

AD/A-002 757

PROPELLANT TEST RESULTS, LGM-30
STAGE III, DISSECTED MOTOR PROGRAM

Elizabeth M. Dalaba

Ogden Air Logistics Center
Hill Air Force Base, Utah

October 1974

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1. ORIGINATING ACTIVITY (Corporate author) Propellant Lab Section Directorate of Maintenance Hill AFB, Utah 84406		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	
		2b. GROUP	
3. REPORT TITLE Propellant Test Results, LGM-30 Stage III, Dissected Motor Program			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Test Results - Semi Annual			
5. AUTHOR(S) (First name middle initial, last name) Elizabeth M. Dalaba			
6. REPORT DATE October 1974		7a. TOTAL NO. OF PAGES	7b. NO. OF REFS 17
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 2MP 105P c. d.		9a. ORIGINATOR'S REPORT NUMBER(S) MANCP Report Nr 311(74) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
10. DISTRIBUTION STATEMENT APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Service Engineering Division Directorate of Materiel Management Hill AFB, Utah 84406	
13. ABSTRACT This report contains results of propellant testing of LGM-30 Stage III dissected motors. Testing was accomplished in accordance with General Test Directive 3 and MME 74NE102. Data from this test period and from previous test periods have been combined and included in regression analyses. Motors 0031064, 0031134, 0032434, 0033174 and Grain 131 have been combined in composite regressions. In general, data are in agreement with past data. Shore A hardness is an exception. There are some statistically significant trends which are not of immediate concern. KEY WORDS: Solid propellant Dissected Motors Physical/mechanical and combustion tests			

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LGM-30 3RD STAGE

DISSECTED MOTOR PROGRAM

PROPELLANT TEST RESULTS

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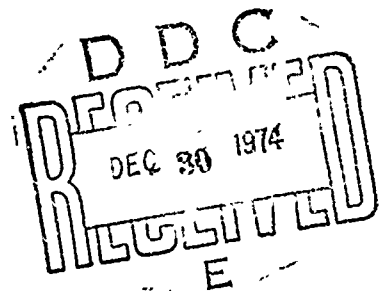
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This report contains results of propellant testing of LGM-30 Stage III dissected motors. Testing was accomplished in accordance with General Test Directive 3 and MME 74NE102.

Data from this test period and from previous test periods have been combined and included in regression analyses. Motors 0031064, 0031134, 0032434, 0033174 and Grain 131 have been combined in composite regressions. In general, data are in agreement with past data. Shore A hardness is an exception.

There are some statistically significant trends which are not of immediate concern.

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
Abstract	ii
List of Tables	iv
List of Figures	v
Related Documents	ix
Glossary of Abbreviations and Terms	x
I. Introduction	1-1
II. Summary of Test Results	2-1
III. Statistical Approach	3-1
IV. Low Rate Tensile	4-1
V. Very Low Rate Tensile	5-1
VI. Biaxial Tensile	6-1
VII. High Rate Triaxial Tensile	7-1
VIII. Stress Relaxation	8-1
IX. High Rate Testing	9-1
X. Hardness	10-1
XI. Thermal Analysis	11-1
XII. Case-Liner Bond	12-1
XIII. Dynamic Response	13-1
XIV. Distribution List	14-1
XV. DD 1473	15-1

LIST OF TABLES

<u>Number</u>		<u>Page</u>
1-1	Third Stage Propellant Program	1-2
1-2	Motor Cast Dates	1-4
2-1	Summary of Test Results	2-3
2-2	Coefficient of Variance at 10 years	2-5
3-1	Stage 3 Dissected Motors, Test Significance	3-2
3-2	Individual Sunflower Motors vs 13 Motor Composite and Individual RAD Motors vs 3 Motor Composite, Strain at Max Stress	3-3
5-1	Effect of Humidity on Test Data	5-22

LIST OF FIGURES

<u>Number</u>		<u>Page</u>
4-1	Tensile Strain at Max Stress, 2 in/min, 5 Motor Composite	4-3
4-2	Tensile Maximum Stress, 2 in/min, 5 Motor Composite	4-5
4-3	Tensile Strain at Rupture, 2 in/min, 5 Motor Composite	4-7
4-4	Tensile Stress at Rupture, 2 in/min, 5 Motor Composite	4-9
4-5	Tensile Modulus, 2 in/min, 5 Motor Composite	4-11
4-6	Tensile Strain at Max Stress, 2 in/min 0031064	4-13
4-7	Tensile Strain at Max Stress, 2 in/min 0031134	4-15
4-8	Tensile Strain at Max Stress, 2 in/min 0032434	4-17
4-9	Tensile Strain at Max Stress, 2 in/min 0033174	4-19
4-10	Tensile Strain at Max Stress, 2 in/min 00Gr131	4-21
4-11	Failure Envelope 0031064	4-22
4-12	Failure Envelope 0031134	4-23
4-13	Failure Envelope 0032434	4-24
4-14	Failure Envelope 0033174	4-25
4-15	Failure Envelope 00Gr131	4-26
5-1	Tensile Strain at Max Stress, .0002 in/min, 5 Motor Composite	5-3
5-2	Tensile Maximum Stress, .0002 in/min, 5 Motor Composite	5-5
5-3	Tensile Strain at Rupture, .0002 in/min, 5 Motor Composite	5-7

LIST OF FIGURES (cont)

<u>Number</u>		<u>Page</u>
5-4	Tensile Stress at Rupture, .0002 in/min, 5 Motor Composite	5-9
5-5	Tensile Modulus, .0002 in/min, 5 Motor Composite	5-11
5-6	Tensile Strain at Max Stress, .0002 in/min 0031064	5-13
5-7	Tensile Strain at Max Stress, .0002 in/min 0031134	5-15
5-8	Tensile Strain at Max Stress, .0002 in/min 0032434	5-17
5-9	Tensile Strain at Max Stress, .0002 in/min 0033174	5-19
5-10	Tensile Strain at Max Stress, .0002 in/min 00Gr131	5-21
6-1	Tensile Strain at Max Stress, .2 in/min, 5 Motor Composite	6-3
6-2	Tensile Maximum Stress, .2 in/min, 5 Motor Composite	6-5
6-3	Tensile Strain at Rupture, .2 in/min, 5 Motor Composite	6-7
6-4	Tensile Stress at Rupture, 0.2 in/min, 5 Motor Composite	6-9
6-5	Tensile Modulus, 0.2 in/min, 5 Motor Composite	6-11
6-6	Tensile Strain at Max Stress, 0.2 in/min, 0031064	6-13
6-7	Tensile Strain at Max Stress, 0.2 in/min, 0031134	6-15
6-8	Tensile Strain at Max Stress, 0.2 in/min, 0032434	6-17

LIST OF FIGURES (cont)

<u>Number</u>		<u>Page</u>
6-9	Tensile Strain at Max Stress, 0.2 in/min, 0033174	6-19
6-10	Tensile Strain at Max Stress, 0.2 in/min, 00Gr131	6-21
7-1	Strain at Max Stress, Triaxial Tensile, 5 Motor Composite	7-3
7-2	Maximum Stress, Triaxial Tensile, 5 Motor Composite	7-5
7-3	Strain at Rupture, Triaxial Tensile, 5 Motor Composite	7-7
7-4	Stress at Rupture, Triaxial Tensile, 5 Motor Composite	7-9
7-5	Modulus, Triaxial Tensile, 5 Motor Composite	7-11
7-6	High Rate Triaxial Strain at Max Stress, 0031064	7-13
7-7	High Rate Triaxial Strain at Max Stress, 0031134	7-15
7-8	High Rate Triaxial Strain at Max Stress, 0032434	7-17
7-9	High Rate Triaxial Strain at Max Stress, 0033174	7-19
7-10	High Rate Triaxial Strain at Max Stress, 00Gr131	7-21
8-1	Relaxation Modulus at 10 Sec, 5 Motor Composite	8-3
8-2	Relaxation Modulus at 50 Sec, 5 Motor Composite	8-5
8-3	Relaxation Modulus at 100 Sec, 5 Motor Composite	8-7
8-4	Relaxation Modulus at 1000 Sec, 5 Motor Composite	8-9

LIST OF FIGURES (cont)

<u>Number</u>		<u>Page</u>
8-5	Relaxation Modulus at 10 Sec, 0031064	8-11
8-6	Relaxation Modulus at 1000 Sec, 0031064	8-13
8-7	Relaxation Modulus at 10 Sec, 0031134	8-15
8-8	Relaxation Modulus at 1000 Sec, 0031134	8-17
8-9	Relaxation Modulus at 10 Sec, 0032434	8-19
8-10	Relaxation Modulus at 1000 Sec, 0032434	8-21
8-11	Relaxation Modulus at 10 Sec, 0033174	8-23
8-12	Relaxation Modulus at 1000 Sec, 0033174	8-25

RELATED DOCUMENTS

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March 1972

GLOSSARY OF ABBREVIATIONS AND TERMS

Aging Trend	A change in properties or performance resulting from aging of material or component
ATR	Attenuated Total Reflectance
Degradation	Gradual deterioration of properties or performance
DTA	Differential Thermal Analysis
E	Modulus (psi), defined as ratio of nominal stress to corresponding nominal strain
e_m	Strain at maximum stress (in/in)
e_r	Strain at rupture (in/in)
E(t)	Stress Relaxation Modulus
Failure Criterion	Defined as measureable performance parameter or material property limit which if exceeded will cause the motor to fail to perform within model specification requirements.
"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.
MANCP	Propellant Laboratory Section, Directorate of Maintenance, Ogden Air Logistics Center
MMEMP	Propulsion Engineering Section, Mechanical and Aero Engineering Branch, Directorate of Materiel Management, Ogden ALC
Regression Equation	The general form of the regression equation is $Y = a + bx$, where x = value of the independent variable in months.
Regression Line	Line representing mean test values with respect to time
SAMSO	Space and Missile Systems Organization, Air Force Systems Command

GLOSSARY OF ABBREVIATIONS AND TERMS (Cont)

S_b	Standard error of estimate of the regression coefficient
S_e or $S_{y.x}$	Standard deviation of the data about the regression line
S_m	Maximum stress (psi)
S_r	Stress at rupture (psi)
Standard Deviation (S_y)	Square root of variance
"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)
TCLE	Thermal Coefficient of Linear Expansion
TGA	Thermogravimetric Analysis
TRW	TRW Systems
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

SECTION I

INTRODUCTION

A. PURPOSE:

The purpose of testing was to determine the effects of aging on LGM-30 Stage III Dissected Motors in support of service life estimates by MEMEP. Secondary aging effects, if any, were to be determined. Work was performed in accordance with General Test Directive GTD-3C.

B. BACKGROUND

Testing of propellant from dissected grains (Grains 131, 216 and 336) was a part of the component program. In 1968 ten dissected motors were secured and a separate testing program was designed to complement the surveillance testing (ATP) of block propellant. Additional motors and Grain 70 were added to a revised program. In 1973 three motors 0031064, 031134 and 0032434 were further dissected by Hercules.

Current testing of dissected motors is limited to five motors per year. Motor numbers 0031064, 0031134 and 0032434 will be tested each year together with Grain 131. Grain 70 will be tested in even numbered years and motor number 0033174 will be tested in odd numbered years.

The test program is shown in Table 1-1. Motor cast dates and powder lot numbers for all motors are shown in Table 1-2.

TABLE 1-1

THIRD STAGE PROPELLANT PROGRAM

<u>Test</u>	<u>Configuration</u>	<u>Test Conditions</u>
Low Rate Tensile	1/4" JANNAF Dogbone	77°F, 2.0 in/min
Failure Envelope	1/4" JANNAF Dogbones	-30, -10, 20, 77, and 130°F .02, 0.2, 2, and 20 in/min
Very Low Rate Tensile	1/4" JANNAF Dogbone	77°F, 2×10^{-4} in/min 50% RH
Low Rate Biaxial	3/4" GL Rail, 3/16" thick	77°F, 0.2 in/min
High Rate Triaxial	3/4" GL Rail, 3/16" thick	77°F, 300 psi N ₂ 1000 in/in/min
High Rate Tensile	3/4" GL Dogbones 1/2" thick	77°F, 1000 in/in/min
High Rate Hydrostatic	3/4" GL Dogbones 1/2" thick	77°F, 1000 in/in/min 300 psi
Stress Relaxation	1/2" x 1/2" x 4" EB	77°F, 3%
Hardness	1/4" JANNAF Dogbone ends	Shore A & C 10 sec
DTA	.040" wafers	12°C rise/min
TGA	.040" wafers	9°C rise to ign 12°C rise to 140° hold for 50 min
Burning Rate	.156 x .156" x 5"	500 psig
Heat of Explosion	1/2" x 3/8" x 2"	77°F, N ₂ pressure
TCLE	0.200" wafer	5°C rise/min -100°C to + 80°C

TABLE 1-1 (Cont)

THIRD STAGE PROPELLANT PROGRAM

<u>Test</u>	<u>Configuration</u>	<u>Test Conditions</u>
Case Bond Tensile	1.128" dia milled from 1 1/2" block	CHS 0.1 in/min
Case Bond Peel	1 block 3" wide cut in 3 strips	CHS 5 in/min
ATR	.118 x .709 x 2.008"	

TABLE 1-2

MOTOR CAST DATES

<u>Motor Nr</u>	<u>Powder Lot</u>	<u>Cast Date</u>
Grain 79	SR-47-60	Jun 60
Grain 131	SR-69A-60	21 Jan 61
00 31036	SR-100-61	3 Oct 62
00 31057	SR-68-62	23 Oct 62
00 31064	SR-56-62	21 Oct 62
00 31097	SR-68-62	8 Dec 62
00 31134	SR-68-62	28 Jan 63
00 31136	SR-68-62	2 Feb 63
00 31158	SR-68-62	20 Feb 63
00 32248	SR-58-63	28 Aug 63
00 32107	SR-28-63	19 May 63
00 32116	SR-28-63	17 May 63
00 32133	SR-51-63	10 Jun 63
00 32137	SR-51-63	13 Jun 63
00 32140	SR-28-63	29 Apr 63
00 32434	RAD-1-1-63	21 Jan 64
00 32831	RAD-1-8-65	29 Jun 65
00 33174	RAD-1-10-66	20 Jan 67

SECTION II

SUMMARY AND EVALUATION OF TEST RESULTS

Test results are summarized by the significance of the "t" test in Table 2-1. Using the regression line, the coefficient of variation at 10 years has been determined for several tests, and this data is summarized in Table 2-2. Strain at maximum has been determined for individual motors.

There are noticeable discrepancies when the significance of the slope is examined particularly for uniaxial tensile at 2 in/min. Although the combined data shows a significant increase in strain, motors 0031064 and 0033174 show a significant decrease. Other tensile tests (very low rate biaxial and high rate triaxial) show an increase in strain for the composite regression. Decreases for individual motors are not significant.

Table 2-2 shows clearly the differences in the powder lots. Strain at maximum stress is higher for Sunflower lots than for Radford, and in general Gr 131 falls between the average of the other values.

Relaxation modulus shows a significant increase not only for the composite regression but for individual motors as well.

Shore A hardness composite regression shows a significant decrease. The shift in trend has resulted from the 1973 values

which are lower than for any previous test period. Shore C hardness shows a significant increase.

Storage shear modulus continues to show a decrease while loss tangent shows a significant increase.

Case bond tensile shows a significant increase in strength. Although the average peel strength of the composite shows a significant decrease only motor 0032434 shows this trend.

Despite some inconsistencies in the data in some tests, there does not appear to be any trend of immediate concern.

TABLE 2-1

SUMMARY OF TEST RESULTS

*Significance of "t" Test

Test/Parameter	5 Mtr	31064	31134	32434	33174	Gr 131
Low Rate Tensile (2 in/min)						
em	sig +	sig -	sig +	N/S -	sig -	sig +
Sm	sig +					
er	N/S +					
Sr	sig +					
E	sig +					
Very Low Rate Tensile (.0002 in/min)						
em	N/S +	sig +	N/S +	N/S -	N/S -	N/S -
Sm	sig -					
er	N/S -					
Sr	sig -					
E	sig +					
Biaxial Tensile (0.2 in/min)						
em	sig +	sig +	N/S +	sig +	N/S +	N/S -
Sm	N/S +					
er	sig +					
Sr	N/S +					
E	sig -					
High Rate Triaxial (1750 in/min, 300 psi)						
em	sig +	N/S +	N/S +	sig +	sig +	N/S +
Sm	N/S +					
er	sig +					
Sr	sig +					
E	N/S -					

TABLE 2-1 (cont)

Test/Parameter	5 Mtr	31064	31134	32434	33174	Gr 131
Relaxation Modulus (3% Strain)						
10 sec	sig +	sig +	sig +	sig +	sig +	
50 sec	sig +					
100 sec	sig +					
1000 sec	sig +	sig +	sig +	sig +	sig +	
Hardness						
Shore A	sig -					
Shore C	sig +					
Case Bonds						
Tensile	sig +	N/S +	sig +	sig +	sig -	sig +
Av Peel	sig -	N/S -	N/S +	sig -	N/S +	sig +
Dynamic Response						
Shear Modulus						
200 Hz	N/S -					
600 Hz	Sig -					
Loss Tangent						
200 Hz	sig +					
600 Hz	sig +					

* N/S = Not Significant
sig = Significant

TABLE 2-2

Coefficient of Variation at 10 Years

Parameter	Crosshead Rate	Figure Nr	N	$\bar{x}$ 10 yrs	Se	Se/ $\bar{x}$ x 100	Y Intercept
Uniaxial, em Sm er E	2 in/min	4-1 4-2 4-3 4-5	194 194 194 194	0.433 434. 0.487 1770.	0.030 42.9 0.03 209.0	6.9 9.9 6.2 15.2	0.389 334.4 0.483 1533.
0031064 0031134 0032434 0033174 00GR131		4-6 4-7 4-8 4-9 4-10	50 49 50 20 25	0.446 0.456 0.382 0.379 0.420	0.012 0.013 0.015 0.013 0.014	2.7 2.8 3.9 3.4 3.3	0.482 0.387 0.389 0.443 0.388
Uniaxial, em Sm er E	2×10^{-4} in/min	5-1 5-2 5-3 5-5	133 133 133 133	0.29 70.8 0.323 588.	0.047 8.8 0.043 94.5	16.2 12.4 13.3 16.1	0.264 82. 0.323 407.0
0031064 0031134 0032434 0033174 00GR131		5-6 5-7 5-8 5-9 5-10	31 31 31 15 25	0.318 0.307 0.248 0.254 0.278	0.054 0.050 0.024 0.040 0.025	17.0 16.1 9.7 15.7 9.0	0.159 0.250 0.278 0.365 0.310

TABLE 2-4 (cont)

Parameter	Crosshead Rate	Figure Nr	N	$\bar{x}$ 10 yrs	Se	Se/ $\bar{x}$ x 100	Y Intercept
Biaxial, em	0.2 in/min	6-1	62	0.288	0.022	7.8	0.234
Sm		6-2	62	284.	24.2	8.5	271.4
er		6-3	62	0.332	0.027	8.1	0.284
E		6-5	62	1396.	218.1	15.6	1785.8
0031064 em		6-6	17	0.292	0.009	3.0	0.262
0031134 em		6-7	17	0.286	0.019	6.6	0.281
0032424 em		6-8	17	0.243	0.010	4.1	0.196
0033174 em		6-9	4	0.328	0.017	5.2	0.174
00GR131 em		6-10	7	0.279	0.026	9.3	0.313
Triaxial, em	1750 in/min 300 psi	7-1	81	0.253	0.029	11.5	0.248
Sm		7-2	81	1516.	82.8	5.5	1458.2
er		7-3	81	0.296	0.025	8.4	0.266
E		7-5	81	8550.	1457.7	17.0	9251.
0031064 em		7-6	19	0.290	0.024	8.3	0.284
0031134 em		7-7	20	0.289	0.017	5.9	0.261
0032434 em		7-8	19	0.282	0.028	9.9	0.223
0033174 em		7-9	9	0.382	0.042	11.0	0.079

TABLE 2-2 (cont)

Parameter	Crosshead Rate	Figure Nr	N	$\bar{x}$ 10 yrs	Se	Se/ $\bar{x}$ x 100	Y Intercept
Relaxation ER	10 Sec	8-1	135	1244.	138.8	11.1	1095.
Modulus (3%)	1000 Sec	8-4	135	746.	77.1	10.3	616.
0031064 ER	10 Sec	8-5	34	1235.	86.2	7.0	889.
	1000 Sec	8-6	34	748.	37.1	5.0	454.
0031134 ER	10 Sec	8-7	34	1292.	81.0	6.3	1032.
	1000 Sec	8-8	34	739.	42.8	5.8	581.
0032434 ER	10 Sec	8-9	34	1590.	101.5	6.4	968.
	1000 Sec	8-10	34	898.	46.0	5.1	611.
0033174 ER	10 Sec	8-11	12	1104.	53.8	4.9	1180.
	1000 Sec	8-12	12	748.	40.8	5.5	563.

SECTION III

STATISTICAL APPROACH

Data from testing of motors 0031064, 0031134, 0032434, 0033174 and Grain 131 are used in composite regressions in this report. Although Sunflower and Radford powder lots are combined in these statistical analyses, covariance analysis indicates that the lots are dissimilar and technically should not be combined (See Tables 3-1 and 3-2). However, based on Service Engineerings' request composite regressions were made. These tables represent stored test data including 1973 testing where this was available (i.e. low rate tensile).

A linear trend analysis has been used throughout. Variation in some test data is very large. "Significant" in this report refers to the statistical significance of "t" or slope.

Motors have not been identified on the data plots since the composite regressions represent the average of test data for that age. The limits about regression change the scale of values so that it is difficult to make direct comparisons between motors and between parameters.

TABLE 3-1

STAGE 3 DISSECTED MOTORS

TEST	TEST PARAMETER	13 SINFLOWER MOTORS			3 RAD MOTORS			ANALYSIS OF COVARIANCE		
		SLOPE	F	t	SLOPE	F	t	SLOPE	B ₀	Total
TENSILE 2 in/min	SM	+	NS	NS	+	S	S	NS	NS	NS
	EM	-	S	S	-	S	S	NS	S	S
	ER	-	S	S	-	S	S	NS	S	S
	SR	+	S	S	+	S	S	NS	NS	NS
	E	+	S	S	+	S	S	NS	S	S
TENSILE 1750 in/min 300 psi	SM	+	S	S	+	NS	NS	NS	S	NS
	EM	-	NS	NS	+	NS	NS	NS	S	S
	ER	-	NS	NS	+	S	NS	NS	S	S
	SR	+	S	S	+	S	NS	NS	NS	NS
	E	-	S	NS	-	NS	NS	NS	NS	NS
STRESS RELAXATION 3%	E(t) 10 sec	+	S	S	+	S	S	NS	S	S
	E(t) 1000 sec	+	S	S	+	S	S	NS	S	S
CREEP 7 lb	1000 sec	-	S	NS	-	S	NS	NS	S	S
	10000 sec	+	S	S	-	S	S	S	S	S
HARDNESS Shore A	10 sec	-	S	NS	-	S	NS	NS	NS	NS

S = SIGNIFICANT DIFFERENCE

NS = NOT SIGNIFICANT

B₀ = INTERCEPT

TABLE 3-2

INDIVIDUAL SUNFLOWER MOTORS VS 13 MOTOR COMPOSITE AND
INDIVIDUAL RAD MOTORS VS 3 RAD MOTOR COMPOSITE
STRAIN AT MAX STRESS

n	Surflower vs	RAD vs	Individual Motor Statistics			Analysis of Covariance		
			Slope	F	t	Slope	Intercept	Total
45	0031034		-	S	S	NS	S	S
45	0031057		-	S	S	S	S	S
50	0031064		-	S	S	NS	S	S
45	0031097		-	S	S	NS	S	S
49	0031134		+	S	S	S	S	S
45	0031136		+	S	S	S	NS	S
45	0031158		-	S	S	NS	S	S
10	0032107		-	S	S	NS	NS	NS
10	0032116		-	S	S	S	NS	S
10	0032133		-	NS	NS	NS	S	S
10	0032137		-	NS	NS	NS	S	S
10	0032140		-	S	S	NS	NS	NS
45	0032248		-	S	S	S	S	S
50	0032434		-	NS	NS	NS	NS	NS
42	0032831		-	S	S	S	S	S
20	0033174		-	NS	S	NS	S	S

SECTION IV

LOW RATE TENSILE

The specimens used were modified JANNAP dogbones 1/4" thick in a Class B grip and tested in tension. The Instron crosshead speed was 2 in/min (strain rate 0.667 in/in min).

Regression analyses of the 5 motor composite (motors 31064, 31104, 32434, 33174 and Grain 131) are shown in Figures 4-1 thru 4-5. Only strain at rupture does not show a significant increase.

Individual motors do not show the same trend for strain at maximum stress. Motors 31064 (Figure 4-6) and 33174 (Figure 4-9) show a significant decrease; motors 31134 (Figure 4-7) and Grain 131 (Figure 4-10) show a significant increase; and motor 32434 (Figure 4-8) does not exhibit a significant change.

When these analyses are examined for the relationship between 1968 and 1973, it is evident that the data are quite dissimilar. In no instance did the 1973 data show equivalence with the 1968 data.

Failure envelopes were plotted by the computer (Figures 4-11 thru 4-15). All motors showed a point of coincidence at approximately 16% strain, but diverge on either side of the small area of agreement.

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.05)	105
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	19
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	5
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

4+2

TENSILE STRAIN AT MAX STRESS, 5 MOTOR COMPOSITE, STN RT 2.0

$Y = (+.38901152 \times 10^0) + (+.36653694 \times 10^{-03}) \times X$
 $F = +.18043795 \times 10^2$ SIGNIFICANCE OF F = SIGNIFICANT $\sigma^2 = +.31299948 \times 10^{-01}$
 $R = +.29313987 \times 10^0$ SIGNIFICANCE OF R = SIGNIFICANT $S_e = +.86274357 \times 10^{-04}$
 $t = +.42485039 \times 10^1$ SIGNIFICANCE OF t = SIGNIFICANT $S_f = +.30002756 \times 10^{-01}$
 $N = 194$ DEGREES OF FREEDOM = 192
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

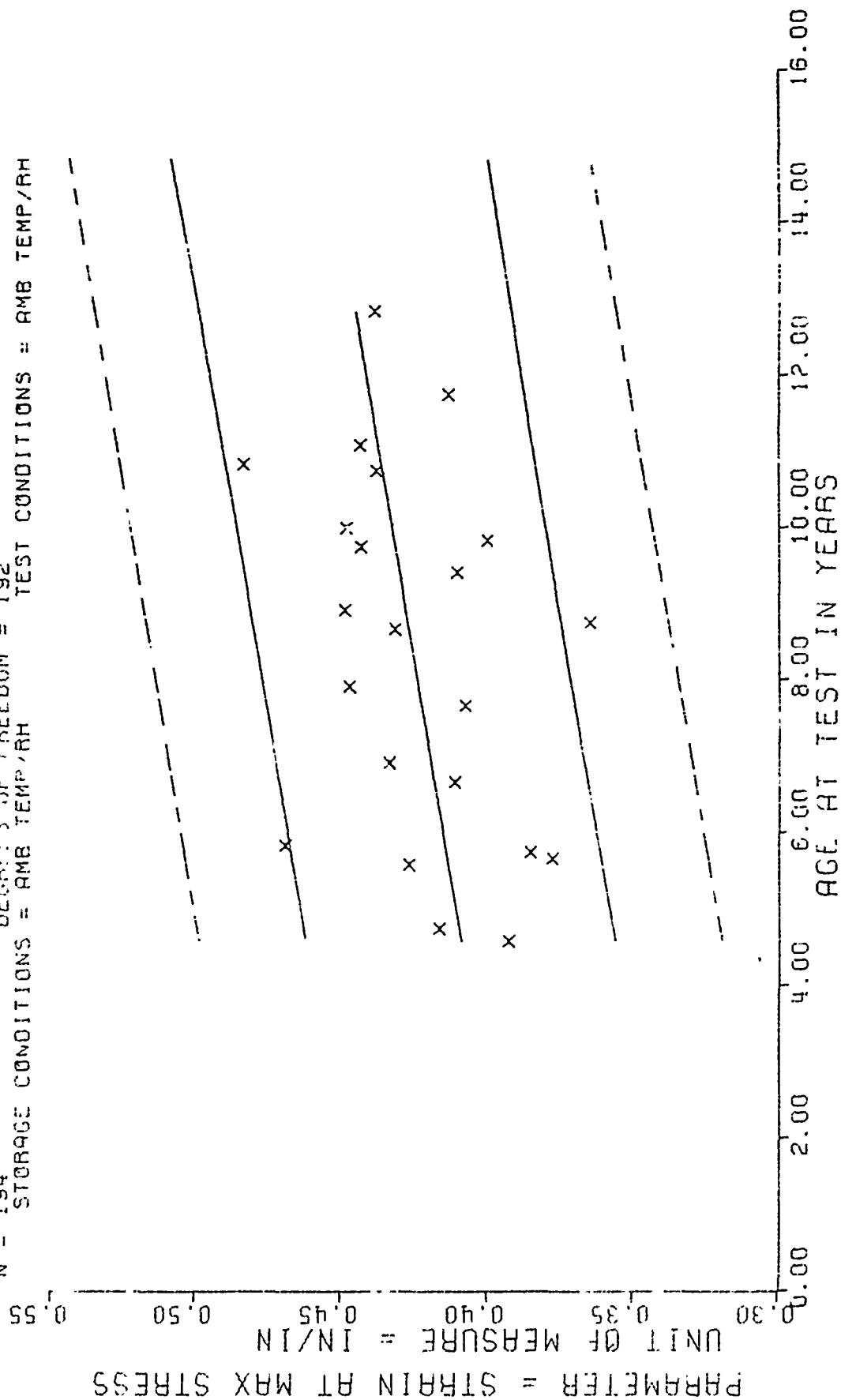


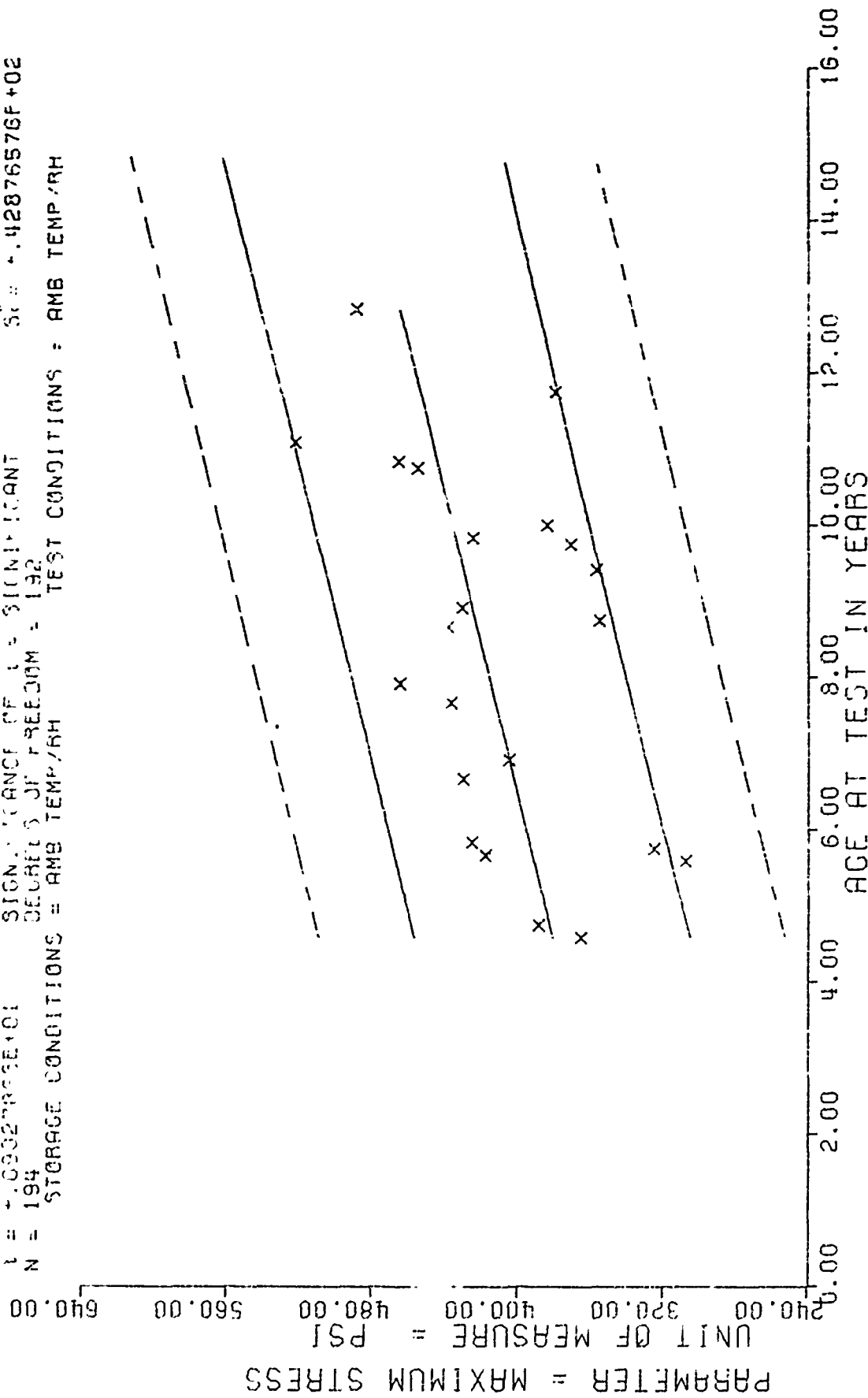
FIGURE 4-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.05	105
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	19
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	5
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

TENSILE MAXIMUM STRESS, 5 MOTOR COMPOSITE, STN RT 2.0

$Y = (+.39444755E+03) + (.35106969E+00) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF T = SIGNIFICANT
 DEGREE OF FREEDOM = 192
 N = 194
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH



TENSILE MAXIMUM STRESS, 5 MOTOR COMPOSITE, SIN RT 2.0

FIGURE 4-2

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.0S)	10S
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	10
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	5
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

TENSILE STRAIN AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 2.0

$F = +.12635000E+00$
 $R = +.25947500E-01$
 $S = +.00000000E+00$
 $N = 124$
 $Y = (+.43324364E+00) + (+.30624002E-04) X$
 SIGNIFICANCE OF F NOT SIGNIFICANT G = +.29892857E-01
 SIGNIFICANCE OF R NOT SIGNIFICANT S = +.86153552E-04
 SIGNIFICANCE OF S NOT SIGNIFICANT ST = +.29360745E-01
 DEGREE OF FREEDOM = 122
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH

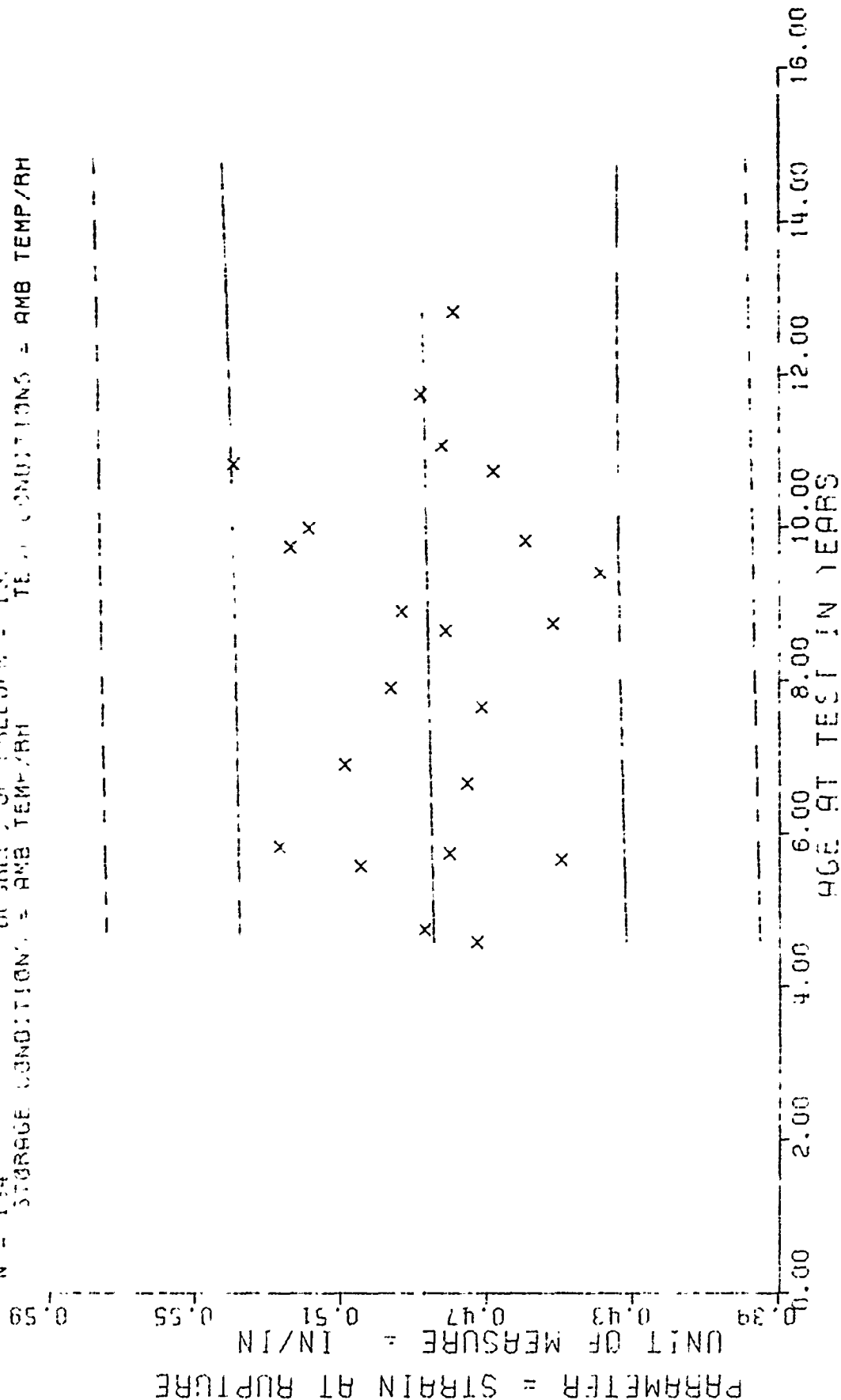


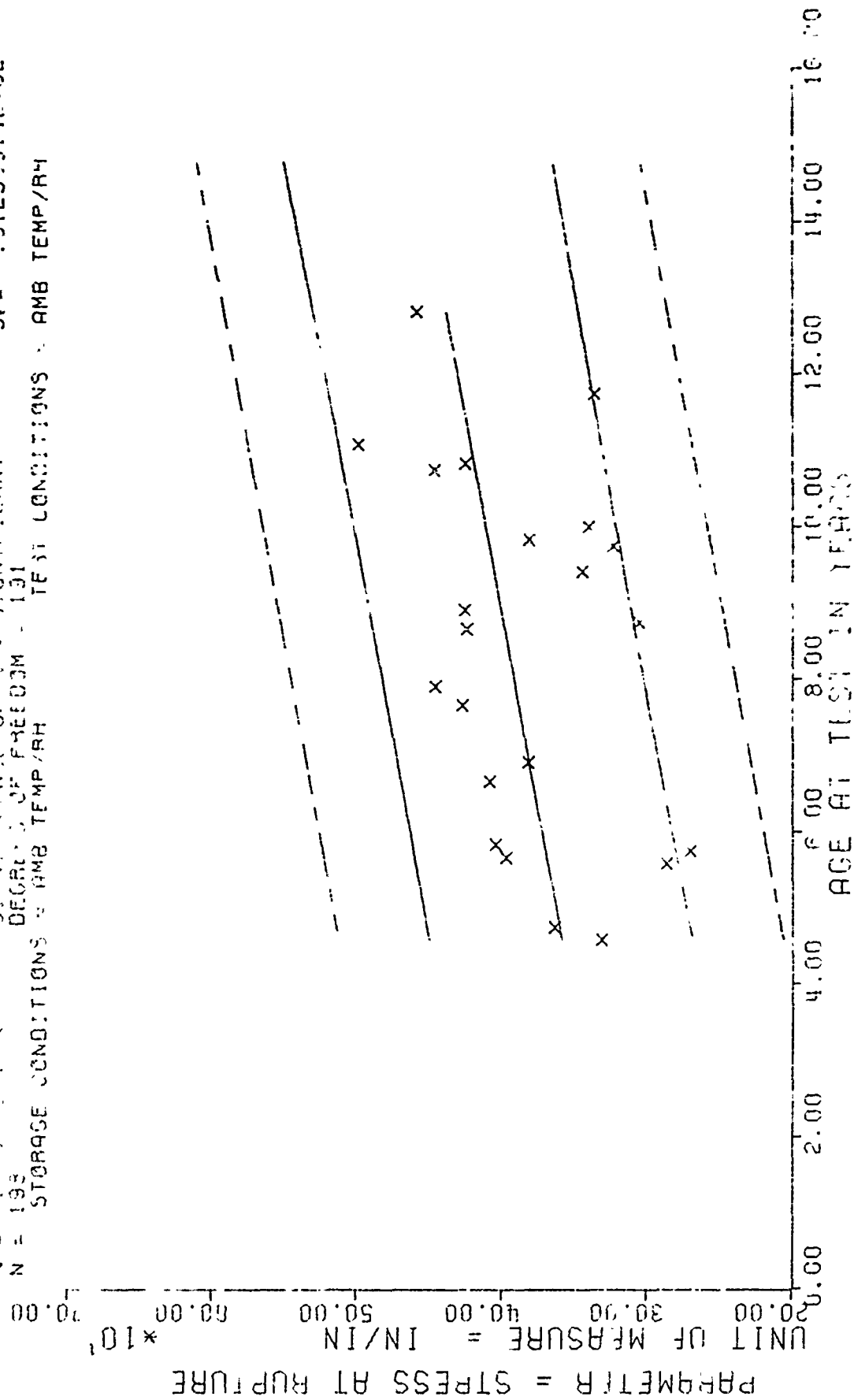
FIGURE 4-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.05	105
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	19
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	4
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

