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ABSTRACT

This document presents the basic test data obtained during the Lift-Propulsive Force Limit Wind Tunnel Test conducted during 1976 at the Boeing Vertol Wind Tunnel. Included are the rotor control positions, blade loads and six components of rotor force and moment, corrected for hub tares. Performance and blade loads are presented as the rotor lift limit is approached at fixed levels of rotor propulsive force coefficients and rotor tip speeds. Performance and blade load trends are presented for fixed levels of rotor lift coefficient as propulsive force is increased to the maximum obtainable by the model rotor. Test data is also included that defines the effect of stall proximity on rotor control power. This test data is presented in Volume II and III and the analysis of the data is presented in Volume I.

FOREWORD

This report was prepared by the Boeing Vertol Company for the National Aeronautics and Space Administration, Langley Research Center, under NASA contract NAS1-14317. It presents the test data and analysis from the Lift-Propulsive Force Limit Wind TUnnel Test. The analysis of the data establishes the useful flight envelope and the characteristics of a conventional rotor in high speed flight. The results are presented in three volumes.

-1 Wind Tunnel Investigation of Rotor Lift and Propulsive Force Limits at High Speed - - Data Analysis -

-2 & -3 Wind Tunnel Investigation of Rotor Lift and Propulsive Force Limits at High Speed - - Test Data Appendix -

Mr. J. L. Jenkins (NASA Langley) was the technical monitor for this work.

The Boeing Vertol Program Manager was F. J. McHugh and was assisted in the testing, data presentation and report preparation by Ross Clark, Aerodynamics Tech. Rep.

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NOMENCLATURE

Symbol	Definition	Units
A	Rotor Area (πR^2)	$m^2 (ft^2)$
Al, a_1	1st Harmonic Longitudinal Flapping Angle	rad(deg)
A_1	Lateral Cyclic (-θ at ψ = 0°)	rad(deg)
Bl, b_1	1st Harmonic Lateral Flapping Angle	rad(deg)
B_1	Longitudinal Cyclic (-θ at ψ = 90°)	rad(deg)
CB12	Alternating Root Chord Bending Moment at 12% Blade Radius (P+P)/2	kg-m(in-lb)
CB53	Alternating Mid Span Chord Bending Moment at 53% Blade Radius (P+P)/2	kg-m(in-lb)
CDE/SB	Rotor Effective Drag Coefficient = $DE/\rho A V_{TIP}{}^2 \sigma$	
CH/SB	Rotor Longitudinal Force Coefficient = $H_{FORCE}/\rho A V_{TIP}{}^2 \sigma$	
CPMB	Rotor Pitching Moment = $PM/\rho A V_{TIP}{}^2 R$	
CP/SB	Rotor Power Coefficient = $Q/\rho A V_{TIP}{}^2 R \sigma$	
CRMB	Rotor Rolling Moment Coefficient = $RM/\rho A V_{TIP}{}^2 R$	
CT'/SB	Rotor Lift Coefficient = $L/\rho A V_{TIP}{}^2 \sigma$	
CX/SB	Rotor Propulsive Force Coefficient = $X/\rho A V_{TIP}{}^2 \sigma$	
CY/SB	Rotor Side Force Coefficient = $S.F./\rho A V_{TIP}{}^2 \sigma$	
FB12	Alternating Root Flap Bending at 12% Blade Radius (P+P)/2	kg-m(in-lb)
FB22	Alternating Inboard Flap Bending Moment at 22% Blade Radius (P+P)/2	kg-m(in-lb)

Symbol	Definition	Units
FB48	Alternating Mid Span Flap Bending Moment at 48% Blade Radius (P+P)/2	kg-m(in-lb)
FB79	Alternating Outboard Flap Bending Moment at 79% Blade Radius (P+P)/2	kg-m(in-lb)
PM	Hub Pitching Moment	m-kg(ft-lb)
Q	Rotor Torque	kg-m(lb-ft)
R	Rotor Radius	m(ft)
RM	Hub Rolling Moment	m-kg(ft-lb)
SF	Rotor Side Force	kg(lb)
T	Rotor Thrust	kg(lb)
TB12	Alternating Root Torsion at 12% Blade Radius = (P+P)/2	kg-m(in-lb)
TB20	Alternating Inboard Torsion at 20% Blade Radius = (P+P)/2	kg-m(in-lb)
TB51	Alternating Mid Span Torsion at 51% Blade Radius = (P+P)/2	kg-m(in-lb)
TB81	Alternating Outboard Torsion at 81% Blade Radius = (P+P)/2	kg-m(in-lb)
V	Tunnel Velocity	m/s(ft/s)
V_{TIP}	Rotor Tipspeed	m/s(ft/s)
X	Rotor X Force	kg(lb)
α_s	Shaft Angle of Attack	rad(deg)
θ	Collective Pitch	rad(deg)
μ	Advance Ratio = V/V_{TIP}	

Symbol	Definition	Units
ρ	Tunnel Density	N/m^2 ($slugs/ft^2$)
σ	Rotor Solidity $bc/\pi R$	

TABLE 5.1 RUN LOG (continued)

TYPE OF TESTING	RUN NO.	ROTOR TIP SPEED V_T	ADVANCE RATIO μ	ROTOR LIFT COEFF. C_T'/σ	ROTOR PROPULSIVE FORCE COEFF $X/qd^2\sigma$	TUNNEL SPEED V	COMMENTS
BASELINE ROTOR CHARACTERISTICS	219	Range			0	For μ	Blade Frequency Check
CHECK AND VERIFICATION RUNS	221 222 224 225 226 227	620 FPS	.53 .50 .50 .45	Range	.05 .05 .05 .05 .05 .05	328 310 FPS 310 FPS 279 FPS	These runs were made to verify that the rotor performance or Part 1 and Part 2 were consistent and did not include any model fouling
LIFT LIMIT TESTING	228 245 246 249	620 FPS	.57	Range	.05 .025 .025 .10	353 FPS	Cruise performance and lift limits at baseline rotor tip speed
	229 248	620 FPS	.61	Range	.05 .075	378 FPS	
	250 251 252 253	570 FPS	.40 .45 .50 .53	Range	.05	228 FPS 256 FPS 285 FPS 302 FPS	Cruise performance and lift limits at reduced rotor tip speed to define effect of advancting tip Mach number
	256 255 254 257 258 259 260	570 FPS	.40 .45 .50 .53 .57 .61 .64	Range	.05	228 FPS 256 FPS 285 FPS 302 FPS 325 FPS 348 FPS 368 FPS	
PROPULSIVE FORCE LIMIT TESTING	230 231	620 FPS	.40	.06 .09	Range	248 FPS	Cruise performance and propulsive force limits at baseline tip speed
	243 244	620 FPS	.45	.06 .076	Range	279 FPS	
	232 233 234 235	620 FPS	.50	.06 .06 .08 .08	Range	311 FPS	

6.0 TEST DATA OPERATION

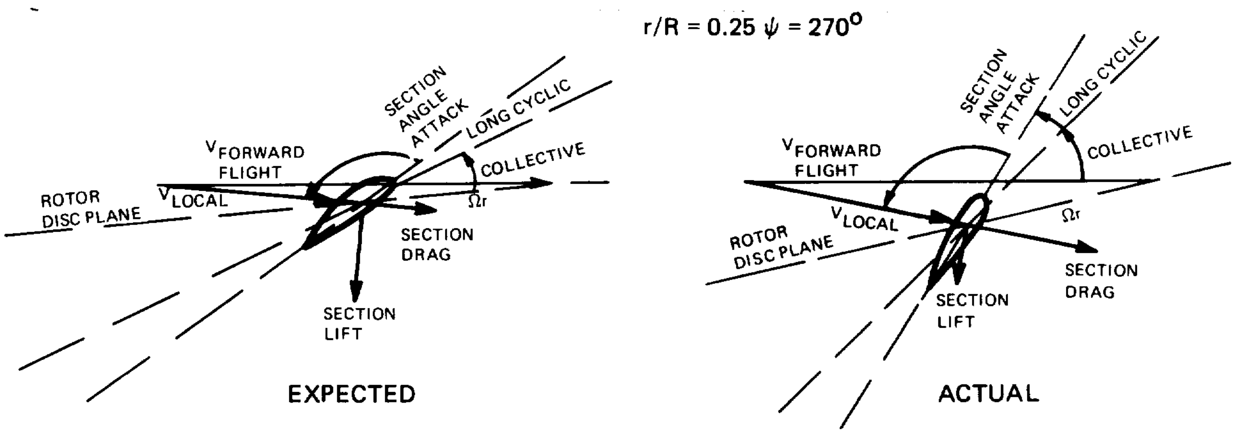
As defined in Section 5, the overall program objective was to define the performance characteristics of a conventional helicopter rotor in high speed forward flight. Six specific test objectives were presented in Section 5.3, in order of priority, and will be discussed in the following sections. Additional areas of test data analysis are included that examine the rotor operation in and out of stall, summarize the model performance and indicate the importance of drag cleanup, correlate theory and test data and show the impact of reduced torsional stiffness.

For the testing and data analysis, the primary rotor tip speed is 620 ft/sec (189 m/sec) and a propulsive requirement defined in coefficient form is $X/qd^2\sigma = 0.05$ which is representative of an advanced helicopter level of drag cleanup. Variation in propulsive force and rotor tip speed are examined to show the impact on the basic trends defined.

Having demonstrated an aerodynamic limit in lift, it is necessary to examine the blade loads to insure that a load limit has not been reached or exceeded. The most critical load is alternating blade root torsion, therefore, the corresponding variation of alternating blade root torsion load with rotor lift coefficient must be monitored at the same time to insure that the limit of 50 in.lb. was not exceeded. Figure 6.1.2 presents this variation but the maximum load indicated was approximately 60 percent of the limit. Since the lift was not limited by loads and we reached an aerodynamic limitation there was obviously no control system limitation for this case. There were only a few cases where longitudinal and lateral cyclic capability limited the testing and there were no limitations imposed on the testing by blade loads.

A summary of the rotor lift limit for the basic propulsive force coefficient of 0.05 is presented in Figure 6.1.3 from hover ($\mu = 0.0$) to 225 knots ($\mu = 0.61$). The lift limit shown at $\mu = 0.0$ was defined by the maximum collective pitch attainable with the normal length pitch links. For the high speed testing a set of long pitch links were used but no hover data was obtained with them. The trend of lift limit with advance ratio is approximately linear up to a $\mu = 0.35$, beyond this value the lift decreases rapidly to a C_T'/σ of 0.098 at $\mu = 0.45$. From $\mu = 0.45$ to 0.50 the lift limit rises rapidly and levels off at a value of $C_T'/\sigma = 0.112$ out to $\mu = 0.53$. After this advance ratio the lift limit drops to C_T'/σ of 0.072 at 225 knots ($\mu = 0.61$). The rotor lift between an advance ratio of 0.50 and 0.53 as shown below.

SECTION LIFT AND DRAG AT $\mu = 0.50$



Also the reverse flow region is reduced significantly by the increased shaft angle, thereby producing a smaller degradation at high advance ratio than anticipated. Beyond an advance ratio of 0.53 the dynamic pressure and working blade area continue to increase in reverse flow. There is also a change in angle of attack produced by the increase in collective and longitudinal cyclic with advance ratio. The combined change in angle of attack dynamic pressure and blade area in reverse flow could result in both lift and drag acting in a direction that reduces lift, or the drag produces a significantly large component of negative rotor lift and offsets the positive contribution of local lift.

To provide some insight into the stall impact on the lift and the change in characteristics with advance ratio, an examination of the flap bending and torsion loads in Figures 6.2.15 through 6.2.22 were combined to provide a qualitative assessment of the is increased up toward the limit, the lift is increased in the inboard forward portion of the rotor and on the outboard aft portion of the rotor. The amount of negative lift generated on the inboard portion of the rotor appears to increase as indicated by the torsion and flap bending loads. On the outboard region of the rotor that had negative, lift becomes smaller. Although qualitative, the lift distributions indicated would produce blade deflections that were representative of those observed visually during the testing.

As shown in Figure 6.1.1 the effect of propulsive force on the lift limit was also defined by the testing at advance ratios of 0.40 and above. A summary of the lift limit at propulsive force coefficients ($X/qd^2\sigma$) of 0.025, 0.10 and 0.20 is presented in Figure 6.1.6 and compared with the basic lift limit shown in Figure 6.1.3. Reducing the $X/qd^2\sigma$ to 0.025 resulted in no change between $\mu = 0.40$ and 0.50 but there was an increase in lift limit (C_T'/σ) of 0.008 at an advance ratio of 0.53. Increasing $X/qd^2\sigma$ from 0.05 to 0.10 resulted in a decrease in lift limit (C_T'/σ) of 0.01 between $\mu = 0.40$ to 0.50 and the decrement in lift limit (C_T'/σ) increases to 0.03 beyond an advance ratio of 0.50 Similar changes were established when the propulsive force coefficient was increased from 0.10 to 0.20.

To define the propulsive force limit, a sweep in propulsive force coefficient was made at a fixed level of rotor lift coefficient. As discussed previously in Section 5.2, the propulsive force was

The lift limits that were defined in Figure 6.1.6 can also be presented as an operational envelope of rotor lift and rotor propulsive force coefficient. This has been done in Figure 6.1.10 and the restriction imposed by an advance ratio of 0.45 is almost as severe as operating at an advance ratio of 0.61. Further study of all the data at an advance ratio of 0.45 is required to determine the cause of reduced capability.

The maximum lift obtained at specific level of propulsive force or the maximum propulsive force obtained at fixed levels of rotor lift combine to establish a restriction on the operational capability of the model rotor system. This in essence is the combination of Figures 6.1.10 and 6.1.9 into an overall operational envelope and is presented in Figure 6.1.11.

Superimposed on Figure 6.1.11 is an equivalent flat plate drag area loading GW/fe = 1500 lb/ft^2, a drag level representative of an advanced helicopter. This established the flight envelope for the model rotor system and specifies that the rotor can operate at a rotor lift coefficient $C_T'/\sigma = 0.10$ up to an advance ratio of 0.57 or 210 knots. Flight at an advance ratio of 0.61 or 225 knots can be achieved when operating at a $C_T'/\sigma = 0.08$. This answers the repeatedly asked question - can the conventional rotor operate at useful lift levels in high speed forward flight without auxiliary lift or auxiliary propulsion? - with a firm YES.

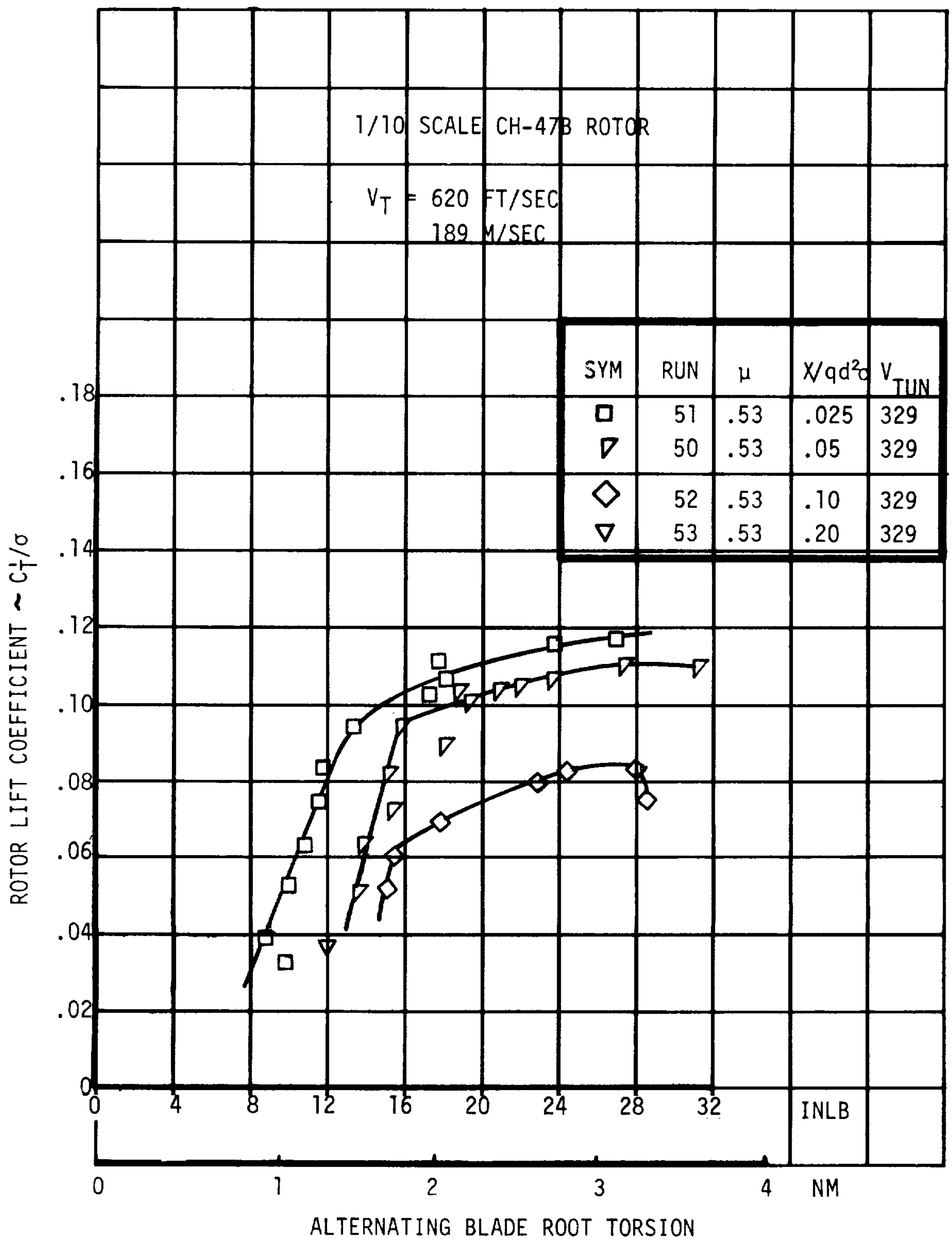


FIGURE 6.1.2 LIFT LIMIT NOT DEFINED BY BLADE LOADS

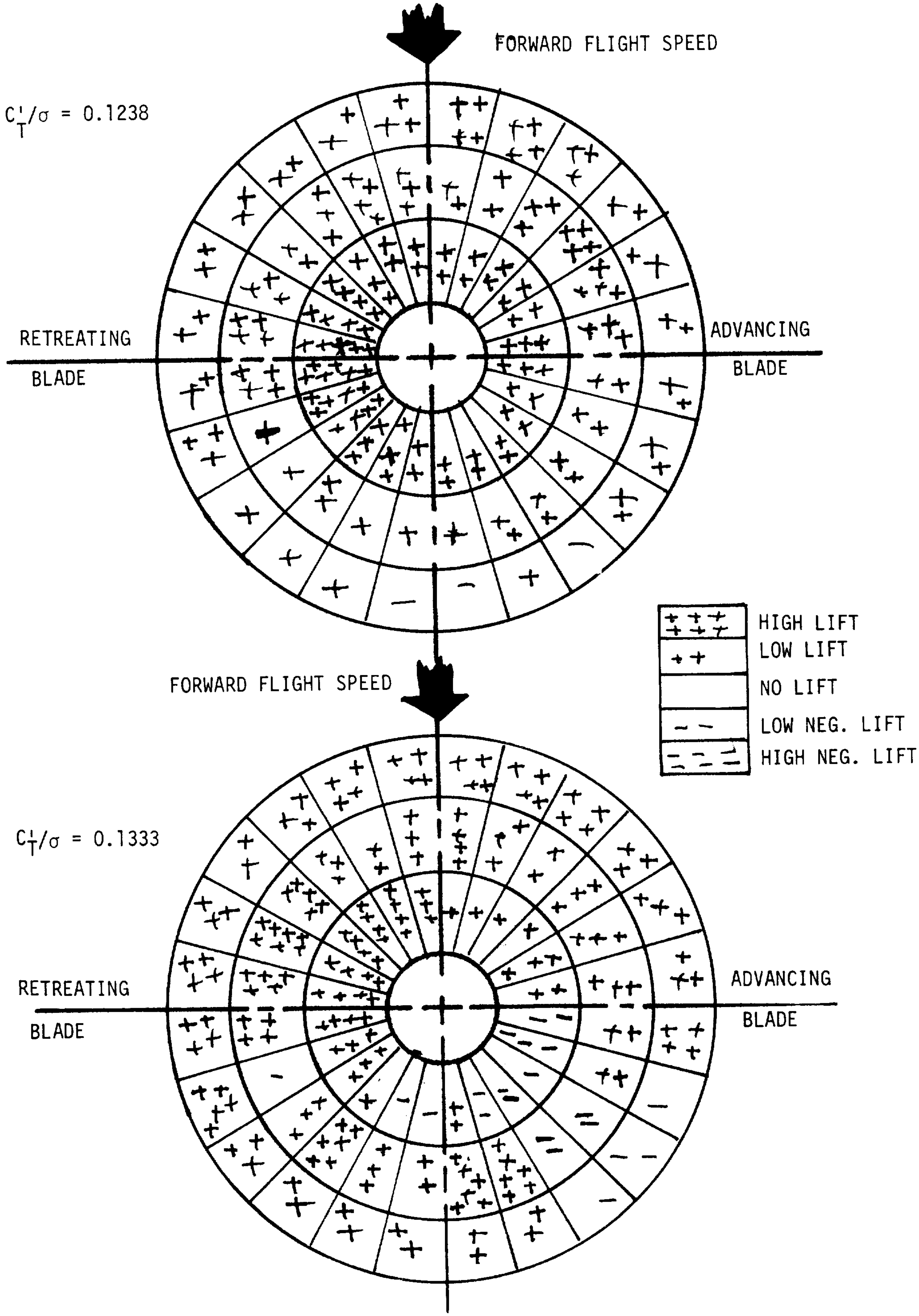


FIGURE 6.1.4 LIFT DISTRIBUTION ESTIMATED FROM TORSION LOADS AT μ = 0.20 AND $X/qd^2\sigma$ = 0.05

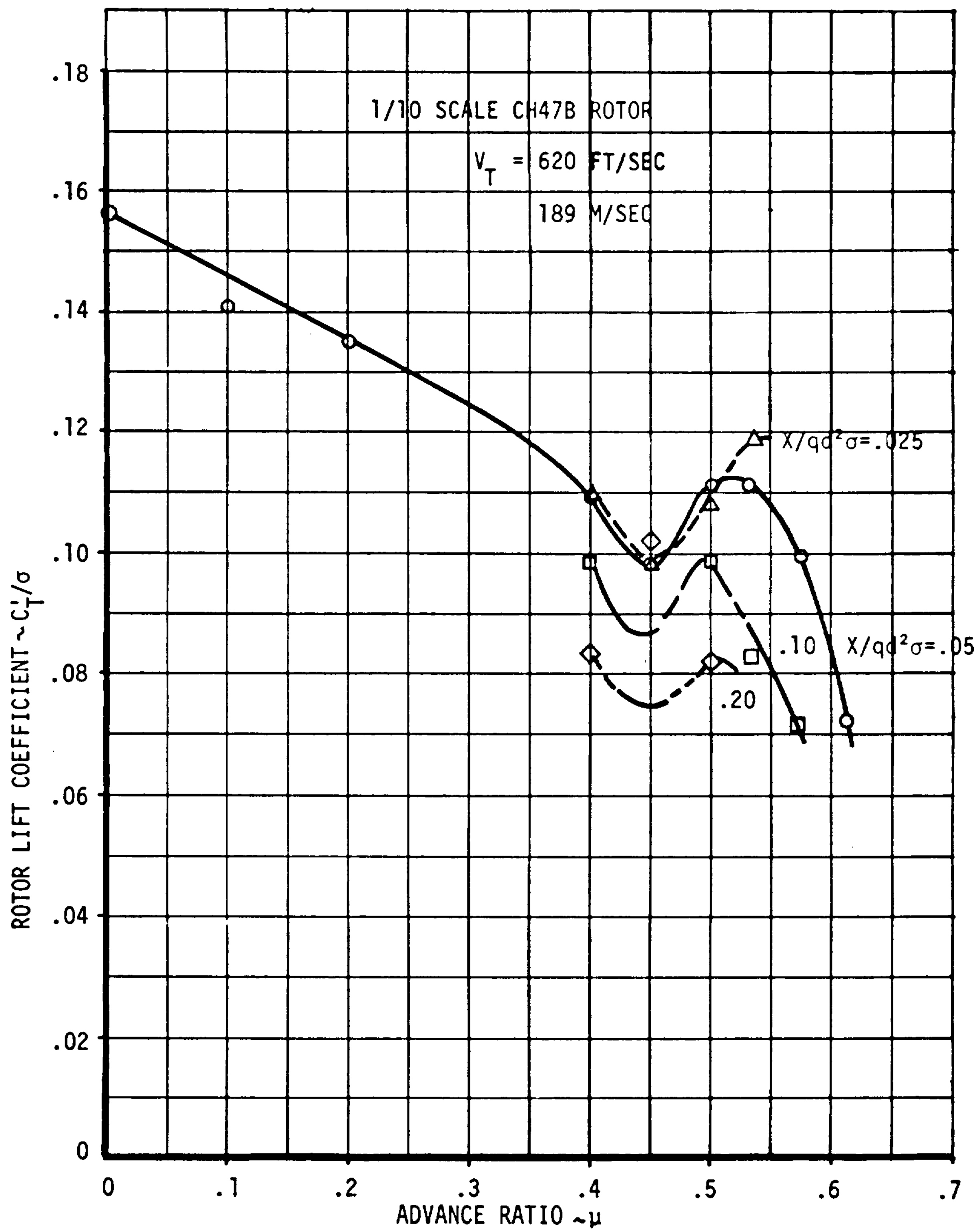


FIGURE 6.1.6 EFFECT OF PROPULSIVE FORCE REQUIREMENTS ON MAXIMUM LIFT LIMIT

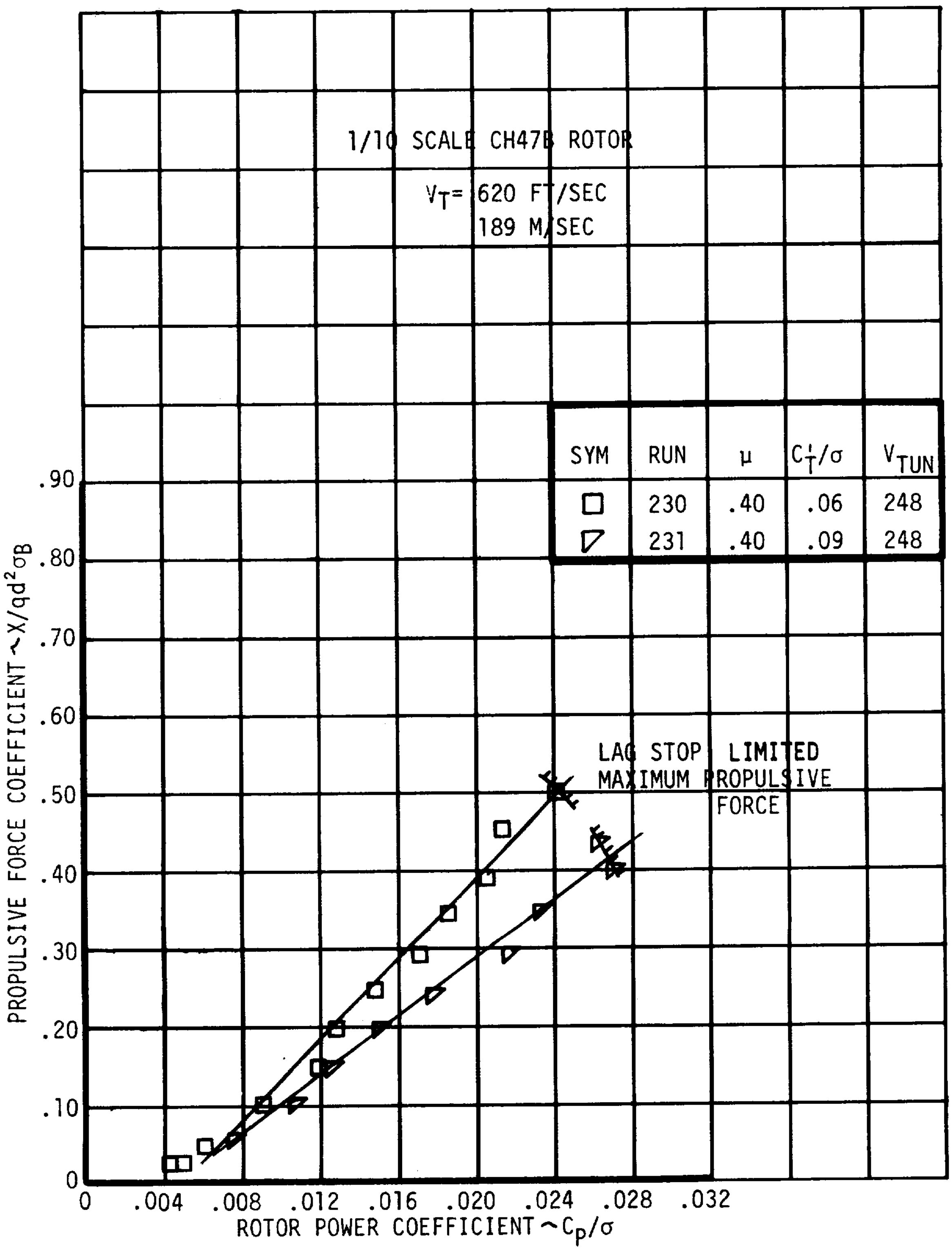


FIGURE 6.1.8 PROPULSIVE FORCE LIMIT NOT DEFINED BY AERODYNAMICS

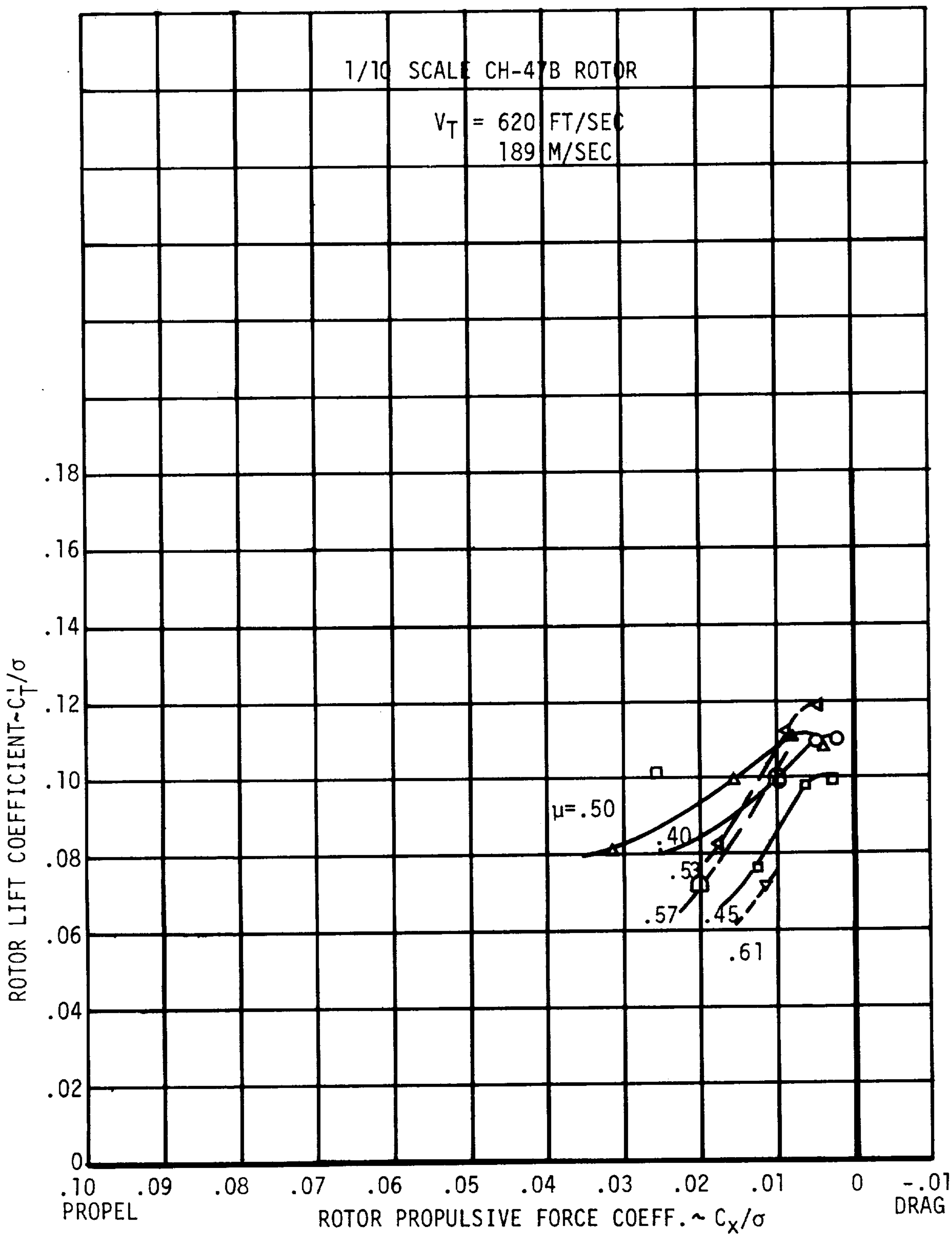


FIGURE 6.1.10 LIFT-PROPULSIVE FORCE ENVELOPE AT THE LIFT LIMIT

6.2 Blade Load Growth Approaching Limits

Test Objective 2: Establish the blade load growth as the lift approaches the limit

Before discussing the load characteristics, it is necessary to establish the blade frequency trends with RPM to insure that there are no critical resonances at the operating conditions. The frequency spectrum for the model rotor blade, as shown in Figure 6.2.1, was obtained from an RPM sweep at an advance ratio of 0.20 and a rotor lift coefficient of 0.10. The first torsion mode and six per rev coalesce at 2100 RPM and the third flap mode and seven per rev also coalesce at 2100 RPM, but normal operation at the basic tip speed of 620 ft/sec is at 2005 RPM. This is sufficiently removed from the resonances to avoid severe load amplification. At the alternate tip speed of 570 ft/sec, a rotor speed of 1840 RPM, there is a coalescence of the second chord mode with the eight per rev but this is not a critical resonance condition.

The loads of torsion, flap and chord bending were measured at ten locations on the blade as described in Section 3.3, presented in Appendix A and summarized in Figures 6.2.2 through 6.2.4. Of these loads, torsion was the load to be monitored most critically since it indicates the presence of stall and had the smallest margin with the anticipated loads. A summary of the alternating blade root torsion loads are presented in Figure 6.2.2

increasing lift is very gradual but for the lift limit, shown in the upper part of the figure, there is an increase in load occurring outboard on the blade. Similar trends are exhibited for an advance ratio of 0.20 as shown in Figure 6.2.6 but the magnitude increases. At an advance ratio of 0.40, a typical load variation is shown for the outboard 20 percent of blade (r/R = 0.80 to 1.00) in Figure 6.2.7. The distinct difference in the distribution at $\mu = 0.4$ with that at $\mu = 0.20$ or 0.0 is demonstrated by the uniform increase in the alternating torsion load from the outboard station, $r/R = 0.80$ to the point where the blade ends $r/R = 0.20$. This may result from the direct trade in section pitching moment coefficient with section dynamic pressure. Figure 6.2.8 presents the radial distribution for an advance ratio of 0.50. Trends for the outboard half of the blade were similar to that shown for $\mu = 0.40$ with an increase in magnitude. The load growth between $r/R = 0.50$ to 0.20 is twice as great as that presented for $r/R = 0.80$ to 0.50 which appears to be the impact of the increased forward speed on the inboard portion of the blade either on the advancing or retreating blade. Figure 6.2.9 presents the data for an advance ratio of 0.57 and the trends shown are similar to those for $\mu = 0.50$.

To better understand the load growth with lift, the blade root torsion waveforms have been superimposed on the alternating root torsion loads of Figure 6.2.2 for the same advance ratios of Figures 6.2.5 to 6.2.9. Figure 6.2.10 presents the loads and torsion load at 240 degrees rotor azimuth, indicating conventional tip stall, and a sharp decrease in nose down load at 300 degrees rotor azimuth possibly reflecting more negative stall.

As the advance ratio is increased to 0.50, the blade torsion load becomes even positive at 300 degrees of rotor azimuth for rotor lift coefficients as low as 0.060, as established in Figure 6.2.13. As C_T'/σ is increased to 0.095 the magnitude of the root torsion load at a rotor azimuth of 300 degrees becomes more positive while the load at an azimuth angle (ψ) of 150 degrees becomes more negative. At the rotor lift limit (C_T'/σ= 0.11) the positive load at ψ = 300 degrees becomes more positive while there has developed an apparent region of stall near a rotor azimuth of 150 degrees and 240 degrees. For an advance ratio of 0.57 the alternating blade root torsion load and also the wave forms are presented in Figure 6.2.14. There is a large nose up load even at a low rotor lift coefficient of 0.060 and is significantly greater than that shown in Figure 6.2.13 for an advance ratio of 0.50. As the lift is increased to 0.087 there is the apparent stall region, defined by the two peaks in nose down load at a rotor azimuth of 150 degrees and 240 degrees. The load at 300 degrees rotor azimuth becomes a significantly large nose up load.

The discussion has presented the radial distribution of the alternating load measured around the azimuth or the azimuthal distribution of the alternating blade root torsion load. In an effort

Referring back to Figure 6.2.2 as the rotor lift is increased above $C_T'/\sigma = 0.129$ the alternating load increases very rapidly, becoming almost asymtotic. It is necessary to determine the cause of this rapid increase in loads and how it is different from the load growth caused by the inboard conventional stall. Figure 6.2.16 presents the three azimuthal distributions for the lift limit $C_T'/\sigma = 0.1333$. The outboard torsion load distribution is approximately uniform from 90 degrees all the way around to 30 degrees azimuth with an increase near 290 degrees possibly caused by stall. Between 30 degrees to 90 degrees the moment increased to a slightly positive value, usually the result of operating at negative angles of attack which would be expected with the lateral hub moments trimmed to zero. The mid blade distribution is approximately uniform between 40 degrees and 210 degrees but the remainder of the wave form shows three distinct peaks in the torsion load. The frequency of these nose down load growths is 6/rev which is the torsional natural frequency definitely establishing stall. The inboard wave form indicates a slight increase in the torsion load at 270 degrees, 315 degrees and 20 degrees azimuth which are the same regions where stall was exhibited on the mid blade trace and is possibly a carry-over of stall to the inboard portion of the blade. Therefore, the increase in the load sensitivity with lift is a result of stall shifting out to the mid and outboard portions of the blade.

the mid blade wave form by increased nose down loads at 240 degrees, 310 degrees and 20 degrees azimuth. The inboard portion indicates conventional stall at 150 degrees and 210 degrees while there is a very large increase in nose up torsion load at 300 degrees rotor azimuth. Again, the change in torsional load sensitivity at high levels of rotor lift results from a significant amount of conventional stall on the mid blade and inboard portion of the blade. The sensitivity for high levels of lift at an advance ratio of 0.50 is less than at 0.20 and appears to be the influence of the large negative stall on the inboard portion of the blade.

Similar characteristics can be generated with the flap bending loads which will indicate the regions of the rotor that are producing high lift and help confirm the regions where the rotor is encountering stall. Figures 6.2.19 to 6.2.22 present mid span and root flap bending wave forms and also an indication of the incremental outboard (r/R=0.48 to 1.00) and inboard (r/R= 0.12 to 0.48) lift distribution around the azimuth. At a rotor lift coefficient of 0.1238 and an advance ratio of 0.20, there is a region of negative flap bending load between 90 degrees and 150 degrees azimuth for the outboard blade region as shown in Figure 6.2.19. For the inboard portion of the blade there is a region of very high flap bending loads between 60 degrees and 150 degrees and slightly reduced load level from 150 degrees to coefficient of 0.1029. The increase in lift on the outboard portion of the blade between 210 degrees and 330 degrees provide support to the mid blade stall indicated in Figure 6.2.18. The very high lift between 120 degrees and 240 degrees azimuth supports the conventional stall on the inboard blade while the negative lift or download occurring between 240 degrees and 270 degrees verifies the operation at large negative angles of attack and the negative stall defined in Figure 6.2.18 for the inboard section of the blade. This estimated lift distribution data in addition to the torsion data of Figures 6.2.15 through 6.2.18 provided the basis for the qualitative lift distributions presented in Section 6.1.

