AD-A133 301 VERNIER ROCKET MOTOR MK 84 MOD 0 QUALITY EVALUATION(U) 1/1
NAVAL ORDNANCE STATION INDIAN HEAD MD W G MITCHELL
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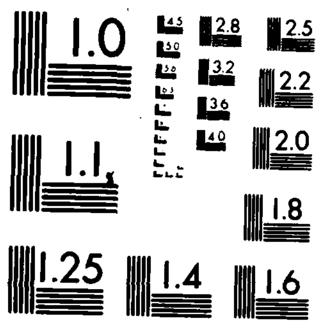

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DEPARTMENT OF THE NAVY
NAVAL ORDNANCE STATION
INDIAN HEAD, MARYLAND 20640

IN REPLY REFER TO
3012C4:WGM
8042/2-6
Ser 93
SEP 14 1983

From: Commanding Officer
To: Commander, Naval Air Systems Command (AIR-4203C1)

Subj: Vernier Rocket Motor Mk 84 Mod 0 Quality Evaluation; results of

Encl: (1) Vernier Rocket Motor Mk 84 Mod 0 Quality Evaluation

1. The purpose of this letter is to present the results of a Quality Evaluation on the Vernier Rocket Motor Mk 84 Mod 0. Test results together with the conclusions and recommendations as pertaining to unit safety and serviceability are presented in enclosure (1).

2. Questions pertaining to this program may be directed to William Mitchell, Code 3012C4, Commercial 301-743-4800 or Autovon 364-4800.

JOHN E. MORGAN
By direction

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VERNIER ROCKET MOTOR MK 84 MOD 0
QUALITY EVALUATION

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Enclosure (1)

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REPORT BRIEF

Evaluation: Vernier Rocket Motor Mk 84 Mod 0

Purpose:

This program was conducted to determine the present performance capability and safety of the Vernier Rocket Motor Mk 84 Mod 0 and to determine the feasibility of extending the service life of the Vernier Rocket Motor Mk 84 Mod 0.

Test Results:

A sample of 12 motors, ranging in age from 89 to 120 months was evaluated. Tests included visual and radiographic inspections, static-firings at either -40°F or 160°F and a post-firing inspection.

Visual: All motors were found to be in good condition both before and after static-firing.

Radiographic: No propellant anomalies were detected and all units were assembled correctly.

Ballistic: Three motors at 160°F exceeded the upper specification limit of 323 msecs for action time. These same three motors also exceeded the upper specification limit of 305 msecs for burn time at 160°F. All other parameters were within the specification limits. At -40°F all motors performed satisfactorily. The variation of the population's performance with age was small and those parameters with failures of the production specifications predicted were found to be within system requirements.

Conclusions:

Based on the results of this evaluation, it was concluded that the Vernier Rocket Motor Mk 84 Mod 0 will perform acceptably for continued safe operation of the ESCAPAC ejection seat.

Enclosure (1)

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Recommendations:

It is recommended that:

(1) The Vernier Rocket Motor Mk 84 Mod 0 produced by Talley Industries remain in the Fleet inventory.

(2) The service life of the Vernier Rocket Motor Mk 84 Mod 0 produced by Talley Industries be extended from 120 months to 144 months from the date of propellant manufacture.

Enclosure (1)

INTRODUCTION

The Vernier Rocket Motor Mk 84 Mod 0, also referred to as the Seat Stabilization Rocket Motor, is used on all four seats of the Viking S-3A aircrew escape system. This gyroscopically aligned rocket motor provides the thrust necessary to maintain the correct pitch attitude of the seat during an ejection. The current service life of this unit is 120 months from the date of propellant manufacture. This quality evaluation program was the fourth to be conducted on this unit since its introduction in the Fleet.

The Vernier Rocket Motor Mk 84 Mod 0, illustrated in Figure 1, is manufactured by Talley Industries of Arizona. The unit is a self-contained, mechanically initiated rocket motor which uses a cartridge loaded, solid composite propellant. The propellant has a carboxyl-terminated polybutadiene binder system and is cast into two inhibiting tubes. The nozzle for this unit is mounted in the center of the unit with its axis perpendicular to the primary axis of the propellant tubes.

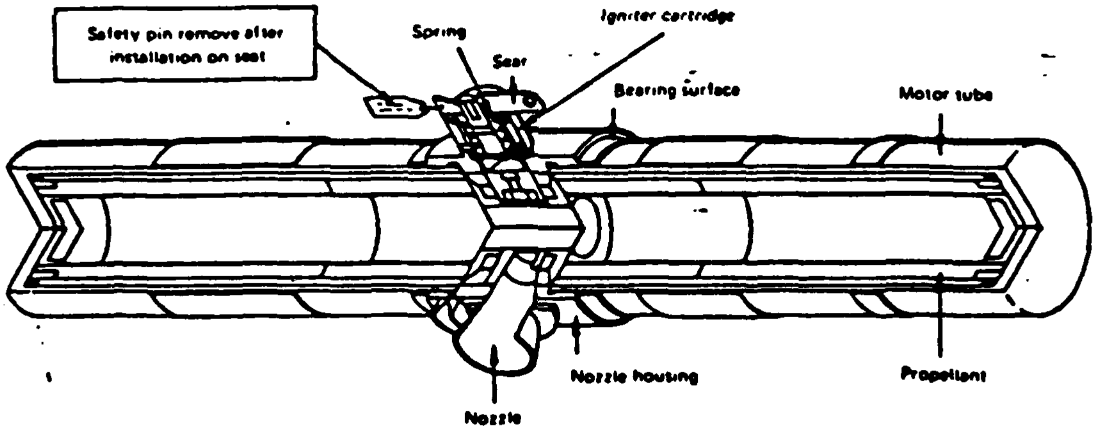


FIGURE 1. ROCKET MOTOR MK 84 MOD 0

TEST PROCEDURE

Upon receipt, all motors were visually and radiographically inspected. The motors were then temperature conditioned to -40°F or 160°F and static-fired. Shown in Table I is the number of units static-fired at each temperature. The operational parameters measured were ignition delay, maximum thrust, action time, total impulse, time to 70% of maximum thrust, burn time, sear force, and maximum torque and direction. Definitions of these parameters may be found in Appendix A.