TENSILE STRESS AT RUPTURE, 5 MOTOR COMPOSITE, STN KT 2.0

$F = +.29806898E+02$
 $R = +.93741029E+00$
 $t = +.0053104E+00$
 $N = 193$
 $Y = (+.31410812E+02) + (+.80055310E+00) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREE OF FREEDOM = 191
 STORAGE CONDITIONS = AMB TEMP/RY
 TEST CONDITIONS = AMB TEMP/RY



TENSILE STRESS AT RUPTURE, 5 MATURA COMPOSITE, SIN AT 2.0

FIGURE 4-4

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.05	105
57.0	10
67.0	10
68.0	10
69.0	5
70.0	10
80.0	19
83.0	15
92.0	20
95.0	10
104.0	15
105.0	5
107.0	10
113.0	5
117.0	5
118.0	5
120.0	5
129.0	5
130.0	5
133.0	5
141.0	5
154.0	5

4-10

TENSILE MODULUS, 5 MOTOR COMPOSITE, STM RT 2.0

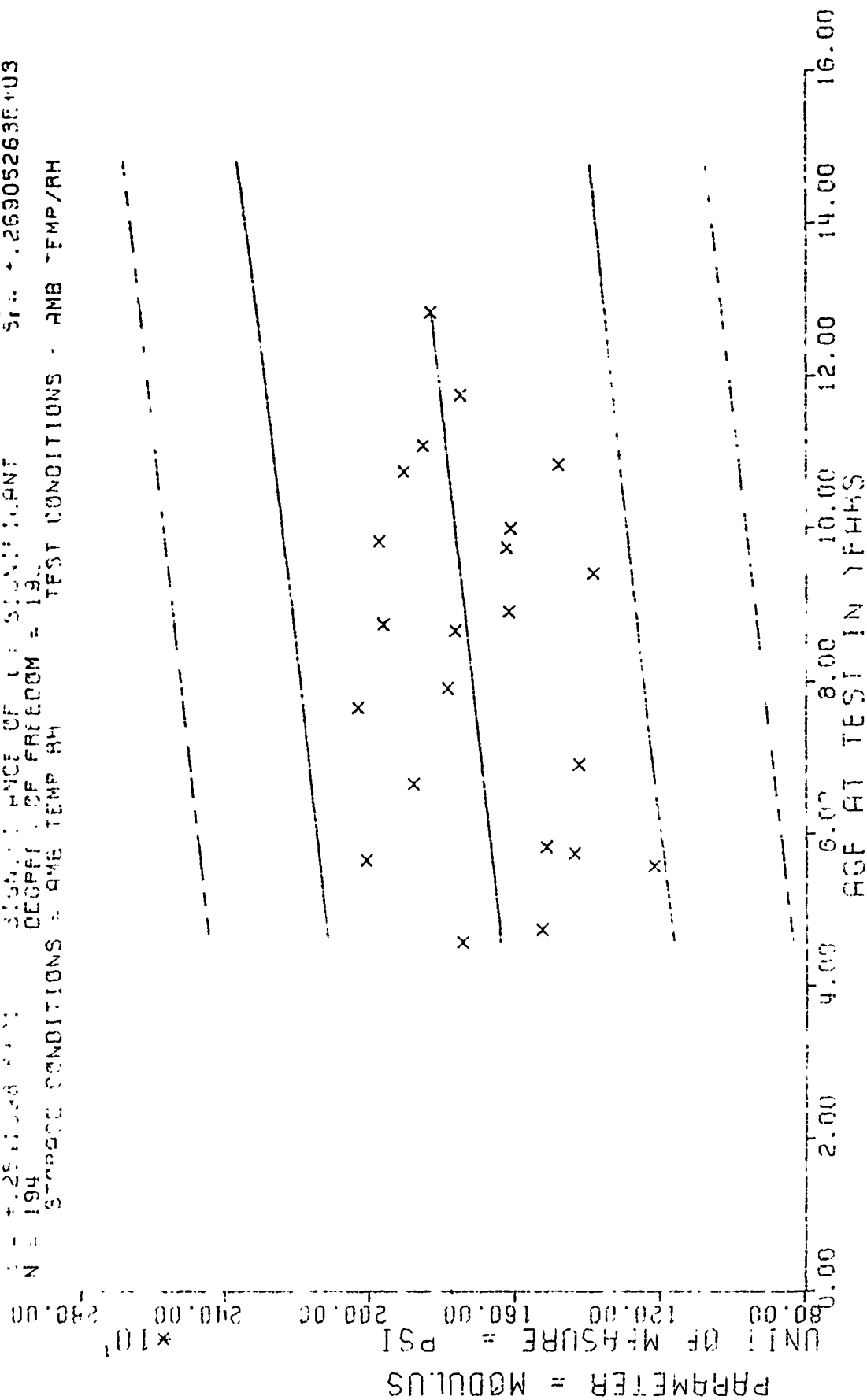


FIGURE 4-5

*** SAMPLE SIZE SUMMARY ***

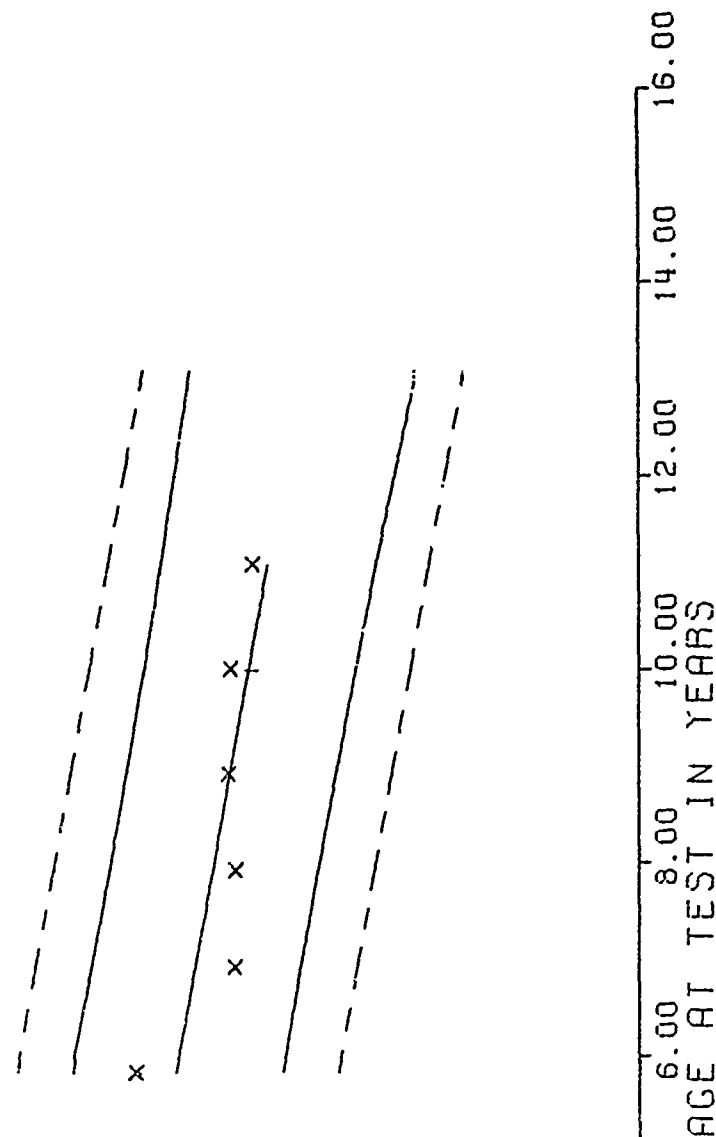
AGE	NO	(CENTIS) SAMPLES
10	10	10
15	10	10
20	10	10
25	5	5
30	5	5

TENSILE STRENGTH AT MAX STRESS, MOTOR & COBLOUT, STEP BY 2.0

PARAMETER = STRAIN AT MAX STRESS

UNIT OF MEASURE = IN/IN

$F = +.14414825E+02$
 $R = -.48057460E+00$
 $1 = +.37965881E+01$
 $N = 50$
 $Y = (+.48218756E+00) + (-.31638173E-03) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF 1 = SIGNIFICANT
 DEGREES OF FREEDOM = 48
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH



TENSILE STRAIN AT MAX STRESS, MOTOR # 0031064, STAN AT 2.0

FIGURE 4--6

*** SAMPLE SIZE SUMMARY ***

AGE	NO. SAMPLES
(17.75)	10
(17.75)	10
100.0	1
100.0	10
100.0	5
100.0	5

TENSILE STAIN AT MAX STRESS. MOTOR # 0031134. STAIN RT 2.0

$Y = (+.38577230E+00) + (+.58302223E-03) \times X$
 $F = +.41100654E+02$ SIGNIFICANCE OF F = SIGNIFICANT
 $R = +.68302217E+00$ SIGNIFICANCE OF R = SIGNIFICANT
 $t = +.64109722E-01$ SIGNIFICANCE OF t = SIGNIFICANT
 $N = 49$ DEGREES OF FREEDOM = 47
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

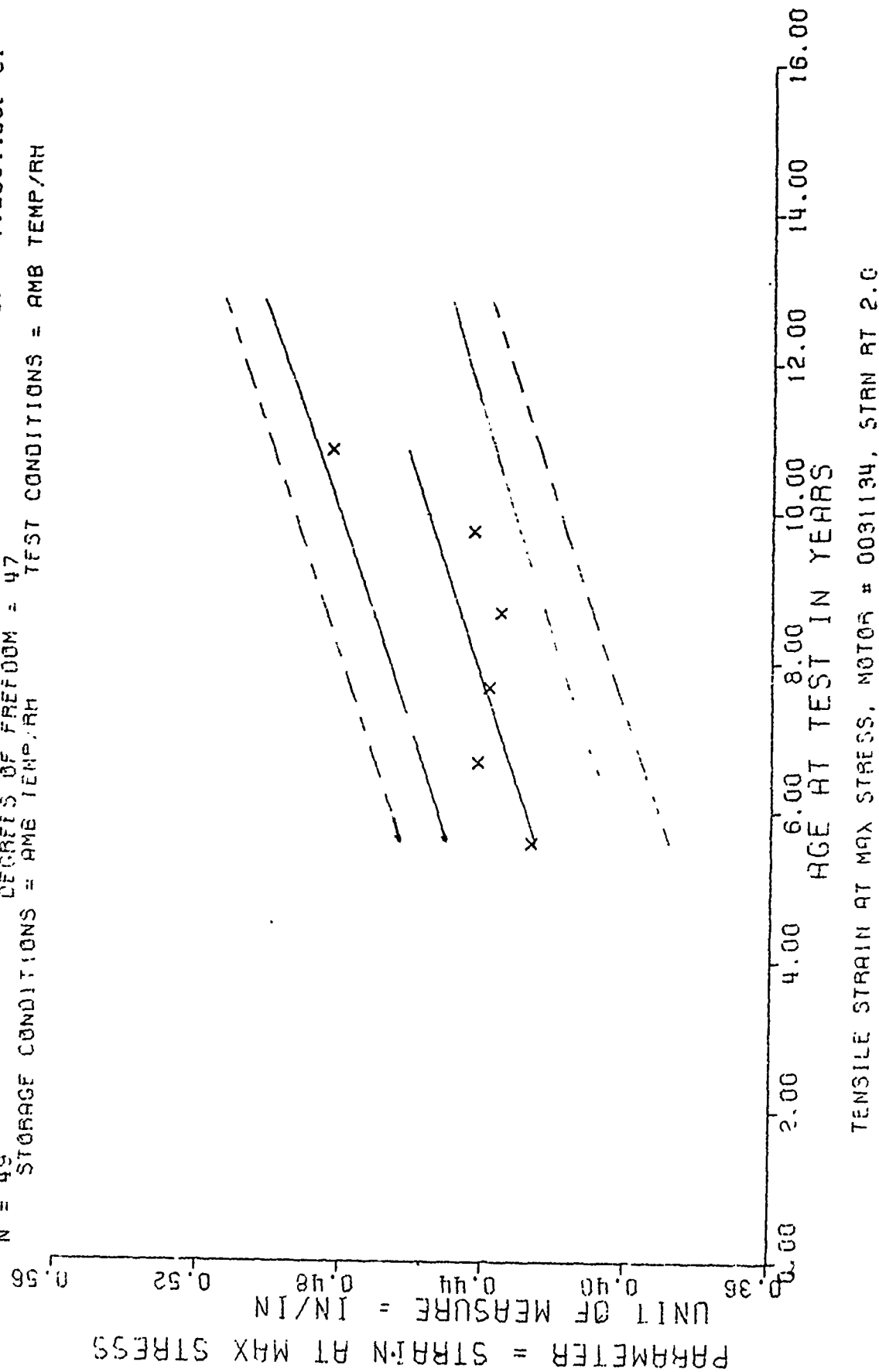


FIGURE 4-7

$Y = (+ 38222726E+00) + (.81024212E-04) \times X$
 $F = +.53920793E+00$ SIGNIFICANCE OF F = NOT SIGNIFICANT $G = +.15292535E-01$
 $R = -.10539785E+00$ SIGNIFICANCE OF R = NOT SIGNIFICANT $S = +.11034094E-03$
 $t = -.73430779E+00$ SIGNIFICANCE OF t = NOT SIGNIFICANT $St = +.15364351E-01$
 $N = 50$ DEGREES OF FREEDOM = 48
 STORAGE CONDITIONS = AMB TEMP., RH TEST CONDITIONS = AMB TEMP., RH

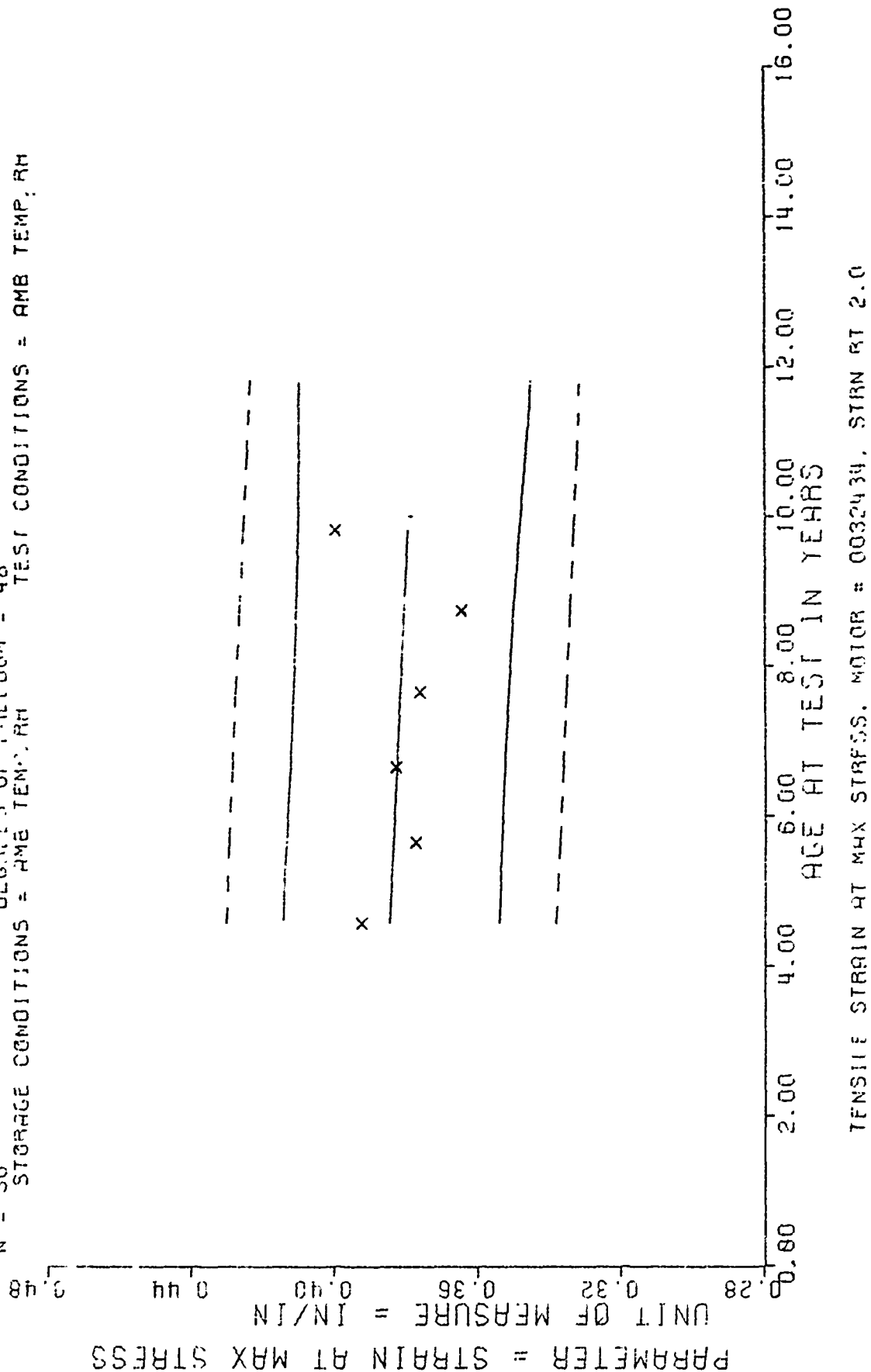


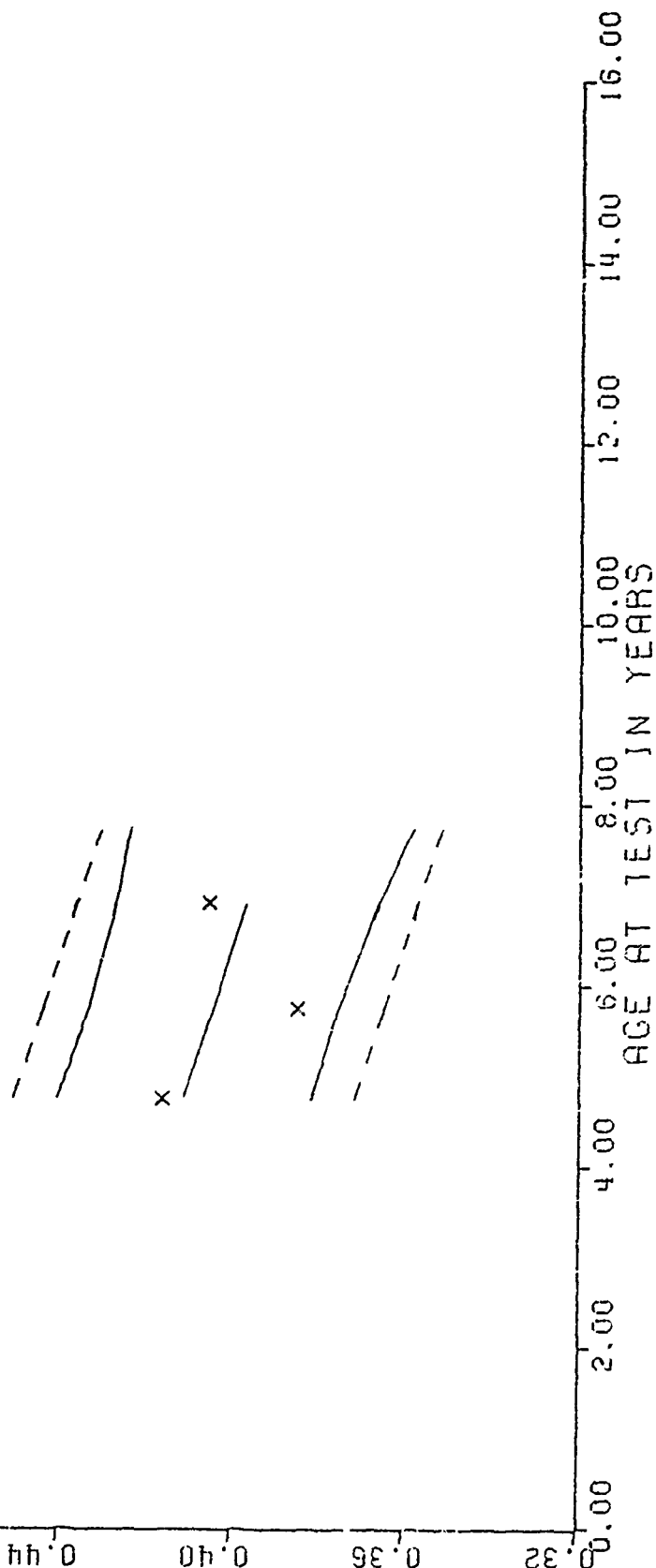
FIGURE 4-8

PARAMETER = STRAIN AT MAX STRESS

UNIT OF MEASURE = IN/IN

0.32 0.36 0.40 0.44 0.48 0.52

Y = (+.44308555F+00) + (-.55997821E-03) * X
 F = +.41004826E+01 SIGNIFICANCE OF F = NOT SIGNIFICANT $\sigma_f = +.14287921E-01$
 R = -.43074133E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT $S_R = +.27653725E-03$
 U = +.20249648E+01 SIGNIFICANCE OF U = SIGNIFICANT $S_U = +.13247837E-01$
 N = 20 DEGREES OF FREEDOM = 18
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TENSILE STRAIN AT MAX STRESS. MOTOR = 0033174, STRN AT 2.0

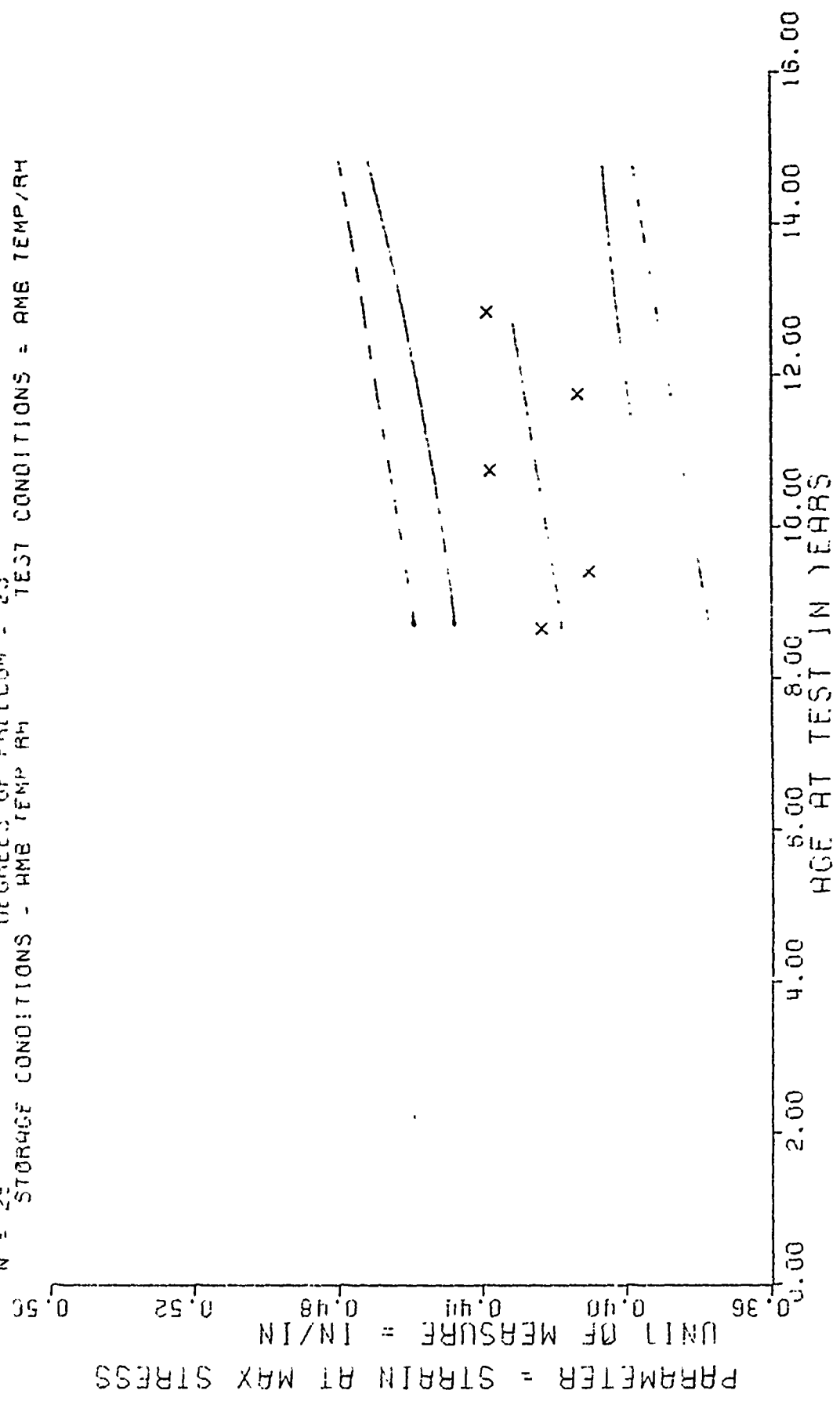
FIGURE 4-9

*** SAMPLE SITE SUMMARY ***

AGE (MONTHS)	NO. SAMPLES
104.05)	55
113.0	5
120.0	5
141.0	5
154.0	5

TENSILE STRENGTH AT MAX STRESS, MPa 1.31, STIFF 2.0

Y = (+.38795875E+00) + (+.28768520E-03) * X
 F = +.36215744E+01 SIGNIFICANCE OF F = NOT SIGNIFICANT G = +.14447260E-01
 R = +.36893475E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT S = +.1511711E-03
 t = +.19030434E+01 SIGNIFICANCE OF t = SIGNIFICANT St = +.13717477E-01
 N = 25 DEGREES OF FREEDOM = 23
 STORAGE CONDITIONS - AMB TEMP RH TEST CONDITIONS = AMB TEMP/RH



TENSILE STRAIN AT MAX STRESS. MOTOR = 000R131. STAN RT 2.0

FIGURE 4-13

TEMPERATURE OF THE AIR



TEMPERATURE OF THE AIR

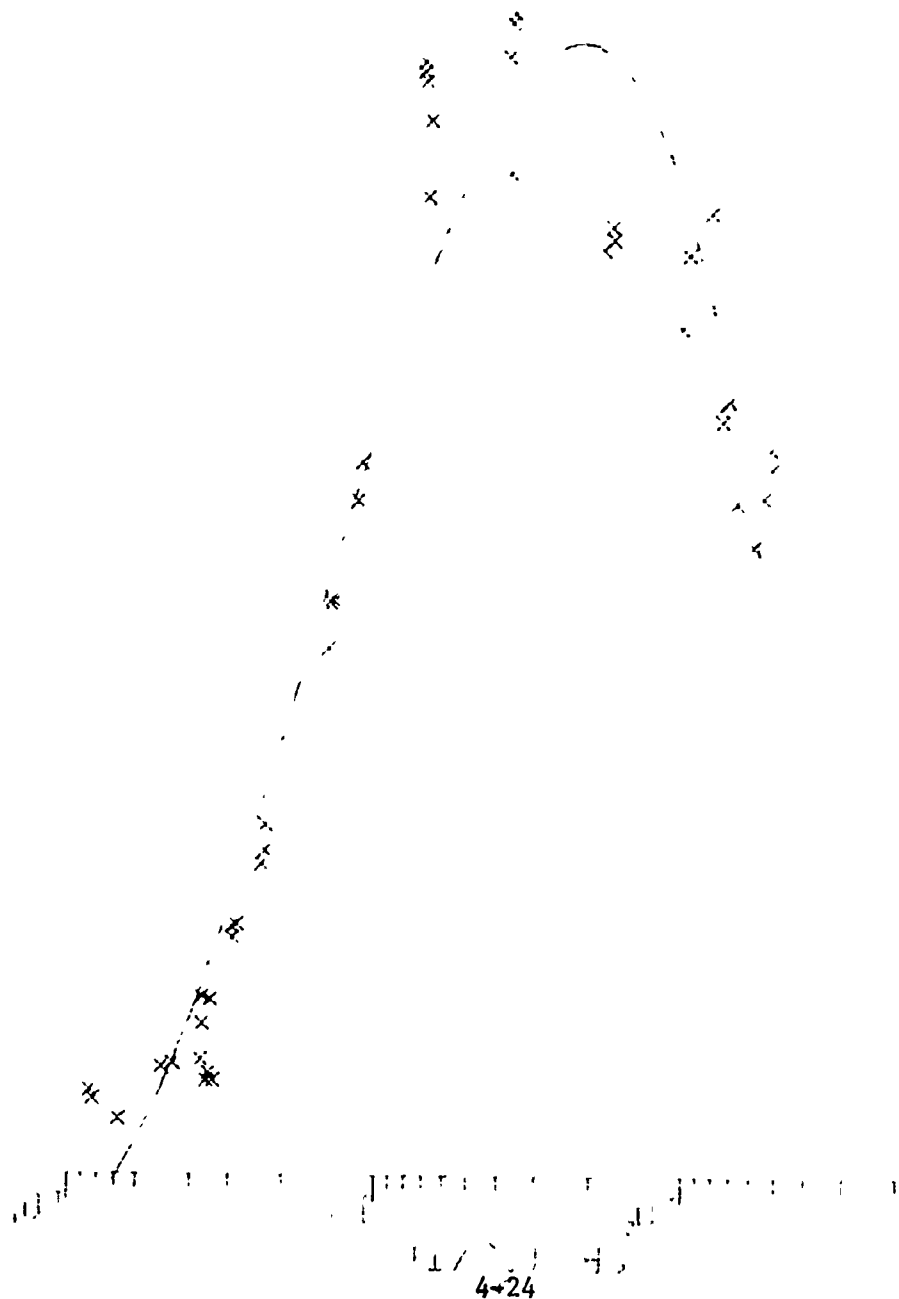
FIGURE 4-11

RECEIVED 10/10/50



FIGURE 4-12

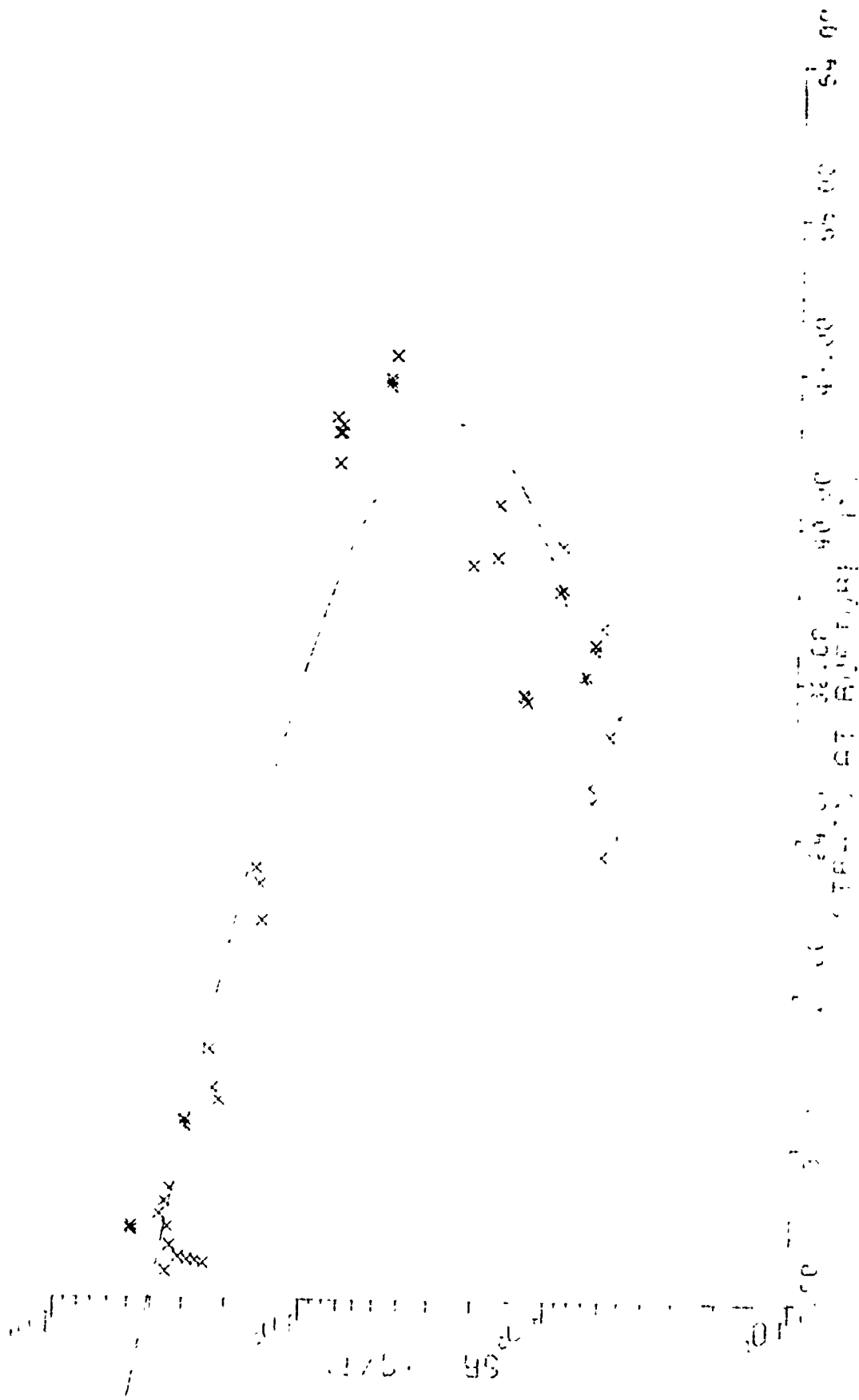
TEMPERATURE CORRECTED RAINFALL



[illegible]

...the fact that the

TEMPERATURE CORRECTED FAILURE ENVELOPE



STAGE III CUM PROPELLANT FAILURE ENVELOPE W/ 90% C.F.

FIGURE 4-15

SECTION V

VERY LOW RATE TENSILE

The specimens used were modified JANNAF dogbones 1/4" thick. Specimens were tested at a crosshead speed of 2×10^{-4} in/min (strain rate of $.167 \times 10^{-4}$ in/in/min) at a relative humidity of $50 \pm 5\%$. Equipment failure reduced the humidity which affected the data as shown in Table 5-1.

Regressions for the five motor composite are given in Figure 5-1 thru 5-5. Stresses show a significant decrease but modulus shows a significant increase. There is no significant change in strain.

There are differences between the data from low rate tensile and very low rate tensile data. Strain at maximum stress shows a significant increase at 2 in/min compared to an insignificant increase at 2×10^{-4} in/min. Maximum stress shows a significant increase at 2 in/min with no significant change at the lower rate. Both sets of data show a significant increase in modulus.

Motor 0C31064 shows a significant increase in strain at maximum stress (Figure 5-6). Other motors do not show a significant change (Figures 5-7 thru 5-10).