To summarize the results there is an inboard stall that produces a moderate increase load sensitivity with lift and a mid blade plus outboard stall that results in the almost asymtotic variation of loads with lift coefficient for low advance ratios. For the high advance ratios there is an inboard stall that has a higher sensitivity with lift than the low advance ratios have. For rotor lift levels near the lift limit there is a decrease in sensitivity to rotor lift for the higher advance ratio. This is a result of operating at negative section angles of attack, negative lift between 240 degrees and 270 degrees azimuth and positive section pitching moments alleviating the load growth with rotor lift. Addition analysis of the loads data in conjunction

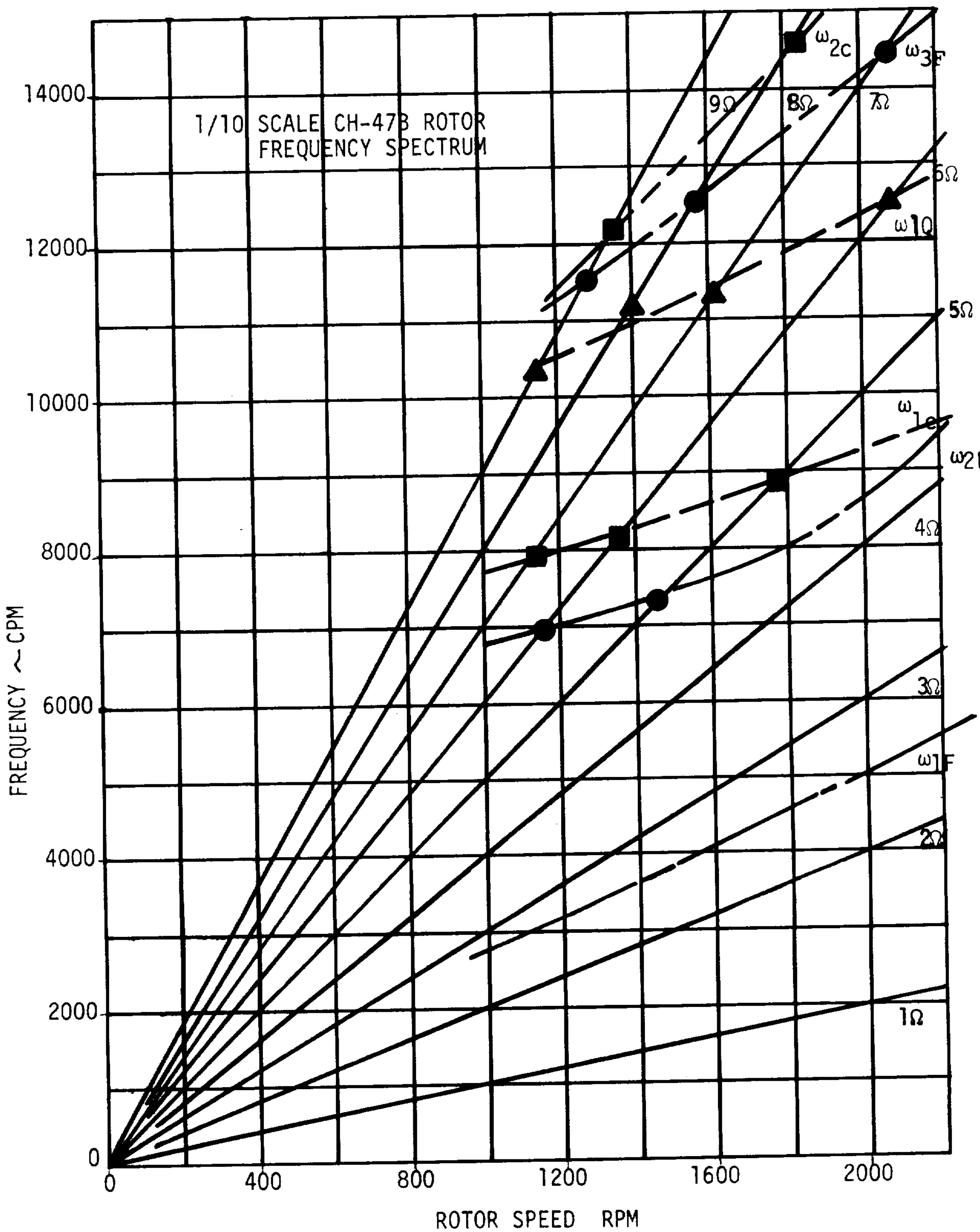


FIGURE 6.2.1 FREQUENCY SPECTRUM FOR 1/10 SCALE CH-47B ROTOR

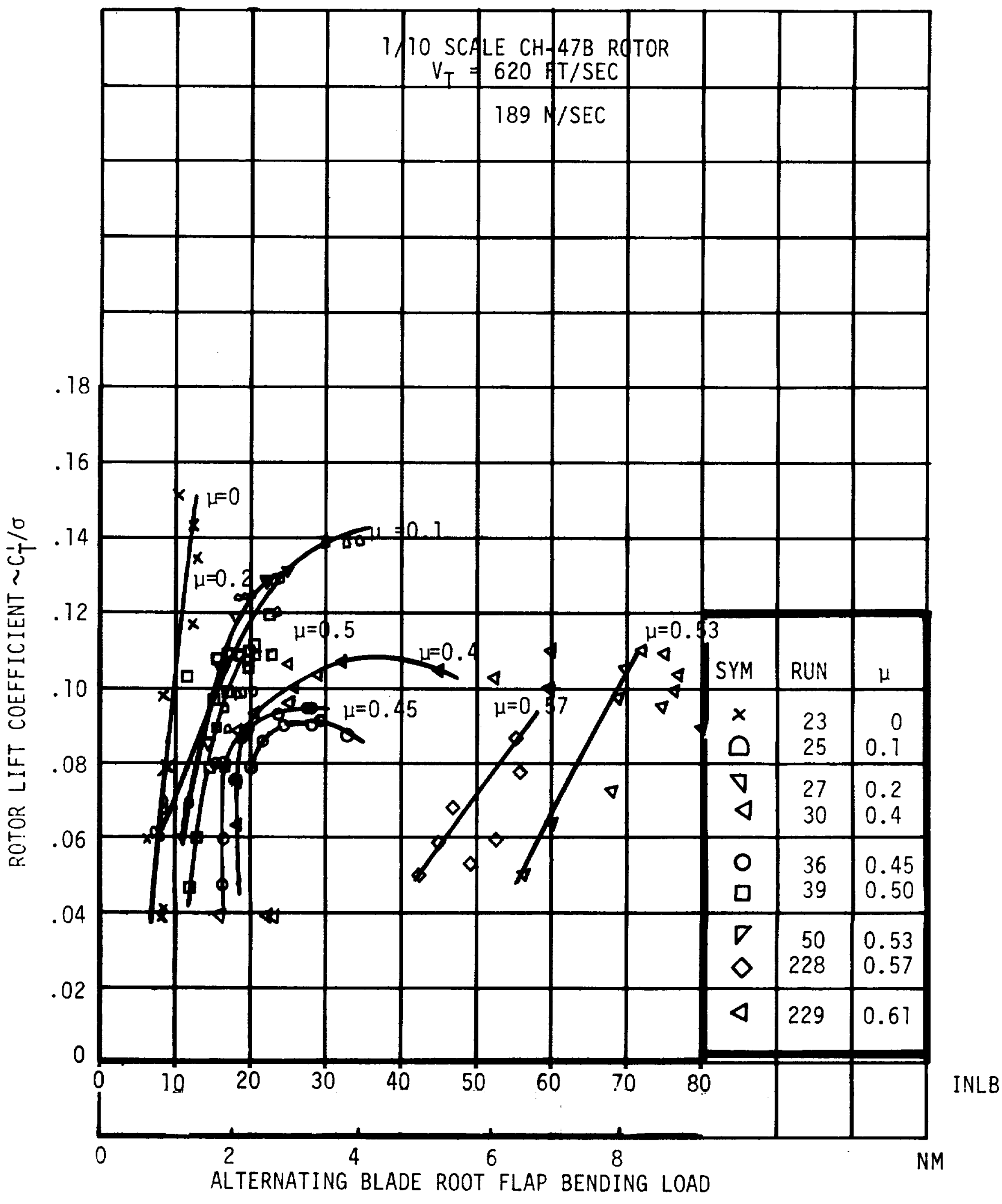


FIGURE 6.2.3 SUMMARY OF ALTERNATING BLADE ROOT FLAP BENDING LOADS

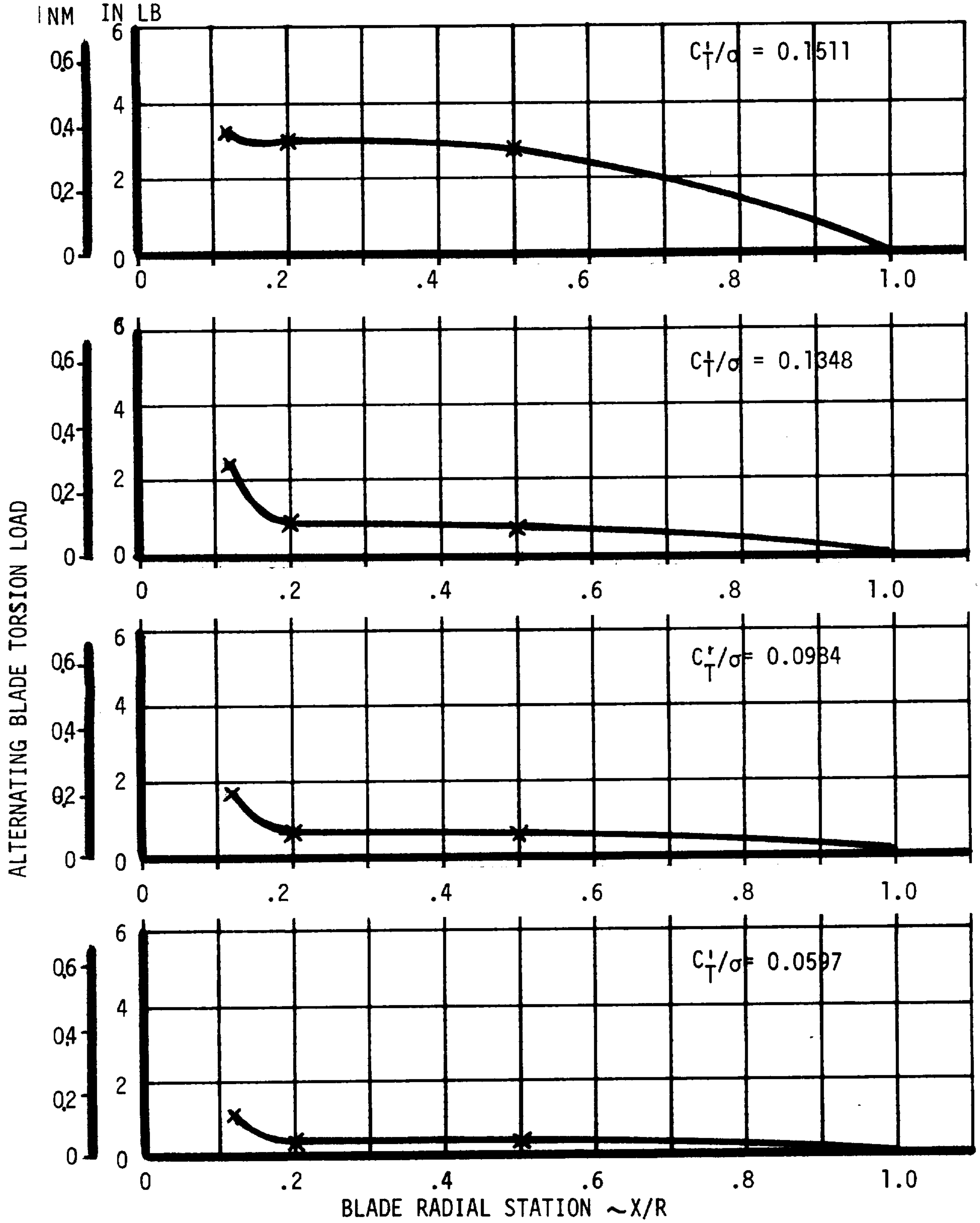


FIGURE 6.2.5 EFFECT OF ROTOR LIFT ON RADIAL DISTRIBUTION OF BLADE TORSION LOAD AT μ = 0

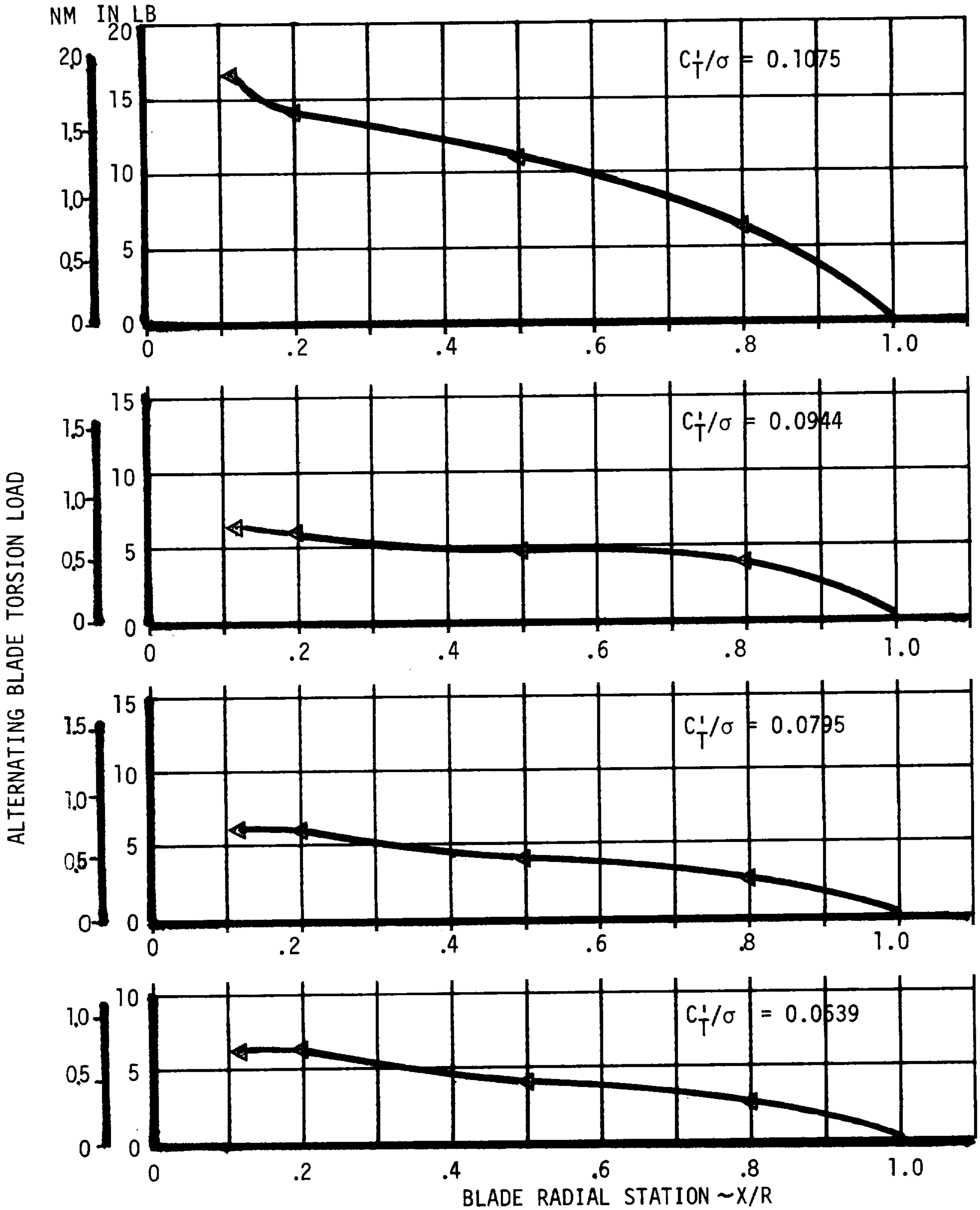


FIGURE 6.2.7 EFFECT OF ROTOR LIFT ON RADIAL DISTRIBUTION OF BLADE TORSION LOAD AT μ= 0.40; $X/qd^2\sigma$ = 0.05

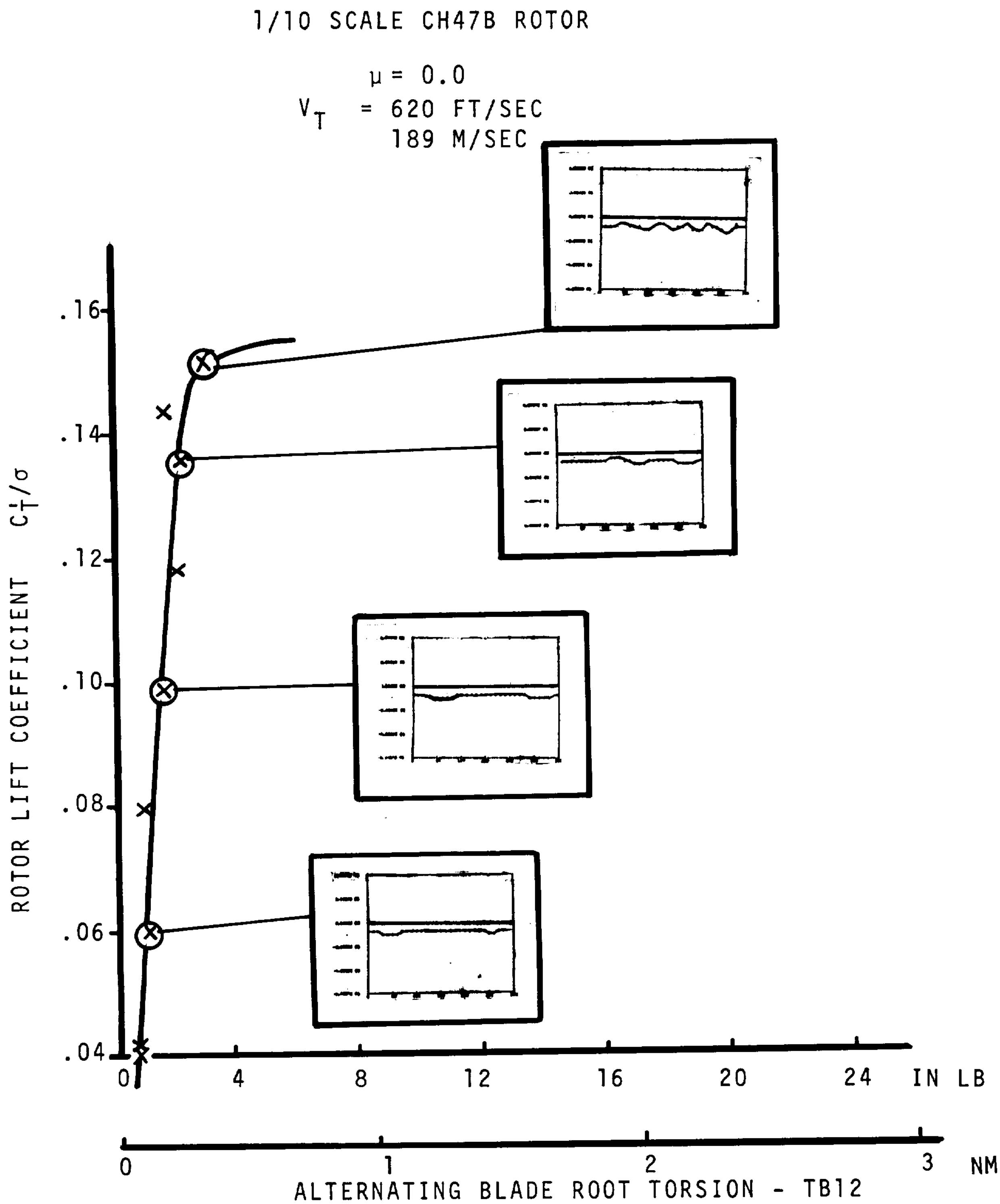


FIGURE 6.2.10 EFFECT OF APPROACHING THE LIFT LIMIT ON THE BLADE TORSION LOAD AT $\mu = 0$

1/10 SCALE CH47B ROTOR
$\mu = 0.40$

V_T = 620 FT/SEC
189 M/SEC

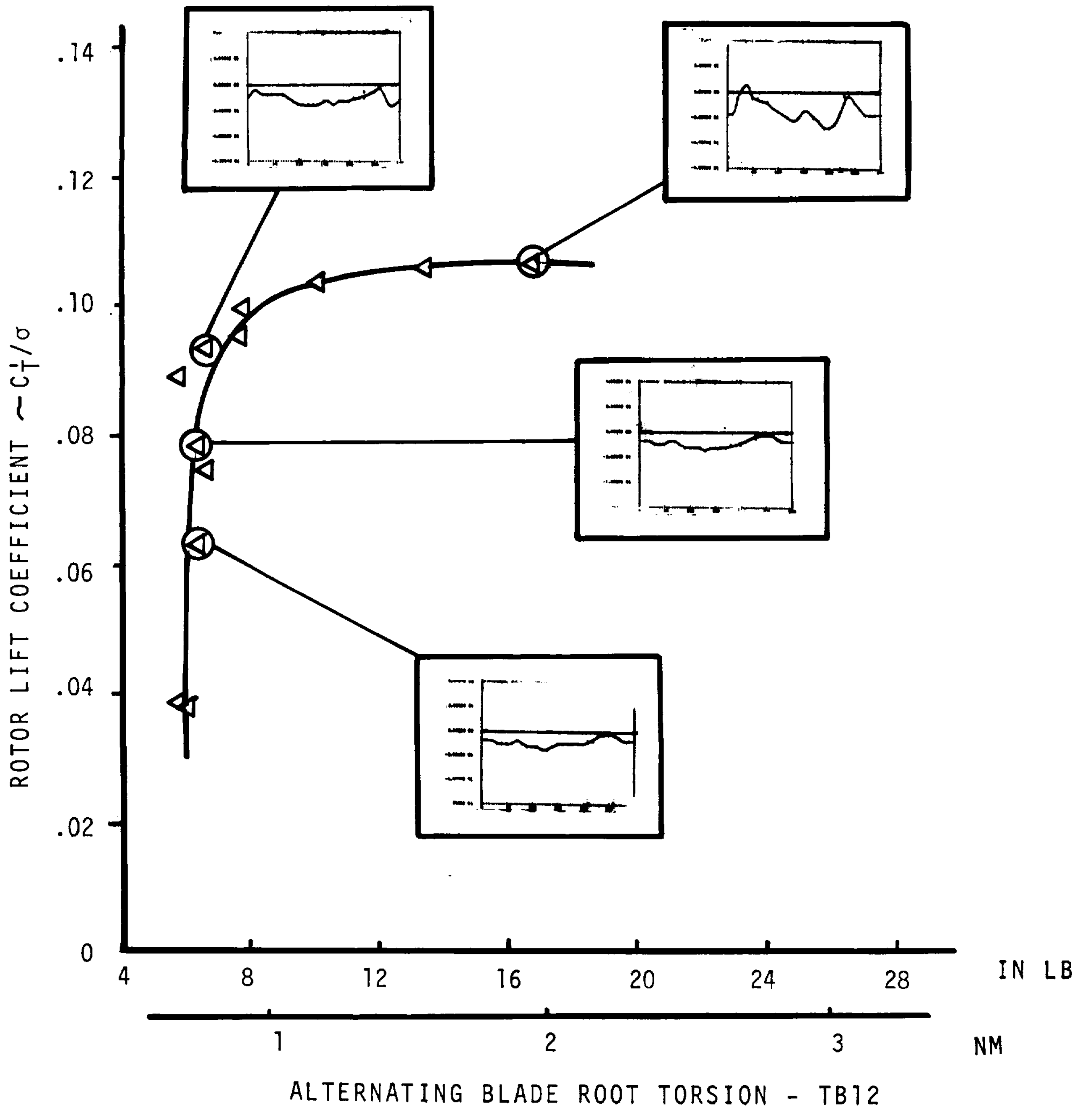


FIGURE 6.2.12 EFFECT OF APPROACHING LIFT LIMIT ON THE BLADE TORSION LOAD AT $\mu = 0.40$

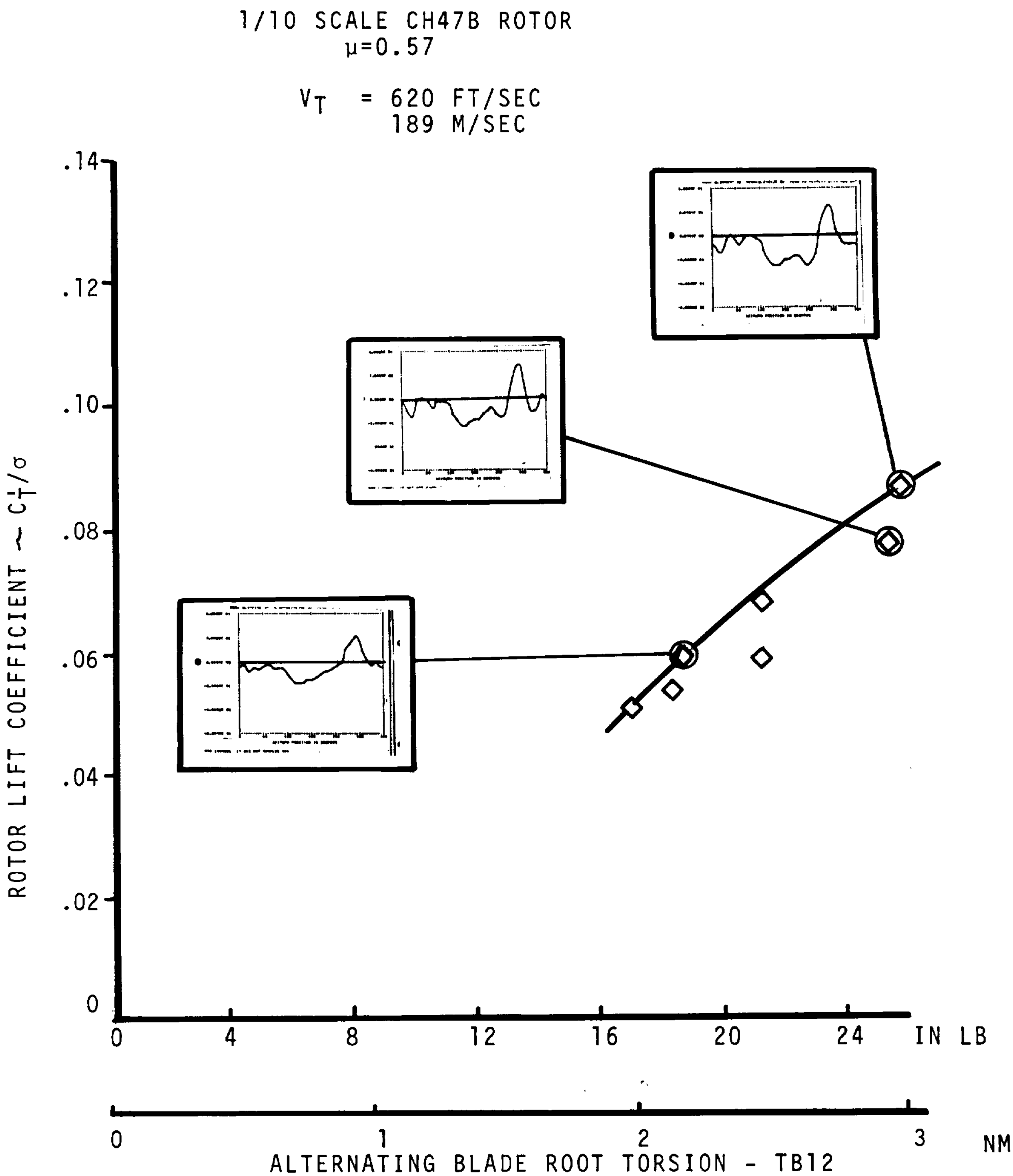


FIGURE 6.2.14 EFFECT OF APPROACHING THE LIFT LIMIT ON THE BLADE TORSION LOAD AT μ = 0.57

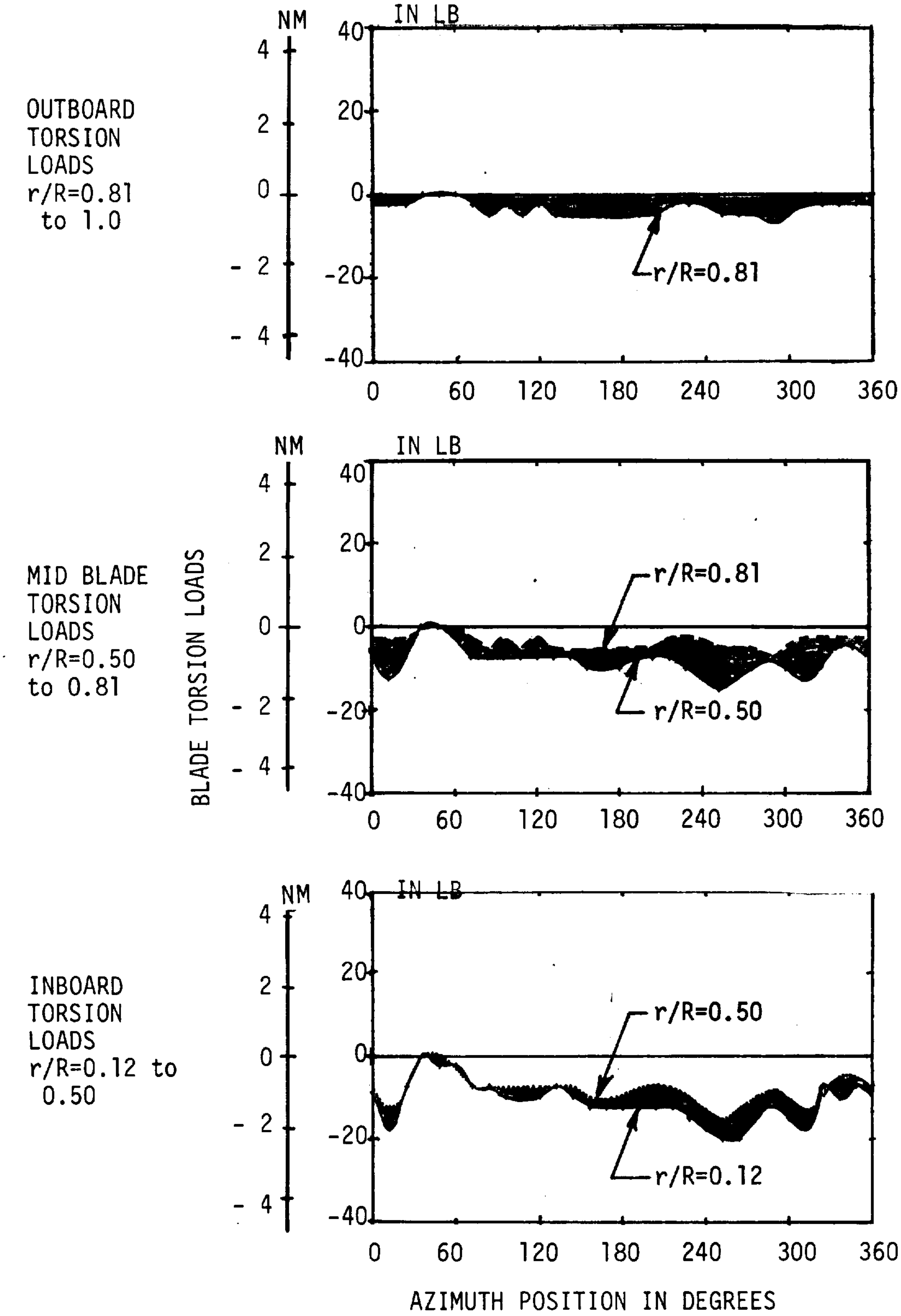


FIGURE 6.2.16 RADIAL AND AZIMUTHAL DISTRIBUTION OF BLADE TORSION LOADS, $\mu = 0.20$, $C_T'/\sigma = 0.1333$, $X/qd^2\sigma = 0.05$

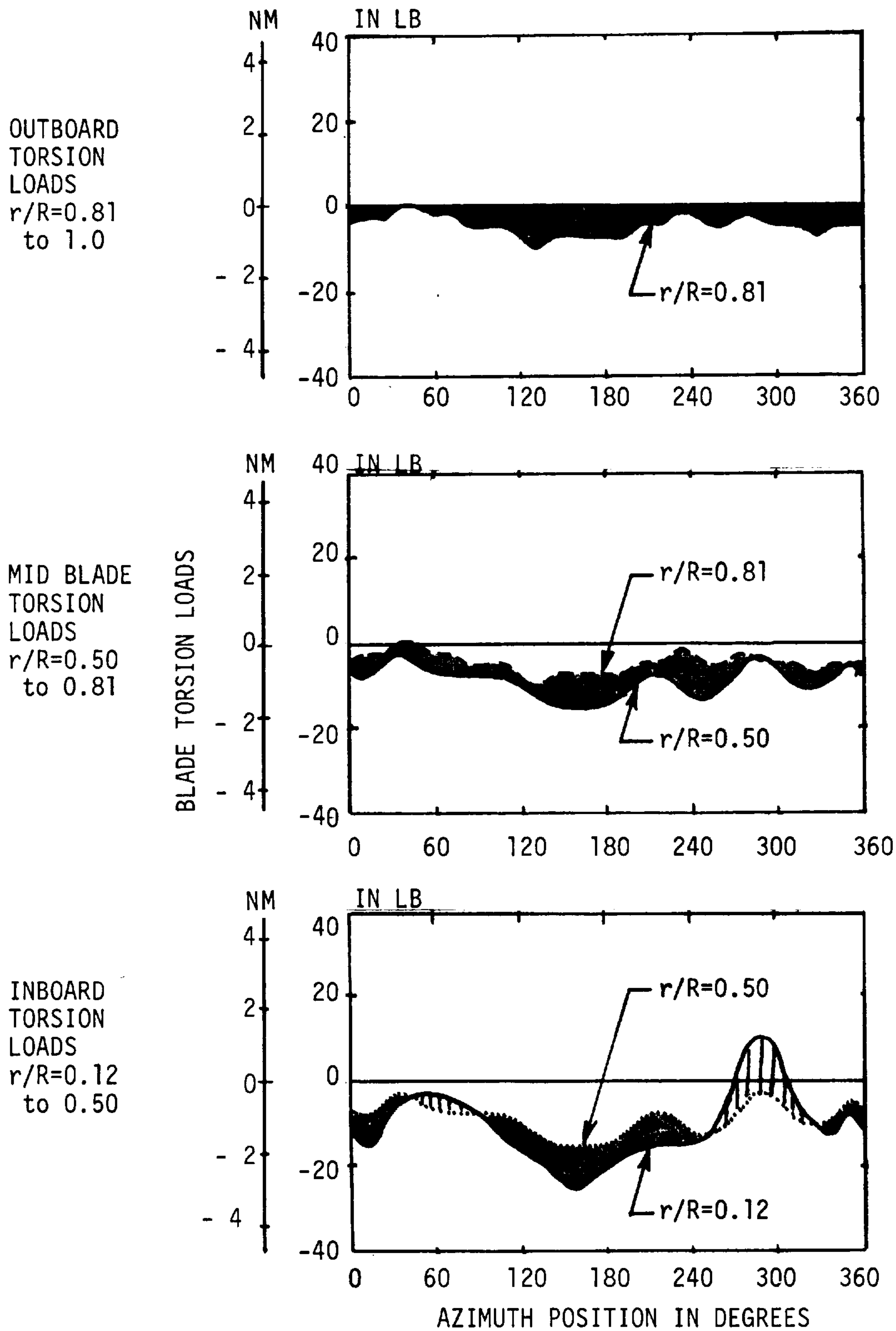


FIGURE 6.2.18 RADIAL AND AZIMUTHAL DISTRIBUTION OF BLADE TORSION LOADS, $\mu = 0.50$ $C_T'/\sigma = 0.1029$, $X/qd^2\sigma = 0.05$

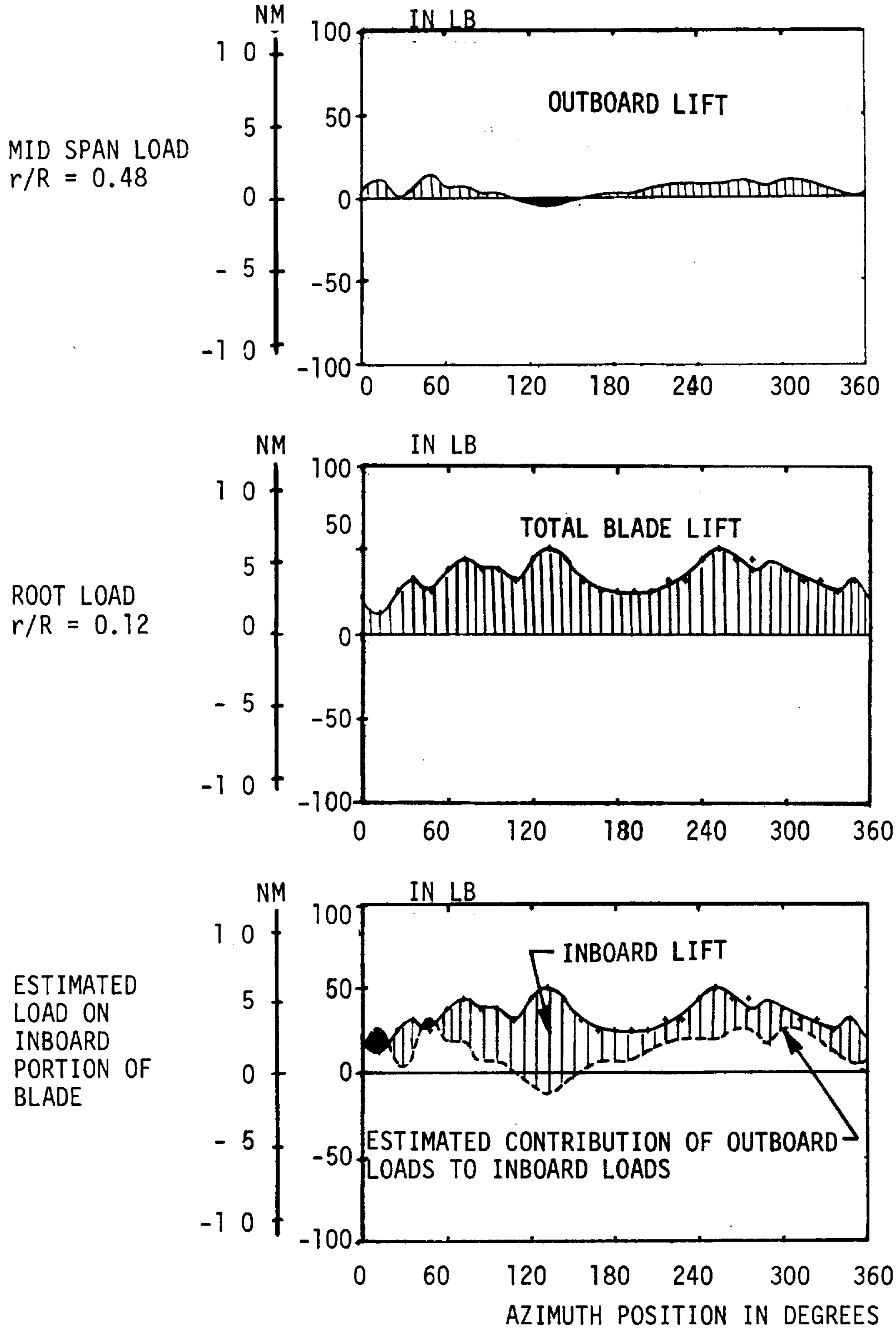


FIGURE 6.2.20 AZIMUTHAL VARIATION IN FLAP BENDING LOAD AND ESTIMATION OF MAJOR AREAS OF ROTOR LIFT $\mu = 0.20$, $C_T'/\sigma = 0.1333$, $X/qd^2\sigma = 0.05$

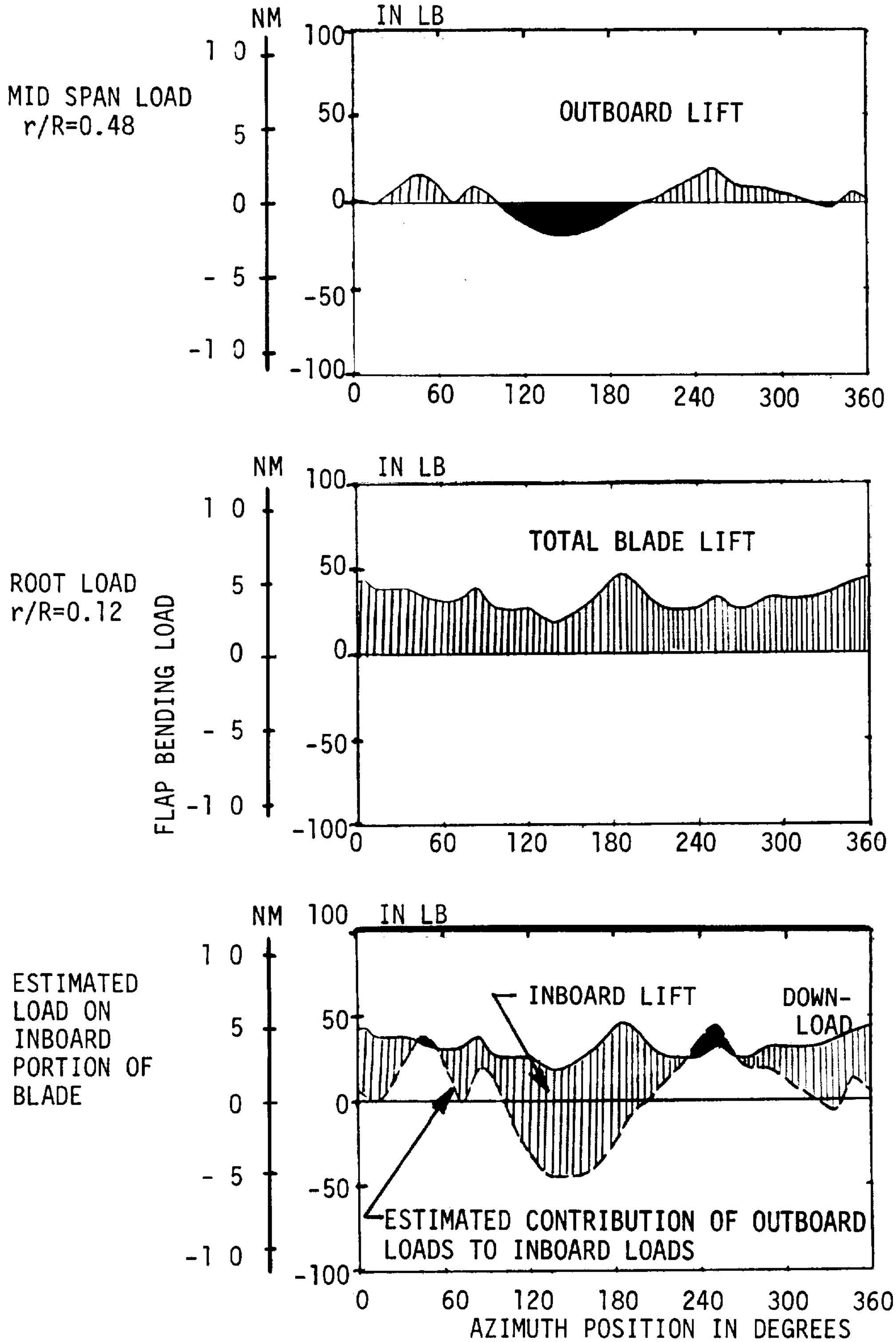


FIGURE 6.2.22 AZIMUTHAL VARIATION IN FLAP BENDING LOAD AND ESTIMATION OF MAJOR AREAS OF ROTOR LIFT - $\mu = 0.50$, $C_T'/\sigma = 0.1029$ $X/qd^2\sigma = 0.05$

Figure 6.3.2 presents the performance data in terms of the rotor effective drag coefficient (C_{D_e}/σ) variation with rotor lift. There is a large improvement in rotor effective drag from an advance ratio of 0.10 to 0.20. A slight increase in effective drag coefficient is shown as the advance ratio is increased to $\mu = 0.40$. For advance ratios of 0.45, 0.50 and 0.53 the effective drag level is slightly increased over an advance ratio of 0.40 and they are all approximately the same. Increasing the advance ratio to 0.57 and then to 0.61 increases the effective drag reaching a level that is equal to that of an advance ratio of $\mu = 0.10$. The general trend evident for each of the advance ratios is that the effective drag starts to increase significantly at lift levels well below the lift limit, but in the lift level that is incurring inboard stall.

