this program, which is presented in Appendices B and C, the cycle-to-cycle variation in modulus is very small.

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Section 3

TEST RESULTS

3.1 Static Tensile Results

Five specimens of each laminate orientation, i.e., $[\pm 45]_{2s}$ and $[\pm 67.5]_{2s}$, were statically tested to obtain ultimate strength values for use during fatigue testing. The results of these static tests are presented in Tables 2 and 3. The shear modulus G_{12}, Poisson's ratio ν_{xy}, and ultimate shear stress at failure in the fiber coordinate system τ_{12}, were calculated using the following equations from Reference [6]:

$$G_{12} = \frac{E_x}{2(1+\nu_{xy})} \tag{1}$$

$$\nu_{xy} = -\frac{\varepsilon_y}{\varepsilon_x} \tag{2}$$

$$\tau_{12} = 0.5\sigma_x \quad ([\pm 45]_{2s} \text{ laminates}) \tag{3}$$

$$\tau_{12} = 0.3535\sigma_x \quad ([\pm 67.5]_{2s} \text{ laminates}) \tag{4}$$

3.2 Tensile Fatigue Results

During the tensile fatigue testing of the two laminates, the dynamic modulus of the specimen was continuously monitored and the cycles to failure were recorded. The stress versus number of cycles to failure of each of the two laminates is presented in Figure 2. The regression equation which best fits the fatigue data points for the $[\pm 45]_{2s}$ laminate is of the form:

$$\sigma_{peak} = 26.1 - 0.8 \ln N \tag{5}$$

For the $[\pm 67.5]_{2s}$ laminate the equation takes the form:

$$\sigma_{peak} = 10.4 - 0.4 \ln N \tag{6}$$

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Table 2

Static Axial Tensile Test Results for $[\pm 45]_{2s}$ Laminates of T300/5208 Graphite/Epoxy

Specimen Number	Ultimate Strength σ_x (MPa)	(ksi)	Axial Strain ε_x^u	Axial Stiffness E_x * (GPa)	(Msi)	Poisson's Ratio ν_{xy} **	Shear Stress in the Fiber Coordinate System τ_{12} *** (MPa)	(ksi)
N45U01	173.6	25.2	0.0236	18.9/17.9	2.75/2.60	0.73	86.8	12.6
N45U02	173.6	25.2	0.0214	18.9/18.6	2.75/2.70	0.75	86.8	12.6
N45U03	168.1	24.4	0.0194	18.1/17.9	2.63/2.61	0.75	84.1	12.2
N45U04	170.2	24.7	0.0240	19.3/19.3	2.80/2.80	0.75	85.4	12.4
N45U05	170.9	24.8	0.0244	18.9/18.6	2.75/2.70	0.80	85.4	12.4
Average	171.3	24.9	0.0226	18.9/18.4	2.74/2.68	0.76	85.4	12.4
S.D.	2.4	0.3	0.0021	0.4/0.6	0.06/0.08	0.03	0.1	0.2

* The first value reported was obtained from the 3.5 in gage length extensometer, while the second value was obtained from the 1.5 in gage length extensometer.

** Calculated using the 3.5 in gage length extensometer.

*** Calculated using Equation 3.

Table 3

Static Axial Tensile Test Results for $[\pm 67.5]_{2s}$ Laminates of T300/5208 Graphite/Epoxy

Specimen Number	Ultimate Strength σ_x^u (MPa)	(ksi)	Axial Strain To Failure ϵ_x^u	Axial Stiffness E_x^* (GPa)	(Msi)	Poisson's Ratio ν_{xy}^{**}	Shear Stress in the Fiber Coordinate System τ_{12}^{***} (MPa)	(ksi)
N67U01	70.3	10.2	0.0067	11.4/11.6	1.65/1.69	0.16	24.8	3.6
N67U02	68.2	9.9	0.0066	11.4/11.4	1.65/1.65	0.15	24.1	3.5
N67U03	75.1	10.9	0.0074	11.9/11.2	1.73/1.63	0.17	26.2	3.8
N67U04	70.3	10.2	0.0066	11.3/11.2	1.65/1.63	0.15	24.8	3.6
N67U05	71.7	10.4	0.0067	11.0/11.1	1.60/1.61	0.16	25.5	3.7
Average	71.0	10.3	0.0068	11.4/11.3	1.66/1.64	0.16	24.8	3.6
S.D.	2.8	0.4	0.0003	0.34/0.21	0.05/0.03	0.01	0.69	0.1

* The first value reported, was obtained from the 3.5 in gage length extensometer, while the second value was obtained from the 1.5 in gage length extensometer.

** Calculated using the 3.5 in gage length extensometer.

*** Calculated using Equation 4.

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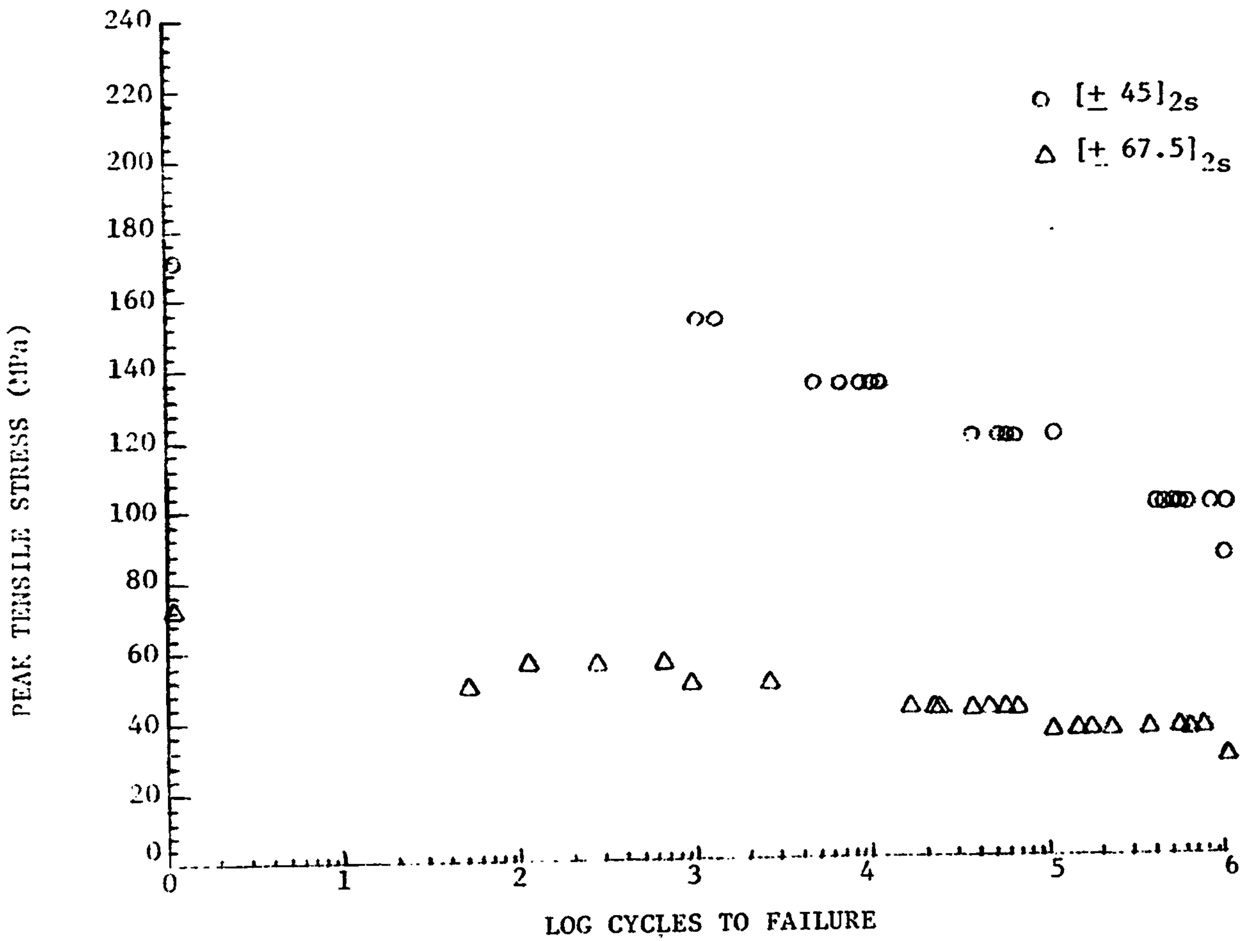

Figure 2. Peak Tensile Stress Versus Log Cycles to Failure

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Additionally, the peak stress versus the number of cycles to failure was plotted on a linear scale to determine if there is a load sensitivity, i.e., a percent of ultimate strength where fatigue life transcends from very short to very long. This plot is shown in Figure 3. These plots indicate a transition between short and long fatigue life occurs at about 119 MPa (17.2 ksi), which correspond to 70 percent of the static ultimate strength for the $[\pm 45]_{2s}$ laminates. For the $[\pm 67.5]_{2s}$ laminates, the transition occurs at about 38 MPa (5.5 ksi), or approximately 55 percent of the static ultimate strength.

The fatigue test load levels for the laminates was originally specified by NASA-Langley to be 60, 50, 40, 30 and 20 percent of the static ultimate strengths, with five fatigue specimens to be tested at each load level. However, the first specimen tested, a $[\pm 45]_{2s}$ laminate loaded to 50 percent of static ultimate, went to 10^6 cycles without failure. Therefore, it was obvious that the load levels selected were too low. Thereafter, load levels for conducting the fatigue tests were selected by the NASA-Langley Contract Monitor in close coordination with the Principal Investigators. Additionally, at the Contract Monitor's request, certain specimens were cycled without taking dynamic data. Instead, the test was periodically stopped and a static test was performed to measure the stiffness.

Tables 4 and 5 are a summary of the results of the fatigue testing of the two laminates. As can be seen, the $[\pm 45]_{2s}$ laminates exhibited a modulus decay that is load-dependent, i.e., the larger the peak stress the greater the modulus decay. For the $[\pm 67.5]_{2s}$ laminates, the modulus decay is essentially nonexistent; on average the magnitude of the modulus decay for this laminate is close to the magnitude of experimental error.

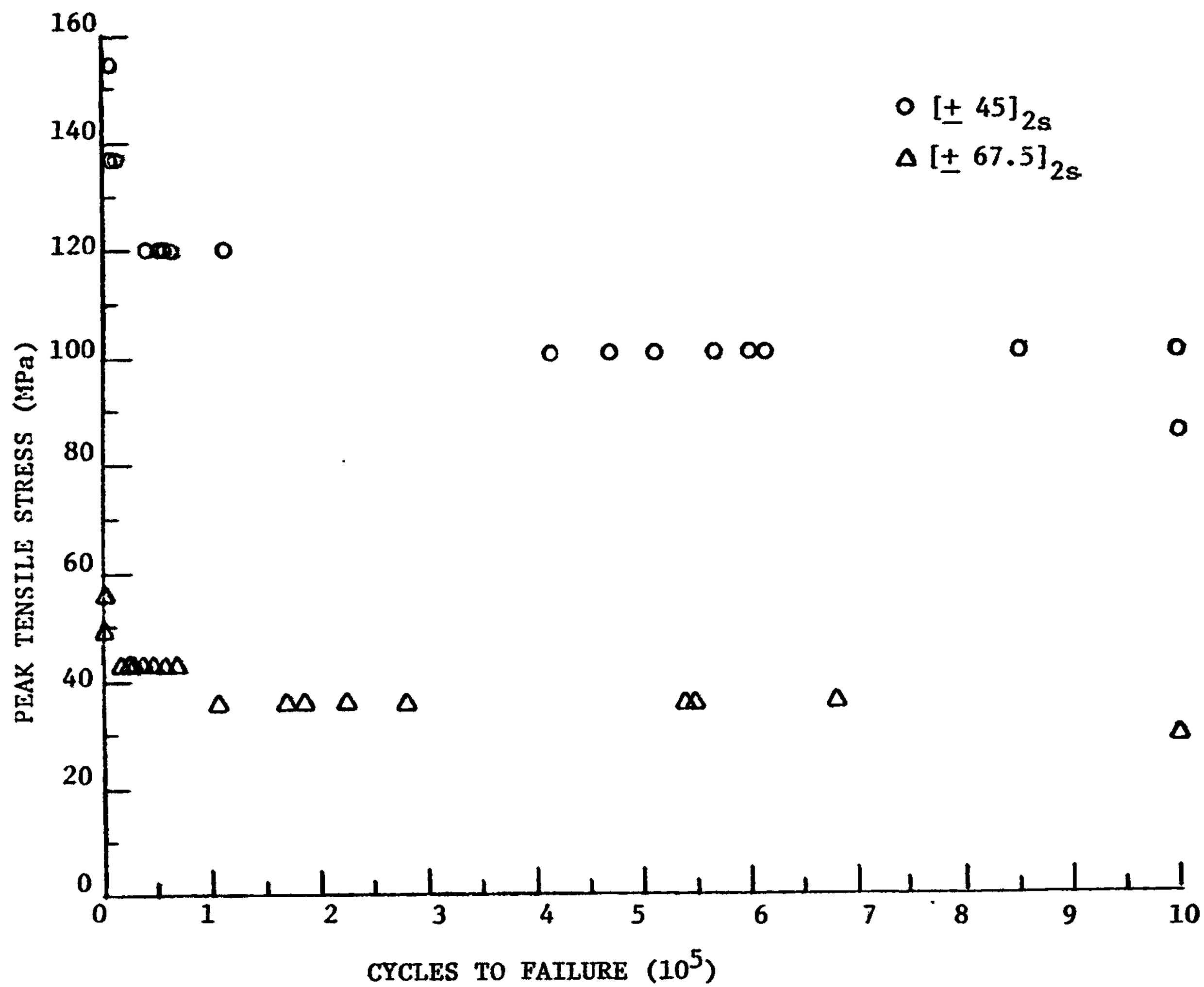

Figure 3. Peak Stress Versus Linear Cycles to Failure

Table 4

Summary of Cyclic Tensile Loading Results for $[\pm 45]_{2s}$ Laminates of T300/5208 Graphite/Epoxy

Specimen Number	Peak Stress MPa (ksi)	Initial Modulus Static GPa (10^6 msi)	Initial Modulus Dynamic GPa (10^6 msi)	Cycles to Failure	Dynamic Modulus Prior to Failure GPa (10^6 msi)	Percent Reduction in Dynamic Modulus at Failure Versus Initial Modulus: Static	Percent Reduction in Dynamic Modulus at Failure Versus Initial Modulus: Dynamic
N45901	154.3 (22.4)	17.5 (2.54)	17.0 (2.47)	1,000	14.0 (2.03)	20.1	17.8
N45902	154.3 (22.4)	18.6 (2.70)	17.5 (2.54)	990	16.7 (2.43)	10.0	4.3
N45903	154.3 (22.4)	17.5 (2.54)	*	1,420	16.3* (2.37)	6.7*	*
N45904	154.3 (22.4)	17.3 (2.51)	*	1,080	15.3* (2.22)	11.6*	*
N45905	154.3 (22.4)	18.6 (2.70)	16.9 (2.45)	995	13.9 (1.87)	30.7	23.7
N45801	137.1 (19.9)	16.2 (2.35)	*	6,690	15.9* (2.31)	1.7*	*
N45802	137.1 (19.9)	17.4 (2.53)	*	8,890	15.5* (2.25)	11.1*	*
N45803	137.1 (19.9)	18.4 (2.68)	17.3 (2.51)	4,910	15.6 (2.26)	15.7	10.0
N45804	137.1 (19.9)	17.6 (2.56)	*	10,710	15.7* (2.28)	10.9*	*
N45805	137.1 (19.9)	17.5 (2.54)	*	10,510	15.6* (2.27)	10.6*	*
N45701	119.9 (17.4)	18.5 (2.68)	18.0 (2.61)	39,380	17.3 (2.50)	6.7	4.2
N45702	119.9 (17.4)	19.3 (2.80)	18.7 (2.72)	112,340	16.5 (2.39)	14.6	12.1

Table 4 (cont'd)

Summary of Cyclic Tensile Loading Results for $[\pm 45]_{2s}$ Laminates of T300/5208 Graphite/Epoxy

N4703	119.9 (17.4)	19.2 (2.78)	18.5 (2.68)	52,030	16.2 (2.36)	15.1	11.9
N4704	119.9 (17.4)	19.1 (2.77)	18.5 (2.69)	63,550	17.5 (2.54)	8.3	5.6
N4705	119.9 (17.4)	19.2 (2.78)	18.6 (2.70)	56,170	17.6 (2.55)	8.3	5.6
N45601	102.7 (14.9)	18.9 (2.74)	18.9 (2.75)	614,758	18.4 (2.67)	2.6	2.9
N45602	102.7 (14.9)	19.6 (2.85)	19.3 (2.80)	1,010,460	18.3 (2.65)	7.0	5.4
N45603	102.7 (14.9)	19.1 (2.77)	18.3 (2.66)	511,960	15.6 (2.27)	18.1	14.6
N45604	102.7 (14.9)	19.2 (2.78)	18.9 (2.74)	468,080	18.4 (2.67)	4.0	2.6
N45605	102.7 (14.9)	19.2 (2.78)	**	416,260	**	**	**
N45606	102.7 (14.9)	19.2 (2.78)	18.6 (2.70)	566,250	18.1 (2.63)	5.4	2.6
N45607	102.7 (14.9)	19.0 (2.76)	18.6 (2.71)	1,017,000	18.1 (2.63)	4.7	3.0
N45608	102.7 (14.9)	19.4 (2.81)	18.6 (2.71)	850,000	18.1 (2.63)	6.4	3.0
N45609	102.7 (14.9)	19.2 (2.78)	18.9 (2.74)	597,830	17.4 (2.53)	9.0	7.7
N45501	85.4 (12.4)	19.3 (2.80)	19.8 (2.87)	1,000,790	19.3 (2.80)	0.0	2.4

* No Dynamic Data Taken
** Data unavailable

Table 5

Summary of Cyclic Tensile Loading Results for $[\pm 67.5]_{2s}$ Laminates of T300/5208 Graphite/Epoxy

Specimen Number	Peak Stress MPa (ksi)	Initial Modulus Static GPa (10^6 msi)	Initial Modulus Dynamic GPa (10^6 msi)	Cycles to Failure	Dynamic Modulus Prior to Failure GPa (10^6 msi)	Percent Reduction in Dynamic Modulus at Failure Versus Initial Modulus Static	Percent Reduction in Dynamic Modulus at Failure Versus Initial Modulus Dynamic
N67801	56.5 (8.2)	10.7 (1.56)	10.9 (1.58)	270	10.7 (1.55)	0.6	1.9
N67802	56.5 (8.2)	10.5 (1.53)	10.7 (1.55)	610	10.5 (1.52)	0.7	1.9
N67803	56.5 (8.2)	7.8 (1.13)	10.8 (1.57)	110	10.6 (1.54)	36.3	1.9
N67701	49.6 (7.2)	10.7 (1.55)	10.8 (1.57)	2,480	10.7 (1.56)	0.0	0.6
N67702	49.6 (7.2)	10.7 (1.55)	10.9 (1.58)	50	10.8 (1.57)	0.0	0.6
N67703	49.6 (7.2)	10.7 (1.55)	10.8 (1.57)	910	10.8 (1.57)	0.0	0.0
N67601	42.7 (6.2)	10.8 (1.57)	11.0 (1.60)	24,280	11.0 (1.59)	0.0	0.6
N67602	42.7 (6.2)	10.7 (1.55)	11.0 (1.60)	68,060	11.0 (1.59)	0.0	0.6
N67603	42.7 (6.2)	10.5 (1.52)	10.7 (1.55)	58,880	10.5 (1.52)	0.0	1.9
N67604	42.7 (6.2)	10.1 (1.47)	10.4 (1.51)	37,430	10.2 (1.48)	0.0	2.0
N67605	42.7 (6.2)	10.7 (1.56)	11.0 (1.59)	340*	10.8 (1.57)	0.0	1.3*
N67606	42.7 (6.2)	10.5 (1.53)	10.8 (1.57)	47,100	10.1 (1.47)	3.9	6.4
N67607	42.7 (6.2)	10.5 (1.53)	10.7 (1.56)	37,700	10.5 (1.52)	0.7	2.6
N67608	42.7 (6.2)	10.5 (1.53)	11.0 (1.59)	17,590	10.9 (1.58)	0.0	0.6

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Table 5 (cont'd)

Summary of Cyclic Tensile Loading Results for $[\pm 67.5]_{2s}$ Laminates of T300/5208 Graphite/Epoxy

N67609	42.7 (6.2)	10.5 (1.53)	10.7 (1.56)	23,760	10.6 (1.54)	0.0	1.3
N67501	35.8 (5.2)	10.6 (1.54)	10.7 (1.55)	186,940	10.7 (1.56)	0.0	0.0
N67502	35.8 (5.2)	10.5 (1.53)	10.7 (1.56)	224,800	10.1 (1.47)	3.9	5.8
N67503	35.8 (5.2)	10.6 (1.54)	10.9 (1.58)	168,820	10.9 (1.58)	0.0	0.0
N67504	35.8 (5.2)	10.7 (1.56)	11.0 (1.59)	547,960	9.9 (1.43)	8.3	10.1
N67505	35.8 (5.2)	10.5 (1.53)	10.9 (1.58)	105,240	10.1 (1.46)	4.6	7.6
N67506	35.8 (5.2)	10.7 (1.55)	10.9 (1.58)	788,170	10.1 (1.46)	5.8	7.6
N67507	35.8 (5.2)	10.7 (1.55)	11.0 (1.59)	377,790	11.0 (1.59)	0.0	0.0
N67508	35.8 (5.2)	11.0 (1.59)	11.0 (1.60)	637,850	11.0 (1.60)	0.0	0.0
N67401	28.2 (4.1)	**	**	1,000,000+	**	**	**
N67402	28.2 (4.1)	10.5 (1.52)	10.7 (1.56)	1,014,000+	10.9 (1.58)	0.0	0.0
N67403	28.2 (4.1)	10.6 (1.54)	10.8 (1.57)	1,023,000+	11.0 (1.59)	0.0	0.0

*Specimen failed in grips
**Data unavailable

Examples of the normalized modulus decay versus number of cycles are presented in Figures 4 through 13. The (dynamic) longitudinal modulus has been normalized by dividing by the (precycling) initial static modulus.

Several attempts were made to correlate the modulus decay data for the $[\pm 45]_{2s}$ laminates, without success. The first attempt at correlating the data was to average the modulus decay at approximately coinciding cycles for the group of specimens run at each load level. This approach was not generally successful since the modulus decay was very small until just prior to specimen failure. Therefore, the average would remain constant until the first specimen at a given load level approached failure. Then the average would dip until the first specimen did fail, and then rise back up until the second specimen of the group approached. This approach was considered unacceptable. The second approach to correlating the $[\pm 45]_{2s}$ data was to study each normalized modulus versus number of cycles plot presented in Appendix C, to determine the cycle where modulus decay began, and then to compare this value with the number of cycles to failure. This approach was hampered by not being able to establish in all cases the cycle when modulus decay began. However, for the plots where it was possible, the percent of cycles to failure at which modulus decay began ranged from approximately zero percent for the specimens tested at a high peak stress, to approximately 60 percent for the specimens tested at the lower peak stresses. However, it must be added that the scatter of the data from this attempt was quite large, and not all specimens could be included. Consequently this approach was not considered acceptable.

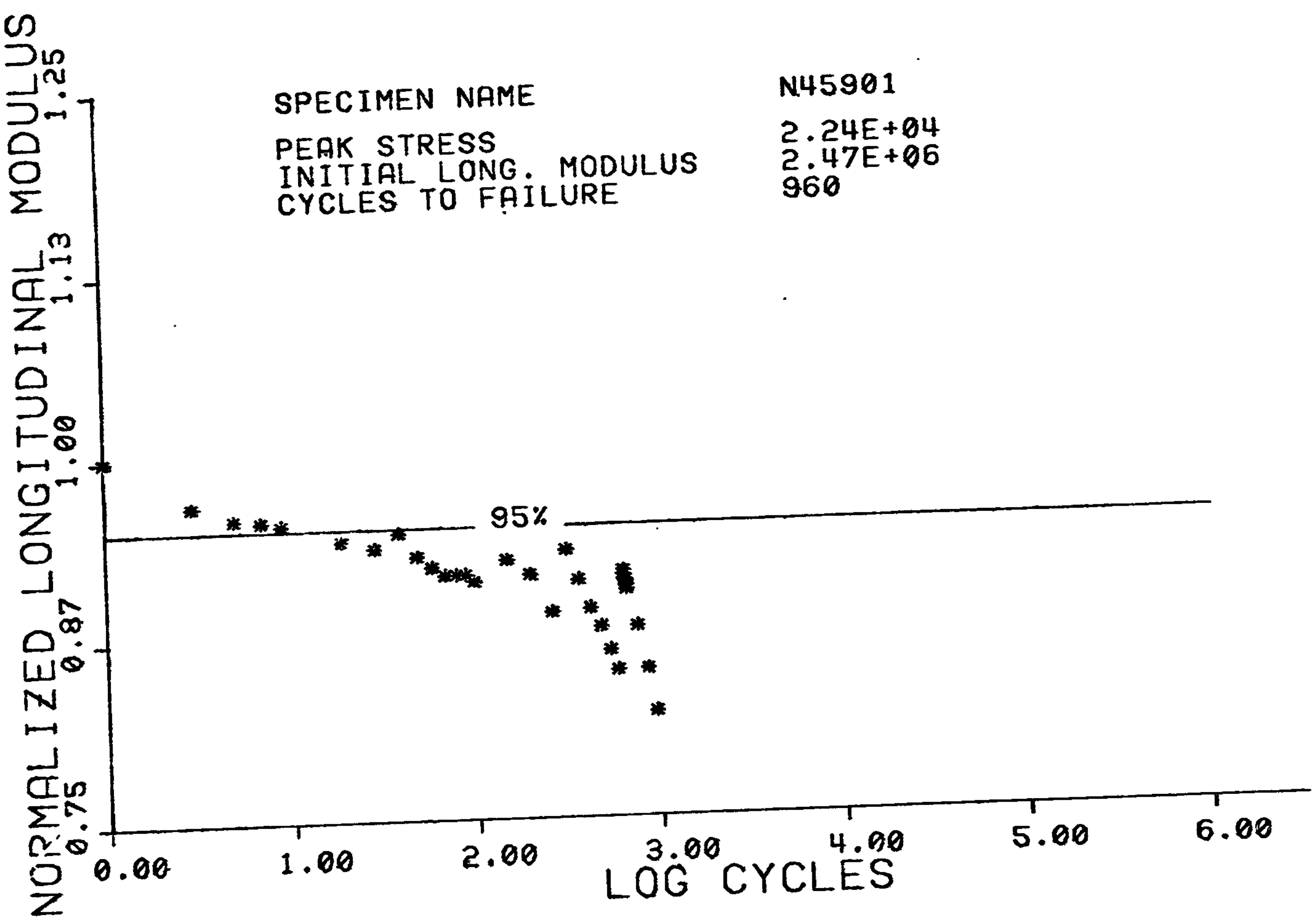

Figure 4. Normalized Stiffness Versus Log Cycles for Specimen N45901.

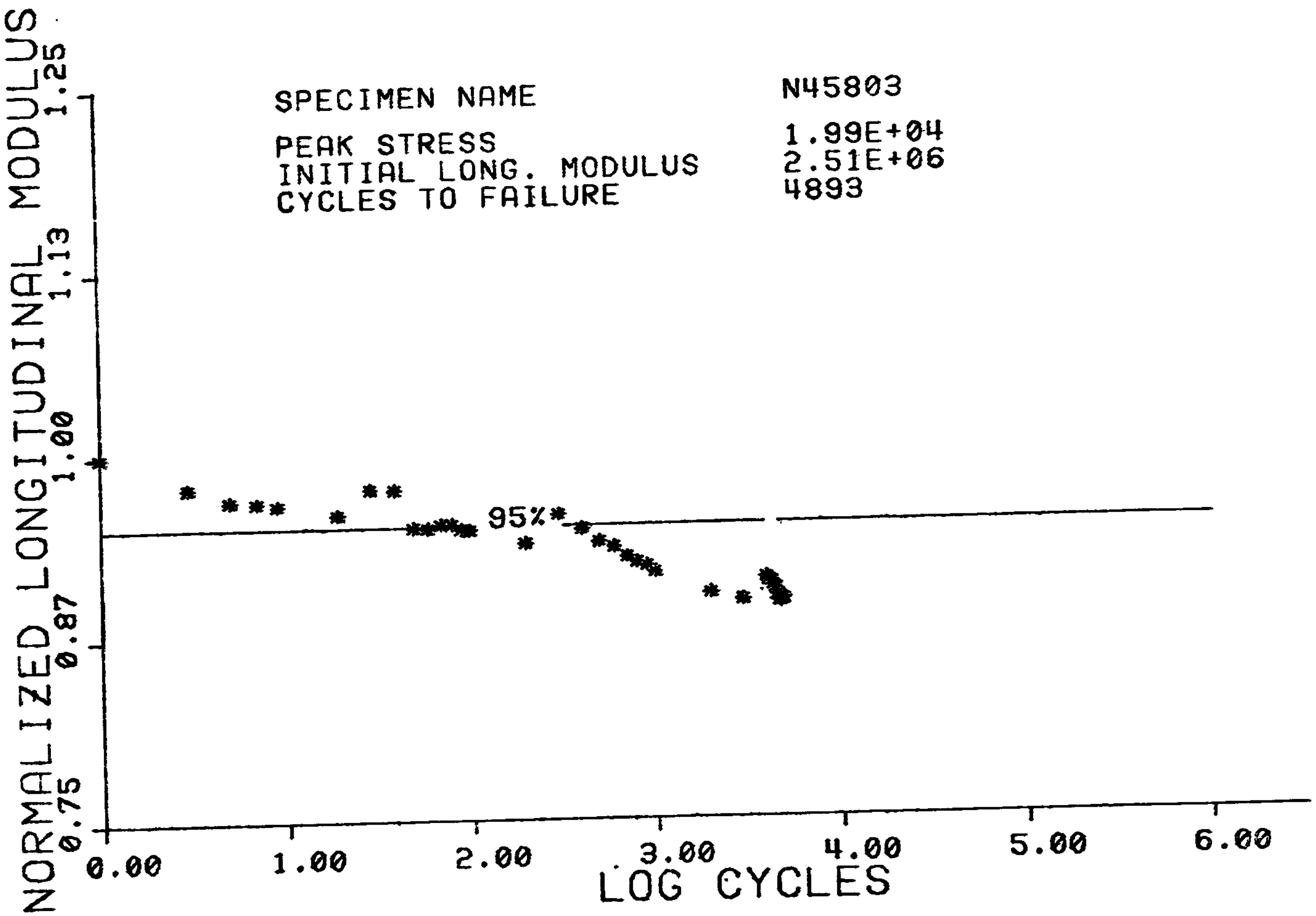

Figure 5. Normalized Stiffness Versus Log Cycles for Specimen N45803.

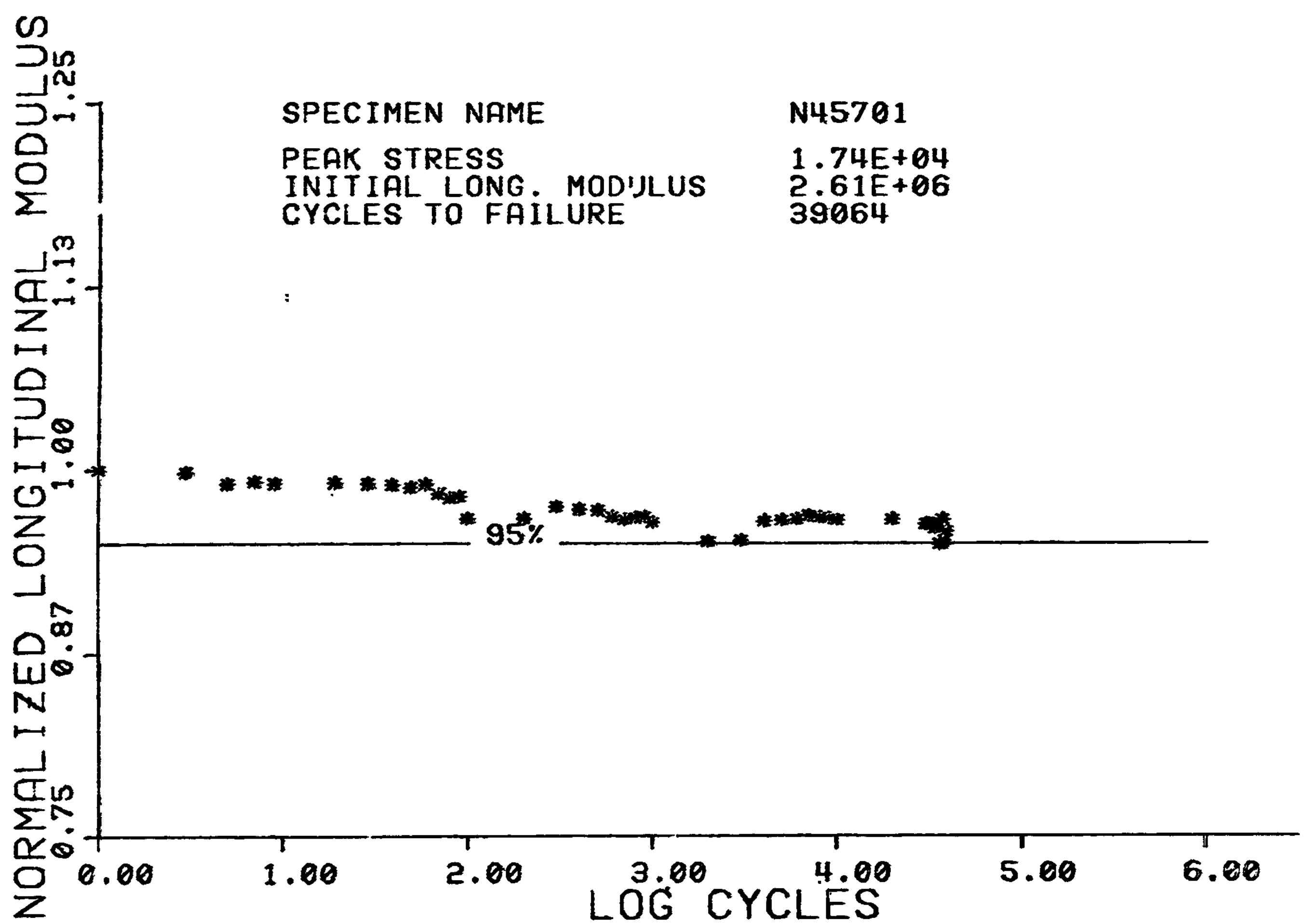

Figure 6. Normalized Stiffness Versus Log Cycles for Specimen N45701.

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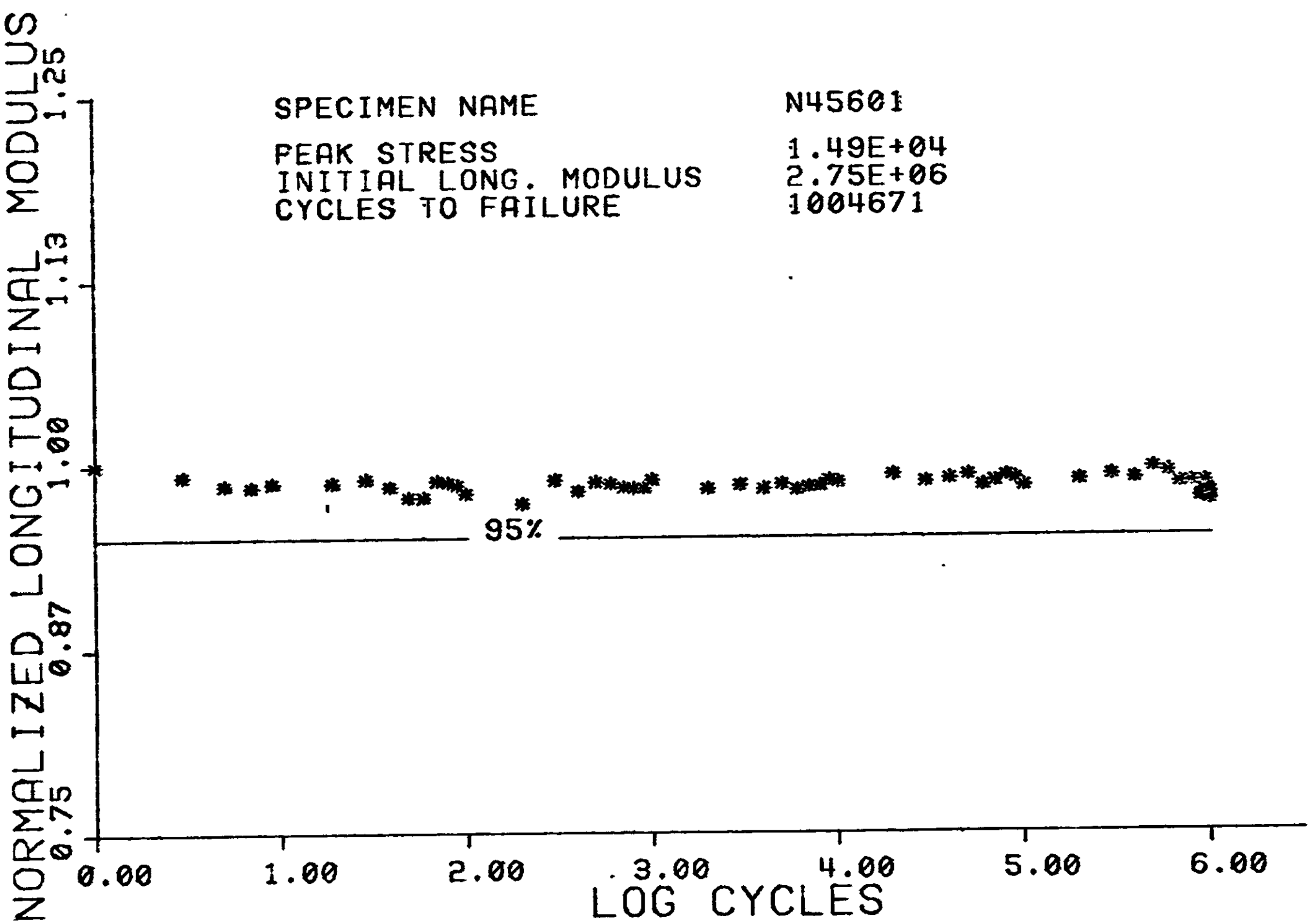

Figure 7. Normalized Stiffness Versus Log Cycles for Specimen N45601.

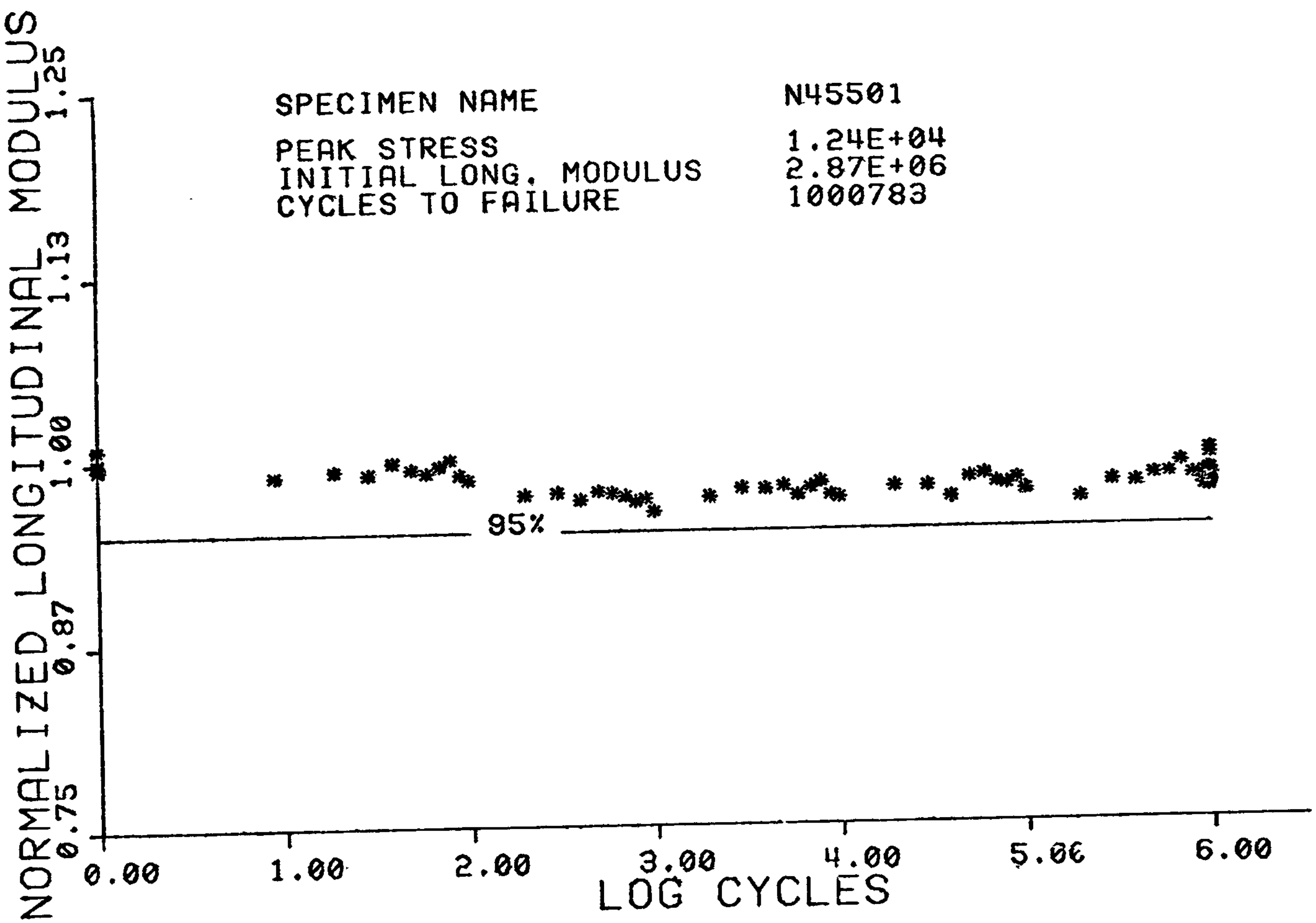

Figure 8. Normalized Stiffness Versus Log Cycles for Specimen N45501.

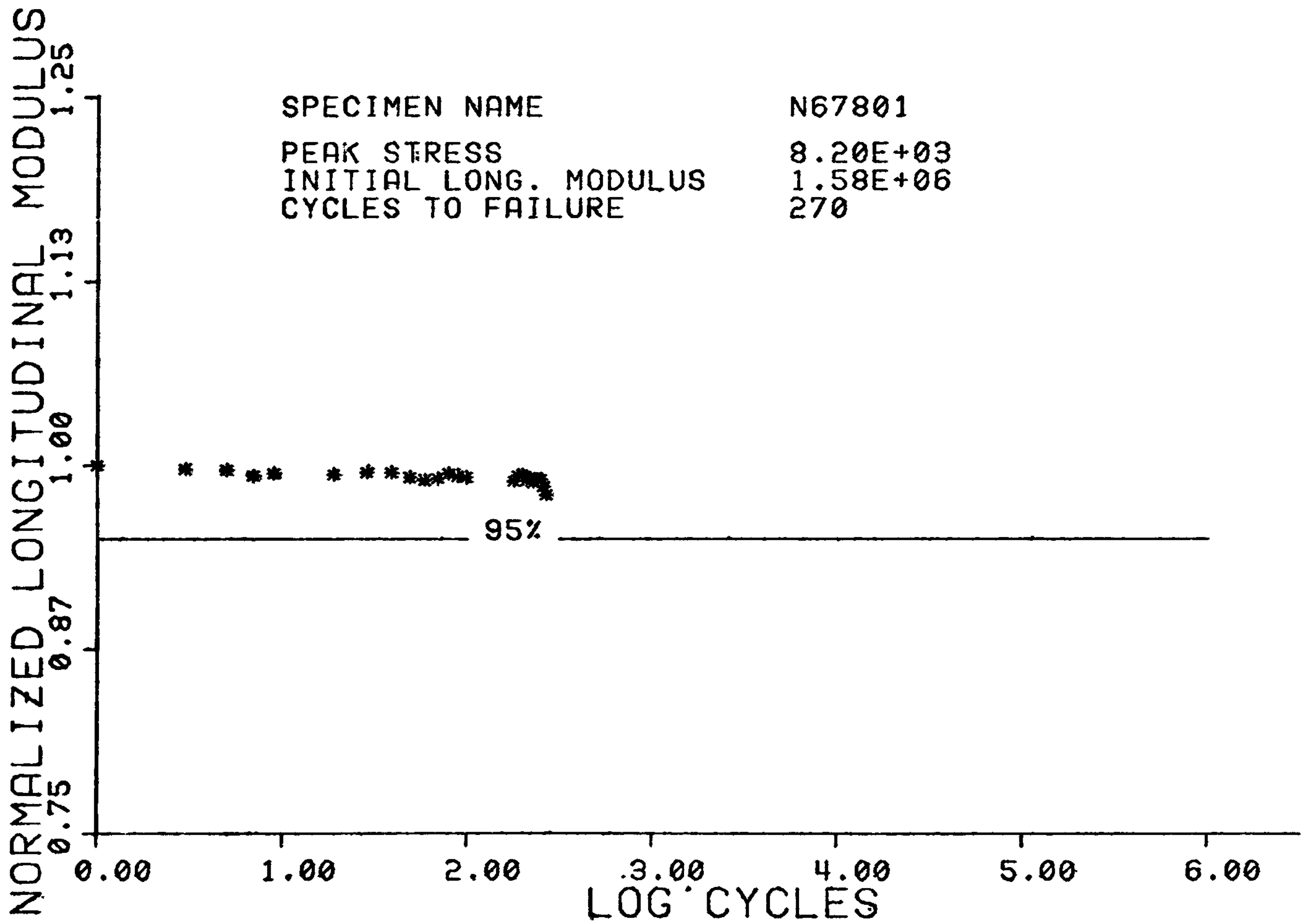

Figure 9. Normalized Stiffness Versus Log Cycles for Specimen N45801.

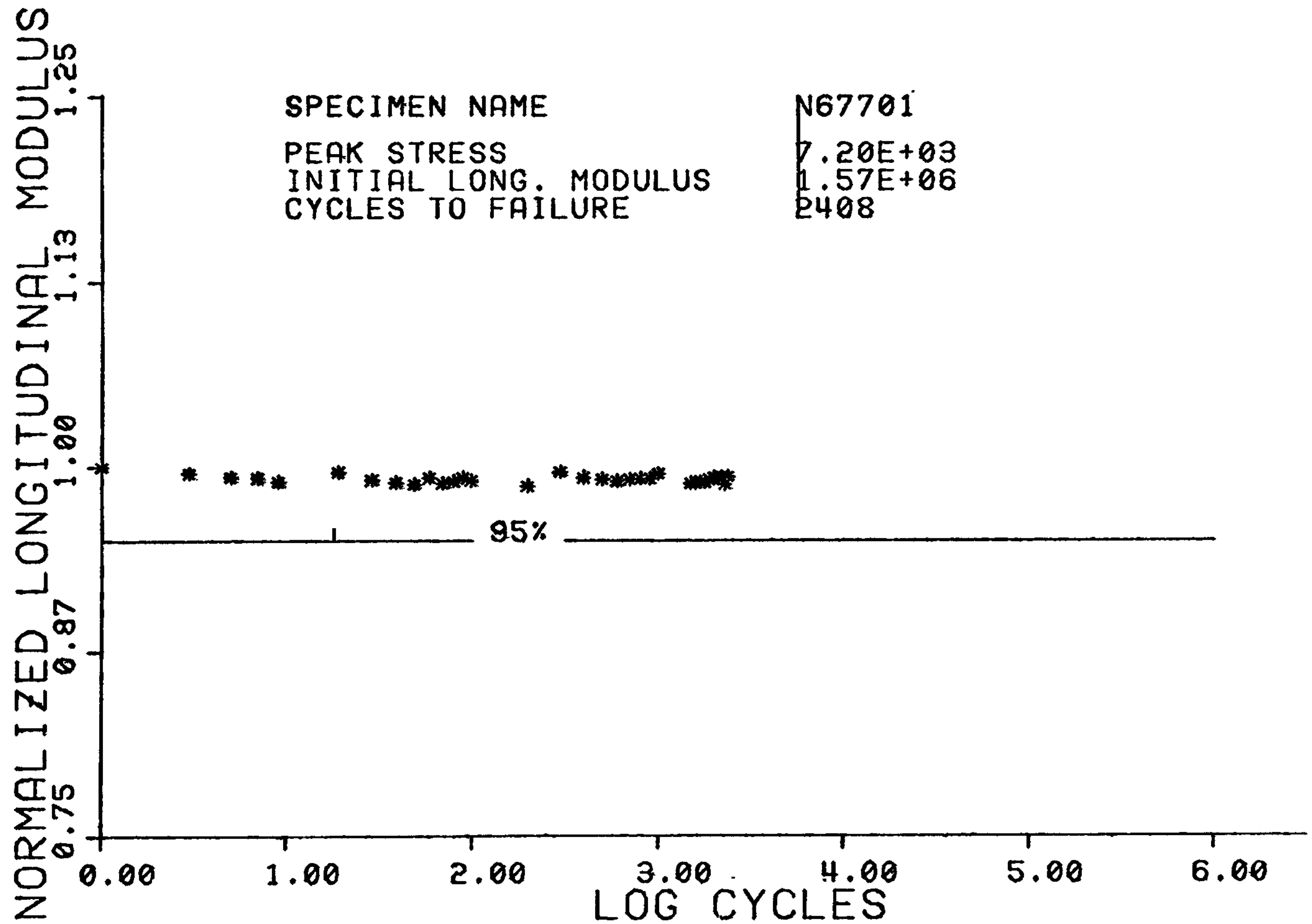

Figure 10. Normalized Stiffness Versus Log Cycles for Specimen N67701.

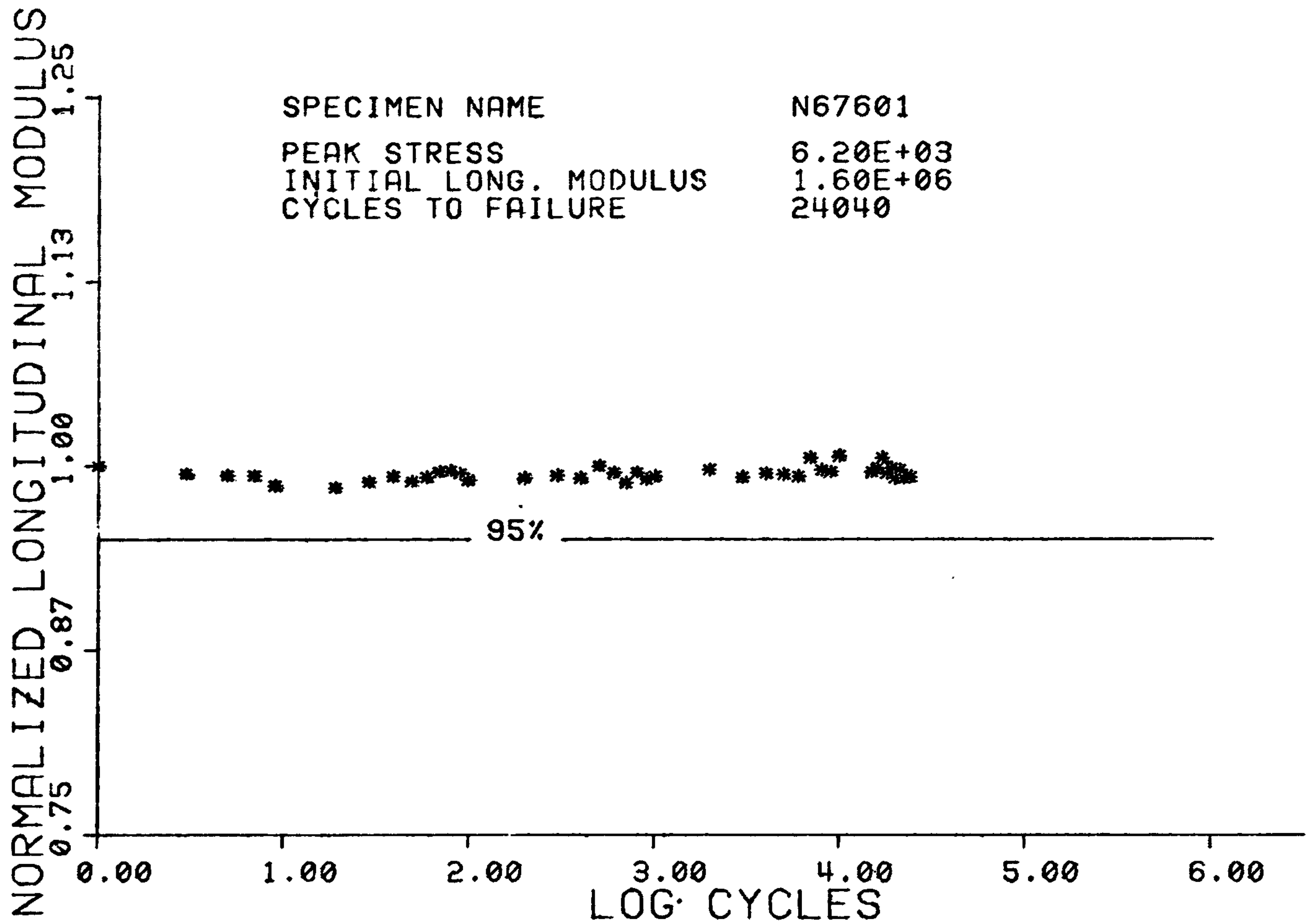

Figure 11. Normalized Stiffness Versus Log Cycles for Specimen N67601.

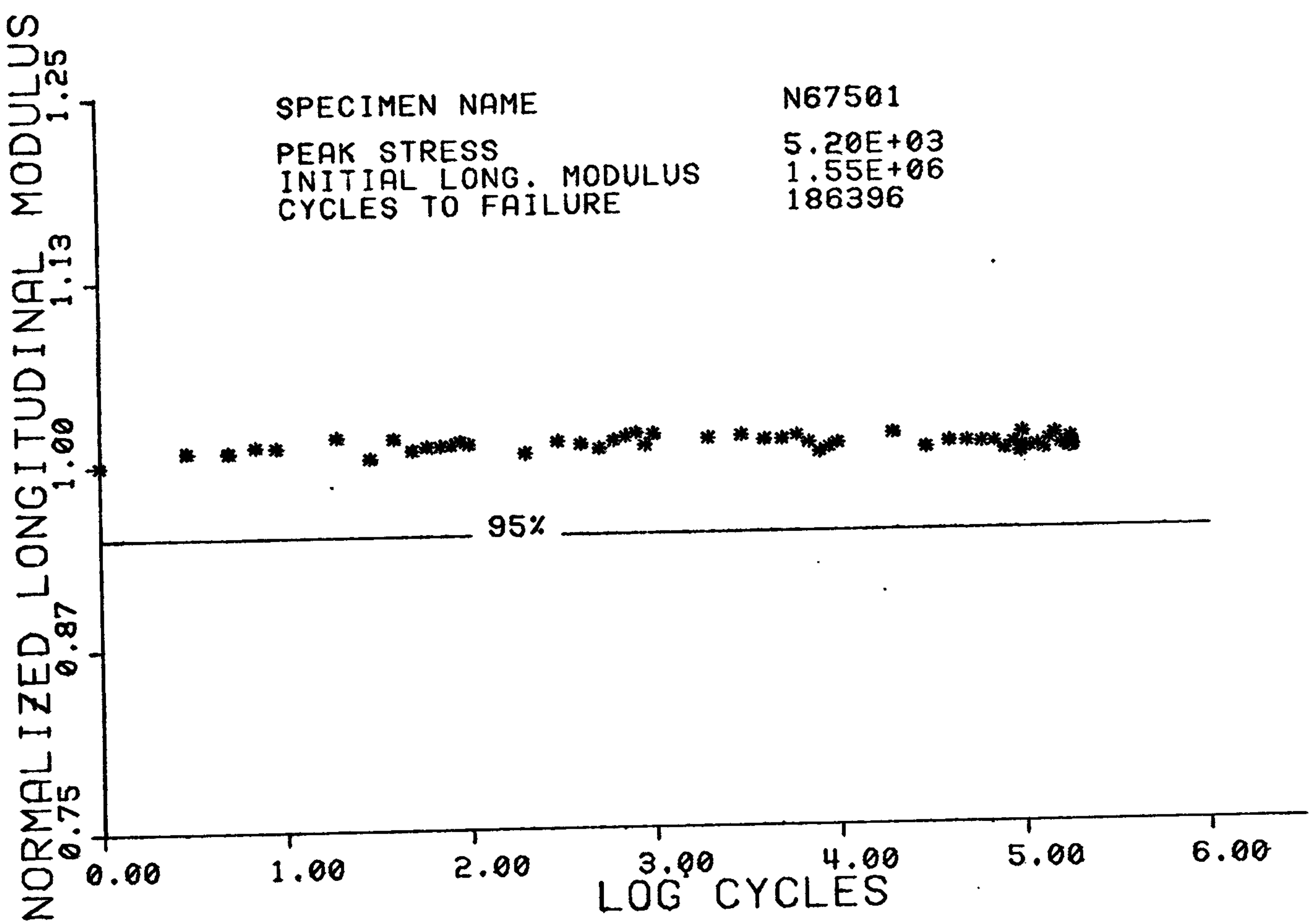

Figure 12. Normalized Stiffness Versus Log Cycles for Specimen N67501.

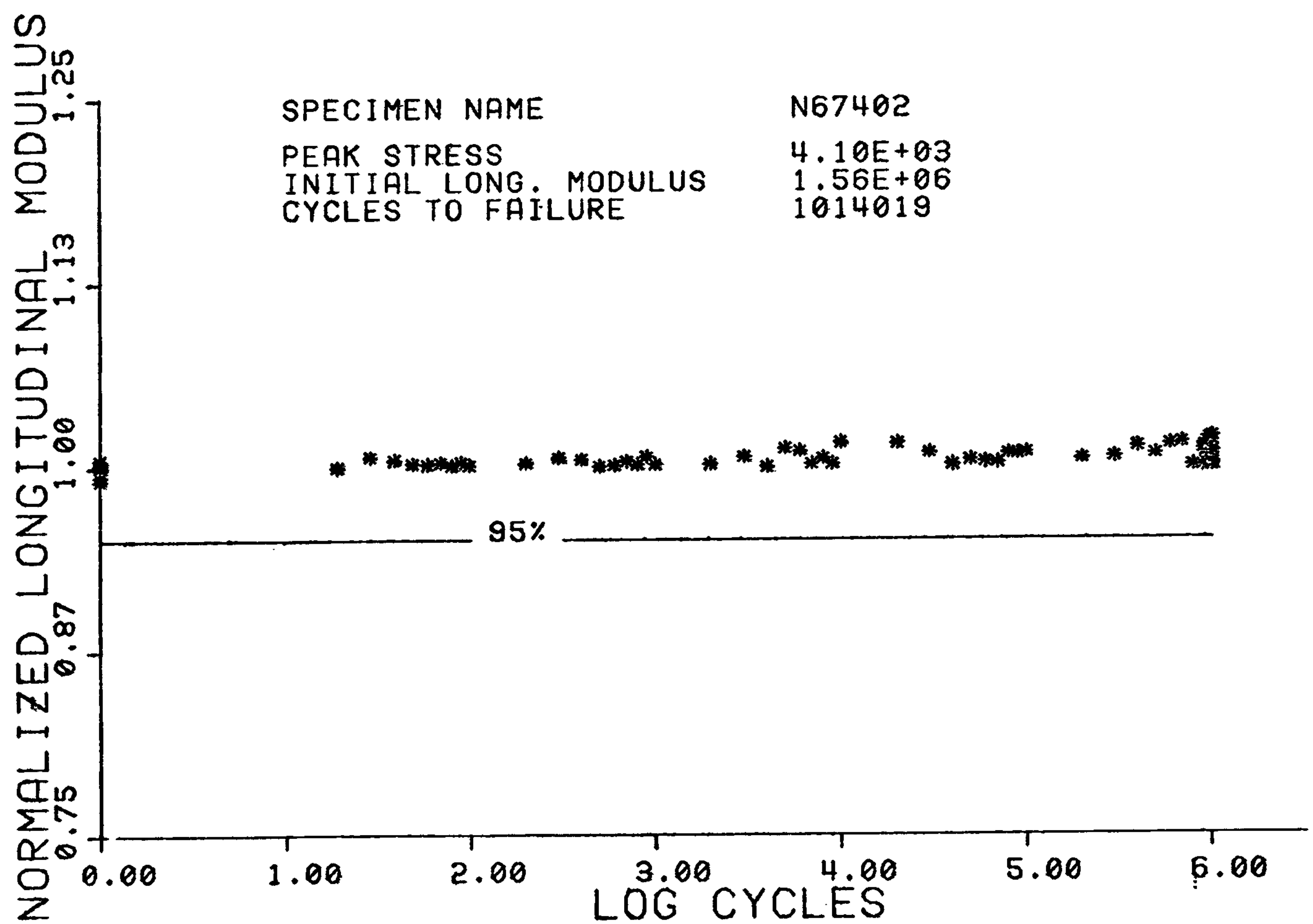

Figure 13. Normalized Stiffness Versus Log Cycles for Specimen N67401.