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(57.95)	115
67.0	6
68.0	5
70.0	6
83.0	5
84.0	10
86.0	5
93.0	5
96.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	5
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TENSILE STRAIN AT MAX STRESS, 5 MOTOR COMPOSITE, STN RT 0.0002

PARAMETER - STRAIN AT MAX STRESS

UNIT OF MEASURE - IN/IN

0.48

0.40

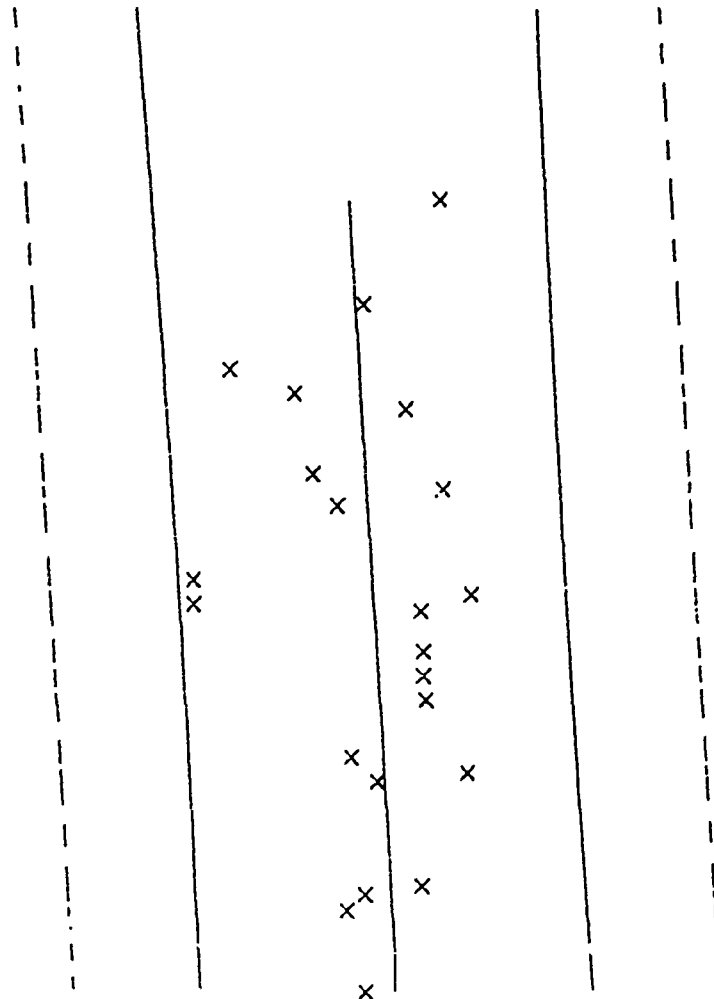
0.32

0.24

0.16

0.08

Y = (+.26361194E+00 , + (+.20274827E-03 , * X
SIGNIFICANCE OF F = NOT SIGNIFICANT G= +.47002943E-01
SIGNIFICANCE OF R = NOT SIGNIFICANT S= +.15865216E-03
SIGNIFICANCE OF T = NOT SIGNIFICANT SE = +.46899623E-01
DEGREES OF FREEDOM = 13
STORAGE CONDITIONS = PMB TEMP/RH TEST CONDITIONS = PMB TEMP/RH



TENSILE STRAIN AT MAX STRESS, 5 MOTOR COMPOSITE, STA AT 0.0002

FIGURE 5-1

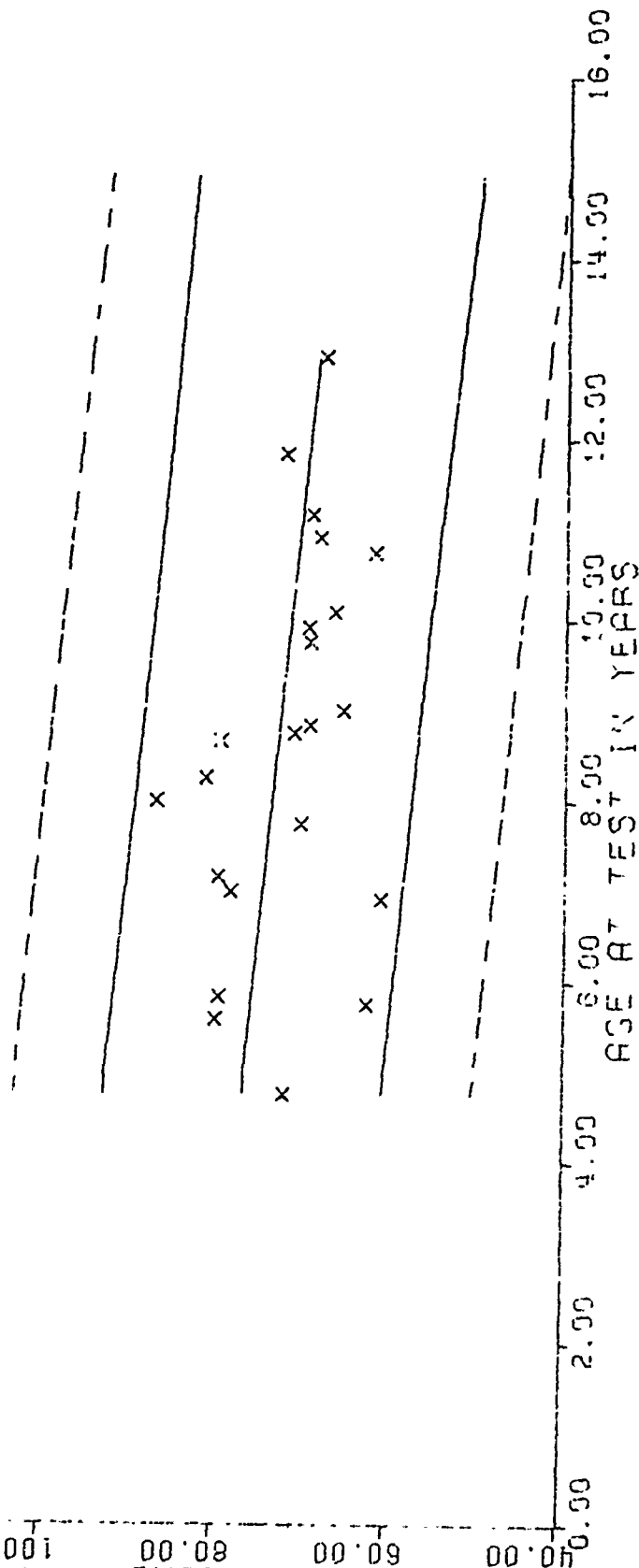
*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
57.0-58.9	115
67.0	6
68.0	5
70.0	6
83.0	5
84.0	10
86.0	5
93.0	5
98.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	5
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TENSILE MAXIMUM STRESS, 5 MOTOR COMPOSITE, STN RT 0.0002

$Y = (-.82018088E+02) + (-.86686975E-01) \times X$
 $F = +.84458631E+01$ SIGNIFICANCE OF F = SIGNIFICANT
 $R = -.24610430E+00$ SIGNIFICANCE OF R = SIGNIFICANT
 $t = +.29061767E+01$ SIGNIFICANCE OF t = SIGNIFICANT
 $N = 133$ DEGREES OF FREEDOM = 131
 STORAGE CONDITIONS = PMB TEMP/RH TEST CONDITIONS = PMB TEMP/RH

PARAMETER = MAXIMUM STRESS
 UNIT OF MEASURE = PSI



*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	Nr SAMPLES
(57.55)	115
67.0	6
69.0	5
70.0	6
83.0	5
84.0	10
86.0	5
93.0	5
96.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	5
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TEXTILE STAIN AT CAPTURE, 5 MOTOR COMPOSITE, SIN RT 0.0002

PARAMETER - STRAIN AT RUPTURE

UNIT OF MEASURE - IN/IN

Y = { +.32300776E+00 , + { -.12418462E-04 , * X
SIGNIFICANCE OF F = NOT SIGNIFICANT
SIGNIFICANCE OF R = NOT SIGNIFICANT
SIGNIFICANCE OF t = NOT SIGNIFICANT
DEGREES OF FREEDOM = 131
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

F = +.71541555E-02
R = -.73897829E-02
t = -.84582241E-01
N = 133

G = +.43230395E-01
S = +.14682116E-03
St = +.43393838E-01

0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00
AGE AT TEST IN YEARS

TENSILE STRAIN AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.0002

FIGURE 5-3

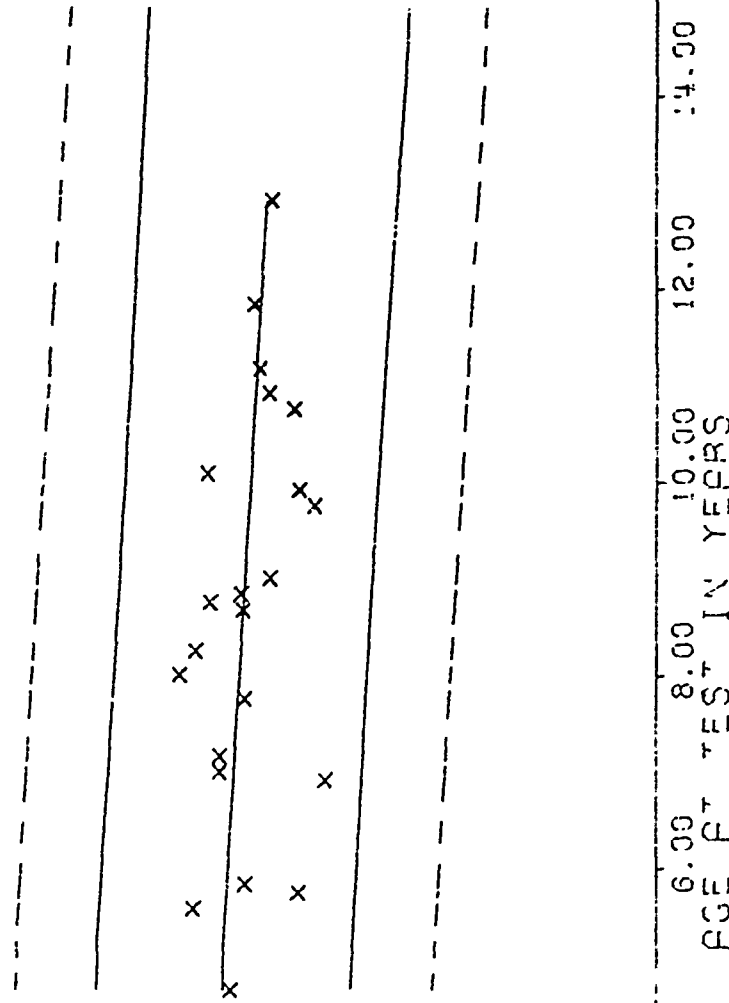
*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
57.0	115
67.0	6
69.0	5
70.0	6
83.0	5
84.0	10
88.0	5
93.0	5
96.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	5
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TENSILE STRESS AT RUPTURE, 5 MOTOR COMPOSITE, SIN AT 0.0002

$F = +.36667930E+01$
 $R = -.1650101E+00$
 $A = +.15148872E+01$
 $N = 133$
 $Y = (+.69682667E+02) + (-.48890085E-01) \times X$
 SIGNIFICANCE OF F = NOT SIGNIFICANT $G = +.76218588E+01$
 SIGNIFICANCE OF R = NOT SIGNIFICANT $S = +.25531574E-01$
 SIGNIFICANCE OF A = NOT SIGNIFICANT $St = +.75460140E+01$
 DEGREES OF FREEDOM = 131
 STORAGE CONDITIONS = 9MB TEMP/RH
 TEST CONDITIONS = 9MB TEMP/RH

PARAMETER = STRESS AT RUPTURE
 UNIT OF MEASURE = IN/IN
 20.00
 40.00
 60.00
 80.00
 100.00
 120.00



TENSILE STRESS AT RUPTURE, 5 MOTOR COMPOSITE, SYN AT 0.0002

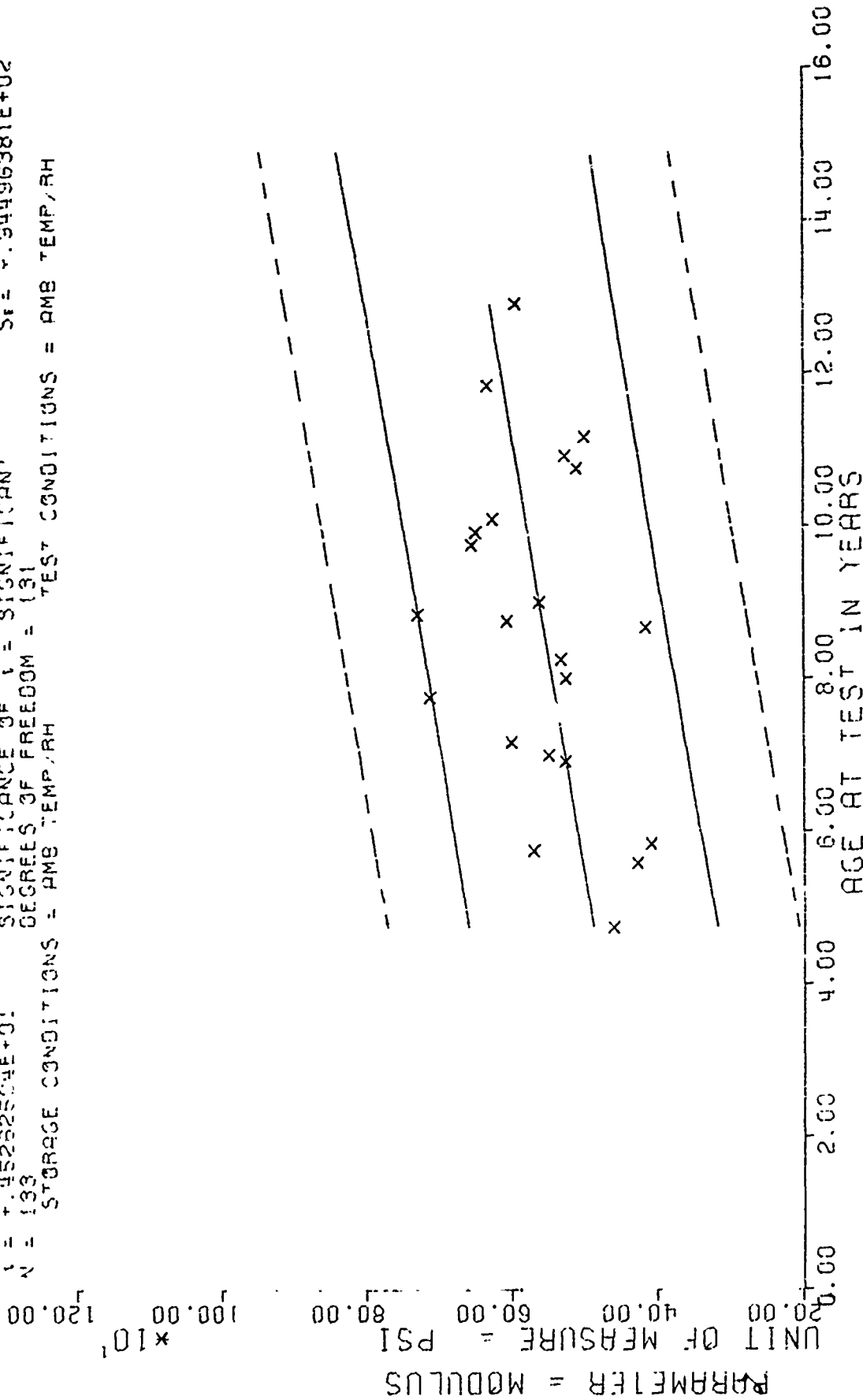
FIGURE 5-4

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
57.05	115
67.0	6
69.0	5
70.0	6
83.0	5
84.0	10
86.0	5
93.0	5
96.0	10
99.0	10
104.0	5
105.0	5
106.0	5
108.0	5
117.0	5
119.0	5
121.0	5
129.0	5
131.0	5
134.0	5
142.0	5
155.0	5

TENSILE MODULUS, 5 MOTOR COMPOSITE, SIN RT 0.0002

$F = +.23486943E+02$
 $R = +.36774856E+03$
 $V = +.45262504E+01$
 $N = 133$
 $Y = (+.40747895E+03) + (+.14471506E+01) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF V = SIGNIFICANT
 DEGREES OF FREEDOM = 131
 STORAGE CONDITIONS = PMB TEMP/RH
 TEST CONDITIONS = PMB TEMP/RH



TENSILE MODULUS, 5 MOTOR COMPOSITE, STN RT 0.0002

FIGURE 5-5

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
70.0SJ	65
99.0	10
106.0	5
121.0	5
134.0	5

IFNSILE STRAIN AT MAX STRESS, MOTOR # -0031064, STEN RT -0002

$Y = (+.15583737E+00) + (+.13898732E-02) \times X$
 F = +.87322524E+01 SIGNIFICANCE OF F = SIGNIFICANT $G_1 = +.60628261E-01$
 R = +.48105933E+00 SIGNIFICANCE OF R = SIGNIFICANT $S_1 = +.47034016E-03$
 t = +.29550384E+01 SIGNIFICANCE OF t = SIGNIFICANT $S_F = +.54060415E-01$
 N = 31 DEGREES OF FREEDOM = 29
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

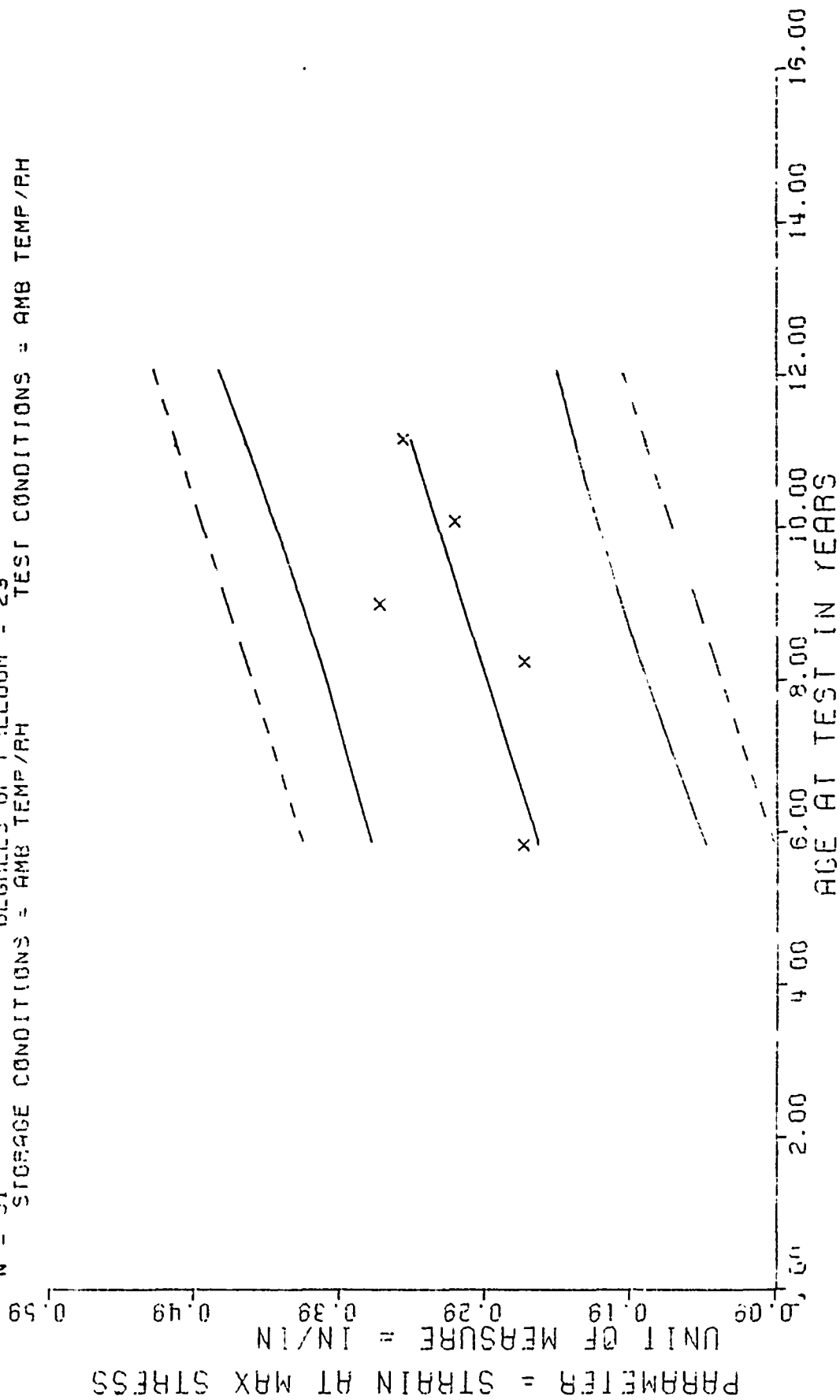


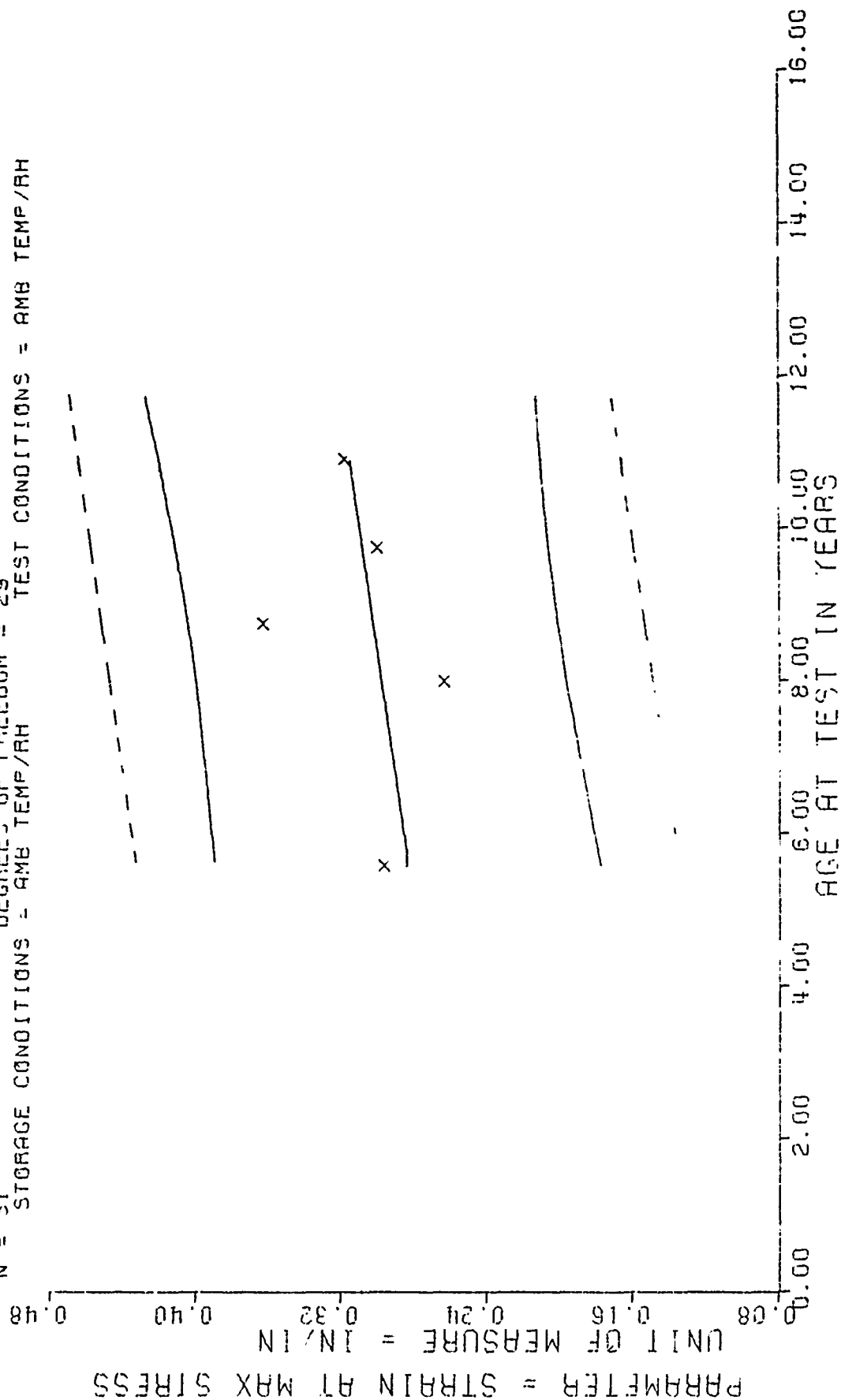
FIGURE 5-6

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
67.05	65
96.7	10
105.0	5
117.0	5
131.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR # 0031134, STRN RT .0002

$F = +.13243522E+01$
 $R = +.20898060E+00$
 $t = +.11509050E-01$
 $N = 31$
 $Y = (+.24973085E+00) + (+.50260428E-03) * X$
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF t = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 29
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH



TENSILE STRAIN AT MAX STRESS, MOTOR # 0031134 STAN AT .0002

FIGURE 5-7

*** SAMPLE SIZE SUMMARY ***

AGE (CENTHS)	NR SAMPLES
57.05	65
34.0	10
93.0	5
106.0	5
119.0	5

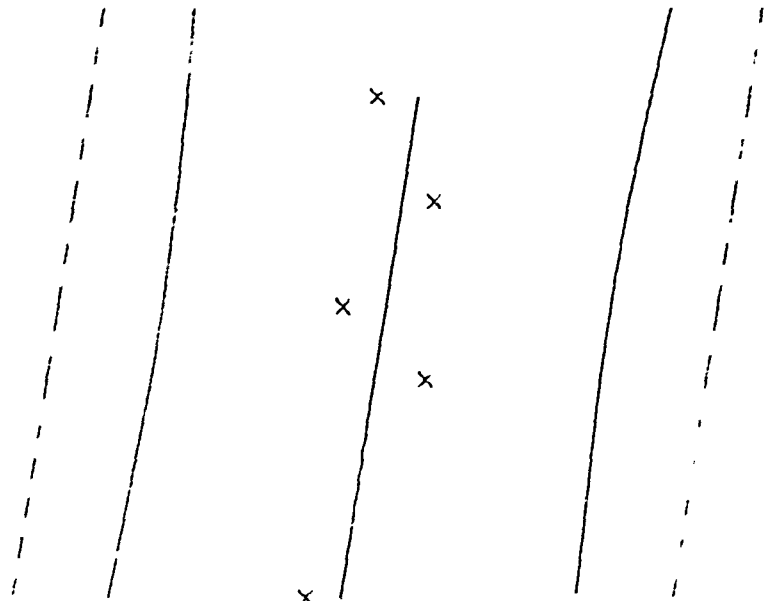
TENSILE STRAIN AT MAX STRESS, MOTOR # 0032434, STRN RT 0002

PARAMETER = STRAIN AT MAX STRESS

UNIT OF MEASURE = IN/IN

0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0.00

F = +.15993925E+01
R = -.22862364E+00
I = +.12646709E+01
N = SI
Y = (+.27751362E+00) + (-.27089548E-03) * Y
SIGNIFICANCE OF F = NOT SIGNIFICANT
SIGNIFICANCE OF R = NOT SIGNIFICANT
SIGNIFICANCE OF I = NOT SIGNIFICANT
DEGREES OF FREEDOM = 29
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH



AGE AT TEST IN YEARS

TENSILE STRAIN AT MAX STRESS, MOTOR # 0032434, STRN AT .0002

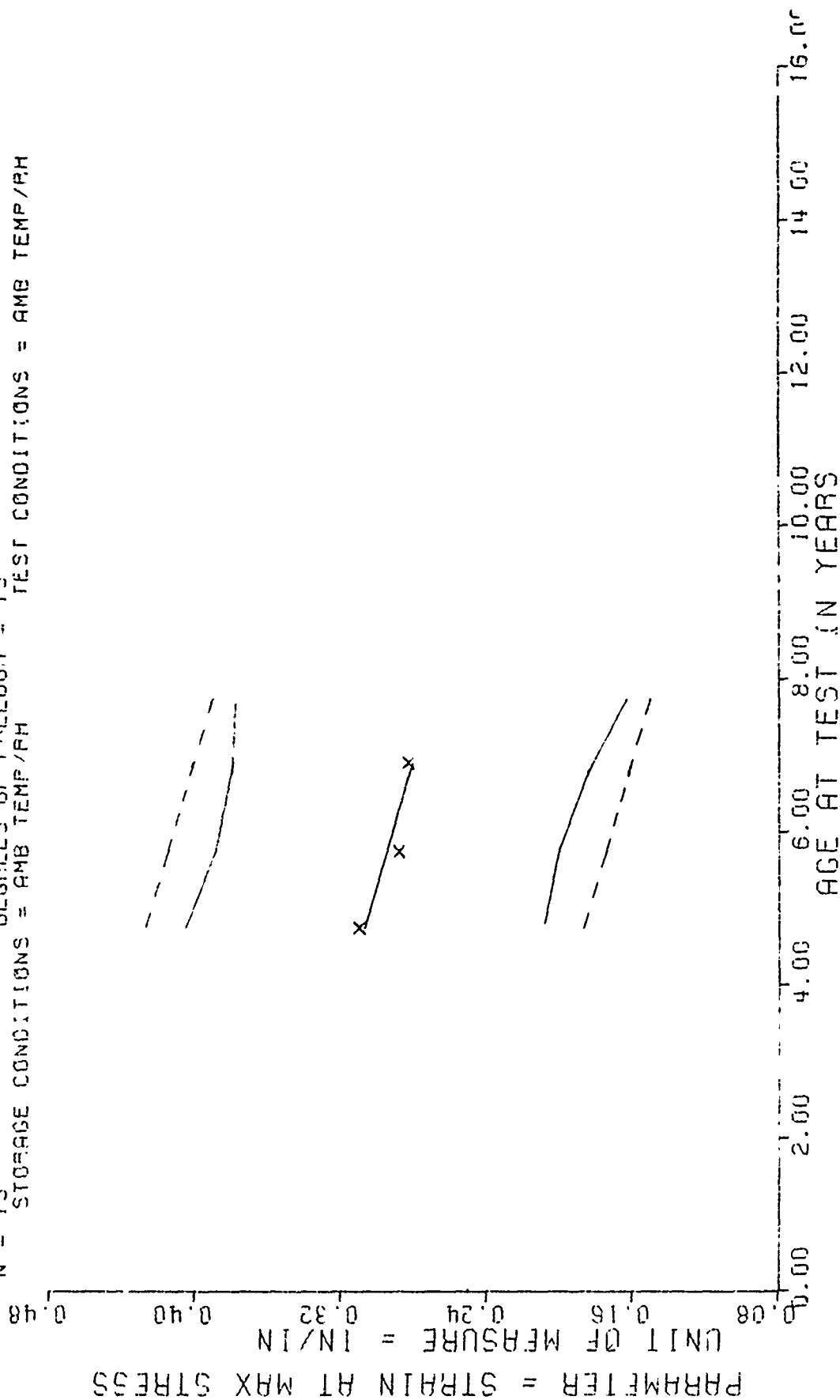
FIGURE 5-8

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
1 57.051	55
69.0	5
93.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR # 0033174, STRN FT .0002

$F = +.10910358E+01$
 $R = -.27825825E+00$
 $T = +.10445266E+01$
 $N = 15$
 $Y = (\dots) + (\dots) \times Y$
 CHANCE OF F = NOT SIGNIFICANT
 CHANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF T = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 13
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH



TENSILE STRAIN AT MAX STRESS, MOTOR # 0033174, STAN AT .0002

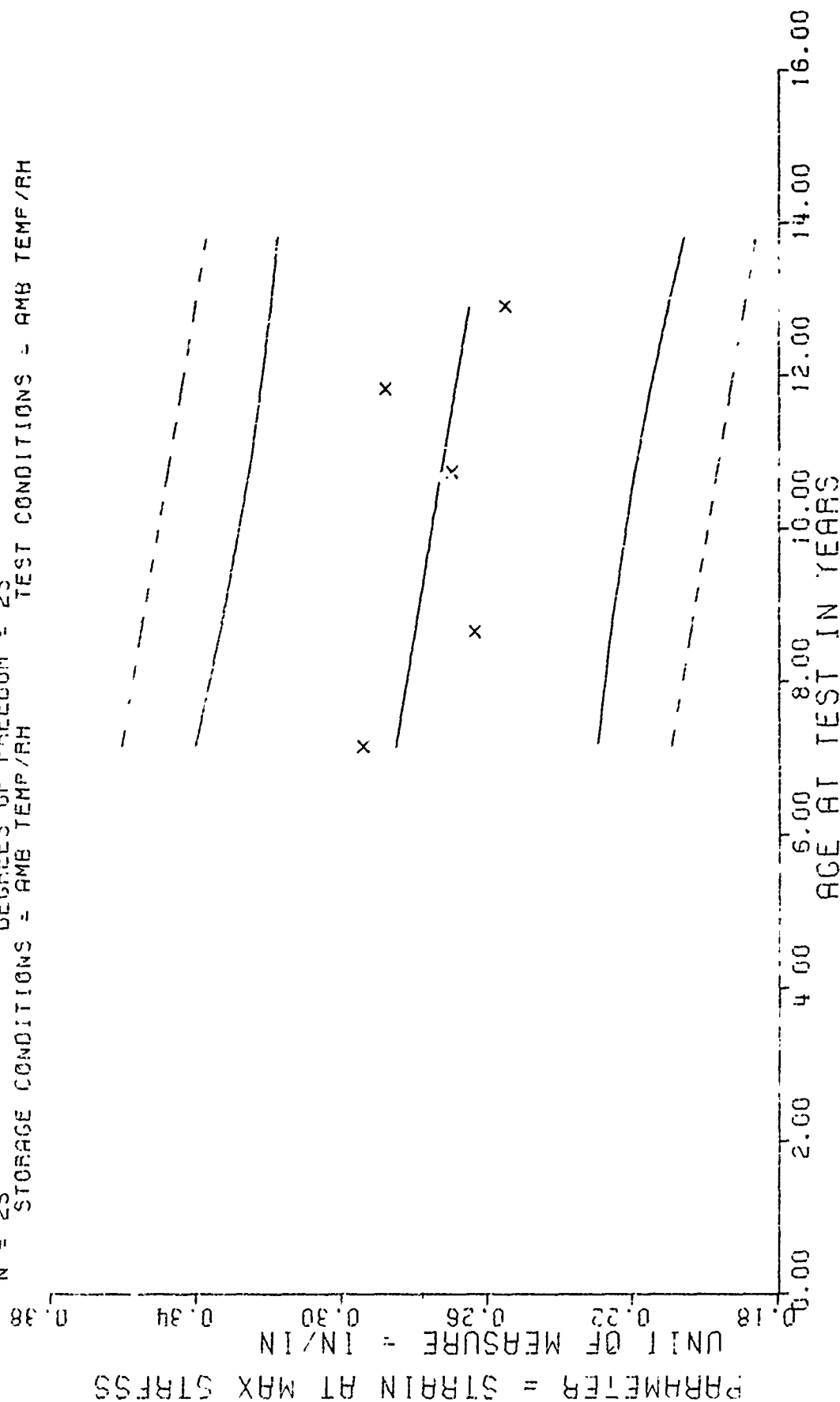
FIGURE 5-9

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
{ 85.05}	55
104.0	5
129.0	5
142.0	5
155.0	5

TENSILE STRAIN AT MAX STRESS, MOTOR # C00K131, STRN RT .0002

$Y = (+.31007345E+00) + (-.28988193E-03) \times X$
 SIGNIFICANCE OF F = NOT SIGNIFICANT $G = +.25771237E-01$
 SIGNIFICANCE OF R = NOT SIGNIFICANT $S = -.20084168E-03$
 SIGNIFICANCE OF t = NOT SIGNIFICANT $SI = -.25208631E-01$
 N = 25 DEGREES OF FREEDOM = 23
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TENSILE STRAIN AT MAX STRESS, MOTOR = 006R131, STAN RT .0002

FIGURE 5-10

TABLE 5-1
EFFECT OF HUMIDITY ON TEST DATA

<u>Motor Nr</u>	<u>Humidity</u>	<u>em</u>	<u>Sm</u>	<u>er</u>	<u>Sr</u>	<u>G</u>
0031064	50	.377	67.00	.381	57.56	518
	50	.384	69.59	.411	55.98	480
	20	.286	69.50	.294	66.30	501
	20	.360	69.90	.376	66.30	511
	20	.326	71.00	.330	68.60	490
0031134	50	.343	65.66	.363	54.78	532
	50	.304	63.03	.353	53.06	490
	20	.336	70.20	.344	65.10	540
	20	.300	70.60	.308	67.80	555
	20	.308	72.50	.320	68.70	523
0032434	50	.246	65.70	.300	53.90	604
	50	.244	64.26	.292	53.27	630
	20	.268	72.30	.278	68.90	672
	20	.244	74.00	.260	60.60	655
	20	.270	72.50	.280	56.50	693
0033174	50	.252	56.68	.327	47.70	531
	50	.256	58.25	.318	48.49	560
	20	.300	65.00	.306	62.70	544
	20	.292	63.10	.298	61.60	490
	20	.316	62.70	.322	58.20	511
Gr 131	50	.268	63.25	.302	52.70	595
	50	.276	67.37	.292	57.61	613
	20	.254	71.20	.266	69.50	608
	20	.228	67.40	.230	61.20	608
	20	.250	70.60	.258	67.60	554

SECTION VI

LOW RATE BIAXIAL

A 3/4" GL rail specimen, 3/16" thick is used for this test. The specimens are tested on the Instron Tensile Tester at a cross-head speed of 0.2 in/min (strain rate of .1143 in/in/min).

Strains for the five motor composite show a significant increase while the stresses do not show a significant change (Figure 6-1 through 6-4). Modulus shows a significant decrease (Figure 6-5). However, there was only one data point available for each motor for 1972 and 1973. The regression analyses was conducted using this limited data base in order to satisfy Service Engineerings' requirements to establish an aging trend for this test, recognizing that the validity was compromised by the limited sampling.

The significant increase in strain is probably due to long storage after cutting. For the three motors first tested in 1968, the strains are now approximately 11% higher than in 1968. The stress data do not show a consistent increase.

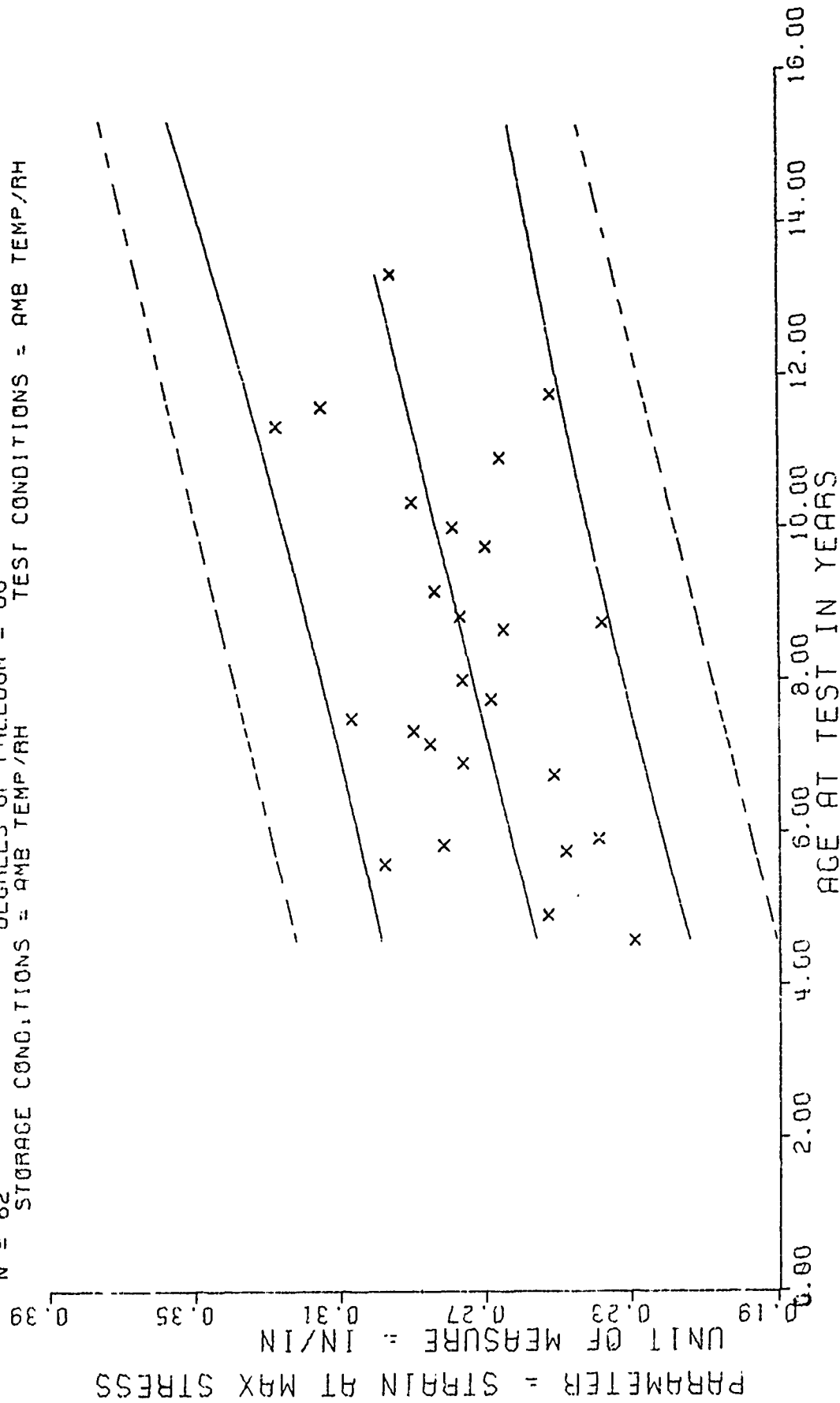
Strain at maximum stress for Motors 0031064 and 0031434 shows a significant increase (Figures 6-6 and 6-8). There is no significant change for the other motors (Figures 6-7, 6-9 and 6-10).