Rotor lift to effective drag ratio is a measure of cruise efficiency. The slope to any point on Figure 6.3.2 provides the L/D_E and the position of each advance ratio on this figure indicates their efficiency relative to each other. Maximum L/D_E indicated is 9.0 for an advance ratio of 0.20, decreases to 6.5 for $\mu = 0.40$ and then down to 1.8 at $\mu = 0.61$. A summary of the maximum rotor L/D_E is presented in Figure 6.3.3 indicating a peak value of 9.5 at $\mu = 0.28$. The trend from $\mu = 0.40$ to 0.61 resembles the lift limit trend showing a dip at an advance ratio of 0.45 and a lower peak of 4.5 at $\mu = 0.52$.

cyclic and lateral cyclic that correspond to the performance summary of Figure 6.3.1 are presented in Figures 6.3.4 through Figure 6.3.7. The other aspect of rotor performance is the capability of the rotor to accelerate from one steady state cruise condition to another and/or carry external loads. Performance data that addresses this was obtained during the propulsive force testing. At fixed levels of lift, the propulsive force was increased until a model physical limit was reached. This data is presented in Appendix B of Volume 2 and Figures 6.3.8 through Figure 6.3.10 are selected to present the performance data obtained at three advance ratios. Figure 6.3.8 shows the variation in rotor power coefficient with the increasing propulsive force requirements at $\mu = 0.40$. The two data trends are for 80 percent and 60 percent of the maximum lift limit when $X/qd^2\sigma = 0.05$. The resulting trends are linear with a slight decrease in slope as the lift is increased. A linear variation indicates a fixed effectiveness of the rotor for converting power to propulsive force and is defined as rotor propulsive efficiency (η_P). A rotor propulsive efficiency of 100% is the ideal conversion of power to propulsive force.

$$\eta_P = \frac{\Delta(X)}{\Delta(P/V)}$$

$$\text{Ideal } \eta_P = 100\%$$

$$\frac{\Delta P}{V} = \Delta X$$

understand the differences in performance resulting at the higher levels of lift and at $\mu = 0.53$ and 0.57. These differences are also reflected in the lift limits that are discussed in Section 6.5.

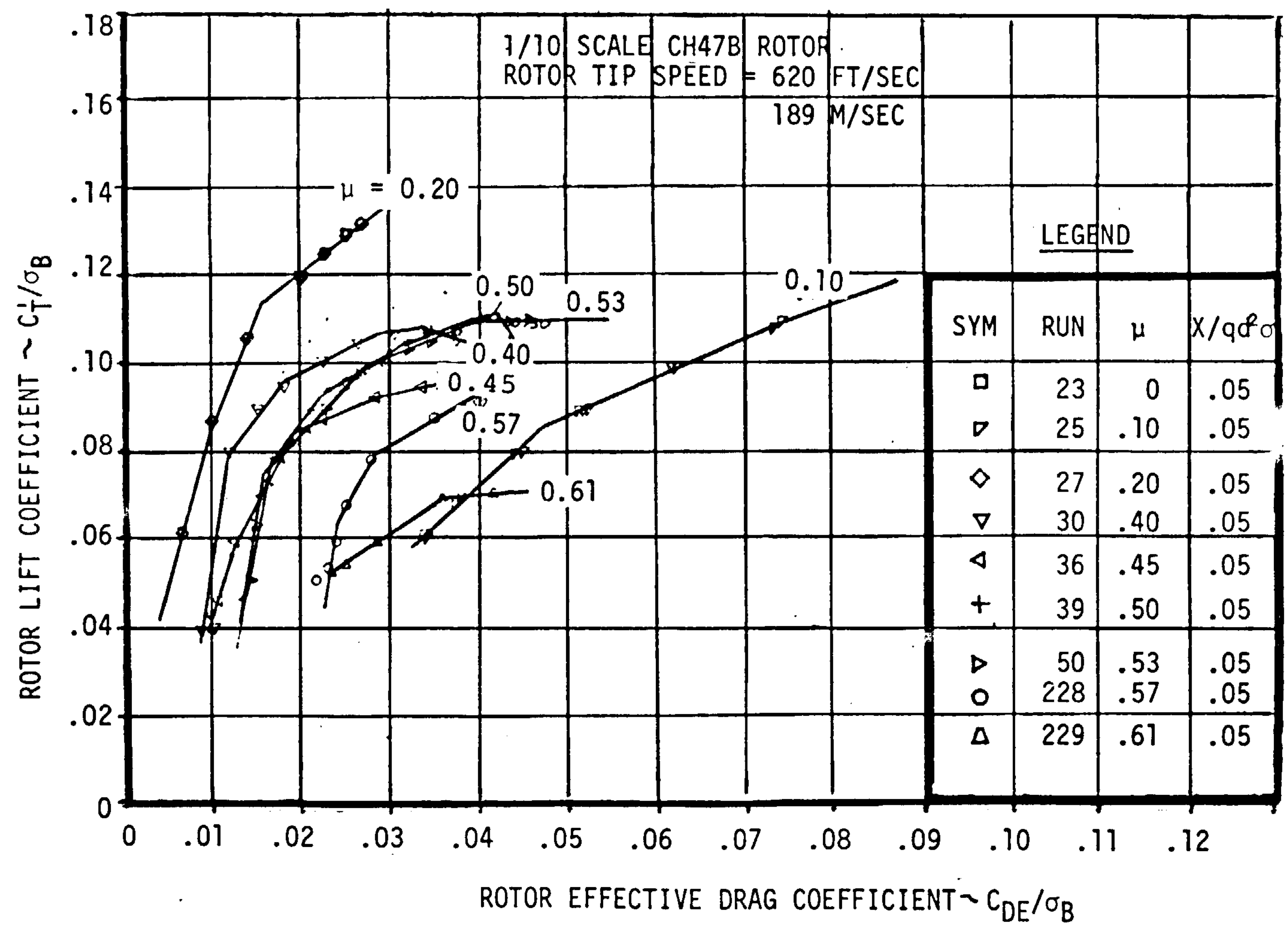


FIGURE 6.3.2 ROTOR EFFECTIVE DRAG FOR PERFORMANCE SUMMARY V_T = 620 FT/SEC

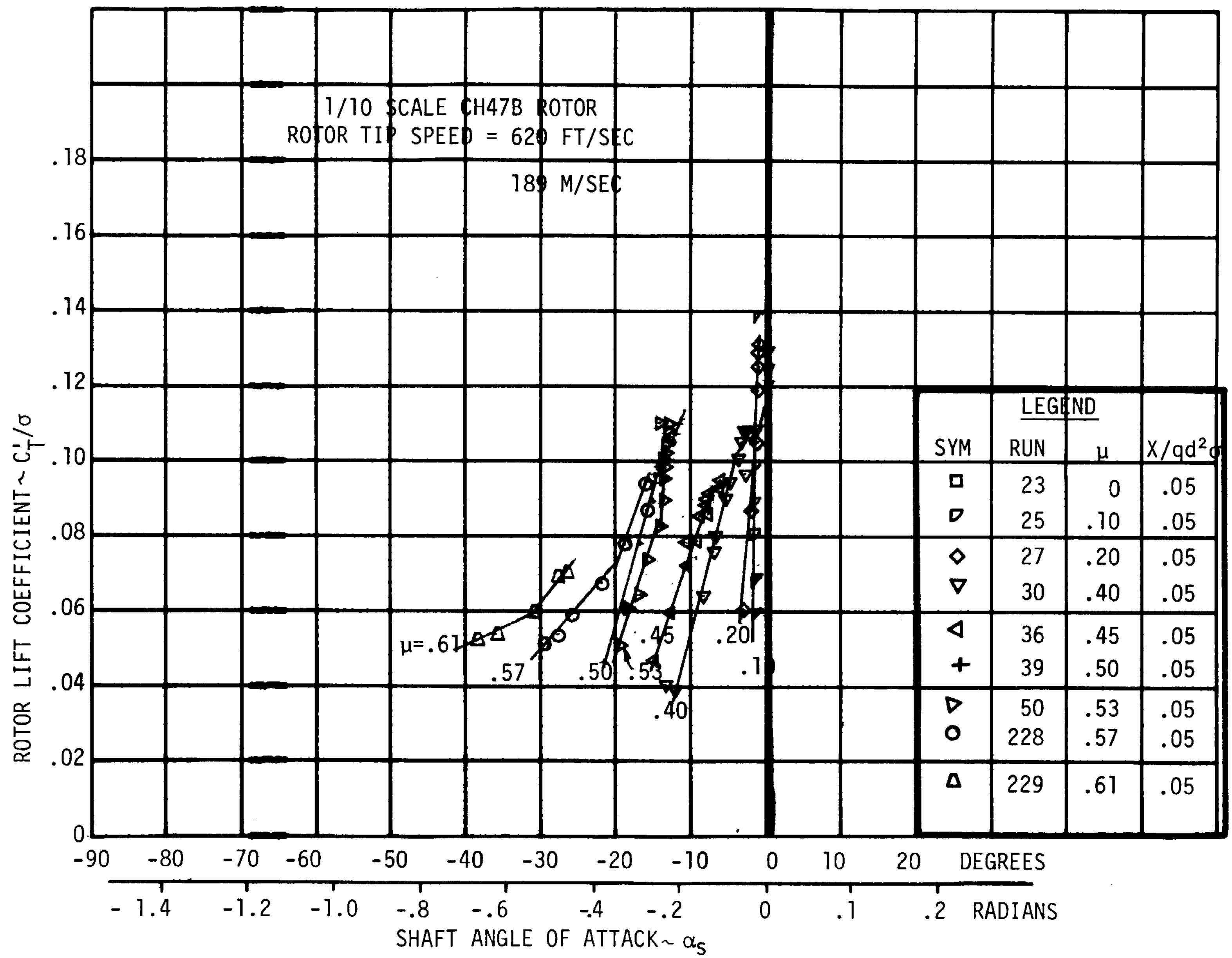


FIGURE 6.3.4 SHAFT ANGLE OF ATTACK FOR PERFORMANCE SUMMARY V_T = 620 FT/SEC

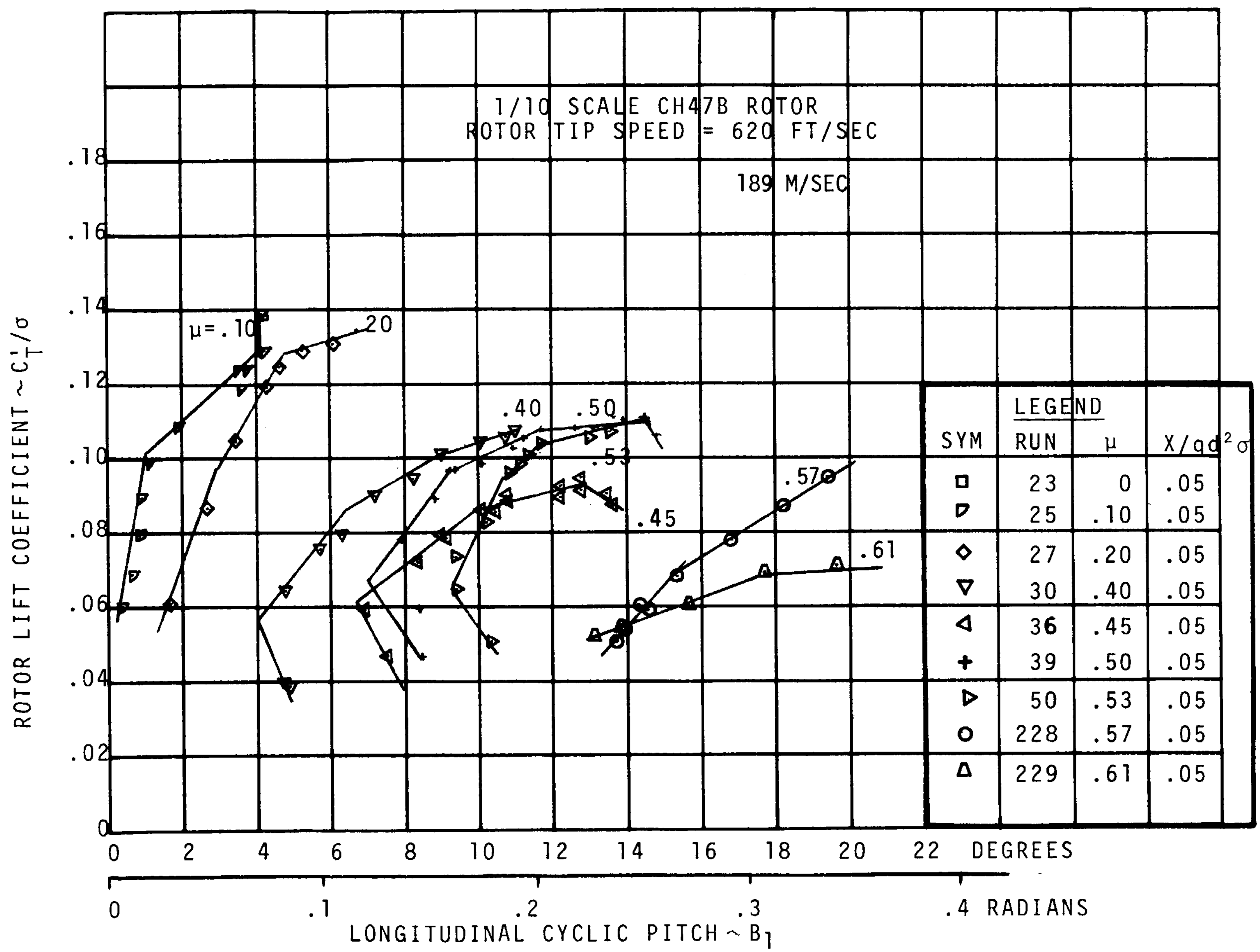


FIGURE 6.3.6 LONGITUDINAL CYCLIC PITCH FOR PERFORMANCE SUMMARY V_T = 620 FT/SEC

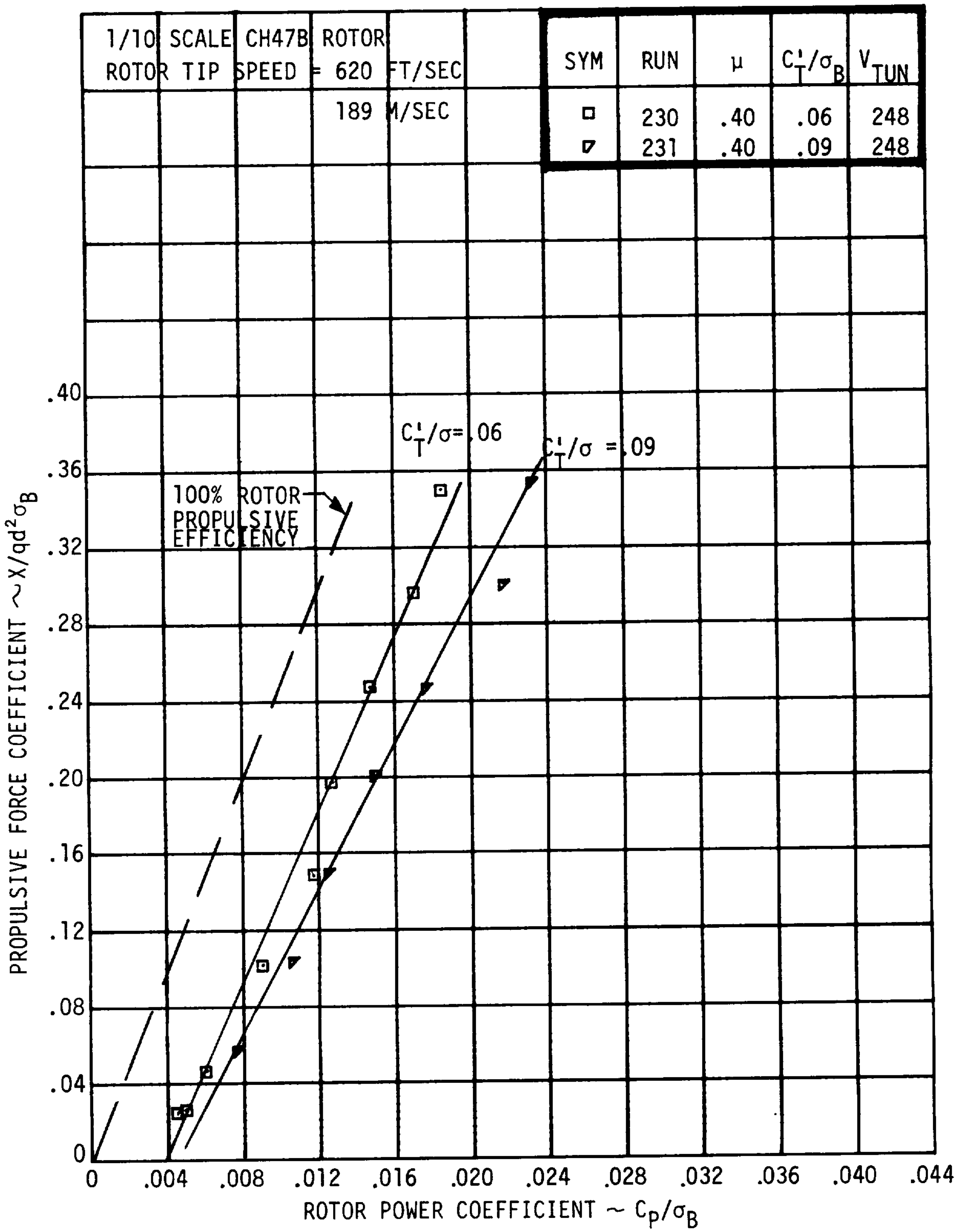


FIGURE 6.3.8 EFFECT OF PROPULSIVE FORCE ON ROTOR POWER REQUIRED AT CONSTANT LIFT, $\mu = 0.40$

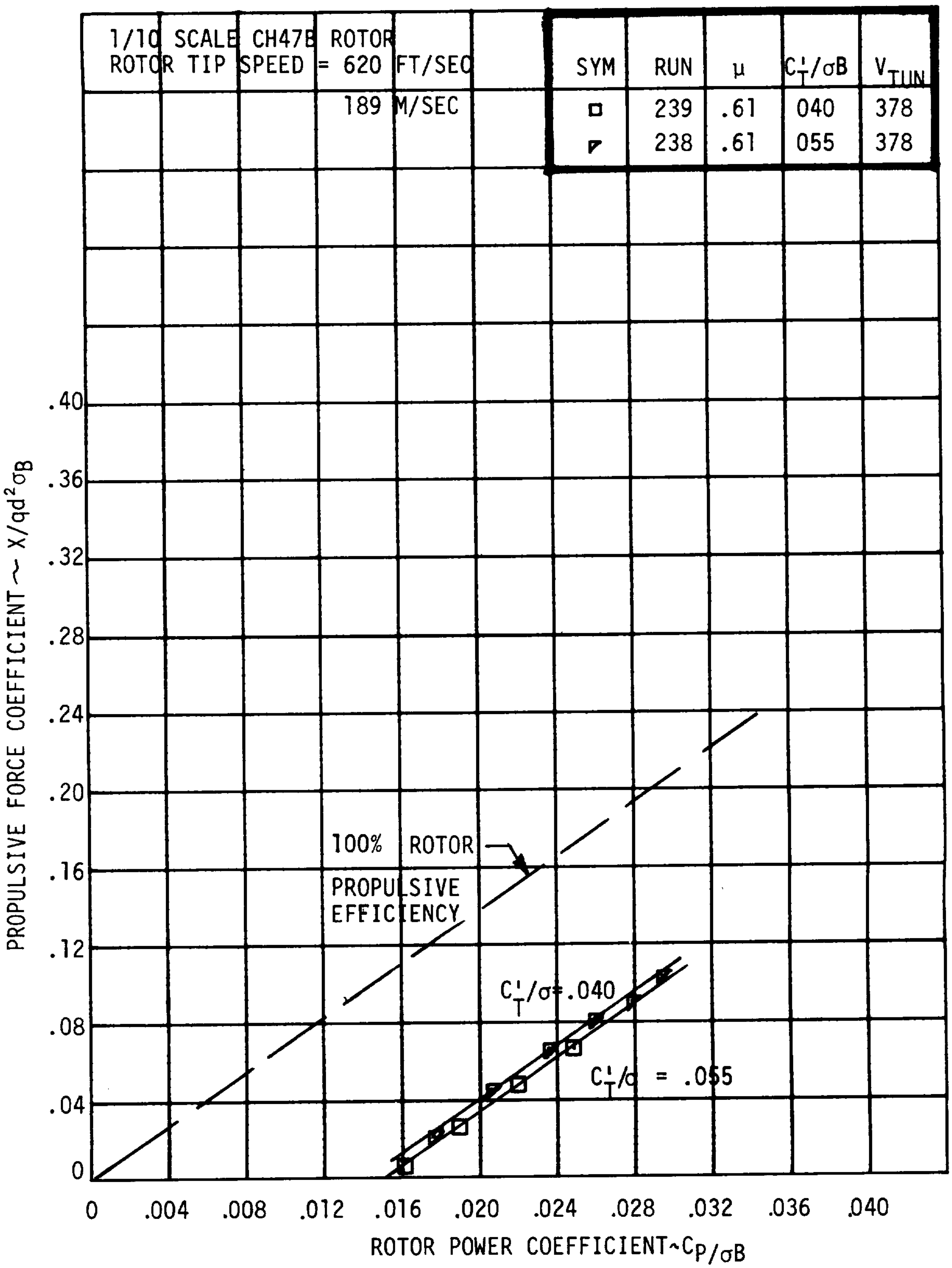


FIGURE 6.3.10 EFFECT OF PROPULSIVE FORCE ON ROTOR POWER REQUIRED AT CONSTANT LIFT, μ = 0.61

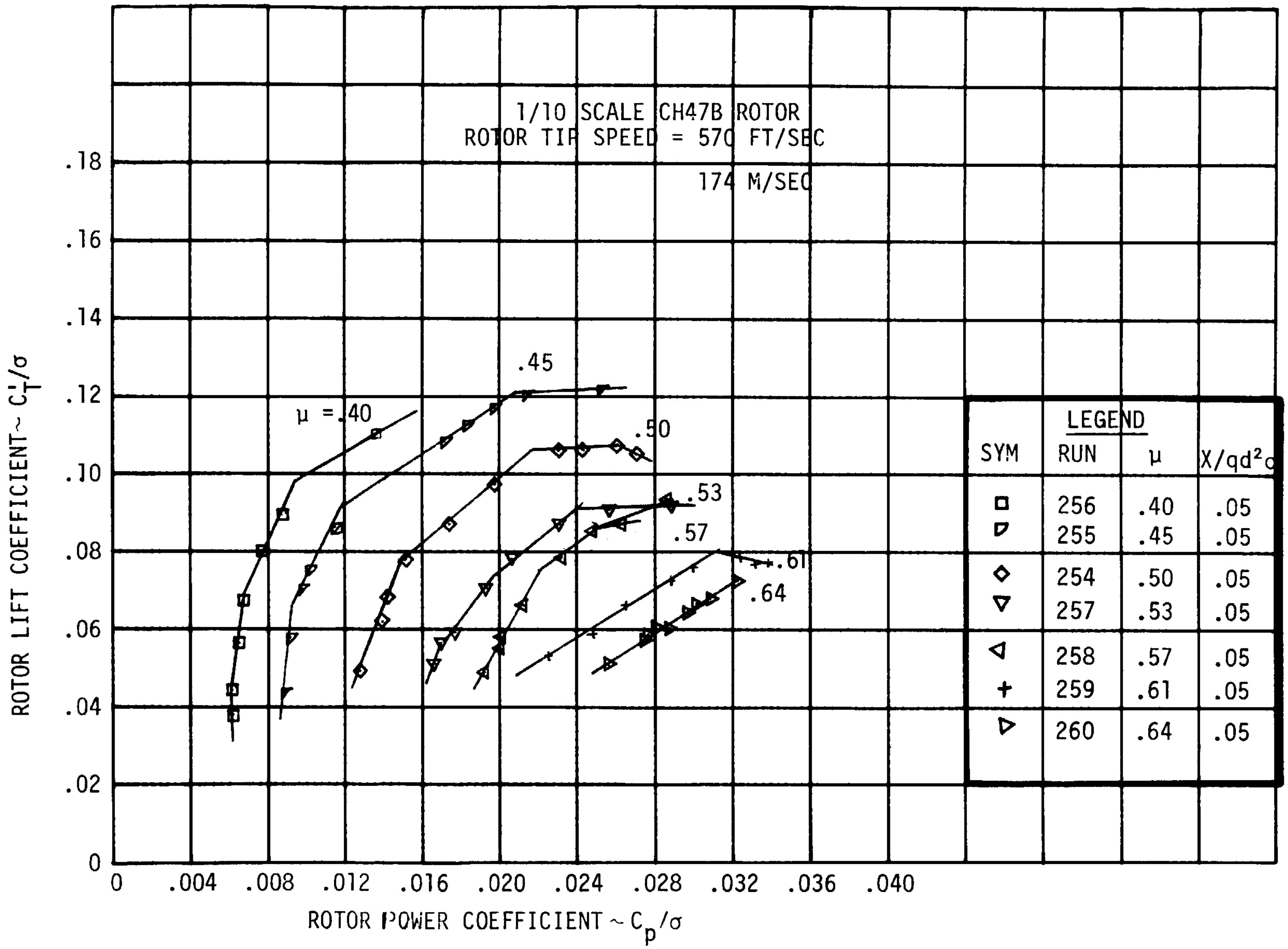


FIGURE 6.3.12 ROTOR PERFORMANCE SUMMARY AT V_T = 570 FT/SEC

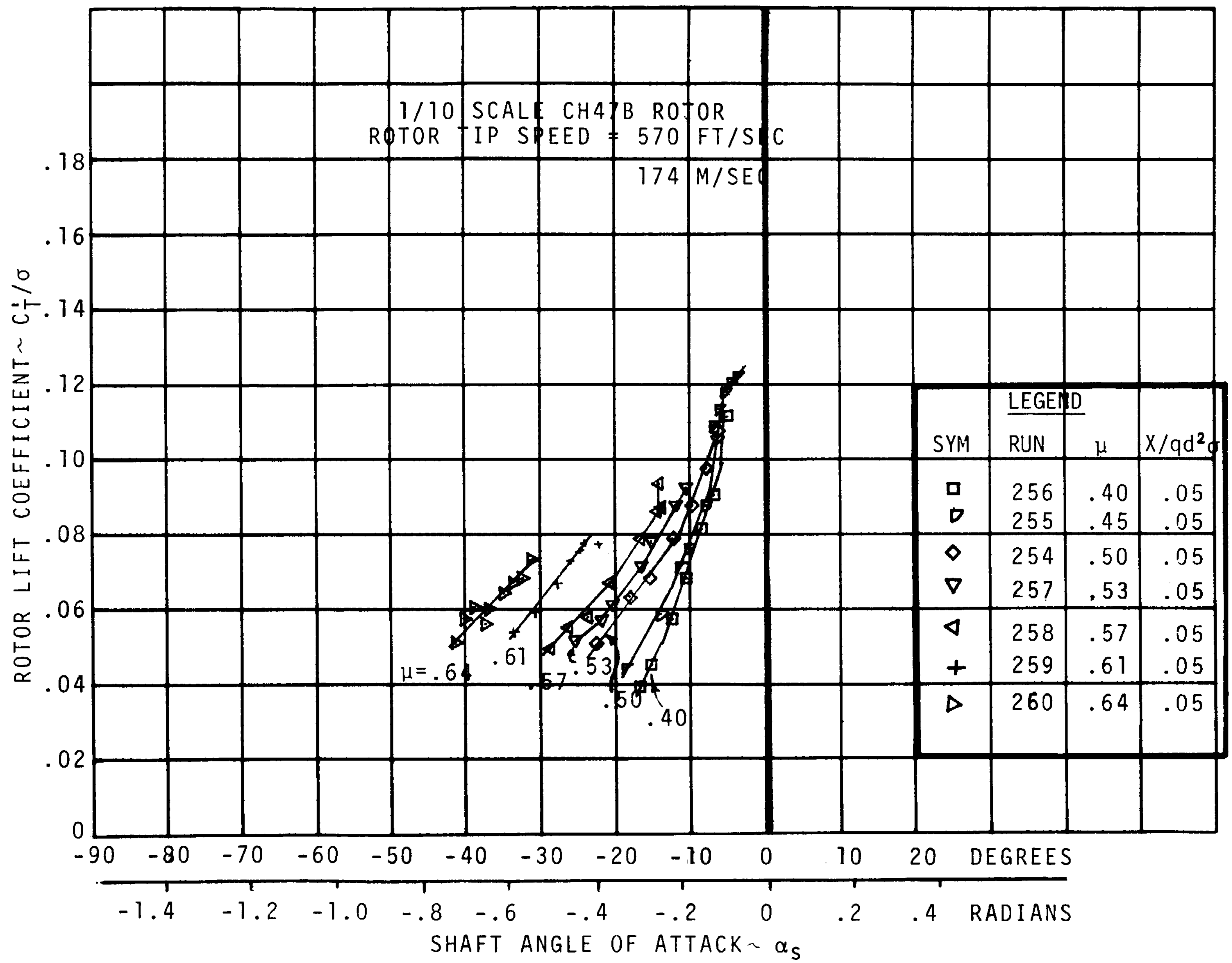


FIGURE 6.3.14 SHAFT ANGLE OF ATTACK FOR PERFORMANCE SUMMARY V_T = 570 FT/SEC

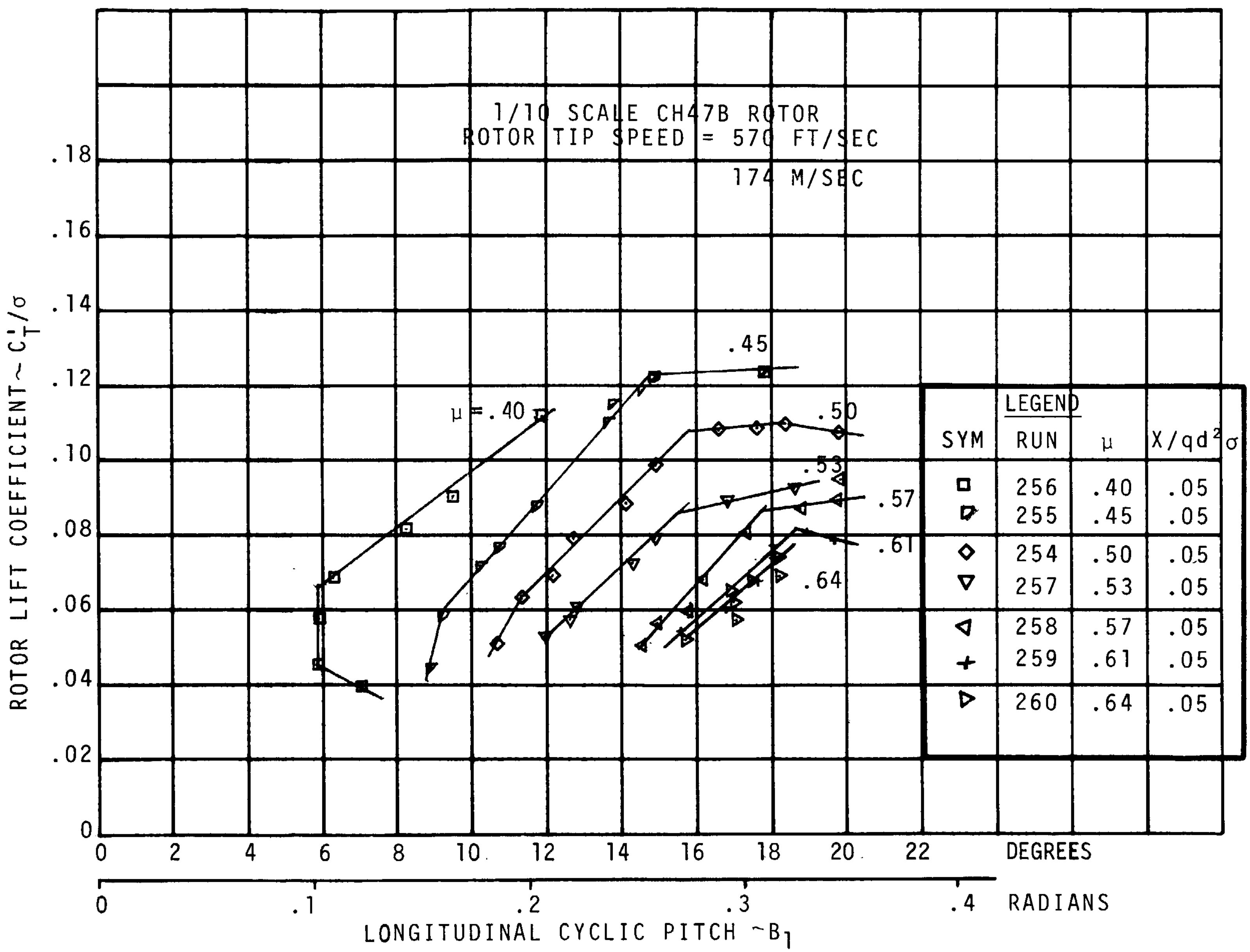


FIGURE 6.3.16 LONGITUDINAL CYCLIC PITCH FOR PERFORMANCE SUMMARY V_T = 570 FT/SEC

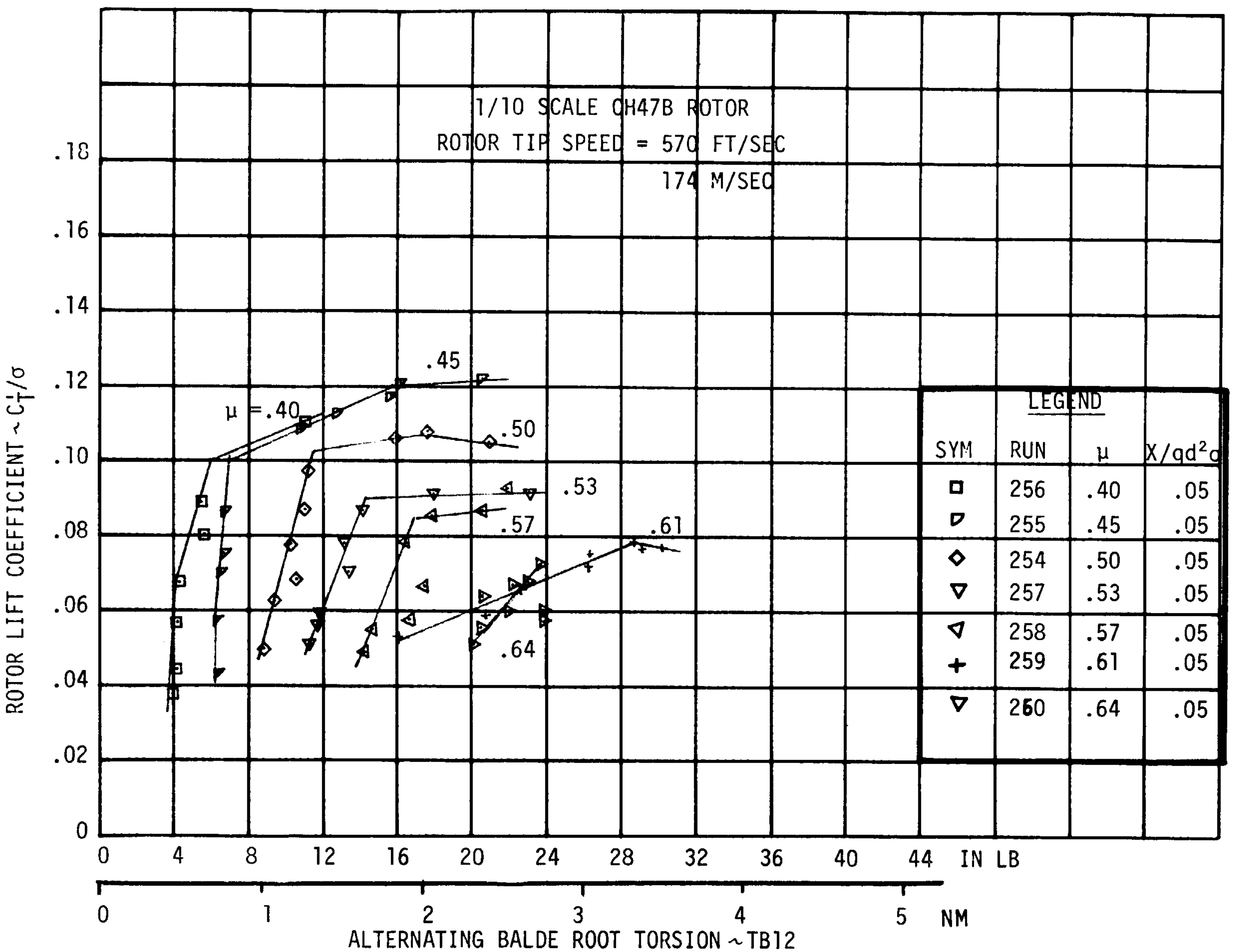


FIGURE 6.3.18 ALTERNATING BLADE ROOT TORSION LOADS FOR PERFORMANCE SUMMARY AT V_T = 570 FT/SEC

longitudinal force indicate no change in sensitivity when operating near the lift limit. Rotor thrust and power variations with longitudinal or lateral cyclic are unaffected as the rotor lift is increased from 70 percent to 90 percent of the lift limit at an advance ratio of 0.20, as indicated in Figure 6.4.3.

For an advance ratio of 0.40, the sensitivity of rotor hub moments and inplane forces to longitudinal cyclic are presened in Figure 6.4.4 and to lateral cyclic in Figure 6.4.5. There is no change in any of the sensitivities as a result of operating near stall. The impact of longitudinal or lateral cyclic on rotor thrust and power is presented in Figure 6.4.6 and indicates no change results from operating at the higher lift level.

When increasing the operating speed up to an advance ratio of 0.53 the sensitivity of rotor pitching moment and longitudinal force are slightly increased when operating near the lift limit as shown in Figure 6.4.7. The sensitivities become slightly greater in the cross coupling terms of rotor rolling moment and side force when operating near stall. The lateral control characteristics of Figure 6.4.8 are less affected by operation near stall than the longitudinal control characteristics. At $\mu = 0.53$ there was no effect on the thrust or power sensitivities to longitudinal or lateral cyclic. The conclusion drawn from these data trends is that there is a negligible effect on the control power resulting from operation at 90 percent of the lift limit at all speeds up to an advance ratio of 0.53.

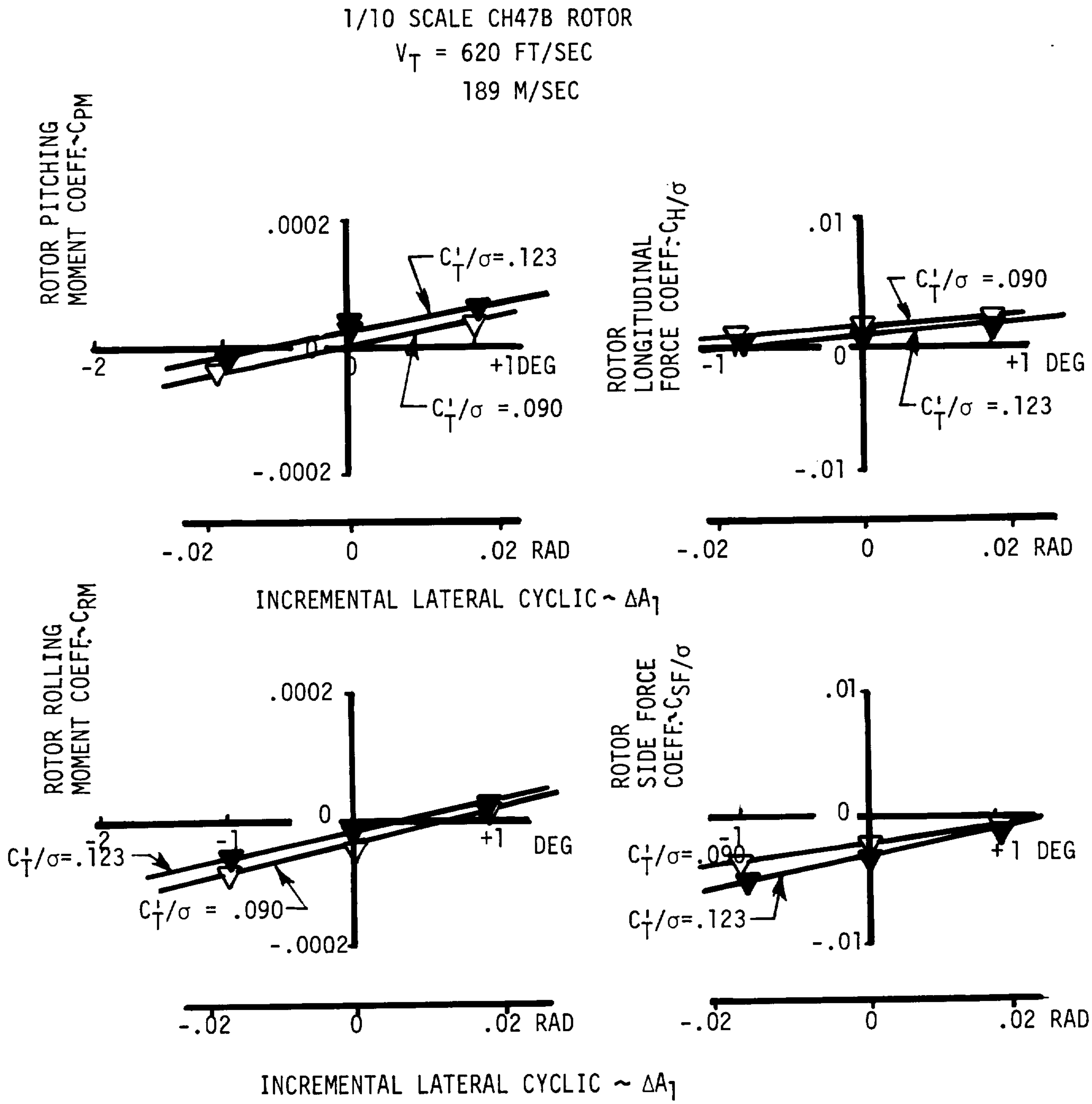


FIGURE 6.4.2 EFFECT OF STALL PROXIMITY ON LATERAL CONTROL POWER - ROTOR MOMENTS & INPLANE FORCES AT μ=0.20, $X/qd^2\sigma$ = 0.05

C. Basic Test Data from Control Power Testing

As indicated in Section 5, of the main report, the control power testing was conducted concurrently with the lift limit testing at fixed levels of propulsive force. The control power characteristics are defined by the changes in rotor forces and moments produced by increasing or decreasing the cyclic pitch from a trimmed flight condition at 90 percent and 70 percent of the maximum lift achieved at that specific advance ratio and propulsive force level. This was repeated at each propulsive force level and advance ratio for the basic rotor tip speed of 620 ft/sec.