3.3 Secondary Effects

The primary emphasis of this study was the monitoring of the modulus decay of two graphite/epoxy laminates, and to then correlate the modulus decay. However, as presented in the previous section, the $[\pm 67.5]_{2s}$ laminates did not exhibit measurable modulus decay, and the $[\pm 45]_{2s}$ laminates, while indicating modulus decay at the higher peak stress levels, could not be correlated.

However, during the course of testing and data reduction, several other phenomena were observed. For example, in comparing the initial static modulus to the initial dynamic modulus (see Table 4), it will be noted that in all cases except two, the static modulus was slightly higher than the dynamic modulus for the $[\pm 45]_{2s}$ laminates. However, the reverse of the above is true for the $[\pm 67.5]_{2s}$ laminates, as can be seen in Table 5. The difference in both cases are quite small, and might be attributed to experimental error except for the consistent trend indicated. It is reasonable to assume that the static values for each of the laminates are the "correct" values since they were obtained in a very controlled manner, as explained in Section 2. Therefore, it would be reasonable to assume that the laminate must have a physical characteristic that is dependent on dynamic loading.

As noted above, the initial static moduli of the $[\pm 45]_{2s}$ laminates were greater than the initial dynamic moduli measured during fatigue testing. Additionally, when testing was suspended during fatigue testing due to a 5 percent loss of dynamic modulus, it was noted that the subsequently measured static modulus was greater than the dynamic modulus calculated prior to test interruption. However, when fatigue testing was resumed, the first dynamic modulus measured was also greater than the last dynamic modulus measured prior to test interruption. This characteristic is indicated, for example, by Specimens N45901, N45701 and N45703 in Appendix B. This occurrence is actually much more pronounced than the data from these tests indicate, since the first dynamic modulus stored after test resumption was typically that measured a number of cycles after test resumption. In some cases it was noted that the dynamic modulus after test interruption nearly recovered to the initial dynamic modulus, but very quickly decayed back to the dynamic modulus measured prior to test interruption. This type of behavior is most clearly indicated by Specimen N45901, due to the test being stopped at a very low cycle number, where the number of cycles between a data storage cycle, as explained in Section 2.3, was small. It is presently believed that this apparent modulus recovery is due to a viscoelastic response of the matrix material of the laminate when subjected to a high shear loading. This response was not noted in the $[\pm 67.5]_{2s}$ laminate. However, this laminate did not indicate any modulus decay, and therefore testing was not suspended to conduct static tests.

The previous phenomena, i.e., differences in static and dynamic moduli and modulus recovery, were initially believed to be experimental errors, due to the small magnitude involved. While trying to find the cause of these apparent discrepancies, by checking the test equipment and by studying the cyclic data, yet another phenomena was noted. During the study of the cyclic data for the $[\pm 45]_{2s}$ laminate, it was noticed that the stress-strain hysterices loop was shifting from cycle to cycle. Further investigation revealed that the mean strain of specimens of the $[\pm 45]_{2s}$ laminate was increasing as the fatigue test progressed. This phenomenon is lso attributed to a viscoelastic response of the material. Figures 14, 15 and 16 indicate the slope of the lines that resulted from the linear regression fit of the stress-strain data taken at various cycles. As can be seen, these lines are moving to the right, and rotating in a clockwise manner. Additionally, the higher the peak stress during cyclic loading, the greater the shift. The rotation of lines in the figures is the modulus decay of the specimen, while the shift indicates the viscoelastic response. From these curves, which are typical of the $[\pm 45]_{2s}$ laminates, it would seem that the viscoelastic response is dominating the results obtained during the fatigue testing. It is presently believed that the viscoelastic mechanism may provide an explanation for the lack of modulus decay of the $[\pm 45]_{2s}$ laminates at low load levels. What may be occurring is that the stresses for the lower load levels are being relaxed, and therefore not propagating damage zones that would show up as modulus decay. Conversely, at the higher load levels, the stresses may be high enough to overcome the viscoelastic response of the material and propagate the damage zones.

3.4 Failure Modes

Figures 17 and 18 indicate typical failures of the $[\pm 45]_{2s}$ and $[\pm 67.5]_{2s}$ laminates, respectively. The $[\pm 45]_{2s}$ laminate indicates a failure mode dominated by delamination and matrix failure. The $[\pm 67.5]_{2s}$ laminates indicate a failure mode highly dominated by matrix failure and fiber fracture.

When this program was initiated, it was expected that the test specimens would accumulate internal damage during cyclic loading, and that this damage would significantly reduce the stiffness of the test specimen. To determine the extent of this damage, the test specimens

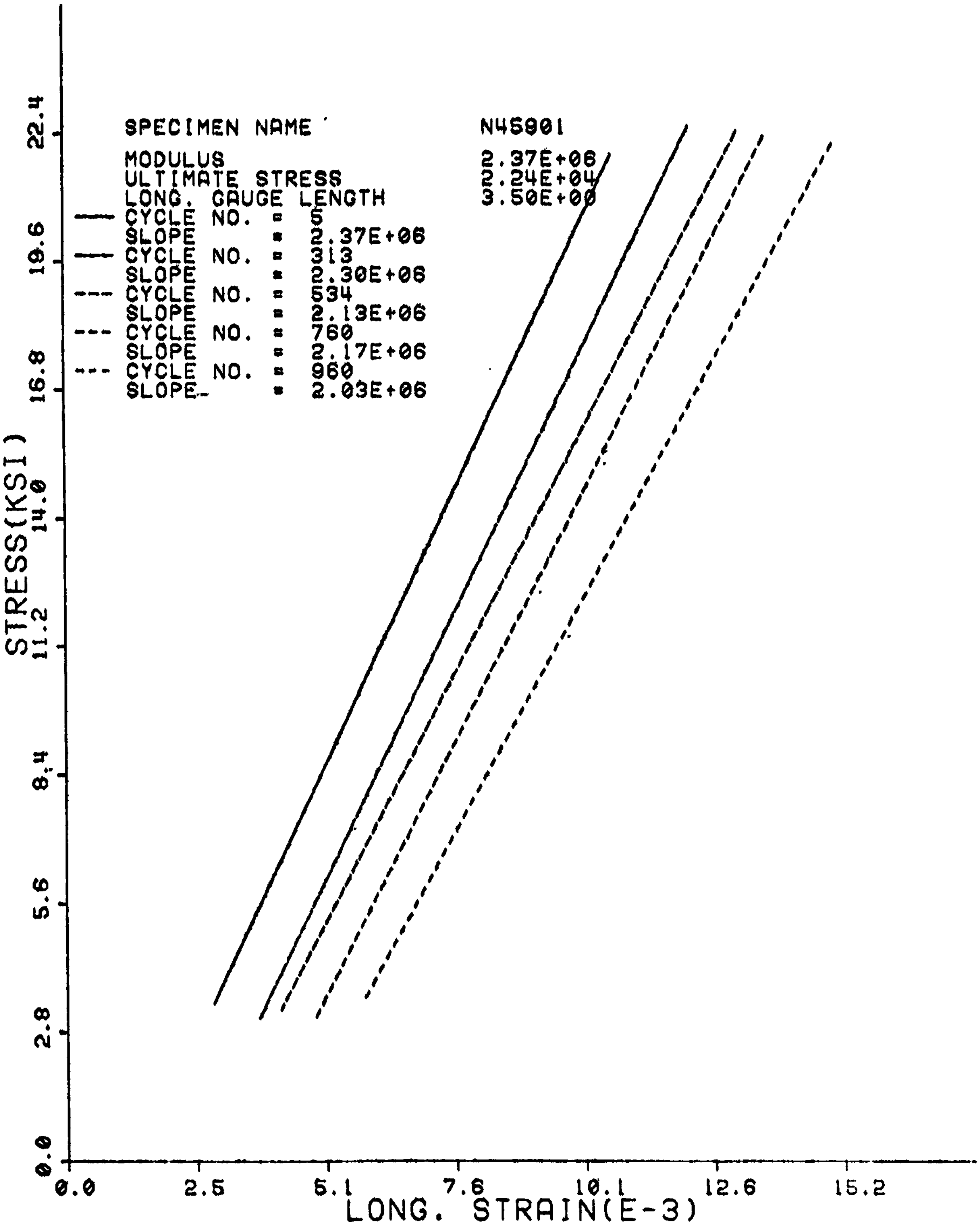

Figure 14. Slopes of the Stress-Strain Curves for Specimen N45901 at Various Numbers of Cycles During the Fatigue Test.

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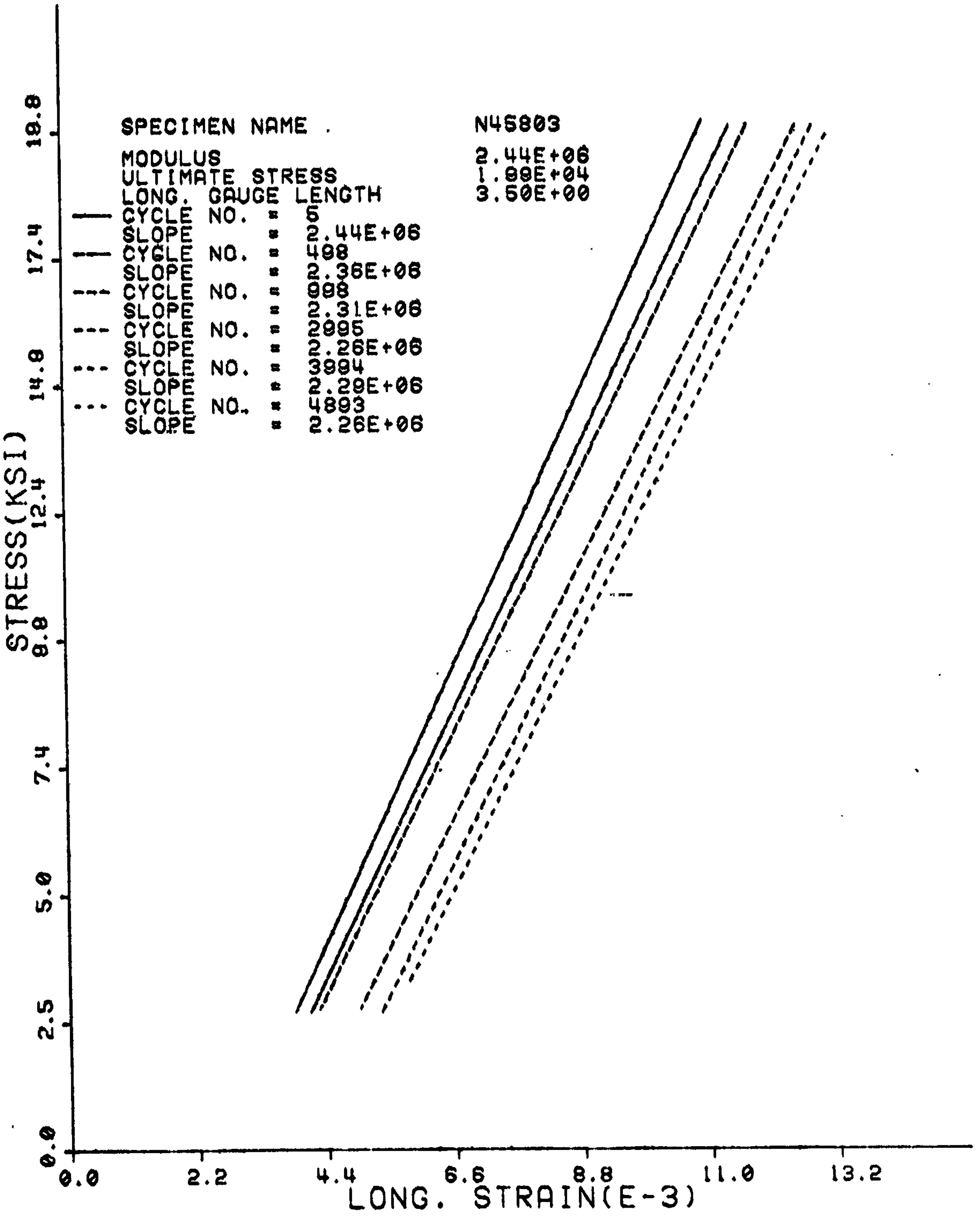


Figure 15. Slopes of the Stress-Strain Curves for Specimen N45803 at Various Numbers of Cycles During the Fatigue Test.

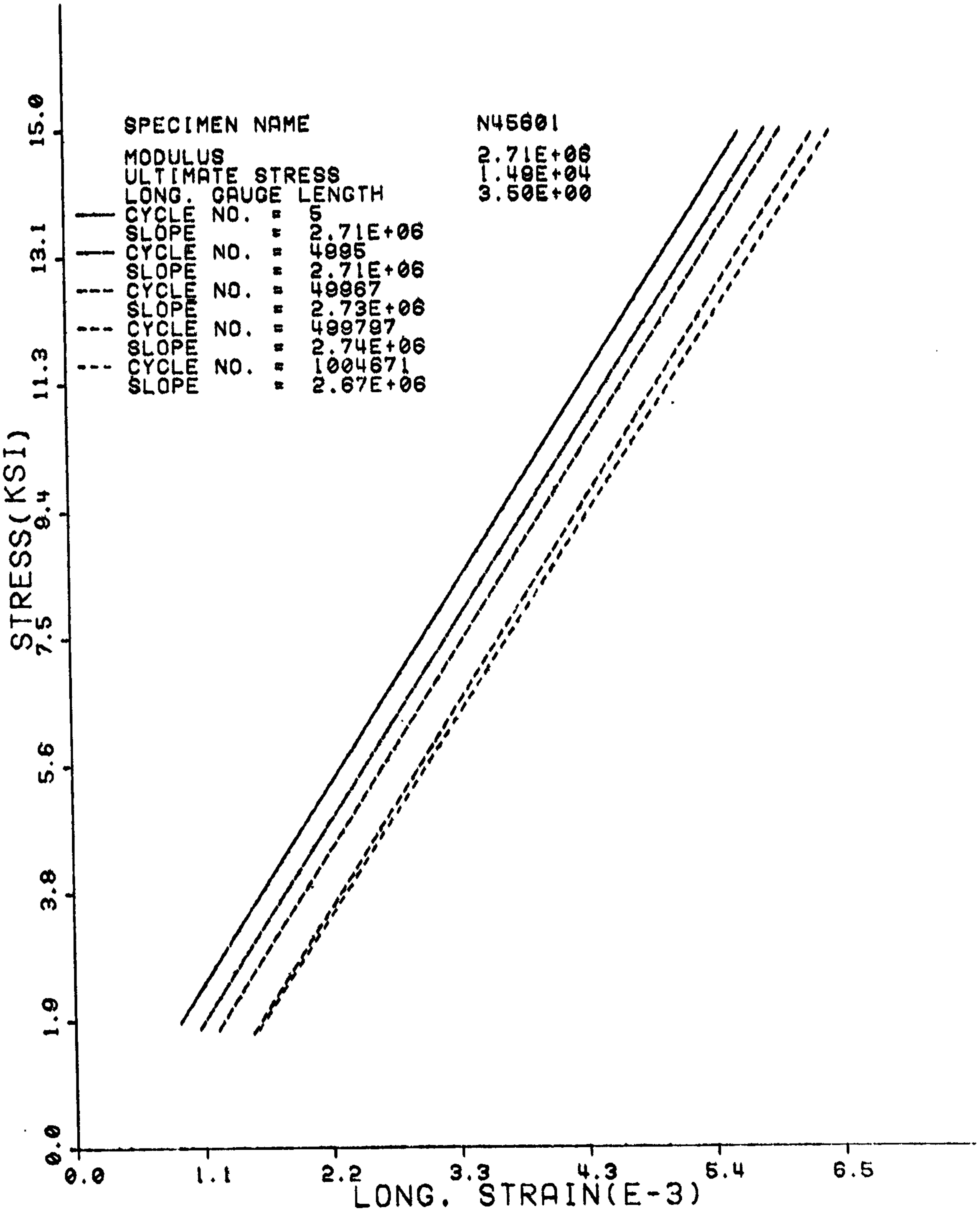


Figure 16. Slopes of the Stress-Strain Curves for Specimen N45601 at Various Numbers of Cycles During the Fatigue Test.

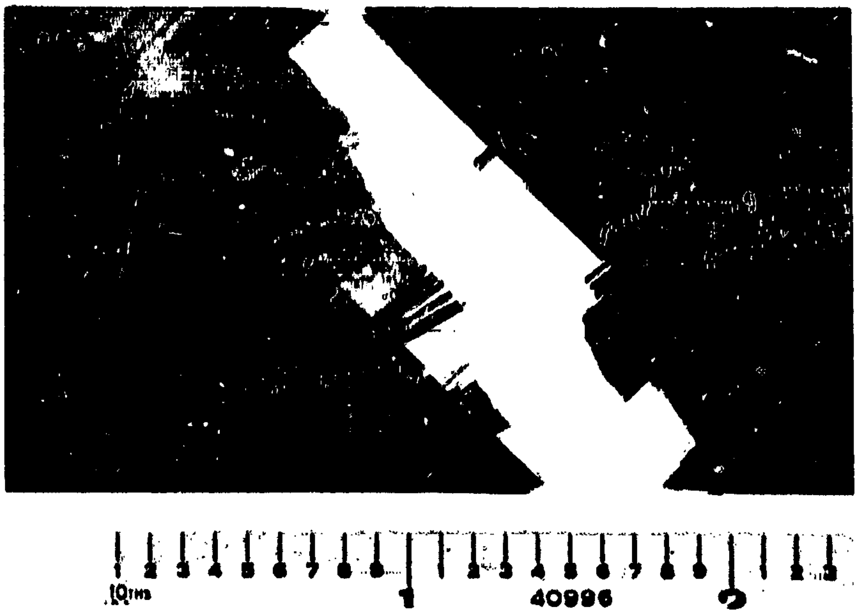


Figure 17. Typical Failure of a $[\pm 45]_{2s}$ Laminate

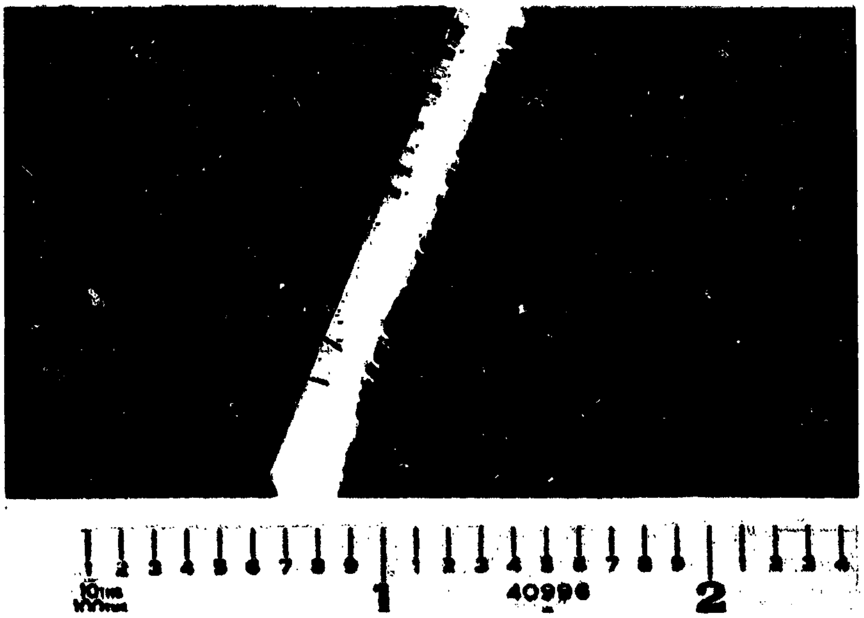
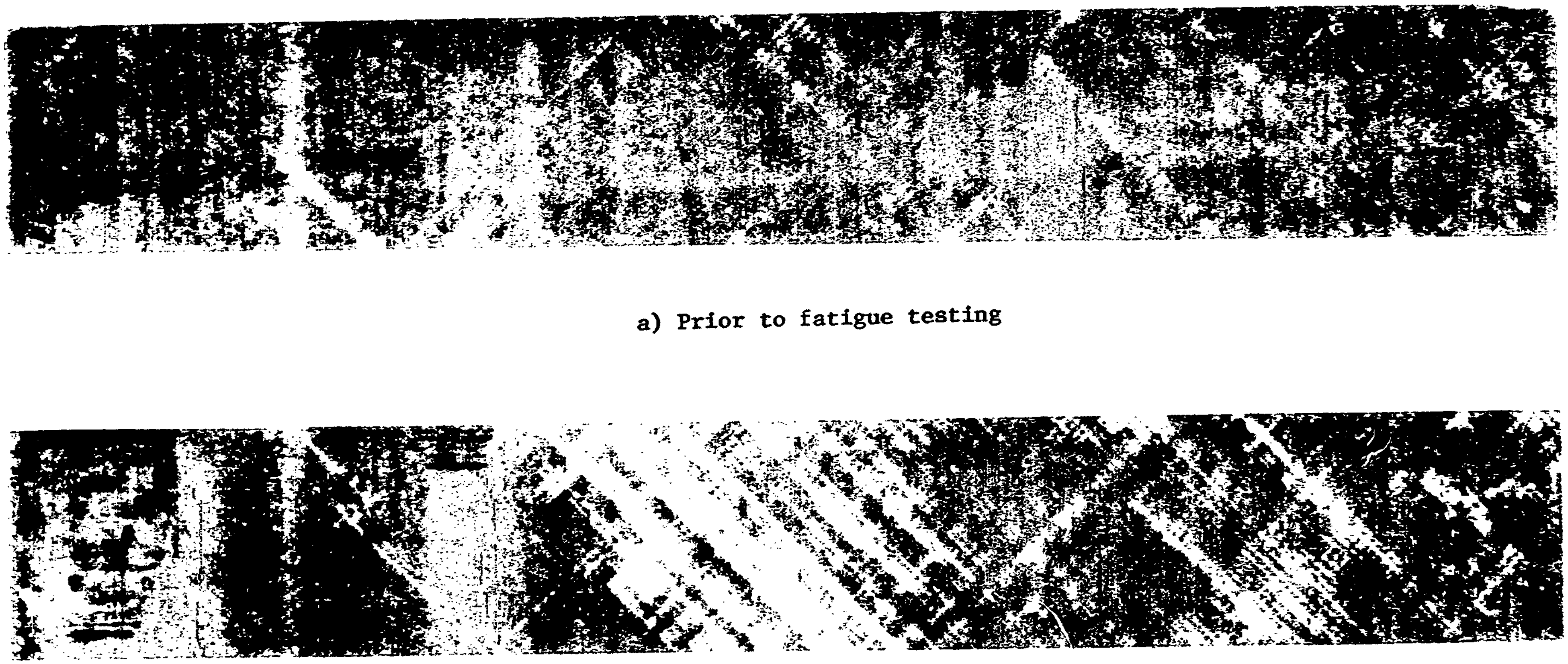


Figure 18. Typical Failure of a $[\pm 67.5]_{s2}$ Laminate

were inspected using an ultrasonic C-scan before cyclic loading. After the loading of each specimen was terminated, the specimen was scanned again. By comparing the before and after scans of these specimens, accumulated damage can be seen.

Figure 19 indicates an example of these scans for Specimen N45602, which did not fail after 10^6 cycles. As can be seen, there are more white areas after fatigue cycling than before testing. These white areas indicate a material anomaly.

At the present time, C-scan techniques are not advanced enough to establish that these white areas are delaminations, or areas of matrix and fiber fracture. The first impression might be that they are areas of delamination. However, a subsequent sectioning of selected specimens followed by examination in both an optical microscope and a scanning electron microscope failed to reveal significant numbers of failures of any type. Figure 20 is a low (100X) magnification SEM photograph of an edge of Specimen N45602, a $[\pm 45]_{2s}$ laminate, indicating the only observed damage in the specimen. What appears to be a crack has propagated across the specimen thickness, from the upper left corner of the photograph to the lower right. (The dark spots are shadows during to flaring in the SEM caused by poorly conducting regions of the surface where electron charge build-up occurred.) It will be noted that particularly in the upper left center of the crack path, the "crack" appears to be more of a "smear". Figure 21 is a higher magnification (600X) close-up of this "smeared" region, which can be identified in Figure 20 as being just to the left of the bright region (the tip of which is at the right edge of Figure 21). This narrow band of material does not appear to be smeared, although it was not done in the cutting



a) Prior to fatigue testing

b) After 1,010,460 cycles

Figure 19. Ultrasonic C-Scans of Specimen N45602, a $[\pm 45]_{2s}$ Laminate

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Figure 20. Edge Crack in Specimen N45602 of the $[\pm 45]_{2s}$ Laminate.

process. It is possible that the matrix material, and perhaps parts of the fibers as well, have been pulverized by the cyclic fatigue action, conceivably in a shear mode. Obviously further study of this damage mode will be required.

For comparison, Figure 22 is an even higher magnification view (100X) of the same defect shown in Figure 20, in a region where a distinct crack is exhibited. A good fiber-matrix interface bond is evident, no bare fiber surfaces being exposed. Some suggestion of shear lacerations in the matrix can be seen. The lack of damage even one fiber diameter away from the crack will also be noted.

Figure 21. Close-up of Smeared Region of the Crack of Figure 20.

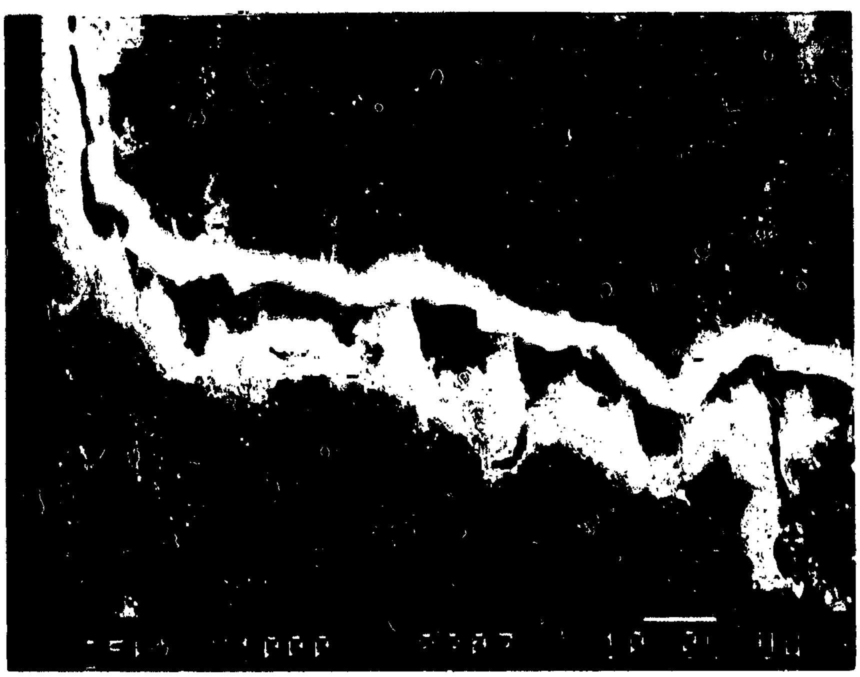

Figure 22. Close-up of a Distinct Crack in the Specimen of Figure 20.

SECTION 4

CONCLUSIONS

During this study, two T300/5208 graphite/epoxy laminates were tested to determine modulus decay during cyclic loading. The results of the fatigue tests of the $[\pm 45]_{2s}$ laminate indicate a cyclic peak stress-dependent modulus decay, i.e., the higher the peak stress, the greater the modulus decay. For the $[\pm 67.5]_{2s}$ laminate tests, modulus decay was nonexistent.

During the cyclic testing, three secondary effects were noted. First, the two laminate orientations respond differently when subjected to dynamic loads. This was noted in observing the difference between static and dynamic stiffness measurement. Second, it was observed that there was a modulus recovery when the cyclic loading was interrupted. However, this modulus recovery very quickly decayed after cyclic loading was resumed. Third, the $[\pm 45]_{2s}$ laminate exhibited a very strong viscoelastic response when subjected to cyclic loading. All of these secondary responses were unexpected, and are not fully understood at the present time. Additionally, since these effects are secondary, they are unlikely to receive much attention. Nevertheless, by having an awareness of their existence when beginning any future fatigue testing program, their occurrence is less likely to obscure the interpretation of the results obtained.

References

1. G.C. Grimes and D.F. Adams, "Investigation of Compression Fatigue Properties of Advanced Composites," Northrop Technical Report NOR 79-17, Naval Air Systems Command Contract N00019-77-C-0519, October 1979.

2. D.E. Walrath and D.F. Adams, "Fatigue Behavior of Hercules 3501-6 Epoxy Resin," Report No. NADC-78139-60, Naval A' Development Center Contract No. N62269-78-C-0340, January 1980.

3. D.E. Walrath and D.F. Adams, "Through-the-Thickness Compression-Compression Fatigue of SMC-R50 Composites," Report UWME-DR-004-102-1, University of Wyoming, Department of Mechanical Engineering, February, 1980.

4. D.E. Walrath and D.F. Adams, "Static and Dynamic Shear Testing of SMC Composite Materials," Report UWME-DR-004-103-1, University of Wyoming, Department of Mechanical Engineering, May 1980.

5. G.C. Grimes, D.F. Adams and E.G. Dusablon, "The Effects of Discontinuities on Compression Fatigue Properties of Advanced Composites," Northrop Technical Report NOR 80-158, Naval Air Systems Command Contract N00019-79-C-0276, October 1980.

6. B.W. Rosen, "A Simple Procedure for Experimental Determination of the Longitudinal Shear Modulus of Unidirectional Composites," J. of Composite Materials, Vol. 6, No. 4, October 1972, pp. 552-554.

Appendix A

Static Tensile Stress-Strain Plots

This appendix includes the stress-strain data for the 10 static tests performed. Each plot includes two stress-strain curves, which were obtained by utilizing two axial extensometers, one having a 3.5 in gage length and the other a 1.5 in gage length. There is a difference between the two curves; however, the difference is small. Importantly, there is no divergence at the beginning of the curves, which would indicate the presence of binding. Additionally, the calculated tangent moduli of these curves are very close, as indicated in Tables 2 and 3 also.

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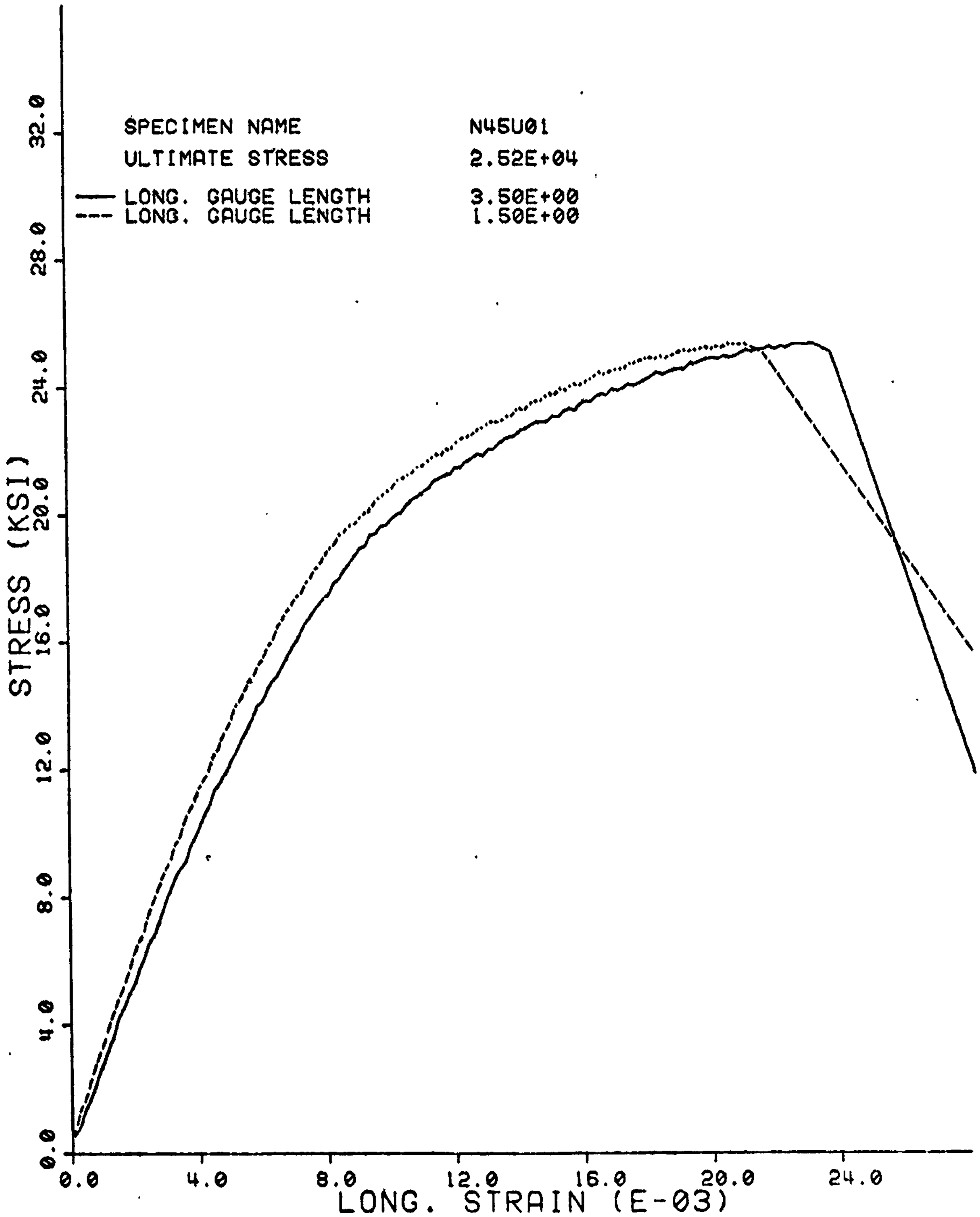

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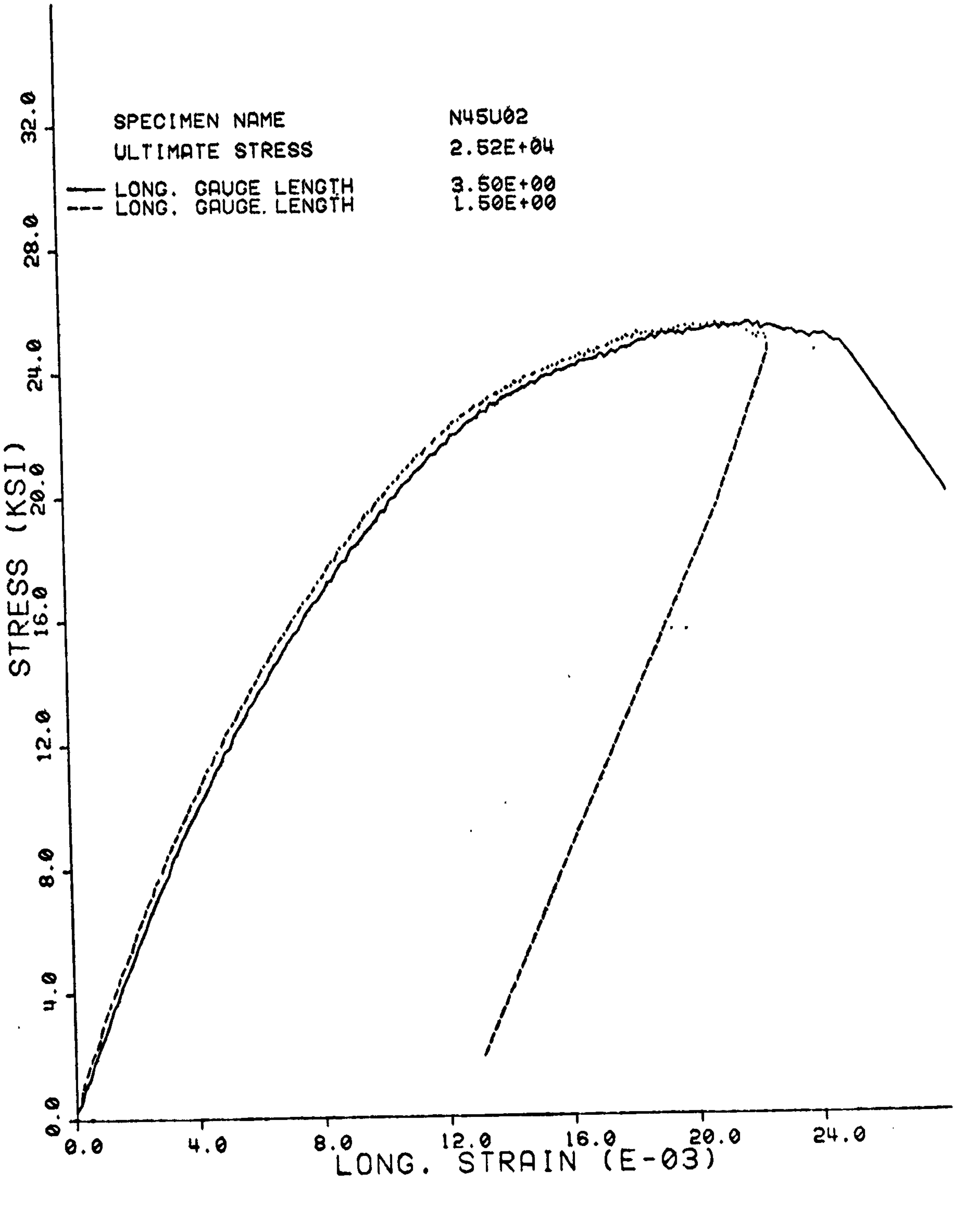

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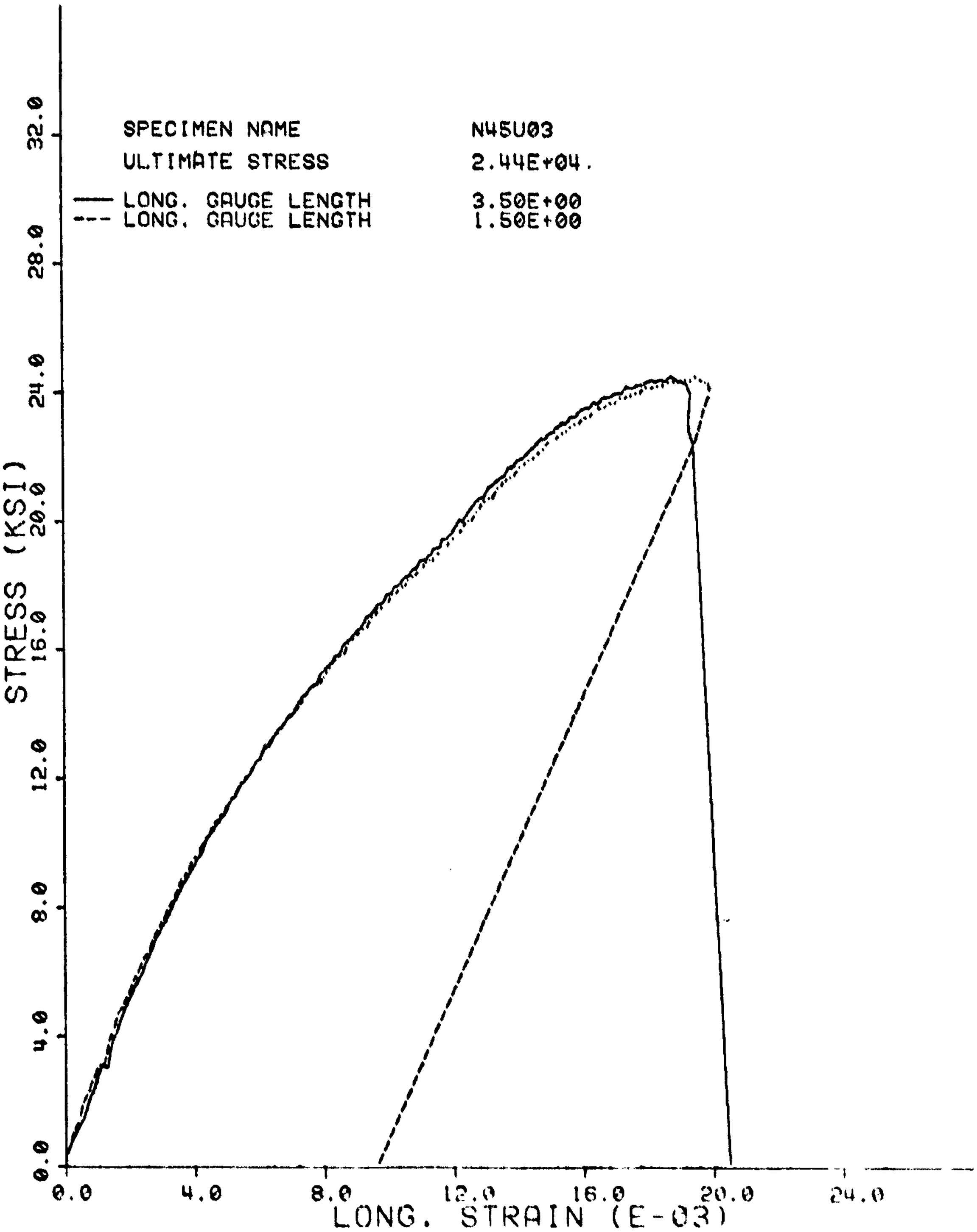

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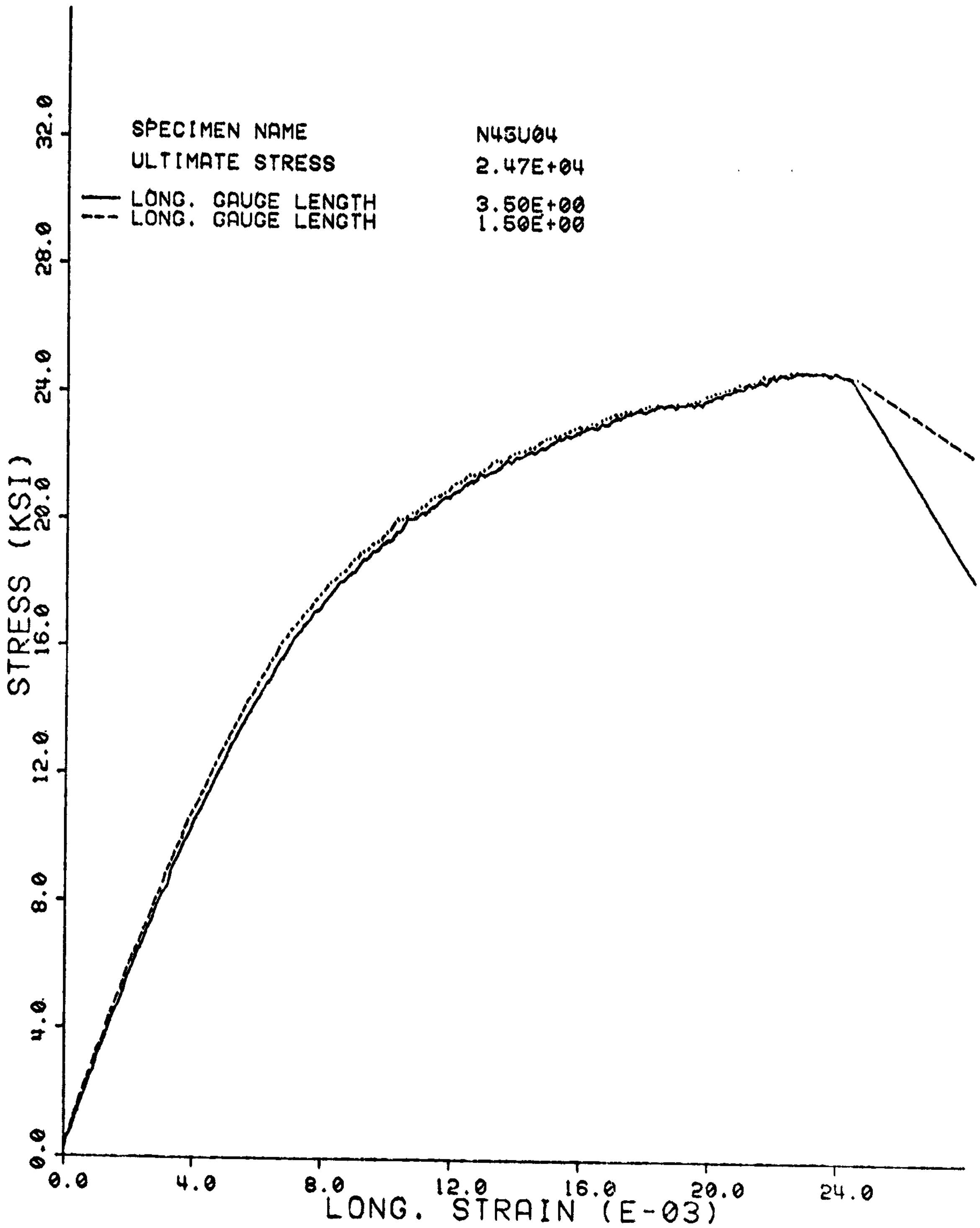

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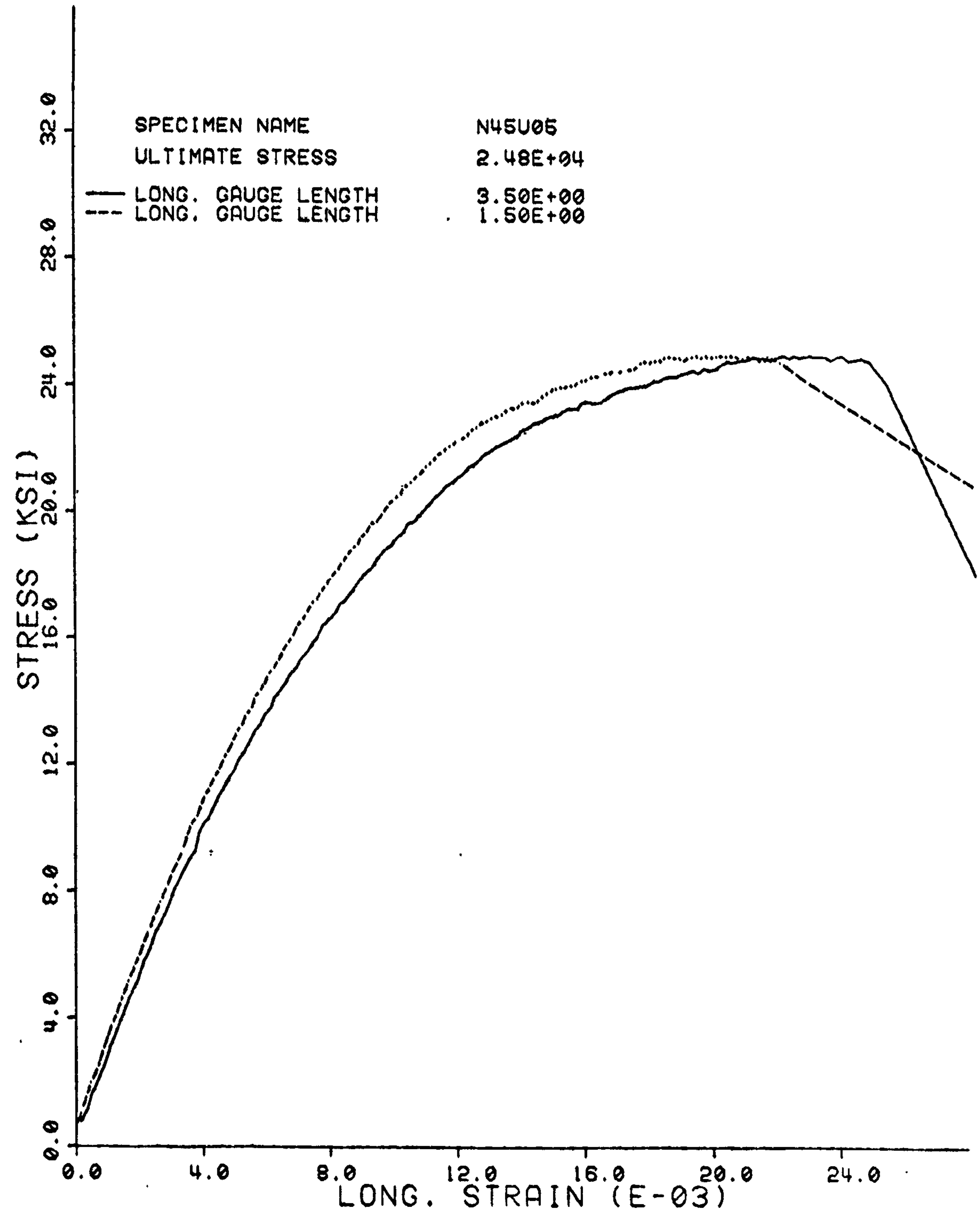

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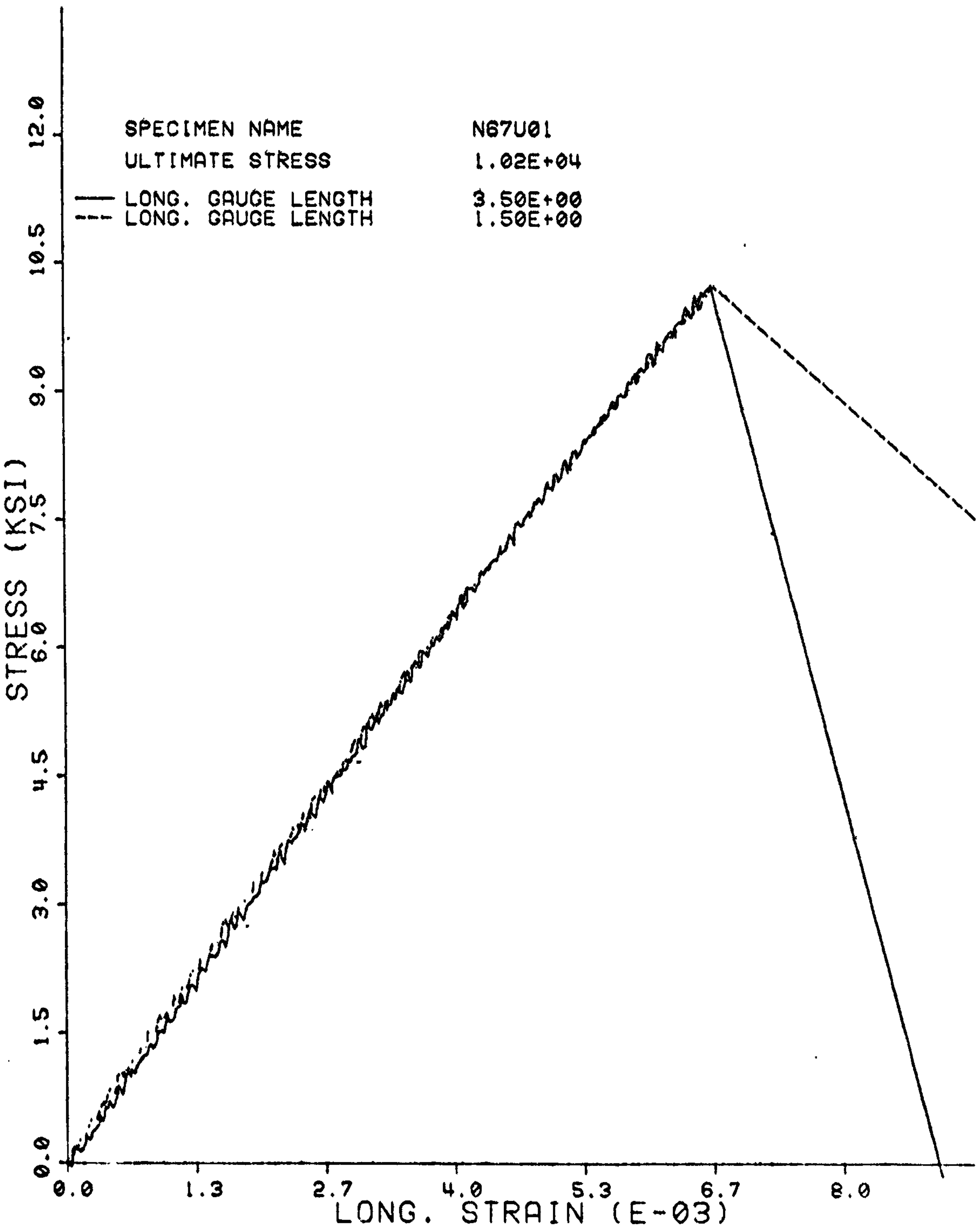

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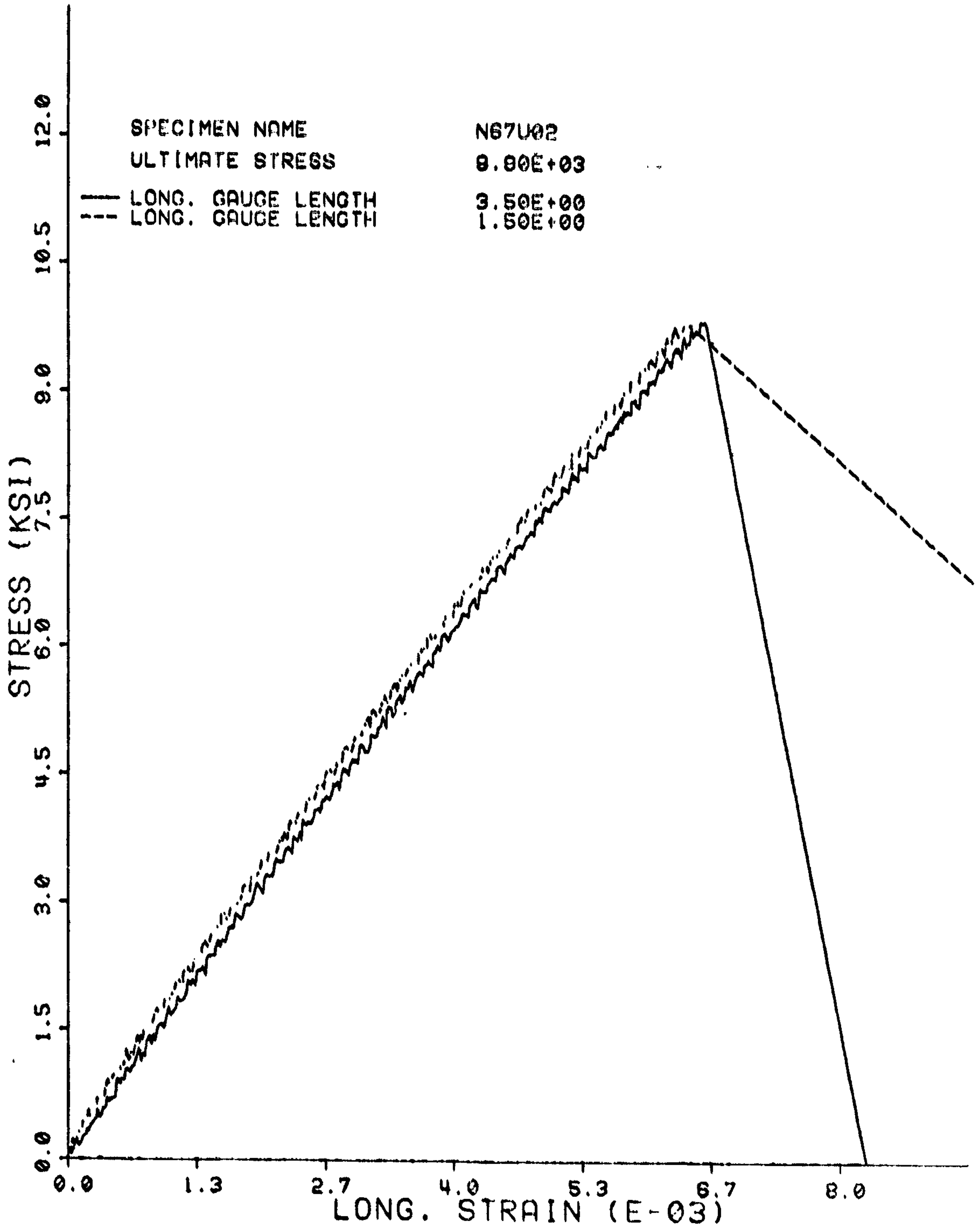

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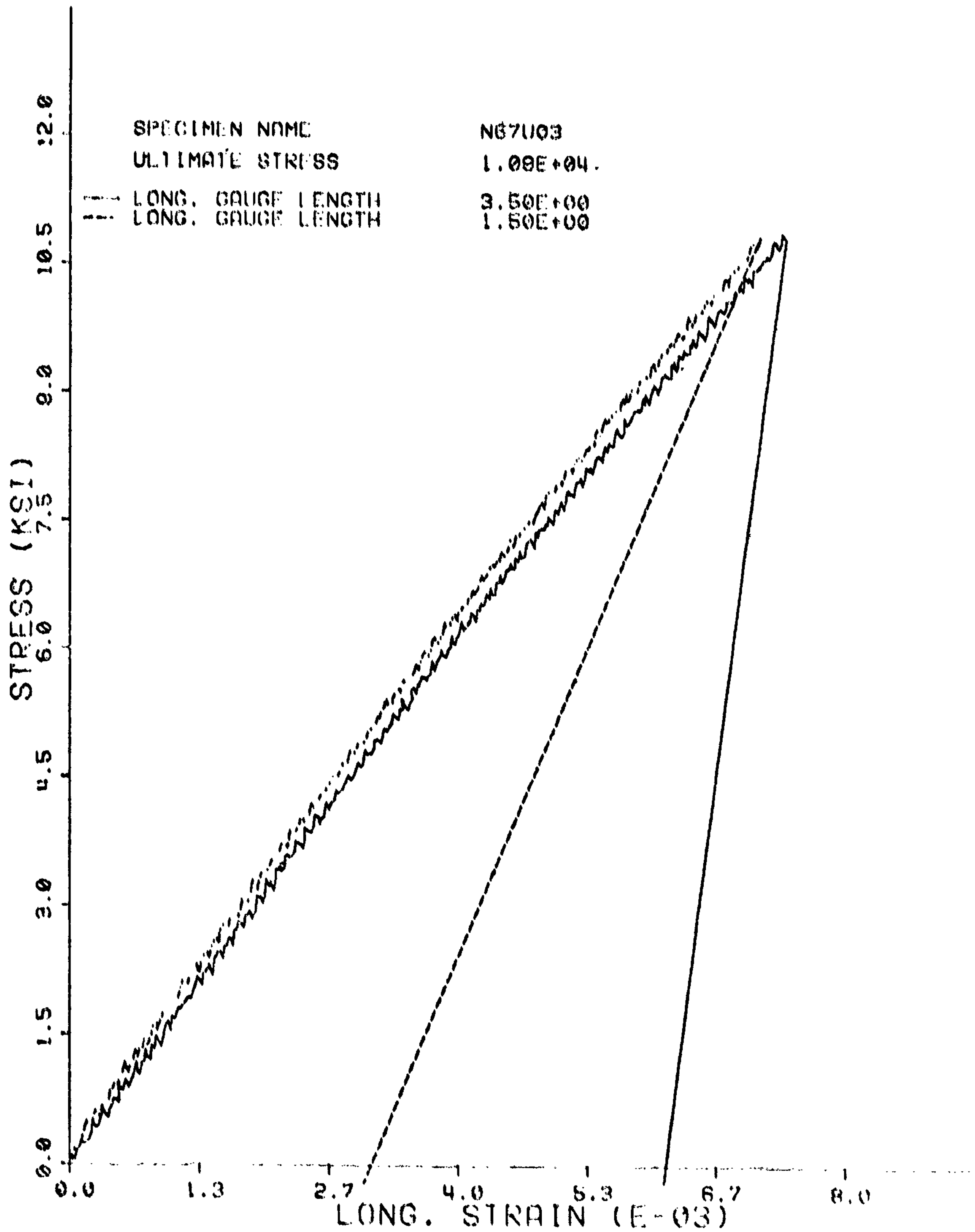

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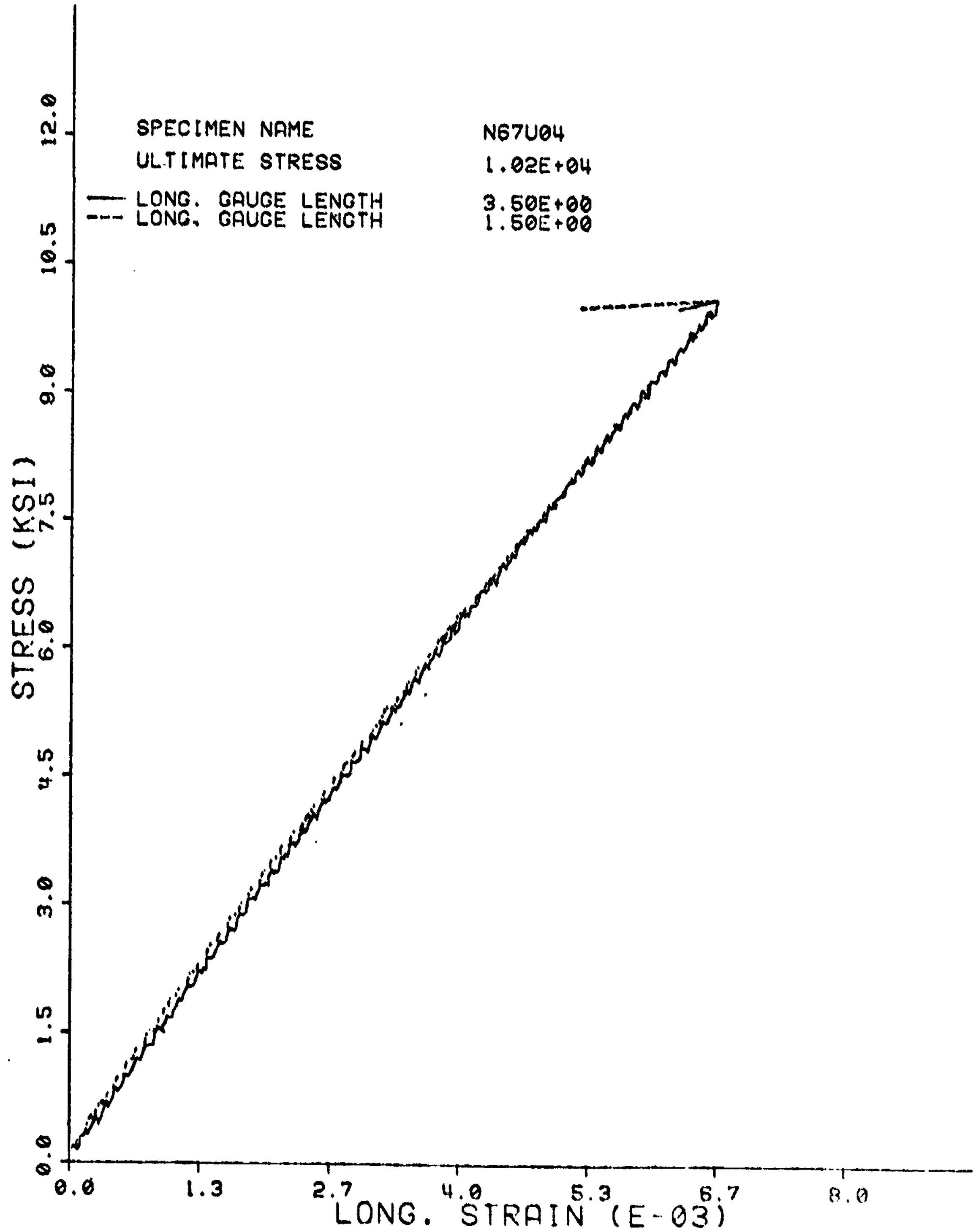

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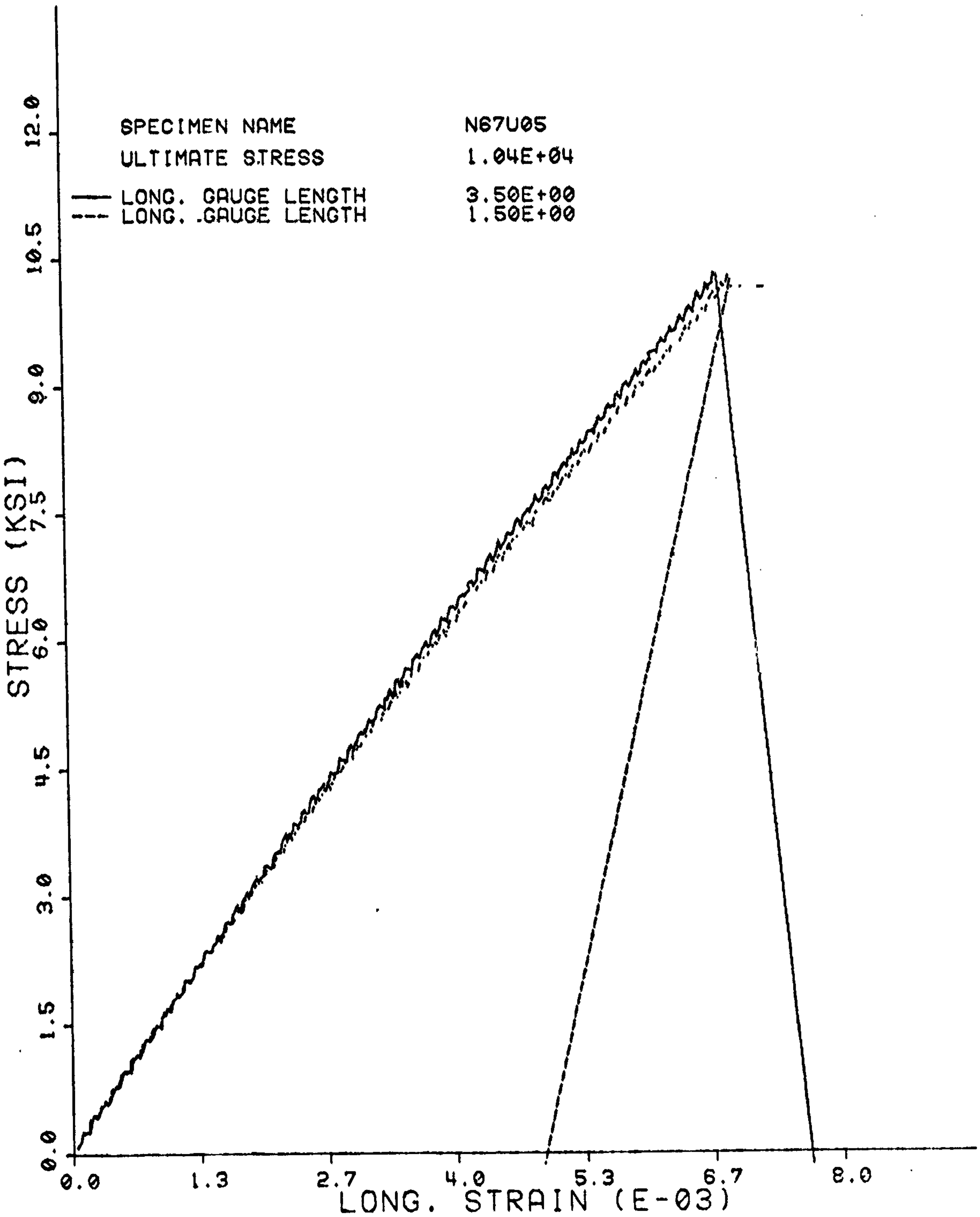

Appendix B

Tables of Static and Dynamic Moduli of Fatigue Test Specimens

This appendix includes the static and dynamic modulus values stored for each specimen during the fatigue testing.

