AD-A078 778 OGDEN AIR LOGISTICS CENTER HILL AFB UTAH PROPELLANT L--ETC F/G 21/9.2
PROPELLANT SURVEILLANCE REPORT LGM-30 A, B, F & G, STAGE I, TP---ETC(U)
NOV 79 J A THOMPSON

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HEADQUARTERS

OGDEN AIR LOGISTICS CENTER

UNITED STATES AIR FORCE

HILL AIR FORCE BASE, UTAH 84056

PROPELLANT SURVEILLANCE REPORT LGM-30A, B, F&G STAGE 1 TP-H 1043

PROPELLANT LAB SECTION

MANCP REPORT

NR 424(79)

NOVEMBER 1979

(14) MANCP REPORT NR 424(79)
MMWRM PROJECT M829340

(6) PROPELLANT SURVEILLANCE REPORT
LGM-30 A, B, F & G, STAGE I,
TP-H1043 AFT CLOSURE PROPELLANT.

(2)

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(11) NOVEMBER 1979

(12) 33

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ABSTRACT

This report contains propellant test results from cartons of TP-H1043 propellant representing selected batches used in the aft closure of First Stage Minuteman Motors. Data from TP-H1043 propellant obtained from the aft closures of the LGM-30 A, B, F and G Motors are reported in regression analyses for the fifth time and the fourth time using the G085 computer system. Testing was accomplished in accordance with MMWRME Project M82934C.

An analysis of all parameters indicate that no significant degradation is anticipated for at least two years past the oldest data point.

Each point on the regression plot represents all samples at that particular age. The number of samples at each point is indicated on the sample size summary sheet on the page accompanying each regression plot. The data range at any age can be found by suitable inquiry of the G085 system.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF REFERENCES

Report Nr	Title	Report Date
	LGM-30 First Stage, Wing I Test Reports	
29D	Zero Time Test Results (Aft Closure)	9 Jun 64
29E	Zero Time (Aft Closure Supplement 1)	24 Jun 64
32B	Zero Time, Wings II-V Test Results (Aft Closure)	18 Mar 65
185	ATP Phase I, Wing VI Series III	Jun 70
195	ATP Phase III, Wing II-V	Nov 70
239	Propellant Surveillance Report (TP-H1043)	Apr 72
288	Propellant Surveillance Report (TP-H1043)	Mar 74
337	Propellant Surveillance Report (TP-H1043)	Feb 76

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
MAGCP	Propellant Lab Section at OOAMA
OOAMA	Ogden Air Materiel Area, Air Force Logistics Command
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
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_x)	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.

SECTION I

INTRODUCTION

A. PURPOSE:

Quality assurance tests have been conducted for 12 1/2 years on First Stage LGM-30 TP-H1043 aft closure propellant.

Statistical analysis of the tests performed, as directed by Engineering, should provide early warning if serious degradation trends occur. Evaluation of the propellant provides data that can be put directly into engineering reliability and service life predictions. Testing was performed in accordance with MMWRME Directive GTD-1C, Amendments 1 and 2.

B. BACKGROUND:

TP-H1043 propellant is used in the aft closure of LGM-30 A, B, F and G First Stage Motors.

This test period represents the fifth time that TP-H1043 propellant has been reported by regression analysis. This is also the fourth time that data has been processed utilizing the G085 System.

This report represents a large increase in the number of samples tested. Moreover, the age distribution increased to cover a 12 1/2 year time period (4 to 16 1/2 years).

The slope of the respective regressions for this report (Figures 1 thru 14) and the previous reports (1976 and 1977) are very close. The regression slopes of three successive test periods matched very well. This is probably due to the increased number of samples and the stabilizing of post cure chemical changes in the binder.

C. SAMPLING PLAN:

As many as four aft closures are cast from the one TP-H1043 propellant mix. In order to reduce the number of tests, only one batch from each mix will be tested to obtain uniform test results. The selected batches are from the same batch as those previously tested and reported in MAGCP Reports 185(70), 195(70), 239(72), 288(74) and 385(77).

Low rate tensile, high rate tensile and hardness tests were performed on each propellant batch mix.

D. STATISTICAL APPROACH:

Linear regression analysis was used as the method of data evaluation. Data from different time periods were used to establish a least squares trend line for the 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 sample distribution fall within this interval. This tolerance interval was extrapolated to a maximum of 24 months. The "t" values and the significance of this statistic, which are reported for each regression model, give an indication of the "statistical significance" of the slope of the trend line as compared to a line of zero slope.

Each point on the regression analysis is a calculation of all samples at that particular age. The number of samples at each point is indicated on the sample size summary sheet accompanying each regression plot. The data range at any age can be found by suitable inquiry of the G085 system.

SECTION II

TEST RESULTS

A. LOW RATE TENSILE:

All of the low rate test parameters show a statistically significant decrease (Figures 1 thru 5). The strain regressions (Figures 1 and 3) show a very gradual decrease. Regression slopes for stresses and modulus (Figures 2, 4 and 5) show a change with respect to time. This change is less than in the previous report. Although all of the regression trends show a decrease, the propellant still shows good stability and from this analysis the propellant will perform satisfactorily for at least two years beyond the last data point.

B. HIGH RATE TENSILE:

The strains and maximum stress regressions show a statistically significant decrease. The stress at rupture shows no significant change. The modulus shows a statistically significant increase (Figures 6 thru 10). For those regressions showing a statistically significant change, the slopes are gradual.

C. HARDNESS:

Shore A initial hardness test data regressions shows no significant change while the ten second regression shows a statistically significant gradual increase (Figures 11 and 12). The Shore C regressions show a statistically significant decrease (Figures 13 and 14).

SECTION III

CONCLUSIONS AND RECOMMENDATIONS

The slopes of the regressions are gradual and close to a line of zero slope. From this analysis, no significant degradation seems likely and the propellant service life may be extended for at least two years beyond the date of the last testing.

It is recommended that testing be continued to assure service life extension and confirm the present trend.

*** SAMPLE SIZE SUMMARY ***

AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP
57	3	93	54	119	3	145	15	171	3
59	9	94	83	120	15	146	18	172	12
60	3	95	33	121	21	147	6	173	12
61	6	96	27	122	3	148	15	174	3
62	9	97	3	123	12	149	9	175	9
63	6	98	3	124	9	150	5	177	6
64	3	99	6	126	6	151	3	178	6
65	6	101	6	127	3	152	15	179	6
66	9	102	9	128	12	154	6	180	6
67	6	103	9	129	3	155	5	181	3
69	3	104	3	130	9	156	9	182	3
79	5	105	6	131	9	157	12	184	18
80	3	106	6	132	12	158	12	185	13
81	12	107	21	133	18	159	8	186	8
82	9	108	33	134	24	160	6	187	6
83	15	109	33	135	17	161	12	188	12
84	39	110	27	136	21	162	9	189	12
85	28	111	33	137	15	163	6	190	15
86	29	112	27	138	18	164	9	191	12
87	33	113	33	139	9	165	9	192	15
88	30	114	26	140	12	166	12	193	13
89	56	115	15	141	12	167	17	195	17
90	67	116	12	142	12	168	9	196	9
91	151	117	5	143	17	169	10		
92	144	118	23	144	9	170	12		