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	4
59.0	2
67.0	4
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE STRAIN AT MAX STRESS, 5 MOTOK COMPOSITE, STN RT 0.2

$Y = (+.23362212E+00) + (+.41301872E-03) \times X$
 $F = +.11342552E+02$ SIGNIFICANCE OF F = SIGNIFICANT
 $R = +.39873199E+00$ SIGNIFICANCE OF R = SIGNIFICANT
 $t = +.33678705E+01$ SIGNIFICANCE OF t = SIGNIFICANT
 $N = 62$ DEGREES OF FREEDOM = 60
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

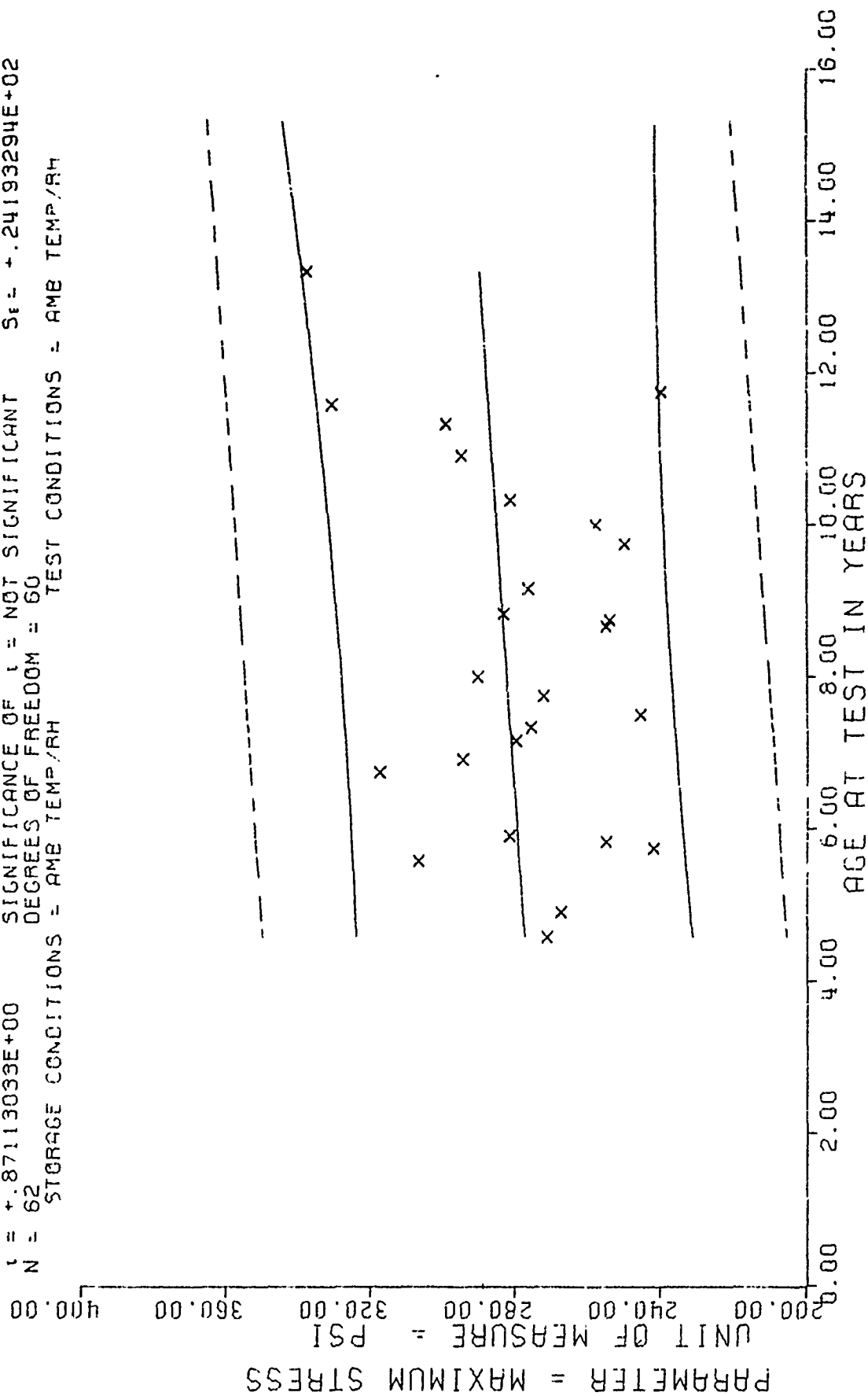


*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS) NR SAMPLES

55.0	4
59.0	2
67.0	4
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE MAXIMUM STRESS, 5 MOTOR COMPOSITE, STN RT 0.2

$$\begin{aligned}
 F &= +.75886306E+00 & \text{SIGNIFICANCE OF } F &= \text{NOT SIGNIFICANT} & G^2 &= +.24145428E+02 \\
 R &= +.1175731E+00 & \text{SIGNIF. CANCE OF } R &= \text{NOT SIGNIFICANT} & S^2 &= +.13631446E+00 \\
 t &= +.87113033E+00 & \text{SIGNIFICANCE OF } t &= \text{NOT SIGNIFICANT} & S^2 &= +.24193294E+02 \\
 N &= 62 & \text{DEGREES OF FREEDOM} &= 60 & & \\
 & & \text{STORAGE CONDITIONS} &= \text{AMB TEMP/RH} & \text{TEST CONDITIONS} &= \text{AMB TEMP/RH}
 \end{aligned}$$


*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	4
59.0	2
67.0	1
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE STRAIN AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.2

$F = +.66091837E+01$
 $R = +.31499731E+00$
 $t = +.25708332E+01$
 $N = 62$

$Y = (+.28474589E+00) + (+.39727995E-03) \times X$

SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 60

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

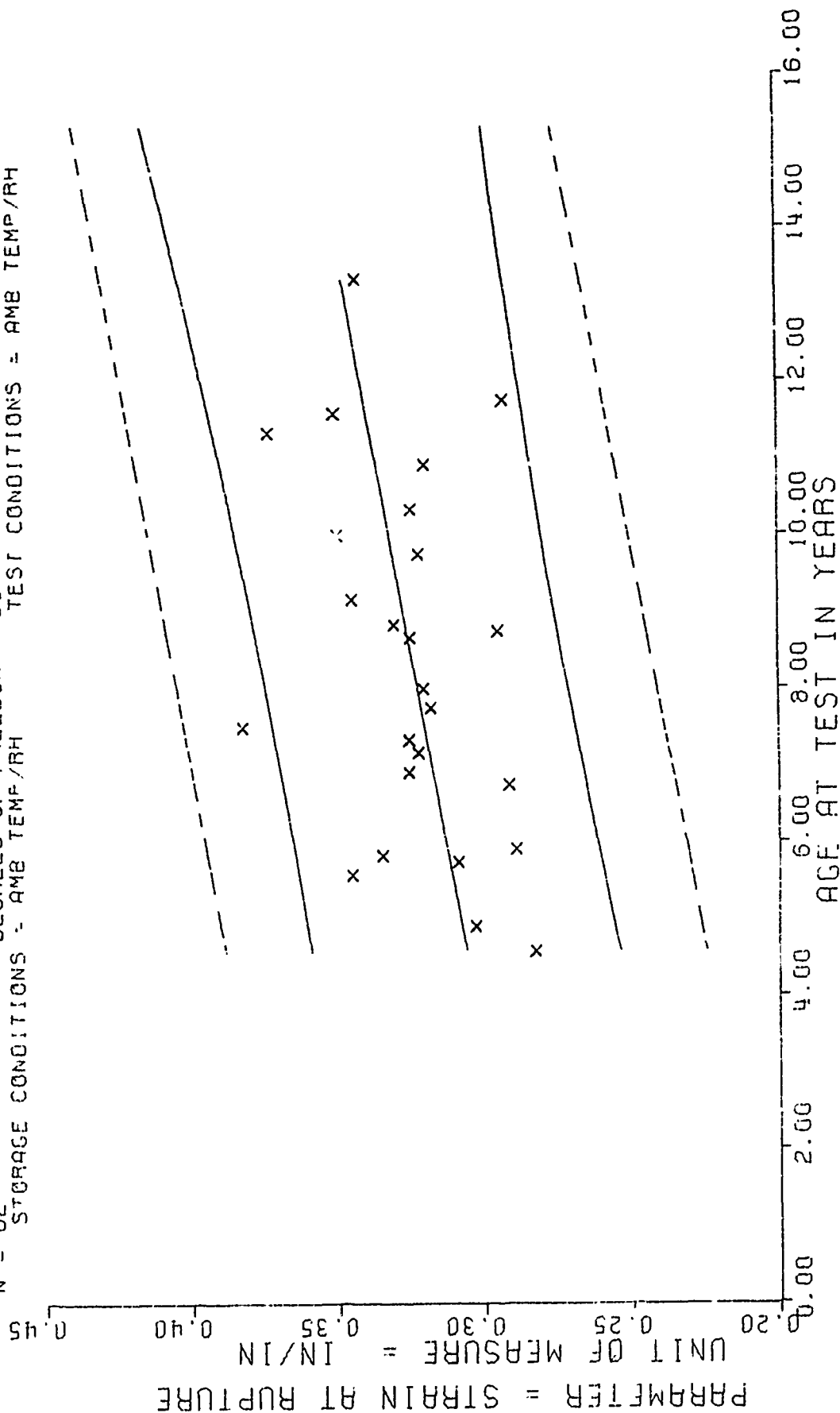


FIGURE 6-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS) NR SAMPLES

55.0	4
59.0	2
67.0	4
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE STRESS AT RUPTURE, 5 MOTOR COMPOSITE, STN RT 0.2

$Y = (+.25114461E+03) + (+.13139258E+00) \times X$
 F = +.85187674E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT $G = +.25235250E+02$
 R = +.11231815E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT $S_0 = +.14235820E+00$
 t = +.92297169E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT $S_1 = +.25265944E+02$
 N = 62 DEGREES OF FREEDOM = 60
 STORAGE CONDITIONS : AMB TEMP/RH TEST CONDITIONS : AMB TEMP/RH

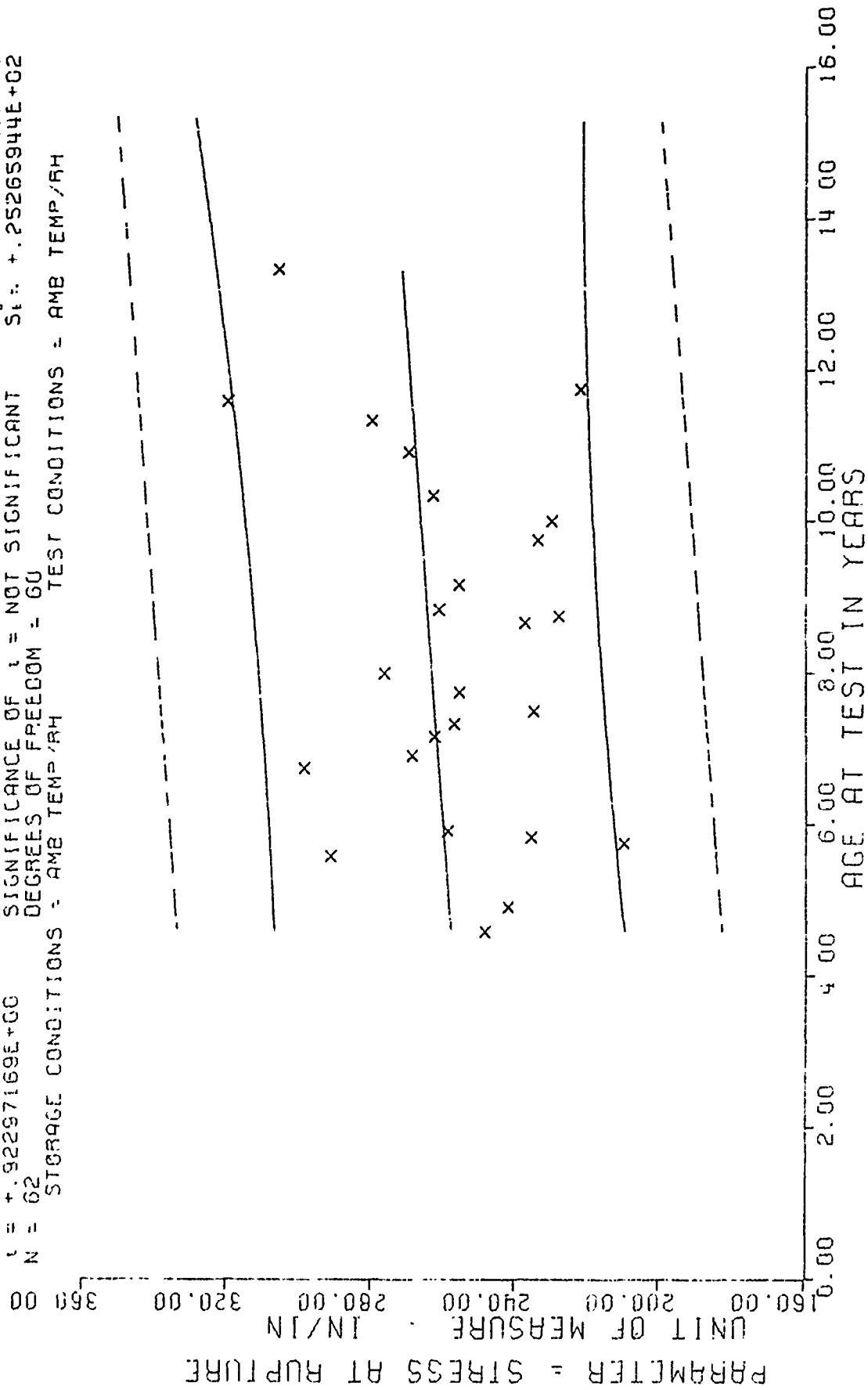


FIGURE 6-4

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS) NK SAMPLES

55.0	4
59.0	2
67.0	4
69.0	1
70.0	4
71.0	3
81.0	6
83.0	3
86.0	3
88.0	1
90.0	2
93.0	6
96.0	8
104.0	2
105.0	1
106.0	2
110.0	2
117.0	1
120.0	1
124.0	1
131.0	1
136.0	1
139.0	1
141.0	1
160.0	1

TENSILE MODULUS, 5 MOTOR COMPOSITE, SYN RT 0.2

$F = +.74542425E+01$
 $R = -.33242753E+00$
 $t = +.27302458E+01$
 $N = 62$
 $Y = (+.17858351E+04) + (-.33555643E+01) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 60
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH

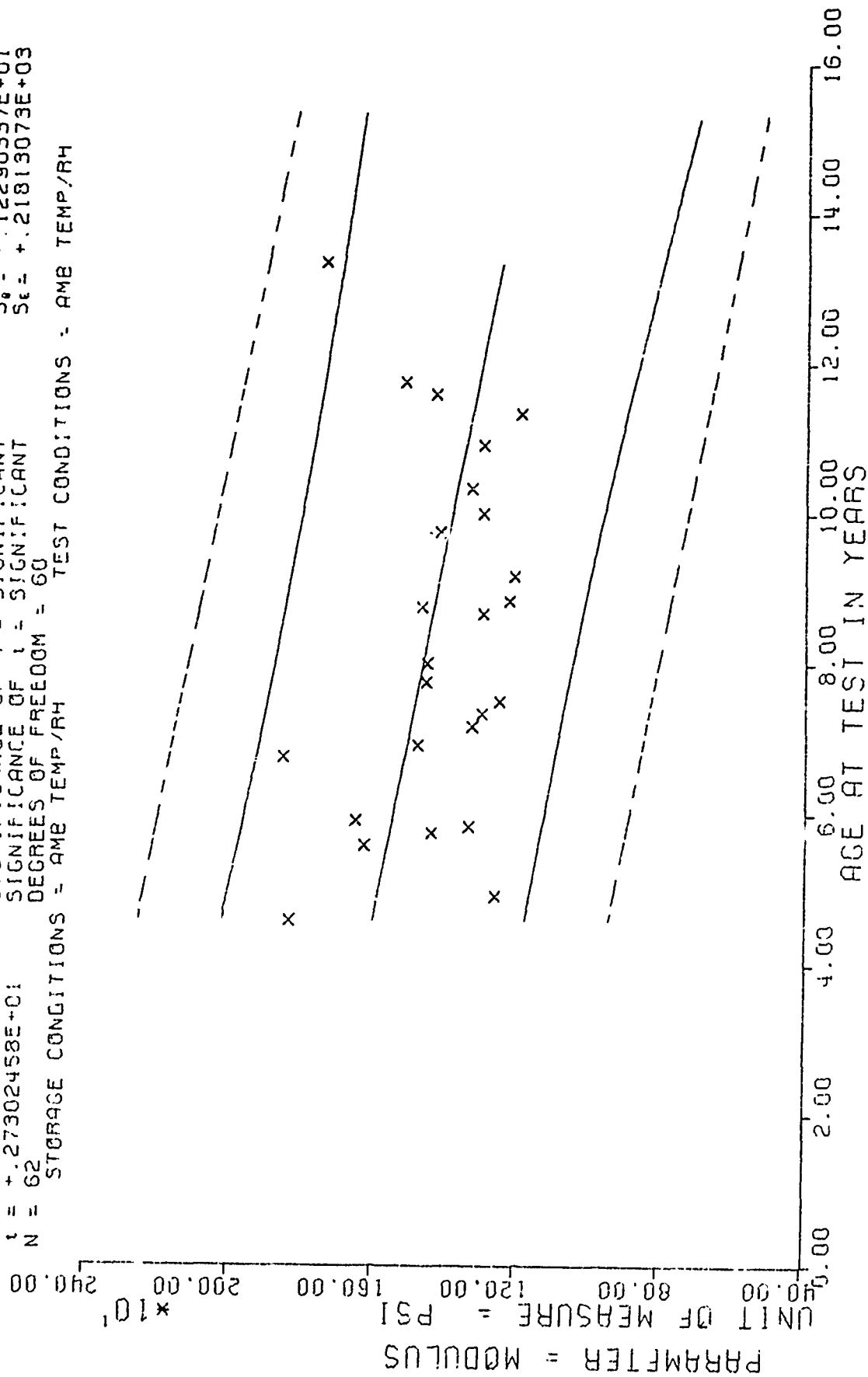


FIGURE 6-5

*** SAMPLE SIZE SUMMARY ***

Size (inches) SAMPLES

20.0	4
20.5	3
21.0	4
21.5	2
22.0	1
22.5	1

FLUSILE STEEL AT MAX STRESS, MOTOR # C021064, STPR RT 0.2

$Y = (+.26170878E+00) + (+.26506629E-03) \times X$
 F = +.51951913E+01 SIGNIFICANCE OF F = SIGNIFICANT $G_1 = 1.98912914E-02$
 R = +.50719712E+00 SIGNIFICANCE OF R = SIGNIFICANT $S_A = 1.11623304E-03$
 T = +.22732362E+01 SIGNIFICANCE OF T = SIGNIFICANT $S_E = 1.88041818E-02$
 N = 17 DEGREES OF FREEDOM = 15 TEST CONDITIONS = AMB TEMP/RH

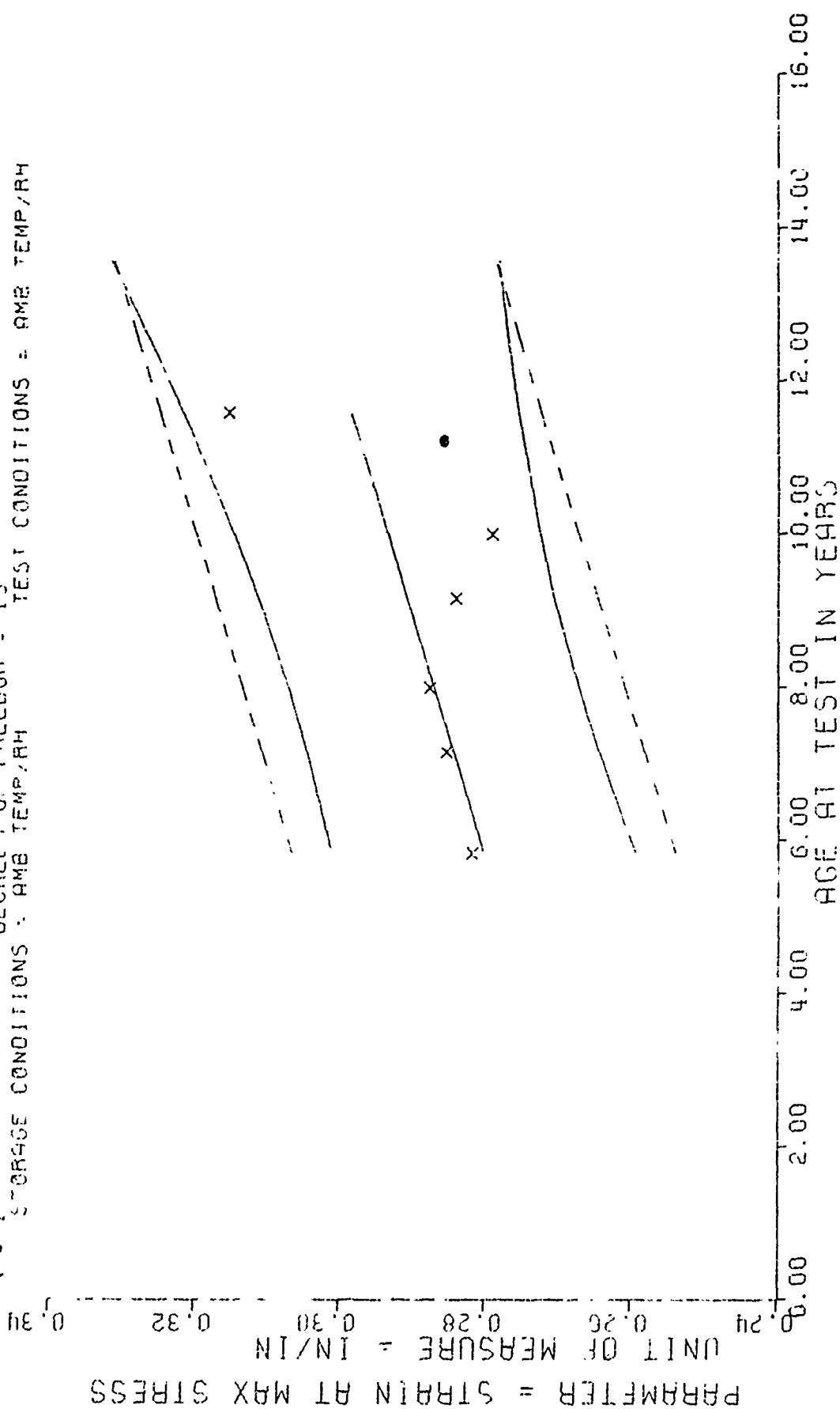


FIGURE 6-6

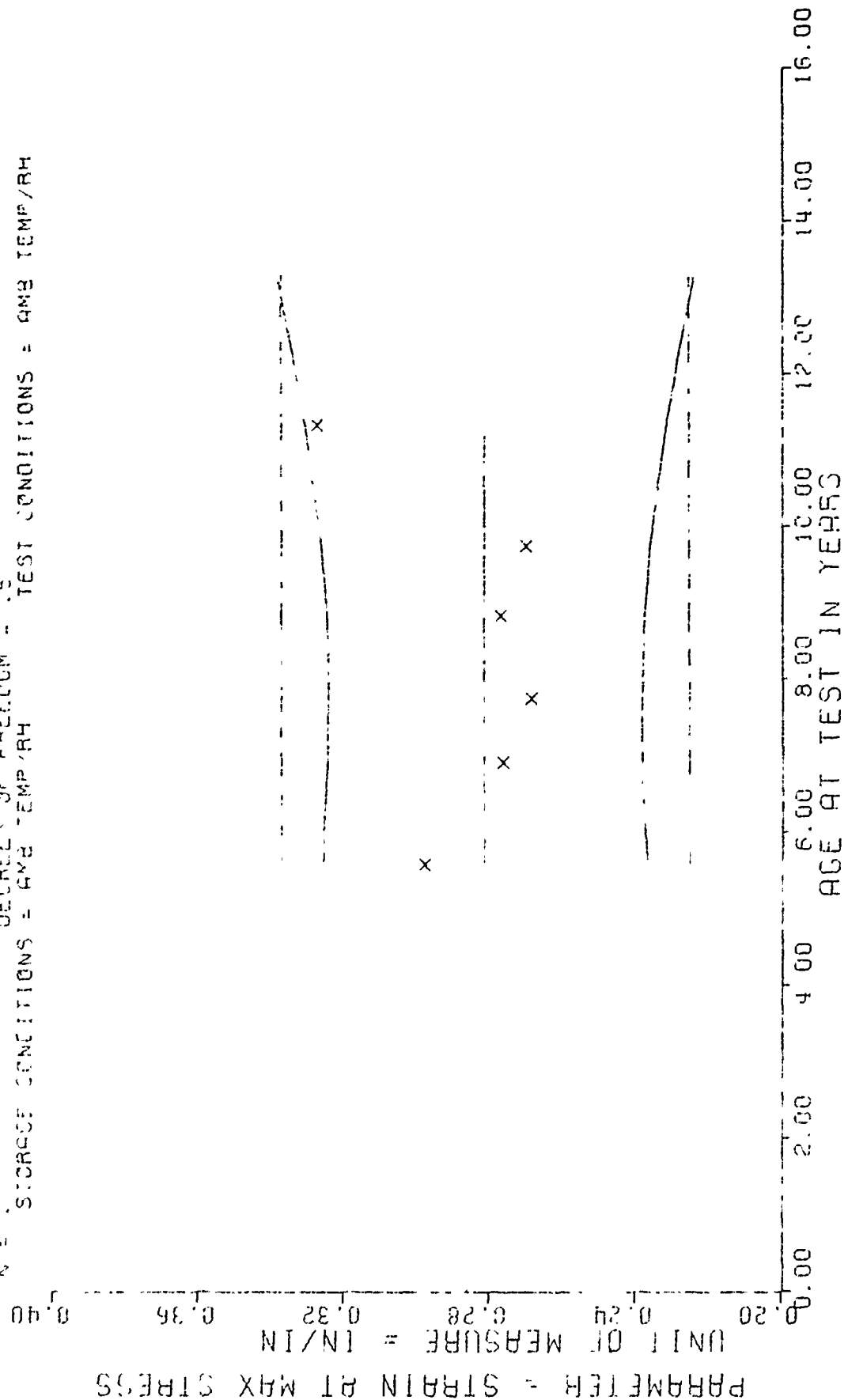
*** SAMPLE SIZE SUMMARY ***

(CONTINUED) SAMPLES

67.3	4
83.	3
95.	6
106.7	2
117.0	1
136.0	1

TENSILE STRAIN AT MAX STRESS, MUTR # 0031134, STPK RT 0.2

F = +.40023743E-03
 R = +.5165413E-02
 U = +.2000000E-01
 V = +.2000000E-01
) = (+.28094248E+02) + (+.43855746F-05) * X
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF U = NOT SIGNIFICANT
 SIGNIFICANCE OF V = NOT SIGNIFICANT
 DEGREE OF FREEDOM = 15
 STORAGE CONDITIONS = AVE TEMP/RH
 TEST CONDITIONS = AVE TEMP/RH



TENSILE STRAIN AT MAX STRESS, MOTOR # 0031134, STAN AT 0.2

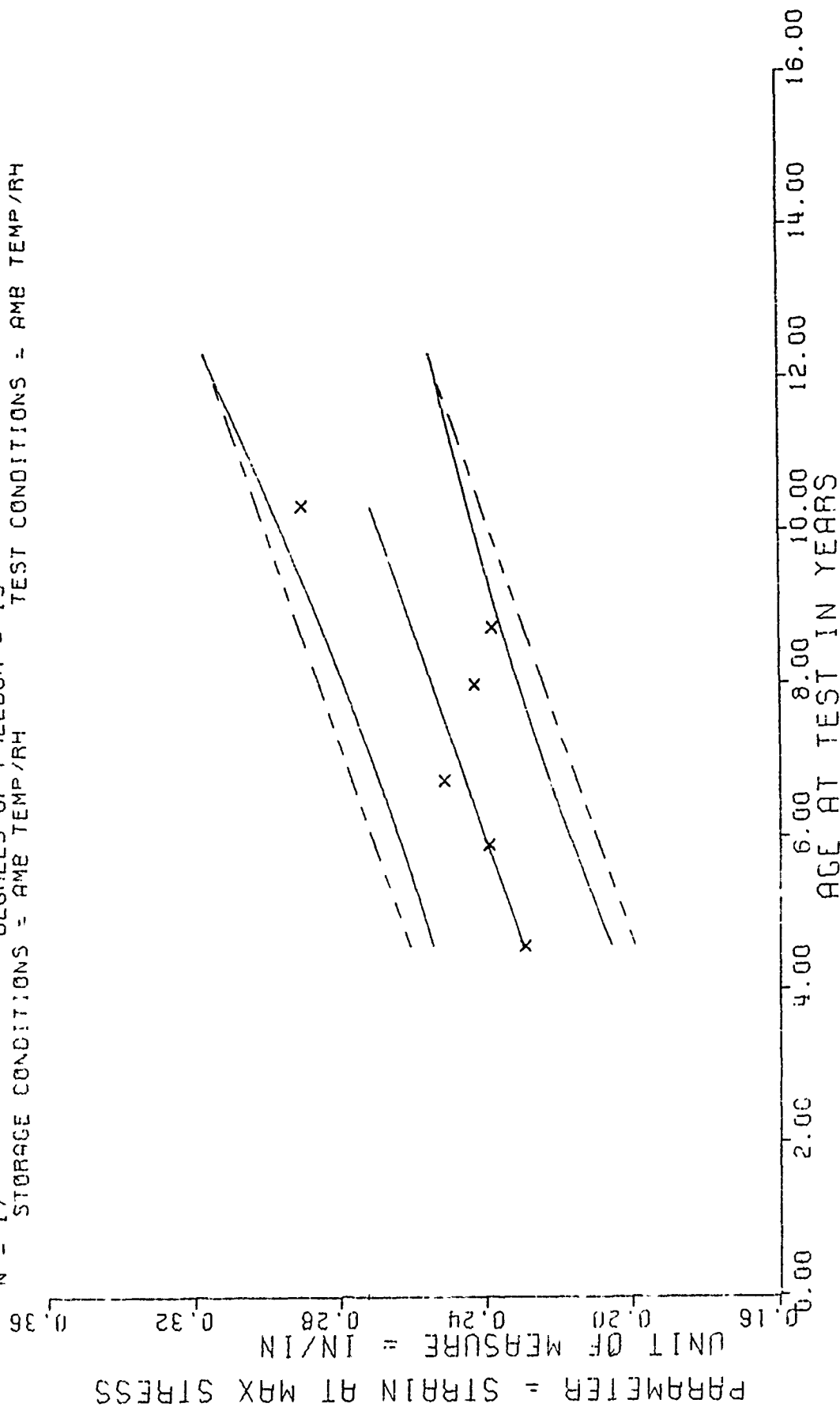
FIGURE 6-7

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	4
71.0	3
81.0	6
96.0	2
105.0	1
124.0	1

TENSILE STRAIN AT MAX STRESS, MOTOR # 0032434, STRN RT 0.2

$Y = (+.19662272E+00) + (+.60650272E-03) \times X$
 $F = +.19889253E+02$ SIGNIFICANCE OF F = SIGNIFICANT $G_1 = +.15292063E-01$
 $R = +.75502860E+00$ SIGNIFICANCE OF R = SIGNIFICANT $S_1 = +.13593517E-03$
 $t = +.44597363E+01$ SIGNIFICANCE OF t = SIGNIFICANT $S_E = +.10355718E-01$
 $N = 17$ DEGREES OF FREEDOM = 15
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TENSILE STRAIN AT MAX STRESS, MOTOR # 0032434, STRN AT 0.2

FIGURE 6-8

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
59.0	2
69.0	1
88.0	1

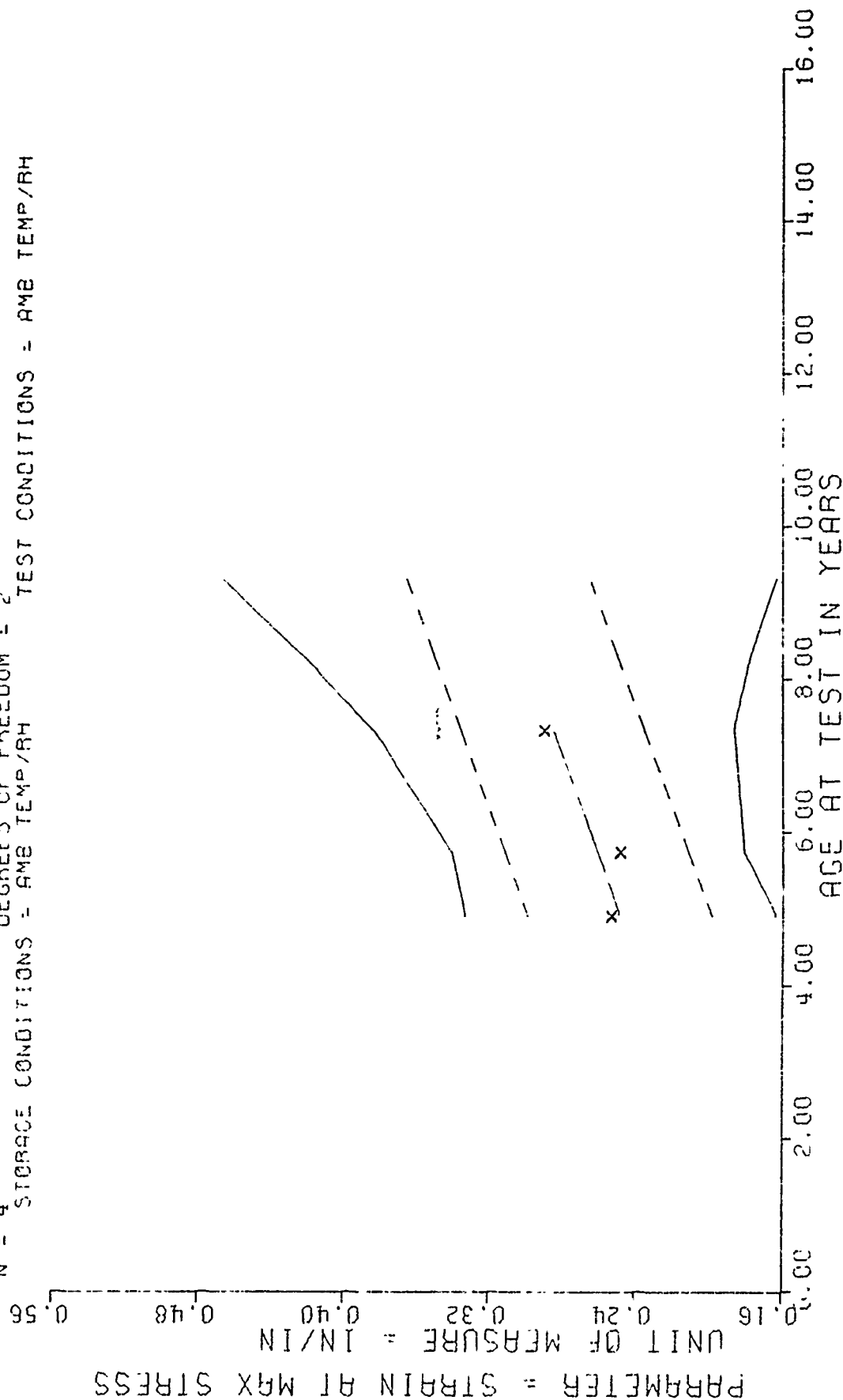
TENSILE STRAIN AT MAX STRESS, MOTOR # 0033174, STRN RT 0.2

$F = +.31145007E+01$
 $R = +.78035583E-00$
 $t = +.17647948E+01$
 $N = 4$

$Y = (+.17425082E+00) + (+.12610789E-02) \times X$

SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF t = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 2

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



TENSILE STRAIN AT MAX STRESS, MOTOR # 0033174, STRN RT 0.2

FIGURE 6-9

*** SAMPLE SIZE SUMMARY ***

Age AA
(MONTHS) SAMPLES

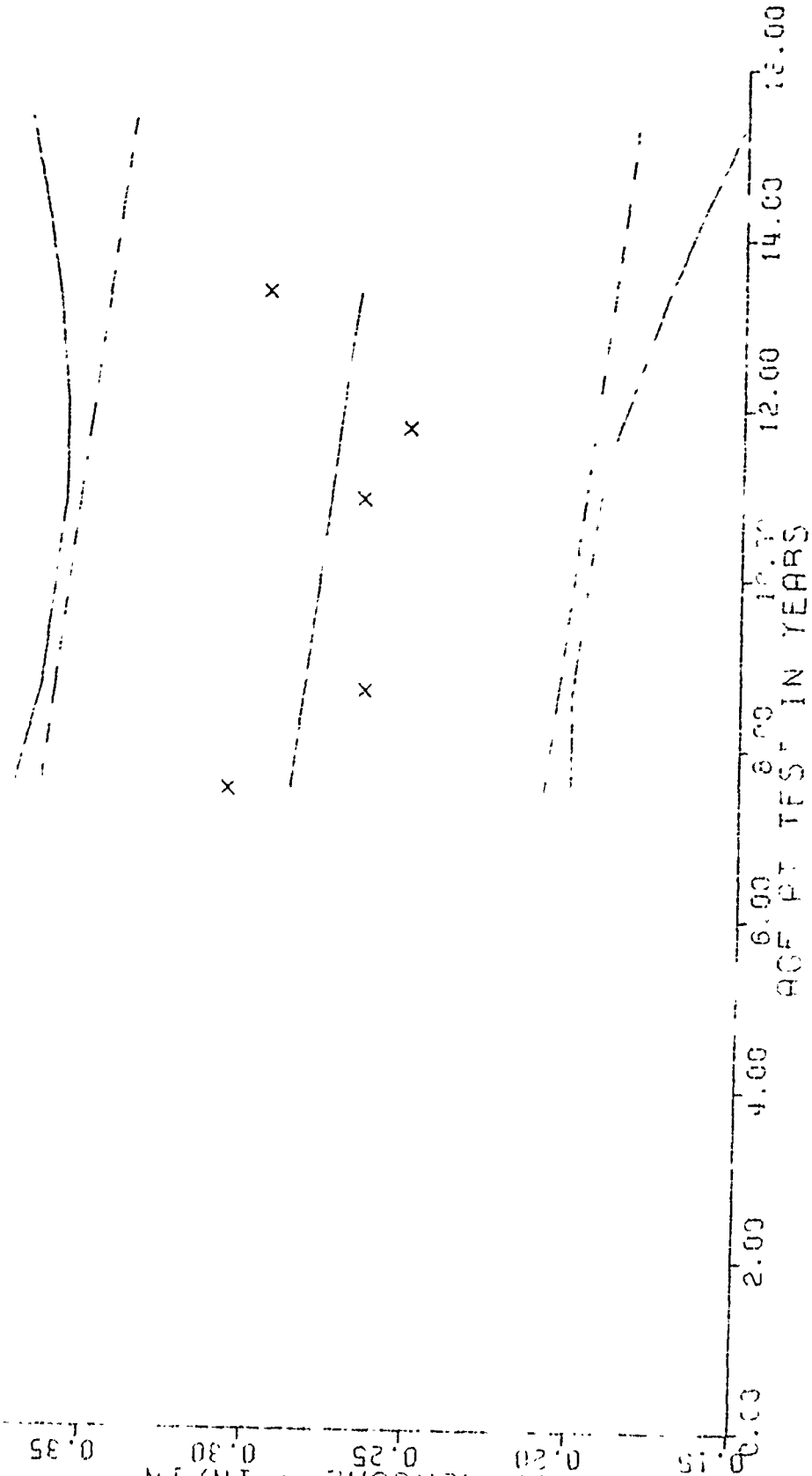
96.0	2
104.0	2
131.0	1
141.0	1
160.0	1

TENSILE STRAIN AT MAX STRESS: MOTOR # C06K131, STAN RT-0-2

$Y = (-.31280587E+00) + (-.28248916E-03) X$
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF T = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 5
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS AMB TEMP/RH

PARAMETER = STRAIN AT MAX STRESS

UNIT OF MEASURE = IN/IN



TESTING STRAIN AT MAX STRESS, MEAN = 0.0013; STRAIN AT 0.2

FIGURE 6-10

SECTION VII

HIGH RATE TRIAXIAL

A 3/4" GL rail specimen, 3/16" thick is used for this test. The specimens are tested on the Plastechon at a crosshead speed of 1750 in/min under 300 psi N₂.