N45901

```
TEST DATE                            8/18/1981 * CONTRACT NO. 43-0335     PROJECT NASA
                                               *
TYPE-09  11321 TENSION TENSION                 * SPECIMEN NAME  N45901
TEST DIRECTION IS  UP                          *
MATERIAL: +-45 GR/EP,90% FATIGUE               * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C. HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ           * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG.MULT--- 10.09        100.00   * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ             * THICKNESS (IN)------  .044
OPERATOR #1   MOHAN                            *
OPERATOR #2                                    *
*************************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	-.013	10.010	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.005	10.005	0.00000	.07000	3.50000	LONG. EXT.
6	49	.005	10.010	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45901

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.54	2.47	.72
3		2.39	.69
5		2.37	.69
7		2.36	.68
9		2.36	.68
19		2.33	.67
29		2.31	.67
39		2.34	.67
49		2.30	.66
59		2.28	.65
69		2.27	.65
79		2.27	.65
89		2.27	.65
99		2.25	.65
150		2.29	.66
200		2.26	.65
259		2.20	.63
313		2.30	.66
363		2.25	.64
420		2.20	.63
479		2.17	.62
534		2.13	.60
586	2-39	2.10	.59
632		2.26	.64
637		2.27	.64
642		2.25	.64
647		2.25	.64
652		2.25	.64
657		2.24	.64
662		2.24	.63
760		2.17	.61
860		2.10	.59
960		2.03	.57

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N45902 -

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TEST DATE                                8/24/1981 * CONTRACT NO. 43-0336      PROJECT NASA
                                                   *
TYPE-09   11321 TENSION TENSION                    * SPECIMEN NAME  N45902
TEST DIRECTION IS  UP                              *
MATERIAL: +-45 GR-EP,90% FATIGUE                   * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.08 *
CYCLING FREQ.----------- 10.00 HERTZ              * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG.MULT--- 10.00       100.00      * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ               * THICKNESS (IN)------  .044
OPERATOR #1   MOHAN                               *
OPERATOR #2                                       *
***********************************************************************************
  CHAN.  TYPE          LOW    HIGH     CAL-LOW  CAL-HIGH GAGE LEN.    DESCRIPTION
     8     41       -.013  10.010     0.00000 2000.0000   0.00000    20KLB L.CELL
     7     48        .005  10.005     0.00000    .07000   3.50000    LONG. EXT.
     6     49        .005  10.010     0.00000    .01970    .98430    LAT.  EXT.
```

SPECIMEN: N45902

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.70	2.54	.72
3		2.47	.70
5		2.44	.69
7		2.42	.69
9		2.41	.68
18		2.41	.68
28		2.38	.67
38		2.37	.67
48		2.35	.67
58		2.35	.66
68		2.34	.66
78		2.32	.66
88		2.33	.66
98		2.31	.65
149		2.36	.67
200		2.31	.65
251		2.36	.67
277		2.36	.67
282		2.35	.66
287		2.35	.66
292		2.34	.66
297		2.34	.66
302		2.33	.66
307		2.40	.68
607		2.41	.68
804		2.43	.69
904	2.67	2.43	.69

N45903

SPECIMEN: N45903

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
0	2.64		.68
50	2.46		.67
100	2.43		.66
200	2.39		.65
400	2.39		.63
600	2.36		.64
800	2.38		.63
900	2.38		.65
1100	2.37		.65

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N45904

SPECIMEN: N45904

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
0	2.51		.68
50	2.40		.66
200	2.36		.63
400	2.37		.65
600	2.32		.63
800	2.27		.62
1000	2.22		.60

N45905

TEST DATE 8/27/1981 * CONTRACT NO. 43-8335 PROJECT NASA
*
TYPE-09 11321 TENSION TENSION * SPECIMEN NAME N45905
TEST DIRECTION IS UP *
MATERIAL: +-45 GR/EP,90% FATIGUE * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00 100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00 HZ * THICKNESS (IN)------ .044
OPERATOR #1 *
OPERATOR #2 *

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	-.013	10.010	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.003	10.005	0.00000	.07000	3.50000	LONG. EXT.
6	49	.005	10.010	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45905

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.70	2.45	.69
3		2.37	.66
5		2.35	.66
7		2.34	.65
9		2.33	.65
19		2.32	.65
29		2.31	.64
39		2.30	.64
49		2.29	.64
59		2.29	.64
69		2.28	.64
79		2.27	.63
89		2.25	.63
99		2.24	.62
199		2.24	.62
299		2.19	.61
399		2.16	.60
499		2.11	.58
600		2.10	.58
700		2.03	.56
800		1.99	.55
810		1.96	.54
820		1.97	.54
830		1.96	.54
840		1.95	.53
850		1.95	.54
860		1.94	.53
870		1.93	.53
880		1.91	.53
890		1.88	.52
900		1.87	.52

N45801

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SPECIMEN: N45801

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
30	2.35		.64
100	2.26		.61
200	2.31		.63
500	2.31		.63
1000	2.30		.63
1500	2.33		.64
2500	2.29		.63
3500	2.20		.63
4500	2.33		.64
5500	2.32		.64
6500	2.31		.64

N45802

SPECIMEN: N45802

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
0	2.53		.69
1000	2.37		.64
3000	2.29		.63
4000	2.27		.62
5000	2.30		.64
6000	2.24		.62
7000	2.25		.62

N45803

```
TEST DATE                          0/23/1981 * CONTRACT NO. 40-8335    PROJECT NASA
                                             *
TYPE-09  11321 TENSION TENSION               * SPECIMEN NAME  N43003
TEST DIRECTION IS  UP                        *
MATERIAL: +-45 GR/EP,80% FATIGUE             * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ         * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00       100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ           * THICKNESS (IN)------  .044
OPERATOR #1                                  *
OPERATOR #2                                  *
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	-.013	10.010	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.005	10.008	0.00000	.07000	3.50000	LONG. EXT.
6	49	.003	10.010	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45803

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.68	2.51	.72
3		2.46	.70
5		2.44	.69
7		2.43	.69
9		2.43	.69
19		2.41	.68
29		2.48	.70
39		2.45	.70
49		2.39	.68
59		2.39	.68
69		2.39	.68
79		2.39	.68
89		2.38	.67
99		2.38	.67
198		2.36	.67
298		2.41	.68
398		2.38	.67
498		2.36	.67
598		2.35	.66
698		2.33	.66
798		2.32	.66
898		2.32	.65
998		2.31	.65
1996		2.27	.64
2993		2.26	.63
3994		2.29	.65
4094		2.29	.65
4194		2.29	.64
4293		2.28	.64
4393		2.27	.64
4493		2.26	.64
4593		2.26	.64
4693		2.25	.63
4793		2.25	.63
4893		2.26	.64

N45804

SPECIMEN: N45804

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
0	2.56		.68
500	2.38		.64
2030	2.34		.63
4030	2.33		.63
6030	2.31		.63
7030	2.33		.63
[illegible]900	2.28		.62

N45805

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SPECIMEN N45805 -

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
0	2.54		.70
500	2.41		.67
2500	2.36		.66
4000	2.34		.63
6000	2.29		.64
8000	2.27		.63
9000	2.30		.64
10000	2.27		.63

N45701

```
TEST DATE                          7/24/1981 * CONTRACT NO. 43-8335    PROJECT NASA
                                             *
TYPE-09  11321 TENSION TENSION               * SPECIMEN NAME  N45701
TEST DIRECTION IS  UP                        *
MATERIAL: +-45 GR/EP,70%,FATIGUE             * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.------------ 10.00 HERTZ        * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG,MULT--- 10.00      100.00 * WIDTH (IN)----------- 1.500
SCAN RATE----------------320.00  HZ          * THICKNESS (IN)------   .044
OPERATOR #1   MORAN                          *
OPERATOR #2                                  *
*******************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	0.000	9.995	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.003	10.015	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45701

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.68	2.61	.75
3		2.61	.75
5		2.59	.74
7		2.59	.74
9		2.59	.74
19		2.59	.74
29		2.59	.74
39		2.59	.74
49		2.58	.74
59		2.59	.74
69		2.57	.73
79		2.56	.73
89		2.57	.73
99		2.53	.72
199		2.53	.72
299		2.55	.72
400		2.54	.72
500		2.54	.72
600		2.53	.72
700		2.53	.72
801		2.53	.72
901		2.53	.72
1001		2.52	.72
2004		2.49	.71
3037		2.49	.71
4039		2.52	.72
5010		2.52	.72
6012		2.53	.72
7014		2.53	.72
8015		2.53	.72
9017		2.53	.72
10018		2.52	.72
20034		2.53	.72
30050		2.52	.71
31031		2.52	.71
32033		2.52	.71
33034		2.52	.71
34036		2.51	.71
35037		2.51	.71
36039	2.53	2.48	.70
37061		2.53	.71
38062		2.49	.70
39064		2.50	.70

N45702

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```
TEST DATE                    7/27/1981 * CONTRACT NO. 43-8335    PROJECT NASA
                                       *
TYPE-09  11821 TENSION TENSION         * SPECIMEN NAME  N43702
TEST DIRECTION IS  UP                  *
MATERIAL: +-45,GR/EP,70%,FATIGUE       * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 33.0% *
CYCLING FREQ.----------- 10.00 HERTZ   * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00  100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ     * THICKNESS (IN)------  .043
OPERATOR #1  MOHAN                     *
OPERATOR #2                            *
******************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	0.000	9.995	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.005	10.015	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N43702

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.80	2.72	.79
3		2.69	.78
5		2.72	.78
7		2.68	.77
9		2.68	.77
19		2.70	.78
29		2.70	.78
39		2.70	.78
49		2.70	.78
59		2.69	.78
69		2.69	.78
79		2.68	.77
89		2.69	.78
99		2.68	.77
199		2.67	.77
299		2.67	.77
399		2.67	.77
499		2.65	.76
599		2.66	.76
699		2.65	.76
799		2.65	.76
899		2.65	.76
1000		2.65	.76
2000		2.64	.76
3002		2.65	.76
4003		2.65	.76
5003		2.65	.76
6004		2.66	.76
7005		2.67	.77
8006		2.67	.77
9007		2.66	.76
10010		2.67	.77
20028		2.68	.77
30048		2.67	.76
40036		2.67	.76
50055		2.67	.76
60081		2.63	.75
70100		2.64	.75
80125		2.64	.75
90135		2.63	.75
91135		2.63	.74
92136		2.62	.74
93137		2.61	.74
94138		2.62	.74
95139		2.61	.74
96139		2.61	.74
97140		2.61	.74
98141		2.61	.74
99142		2.60	.73
100143		2.60	.73
103145		2.59	.73
104146		2.59	.73
105147	2.62	2.58	.73
106148		2.57	.72
107149		2.57	.72
108134		2.56	.72
109135		2.56	.72
110136		2.55	.71
111137		2.52	.70
112137	2.50	2.39	.66

N45703

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TEST DATE                                 7/27/1981 * CONTRACT NO. 43-8355    PROJECT NASA
                                                    *
TYPE-09  11321 TENSION TENSION                      * SPECIMEN NAME  N45703
TEST DIRECTION IS  UP                               *
MATERIAL: +-45,GR/EP,70%,FATIGUE                    * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ                * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00        100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ                  * THICKNESS (IN)------  .044
OPERATOR #1   MOHAN                                 *
OPERATOR #2                                         *
*********************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	0.000	9.995	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.005	10.015	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45703

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.78	2.68	.76
3		2.66	.75
5		2.65	.75
7		2.65	.75
9		2.65	.75
19		2.64	.75
29		2.63	.75
39		2.62	.74
49		2.62	.74
59		2.63	.74
69		2.63	.74
79		2.63	.74
89		2.62	.74
99		2.62	.74
199		2.60	.73
299		2.59	.73
399		2.59	.72
499		2.58	.72
599		2.57	.72
699		2.62	.73
799		2.61	.73
899		2.60	.73
999		2.60	.73
2000		2.57	.72
3000		2.36	.71
4001		2.56	.71
5001		2.57	.71
6002		2.56	.71
7002		2.57	.71
8003		2.56	.71
9003		2.57	.71
10004		2.57	.71
20009		2.58	.71
30013		2.56	.71
40017		2.54	.70
43019		2.54	.70
44019	2.57	2.53	.70
45020		2.56	.71
46021		2.54	.70
47021		2.54	.70
48022		2.54	.70
49022		2.53	.70
50023		2.49	.69
51023		2.52	.70
52024		2.36	.67

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N45704.

```
TEST DATE                                7/30/1981 * CONTRACT NO. 48-0388     PROJECT NASA
                                                   *
TYPE-09   11331 TENSION TENSION                    * SPECIMEN NAME  N45704
TEST DIRECTION IS  UP                              *
MATERIAL +-45,GR/EP,705,FATIGUE                    * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 50.00           *
CYCLING FREQ.----------- 10.00 HERTZ               * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00        100.00       * WIDTH (IN)---------- 1.000
SCAN RATE--------------- 320.00  HZ                * THICKNESS (IN)------  .044
OPERATOR #1   MOHAN                                *
OPERATOR #2                                        *
*****************************************************************************************
  CHAN.   TYPE         LOW    HIGH     CAL/LOW  CAL/HIGH GAGE LEN.     DESCRIPTION
     8     41        0.000   9.995     0.00000 2000.0000   0.00000     20KLB L.CELL
     7     40         .005  10.015     0.00000    .07000   0.50000     LONG. EXT.
     6     49         .010  10.015     0.00000    .01970    .90430     LAT.  EXT.
```

SPECIMEN: N45704

CYCLE #	STATIC LONG. MODULUS (E+06)	DYNAMIC LONG. MODULUS (E+06)	G(12) (E+06)
1	2.77	2.69	.78
3		2.67	.77
5		2.66	.77
7		2.66	.77
9		2.66	.77
19		2.64	.76
29		2.64	.76
39		2.64	.76
49		2.63	.76
59		2.63	.76
69		2.62	.75
79		2.63	.76
89		2.63	.76
99		2.62	.75
199		2.61	.75
299		2.61	.75
399		2.60	.75
499		2.59	.74
599		2.59	.75
699		2.59	.74
799		2.63	.76
901		2.63	.76
1030		2.63	.76
2000		2.59	.75
3001		2.58	.74
4002		2.58	.74
5002		2.59	.74
6003		2.59	.74
7004		2.58	.74
8005		2.59	.75
9006		2.60	.75
10007		2.59	.75
20014		2.60	.75
30020		2.61	.75
40027		2.60	.75
50032		2.59	.75
54035		2.59	.75
55035		2.58	.75
56036		2.57	.75
57036		2.58	.75
58037		2.57	.75
59037		2.57	.75
60038		2.57	.75
61039		2.56	.75
62039		2.56	.75
63040		2.54	.75

N45705

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TEST DATE                         7/20/1981 * CONTRACT NO. 40-8305    PROJECT NASA
                                            *
TYPE-09   (103) TENSION TENSION             * SPECIMEN NAME  N45705
TEST DIRECTION IS  UP                       *
MATERIAL: +-45,GR/EP,705,FATIGUE            * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.05    *
CYCLING FREQ.----------- 10.00 HERTZ        * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00     100.00   * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ          * THICKNESS (IN)------  .044
OPERATOR #1   MOHAN                         *
OPERATOR #2                                 *
**********************************************************************************
  CHAN.   TYPE       LOW    HIGH      CAL-LOW   CAL-HIGH  GAGE LEN.   DESCRIPTION
    8      41      0.000   9.995     0.00000  2000.0000    0.00000   20KLB L.CELL
    7      48       .003  10.015     0.00000     .07000    3.50000   LONG. EXT.
    6      49       .010  10.015     0.00000     .01970     .98480   LAT.  EXT.
```

SPECIMEN: N45705

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.70	2.70	.78
3		2.68	.77
5		2.68	.77
7		2.67	.77
9		2.67	.77
19		2.65	.76
29		2.66	.76
39		2.65	.76
49		2.65	.76
59		2.64	.76
69		2.65	.76
79		2.64	.76
89		2.64	.76
99		2.64	.76
199		2.63	.75
299		2.63	.75
399		2.63	.75
499		2.62	.75
599		2.60	.74
699		2.61	.75
799		2.60	.74
899		2.61	.74
999		2.60	.74
2000		2.60	.74
3001		2.61	.75
4003		2.61	.75
5003		2.61	.75
6004		2.61	.75
7004		2.61	.75
8005		2.60	.74
9006		2.61	.75
10006		2.61	.75
20023		2.62	.75
30035		2.61	.74
40039		2.59	.73
47042		2.59	.73
48043		2.59	.73
49043		2.58	.73
50044		2.58	.73
51044		2.58	.73
52045		2.58	.73
53045		2.58	.72
54046		2.57	.73
55046		2.57	.72
56046		2.55	.72

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N45601

TEST DATE 7/16/1981	CONTRACT NO. 43-8835 PROJECT NASA
TYPE-00 11891 TENSION TENSION	SPECIMEN NAME N45601
TEST DIRECTION IS UP	SPECIMEN SHAPE RECTANGULAR
MAT'RIAL +-45,GR-EP,608,FATIGUE	
TEMPER.,ORD. 23.00 DEG. C. HUMIDITY 23.0%	LENGTH (IN)---------- 7.000
CYCLIC FREQ.---------- 10.00 HERTZ	WIDTH (IN)---------- 1.300
FUNCTION GEN RNG,MULT--- 10.00 100.00	THICKNESS (IN)------ .044
SCAN RATE---------- 820.00 HZ	
OPERATOR #1 ROHAN	
OPERATOR #2	

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
6	41	.005	10.020	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.005	10.018	0.00000	.07000	3.50000	LONG. EXT.
8	49	.010	10.018	0.00000	.01970	.98430	LAT. EXT.
5	48	.010	10.018	0.00000	.06000	1.50000	LONG. EXT.

SPECIMEN: N45601

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
		2.75	.79
1	2.74	2.73	.78
3		2.71	.78
5		2.71	.78
7		2.71	.78
9		2.72	.78
19		2.72	.78
29		2.71	.77
39		2.69	.77
49		2.69	.77
59		2.72	.78
69		2.71	.78
79		2.71	.77
89		2.69	.77
99		2.67	.76
199		2.72	.78
299		2.70	.77
398		2.71	.78
498		2.71	.78
598		2.70	.77
698		2.70	.77
798		2.70	.77
898		2.72	.78
998		2.70	.77
1997		2.71	.78
2996		2.70	.78
3993		2.71	.78
4995		2.70	.77
5994		2.70	.78
6993		2.71	.78
7992		2.72	.78
8991		2.71	.78
9991		2.73	.78
19986		2.71	.78
29978		2.72	.78
39975		2.70	.79
49967		2.71	.78
59961		2.71	.78
69933		2.72	.78
79946		2.72	.78
89939		2.70	.78
99932		2.71	.79
100876		2.72	.79
200880		2.73	.79
300813		2.74	.79
400797		2.73	.79
500781		2.71	.79
604742		2.71	.78
704719		2.68	.78
804698		2.68	.78
814693		2.68	.78
824691		2.69	.79
834688		2.71	.78
844686		2.68	.78
854684		2.69	.78
864681		2.69	.78
874679		2.68	.78
884676		2.69	.78
894673		2.67	
904671			

N45602

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TEST DATE                        7/21/1981 * CONTRACT NO. 43-8338    PROJECT NASA
                                           *
TYPE-09  11321 TENSION TENSION             * SPECIMEN NAME  N45602
TEST DIRECTION IS  UP                      *
MATERIAL: +-45,GR/EP,60%,FATIGUE           * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C. HUMIDITY 28.0% *
CYCLING FREQ.----------- 10.00 HERTZ       * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00      100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ         * THICKNESS (IN)------  .043
OPERATOR #1  MOHAN                         *
OPERATOR #2                                *
**********************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	-.008	9.983	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.010	10.013	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.010	0.00000	.01970	.98430	LAT. EXT.
5	48	.010	10.010	0.00000	.06000	1.50000	LONG. EXT.

SPECIMEN: N45602

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.85	2.80	.81
3		2.80	.81
5		2.79	.80
7		2.79	.80
9		2.78	.80
19		2.78	.80
29		2.78	.80
39		2.78	.80
49		2.78	.80
59		2.78	.80
69		2.78	.80
79		2.77	.79
89		2.77	.79
99		2.77	.79
199		2.77	.79
299		2.77	.79
399		2.77	.79
499		2.77	.79
599		2.76	.79
699		2.76	.79
799		2.77	.79
899		2.76	.79
999		2.76	.79
1999		2.77	.79
2999		2.76	.79
3998		2.77	.79
4998		2.78	.79
5998		2.78	.79
6998		2.77	.79
7998		2.77	.79
8998		2.77	.79
9998		2.77	.79
19998		2.79	.79
29997		2.78	.79
39997		2.78	.79
49996		2.78	.79
59994		2.77	.79
69993		2.78	.79
79992		2.76	.79
89990		2.76	.79
99991		2.76	.79
199974		2.75	.78
299962		2.74	.78
399961		2.73	.78
499934		2.74	.78
600034		2.74	.78
700102		2.74	.78
800181		2.73	.77
900277		2.69	.76
920297		2.68	.76
930317		2.69	.76
940316		2.68	.76
950323		2.67	.76
960334	2.61	2.65	.75
970333		2.67	.76
980343		2.66	.75
990348		2.66	.75
1000352		2.65	.75
1010358	2.59	2.65	..75

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N45603

TEST DATE 7/20/1981 * CONTRACT NO. 40-0305 PROJECT NASA
*
TYPE-09 11021 TENSION TENSION * SPECIMEN NAME N45603
TEST DIRECTION IS UP *
MATERIAL: +-45,GR/EP,60%,FATIGUE * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.------------ 10.00 HERTZ * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG,MULT--- 10.00 100.00 * WIDTH (IN)----------- 1.500
SCAN RATE----------------320.00 HZ * THICKNESS (IN)------ .044
OPERATOR #1 MOHAN *
OPERATOR #2 *
****

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	0.000	9.995	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.005	10.015	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45603

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.77	2.66	.40
3		2.66	.40
5		2.65	.40
7		2.66	.41
9		2.65	.40
19		2.64	.40
29		2.65	.40
39		2.65	.40
49		2.64	.40
59		2.64	.40
69		2.63	.40
79		2.64	.40
89		2.64	.40
99		2.63	.40
199		2.63	.40
299		2.63	.40
399		2.63	.40
499		2.62	.40
599		2.63	.41
699		2.62	.40
799		2.62	.40
899		2.62	.40
999		2.62	.40
1999		2.62	.40
2999		2.62	.40
4000		2.63	.40
5000		2.64	.40
6000		2.64	.40
7000		2.64	.40
8031		2.64	.40
9001		2.64	.40
10031		2.64	.40
20004		2.64	.40
30006		2.64	.40
40016		2.65	.77
50020		2.61	.76
60023		2.63	.76
70027		2.65	.77
80028		2.64	.76
90033		2.63	.76
100037		2.63	.76
200054		2.64	.76
300101		2.65	.77
400157		2.63	.77
410164		2.63	.76
420170		2.62	.76
430177		2.62	.76
440183		2.62	.76
450190		2.62	.76
460196		2.61	.76
470203		2.60	.76
480210		2.60	.76
490217		2.58	.76
500223		2.56	.75
501224		2.56	.75
502225		2.56	.75
503225		2.56	.75
504226		2.56	.75
505227		2.55	.75
506227		2.55	.75
507228		2.54	.75
508229		2.53	.75
509230		2.53	.75

N45603 CONTINUED

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
509241	2.83	2.58	.76
509243		2.58	.76
509243		2.57	.76
509247		2.57	.76
509249		2.57	.76
509239		2.57	.76
509269		2.56	.76
509279		2.57	.76
509289		2.57	.76
509299		2.56	.76
509399		2.56	.76
509319		2.56	.76
509329		2.56	.76
509339		2.55	.76
509439		2.55	.75
509539		2.54	.75
509639		2.54	.75
509739		2.53	.75
509839		2.51	.74
509939		2.50	.74
510039		2.52	.75
510139		2.52	.75
510240		2.52	.75
511040		2.50	.74
511140		2.50	.74
511240		2.49	.74
511340		2.49	.74
511440		2.48	.74
511540		2.47	.74
511641		2.46	.74
511741	2.46	2.43	.73
511841		2.39	.73
511941	2.45	2.27	.69

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N45604

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TEST DATE                              7/29/1981 * CONTRACT NO. 43-8335     PROJECT NASA
                                                 *
TYPE-09   F1321 TENSION TENSION                  * SPECIMEN NAME  N43604
TEST DIRECTION 45  UP                            *
MATERIAL: +-45,GR/EP,60%,FATIGUE                 * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C. HUMIDITY 23.03         *
CYCLING FREQ.------------ 10.00 HERTZ            * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG.MULT--- 10.00       100.00      * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00   HZ              * THICKNESS (IN)------  .044
OPERATOR #1  NOLAN                               *
OPERATOR #2                                      *
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```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	0.000	9.995	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.003	10.015	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45604

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.78	2.74	.80
3		2.74	.80
5		2.72	.80
7		2.72	.80
9		2.72	.80
19		2.71	.80
29		2.71	.80
39		2.72	.80
49		2.70	.79
59		2.70	.79
63		2.70	.79
65		2.70	.79
67		2.69	.79
69		2.69	.79
71		2.69	.79

N45604 CONTINUED

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CYCLE #	STATIC LONG. MODULUS (E+06)	DYNAMIC LONG. MODULUS (E+06)	G-[illegible](E+06)
72		2.76	.81
74		2.75	.81
76		2.74	.80
78		2.74	.80
80		2.74	.81
90		2.72	.80 -
100		2.73	.80
110		2.73	.80
120		2.72	.80
130		2.72	.80
140		2.72	.80
150		2.72	.80
160		2.72	.80
170		2.71	.79
270		2.71	.79
370		2.70	.79
470		2.70	.79
570		2.69	.79
670		2.69	.79
770		2.69	.79
870		2.69	.79
970		2.68	.79
1071		2.68	.79
2071		2.68	.79
3072		2.68	.79
4073		2.67	.78
5074		2.69	.79
6075		2.68	.79
7076		2.67	.78
8077		2.68	.79
9078		2.69	.79
10078		2.69	.79
20087		2.70	.79
30096		2.69	.79
40104		2.70	.79
50114		2.71	.79
60127		2.70	.79
70141		2.69	.79
80163		2.70	.79
90171		2.70	.79
100184		2.69	.79
200260		2.68	.78
300324		2.67	.78
360363		2.67	.78
370374		2.66	.78
380383		2.66	.78
390390		2.67	.78
400420		2.68	.78
410429		2.67	.78
420419		2.65	.77
430427		2.67	.78
440436		2.68	.78
450445		2.67	.78
458453		2.67	.78
459454		2.67	.78
460456		2.67	.78
461457		2.68	.78
462458		2.66	.77
463458		2.68	.78
464459		2.68	.78
465460		2.68	.78
466461		2.67	.77
467462		2.67	.78

N45606.

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TEST DATE                          9/ 8/1981 * CONTRACT NO. 43-8335     PROJECT NASA
                                             *
TYPE-09  11321 TENSION TENSION               * SPECIMEN NAME  N45606
TEST DIRECTION IS  UP                        *
MATERIAL: +-45,GR/EP,60%,FATIGUE             * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ         * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG.MULT--- 10.00      100.00   * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ           * THICKNESS (IN)------  .044
OPERATOR #1   SHIPPEN                        *
OPERATOR #2                                  *
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CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	-.013	10.010	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.005	10.005	0.00000	.07000	3.50000	LONG. EXT.
6	49	.003	10.010	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45606

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.78	2.70	.78
3		2.68	.78
5		2.66	.77
7		2.65	.77
9		2.65	.77
19		2.64	.77
29		2.64	.77
39		2.63	.76
49		2.64	.77
59		2.64	.77
69		2.64	.77
79		2.63	.76
89		2.63	.76
99		2.63	.76
3270		2.62	.76
4937		2.63	.76
6605		2.65	.77
8272		2.63	.77
9940		2.63	.76
11607		2.63	.76
13275		2.64	.77
14942		2.65	.77
16610		2.66	.78
33290		2.65	.77
49970		2.68	.78
66649		2.65	.77
83328		2.67	.78
100006		2.65	.77
116683		2.68	.78
133363		2.67	.78
150041		2.67	.78
166719		2.67	.78
333398		2.65	.78
400224		2.65	.78
416904		2.64	.78
433583		2.64	.78
450263		2.64	.78
466943		2.64	.78
483623		2.64	.77
500304		2.65	.78
516984		2.65	.78
533665		2.62	.77
550346		2.63	.77

N45607

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TEST DATE 9/10/1981	CONTRACT NO. 43-8335 PROJECT NASA
TYPE-09 11321 TENSION TENSION	SPECIMEN NAME N45607
TEST DIRECTION IS UP	
MATERIAL: +-45,GR/EP,60%,FATIGUE	SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0%	
CYCLING FREQ.----------- 10.00 HERTZ	LENGTH (IN)---------10.000
FUNCTION GEN RNG,MULT--- 10.00 100.00	WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00 HZ	THICKNESS (IN)------ .044
OPERATOR #1 SHIPPEN	
OPERATOR #2 MOHAN	

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	-.013	10.010	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.003	10.003	0.00000	.07000	3.50000	LONG. EXT.
6	49	.005	10.010	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45607

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.76	2.71	.78
3		2.68	.77
5		2.69	.77
7		2.68	.77
9		2.68	.77
19		2.67	.77
29		2.66	.77
39		2.66	.77
49		2.66	.77
59		2.67	.77
69		2.67	.77
79		2.66	.77
89		2.66	.77
99		2.66	.77
3270		2.64	.76
4938		2.64	.76
6603		2.66	.77
8273		2.64	.76
9940		2.65	.76
11608		2.64	.76
13275		2.65	.76
14943		2.65	.76
16640		2.66	.76
33241		2.67	.77
49972		2.66	.76
66633		2.66	.77
83333		2.68	.77
100013		2.66	.76
116693		2.66	.77
133372		2.67	.77
150031		2.67	.77
166731		2.66	.76
333526		2.66	.77
500327		2.66	.77
667143		2.68	.77
833980		2.65	.76
867348		2.66	.76
884031		2.66	.76
900713		2.64	.76
917399		2.63	.76
934082		2.65	.76
950765		2.63	.75
967417		2.63	.76
984130		2.64	.76
1000812		2.63	.75
1017080	2.62	2.63	.76

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N45608

TEST DATE 9/10/1981 * CONTRACT NO. 43-8335 PROJECT NASA
*
TYPE-09 11321 TENSION TENSION * SPECIMEN NAME N45608
TEST DIRECTION IS UP *
MATERIAL: +-45,GR/EP,60%,FATIGUE * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ * LENGTH (IN)---------10.000
FUNCTION GEN RNG,MULT--- 10.00 100.00 * WIDTH (IN)----------- 1.500
SCAN RATE--------------- 320.00 HZ * THICKNESS (IN)------ .044
OPERATOR #1 SHIPPEN *
OPERATOR #2 MOHAN *

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	-.013	10.010	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.005	10.005	0.00000	.07000	3.50000	LONG. EXT.
6	49	.005	10.010	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45608

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.81	2.71	.78
3		2.68	.77
5		2.69	.77
7		2.68	.77
9		2.68	.77
19		2.67	.77
29		2.66	.77
39		2.66	.77
49		2.66	.77
59		2.67	.77
69		2.67	.77
79		2.66	.77
89		2.66	.77
99		2.66	.77
3270		2.64	.76
4938		2.64	.76
6605		2.66	.77
8273		2.64	.76
9940		2.65	.76
11608		2.64	.76
13275		2.65	.76
14943		2.65	.76
16610		2.66	.76
33291		2.67	.77
49972		2.66	.76
66653		2.66	.77
83333		2.68	.77
100013		2.66	.76
116693		2.66	.77
133372		2.67	.77
150031		2.67	.77
166731		2.66	.76
333526		2.66	.77
500327		2.66	.77
667143		2.68	.77
833980		2.65	.76
867348		2.66	.76
884031		2.66	.76
900715		2.64	.76
917399		2.63	.76
934082		2.65	.76
950765		2.63	.75
967447		2.63	.76
984130		2.64	.76
1000812		2.63	.75
1017080		2.63	.76

N45609

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TEST DATE                      7/20/1981 * CONTRACT NO. 43-8335    PROJECT NASA
                                         *
TYPE-09  11321 TENSION TENSION           * SPECIMEN NAME  N43609
TEST DIRECTION IS  UP                    *
MATERIAL: +-45,GR/EP,60%,FATIGUE         * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C. HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ     * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00    100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ       * THICKNESS (IN)------  .044
OPERATOR #1  MOHAN                       *
OPERATOR #2                              *
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CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	-.003	9.985	0.00000	2000.0000	0.00000	20KLB L. CELL
7	48	.010	10.013	0.00000	.07000	3.30000	LONG. EXT.
6	49	.010	10.010	0.00000	.01970	.93430	LAT. EXT.
5	48	.010	10.010	0.00000	.06000	1.50000	LONG. EXT.

SPECIMEN: N45609

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.78	2.74	.80
3		2.73	.79
5		2.73	.79
7		2.71	.79
9		2.72	.79
19		2.71	.79
29		2.71	.79
39		2.71	.79
49		2.71	.79
59		2.71	.79
69		2.71	.79
79		2.70	.78
89		2.71	.79
99		2.70	.79
198		2.71	.79
298		2.70	.78
399		2.70	.78
498		2.70	.78
598		2.71	.78
698		2.71	.78
798		2.70	.78
898		2.69	.78
998		2.70	.73
1997		2.69	.78
2996		2.68	.77
3996		2.69	.78
4994		2.69	.78
5994		2.70	.78
6994		2.70	.78
7992		2.70	.78
8992		2.71	.78
9991		2.70	.78
19976		2.70	.78
29960		2.71	.78
39947		2.73	.79
49931		2.71	.78
59915		2.72	.78
69900		2.71	.78
79885		2.69	.78
89870		2.70	.78
99853		2.71	.78
199728		2.69	.78
299610		2.68	.77
399518		2.67	.77
499450		2.66	.77
509445		2.66	.77
519440		2.65	.77
529435		2.68	.77
539430		2.64	.77
549426		2.64	.77
559422		2.63	.76
569418		2.62	.76
579414		2.61	.76
589411	2.58	2.59	.76
599412		2.58	.75

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N45501

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TEST DATE                              8/17/1981 * CONTRACT NO. 43-8335     PROJECT NASA
                                                 *
TYPE-00  11321 TENSION TENSION                   * SPECIMEN NAME  N43301
TEST DIRECTION IS  UP                            *
MATERIAL: +-45,GR/EPOXY,50% FATIGU               *-SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0%         *
CYCLING FREQ.----------- 10.00 HERTZ             * LENGTH (IN)--------- 1.000
FUNCTION GEN RNG,MULT--- 10.00      100.00       * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ               * THICKNESS (IN)------  .044
OPERATOR #1  MOHAN                               *
OPERATOR #2                                      *
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CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	41	-.013	10.010	0.00000	2000.0000	0.00000	20KLB L.CELL
7	48	.005	10.003	0.00000	.07000	3.50000	LONG. EXT.
6	49	.003	10.010	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N45501

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	2.80	2.87	.83
3		2.86	.83
5		2.87	.83
7		2.90	.84
9		2.84	.82
19		2.83	.82
29		2.84	.82
39		2.86	.83
49		2.85	.82
59		2.84	.82
69		2.85	.83
79		2.87	.83
89		2.84	.82
99		2.83	.82
199		2.80	.81
298		2.80	.81
398		2.79	.81
498		2.80	.81
598		2.80	.81
698		2.79	.80
798		2.78	.80
897		2.79	.80
997		2.76	.79
1996		2.79	.80
2995		2.80	.80
3993		2.80	.80
4992		2.81	.80
5990		2.79	.80
6989		2.81	.80
7988		2.82	.80
8986		2.79	.80
9983		2.79	.80
19971		2.81	.80
29957		2.81	.80
39943		2.78	.80
49928		2.82	.81
59914		2.83	.81
69900		2.81	.80
79883		2.81	.80
89869		2.82	.80
99854		2.80	.80
199706		2.78	.79
299537		2.81	.80
399420		2.81	.80
499298		2.82	.81
599183		2.82	.81
699078		2.84	.81
798980	2.73	2.83	.81
898386		2.81	.81
908876		2.82	.81
918866		2.81	.80
928853		2.82	.81
938843		2.82	.81
948833		2.80	.80
958824		2.80	.80
968815		2.81	.81
978895		2.82	.81
988795		2.80	.80
991792		2.83	.81
992791		2.79	.80
993790		2.82	.81
994789		2.83	.81
995788		2.81	.80
996787		2.81	.80
997786		2.81	.80
998785		2.79	.80
999784		2.81	.80
1000783	2.73	2.80	.80

N67801

```
TEST DATE                          9/29/1981 * CONTRACT NO. 43-0333    PROJECT NASA
                                             *
TYPE-09  11321 TENSION TENSION              * SPECIMEN NAME  N67801
TEST DIRECTION IS  UP                        *
MATERIAL: +-67.5,GR/EP,80% FATIGUE          * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ        * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG.MULT--- 10.00     100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ          * THICKNESS (IN)------  .044
OPERATOR #1                                  *
OPERATOR #2                                  *
*********************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	-.013	10.005	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.020	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.045	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N67801

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.56	1.58	.69
3		1.58	.69
5		1.57	.69
7		1.57	.69
9		1.57	.69
19		1.57	.69
29		1.57	.69
39		1.57	.68
49		1.57	.68
59		1.56	.68
69		1.57	.68
79		1.57	.68
89		1.57	.68
99		1.57	.68
179		1.56	.68
189		1.57	.68
200		1.57	.69
210		1.56	.68
220		1.57	.68
230		1.56	.68
240		1.56	.68
250		1.56	.68
260		1.56	.68
270		1.55	.68

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N67802

```
TEST DATE                    10/12/1981-* CONTRACT NO. 40-8335    PROJECT NASA
                                        *
TYPE-09  11321 TENSION TENSION          * SPECIMEN NAME  N67802
TEST DIRECTION IS  UP                   *
MATERIAL: +-67.5,GR/EP,80% FATIGUE      * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 28.0% *
CYCLING FREQ.----------- 10.00 HERTZ    * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG.MULT--- 10.00    100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ      * THICKNESS (IN)------  .044
OPERATOR #1  SHIPPEN                    *
OPERATOR #2                             *
*****************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	.015	10.010	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.015	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N67802

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.53	1.55	.67
3		1.54	.67
5		1.54	.67
7		1.54	.67
9		1.54	.67
19		1.53	.67
29		1.54	.67
39		1.54	.67
49		1.54	.67
59		1.54	.67
69		1.54	.67
79		1.54	.67
89		1.54	.67
99		1.54	.67
199		1.54	.67
299		1.53	.67
399		1.53	.67
500		1.53	.67
520		1.53	.67
530		1.53	.67
540		1.53	.66
550		1.53	.66
560		1.53	.66
570		1.53	.66
580		1.53	.66
590		1.53	.66
600		1.53	.66
610		1.52	.66

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OF POOR QUALITY

N67803

TEST DATE 10/13/1981 * CONTRACT NO. 40-0308 PROJECT NASA

TYPE-00 11031 TENSION TENSION * SPECIMEN NAME . N67803
TEST DIRECTION IS UP
MATERIAL: +-67.5,Gr-EP,008 FATIGUE * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 20.00 DEG. C. HUMIDITY 50.00
CYCLIC FREQ.============ 10.00 HERTZ * LENGTH (IN)========== 7.000
FUNCTION GEN RNG.MULT--- 10.00 100.00 * WIDTH (IN)=========== 1.500
SCAN RATE----------------500.00 HZ * THICKNESS (IN)======= .044
OPERATOR #1 SHIPPEN
OPERATOR #2

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	.015	10.010	0.00000	1000.0000	0.00000	1K LB L. CELL
7	40	.010	10.015	0.00000	.07000	0.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.90480	LAT. EXT.

SPECIMEN: N67803

CYCLE-#	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.18	1.57	.67
3		1.56	.67
5		1.55	.67
7		1.55	.67
9		1.55	.67
19		1.55	.67
29		1.55	.67
39		1.55	.67
49		1.55	.67
59		1.55	.67
69		1.56	.67
79		1.55	.67
89		1.56	.67
93		1.56	.67
95		1.55	.67
97		1.56	.67
99		1.55	.67
109		1.54	.66

N67701

```
TEST DATE                          9/29/1981 * CONTRACT NO. 40-0006    PROJECT NASA
                                             *
TYPE-09  11021 TENSION TENSION               * SPECIMEN NAME  N67701
TEST DIRECTION IN  UP                        *
MATERIAL: +-67.5,GR/EP,707 FATIGUE           * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 20.00 DEG. C. HUMIDITY 33.00     *
CYCLING FREQ.------------ 10.00 HERTZ        * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG,MULT--- 10.00      100.00   * WIDTH (IN)----------- 1.500
SCAN RATE----------------020.00  HZ          * THICKNESS (IN)------  .044
OPERATOR #1                                  *
OPERATOR #2                                  *
************************************************************************************
  CHAN.  TYPE        LOW    HIGH      CAL-LOW   CAL-HIGH  GAGE LEN.    DESCRIPTION
    8     42       -.010  10.005     0.00000  1000.0000    0.00000    1KLB L. CELL.
    7     48        .010  10.020     0.00000     .07000    3.50000    LONG. EXT.
    6     49        .010  10.015     0.00000     .01970     .90430    LAT.  EXT.
```

SPECIMEN: N67701

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	C(12)*(E+06)
1	1.55	1.57	.68
3		1.56	.68
5		1.56	.68
7		1.56	.68
9		1.56	.63
19		1.57	.68
29		1.56	.68
39		1.55	.68
49		1.55	.67
59		1.56	.68
69		1.55	.68
79		1.56	.68
89		1.56	.68
99		1.56	.68
200		1.55	.68
300		1.57	.69
400		1.56	.68
501		1.56	.68
601		1.56	.68
701		1.56	.68
802		1.56	.68
902		1.56	.68
1003		1.56	.68
1505		1.53	.68
1606		1.55	.68
1706		1.53	.68
1806		1.55	.68
1907		1.56	.68
2007		1.56	.68
2107		1.56	.68
2208		1.56	.68
2308		1.55	.68
2408		1.56	.68

N67702

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TEST DATE                          10/12/1981 * CONTRACT NO. 40-0835    PROJECT NASA
                                              *
TYPE-09  11321 TENSION TENSION                * SPECIMEN NAME  N67702
TEST DIRECTION IS  9P                         *
MATERIAL  +-67.5,GR-EP,70% FATIGUE            * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.08      *
CYCLING FREQ.------------ 10.00 HERTZ         * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG,MULT---  10.00      100.00   * WIDTH (IN)----------- 1.500
SCAN RATE------------------820.00  HZ         * THICKNESS (IN)------   .044
OPERATOR #1   SHIPPEN                         *
OPERATOR #2                                   *
****************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	.015	10.010	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.013	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98400	LAT. EXT.

SPECIMEN: N67702

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.55	1.58	.68
3		1.58	.68
5		1.58	.68
7		1.58	.68
9		1.57	.68
19		1.58	.68
29		1.57	.67
39		1.57	.68
43		1.58	.68
45		1.58	.68
47		1.58	.68
49		1.57	.68
51		.40	.23

N67703

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OF POOR QUALITY

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TEST DATE                              10/19/1981 * CONTRACT NO. 43-8335     PROJECT NASA
                                                  *
TYPE-09   11321 TENSION TENSION                   * SPECIMEN NAME  N67703
TEST DIRECTION IS  UP                             *
MATERIAL: +-67.5,GR/EP,70% FATIGUE                * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.03          *
CYCLING FREQ.------------- 10.00 HERTZ            * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG,MULT---  10.00        100.00     * WIDTH (IN)----------- 1.500
SCAN RATE------------------820.00  HZ             * THICKNESS (IN)- ----   .044 .
OPERATOR #1   SHIPPEN                             *
OPERATOR #2                                       *
*****************************************************************************************
  CHAN.  TYPE        LOW    HIGH     CAL-LOW   CAL-HIGH GAGE LEN.   DESCRIPTION
    8     42        .015  10.010     0.00000  1000.0000   0.00000   INST L. CELL
    7     48        .010  10.015     0.00000     .07000   3.50000   LONG. EXT.
    6     49.       .010  10.015     0.00000     .01970    .98400   LAT.  EXT.  .
```

SPECIMEN: N67703

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.55	1.57	.69
3		1.57	.69
5		1.56	.69
7		1.56	.69
9		1.56	.69
19		1.57	.69
29		1.56	.69
39		1.56	.69
49		1.57	.69
59		1.56	.69
69		1.56	.69
79		1.56	.69
89		1.56	.69
99		1.57	.69
199		1.56	.69
299		1.56	.69
400		1.56	.69
500		1.56	.69
600		1.56	.69
700		1.57	.69
801		1.57	.69
820		1.57	.69
830		1.57	.69
841		1.56	.69
851		1.57	.69
861		1.56	.69
871		1.57	.69
881		1.57	.69
891		1.56	.69
901		1.57	.69
911		1.57	.69

ORIGINAL PAGE IS
OF POOR QUALITY

N67601

TEST DATE 9/17/1981 * CONTRACT NO. 43-8335 PROJECT NASA

TYPE-09 11821 TENSION TENSION
TEST DIRECTION IS UP
MATERIAL: +-67 GR/EP 603 FATIGUE
TEMPERATURE 23.00 DEG. C. HUMIDITY 0.0%
CYCLING FREQ.----------- 10.00 HERTZ
FUNCTION GEN RNG.MULT--- 10.00 100.00
SCAN RATE---------------320.00 HZ
OPERATOR #1 SHIPPEN
OPERATOR #2

SPECIMEN-NAME N67601
SPECIMEN-SHAPE RECTANGULAR
LENGTH (IN)---------- 7.000
WIDTH (IN)---------- 1.503
THICKNESS (IN)------ .044

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	43	-.013	10.005	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.020	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.013	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N67601

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.57	1.60	.69
3		1.60	.69
5		1.59	.69
7		1.59	.69
9		1.58	.68
19		1.58	.68
29		1.59	.69
39		1.59	.69
49		1.59	.69
59		1.59	.69
69		1.60	.69
79		1.60	.69
89		1.60	.69
99		1.59	.69
199		1.59	.69
299		1.59	.69
399		1.59	.69
500		1.60	.70
601		1.60	.69
700		1.59	.69
800		1.60	.69
900		1.59	.69
1000		1.59	.69
2002		1.60	.69
3004		1.59	.69
4006		1.60	.69
5007		1.59	.69
6009		1.59	.69
7011		1.61	.70
8012		1.60	.69
9014		1.60	.69
10016		1.61	.70
15025		1.60	.69
16026		1.60	.70
17028		1.61	.70
18030		1.60	.69
19031		1.60	.70
20033		1.59	.69
21033		1.60	.70
22037		1.59	.69
23038		1.59	.69
24040		1.59	.69

N67602

ORIGINAL PAGE IS
OF POOR QUALITY

TEST DATE 9/22/1981 * CONTRACT NO. 43-8335 PROJECT NASA

TYPE-09 11021 TENSION TENSION * SPECIMEN NAME N67602
TEST DIRECTION IS TIP
MATERIAL: +-67 GR/E" 60% FATIGUE * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C. HUMIDITY 0.0%
CYCLING FREQ:------------ 10.00 HERTZ * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG.MULT--- 10.00 100.00 * WIDTH (IN)---------- 1.504
SCAN RATE-----------------320.00 HZ * THICKNESS (IN)------ .044
OPERATOR #1 SHIPMEN
OPERATOR #2

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	-.013	10.005	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.020	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N67602

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.56	1.60	.69
3		1.58	.69
5		1.59	.69
7		1.60	.69
9		1.59	.69
19		1.60	.69
29		1.59	.69
39		1.59	.69
49		1.59	.69
59		1.59	.69
69		1.59	.69
79		1.59	.69
89		1.59	.69
99		1.59	.69
199		1.59	.69
299		1.59	.69
399		1.60	.69
500		1.59	.69
600		1.60	.69
700		1.59	.69
800		1.58	.69
900		1.58	.69
1001		1.59	.69
2003		1.59	.69
3005		1.59	.69
4007		1.59	.68
5009		1.59	.69
6011		1.58	.68
7013		1.59	.69
8015		1.58	.69
9017		1.60	.69
10019		1.59	.69
20039		1.59	.69
30058		1.59	.69
40078		1.59	.69
50099		1.59	.69
58115		1.58	.68
59117		1.57	.68
60119		1.58	.68
61121		1.59	.69
62123		1.58	.68
63125		1.58	.68
64127		1.58	.68
65129		1.59	.68
66131		1.58	.68
67133		1.59	.68

N67603

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TEST DATE                         9/22/1981 * CONTRACT NO. 43-8335     PROJECT NASA
                                            *
TYPE-09   11321 TENSION TENSION             * SPECIMEN NAME  N67603
TEST DIRECTION IS  UP                       *
MATERIAL: +-67 GR/EP 603 FATIGUE            * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY  0.0%-   *
CYCLING FREQ.------------ 10.00 HERTZ       * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00      100.00  * WIDTH (IN)---------- 1.590
SCAN RATE----------------320.00  HZ         * THICKNESS (IN)------  .044
OPERATOR #1: SHIPPEN                        *
OPERATOR #2                                 *
*********************************************************************************
  CHAN.  TYPE         LOW    HIGH     CAL-LOW  CAL-HIGH GAGE LEN.    DESCRIPTION
    8     42        -.018  10.008    0.00000 1000.0080   0.00000    INLB L. CELL
    7     48         .010  10.020    0.00000    .07000   3.50000    LONG. EXT.
    6     49         .010  10.013    0.00000    .01970    .98430    LAT.  EXT.
```

SPECIMEN: N67603

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.52	1.53	.66
3		1.34	.63
5		1.54	.65
7		1.35	.66
9		1.54	.65
19		1.54	.65
29		1.54	.65
39		1.55	.66
49		1.54	.65
59		1.54	.66
69		1.55	.66
79		1.55	.66
89		1.54	.65
99		1.55	.66
199		1.55	.66
299		1.53	.66
399		1.55	.66
500		1.53	.65
600		1.54	.65
700		1.53	.65
800		1.54	.65
900		1.54	.65
1001		1.54	.65
2003		1.54	.66
3005		1.54	.66
4007		1.54	.66
5009		1.53	.66
6011		1.54	.66
7013		1.35	.66
8015		1.54	.66
9017		1.54	.66
10019		1.55	.66
20040		1.54	.66
30060		1.54	.66
40081		1.54	.66
49100		1.54	.66
50102		1.54	.66
51104		1.54	.66
52106		1.54	.63
53108		1.53	.63
54111		1.52	.65
55113		1.53	.65
56115		1.54	.66
57117		1.53	.65
58119		1.52	.65

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N67604

TEST DATE 9/23/1981 * CONTRACT.NO. 43-3335 PROJECT NASA

TYPE-09 11321 TENSION TENSION
TEST DIRECTION IS UP
MATERIAL: +-67 GR/EP 60% FATIGUE
TEMPERATURE 23.00 DEG. C, HUMIDITY 0.0%
CYCLING FREQ.----------- 10.00 HERTZ
FUNCTION GEN RNG.MULT--- 10.00 100.00
SCAN RATE--------------320.00 HZ
OPERATOR #1 SHIPPEN
OPERATOR #2

SPECIMEN NAME N67604
SPECIMEN SHAPE RECTANGULAR
LENGTH (IN)--------- 7.000
WIDTH (IN)---------- 1.500
THICKNESS (IN)------ .044

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	-.013	10.003	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.020	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N67604

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.47	1.51	.66
3		1.52	.66
5		1.53	.66
7		1.52	.66
9		1.52	.66
19		1.51	.66
29		1.52	.66
39		1.52	.66
49		1.51	.66
59		1.52	.66
69		1.53	.67
79		1.53	.66
89		1.51	.66
99		1.53	.67
199		1.52	.66
299		1.53	.66
400		1.52	.66
500		1.52	.66
600		1.53	.66
700		1.53	.66
801		1.52	.66
901		1.53	.66
1001		1.53	.67
2003		1.53	.66
3006		1.53	.66
4008		1.52	.66
5010		1.53	.66
6013		1.53	.66
7015		1.53	.66
8017		1.52	.66
9020		1.53	.66
10022		1.52	.66
20046		1.53	.66
28064		1.52	.66
29067		1.52	.66
30069		1.53	.67
31071		1.51	.66
32074		1.52	.66
33076		1.51	.66
34078		1.51	.66
35081		1.51	.65
36083		1.50	.65
37085		1.48	.64

N67605

ORIGINAL PAGE IS
OF POOR QUALITY

```
TEST DATE                          9/23/1981 * CONTRACT NO. 43-8833     PROJECT NASA
                                             *
TYPE-09  11021 TENSION TENSION              * SPECIMEN NAME  N67605
TEST DIRECTION IS  UP                        *
MATERIAL: +-67 GR/EP 605 FATIQUE            * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY  0.0%    *
CYCLING FREQ.------------ 10.00 HERTZ       * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG,MULT--- 10.00      100.00  * WIDTH (IN)----------- 1.503
SCAN RATE----------------320.00  HZ         * THICKNESS (IN)------  .043
OPERATOR #1  SHIPPEN                         *
OPERATOR #2                                  *
*************************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	-.013	10.005	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.020	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N67605

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.56	1.59	.69
3		1.58	.69
5		1.57	.69
7		1.58	.69
9		1.58	.69
19		1.59	.70
29		1.58	.69
39		1.59	.69
49		1.58	.69
59		1.58	.69
69		1.59	.69
79		1.59	.69
89		1.59	.69
99		1.58	.69
199		1.58	.69
249		1.58	.69
259		1.59	.69
269		1.59	.69
279		1.59	.69
289		1.58	.69
299		1.59	.69
309		1.58	.69
319		1.58	.69
329		1.58	.69
339		1.57	.68

ORIGINAL PAGE IS
OF POOR QUALITY

N67606

```
TEST DATE                         10/12/1981 * CONTRACT NO. 43-8035     PROJECT NASA
                                             *
TYPE-09  11321 TENSION TENSION               * SPECIMEN NAME  N67606
TEST DIRECTION IS  UP                        *
MATERIAL: +-67 GR/EP 60% FATIQUE             * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C. HUMIDITY  0.0%-*
CYCLING FREQ.----------- 10.00 HERTZ         * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG.MULT--- 10.00     100.00    * WIDTH (IN)----------- 1.500
SCAN RATE---------------320.00  HZ           * THICKNESS (IN)------  .044
OPERATOR #1                                  *
OPERATOR #2                                  *
*************************************************************************************
  CHAN.  TYPE          LOW    HIGH     CAL-LOW  CAL-HIGH  GAGE LEN.    DESCRIPTION
    8     42          .015  10.010    0.00000  1000.0000   0.00000    1KLB L. CELL
    7     48          .010  10.015    0.00000    .07000    3.50000    LONG. EXT.
    6     49          .010  10.015    0.00000   -.01970     .98430    LAT.  EXT.
```

SPECIMEN: N67606

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.53	1.57	.69
3		1.56	.68
5		1.57	.69
7		1.56	.69
9		1.57	.69
19		1.57	.69
29		1.57	.69
39		1.56	.69
49		1.57	.69
59		1.57	.69
69		1.57	.69
79		1.56	.69
89		1.56	.68
99		1.57	.69
199		1.57	.69
299		1.57	.68
399		1.57	.69
500		1.57	.69
600		1.57	.69
700		1.57	.69
800		1.57	.69
900		1.57	.69
1001		1.57	.69
2003		1.56	.68
3005		1.57	.69
4007		1.57	.69
5009		1.57	.69
6011		1.58	.69
7013		1.57	.69
8014		1.57	.69
9016		1.57	.69
10018		1.57	.69
20038		1.57	.69
30038		1.56	.69
38074		1.55	.68
39076		1.56	.68
40078		1.56	.68
41080		1.55	.68
42082		1.56	.68
43084		1.55	.68
44086		1.55	.68
45088		1.54	.68
46090		1.53	.67
47092		1.47	.65

N67607

ORIGINAL PAGE IS
OF POOR QUALITY

TEST DATE 10/13/1981 * CONTRACT NO. 43-3335 PROJECT NASA

TYPE-09 11321 TENSION TENSION
TEST DIRECTION IS UP
MATERIAL: +-67 GR/EP 60% FATIQUE
TEMPERATURE 23.00 DEG. C, HUMIDITY 0.0%
CYCLING FREQ:----------- 10.00 HERTZ
FUNCTION GEN RNG,MULT--- 10.00 100.00
SCAN RATE---------------320.00 HZ
OPERATOR #1
OPERATOR #2

SPECIMEN NAME N67607
SPECIMEN SHAPE RECTANGULAR
LENGTH (IN)--------- 7.000
WIDTH (IN)---------- 1.500
THICKNESS (IN)------ .044

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	.015	10.010	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.015	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	-.98430	LAT. EXT.