Test data obtained from each of the test runs has been combined to show the impact of advance ratio, propulsive force level, and stall proximity on the control power characteristics. The combinations, identified as plot sets, are defined in Table C-1 and are marked on the bottom of each sheet. Within each plot set are a series of graphs presenting the variation of each component of measured data with lateral cyclic or longitudinal cyclic noting the base point or trimmed flight condition. An example of the sequence of these graphs is presented below for lateral cyclic and the sequence will be the same for longitudinal cyclic.

Rotor Lift Coefficient versus Lateral Cyclic

Rotor Propulsive Force Coefficient versus Lateral Cyclic

Rotor Power Coefficient versus Lateral Cyclic

Rotor Pitching Moment Coefficient versus Lateral Cyclic

Rotor Rolling Moment Coefficient versus Lateral Cyclic

Rotor Longitudinal Force Coefficient versus Lateral Cyclic

Rotor Side Force Coefficient versus Lateral Cyclic

Alternating Root Flap Bending FB12 versus Lateral Cyclic

Alternating Root Chord Bending CB12 versus Lateral Cyclic

Alternating Root Torsion TB12 versus Lateral Cyclic

TABLE C-1 DATA PLOTTING SUMMARY FOR THE CONTROL POWER TESTING

PLOT SET	RUN NO.	ROTOR TIP SPEED V_T	ADVANCE RATIO μ	ROTOR LIFT COEFF. C_T^1/σ	ROTOR PROPULSIVE FORCE COEFF. $X/qd^2\sigma$	TUNNEL SPEED V	COMMENTS
8	25	620FPS	.1	.124	.05	62FPS	Control power in cruise
	28	620FPS	.2	.123	.05	124FPS	
	29	620FPS	.3	.098	.05	186FPS	lateral
	30	620FPS	.4	.095	.05	248FPS	
9	28	620FPS	.2	.123	.05	124FPS	lateral
	28	620FPS	.2	.090	.05	124FPS	
10	30	620FPS	.4	.095	.05	248FPS	lateral
	30	620FPS	.4	.076	.05	248FPS	
11	25	620FPS	.10	.124	.05	62FPS	longitudinal
	28	620FPS	.20	.123	.05	124FPS	
	30	620FPS	.40	.095	.05	248FPS	
12	28	620FPS	.20	.123	.05	124FPS	longitudinal
	28	620FPS	.20	.090	.05	124FPS	
13	30	620FPS	.40	.095	.05	248FPS	longitudinal
	30	620FPS	.40	.076	.05	248FPS	
14	32	620FPS	.40	.100	.01	248FPS	lateral
	30	620FPS	.40	.095	.05	248FPS	
	33	620FPS	.40	.088	.10	248FPS	

TABLE C-1 DATA PLOTTING SUMMARY FOR THE CONTROL POWER SETTING
(Continued)

PLOT SET	RUN NO.	ROTOR TIP SPEED V_T	ADVANCE RATIO μ	ROTOR LIFT COEFF. C_{L_T}/σ	ROTOR PROPULSIVE FORCE COEFF. $X/qd^2\sigma$	TUNNEL SPEED V	COMMENTS
15	32	620FPS	.40	.077	.01	248FPS	lateral
	30	620FPS	.40	.076	.05	248FPS	
	33	620FPS	.40	.070	.10	248FPS	
16	32	620FPS	.40	.100	.01	248FPS	lateral
	32	620FPS	.40	.077	.01	248FPS	
17	33	620FPS	.40	.088	.10	248FPS	lateral
	33	620FPS	.40	.070	.10	248FPS	
18	32	620FPS	.40	.100	.01	248FPS	longitudinal
	30	620FPS	.40	.095	.05	248FPS	
	33	620FPS	.40	.088	.10	248FPS	
19	32	620FPS	.40	.076	.01	248FPS	longitudinal
	30	620FPS	.40	.076	.05	248FPS	
	33	620FPS	.40	.070	.10	248FPS	
20	32	620FPS	.40	.100	.01	248FPS	longitudinal
	32	620FPS	.40	.76	.01	248FPS	
21	33	620FPS	.40	.088	.10	248FPS	longitudinal
	33	620FPS	.40	.070	.10	248FPS	
22	39	620FPS	.50	.098	.05	310FPS	Control power in cruise
	41	620FPS	.50	.090	.10	310FPS	lateral
	42	620FPS	.50	.073	.20	310FPS	

TABLE C-1 DATA PLOTTING SUMMARY FOR THE CONTROL POWER SETTING (CONTINUED)

PLOT SET	RUN NO.	ROTOR TIP SPEED V_T	ADVANCE RATIO μ	ROTOR LIFT COEFF. C_T/σ	ROTOR PROPULSIVE FORCE COEFF. $X/qd^2\sigma$	TUNNEL SPEED V	COMMENTS
23	39	620FPS	.50	.078	.05	310FPS	lateral
	41	620FPS	.50	.069	.10	310FPS	
	42	620FPS	.50	.059	.20	310FPS	
24	39	620FPS	.50	.098	.05	310FPS	lateral
	39	620FPS	.50	.078	.05	310FPS	
25	41	620FPS	.50	.090	.10	310FPS	lateral
	41	620FPS	.50	.069	.10	310FPS	
26	43	620FPS	.50	.073	.20	310FPS	lateral
	43	620FPS	.50	.059	.20	310FPS	
27	39	620FPS	.50	.098	.05	310FPS	longitudinal
	41	620FPS	.50	.090	.10	310FPS	
	42	620FPS	.50	.073	.20	310FPS	
28	39	620FPS	.50	.078	.05	310FPS	longitudinal
	41	620FPS	.50	.069	.10	310FPS	
	42	620FPS	.50	.059	.20	310FPS	
29	39	620FPS	.50	.098	.05	310FPS	longitudinal
	39	620FPS	.50	.078	.05	310FPS	
30	41	620FPS	.50	.090	.10	310FPS	longitudinal
	41	620FPS	.50	.069	.10	310FPS	

TABLE C-1 DATA PLOTTING SUMMARY FOR THE CONTROL POWER SETTING (CONTINUED)

PLOT SET	RUN NO.	ROTOR TIP SPEED V_T	ADVANCE RATIO μ	ROTOR LIFT COEFF. C_T/σ	ROTOR PROPULSIVE FORCE COEFF. $X/qd^2\sigma$	TUNNEL SPEED V	COMMENTS
31	42	620FPS	.50	.073	.20	310FPS	longitudinal
	42	620FPS	.50	.059	.20	310FPS	
32	50	620FPS	.53	.102	.05	329FPS	lateral
	50	620FPS	.53	.079	.05	329FPS	
33	50	620FPS	.53	.102	.05	329FPS	longitudinal
	50	620FPS	.53	.079	.05	329FPS	

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Figure C-1

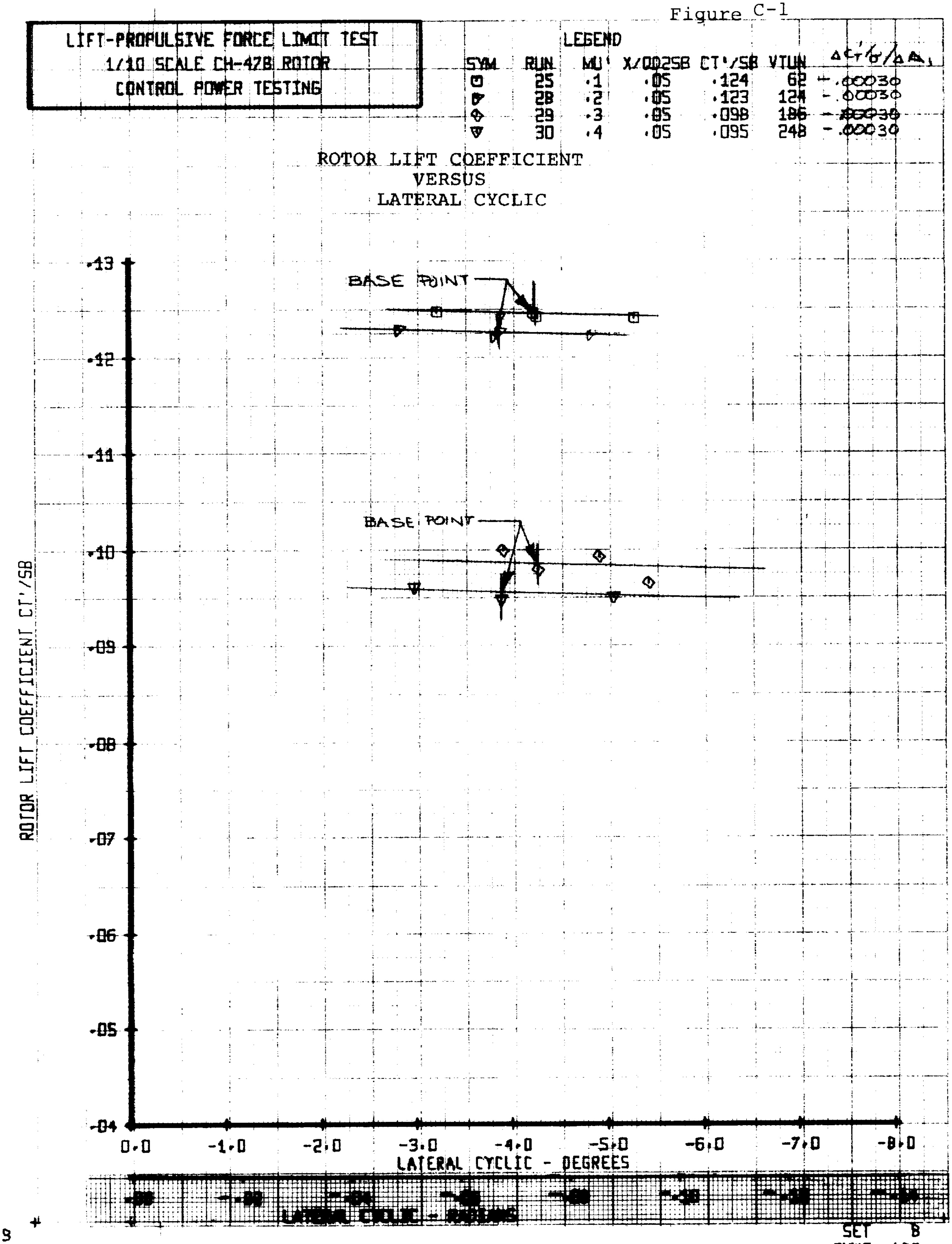
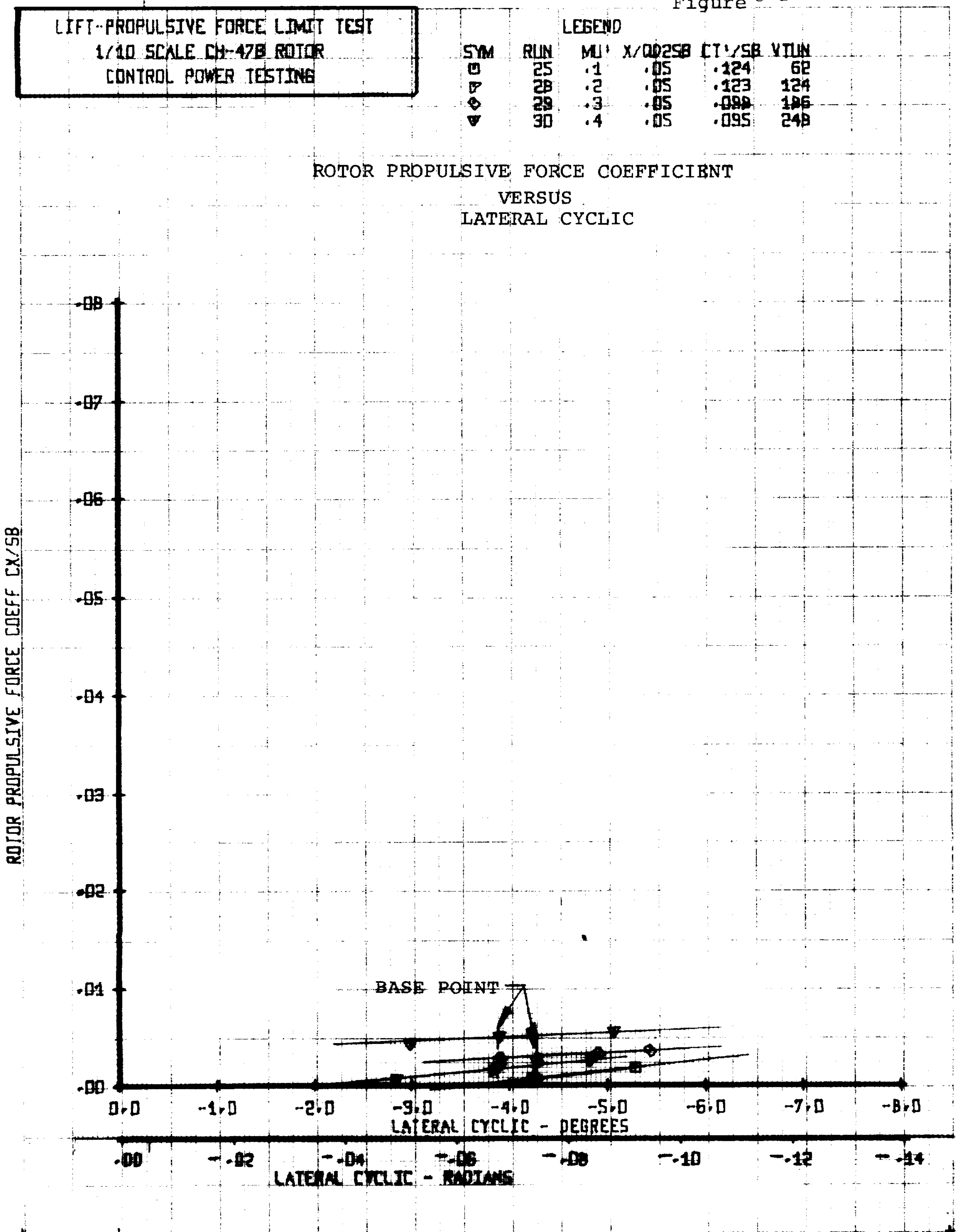

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
25 .1 .05 .124 62
28 .2 .05 .123 124
29 .3 .05 .098 186
30 .4 .05 .095 248
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
BASE POINT
ROTOR LIFT COEFFICIENT CT'/SB
LATERAL CYCLIC - DEGREES
SET 8
BVWT 187

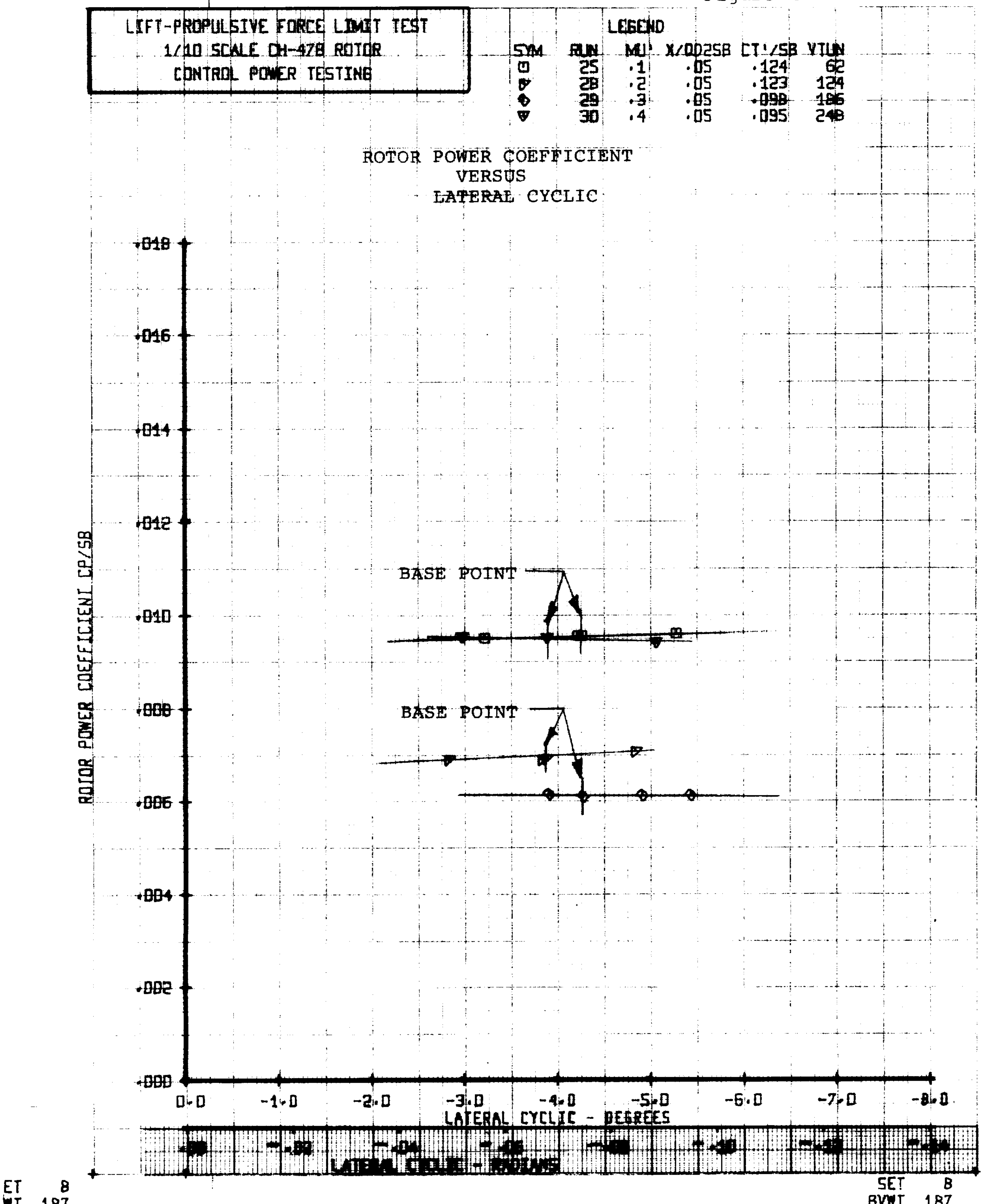
Figure C-2

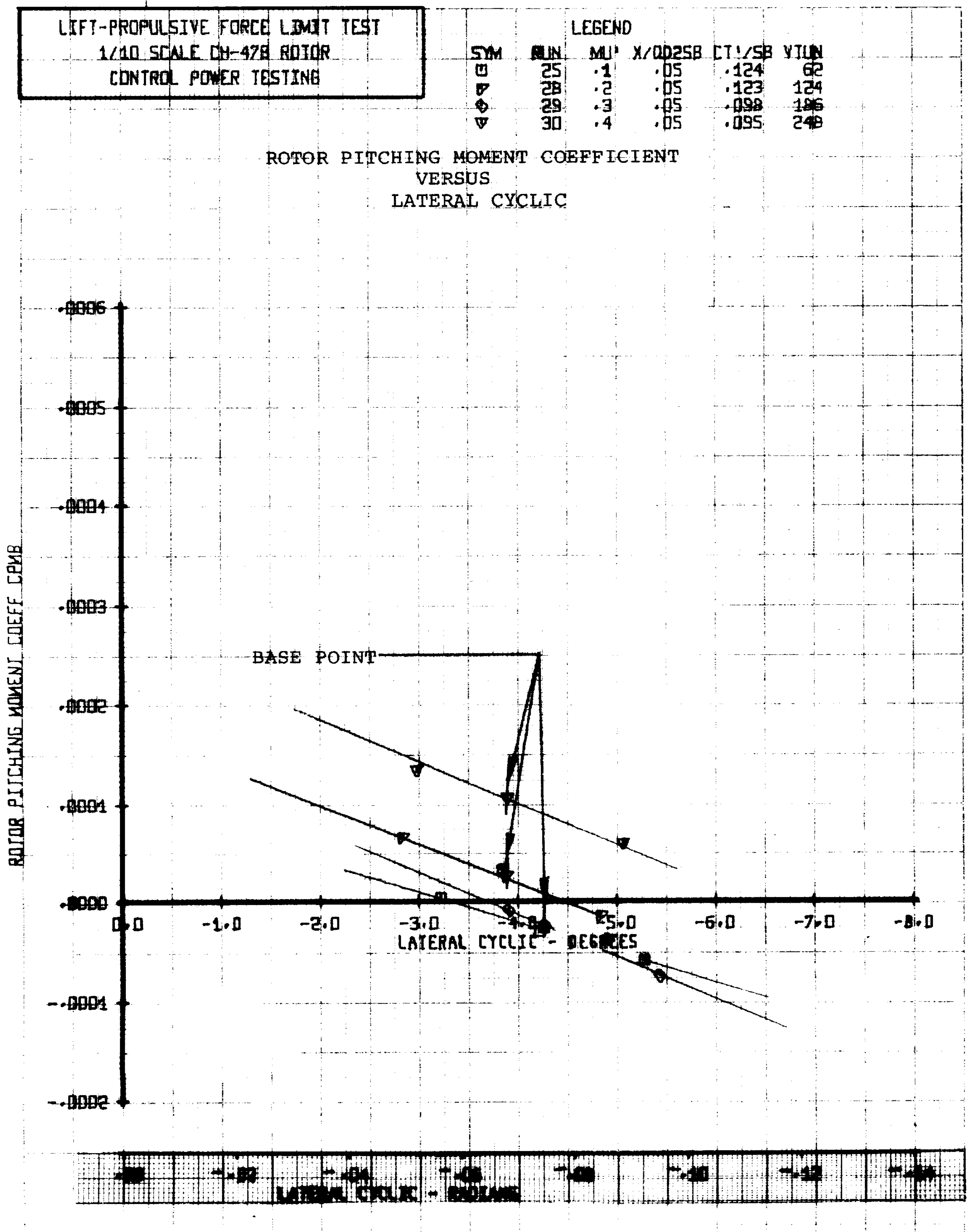


ET 8
WT 187

SET 8
BVWT 187

Figure C-3


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD2SB CT'/SB VTUN
25 .1 .05 .124 62
28 .2 .05 .123 124
29 .3 .05 .098 186
30 .4 .05 .095 248
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
ET 8
WT 187
SET 8
BVWT 187



ET B
WT 187

SET B
BVWT 187

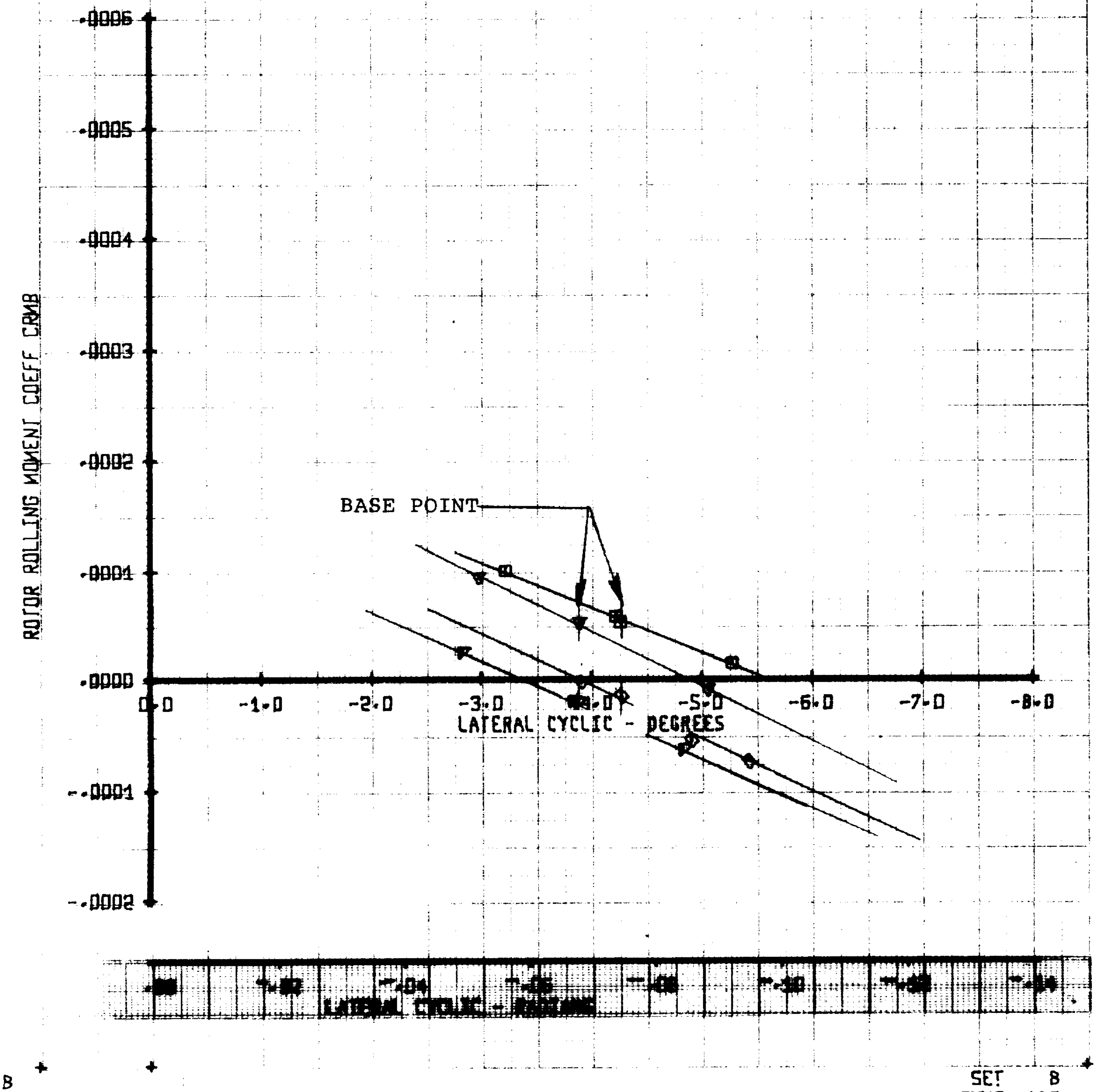
Figure C-5

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
⊡	25	.1	.05	.124	62
▽	28	.2	.05	.123	124
◇	29	.3	.05	.098	186
▽	30	.4	.05	.095	248

ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC

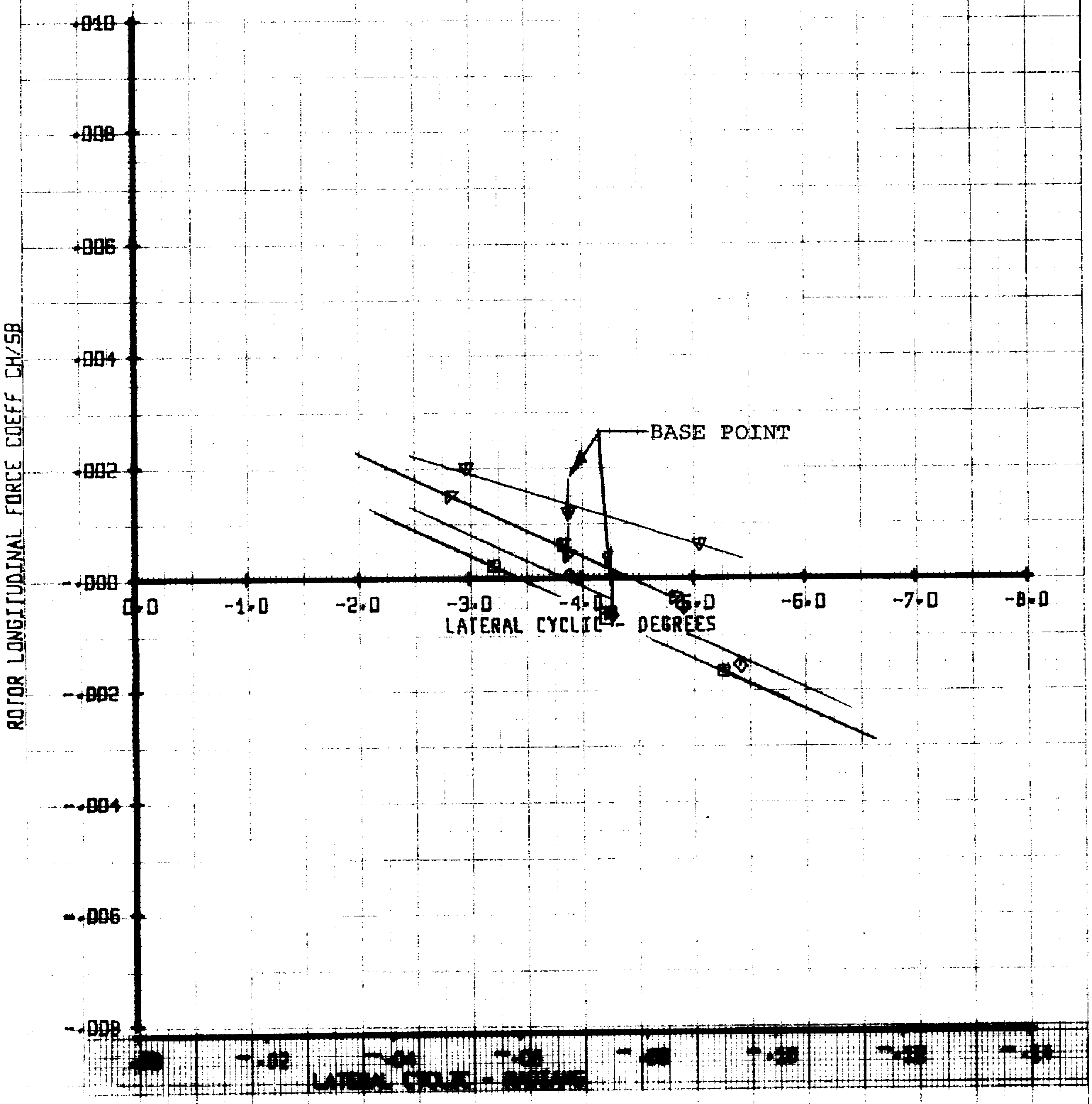


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
⊡	25	.1	.05	.124	62
▽	28	.2	.05	.123	124
◇	29	.3	.05	.098	186
▽	30	.4	.05	.095	248

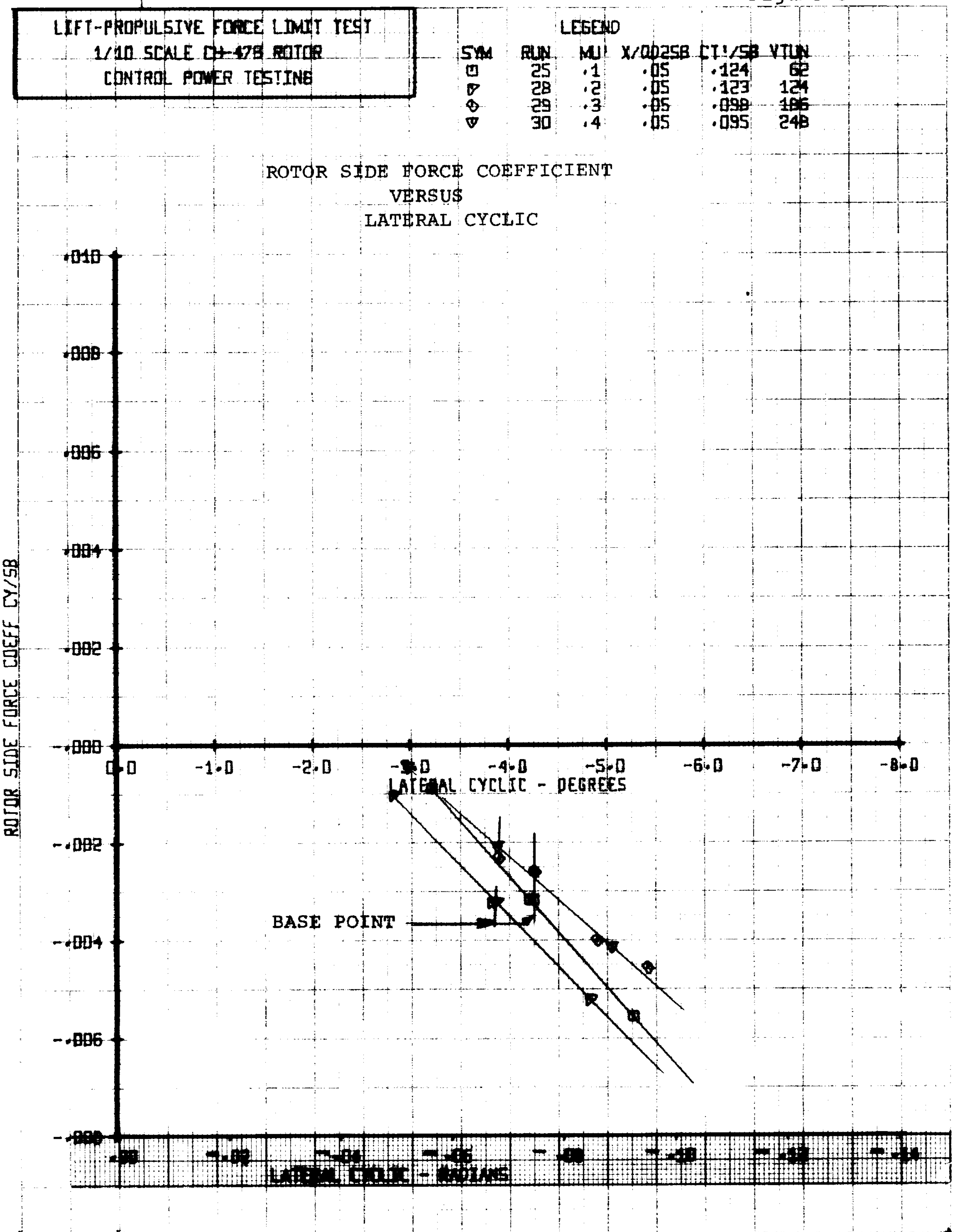
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC



ET 8
WT 187

SET 8
BVWT 187

Figure C-7



ET 8
WT 187

SET 8
BVWT 187

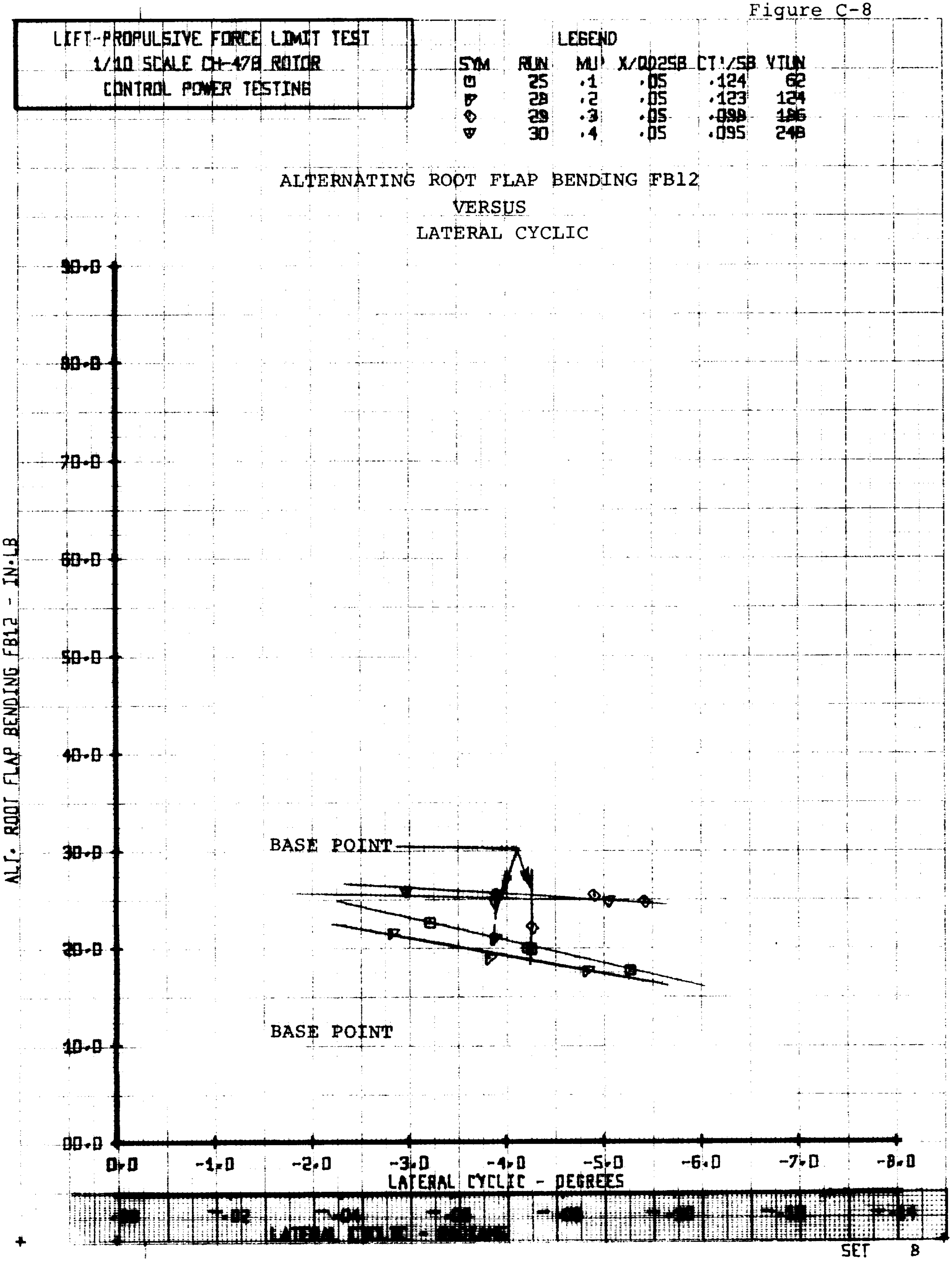
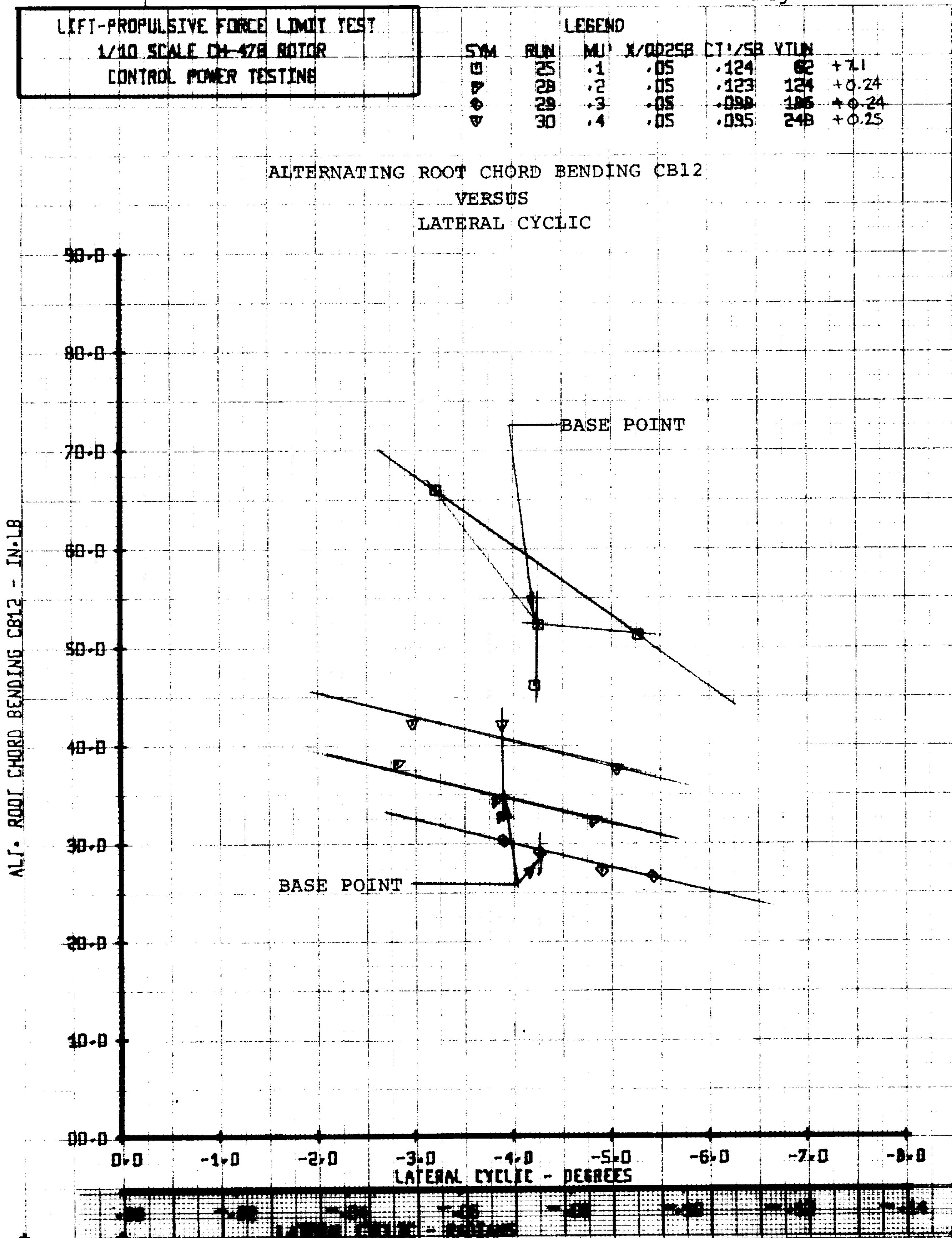

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
25 .1 .05 .124 62
28 .2 .05 .123 124
29 .3 .05 .098 186
30 .4 .05 .095 248
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LATERAL CYCLIC
ALT. ROOT FLAP BENDING FB12 - IN-LB
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
00.0
BASE POINT
BASE POINT
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
ET 8
WT 187
SET 8
BVWT 187

