AD-A081 535 OGDEN AIR LOGISTICS CENTER HILL AFB UT PROPELLANT LAB--ETC F/G 21/9.2
SURVEILLANCE REPORT. STAGE I DISSECTED MOTORS. PHASE XI. PROPEL--ETC(U)
NOV 79 J A THOMPSON

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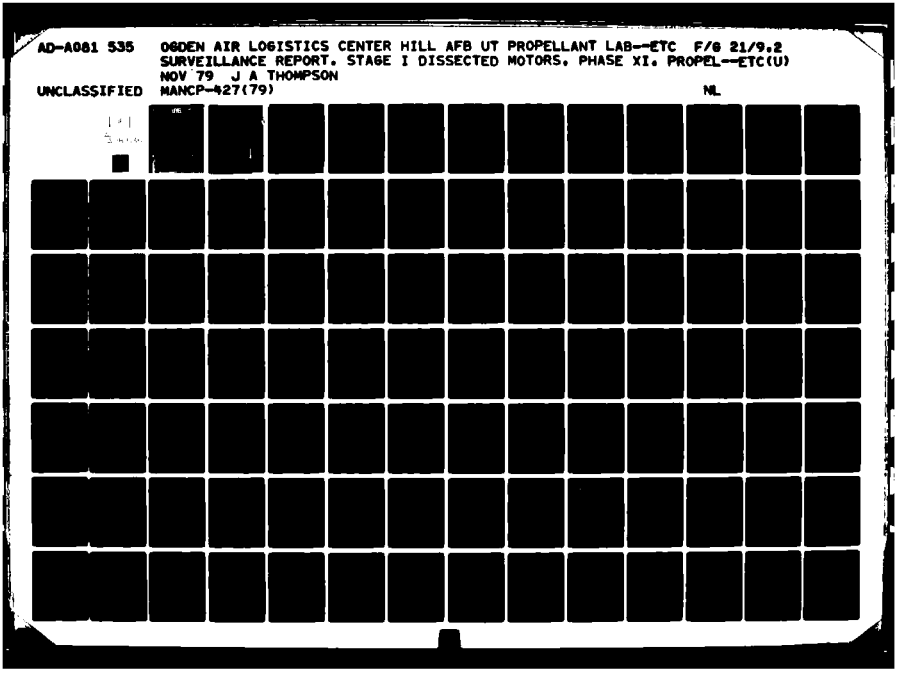

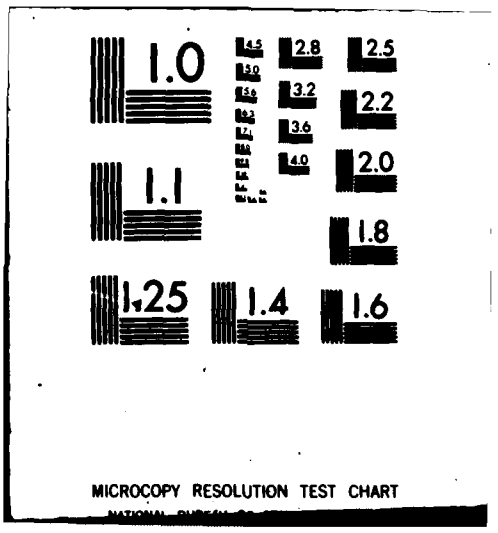
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1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
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3.6
4.0
4.5
5.0
5.6
6.3
MICROCOPY RESOLUTION TEST CHART

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MANCP REPORT NR 427(79)
MMWRM PROJECT M82934C

(6)

SURVEILLANCE REPORT •

STAGE I DISSECTED MOTORS •

PHASE XI, PROPELLANT & COMPONENT TESTING •

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ABSTRACT

Testing was performed to determine the useful shelf/service life for LGM-30 Stage I Rocket Motors. A three year storage program for propellant and components was started in May 1961. This program was then extended to a ten year study and later continued indefinitely to assure that a deterioration in motor physical characteristics could be detected in time to take some corrective actions before the weapon system performance deteriorated below an acceptable level.

This report covers only propellant data and limited case bond data. The malfunction of an environmental chamber destroyed component samples that had originally been part of this testing program (and the inadvertent burning of some motors during dissection reduced the material available for testing). Planned dissection of selected motors in the future will provide samples for continued component testing. Test specimens for this reporting period were obtained from motors STM-012, 0012099, and 0012199. UP-7775 block propellant was not tested since that propellant has been used up.

Regression analyses were made using all data accumulated through this test period. Unique plotting symbols were used so that each motor and block propellant can be identified in the regression analysis. The plotting symbols for each motor and block propellant are listed in the statistical analyses section.

The data from this test period was combined with data from previous testing and entered into the G085 computer for storage, analysis, and regression analysis. From the statistical analysis of all data tested to date, significant degradation of the propellant does not appear likely for at least two years past the oldest data point.

Future testing will be conducted on dissected motors.

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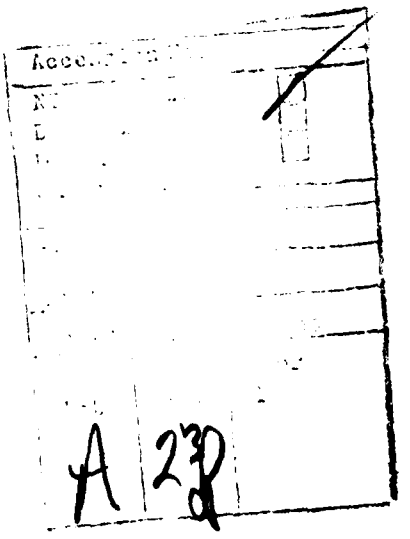


LIST OF FIGURES

LIST OF FIGURES (cont)

LIST OF FIGURES (cont)

GLOSSARY OF TERMS AND ABBREVIATIONS

Aging Trend	A change in properties or performance resulting from aging of material or component
CSA	Cross Sectional Area
DB	Dogbone
Degradation	Gradual deterioration of properties or performance
E	Modulus (psi), defined as stress divided by strain along the initial linear portion of the curve.
EB	End Bonded
EGL	Effective Gage Length
em	Strain at maximum stress
er	Strain at rupture
"F" ratio	The ratio of the variance accounted for by the regression function to the random unexplained variance. The regression function having the most significant "F" ratio is used for plotting data. The ratio is also used in detecting significant changes in random variation between succeeding time points
JANNAF	Joint Army, Navy, NASA, Air Force Committee
MANCP	Propellant Lab Section at Ogden Air Logistics Center
Ogden ALC	Ogden Air Logistics Center, Air Force Logistics Command
r or R	The Correlation Coefficient is a measure of the degree of closeness of the linear relationship between two variables
Regression Equation	The general form of the regression equation is $Y = a + bx$
Regression Line	Line representing mean test values with respect to time
S_b	Standard error of estimate of the regression coefficient

GLOSSARY OF TERMS AND ABBREVIATIONS (cont)

S_e or $S_{Y.X}$	Standard deviation of the data about the regression line
Sm	Maximum Stress
Sr	Stress at rupture
Standard Deviation (S_y)	Square root of variance
Strain Rate	Crosshead speed divided by the EGL
"t" test	A statistical test used to detect significant differences between a measured parameter and an expected value of the parameter (determines if regression slope differs from zero at the 95% confidence level)
Variance	The sum of squares of deviations of the test results from the mean of the series after division by one less than the total number of test results
3 Sigma Band	The area between the upper and lower 3 sigma limit. It can be expected that 99.73% of the inventory represented by the test samples would fall within this range assuming that the population is normally distributed.
90-90 Band	It can be stated with 90% confidence that 90% of the inventory represented by the test samples would fall within this range assuming that the population is normally distributed

INTRODUCTION

A. PURPOSE:

This report contains test data from samples of LGM-30 Stage I, Wings I-V TP-H1011 propellant and case bond specimens. Testing was performed by the Propellant Laboratory Section (MANCP) for the Engineering and Reliability Branch of the Airmunitions Management Division (MMWRM) under Project M82934C-WNL17514. This report is the eleventh in this series. Data from this test period and propellant test data from the ten previous reports were entered into the G085 computer for regression analysis. The regressions are shown in this report.

B. TEST PROGRAM:

The LGM-30 Laboratory and Component Program includes the testing of materials used in the main case and main grain propellant. This report covers TP-H1011 propellant and case bond specimens. Table I outlines the test program.

Propellant for testing was obtained from three dissected motors; STM-012, a motor prepared by Thiokol specifically for dissection; S/N 0012099, a SLIM motor and S/N 0012199 which was selected for dissection. UP-7775 block propellant which had been tested during previous test periods was not tested at this test period as it was used up during the last test period.

C. HISTORICAL BACKGROUND:

In May 1961, Thiokol began a three year LGM-30 laboratory storage and test program to determine the rate of degradation with age for Stage I materials. During June 1962 and again in August 1963, additional samples were included. New samples were added in July and August 1964 when the

surveillance testing program was extended to ten years (Test Plan 0717-62-0967, 53-8). Carton block propellant, batch UP-7775, containing TP-H1011 propellant cast in March 1962 was added to the program in 1964.

Samples added to the inventory in 1964 were considered to be a new population, but were combined in regression analysis with the three dissected motors. The history of testing of these materials is found in MQQP Report Nrs. 109A(67), 144(68), 208(71), and MANCP Report 358(76). Physical transfer of the specimens from Thiokol to Ogden ALC was made in June 1967.

TABLE I

TEST PROGRAM

All Temperatures in Fahrenheit
Motors STM-012, S/N 0012099, S/N 0012199

(Block Propellant UP-7775 was included in this portion of the test program in previous test periods)

Test	Conditions	Spec/Cond	Spec Config
Tensile	77°, 2.0 & 20 in/min	5 ea	JANNAF Dogbone
Creep	77°, 10 & 12 lb load	3 ea	JANNAF Dogbone
Stress Relax	77°, 3 & 5% strains	3 ea	1/2" x 1/2" x 4"
Strain Dilatation	77°, .25 in/ in/min	3 ea	1/2" x 1/2" x 4"
Hardness	77°, initial & 10 seconds	5 ea	Dogbone Ends
HOE	77°	3 ea	1/2' x 3/8" x 1"
Burning Rate	77°, 500 & 1000 psi	5 ea	.156" x .156" x 5"
DTA	77° start	3 ea	0.040" wafer
Ignitability	77°, 168 cal/ cm^2 - sec	3 ea	0.050" wafer
Sol Gel	77°	6 ea	1/2" x 1/2" x 1/2"
UP-7775 was NOT included in this portion of the test program in previous test periods.			
High Rate Tensile	77°, 1000 in/in/min	5 ea	3/4" GL Dogbone
High Rate Triaxial Ten	77°, 1000 in/in/ min, 600 psi	3 ea	3/4" GL Rail
Dynamic Response	77°, 70 gm ct. wt.	3 ea	3.3" x 3.3" x 0.690" disc
Biaxial Constant Strain	77°	3 ea	3/4" GL Rail

TABLE I (cont)

Test	Conditions	Spec/Cond	Spec Config
Failure Envelope	Temp: -50°, -20°, 10°, 40°, 77°, 130° & 180°F at a rate of 0.2, 2.0 & 20 in/min	3 ea	JANNAF Dogbone
STM-012 and S/N 0012199 only were used for the following tests:			
Case Bond Tensile	77°, 0.2 in/min	10 ea	1" x 5/8" x 3/4"
Tear Energy	77°F ± 2°	8 ea	0.1" x 1.18" x 3"
Poisson's Ratio (Strain Dilatation)	77°F ± 2° 10, 15, 20, 25, 30%	6 per/ condition	0.50" x 0.50" x 4"

STATISTICAL ANALYSIS

The objective of this statistical analysis was to determine whether or not any aging trends are demonstrated by accumulated test data in order to assist Service Engineering to more accurately predict motor serviceability.

Propellant was made available for testing and statistical analysis was performed on the resultant data in order to obtain an overall view of the aging trends affecting the First Stage Dissected Motor Program. The sampling consisted of data from two dissected operational motors (0012099 and 0012199), and one motor (STM-012) which was prepared by Thiokol specifically for the dissection program. In addition, carton propellant data (batch UP-7775) which was tested previously was included in the regression analyses.

A Multi-symbol Regression Analysis Program was used to determine aging trends. The sampling is combined for each test parameter in a single regression analysis. The linear equation ($Y = a + bX$) was found to be the best fit model for the data in this report. A composite population aging trend line is then calculated accepting the fact that individual aging of different populations may be masked.

The Multi-symbol Program uses a unique plotting code for each motor and carton data on the regression plots. This method of data plotting allows a visual display of the overall relationship between the various origins of data and how they relate to the overall least square aging trend line.

The regression program uses an analysis with individual data points from different time periods combined to establish a least squares aging trend line for the overall data. The variance about the regression line, obtained using individual values of the dependent variable, was used to compute a tolerance interval such that at the 90% confidence level 90% of the population falls within this interval. This tolerance interval was

extrapolated to a maximum of 24 months to give an indication of the statistical significance of the slope of any aging trends. The computer tolerance interval about the composite regression line is wider than what the tolerance interval would be about any individual motor or carton regression line because of the increased data spread introduced by combining different populations of data. The "t" values and the significance of this statistic, which are reported for each regression model, gives an indication of the "statistical significance" of the slope of the aging trend in the Y-axis. Data and regression trend lines were plotted utilizing an IBM-360/65 computer.

ORIGIN SYMBOL TABLE

Origin	DOM	Wing	Symbol
Motor 0012099	63166	2	0
Motor 0012199	63227	2	1
Motor STM-012	61221	1	S
* Carton UP-7775	62075	1	U

* The last of carton UP-7775 block propellant was used up on the previous testing period. No new data for UP-7775 will appear in this report.

TEST RESULTS

Regression analysis is the method of evaluation used in the analysis of the test results.

A. TENSILE:

Low rate tensile test data at 2.0 in/min shows a statistically significant gradual decrease for strain at maximum stress and strain at rupture. Maximum stress and stress at rupture do not show a significant change. The modulus shows a statistically significant increase (Figures 1 thru 5).

The 20 in/min low rate tensile test data shows a statistically significant decrease for the strain at maximum stress, strain at rupture and stress at rupture. Maximum stress and modulus do not show a significant change (Figures 6 thru 10).

No significant change is shown for the high rate regressions (Figures 11 thru 15).

High rate triaxial testing shows a statistically significant increase for the strains with the stresses showing no significant change. Modulus shows a statistically significant decrease (Figures 16 thru 20).

Case bond tensile data shows no significant change (Figure 21). For this test period 10 specimens were tested. The failure mode for all specimens was 100% adhesive, liner to propellant.

B. CREEP:

For the 10 pound load test data the regressions show a statistically significant decrease except for the 1000 second regression which shows no significant change (Figures 22 thru 25).

For the 12 pound load a statistically significant decrease in creep compliance is shown for the 10 and 20 second regressions (Figures 26 and 27). The 1000 second and strain at rupture regressions do not show a significant change (Figures 28 and 29).

C. STRESS RELAXATION:

Stress relaxation modulus for both 3% and 5% strain shows no significant change except for 5% strain at 10 seconds which shows a statistically significant increase (Figures 30 thru 37).

D. CONSTANT STRAIN:

A statistically significant decrease is shown for constant strain (Figure 38).

E. SHORE HARDNESS:

The Shore A ten second hardness shows no significant change (Figure 39).

F. DYNAMIC RESPONSE:

The loss tangent regression for 200 and 400 Hz show a non-significant trend. The storage shear modulus at 200 and 400 Hz shows a statistically significant decrease (Figures 40 thru 43).

PHYSICAL TESTING SUMMARY:

Where statistically significant changes are shown, the trends are gradual. These trends indicate that the propellant's physical properties have a higher tensile strength with less elasticity.

G. BURNING RATE:

A statistically significant decrease is shown for both the 500 and 1000 psi testing (Figures 44 and 45).

H. HEAT OF EXPLOSION (HOE):

The HOE regression does not show a significant change (Figure 46).

I. IGNITABILITY:

No significant change is seen in the data (Figure 47).

J. DIFFERENTIAL THERMAL ANALYSIS (DTA):

The endotherm does not show a significant change (Figure 48). The exotherm shows a statistically significant decrease and the ignition temperature shows a statistically significant increase (Figures 49 and 50).

K. FAILURE ENVELOPE:

The failure envelope for Motor STM-012 is shown in Figure 51.

CONCLUSIONS

The test results show that, under present storage conditions, some of the physical/mechanical and combustion properties of the propellant indicate statistically significant aging trends. On some regressions where a significant trend is indicated, the slope of the trend line is quite gradual and no operational problems are expected. On other regressions, i.e., triaxial tensile and burning rate, the slope of the trend line appears quite steep although, in reality, the percent change is minor as indicated by the formulas found at the top of each figure. The Y-axis range is automatically varied by the data spread to provide visibility between individual data means. As a result, the range values (on Y-axis) must be considered when visually analyzing regression slopes.

Although some aging trends have been observed, it does not appear that any significant degredation will occur in the propellant within the next two years.

RECOMMENDATIONS

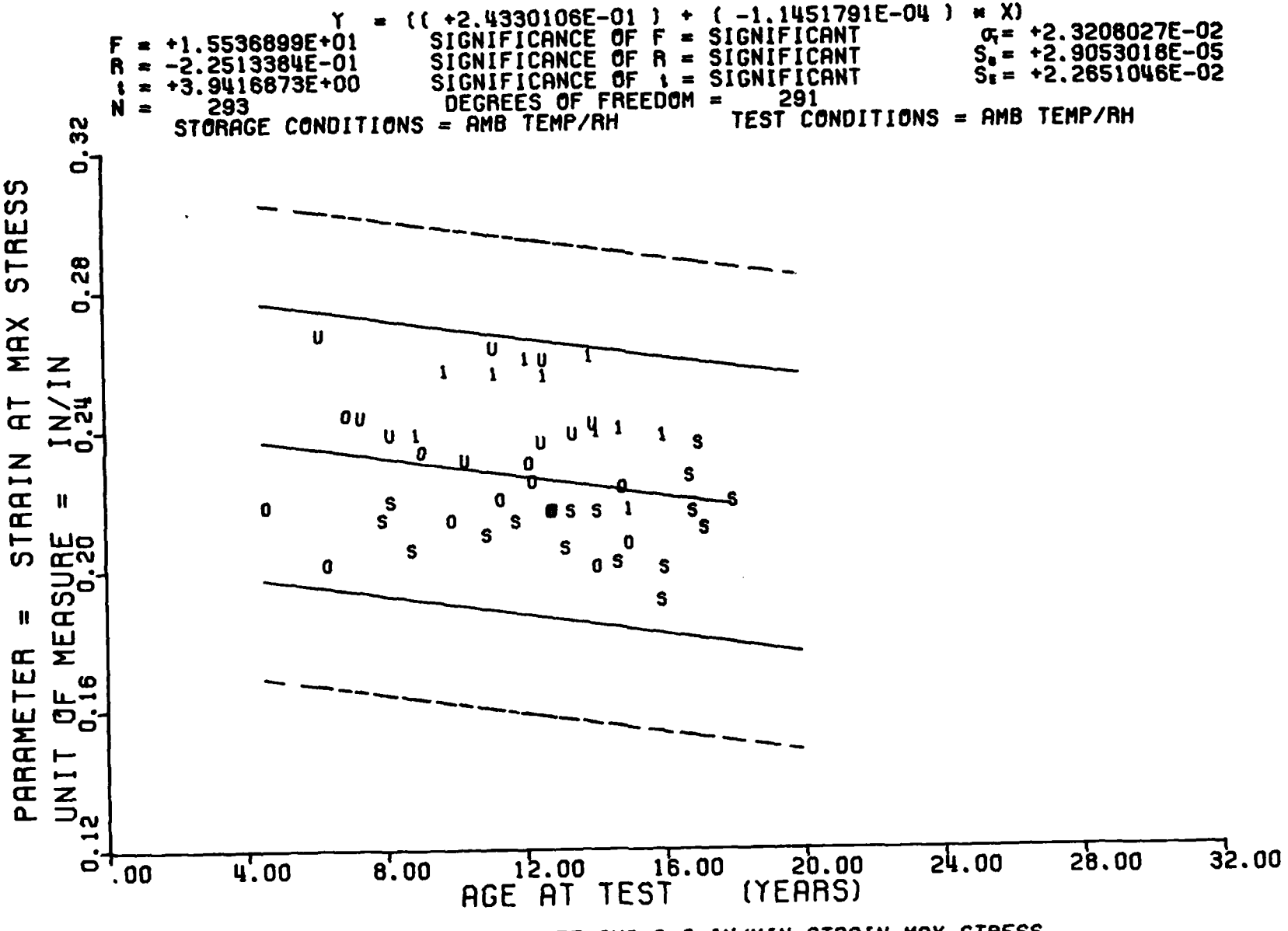
It is recommended that continued testing be conducted on the three dissected motors presently being tested and also on those motors selected for future dissection and testing by Service Engineering. On those motors selected for future dissection, testing should include the propellant, casebond specimens, and component materials.

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
54.0	24	159.0	24
73.0	24	160.0	5
75.0	2	166.0	5
82.0	5	167.0	5
87.0	5	168.0	16
94.0	16	173.0	8
97.0	7	176.0	3
104.0	5	177.0	5
106.0	5	179.0	8
108.0	8	190.0	3
116.0	5	191.0	13
118.0	5	200.0	3
123.0	4	201.0	3
130.0	5	203.0	5
133.0	15	205.0	3
135.0	3	215.0	8
140.0	5		
144.0	5		
145.0	3		
146.0	2		
149.0	3		
150.0	10		
152.0	3		
153.0	3		
157.0	3		

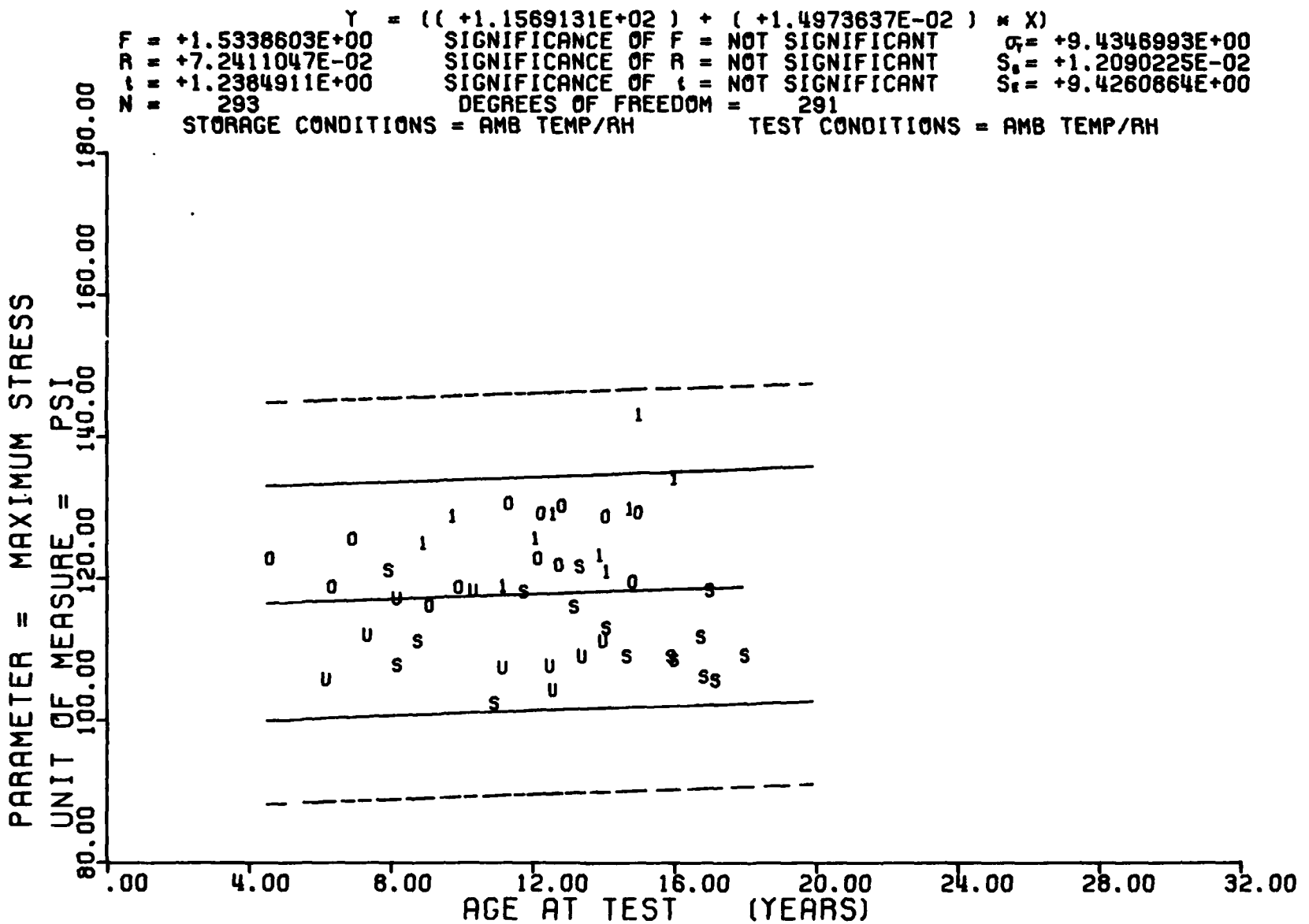
STAGE 1 DISSECTED MOTORS,LOW RATE CHG=2.0 IN/MIN,STRAIN MAX STRESS

This sample size summary is applicable to figures 1 thru 4



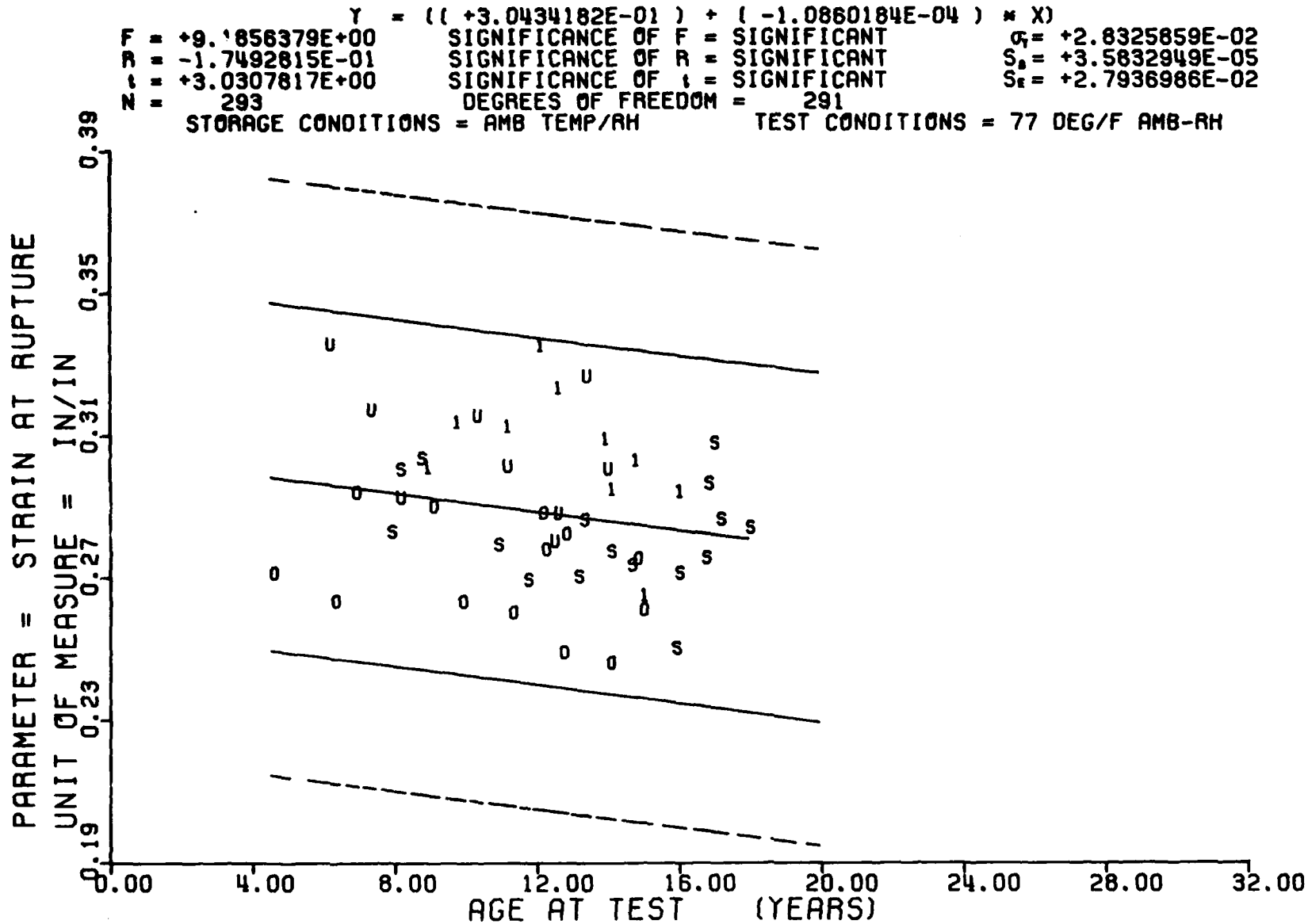
STAGE 1 DISSECTED MOTORS,LOW RATE CHS=2.0 IN/MIN,STRAIN MAX STRESS

Figure 1



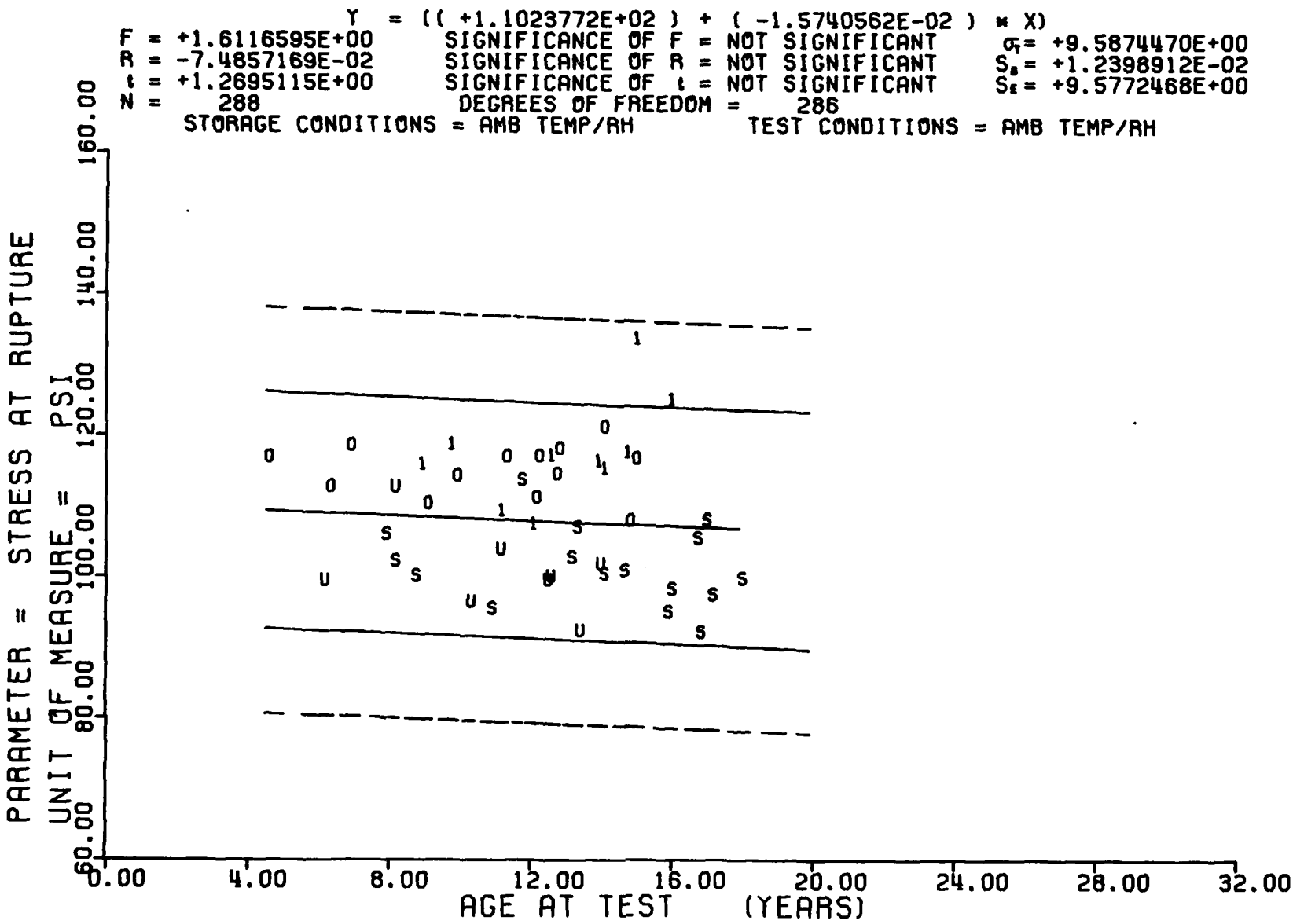
STAGE 1 DISSECTED MOTORS,LOW RATE CHS=2.0 IN/MIN,MAXIMUM STRESS

Figure 2



STAGE 1 DISSECTED MOTORS,LOW RATE CHS=2.0 IN/MIN,STRAIN AT RUPTURE

Figure 3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R = -7.4857169E-02 SIGNIFICANCE OF R = NOT SIGNIFICANT S_B = +1.2398912E-02
t = +1.2695115E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S_E = +9.5772468E+00
N = 288 DEGREES OF FREEDOM = 286
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRESS AT RUPTURE
UNIT OF MEASURE = PSI
160.00
140.00
120.00
100.00
80.00
60.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
STAGE 1 DISSECTED MOTORS,LOW RATE CHS=2.0 IN/MIN,STRESS AT RUPTURE