SPECIMEN: N67607

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.53	1.56	.69
3		1.56	.69
5		1.56	.69
7		1.56	.69
9		1.56	.69
19		1.56	.69
29		1.56	.69
39		1.56	.69
49		1.56	.69
59		1.56	.69
69		1.56	.69
79		1.57	.69
89		1.56	.69
99		1.56	.69
199		1.56	.69
299		1.56	.69
399		1.57	.69
500		1.56	.69
600		1.56	.69
700		1.56	.69
800		1.57	.69
900		1.56	.69
1001		1.56	.69
2003		1.57	.69
3005		1.56	.69
4007		1.57	.69
5009		1.56	.69
6011		1.57	.69
7013		1.56	.69
8015		1.56	.69
9017		1.56	.69
10019		1.56	.69
20039		1.56	.69
28035		1.56	.69
29037		1.55	.69
30039		1.55	.68
31061		1.55	.69
32063		1.55	.69
33065		1.55	.68
34067		1.55	.69
35069		1.55	.68
36071		1.54	.68
37073		1.52	.68

ORIGINAL PAGE IS
OF POOR QUALITY

N67608

```
TEST DATE                          10/13/1981 * CONTRACT NO. 43-8838     PROJECT NASA
                                              *
TYPE-09  1132  TENSION TENSION                * SPECIMEN NAME  N67608
TEST DIRECTION IS  UP                         *
MATERIAL: +-67 GR/EP 608 FATIQUE              * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY  0.08      *
CYCLING FREQ.------------ 10.00 HERTZ         * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG.MULT---  10.00      100.00   * WIDTH (IN)----------- 1.508
SCAN RATE----------------320.00  HZ           * THICKNESS (IN)------   .044
OPERATOR #1   SHIPPEN                         *
OPERATOR #2                                   *
*************************************************************************************
  CHAN.  TYPE         LOW    HIGH     CAL-LOW   CAL-HIGH GAGE LEN.    DESCRIPTION
     8    42         .015  10.010    0.00000  1000.0000   0.00000    1KLB L. CELL
     7    48         .010  10.015    0.00000     .07000   3.50000    LONG. EXT.
     6    49         .010  10.015    0.00000     .01970    .98430    LAT. -EXT.
```

SPECIMEN: N67608

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.53	1.59	.69
3		1.59	.69
5		1.59	.68
7		1.58	.68
9		1.58	.68
19		1.58	.68
29		1.59	.69
39		1.59	.69
49		1.59	.68
59		1.59	.68
69		1.58	.68
79		1.58	.68
89		1.58	.68
99		1.58	.68
199		1.59	.68
299		1.58	.68
400		1.59	.68
500		1.59	.68
600		1.59	.68
700		1.59	.68
800		1.59	.68
900		1.58	.68
1001		1.59	.68
2003		1.59	.68
3005		1.59	.68
4007		1.58	.68
5009		1.59	.68
6011		1.58	.68
7013		1.58	.68
8015		1.59	.68
9017		1.59	.68
9818		1.59	.68
9919		1.59	.68
10019		1.59	.68
11021		1.58	.68
12023		1.59	.68
13025		1.58	.68
14027		1.59	.68
15029		1.59	.68
16031		1.58	.68
17033		1.58	.68

N67609

ORIGINAL PAGE IS
OF POOR QUALITY

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TEST DATE                     10/18/1981 * CONTRACT NO. 43-0005    PROJECT NASA
                                         *
TYPE-09  11081 TENSION TENSION           * SPECIMEN NAME  N67609
TEST DIRECTION IS  UP                    *
MATERIAL: +-67 GR/EP 60% FATIGUE         * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C. HUMIDITY  0.05 *
CYCLING FREQ.------------ 10.00 HERTZ    * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG,MULT--- 10.00    100.00 * WIDTH (IN)----------- 1.500
SCAN RATE---------------020.00  HZ       * THICKNESS (IN)------  .044
OPERATOR #1                              *
OPERATOR #2                              *
*******************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	43	.015	10.010	0.00000	1000.0000	0.00000	1ELB L. CELL
7	40	.010	10.015	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.90430	LAT. EXT.

SPECIMEN: N67609

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.55-	1.56	.67
3		1.56	.67
5		1.55	.67
7		1.56	.67
9		1.56	.67
19		1.56	.67
29		1.56	.67
39		1.56	.67
49		1.56	.67
59		1.56	.67
69		1.56	.67
79		1.56	.67
89		1.56	.67
99		1.56	.67
199		1.56	.67
299		1.56	.67
399		1.56	.67
500		1.56	.67
600		1.56	.67
700		1.56	.67
800		1.56	.67
900		1.56	.67
1001		1.56	.67
2003		1.56	.67
3005		1.56	.67
4007		1.56	.67
5009		1.56	.67
6011		1.56	.67
7013		1.56	.67
8015		1.56	.67
9017		1.56	.67
10019		1.56	.67
14027		1.56	.67
15029		1.56	.67
16031		1.56	.67
17033		1.53	.67
18035		1.55	.67
19037		1.56	.67
20039		1.56	.67
21041		1.55	.66
22043		1.54	.66
23045		1.54	.66

N67501

ORIGINAL PAGE IS OF POOR QUALITY

TEST DATE	9/28/1981	CONTRACT NO. 48-0555 PROJECT NASA
TYPE-99 11021 TENSION TENSION		SPECIMEN NAME N67501
TEST DIRECTION I= UP		
MATERIAL: +-67DEG,GR/EP,50% FATIGU		SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 20.00 DEG. C. HUMIDITY 50.0%		
CYCLING FREQ.----------- 10.00 HERTZ		LENGTH (IN)---------- 7.000
FUNCTION GEN RNG,MULT--- 10.00 100.00		WIDTH (IN)---------- 1.508
SCAN RATE---------------320.00 HZ		THICKNESS (IN)------ .044
OPERATOR #1 SHIPPEN		
OPERATOR #2		

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
0	42	-.013	10.005	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.020	0.00000	.07000	5.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98480	LAT. EXT.

SPECIMEN: N67501

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.54	1.55	.67
3		1.57	.68
5		1.57	.68
7		1.57	.68
9		1.57	.68
19		1.58	.69
29		1.56	.68
39		1.58	.68
49		1.57	.63
59		1.57	.68
69		1.57	.68
79		1.57	.68
89		1.57	.68
99		1.57	.68
199		1.56	.67
299		1.57	.68
400		1.57	.68
500		1.57	.68
600		1.57	.68
700		1.58	.68
800		1.58	.68
901		1.57	.68
1001		1.58	.68
2003		1.57	.68
3005		1.58	.68
4007		1.57	.67
5009		1.57	.67
6011		1.58	.67
7013		1.57	.67
8016		1.56	.66
9018		1.56	.67
10020		1.57	.67
20041		1.58	.67
30062		1.56	.66
40083		1.57	.67
50105		1.57	.67
60126		1.57	.67
70147		1.57	.67
80169		1.56	.66
90190		1.57	.66
98207		1.56	.66
99209		1.56	.66
100211		1.58	.67
110233		1.56	.66
120254		1.56	.66
130275		1.56	.66
140296		1.57	.67
150318		1.57	.67
160339		1.56	.67
170361		1.56	.66
177376		1.56	.66
178378		1.56	.66
179381		1.56	.66
180383		1.57	.67
181385		1.57	.67
182387		1.56	.66
183389		1.57	.66
184391		1.57	.67
185394		1.56	.66
186396		1.56	.67

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N67502

```
TEST DATE                       9/24/1981 * CONTRACT NO. 48-8985    PROJECT NASA
                                          *
TYPE=09  11081 TENSION TENSION            * SPECIMEN NAME  N67502
TEST DIRECTION IS  UP                     *
MATERIAL: +-67DEG,GR/EP,50R FATIGUE       * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C. HUMIDITY 50.00  *
CYCLING FREQ.============ 10.00 HERTZ     * LENGTH (IN)=========== 7.000
FUNCTION GEN RNG,MULT=== 10.00    100.00  * WIDTH (IN)============ 1.500
SCAN RATE===============200.00  HZ        * THICKNESS (IN)======   .044
OPERATOR #1  SHIPPEN                      *
OPERATOR #2                               *
********************************************************************************
 CHAN.  TYPE         LOW   HIGH     CAL-LOW  CAL-HIGH  GAGE LEN.   DESCRIPTION
    0     42       -.019 10.005    0.00000 1000.0000   0.00000    TELD L. CELL
    7     48        .010 10.020    0.00000    .07000   0.50000    LONG. EXT.
    6     49        .010 10.015    0.00000  . .01970    .98430    LAT... EXT.
```

SPECIMEN: N67502

CYCLE #	STATIC LONG. MODULUS*(E+06).....	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.53	1.56	.68
3		1.54	.67
5		1.56	.68
7		1.55	.67
9		1.55	.67
19		1.56	.68
29		1.54	.67
39		1.56	.68
49		1.55	.67
59		1.56	.68
69		1.55	.68
79		1.56	.68
89		1.55	.67
99		1.54	.67
199		1.56	.68
299		1.55	.68
400		1.56	.68
500		1.55	.68
600		1.55	.68
700		1.56	.68
800		1.55	.68
901		1.56	.68
1001		1.56	.68
2003		1.57	.68
3005		1.55	.68
4007		1.56	.68
5009		1.56	.67
6012		1.56	.68
7014		1.57	.68
8016		1.56	.68
9018		1.56	.68
10020		1.56	.68
20042		1.56	.68
30064		1.56	.68
40085		1.57	.68
50107		1.56	.68
60128		1.57	.68
70150		1.57	.68
80[illegible]		1.57	.68
901[illegible]		1.56	.68
1002[illegible]5		1.57	.68
120239		1.57	.68
130281		1.56	.68
140303		1.56	.68
150324		1.56	.68
160346		1.55	.67
170368		1.56	.68
180390		1.56	.68
190411		1.55	.67
200433		1.56	.67
210435		1.56	.68
215466		1.55	.67
216469		1.54	.67
217471		1.55	.67
218473		1.55	.67
219475		1.54	.67
220477		1.55	.67
221479		1.55	.66
222482		1.55	.67
223484		1.51	.65
224486	1.47	1.47	.64

ORIGINAL PAGE IS
OF POOR QUALITY

N67503

TEST DATE 9/25/1981 * CONTRACT NO. 43-0335 PROJECT-NASA
*
TYPE-09 11021 TENSION TENSION * SPECIMEN NAME N67503
TEST DIRECTION IN UP *
MATERIAL: +-67DEG,GR/EP,50% FATIGU * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 20.0% *
CYCLING FREQ.------------ 10.00 HERTZ * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00 100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00 HZ * THICKNESS (IN)------ .044
OPERATOR #1 SHIPPEN *
OPERATOR #2 WALKER *

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	-.013	10.003	0.00000	1000.0000	0.00000	1KLB L. CELL
7	40	.010	10.020	0.00000	.07000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N67503

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
152770	1.54	1.58	.68
152772		1.57	.67
152774		1.57	.68
152776		1.58	.68
152778		1.57	.67
152788		1.57	.68
152798		1.57	.67
152808		1.57	.68
152818		1.57	.67
152828		1.57	.68
152838		1.57	.68
152848		1.58	.68
152858		1.57	.68
152868		1.57	.67
152968		1.57	.67
153068		1.57	.68
153169		1.57	.67
153269		1.57	.68
153369		1.57	.67
153469		1.57	.67
153571		1.58	.68
153670		1.57	.67
153770		1.57	.67
154772		1.56	.67
155774		1.57	.68
156776		1.57	.67
157779		1.57	.68
158781		1.57	.67
159783		1.56	.67
160785		1.57	.68
161788		1.57	.68
162489		1.57	.68
162589		1.57	.68
162690		1.57	.68
162790		1.57	.68
163792		1.56	.67
164794		1.56	.67
165796		1.56	.67
166799		1.57	.68
167801		1.58	.68
168803		1.58	.68

C-2

ORIGINAL PAGE IS
OF POOR QUALITY

N67504

TEST DATE	9/20/1981	CONTRACT NO. 48-0886	PROJECT NASA
TYPE-09 11821 TENSION TENSION		SPECIMEN NAME N67504	
TEST DIRECTION IS UP		SPECIMEN SHAPE RECTANGULAR	
MATERIAL: +-67DEG,GR/EP,80% FATIGU			
TEMPERATURE 28.00 DEG. C, HUMIDITY 28.0%		LENGTH (IN)----------77.000	
CYCLING FREQ.------------ 10.00 HERTZ		WIDTH (IN)---------- 1.500	
FUNCTION GEN RNG,MULT--- 10.00 100.00		THICKNESS (IN)------ .044	
SCAN RATE----------------320.00 HZ			
OPERATOR #1			
OPERATOR #2			

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
				0.00000	1000.0000	0.00000	1KLB L. CELL
8	42	-.013	10.005	0.00000	.67000	8.00000	LONG. EXT.
7	48	.010	10.020	0.00000	.01970	.98300	LAT. EXT.
6	49	.010	10.015	0.00000			

SPECIMEN: N67504

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.56	1.59	.68
3		1.59	.68
5		1.59	.68
7		1.57	.67
9		1.59	.68
19		1.58	.68
29		1.58	.68
39		1.57	.67
49		1.58	.68
59		1.59	.68
69		1.58	.68
79		1.59	.68
89		1.59	.68
99		1.59	.68
199		1.58	.68
300		1.59	.68
400		1.58	.68
500		1.59	.68
601		1.60	.69
701		1.59	.68
801		1.60	.69
902		1.58	.68
1002		1.59	.68
2005		1.59	.68
3009		1.59	.68
4012		1.58	.68
5015		1.60	.68
6019		1.60	.69
7022		1.60	.69
8025		1.60	.68
9029		1.59	.68
10032		1.38	.68
20065		1.60	.68
30098		1.60	.69
40132		1.60	.69
50165		1.59	.68
60198		1.59	.68
70231		1.58	.68
80265		1.60	.69
90298		1.61	.69
98325		1.60	.69
99328		1.60	.69
100332		1.59	.68
110365		1.59	.68
120398		1.59	.68
130432		1.59	.68
140465		1.59	.68
150498		1.59	.68
160532		1.59	.68
170565		1.60	.68
179596		1.60	.69
180599		1.59	.68
181603		1.60	.68
182606		1.58	.68
183610		1.59	.68
184613		1.60	.68
185616		1.59	.68
186620		1.60	.68
187623		1.58	.68
188627			

N67504 CONTINUED

SPECIMEN: N67504

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(-12)*(E+06)
191630		1.60	.69
191632		1.59	.68
191634		1.60	.68
191636		1.59	.68
191638		1.59	.68
191668		1.58	.67
191678		1.59	.68
191688		1.59	.68
191698		1.59	.68
191708		1.60	.68
191718		1.61	.69
191728		1.59	.68
191738		1.59	.68
191748		1.59	.68
191848		1.59	.68
191949		1.60	.68
192049		1.59	.68
192149		1.60	.68
192250		1.60	.69
192350		1.60	.68
192450		1.60	.68
192551		1.59	.68
192651		1.60	.68
193654		1.60	.68
194658		1.59	.68
195661		1.59	.68
196665		1.60	.68
197668		1.59	.68
198672		1.60	.69
199675		1.59	.68
200679		1.59	.68
201682		1.60	.68
211716		1.59	.68
221749		1.58	.68
231783		1.59	.68
241816		1.59	.68
251851		1.59	.68
261885		1.59	.68
271919		1.59	.68
281953		1.58	.68
291987		1.59	.68
392328		1.58	.67
442501		1.58	.67
452536		1.58	.68
462571		1.59	.68
472606		1.59	.68
482640		1.58	.68
492676		1.59	.68
502711		1.59	.68
512746		1.58	.67
522781		1.58	.67
532816		1.57	.67
538838		1.55	.66
539841		1.54	.66
540845		1.56	.67
541848		1.54	.66
542852		1.54	.66
543855		1.53	.65
544859		1.52	.65
545862		1.51	.65
546866	1.48	1.48	.64
547870		1.43	.62

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N67505

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TEST DATE                          10/13/1981 * CONTRACT NO. 48-8335     PROJECT-NASA
                                              *
TYPE-69  11821 TENSION TENSION                * SPECIMEN NAME  N67505
TEST DIRECTION IS  UP                         *
MATERIAL. +-67DEG,GR/EP,50% FATIGU            * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 28.0% *
CYCLING FREQ.----------- 10.00 HERTZ          * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00      100.00   * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ            * THICKNESS (IN)------  .044
OPERATOR #1  SHIPPER                          *
OPERATOR #2                                   *
**********************************************************************************
  CHAN.  TYPE        LOW    HIGH     CAL-LOW   CAL-HIGH  GAGE LEN.   DESCRIPTION
    8     42        .015  10.010    0.00000  1000.0000    0.00000   1KLB L. CELL
    7     48        .010  10.015    0.00000    .07000     3.50000   LONG. EXT.
    6     49        .010  10.015    0.00000    .01970      .98430   LAT.  EXT.
```

SPECIMEN: N67505

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.53	1.58	.66
3		1.57	.66
5		1.57	.66
7		1.57	.66
9		1.57	.66
19		1.57	.66
29		1.58	.66
39		1.57	.66
49		1.57	.66
59		1.58	.66
69		1.57	.66
79		1.57	.66
89		1.58	.66
99		1.57	.66
199		1.57	.66
299		1.57	.66
400		1.58	.66
500		1.58	.66
600		1.57	.66
700		1.57	.66
800		1.58	.66
901		1.57	.66
1001		1.57	.66
2003		1.57	.66
3003		1.57	.66
4008		1.57	.66
5010		1.57	.66
6012		1.57	.66
7014		1.57	.66
8016		1.56	.66
9019		1.57	.66
10021		1.57	.66
20043		1.57	.66
30066		1.57	.66
40088		1.56	.66
50110		1.56	.66
60132		1.57	.66
70155		1.56	.66
80177		1.56	.66
90200		1.56	.65
91202		1.55	.65
92204		1.56	.65
93206		1.55	.65
94209		1.55	.65
95211		1.55	.65
96213		1.55	.64
97215		1.54	.64
98218		1.55	.64
99220		1.54	.63
100232		1.53	.63
101224		1.54	.63
102227		1.53	.63
103229		1.52	.62
104231		1.51	.62
105233		1.46	.57

N67506

```
TEST DATE                         10/14/1981 * CONTRACT NO. 43-0333     PROJECT NASA
                                             *
TYPE-09  11031 TENSION TENSION-              * SPECIMEN NAME  N67506
TEST DIRECTION IS  UP                        *
MATERIAL: +-67DEG,GR/EP,50% FATIGU           * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ         * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG.MULT--- 10.00     100.00    * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ           * THICKNESS (IN)------  .044
OPERATOR #1   WALKER                         *
OPERATOR #2                                  *
**********************************************************************************
```

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	.015	10.010	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.015	0.00000	.87000	3.50000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98480	LAT. EXT.

SPECIMEN N67506

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1390	1.55	1.58	.69
1392		1.58	.69
1394		1.58	.69
1396		1.58	.69
1398		1.58	.69
1408		1.58	.69
1418		1.58	.69
1428		1.58	.69
1439		1.58	.69
1449		1.58	.69
1459		1.59	.69
1469		1.58	.69
1479		1.58	.69
1489		1.58	.69
1588		1.58	.69
1688		1.58	.69
1789		1.58	.69
1889		1.58	.69
1989		1.58	.69
2089		1.58	.69
2189		1.58	.69
2290		1.57	.69
2390		1.58	.69
3392		1.58	.69
4395		1.58	.69
5397		1.59	.70
6399		1.58	.69
7401		1.38	.69
8404		1.58	.69
9406		1.58	.69
10408		1.58	.69
11411		1.58	.69
21434		1.58	.69
31437		1.58	.69
41480		1.59	.69
51503		1.58	.69
61527		1.58	.69
71550		1.58	.69
81573		1.58	.69
91597		1.58	.69
101620		1.58	.69
201835		1.58	.69
302090		1.58	.69
402326		1.58	.69
502366		1.57	.69
602[illegible]		1.57	.69
683037		1.57	.69
693031		1.58	.69
703056		1.57	.69
713081		1.56	.68
723106		1.56	.68
733131		1.56	.68
743156		1.56	.68
753183		1.55	.68
763208		1.54	.68
773233		1.54	.67
778246		1.54	.68
779248		1.53	.67
780231		1.53	.67
781253		1.53	.67
782236		1.52	.67
783239		1.51	.66
784261		1.50	.66
785264		1.50	.66
786266		1.48	.65
787269		1.46	.64

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N67507

TEST DATE. 10/10/1981 * CONTRACT NO. 43-0335 PROJECT NASA
*
TYPE-02 11821 TENSION TENSION * SPECIMEN NAME N67507
TEST DIRECTION IS UP *
MATERIAL: +-67DEG,GR/EP,50% FATIQU * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 24.00 DEG. C. HUMIDITY 23.0% *
CYCLING FREQ.---------- 10.00 HERTZ * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00 100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00 HZ * THICKNESS (IN)------ .044
OPERATOR #1 *
OPERATOR #2 *
****

CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	.015	10.010	0.00000	1000.0000	0.00000	1KLB L. CELL
7	45	.010	10.015	0.00000	.07000	3.30000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N67507

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.55	1.59	.69
3		1.59	.68
5		1.58	.68
7		1.58	.68
9		1.58	.68
19		1.58	.68
29		1.58	.68
39		1.58	.68
49		1.58	.68
59		1.58	.68
69		1.58	.68
79		1.58	.68
89		1.59	.68
99		1.58	.68
199		1.58	.68
300		1.59	.69
400		1.59	.68
500		1.58	.68
600		1.59	.68
700		1.58	.68
801		1.59	.69
901		1.58	.68
1001		1.58	.68
2004		1.59	.69
3007		1.59	.69
4009		1.60	.70
5012		1.59	.69
6014		1.60	.69
7017		1.59	.69
8020		1.60	.69
9022		1.59	.69
10025		1.59	.69
20031		1.59	.69
30078		1.59	.69
40104		1.60	.69
50130		1.59	.69
60156		1.60	.69
70183		1.60	.69
80209		1.60	.69
90235		1.59	.69
100261		1.59	.69
200528		1.59	.69
270714		1.59	.69
280740		1.59	.69
290767		1.59	.69
300794		1.59	.69
310820		1.59	.69
320847		1.59	.69
330374		1.59	.69
340901		1.59	.69
350927		1.59	.69
360934		1.59	.69
367973		1.59	.69
368976		1.59	.69
369978		1.59	.69
370981		1.59	.69
371984		1.59	.69
372986		1.59	.69
373989		1.59	.68
374992		1.59	.69
375995		1.59	.69
376997		1.59	.69

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N67508

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TEST DATE                            10/18/1984 * CONTRACT NO. 43-0335     PROJECT NASA
                                                *
TYPE-80  1621 TENSION TENSION                   * SPECIMEN NAME  N67508
TEST DIRECTION IN  UP                           *
MATERIAL: +-67DEG,GR/EP,50% FATIGU              * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE: 23.00 DEG. C, HUMIDITY 20.0%       *
CYCLING FREQ.----------- 10.00 HERTZ            * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT--- 10.00       100.00     * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ              * THICKNESS (IN)------  .044
OPERATOR #1  SHIPPEN                            *
OPERATOR #2                                     *
***************************************************************************************
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CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
8	42	.015	10.010	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.015	0.00000	.07000	3.00000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98400	LAT. EXT.

SPECIMEN: N67508

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.59	1.60	.68
3		1.59	.68
5		1.60	.68
7		1.59	.68
9		1.61	.68
19		1.59	.68
29		1.59	.68
39		1.59	.68
49		1.60	.68
59		1.59	.68
69		1.59	.68
80		1.60	.68
90		1.61	.68
100		1.60	.68
199		1.60	[illegible]
300		1.59	.68
400		1.60	.68
501		1.60	.68
601		1.60	.68
701		1.59	.68
802		1.61	.68
902		1.60	.68
1002		1.61	.68
2006		1.58	.67
3010		1.59	.68
4014		1.59	.68
5017		1.59	.68
6021		1.60	.68
7025		1.60	.68
8029		1.60	.68
9032		1.60	.68
10036		1.58	.68
20074		1.61	.68
30112		1.61	.68
40149		1.59	.68
50187		1.60	.68
60225		1.59	.68
70263		1.59	.68
80301		1.60	.68
90339		1.61	.69
100377		1.60	.68
200764		1.59	.68
301158		1.59	.68
401537		1.59	.68
501938		1.59	.68
532079		1.59	.68
542119		1.59	.68
552160		1.58	.68
562200		1.59	.68
572241		1.59	.68
582281		1.59	.68
592322		1.59	.68
602362		1.58	.67
612403		1.60	.68
622443		1.59	.68
628468		1.59	.68
629472		1.59	.68
630476		1.59	.68
631480		1.59	.68
632484		1.59	.68
633488		1.60	.68
634492		1.60	.68
635496		1.60	.68
636500		1.60	.68
637504		1.60	.68

ORIGINAL PAGE IS
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N67402

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TEST DATE                       9/30/1981 * CONTRACT NO.--NAG-3-8305     PROJECT NASA
                                          *
TYPE-09  11821 TENSION TENSION            * SPECIMEN NAME  N67402
TEST DIRECTION IS  UP                     *
MATERIAL: +-67.5,GR/EP,40% FATIGUE        * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 23.0% *
CYCLING FREQ.----------- 10.00 HERTZ      * LENGTH (IN)--------- 7.000
FUNCTION GEN RNG,MULT*-- 10.00     100.00 * WIDTH (IN)---------- 1.500
SCAN RATE---------------320.00  HZ        * THICKNESS (IN)------  .044
OPERATOR #1  MOHAN                        *
OPERATOR #2                               *
************************************************************************************
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CHAN.	TYPE	LOW	HIGH	CAL-LOW	CAL-HIGH	GAGE LEN.	DESCRIPTION
5	42	-.013	10.055	0.00000	1000.0000	0.00000	1KLB L. CELL
7	48	.010	10.020	0.00000	.07000	3.30000	LONG. EXT.
6	49	.010	10.015	0.00000	.01970	.98430	LAT. EXT.

SPECIMEN: N67402

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.52	1.56	.67
3		1.56	.68
5		1.57	.68
7		1.56	.68
9		1.56	.68
19		1.56	.67
29		1.57	.68
39		1.56	.68
49		1.56	.68
59		1.56	.68
69		1.56	.68
79		1.56	.68
89		1.56	.68
99		1.56	.68
199		1.56	.68
300		1.57	.68
400		1.56	.68
501	-	1.56	.68
601		1.56	.68
701		1.56	.68
802		1.56	.68
902		1.57	.68
1003		1.56	.68
2006		1.56	.68
3010		1.57	.68
4014		1.56	.68
5018		1.58	.69
6022		1.57	.68
7025		1.56	.68
8029		1.57	.68
9033		1.56	.68
10037		1.58	.69
20075		1.58	.69
30114		1.37	.68
40152		1.56	.68
50190		1.56	.68
60229		1.56	.68
70267		1.56	.68
80305		1.57	.68
90344		1.57	.68
100383		1.57	.68
200772		1.56	.68
301164		1.57	.68
401537		1.58	.69
501933		1.57	.68
602352		1.58	.69
702753		1.58	.69
803158		1.56	.68
903565		1.56	.68
913606		1.57	.68
923647		1.58	.69
933688		1.56	.68
943729		1.57	.68
953770		1.57	.68
963812		1.58	.69
973853		1.58	.69
983894		1.58	.69
993936		1.57	.68
1003977		1.57	.69
1004982		1.58	.69
1005986		1.57	.68
1006990		1.57	.68
1007994		1.56	.68
1008998		1.59	.69
1010002		1.58	.69
1011007		1.57	.68
1012011		1.56	.68
1013015		1.57	.68
1014019	1.54	1.58	.68

ORIGINAL PAGE IS
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N67403

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TEST DATE                           10/16/1981 * CONTRACT NO. 48-0035    PROJECT NASA
                                               *
TYPE-09   11021 TENSION TENSION                * SPECIMEN NAME  N67403
TEST DIRECTION IS  UP                          *
MATERIAL: +-67.5,GR/EP,405 FATIGUE             * SPECIMEN SHAPE RECTANGULAR
TEMPERATURE 23.00 DEG. C, HUMIDITY 50.00       *
CYCLING FREQ.------------ 10.00 HERTZ          * LENGTH (IN)---------- 7.000
FUNCTION GEN RNG.MULT---- 10.00     100.00     * WIDTH (IN)----------- 1.500
SCAN RATE---------------320.00  HZ             * THICKNESS (IN)------- .044
OPERATOR #1                                    *
OPERATOR #2                                    *
***************************************************************************************
   CHAN.   TYPE          LOW   HIGH      CAL-LOW   CAL-HIGH  GAGE LEN.    DESCRIPTION
     5      42          .015 15.010     0.00000  1000.0000    0.00000    1KLB L. CELL
     7      48          .010 10.015     0.00000     .01900    0.50000    LONG. EXT.
     6      49          .010 10.015     0.00000     .01970     .98430    LAT.  EXT.
```

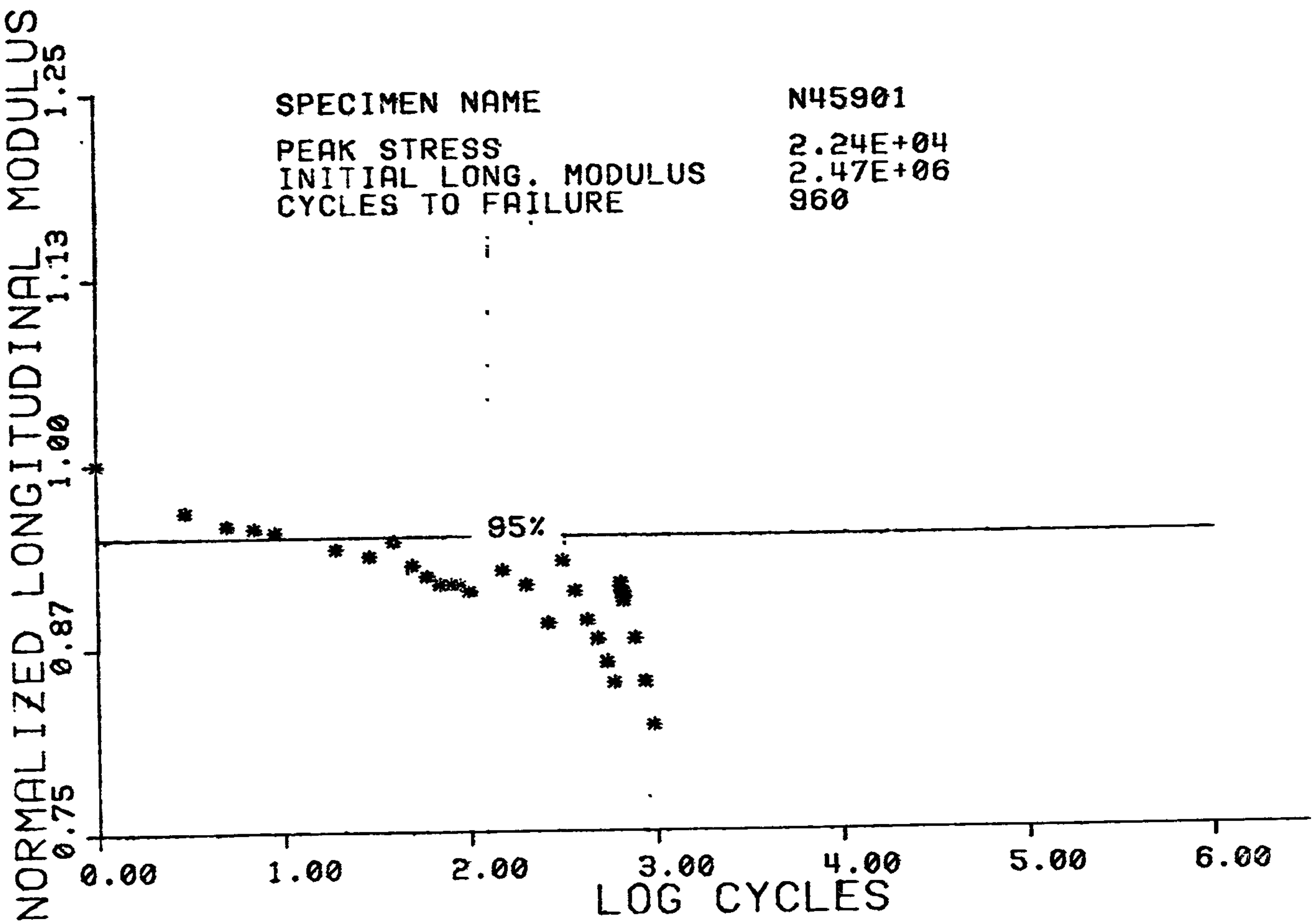
SPECIMEN: N67403

CYCLE #	STATIC LONG. MODULUS*(E+06)	DYNAMIC LONG. MODULUS*(E+06)	G(12)*(E+06)
1	1.54	1.57	.67
3		1.58	.67
5		1.57	.67
7		1.58	.67
9		1.57	.67
19		1.58	.67
29		1.57	.67
39		1.58	.67
49		1.58	.68
59		1.58	.68
69		1.57	.67
79		1.58	.67
89		1.58	.67
99		1.57	.67
199		1.58	.67
300		1.58	.68
400		1.58	.68
500		1.58	.67
601		1.59	.68
701		1.58	.67
801		1.59	.68
901		1.58	.67
1002		1.58	.68
2004		1.58	.67
3007		1.59	.68
4010		1.59	.68
5013		1.57	.67
6016		1.56	.67
7019		1.59	.68
8022		1.59	.68
9024		1.58	.68
10027		1.59	.68
20056		1.58	.68
30084		1.58	.67
40112		1.59	.68
50141		1.59	.68
60169		1.59	.68
70198		1.60	.68
80227		1.60	.68
90255		1.59	.68
100284		1.60	.68
200569		1.58	.67
300856		1.61	.69
401145		1.59	.68
501435		1.59	.68
601726		1.58	.68
702022		1.59	.68
802322		1.59	.68
902626		1.59	.68
922688		1.59	.68
932719		1.59	.68
942750		1.58	.68
952781		1.59	.68
962812		1.58	.68
972843		1.59	.68
982874		1.59	.68
992905		1.58	.67
1002936		1.59	.68
1012967		1.58	.68
1013970		1.58	[illegible]
1014973		1.60	[illegible]
1015976		1.59	.68
1016979		1.59	.68
1017982		1.59	.68
1018985		1.59	.68
1019988		1.57	.67
1020992		1.60	.68
1021995		1.60	.68
1022998	1.56	1.59	.68

Appendix C

Modulus Decay Plots

This appendix includes normalized plots of the dynamic modulus for both the $[\pm 45]_{2s}$ and the $[+67.5]_{2s}$ laminates. Additionally, per the request of the NASA-Langley Program Monitor, normalized plots of G_{12} for the $[\pm 45]_{2s}$ laminates are also included.



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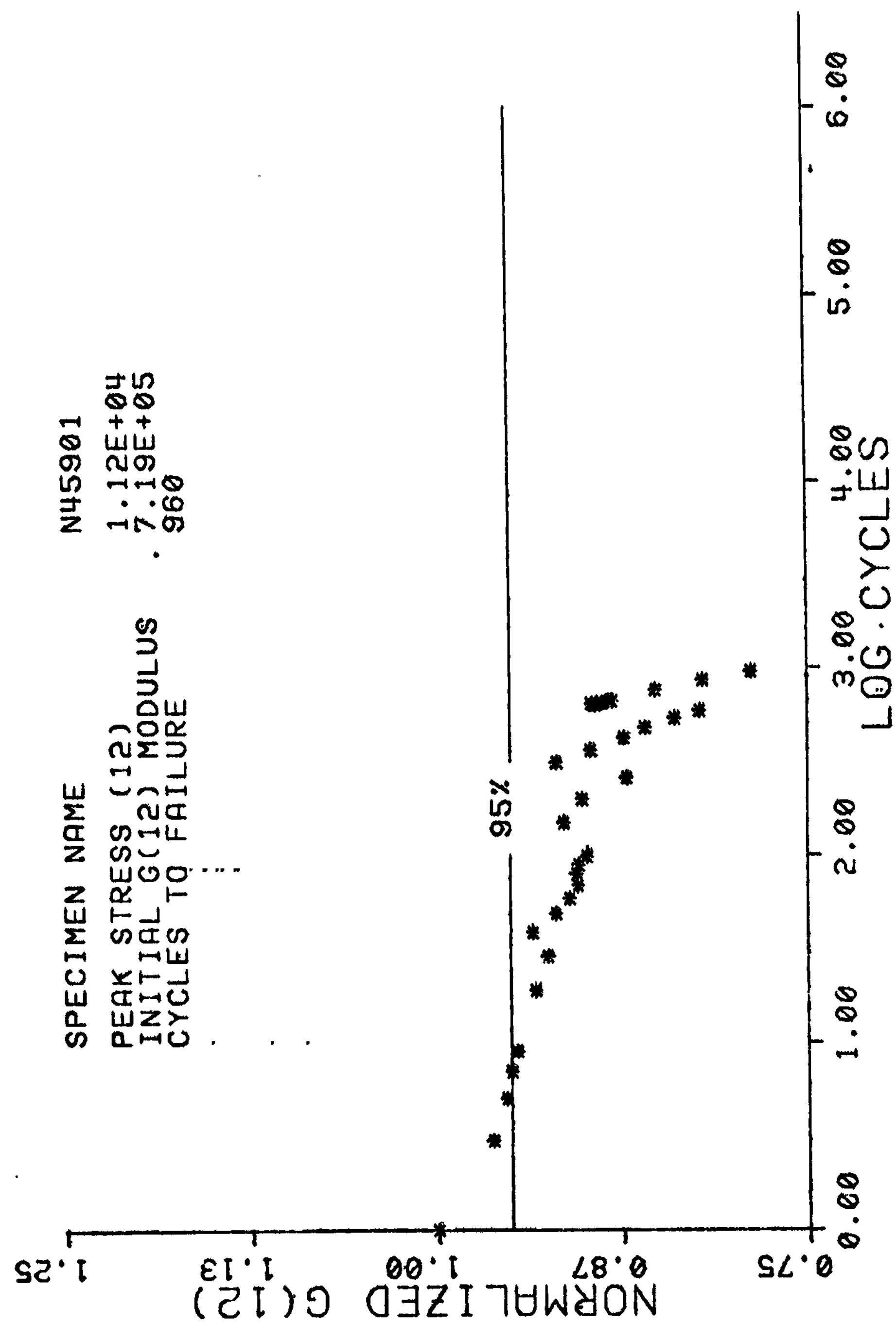
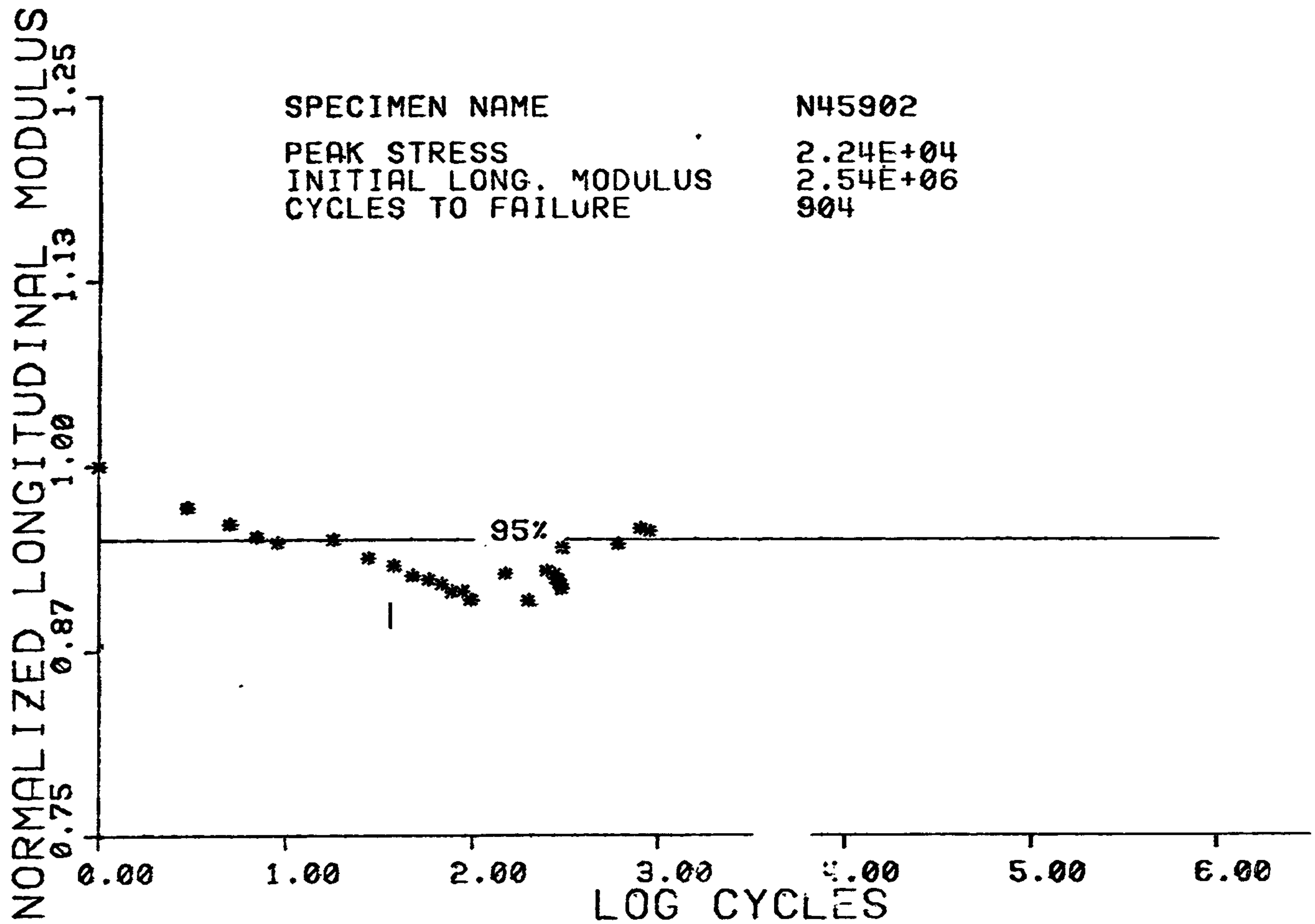
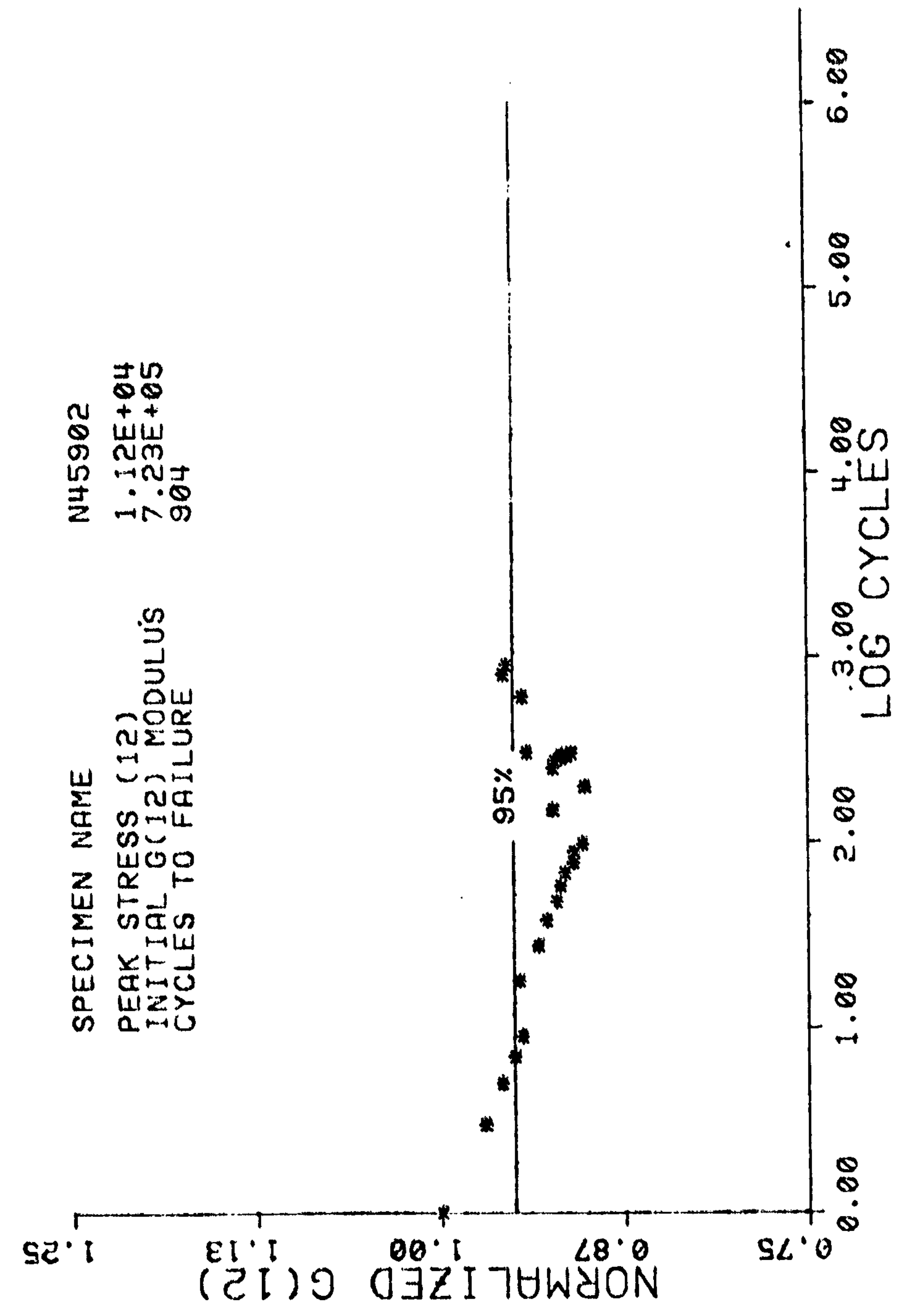
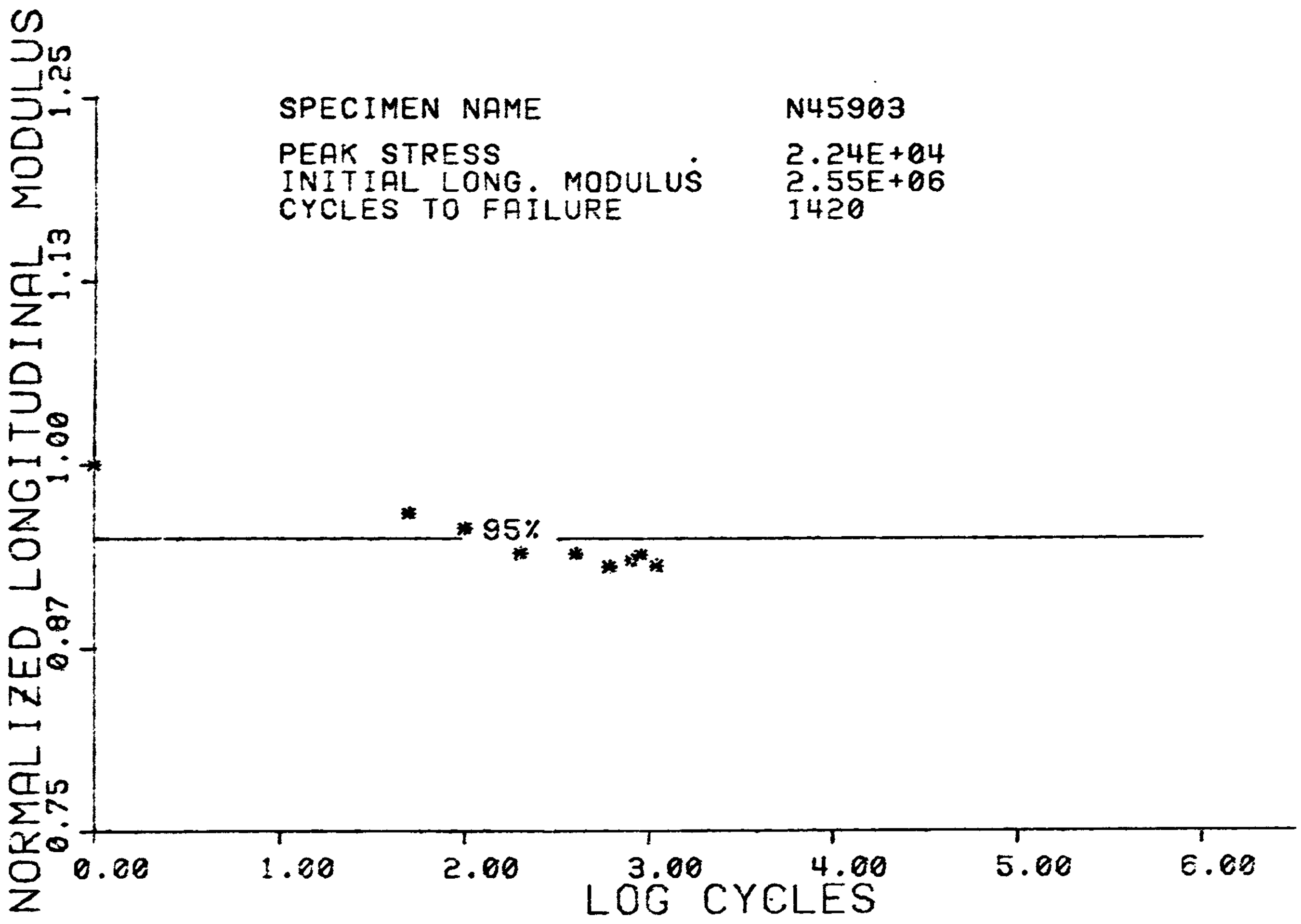
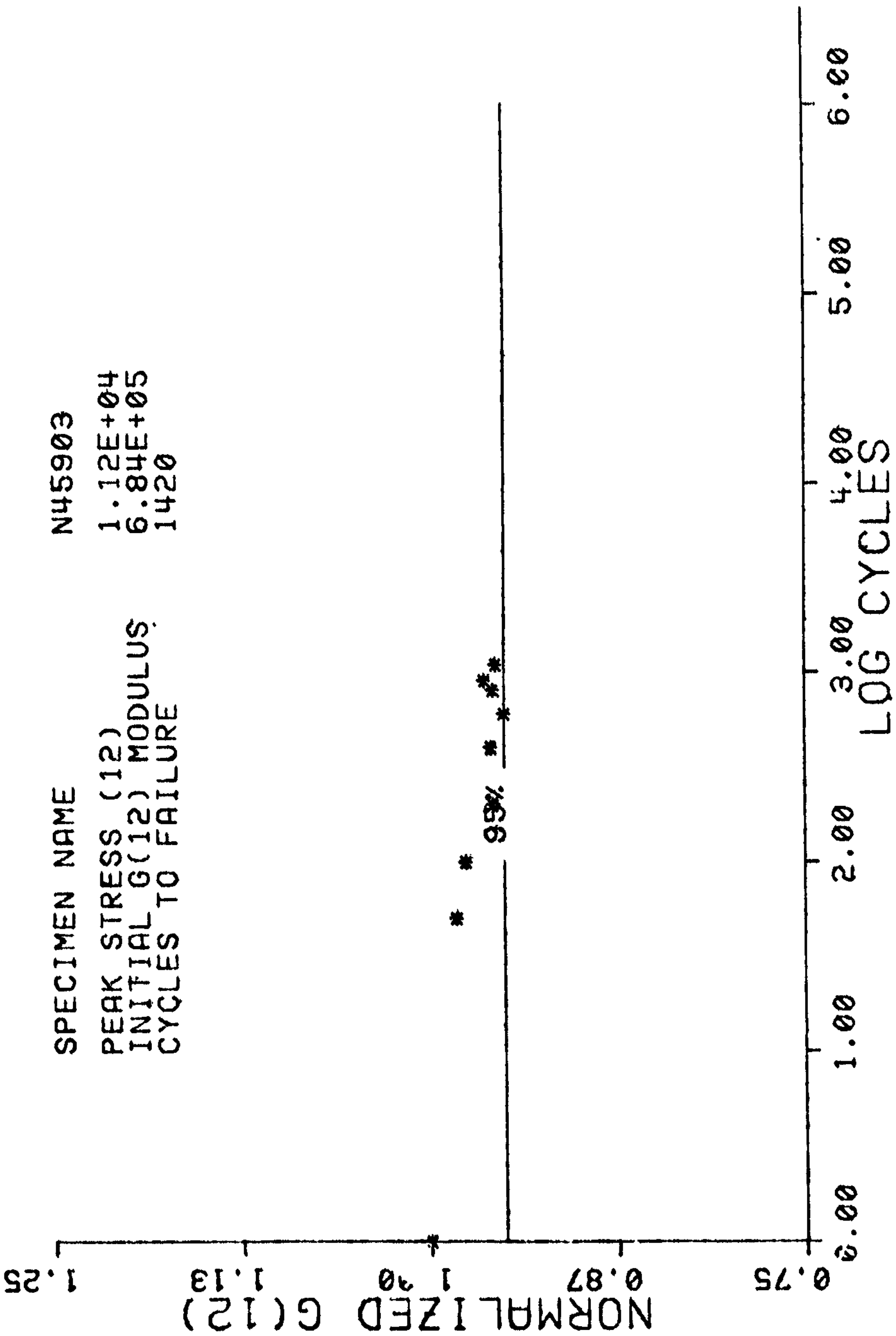


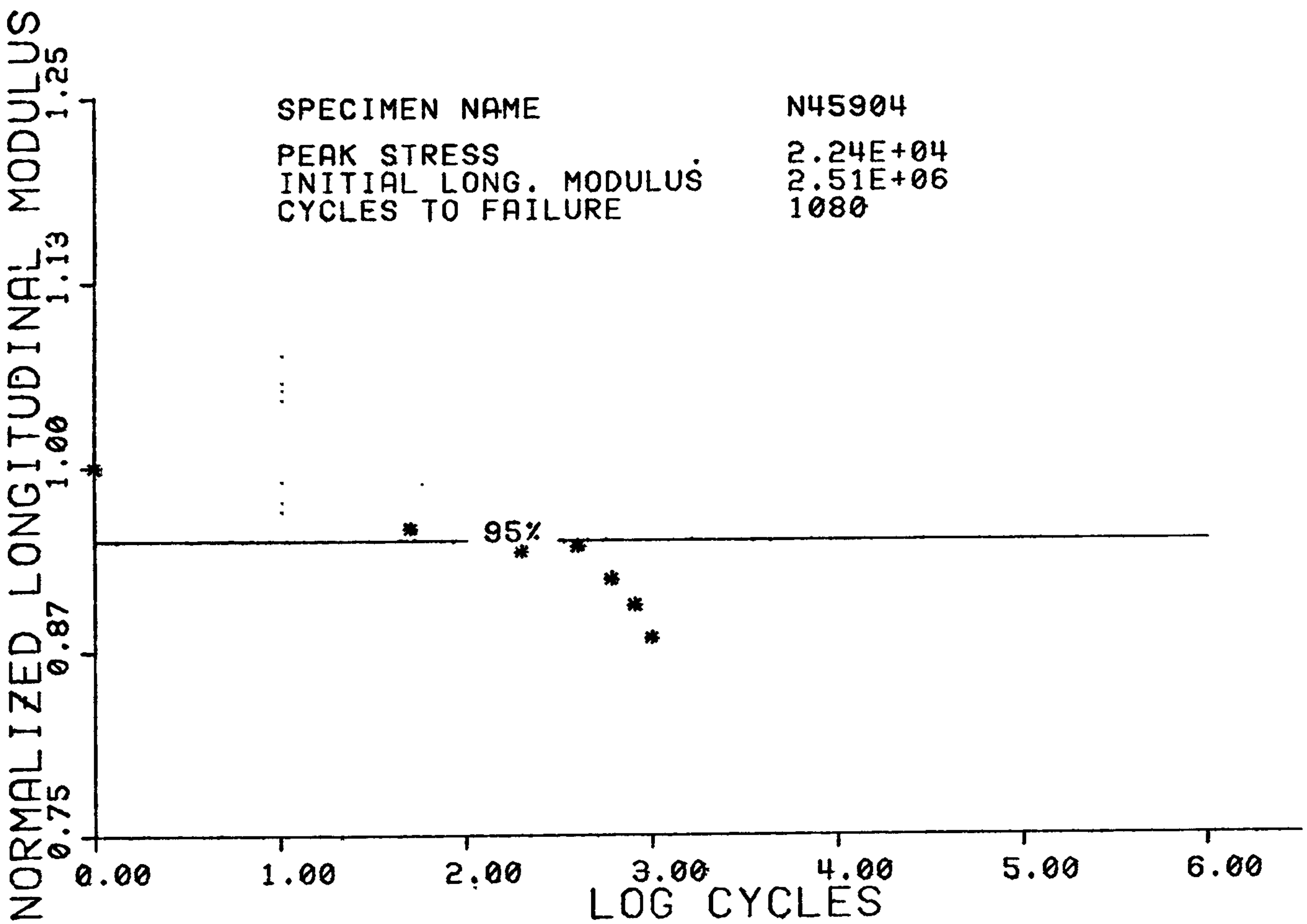

SPECIMEN NAME N45902
PEAK STRESS 2.24E+04
INITIAL LONG. MODULUS 2.54E+06
CYCLES TO FAILURE 904
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45902
PEAK STRESS (12) 1.12E+04
INITIAL G(12) MODULUS 7.23E+05
CYCLES TO FAILURE 904
95%
NORMALIZED G(12)
0.75
0.87
1.00
1.13
1.25
LOG CYCLES
0.00
1.00
2.00
3.00
4.00
5.00
6.00



SPECIMEN NAME N45903
PEAK STRESS 2.24E+04
INITIAL LONG. MODULUS 2.55E+06
CYCLES TO FAILURE 1420
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45903
PEAK STRESS (12) 1.12E+04
INITIAL G(12) MODULUS 6.84E+05
CYCLES TO FAILURE 1420
99%
NORMALIZED G(12)
1.25
1.13
1.00
0.87
0.75
LOG CYCLES
0.00
1.00
2.00
3.00
4.00
5.00
6.00


SPECIMEN NAME N45904
PEAK STRESS 2.24E+04
INITIAL LONG. MODULUS 2.51E+06
CYCLES TO FAILURE 1080
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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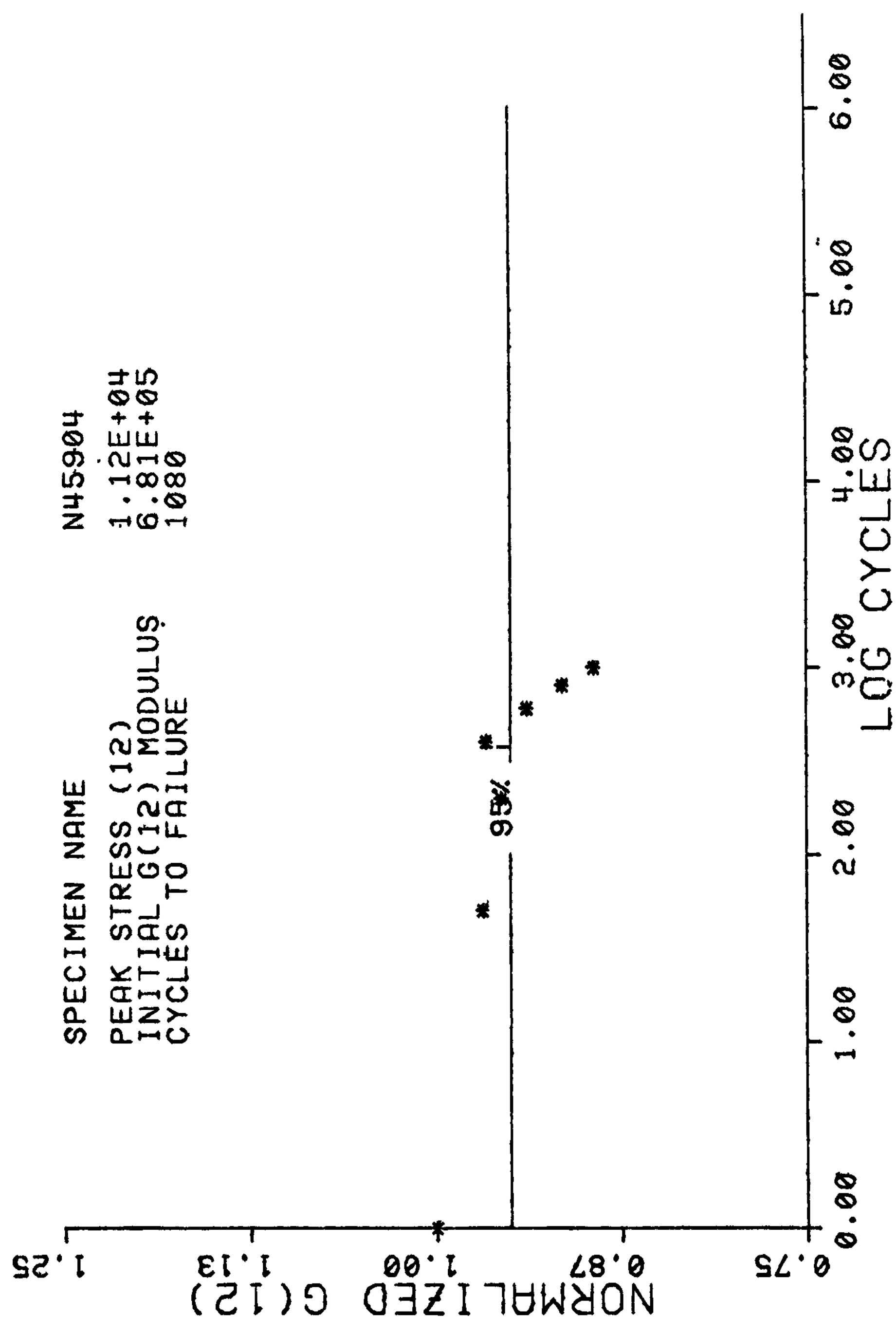