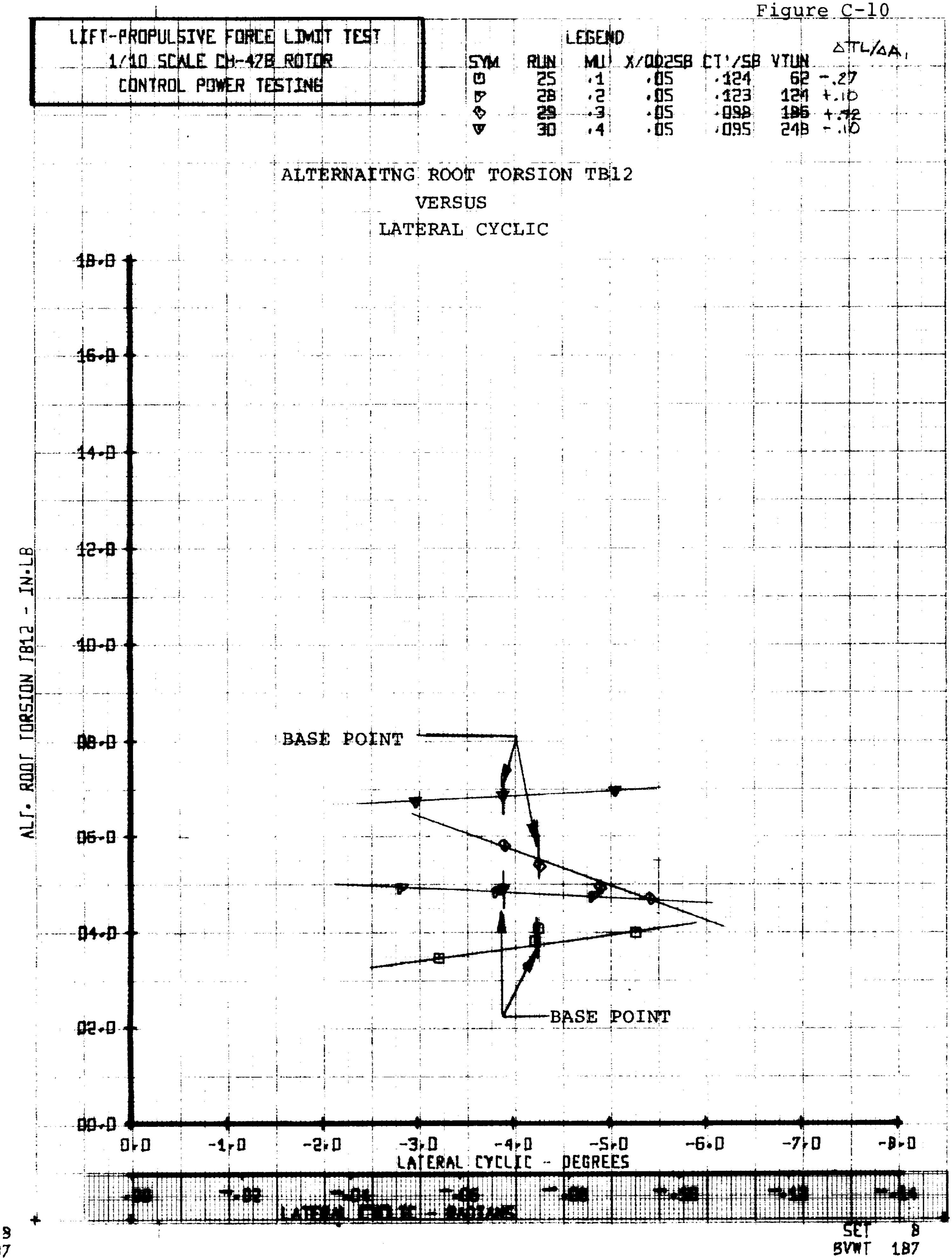
Figure C-9

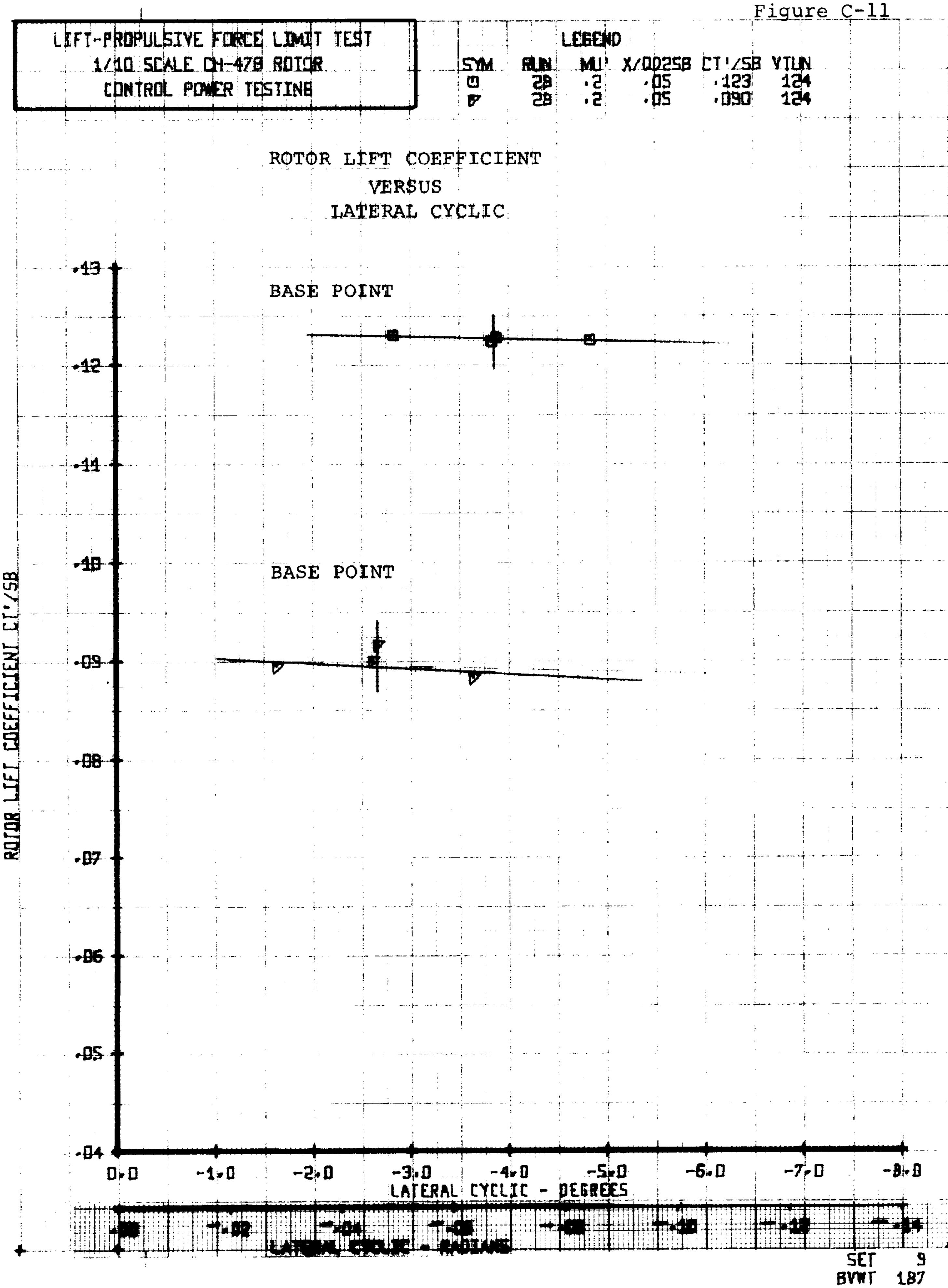


ET 8
WT 1B7

SET 8
BVWT 1B7

Figure C-10


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN ΔTL/ΔA1
25 .1 .05 .124 62 -.27
28 .2 .05 .123 124 +.10
29 .3 .05 .098 186 +.42
30 .4 .05 .095 248 -.10
ALTERNAITNG ROOT TORSION TB12
VERSUS
LATERAL CYCLIC
ALT. ROOT TORSION TB12 - IN.LB
18.0
16.0
14.0
12.0
10.0
08.0
06.0
04.0
02.0
00.0
BASE POINT
BASE POINT
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
ET 8
WT 187
SET 8
BVWT 187



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD25B CT'/SB VTUN
28 .2 .05 .123 124
28 .2 .05 .090 124
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
BASE POINT
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 9
BVWT 187

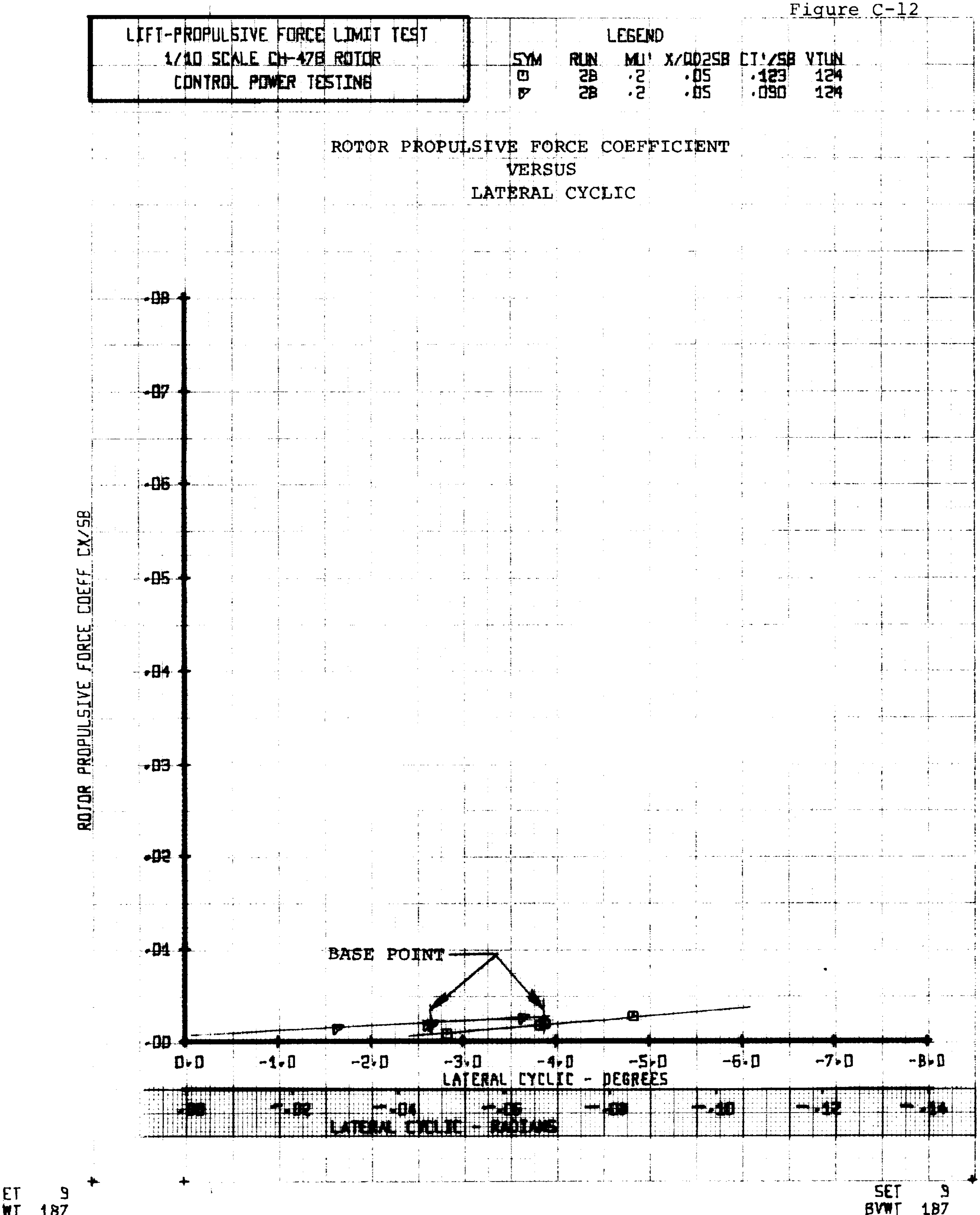
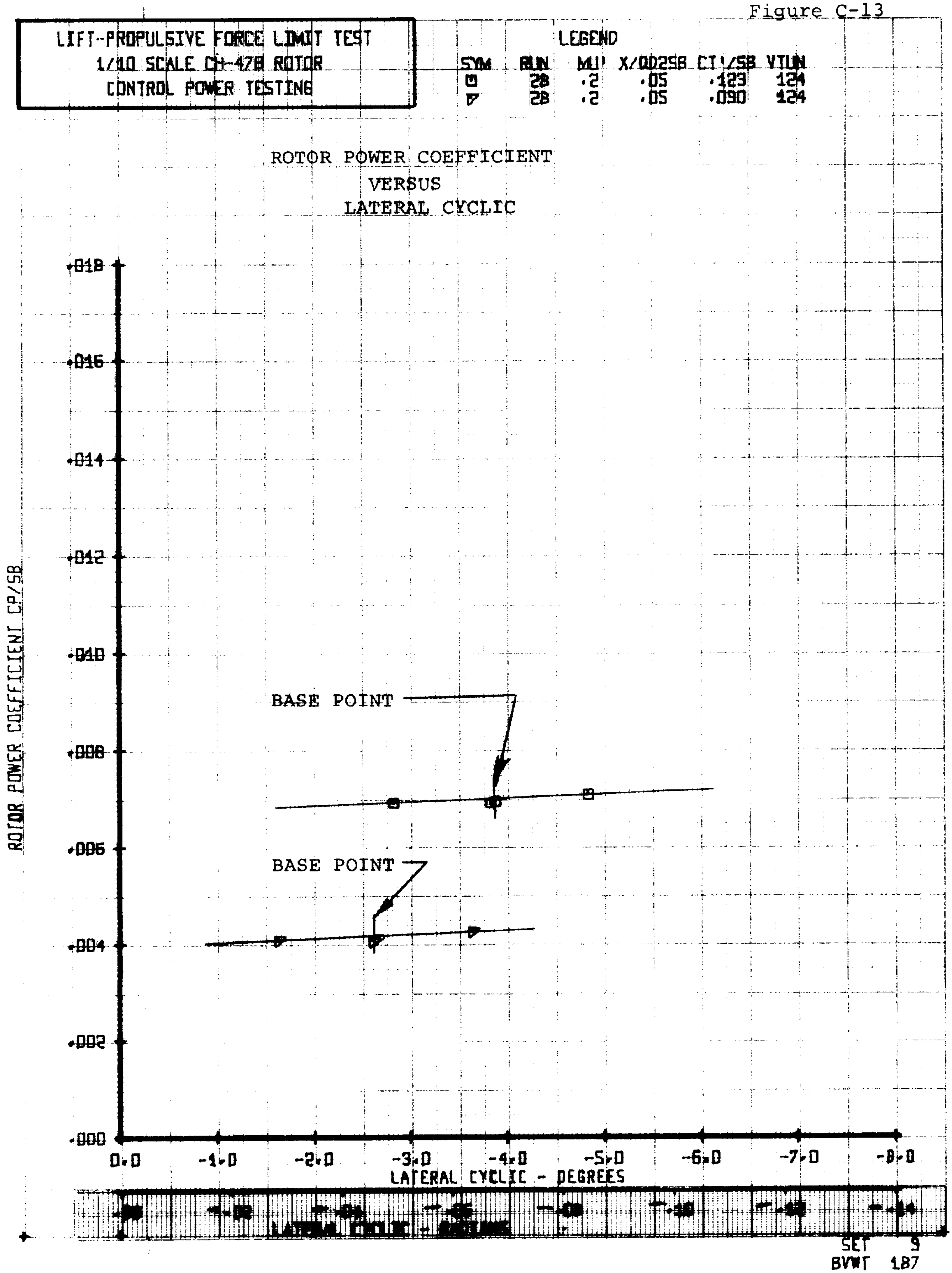

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
28 .2 .05 .123 124
28 .2 .05 .090 124
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PROPULSIVE FORCE COEFF CX/SB
.08
.07
.06
.05
.04
.03
.02
.01
.00
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
ET 9
WT 187
SET 9
BVWT 187

Figure C-13


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
28 .2 .05 .123 124
28 .2 .05 .090 124
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
ET 9
WT 187
SET 9
BVWT 187

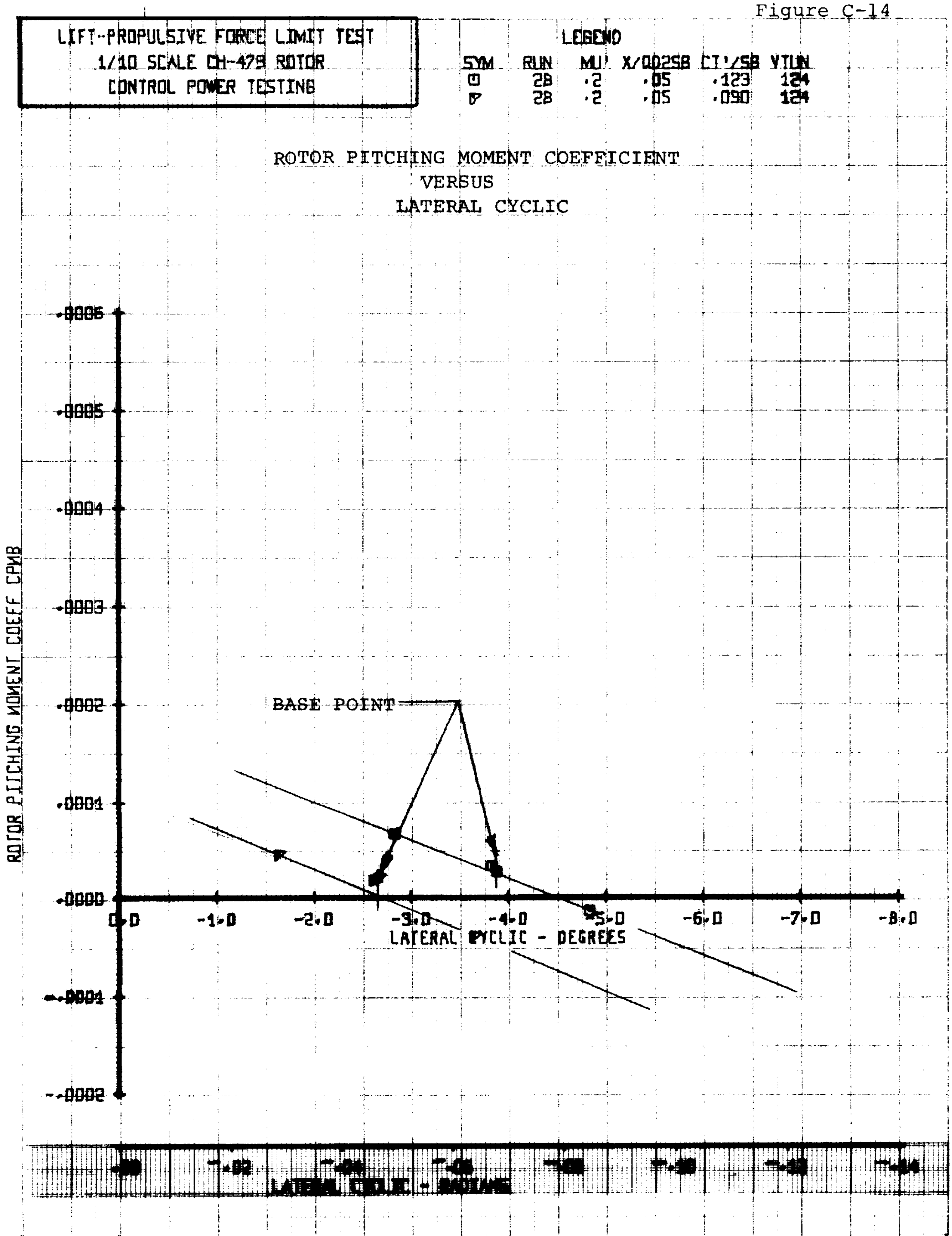
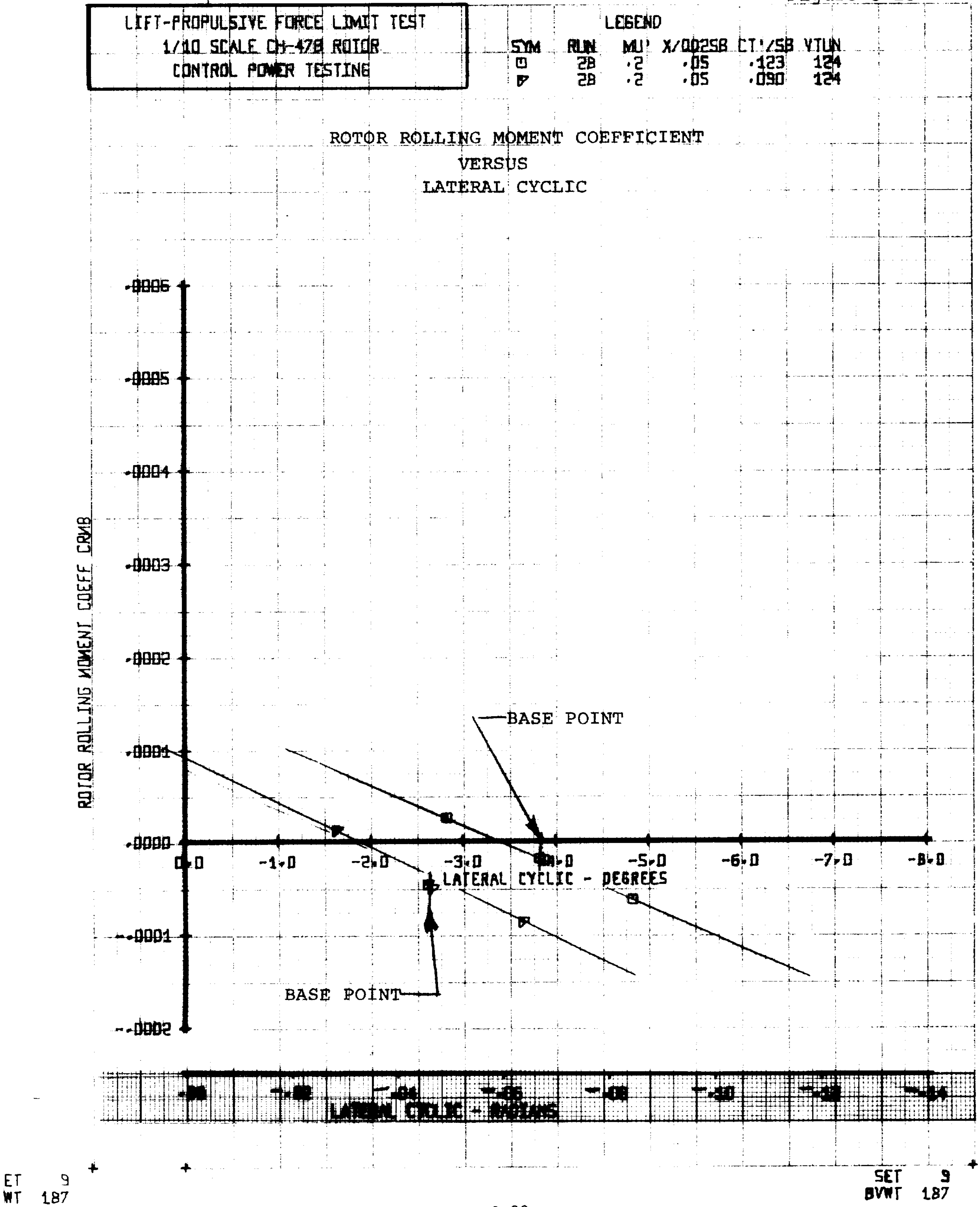

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
28 .2 .05 .123 124
28 .2 .05 .090 124
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
ET 9
WT 187
SET 9
BVWT 187

Figure C-15



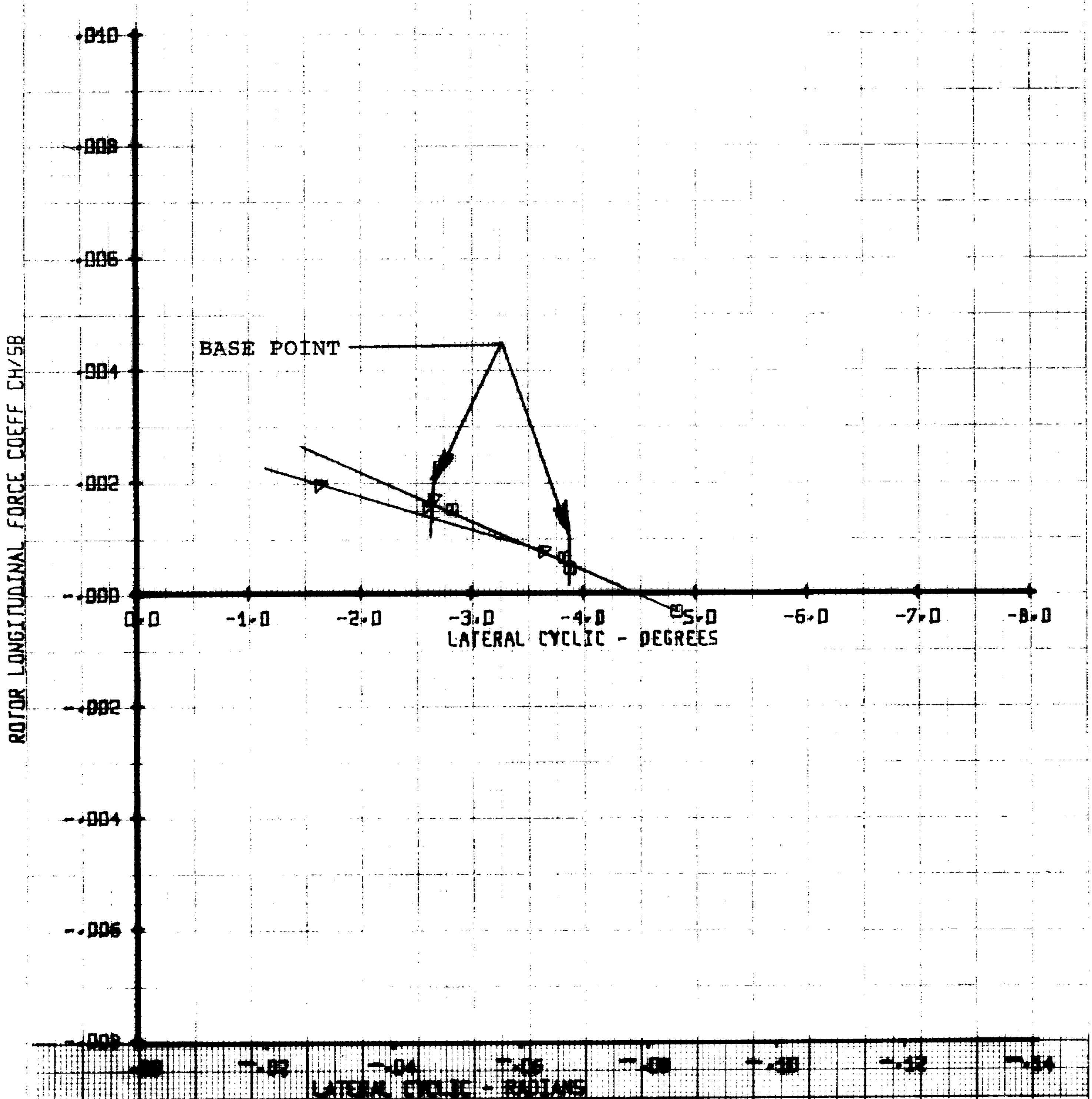
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QQ2SB CT'/SB VTUN
28 .2 .05 .123 124
28 .2 .05 .090 124
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR ROLLING MOMENT COEFF CRMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
BASE POINT
BASE POINT
LATERAL CYCLIC - RADIANS
ET 9
WT 187
SET 9
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU	X/QD2SB	CT'/SB	VTUN
□	28	.2	.05	.123	124
▽	28	.2	.05	.090	124

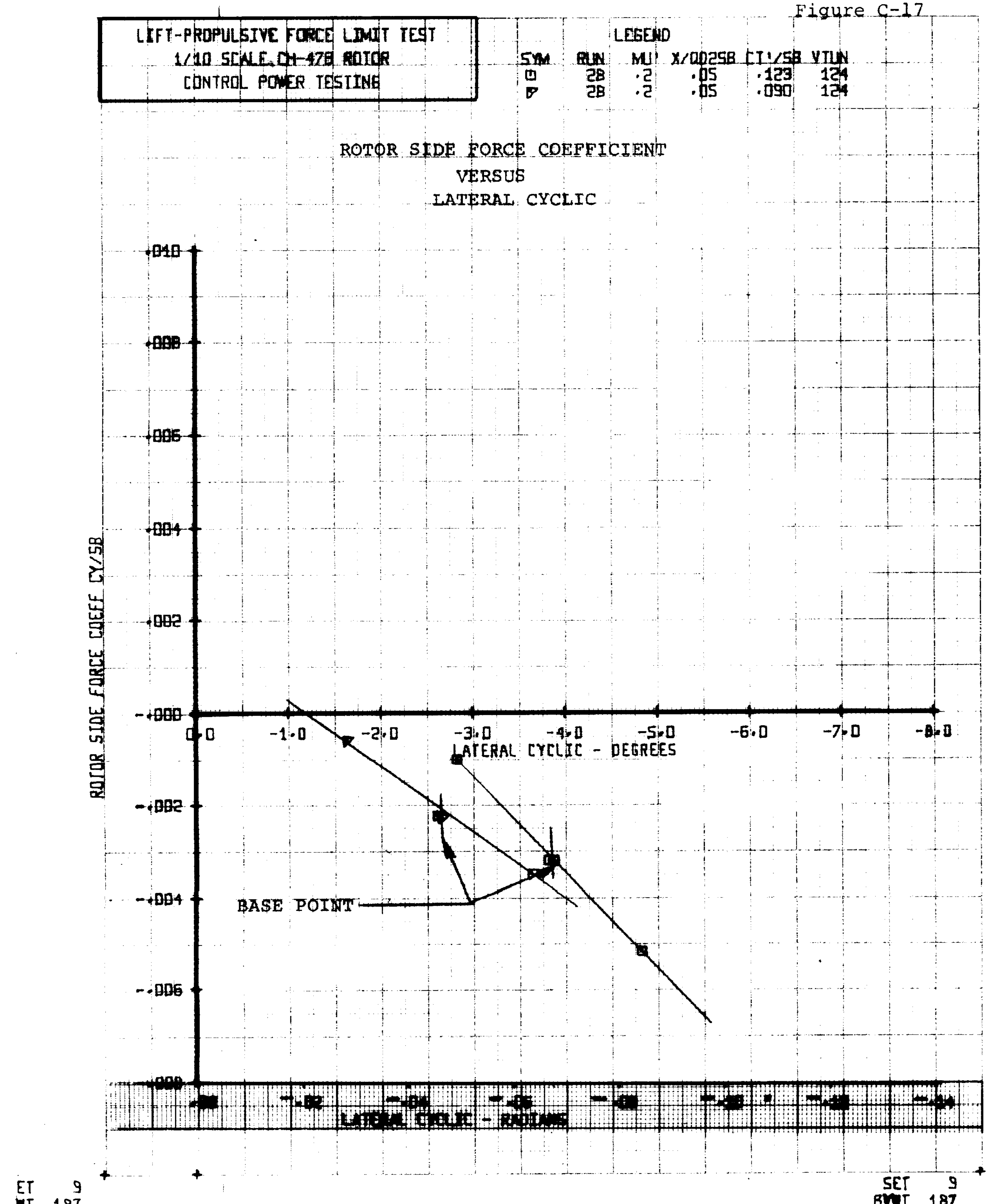
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC



ET 9
WT 187

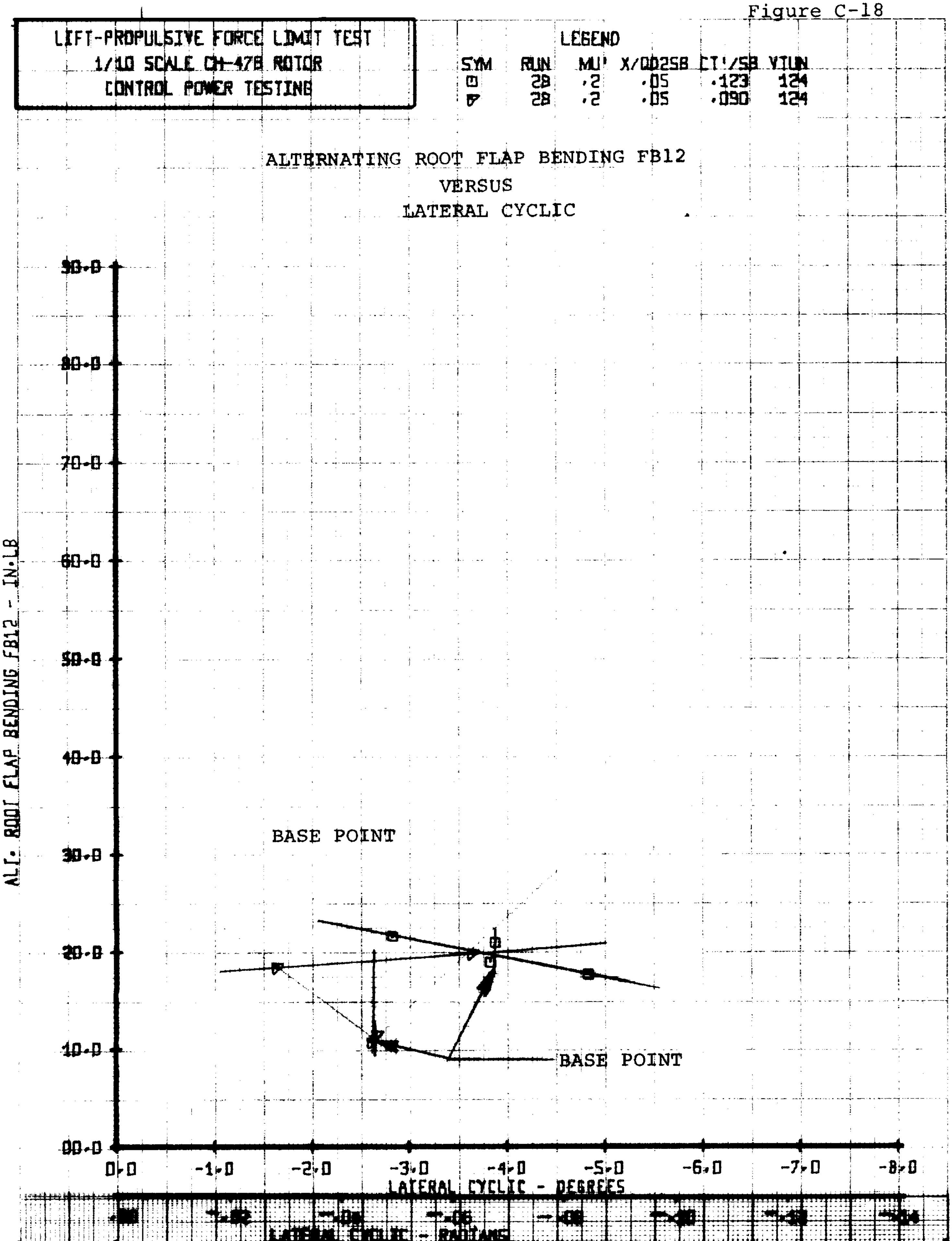
SET 9
BVWT 187

Figure C-17



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QQ2SB CT'/SB VTUN
28 .2 .05 .123 124
28 .2 .05 .090 124
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR SIDE FORCE COEFF CY/SB
.010
.008
.006
.004
.002
-.000
-.002
-.004
-.006
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
BASE POINT
LATERAL CYCLIC - RADIANS
ET 9
WT 187
SET 9
BWWT 187