Strains for the five motor composite show a significant increase (Figures 7-1 and 7-3). Maximum stress does not show a significant increase (Figure 7-2) but stress at rupture does show a significant increase (Figure 7-4). Modulus does not show a significant decrease (Figure 7-5).

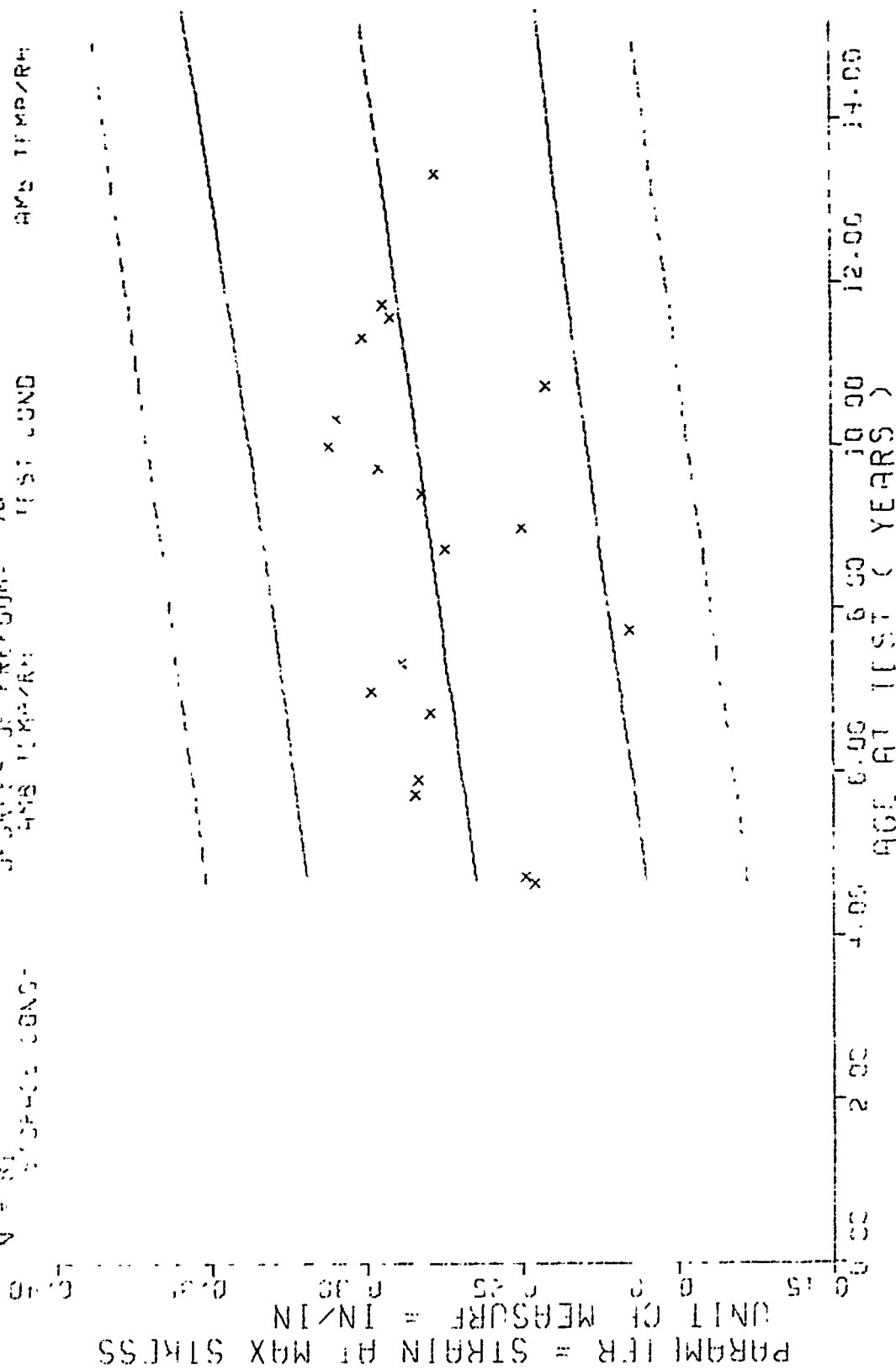
Three of the five motors do not show a significant increase in strain at maximum stress (Figures 7-6, 7-7 and 7-10). Both motors 32434 and 33174 do show a significant increase in this parameter (Figures 7-8 and 7-9).

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
56.0	5
57.0	8
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

STRAIN AT MAX STRESS, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

Y = (0.248133) + (0.000221) * X
 SIGNIFICANCE OF F - SIGNIFICANT
 SIGNIFICANCE OF R - SIGNIFICANT
 SIGNIFICANCE OF t - SIGNIFICANT
 OF DEGREE OF FREEDOM = 72
 RMS TEMP/RH TEST COND
 RMS TEMP/RH
 RMS TEMP/RH



STRAIN AT MAX STRESS. 1750 MIN TRIAXIAL TENSILE AT 300 PSI. 5 MOTOR COMPOSITE

FIGURE 7-1

SAMPLE SIZE SUMMARY

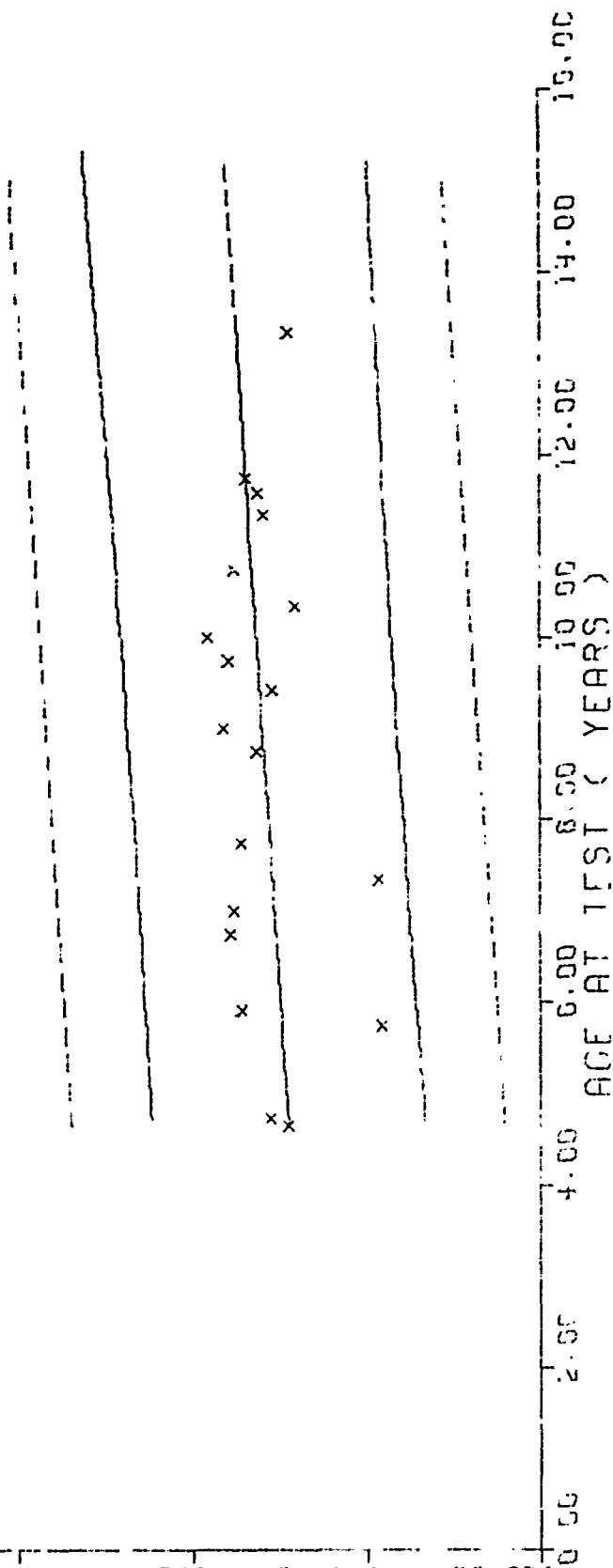
AGE (MONTHS)	NR SAMPLES
56.0	5
57.0	6
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

MAXIMUM STRESS, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

$Y = (1458.175781) + (0.566.30) X$
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF t = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 79
 RMS TEMP/RH TEST COND - RMS TEMP/RH

F = 3.278515
 R = 0.199619
 t = 1.310657

PARAMETER = MAXIMUM STRESS
 UNIT OF MEASURE - PSI
 *10³



MAXIMUM STRESS, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOIOP COMPOSITE

FIGURE 7-2

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
56.0	5
57.0	8
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

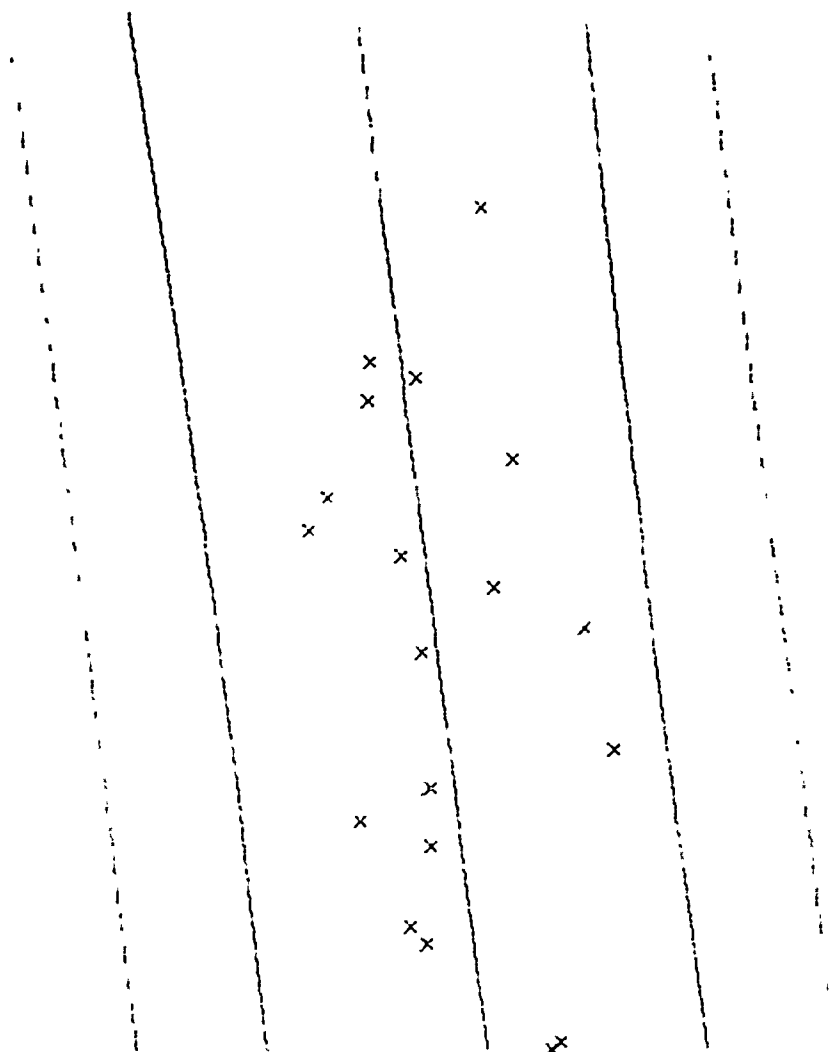
STRAIN AT RUPTURE, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

Y = (0.266038) + (0.000219) * X
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF U = SIGNIFICANT
 DEGREES OF FREEDOM = 78
 RMS TIME/RM TEST COND
 RMS TIME/RM

F = 5.302051
 R = 0.250941
 U = 2.351137
 Y = 3.044211
 RMS TIME/RM

F = 5.302051
 R = 0.250941
 U = 2.351137
 Y = 3.044211
 RMS TIME/RM

PARAMETER STRAIN AT RUPTURE
 UNIT OF MEASURE = IN/IN
 0.19
 0.27
 0.33
 0.39



STRAIN AT RUPTURE, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE
 AGE AT TEST (YEARS)
 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00

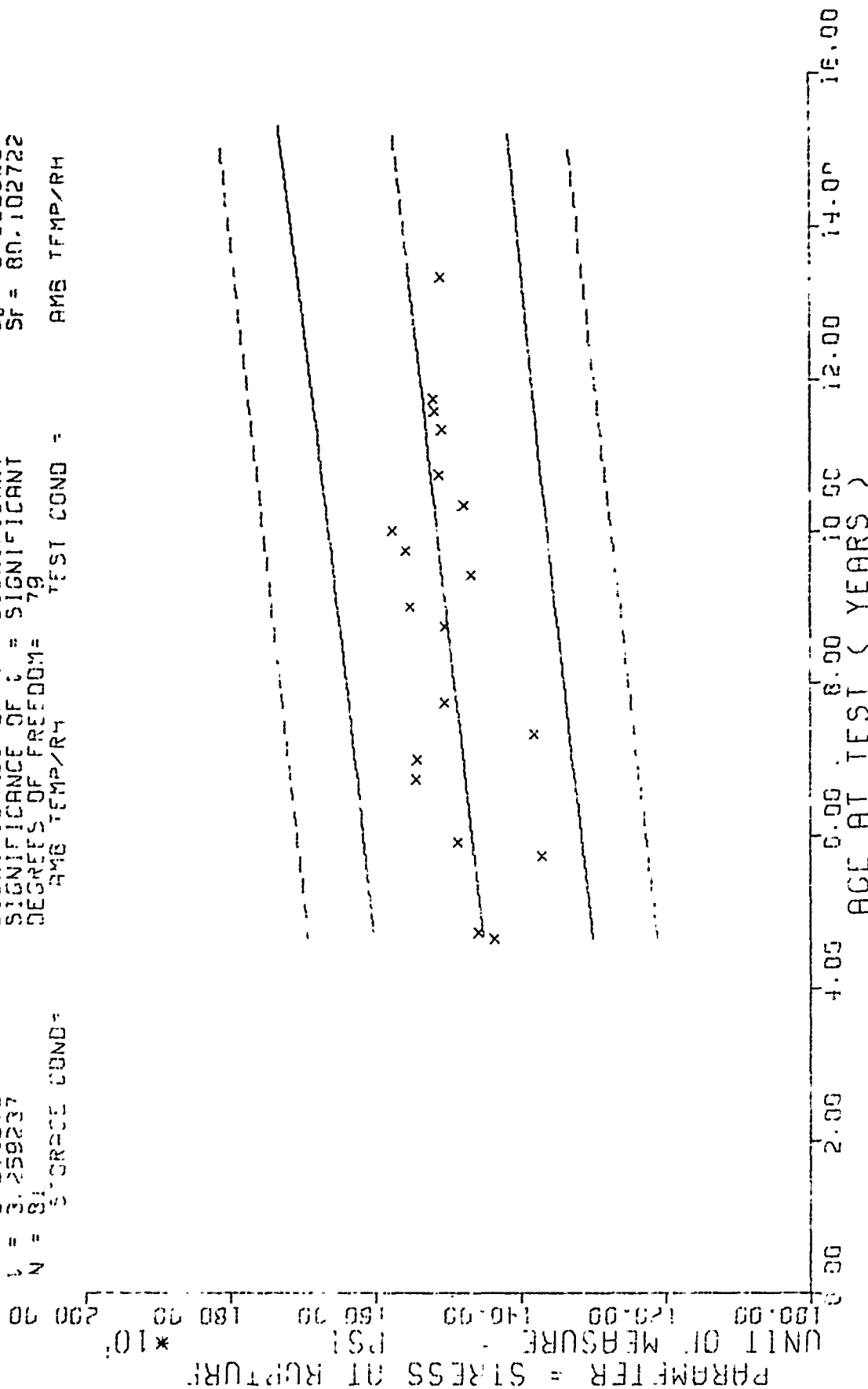
FIGURE 7-3

SAMPLE SIZE SUMMARY

<u>AGE</u> <u>(MONTHS)</u>	<u>NR</u> <u>SAMPLES</u>
56.0	5
57.0	6
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

STRESS AT RUPTURE, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

$Y = (1395.835937) + (0.986442) * X$
 F = 10.622627
 R = 0.344276
 S = 3.259237
 N = 81
 DEGREES OF FREEDOM = 79
 TEST COND =
 RMS TEMP/RH
 RMS TEMP/RH
 QY = 84.783447
 SB = 0.302660
 SF = 80.102722



STRESS AT RUPTURE. 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI. 5 MOTOR COMPOSITE

FIGURE 7-4

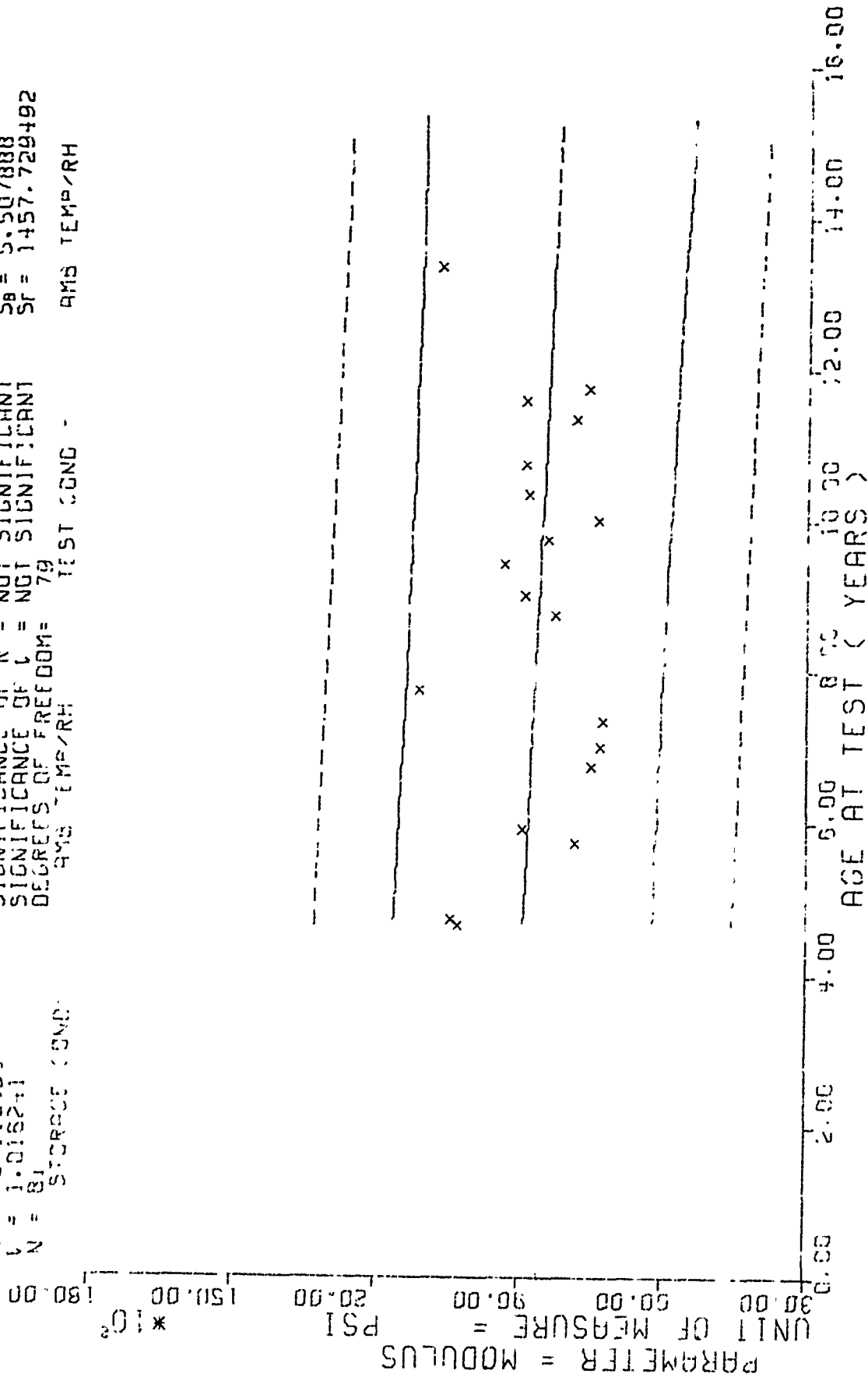
SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
56.0	5
57.0	8
69.0	8
71.0	4
81.0	6
84.0	6
88.0	3
93.0	3
105.0	9
108.0	3
113.0	2
117.0	3
120.0	3
124.0	3
129.0	3
136.0	3
139.0	3
141.0	3
160.0	3

MODULUS, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

Y = (9251.207031) + (5.597343) " X
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF U = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 79
 RMS TEMP/RH
 TEST COND -
 RMS TEMP/RH

F = 1.032745
 R = -0.113595
 U = 1.016211
 N = 81
 STORAGE COND -



MODULUS, 1750 IN/MIN TRIAXIAL TENSILE AT 300 PSI, 5 MOTOR COMPOSITE

FIGURE 7-5

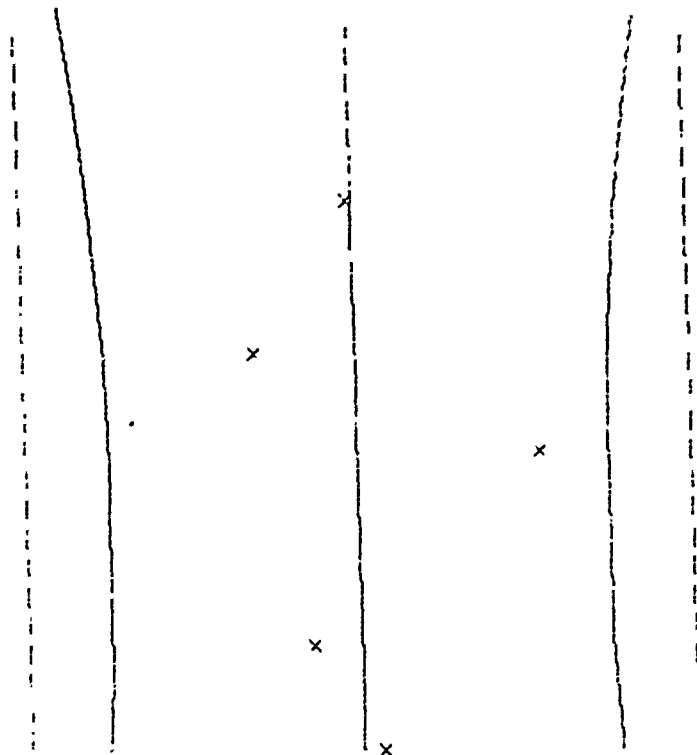
SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
71.0	4
84.0	6
108.0	3
120.0	3
139.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI 0031064

) = (0.231230) + (0.000045) * X
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF S = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 17
 RMS TEMP/R
 TEST COND = F QMB TEMP/RH
 STORAGE COND-

PARAMETER = STN AT MAX STRESS
 UNIT OF MEASURE = IN/IN
 0.20
 0.21
 0.22
 0.23
 0.24
 0.25
 0.26
 0.27
 0.28
 0.29
 0.30
 0.31
 0.32
 0.33
 0.34
 0.35
 0.36
 0.37
 0.38
 0.39
 0.40



HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS LHS 1710.0 RSP FSI QMB1001

FIGURE 7-6

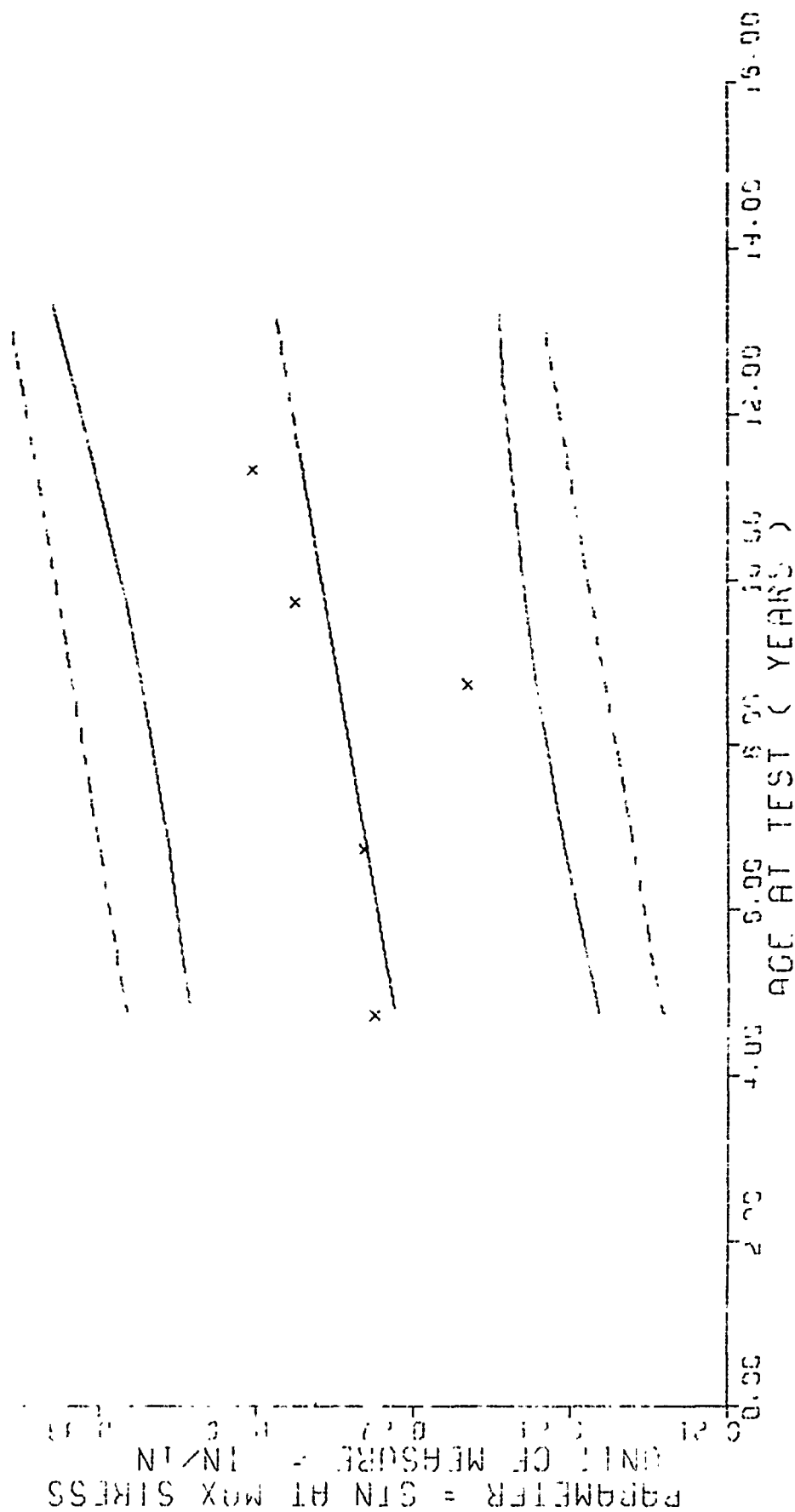
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 best available copy.

SAMPLE SIZE SUMMARY

<u>AGE</u> <u>(MONTHS)</u>	<u>NR</u> <u>SAMPLES</u>
57.0	5
81.0	6
105.0	3
117.0	3
136.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI 0031134

F = 2.909937
 R = 0.956593
 Y = (0.250553) + (0.000224) * X
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF U = NOT SIGNIFICANT
 DEGREE OF FREEDOM = 13
 RMS TEMP/R
 TEST COND -
 TEST COND -



HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS (MS 1/50.0 350 PSI 003113)

FIGURE 7-7

SAMPLE SIZE SUMMARY

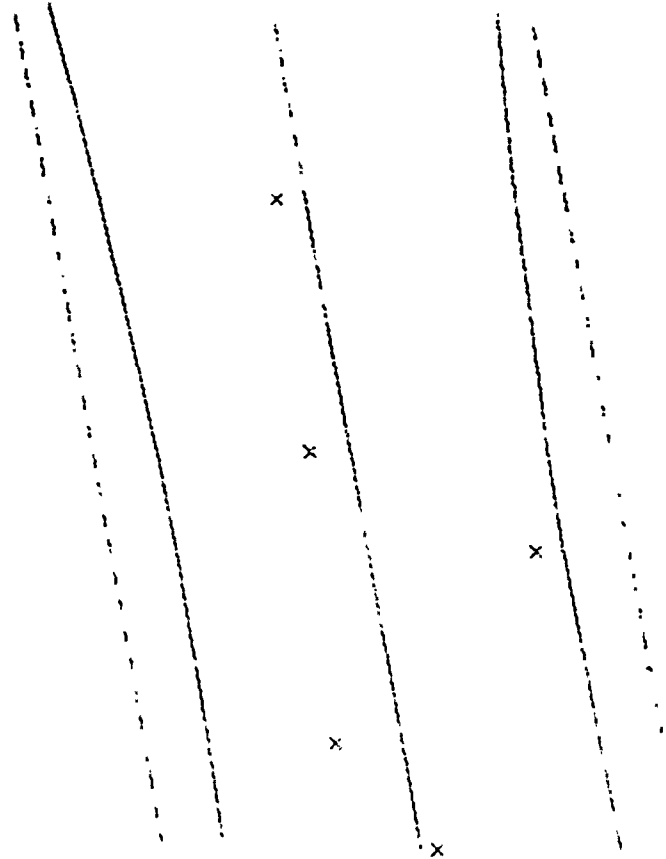
<u>AGE</u> <u>(MONTHS)</u>	<u>NR</u> <u>SAMPLES</u>
56.0	5
69.0	5
93.0	3
105.0	3
136.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI 0032434

PURPOSE = STN AT MAX STRESS (IN/IN)
UNIT OF MEASURE = IN/IN

Y = (0.222567) + (0.000501) * X
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
SIGNIFICANCE OF T = SIGNIFICANT
DEGREE OF FREEDOM = 17
STRESS - CONC - TEST CONC - H QMS TEMPR/RH

F = 4.555006
T = 2.152270
R = 0.832515
S = 0.000000



STRESS - CONC - TEST CONC - H QMS TEMPR/RH
ACF AT TEST (YEARS)
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00

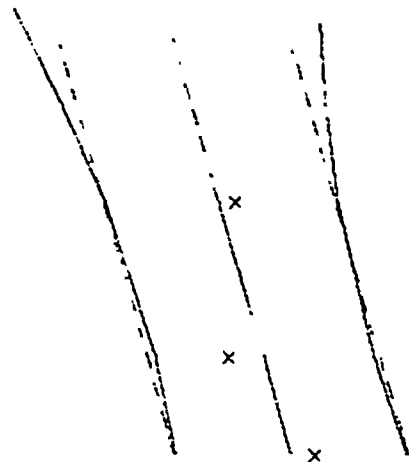
STRESS - CONC - TEST CONC - H QMS TEMPR/RH
ACF AT TEST (YEARS)
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00

FIGURE 7-8

SAMPLE SIZE SUMMARY

<u>AGE</u> <u>(MONTHS)</u>	<u>NR</u> <u>SAMPLES</u>
57.0	3
69.0	3
88.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI 0033174

[illegible]

TIME	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00
NOF AT TEST (YEARS)								
HIGH RATE TRIAXIAL TEST : SIN AT MAX STRESS 105 1750.1 355 PSI 0023.74								

FIGURE 7-9

SAMPLE SIZE SUMMARY

<u>AGE</u> <u>(MONTHS)</u>	<u>NR</u> <u>SAMPLES</u>
105.0	3
113.0	2
129.0	3
141.0	3
160.0	3

HIGH RATE TRIAXIAL TENSILE STN AT MAX STRESS CHS 1750.0 300 PSI Q 131

11

SECTION VIII
STRESS RELAXATION

End bonded 1/2" x 1/2" x 4" specimens are tested on the RCK Stress Relaxometer. Specimens are strained initially to 3% and then permitted to relax up to 1000 seconds. The strain rate is 0.5 in/in/min.

Stress relaxation modulus for the five motors composite shows a significant increase (Figure 8-1 thru 8-4).

A comparison with 1968 data shows that Motor 0031064 has a slightly higher modulus now (1066 psi vs 1197), 0031134 remains the same (1123 psi vs 1153), and 0032434 is higher (1176 psi vs 1457).

When 10 sec and 1000 sec relaxation modulus is examined for individual motors the trend is significant for motors 0031064, 0031134 and 0032434. There is no trend for 0033174. The modulus at 1000 sec is less than 50% of the 10 sec value. Motor 0031064 shows approximately 50% reduction but motors 0032434 has a 1000 sec modulus which is more than 60% of the 10 sec value.

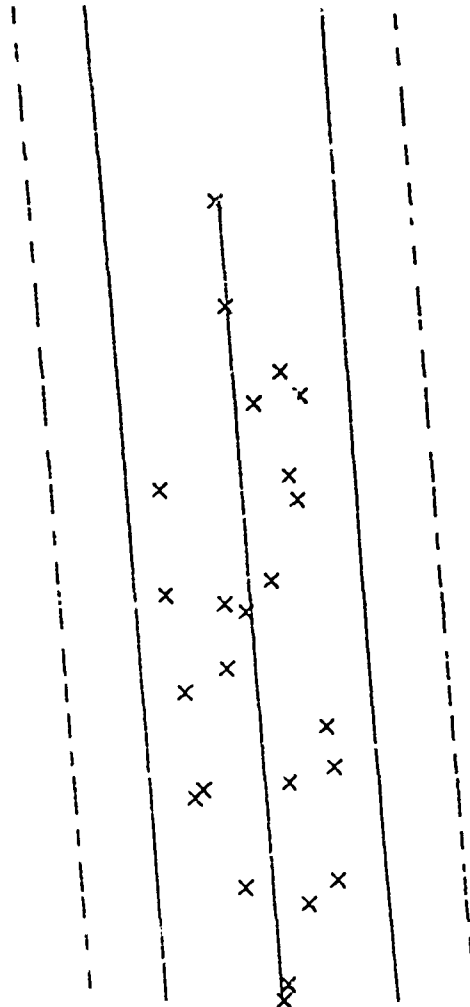
*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NP SAMPLES
55.0	10
57.0	6
67.0	10
69.0	6
70.0	10
80.0	3
81.0	12
82.0	3
84.0	6
89.0	3
93.0	12
96.0	6
103.0	6
104.0	6
105.0	3
107.0	6
117.0	6
118.0	3
120.0	3
129.0	3
130.0	3
133.0	3
141.0	3
154.0	3

RELAXATION MODULUS AT 10 SEC. 3 PCT STN. 5 MOTOR COMPOSITE

$Y = (-.095546E+04) + (.526214E+01) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 133
 N = 135
 STORAGE CONDITIONS = PMB TEMP/RH
 TEST CONDITIONS = PMB TEMP/RH
 S₁ = +.14328002E+03
 S₂ = +.48562708E+00
 S₃ = +.13875763E+03

UNIT OF MEASURE = PSI
 RELAXATION MODULUS
 X 10¹
 240.00
 200.00
 160.00
 120.00
 80.00
 40.00
 0.00



RELAXATION MODULUS AT 10 SEC. 3 PCT STN. 5 MOTOR COMPOSITE

Figure 8-1

*** SA SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
55.0	105
57.0	6
67.0	10
69.0	6
70.0	10
80.0	3
81.0	12
82.0	3
84.0	6
89.0	3
93.0	12
96.0	6
103.0	6
104.0	6
105.0	3
107.0	6
117.0	6
118.0	3
120.0	3
129.0	3
130.0	3
133.0	3
141.0	3
154.0	3