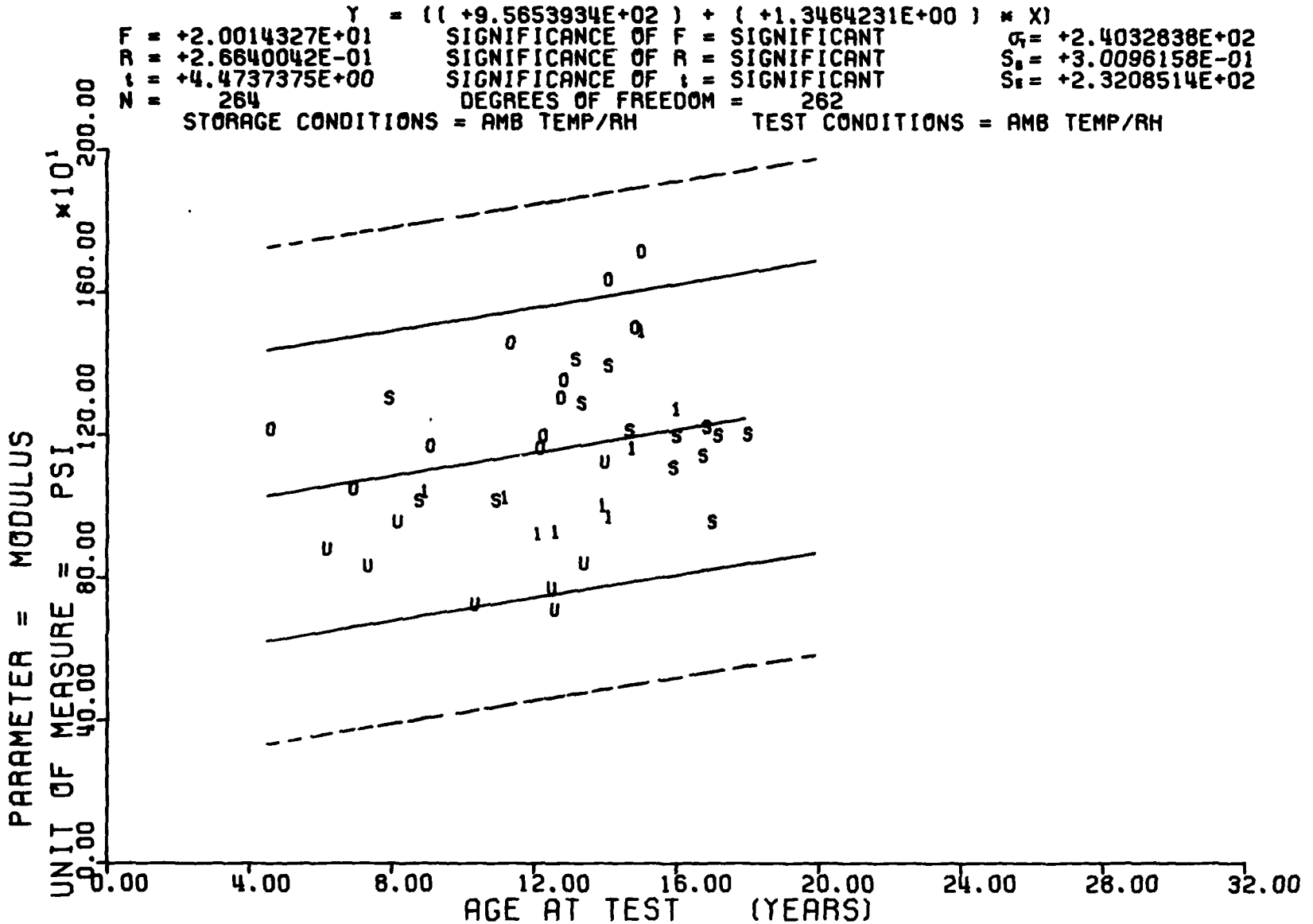
Figure 4

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
54.0	26	168.0	16
73.0	24	175.0	8
82.0	5	176.0	3
87.0	5	177.0	5
94.0	16	179.0	8
97.0	5	190.0	3
104.0	5	191.0	13
106.0	5	200.0	5
108.0	5	201.0	3
123.0	4	203.0	5
130.0	5	205.0	5
133.0	5	215.0	8
135.0	3		
144.0	5		
145.0	3		
146.0	2		
149.0	3		
150.0	10		
152.0	3		
153.0	5		
157.0	3		
159.0	24		
160.0	5		
166.0	5		
167.0	5		

STAGE I DISSECTED MOTORS,LOW RATE CHS=2.0 IN/MIN,MODULUS

This sample size summary is applicable to figure 5



STAGE 1 DISSECTED MOTORS,LOW RATE CHS=2.0 IN/MIN,MODULUS

Figure 5

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
82.0	2	177.0	2
97.0	5	179.0	8
104.0	2	190.0	3
106.0	5	191.0	13
108.0	5	200.0	3
116.0	5	201.0	3
118.0	5	203.0	5
123.0	5	205.0	3
130.0	5	215.0	9
133.0	14		
135.0	3		
140.0	5		
144.0	4		
145.0	3		
146.0	2		
150.0	9		
152.0	3		
153.0	5		
157.0	7		
160.0	5		
166.0	8		
167.0	7		
168.0	15		
175.0	8		
176.0	3		

STAGE 1 DISSECTED METERS,LOW RATE CHS=20.0 IN/MIN,STRAIN MAX STRESS

This sample size summary is applicable to figures 6 thru 10

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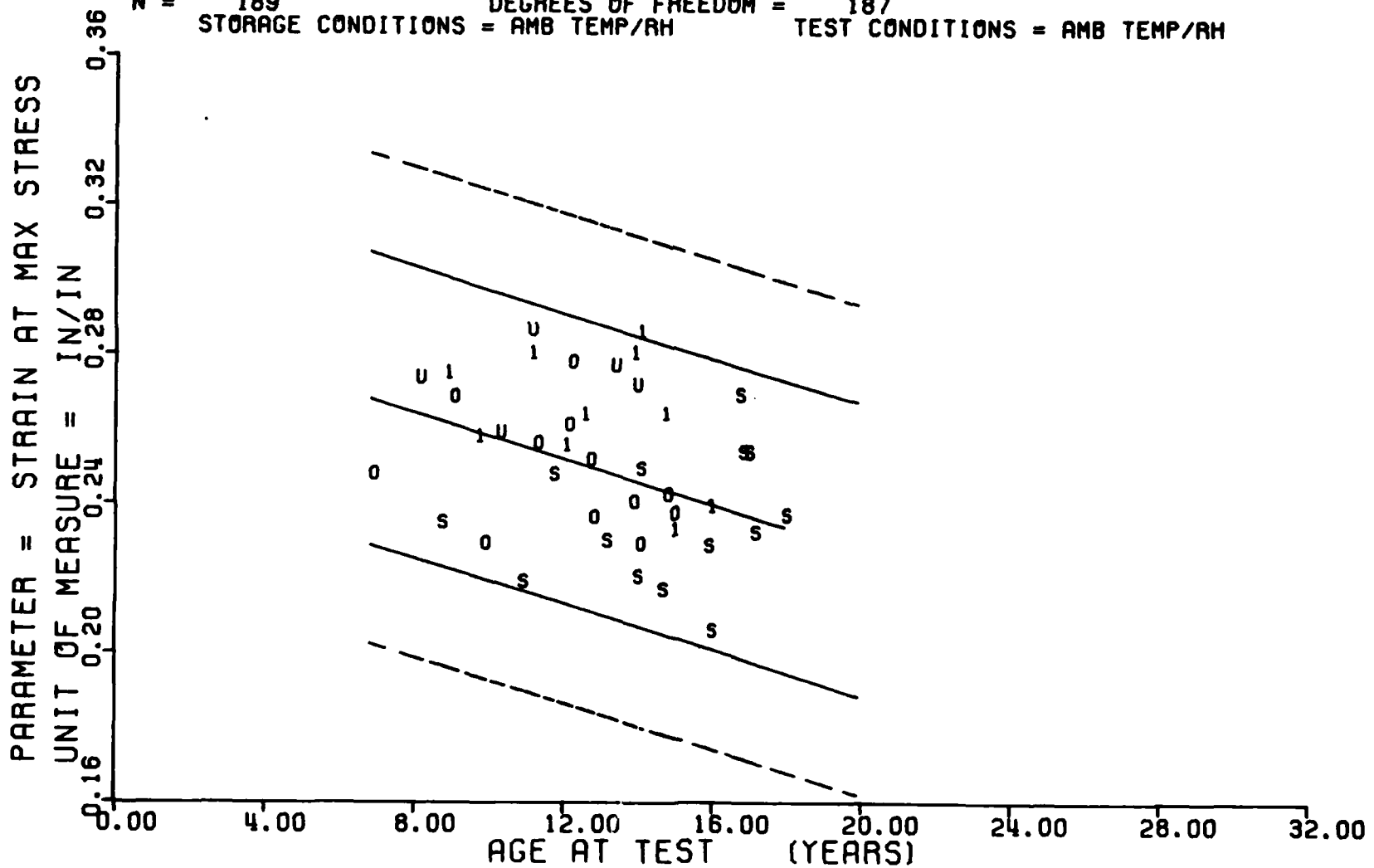
R = -3.4903829E-01 SIGNIFICANCE OF R = SIGNIFICANT S_b = +5.0607448E-05

t = +5.0933558E+00 SIGNIFICANCE OF t = SIGNIFICANT S_t = +2.1895609E-02

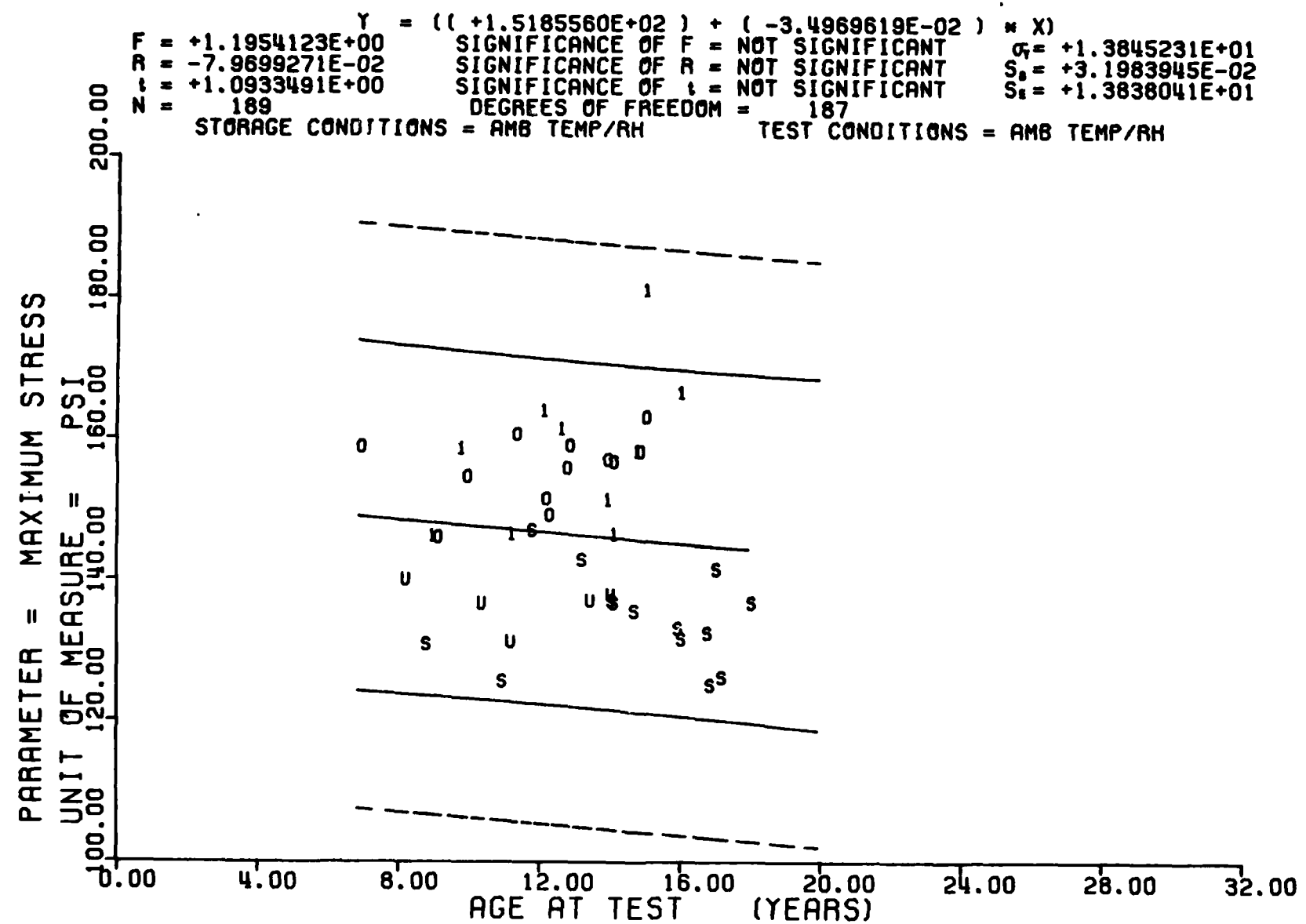
N = 189 DEGREES OF FREEDOM = 187

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



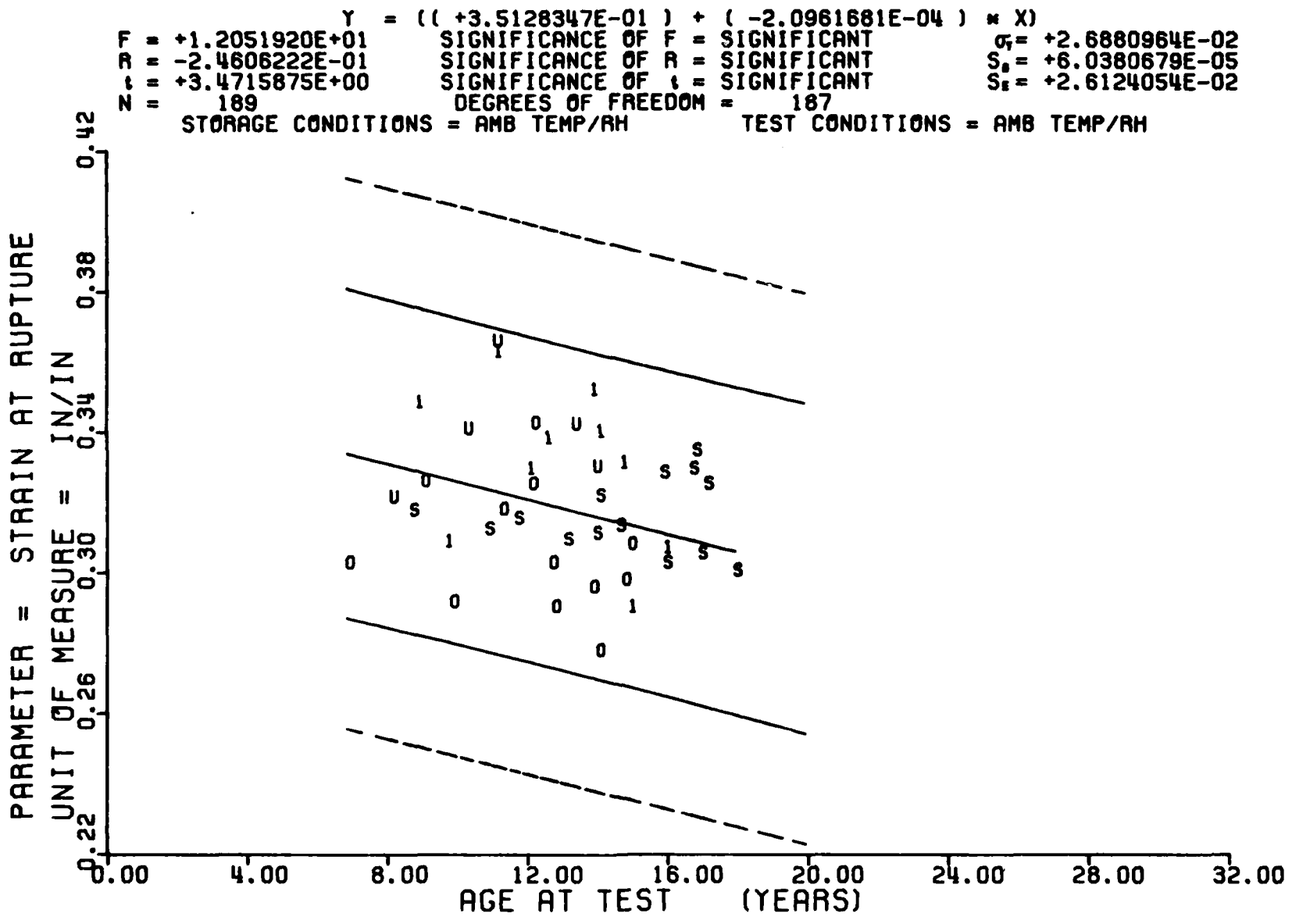
STAGE 1 DISSECTED MOTORS,LOW RATE CHS=20.0 IN/MIN,STRAIN MAX STRESS

Figure 6



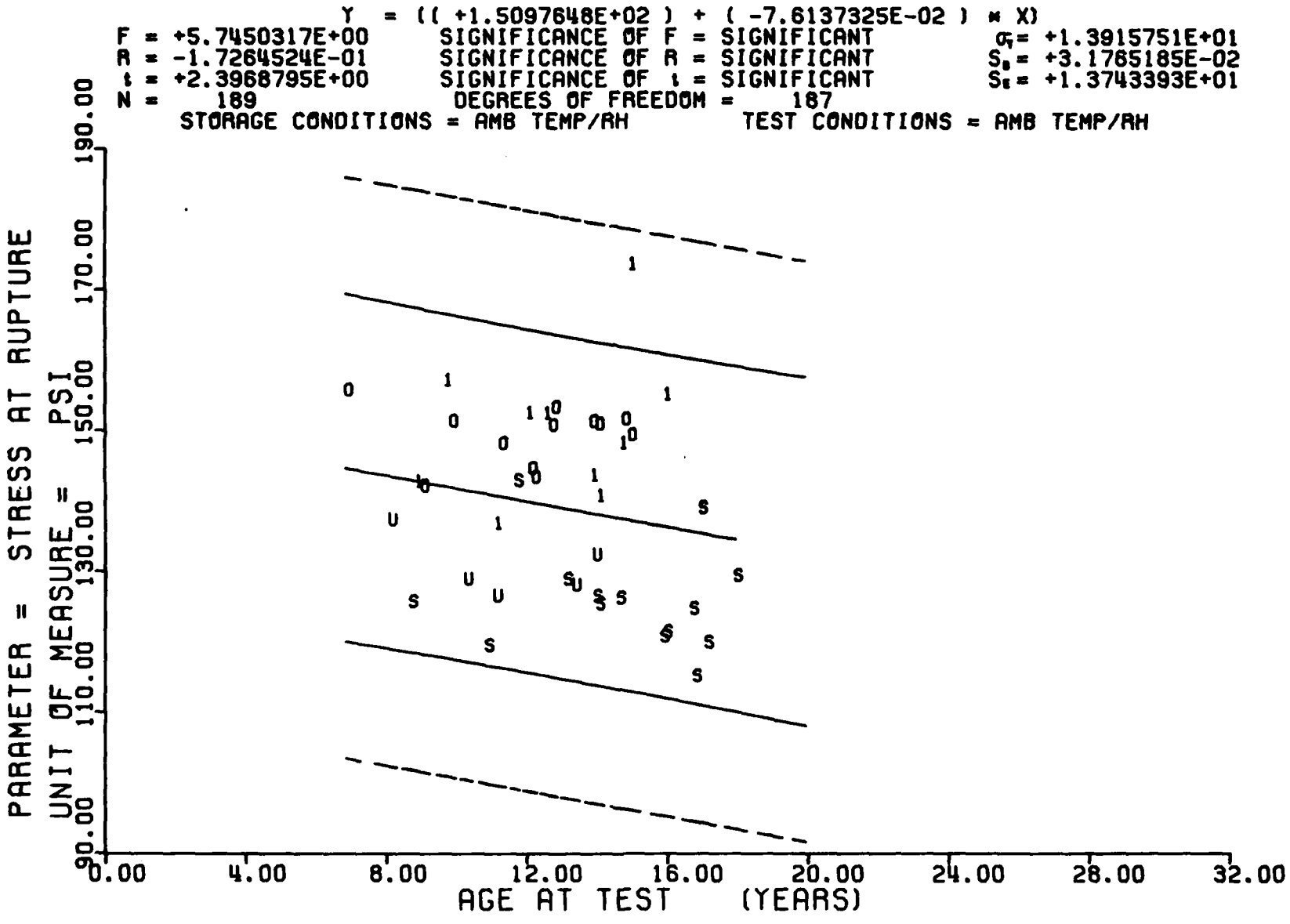
STAGE 1 DISSECTED MOTORS, LOW RATE CHS=20.0 IN/MIN, MAXIMUM STRESS

Figure 7



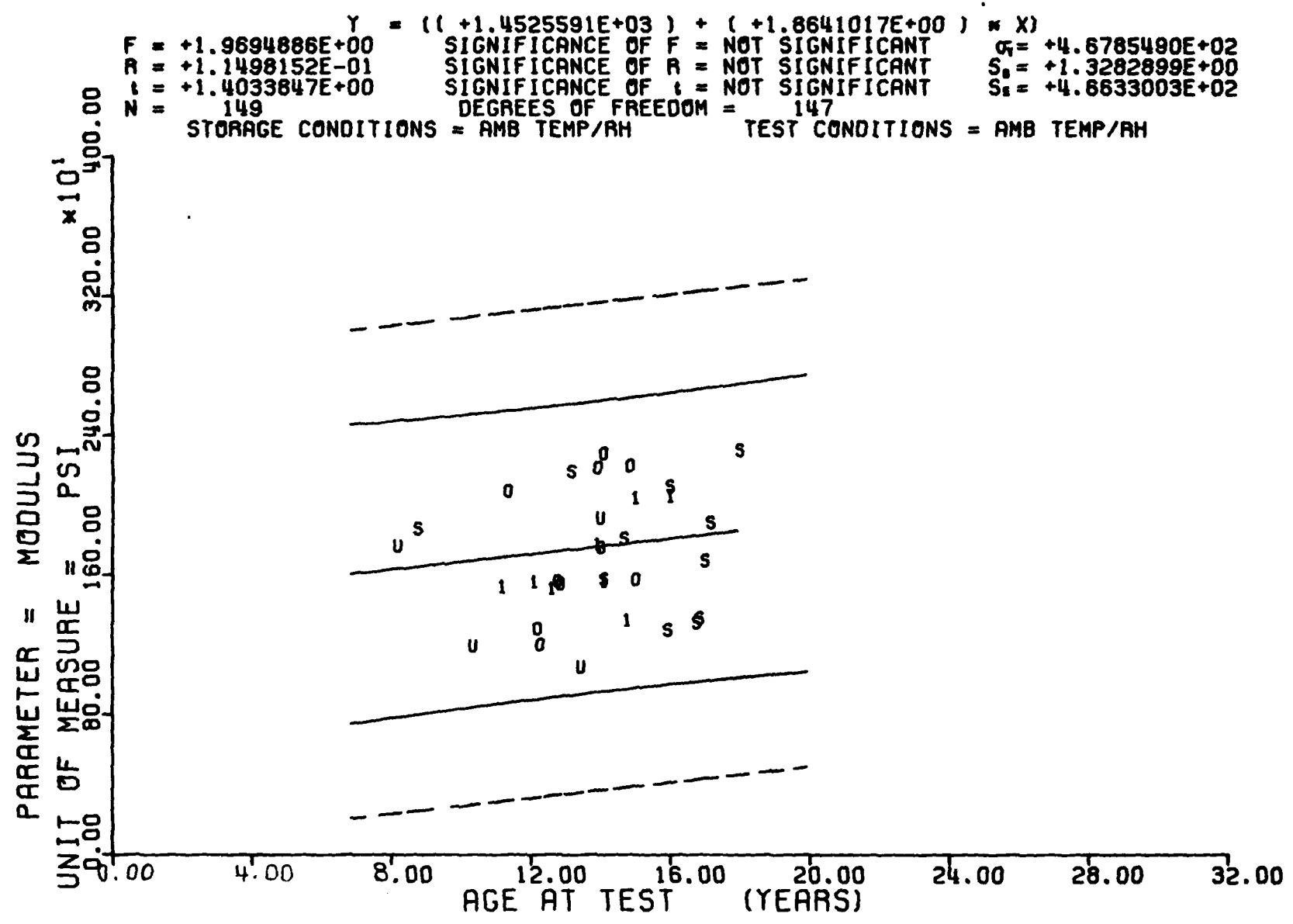
STAGE 1 DISSECTED MOTORS,LOW RATE CHS=20.0 IN/MIN,STRAIN AT RUPTURE

Figure 8



STAGE 1 DISSECTED MOTORS,LOW RATE CHS=20.0 IN/MIN,STRESS AT RUPTURE

Figure 9



STAGE 1 DISSECTED MOTORS,LOW RATE CHS=20.0 IN/MIN,MODULUS

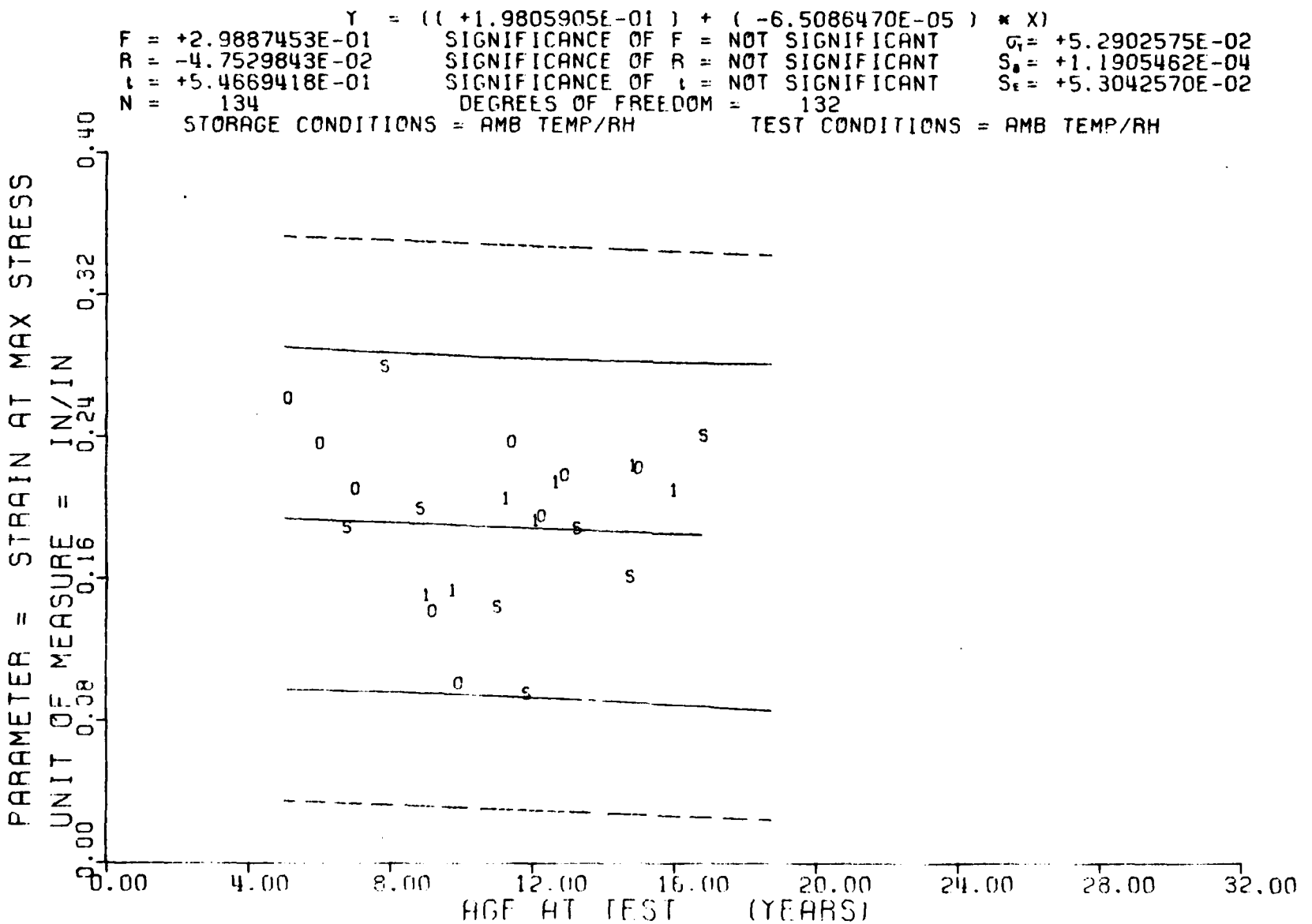
Figure 10

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
66.0	6
71.0	4
80.0	16
83.0	5
93.0	6
105.0	6
107.0	5
109.0	5
116.0	6
118.0	6
131.0	5
134.0	5
136.0	4
141.0	6
144.0	5
146.0	5
151.0	5
154.0	5
158.0	5
176.0	5
177.0	6
179.0	3
191.0	5
201.0	5