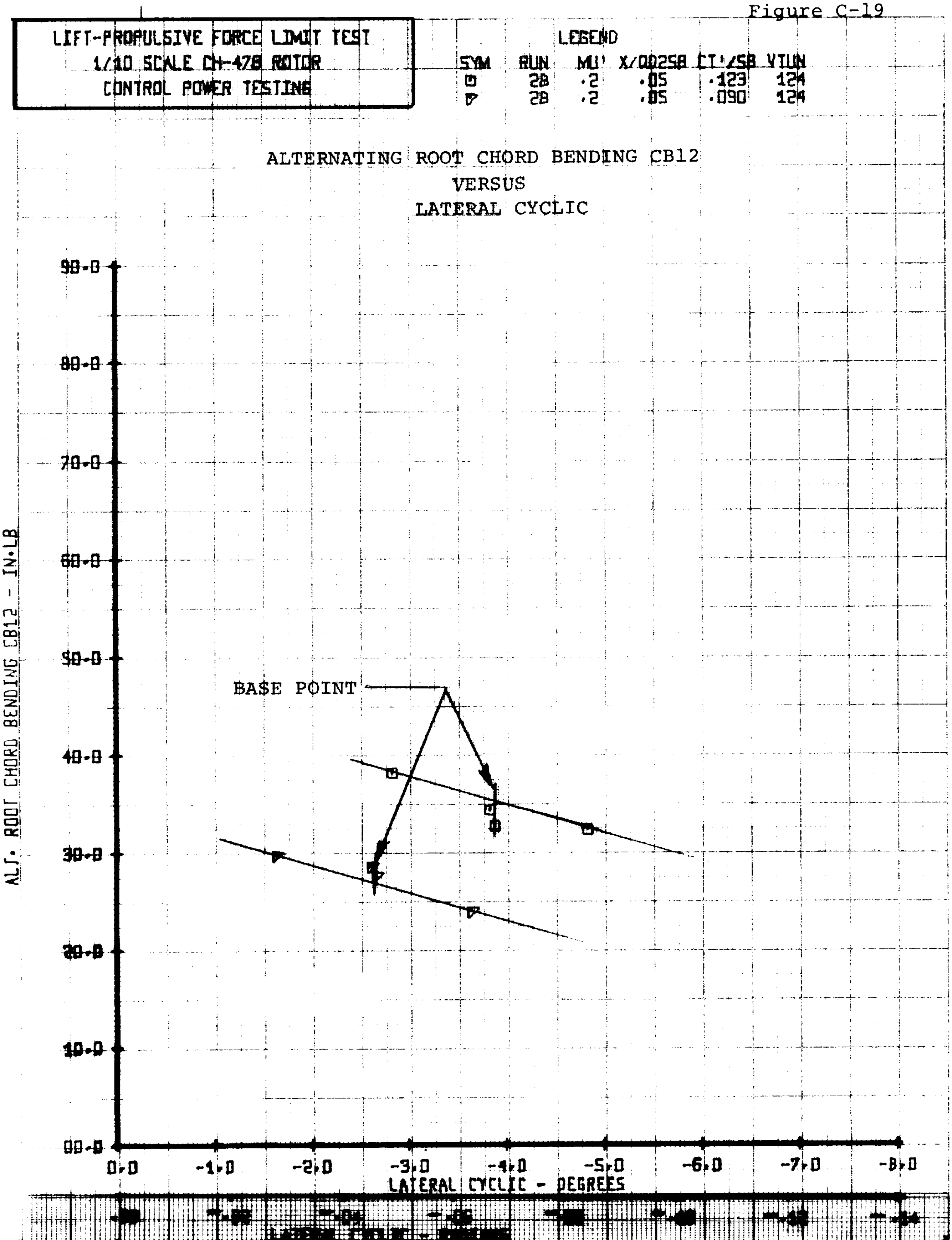
Figure C-18



ET 9
WT 187

SET 9
BVWT 187

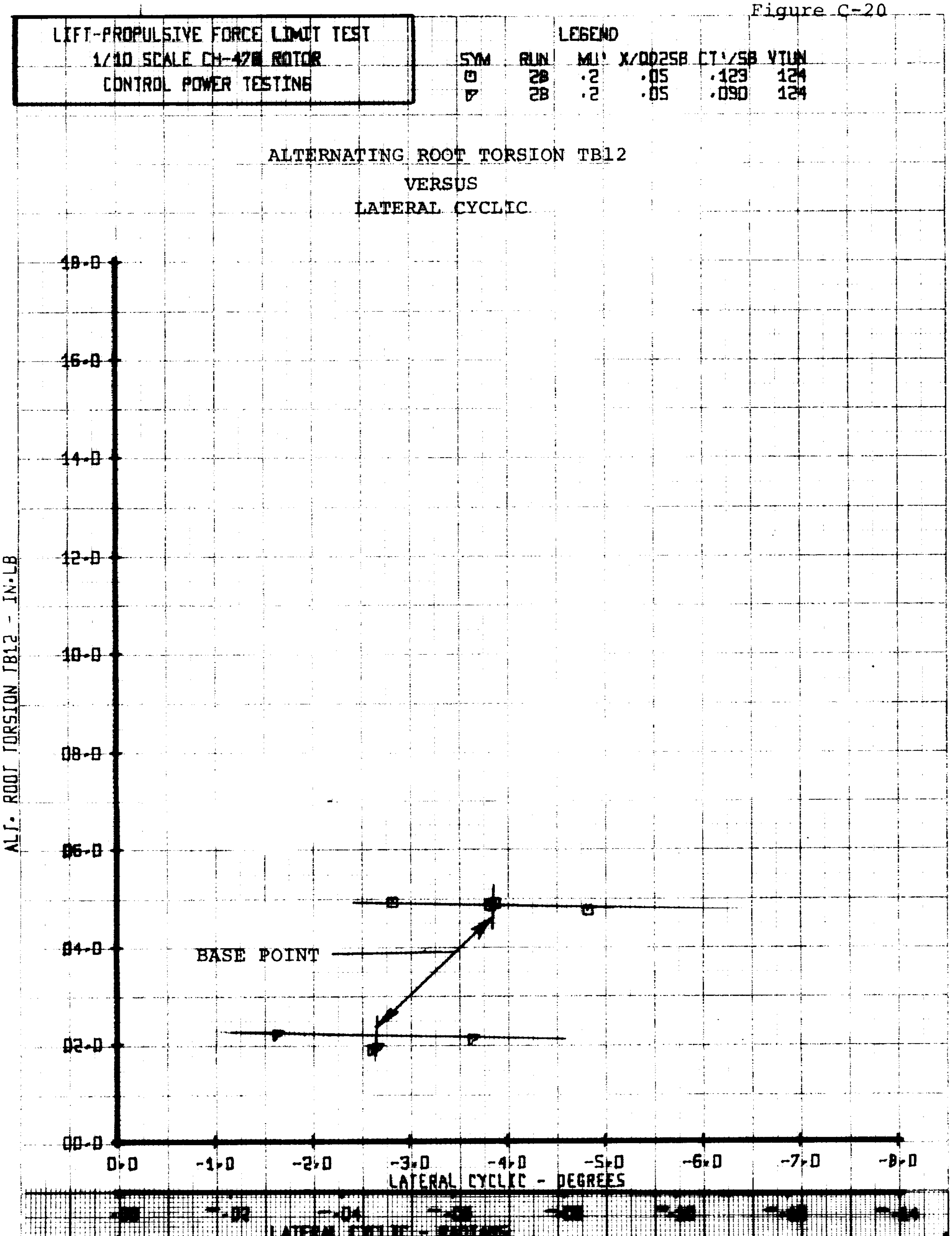
Figure C-19



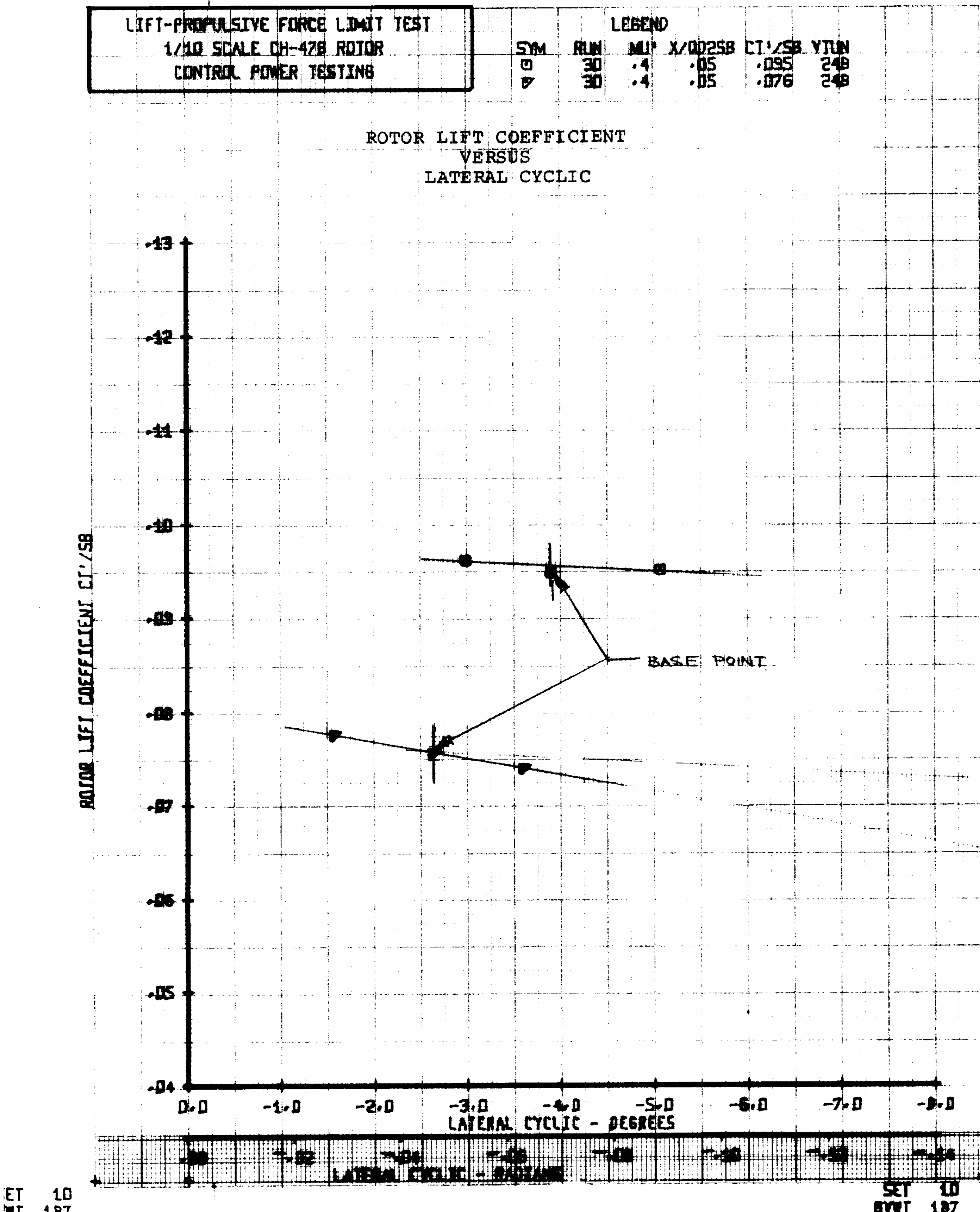
ET 9
WT 187

SET 9
BVWT 187

Figure C-20

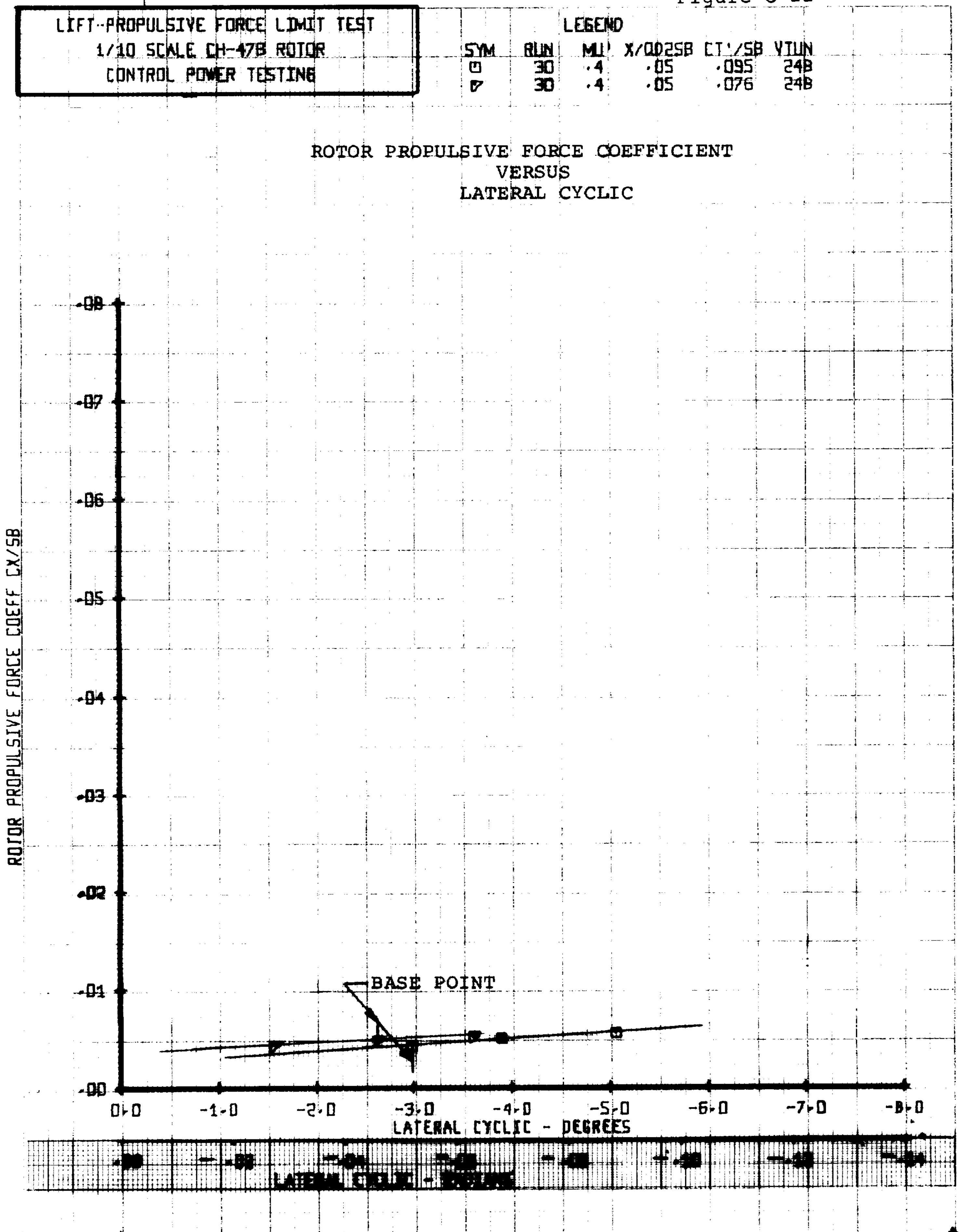


ET 9
WT 187



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD25B CT'/SB VTUN
30 .4 .05 .095 248
30 .4 .05 .076 248
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 10
BVWT 187

Figure C-22



ET 10
WT 187

SET 10
BVWT 187

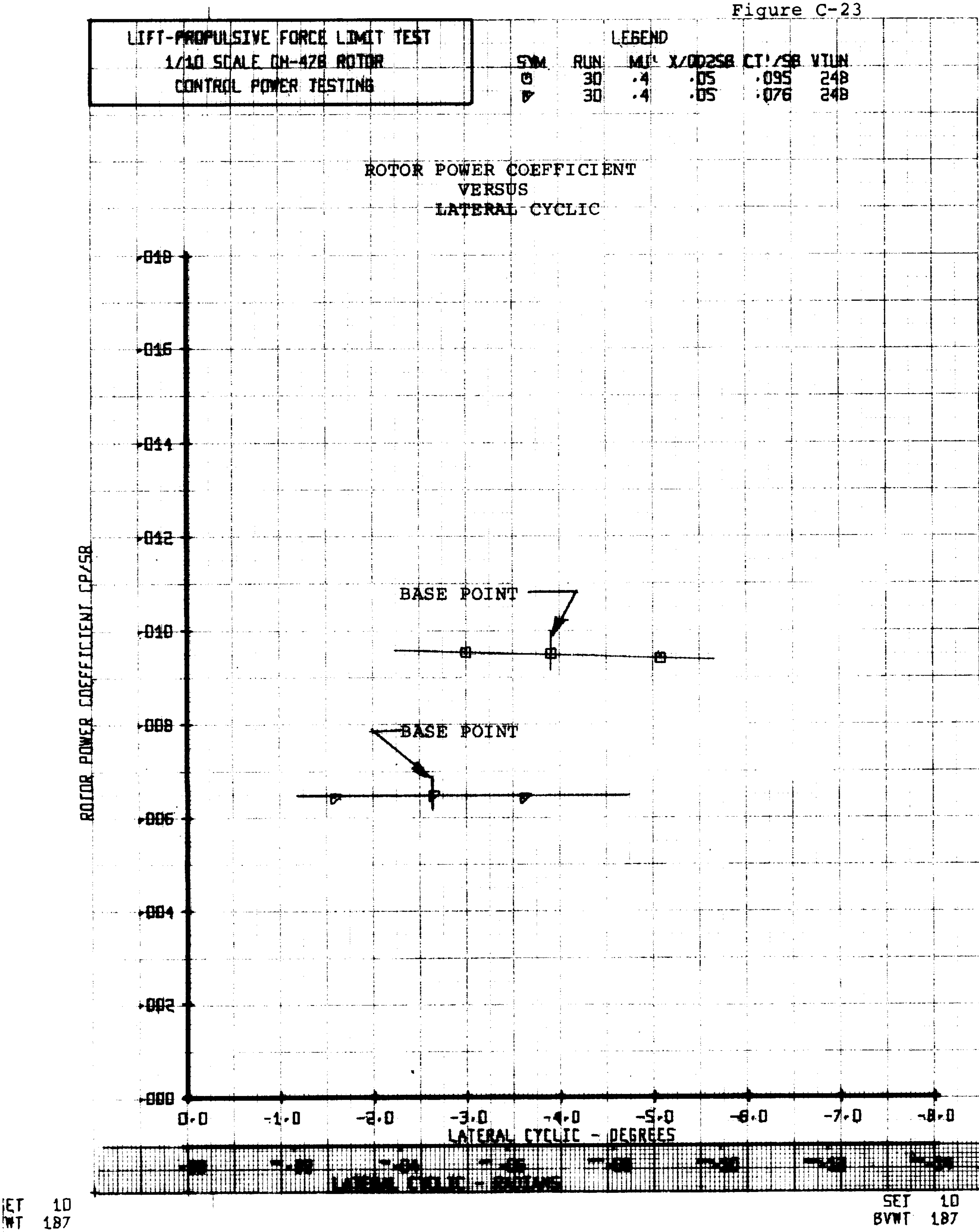

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT/SB VTUN
30 .4 .05 .095 248
30 .4 .05 .076 248
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 10
BVWT 187

Figure C-24

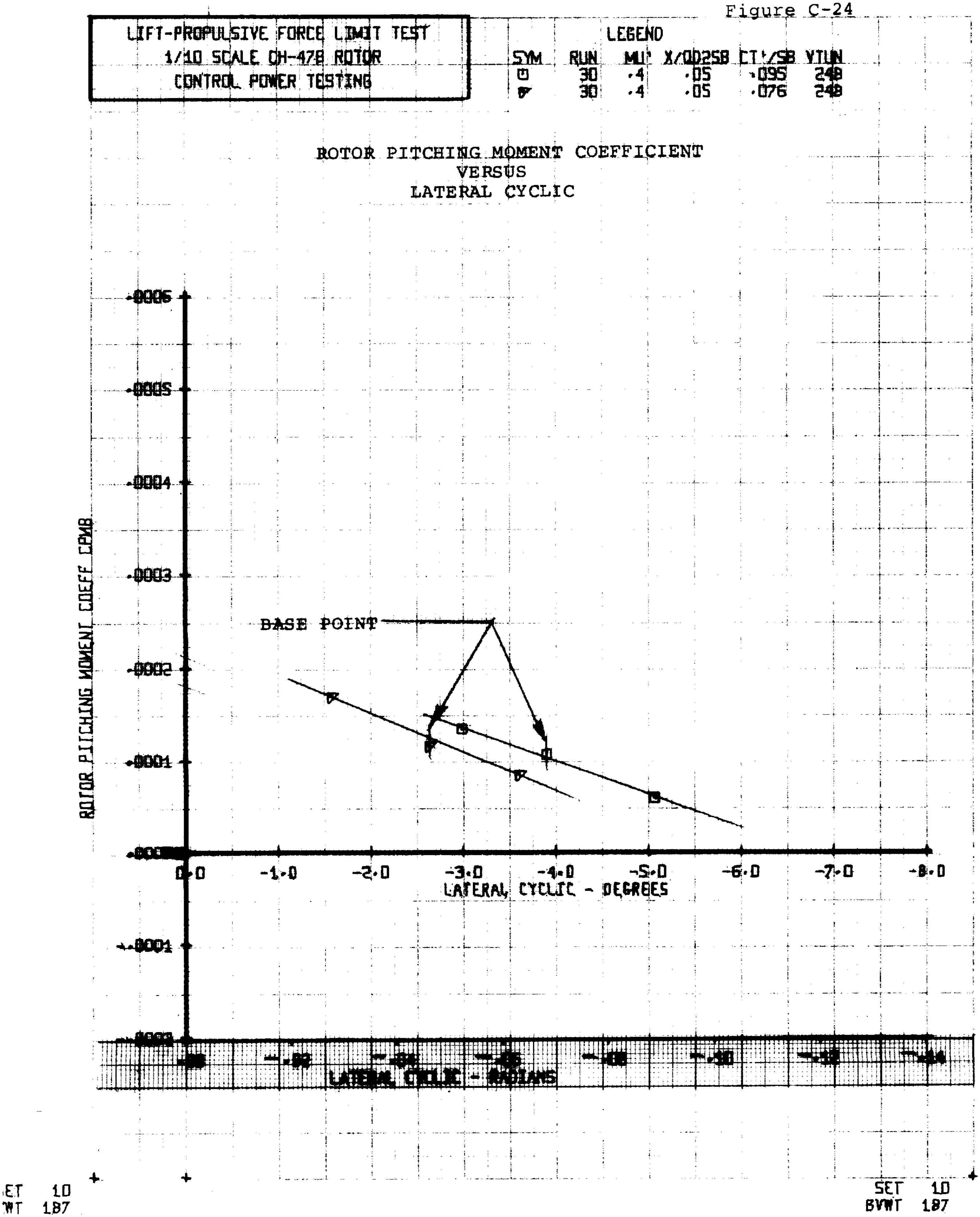
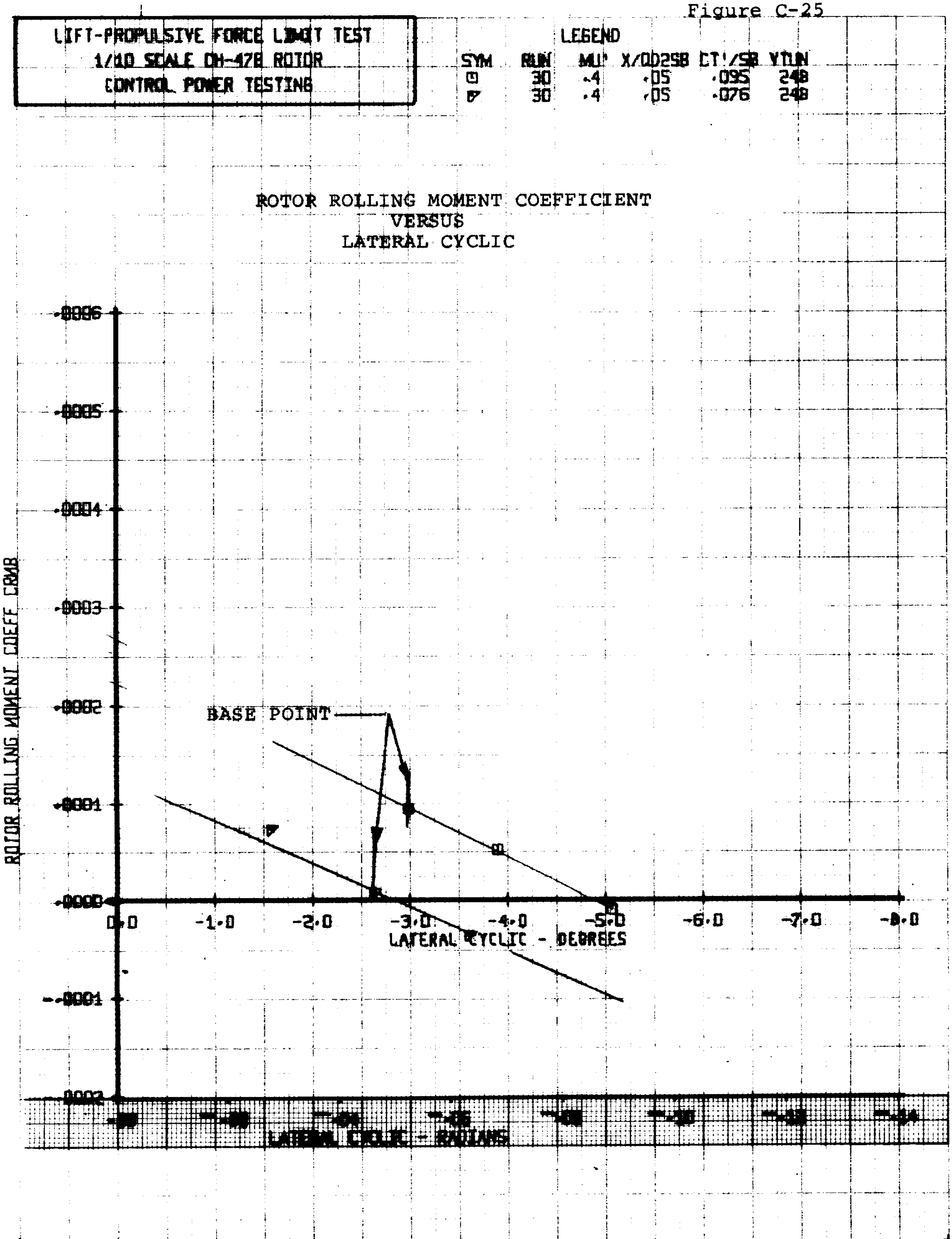

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD25B CT'/SB VTUN
30 .4 .05 .095 240
30 .4 .05 .076 240
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMB
.0006
.0005
.0004
.0003
.0002
.0001
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
-.0001
LATERAL CYCLIC - RADIANS
SET 10
BVWT 187

Figure C-25



SET 10
BVWT 187

Figure C-26

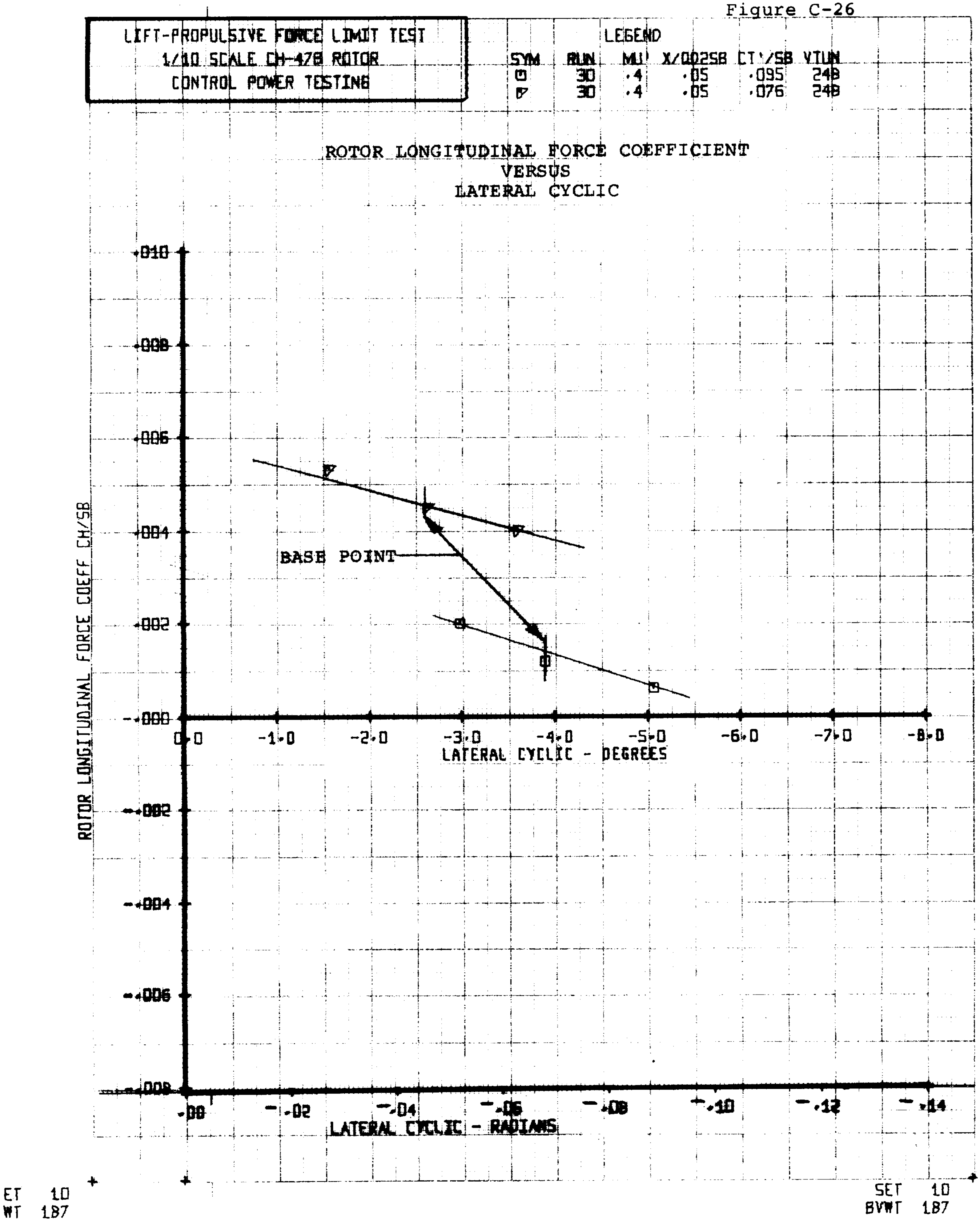
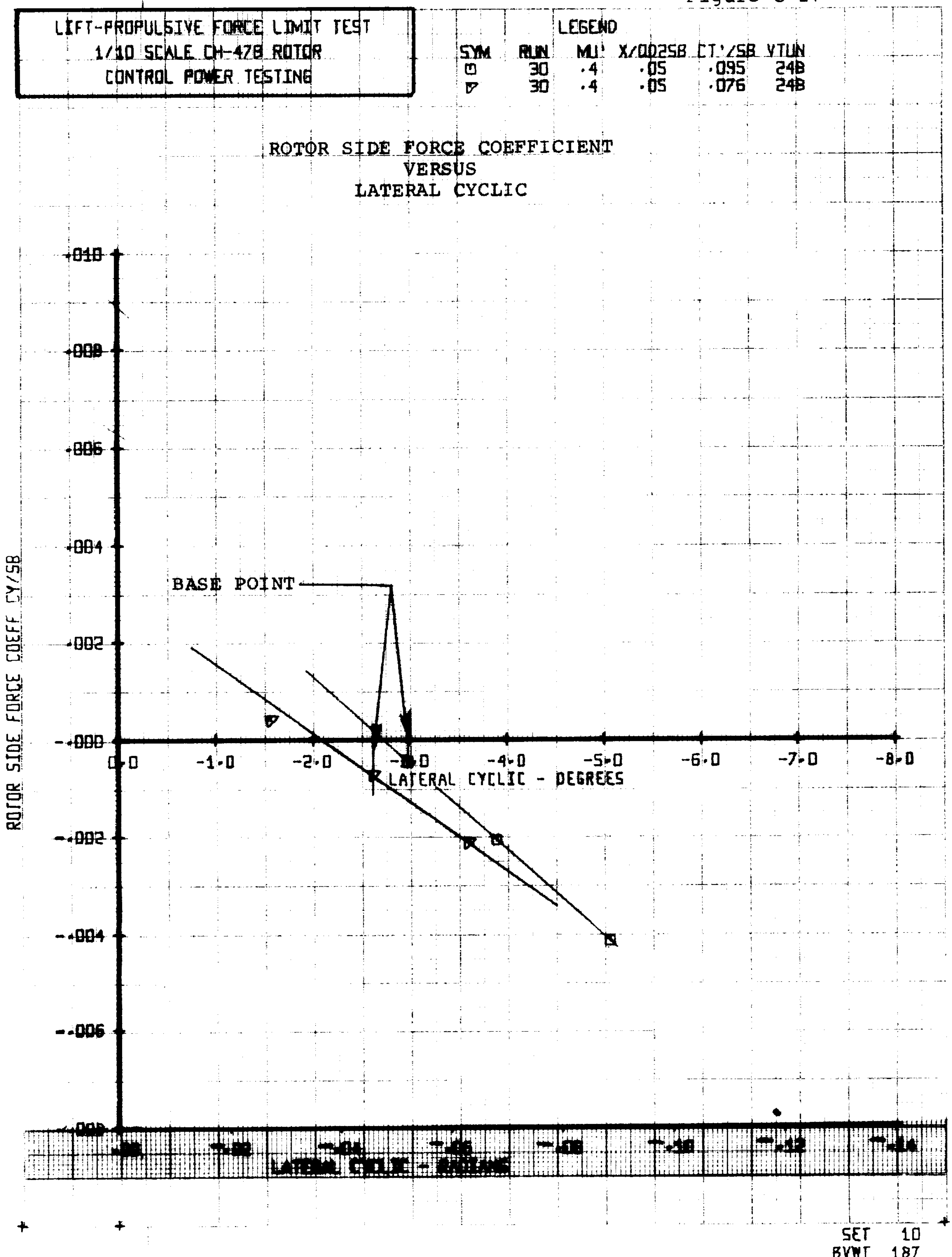
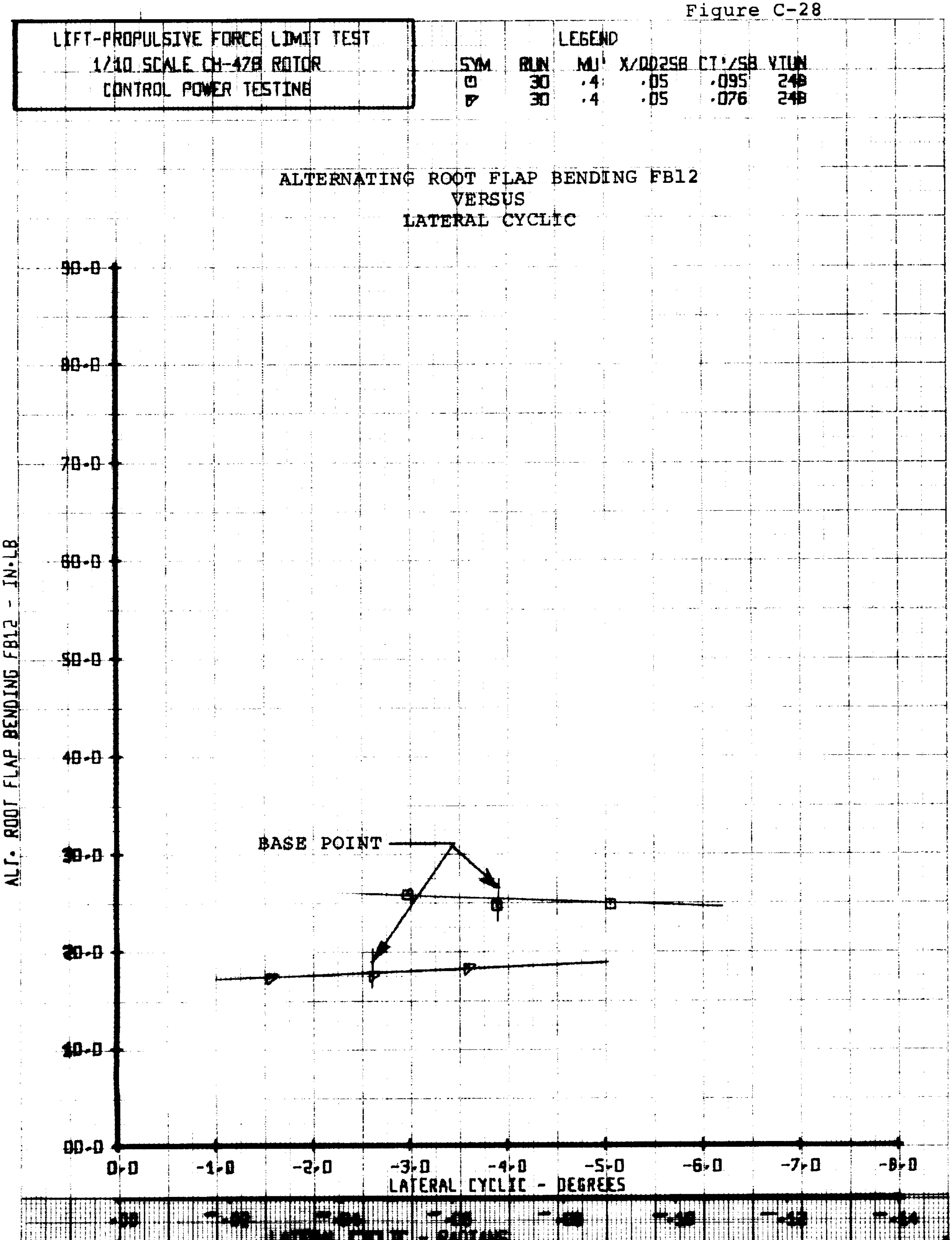

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/Q02SB CT'/SB VTUN
□ 30 .4 .05 .095 248
▽ 30 .4 .05 .076 248
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR LONGITUDINAL FORCE COEFF CH/SB
.010
.008
.006
.004
.002
-.000
-.002
-.004
-.006
-.008
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
.00
-.02
-.04
-.06
-.08
-.10
-.12
-.14
LATERAL CYCLIC - RADIANS
ET 10
WT 187
SET 10
BVWT 187

Figure C-27



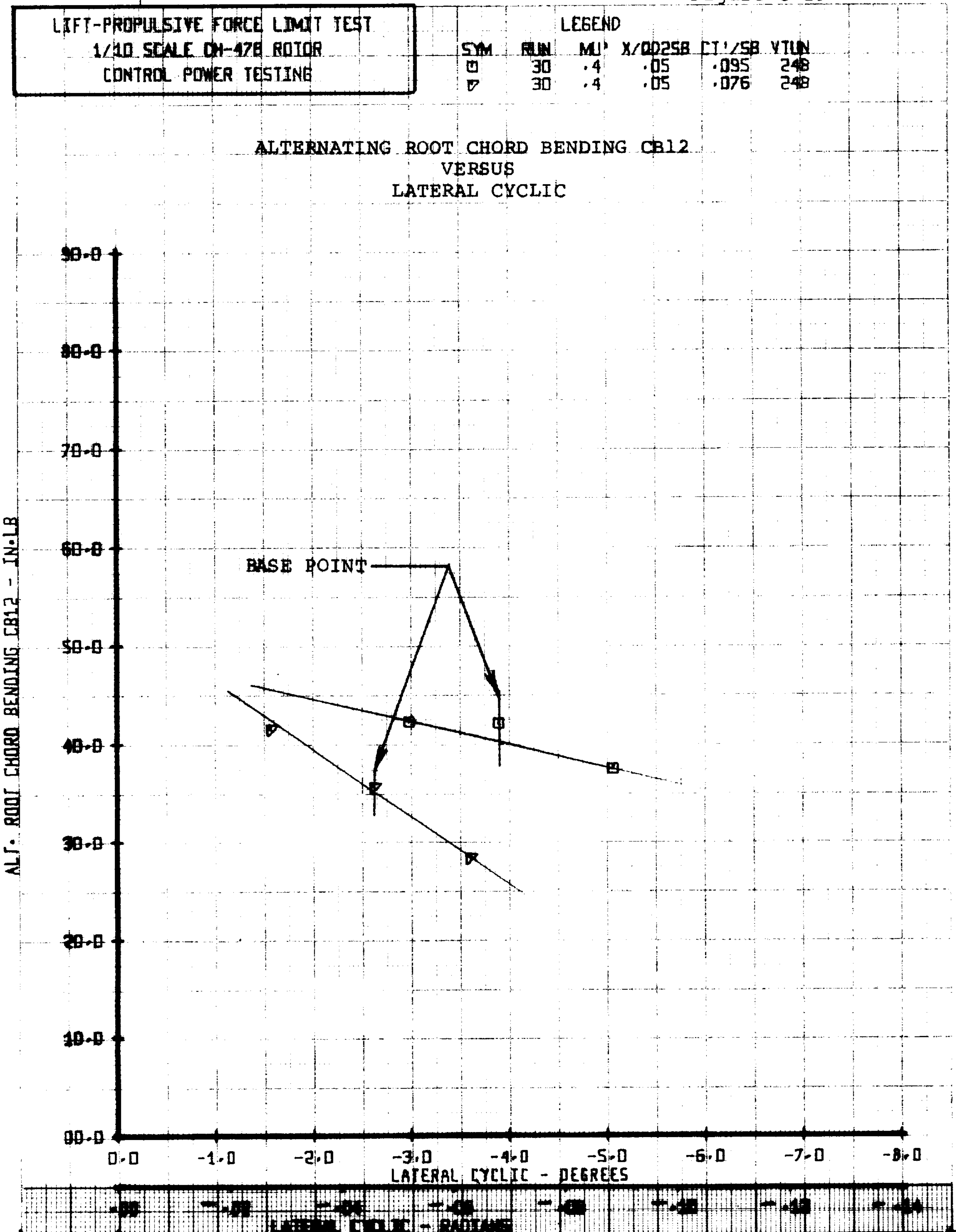
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
30 .4 .05 .095 248
30 .4 .05 .076 248
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR SIDE FORCE COEFF CY/SB
LATERAL CYCLIC - DEGREES
.010
.008
.006
.004
.002
-.000
-.002
-.004
-.006
0.0
-1.0
-2.0
-4.0
-5.0
-6.0
-7.0
-8.0
ET 10
WT 187
SET 10
BVWT 187