RELAXATION MODULUS AT 50 SEC, 3 PCT STN, 5 MOTOR COMPOSITE

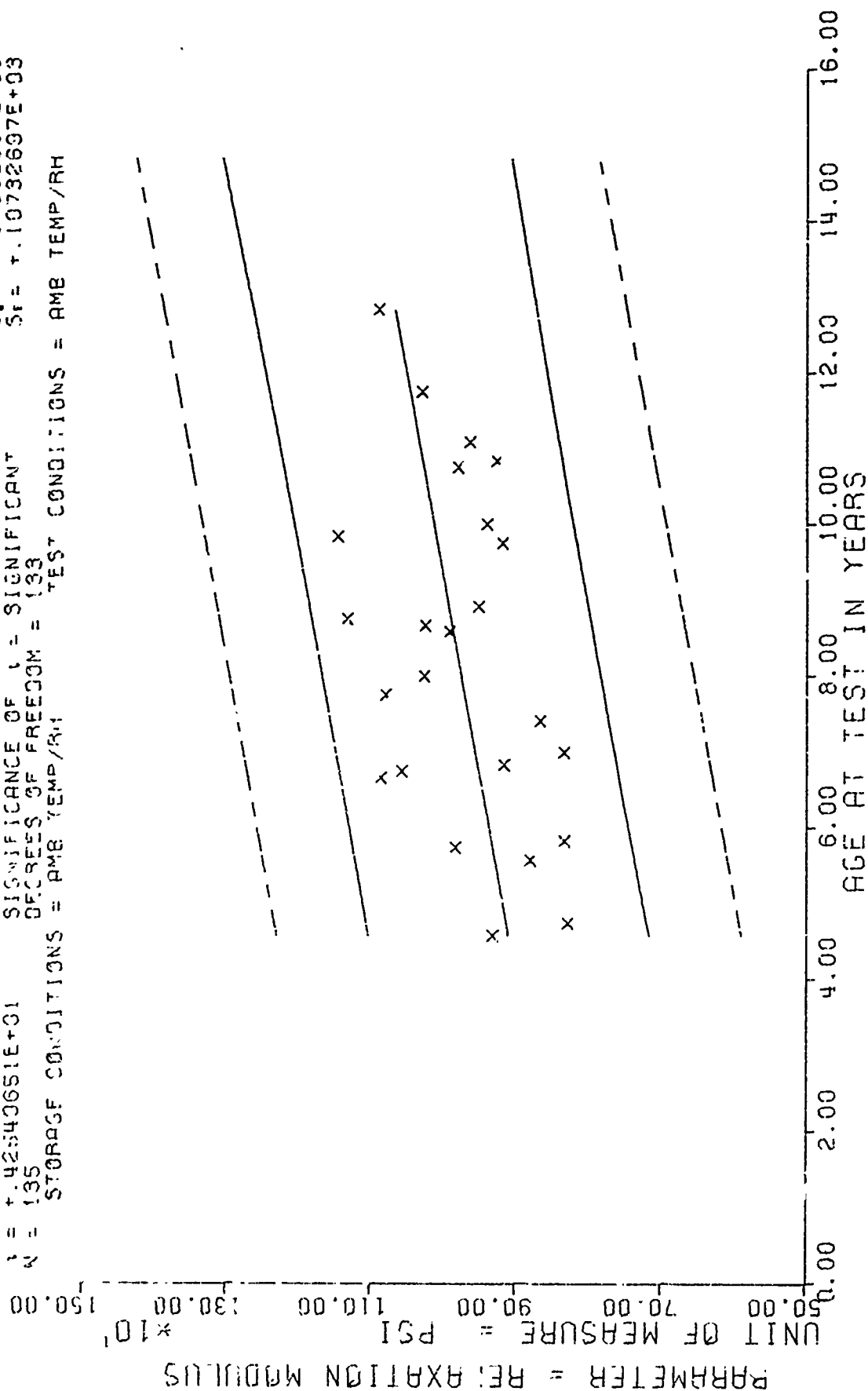


Figure 8-2

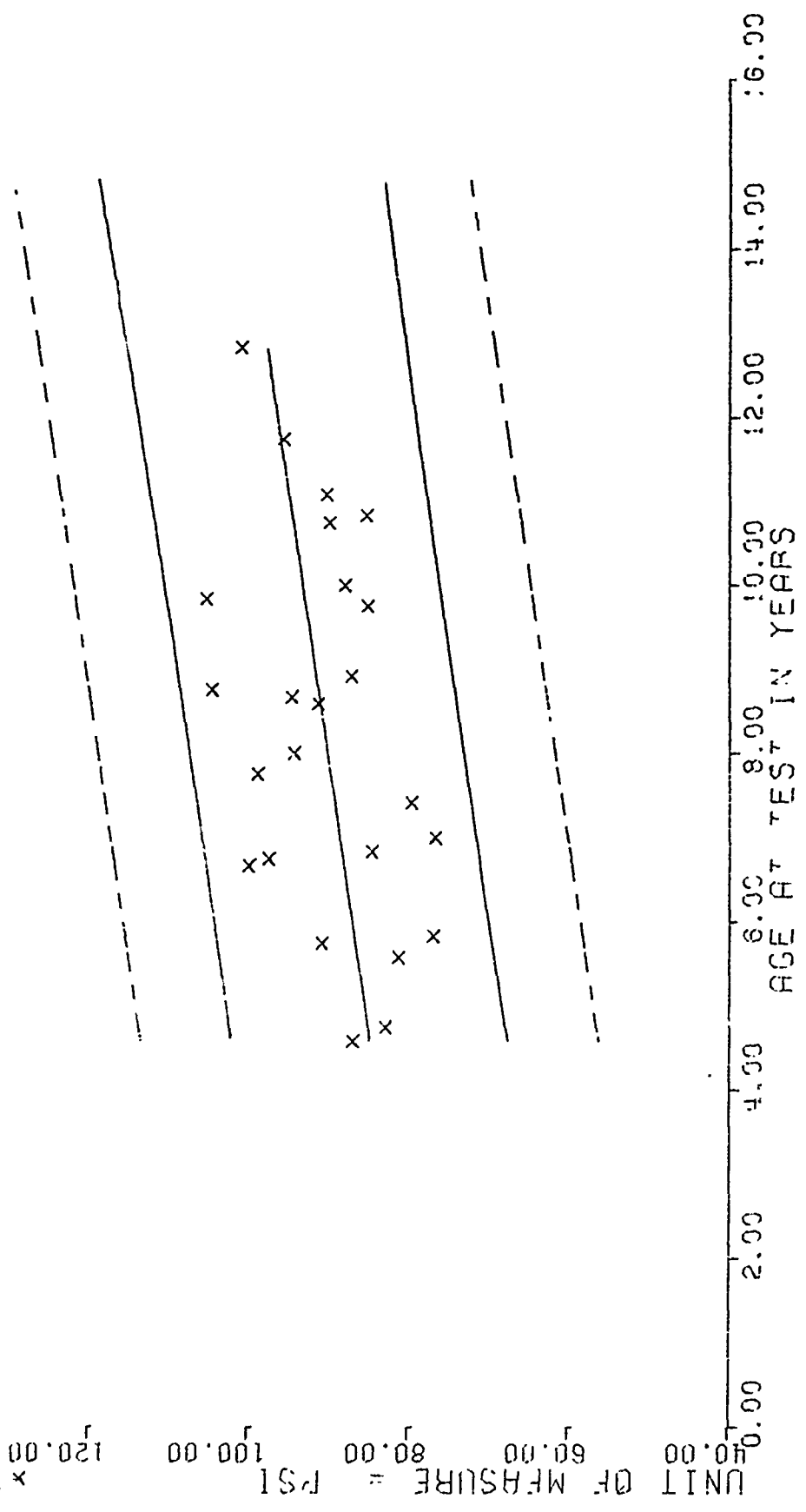
*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.05	105
57.0	6
67.0	10
69.0	6
70.0	10
80.0	3
81.0	12
82.0	3
84.0	6
89.0	3
93.0	12
96.0	6
103.0	6
104.0	6
105.0	3
107.0	6
117.0	6
118.0	3
123.0	3
129.0	3
130.0	3
133.0	3
141.0	3
154.0	3

RELAXATION MODULUS AT 100 SEC, 3 PCT STN, 5 MOTOR COMPOSITE

$F = +.15307803E+02$
 $R = +.32127315E+00$
 $t = +.33125188E+01$
 $N = 135$
 $Y = (+.77634488E+03) + (+.13120215E+01) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 133
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH

PARAMETER - RELAXATION MODULUS
 UNIT OF MEASURE = PSI
 $\times 10^1$



RELAXATION MODULUS AT 100 SEC, 3 PCT STN, 5 MOTOR COMPOSITE

Figure 8-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(55.0S)	105
57.0	6
67.0	10
69.0	6
70.0	10
80.0	3
81.0	12
82.0	3
84.0	6
89.0	3
93.0	12
96.0	6
103.0	6
104.0	6
105.0	3
107.0	6
117.0	6
118.0	3
120.0	3
129.0	3
130.0	3
133.0	3
141.0	3
154.0	3

RELAXATION MODULUS AT 1000 SEC. 3 PCT STN. 5 MOTOR COMPOSITE

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$\gamma = (+.61606961E+03) + (+.11269129E+01) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF χ^2 = SIGNIFICANT
 DEGREES OF FREEDOM = 133
 STORAGE CONDITIONS = AMB TEMP/HR
 TEST CONDITIONS = AMB TEMP/HR

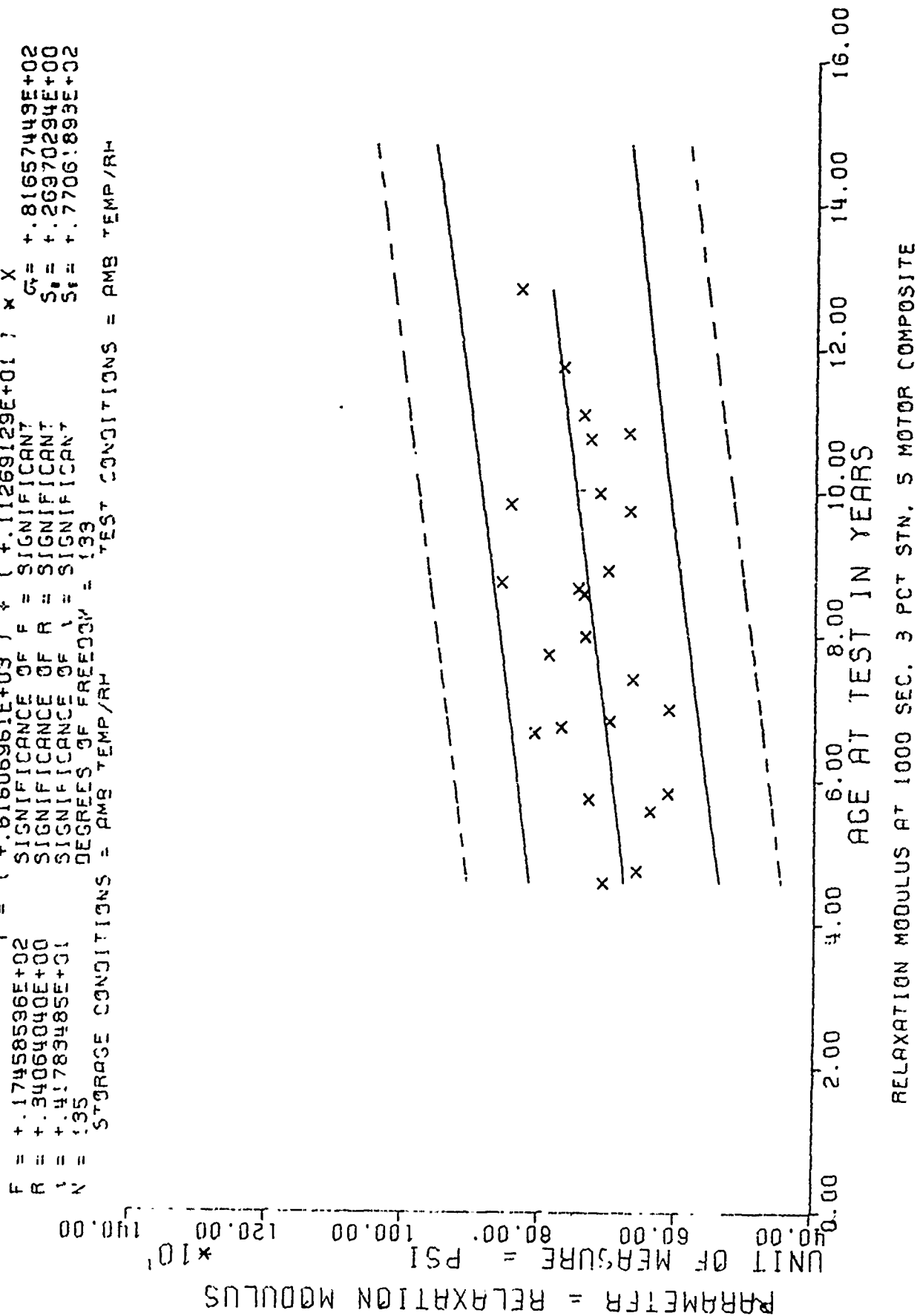


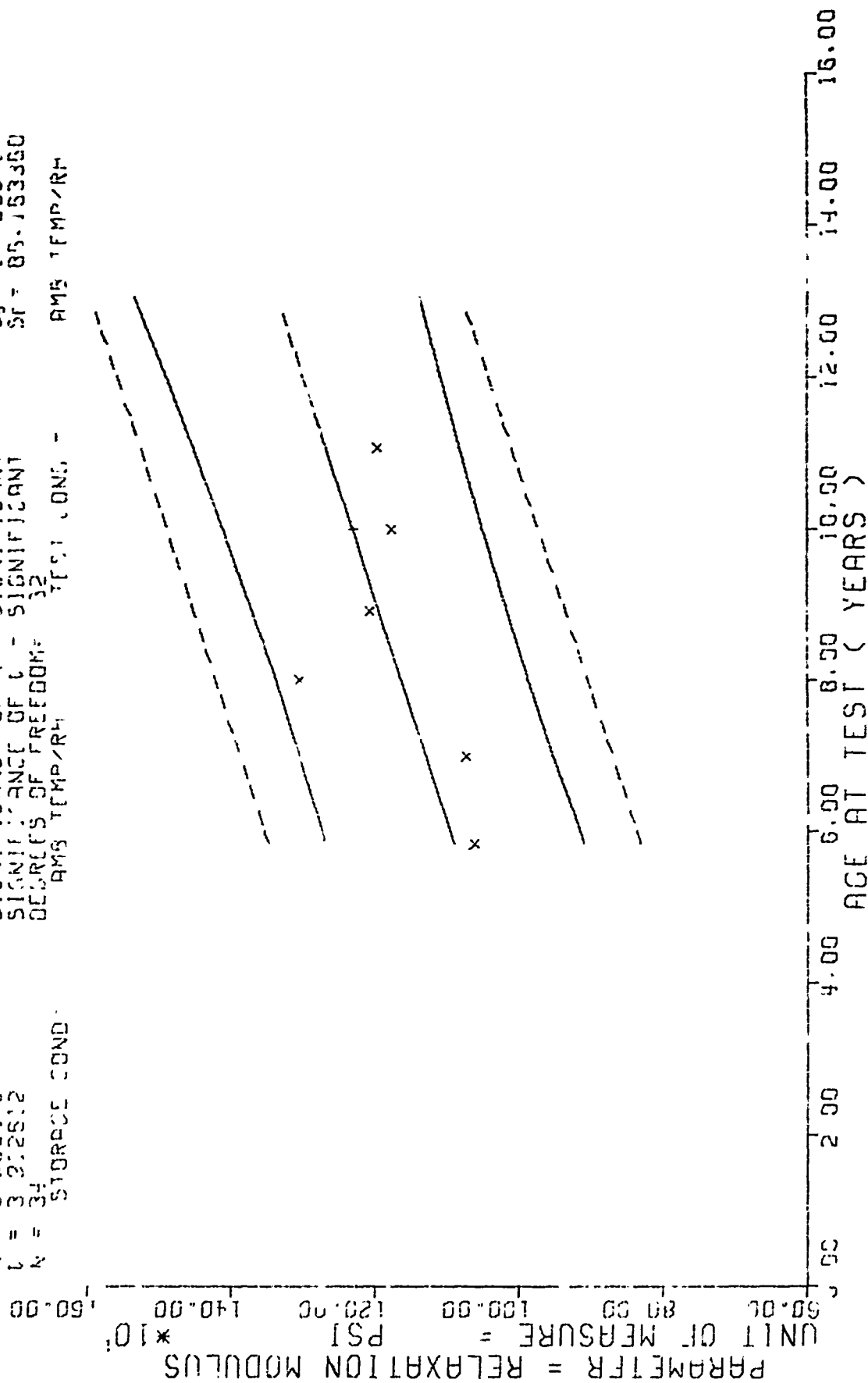
Figure 8-4

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
70.0	10
84.0	6
96.0	6
107.0	6
120.0	3
133.0	3

10 Sec Stress Relaxation Modulus E(T) at 3% Strain, Motor 0031064

F = 15.308540
 R = 0.568419
 U = 3.92612
 N = 37
 STORAGE COND -
 Y = (888.732013) + (2.951011) * X
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF U = SIGNIFICANT
 DEGREES OF FREEDOM = 32
 RMS TEMP/RH TEST COND. - RMS TEMP/RH
 QV = 103.165710
 Sg = 0.728572
 Sf = 85.153360



10 SEC STRESS RELAXATION MODULUS E(T) AT 37 STRAIN, MOTOR POSITION

Figure 8-5

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
70.0	10
84.0	6
96.0	6
107.0	6
120.0	3
133.0	3

1000 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0031064

SAMPLE SIZE SUMMARY

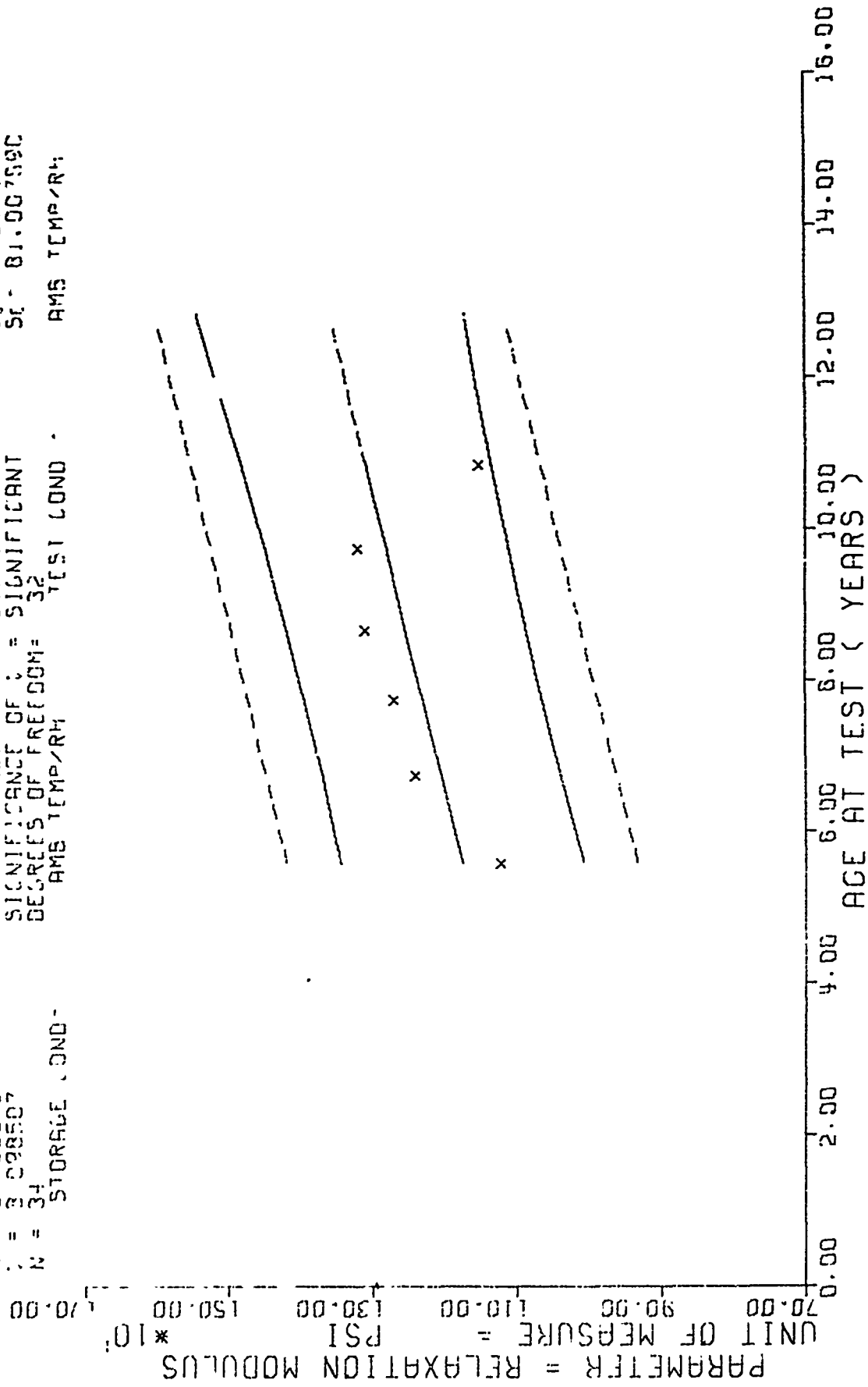
AGE (MONTHS)	NR SAMPLES
67.0	10
81.0	6
93.0	6
104.0	6
117.0	3
130.0	3

10 Sec Stress Relaxation Modulus E(T) at 3% Strain, Motor 0031134

$F = 9.600749$
 $R = 0.480399$
 $S = 3.098507$
 $N = 34$

$Y = (1032.329589) + (2.122697) \times X$

SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF S = SIGNIFICANT
 DEGREES OF FREEDOM = 32
 AMS TEMP/RH TEST COND AMS TEMP/RH



10 SEC STRESS RELAXATION MODULUS E(t) AT 3% STRAIN, MOTOR 0031134

Figure 8-7

SAMPLE SIZE SUMMARY

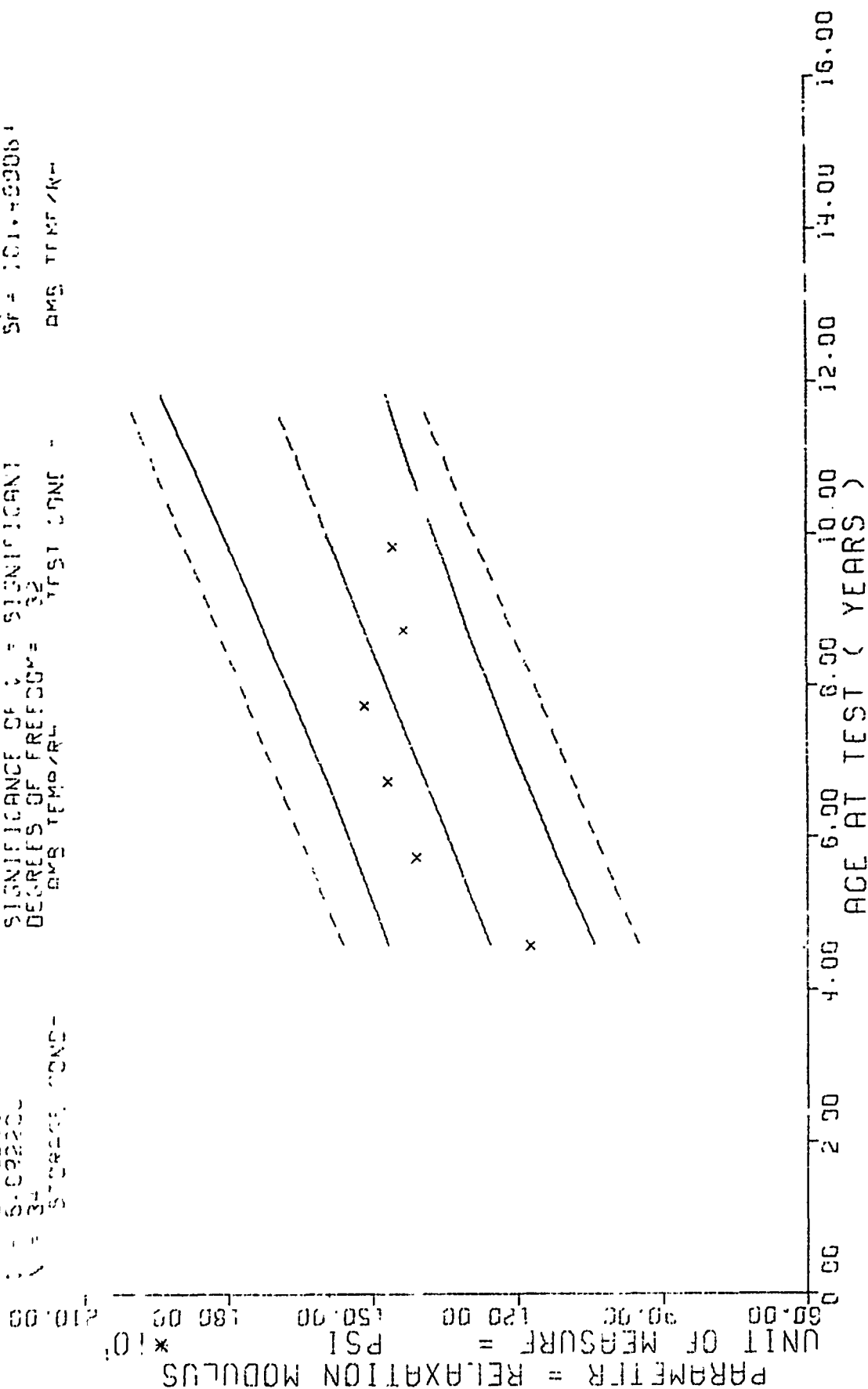
AGE (MONTHS)	NR SAMPLES
67.0	10
81.0	6
93.0	6
104.0	6
117.0	3
130.0	3

1000 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0031134

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
55.0	10
69.0	6
81.0	6
93.0	6
105.0	3
118.0	3

10 Sec Stress Relaxation Modulus E(T) at 3% Strain, Motor 0032434



10 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0032434

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
55.0	10
69.0	6
81.0	6
93.0	6
105.0	3
118.0	3

1000 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0032434

154 - REF : 114 - 11 NC

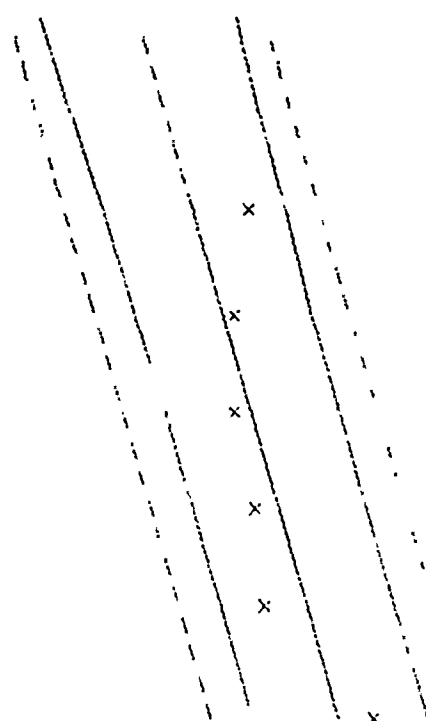
33X

[illegible]

1997

11/11/11 11:11:11

5-1-22
10-1-22
10-1-22
10-1-22

[illegible]

Year	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
Population (millions)	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	

IN PRESS. MAXIMIZATION OF STIRLING MOTOR EFFICIENCY

Figure 8-10

SAMPLE SIZE SUMMARY

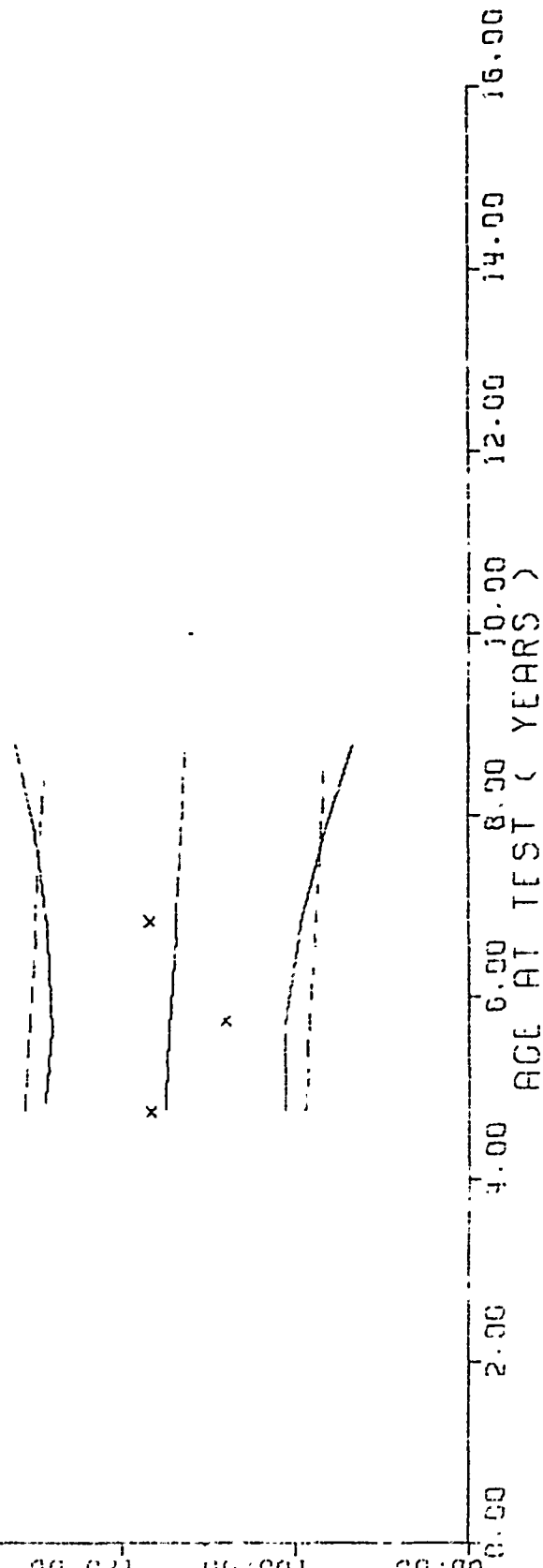
AGE (MONTHS)	NR SAMPLES
57.0	6
69.0	3
82.0	3

10 Sec Stress Relaxation Modulus E(T) at 3% Strain, Motor 0033174

Y = (1179.836914) + (-0.500583) * X
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF U = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 10
 RMS TEMP/RH TEST COND - RMS TEMP/RH

F = 0.110753
 R = -0.10186
 U = 0.110796
 D = 12

PARAMETER = RELAXATION MODULUS
 UNIT OF MEASURE = PSI * 10¹⁰



10 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN. MOTOR 0033:74

Figure 8-11

SAMPLE SIZE SUMMARY

AGE (MONTHS)	NR SAMPLES
57.0	6
69.0	3
82.0	3

1000 SEC STRESS RELAXATION MODULUS E(T) AT 3% STRAIN, MOTOR 0033174

1000000
 500000
 250000
 125000
 62500
 31250
 15625
 7812.5
 3906.25
 1953.125
 976.5625
 488.28125
 244.140625
 122.0703125
 61.03515625
 30.517578125
 15.2587890625
 7.62939453125
 3.814697265625
 1.9073486328125
 0.95367431640625
 0.476837158203125
 0.2384185791015625
 0.11920928955078125
 0.059604644775390625
 0.0298023223876953125
 0.01490116119384765625
 0.007450580596923828125
 0.0037252902984619140625
 0.00186264514923095703125
 0.000931322574615478515625
 0.0004656612873077392578125
 0.00023283064365386962890625
 0.000116415321826934814453125
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 0.00002910383045673370361328125
 0.000014551915228366851806640625
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 0.00000045474735088646411895751953125
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 0.00000000000000000010339757656912845935892385838374535669557618468923828125
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 0.0000000000000000000258493941422821148397309645959363391738940461723095703125
 0.00000000000000000001292469707114105741986548229796816958694702308615478515625
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 0.000000000000000000001615587133892632177483185287247102198368377885769348203125
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 0.000000000000000000000000788860905221011805411483341038624120297059514535814552001953125
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 0.00000000000000000000000019721522630525295135287083525965603007426487863395363800048828125
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 0.00000000000000000000000000000000000000000068422776578360208541176347316694450508714089388714005277885624949576562500610351562500000

SECTION IX
HIGH RATE TENSILE

In an effort to bring the MANCP program closer to the proposed LRSLA program, limited dogbones were tested under high rate conditions. Data with and without pressure are given in the table below.

High Rate Dogbones - EGL 1.75 CSA 0.1875

<u>Motor</u>	<u>Test Date</u>	<u>Without Pressure</u>		<u>er</u>	<u>Sr</u>	<u>E</u>
		<u>em</u>	<u>Sm</u>			
31134	74028	.329	1552	.334	1546	7547
		.339	1543	.348	1532	7289
32434		.361	1351	.364	1345	5028
		.312	1461	.323	1456	6870
		.304	1486	.311	1477	6645
33174		.297	1465	.304	1455	7032
		.294	1459	.299	1454	7717
		.310	1487	.321	1476	6902
31134	74165	<u>300 psi</u>				
		.324	1343	.335	1334	5483
		.301	1379	.308	1369	6058
32434		.301	1290	.305	1286	5550
		.329	1261	.347	1247	5684
		.343	1277	.347	1270	5409
33174		.306	1474	.309	1464	8375
		.290	1281	.300	1270	6155
		.311	1334	.320	1325	6020
		.324	1413	.329	1408	6494

From this data, there does not seem to be an appreciable difference between specimens tested with and without pressure. The expected increase in strain capability is absent. This may be a result of the longer storage after specimen preparation.

SECTION X

HARDNESS

Shore A and Shore C durometer readings are taken on JANNAP dogbone ends prior to tensile testing.

There is a significant decrease in Shore A 10 second readings (Figure 10-1). This trend is undoubtedly the result of the lower values for 1973 testing.

There is a significant increase in Shore C 10 second readings (Figure 10-2). There is no consistency of readings between Shore A and Shore C, that is, the lows and highs do not show up in both sets of data at the same test period.

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	15
58.0	10
67.0	1
68.0	1
69.0	5
70.0	1
80.0	1
82.0	5
83.0	1
84.0	5
93.0	5
95.0	5
97.0	5
98.0	5
103.0	4
105.0	20
108.0	10
113.0	5
116.0	5
118.0	5
120.0	5
130.0	10
133.0	5
138.0	5
154.0	5

SHORE A 10 SECOND HARDNESS, 5 MOTOR COMPOSITE

$\gamma = (+.84924580E+02) + (-.23428447E-01) \times X$
 F = +.71188091E+01 SIGNIFICANCE OF F = SIGNIFICANT G = +.23835672E+01
 R = -.23403021E+00 SIGNIFICANCE OF R = SIGNIFICANT S = +.86015498E-02
 N = +.27237490E-01 SIGNIFICANCE OF N = SIGNIFICANT SE = +.23263913E+01
 N = 190 DEGREES OF FREEDOM = 128
 STORAGE CONDITIONS = AVG TEMP/RH TEST CONDITIONS = AVG TEMP/RH

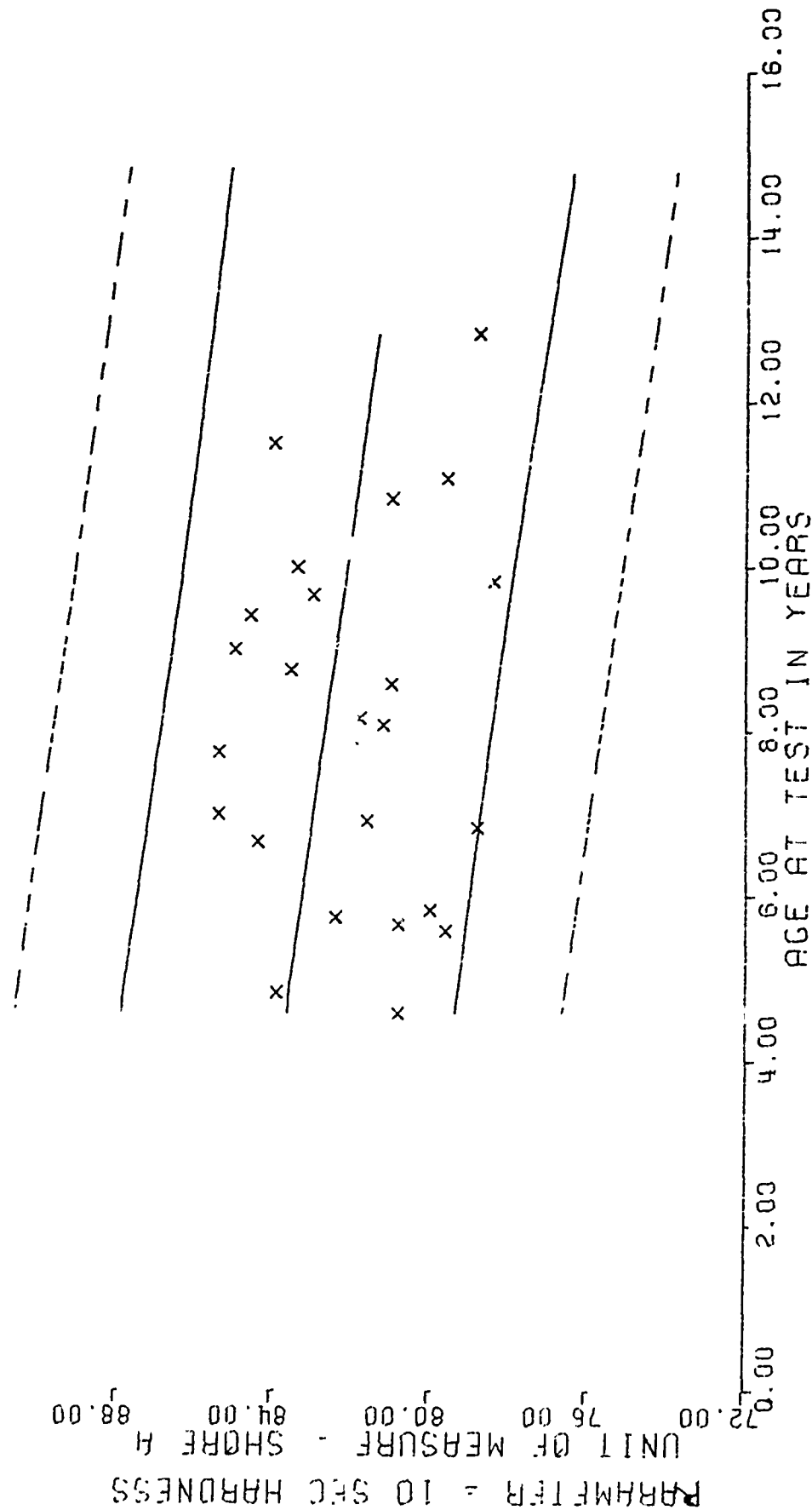


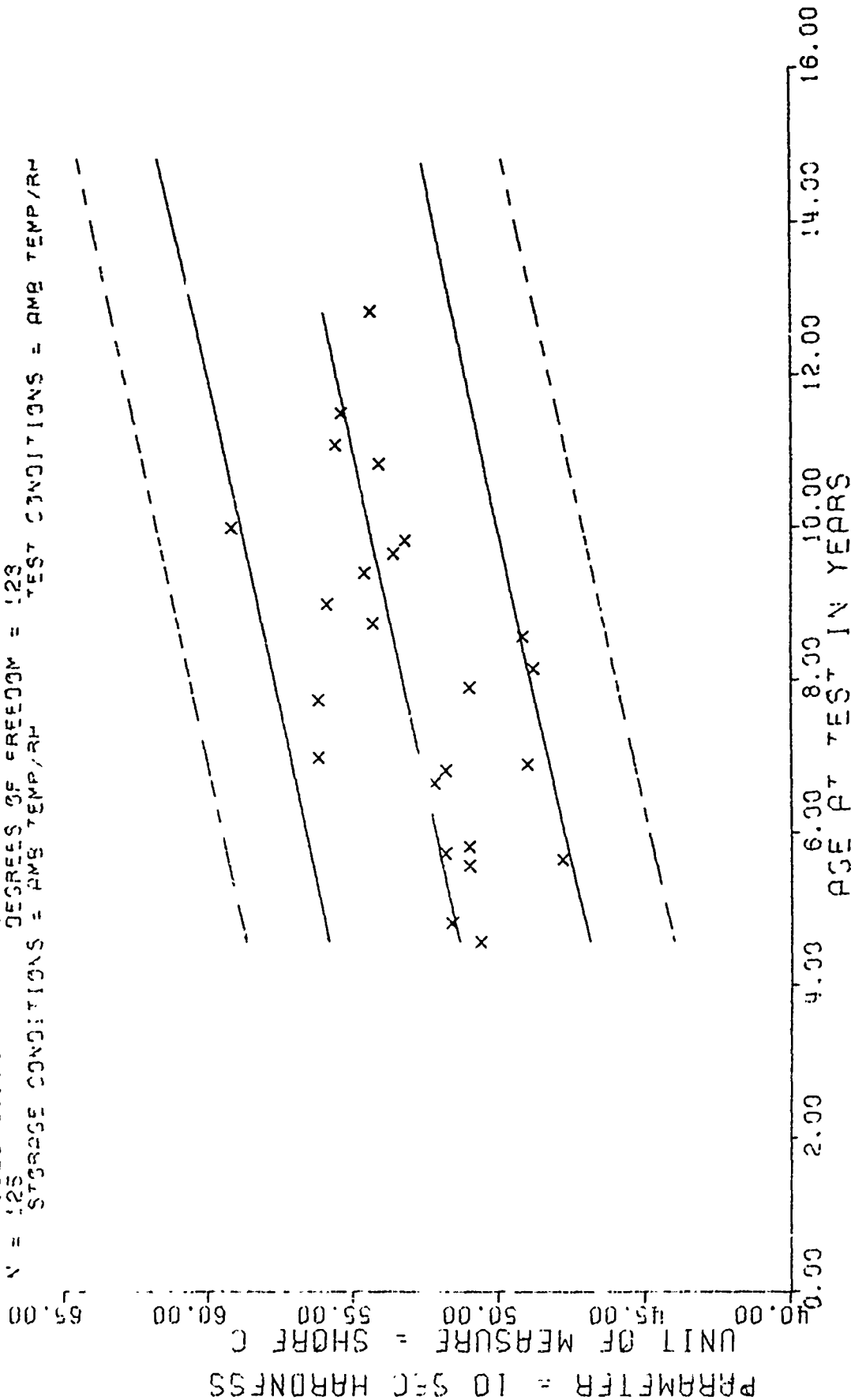
Figure 10-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
55.00	15
58.0	10
67.0	1
68.0	1
69.0	5
70.0	1
80.0	1
82.0	5
83.0	1
84.0	5
93.0	5
95.0	5
98.0	5
103.0	4
105.0	20
108.0	10
113.0	5
116.0	5
118.0	5
120.0	5
130.0	10
133.0	5
138.0	5
154.0	5

SHORE C 10 SECOND HARDNESS, 5 MOTOR COMPOSITE

$F = +.27607253E+02$
 $R = +.42814281E+00$
 $N = +.52542605E+01$
 $Y = (+.48727587E+02) + (+.47704592E-01) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF N = SIGNIFICANT
 DEGREES OF FREEDOM = 128
 STORAGE CONDITIONS = RMS TEMP/RH
 TEST CONDITIONS = RMS TEMP/RH
 $G = +.27022739E+01$
 $S = +.90792210E-02$
 $S = +.24513814E+01$



SECTION XI

THERMAL ANALYSIS

Thermo-analytical testing was limited during this test period. The new TGA was not available and testing of TCLE was delayed so long that the data are not comparable to previous data. The Tg of the recent tests is lower and the TCLE after transition is also lower.