TABLE I. STATIC-FIRING TEMPERATURE BREAKDOWN FOR THE VERNIER ROCKET MOTOR MK 84 MOD 0

MANUFACTURER	NO. UNITS	FIRING TEMPERATURE (°F)
Talley	7	-40
Talley	5	160

TEST RESULTS

Visual Inspection:

All motors were in good external condition.

Radiographic:

No propellant abnormalities were observed and all units were assembled correctly.

Ballistic:

The ballistic data obtained from the static-firings are presented in Table II. These results revealed that all motors performed satisfactorily at -40°F. However, at 160°F three motors exceeded the upper specification limit of 305 msec for burn time.

TABLE II. VERNIER ROCKET MOTOR MK 84 MOD 0 BALLISTIC DATA

Lot No.	Serial No.	Age (mo.)	Ignition Delay (msec)	Maximum Thrust (lbf)	Action Time (msec)	Total Impulse (lbf-sec)	Time to 70% Max. Thrust (msec)	Burn Time (msec)	Minimum Torque (in-lbf)	Maximum Torque (in-lbf)	Sear Force (lfb)
						-40°F					
TAC-1-11	197	120	12	757	386	234	2.2	376	-0.6	1.0	31
TAC-1-11	236	120	8	694	412	232	4.2	401	-0.5	1.7	29
TAC-1-12	351	113	16	788	389	232	2.6	374	-0.3	2.7	29
TAC-1-12	303	113	9	746	400	231	1.8	386	0.2	2.6	29
TAC-1-13	587	102	10	753	409	237	2.8	397	0.0	2.6	30
TAC-2-2	1087	83	12	713	420	241	2.4	406	-0.6	1.9	29
001TAC1175	912	89	8	712	415	237	2.4	398	-0.7	1.5	29
[1]Specifications:											
Maximum			35	878	450	244	10	424	-6	6	35
Minimum			--	623	352	220	--	331	0	0	25
						160°F					
TAC-1-11	202	120	7	951	317	239	3.0	304	0.3	2.6	30
TAC-1-12	377	113	6	1016	301	234	2.4	284	-0.4	1.4	27
TAC-1-13	582	102	7	997	329*	239	2.6	315*	-0.1	1.9	28
TAC-2-2	1098	83	7	920	336*	245	4.2	321*	-2.9	0.8	28
001TAC1175	947	89	6	905	339*	245	2.2	322*	-3.1	2.4	30
[1]Specifications:											
Maximum			20	1140	323	249	10	305	-6	6	35
Minimum			--	877	278	220	--	257	0	0	25

[1]MIL-A-85097/7(AS)
*Exceeds Spec.

Enclosure (1)

The same three motors also exceeded the upper specification limit of 323 msec for action time. These failures were small in magnitude and would not have degraded the ejection seat's capabilities or safety since the escape system requirements of 450 msec for action time and 424 msec for burn time were met (per the system specification, AS115131). Following the static-firings, a post-firing inspection was conducted which revealed no abnormalities in the motors fired at either temperature.

DATA ANALYSIS

The data generated in this evaluation were compared with data from previous evaluations and revealed that all parameters except ignition delay at 160°F could be considered homogeneous. Thus, all statistics herein are based on the combined data. When combining statistics for ignition delay at 160°F, an effective degree of freedom and the total standard deviation were used. The torque value used in the analysis was the greatest torque, irrespective of direction. Sear force was recorded for the first time so no performance or aging equations were computed.

Statistical analyses were performed to determine the population's current reliability as well as aging trends in performance. A discussion of these data follows.

Reliability:

To estimate the pobability that a unit will perform successfully, reliability $(\hat{R})$ estimates with upper (R^{90}) and lower (R_{90}) 90% confidence limits were calculated. Two different modes of reliability are presented: catastrophic, which is based on the number of units failing to complete the operational cycle, and functional, which is based on the number of units failing specifications that would not endanger the life of an ejecting aircrewman. There have been no catastrophic failures during lot acceptance or quality evaluations. The reliability statistics are presented in Table III.

TABLE III. VERNIER ROCKET MOTOR MK 84 MOD 0
RELIABILITY STATISTICS

		Catastrophic			Functional			
Temp.	No. Tested	No. Failed	$\hat{R}$	R_{90}	No. Failed	R_{90}	$\hat{R}$	R_{90}
-40°F	22	0	1.000	0.901	2	0.976	0.909	0.776
160°F	19	0	1.000	0.886	11	0.592	0.421	0.263
Comb.	41	0	1.000	0.945	13	0.778	0.683	0.571

Strong temperature dependence was indicated for the functional reliability. This is primarily due to the long action times and burn times experienced at 160°F.