Figure C-28



SET 10
BVWT 187

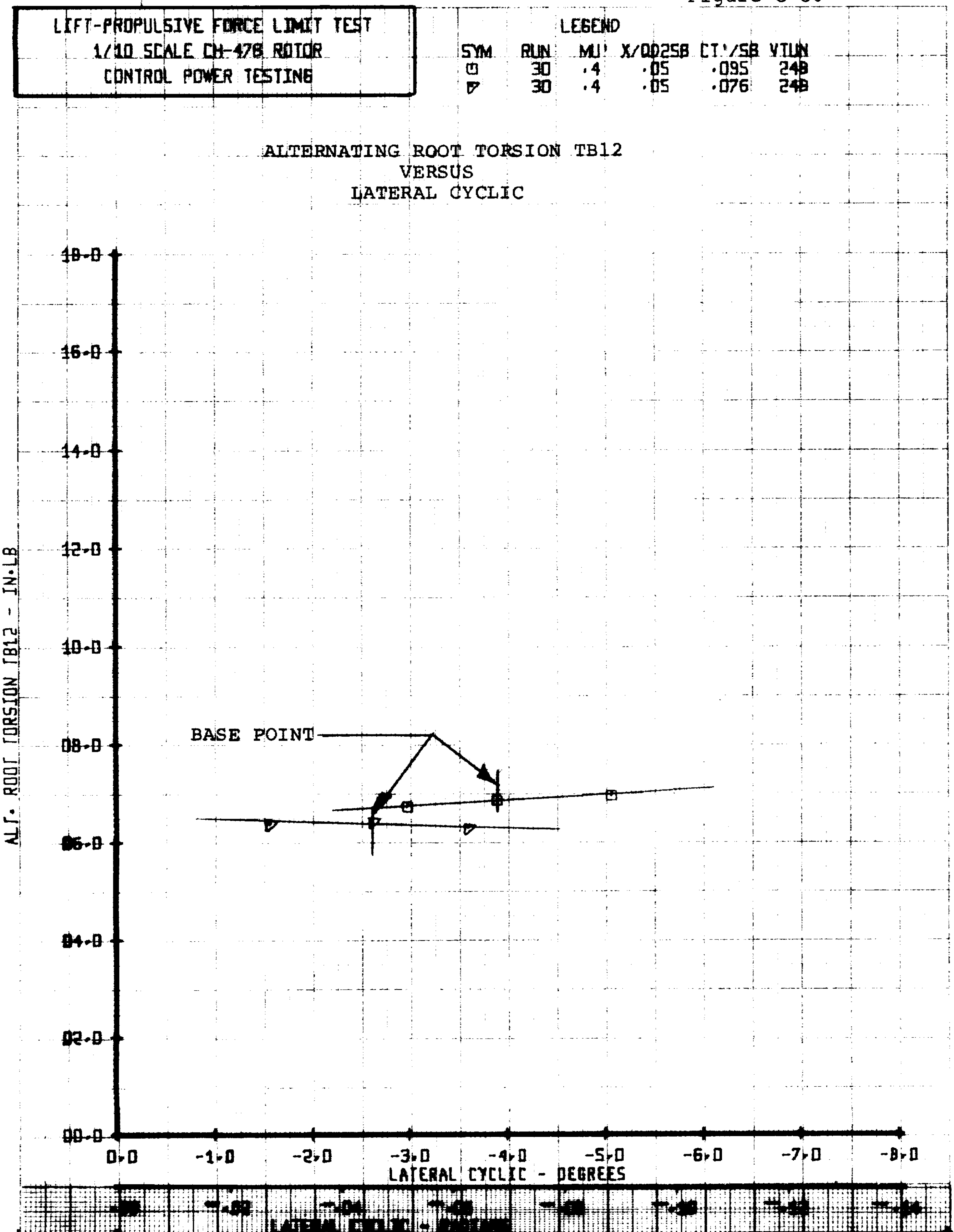
Figure C-29



ET 10
WT 187

SET 10
BVWT 187

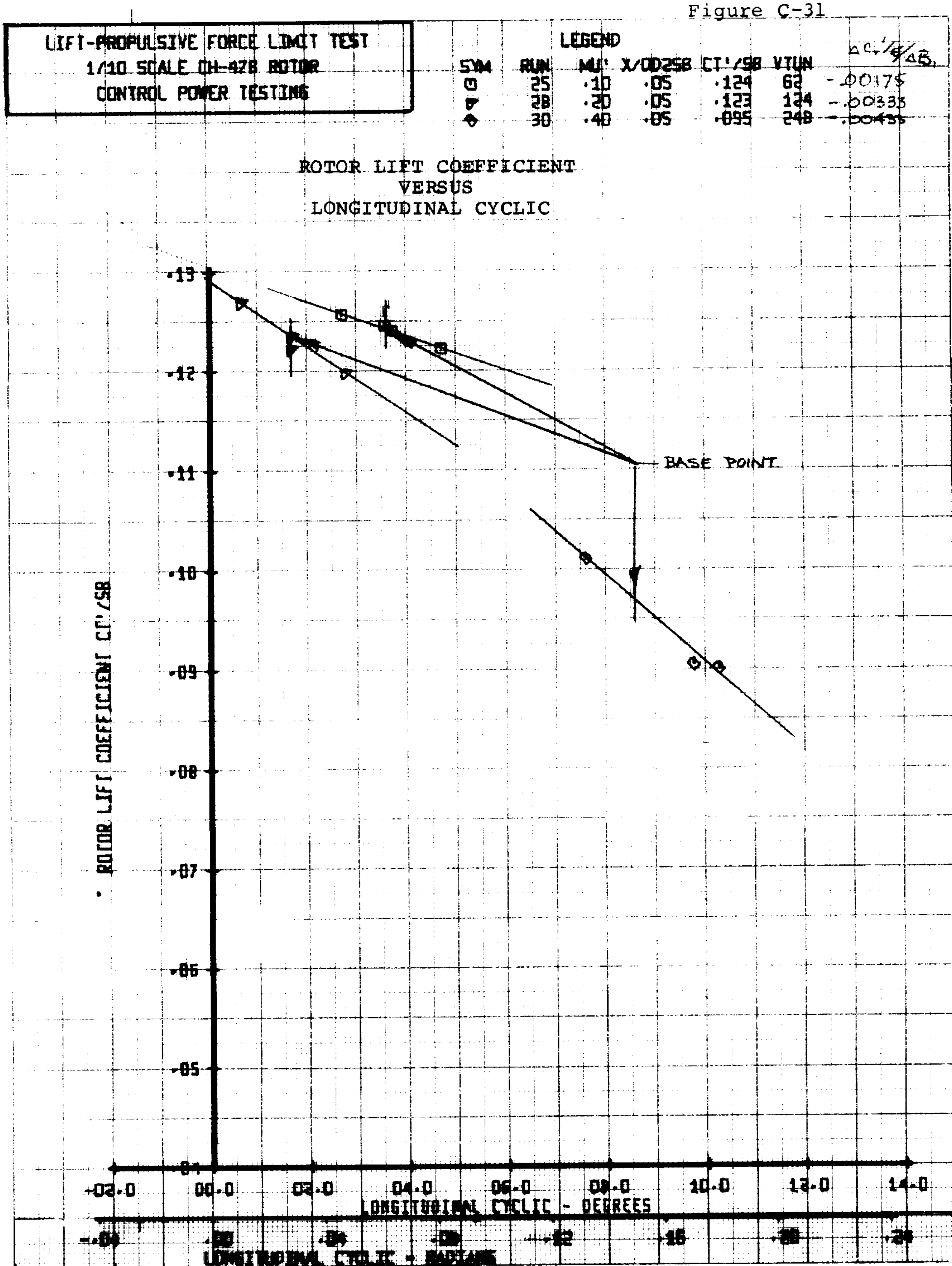
Figure C-30



SET 10
WT 187

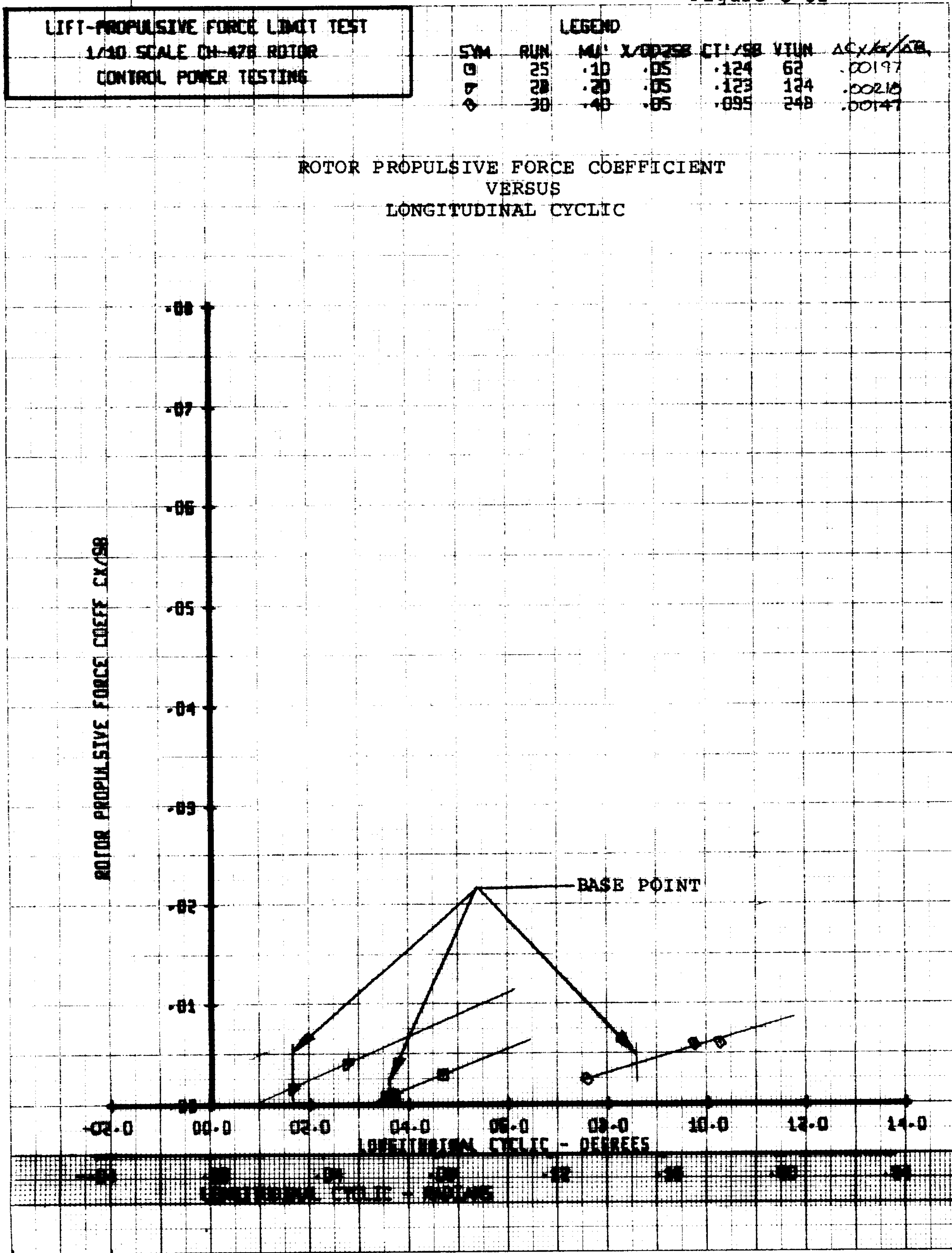
SET 10
BVWT 187

Figure C-31



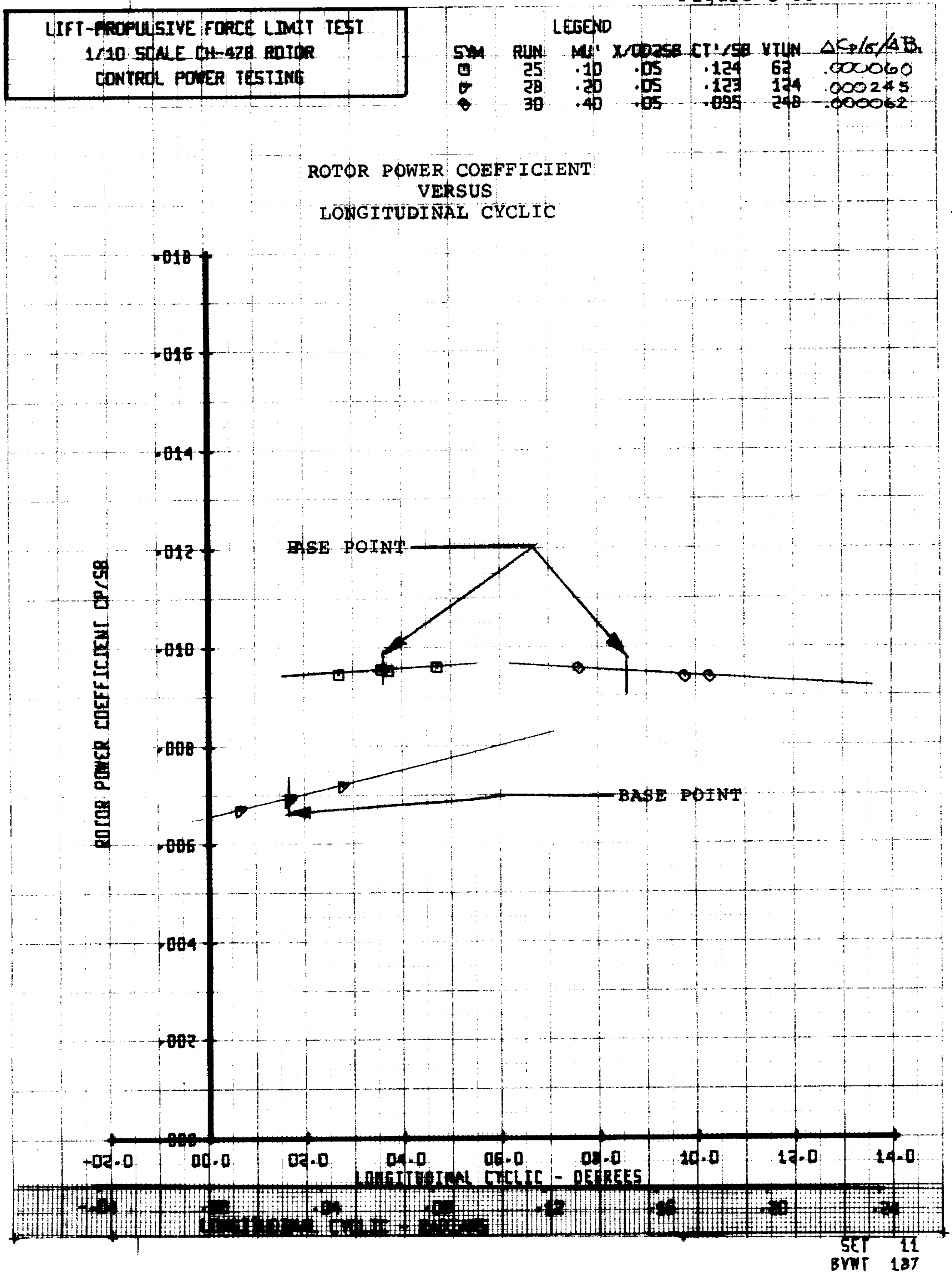
SET 11
BVWT 187

Figure C-32



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
25 .10 .05 .124 62 .00197
28 .20 .05 .123 124 .00218
30 .40 .05 .095 248 .00147
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR PROPULSIVE FORCE COEFF CX/SB
BASE POINT
.08
.07
.06
.05
.04
.03
.02
.01
.00
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 11
BVWT 187

Figure C-33



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN ΔCp/σ/ΔB1
25 .10 .05 .124 62 .000060
28 .20 .05 .123 124 .000245
38 .40 .05 .095 248 .000062
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 11
BVWT 187

Figure C-34

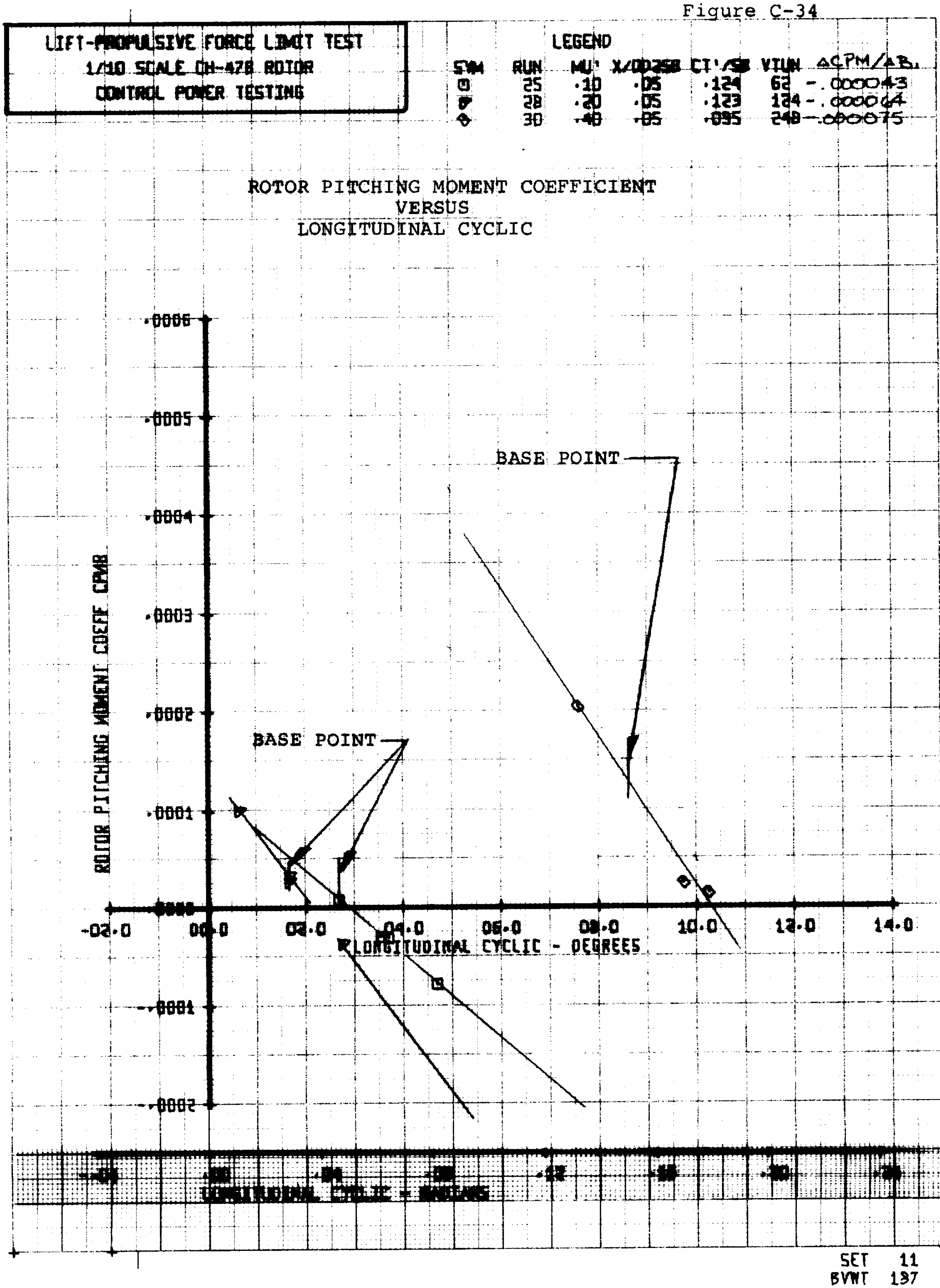
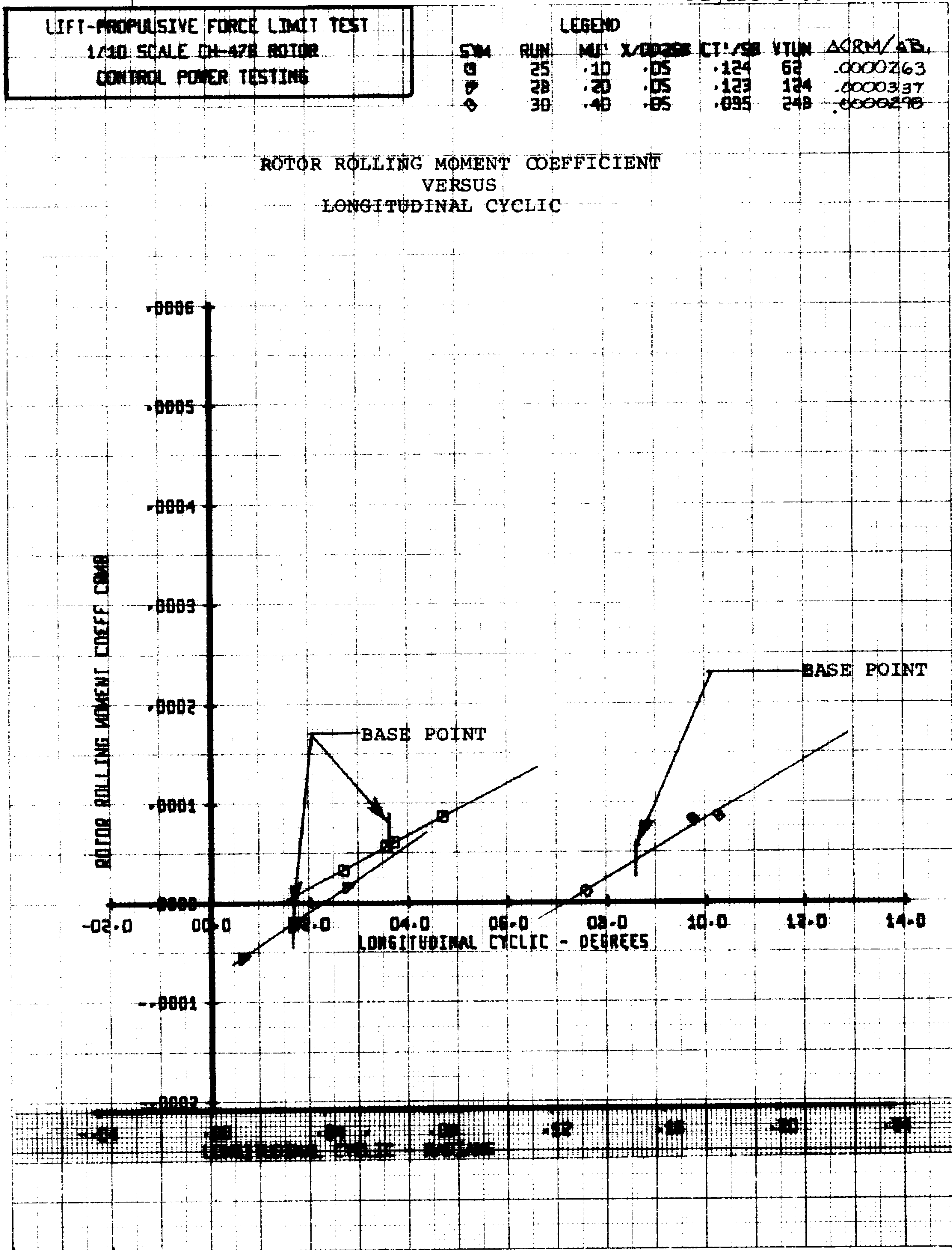

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN ΔCPM/ΔB1
25 .10 .05 .124 62 -.000043
28 .20 .05 .123 124 -.000064
30 .40 .05 .095 248 -.000075
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMR
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 11
BVWT 137

Figure C-35



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN ΔCRM/ΔB1
25 .10 .05 .124 62 .0000263
28 .20 .05 .123 124 .0000337
30 .40 .05 .095 248 .0000298
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR ROLLING MOMENT COEFF COMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
BASE POINT
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 11
BYWT 187

Figure C-36

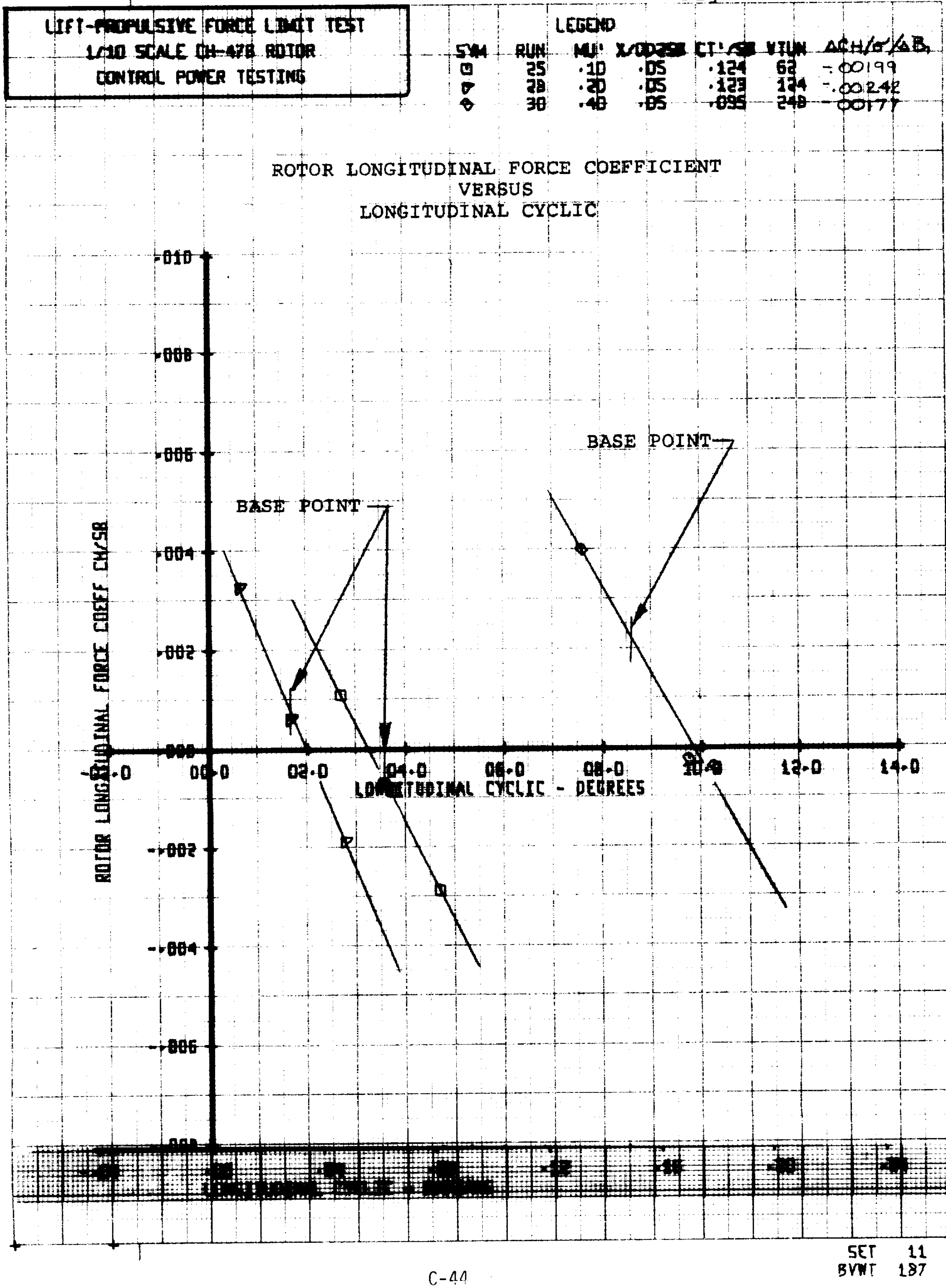

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SR CT'/SR VTUN ΔCH/σ/ΔB
25 .10 .05 .124 62 -.00199
28 .20 .05 .123 124 -.00242
30 .40 .05 .095 248 -.00177
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
BASE POINT
ROTOR LONGITUDINAL FORCE COEFF CH/SR
LONGITUDINAL CYCLIC - DEGREES
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-2.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
SET 11
BVWT 187

Figure C-37

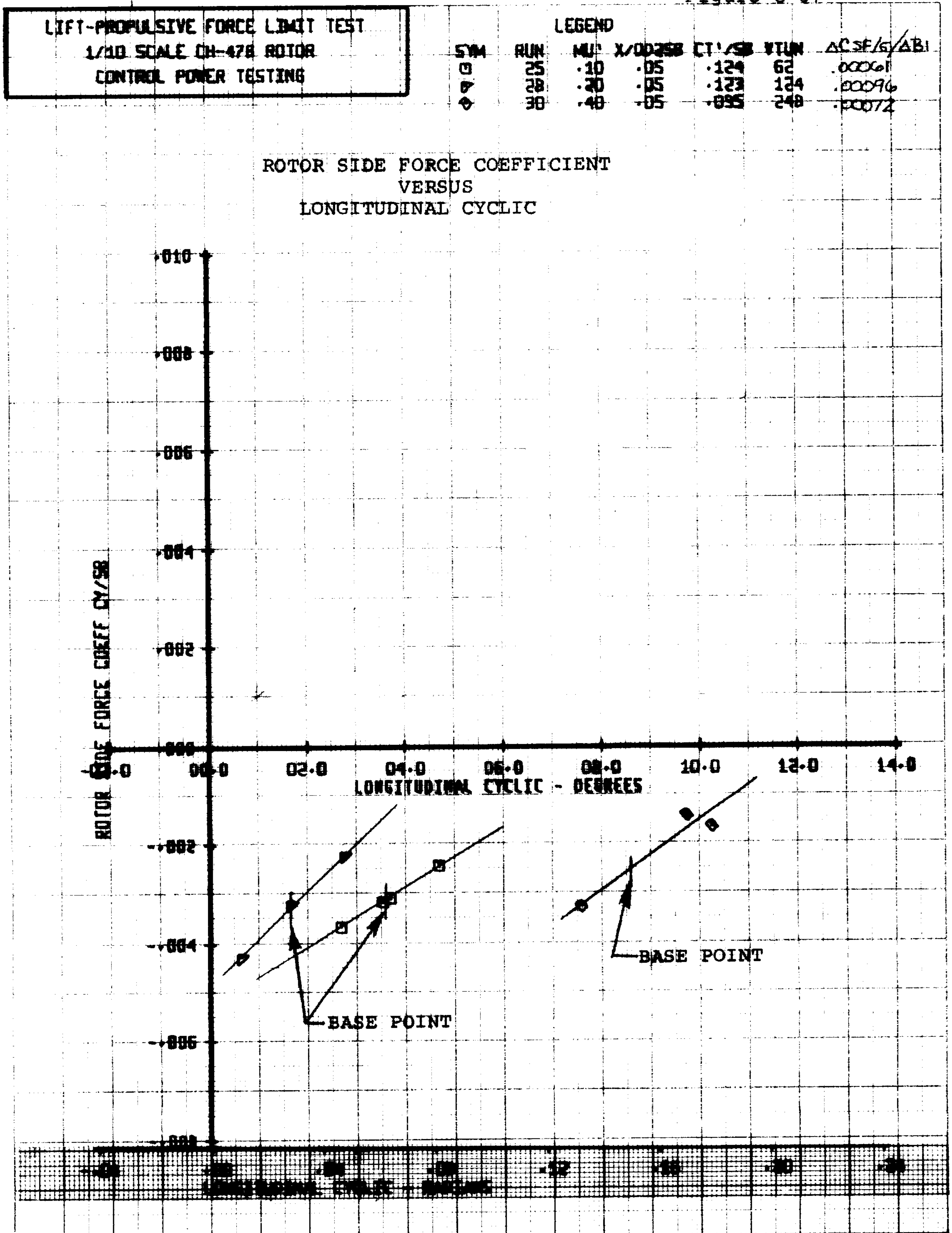
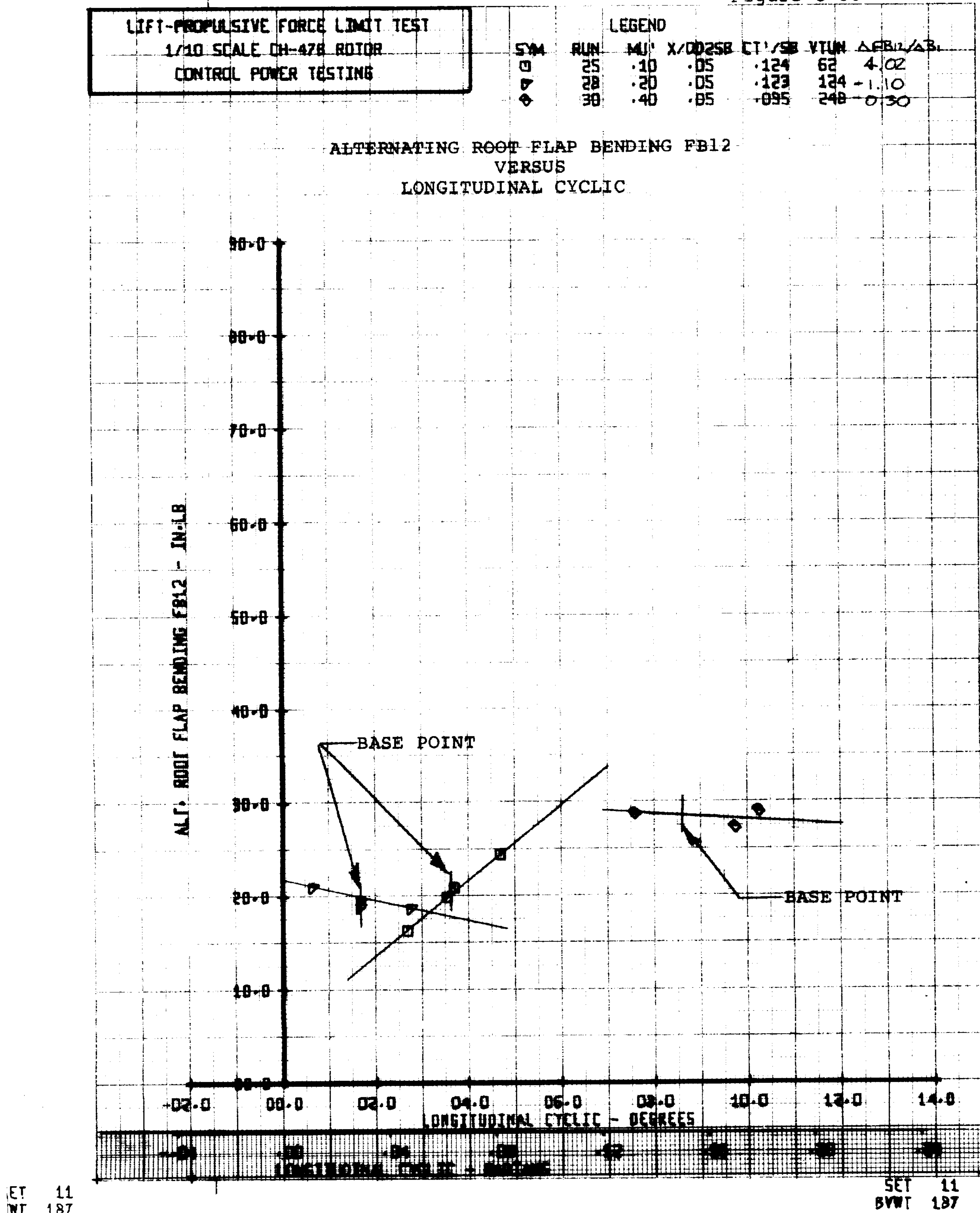

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/OD25B CT'/SB VTUN ΔCSF/σ/ΔB1
25 .10 .05 .124 62 .00061
28 .20 .05 .123 124 .00096
30 .40 .05 .095 248 .00072
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR SIDE FORCE COEFF CY/SB
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
BASE POINT
BASE POINT

Figure C-38



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/OD25B CT'/SB VTUN ΔFB12/ΔB1
25 .10 .05 .124 62 4.02
28 .20 .05 .123 124 -1.10
30 .40 .05 .095 248 -0.30
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LONGITUDINAL CYCLIC
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
00.0
ALT. ROOT FLAP BENDING FB12 - IN-LB
BASE POINT
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 11
BVWT 187

Figure C-39

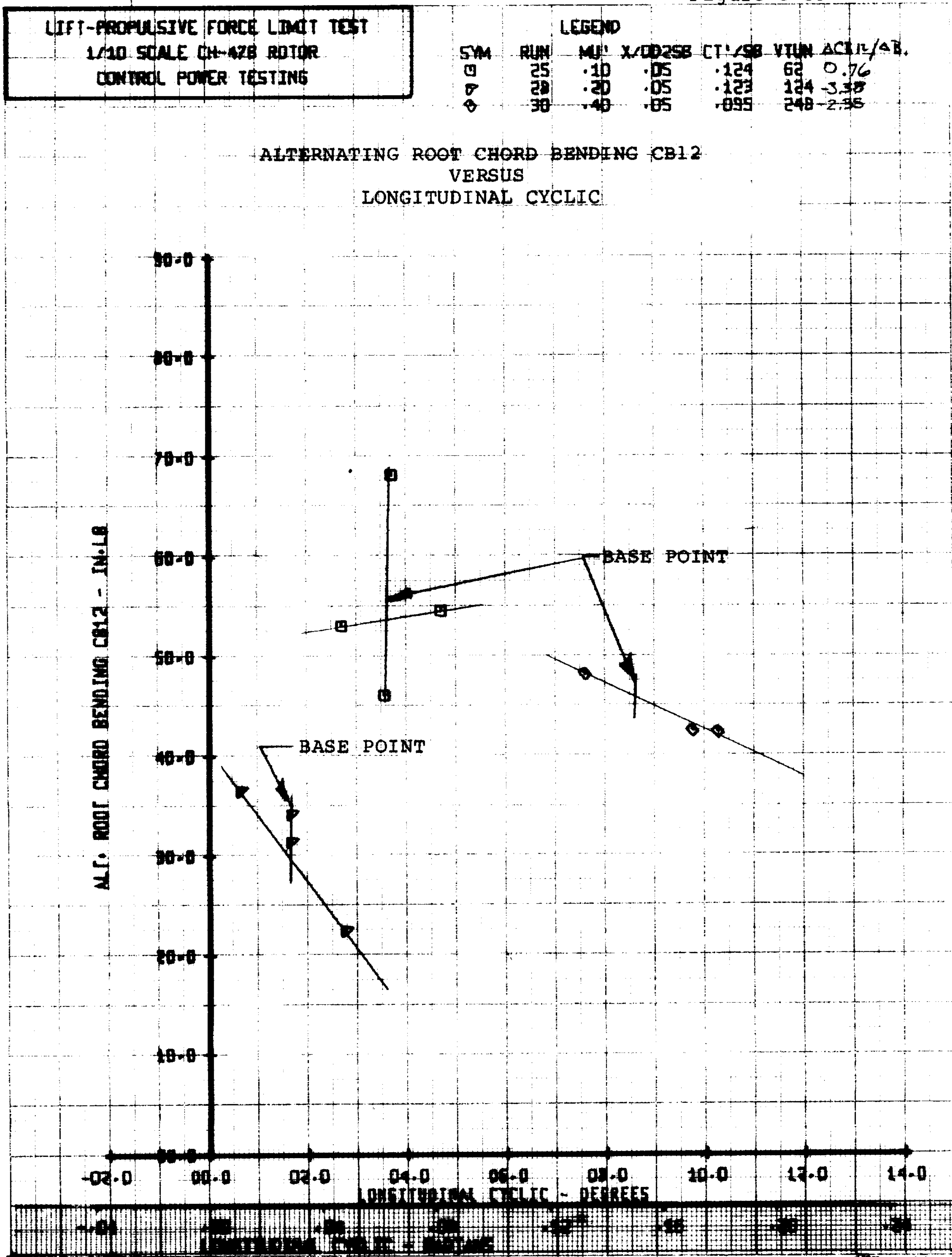
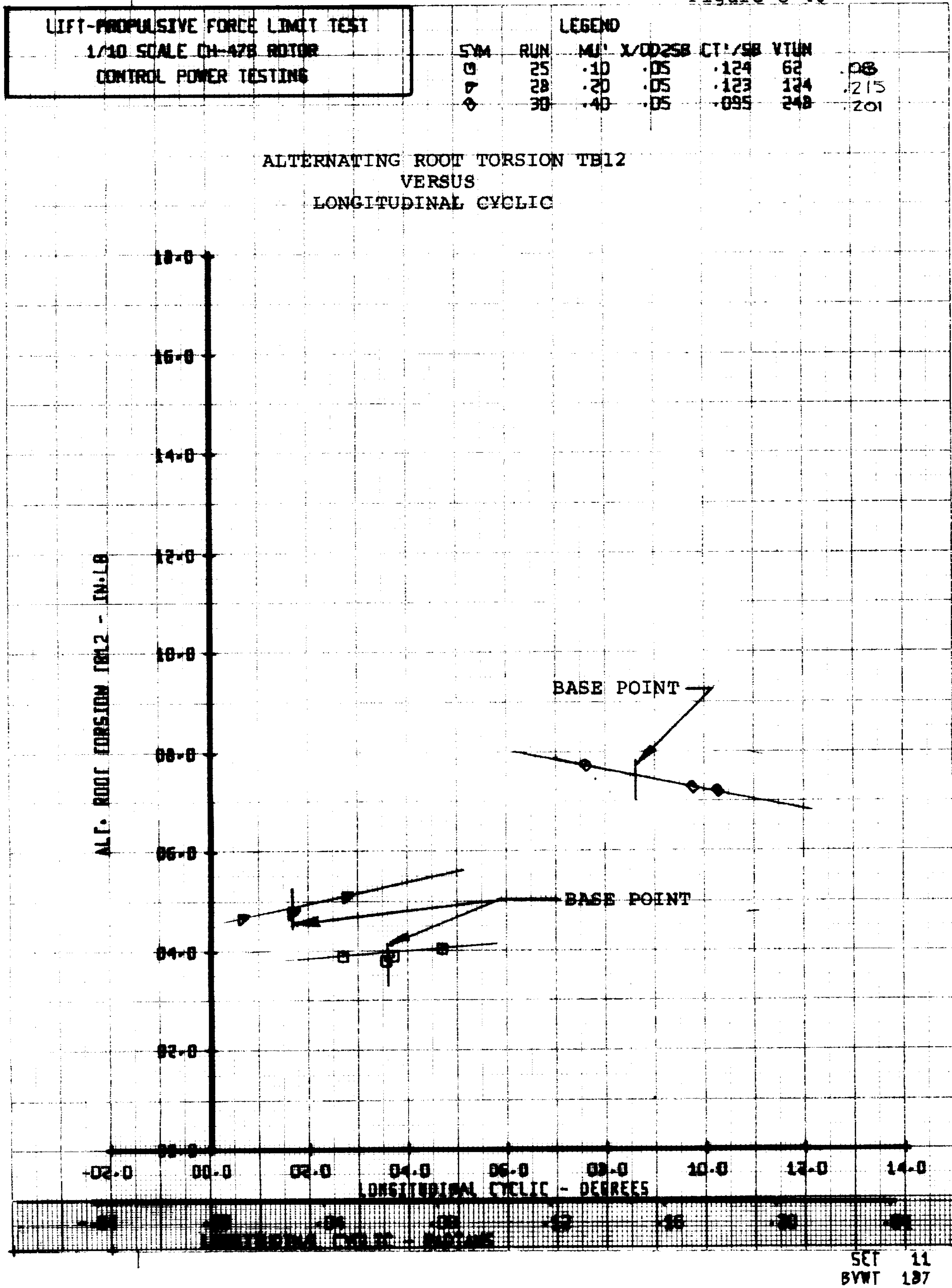
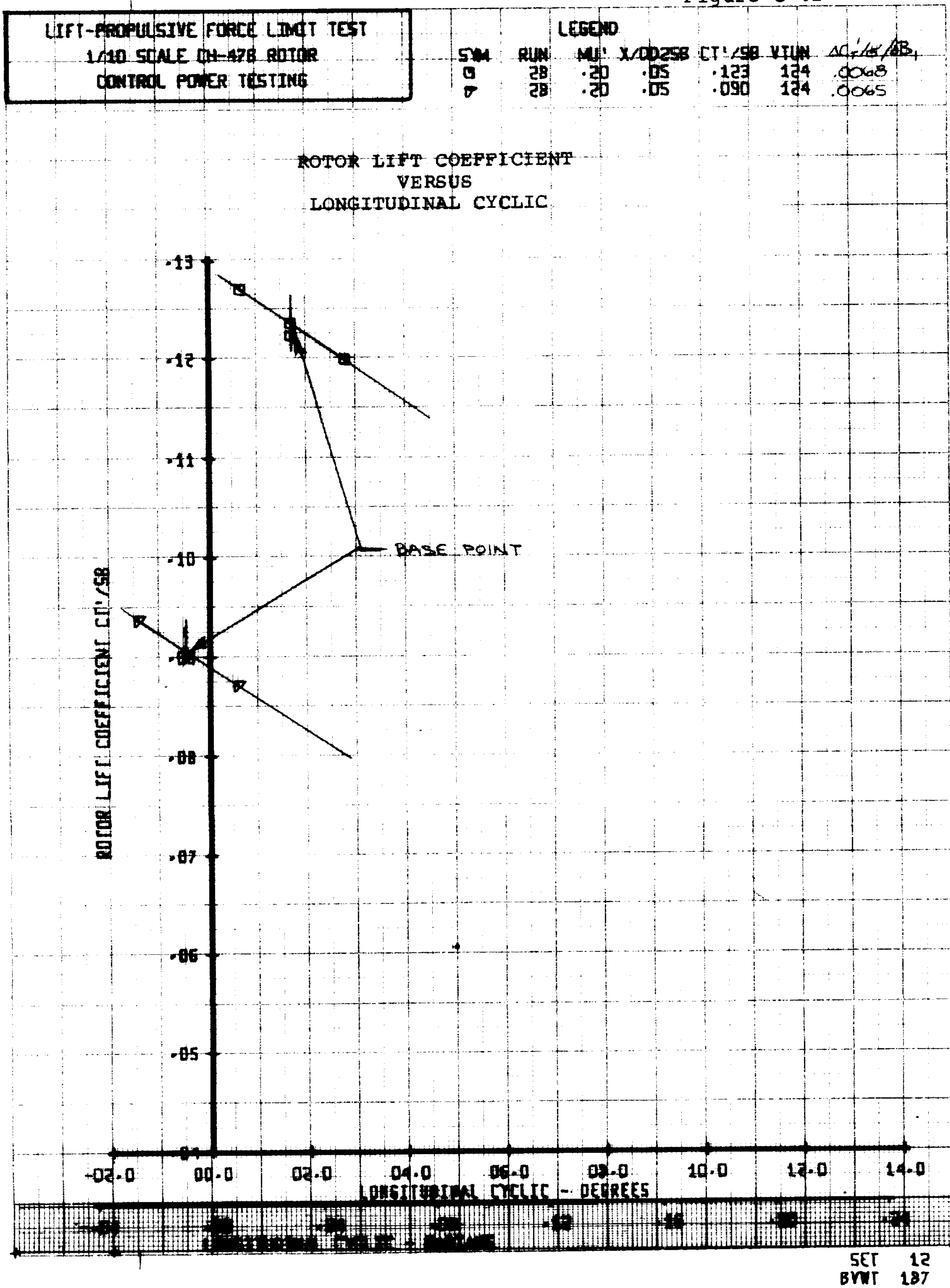

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN ΔC1s/ΔB1
25 .10 .05 .124 62 0.76
28 .20 .05 .123 124 -3.38
30 .40 .05 .095 248 -2.56
ALTERNATING ROOT CHORD BENDING CB12
VERSUS
LONGITUDINAL CYCLIC
ALT. ROOT CHORD BENDING CB12 - IN-LB
BASE POINT
BASE POINT
LONGITUDINAL CYCLIC - DEGREES
SET 11
BYWT 187

Figure C-40



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
25 .10 .05 .124 62 .08
28 .20 .05 .123 124 .215
30 .40 .05 .095 248 .201
ALTERNATING ROOT TORSION TB12
VERSUS
LONGITUDINAL CYCLIC
ALT. ROOT TORSION TB12 - IN-LB
BASE POINT
BASE POINT
18.0
16.0
14.0
12.0
10.0
08.0
06.0
04.0
02.0
00.0
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 11
BYWT 187

Figure C-41



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD258 CT'/SB VTUN $\Delta C_T'/\sigma/\Delta B_1$
28 .20 .05 .123 124 .0068
28 .20 .05 .090 124 .0065
ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.08
.07
.06
.05
.04
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 12
BYWT 187