TENSILE STRAIN AT MAX STRESS (EM),CHS=2.0 IN/MIN,TP-H1043,WING 2&6

This sample size summary is applicable to figures 1 thru 5

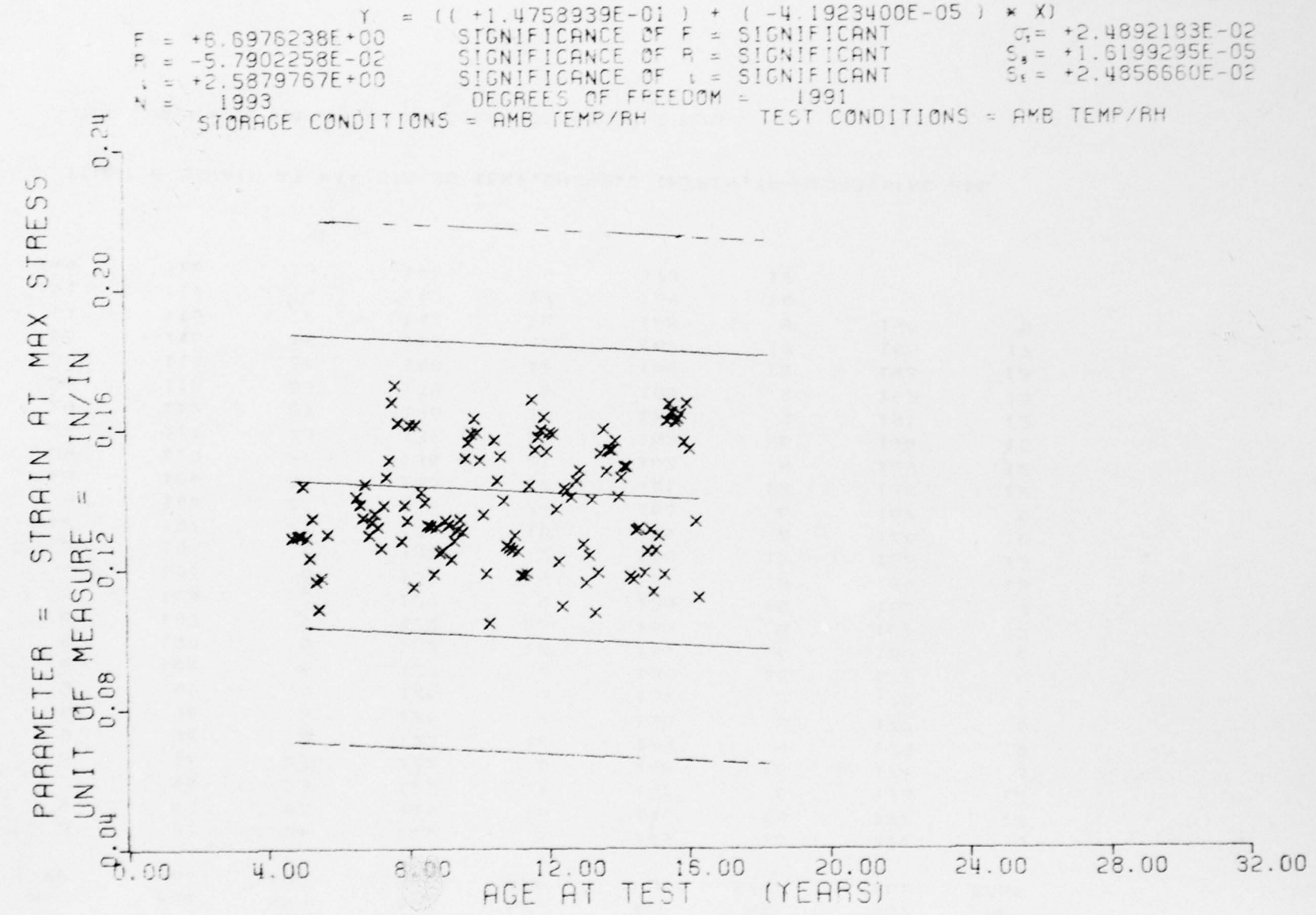
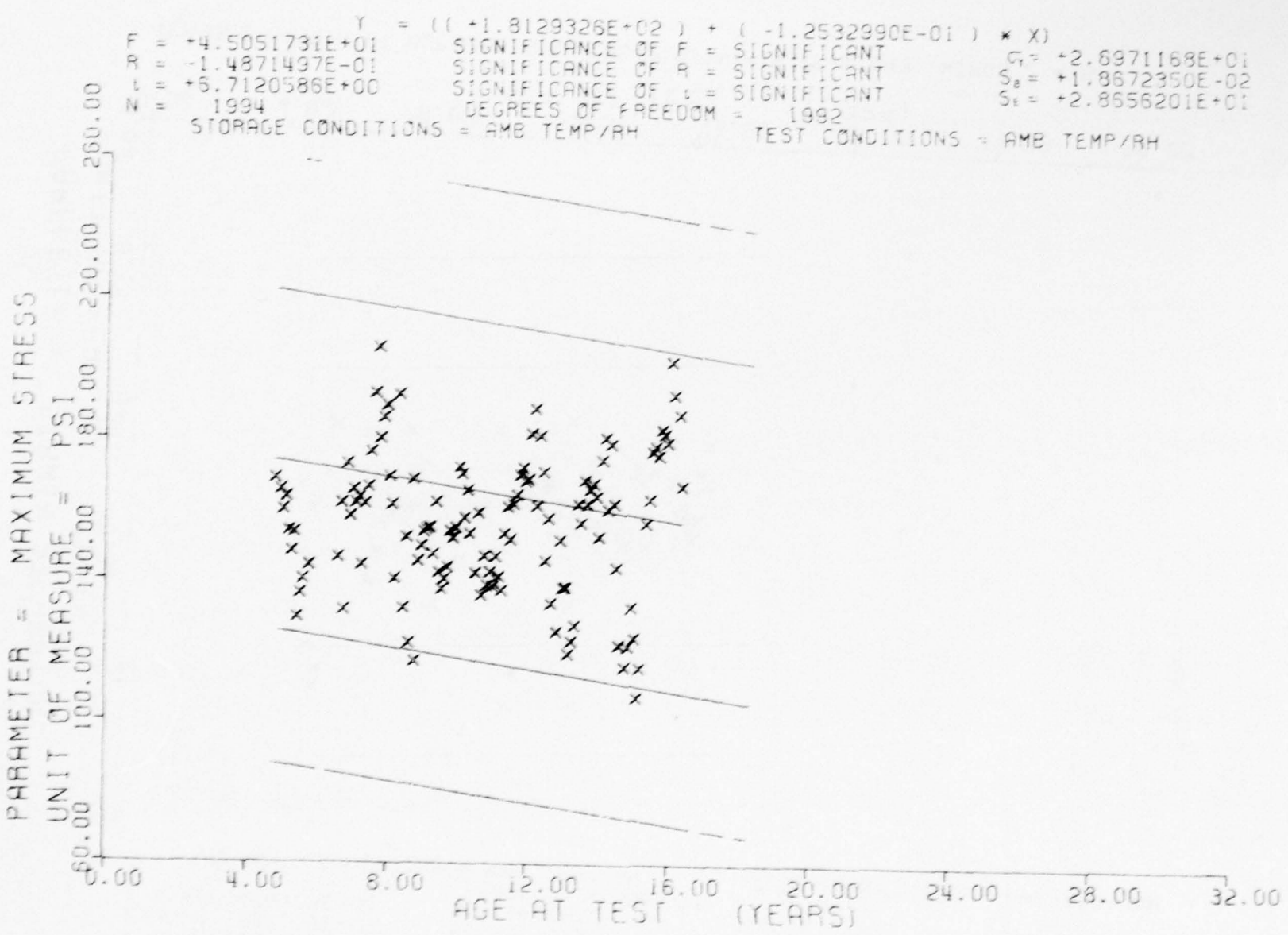

Y = ((+1.4758939E-01) + (-4.1923400E-05) * X)
F = +6.6976238E+00
R = -5.7902258E-02
S = +2.5879767E+00
N = 1993
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
SIGNIFICANCE OF S = SIGNIFICANT
DEGREES OF FREEDOM = 1991
σ1 = +2.4892183E-02
Sβ = +1.6199295E-05
Sε = +2.4856660E-02
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.04
0.08
0.12
0.16
0.20
0.24
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TENSILE STRAIN AT MAX STRESS (EM),CHS=2.0 IN/MIN,TP-H1043,WING 2&6

Figure 1



TENSILE MAXIMUM STRESS, CHS=2.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 2

Y = ((+3.0074709E-01) + (-9.0614671E-05) * X)

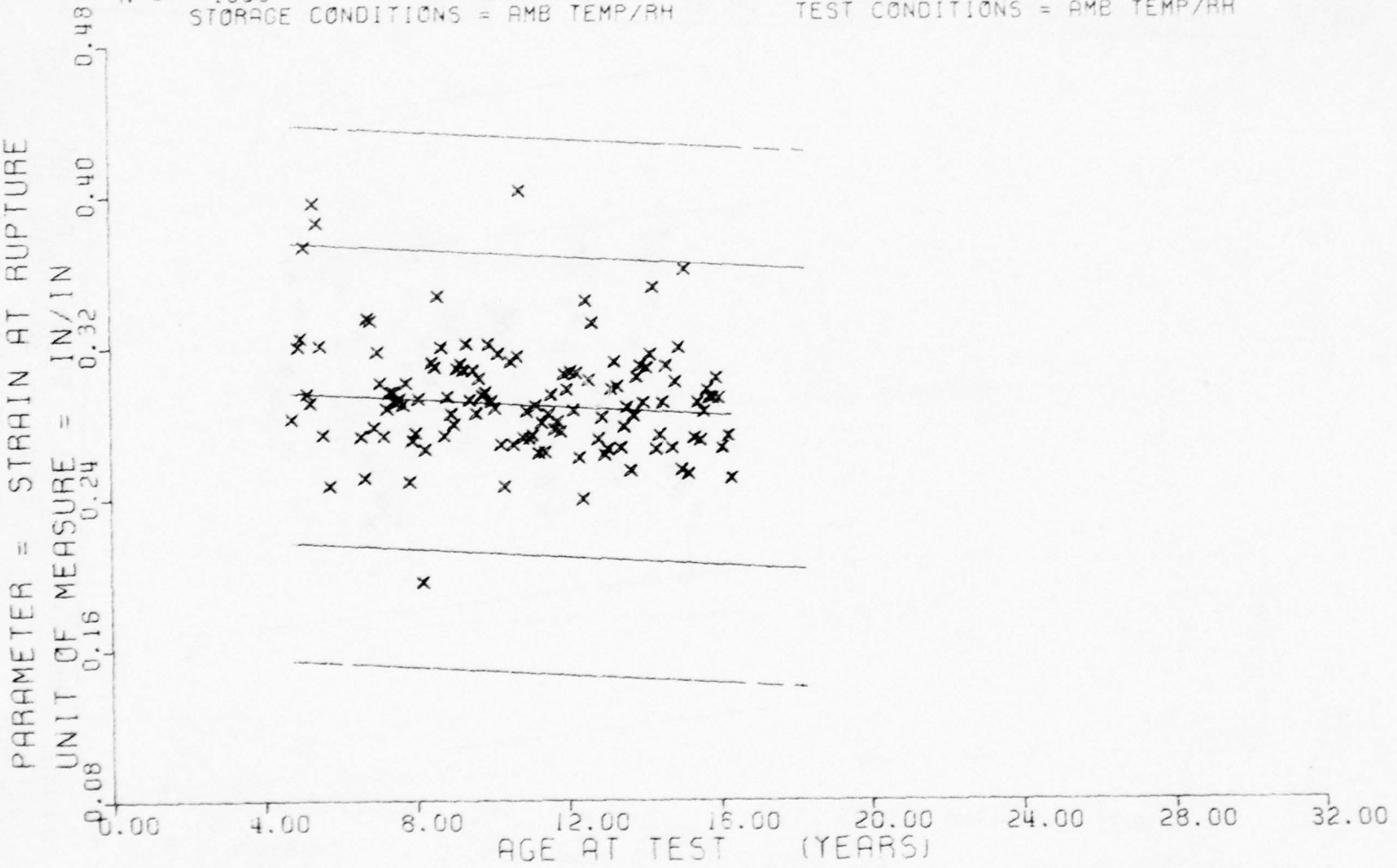
F = +8.6827046E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_Y = -4.7277395E-02