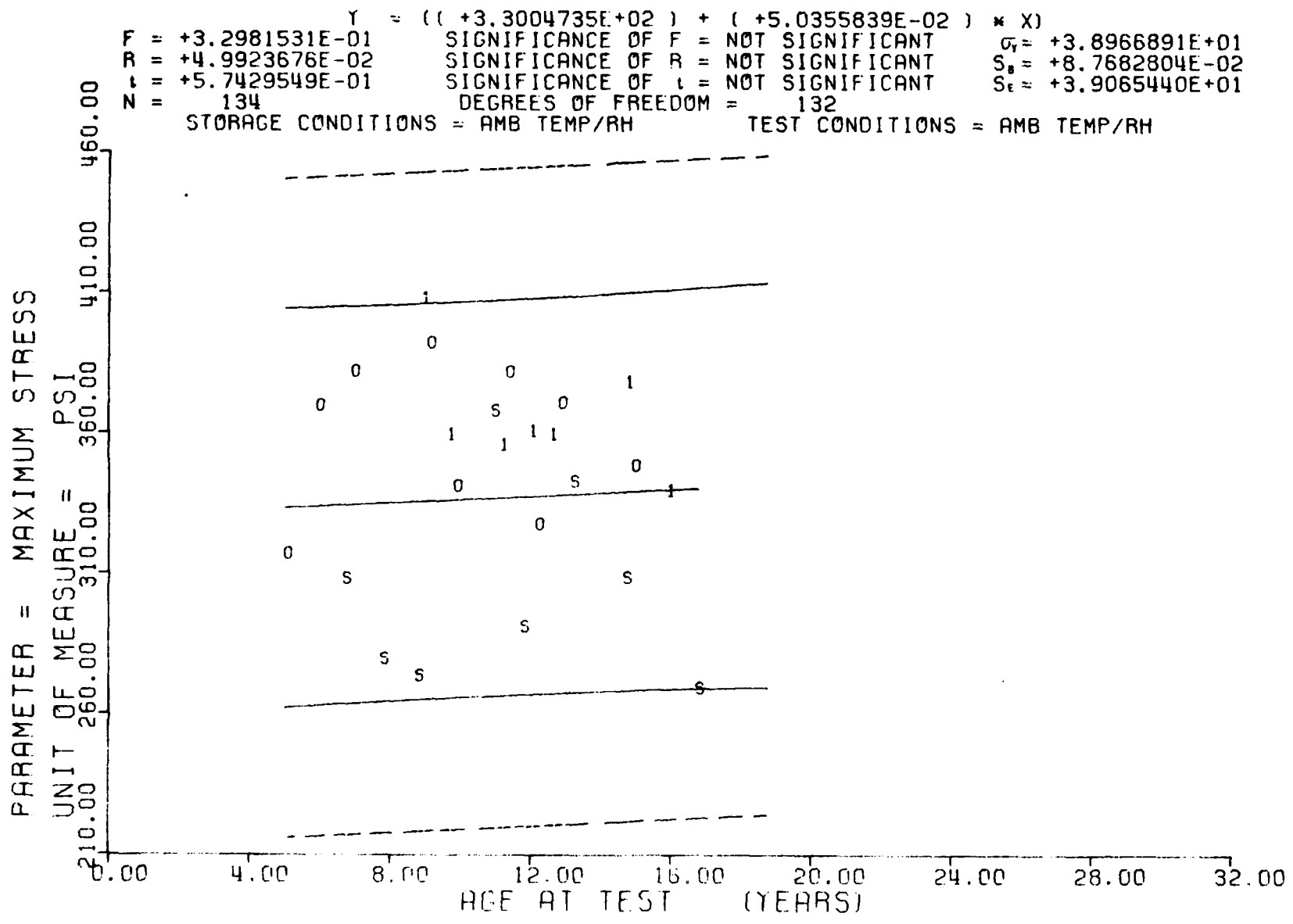
STAGE 1 DISSECTED MOTORS,HIGH RATE CHS=1750 IN/MIN,STRAIN MAX STRESS

This sample size summary is applicable to figures 11 thru 15



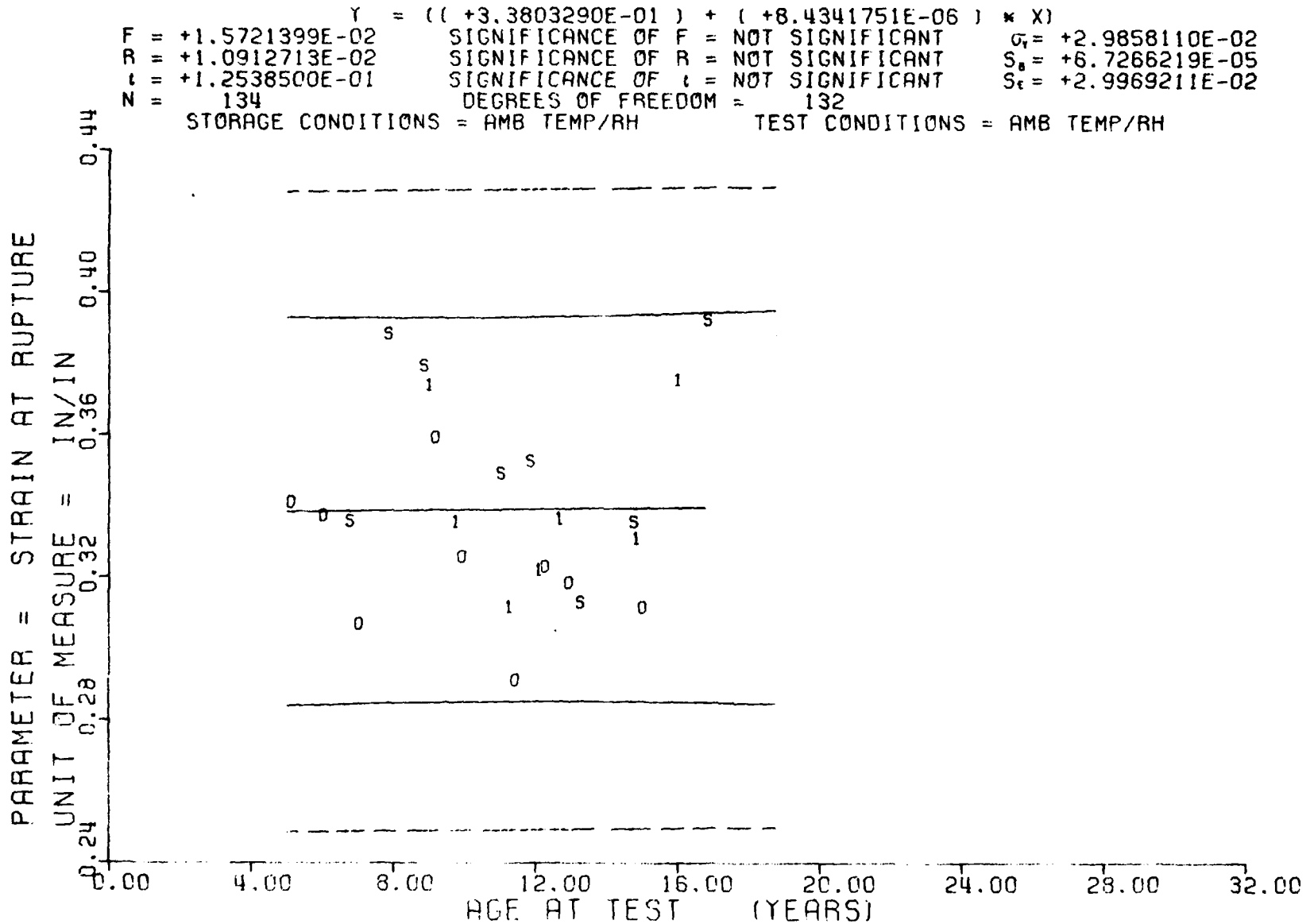
STAGE I DISSECTED MOTORS, HIGH RATE (HS=1750 IN/MIN, STRAIN MAX STRESS

Figure 11



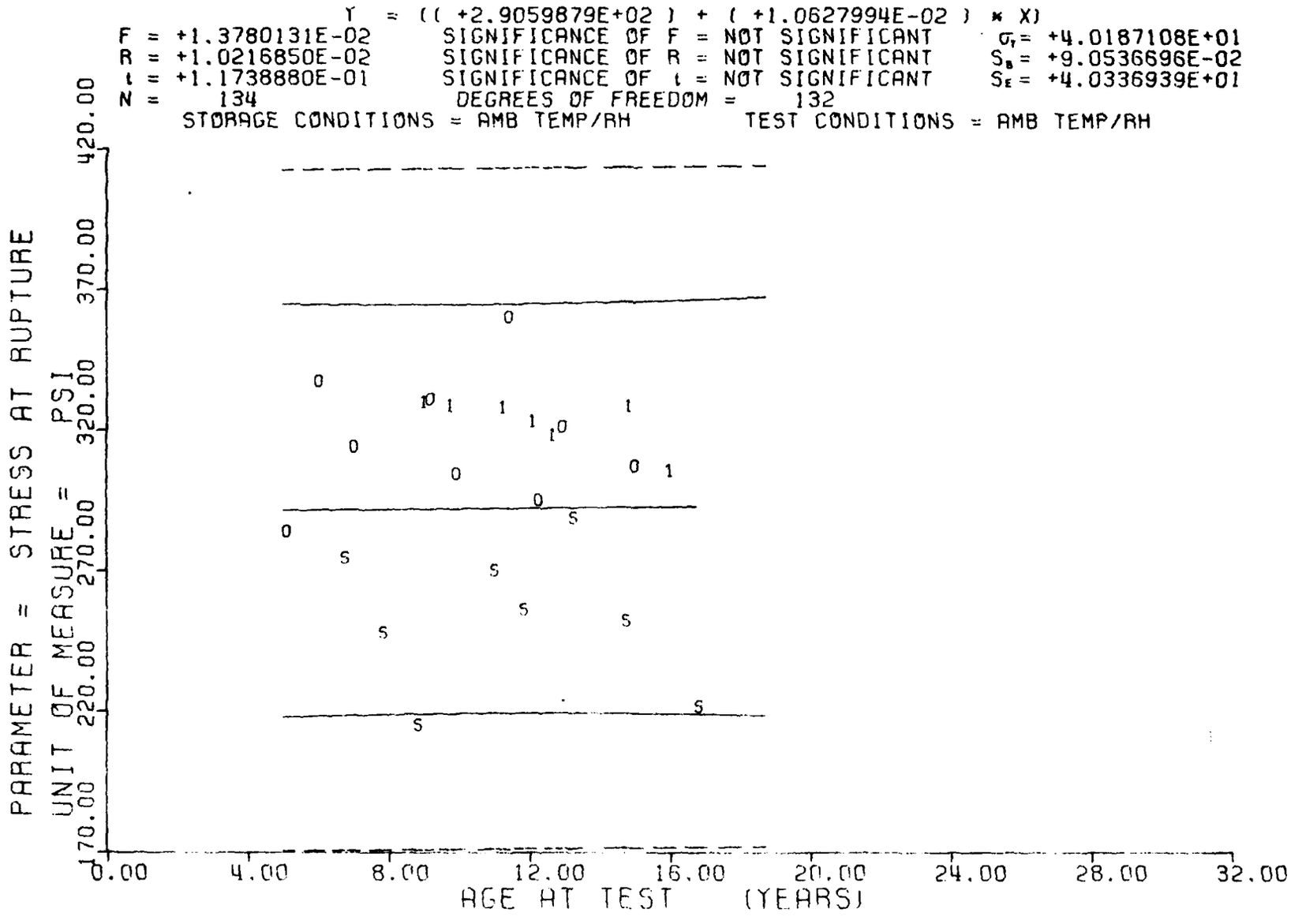
STAGE 1 DISSECTED MOTORS, HIGH RATE CHS=1750 IN/MIN, MAXIMUM STRESS

Figure 12



STAGE I DISSECTED MOTORS, HIGH RATE CHS=1750 IN/MIN, STRAIN AT RUPTURE

Figure 13



STAGE 1 DISSECTED MOTORS, HIGH RATE CHS=1750 IN/MIN, STRESS AT RUPTURE

Figure 14

Y = ((+6.8196621E+03) + (-1.3850396E+00) * X)

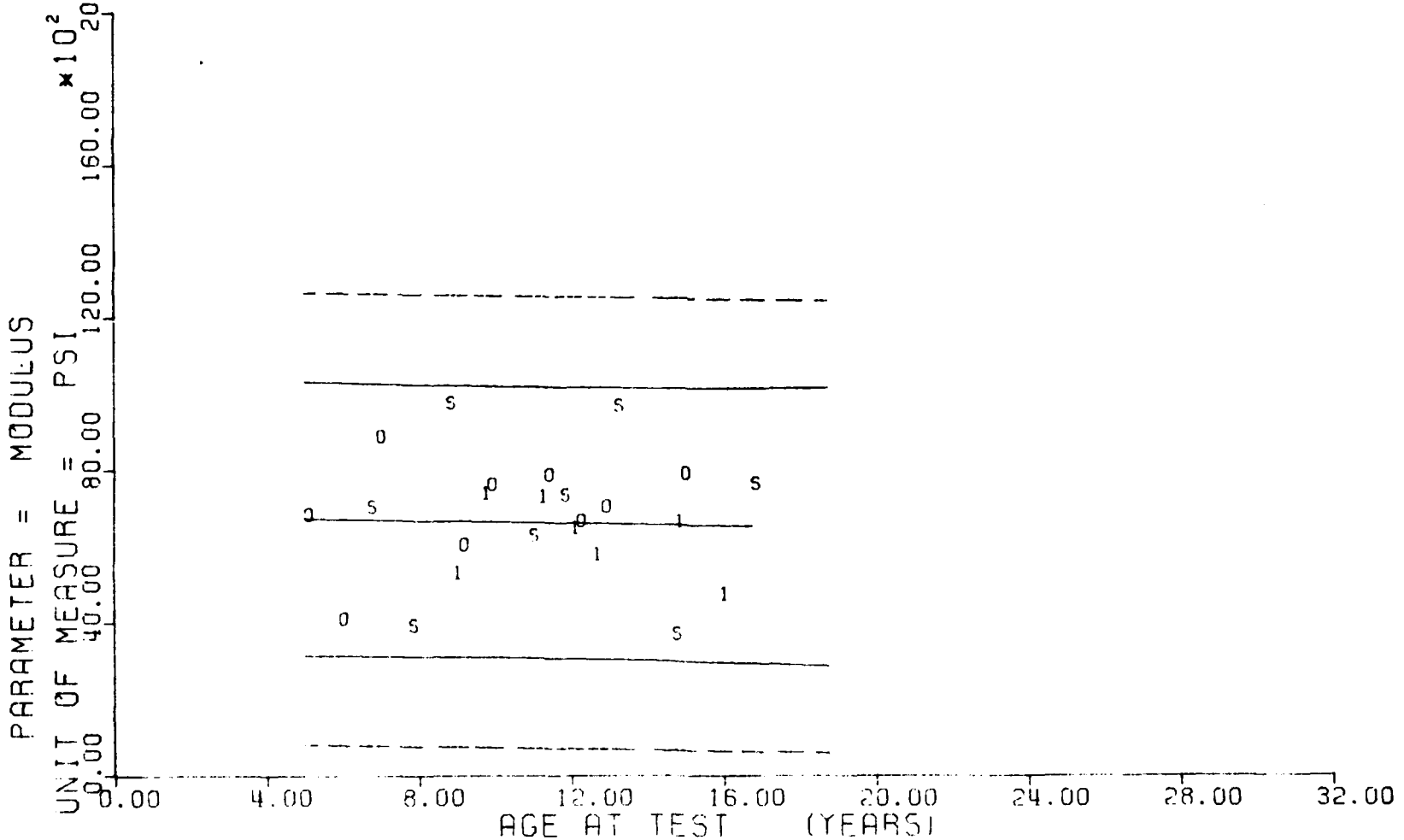
F = +9.7651643E-02 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_Y = +1.9679880E+03

R = -2.7188937E-02 SIGNIFICANCE OF R = NOT SIGNIFICANT S_B = +4.4322315E+00

t = +3.1249262E-01 SIGNIFICANCE OF t = NOT SIGNIFICANT S_E = +1.9746982E+03

N = 134 DEGREES OF FREEDOM = 132

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



STAGE 1 DISSECTED MOTORS, HIGH RATE CHS=1750 IN/MIN, MODULUS

Figure 15

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
71.0	2
72.0	8
83.0	2
93.0	2
105.0	2
108.0	2
110.0	2
132.0	2
134.0	4
136.0	2
144.0	2
146.0	2
151.0	2
153.0	3
158.0	2
168.0	2
175.0	2
177.0	3
179.0	3
191.0	2
201.0	3
215.0	3

DISSECTED TF-F1011,H.R.TRIAXIAL CHS=1750 IN/MIN,600 PSI,STRAIN MAX STRESS

This sample size summary is applicable to figures 16 thru 20

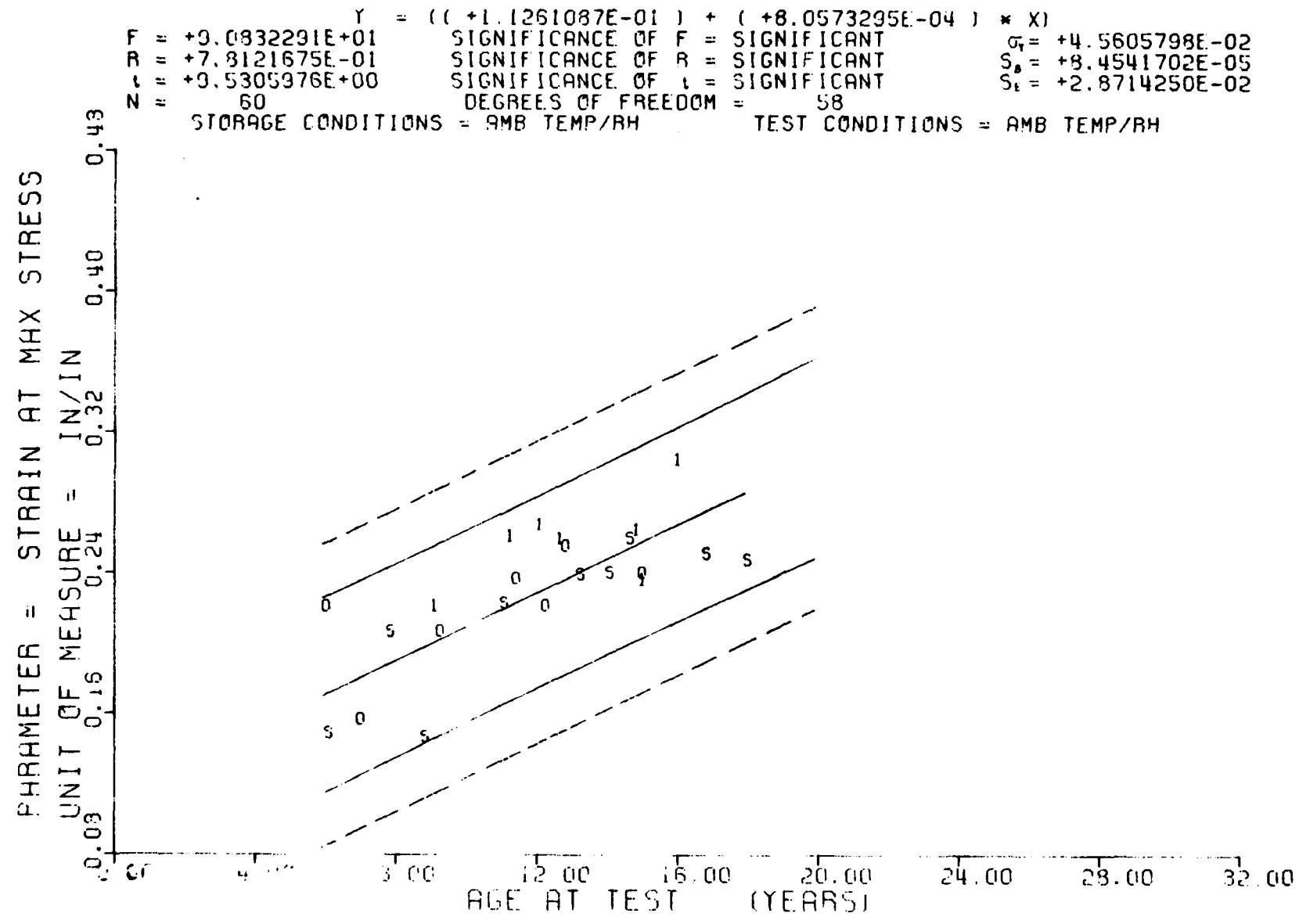
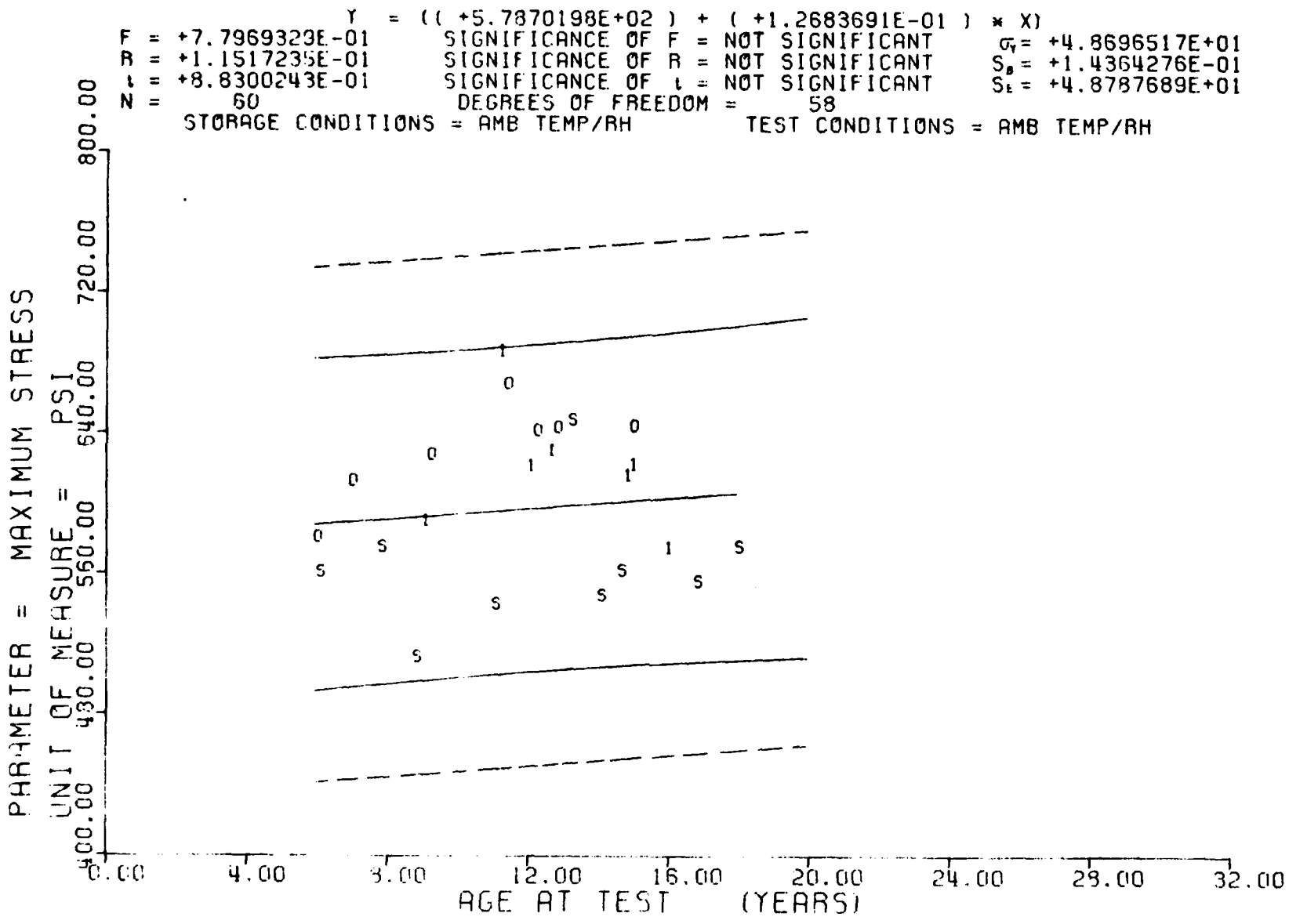

Y = ((+1.1261087E-01) + (+8.0573295E-04) * X)
F = +9.0832291E+01 SIGNIFICANCE OF F = SIGNIFICANT σ = +4.5605798E-02
R = +7.8121675E-01 SIGNIFICANCE OF R = SIGNIFICANT S = +8.4541702E-05
t = +9.5305976E+00 SIGNIFICANCE OF t = SIGNIFICANT S = +2.8714250E-02
N = 60 DEGREES OF FREEDOM = 58
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.03
0.16
0.24
0.32
0.40
0.43
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
DISSECTED TP-HIGH H.R. TRIAXIAL CHS-1750 IN/MIN, 600 PSI. STRAIN MAX STRESS