A. Heat of Explosion

This test is run on a 5 gram sample in the Parr Adiabatic Calorimeter under 25 atm of nitrogen.

The five motor composite shows a significant increase (Figure 11-1). This change from lowest to highest values represents a spread of less than 2% of the caloric value.

B. Burning Rate

This test is performed on surface-inhibited strands of propellant (.156" x .156" x 5") at 500 psi N₂ in the Strand Burner Test Apparatus.

The five motor composite has not shown a significant change (Figure 11-2).

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
59.0	1
70.0	3
82.0	5
95.0	7
98.0	5
106.0	1
107.0	8
110.0	2
118.0	5
121.0	1
130.0	3
131.0	2
133.0	3
142.0	1
154.0	3

11-2

HEAT OF EXPLOSION, 5 MOTOR COMPOSITE

$Y = (+.16920383E+04) + (+.12915452E+00) \times X$
 F = +.30110813E+01 SIGNIFICANCE OF F = NOT SIGNIFICANT $G = +.11576188E+02$
 R = +.24060098E+00 SIGNIFICANCE OF R = NOT SIGNIFICANT $S = +.74430054E-01$
 t = +.17352460E+01 SIGNIFICANCE OF t = SIGNIFICANT $SE = +.11350177E+02$
 N = 51 DEGREES OF FREEDOM = 49 TEST CONDITIONS = N/A
 STORAGE CONDITIONS = AMBI TEMP AT

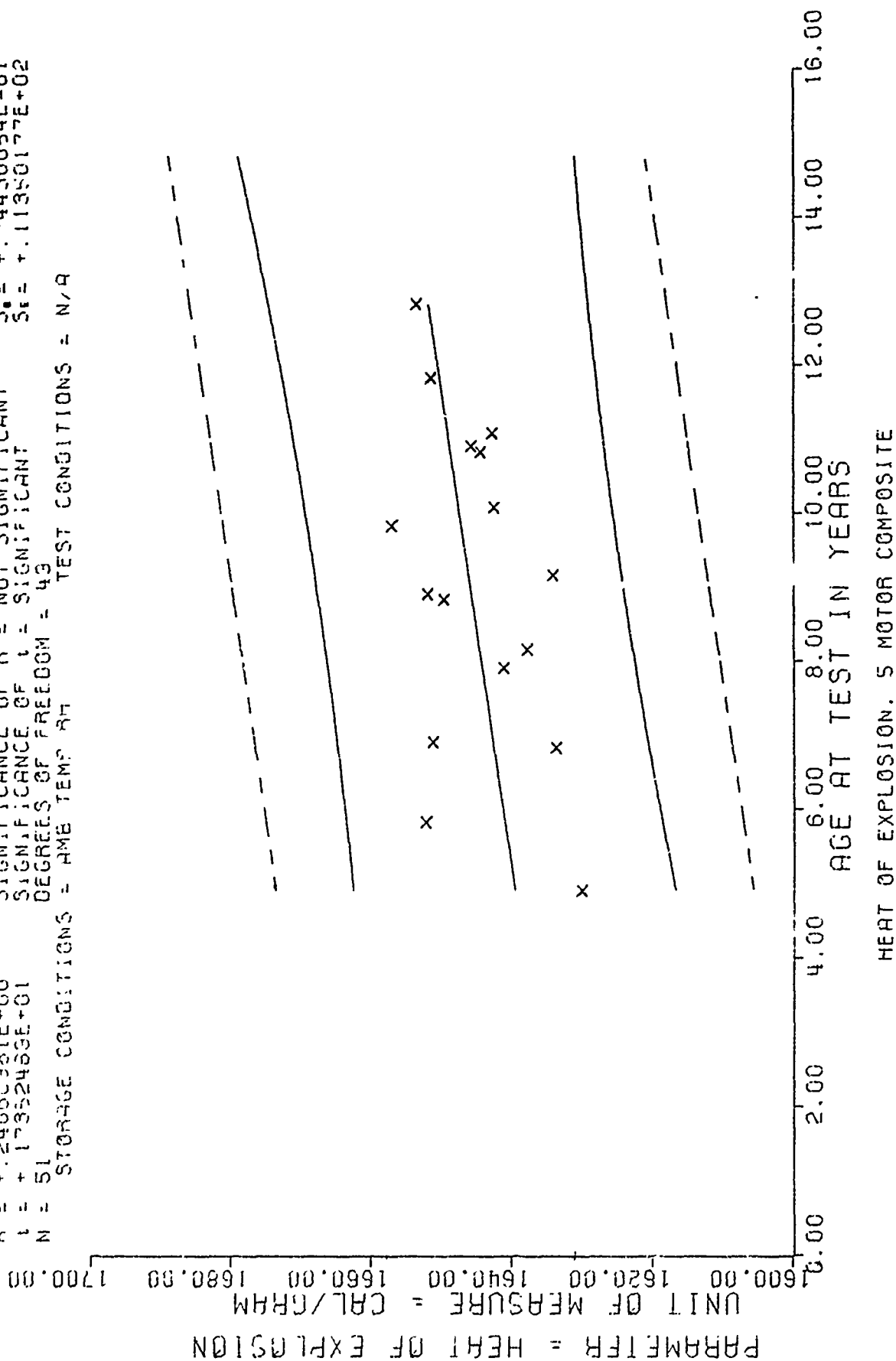


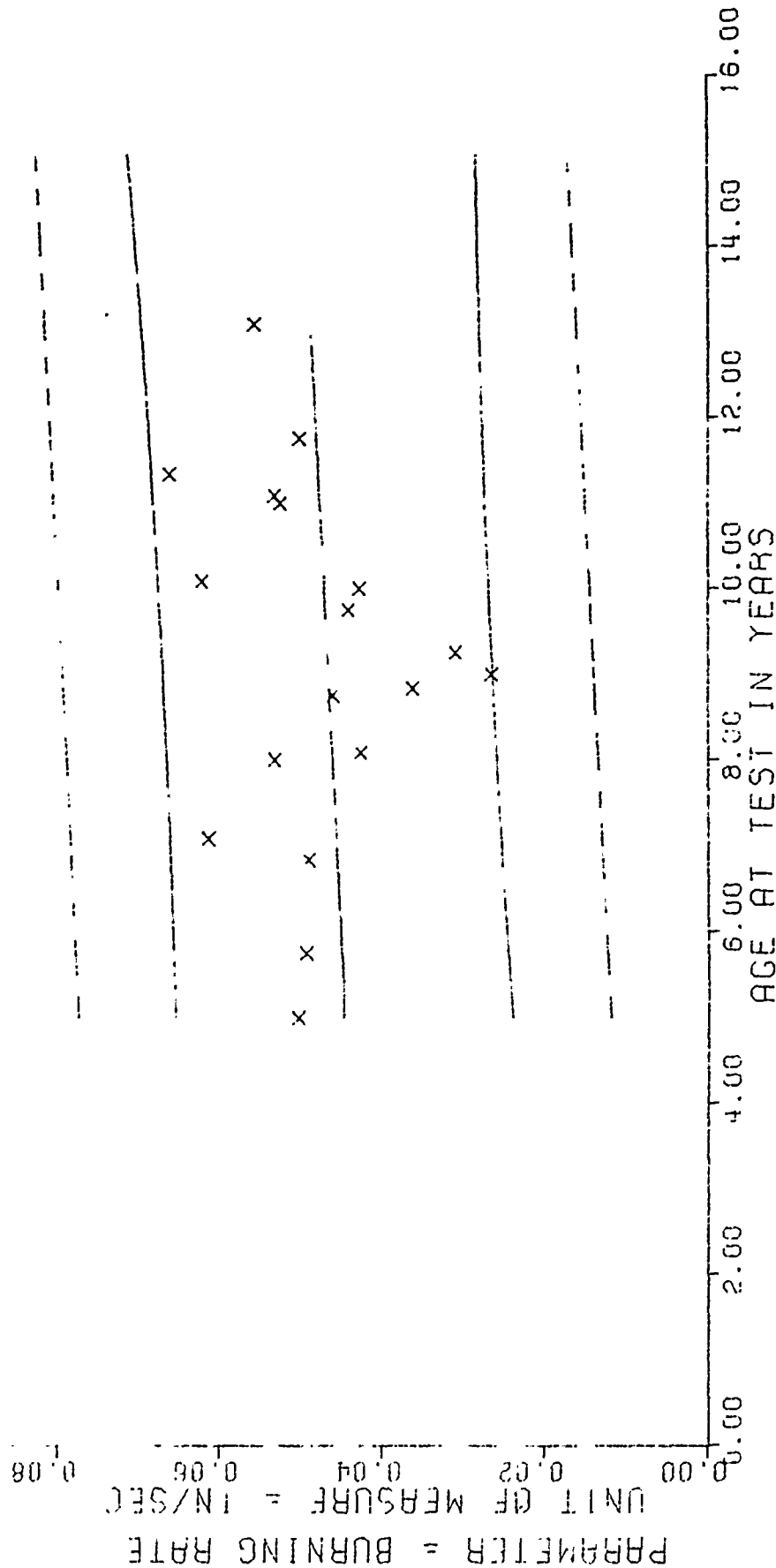
Figure 11-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
60.0-65.0	65
65.0	3
82.0	6
85.0	3
96.0	6
97.0	6
105.0	3
106.0	6
108.0	6
111.0	6
117.0	3
120.0	3
121.0	3
132.0	6
133.0	3
136.0	3
141.0	3
157.0	3

BOLWIN, RAY, 500 PSI, 5 VOLT COMPOSITE

$Y = (+.42008895E-01) + (+.43509890E-04) X$
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF S.E. = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 15
 CORRELATION COEFFICIENT = .00000000
 CONDITIONS = 500 PSI
 AGE TEMP / RH



BURNING RATE, 500 PSI, 5 MOTOR COMPOSITE

Figure 11-2

SECTION XXII

CASE BONDS

The case-liner bond system has been tested for tensile strength and peel strength.

A. The case bond tensile specimens were tested on the Instron at a crosshead speed of 0.1 in/min. The specimens usually failed cohesively in the propellant with some failures in the embedment grain.

The composite regression shows a significant increase in tensile bond strength (Figure 12-1). Individually the motors show a significant increase (Figures 12-2 thru 12-6) except 0033174 (Figure 12-5).

The 1968 and 1973 data for 0031064 are very close. Both sets of data are lower than for any other years (Figure 12-2). The same is true of 0031134 and 0032434 (Figure 12-3 and 4). Grain 131 has a higher value than in 1968 and, in fact, is greater than for any other test period (Figure 12-6).

B. The case bond peel specimens were tested on the Instron at a crosshead speed of 5 in/min in the 90° peel fixture. Motors 0031064 and 0031134 showed embedment grain to resin failure. Motor 0032434 rubber to resin failure and motor 0033174 showed cohesive failure in embedment grains, resin to grain failure and cohesive failure in resin. One peel strip for Grain 131 showed excellent embedment with cohesive failure in the granules. The other two showed approximately 40% exposure of rubber.

Average peel strength shows a significant decrease for the five motor composite (Figure 12-7). The change in peel strength is not significant for motors 0031064, 0031134 and 0033174 (Figure 12-8, 9 and 11). Motor 0032434 shows a significant decrease (Figure 12-10) and Grain 131 shows a significant increase (Figure 12-12).

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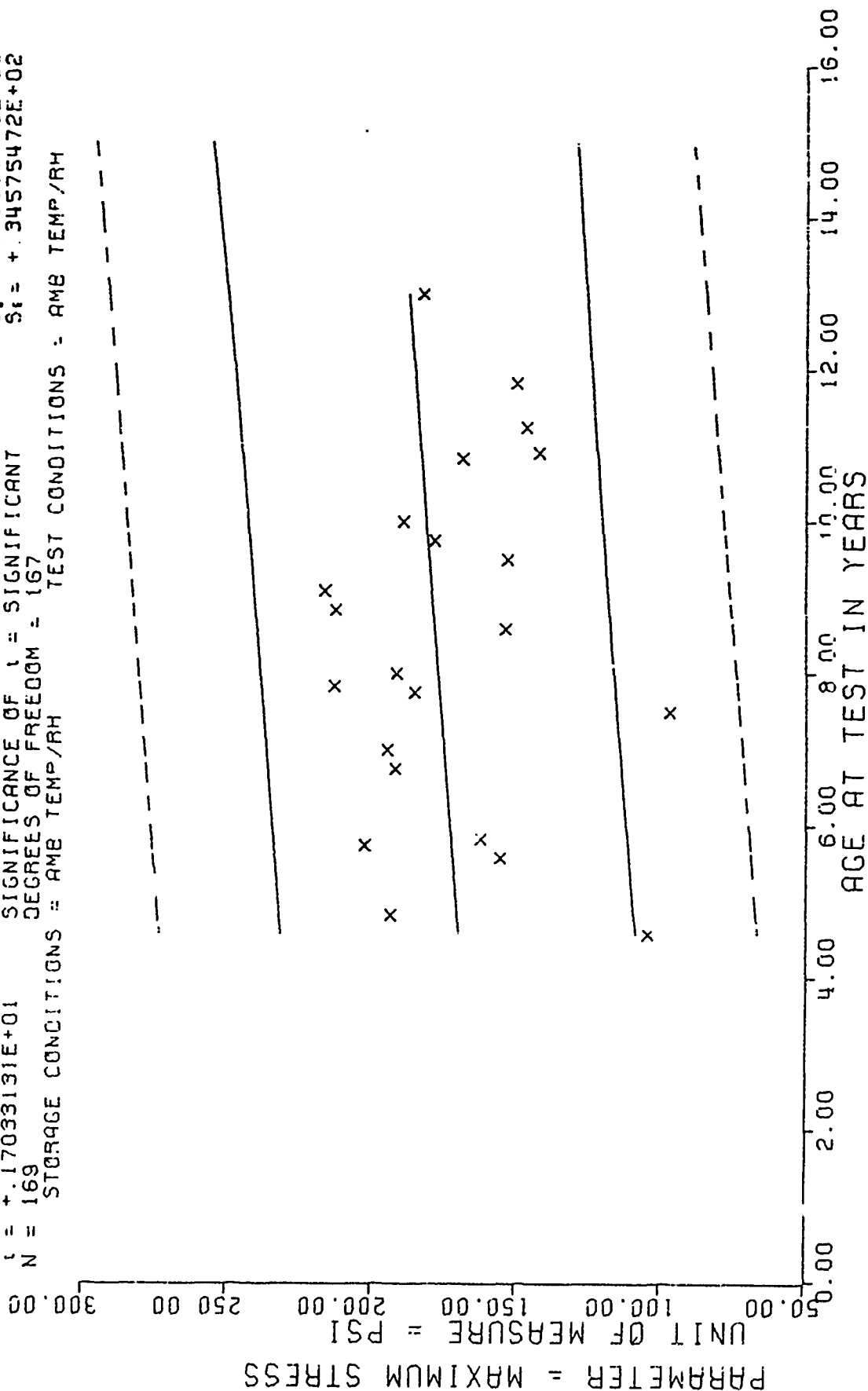
*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
55.0	12
58.0	6
67.0	12
69.0	14
70.0	11
81.0	16
84.0	13
90.0	2
93.0	6
94.0	6
96.0	6
103.0	6
106.0	12
109.0	6
114.0	5
117.0	6
120.0	9
130.0	6
131.0	3
135.0	3
142.0	6
156.0	3

12-3

CASE BCND TENSILE MAXIMUM STRESS, CHS 0.1, CSA 1.0, 5 MOYOR COMPOSITE

$F = +.29012758E+01$
 $R = +.13067610E+00$
 $t = +.17033131E+01$
 $N = 169$
 $Y = \{ +.16036816E+03 \} + \{ +.17710660E+00 \} \times X$
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 167
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH



CASE BOND TENSILE MAXIMUM STRESS, CHS 0.1, CSA 1.0, 5 MOTOR COMPOSITE

FIGURE 12-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
70.0	11
84.0	10
96.0	6
109.0	6
120.0	6
135.0	3

CASE BOND TENSILE MAXIMUM STRESS, CHS 0.1, CSA 1.0, MOTOR # 0031064

$$Y = \{ +.17009567E+03 \} + \{ +.18309751E+00 \} \times X$$

$$F = +.91230721E+00$$

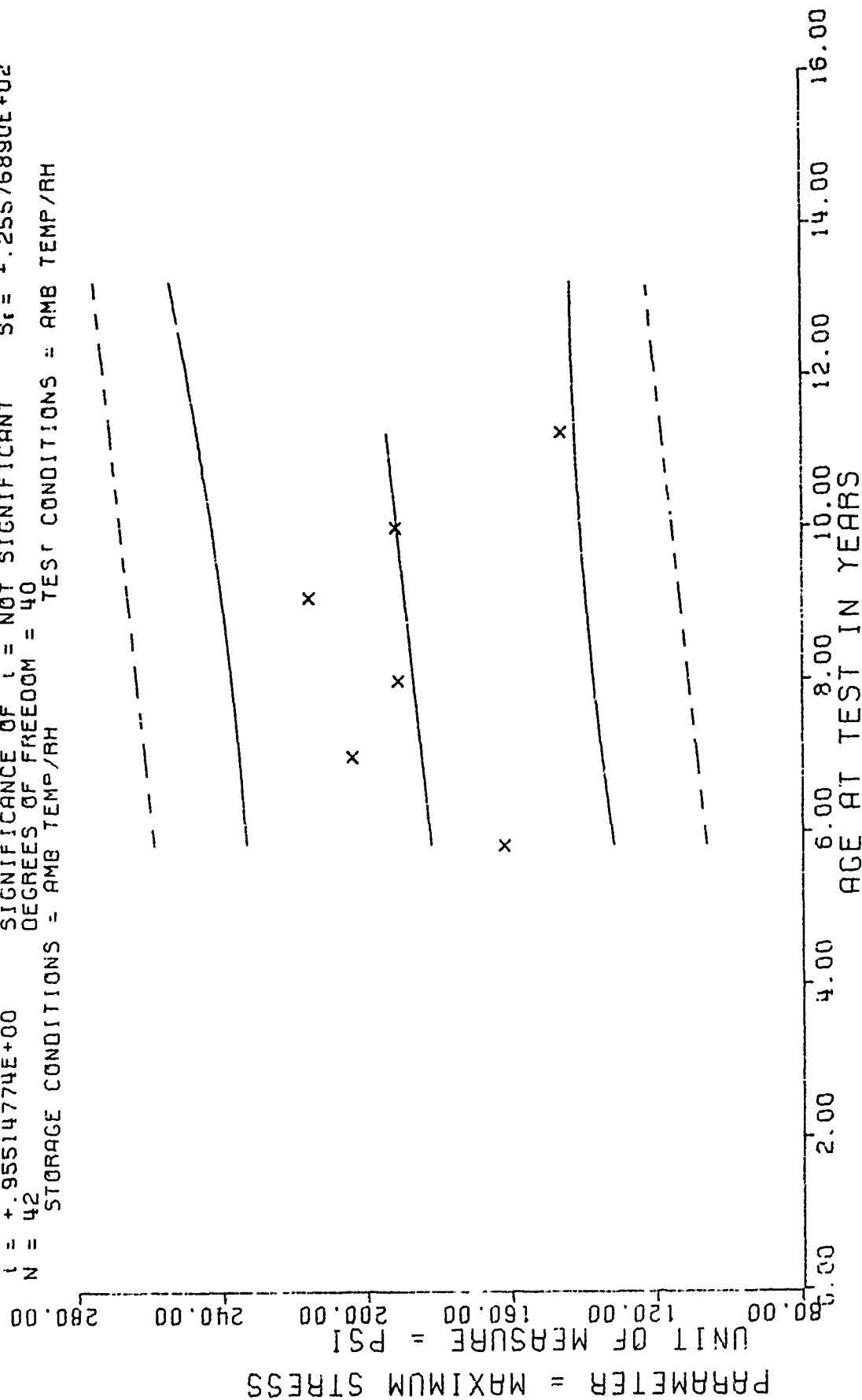
$$R = +.14932879E+00$$

$$t = +.95514774E+00$$

$$N = 42$$

SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF t = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 40

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



CASE BOND TENSILE MAXIMUM STRESS, CHS 0.1. CSA 1.0. MOTOR # 0031064

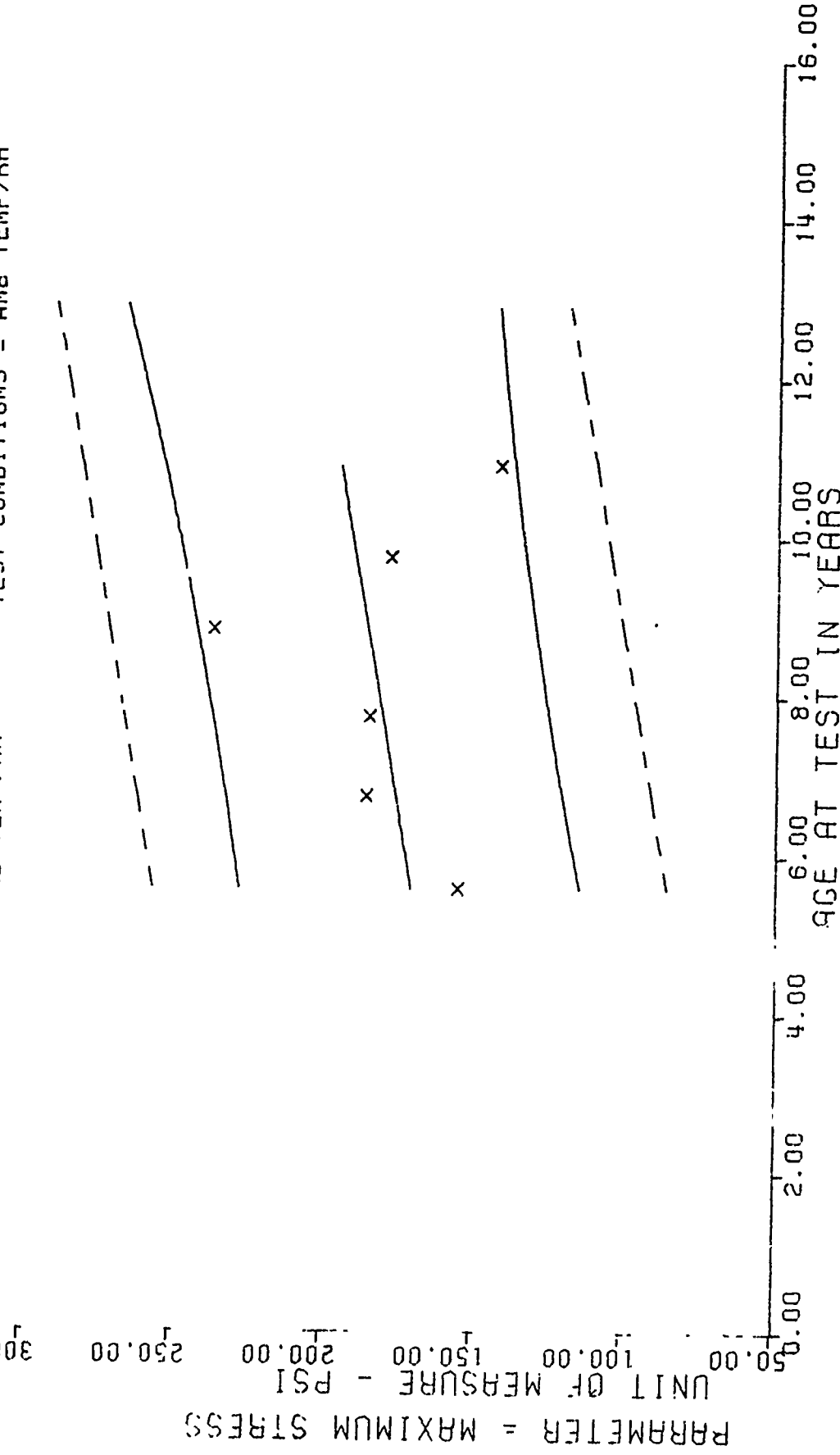
FIGURE 12-2

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
67.05	125
81.0	10
93.0	6
106.0	6
117.0	6
131.0	3

CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, SIN RT 0.1, MOTOR # 0031134

$Y = (+.14607616E+03) + (+.37707530E+00) \times X$
 $F = +.31615576E+01$ SIGNIFICANCE OF F = NOT SIGNIFICANT $G_1 = +.292888007E+02$
 $R = +.25756442E+00$ SIGNIFICANCE OF R = NOT SIGNIFICANT $S_1 = +.21206916E+00$
 $t = +.17780769E+01$ SIGNIFICANCE OF t = SIGNIFICANT $S_t = +.28562240E+02$
 $N = 43$ DEGREES OF FREEDOM = 41
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN AT 0.1, MOTOR * 0031134

FIGURE 12-3

PARAMETER = MAXIMUM STRESS

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
(-55.05)	125
69.0	10
81.0	6
94.0	6
106.0	6
120.0	3

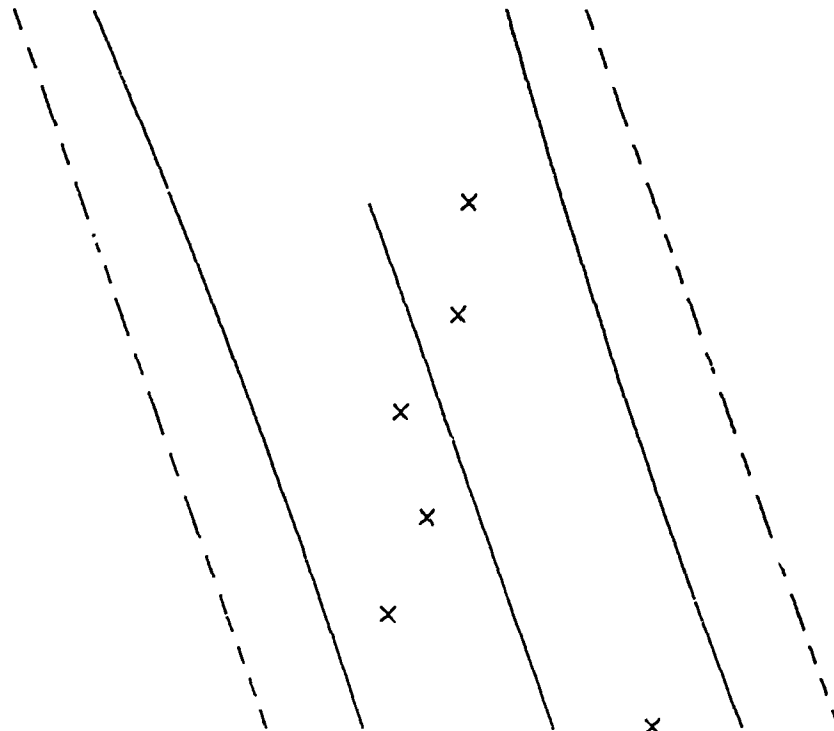
CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR # 0032434

PARAMETER = MAXIMUM STRESS

UNIT OF MEASURE = PSI

0.00 80.00 160.00 240.00 320.00 400.00

F = +.16293092E+02) + (+.12261920E+01) * X
 R = +.53327426E+00 SIGNIFICANCE OF F = SIGNIFICANT
 t = +.40364702E+01 SIGNIFICANCE OF R = SIGNIFICANT
 N = 43 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 41
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



AGE AT TEST IN YEARS

0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00

CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN AT 0.1, MODUL * 0032434

FIGURE 12-4

*** SAMPLE SIZE SUMMARY ***

AVE (MONTHS)	Nr. SAMPLES
58.05	65
69.0	4
84.0	3

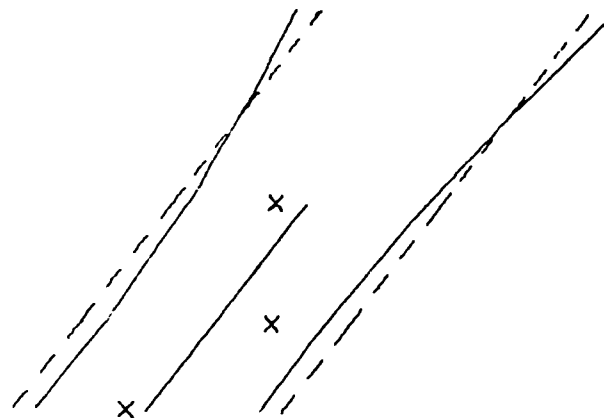
CASE BUND TENSILE MAXIMUM STRESS, CSA 1.0, SIN RT 0.1, MOTOR # 0033174

$\gamma = (+.26416542E+03) + (-.13015417E+01) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 11
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH

F = +.24639310E+02
 R = -.83147582E+00
 t = +.49638000E+01
 N = 13

PARAMETER = MAXIMUM STRESS

UNIT OF MEASURE = PSI



CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN AT 0.1, MOTOR = 0033174

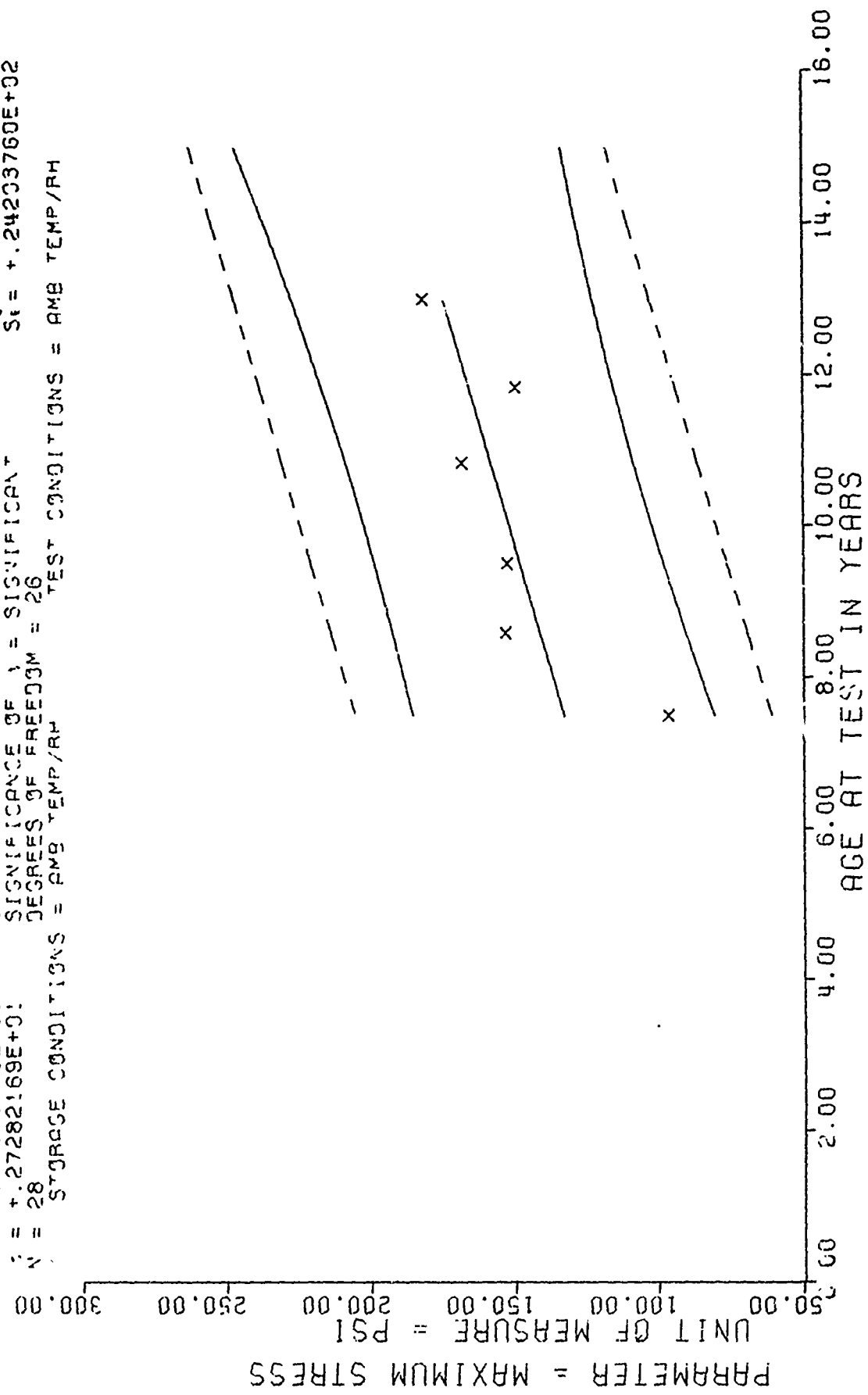
FIGURE 12-5

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NR SAMPLES
90.00	25
103.0	6
114.0	5
130.0	6
142.0	6
156.0	3

CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR # 00GR131

$Y = ($
 $F = +.74431674E+01$
 $R = +.47176443E+00$
 $S = +.27282169E+01$
 $N = 28$
 $Y = ($
 $0418E+02) + (+.63868174E+00) \times X$
 $SIGNIFICANCE OF F = SIGNIFICANT$
 $SIGNIFICANCE OF R = SIGNIFICANT$
 $SIGNIFICANCE OF S = SIGNIFICANT$
 $DEGREES OF FREEDOM = 26$
 $STORAGE CONDITIONS = AMB TEMP/RH$
 $TEST CONDITIONS = AMB TEMP/RH$



CASE BOND TENSILE MAXIMUM STRESS, CSA 1.0, STN RT 0.1, MOTOR # 006R131

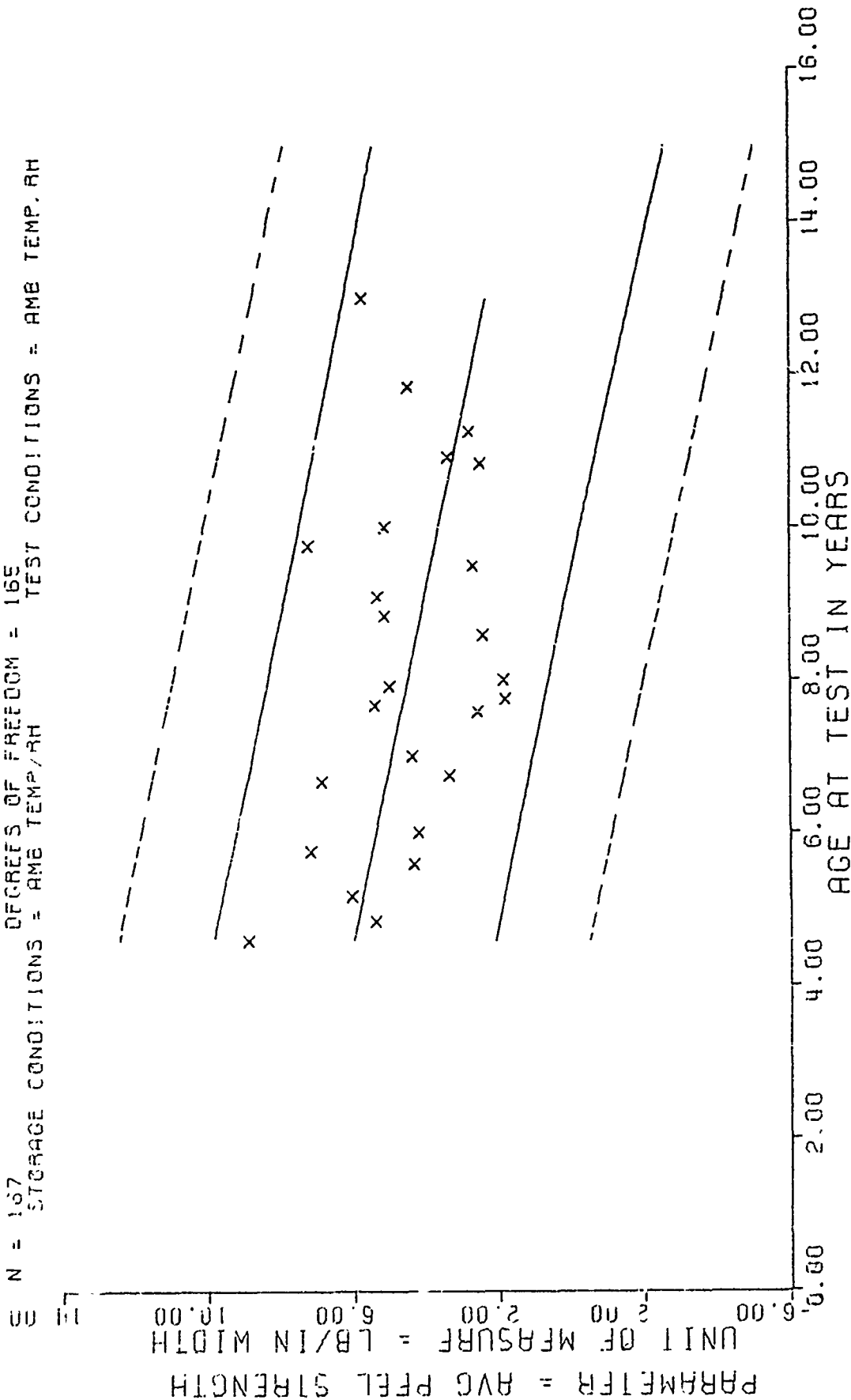
FIGURE 12-6

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	No SAMPLES
55.0-59.9	125
58.0	1
62.0	3
67.0	10
69.0	17
72.0	11
80.0	5
81.0	18
84.0	15
91.0	6
92.0	6
93.0	6
95.0	6
96.0	6
103.0	6
108.0	6
109.0	3
114.0	3
117.0	3
120.0	6
130.0	6
131.0	3
135.0	3
142.0	3
156.0	3

AVERAGE CASE BCID PEEL, CHS 5.0 IN/IN, 5 MOTUP COMPOSITE

$F = + 25359214E+02$
 $R = - 37114322E+00$
 $t = + 51341225E+01$
 $N = 167$
 $t = (+.79948472E+01) + (-.36464957E-01) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT $G_1 = +.23149389E+01$
 SIGNIFICANCE OF R = SIGNIFICANT $S_1 = -.71024713E-02$
 SIGNIFICANCE OF t = SIGNIFICANT $S_t = +.21560999E+01$
 DEGREES OF FREEDOM = 166
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP, RH