R = -6.5894136E-02 SIGNIFICANCE OF R = SIGNIFICANT S_B = +3.0751833E-05

t = +2.9466429E+00 SIGNIFICANCE OF t = SIGNIFICANT S_t = -4.7186488E-02

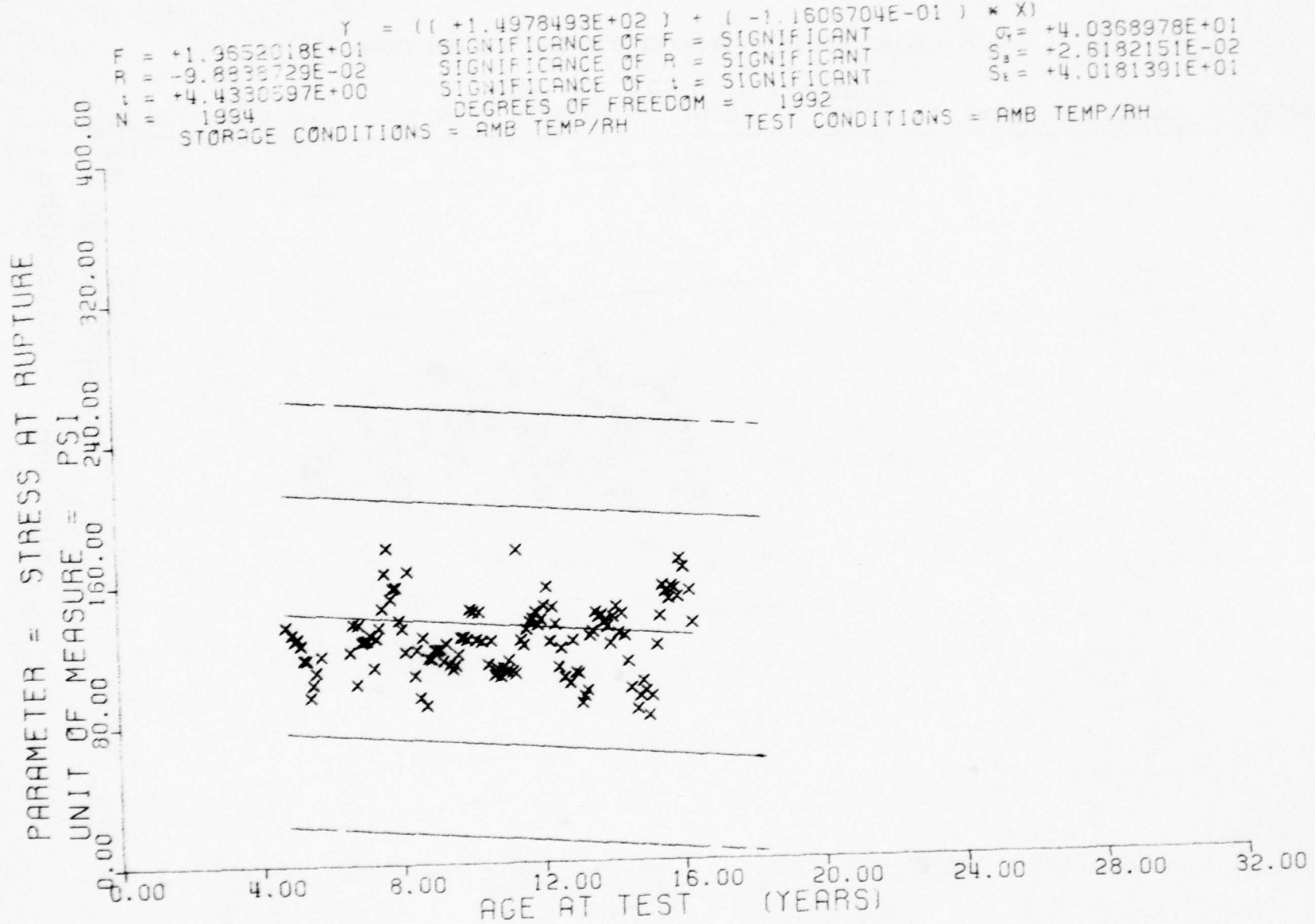
N = 1993 DEGREES OF FREEDOM = 1991

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



TENSILE STRAIN AT RUPTURE (ER), CHS=2.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 3



TENSILE STRESS AT RUPTURE (SR), CHS=2.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 4

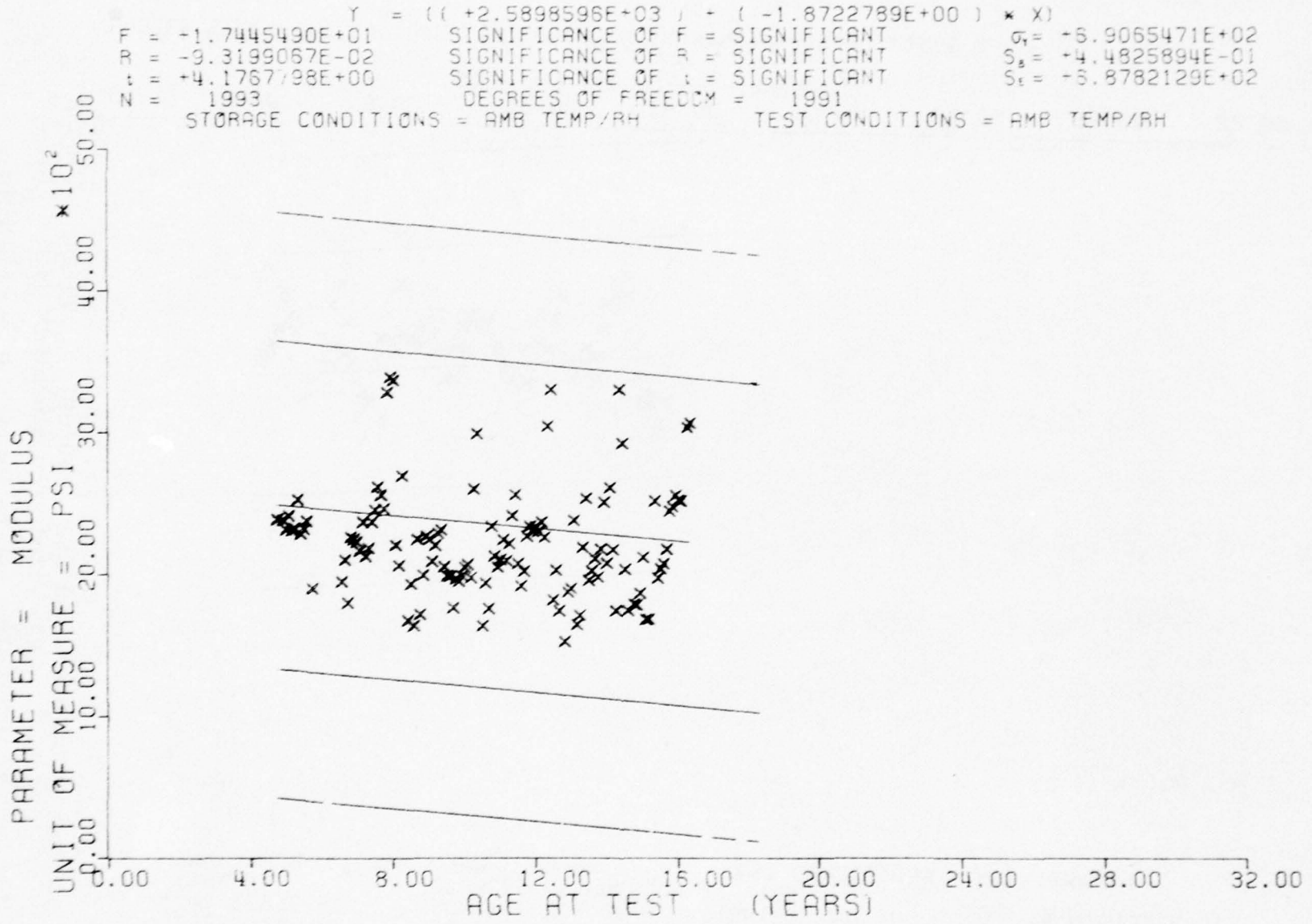

Y = ((+2.5898596E+03) + (-1.8722789E+00) * X)
F = +1.7445490E+01 SIGNIFICANCE OF F = SIGNIFICANT σr = +5.9065471E+02
R = -9.3199067E-02 SIGNIFICANCE OF R = SIGNIFICANT Sb = +4.4825894E-01
t = +4.1767798E+00 SIGNIFICANCE OF t = SIGNIFICANT St = -5.8782129E+02
N = 1993 DEGREES OF FREEDOM = 1991
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = MODULUS
UNIT OF MEASURE = PSI
x10²
50.00
40.00
30.00
20.00
10.00
0.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TENSILE MODULUS (E),CHS=2.0 IN/MIN,TP-H1043, WINGS 2 & 6