Figure 16



DISSECTED TP-H1011, H.R. TRIAXIAL CHS-1750 IN/MIN, 600 PSI, MAXIMUM STRESS

Figure 17

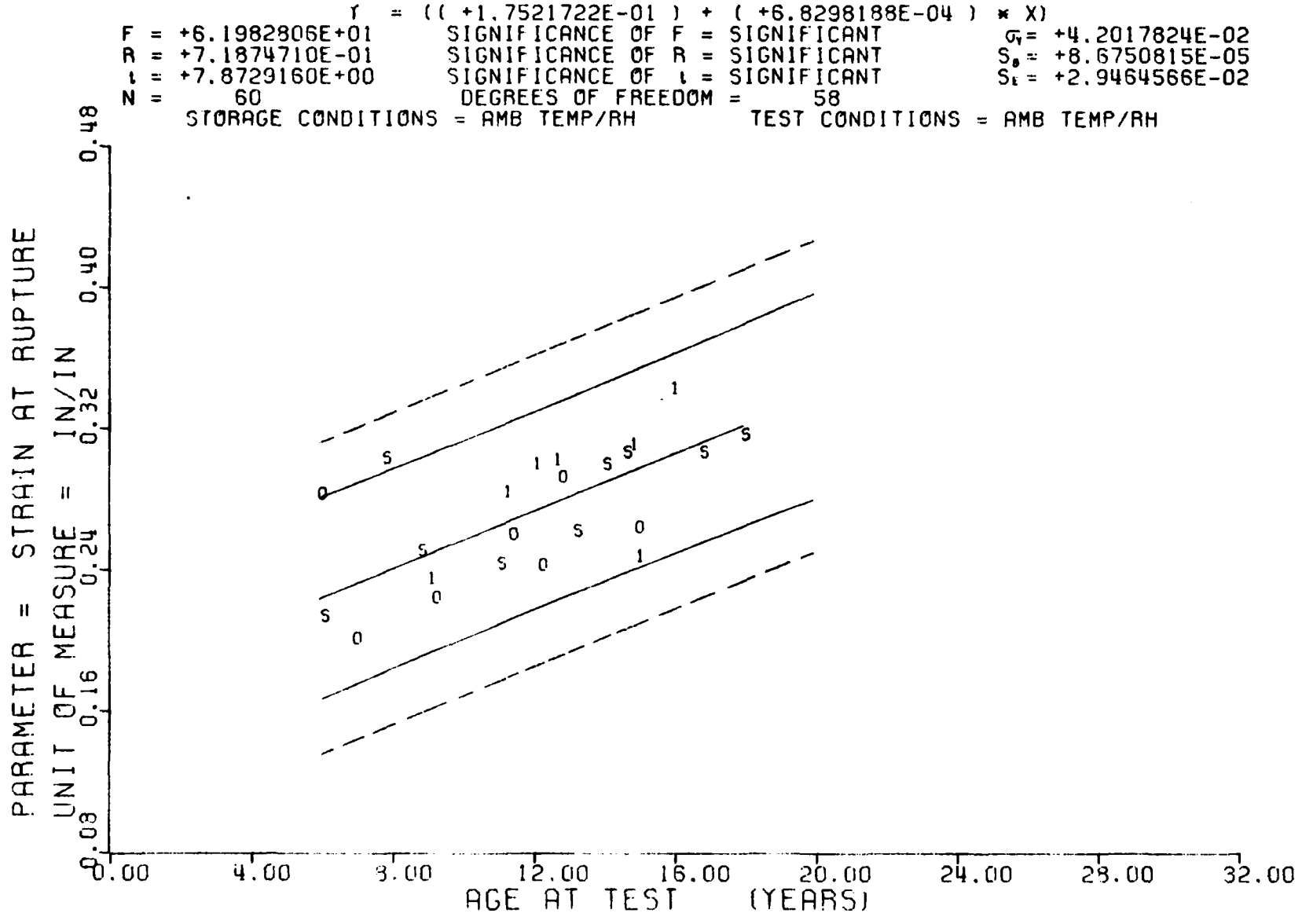

Y = ((+1.7521722E-01) + (+6.8298188E-04) * X)
F = +6.1982806E+01 SIGNIFICANCE OF F = SIGNIFICANT σ1 = +4.2017824E-02
R = +7.1874710E-01 SIGNIFICANCE OF R = SIGNIFICANT Sb = +8.6750815E-05
t = +7.8729160E+00 SIGNIFICANCE OF t = SIGNIFICANT St = +2.9464566E-02
N = 60 DEGREES OF FREEDOM = 58
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT RUPTURE
UNIT OF MEASURE = IN/IN
0.03
0.16
0.24
0.32
0.40
0.48
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
DISSECTED TP-H1011, H.R. TRIAXIAL CHS=1750 IN/MIN, 600 PSI, STRAIN AT RUPTURE

Figure 18

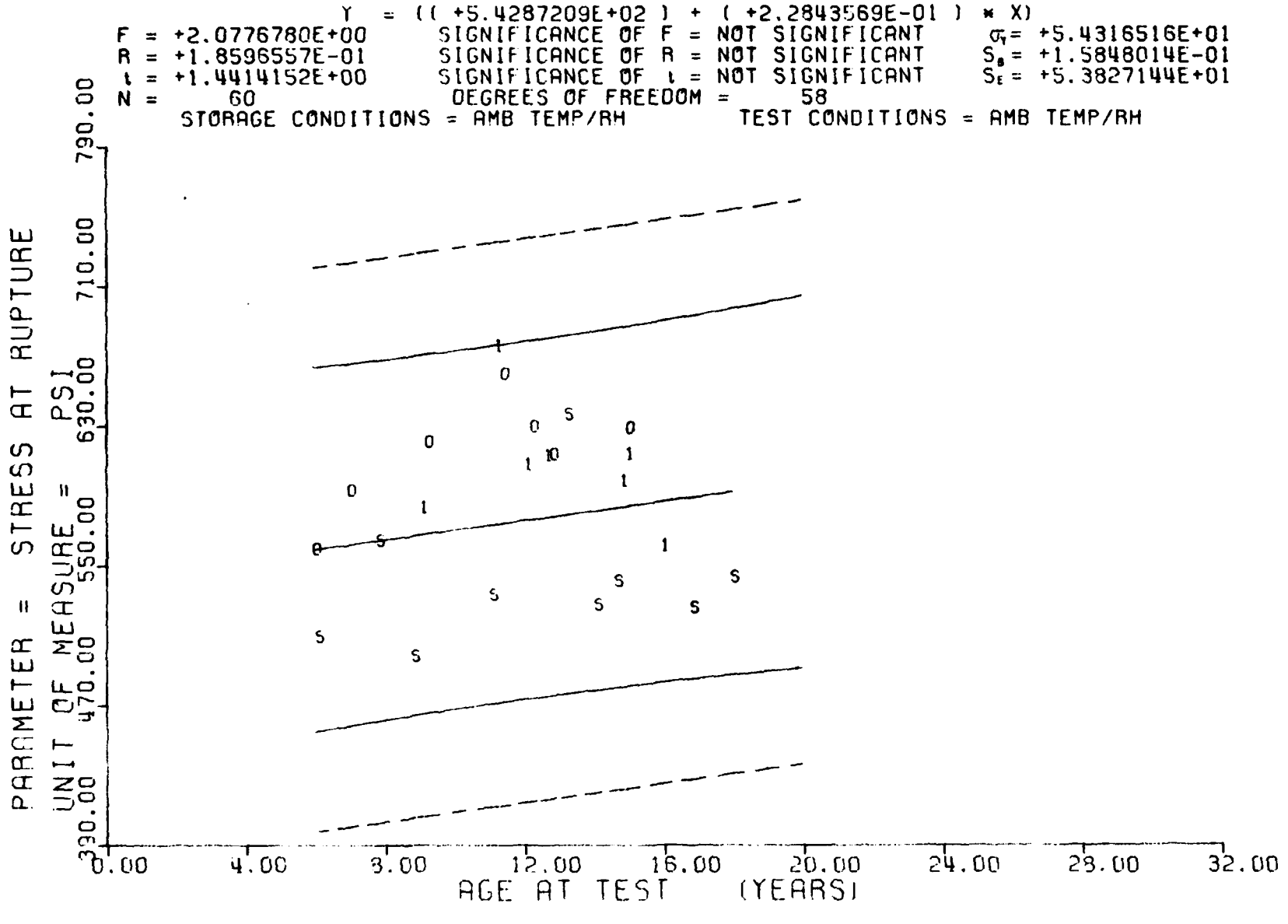

Y = ((+5.4287209E+02) + (+2.2843569E-01) * X)
F = +2.0776780E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σY = +5.4316516E+01
R = +1.8596557E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT Sb = +1.5848014E-01
t = +1.4414152E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT Se = +5.3827144E+01
N = 60 DEGREES OF FREEDOM = 58
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRESS AT RUPTURE
UNIT OF MEASURE = PSI
790.00
710.00
630.00
550.00
470.00
390.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
DISSECTED TP-H1011,H.B.TRIAXIAL CHS-1750 IN/MIN,600 PSI,STRESS AT RUPTURE

Figure 19

Y = ((+9.3975731E+03) + (-2.5101532E+01) * X)

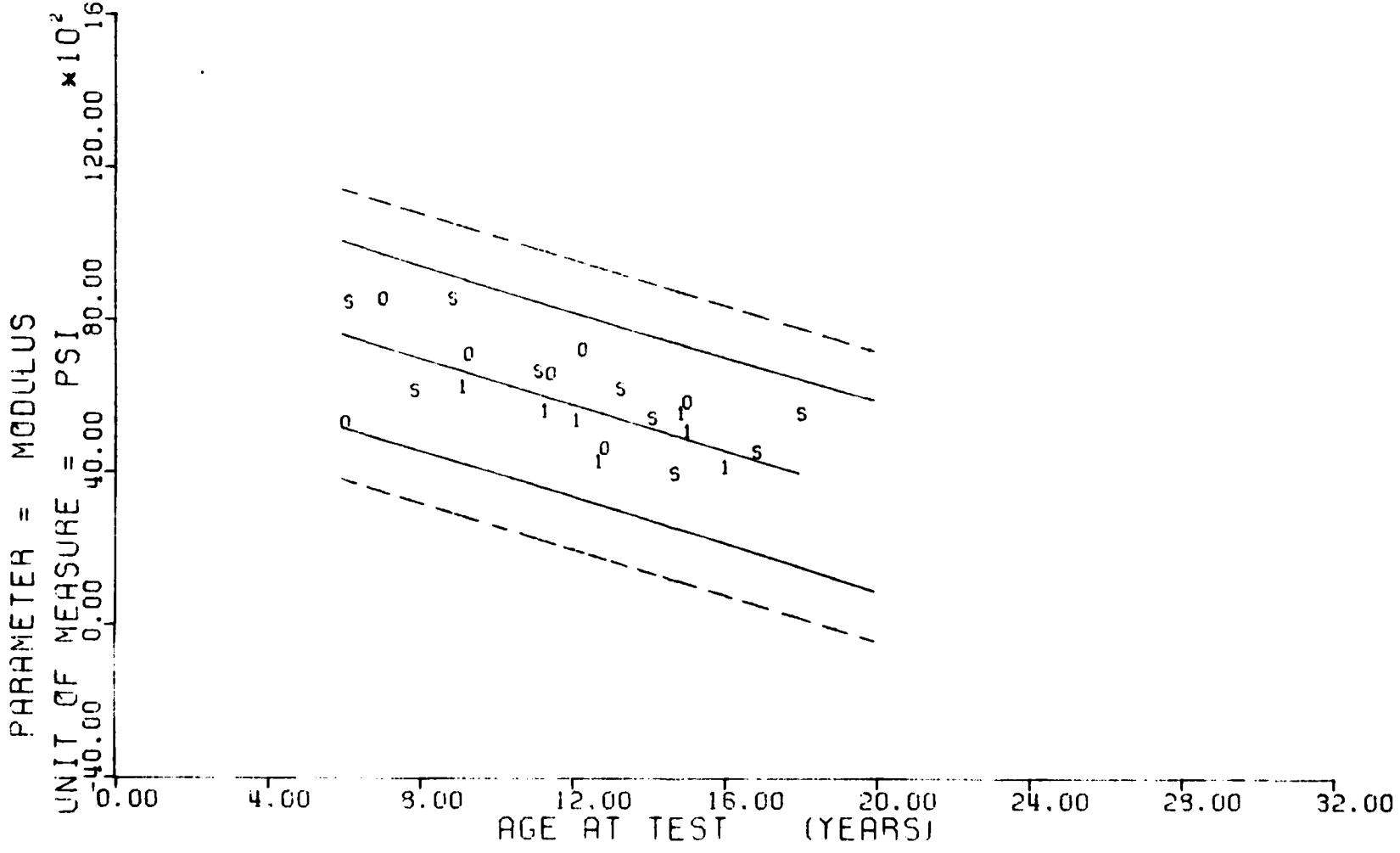
F = +4.5405634E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.6750121E+03

R = -6.6264781E-01 SIGNIFICANCE OF R = SIGNIFICANT S_a = +3.7251636E+00

t = +6.7383703E+00 SIGNIFICANCE OF t = SIGNIFICANT S_ε = +1.2652369E+03

N = 60 DEGREES OF FREEDOM = 58

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



DISSECTED TP-H1011, H.R. TRIAXIAL CHS=1750 IN/MIN, 600 PSI. MODULUS

Figure 20

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
80.0	27
94.0	2
104.0	10
113.0	12
116.0	12
141.0	11
154.0	9
156.0	22
166.0	9
177.0	10
178.0	8
189.0	11
201.0	12
216.0	10

CASEBOND TENSILE, STAGE 1 DISSECTED, CHS 0.2, CSA 0.75

This sample size summary is applicable to figure 21

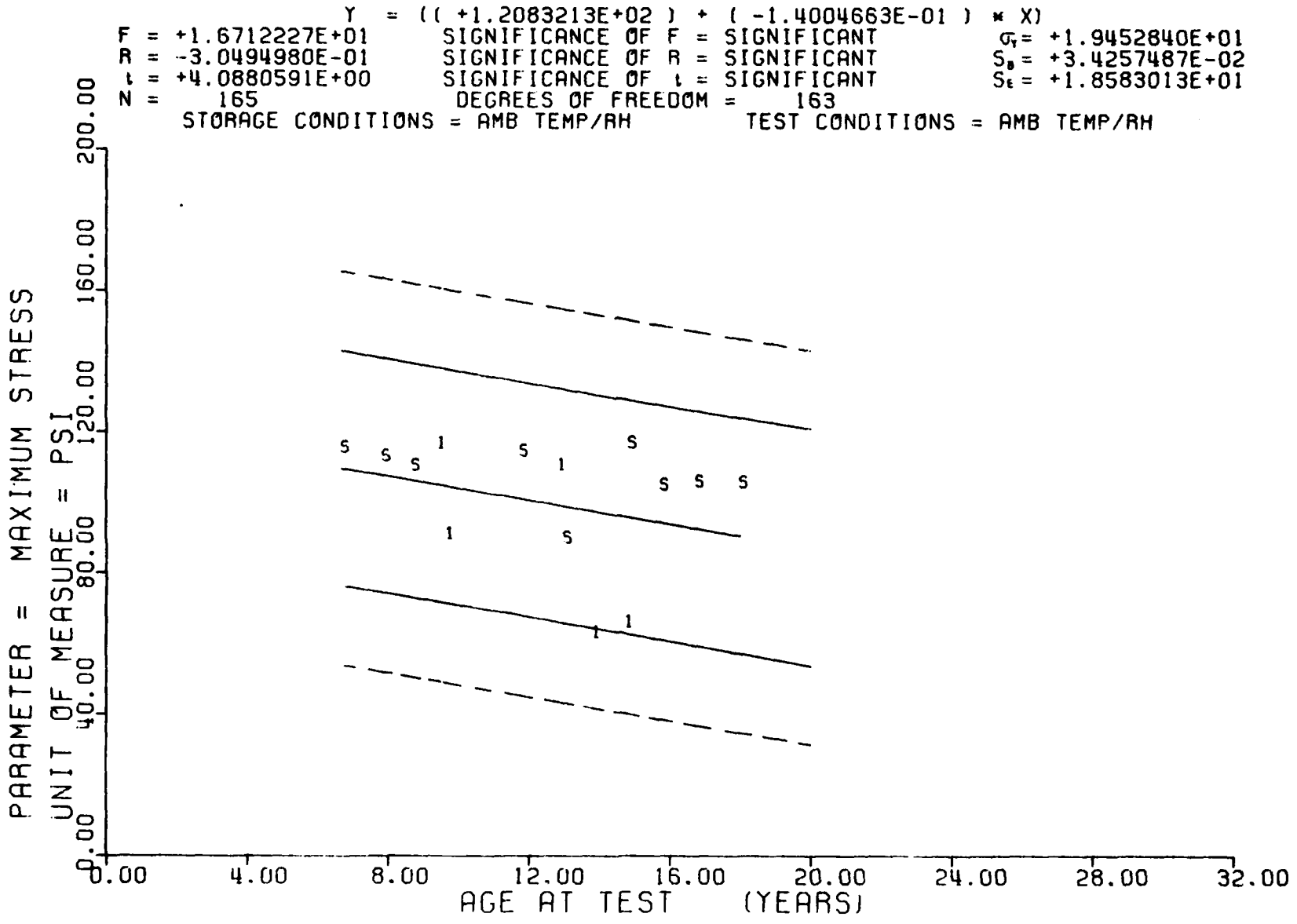

Y = ((+1.2083213E+02) + (-1.4004663E-01) * X)
F = +1.6712227E+01 SIGNIFICANCE OF F = SIGNIFICANT σ = +1.9452840E+01
R = -3.0494980E-01 SIGNIFICANCE OF R = SIGNIFICANT S_b = +3.4257487E-02
t = +4.0880591E+00 SIGNIFICANCE OF t = SIGNIFICANT S_ε = +1.8583013E+01
N = 165 DEGREES OF FREEDOM = 163
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = MAXIMUM STRESS
UNIT OF MEASURE = PSI
0.00
40.00
80.00
120.00
160.00
200.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
CASEBOND TENSILE, STAGE 1 DISSECTED, CHS 0.2, CSA 0.75

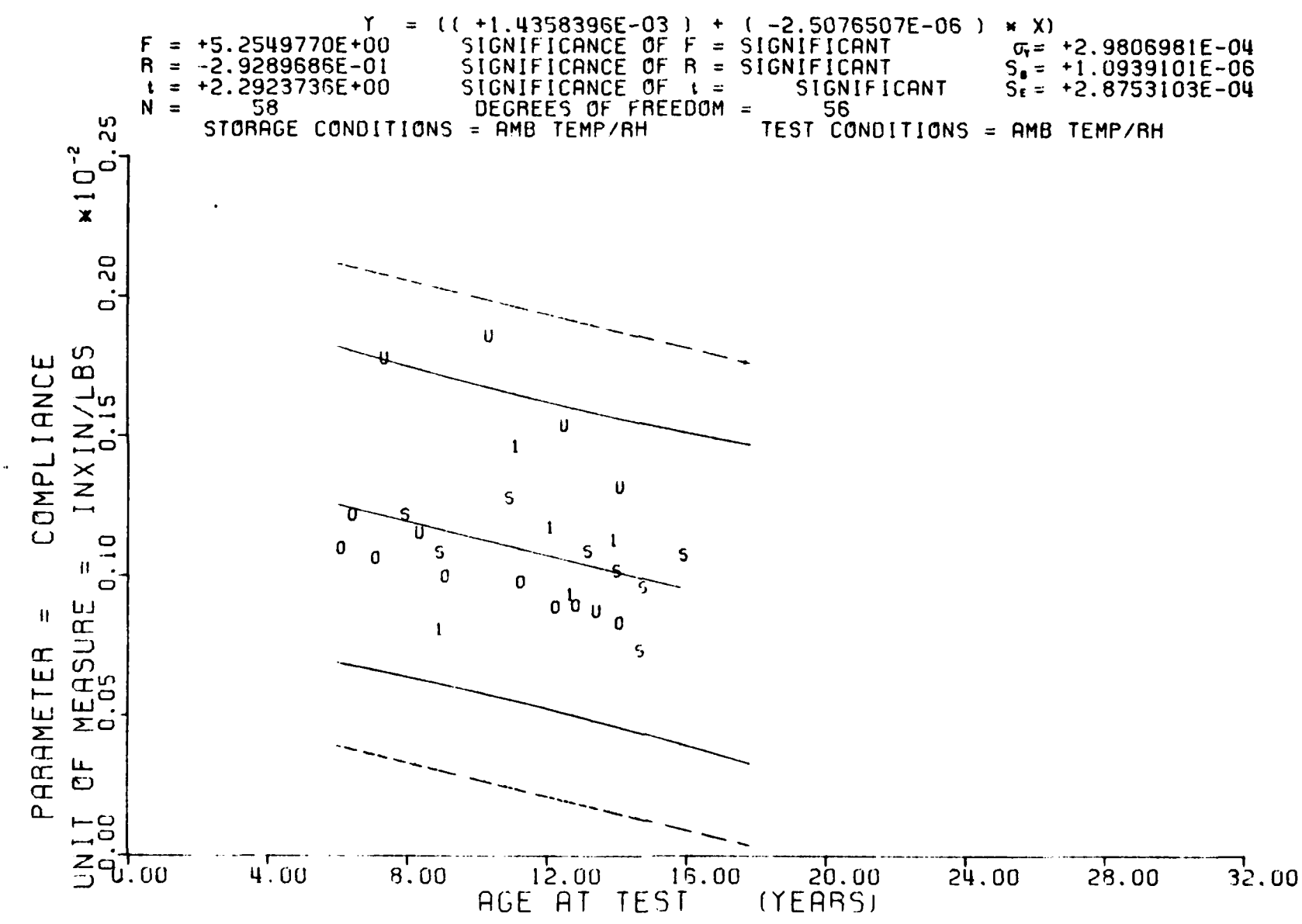
Figure 21

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
72.0	2
78.0	3
84.0	4
87.0	2
94.0	4
99.0	2
106.0	3
108.0	1
123.0	1
130.0	1
132.0	2
134.0	2
144.0	4
146.0	2
149.0	2
151.0	4
153.0	3
157.0	1
160.0	2
166.0	3
167.0	4
168.0	6
175.0	2
178.0	1
196.0	3

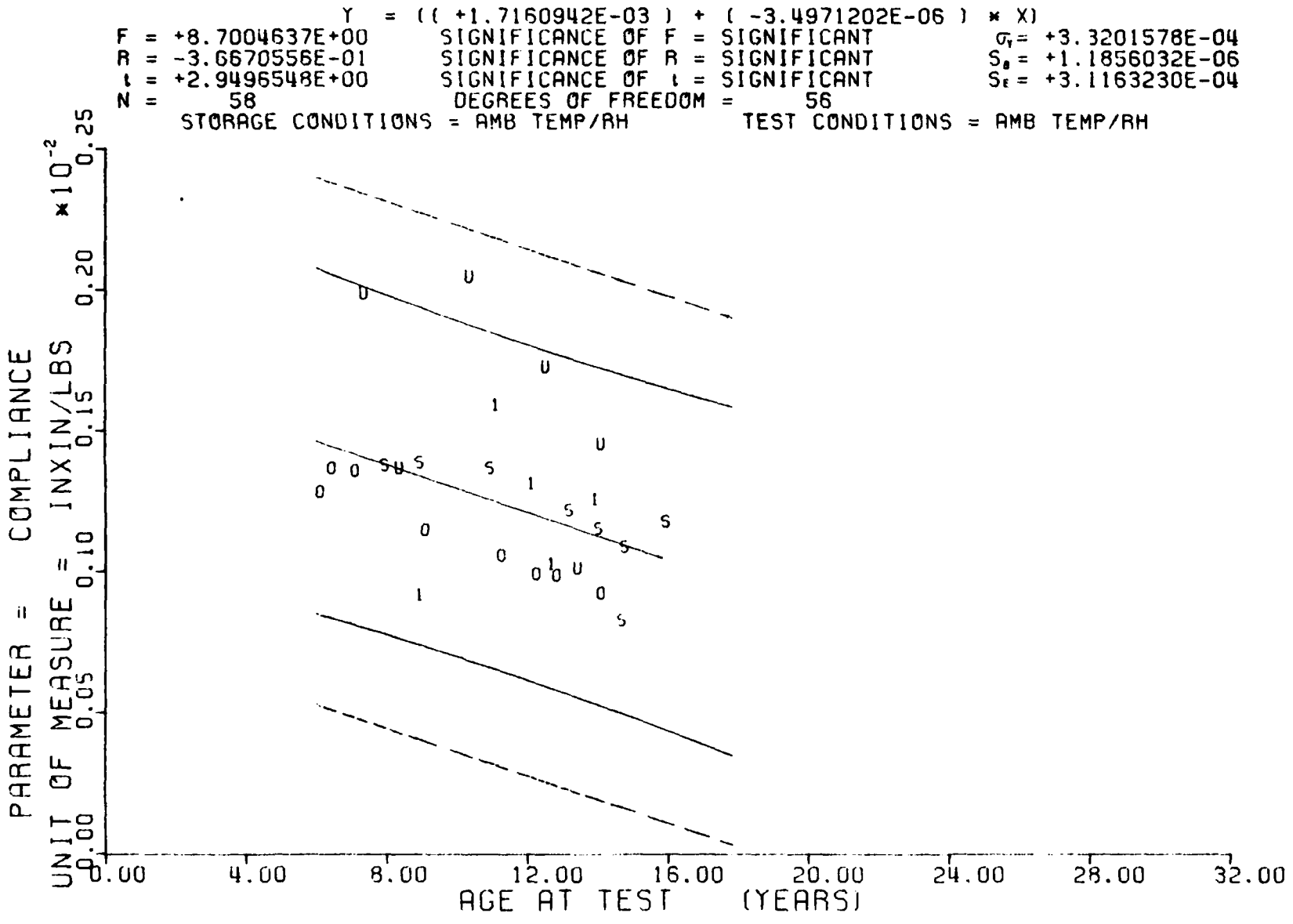
DISSECTED MOTOR TP-H1011,CREEP 10 LB LOAD,COMPLIANCE AT 10 SEC.

This sample size summary is applicable to figures 22, 23 and 24



DISSECTED MOTOR TP-H1011, CREEP 10 LB LOAD, COMPLIANCE AT 10 SEC.

Figure 22



DISSECTED MOTOR TP-H1011, CREEP 10 LB LOAD, COMPLIANCE AT 20 SEC.

Figure 23

Y = ((+2.3591670E-03) + (-3.0793456E-06) * X)

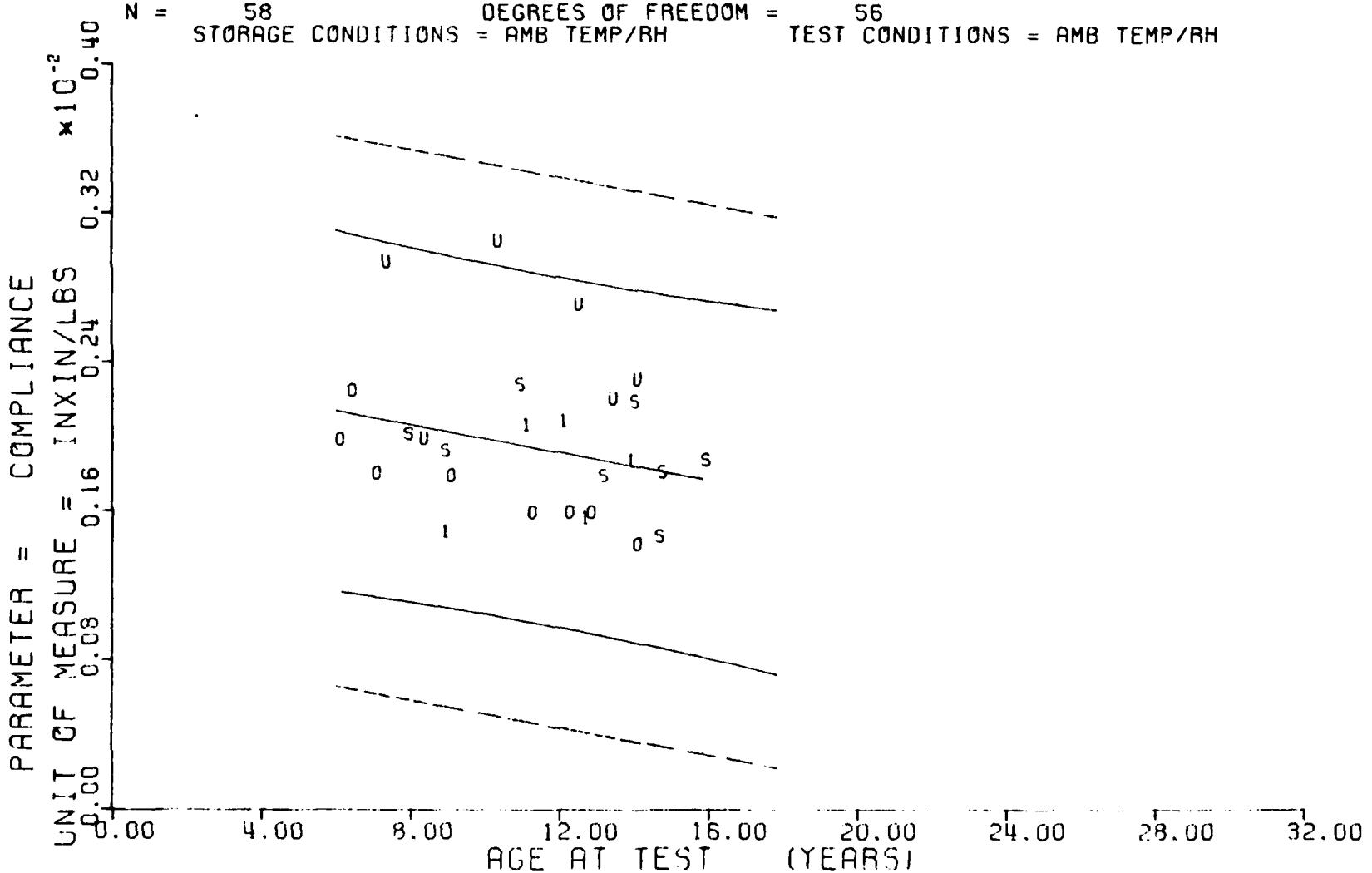
F = +2.7021144E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT S_r = +4.9968822E-04

R = -2.1454826E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT S_b = +1.8732967E-06

t = +1.6438109E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S_t = +4.9239050E-04

N = 58 DEGREES OF FREEDOM = 56

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



DISSECTED MOTOR TP-H1011, CREEP 10 LB LOAD, COMPLIANCE AT 1000 SEC.