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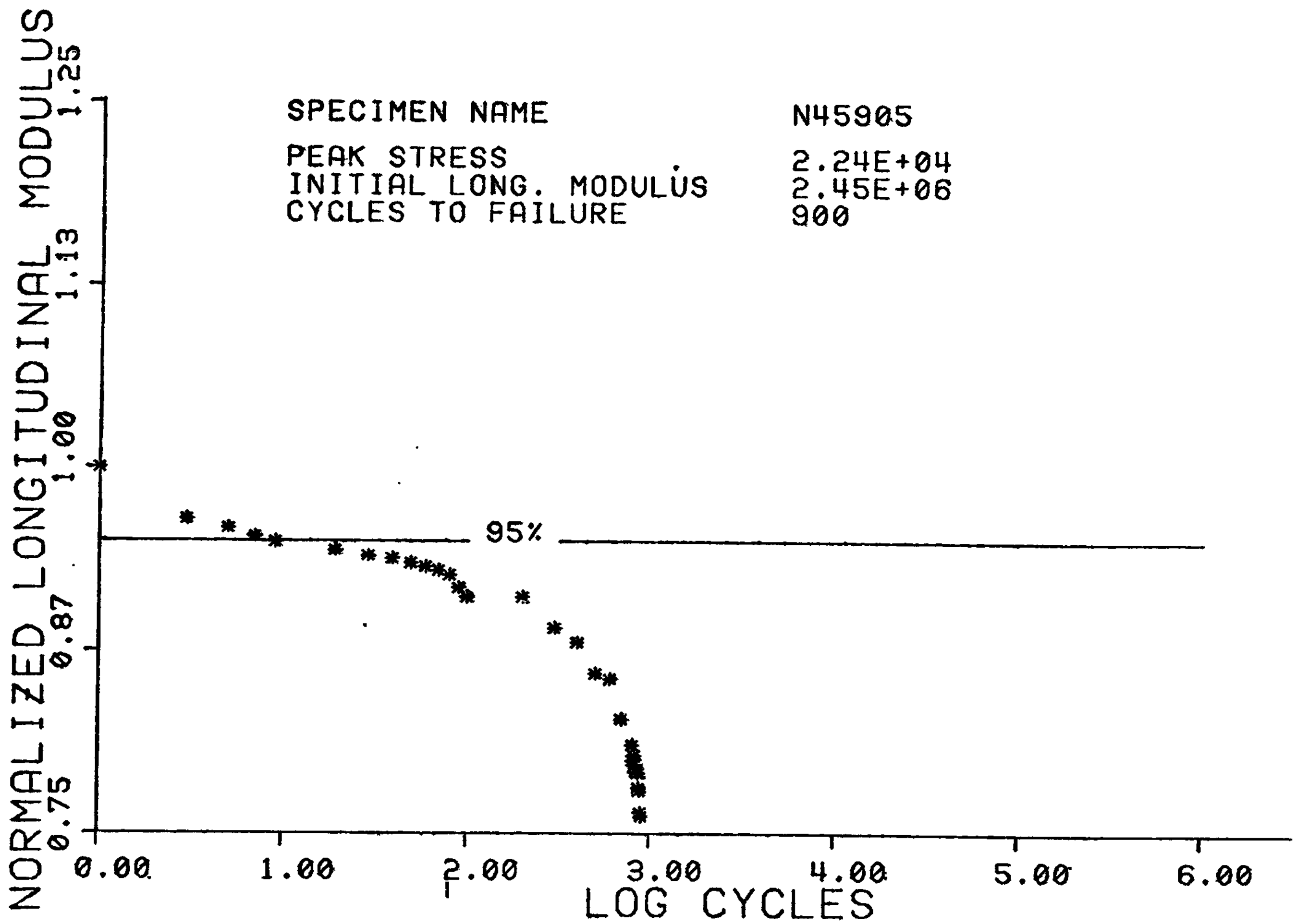

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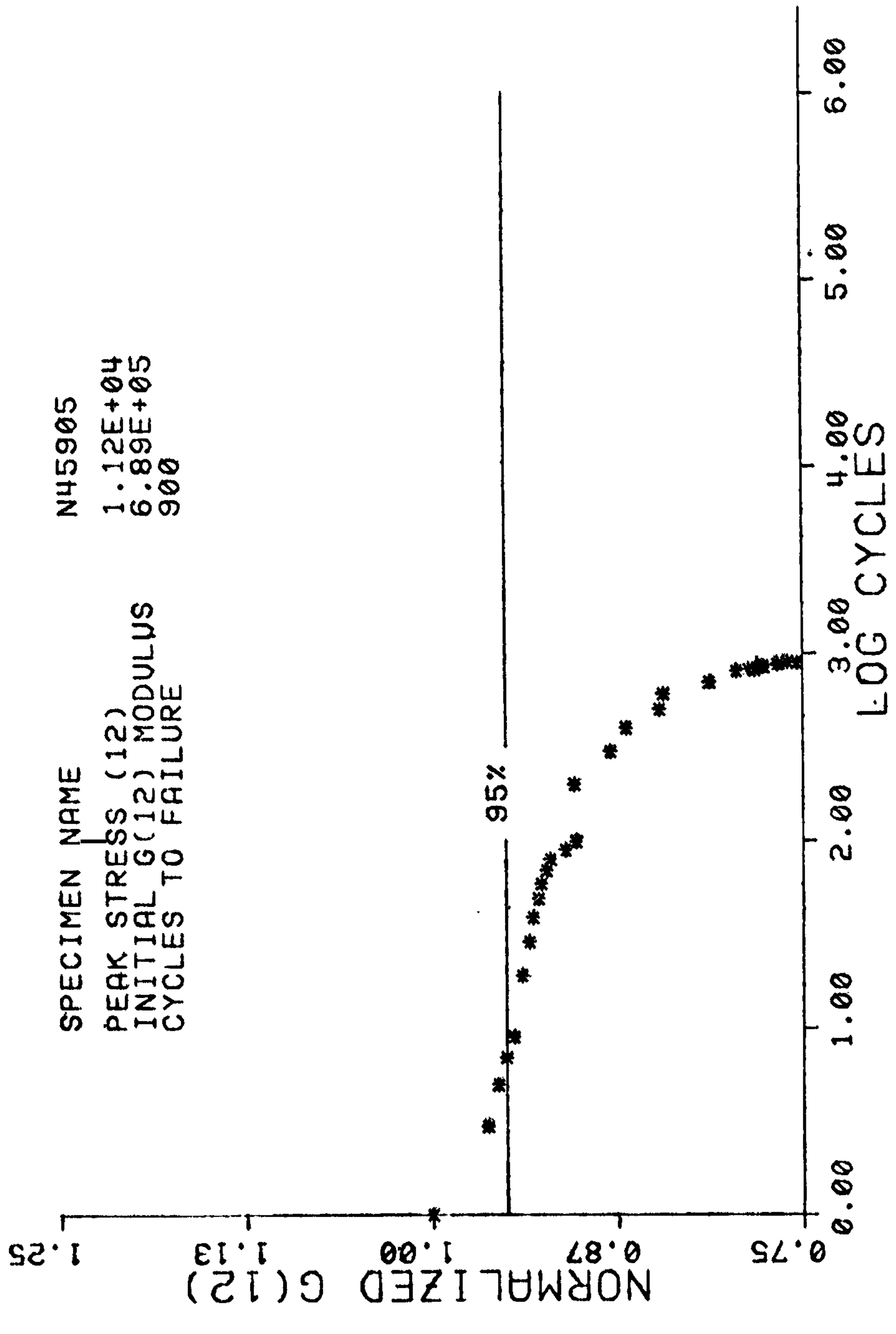
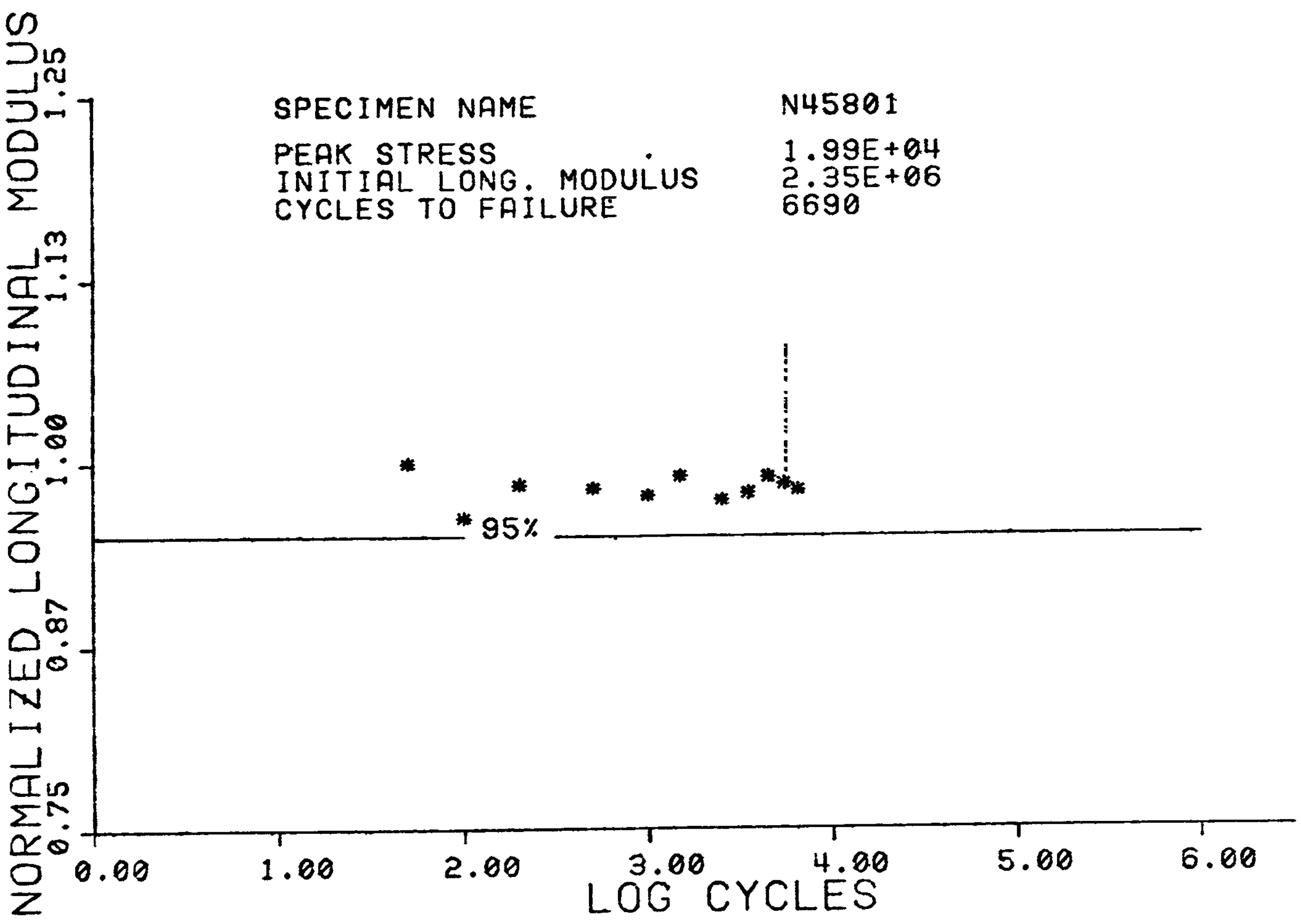
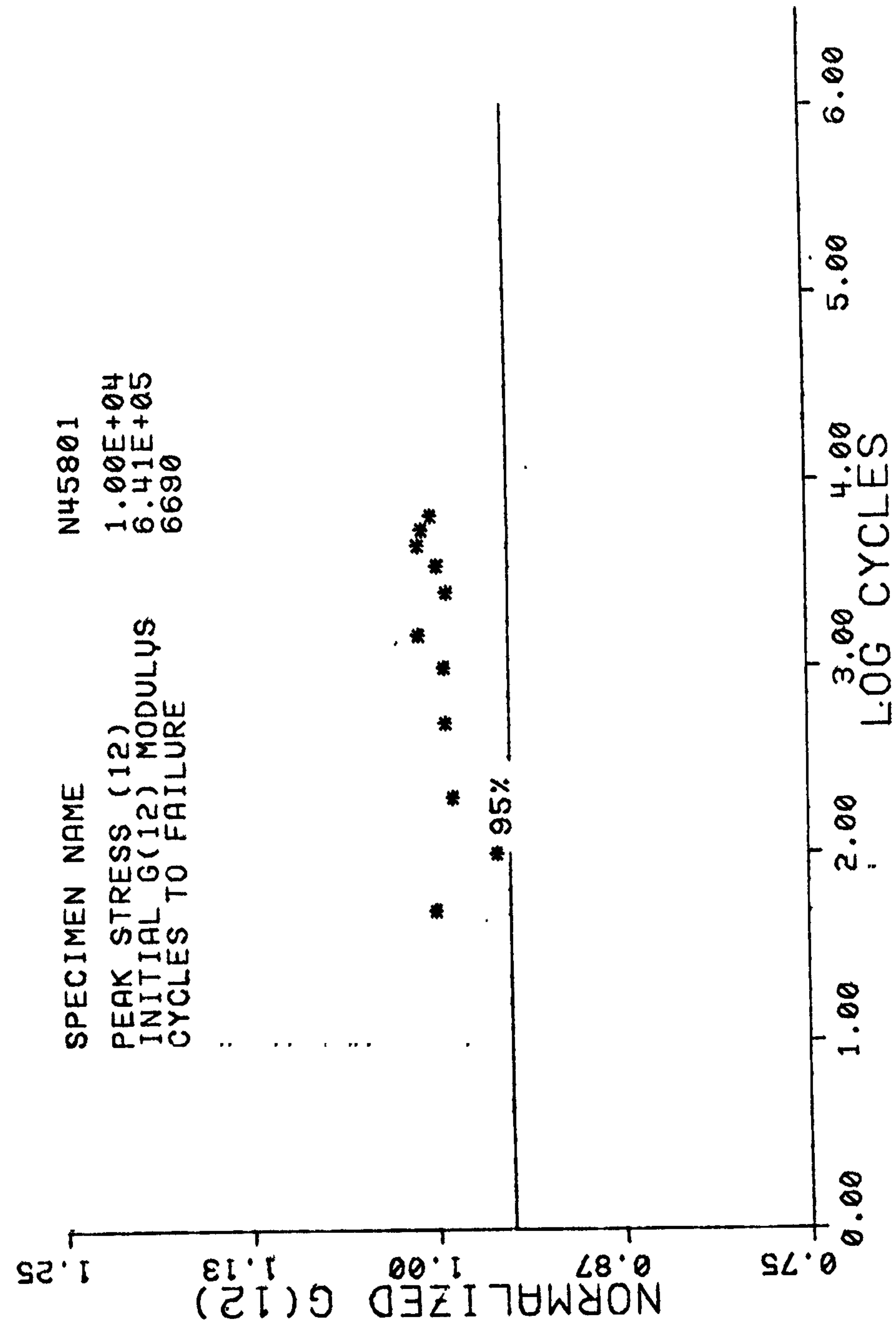
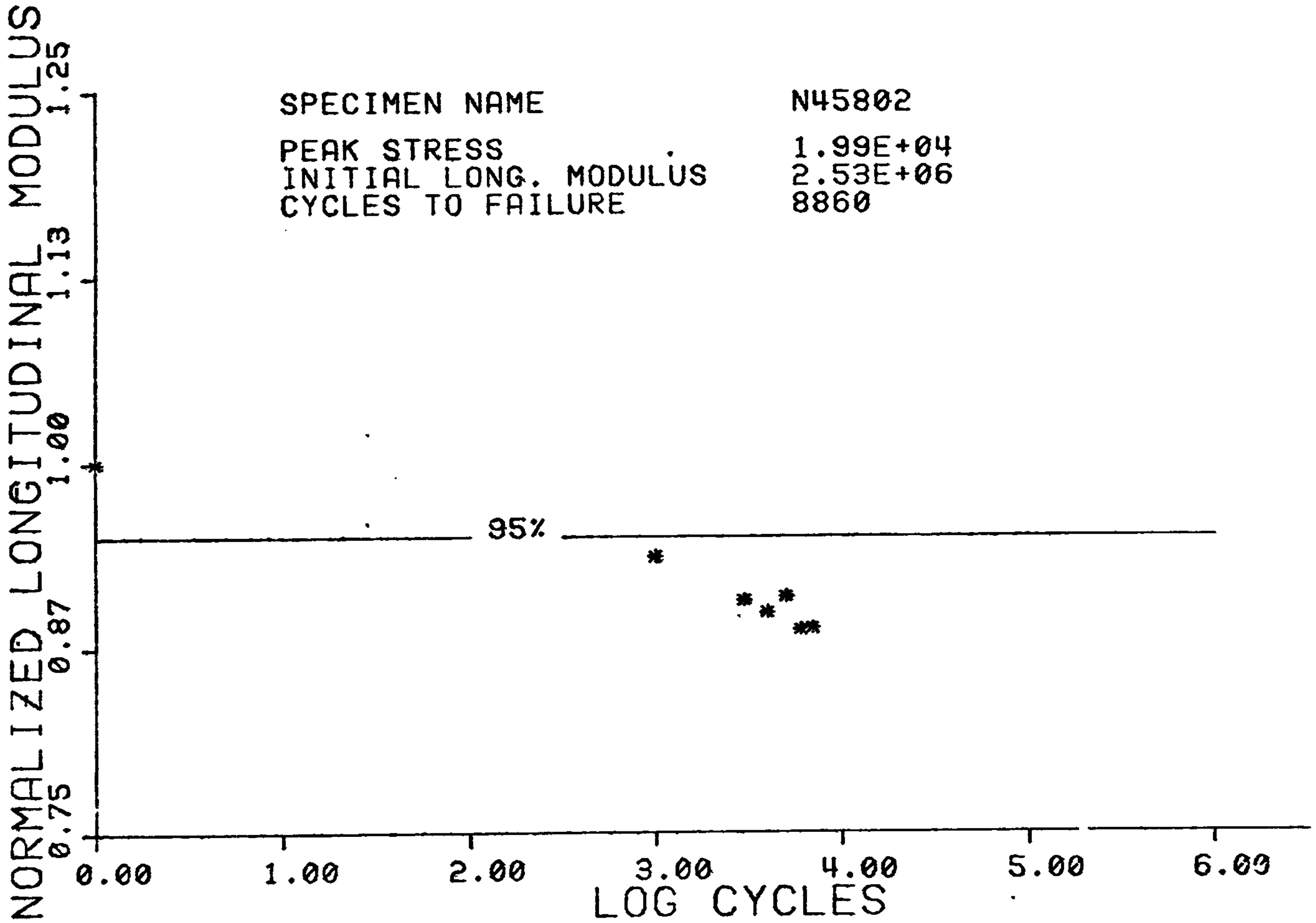



SPECIMEN NAME N45801
PEAK STRESS 1.99E+04
INITIAL LONG. MODULUS 2.35E+06
CYCLES TO FAILURE 6690
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45801
PEAK STRESS (12) 1.00E+04
INITIAL G(12) MODULUS 6.41E+05
CYCLES TO FAILURE 6690
95%
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES
0.75
0.87
1.00
1.13
1.25
NORMALIZED G(12)


SPECIMEN NAME N45802
PEAK STRESS 1.99E+04
INITIAL LONG. MODULUS 2.53E+06
CYCLES TO FAILURE 8860
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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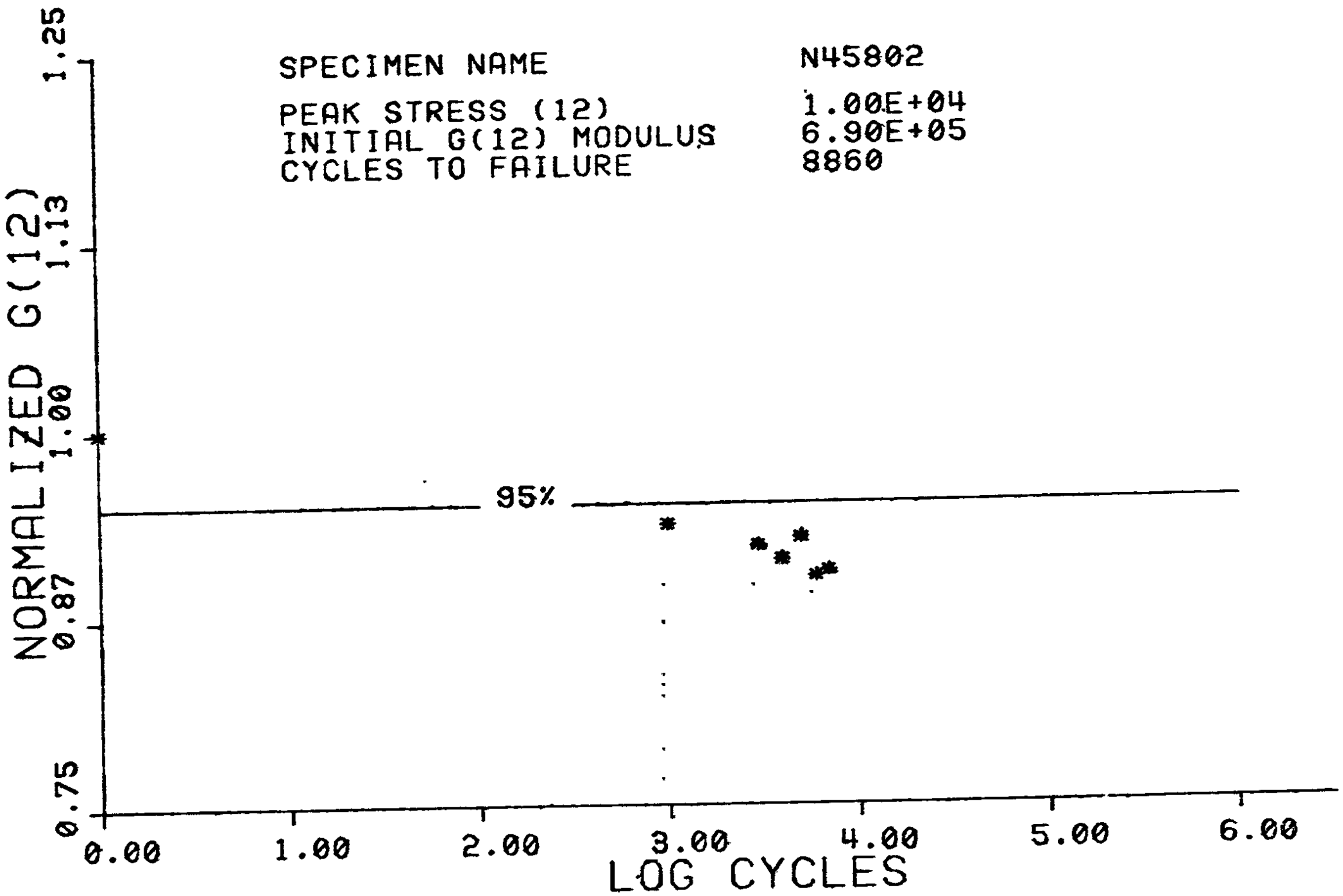
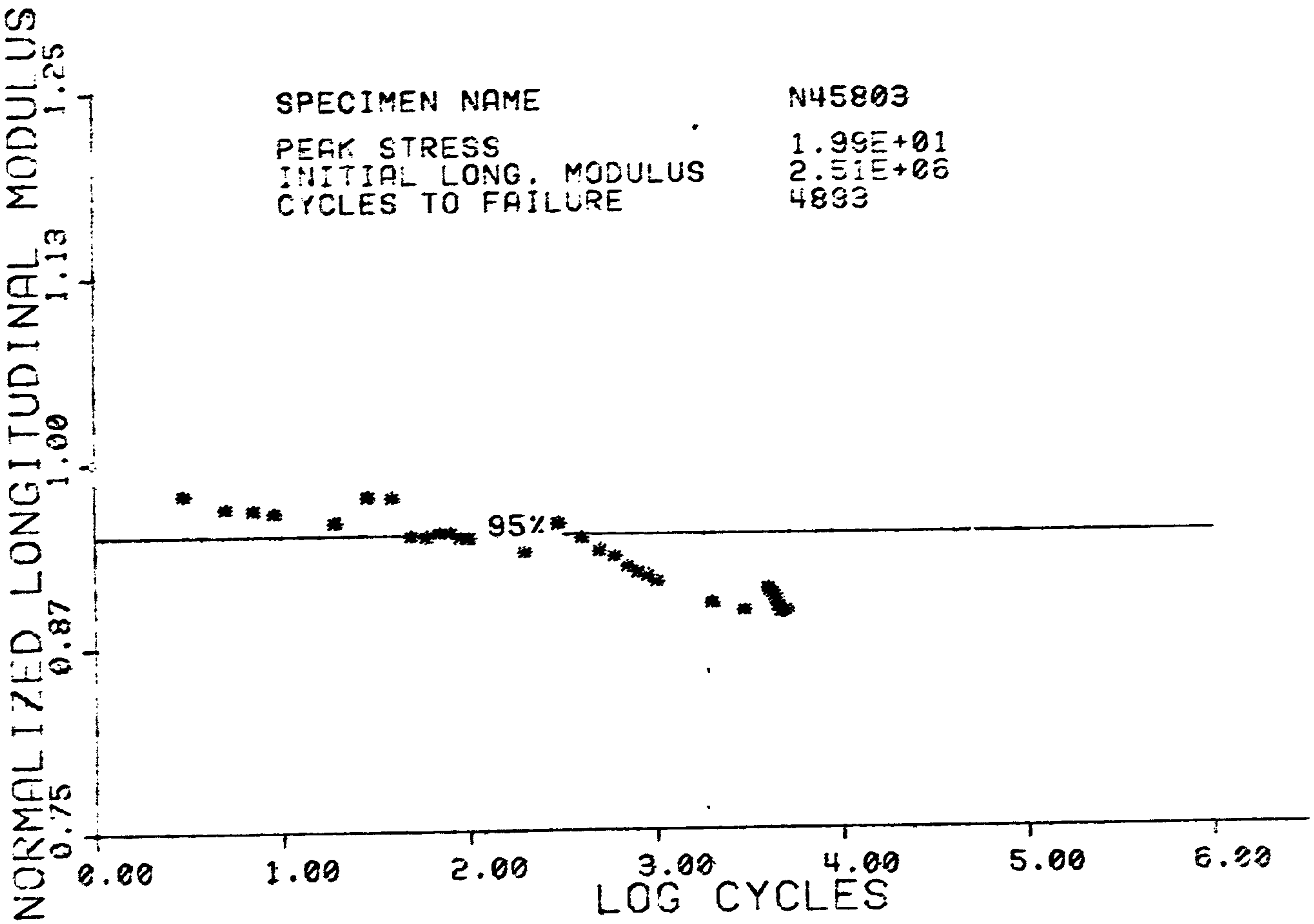
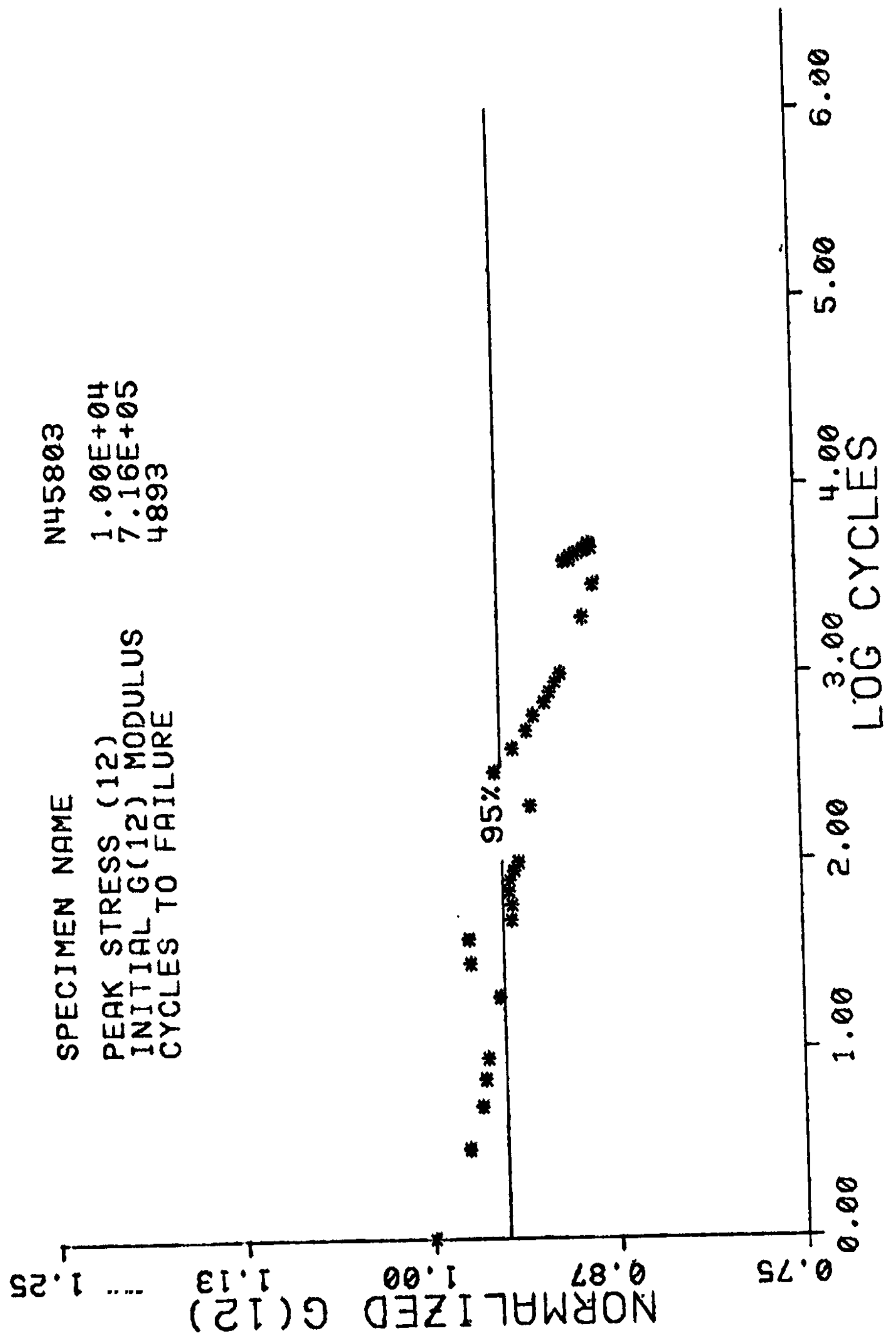
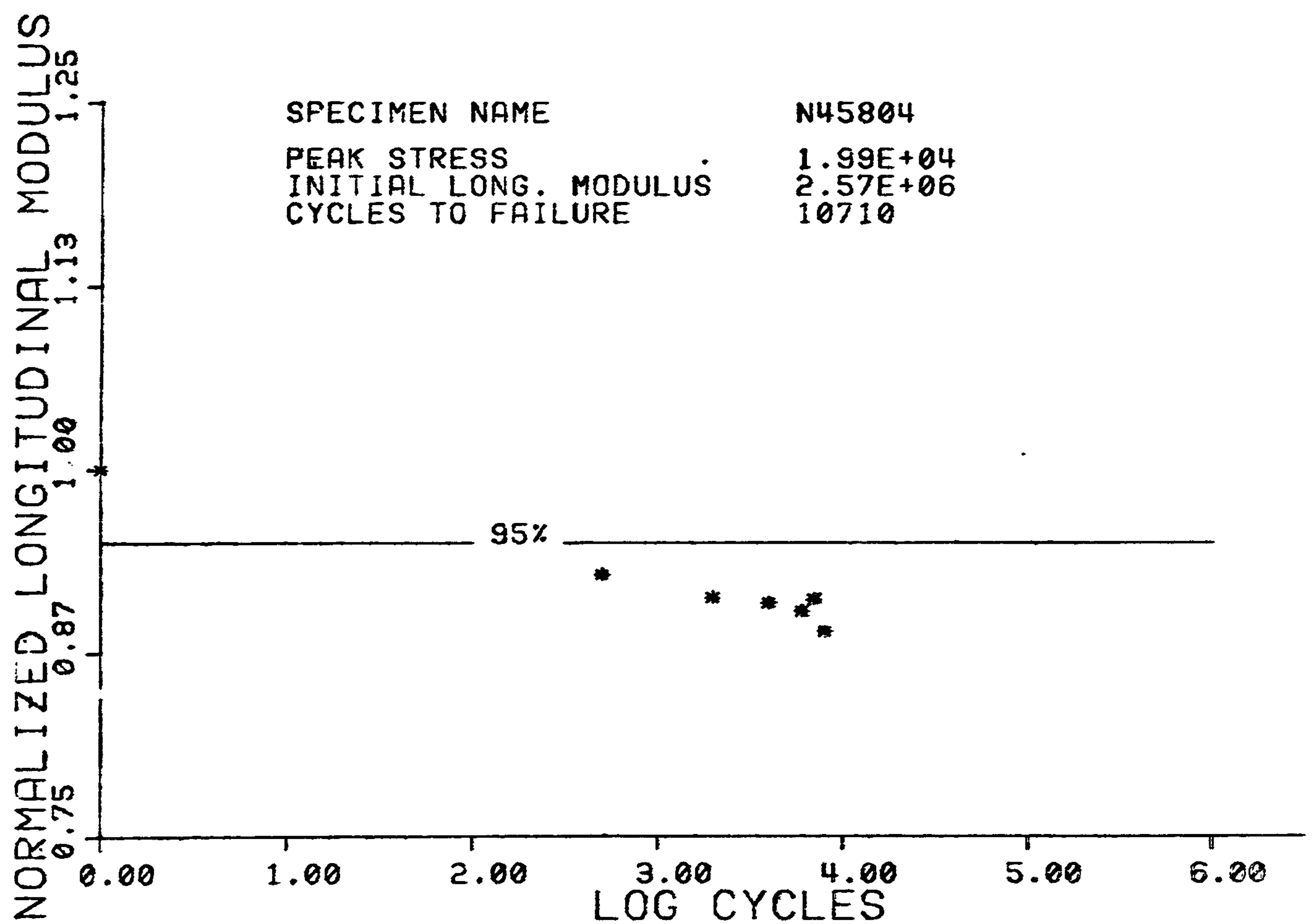



SPECIMEN NAME N45803
PEAK STRESS 1.99E+01
INITIAL LONG. MODULUS 2.51E+06
CYCLES TO FAILURE 4833
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45803
PEAK STRESS (12) 1.00E+04
INITIAL G(12) MODULUS 7.16E+05
CYCLES TO FAILURE 4893
95%
NORMALIZED G(12)
0.75
0.87
1.00
1.13
1.25
LOG CYCLES
0.00
1.00
2.00
3.00
4.00
5.00
6.00



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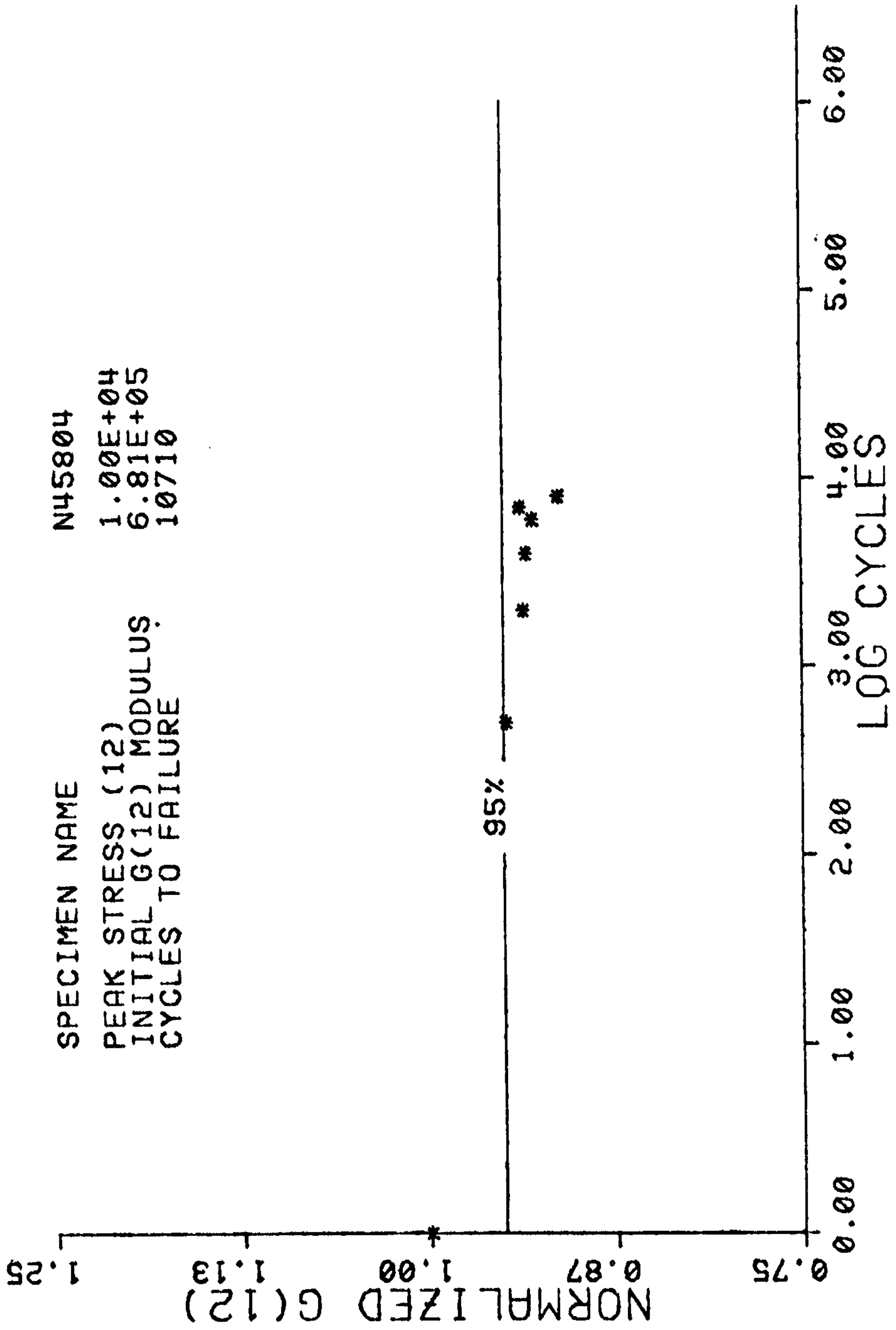
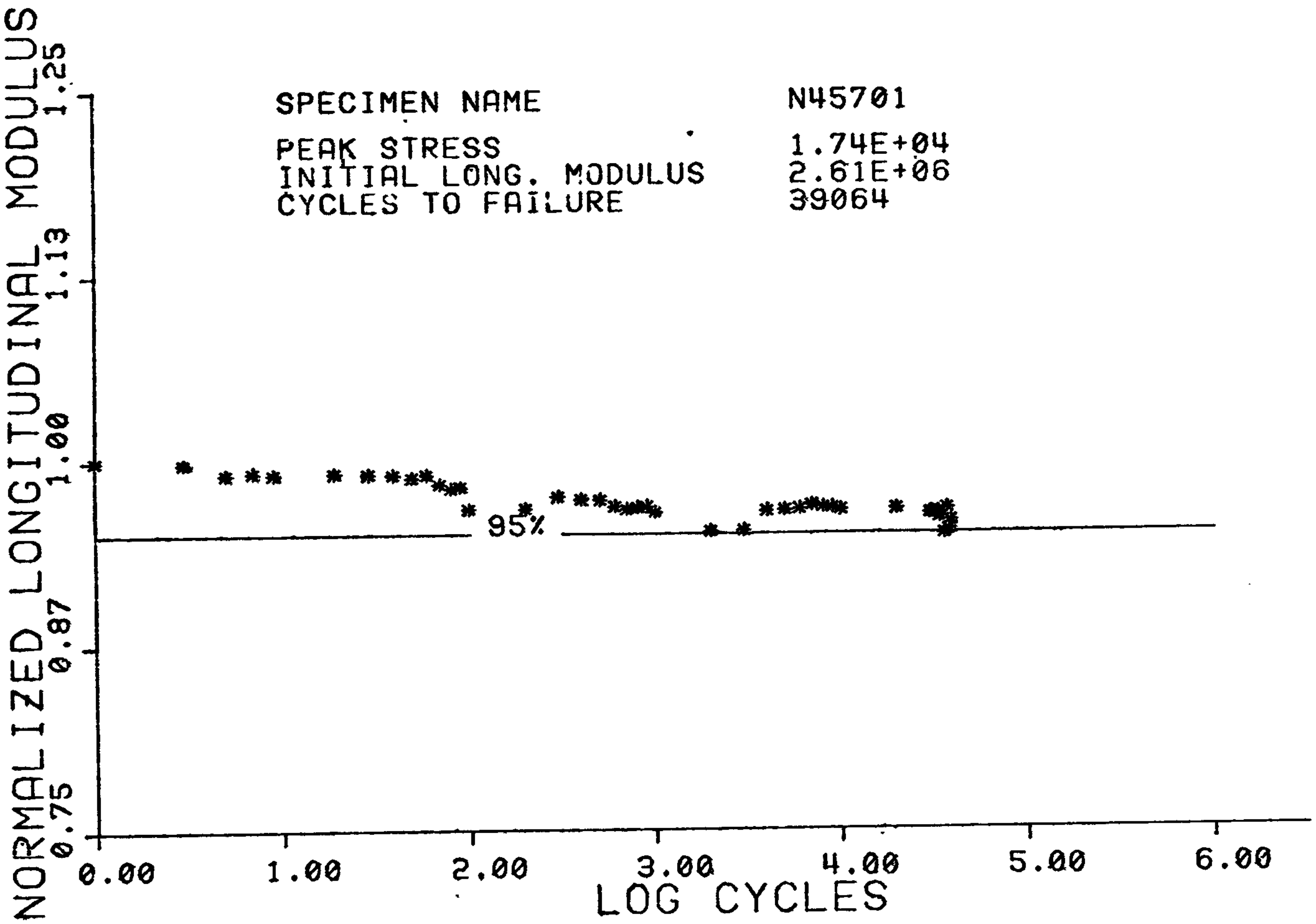
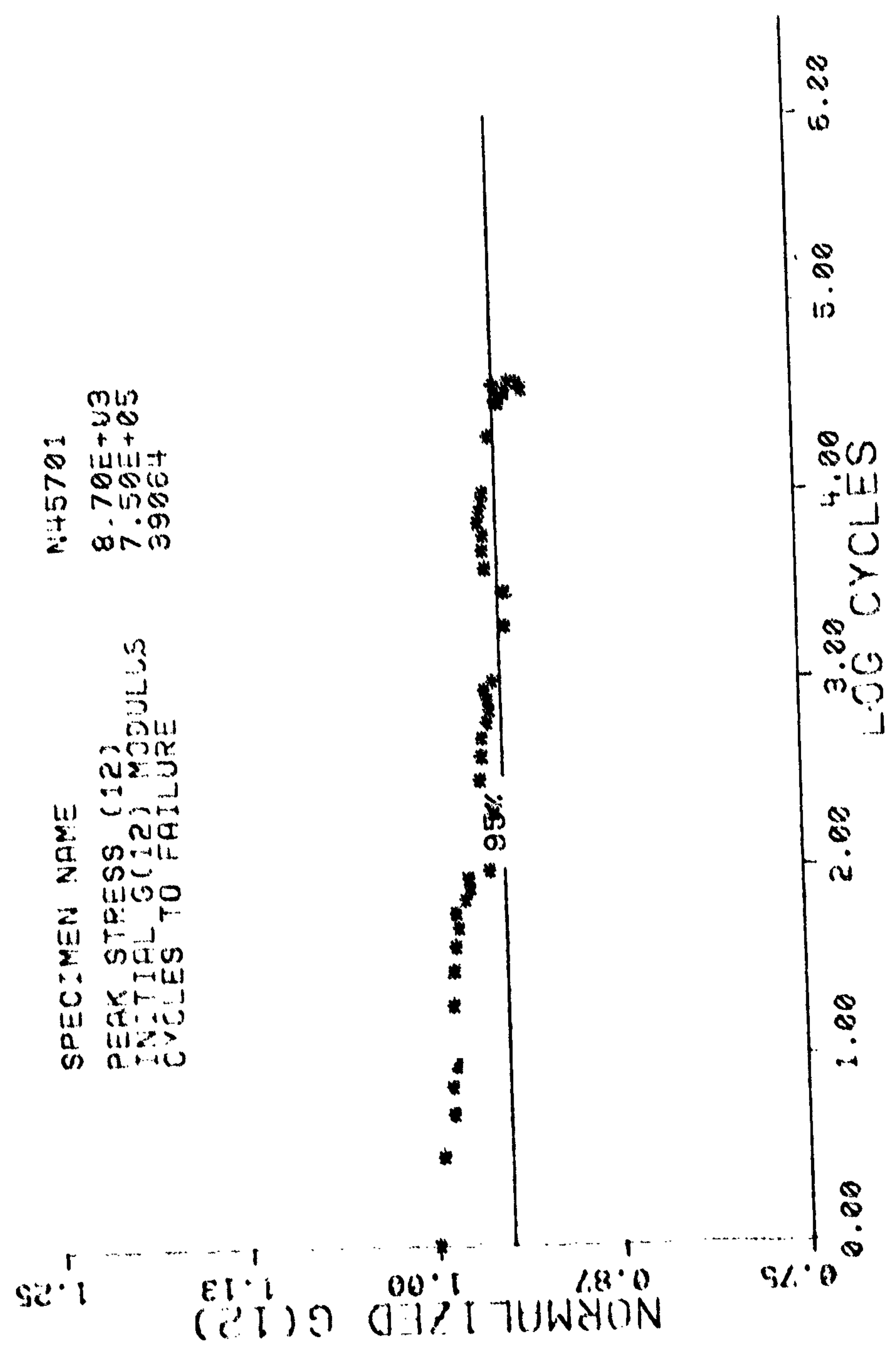
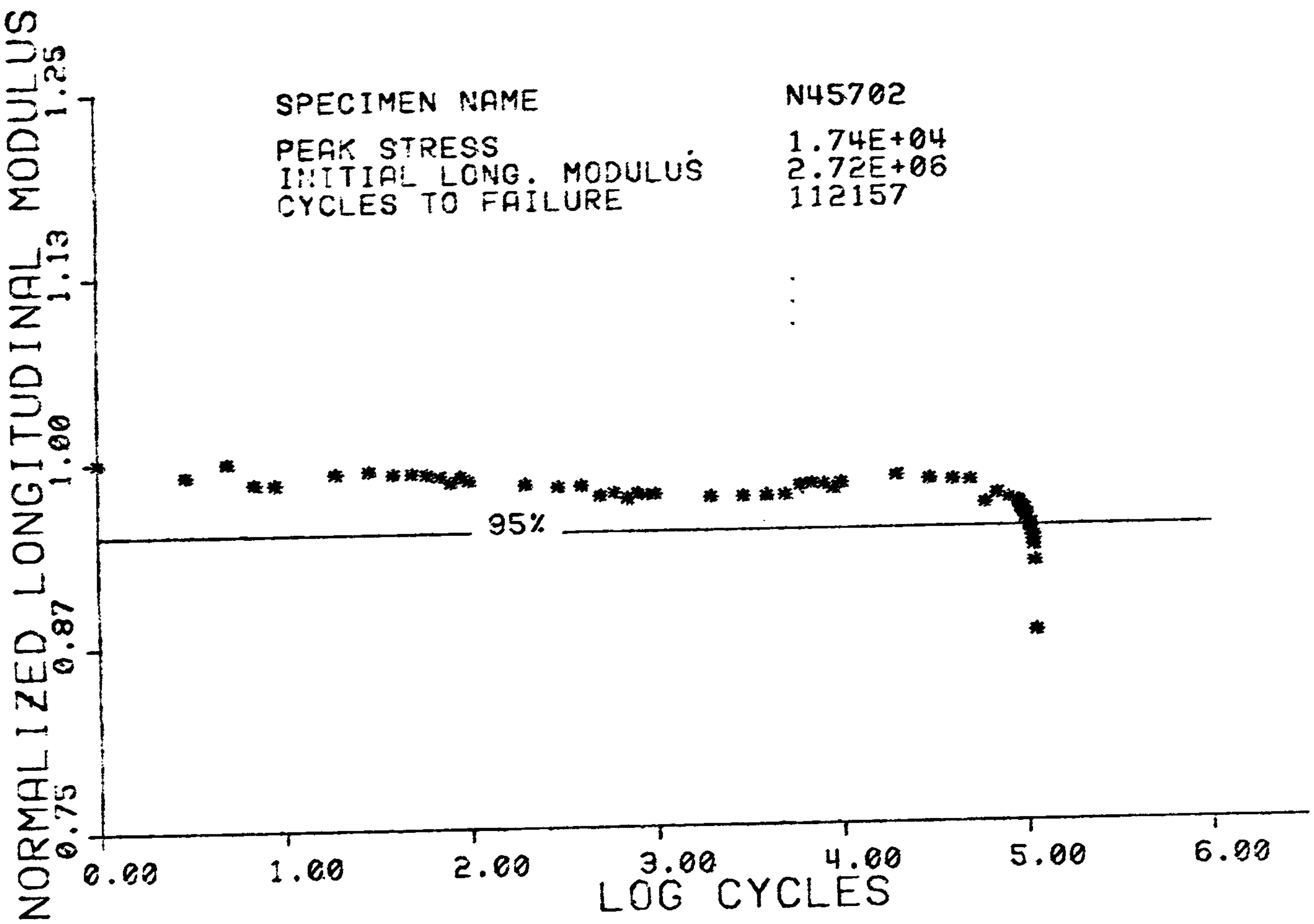
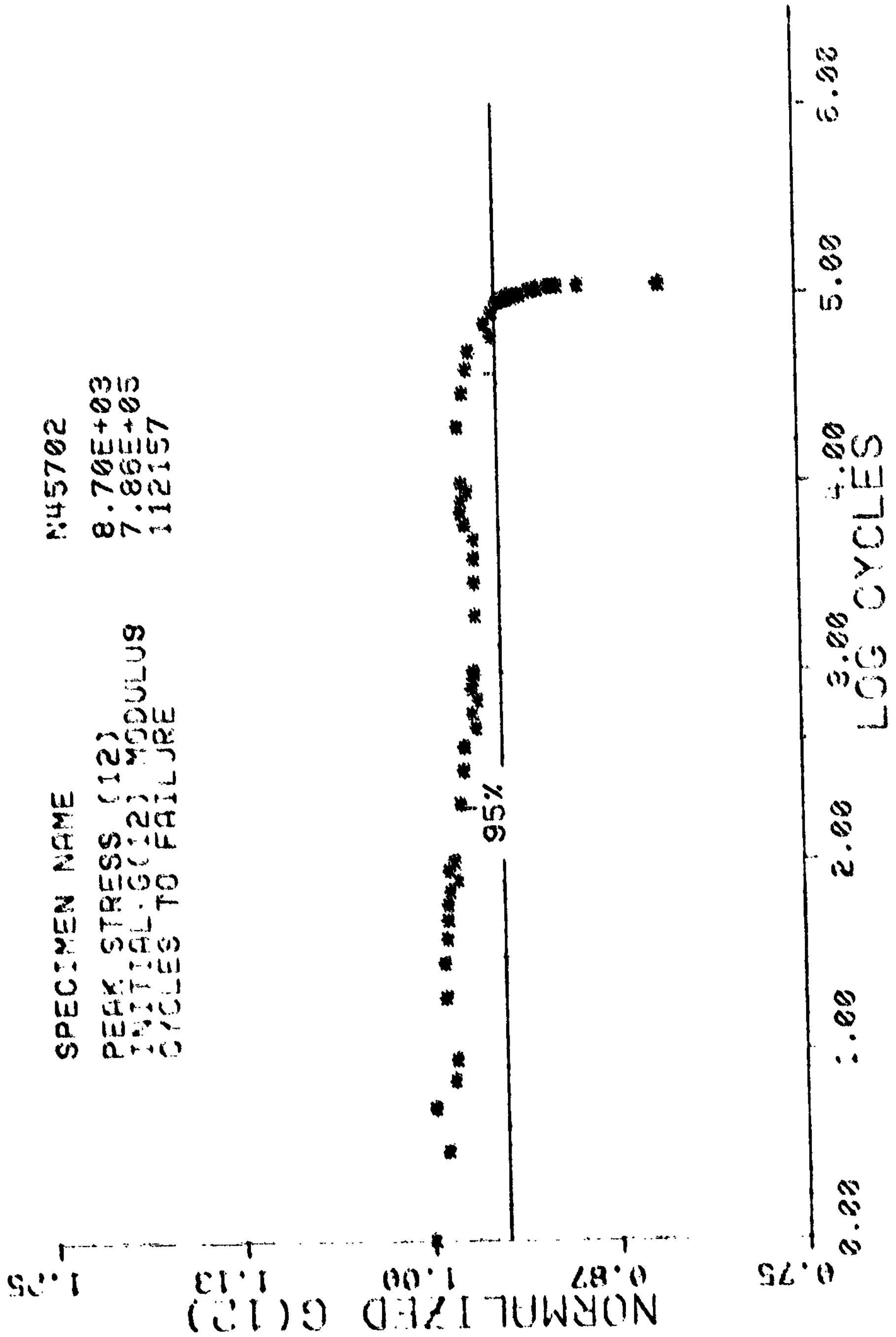

SPECIMEN NAME N45804
PEAK STRESS (12) 1.00E+04
INITIAL G(12) MODULUS 6.81E+05
CYCLES TO FAILURE 10710
95%
NORMALIZED G(12)
0.75
0.87
1.00
1.13
1.25
LOG CYCLES
0.00
1.00
2.00
3.00
4.00
5.00
6.00

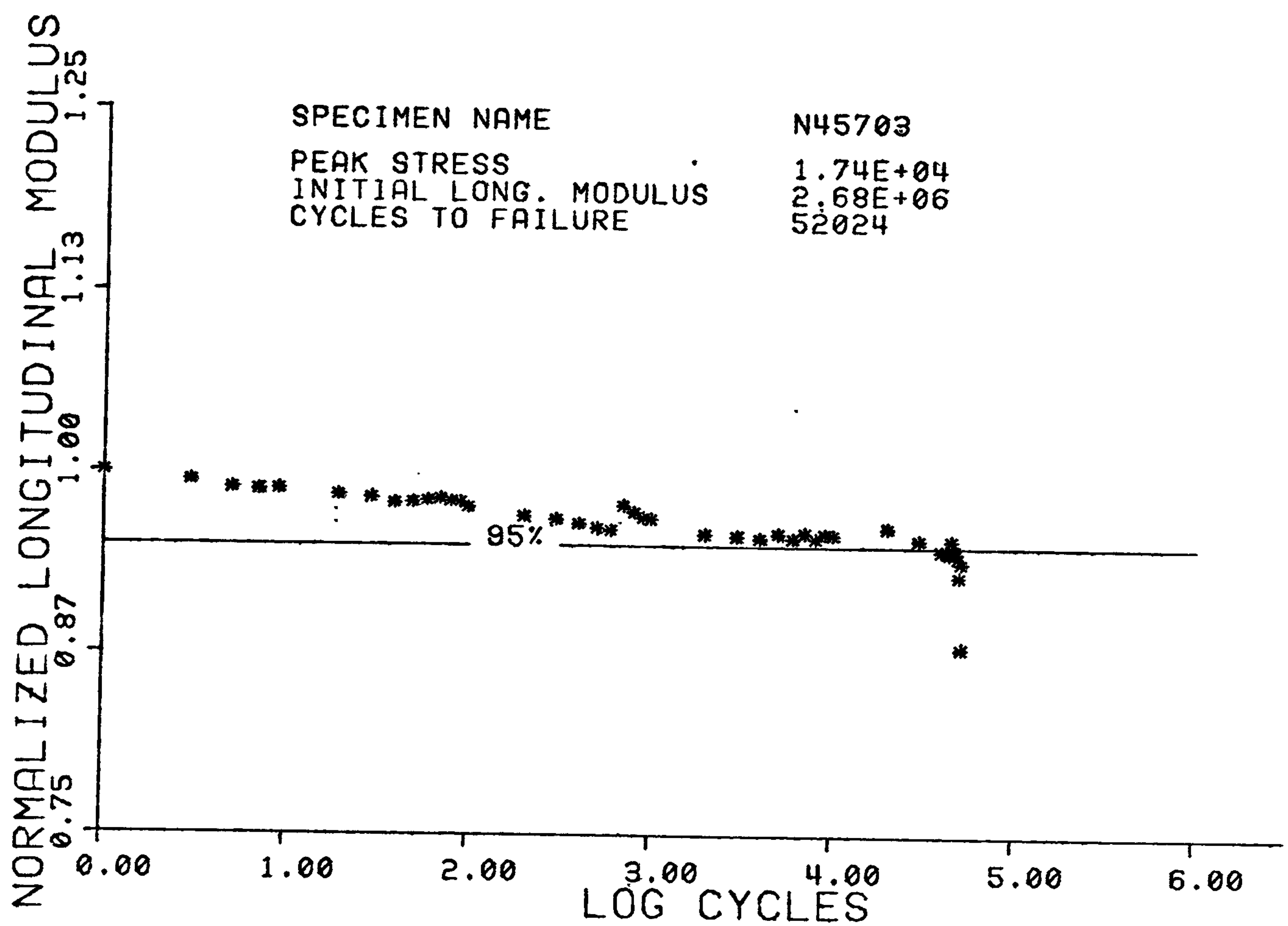

SPECIMEN NAME N45701
PEAK STRESS 1.74E+04
INITIAL LONG. MODULUS 2.61E+06
CYCLES TO FAILURE 39064
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45701
PEAK STRESS (12) 8.70E+03
INITIAL G(12) MODULUS 7.50E+05
CYCLES TO FAILURE 39064
95%
0.00
1.00
2.00
3.00
4.00
5.00
6.20
LOG CYCLES
0.75
0.87
1.00
1.13
1.25
NORMALIZED G(12)