Figure 5

*** SAMPLE SIZE SUMMARY ***

AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP
57	2	93	15	120	15	146	15	173	21
59	3	94	27	121	21	147	6	174	11
60	6	95	15	122	3	148	11	175	9
61	3	96	24	123	12	149	6	176	3
62	6	98	3	124	3	150	7	177	6
63	3	99	21	126	4	151	6	178	6
64	3	100	3	127	3	152	3	179	9
65	3	101	12	128	3	153	12	180	12
66	6	102	12	129	12	155	6	181	12
67	3	103	3	130	15	156	6	183	12
68	6	105	5	131	22	157	9	184	18
70	6	106	3	132	34	158	9	185	8
80	6	107	12	133	34	159	12	186	9
81	9	108	24	134	28	160	9	187	5
82	3	109	32	135	30	161	9	188	15
83	21	110	29	136	31	162	12	189	9
84	30	111	27	137	30	163	9	190	15
85	33	112	33	138	27	164	6	191	15
86	30	113	26	139	12	165	10	192	14
87	30	114	28	140	12	166	9	193	18
88	28	115	26	141	6	167	12	195	15
89	29	116	24	142	12	168	18	196	9
90	34	117	9	143	21	169	9		
91	37	118	23	144	12	170	15		
92	33	119	2	145	12	171	18		

TENSILE STRAIN AT MAX STRESS,CHS=1750.0 IN/MIN,TP-H1043, WINGS 2 & 6

This sample size summary is applicable to figures 6 thru 10

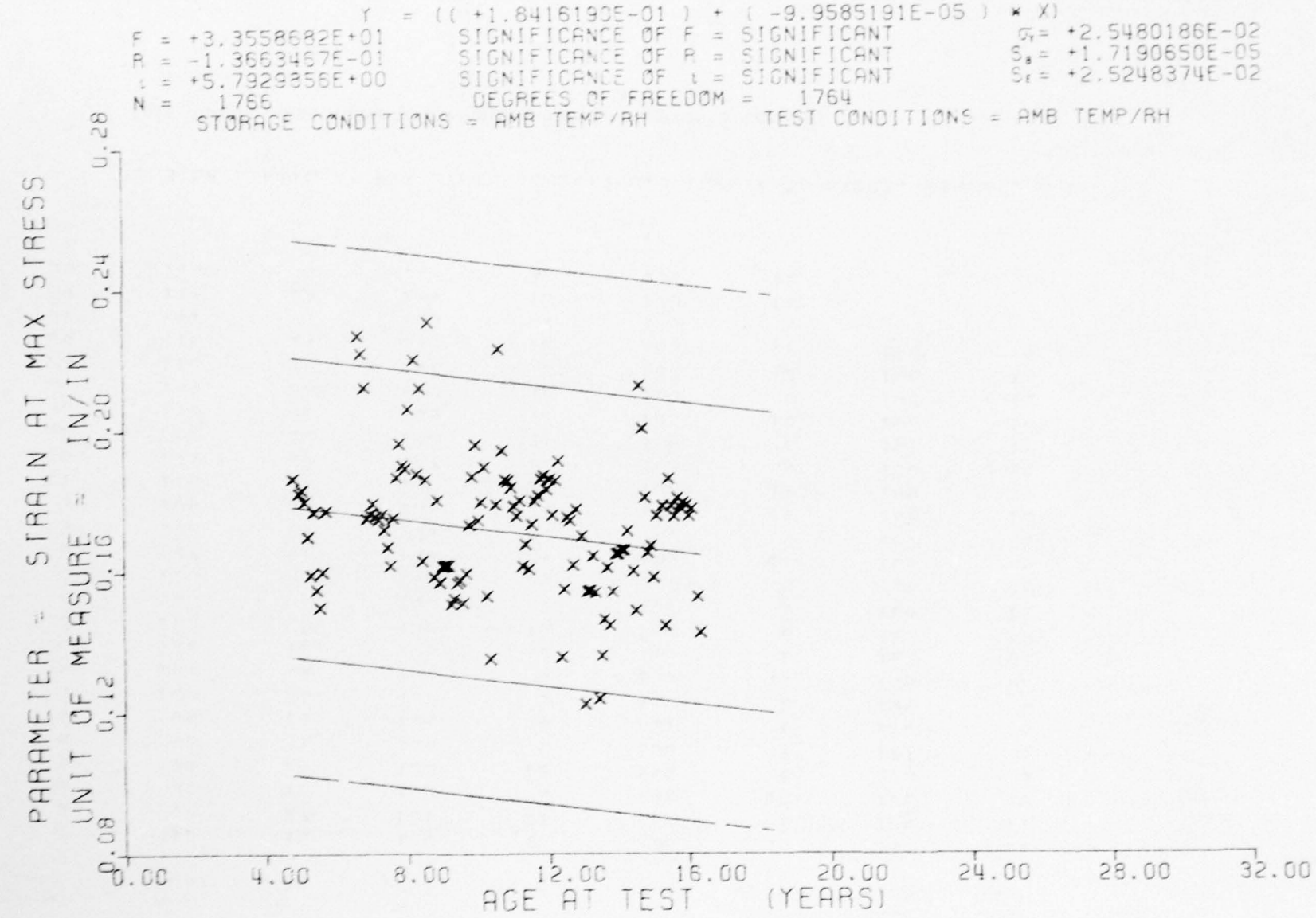
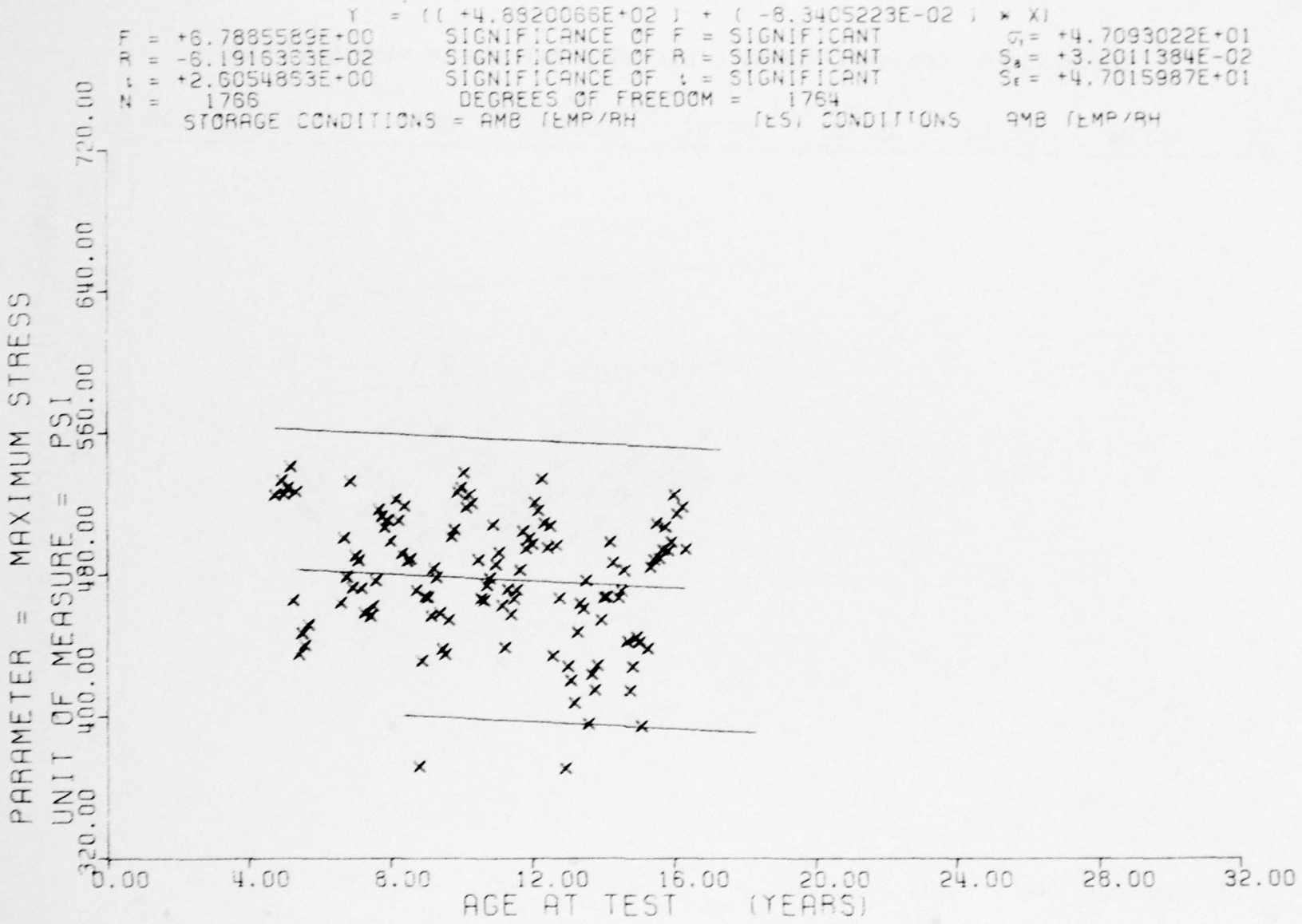