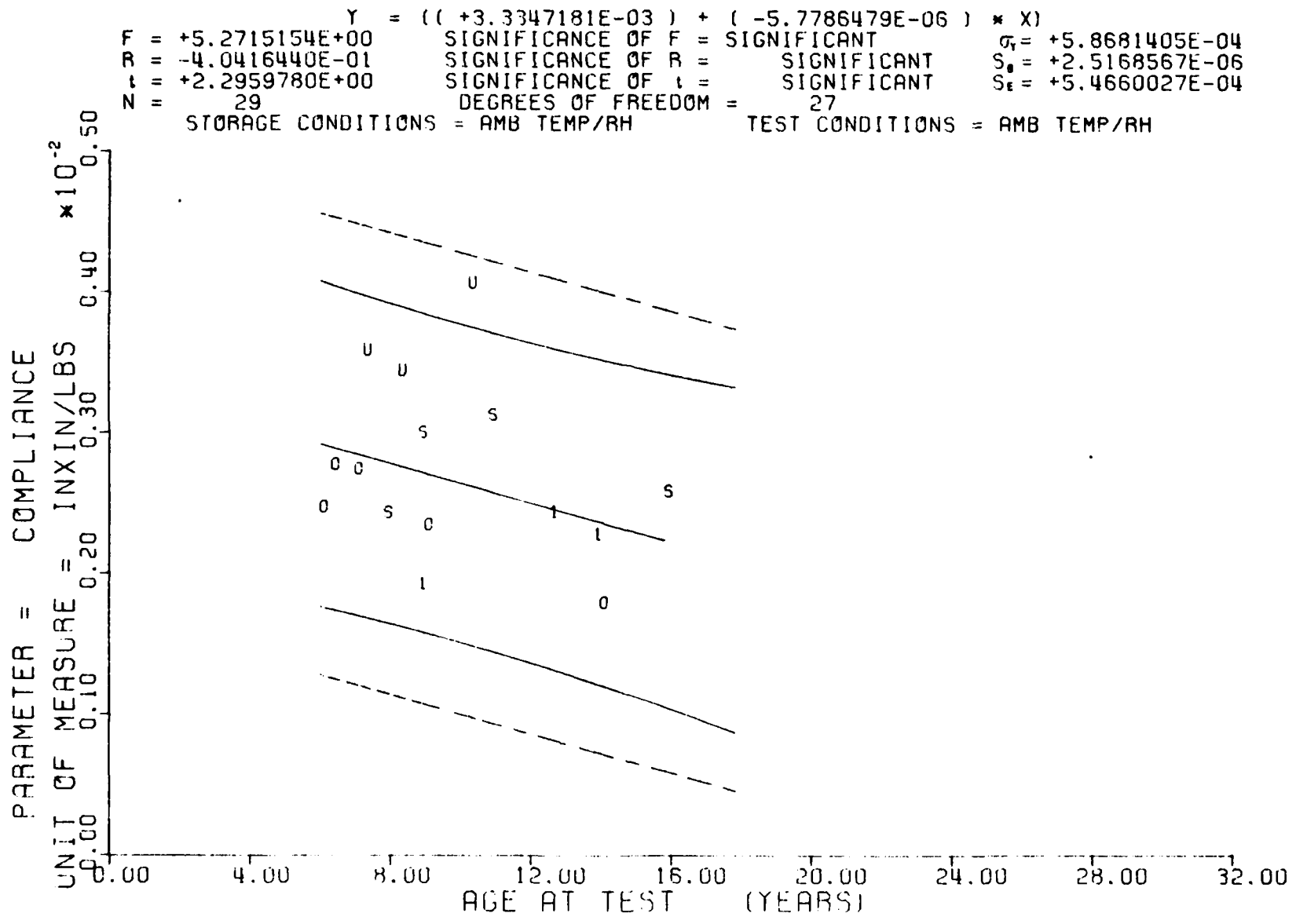
Figure 24

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
72.0	2
76.0	3
84.0	2
87.0	2
94.0	2
99.0	2
106.0	3
108.0	1
123.0	1
130.0	1
151.0	1
166.0	3
168.0	2
190.0	2

DISSECTED MOTOR TP-H1011,CREEP 10 LB LOAD,COMPLIANCE AT 10.000 SEC.

This sample size summary is applicable to figure 25



DISSECTED MOTOR TP-H1011, CREEP 10 LB LOAD, COMPLIANCE AT 10,000 SEC.

Figure 25

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
72.0	2
76.0	2
84.0	2
87.0	2
94.0	2
99.0	2
106.0	3
108.0	1
123.0	1
130.0	1
132.0	2
134.0	2
144.0	2
146.0	2
149.0	2
151.0	2
153.0	3
157.0	2
160.0	2
166.0	3
167.0	1
168.0	6
175.0	2
190.0	3

DISSECTED MUTER TP-H1011,CREEP 12 LB LOAD,COMPLIANCE AT 10 SEC.

This sample size summary is applicable to figures 26, 27 and 28

Y = ((+1.6931521E-03) + (-2.9228175E-06) * X)

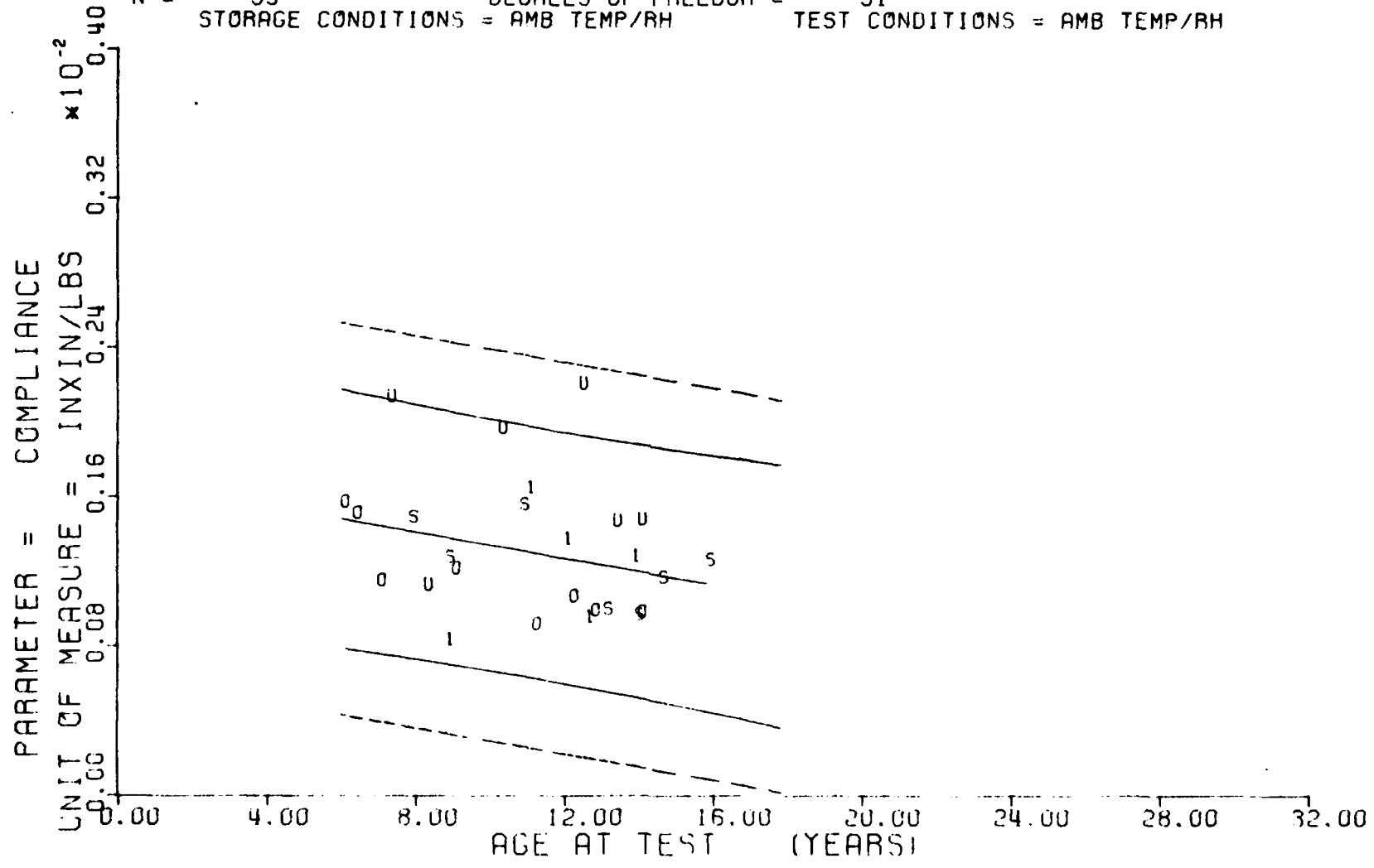
F = +4.5122739E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +3.6187094E-04

R = -2.8510394E-01 SIGNIFICANCE OF R = SIGNIFICANT S_θ = +1.3759541E-06

t = +2.1242113E+00 SIGNIFICANCE OF t = SIGNIFICANT S_ε = +3.5023607E-04

N = 53 DEGREES OF FREEDOM = 51

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



DISSECTED MOTOR TP-H1011, CREEP 12 LB LOAD, COMPLIANCE AT 10 SEC.

Figure 26

Y = ((+1.9888073E-03) + (-3.7685371E-06) * X)

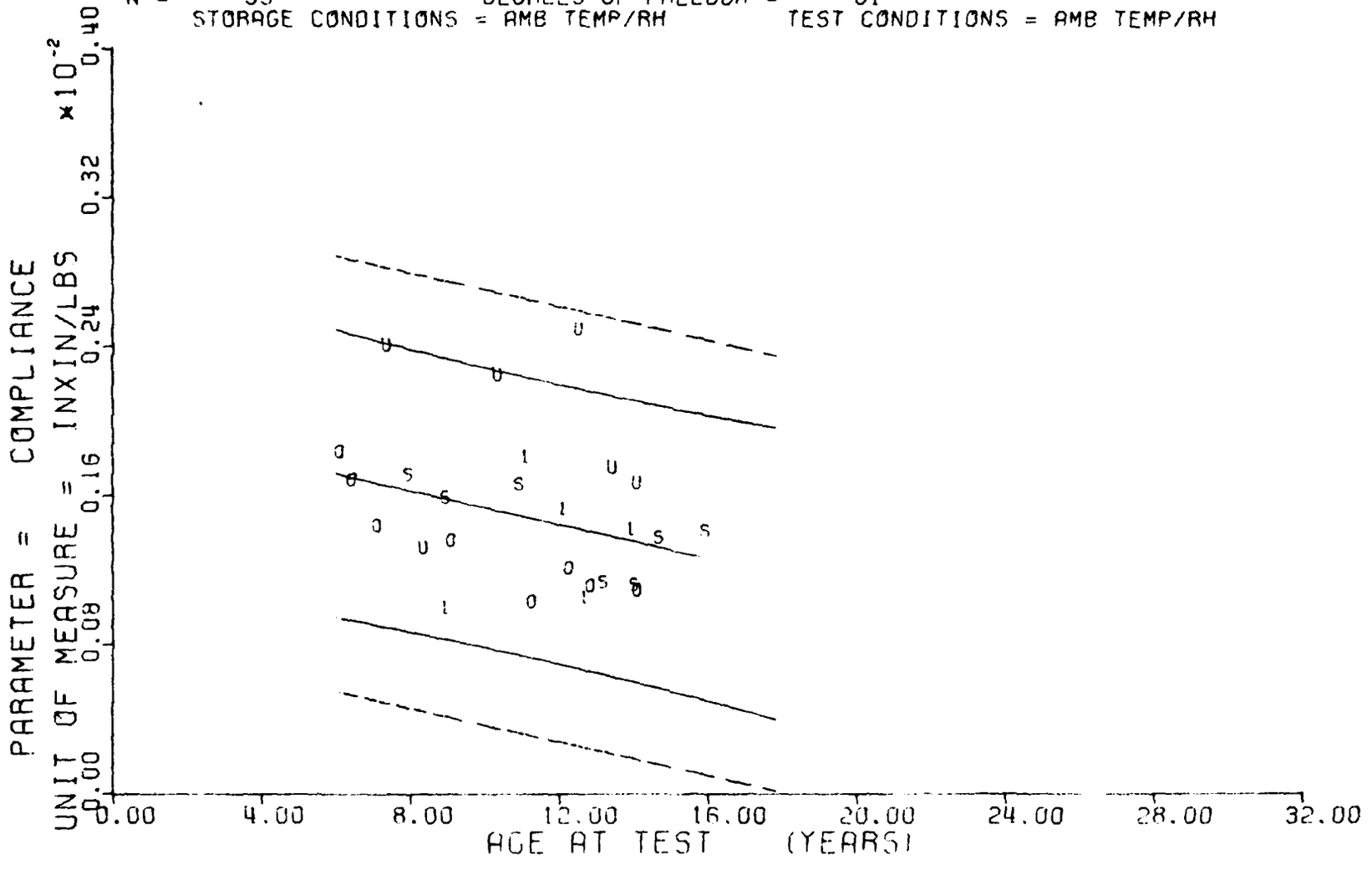
F = +6.0666768E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +4.0798471E-04

R = -3.2604995E-01 SIGNIFICANCE OF R = SIGNIFICANT S_θ = +1.5300209E-06

t = +2.4630624E+00 SIGNIFICANCE OF t = SIGNIFICANT S_t = +3.8945229E-04

N = 53 DEGREES OF FREEDOM = 51

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



DISSECTED MOTOR TP-H1011, CREEP 12 LB LOAD, COMPLIANCE AT 20 SEC.

Figure 27

Y = ((+2.9908003E-03) + (-4.4769364E-06) * X)

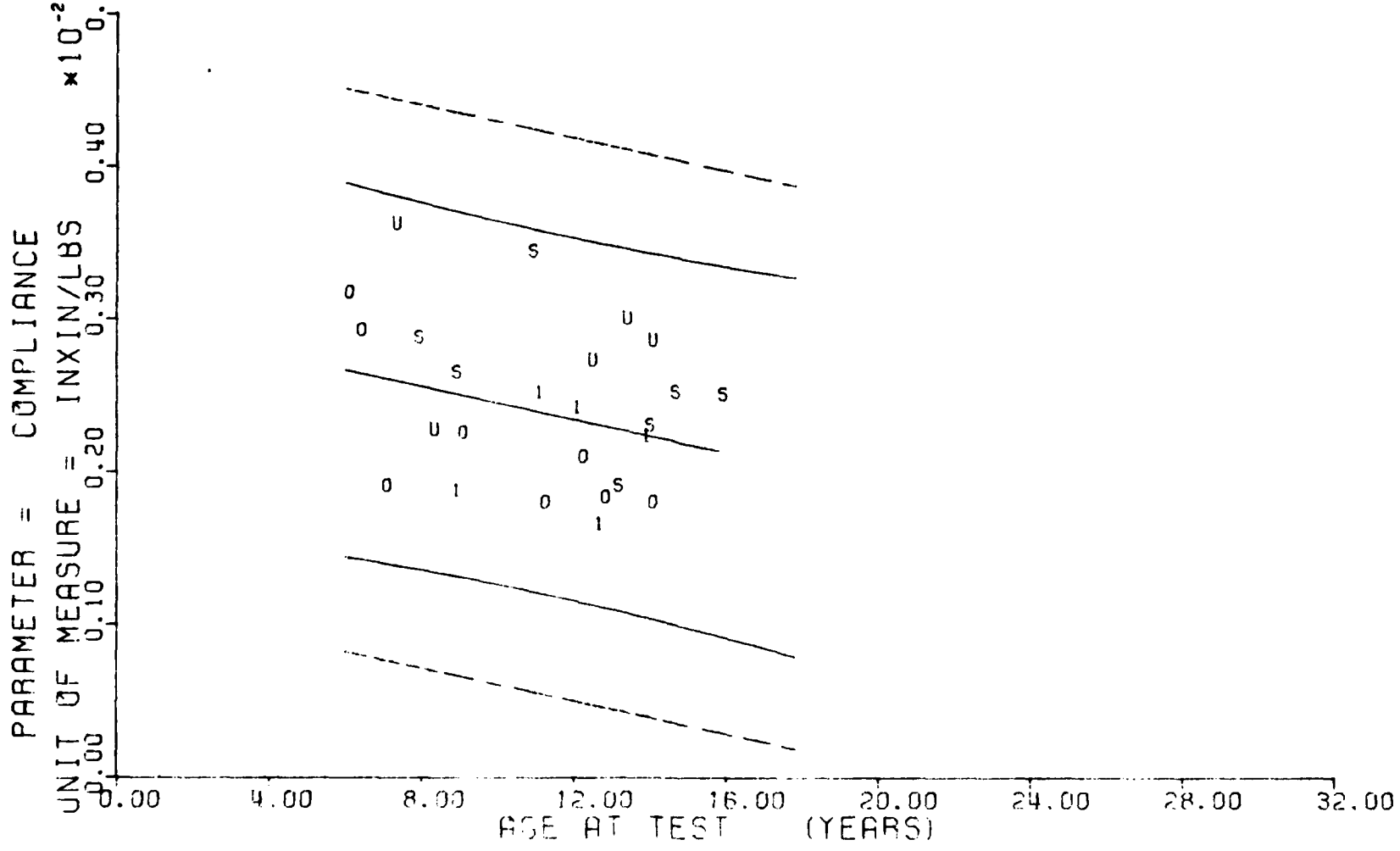
F = +3.2983430E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_Y = +6.2886514E-04

R = -2.5113309E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT S_θ = +2.4650913E-06

t = +1.8161341E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S_ε = +6.1489160E-04

N = 51 DEGREES OF FREEDOM = 49

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



DISSECTED MOTOR TP-H1011, CREEP 12 LB LOAD, COMPLIANCE AT 1000 SEC.

Figure 28

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
84.0	2
87.0	2
99.0	2
106.0	3
108.0	1
123.0	1
130.0	1
166.0	3
168.0	3
190.0	3

TP-H1011 DISSECTED MOTORS, CREEP, % STRAIN AT RUPTURE, 12 LB LOAD

This sample size summary is applicable to figure 29

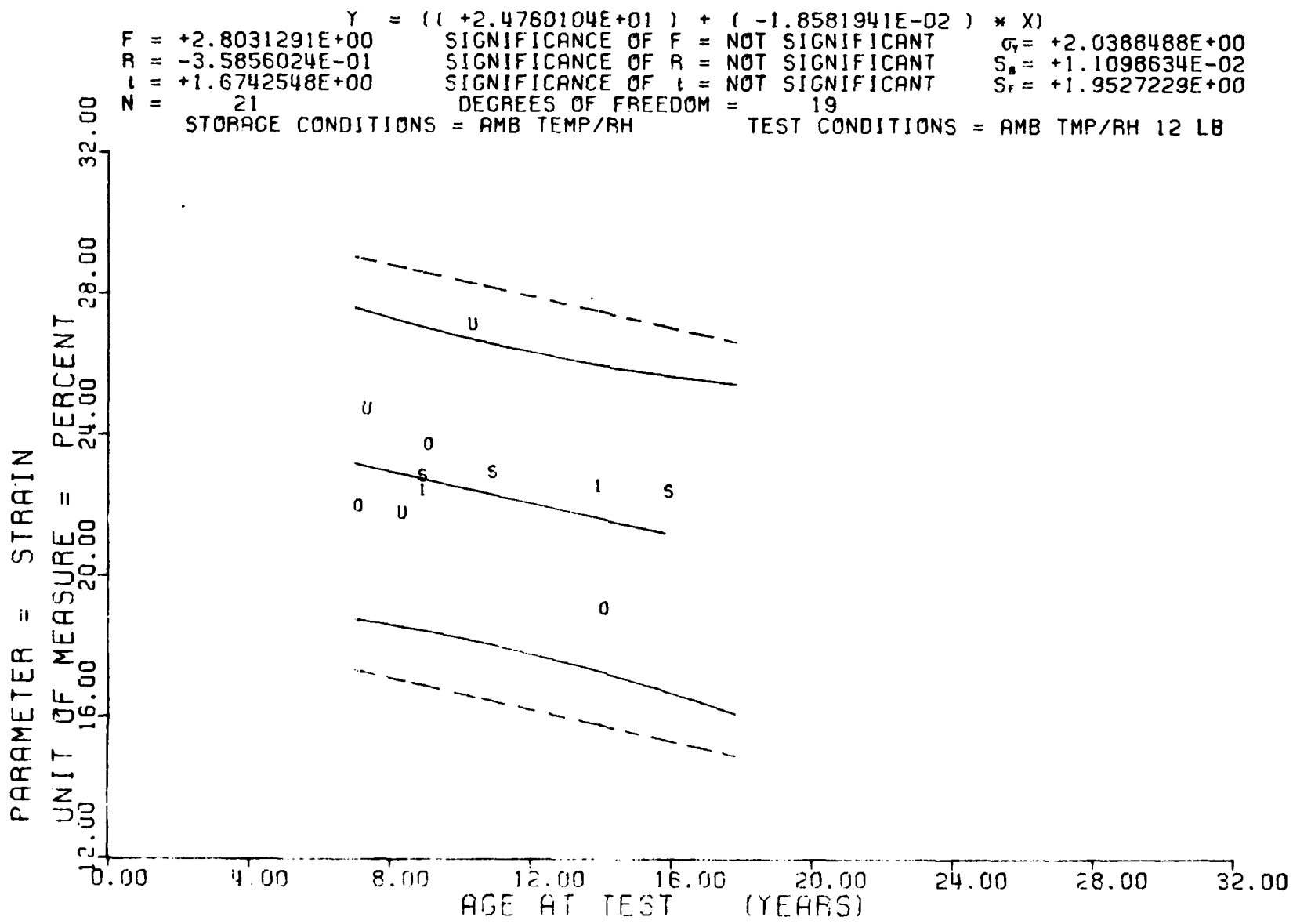

Y = ((+2.4760104E+01) + (-1.8581941E-02) * X)
F = +2.8031291E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σy = +2.0388488E+00
R = -3.5856024E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT Sb = +1.1098634E-02
t = +1.6742548E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT Sr = +1.9527229E+00
N = 21 DEGREES OF FREEDOM = 19
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TMP/RH 12 LB
PARAMETER = STRAIN
UNIT OF MEASURE = PERCENT
32.00
28.00
24.00
20.00
16.00
12.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TP-H1011 DISSECTED MOTORS, CREEP, % STRAIN AT RUPTURE, 12 LB LOAD

Figure 29

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
57.0	3	166.0	3
60.0	3	168.0	9
73.0	3	175.0	3
82.0	3	179.0	3
84.0	3	183.0	3
88.0	3	190.0	3
95.0	4	191.0	3
99.0	3	201.0	3
106.0	6	215.0	3
108.0	3		
116.0	3		
118.0	3		
123.0	3		
130.0	3		
132.0	3		
133.0	3		
134.0	3		
140.0	3		
144.0	4		
145.0	3		
150.0	3		
151.0	3		
153.0	3		
157.0	3		
160.0	3		

TP-H1011 DISSECTED MTRS, STRESS RELAXATION MODULUS, 3 PERCENT STRAIN, 10 SEC

This sample size summary is applicable to figures 30 thru 33

Y = ((+5.8790355E+02) + (+6.9088596E-01) * X)

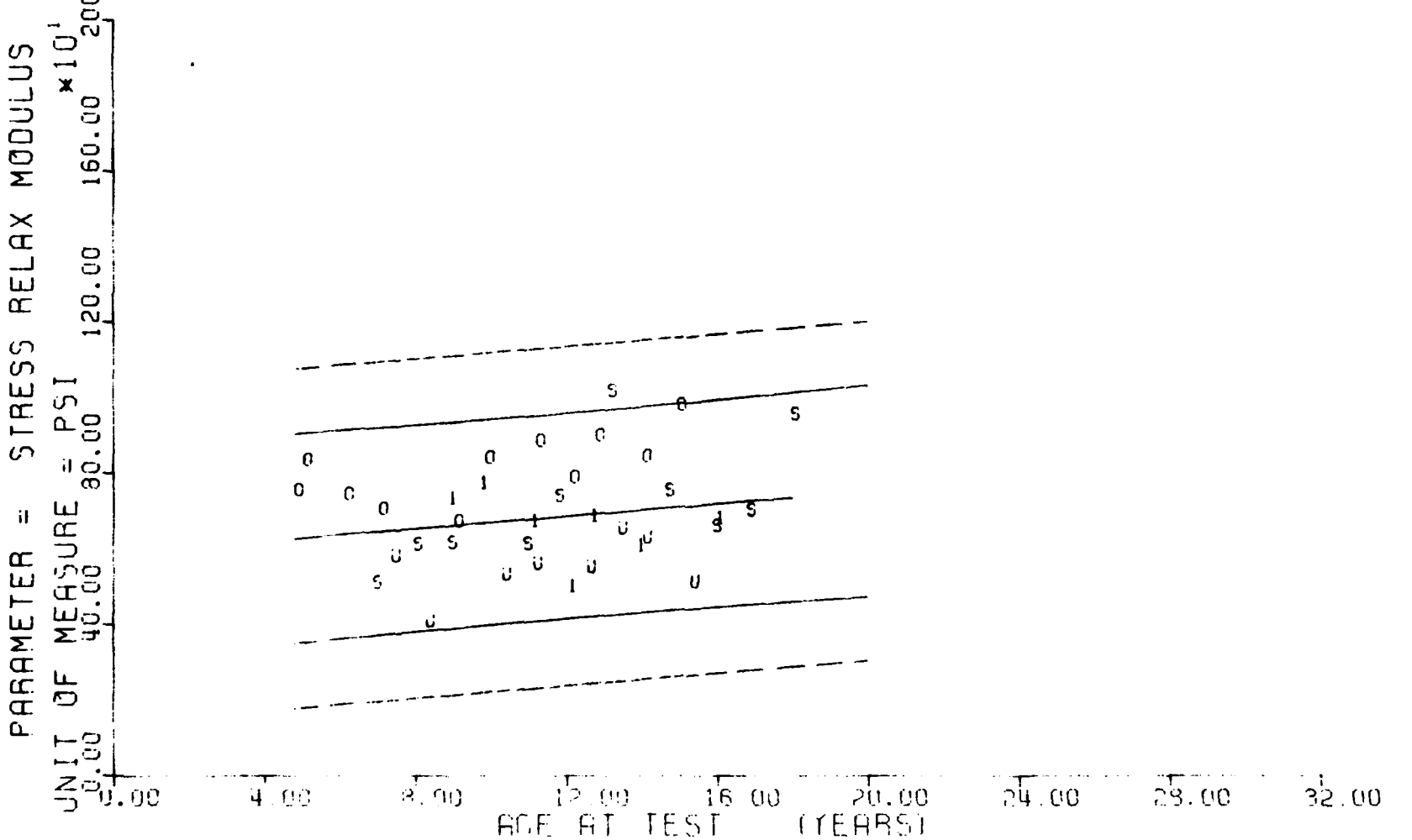
F = +3.7708901E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_r = +1.5143158E+02

R = +1.8126170E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT S_β = +3.5578237E-01

t = +1.9418780E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S_t = +1.4959242E+02

N = 113 DEGREES OF FREEDOM = 111

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TP-H1011 DISSECTED MTBS, STRESS RELAXATION MODULUS, 3 PERCENT STRAIN, 10 SEC

Figure 30

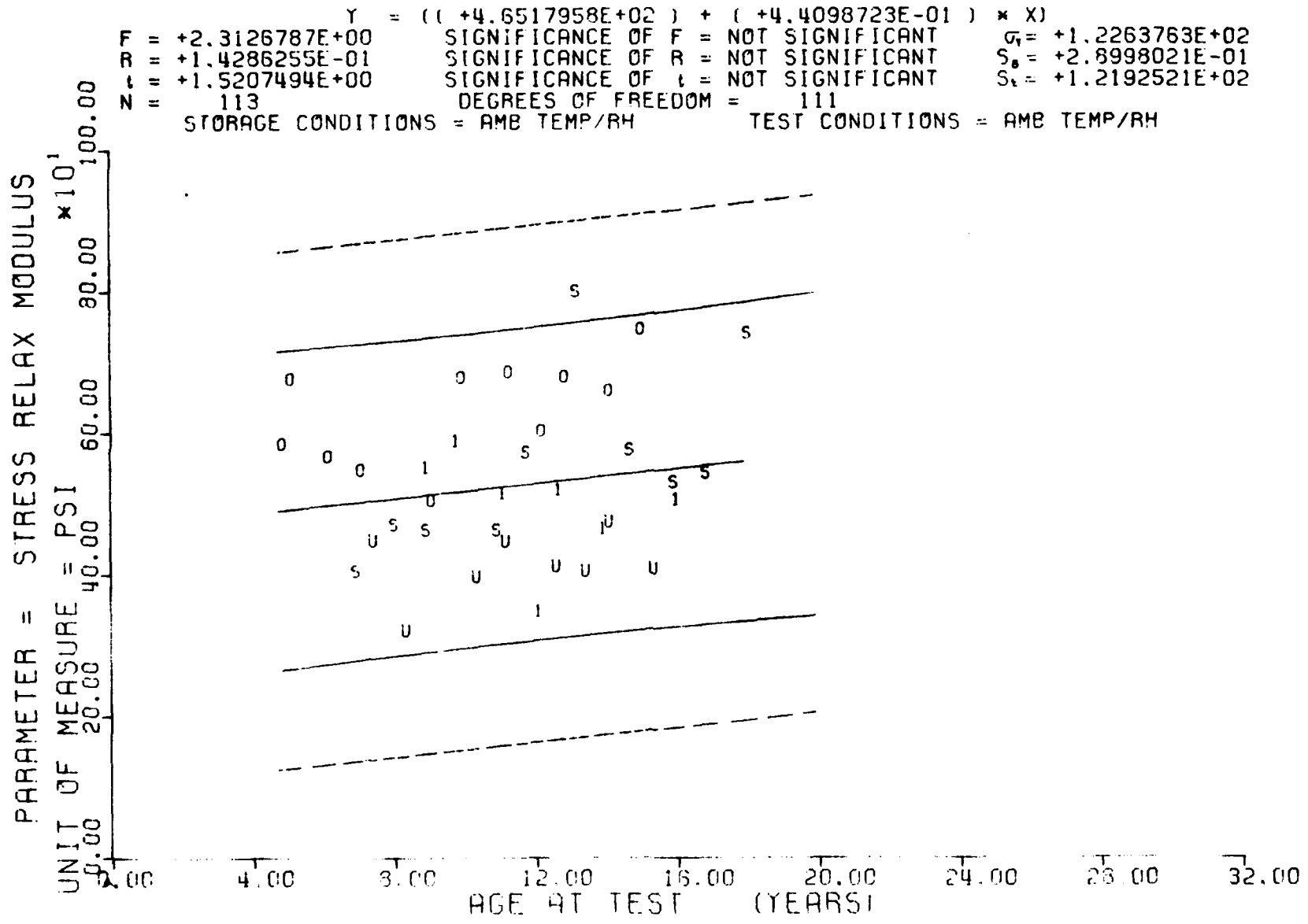

Y = ((+4.6517958E+02) + (+4.4098723E-01) * X)
F = +2.3126787E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σ = +1.2263763E+02
R = +1.4286255E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT S = +2.8998021E-01
t = +1.5207494E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S = +1.2192521E+02
N = 113 DEGREES OF FREEDOM = 111
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRESS RELAX MODULUS
UNIT OF MEASURE = PSI
*10^1
100.00
80.00
60.00
40.00
20.00
0.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TP H101 DISSECTED MTRS, STRESS RELAXATION MODULUS, 3 PERCENT STRAIN, 50 SEC