Aging Trends:

In order to estimate the population's performance with respect to age, the data from lot acceptance tests and quality evaluations were plotted as a function of age. These plots are presented in Figures 2 through 8. A least squares regression curve fit to these data is shown as the solid line drawn through the data and represents the change of the population means with age for each parameter. The tolerance limits are shown as the dotted lines bounding the data points and define an interval within which 90% of the population's performance is predicted to exist with a 90% confidence level. Two acceptance means were considerably more than three standard deviations from the lot acceptance means which makes them statistical outliers. Consequently, these are not used in the regression or tolerance limit analysis. The parameters are listed below.

Parameter	Lot	Temp (°F)	Mean	Figure
Maximum Thrust	TAC-1-13	160	560.7	2
Time to 70% Max. Thrust	TAC-1-11	-40	8.0	5

The performance of these lots at the other temperature was also extreme but, not in excess of the outlier criteria.

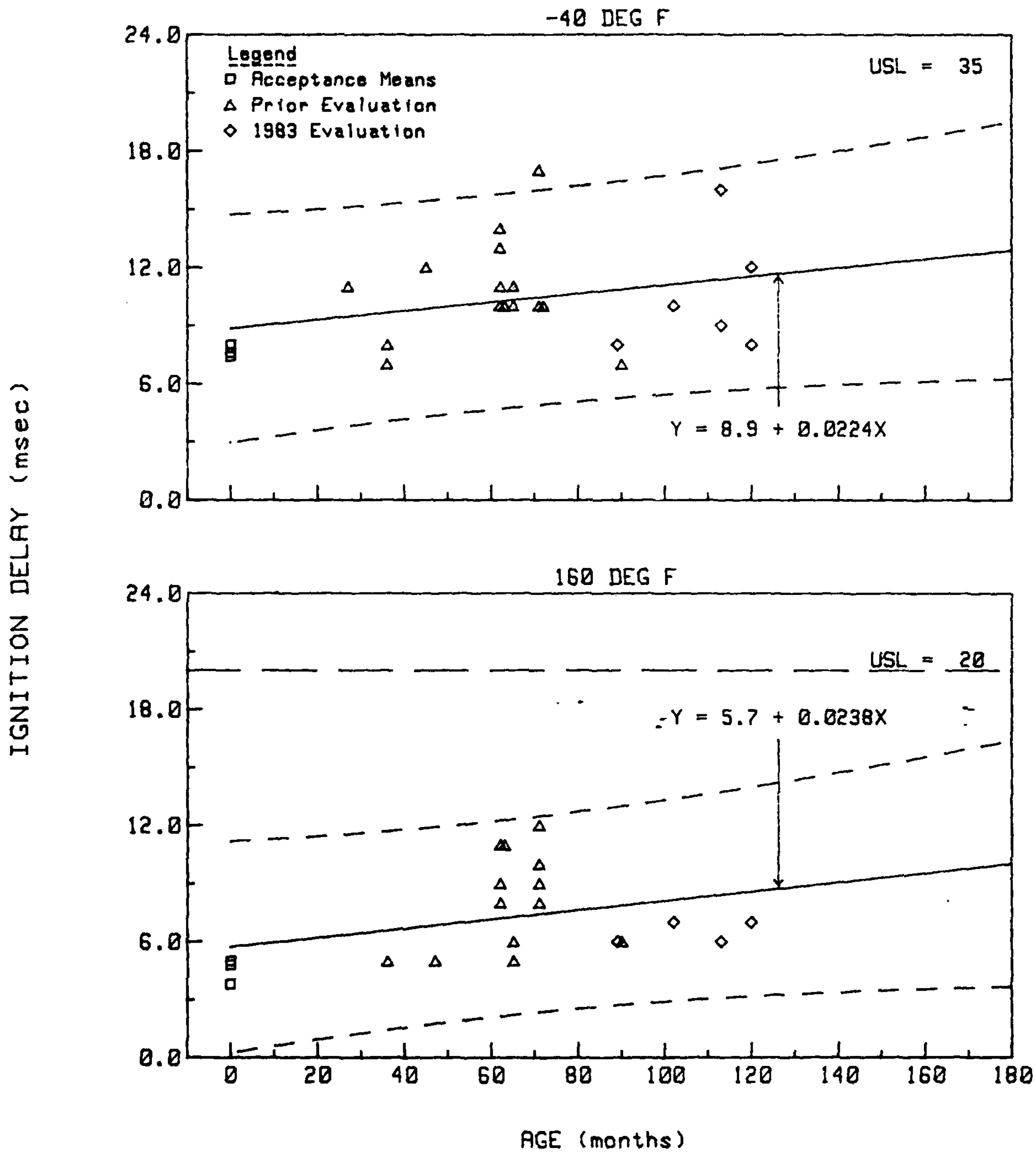
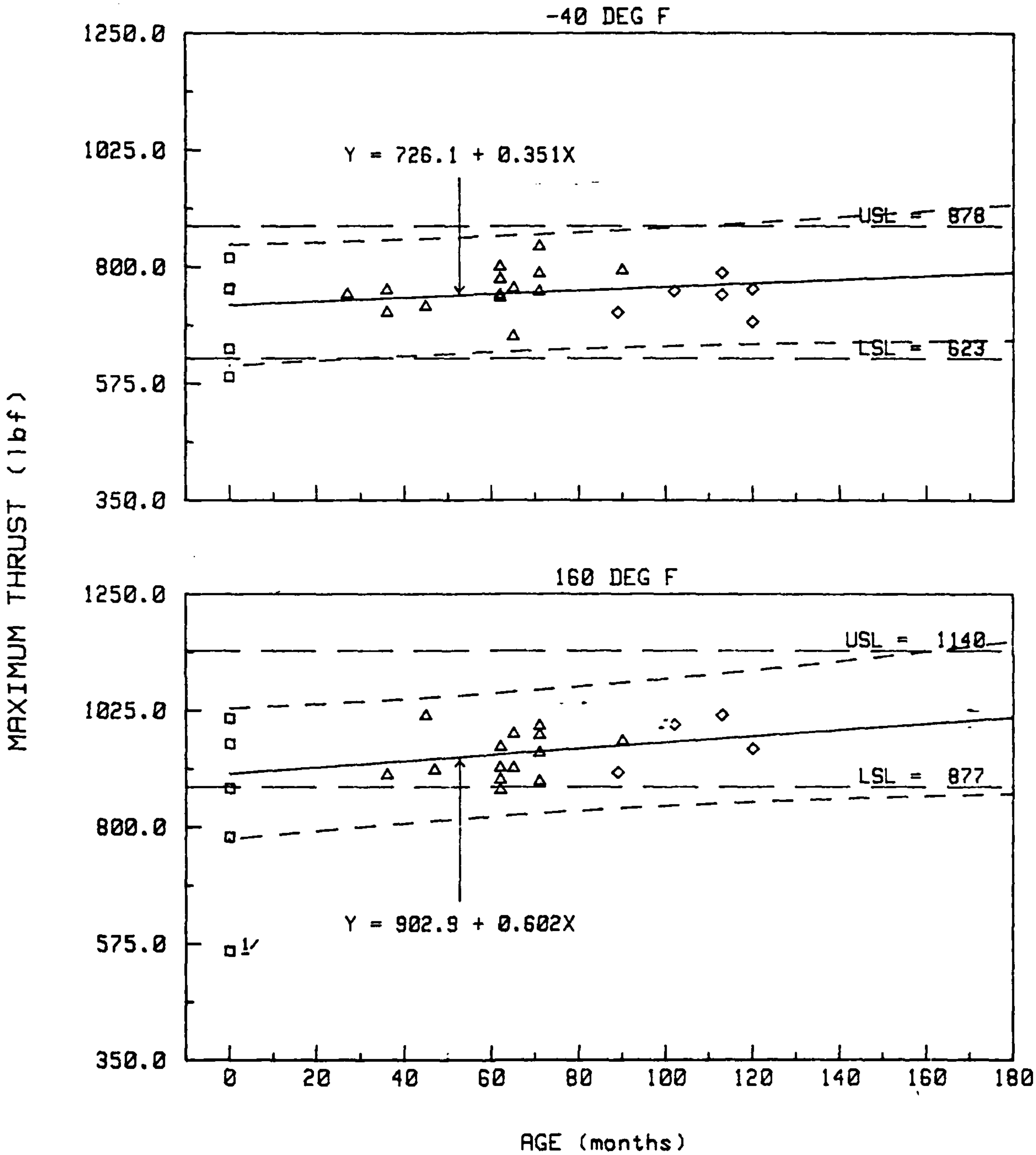