Y = ((+1.8416190E-01) + (-9.9585191E-05) * X)
F = +3.3558682E+01
SIGNIFICANCE OF F = SIGNIFICANT
σy = +2.5480186E-02
R = -1.3663467E-01
SIGNIFICANCE OF R = SIGNIFICANT
Sb = +1.7190650E-05
t = +5.7929856E+00
SIGNIFICANCE OF t = SIGNIFICANT
Sr = +2.5248374E-02
N = 1766
DEGREES OF FREEDOM = 1764
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT MAX STRESS
UNIT OF MEASURE = IN/IN
0.08
0.12
0.16
0.20
0.24
0.28
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TENSILE STRAIN AT MAX STRESS, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 6



TENSILE MAXIMUM STRESS, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 7

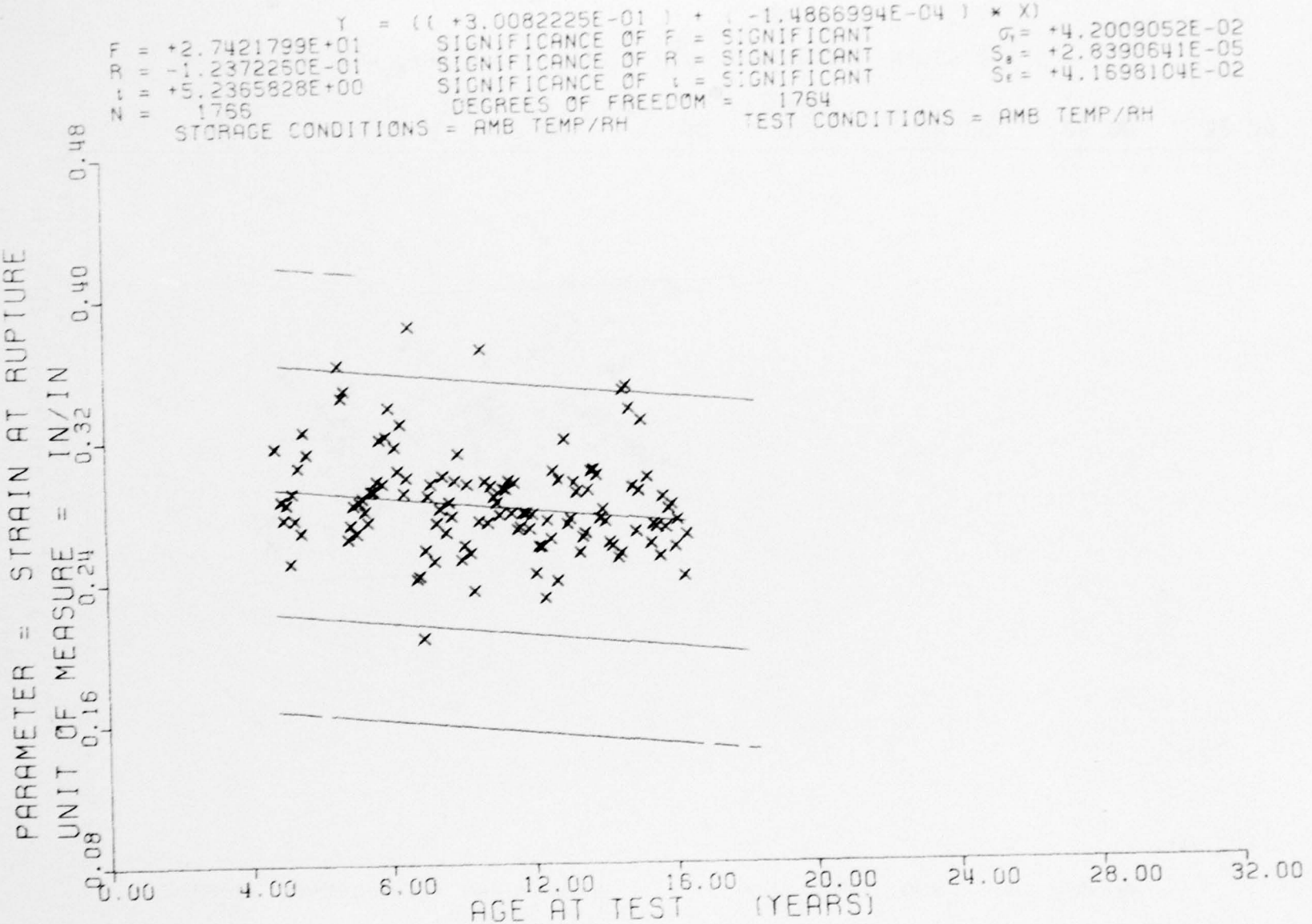
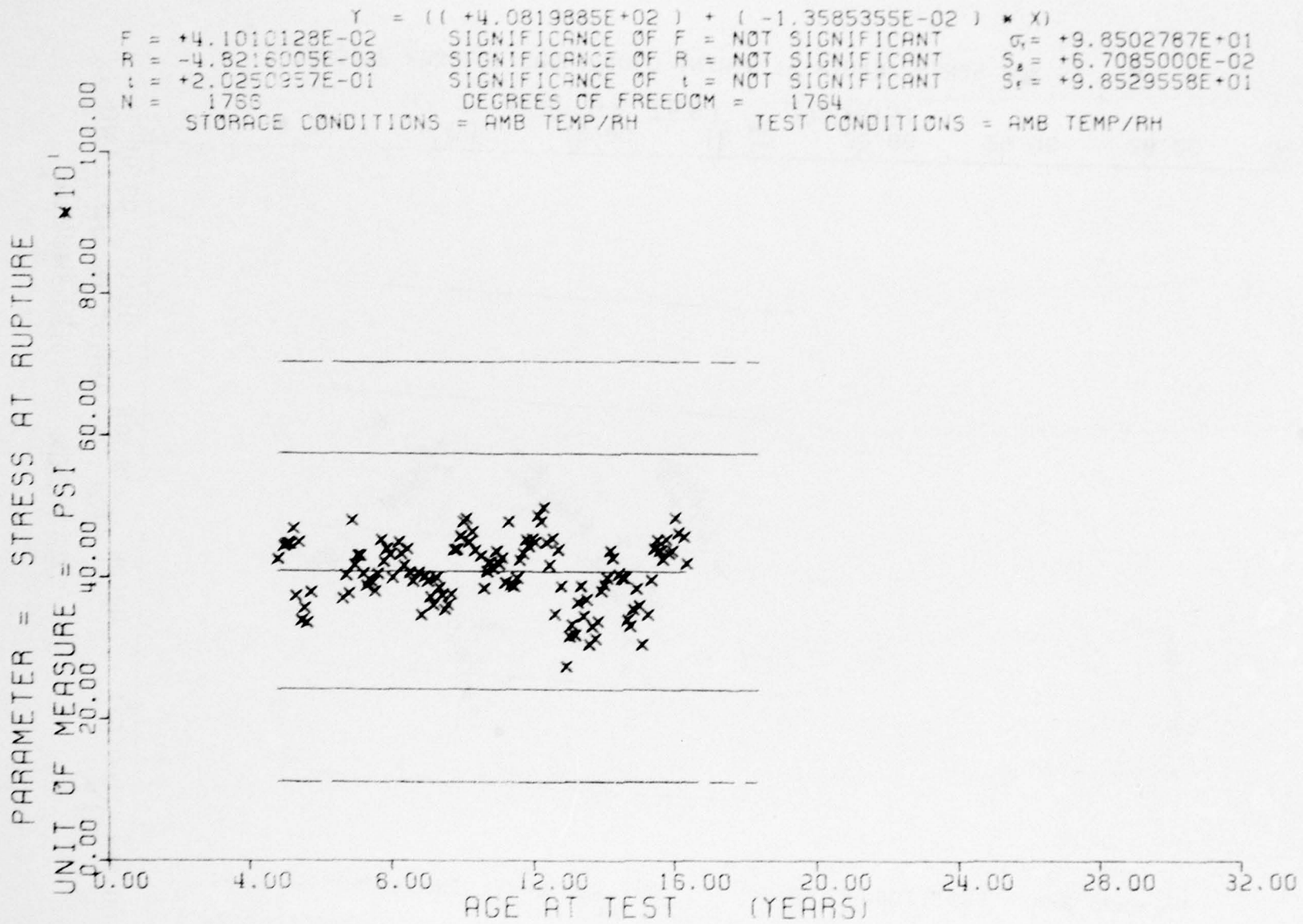