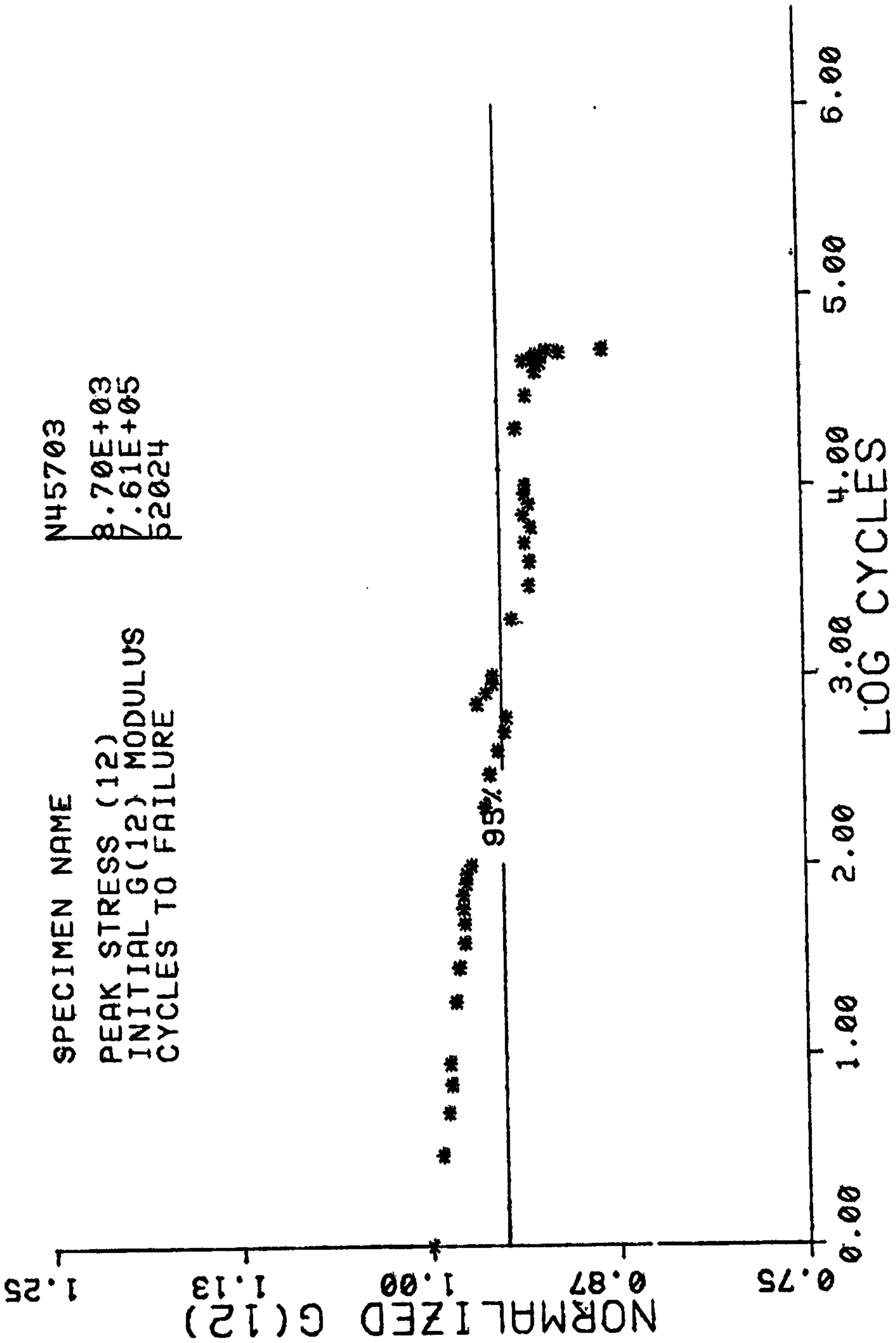


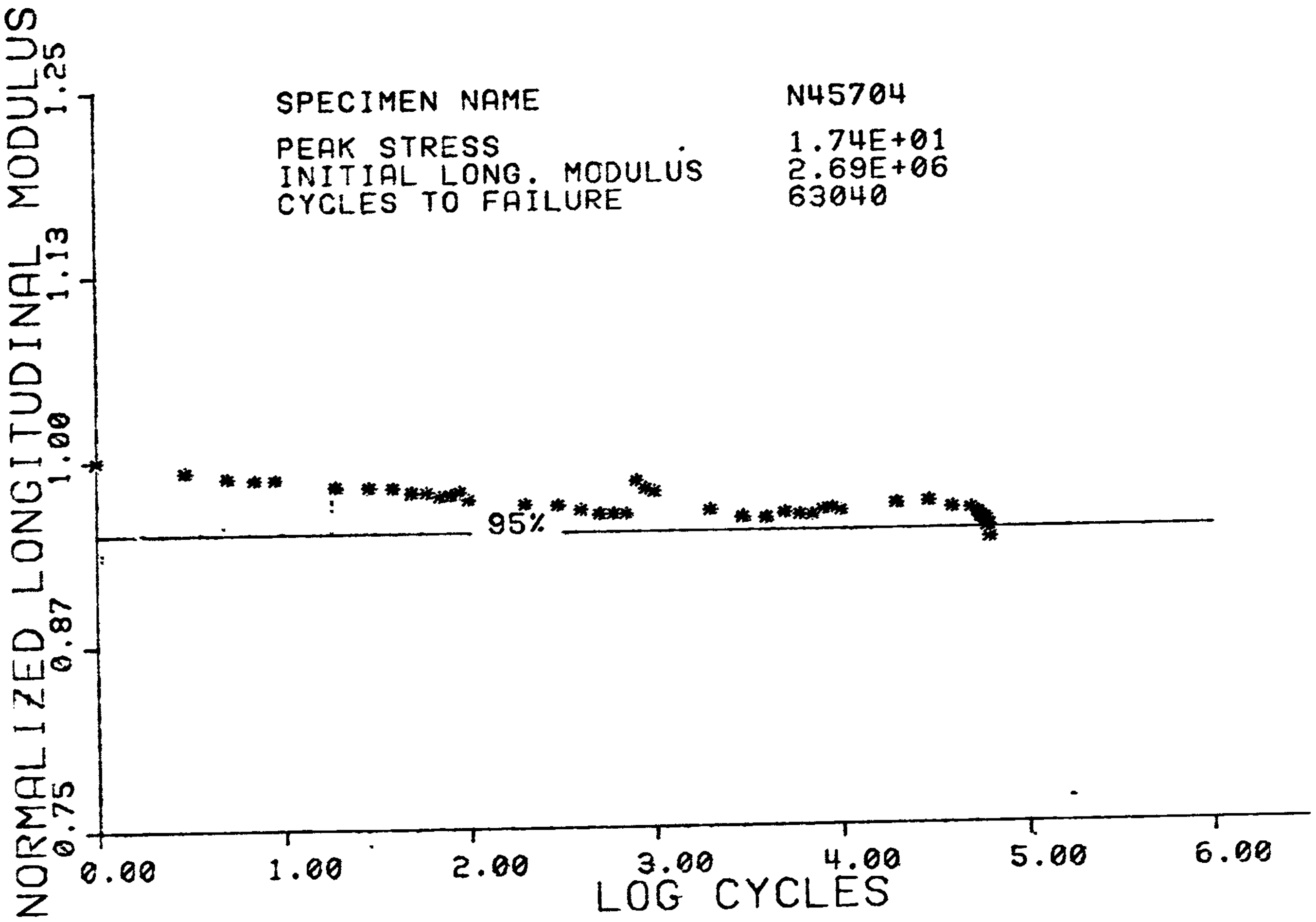
SPECIMEN NAME N45702
PEAK STRESS 1.74E+04
INITIAL LONG. MODULUS 2.72E+06
CYCLES TO FAILURE 112157
95%
NORMALIZED LONGITUDINAL MODULUS
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

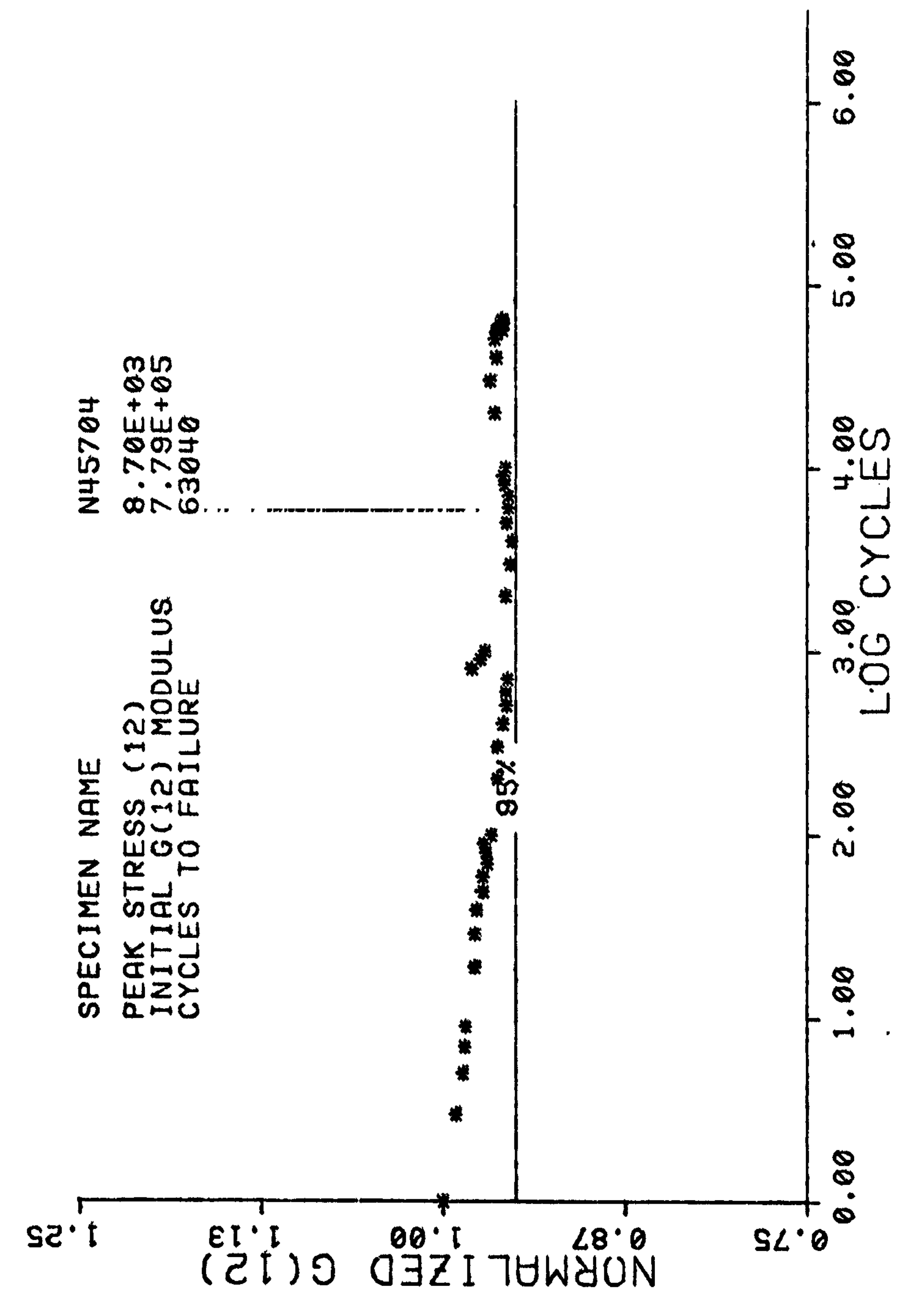

SPECIMEN NAME N45702
PEAK STRESS (12) 8.70E+03
INITIAL G(12) MODULUS 7.86E+05
CYCLES TO FAILURE 112157
95%
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES
0.75
0.87
1.00
1.13
1.25
NORMALIZED G(12)

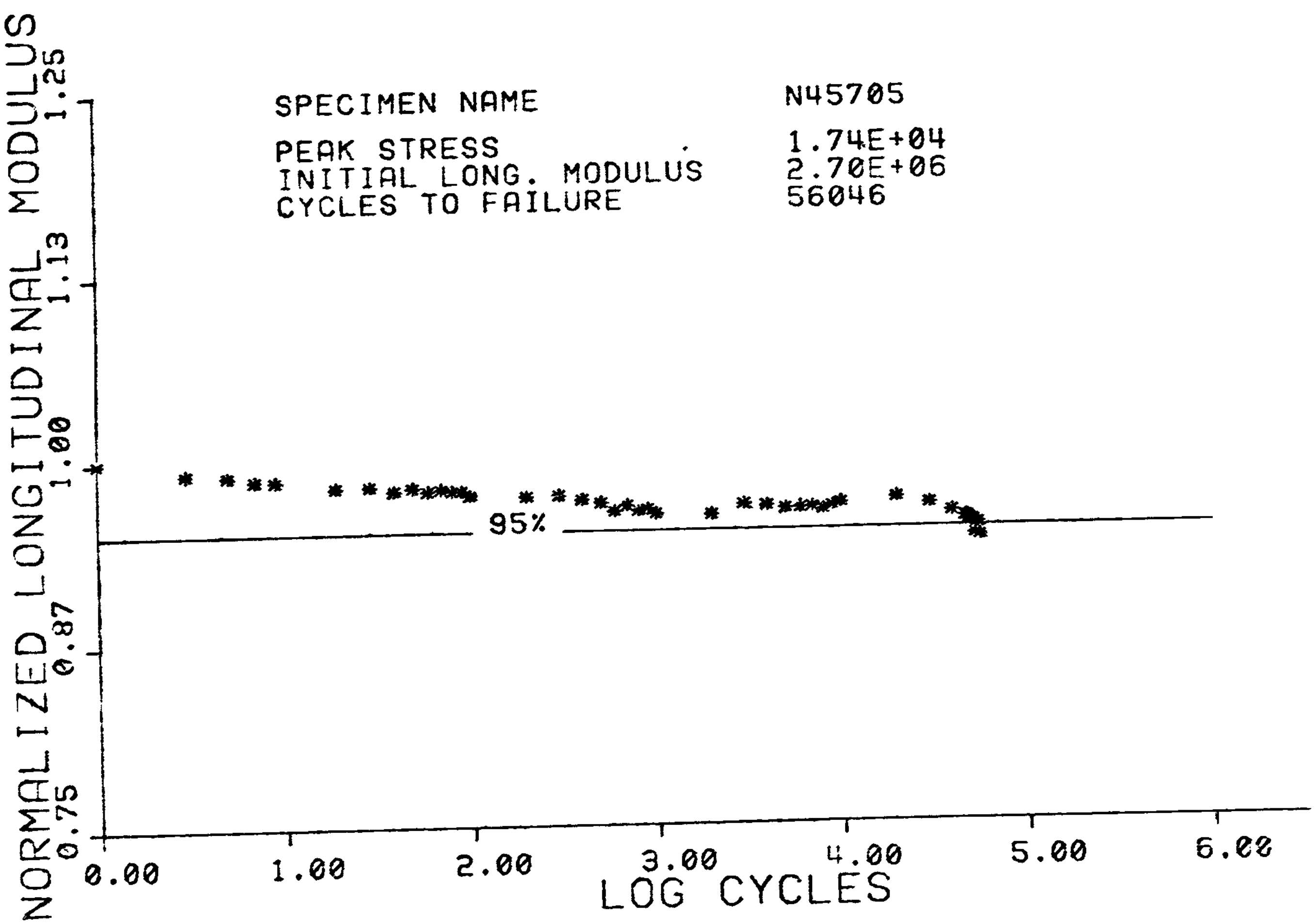


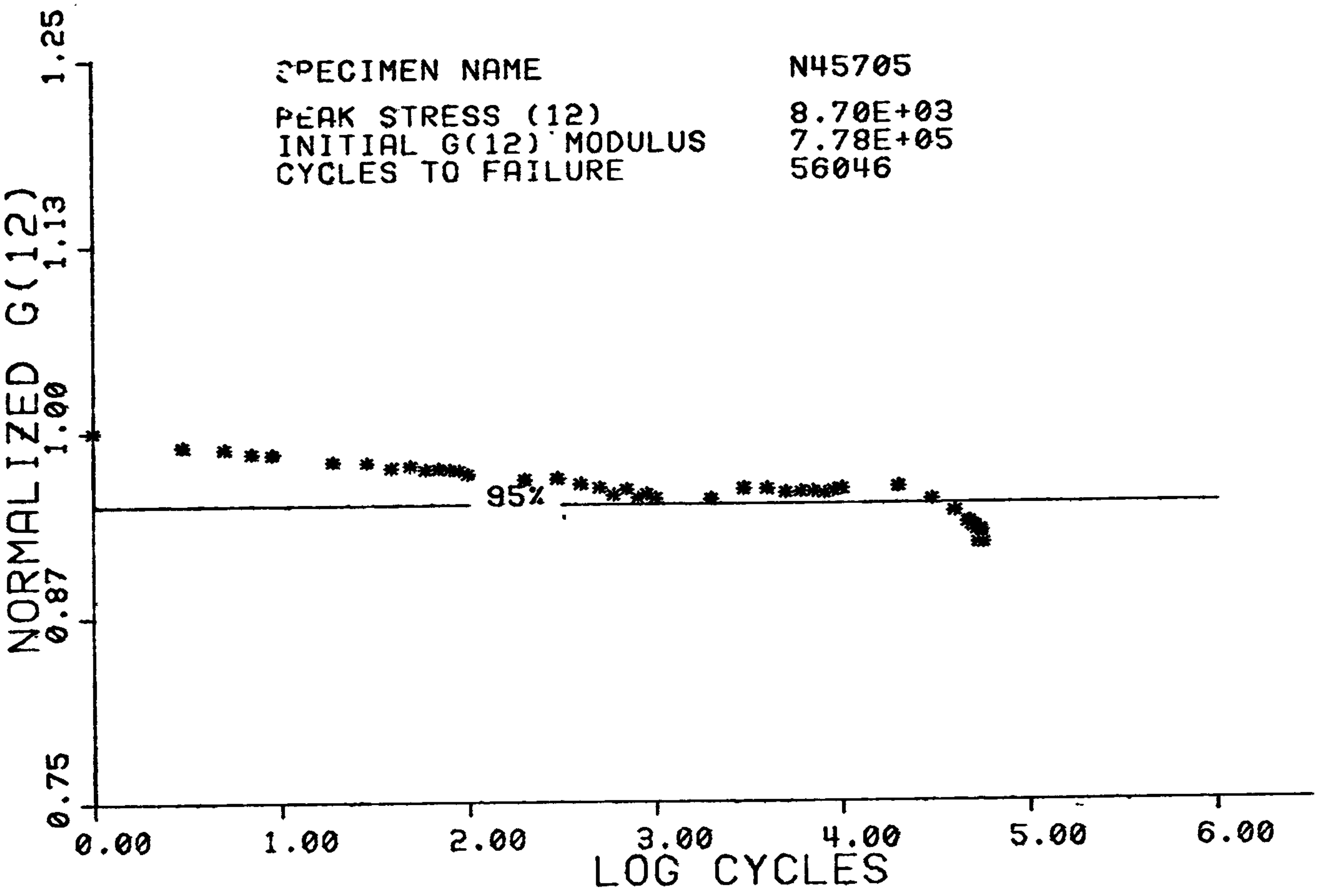
NORMALIZED LONGITUDINAL MODULUS
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES
95%
SPECIMEN NAME N45703
PEAK STRESS 1.74E+04
INITIAL LONG. MODULUS 2.68E+06
CYCLES TO FAILURE 52024


SPECIMEN NAME N45703
PEAK STRESS (12) 8.70E+03
INITIAL G(12) MODULUS 7.61E+05
CYCLES TO FAILURE 52024
95%
LOG CYCLES
0.00
1.00
2.00
3.00
4.00
5.00
6.00
NORMALIZED G(12)
0.75
0.87
1.00
1.13
1.25


SPECIMEN NAME N45704
PEAK STRESS 1.74E+01
INITIAL LONG. MODULUS 2.69E+06
CYCLES TO FAILURE 63040
NORMALIZED LONGITUDINAL MODULUS
1.25
1.13
1.00
0.87
0.75
95%
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45704
PEAK STRESS (12) 8.70E+03
INITIAL G(12) MODULUS 7.79E+05
CYCLES TO FAILURE 63040
95%
NORMALIZED G(12)
1.25
1.13
1.00
0.87
0.75
LOG CYCLES
0.00
1.00
2.00
3.00
4.00
5.00
6.00


SPECIMEN NAME N45705
PEAK STRESS 1.74E+04
INITIAL LONG. MODULUS 2.70E+06
CYCLES TO FAILURE 56046
NORMALIZED LONGITUDINAL MODULUS
1.25
1.13
1.00
0.87
0.75
95%
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45705
PEAK STRESS (12) 8.70E+03
INITIAL G(12) MODULUS 7.78E+05
CYCLES TO FAILURE 56046
95%
NORMALIZED G(12)
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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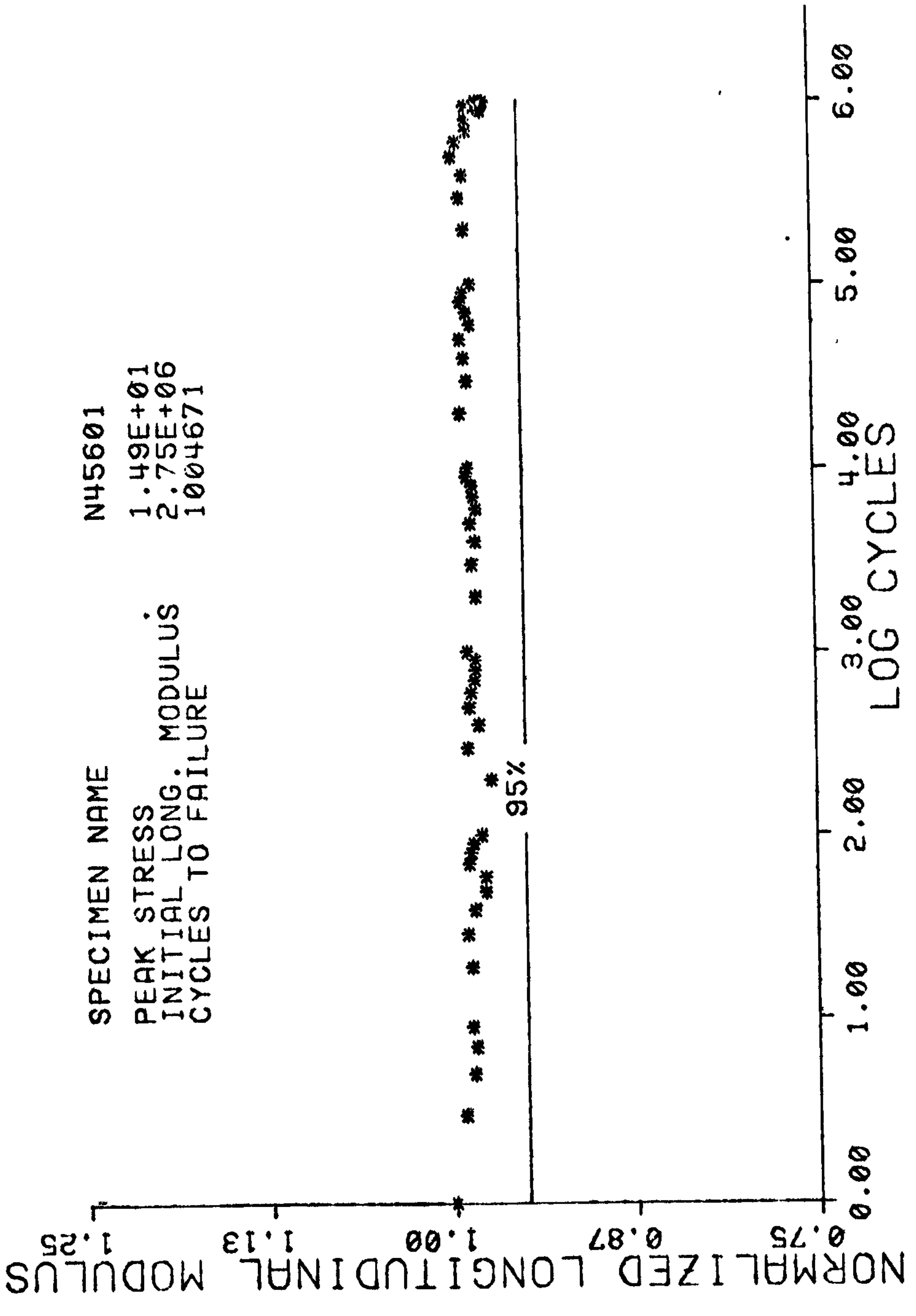

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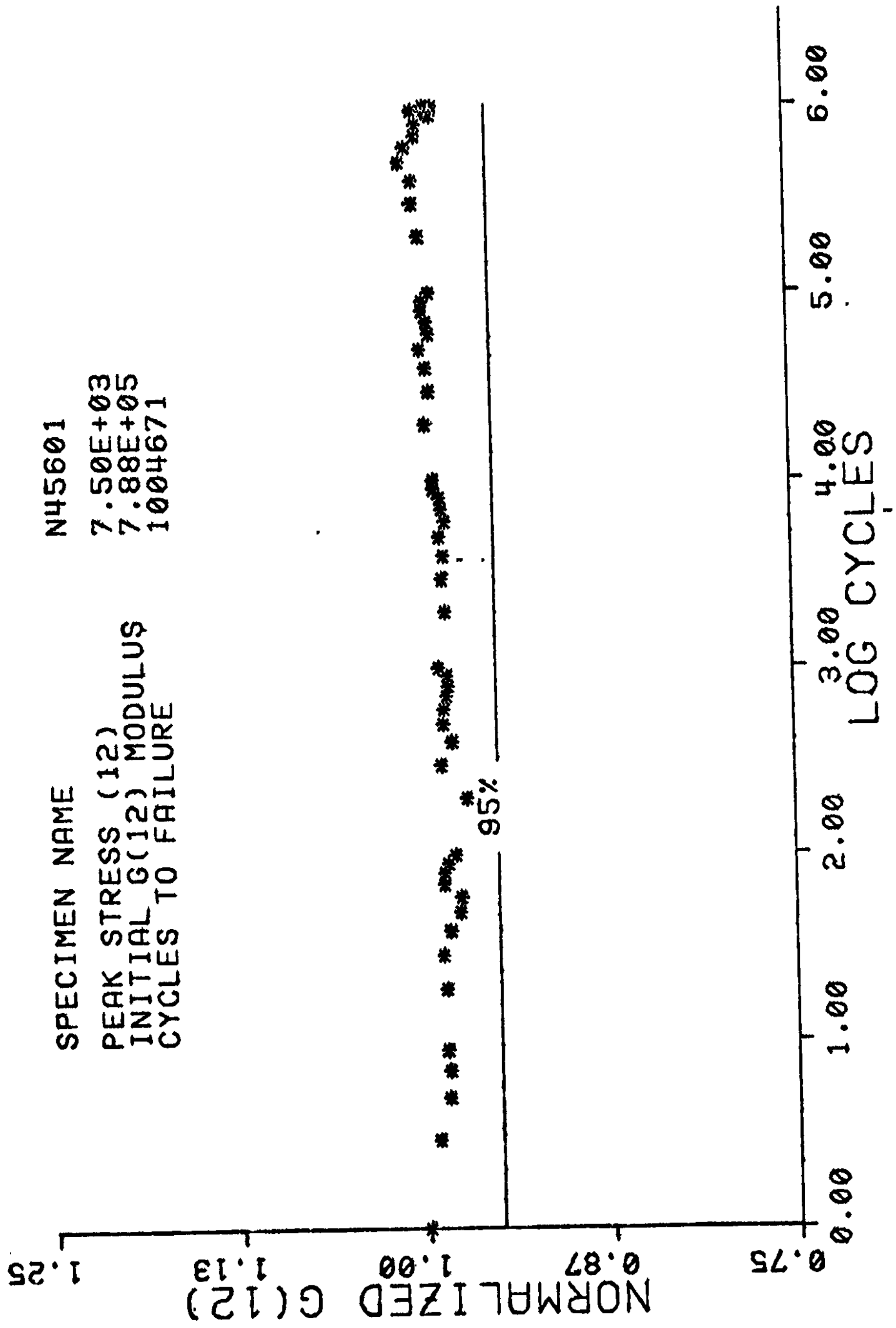
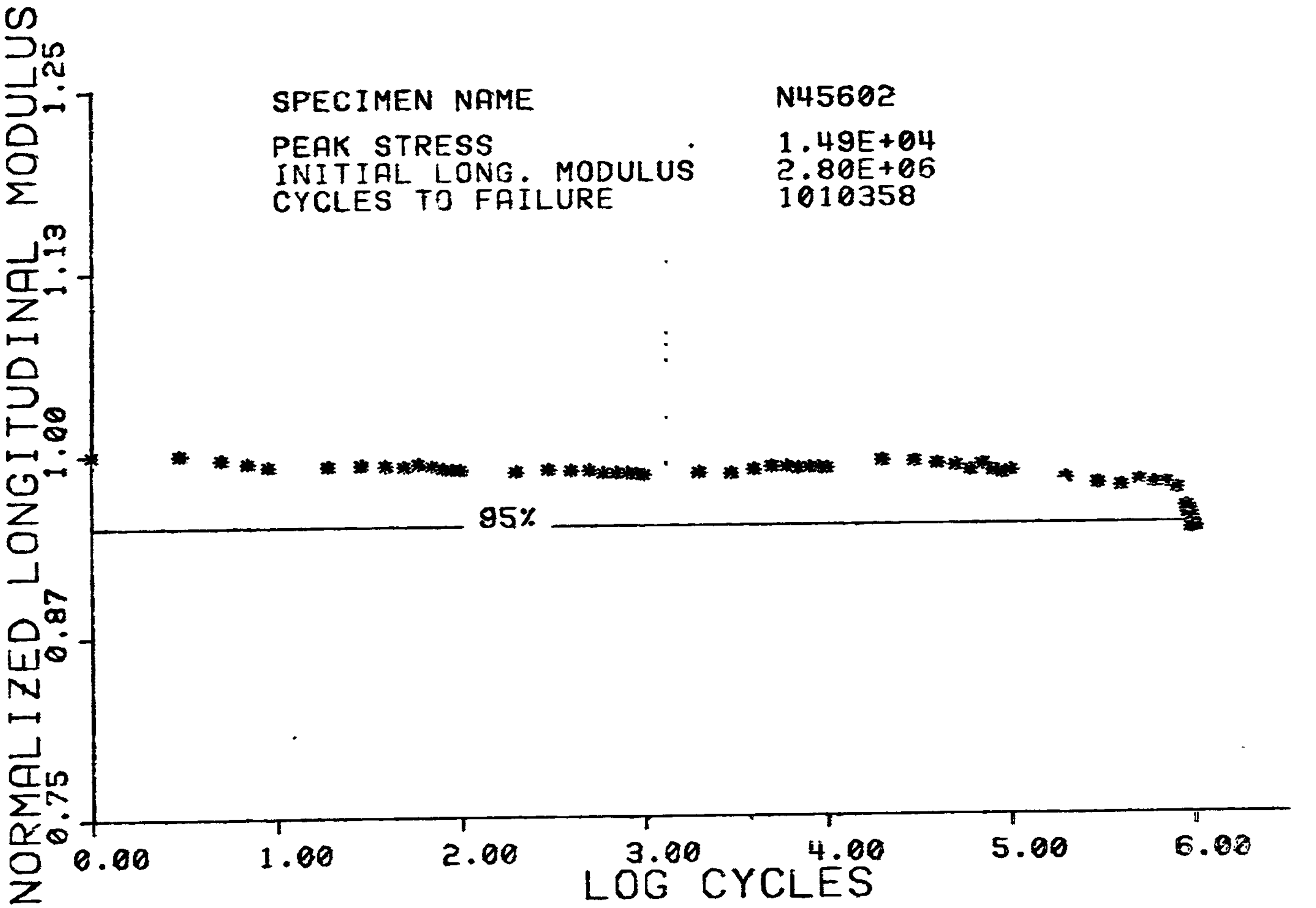
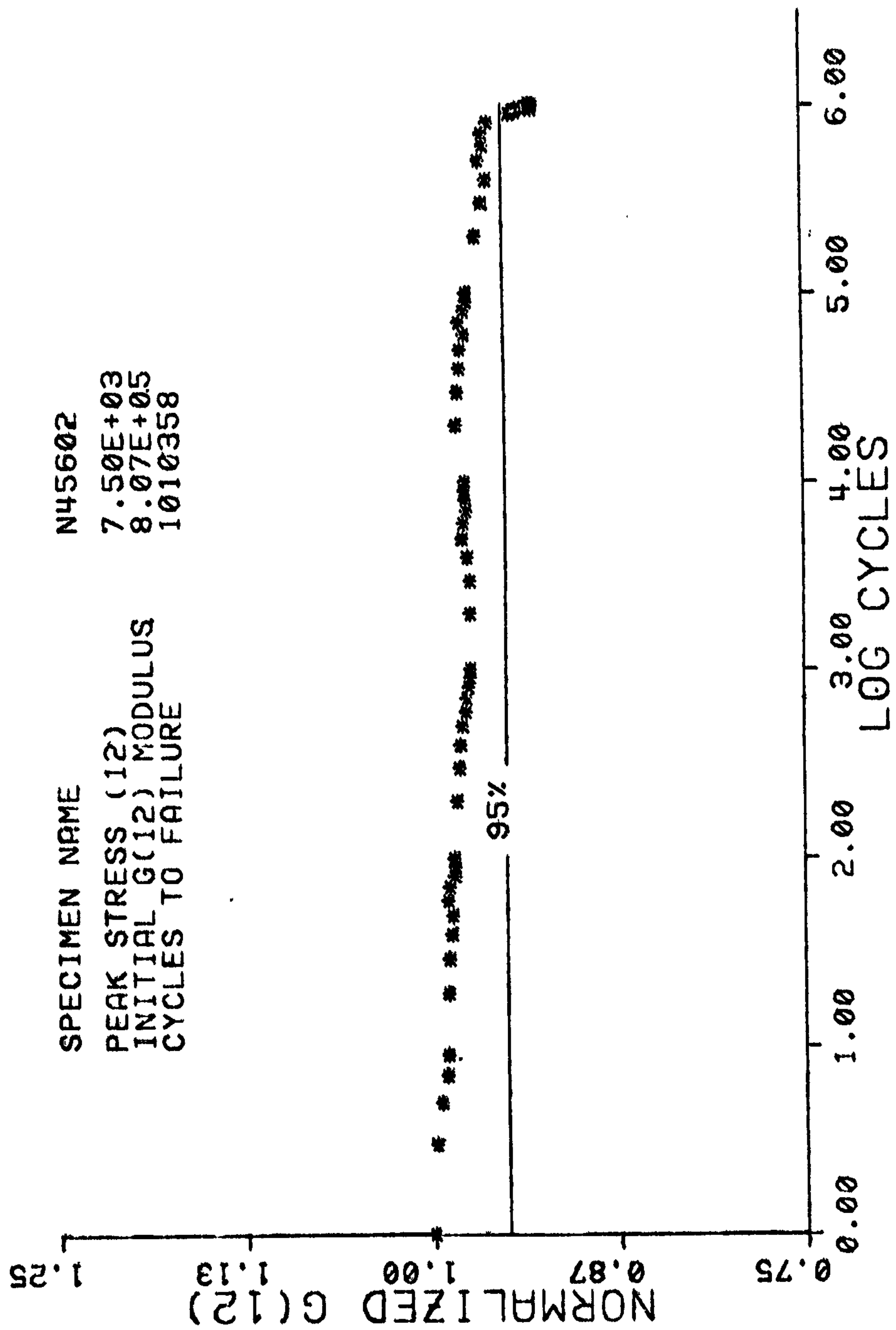



SPECIMEN NAME N45602
PEAK STRESS 1.49E+04
INITIAL LONG. MODULUS 2.80E+06
CYCLES TO FAILURE 1010358
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45602
PEAK STRESS (12) 7.50E+03
INITIAL G(12) MODULUS 8.07E+05
CYCLES TO FAILURE 1010358
95%
NORMALIZED G(12)
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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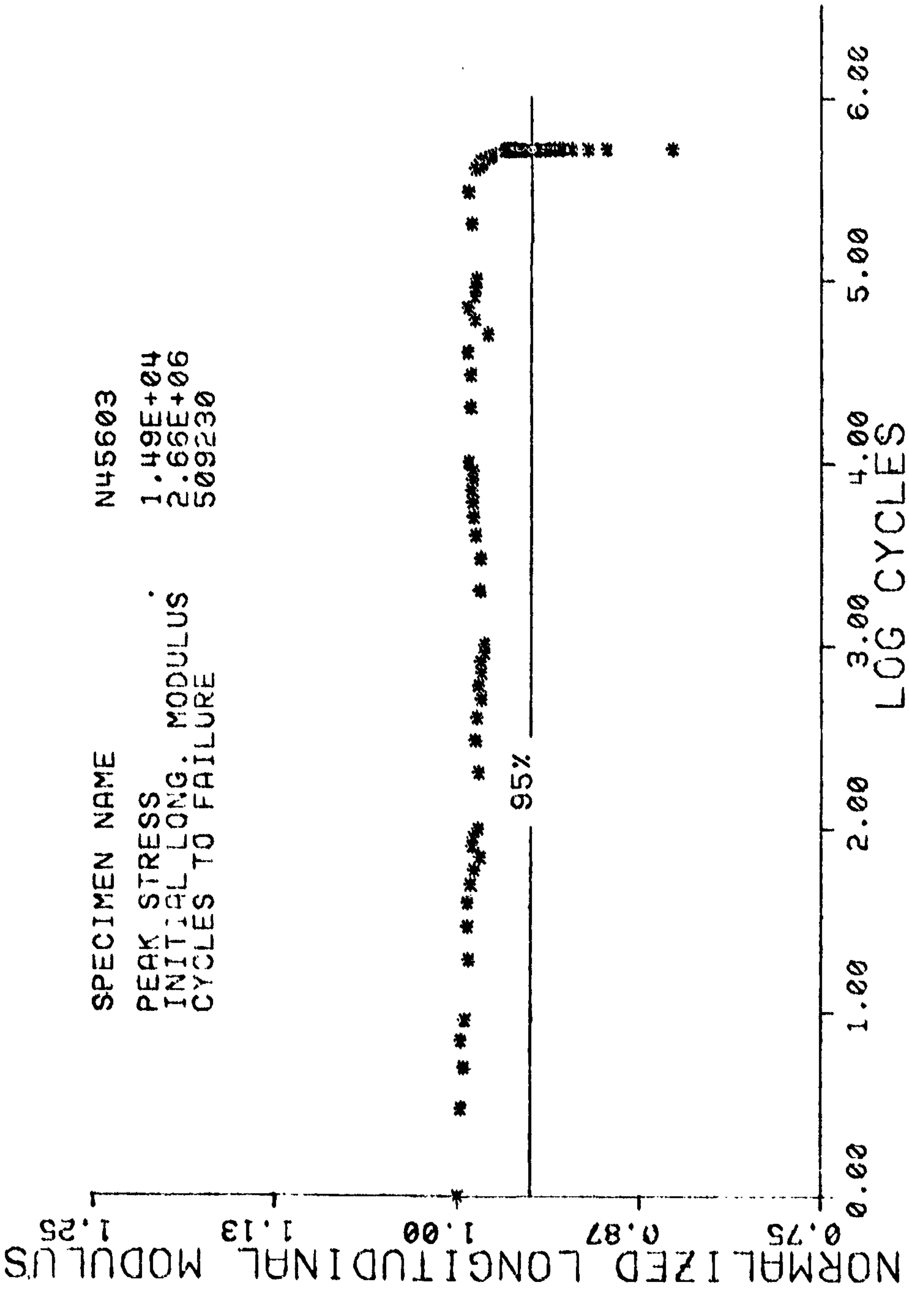

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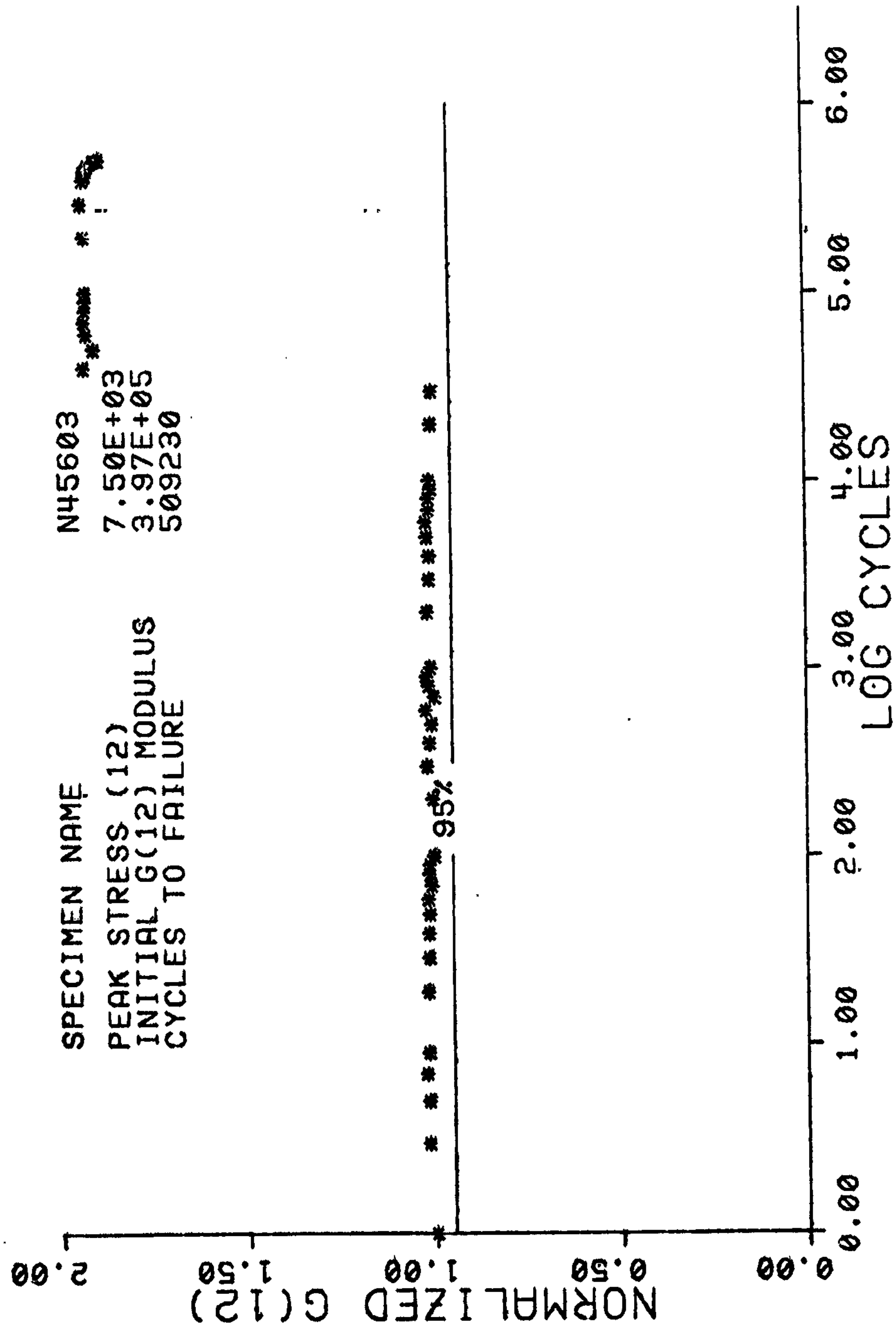

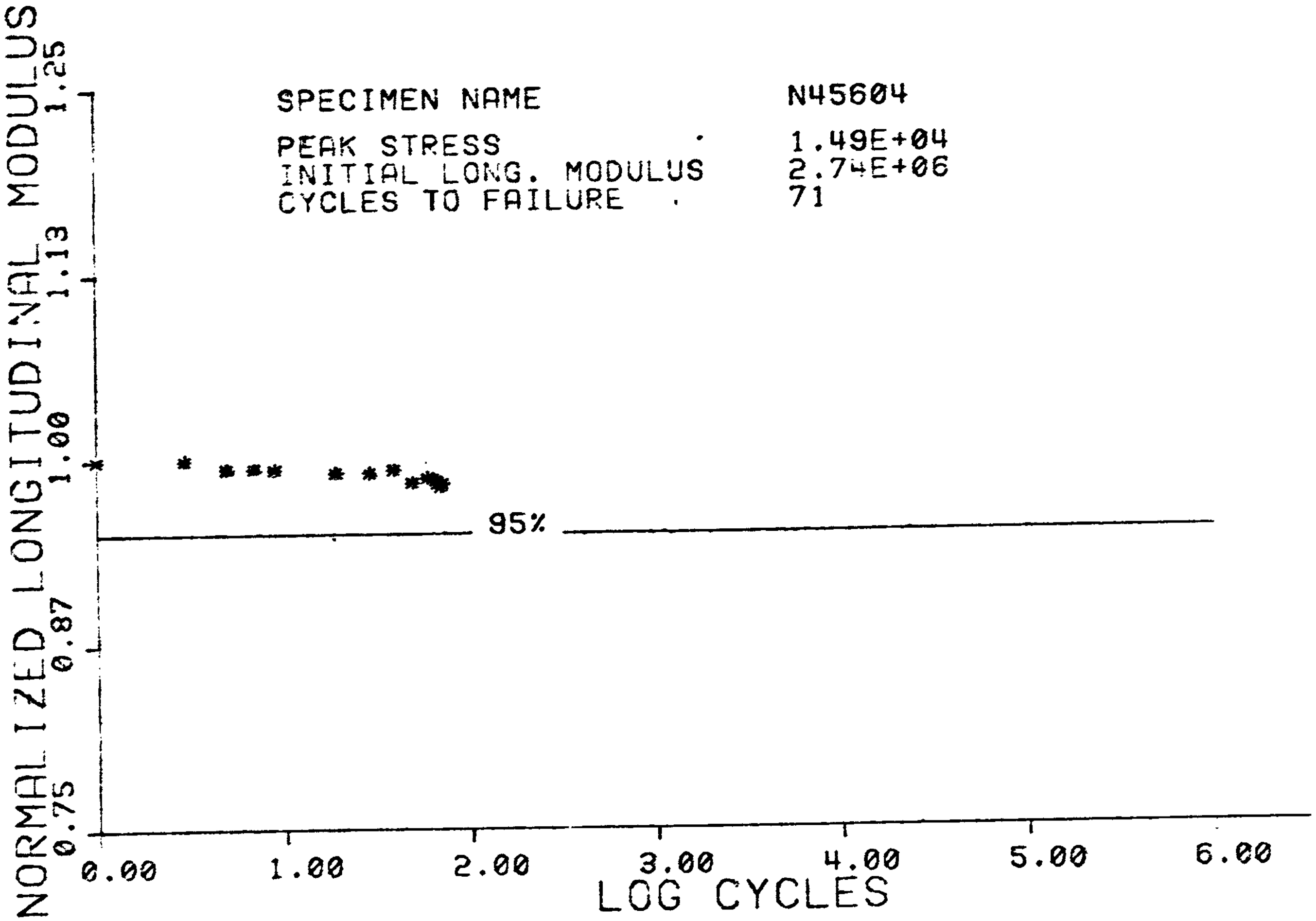

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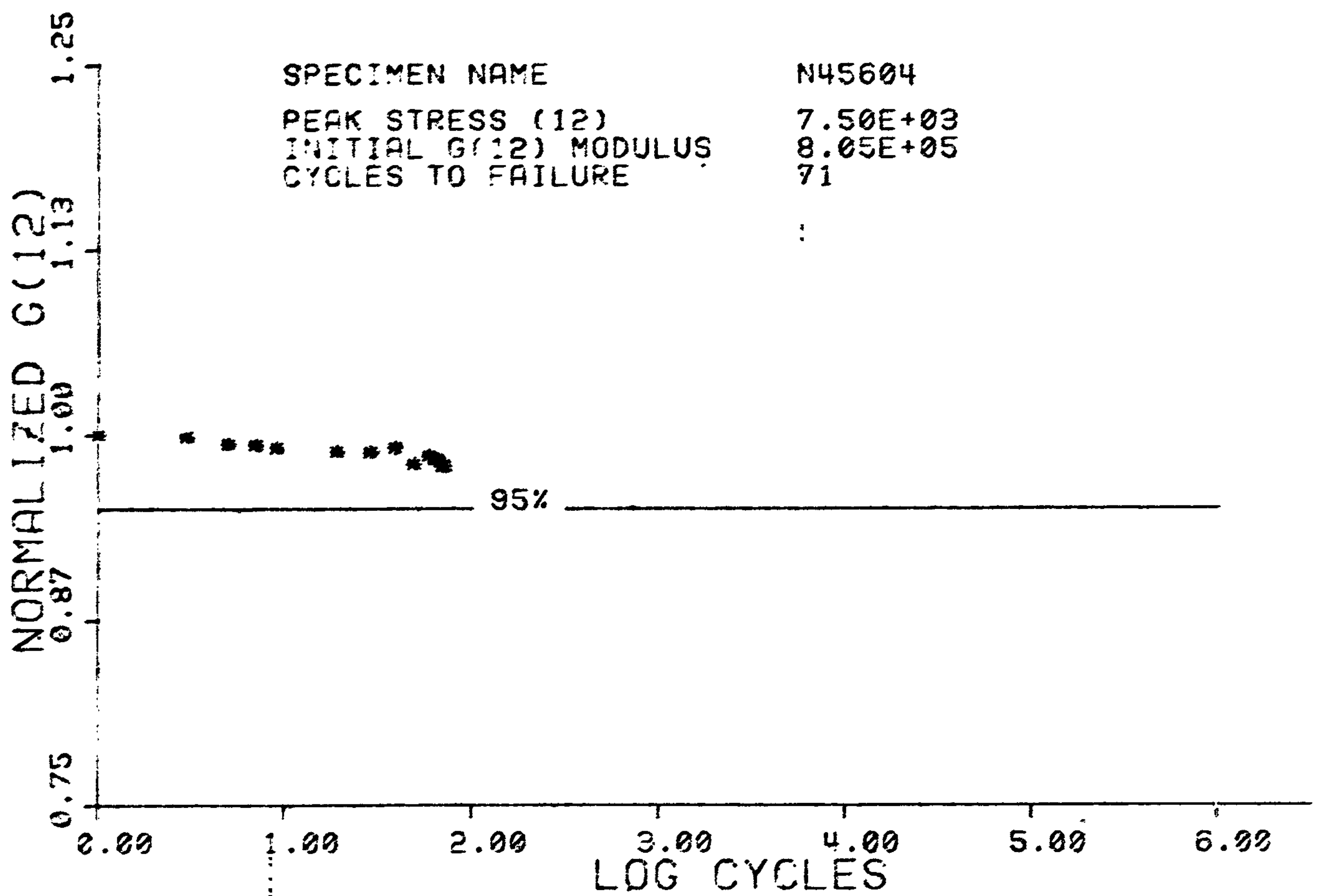
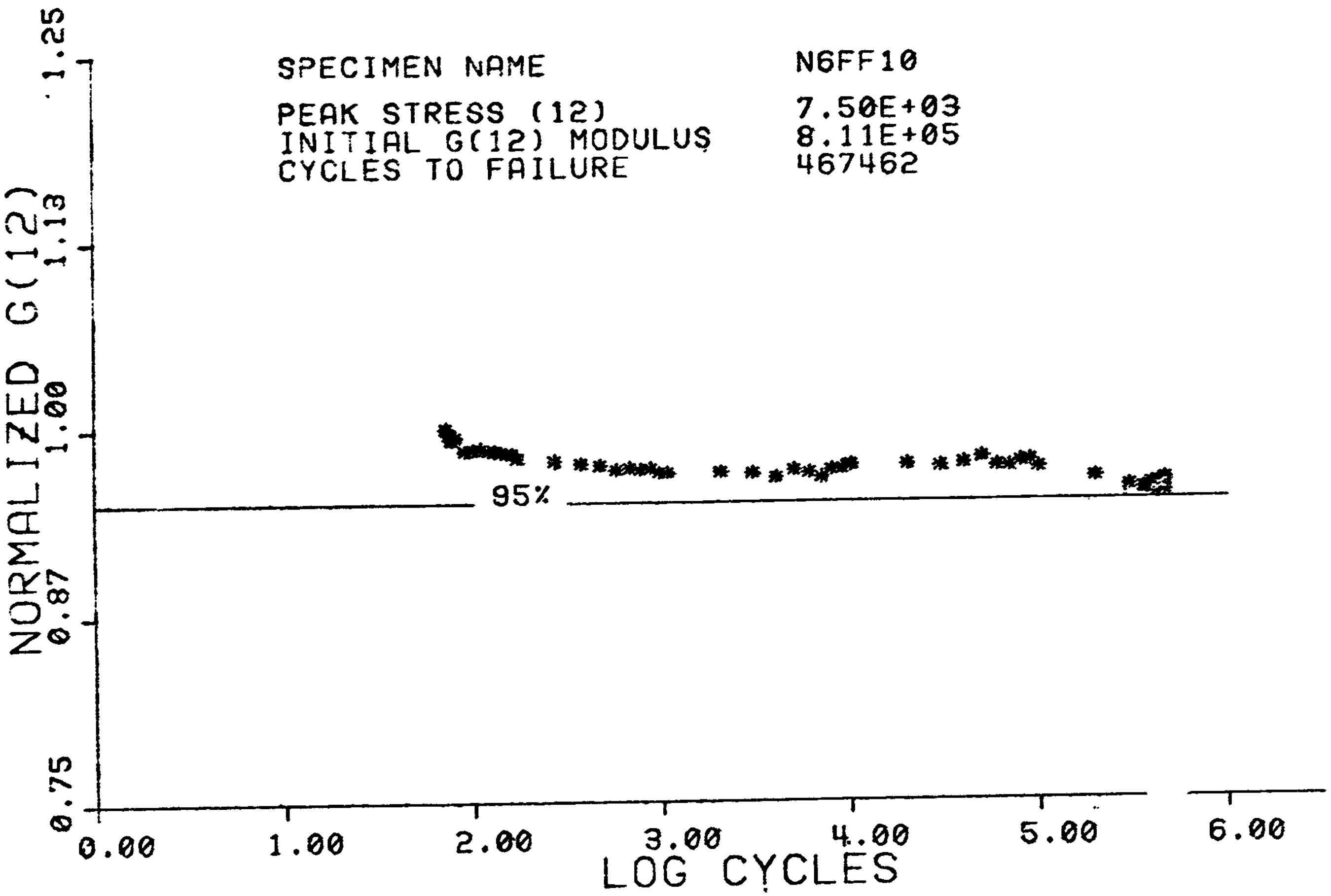

SPECIMEN NAME N45604
PEAK STRESS (12) 7.50E+03
INITIAL G(12) MODULUS 8.05E+05
CYCLES TO FAILURE 71
95%
NORMALIZED G(12)
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES



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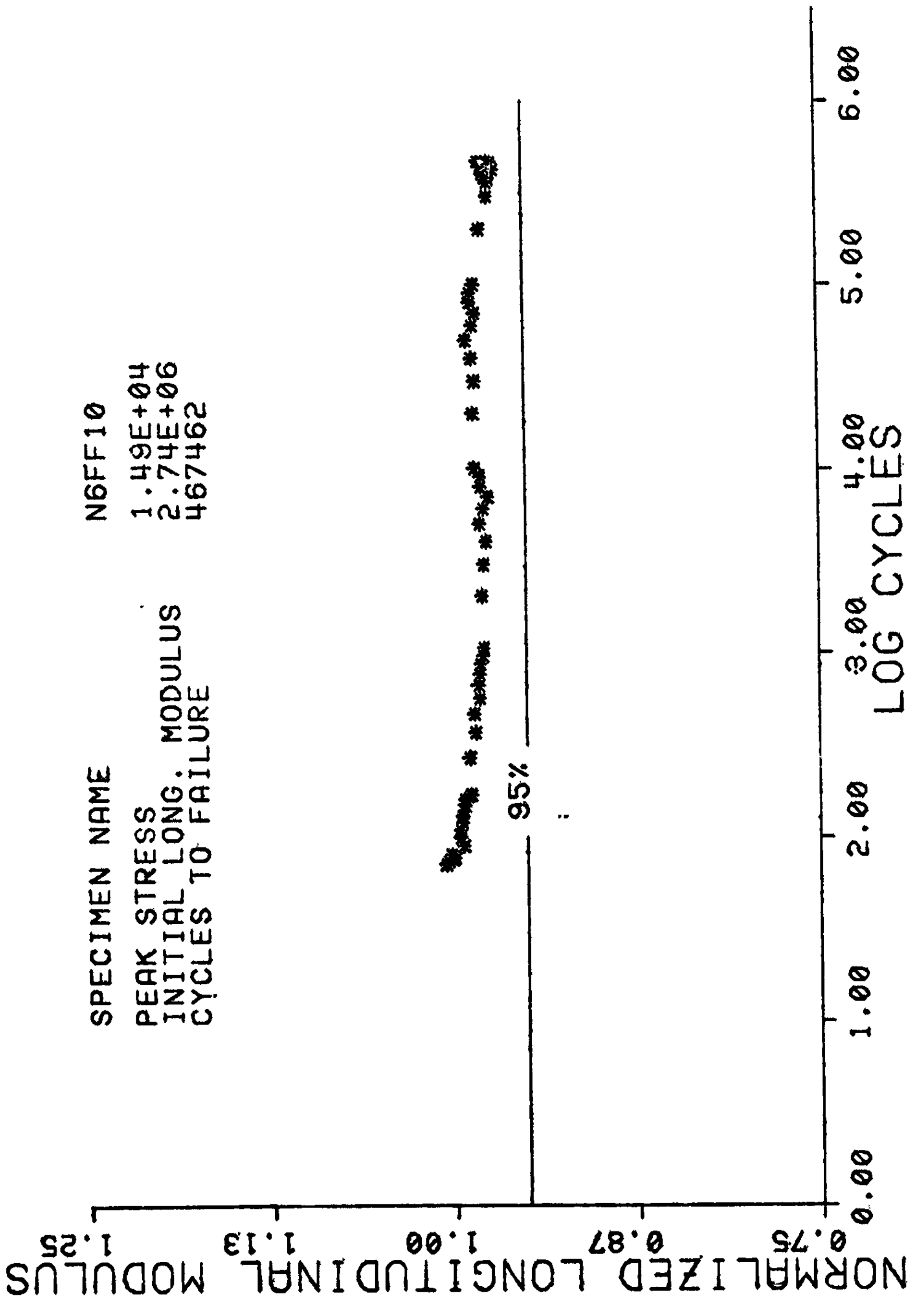
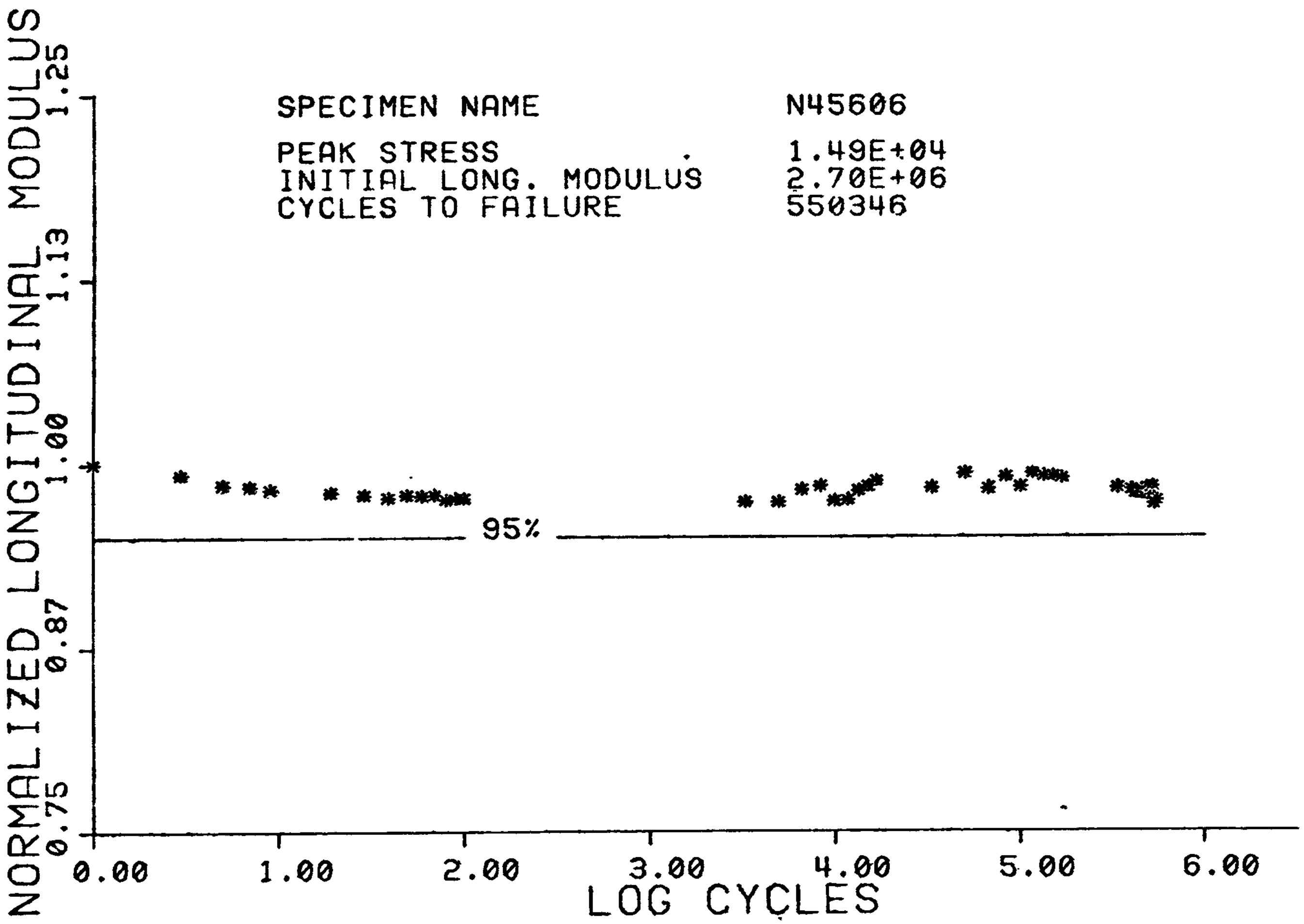
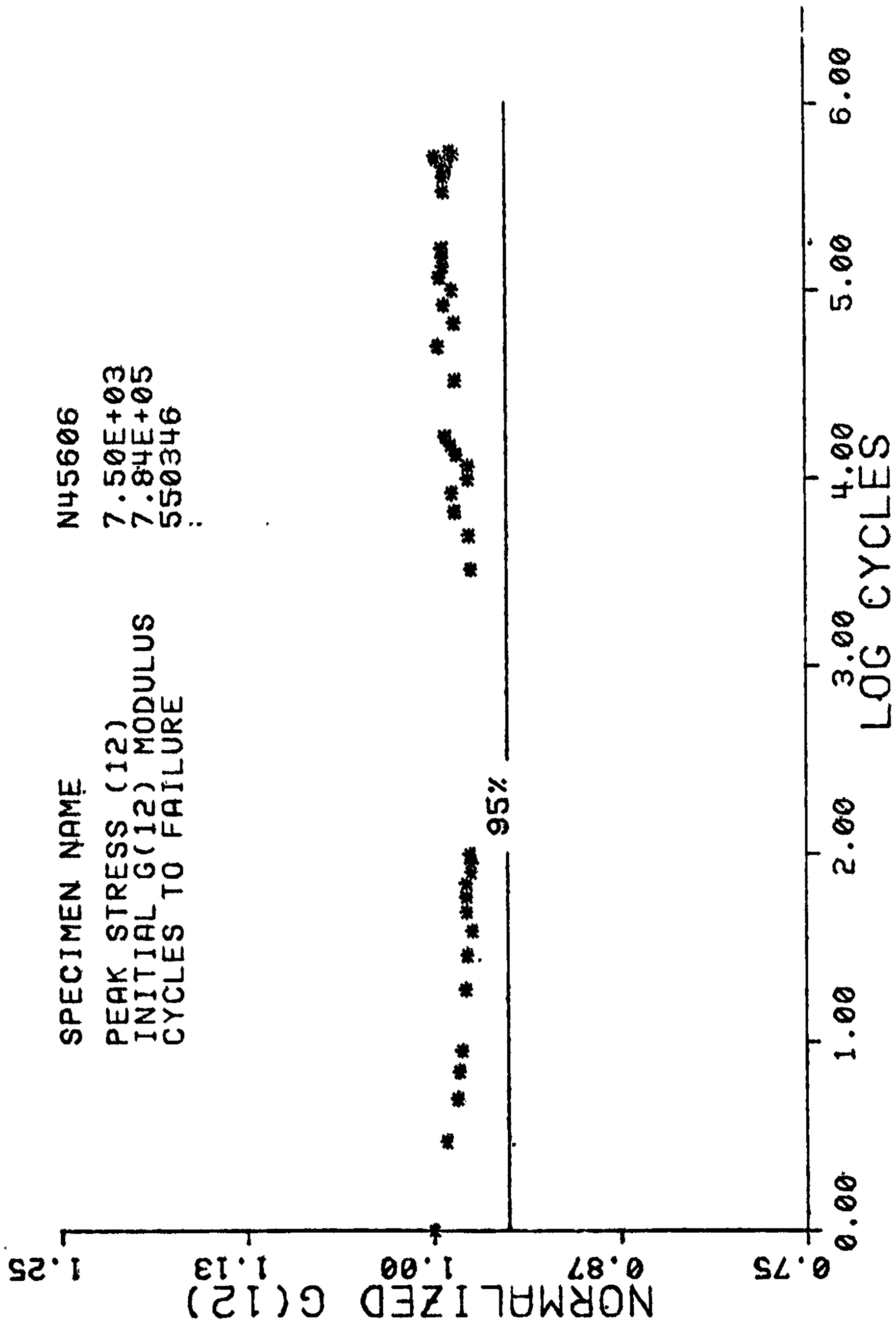
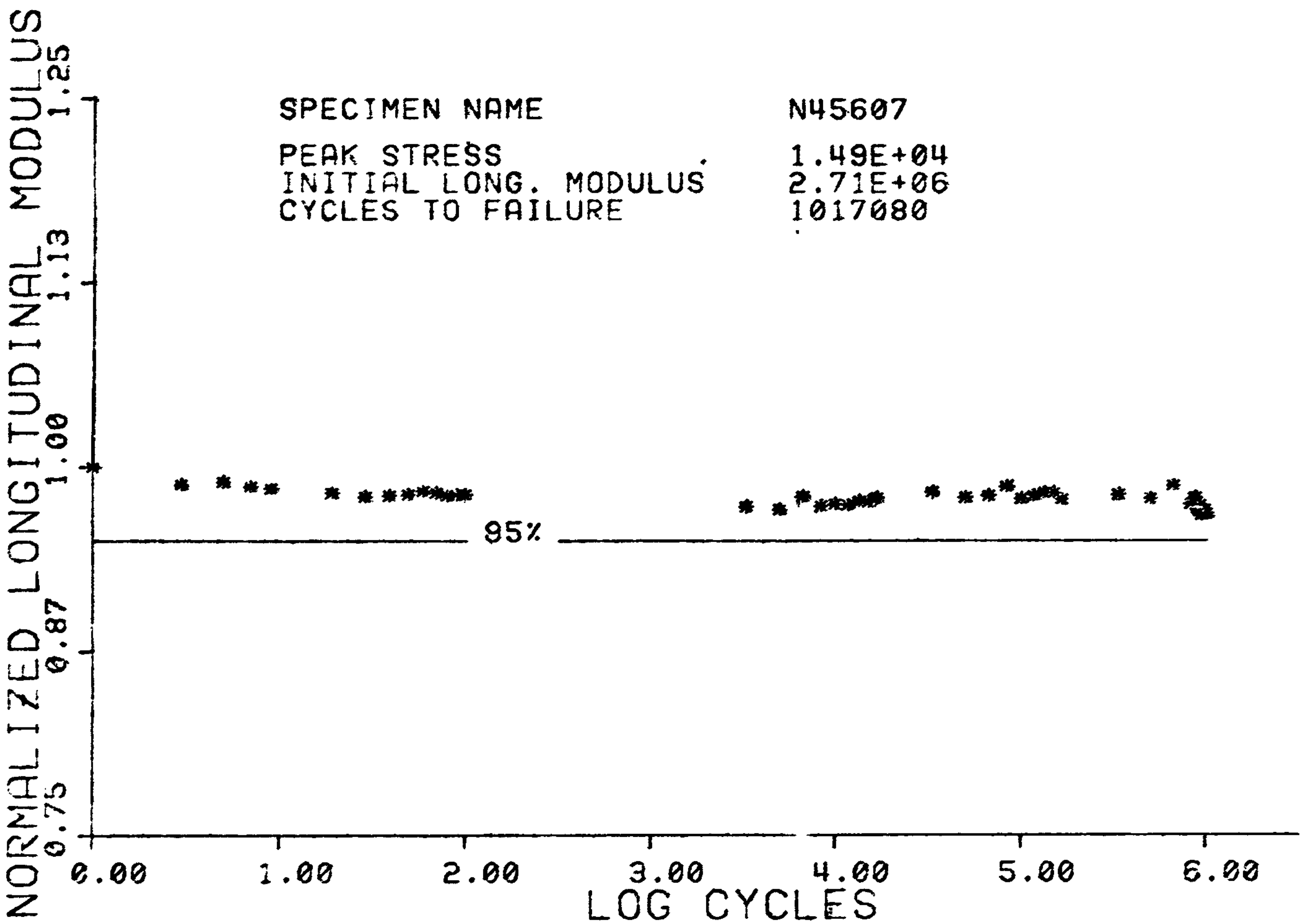
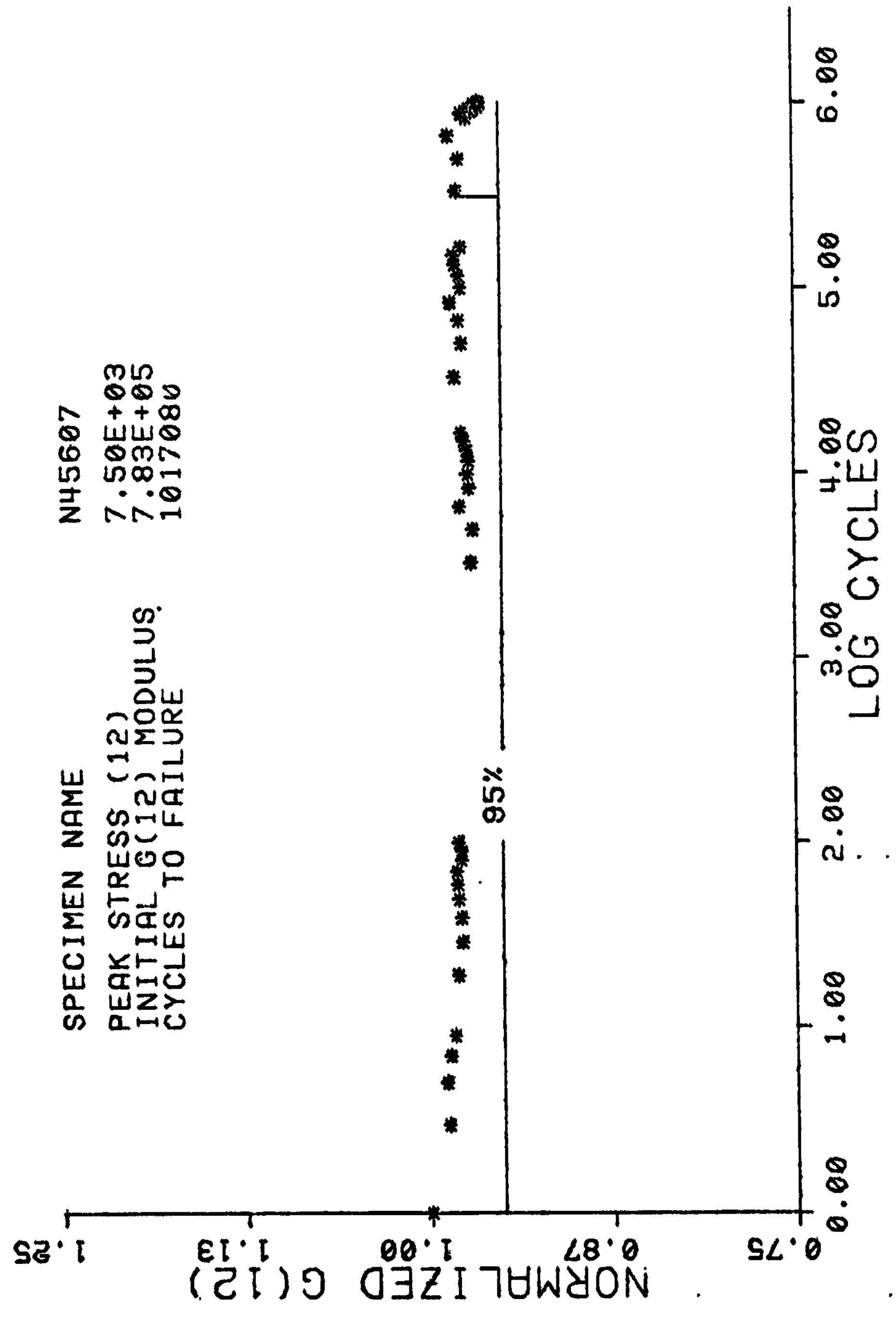

SPECIMEN NAME N6FF10
PEAK STRESS 1.49E+04
INITIAL LONG. MODULUS 2.74E+06
CYCLES TO FAILURE 467462
95%
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES
0.75
0.87
1.00
1.13
1.25
NORMALIZED LONGITUDINAL MODULUS


SPECIMEN NAME N45606
PEAK STRESS 1.49E+04
INITIAL LONG. MODULUS 2.70E+06
CYCLES TO FAILURE 550346
95%
NORMALIZED LONGITUDINAL MODULUS
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45606
PEAK STRESS (12) 7.50E+03
INITIAL G(12) MODULUS 7.84E+05
CYCLES TO FAILURE 550346
95%
NORMALIZED G(12)
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45607
PEAK STRESS 1.49E+04
INITIAL LONG. MODULUS 2.71E+06
CYCLES TO FAILURE 1017080
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N45607
PEAK STRESS (12) 7.50E+03
INITIAL G(12) MODULUS 7.83E+05
CYCLES TO FAILURE 1017080
95%
NORMALIZED G(12)
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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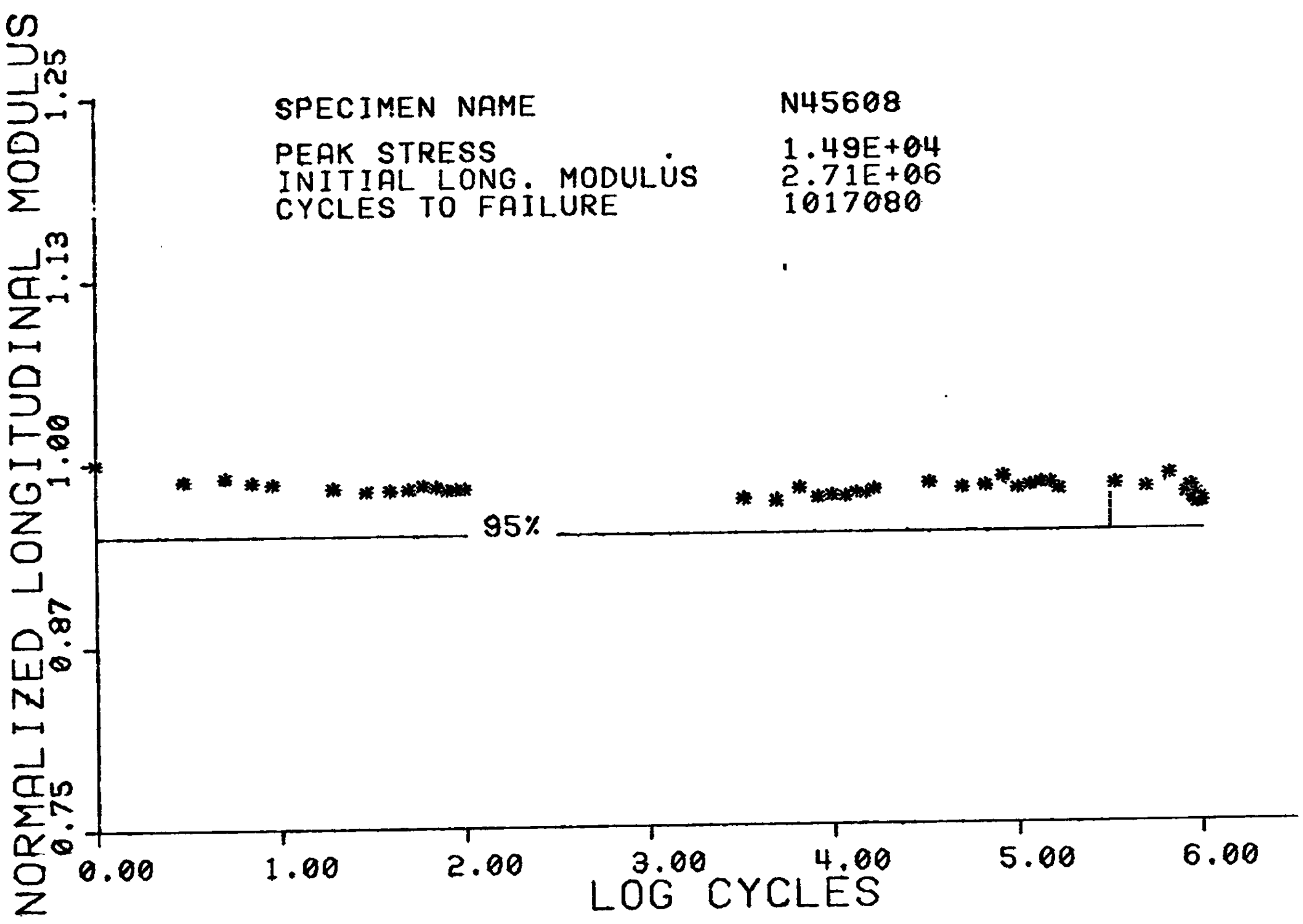

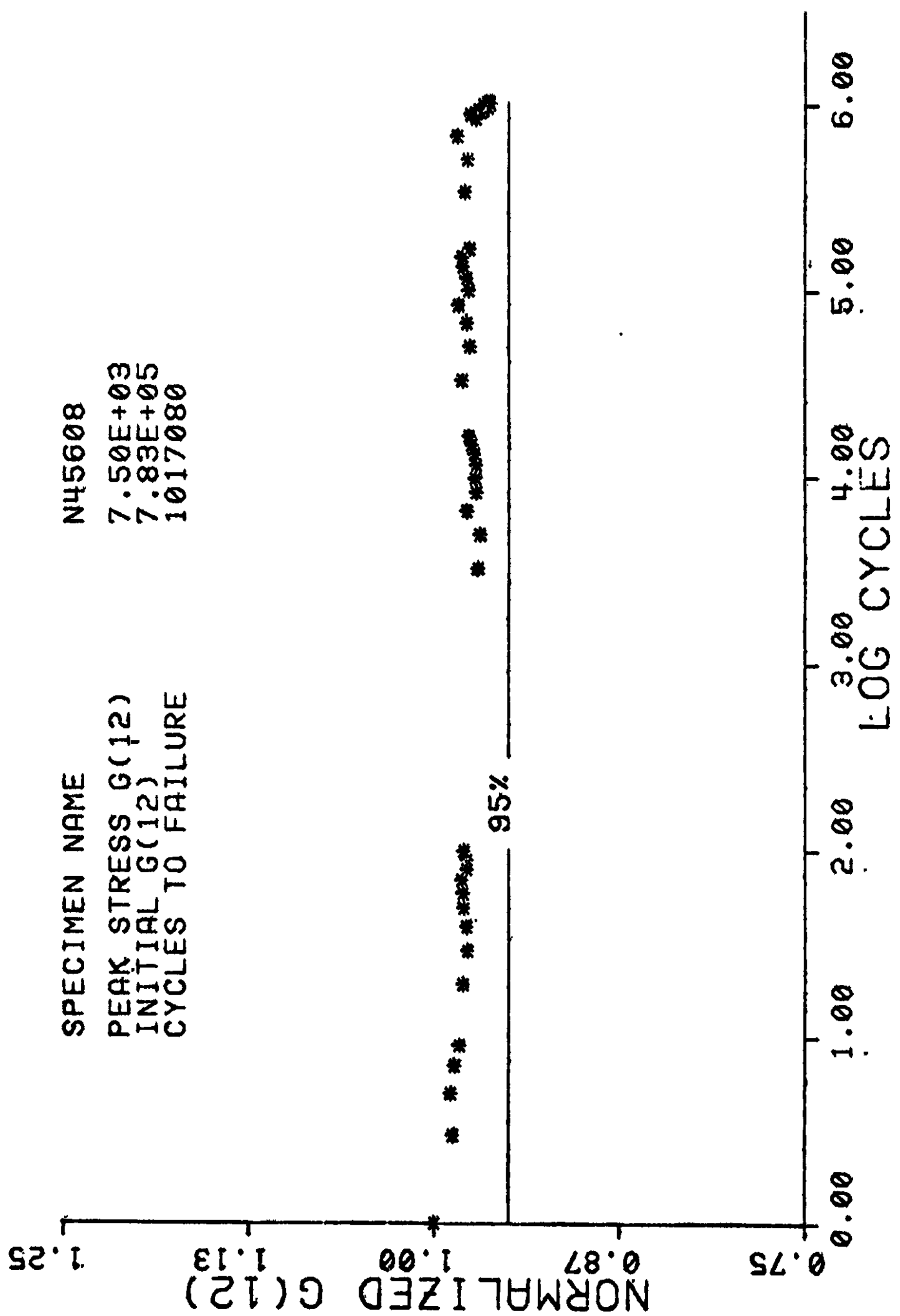
SPECIMEN NAME N45608
PEAK STRESS G(12) 7.50E+03
INITIAL G(12) 7.83E+05
CYCLES TO FAILURE 1017080
95%
NORMALIZED G(12)
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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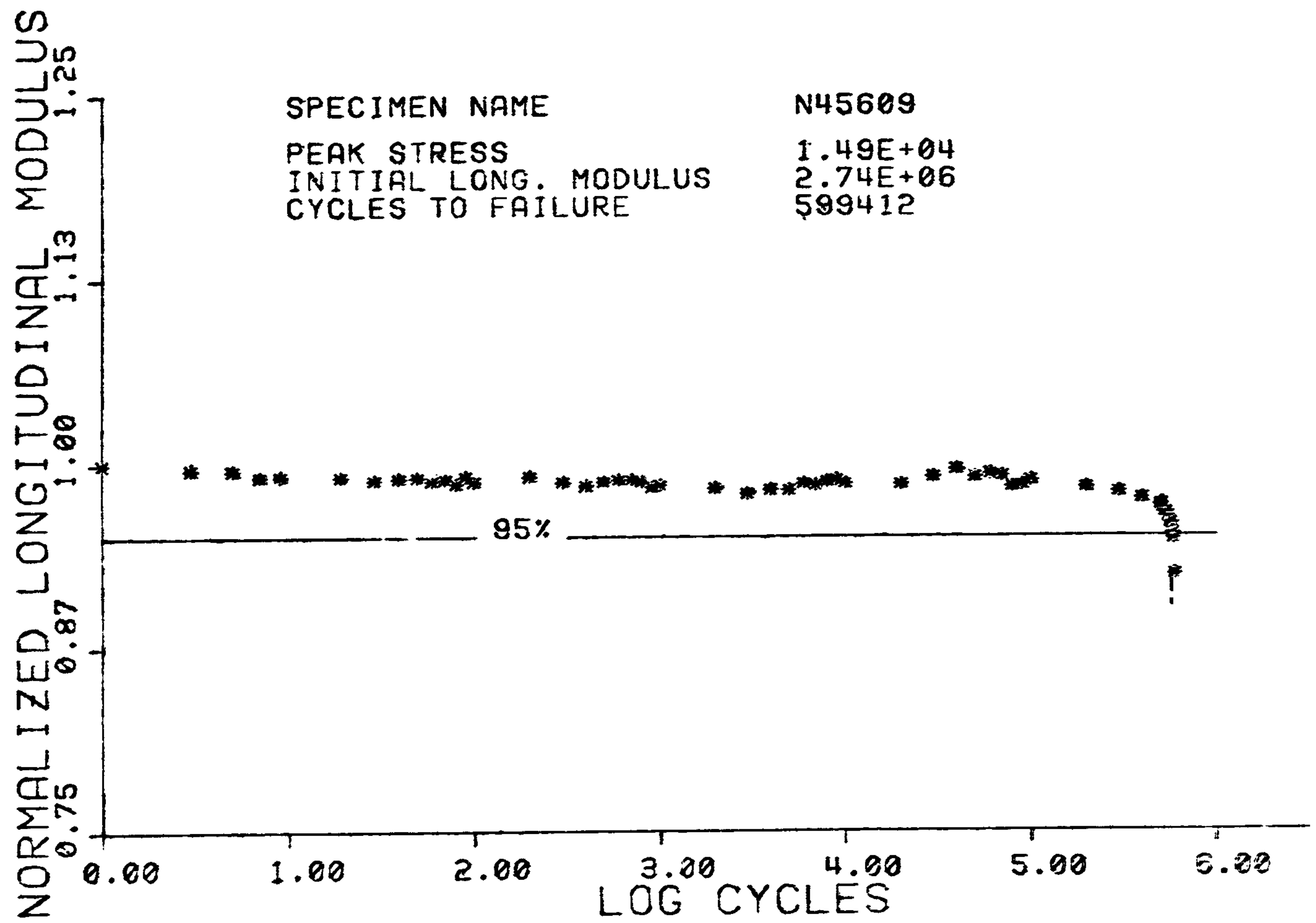
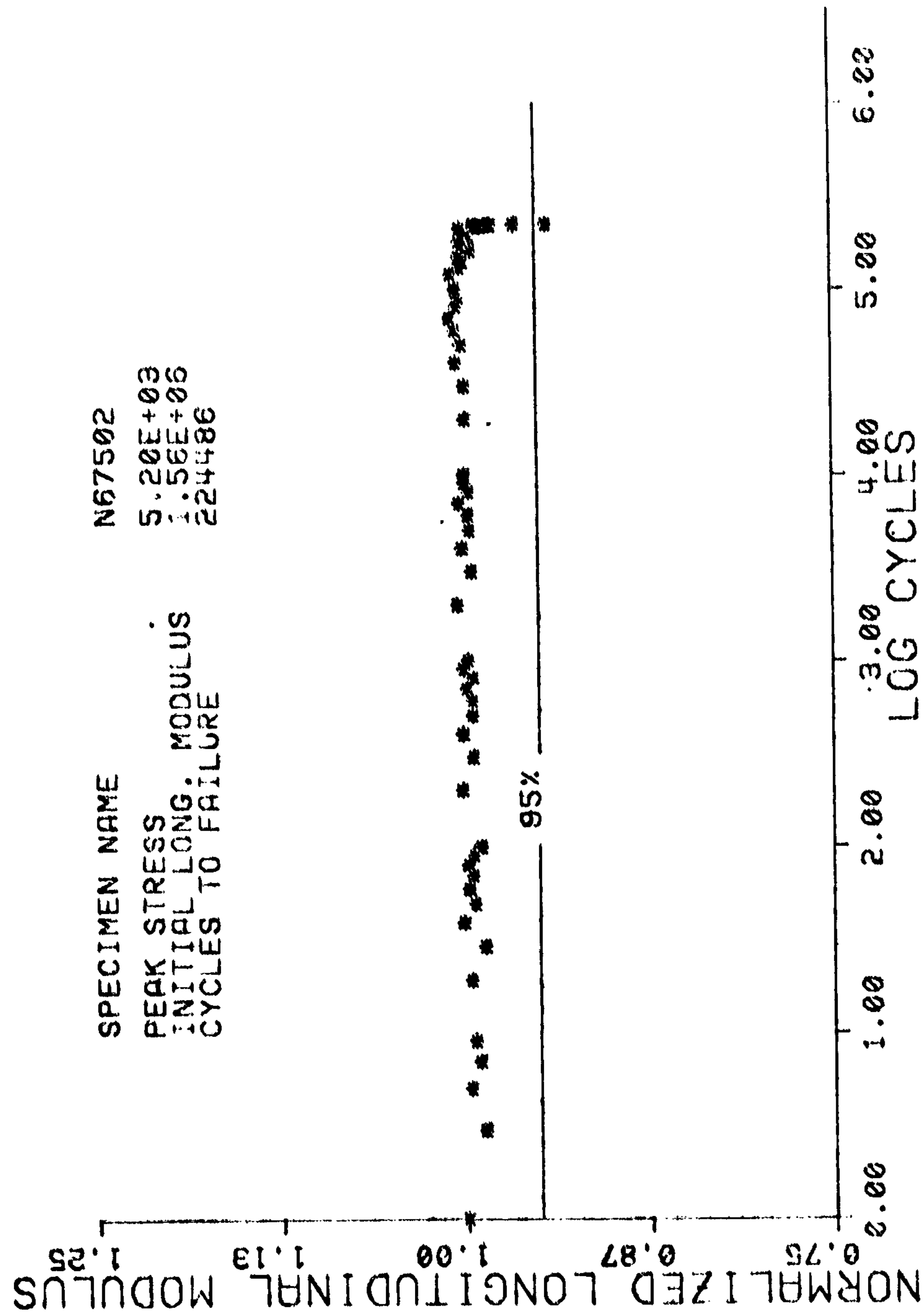
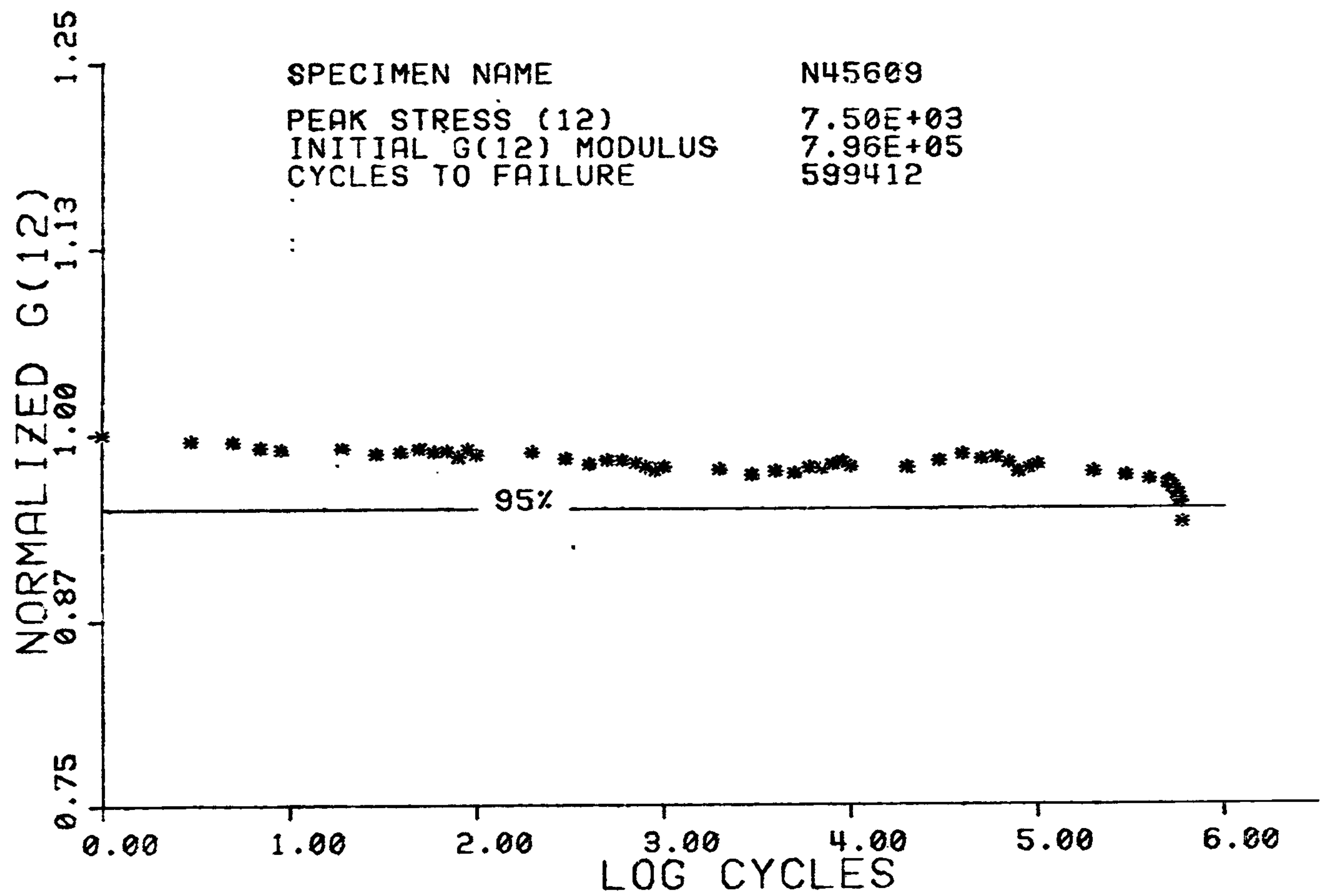



SPECIMEN NAME N67502
PEAK STRESS 5.20E+03
INITIAL LONG. MODULUS 1.56E+06
CYCLES TO FAILURE 224486
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
LOG CYCLES
0.00
1.00
2.00
3.00
4.00
5.00
6.00


SPECIMEN NAME N45609
PEAK STRESS (12) 7.50E+03
INITIAL G(12) MODULUS 7.96E+05
CYCLES TO FAILURE 599412
95%
NORMALIZED G(12)
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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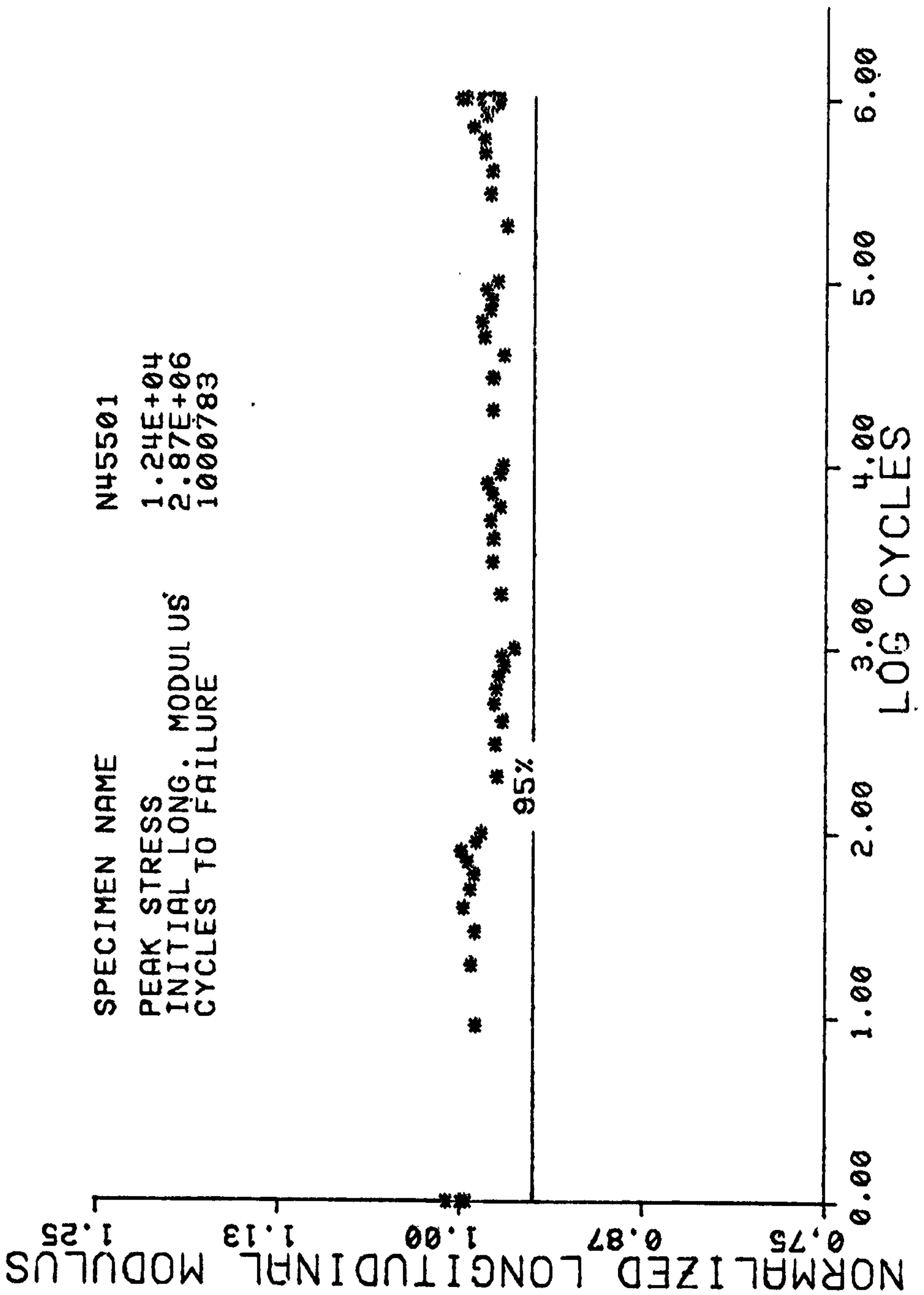

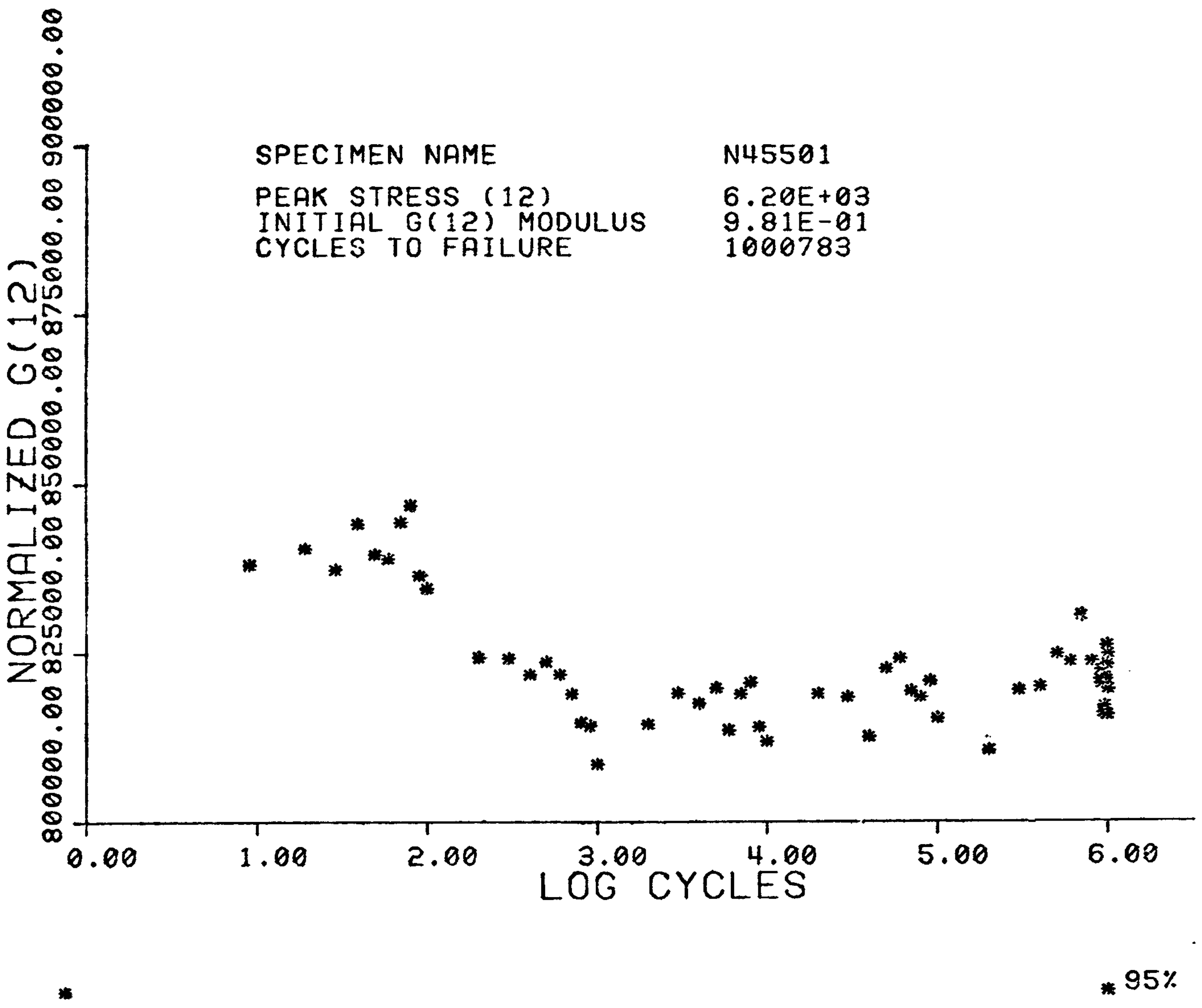

SPECIMEN NAME N45501
PEAK STRESS (12) 6.20E+03
INITIAL G(12) MODULUS 9.81E-01
CYCLES TO FAILURE 1000783
NORMALIZED G(12)
800000.00
825000.00
850000.00
875000.00
900000.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES
95%

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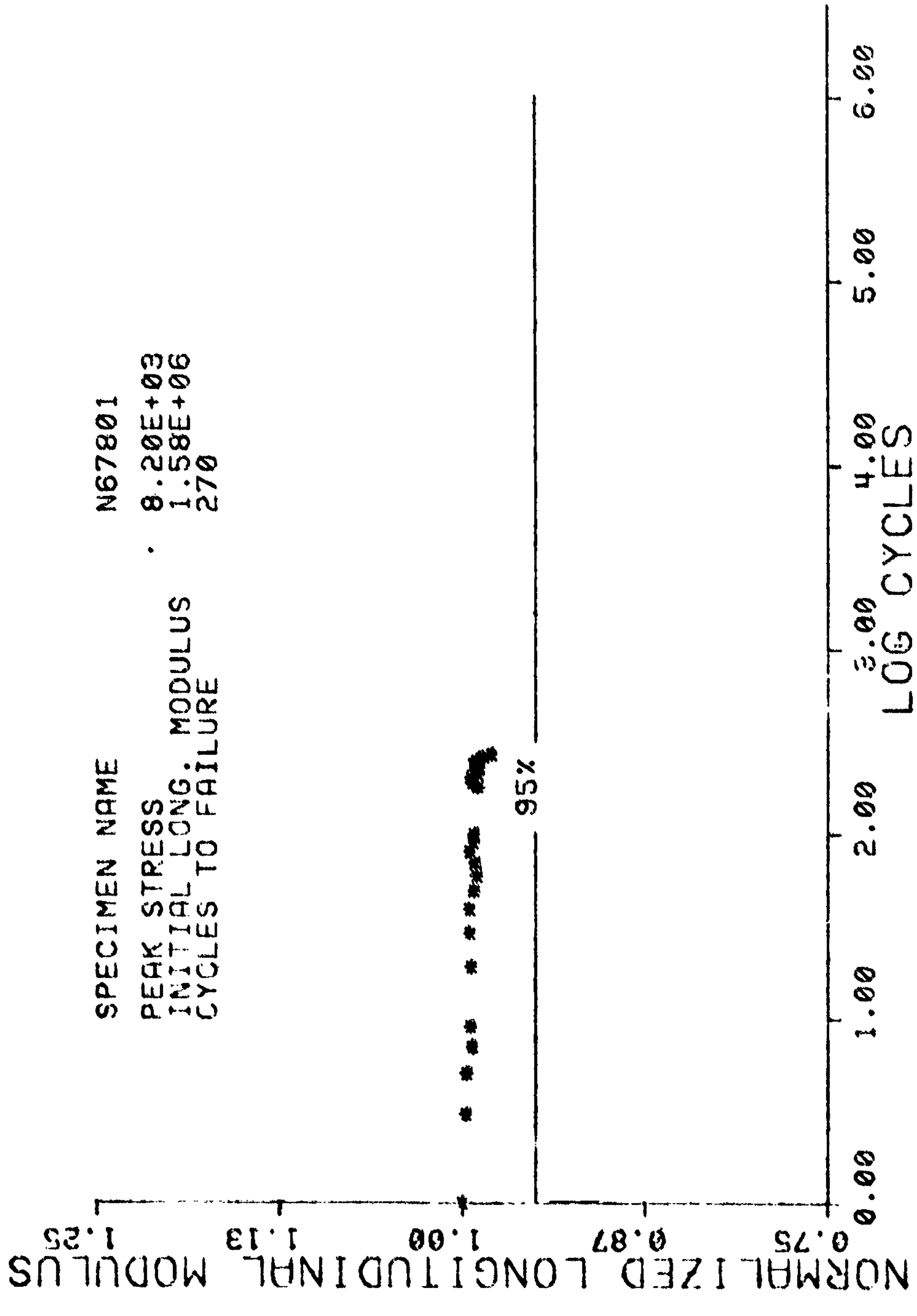

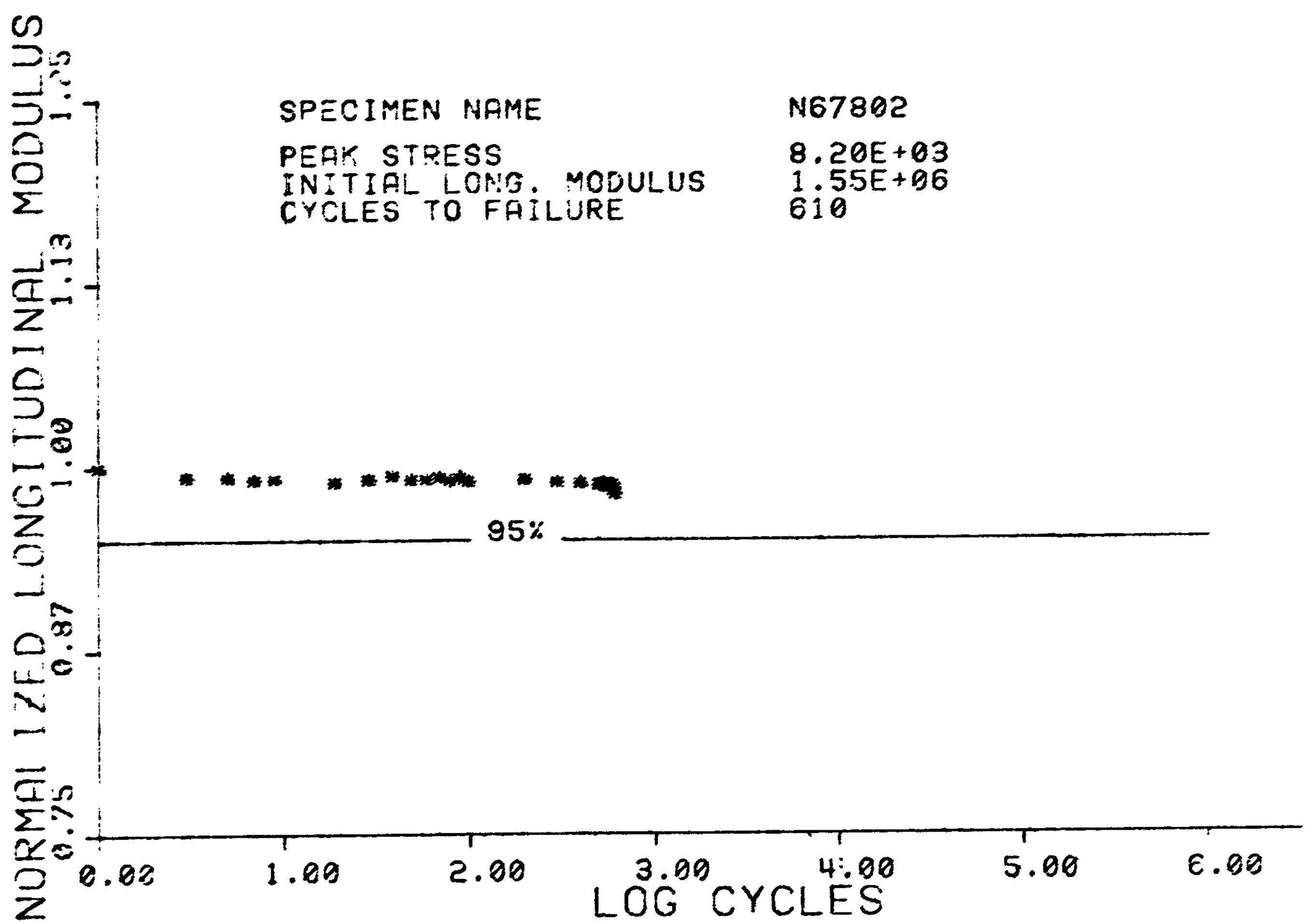

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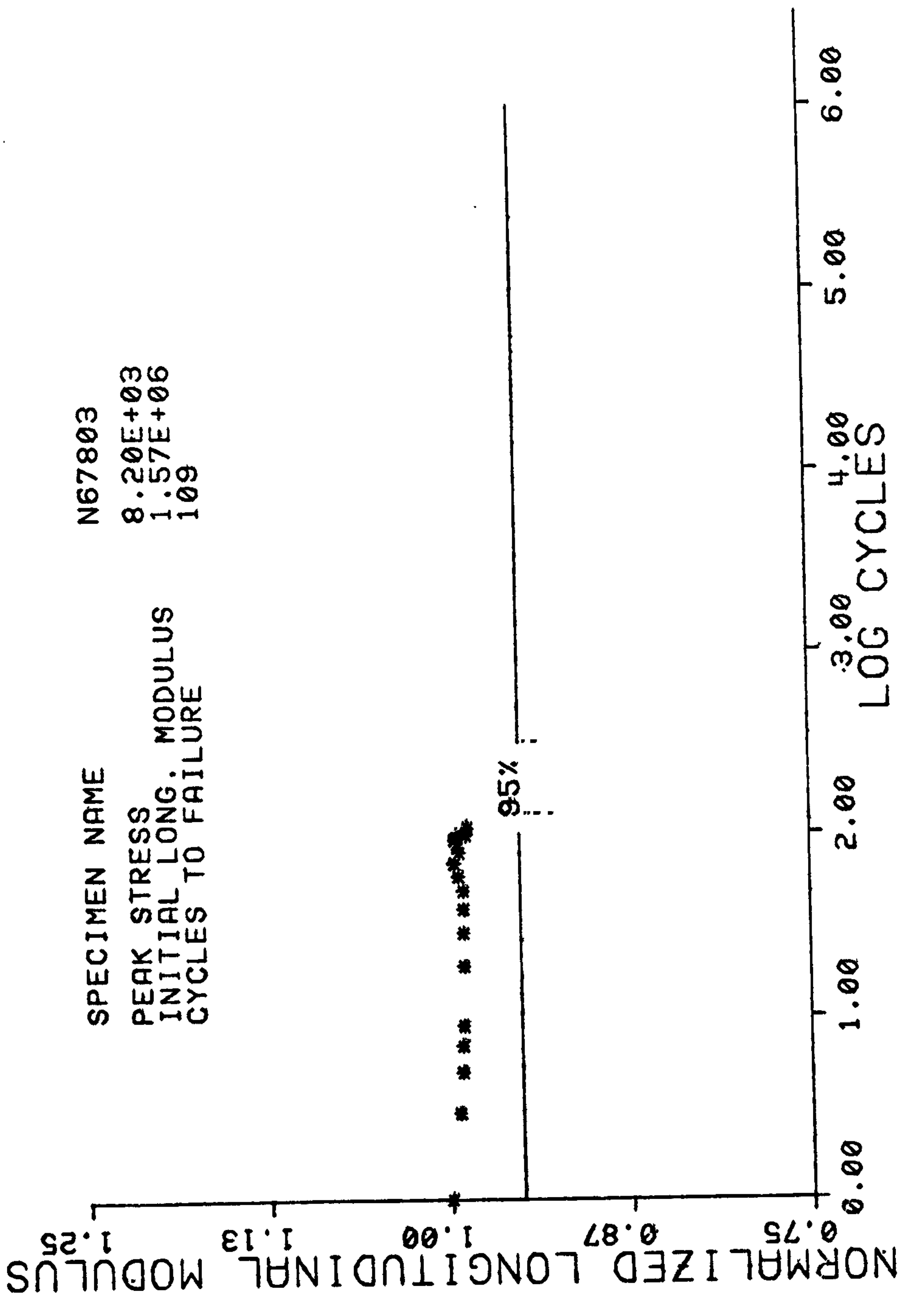
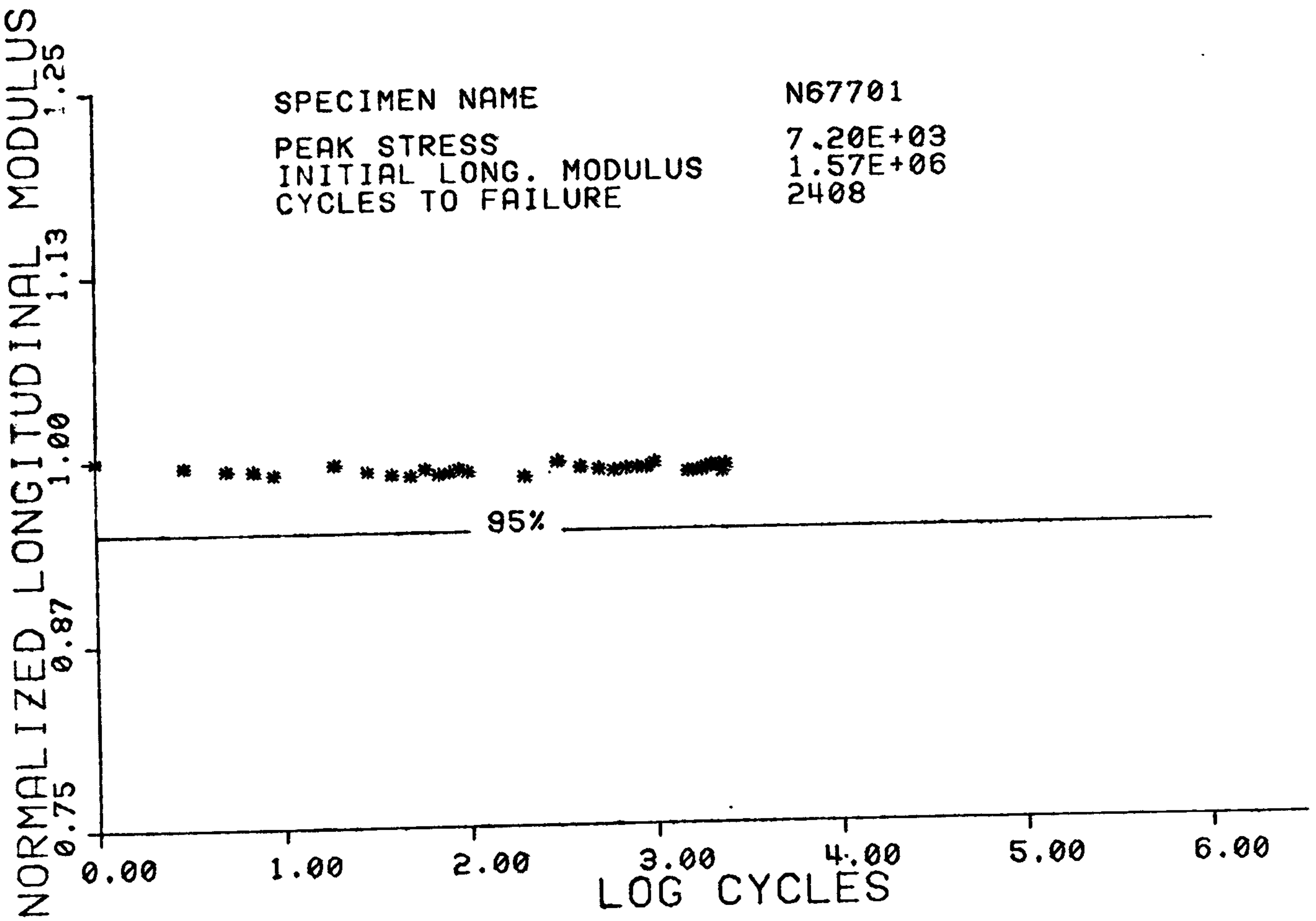

SPECIMEN NAME N67803
PEAK STRESS 8.20E+03
INITIAL LONG. MODULUS 1.57E+06
CYCLES TO FAILURE 109
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
LOG CYCLES
0.00
1.00
2.00
3.00
4.00
5.00
6.00