Figure 31

Y = ((+4.3269229E+02) + (+4.0101222E-01) * X)

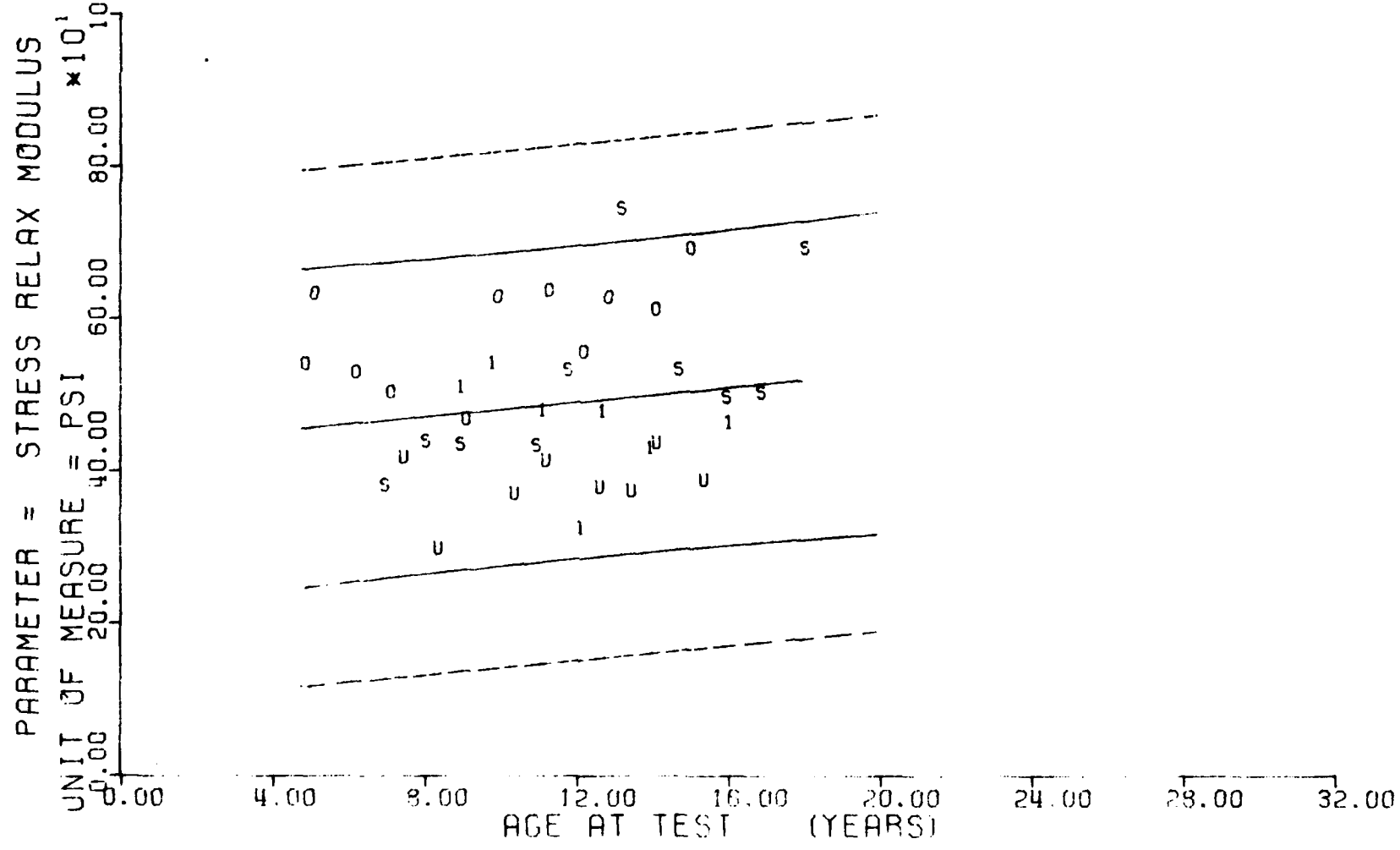
F = +2.2239511E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_Y = +1.1367901E+02

R = +1.4015011E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT S_β = +2.6890259E-01

t = +1.4912917E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S_ε = +1.1306291E+02

N = 113 DEGREES OF FREEDOM = 111

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TP-H1011 DISSECTED MTBS, STRESS RELAXATION MODULUS, 3 PERCENT STRAIN, 100 SEC

Figure 32

Y = ((+3.4776978E+02) + (+2.9294790E-01) * X)

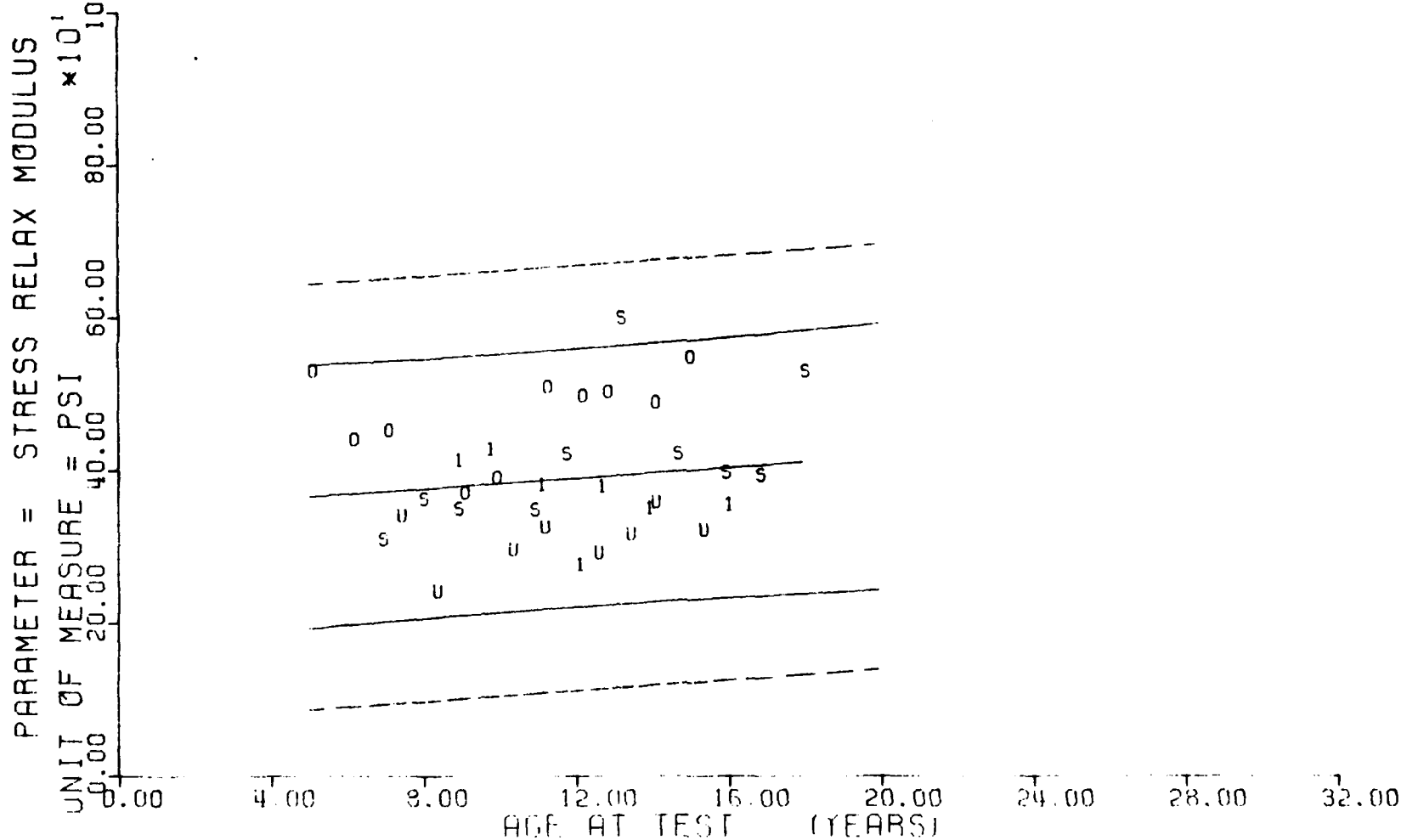
F = +1.5693444E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_Y = +9.3043753E+01

R = +1.1967807E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT S_B = +2.3384670E-01

t = +1.2527348E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S_t = +9.2801701E+01

N = 110 DEGREES OF FREEDOM = 108

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TP-H1011 DISSECTED MTRS, STRESS RELAXATION MODULUS, 3 PERCENT STRAIN, 1000 SEC

Figure 33

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
57.0	3	166.0	3
60.0	3	168.0	3
73.0	3	175.0	3
82.0	3	179.0	3
84.0	3	183.0	3
88.0	3	190.0	3
95.0	4	191.0	3
99.0	3	201.0	3
106.0	3	215.0	3
108.0	3		
116.0	3		
118.0	3		
123.0	3		
130.0	3		
132.0	3		
133.0	3		
134.0	3		
140.0	3		
143.0	3		
145.0	3		
150.0	3		
151.0	3		
153.0	3		
157.0	3		
160.0	3		

TP-H1011 DISSECTED MTRS, STRESS RELAXATION MODULUS, 5 PERCENT STRAIN, 10 SEC

This sample size summary is applicable to figures 34 thru 37

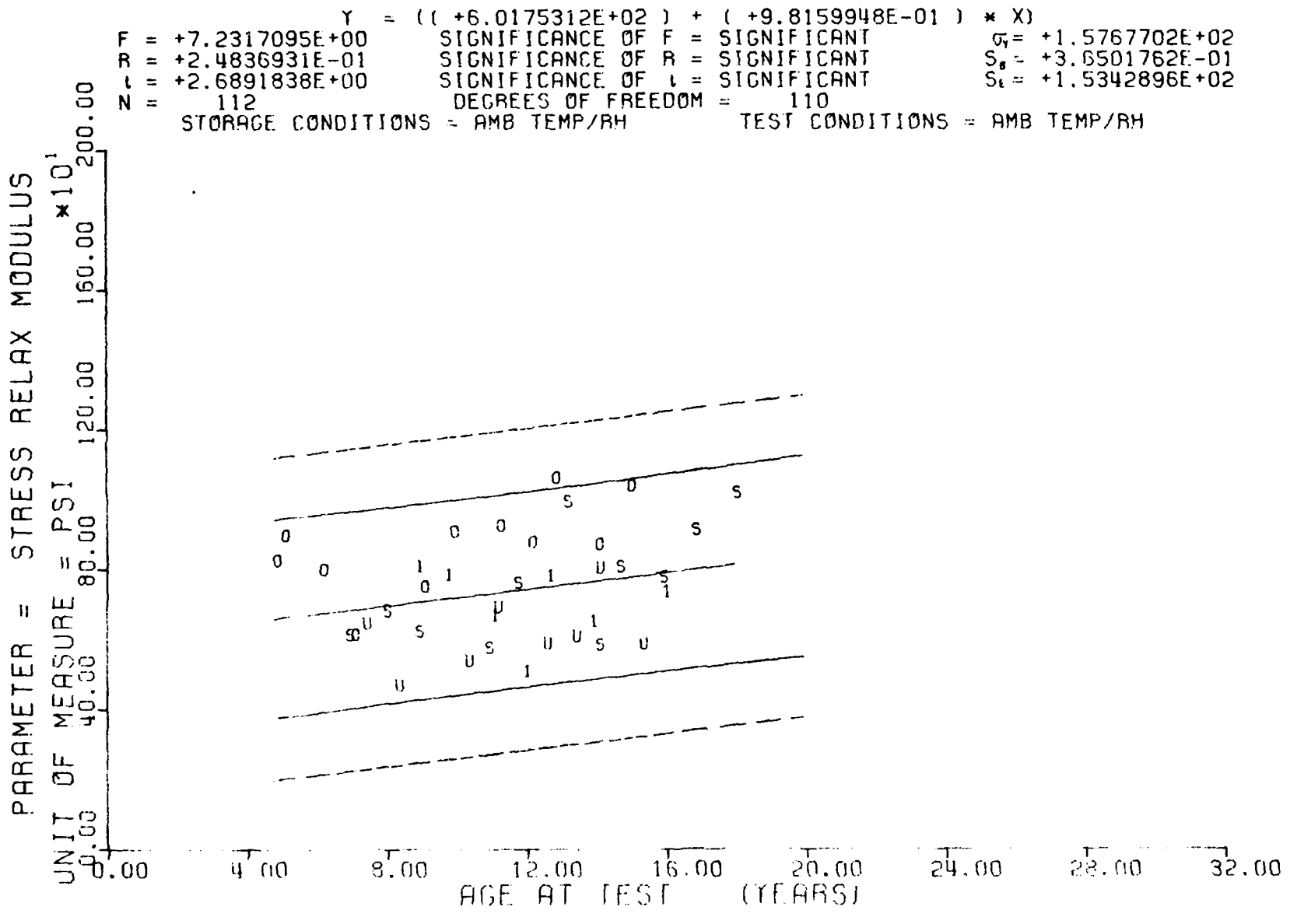

Y = ((+6.0175312E+02) + (+9.8159948E-01) * X)
F = +7.2317095E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.5767702E+02
R = +2.4836931E-01 SIGNIFICANCE OF R = SIGNIFICANT S_β = +3.6501762E-01
t = +2.6891838E+00 SIGNIFICANCE OF t = SIGNIFICANT S_t = +1.5342896E+02
N = 112 DEGREES OF FREEDOM = 110
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRESS RELAX MODULUS
UNIT OF MEASURE = PSI *10^1
200.00
160.00
120.00
80.00
40.00
0.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TP-H1011 DISSECTED MTRS, STRESS RELAXATION MODULUS, 5 PERCENT STRAIN, 10 SEC

Figure 34

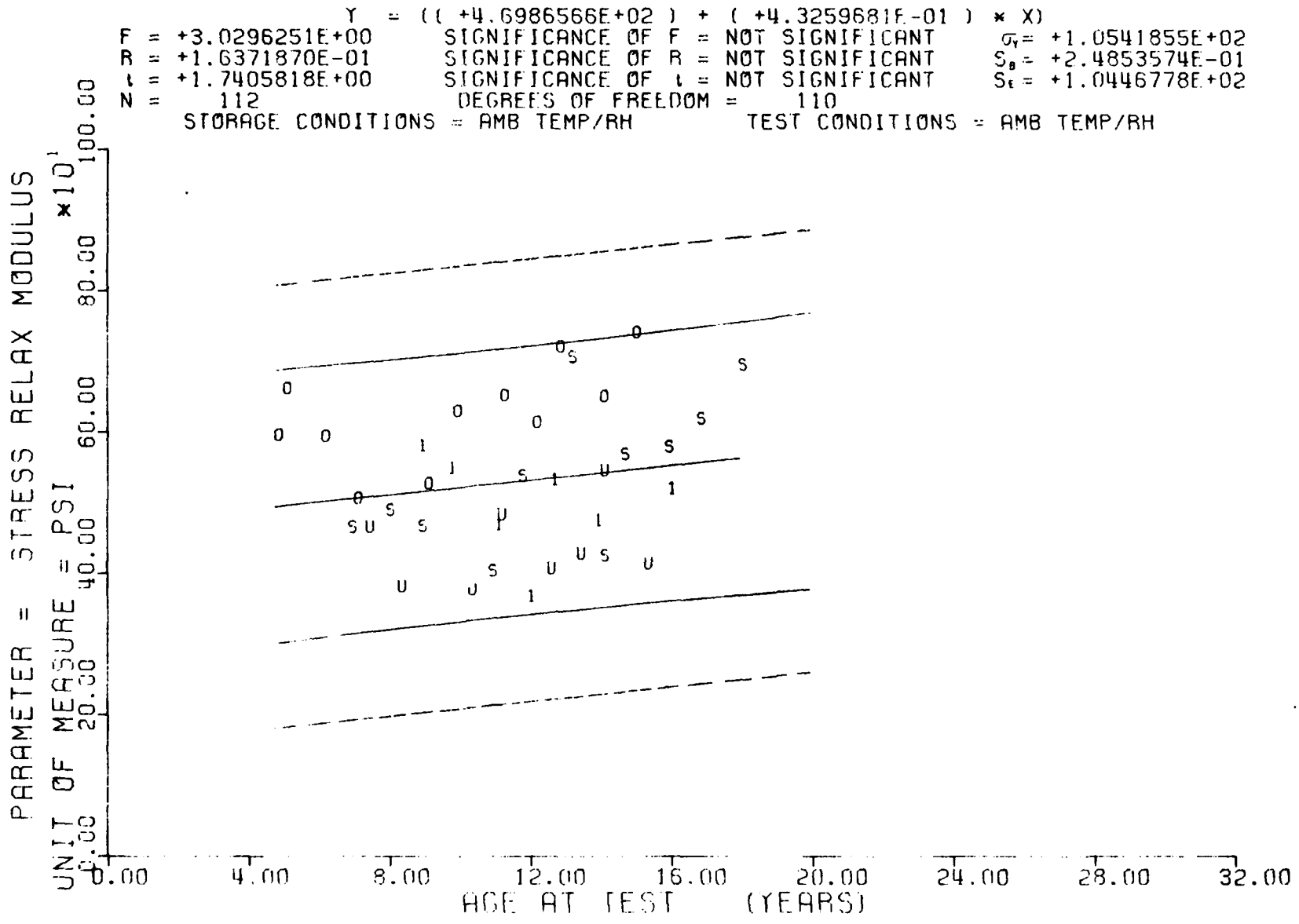

Y = ((+4.6986566E+02) + (+4.3259681E-01) * X)
F = +3.0296251E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σY= +1.0541855E+02
R = +1.6371870E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT Sβ = +2.4853574E-01
t = +1.7405818E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT St = +1.0446778E+02
N = 112 DEGREES OF FREEDOM = 110
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRESS RELAX MODULUS
UNIT OF MEASURE = PSI
*10¹
100.00
80.00
60.00
40.00
20.00
0.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TP-H1011 DISCRETED MTRS, STRESS RELAXATION MODULUS, 5 PERCENT STRAIN, 50 SEC

Figure 35

Y = ((+4.3710000E+02) + (+3.7731684E-01) * X)

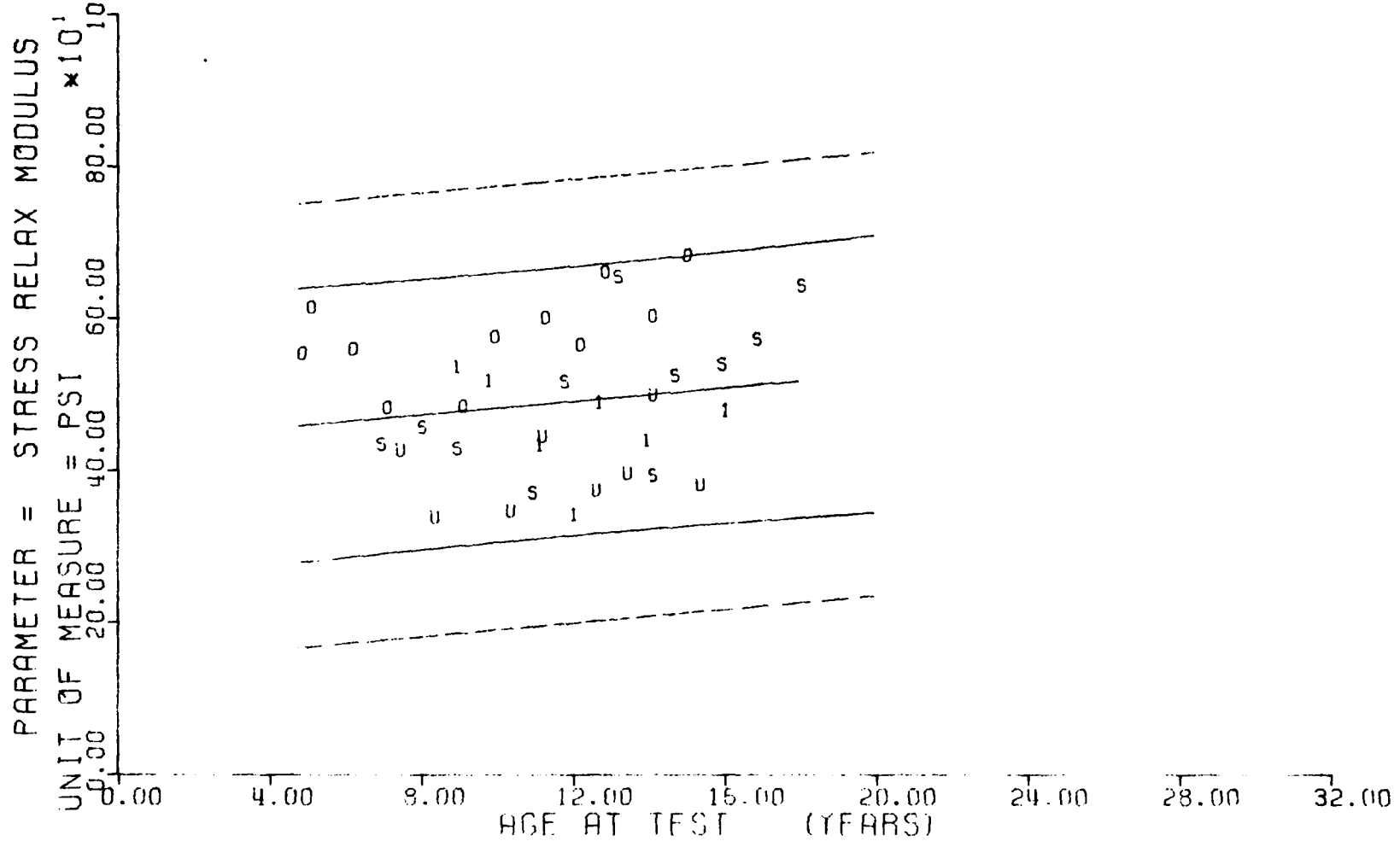
F = +2.6511885E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_Y = +9.8126386E+01

R = +1.5340955E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT S_B = +2.3173193E-01

t = +1.6282470E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S_t = +9.7404585E+01

N = 112 DEGREES OF FREEDOM = 110

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TP-H1011 DISSECTED MTRS, STRESS RELAXATION MODULUS, 5 PERCENT STRAIN, 100 SEC

Figure 36

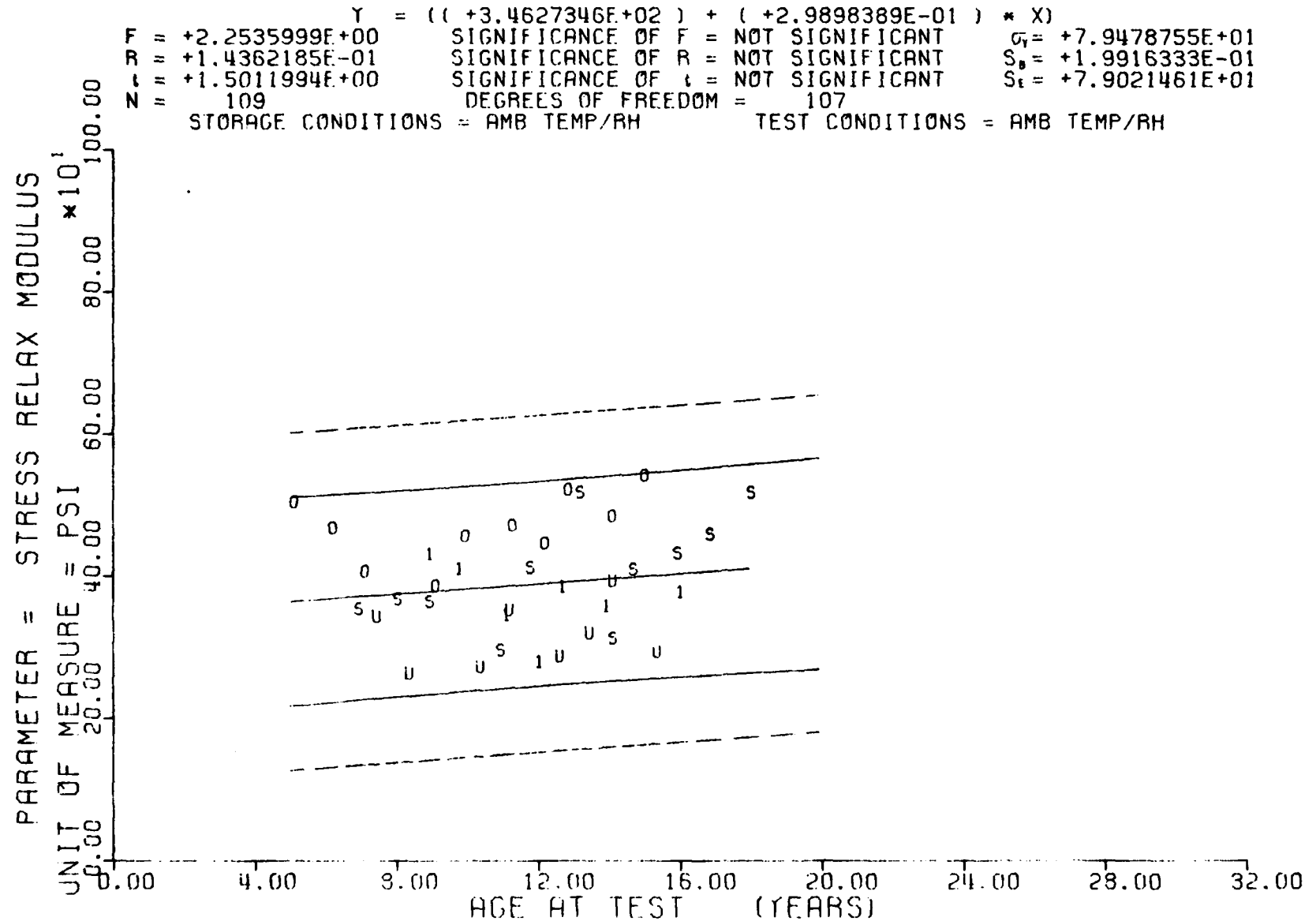

Y = ((+3.4627346E+02) + (+2.9898389E-01) * X)
F = +2.2535999E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σY = +7.9478755E+01
R = +1.4362185E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT Sb = +1.9916333E-01
t = +1.5011994E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT St = +7.9021461E+01
N = 109 DEGREES OF FREEDOM = 107
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRESS RELAX MODULUS
UNIT OF MEASURE = PSI *10¹
100.00
80.00
60.00
40.00
20.00
0.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TP-H1011 DISSECTED MTRS, STRESS RELAXATION MODULUS, 5 PERCENT STRAIN, 1000 SEC

Figure 37

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
72.0	16
83.0	1
94.0	1
105.0	1
107.0	1
109.0	1
117.0	1
120.0	1
131.0	1
135.0	2
137.0	2
142.0	1
159.0	2

STAGE 1 DSSCTD MTRS, CONSTANT STRAIN, STRAIN 0.1 INIT AND 0.01 EVERY 48 HRS

This sample size summary is applicable to figure 38

Y = ((+3.3048871E+01) + (-1.2955493E-01) * X)

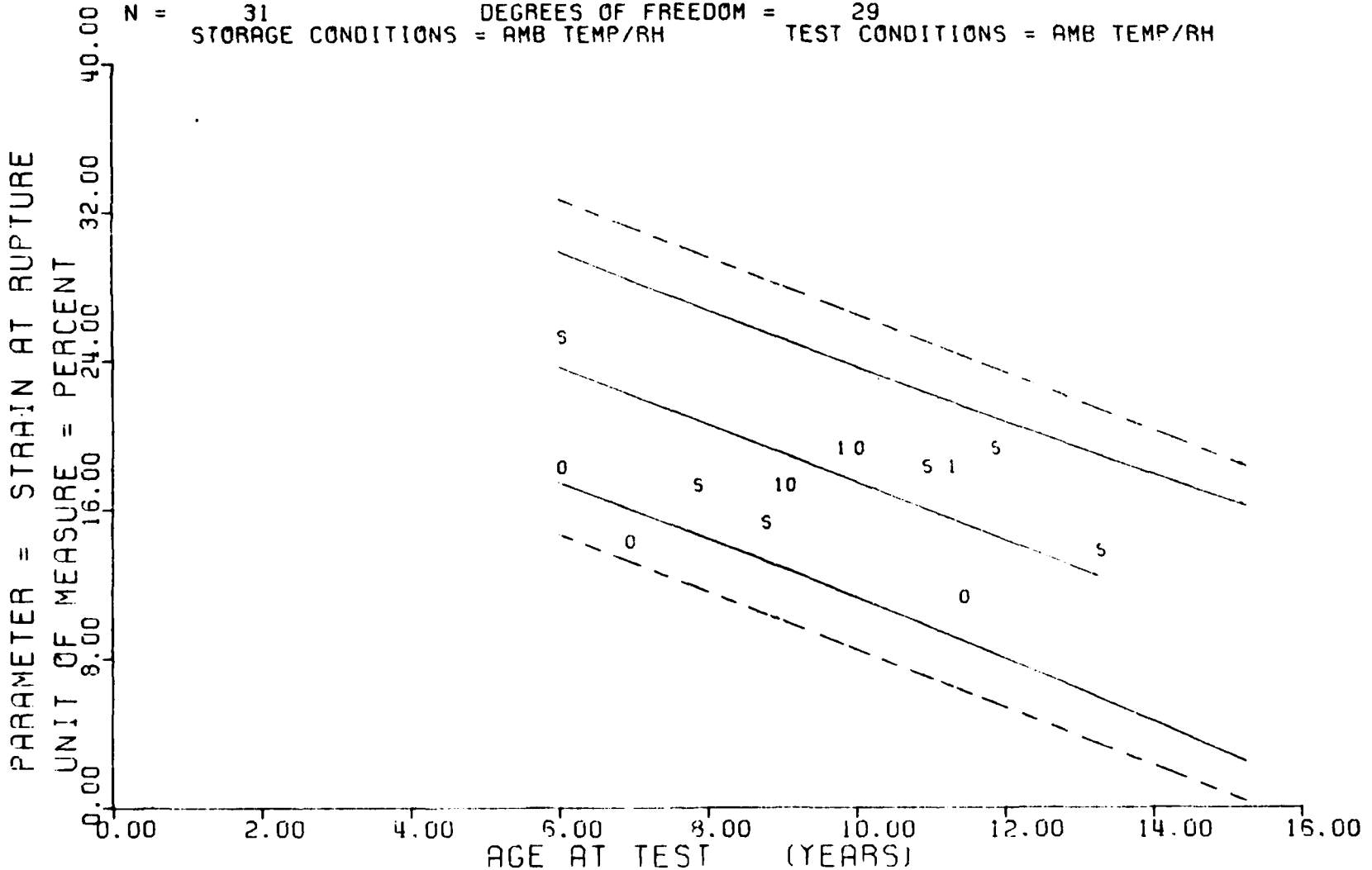
F = +5.2947397E+01 SIGNIFICANCE OF F = SIGNIFICANT σ_1 = +4.9583209E+00