Y = ((+3.0082225E-01) + (-1.4866994E-04) * X)
F = +2.7421799E+01
R = -1.2372250E-01
t = +5.2365828E+00
N = 1756
SIGNIFICANCE OF F = SIGNIFICANT
SIGNIFICANCE OF R = SIGNIFICANT
SIGNIFICANCE OF t = SIGNIFICANT
DEGREES OF FREEDOM = 1764
σr = +4.2009052E-02
Sa = +2.8390641E-05
Se = +4.1698104E-02
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = STRAIN AT RUPTURE
UNIT OF MEASURE = IN/IN
0.08
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)
TENSILE STRAIN AT RUPTURE, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 8



TENSILE STRESS AT RUPTURE, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 9

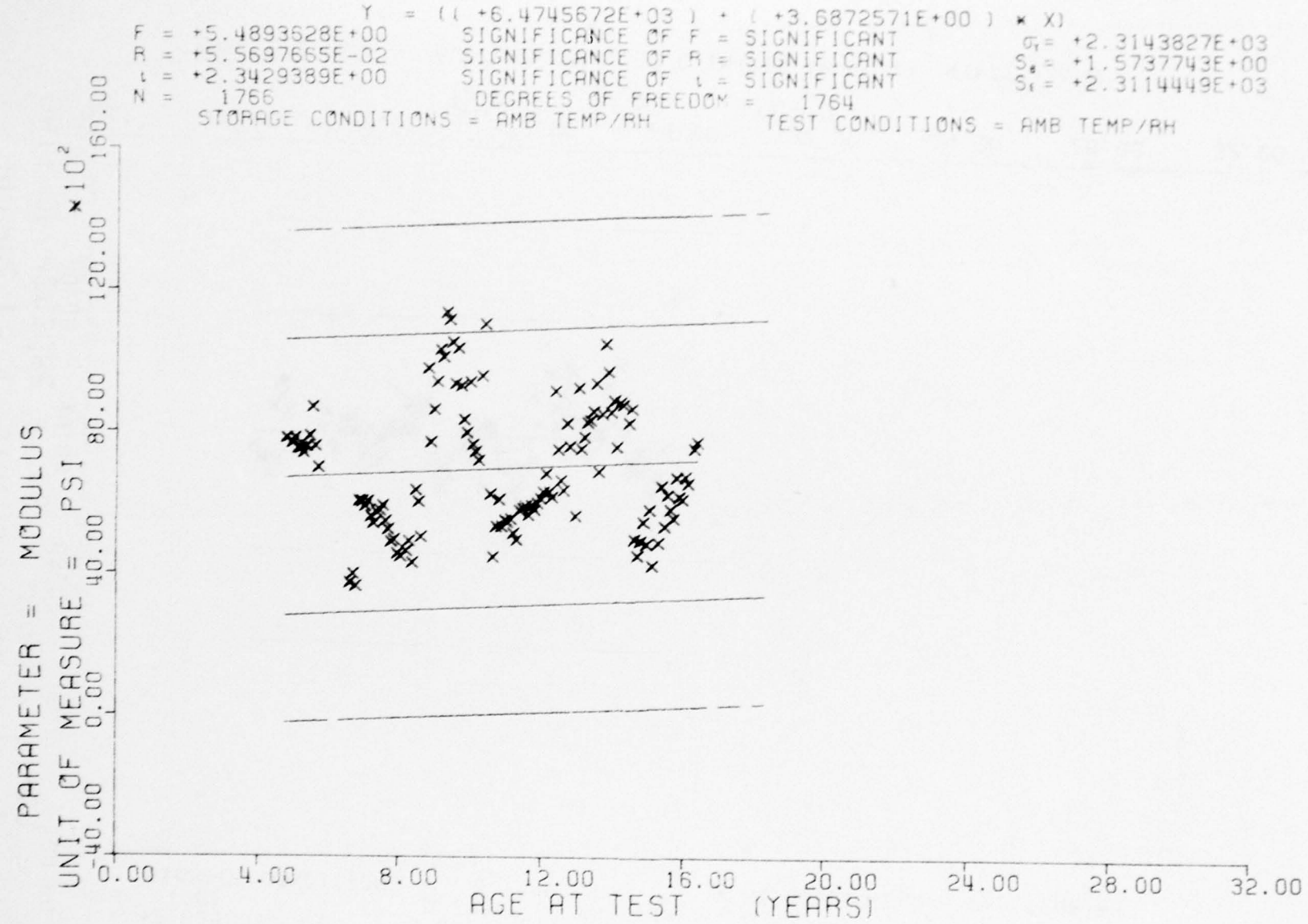

Y = (+6.4745672E+03) + (+3.6872571E+00) * X)
F = +5.4893628E+00 SIGNIFICANCE OF F = SIGNIFICANT σt = +2.3143827E+03
R = +5.5697665E-02 SIGNIFICANCE OF R = SIGNIFICANT Se = +1.5737743E+00
t = +2.3429389E+00 SIGNIFICANCE OF t = SIGNIFICANT St = +2.3114449E+03
N = 1766 DEGREES OF FREEDOM = 1764
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = MODULUS
UNIT OF MEASURE = PSI x10²
160.00
120.00
80.00
40.00
0.00
-40.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
TENSILE MODULUS, CHS=1750.0 IN/MIN, TP-H1043, WINGS 2 & 6

Figure 10

*** SAMPLE SIZE SUMMARY ***

AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP
56	5	92	9	120	20	148	15	186	15
58	5	93	6	121	40	149	9	187	10
59	10	94	11	123	20	150	5	190	5
60	5	95	6	124	13	151	5	191	5
61	15	96	3	126	6	152	5	193	25
62	10	98	1	127	3	153	5	195	25
63	10	99	1	128	12	155	5	196	15
64	10	101	10	130	6	156	10		
65	10	102	11	131	15	158	25		
66	10	103	15	132	19	159	5		
67	11	105	10	133	25	160	5		
68	5	106	10	134	14	161	15		
78	2	107	20	135	17	163	5		
80	4	108	30	136	11	164	5		
81	1	109	35	137	21	165	10		
82	14	110	40	138	3	166	25		
83	16	111	25	139	9	167	10		
84	25	112	35	140	15	168	15		
85	32	113	35	141	9	169	5		
86	19	114	35	142	18	170	10		
87	21	115	30	143	12	171	15		
88	22	116	20	144	8	173	15		
89	28	117	15	145	16	174	5		
90	14	118	40	146	18	181	10		
91	13	119	10	147	3	185	10		