SPECIMEN NAME N67701
PEAK STRESS 7.20E+03
INITIAL LONG. MODULUS 1.57E+06
CYCLES TO FAILURE 2408
95%
NORMALIZED LONGITUDINAL MODULUS
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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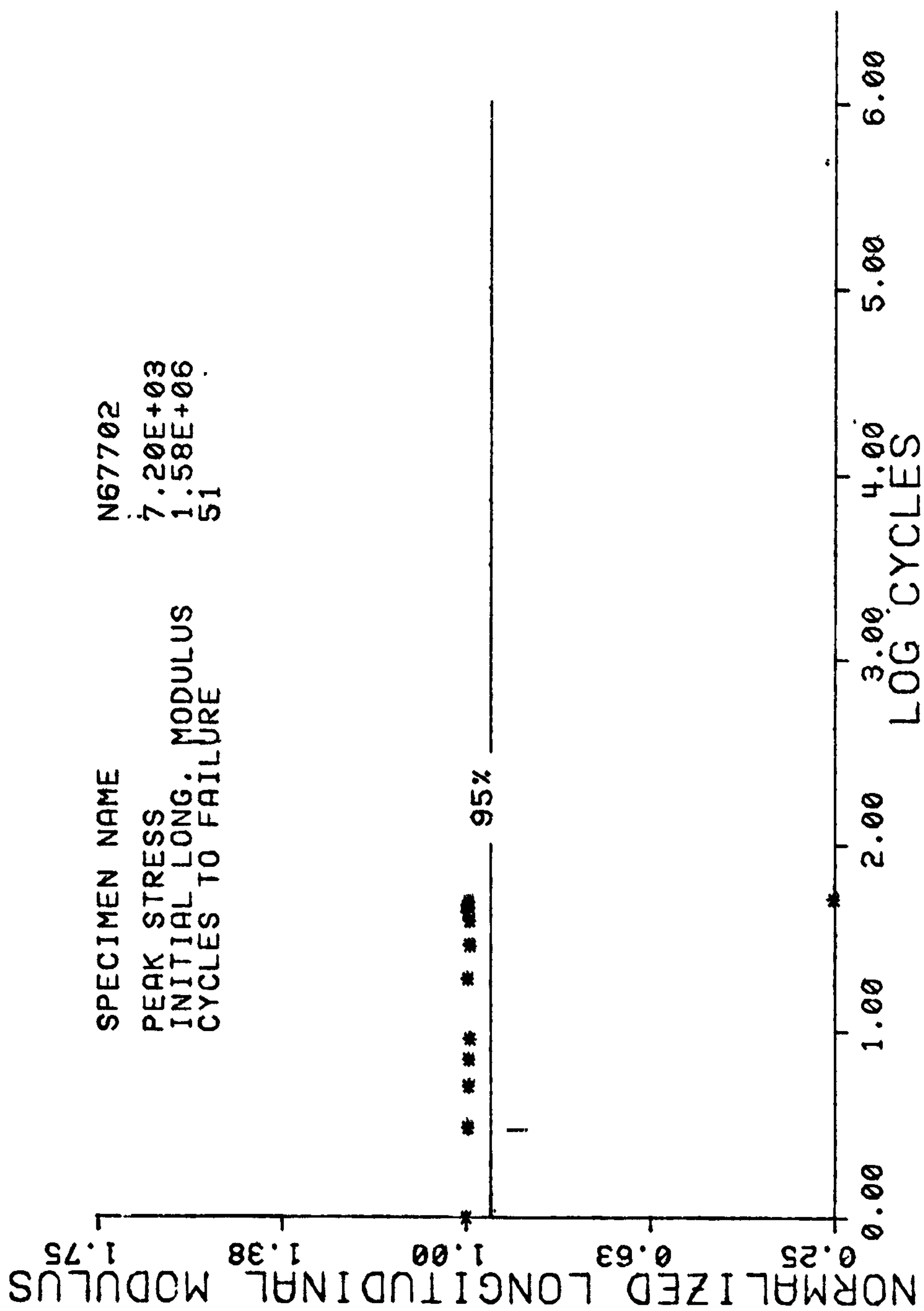
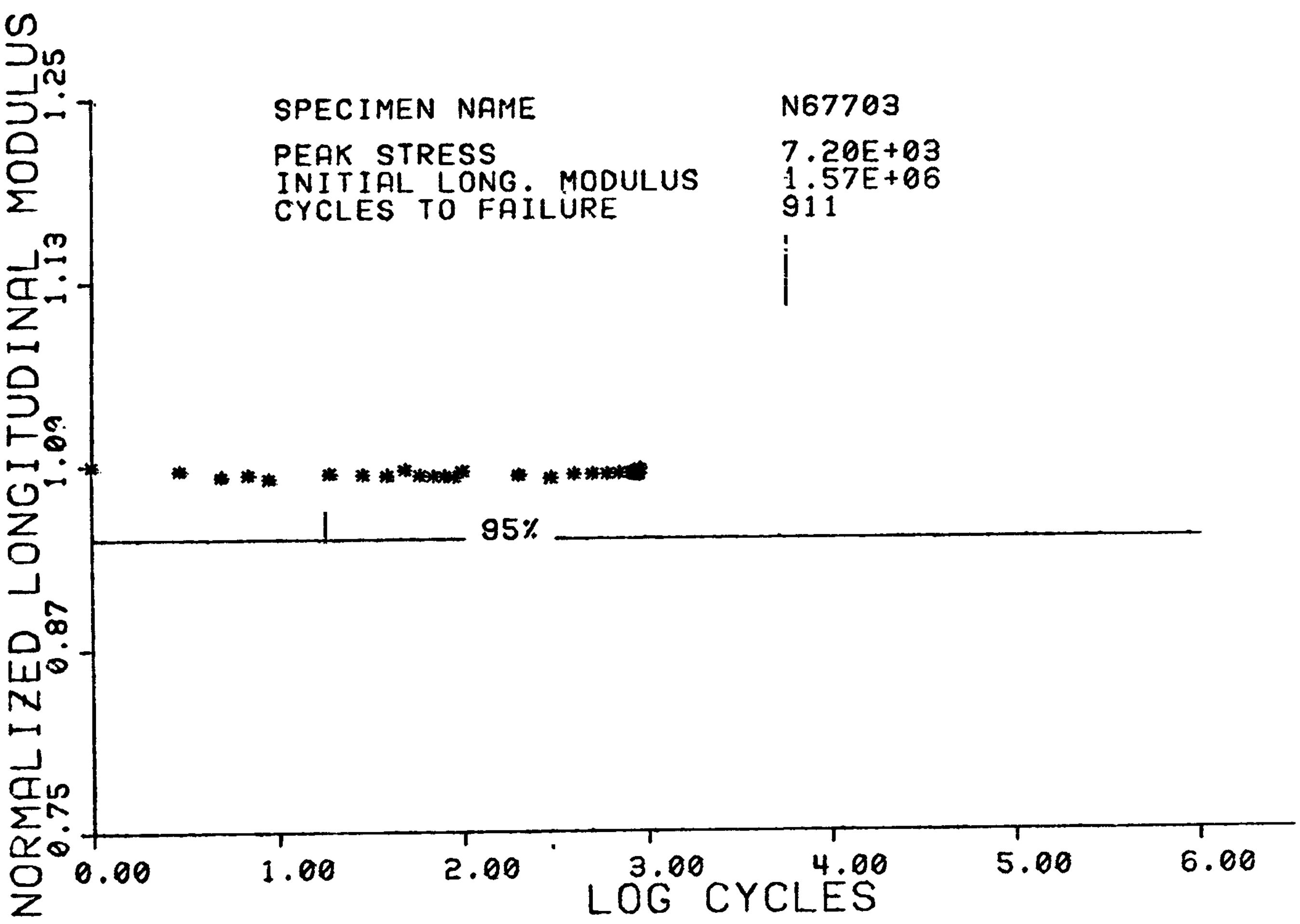
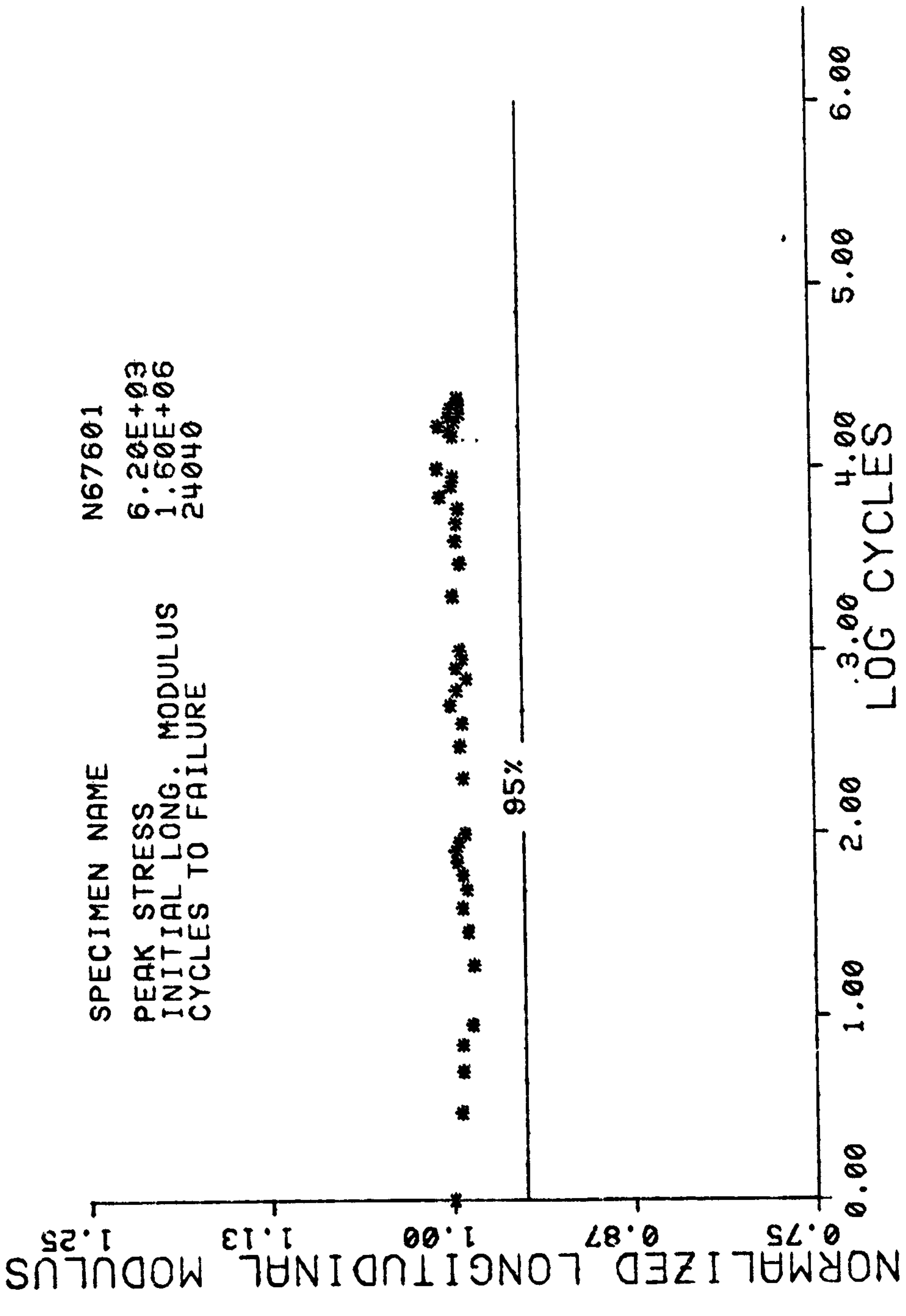
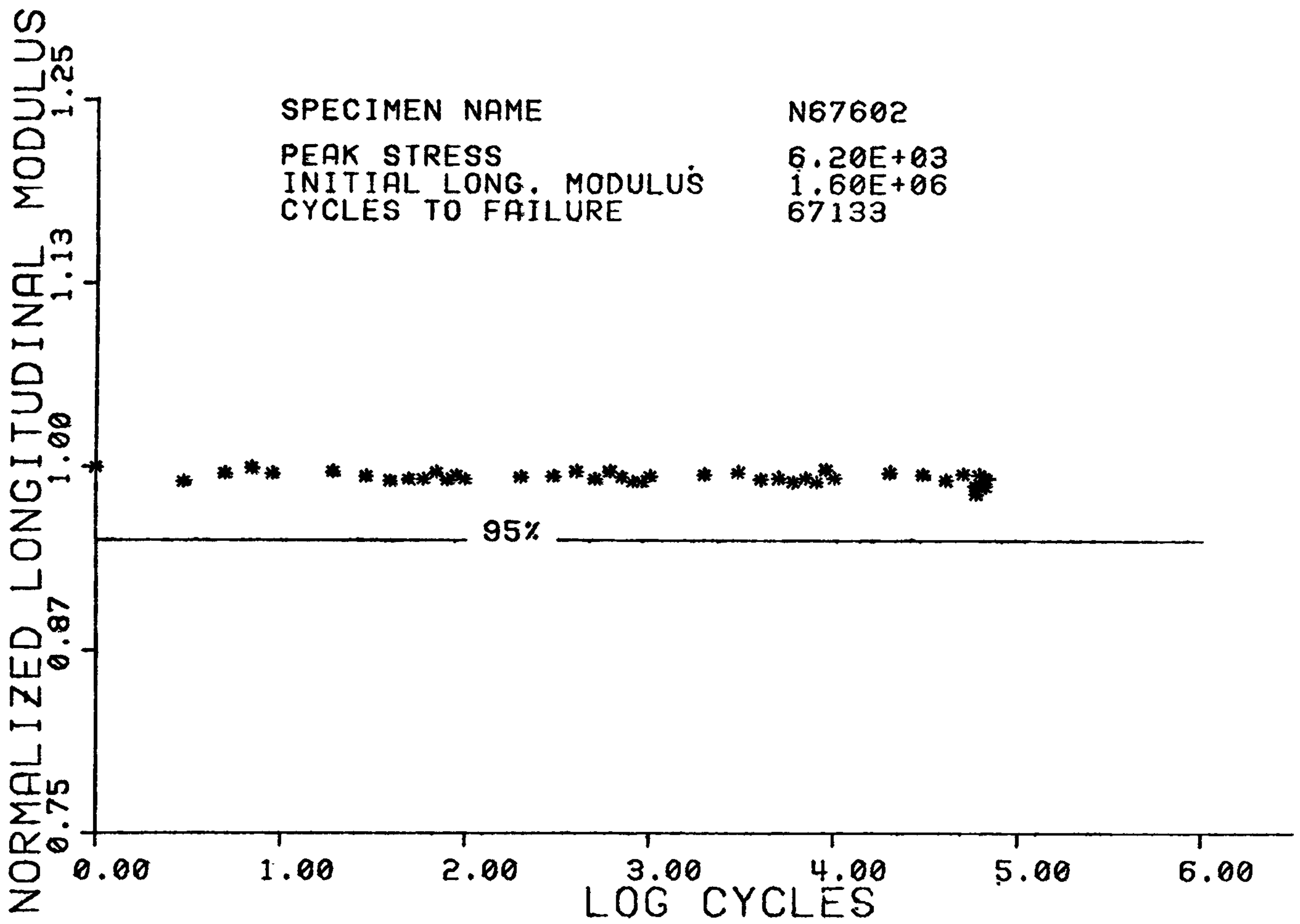
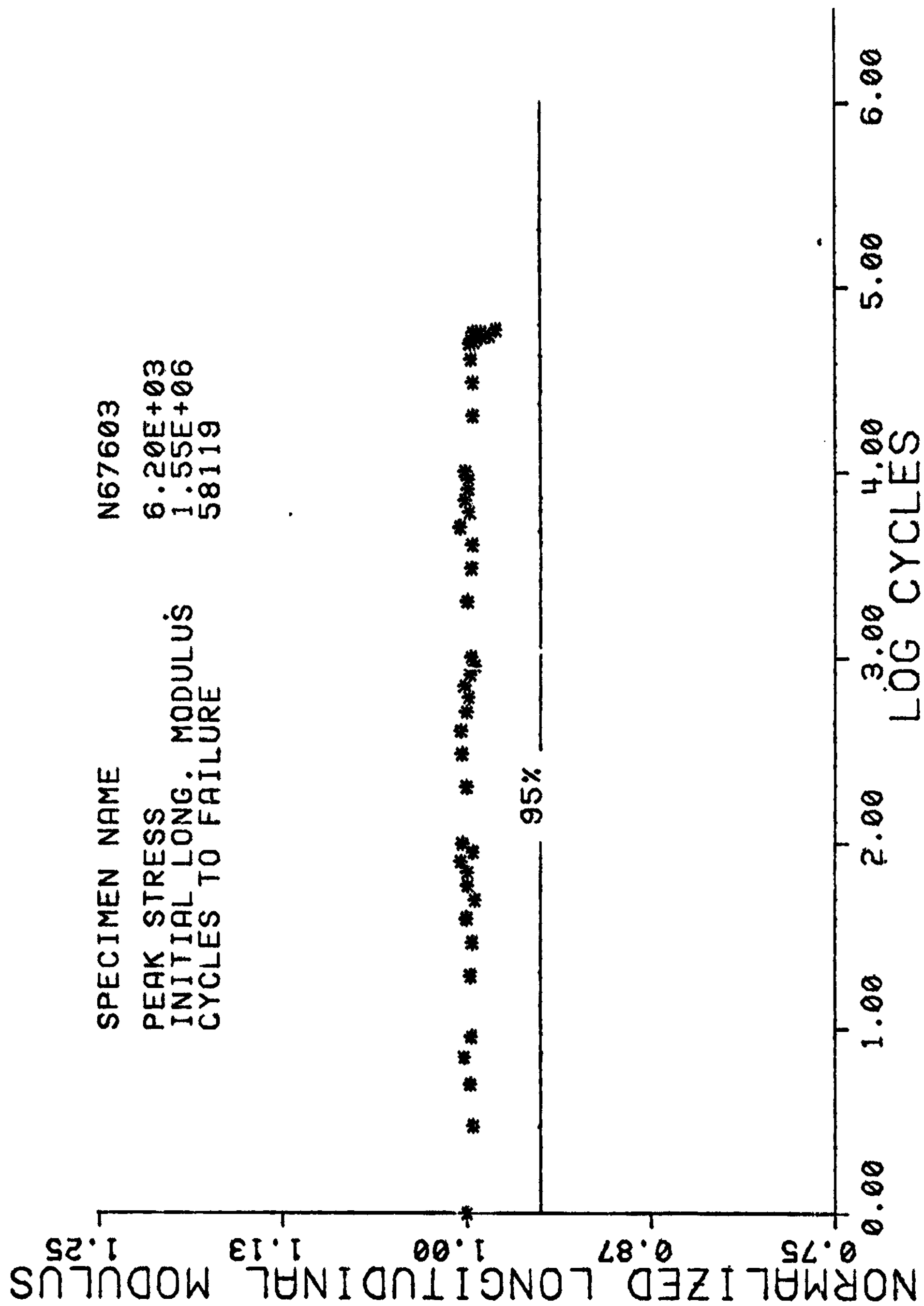
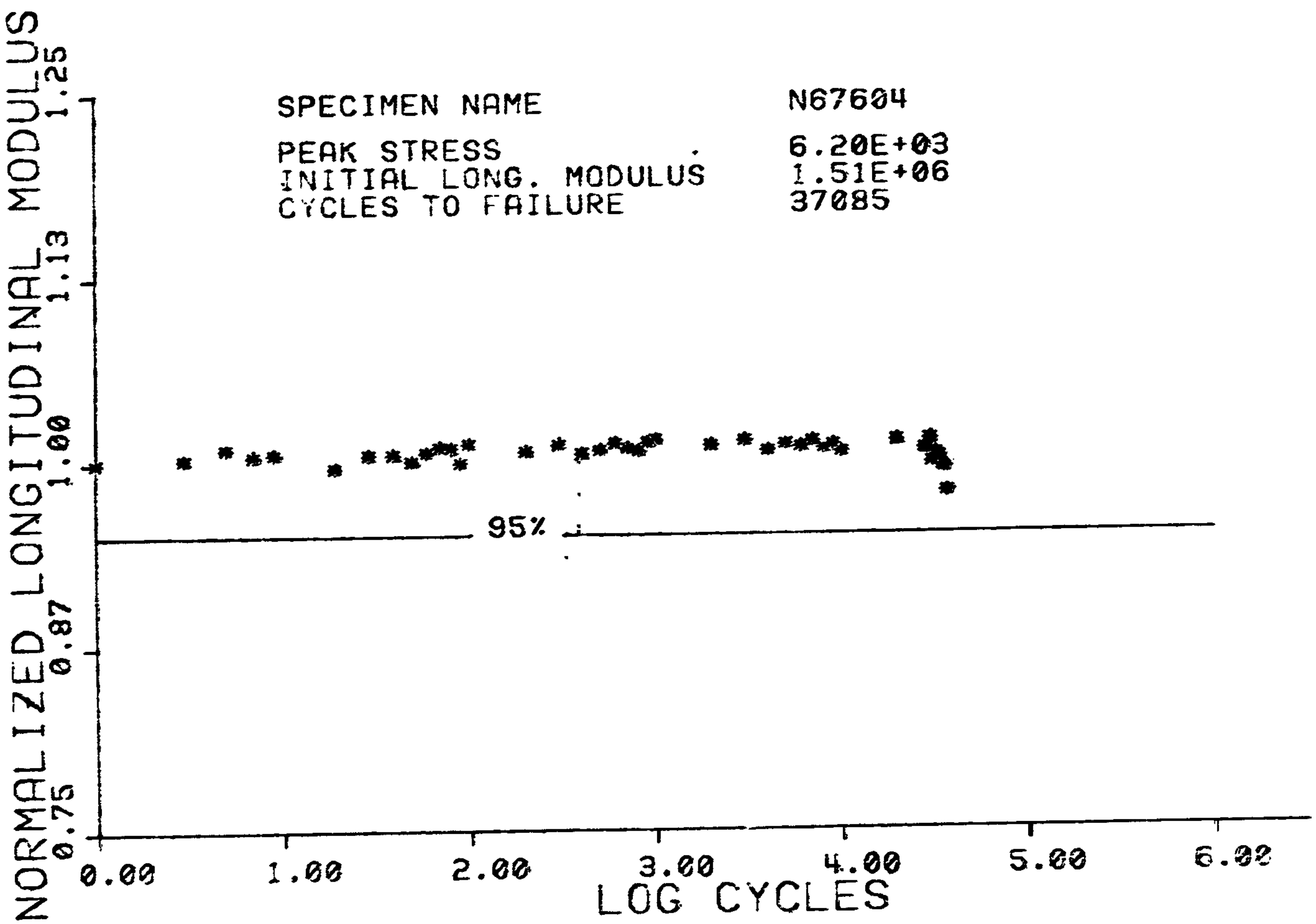



SPECIMEN NAME N67703
PEAK STRESS 7.20E+03
INITIAL LONG. MODULUS 1.57E+06
CYCLES TO FAILURE 911
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N67601
PEAK STRESS 6.20E+03
INITIAL LONG. MODULUS 1.60E+06
CYCLES TO FAILURE 24040
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
LOG CYCLES
0.00
1.00
2.00
3.00
4.00
5.00
6.00


SPECIMEN NAME N67602
PEAK STRESS 6.20E+03
INITIAL LONG. MODULUS 1.60E+06
CYCLES TO FAILURE 67133
95%
NORMALIZED LONGITUDINAL MODULUS
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N67603
PEAK STRESS 6.20E+03
INITIAL LONG. MODULUS 1.55E+06
CYCLES TO FAILURE 58119
95%
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES
0.75
0.87
1.00
1.13
1.25
NORMALIZED LONGITUDINAL MODULUS


SPECIMEN NAME N67604
PEAK STRESS 6.20E+03
INITIAL LONG. MODULUS 1.51E+06
CYCLES TO FAILURE 37085
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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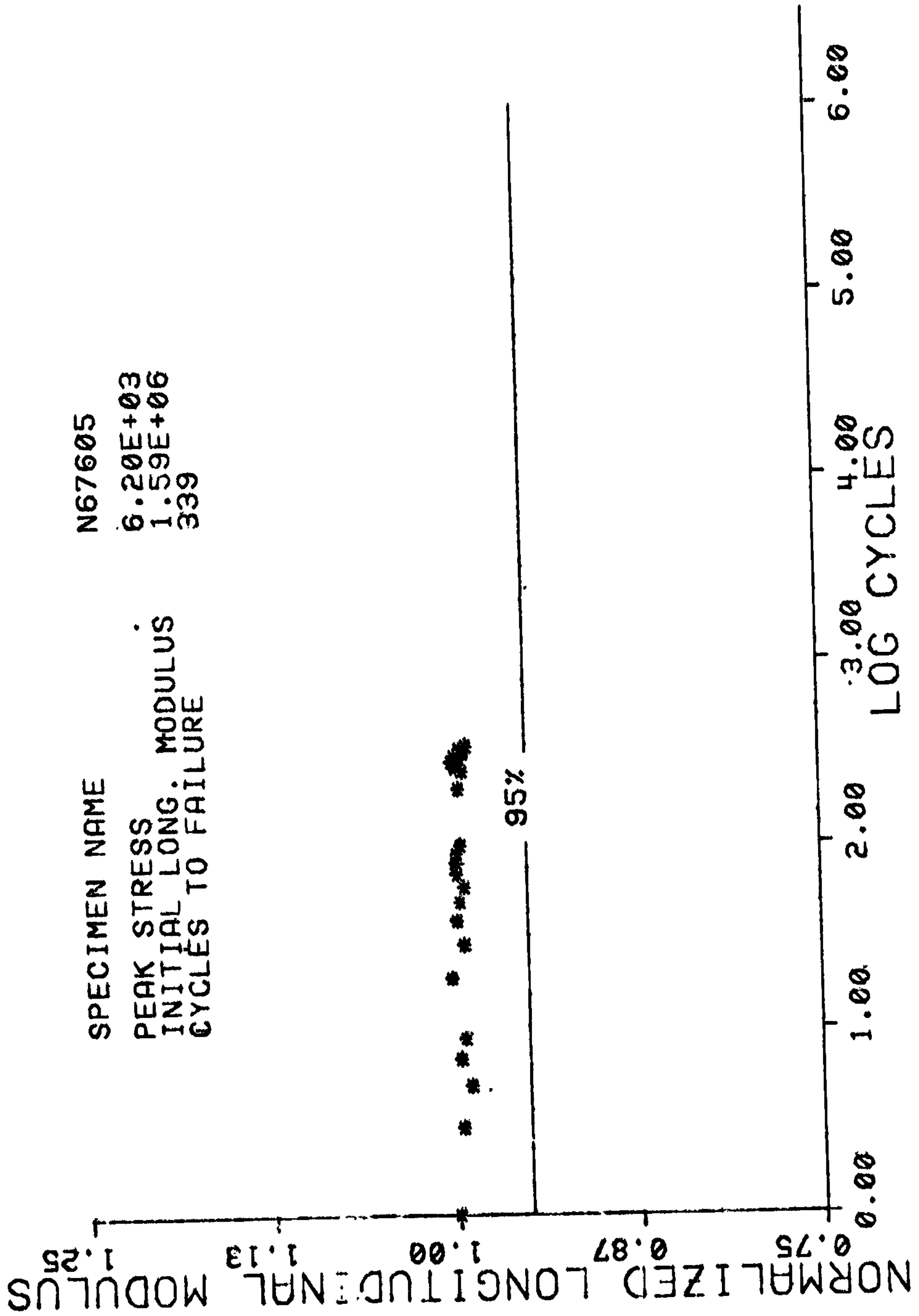

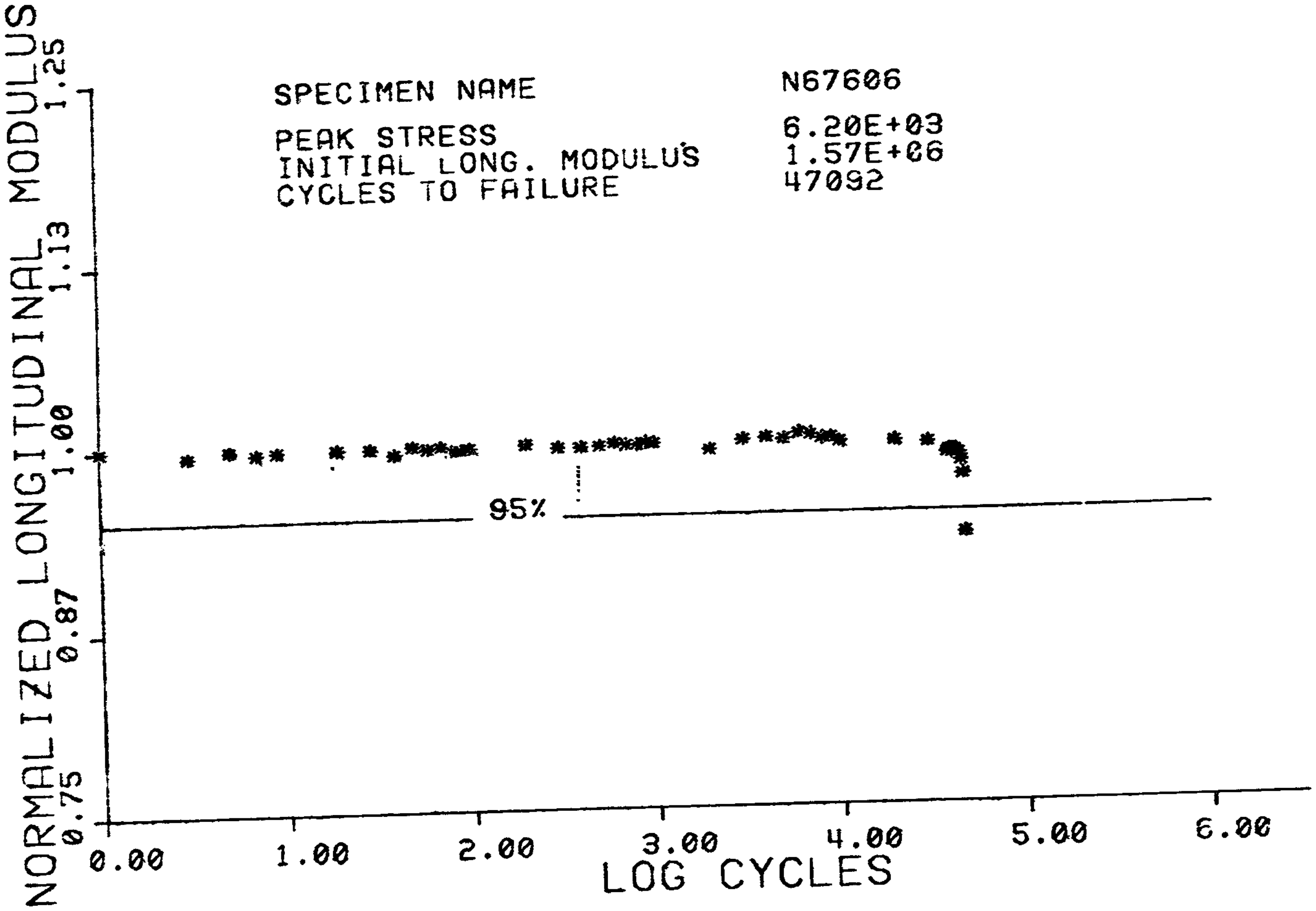
SPECIMEN NAME N67606
PEAK STRESS 6.20E+03
INITIAL LONG. MODULUS 1.57E+06
CYCLES TO FAILURE 47092
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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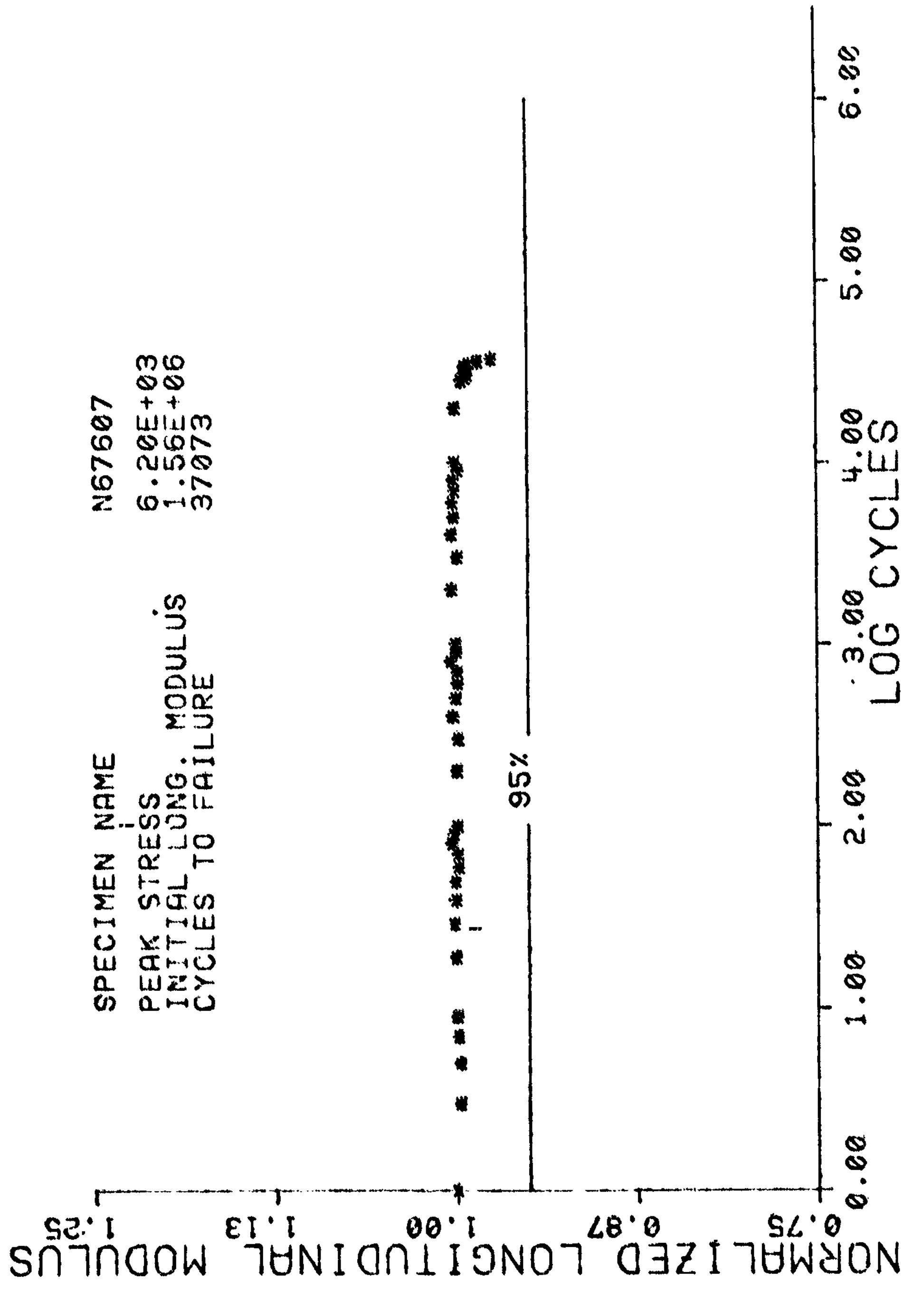

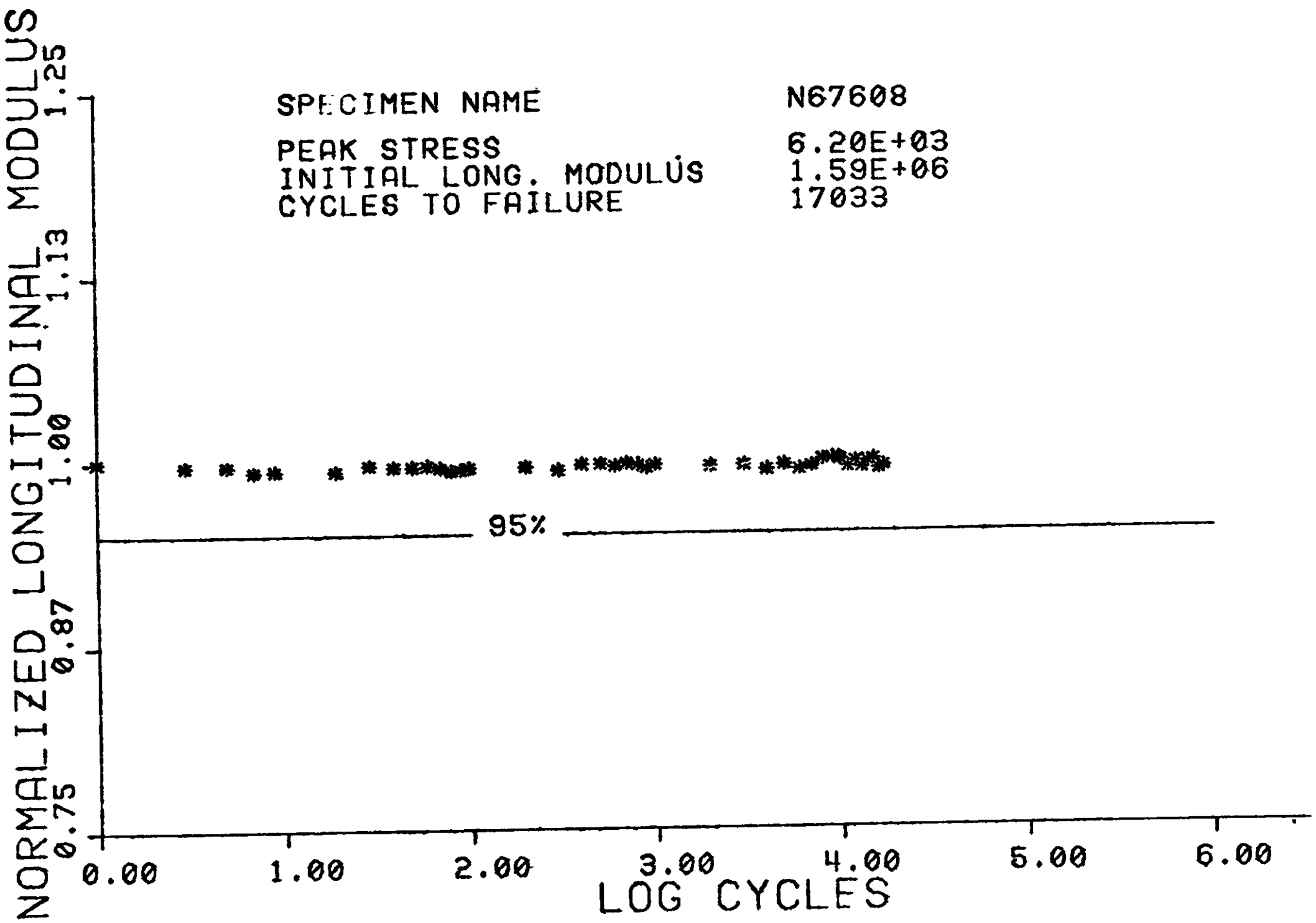
SPECIMEN NAME N67608
PEAK STRESS 6.20E+03
INITIAL LONG. MODULUS 1.59E+06
CYCLES TO FAILURE 17033
95%
NORMALIZED LONGITUDINAL MODULUS
1.25
1.13
1.00
0.87
0.75
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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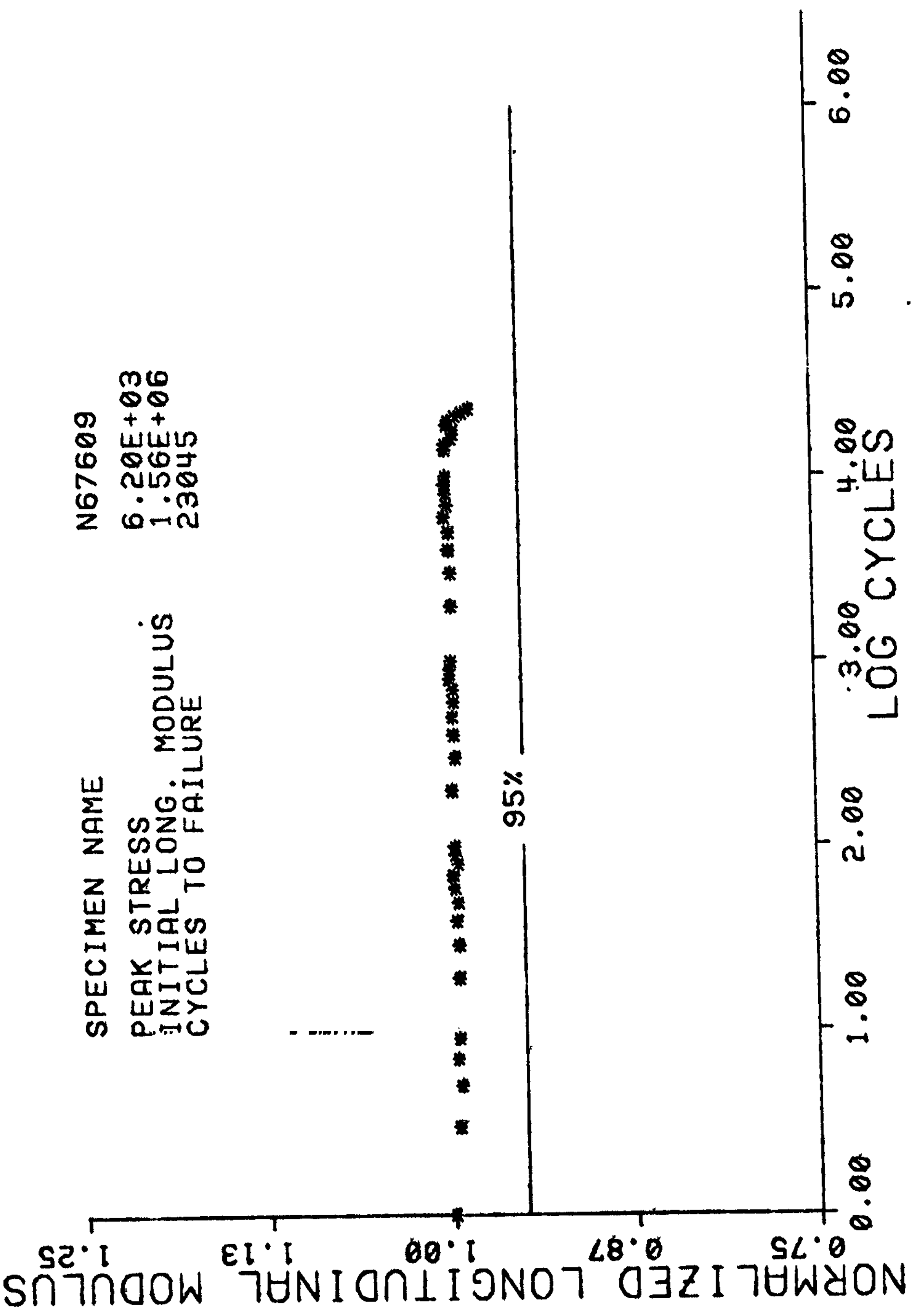

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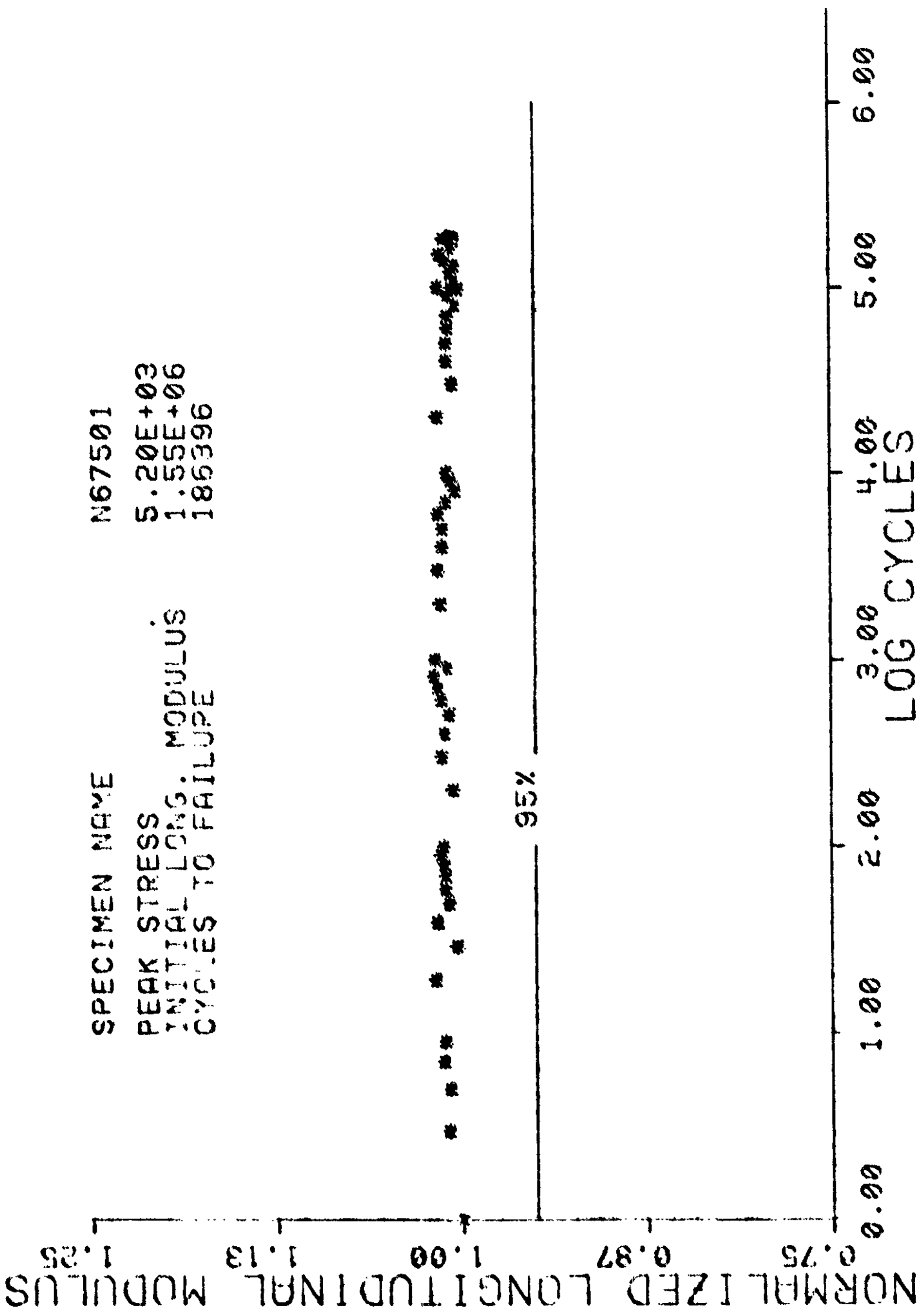

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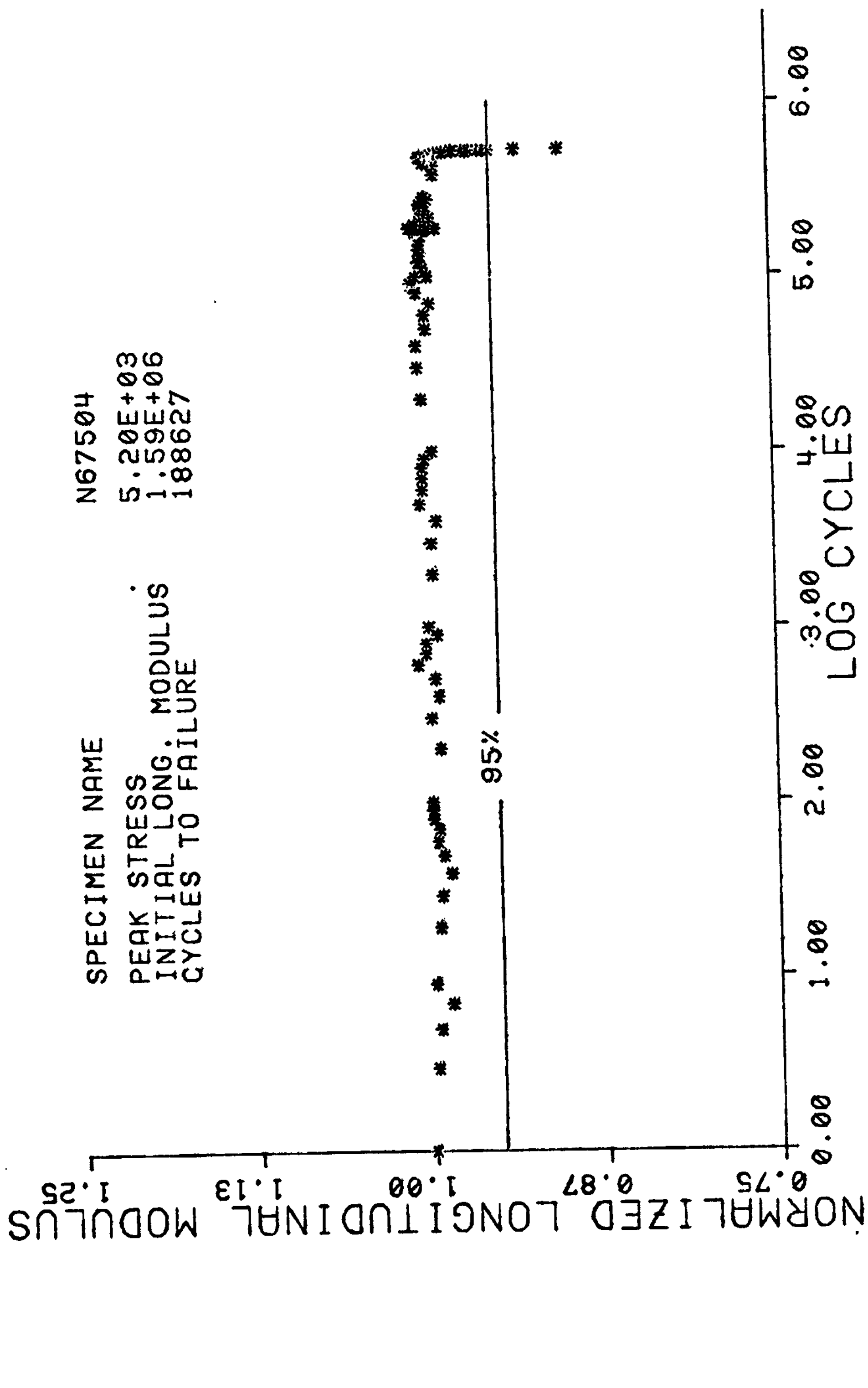
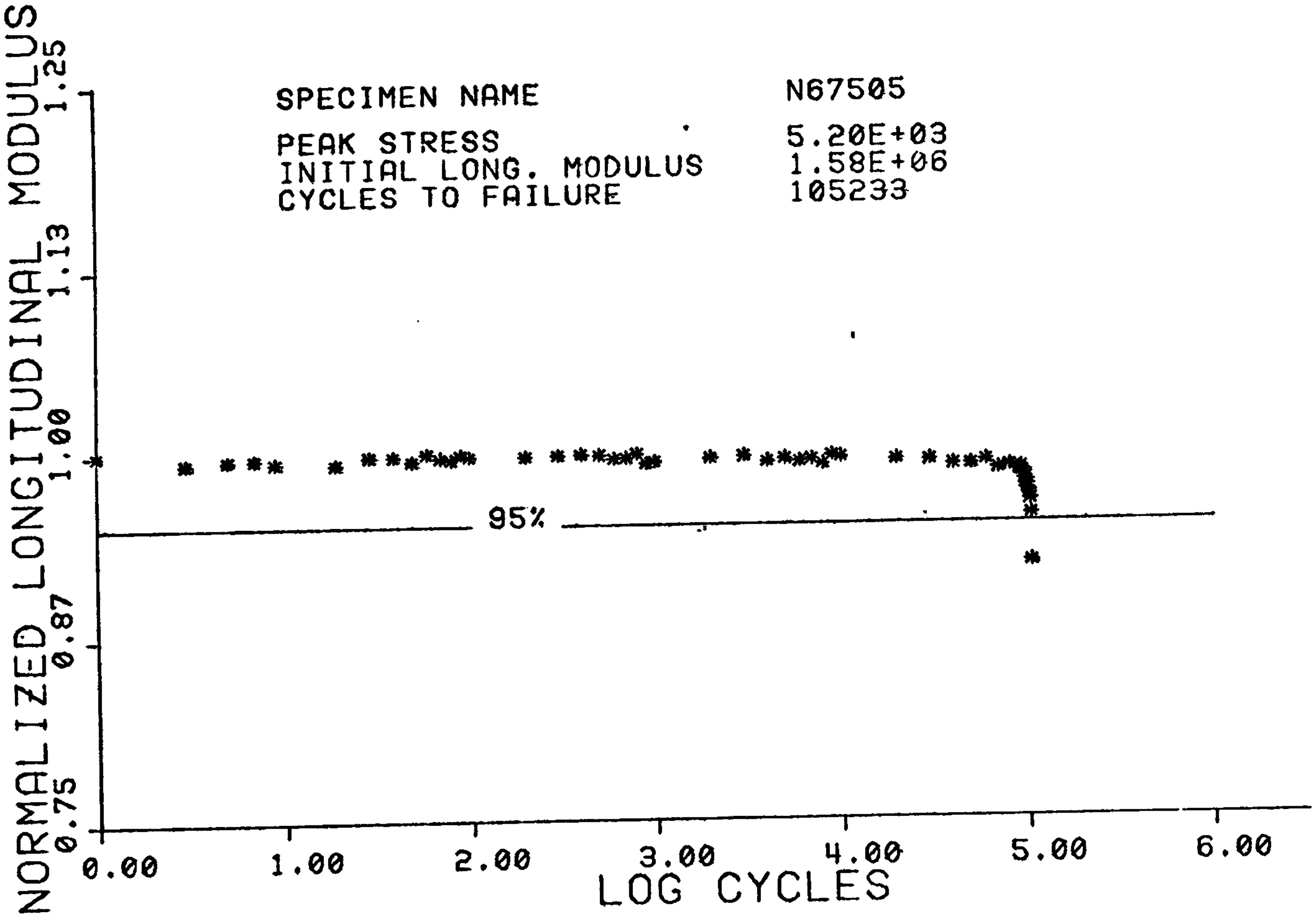
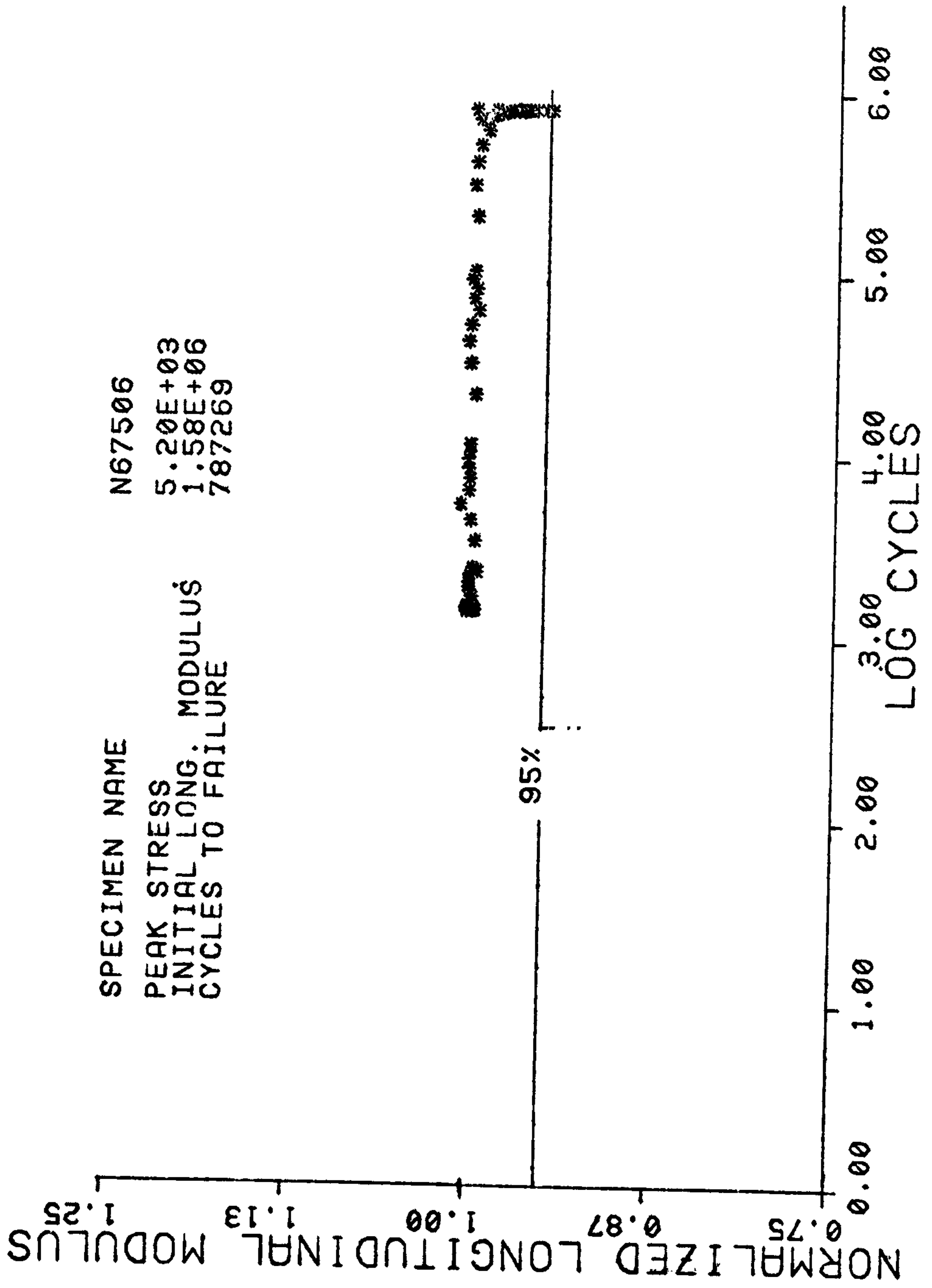



SPECIMEN NAME N67505
PEAK STRESS 5.20E+03
INITIAL LONG. MODULUS 1.58E+06
CYCLES TO FAILURE 105233
NORMALIZED LONGITUDINAL MODULUS
1.25
1.13
1.00
0.87
0.75
95%
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES


SPECIMEN NAME N67506
PEAK STRESS 5.20E+03
INITIAL LONG. MODULUS 1.58E+06
CYCLES TO FAILURE 787269
95%
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES
0.75
0.87
1.00
1.13
1.25
NORMALIZED LONGITUDINAL MODULUS

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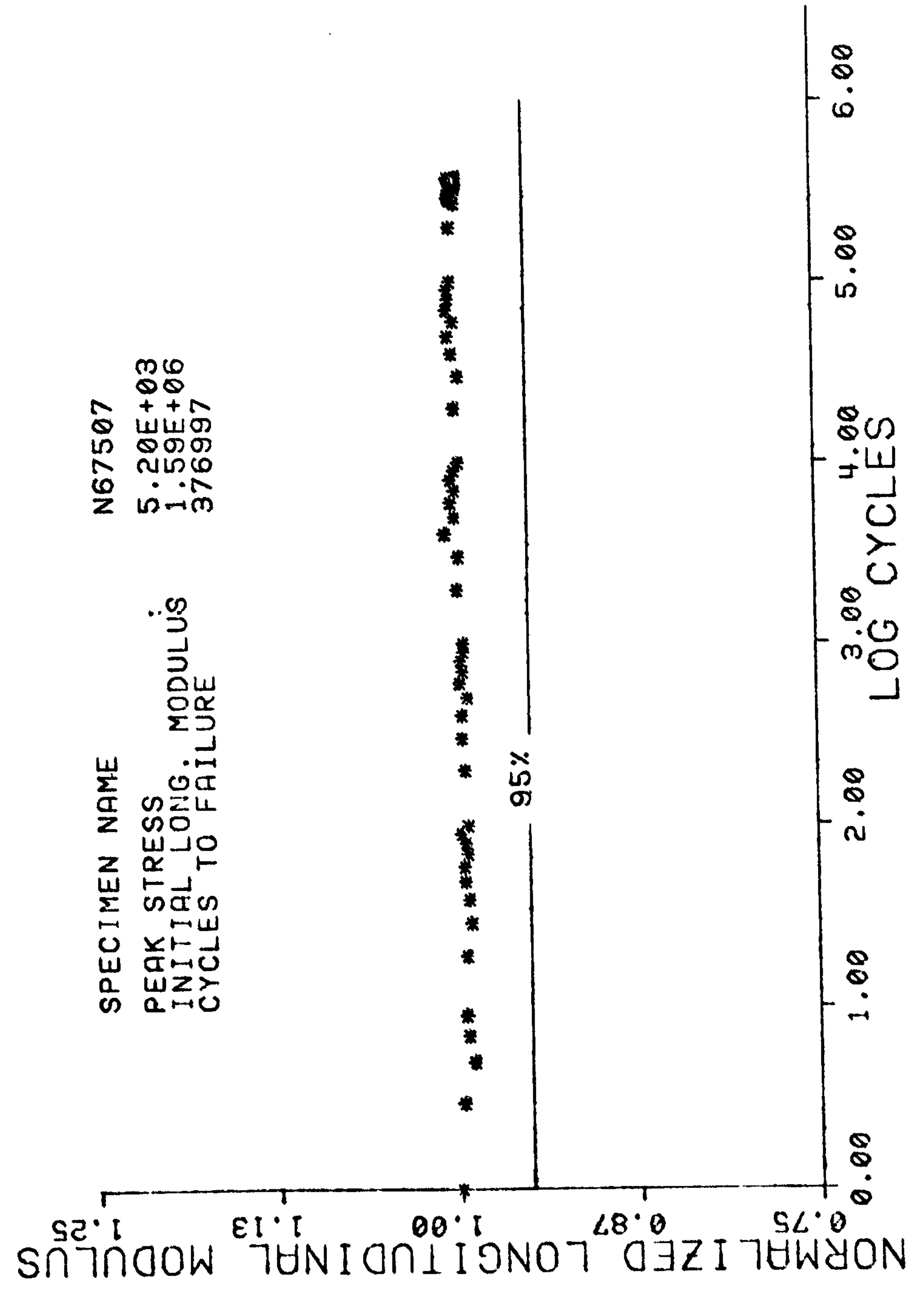

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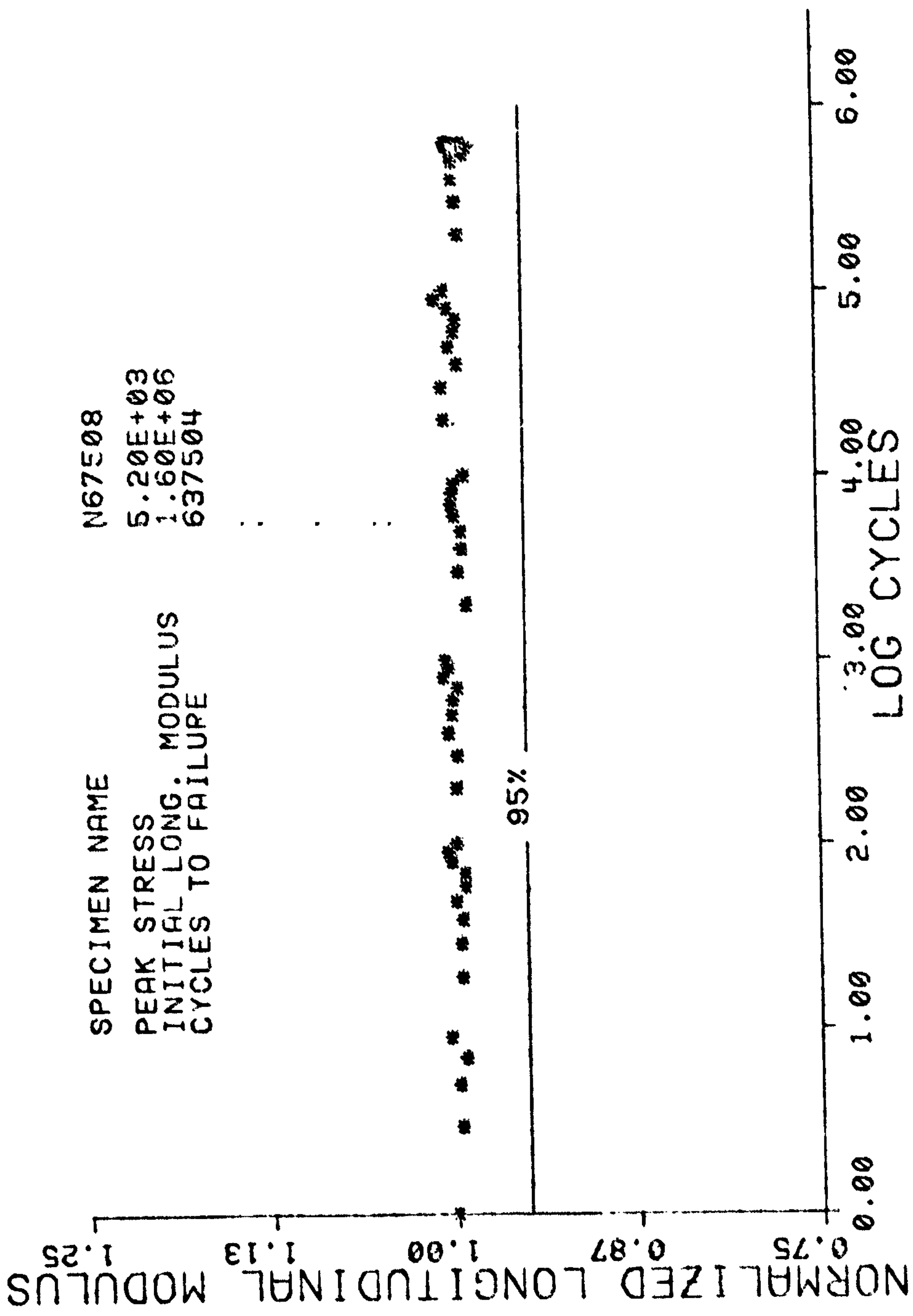

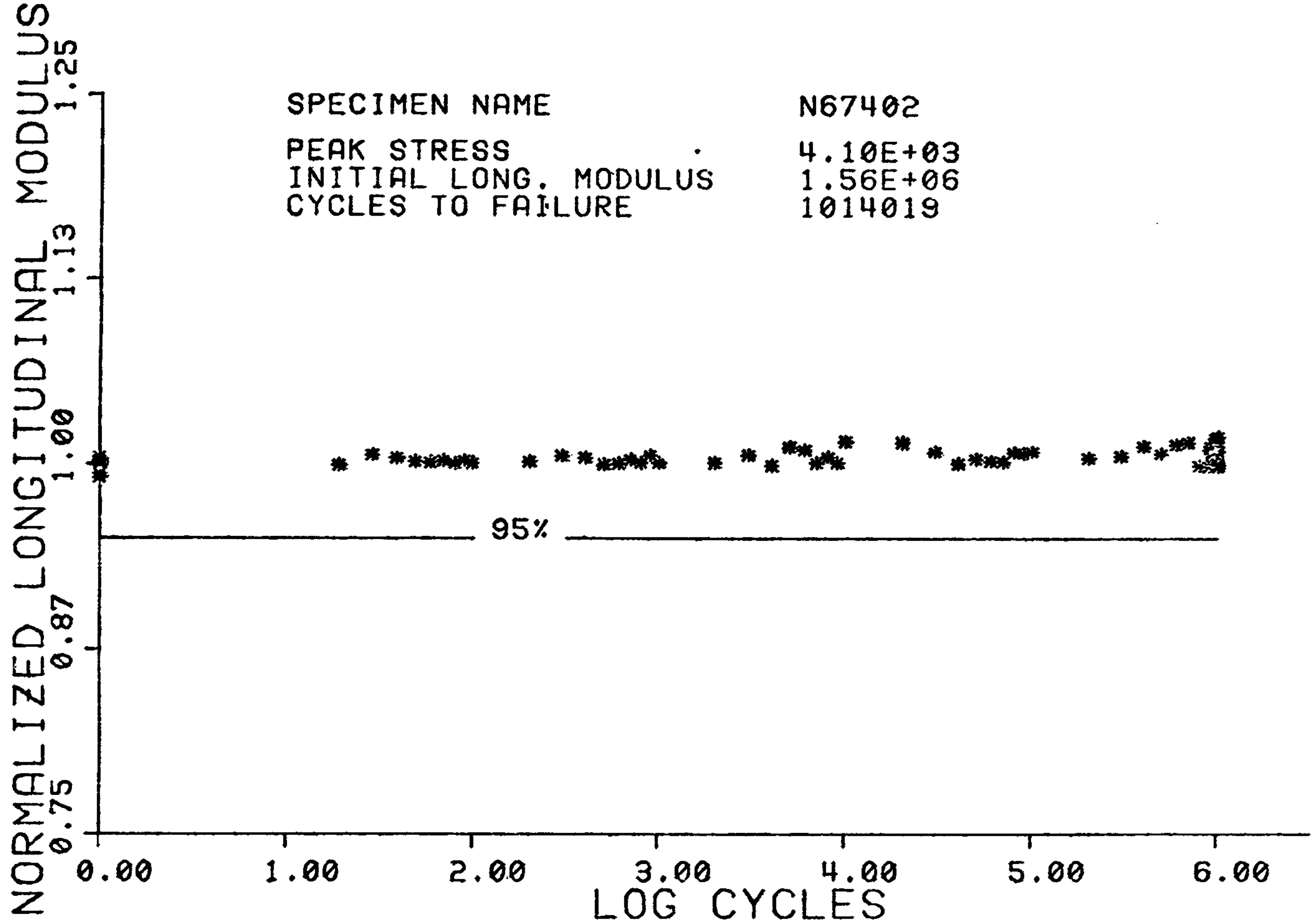
SPECIMEN NAME N67402
PEAK STRESS 4.10E+03
INITIAL LONG. MODULUS 1.56E+06
CYCLES TO FAILURE 1014019
95%
NORMALIZED LONGITUDINAL MODULUS
0.75
0.87
1.00
1.13
1.25
0.00
1.00
2.00
3.00
4.00
5.00
6.00
LOG CYCLES

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