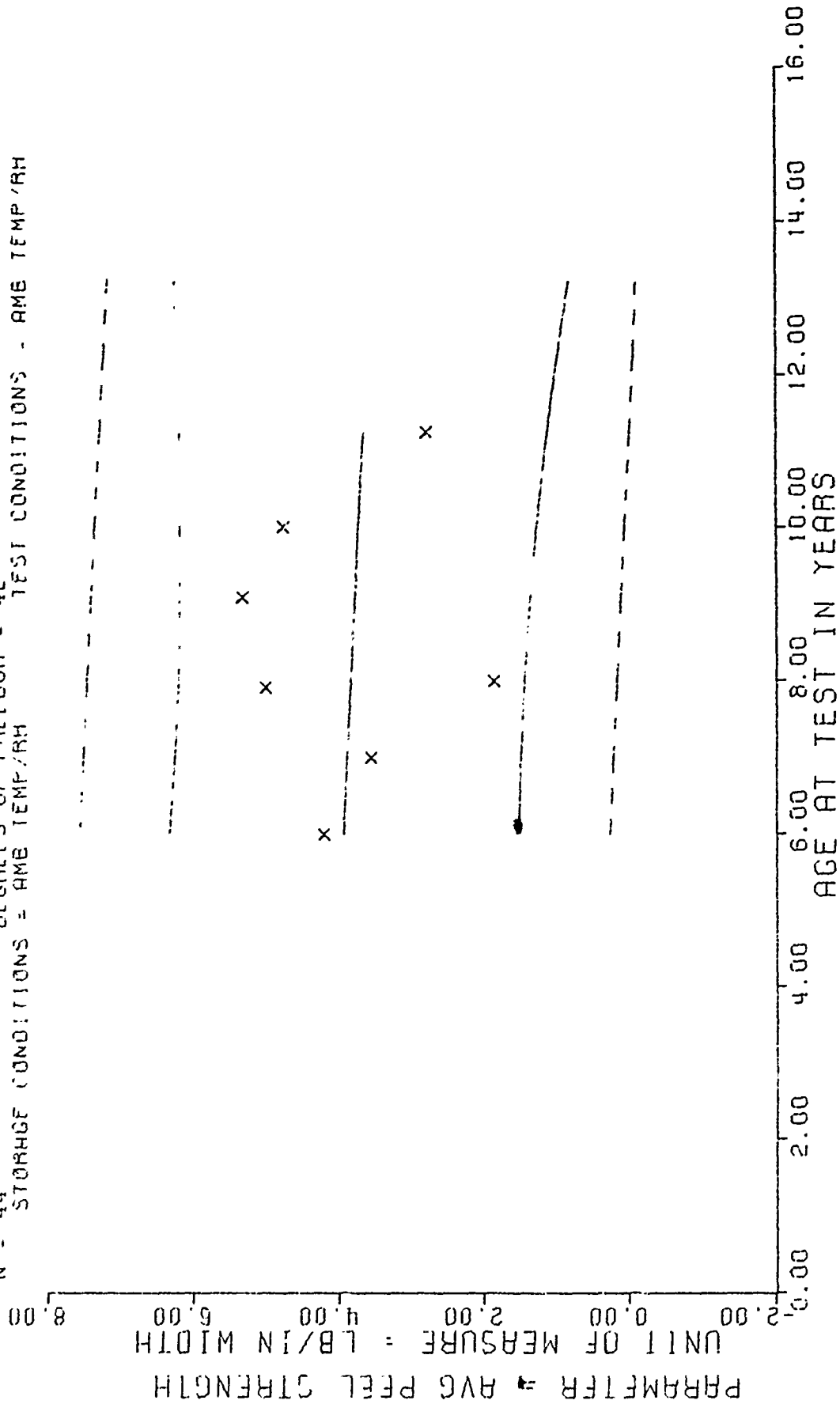


*** SAMPLE SIZE SUMMARY ***

Age	Age
(00.15)	Sample Size
(72.05)	115
84.0)	12
92.0)	6
98.0)	6
109.0)	3
120.0)	3
135.0)	3

AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN, NOT IN # 0031064

$F = +.18732850E+03$
 $R = -.35636308E-01$
 $t = +.43281463E+00$
 $N = 44$
 $S = (+.42502963E+01) + (-.44361164E-02) \times X$
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF t = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 42
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH



AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN. MOTOR # 0031064

FIGURE 12-8

*** CASE SIZE ***

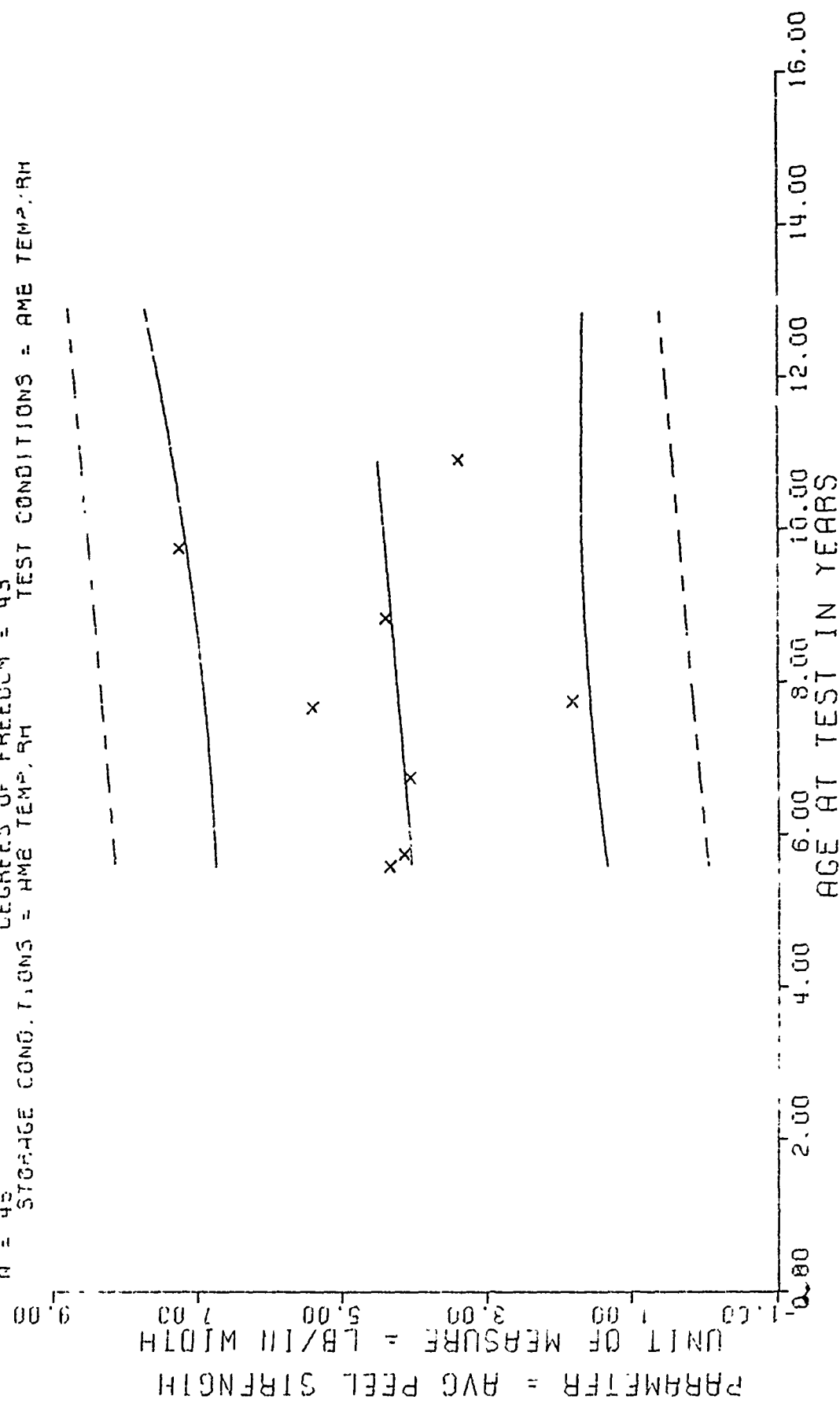
ENTRIES	MA	SAMPLES
107.05	105	2
109.0	12	6
111.0	12	6
112.0	12	6
113.0	12	6
114.0	12	6
115.0	12	6
116.0	12	6
117.0	12	6
118.0	12	6

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AVF-40F CASE BOLD PELL. CHS 5.0 IN/IN. MOTOR # C031134

$Y = (+.35988357E+01) + (+.75790468E-02) \times X$
 $F = +.46161447E+00$ SIGNIFICANCE OF F = NOT SIGNIFICANT $S_e = +.13581330E+01$
 $R = +.10305920E+00$ SIGNIFICANCE OF R = NOT SIGNIFICANT $S_b = +.11155130E+01$
 $t = +.37942215E+00$ SIGNIFICANCE OF t = NOT SIGNIFICANT $S_e = +.13635191E+01$
 $N = 45$ DEGREES OF FREEDOM = 43
 STORAGE CONDITIONS = HMB TEMP, RH TEST CONDITIONS = AME TEMP, RH



AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN, MOTOR # 0031134

FIGURE 12-9

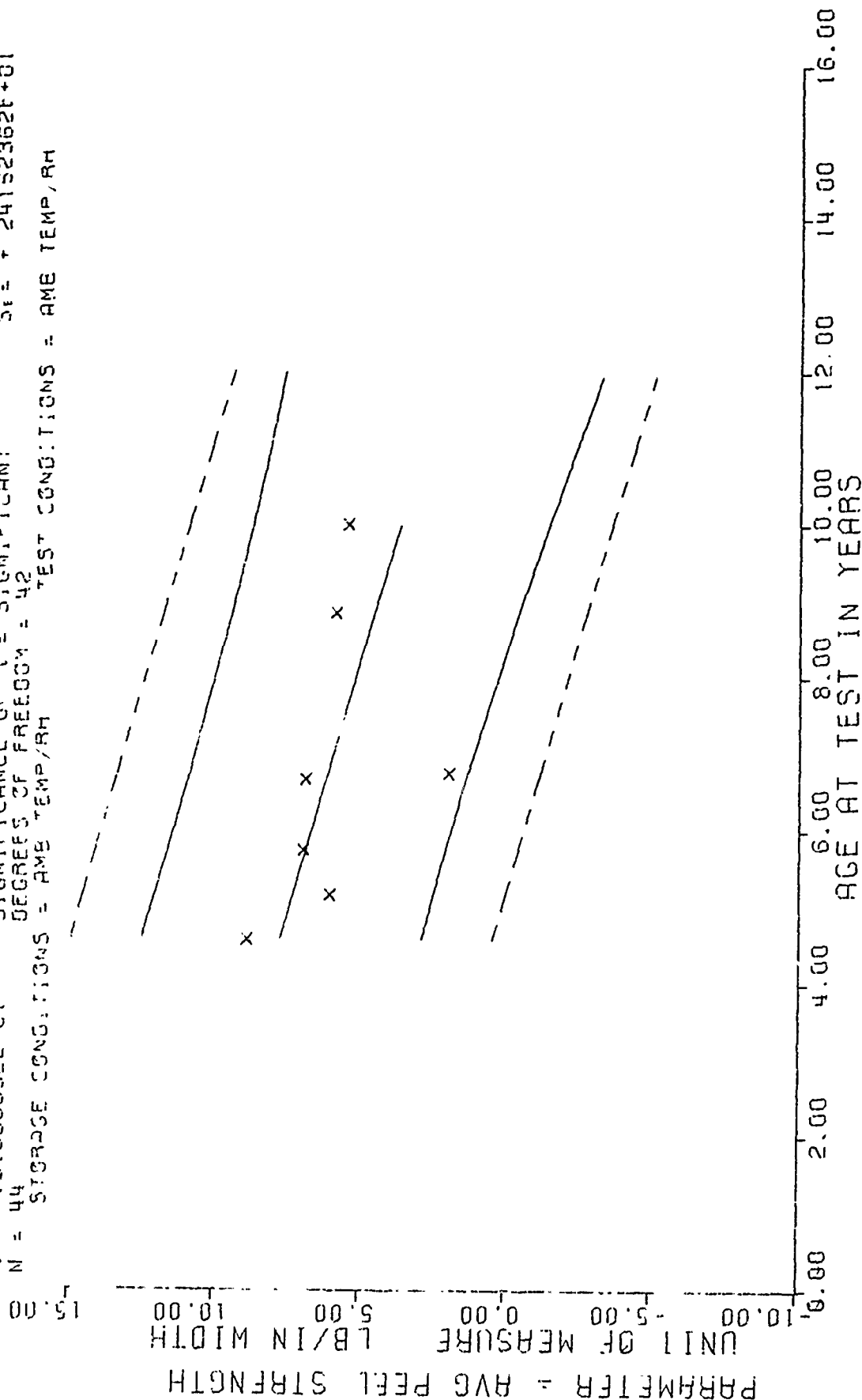
3	0.001
2	0.001
1	0.001
0	0.001
1	0.001
2	0.001
3	0.001
4	0.001
5	0.001
6	0.001
7	0.001
8	0.001
9	0.001
10	0.001
11	0.001
12	0.001
13	0.001
14	0.001
15	0.001
16	0.001
17	0.001
18	0.001
19	0.001
20	0.001
21	0.001
22	0.001
23	0.001
24	0.001
25	0.001
26	0.001
27	0.001
28	0.001
29	0.001
30	0.001
31	0.001
32	0.001
33	0.001
34	0.001
35	0.001
36	0.001
37	0.001
38	0.001
39	0.001
40	0.001
41	0.001
42	0.001
43	0.001
44	0.001
45	0.001
46	0.001
47	0.001
48	0.001
49	0.001
50	0.001
51	0.001
52	0.001
53	0.001
54	0.001
55	0.001
56	0.001
57	0.001
58	0.001
59	0.001
60	0.001
61	0.001
62	0.001
63	0.001
64	0.001
65	0.001
66	0.001
67	0.001
68	0.001
69	0.001
70	0.001
71	0.001
72	0.001
73	0.001
74	0.001
75	0.001
76	0.001
77	0.001
78	0.001
79	0.001
80	0.001
81	0.001
82	0.001
83	0.001
84	0.001
85	0.001
86	0.001
87	0.001
88	0.001
89	0.001
90	0.001
91	0.001
92	0.001
93	0.001
94	0.001
95	0.001
96	0.001
97	0.001
98	0.001
99	0.001
100	0.001

001-11 (ASF, C:00 PFFL, (HS 5.0) 11/11, 0011) 0032434

12-23

$Y = (+.11185639E+02) + (-.62590525E-01) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 42
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = AMB TEMP/RH

F = +.10040353E+02
 R = -.43924605E+00
 t = +.31689832E+01
 N = 44



AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN, MOTOR # 0032434

FIGURE 12-10

*** SAMPLE SIZE 5 ***

AGE	NO	SAMPLES
(10-15)	15	
(16-20)	2	
(21-25)	3	

AVG. CASE FREQ. PEEL. CHS 5.0 IN/4.1. VOTER # 0032174

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$F = +.68547146E-06$
 $R = +.37026243E-03$
 $t = +.627933204E-03$
 $N = 7$
 $Y = (+.84378396E+01) + (+.67934782E-04) \times X$
 SIGNIFICANCE OF F = NOT SIGNIFICANT
 SIGNIFICANCE OF R = NOT SIGNIFICANT
 SIGNIFICANCE OF t = NOT SIGNIFICANT
 DEGREES OF FREEDOM = 5
 STORAGE CONDITIONS - AMB TEMP/HR
 TEST CONDITIONS - AMB TEMP/HR

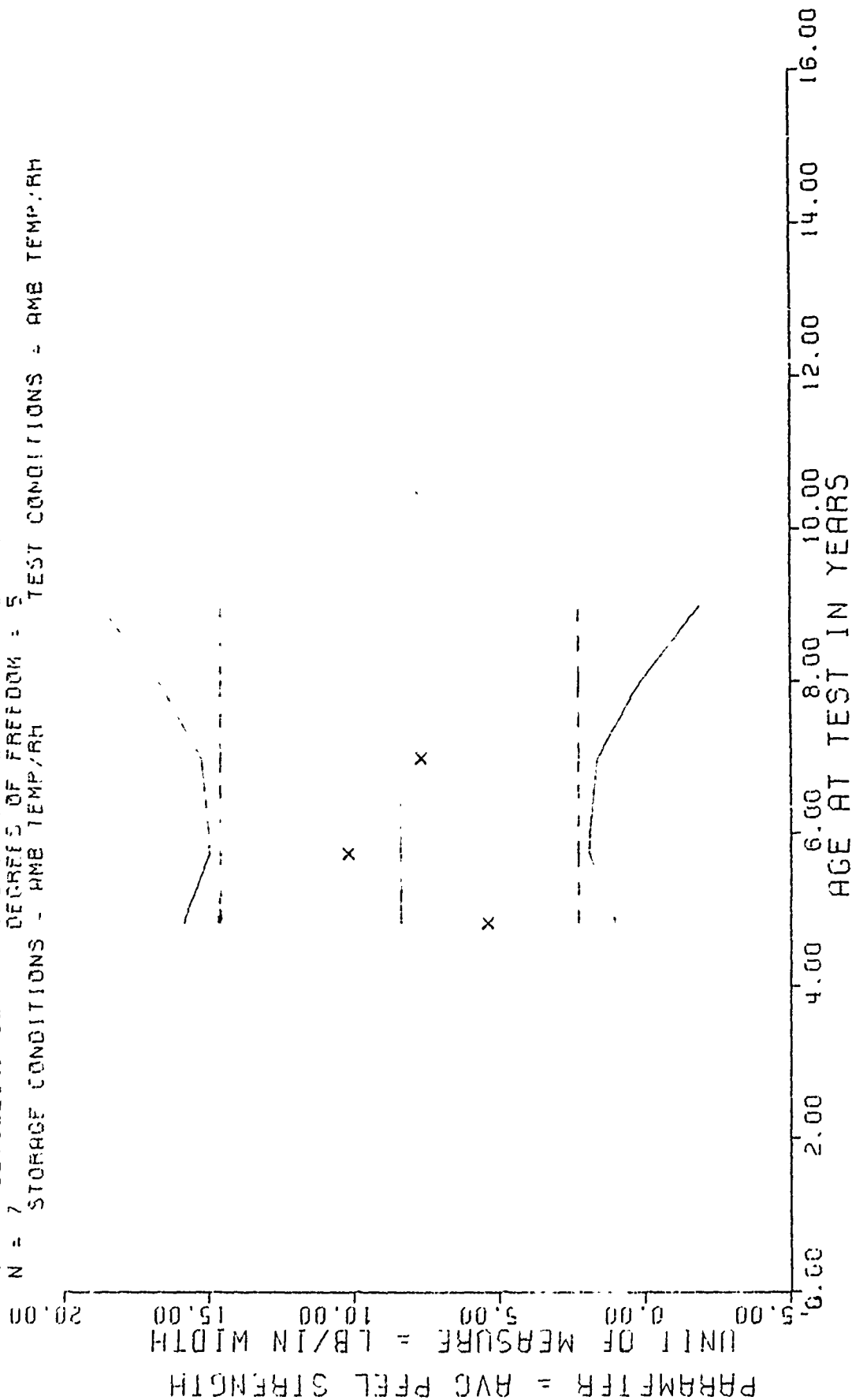
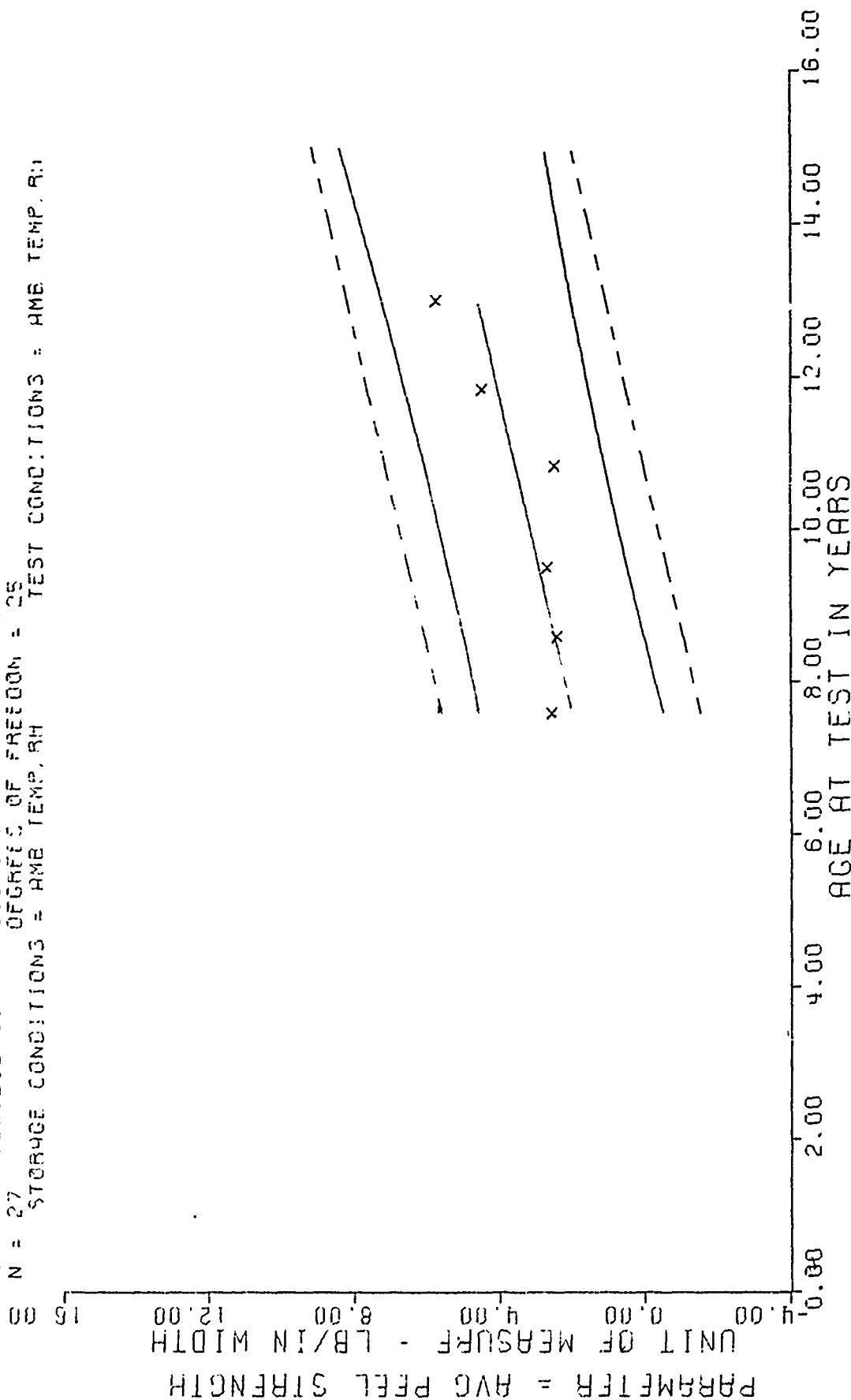


FIGURE 12-11

$Y = (-.16220810E+01) + (+.40187480E-01) * X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 25
 STORAGE CONDITIONS = AMB TEMP, RH
 TEST CONDITIONS = AMB TEMP, RH

F = + 14275545E+02
 R = + 50288740E+00
 t = + 37703125E+01
 N = 27



AVERAGE CASE BOND PEEL, CHS 5.0 IN/MIN. MOTOR # 00GR131

FIGURE 12-12

SECTION XIII

DYNAMIC RESPONSE

This test uses a Gottenberg disc 3.3" in diameter with a 125 gm center weight. An Unholtz-Dickie apparatus is used and the specimen tested at 0.5 g through a range of frequencies. Reduced data from 200 and 600 Hz are shown in regression.

Storage shear modulus at 200 Hz does not show a significant change (Figure 13-1). At 600 Hz there is a significant decrease (Figure 13-2).

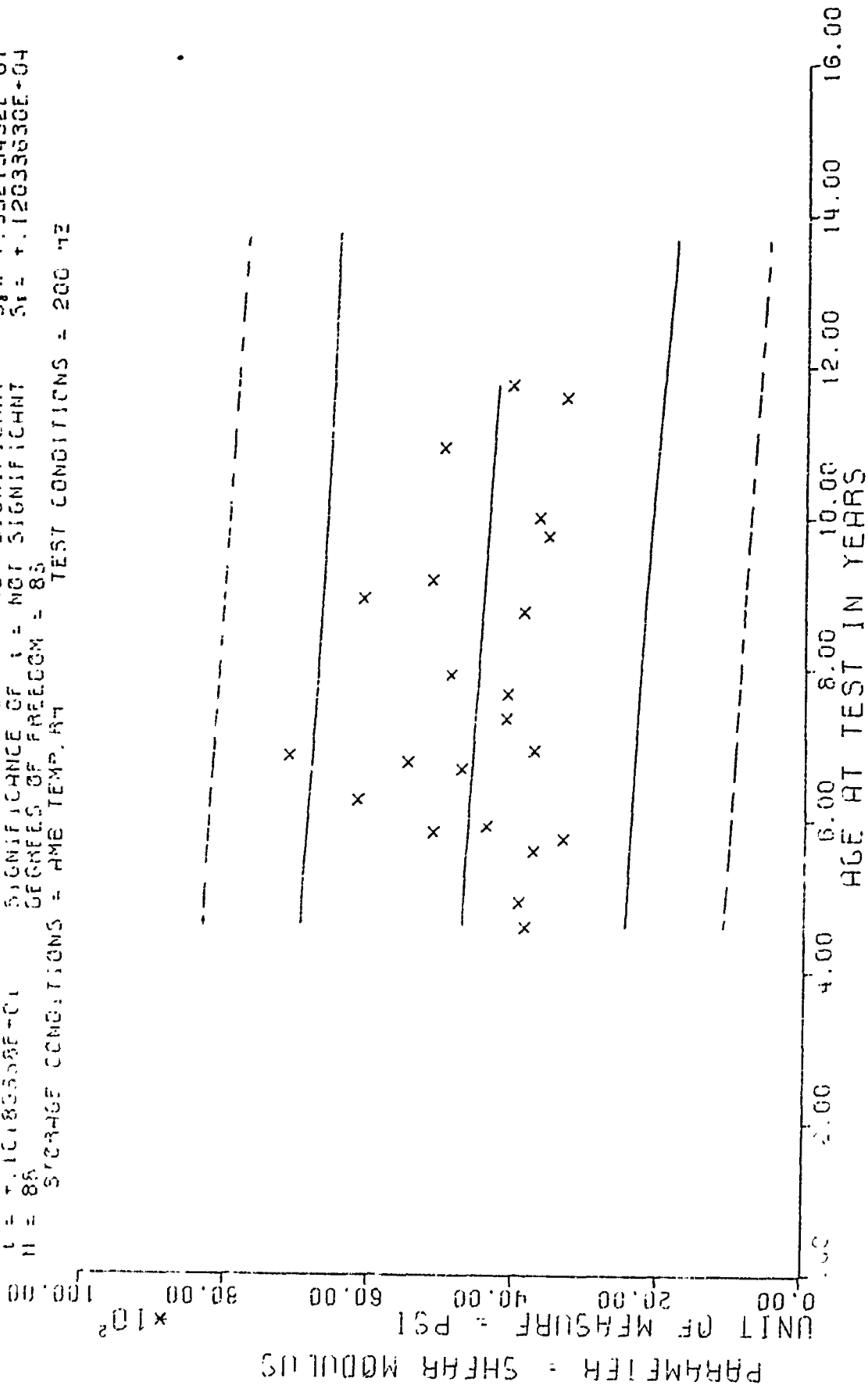
Loss tangent increases significantly at 200 and 600 Hz (Figure 13-3 and 13-4).

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
55.05)	55
59.0	3
67.0	5
69.0	3
70.0	6
71.0	1
75.0	3
80.0	3
81.0	6
82.0	3
83.0	6
88.0	1
92.0	6
95.0	9
105.0	3
107.0	3
110.0	3
117.0	3
120.0	3
131.0	3
139.0	5
141.0	3

SHEAR MODULUS AT 200 HZ. 124 GM CENT. WT. 5 MOTOR COMPOSITE

$Y = (+.50308465E+04) + (-.54222785E+01) \times X$
 SIGNIFICANCE OF $T =$ NOT SIGNIFICANT $Q = +.12036278E+04$
 SIGNIFICANCE OF $R =$ NOT SIGNIFICANT $S = +.53213492E+01$
 SIGNIFICANCE OF $V =$ NOT SIGNIFICANT $S_1 = +.12033630E+04$
 DEGREES OF FREEDOM = 83
 STORAGE CONDITIONS = AMB TEMP. AT TEST CONDITIONS = 200 °F



SHEAR MODULUS AT 200 HZ, 125 GM CENT. WT. 5 MOTOR COMPOSITE

FIGURE 13-1

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
55.05	55
59.0	3
67.0	5
69.0	3
70.0	8
71.0	1
75.0	3
80.0	3
81.0	6
82.0	3
83.0	6
88.0	1
92.0	6
95.0	9
105.0	3
107.0	3
110.0	3
117.0	3
120.0	3
131.0	3
139.0	5
141.0	3

LOSS TANGENT AT 200 HZ. 124 GM CENT. WT. 5 MOTOR COMPOSITE

$Y = (+.53386218E+00) + (+.49907882E-03) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 N = 88
 DEGREES OF FREEDOM = 86
 STORAGE CONDITIONS = AMB TEMP, RH
 TEST CONDITIONS = 200 HZ

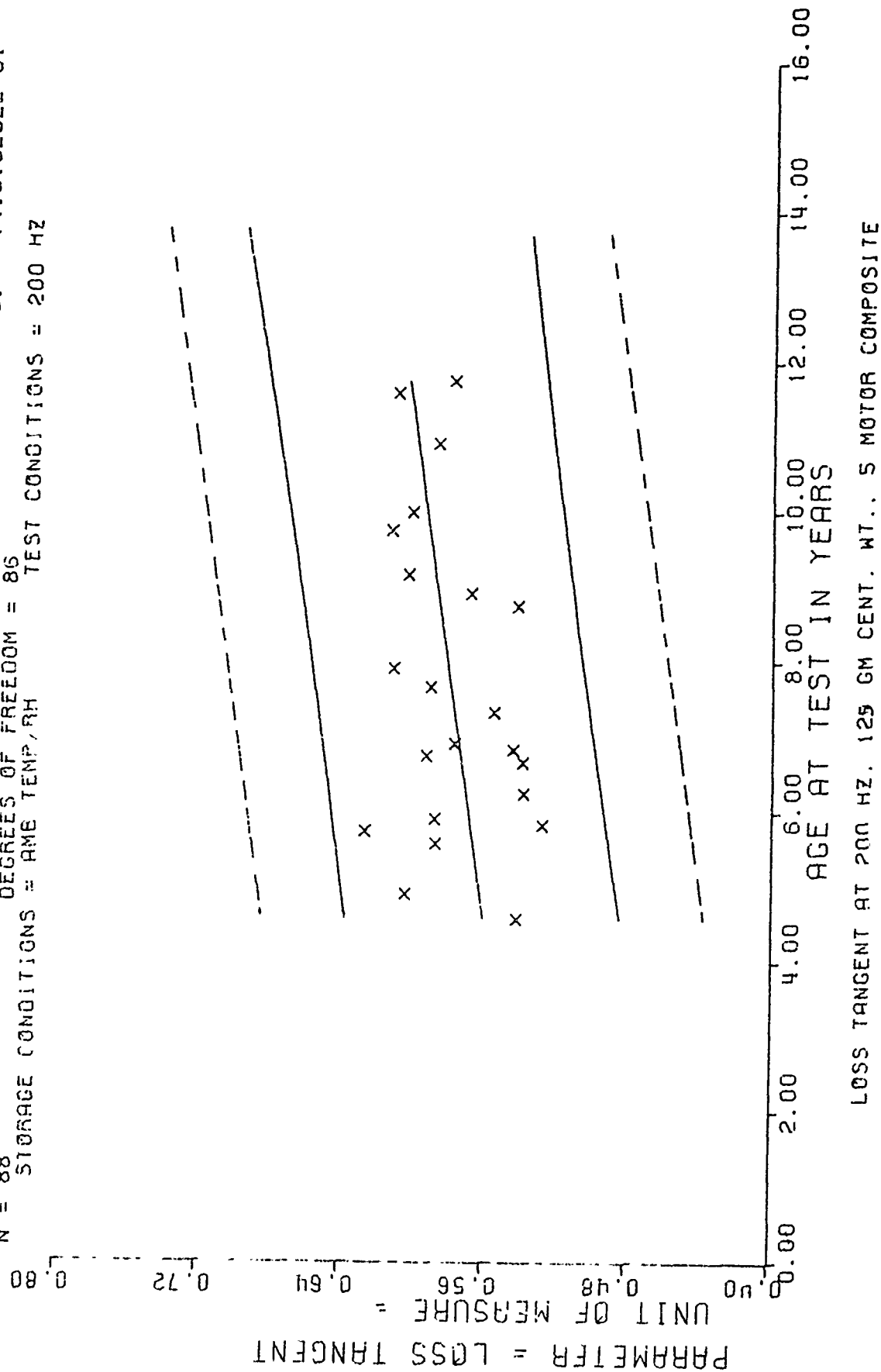


FIGURE 13-2

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
59.0	35
65.0	3
70.0	3
75.0	3
80.0	3
81.0	6
82.0	3
83.0	6
88.0	1
92.0	0
95.0	9
105.0	3
107.0	3
110.0	3
117.0	3
120.0	3
131.0	3
139.0	5
141.0	3

13-6

SHEAR MODULUS AT 600 HZ, 124 GM CENT. WT., 5 MOTOR COMPOSITE

$F = +.13178497E+02$
 $R = -.39804063E+00$
 $t = +.36302200E+01$
 $N = 72$
 $Y = (+.98930000E+04) + (-.36576879E+02) \times X$
 SIGNIFICANCE OF F = SIGNIFICANT
 SIGNIFICANCE OF R = SIGNIFICANT
 SIGNIFICANCE OF t = SIGNIFICANT
 DEGREES OF FREEDOM = 70
 STORAGE CONDITIONS = AMB TEMP/RH
 TEST CONDITIONS = 600 HZ

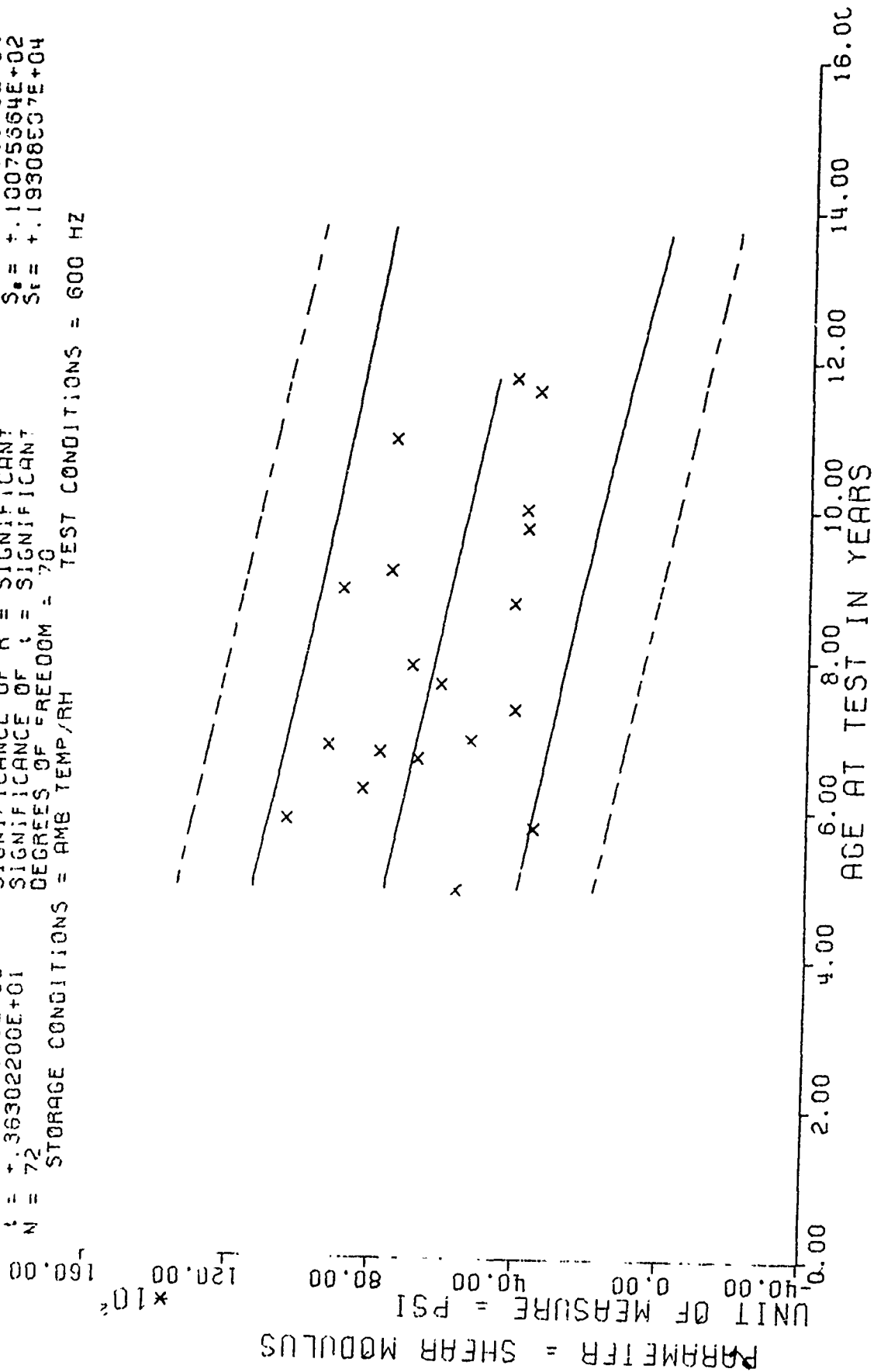


FIGURE 13-3

*** SAMPLE SIZE SUMMARY ***

AGE (MONTHS)	NK SAMPLES
(59.0S)	35
70.0	3
75.0	3
80.0	3
81.0	6
82.0	3
83.0	6
92.0	6
95.0	9
105.0	3
107.0	3
110.0	3
117.0	2
120.0	2
131.0	3
139.0	3
141.0	2

13-8

LOSS TANGENT AT 600 HZ, 124 GM CENT. WT., 5 MOTOR COMPOSITE

Parameter - Loss Tangent

UNIT OF MEASURE =

AGE AT TEST IN YEARS

STORAGE CONDITIONS = 2MB TEMP, RH

TEST CONDITIONS = 600 °F

DEGREES OF FREEDOM = 31

W - 0.03

0.00 0.40 0.80 1.20 1.60 2.00

2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00

The graph displays four data series, each represented by a solid line with dashed confidence intervals. The data points are marked with 'x'. The series show a general increase in loss tangent with age, with the rate of increase varying between conditions. The top series (highest loss tangent) shows a sharp increase after 10 years, while the bottom series (lowest loss tangent) remains relatively flat.

Age at Test (Years)	Series 1 (Top)	Series 2	Series 3	Series 4 (Bottom)
2.00	-	-	-	0.35
4.00	-	-	-	0.35
6.00	-	-	-	0.35
8.00	-	-	-	0.35
10.00	-	-	-	0.35
12.00	-	-	-	0.35
14.00	-	-	-	0.35
16.00	-	-	-	0.35

LOSS TANGENT AT 600 HZ, 125 GM CENT. WT., 5 MOTOR COMPOSITE