WING 266 HARDNESS SHORE A INITIAL TP-H1043 PROPELLANT

This sample size summary is applicable to figures 11 and 12

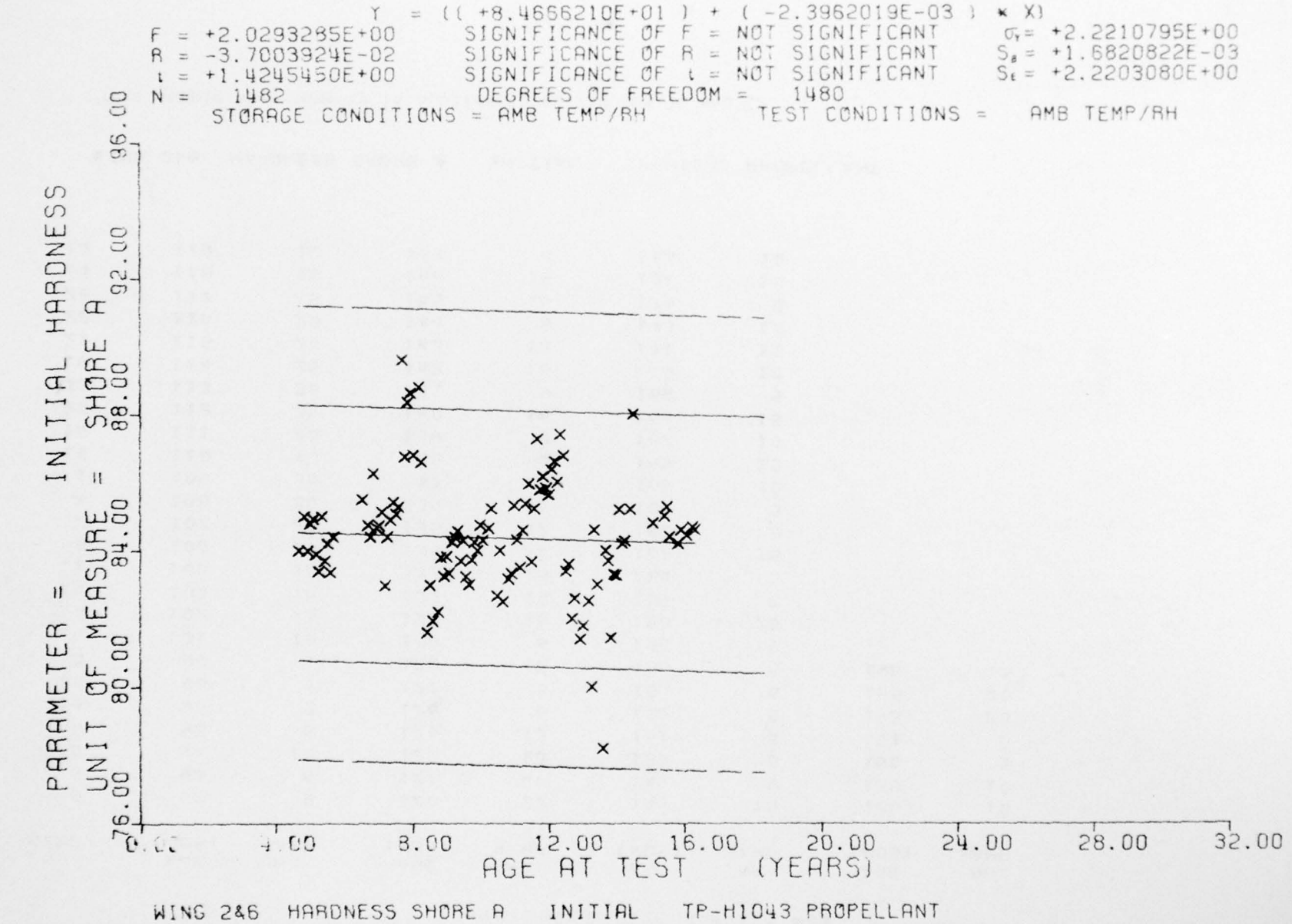
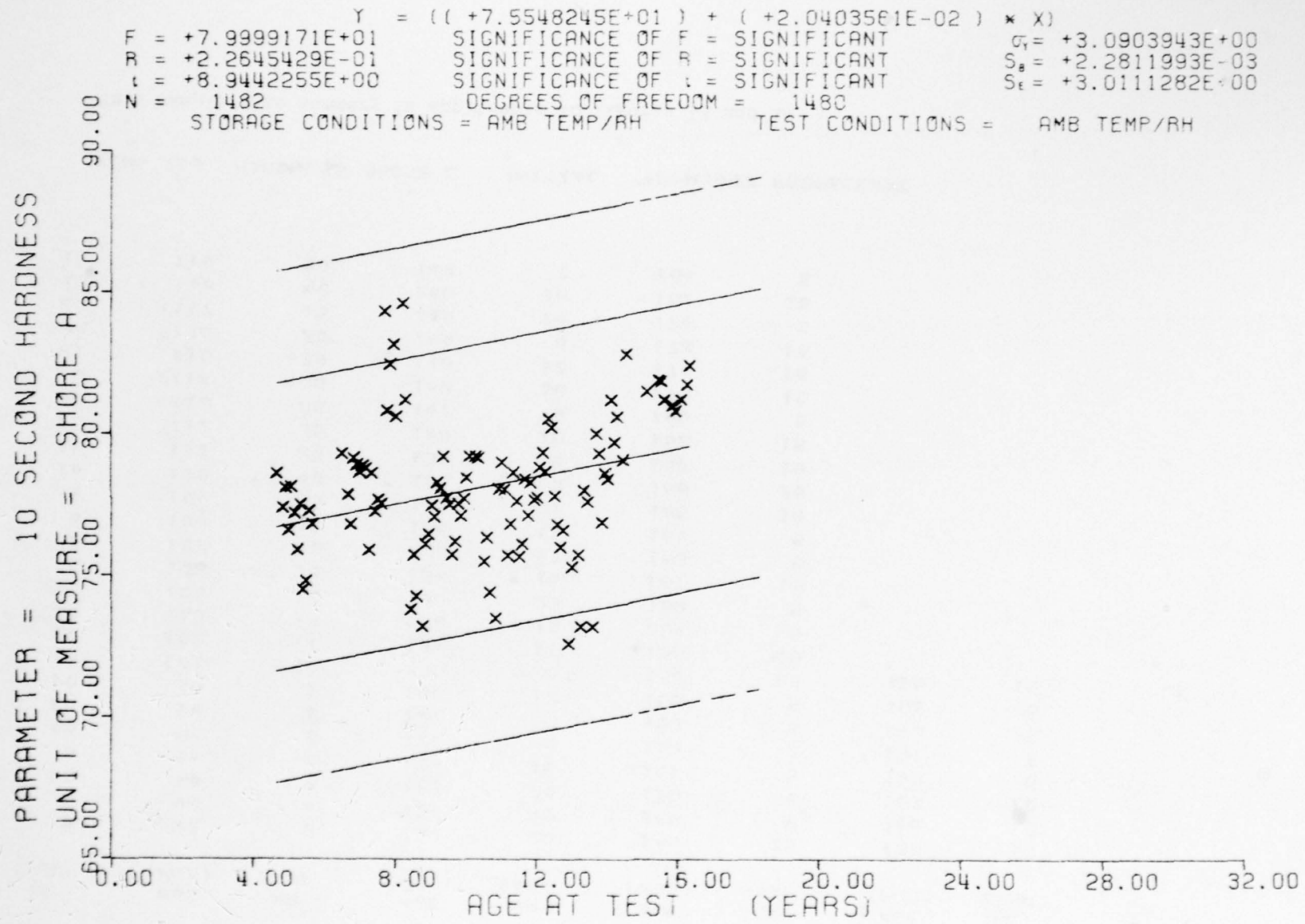

Y = ((+8.4666210E+01) + (-2.3962019E-03) * X)
F = +2.0293285E+00 SIGNIFICANCE OF F = NOT SIGNIFICANT σy = +2.2210795E+00
R = -3.7003924E-02 SIGNIFICANCE OF R = NOT SIGNIFICANT Sb = +1.6820822E-03
t = +1.4245450E+00 SIGNIFICANCE OF t = NOT SIGNIFICANT St = +2.2203080E+00
N = 1482 DEGREES OF FREEDOM = 1480
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = INITIAL HARDNESS
UNIT OF MEASURE = SHORE A
96.00
92.00
88.00
84.00
80.00
76.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
WING 2&6 HARDNESS SHORE A INITIAL TP-H1043 PROPELLANT

Figure 11



WING 2&5 HARDNESS SHORE A 10 SECOND TP-H1043 PROPELLANT

Figure 12

*** SAMPLE SIZE SUMMARY ***

AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP	AGE (MOS)	NR SAMP
56	5	92	2	120	20	148	15	185	10
58	5	93	4	121	40	149	9	186	15
59	10	94	7	123	20	150	5	187	10
60	5	95	4	124	15	151	5	190	5
61	15	96	3	126	6	152	5	191	5
62	10	98	1	127	3	153	5	193	25
63	10	99	1	128	12	155	5	195	25
64	10	101	10	130	6	156	10	196	15
65	10	102	11	131	11	158	30		
66	10	103	15	132	19	159	5		
67	11	105	10	133	25	160	5		
68	5	106	5	134	14	161	15		
78	2	107	20	135	17	163	5		
80	4	108	30	136	11	164	5		
81	1	109	35	137	21	165	10		
82	14	110	40	138	3	166	25		
83	16	111	25	139	9	167	10		
84	25	112	35	140	15	168	15		
85	32	113	35	141	9	169	5		
86	19	114	35	142	18	170	10		
87	21	115	30	143	12	171	15		
88	22	116	20	144	8	173	10		
89	25	117	15	145	16	174	5		
90	13	118	40	146	18	181	10		
91	11	119	10	147	3	184	5		