FIGURE 2. TRENDS IN IGNITION DELAY
MK 84 MOD 0 SEAT STABILIZER



1/ Statistical outlier, not used in the regression analysis

FIGURE 3. TRENDS IN MAXIMUM THRUST
MK 84 MOD 0 SEAT STABILIZER

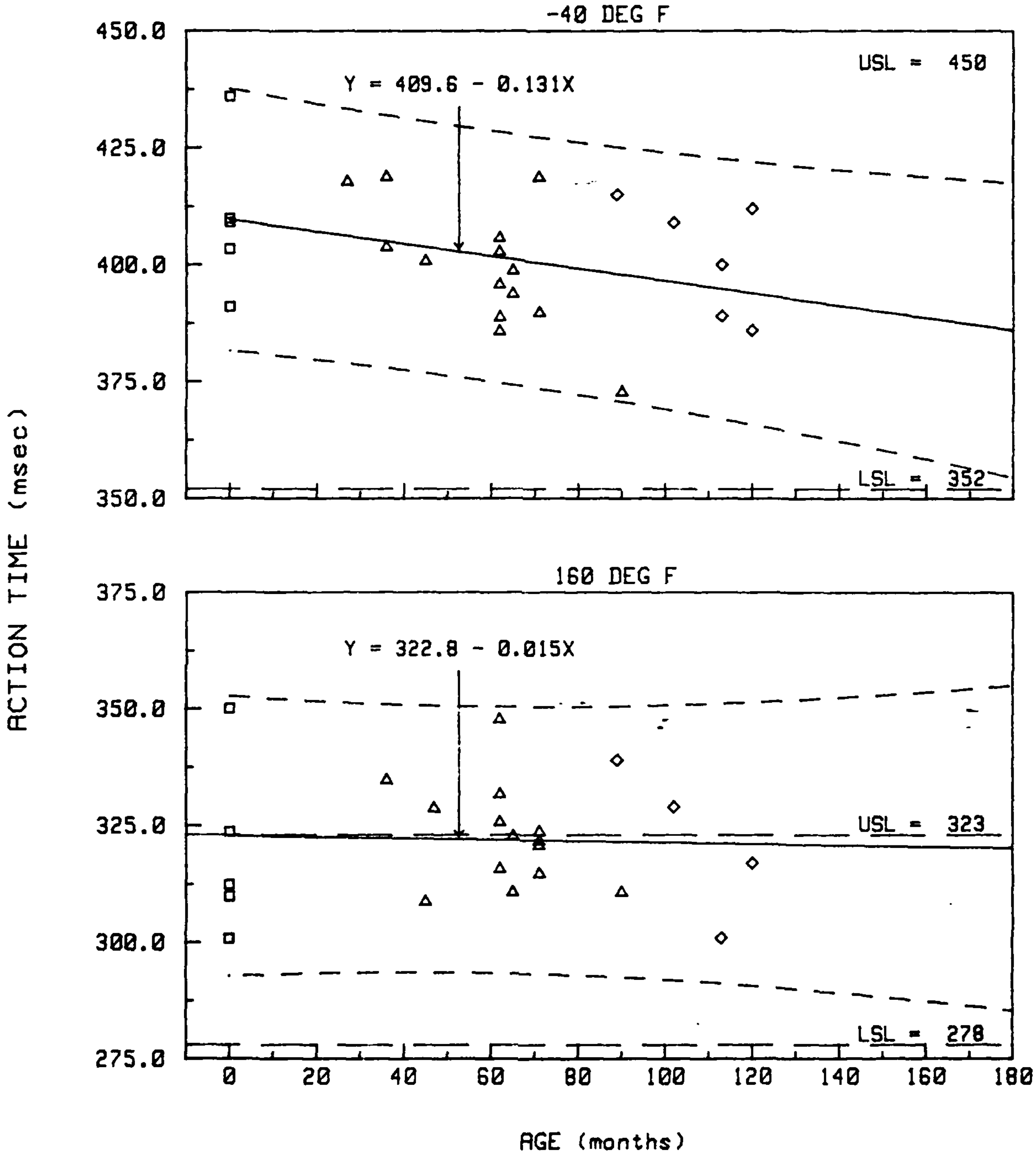


FIGURE 4. TRENDS IN ACTION TIME
MK 84 MOD 0 SEAT STABILIZER

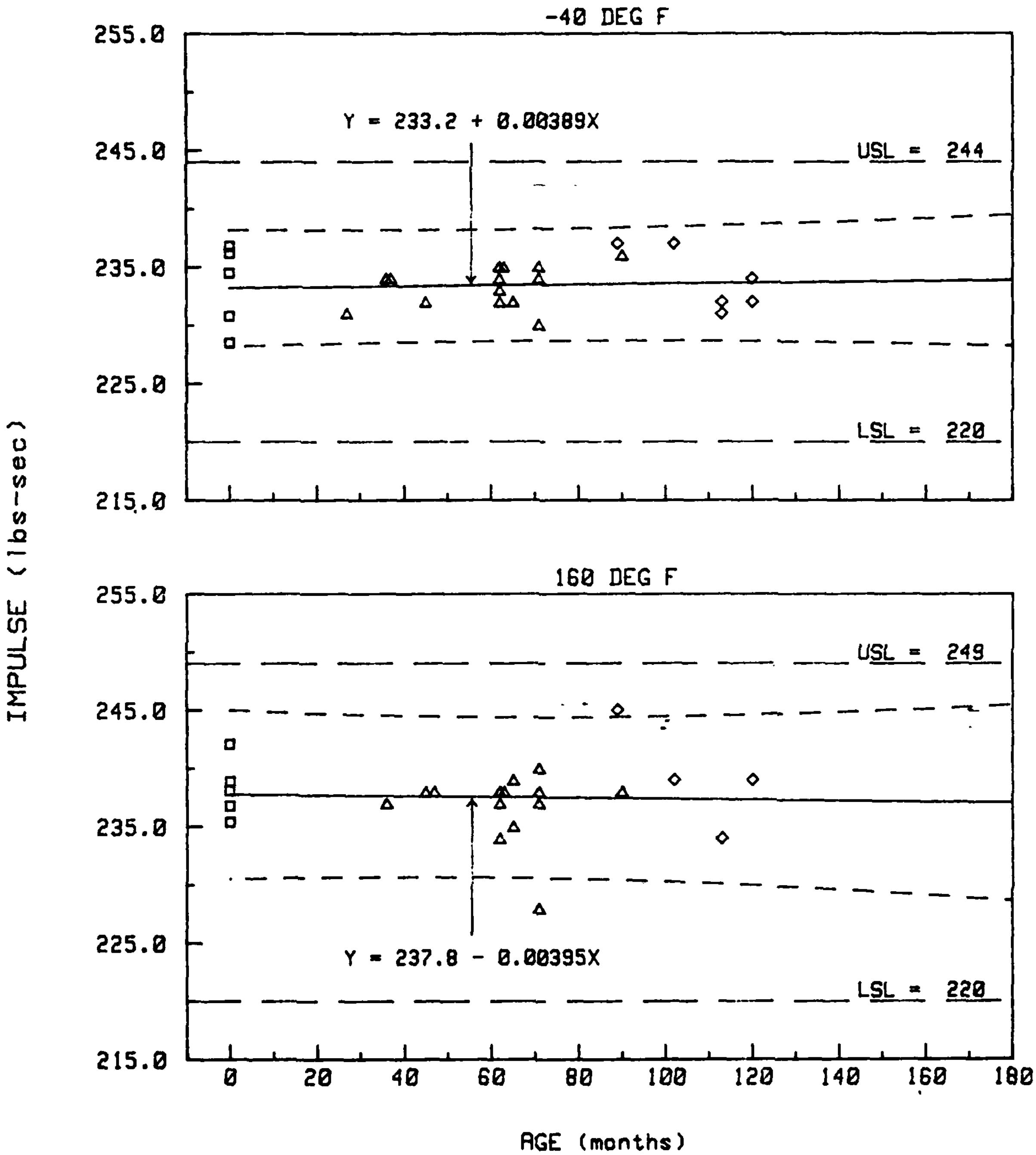
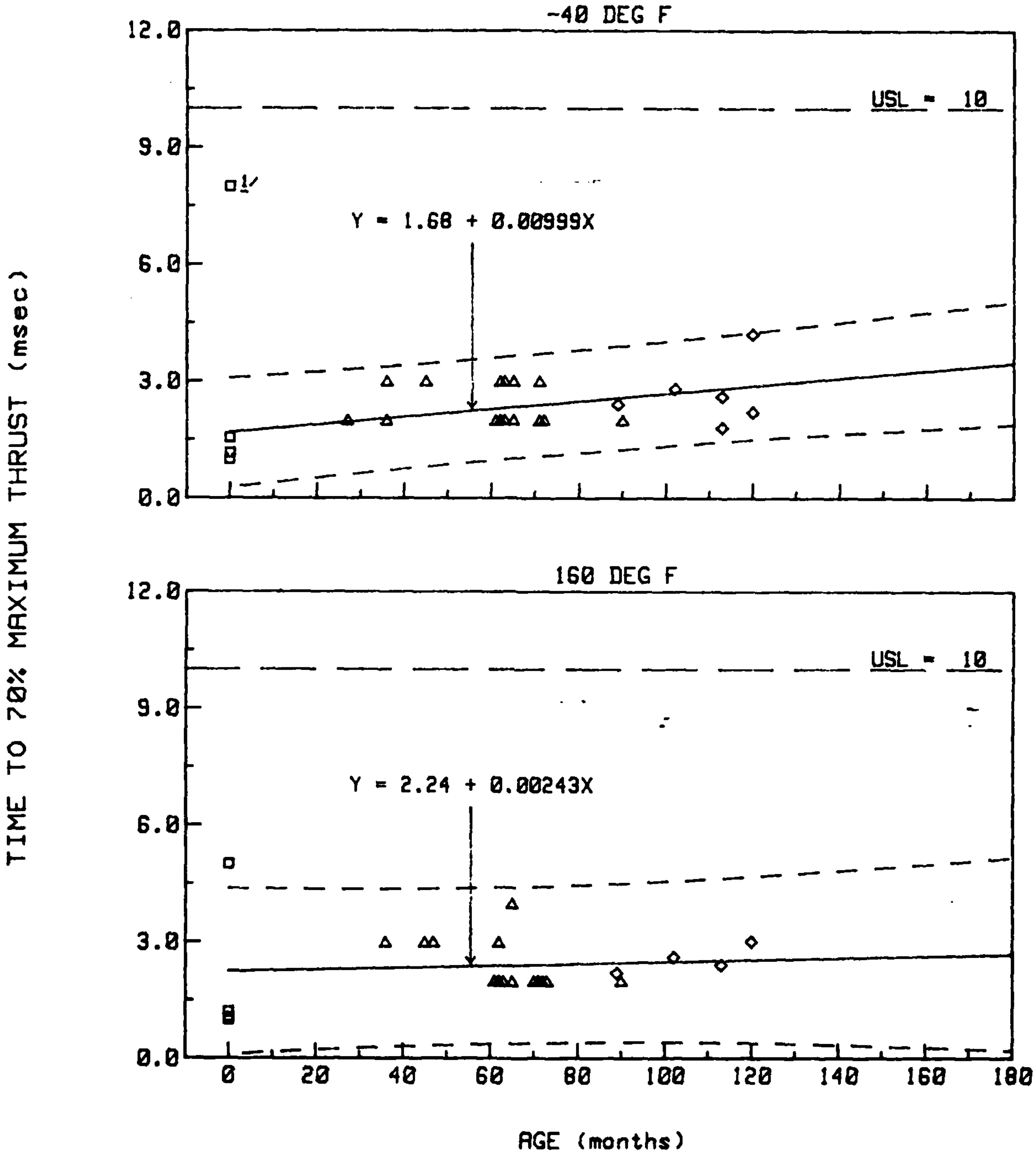