R = -8.0381244E-01 SIGNIFICANCE OF R = SIGNIFICANT S_β = +1.7804576E-02

t = +7.2764962E+00 SIGNIFICANCE OF t = SIGNIFICANT S_t = +3.0000443E+00

N = 31 DEGREES OF FREEDOM = 29

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



STAGE 1 DSSCTD MTRS, CONSTANT STRAIN, STRAIN 0.1 INIT AND 0.01 EVERY 48 HRS

Figure 38

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
71.0	6	175.0	5
82.0	5	178.0	10
86.0	6	133.0	10
95.0	1	186.0	10
97.0	5	189.0	10
104.0	5		
105.0	5		
107.0	5		
115.0	5		
117.0	5		
122.0	5		
130.0	5		
132.0	10		
134.0	5		
140.0	5		
143.0	3		
145.0	5		
149.0	5		
150.0	5		
152.0	5		
156.0	5		
160.0	5		
164.0	10		
167.0	5		
168.0	20		

STAGE 1 DISSECTED MTRLS, SHORE A HARDNESS, 10 SECOND

This sample size summary is applicable to figure 39

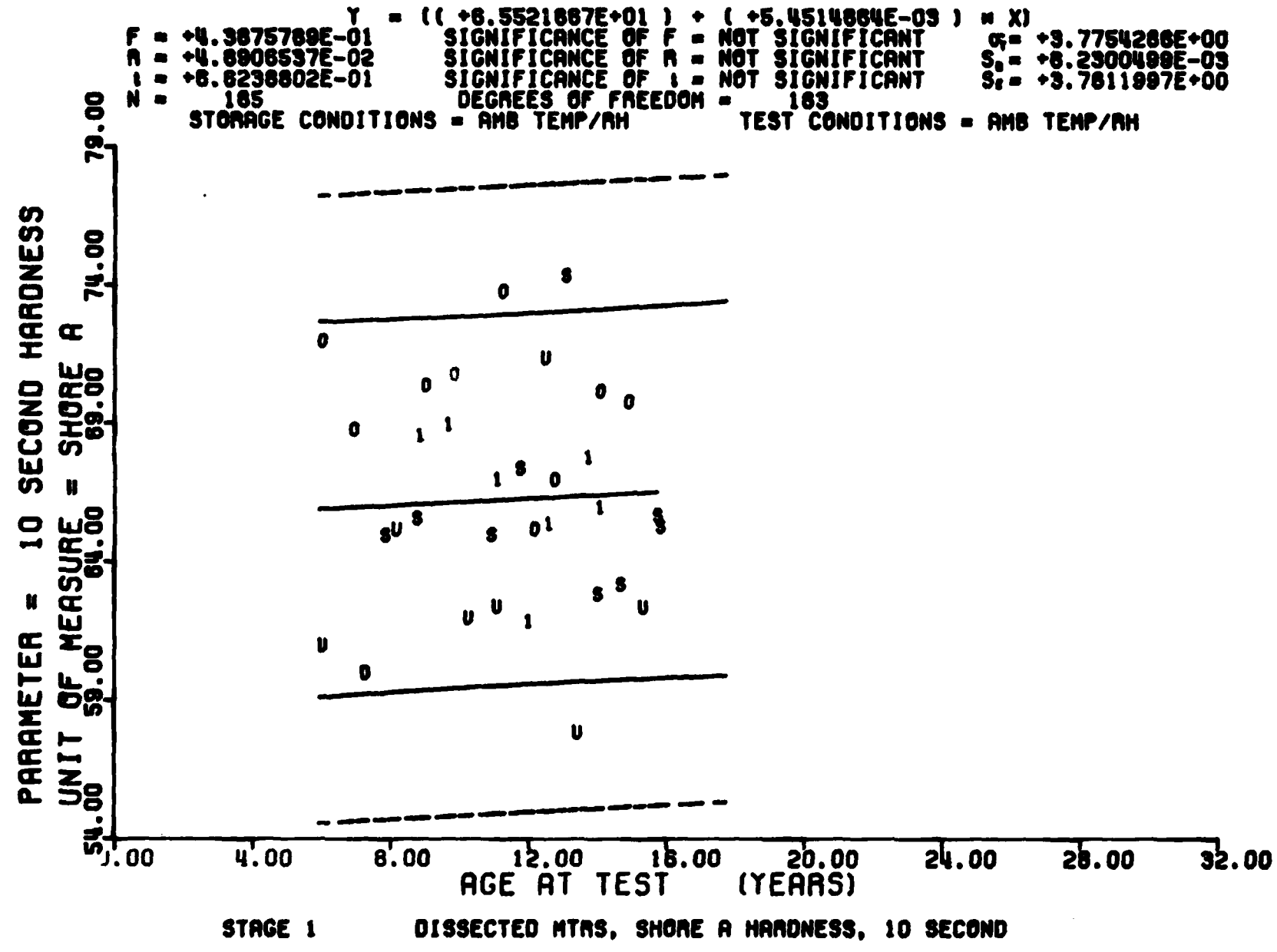

Y = ((+6.5521667E+01) + (+5.4514864E-03) * X)
F = +4.3875789E-01 SIGNIFICANCE OF F = NOT SIGNIFICANT σ = +3.7754286E+00
R = +4.8906537E-02 SIGNIFICANCE OF R = NOT SIGNIFICANT S0 = +8.2300499E-03
t = +6.8238802E-01 SIGNIFICANCE OF t = NOT SIGNIFICANT S1 = +3.7811997E+00
N = 185 DEGREES OF FREEDOM = 183
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = 10 SECOND HARDNESS
UNIT OF MEASURE = SHORE A
79.00
74.00
69.00
64.00
59.00
54.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
STAGE 1 DISSECTED MTRS, SHORE A HARDNESS, 10 SECOND

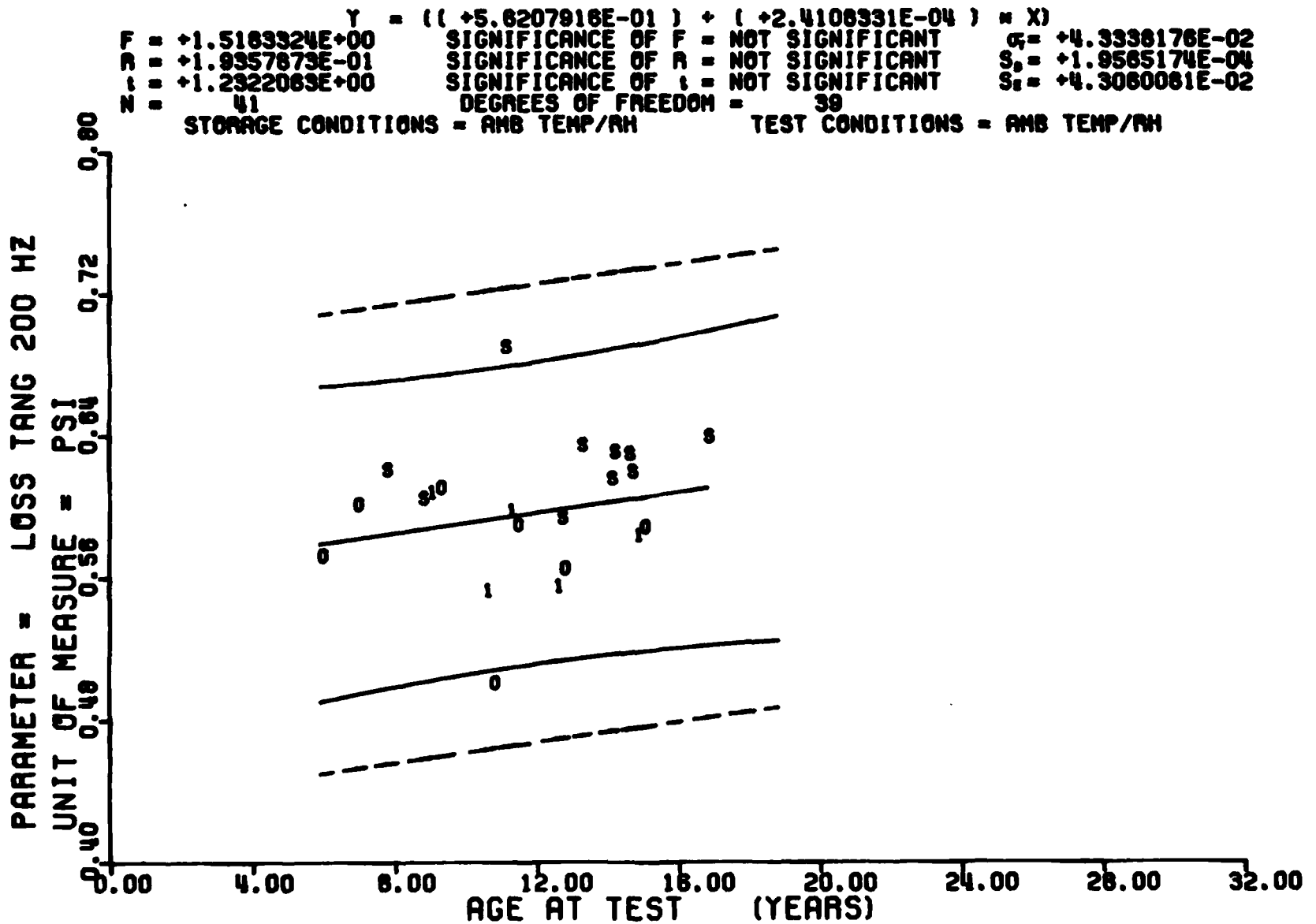
Figure 39

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
71.0	3
83.0	2
93.0	1
105.0	2
108.0	2
111.0	2
127.0	2
129.0	2
133.0	2
135.0	2
137.0	2
151.0	2
152.0	2
155.0	2
159.0	2
169.0	1
170.0	2
175.0	1
176.0	1
178.0	2
180.0	1
202.0	2

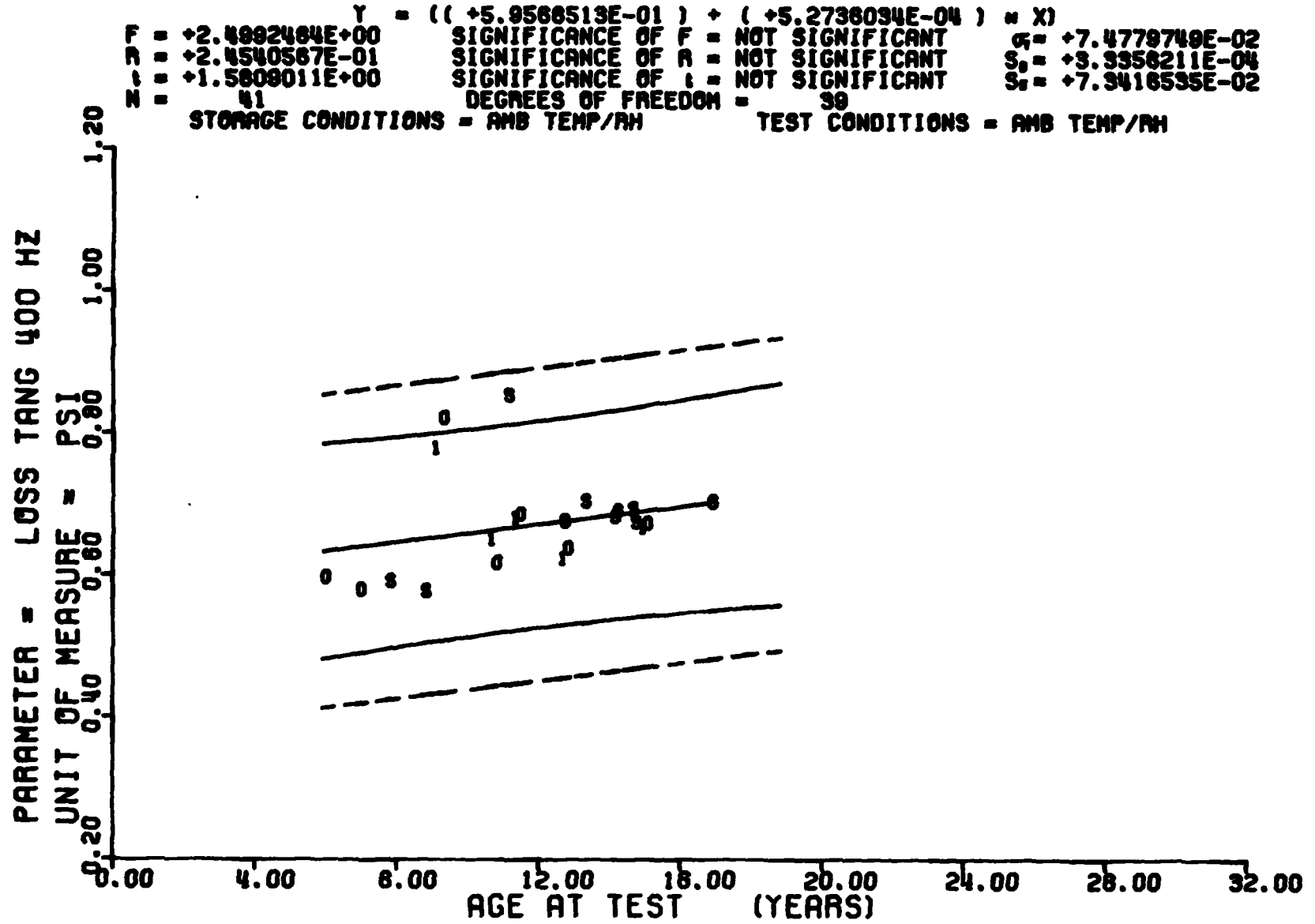
STAGE I DISSECTED MUTANTS,DYNAMIC RESPONSE,CENTER-WT 70 GM,LOSS TANG AT 200 HZ

This sample size summary is applicable to figures 40 thru 43



STAGE I DISSECTED MOTORS, DYNAMIC RESPONSE, CENTER-WT 70 GM, LOSS TANG AT 200 HZ

Figure 40



STAGE I DISSECTED MOTORS, DYNAMIC RESPONSE, CENTER-WT 70 GM, LOSS TANG AT 400 HZ

Figure 41

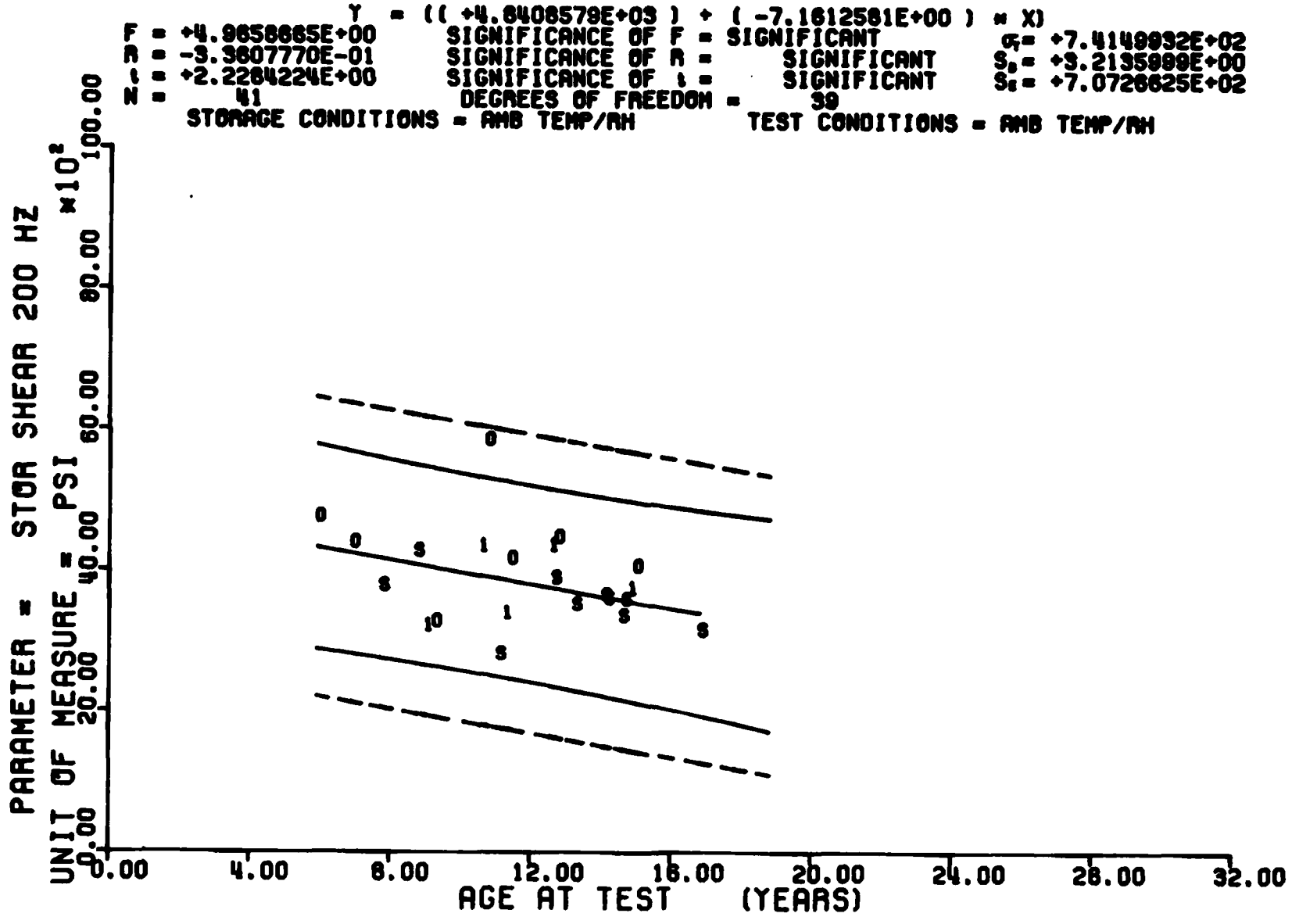
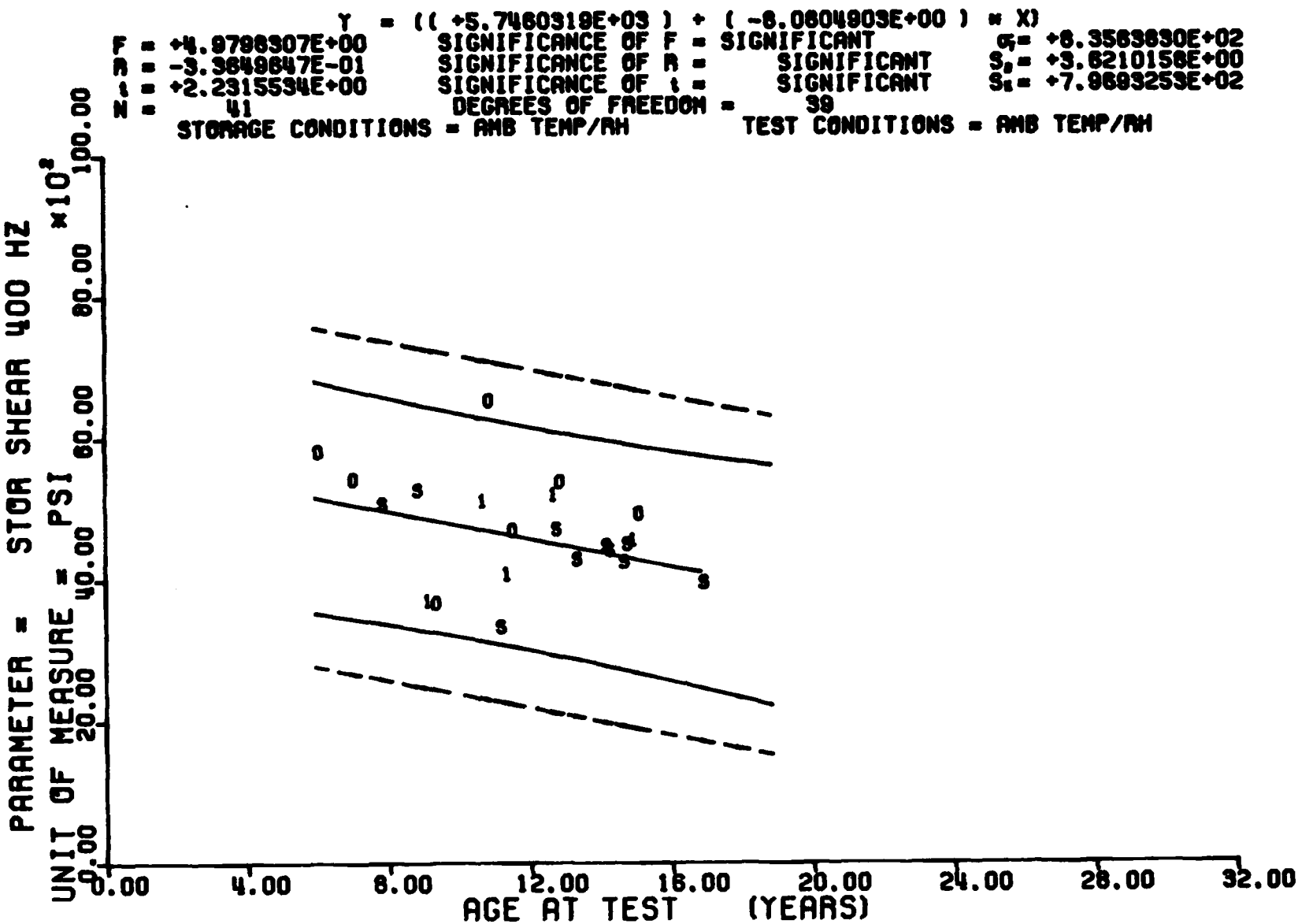

Y = ((+4.8408578E+03) + (-7.1612581E+00) * X)
F = +4.9658665E+00 SIGNIFICANCE OF F = SIGNIFICANT σt= +7.4149892E+02
R = -3.3807770E-01 SIGNIFICANCE OF R = SIGNIFICANT Sb= +3.2135989E+00
t = +2.2284224E+00 SIGNIFICANCE OF t = SIGNIFICANT St= +7.0728625E+02
N = 41 DEGREES OF FREEDOM = 39
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STOR SHEAR 200 HZ
UNIT OF MEASURE = PSI *10²
100.00
80.00
60.00
40.00
20.00
0.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
STAGE I DISSECTED MOTORS, DYNAMIC RESPONSE, CENTER-WT 70 GM, STOR SHEAR AT 200 HZ

Figure 42



STAGE I DISSECTED MOTORS, DYNAMIC RESPONSE, CENTER-WT 70 GM, STOR SHEAR AT 400 HZ

Figure 43

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
74.0	18
83.0	6
89.0	6
97.0	6
98.0	6
105.0	6
106.0	5
108.0	5
118.0	5
120.0	5
123.0	5
135.0	5
142.0	5
152.0	6
154.0	6
168.0	6
169.0	6
170.0	6
176.0	6
179.0	6
181.0	6
185.0	6
193.0	6
204.0	6

STAGE 1 DISSECTED MOTORS, BURNING RATE AT 500 PSI INITIAL PRESSURE

This sample size summary is applicable to figure 44

Y = ((+2.9725563E-01) + (-3.1024938E-04) * X)

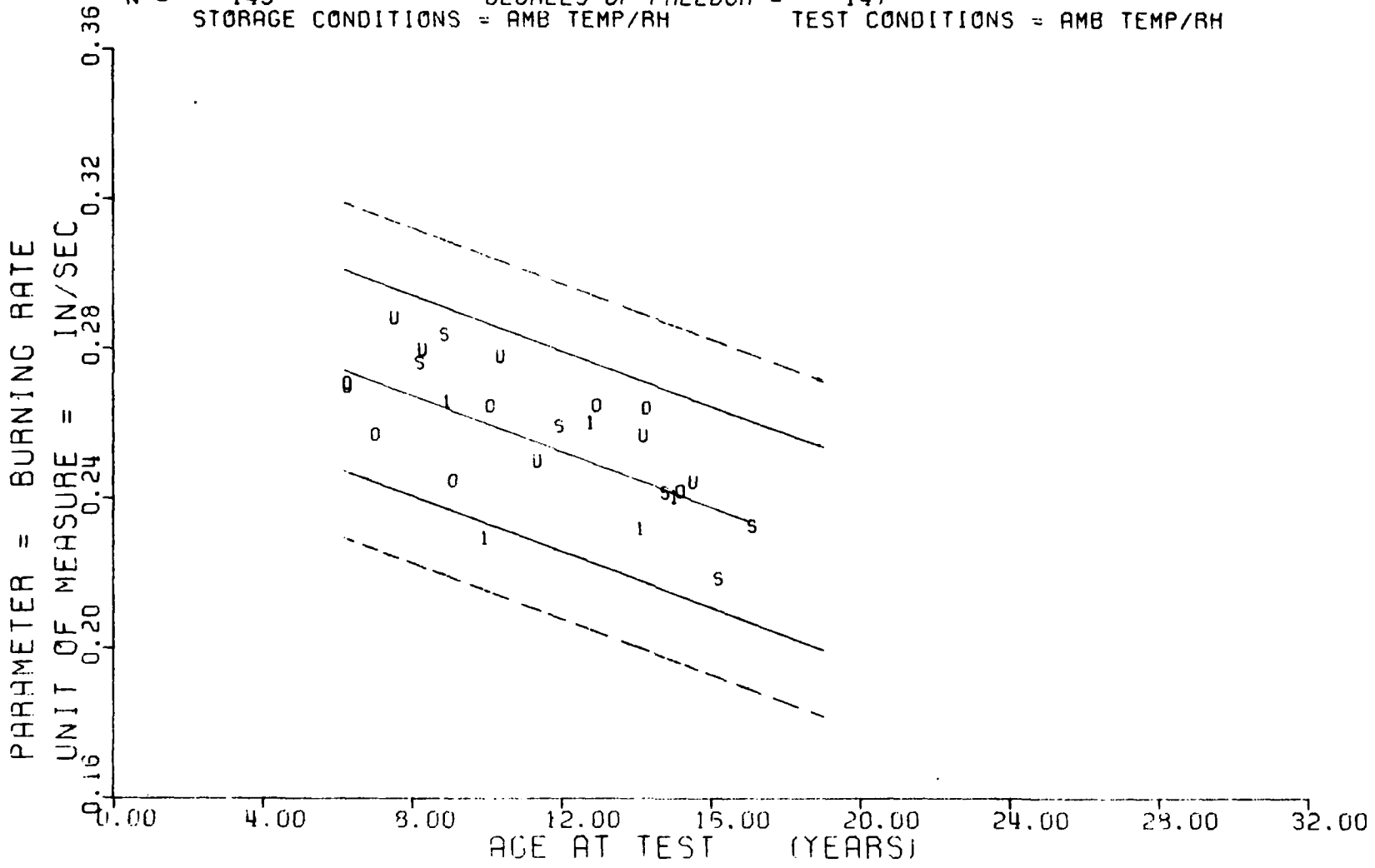
F = +1.0943720E+02 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +1.9610743E-02

R = -6.5326889E-01 SIGNIFICANCE OF R = SIGNIFICANT S_β = +2.9657083E-05

t = +1.0461223E+01 SIGNIFICANCE OF t = SIGNIFICANT S_ε = +1.4898220E-02

N = 149 DEGREES OF FREEDOM = 147

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



STAGE 1 DISSECTED MOTORS, BURNING RATE AT 500 PSI INITIAL PRESSURE

Figure 44

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
74.0	6	176.0	6
83.0	6	179.0	6
89.0	6	181.0	6
97.0	6	185.0	6
98.0	6	193.0	6
105.0	6	204.0	6
106.0	5		
108.0	5		
118.0	5		
120.0	5		
123.0	5		
130.0	5		
135.0	5		
137.0	6		
139.0	5		
142.0	5		
145.0	6		
147.0	5		
152.0	5		
154.0	11		
161.0	5		
162.0	5		
168.0	6		
169.0	11		
170.0	6		

STAGE 1 DISSECTED MOTORS, BURNING RATE AT 1000 PSI INITIAL PRESSURE

This sample size summary is applicable to figure 45

Y = ((+3.6623649E-01) + (-4.0923384E-04) * X)