WING 266 HARDNESS SHORE C INITIAL TP-H1043 PROPELLANT

This sample size summary is applicable to figures 13 and 14

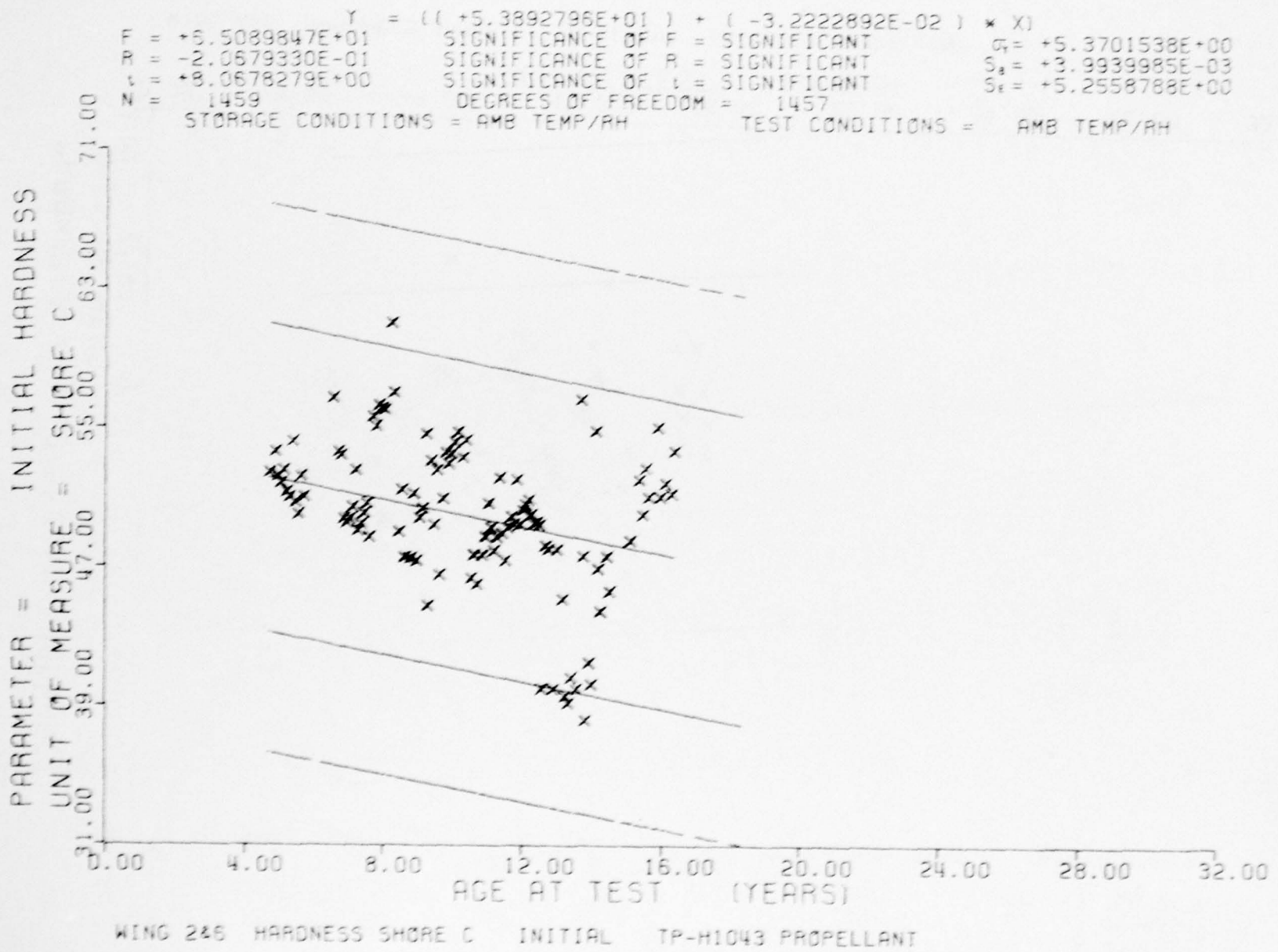

Y = ((+5.3892796E+01) + (-3.2222892E-02) * X)
F = +5.5089847E+01
SIGNIFICANCE OF F = SIGNIFICANT
σY = +5.3701538E+00
R = -2.0679330E-01
SIGNIFICANCE OF R = SIGNIFICANT
Sa = +3.9939985E-03
t = +8.0678279E+00
SIGNIFICANCE OF t = SIGNIFICANT
Se = +5.2558788E+00
N = 1459
DEGREES OF FREEDOM = 1457
STORAGE CONDITIONS = AMB TEMP/RH
TEST CONDITIONS = AMB TEMP/RH
PARAMETER = INITIAL HARDNESS
UNIT OF MEASURE = SHORE C
71.00
63.00
55.00
47.00
39.00
31.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
WING 2&6 HARDNESS SHORE C INITIAL TP-H1043 PROPELLANT

Figure 13

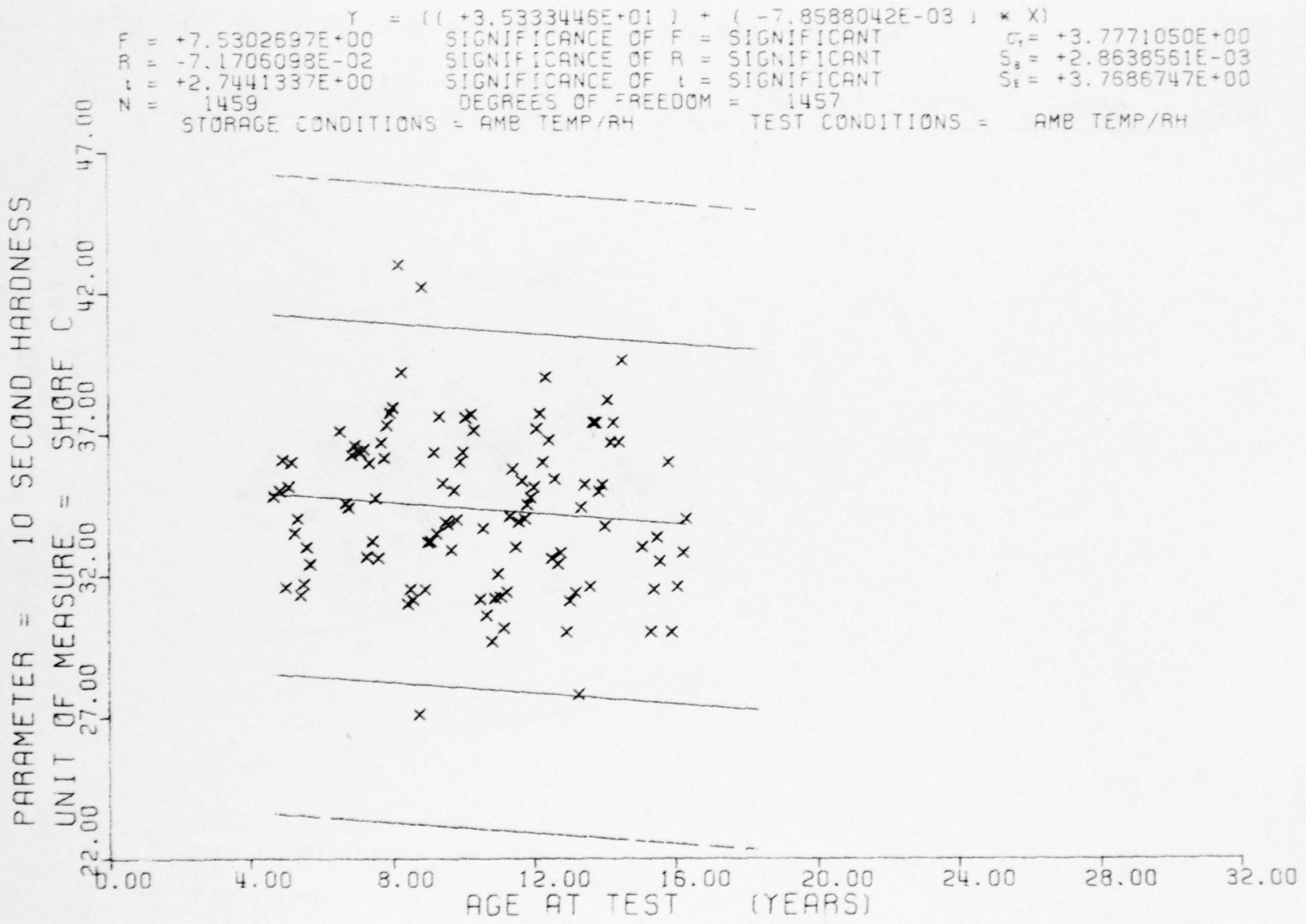

Y = ((+3.5333446E+01) + (-7.8588042E-03) * X)
F = +7.5302697E+00 SIGNIFICANCE OF F = SIGNIFICANT σ_r = +3.7771050E+00
R = -7.1706098E-02 SIGNIFICANCE OF R = SIGNIFICANT S_β = +2.8638561E-03
t = +2.7441337E+00 SIGNIFICANCE OF t = SIGNIFICANT S_ε = +3.7686747E+00
N = 1459 DEGREES OF FREEDOM = 1457
STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH
PARAMETER = 10 SECOND HARDNESS
UNIT OF MEASURE = SHORE C
22.00
27.00
32.00
37.00
42.00
47.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
AGE AT TEST (YEARS)
WING 2&6 HARDNESS SHORE C 10 SECOND TP-H1043 PROPELLANT

Figure 14

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1. REPORT NUMBER MANCP REPORT Nr 424(79)	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Propellant Surveillance Report LGM-30 A, B, F and G Stage I TP-H1043		5. TYPE OF REPORT & PERIOD COVERED Test Results - Semi - annual. 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John A. Thompson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Propellant Lab Section Directorate of Maintenance Hill AFB, Utah 84056		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Service Engineering Division Directorate of Materiel Management Hill AFB, UT 84056		12. REPORT DATE November 1979' 13. NUMBER OF PAGES 35
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains propellant test results from cartons of TP-H1043 propellant representing selected batches used in the aft closure of First Stage Minuteman Motors. Data from TP-H1043 propellant obtained from the aft closures of the LGM-30 A, B, F anf G Motors are reported in regression analyses for the fifth time and the fourth time using the G085 computer system. Testing was accomplished in accordance with MMWRME Project M82934C.

An analysis of all parameters indicate that no significant degradation is

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anticipated for at least two years past the oldest data point.

Each point on the regression plot represents all samples at that particular age. The number of samples at each point is indicated on the sample size summary sheet on the page accompanying each regression plot. The data range at any age can be found by suitable inquiry of the G085 system.