FIGURE 5. TRENDS IN IMPULSE
MK 84 MOD 0 SEAT STABLILZER



1/ Statistical outlier, not used in the regression analysis

FIGURE 6. TRENDS IN TIME TO 70% MAXIMUM THRUST
MK 84 MOD 0 SEAT STABILIZER

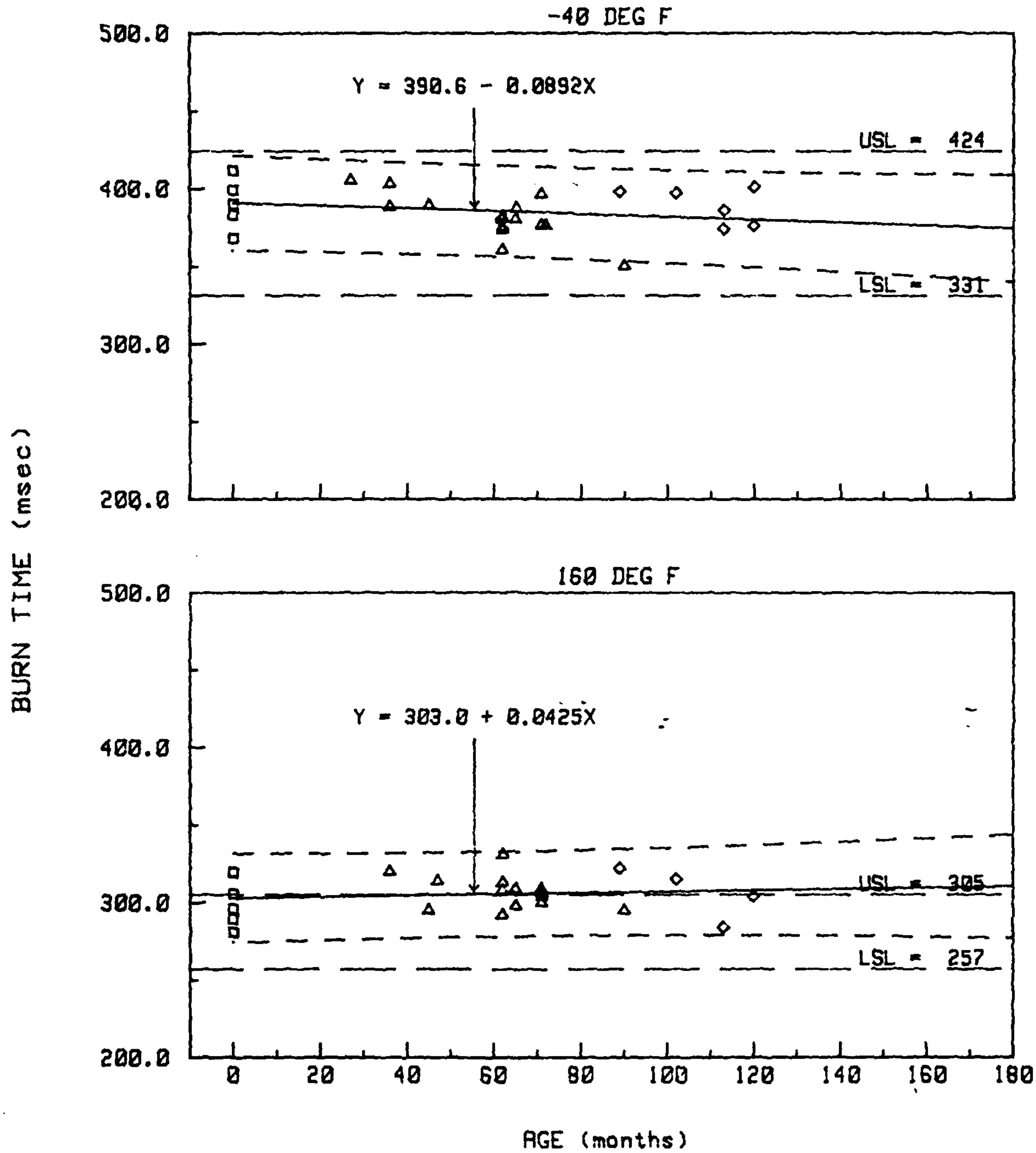


FIGURE 7. TRENDS IN BURN TIME
MK 84 MOD 0 SEAT STABILIZER

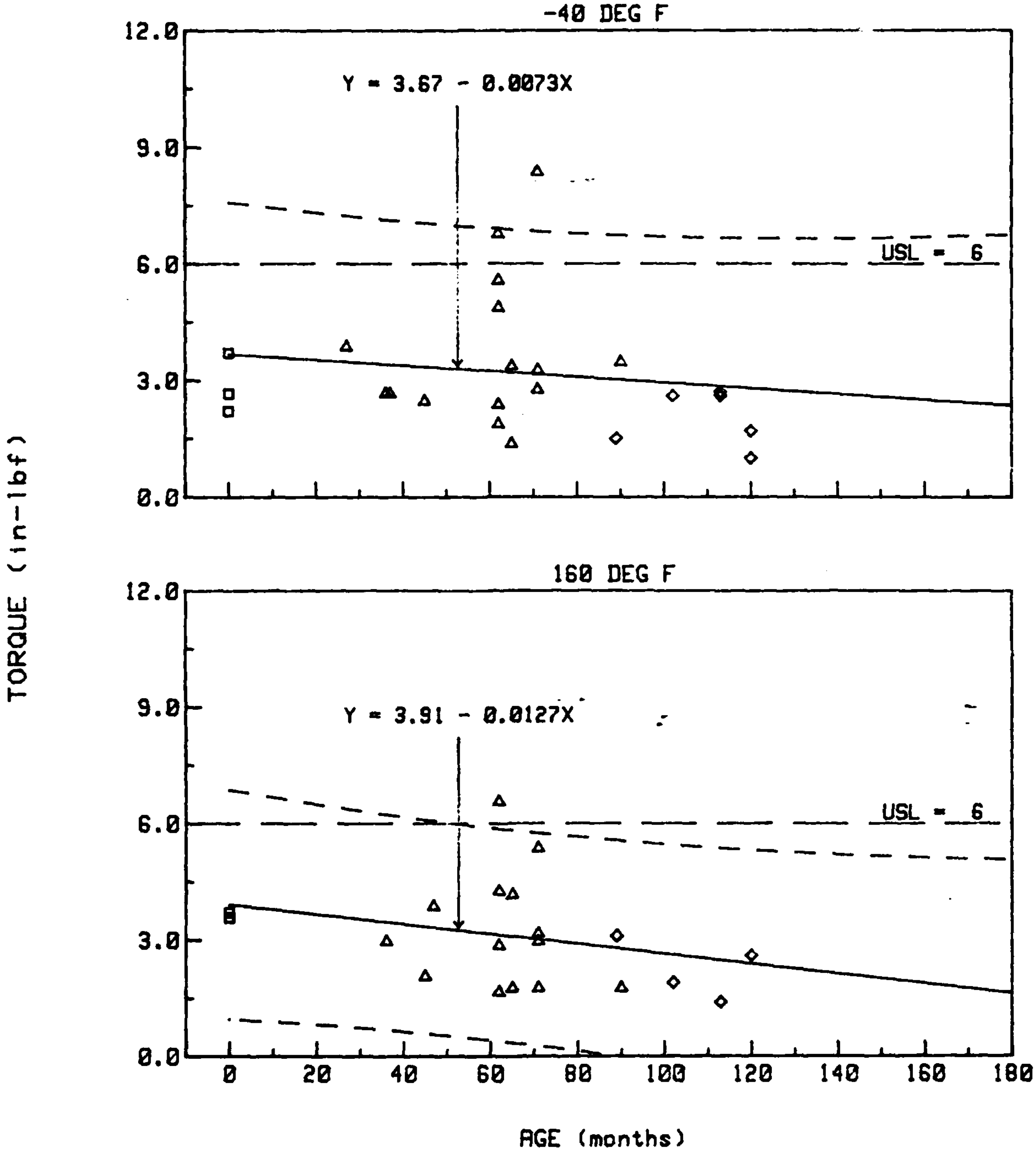


FIGURE 8. TRENDS IN TORQUE
MK 84 MOD 0 SEAT STABILIZER

The aging trends for the ballistic performance of these units indicated that the ignition delay, the maximum thrust, and the time to 70% of maximum thrust are increasing with age, and that the action time and the maximum torque are decreasing with age. No significant variation with age was seen in the total impulse or in the burn time.

The analysis of the inventory for specification compliance determined that some units of the current population will exceed production specifications. The maximum torque, shown in Figure 8, is a measure of the misalignment of the nozzle axis with the primary axis of the motor and, represents the forces that the steering gyroscope must operate against. At 160°F, while some units will fail the specification when 0 to 50 months of age, a decreasing trend results in a lower failure rate for older motors. At -40°F between 5% and 50% of the inventory will fail the upper specification throughout the unit's service life. The tolerance limits predict that the most extreme failures will be no more than 3 in-lbf of torque above the specification which is within the system capabilities.

A large portion of the inventory was predicted to exceed the production specifications for two parameters throughout the life of these units. The parameters were action time and burn time at 160°F. The population mean calculated for these parameters coincides with the upper specification limit in both cases. This indicates that approximately 50% of the inventory will exceed the specification and, since there is no significant variation with age, this situation should exist throughout the life of this unit. However, the tolerance limits calculated for both parameters are well below the overall aircrew escape system requirements of 424 msec for burn time and 450 msec for action time. Since the system requirements will continue to be met, the systems using this unit will continue to operate at full capability.

Estimated Percent Defective:

To estimate the percentage of units expected to fail a given specification, the estimated percent defective (EPD) and the lower and upper 95% confidence limits on the true percent defective (P.05 and P.95) were calculated. Table IV gives the EPD, P.05 and P.95 for those parameters where the EPD was greater than zero. These statistics indicate that a large percentage of units should be expected to fail the action time and burn time upper specification limits at 160°F but, as discussed earlier in this report, this should not adversely affect the aircrew escape system safety or capabilities.

TABLE IV. VERNIER ROCKET MOTOR MK 84 MOD 0
ESTIMATED PERCENT DEFECTIVE STATISTICS

Parameter	Temp.	Spec.	P.05	EPD	P.95
Maximum Thrust	-40°F	U	0	0.1	0.9
Burn Time	-40°F	U	0	0.4	2.7
Torque	-40°F	U	2.0	6.3	15.6
Maximum Thrust	160°F	L	1.9	6.7	17.2
Action Time	160°F	U	36.3	51.2	65.9
Total Impulse	160°F	U	0	0.1	1.6
Burn Time	160°F	U	44.9	60.1	73.9
Torque	160°F	U	0.2	1.6	7.2

CONCLUSIONS

Based on the results of this evaluation, it was concluded that the Vernier Rocket Motor Mk 84 Mod 0 will perform acceptably for continued safe operation of the ESCAPAC ejection seat.

RECOMMENDATIONS

It is recommended that:

(1) The Vernier Rocket Motor Mk 84 Mod 0 produced by Talley Industries remain in the Fleet inventory.

(2) The service life of the Vernier Rocket Motor Mk 84 Mod 0 produced by Talley Industries be extended from 120 months to 144 months from the date of propellant manufacture.

APPENDIX A

BALLISTIC PARAMETER DEFINITIONS

1. Ignition Delay - Ignition delay is the elapsed time from the ignition signal (shear pin or lanyard release) to 10 percent of maximum thrust, as measured on the rising portion of the thrust-time trace.

2. Maximum Thrust - The maximum thrust is the maximum value of thrust on the thrust-time trace.

3. Action Time - Action time is the time interval from 10 percent of maximum thrust on the initial rise of the curve to the corresponding 10 percent of maximum thrust on the declining portion of the thrust-time trace.

4. Total Impulse - Total impulse is obtained by vectorially adding the longitudinal and normal impulse of the rocket motor taken over the action time.

5. Time to 70% Maximum Thrust - Time to 70% Maximum thrust is the interval between the ignition signal (shear pin release) until 70% of maximum thrust is achieved on the initial rise portion of the thrust-time trace.

6. Burn Time - Burn time is the time from 10 percent thrust on the increasing portion of the thrust-time trace until the thrust-time trace breaks sharply downward at web burnout using the tangential method.

7. Sear Force - Sear force is the force required to withdraw the rocket motor sear pin.