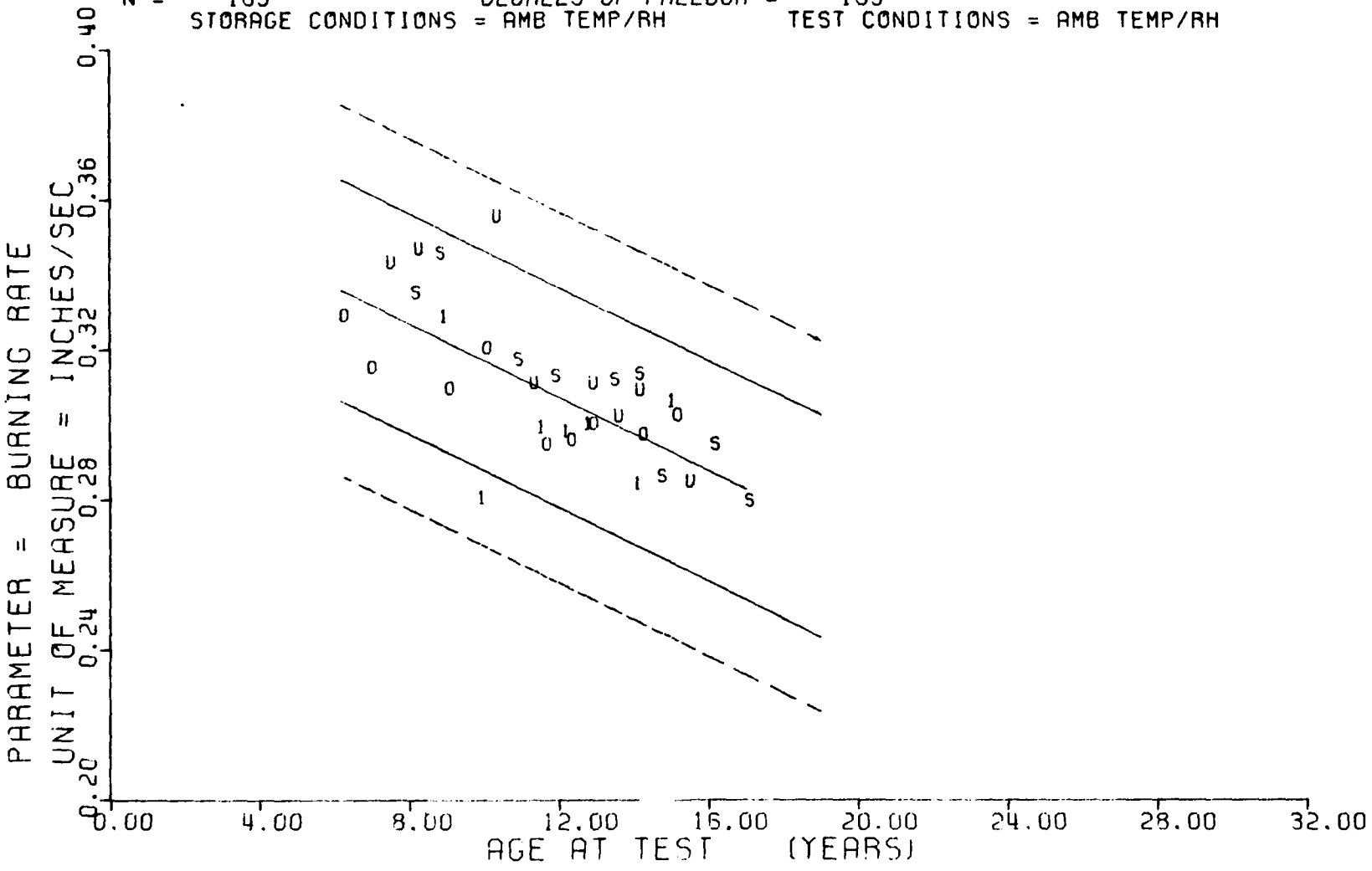
F = +1.3270419E+02 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = +2.1572566E-02

R = -6.4833900E-01 SIGNIFICANCE OF R = SIGNIFICANT S_θ = +3.5524601E-05

t = +1.1519730E+01 SIGNIFICANCE OF t = SIGNIFICANT S_ε = +1.6469125E-02

N = 185 DEGREES OF FREEDOM = 183

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



STAGE 1 DISSECTED MOTORS, BURNING RATE AT 1000 PSI INITIAL PRESSURE

Figure 45

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
74.0	3
76.0	3
83.0	2
91.0	3
98.0	6
105.0	3
108.0	1
110.0	1
125.0	1
132.0	1
136.0	3
138.0	3
152.0	3
153.0	2
154.0	2
160.0	3
167.0	3
169.0	6
175.0	3
176.0	3
184.0	3
191.0	2
200.0	3

STAGE 1 DISSECTED MOTORS, HEAT OF EXPLOSION

This sample size summary is applicable to figure 46

Y = ((+1.5410055E+03) + (+4.8457936E-02) * X)

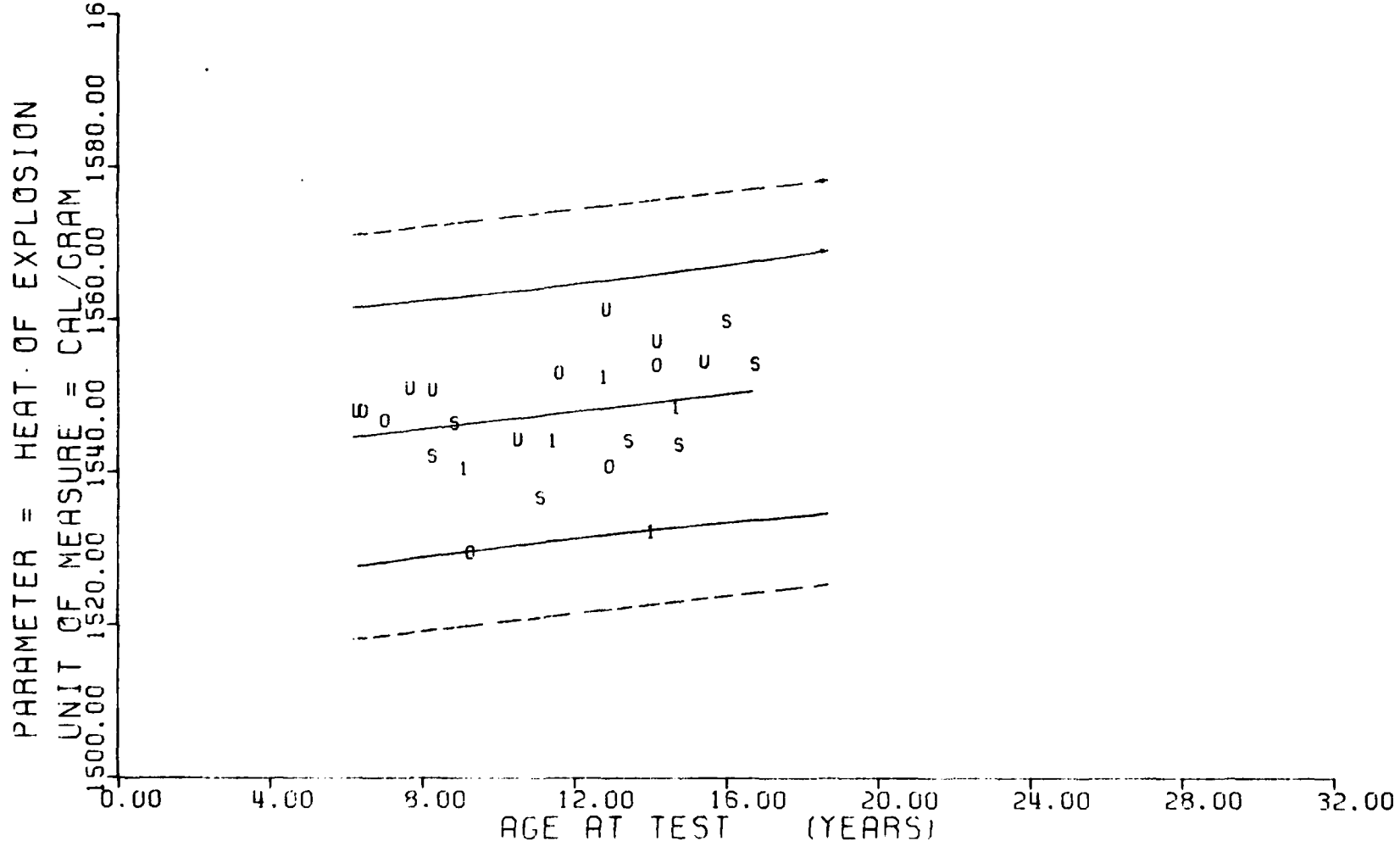
F = +3.0331898E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σ_Y = +8.9653095E+00

R = +2.1114917E-01 SIGNIFICANCE OF R = NOT SIGNIFICANT S_β = +2.7823715E-02

t = +1.7416055E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT S_ε = +8.8303280E+00

N = 67 DEGREES OF FREEDOM = 65

STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



STAGE I DISSECTED MOTORS, HEAT OF EXPLOSION

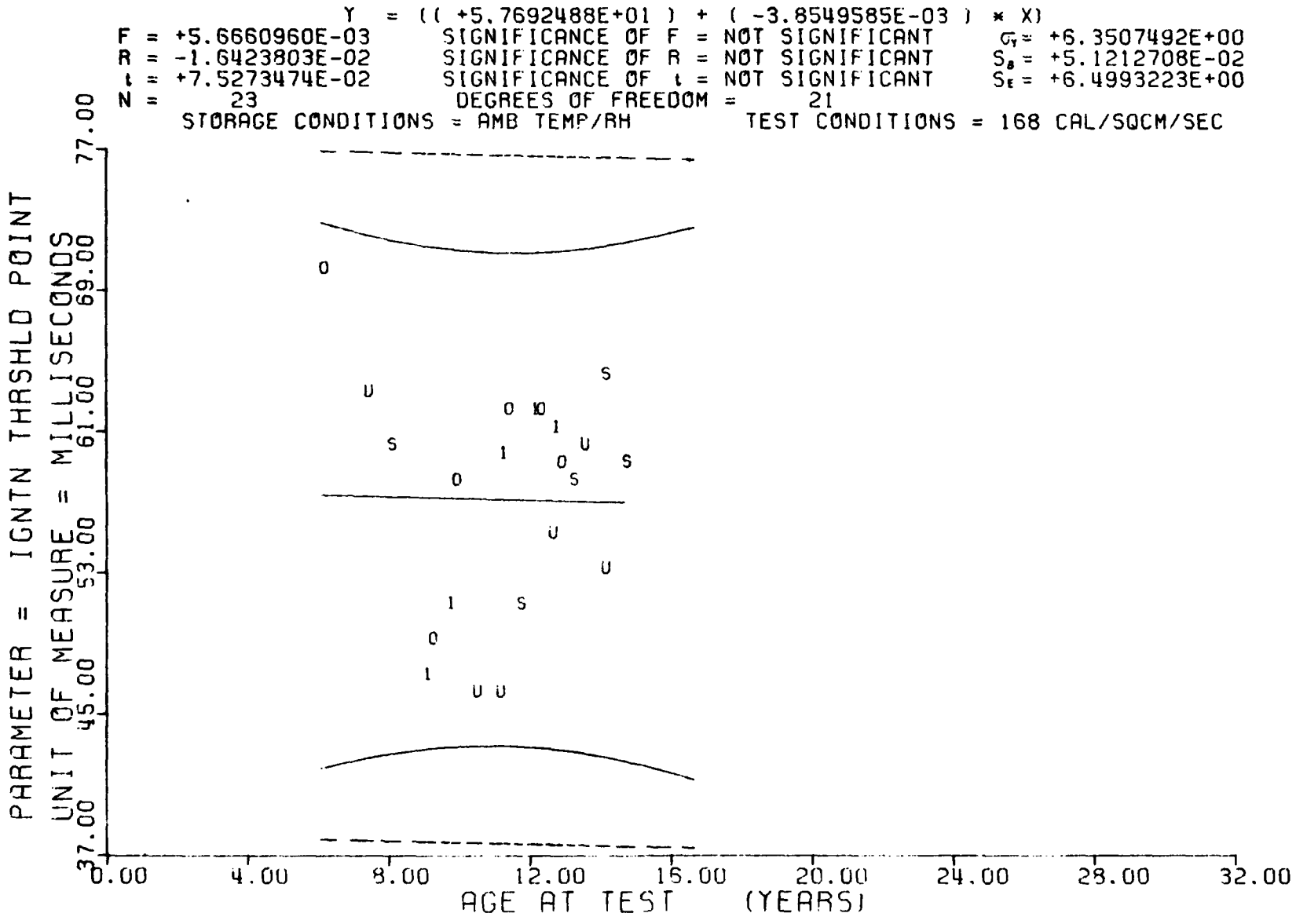
Figure 46

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
73.0	1
88.0	1
96.0	1
108.0	1
110.0	1
116.0	1
118.0	1
125.0	1
133.0	1
134.0	2
136.0	1
140.0	1
145.0	1
147.0	1
151.0	1
152.0	1
154.0	1
158.0	1
162.0	1
169.0	2
176.0	1

STAGE 1 DISSECTED MTRS, IGNITABILITY, IGNTN THRSHLD FCINT 168 (CAL/SQCM)/SEC

This sample size summary is applicable to figure 47



STAGE 1 DISSECTED MTRS, IGNITABILITY, IGNTN THRSHLD POINT 168 (CAL/SQCM)/SEC

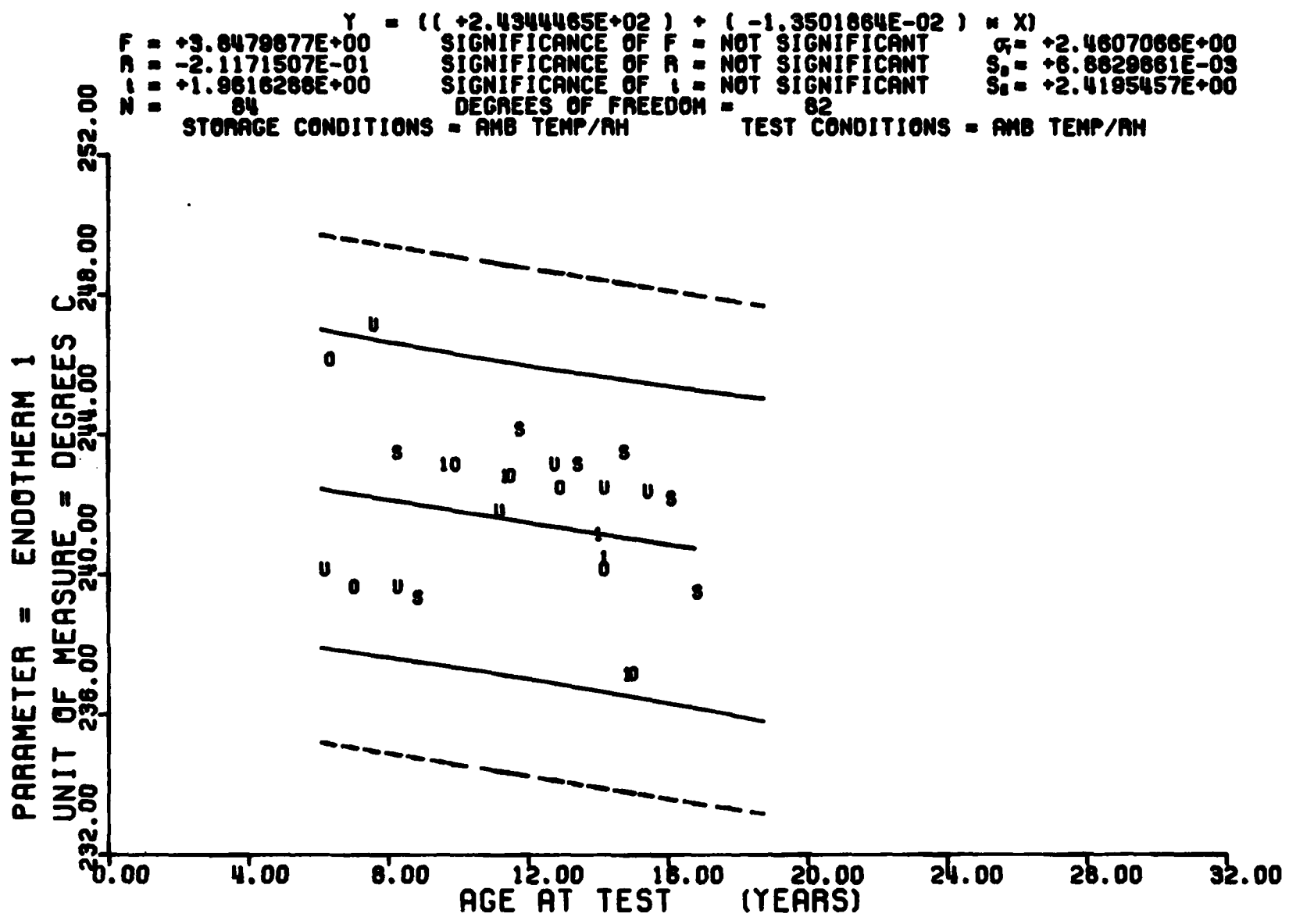
Figure 47

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NO. SAMPLES
73.0	4
75.0	3
83.0	2
90.0	3
98.0	5
105.0	5
114.0	3
118.0	3
133.0	3
135.0	3
137.0	3
143.0	3
152.0	3
154.0	3
160.0	3
167.0	3
169.0	5
176.0	3
177.0	3
179.0	3
184.0	5
192.0	3
201.0	3

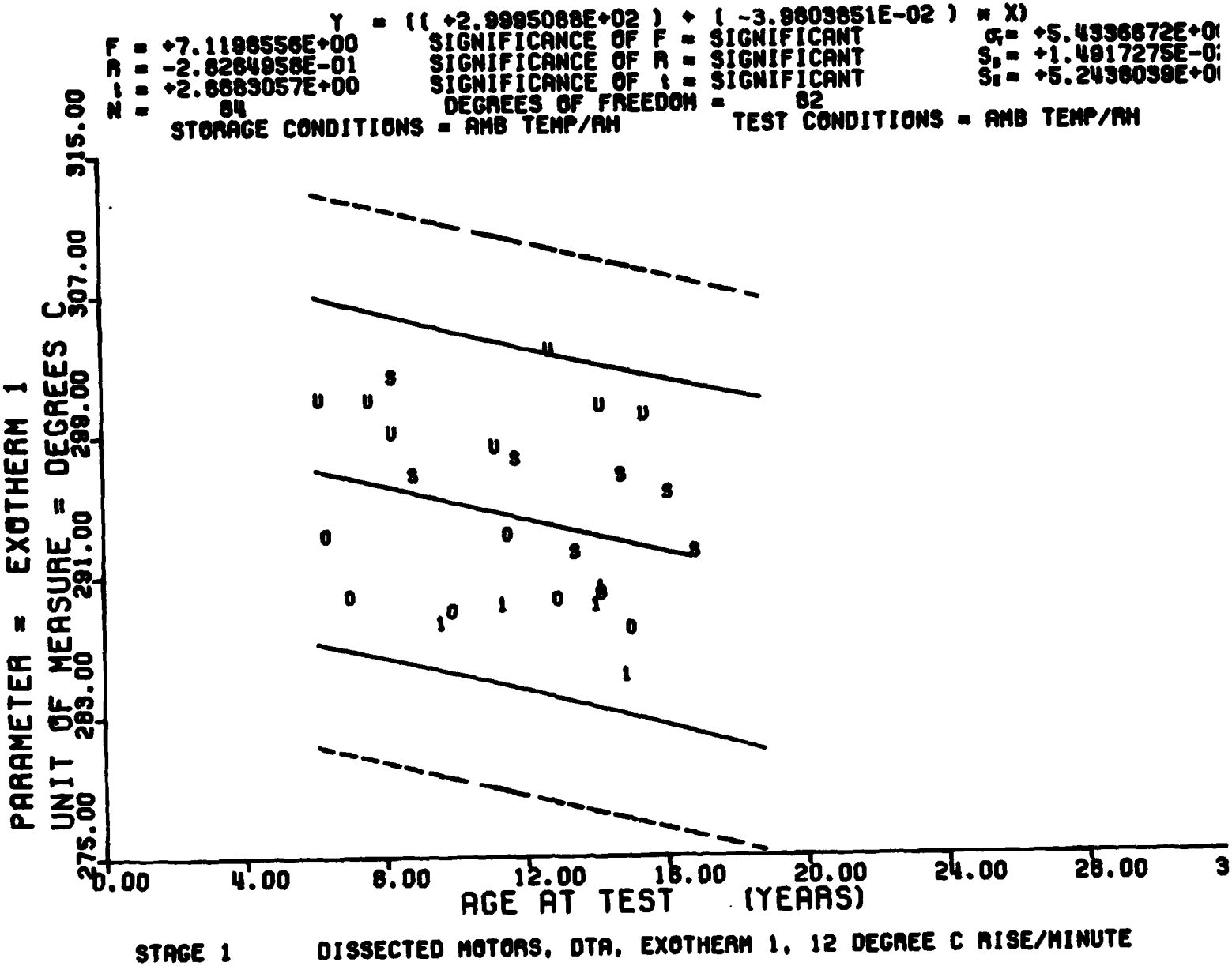
STAGE 1 DISSECTED MOTORS, DTA, ENDOTHERM 1, 1.2 DEGREE C RISE/MINUTE

This sample size summary is applicable to figures 48 and 49



STAGE 1 DISSECTED MOTORS, DTA, ENDOTHERM 1, 12 DEGREE C RISE/MINUTE

Figure 48



STAGE 1 DISSECTED MOTORS, DTA, EXOTHERM 1, 12 DEGREE C RISE/MINUTE

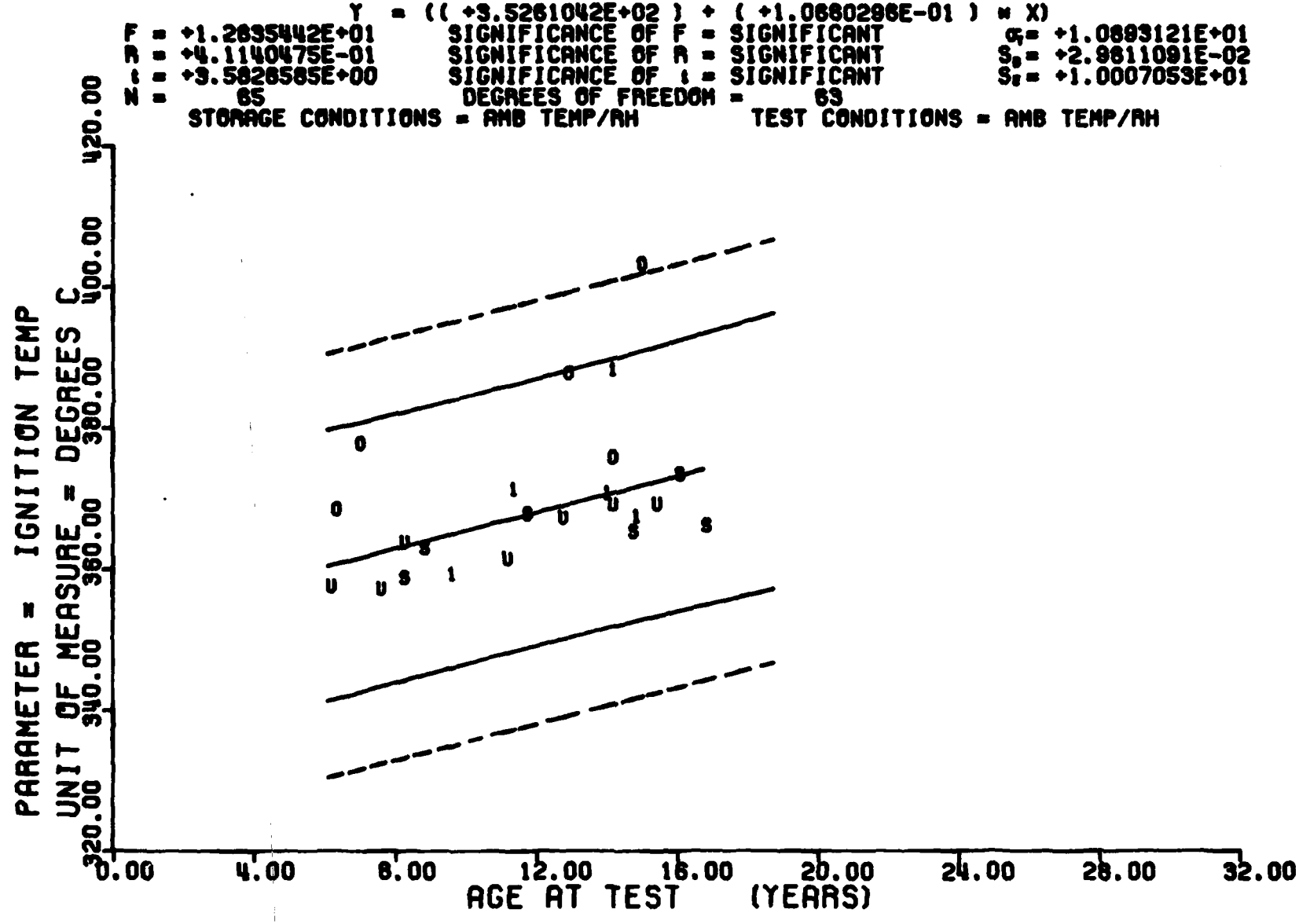
Figure 49

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
73.0	4
75.0	3
83.0	2
90.0	3
96.0	5
103.0	5
114.0	2
133.0	2
135.0	2
140.0	3
152.0	2
154.0	1
167.0	2
169.0	0
176.0	2
177.0	3
179.0	2
184.0	0
192.0	3
201.0	3

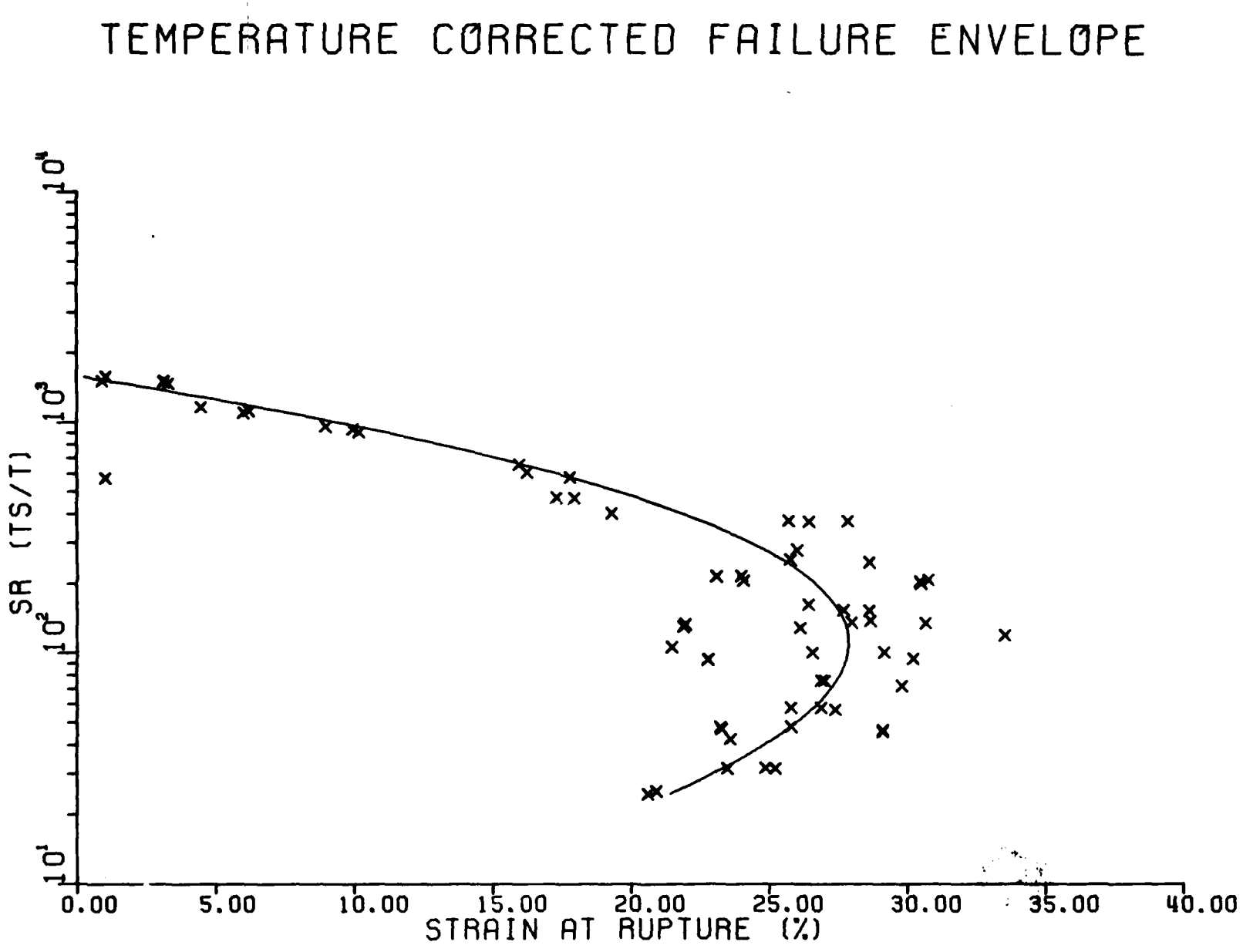
STAGE 1 DISSECTED MOTORS, DTA IGNITION TEMP, 12 DEG C RISE/MINUTE

This sample size summary is applicable to figure 50



STAGE 1 DISSECTED MOTORS, DTA IGNITION TEMP, 12 DEG C RISE/MINUTE

Figure 50



FAILURE ENVELOPE (MOTOR/SN STM-012) DISSECTED MOTOR, STAGE I, TP-H1011, 1979

Figure 51

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	NR COPIES
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Minuteman
Solid Propellant

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Testing was performed to determine the useful shelf/service life for LGM-30 Stage I Rocket Motors. A three year storage program for propellant and components was started in May 1961. This program was then extended to a ten year study and later continued indefinitely to assure that a deterioration in motor physical characteristics could be detected in time to take some corrective actions before the weapon system performance deteriorated below an acceptable level.

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This report covers only propellant data and limited case bond data. The malfunction of an environmental chamber destroyed component samples that had originally been part of this testing program (and the inadvertent burning of some motors during dissection reduced the material available for testing). Planned dissection of selected motors in the future will provide samples for continued component testing. Test specimens for this reporting period were obtained from motors STM-012, 0012099, and 012199. Up-7775 block propellant was not tested since the propellant has been used up.

Separate analyses were made on the respective motors and block propellant for the second time in this report and are shown in the regressions. The plotting symbols for each motor and block propellant are listed in the statistical analyses section.

The data from this test period was combined with data from previous testing and entered into the G085 computer for storage, analysis, and regression analysis. From the statistical analysis of all data tested to date, significant degradation of the propellant does not appear likely for at least two years past the oldest data point.

Future testing will be conducted on dissected motors.

END