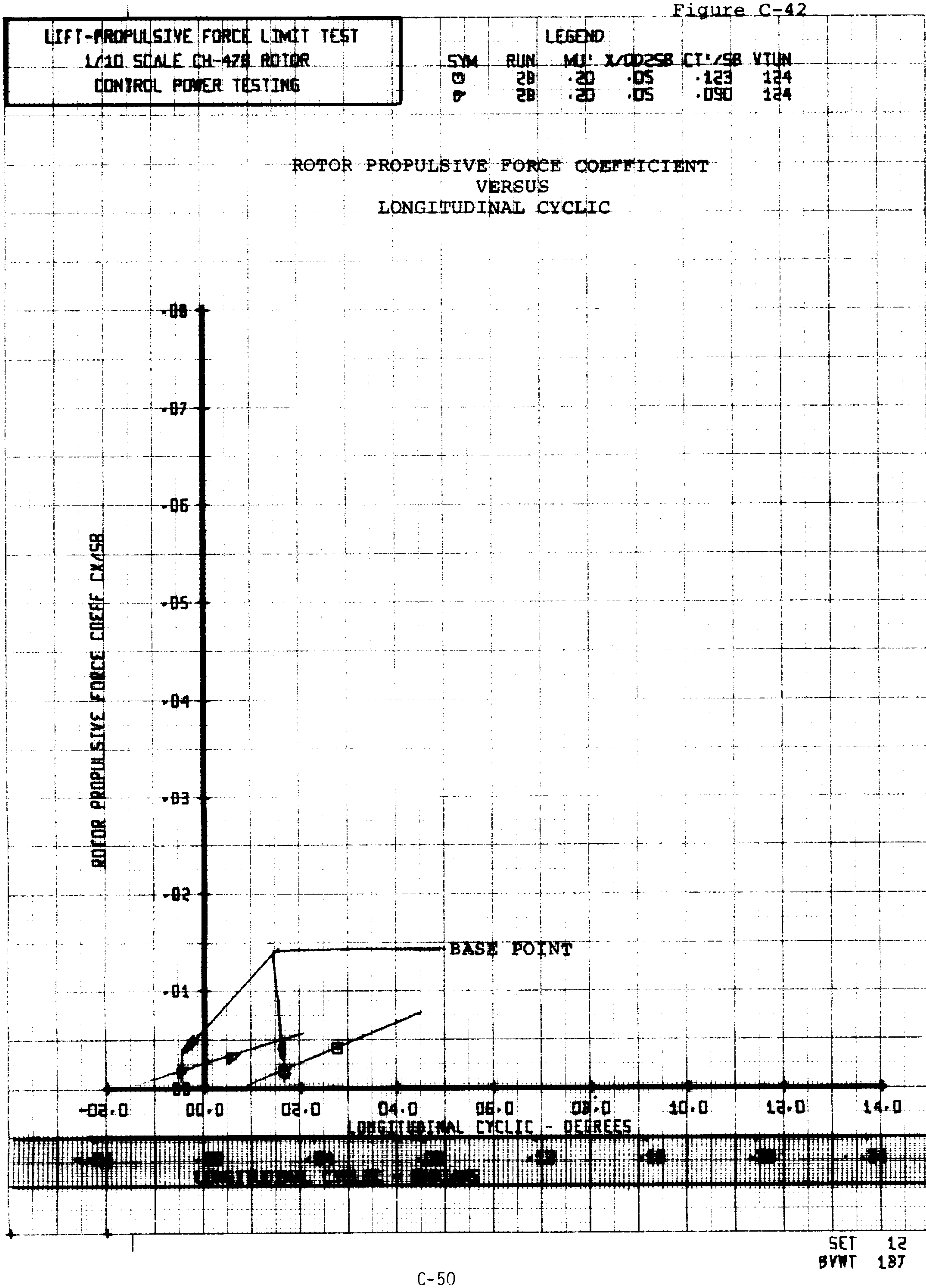

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
28 .20 .05 .123 124
28 .20 .05 .090 124
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR PROPULSIVE FORCE COEFF CX/SB
BASE POINT
LONGITUDINAL CYCLIC - DEGREES
SET 12
BVWT 187

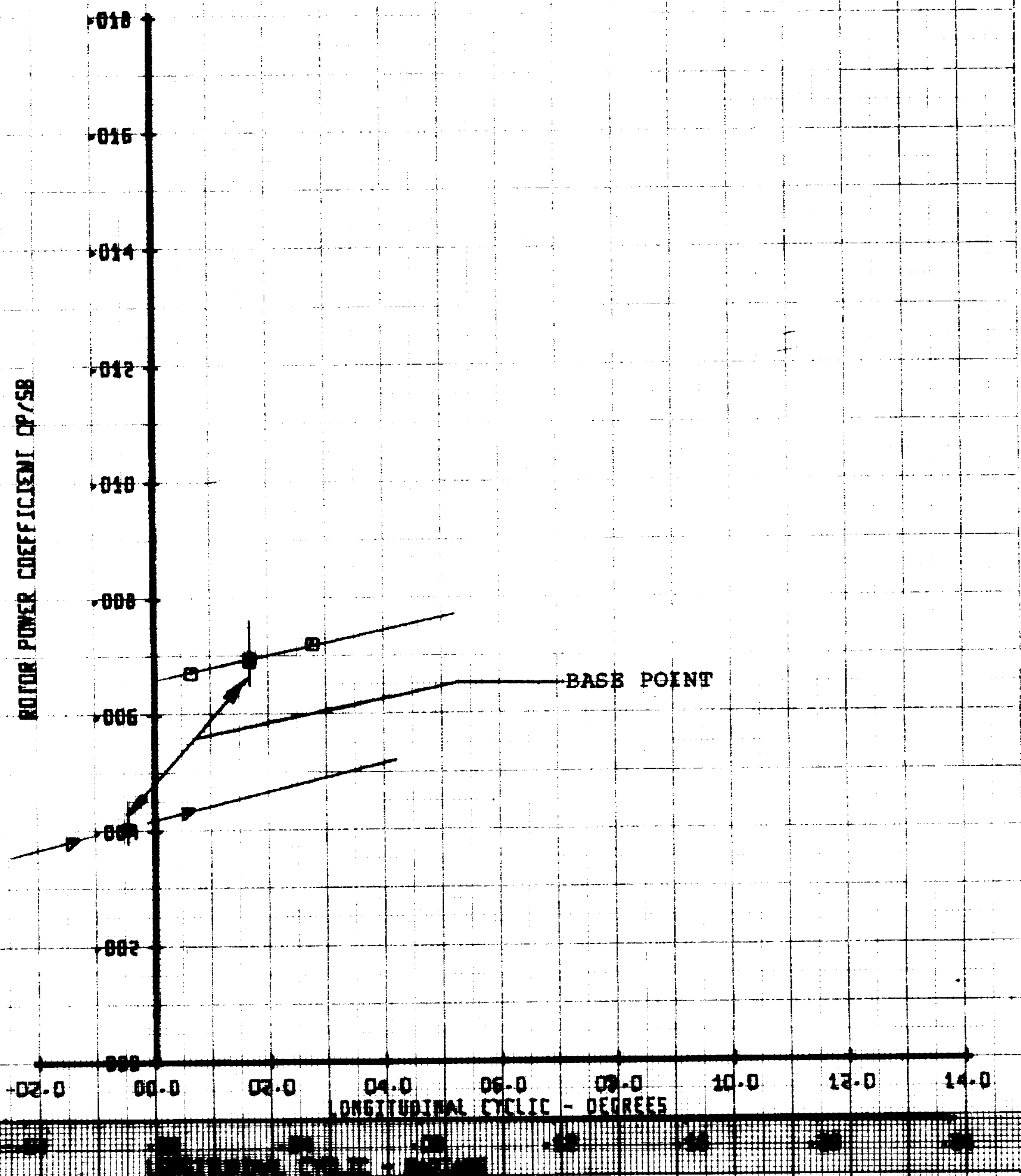
Figure C-43

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/DD2SB	CT'/SB	VTUN	$\Delta C_P/\Delta B_1$
⊡	28	.20	.05	.123	124	.00022
▷	28	.20	.05	.090	124	.00025

ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC



SET 12
BVWT 187

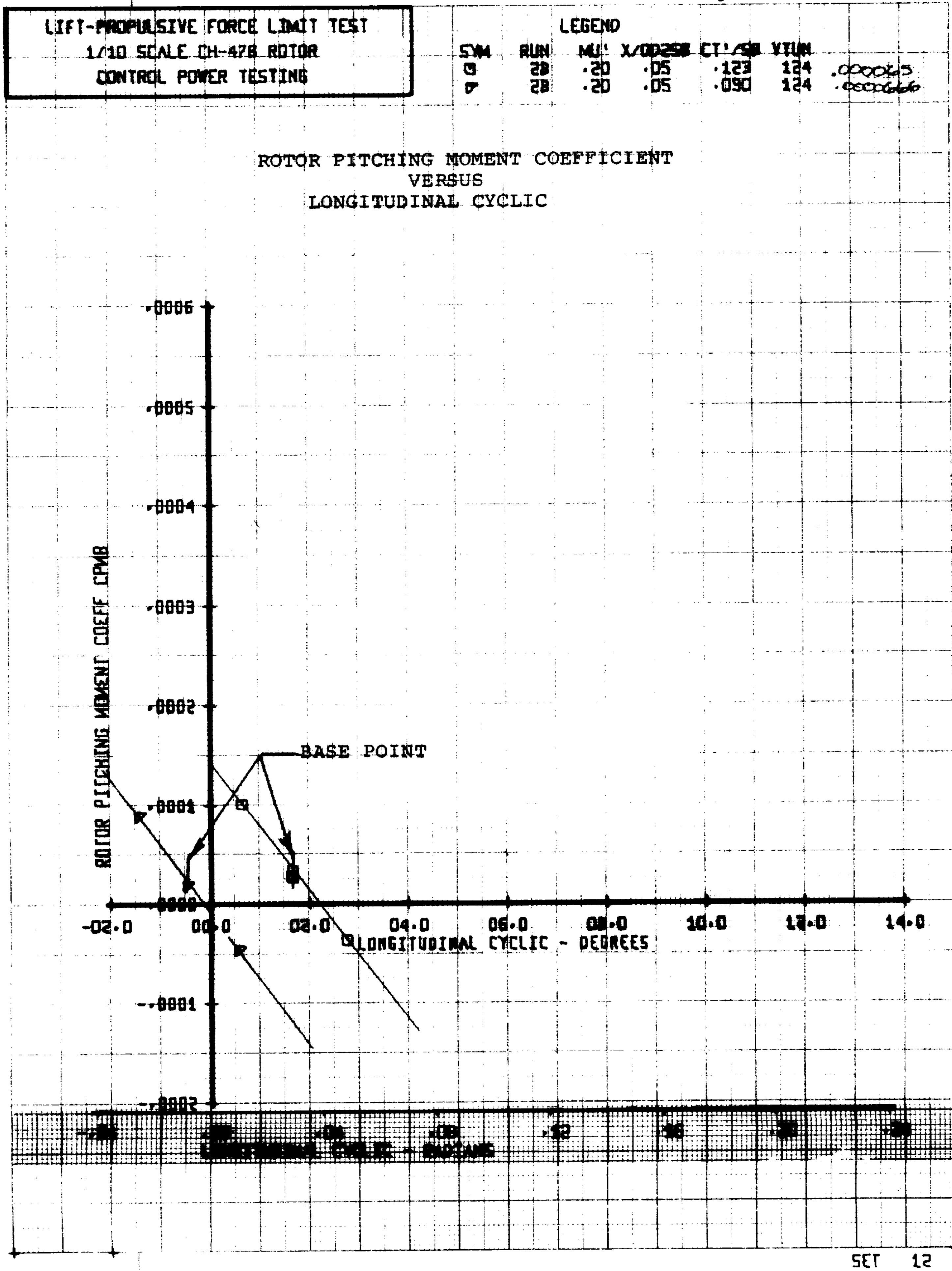
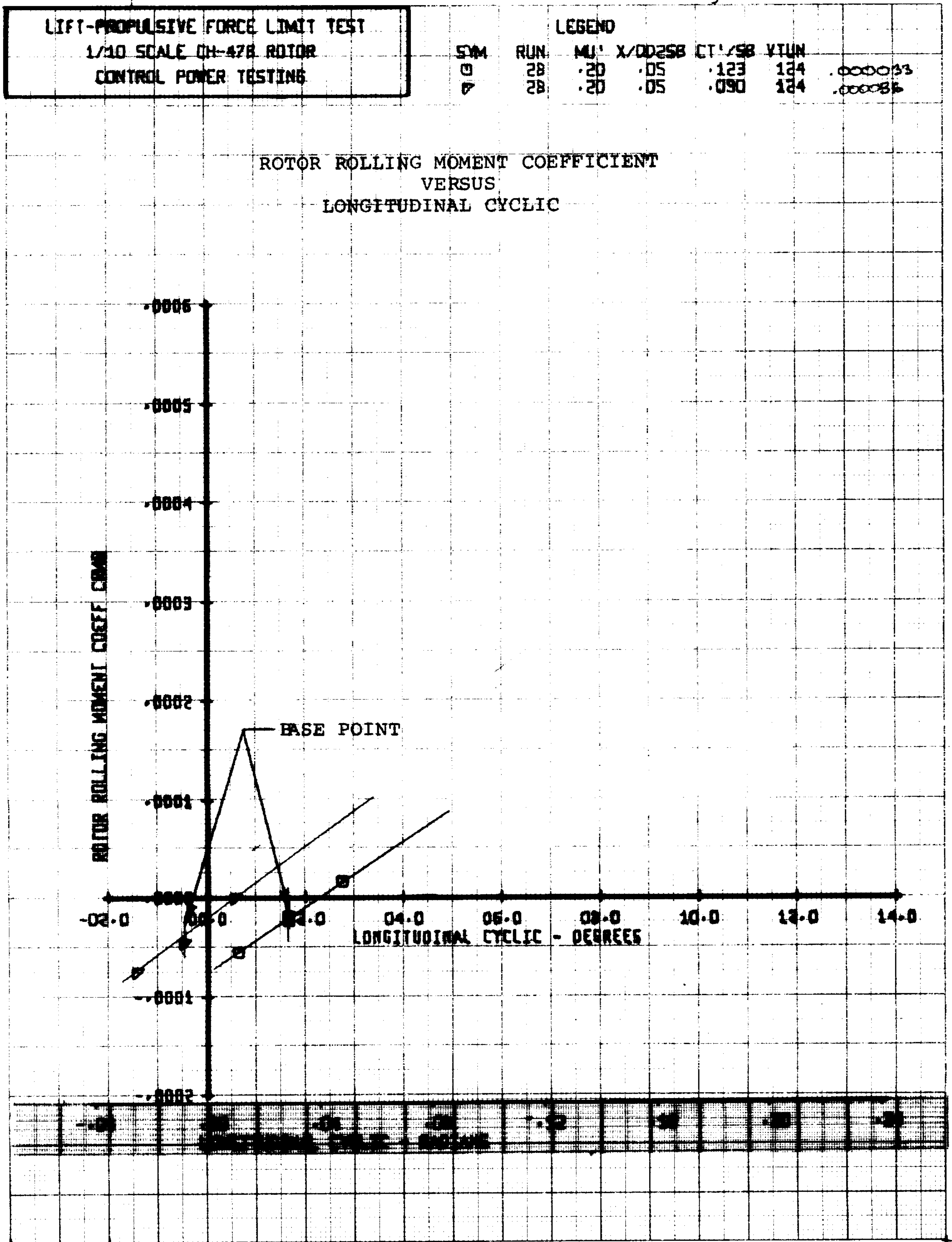

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT/SB VTUN
28 .20 .05 .123 124 .000065
28 .20 .05 .090 124 .0000666
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMR
LONGITUDINAL CYCLIC - DEGREES
SET 12
BVWT 187

Figure C-45



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
28 .20 .05 .123 124 .000033
28 .20 .05 .090 124 .000086
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR ROLLING MOMENT COEFF CRMR
BASE POINT
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 12
BVWT 187

Figure C-46

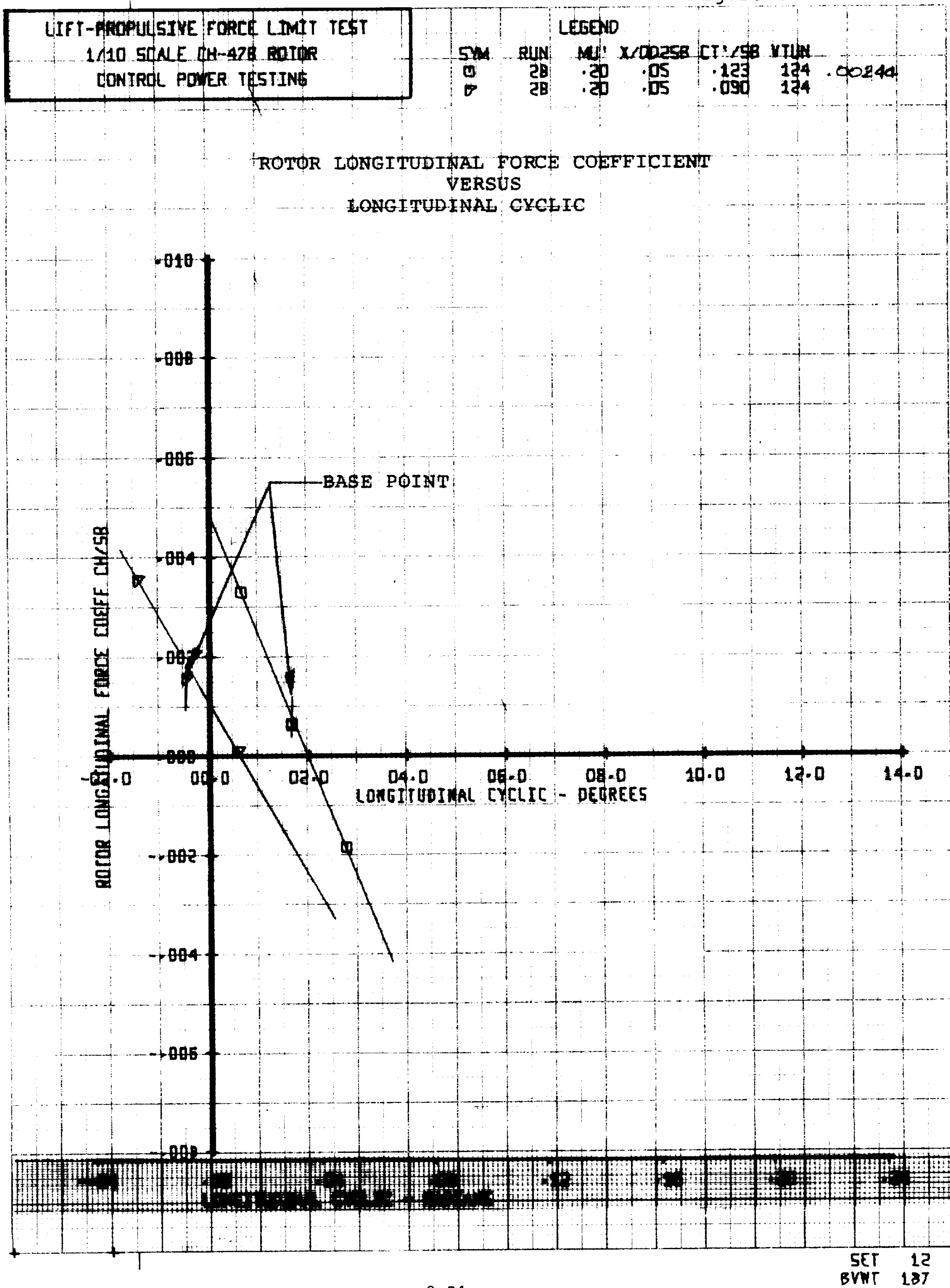
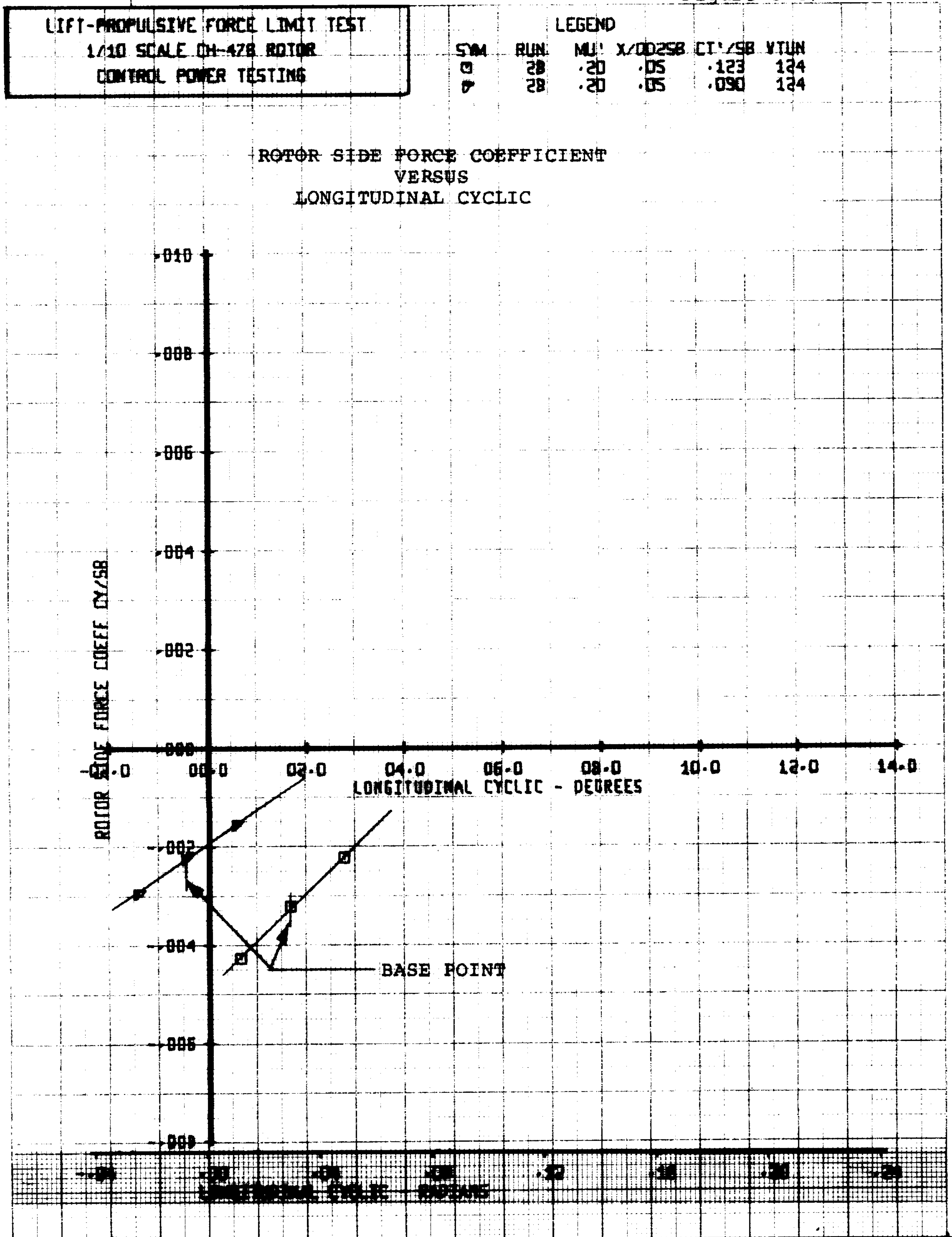

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD25B CT'/SB VTUN
28 .20 .05 .123 124 .00244
28 .20 .05 .090 124
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR LONGITUDINAL FORCE COEFF CH/SB
LONGITUDINAL CYCLIC - DEGREES
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
SET 12
BVWT 187

Figure C-47



SET 12
BVWT 137

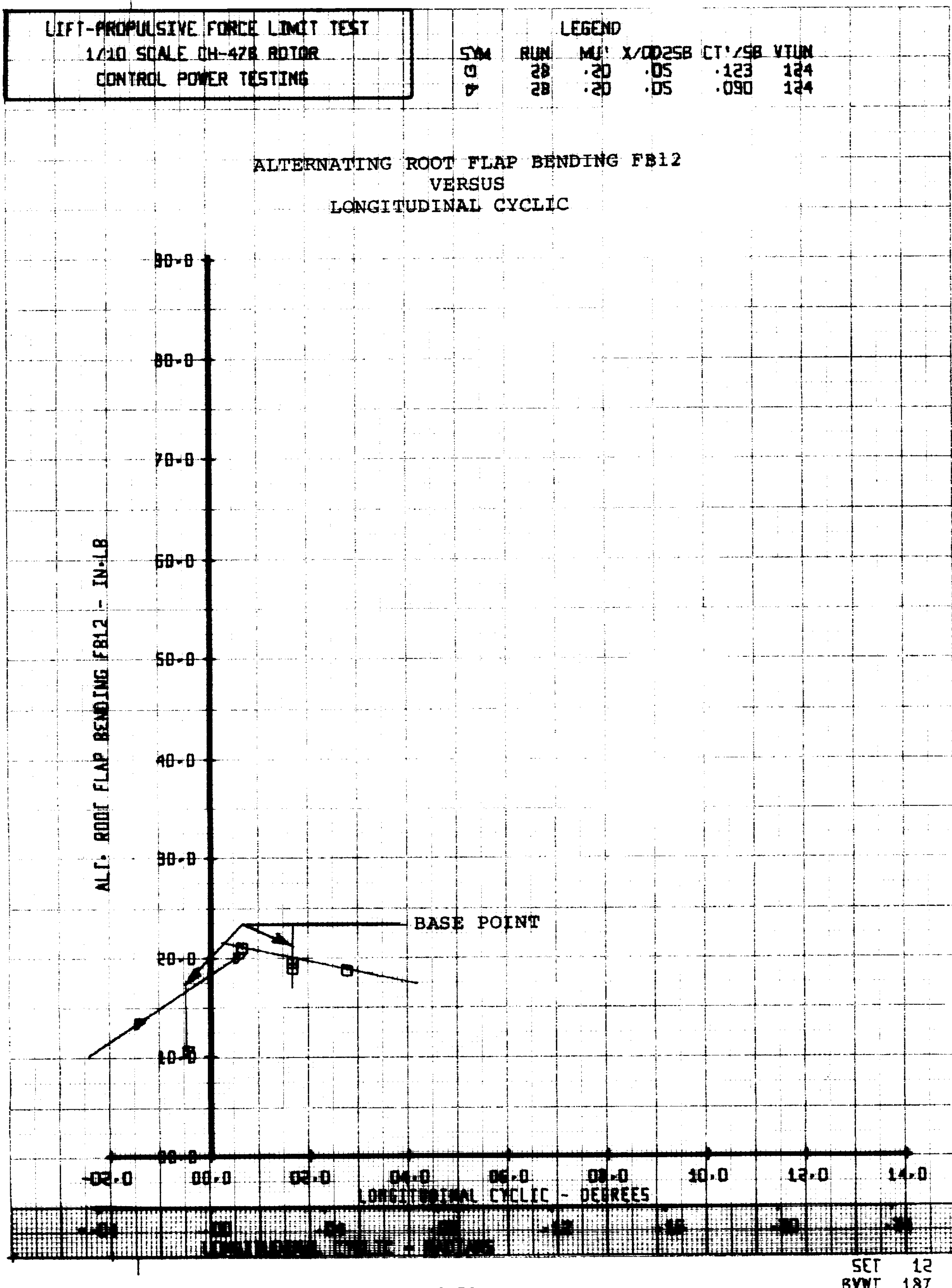
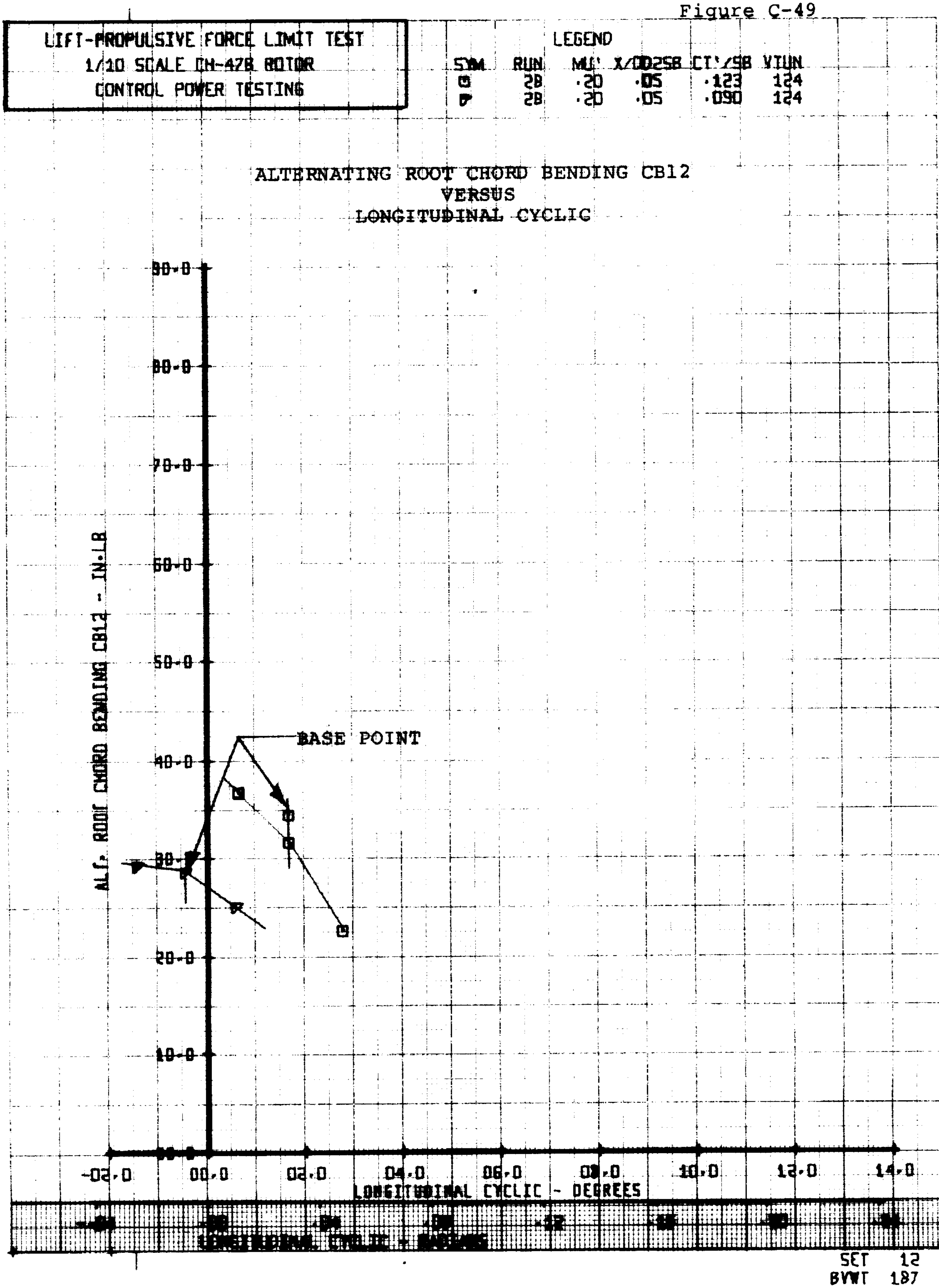
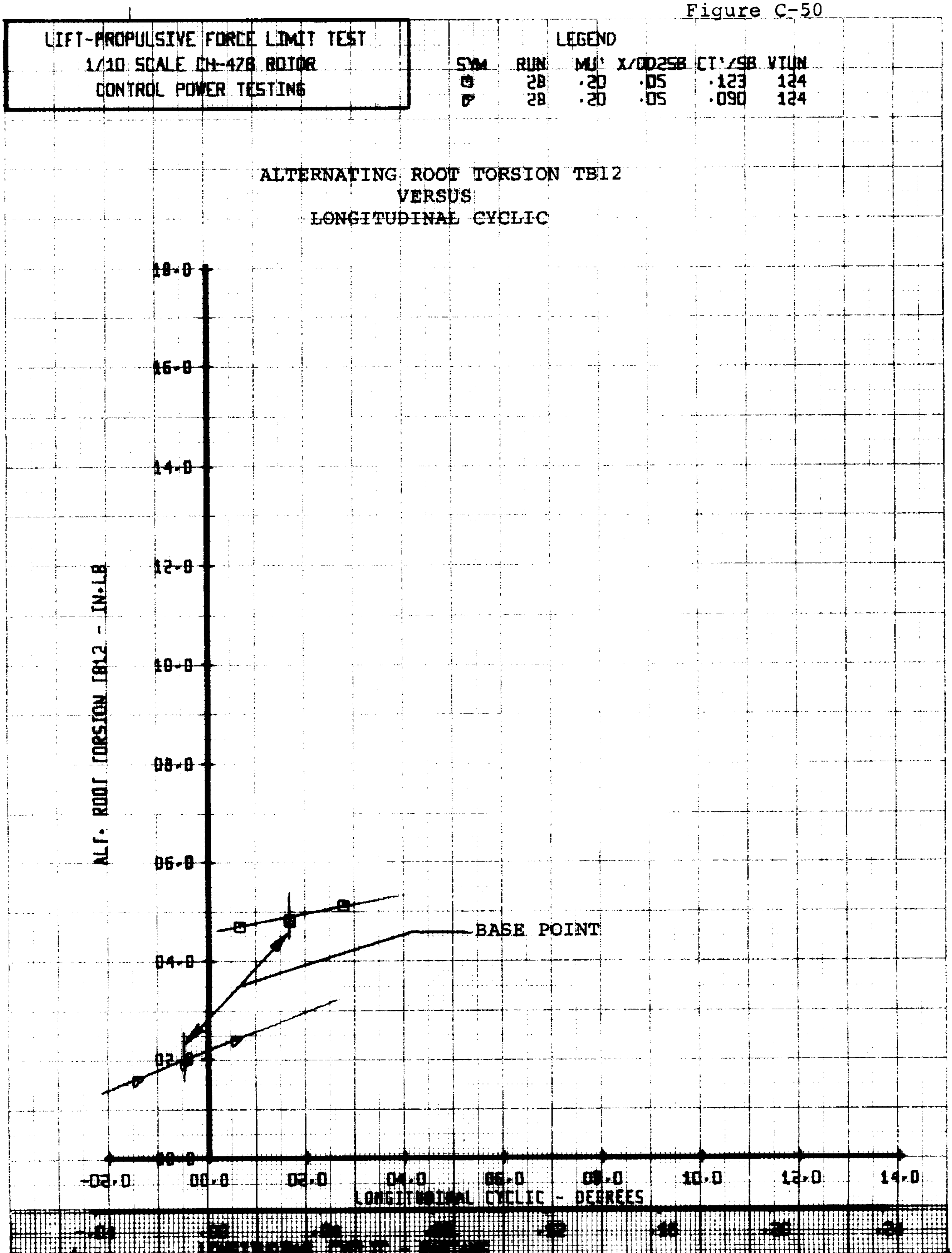

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
28 .20 .05 .123 124
28 .20 .05 .090 124
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LONGITUDINAL CYCLIC
ALT. ROOT FLAP BENDING FB12 - IN-LB
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
00.0
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 12
BVWT 187

Figure C-49

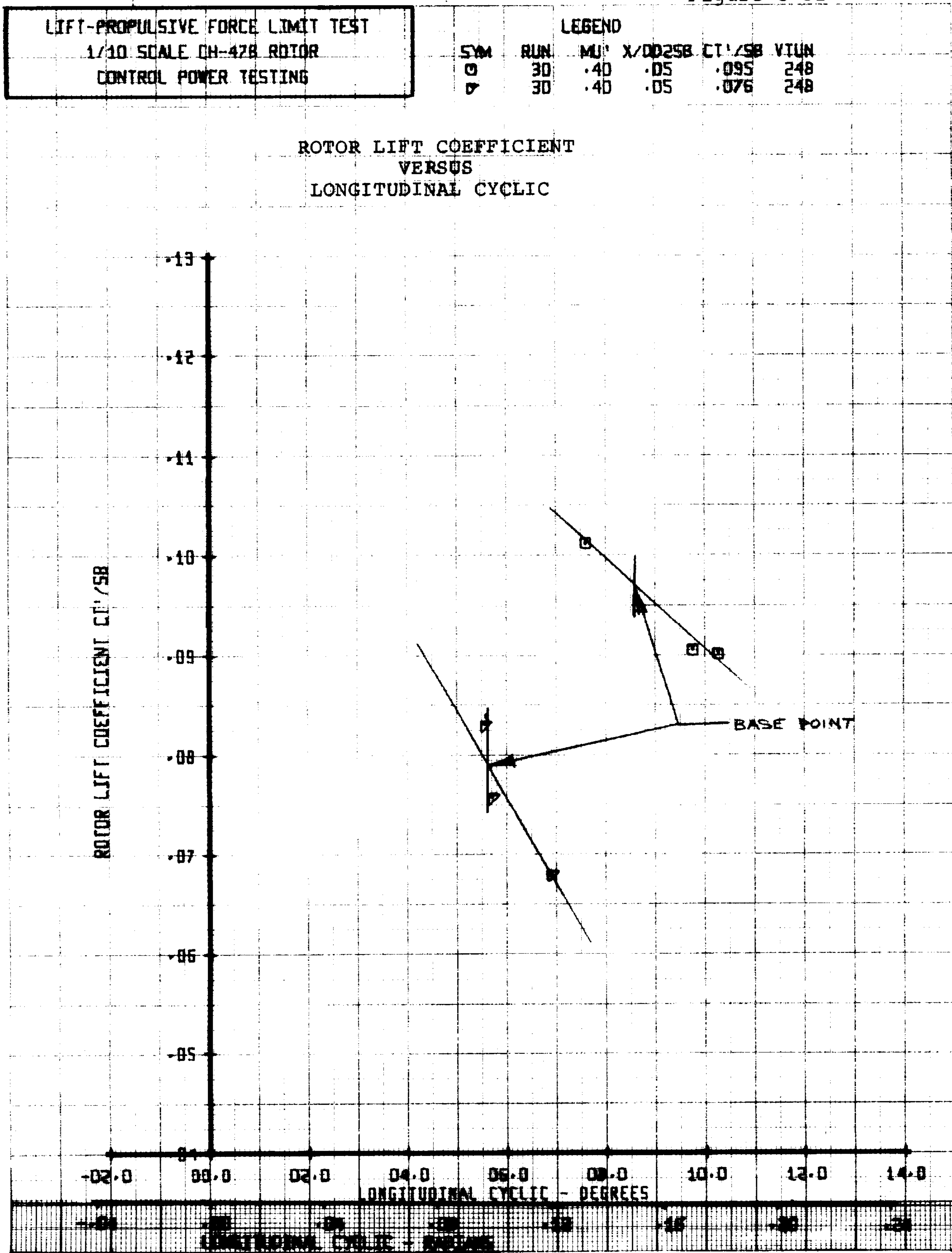


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD25B CT'/SB VTUN
28 .20 .05 .123 124
28 .20 .05 .090 124
ALTERNATING ROOT CHORD BENDING CB12
VERSUS
LONGITUDINAL CYCLIC
ALT. ROOT CHORD BENDING CB12 - IN.LB
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 12
BVWT 187



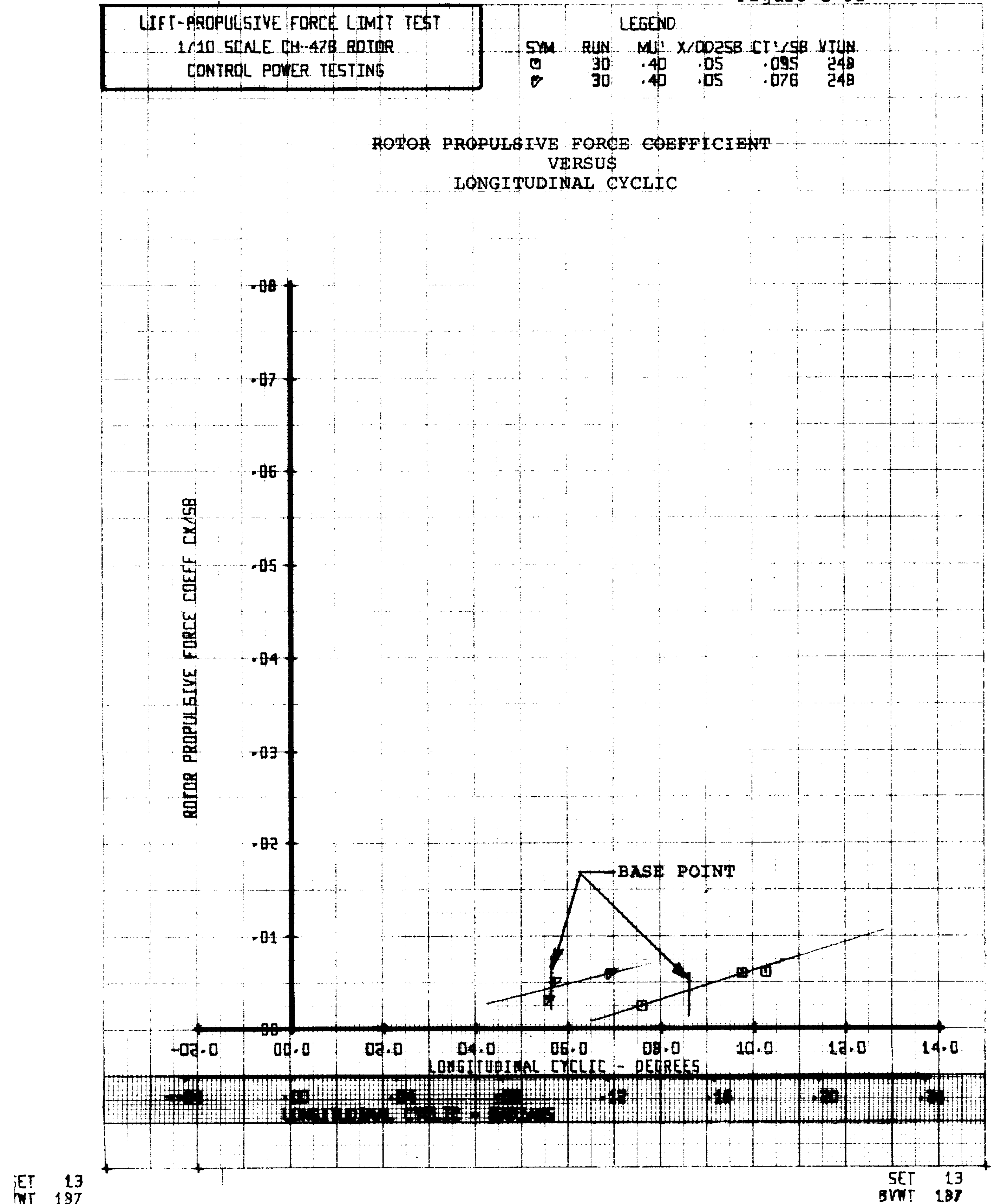
SET 12
BVWT 187

Figure C-51



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD2SB CT'/SB VTUN
30 .40 .05 .095 248
30 .40 .05 .076 248
ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 13
BVWT 187

Figure C-52



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN
30 .40 .05 .095 248
30 .40 .05 .076 248
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
.08
.07
.06
.05
.04
.03
.02
.01
.00
ROTOR PROPULSIVE FORCE COEFF CX/SB
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 13
BVWT 187

Figure C-53

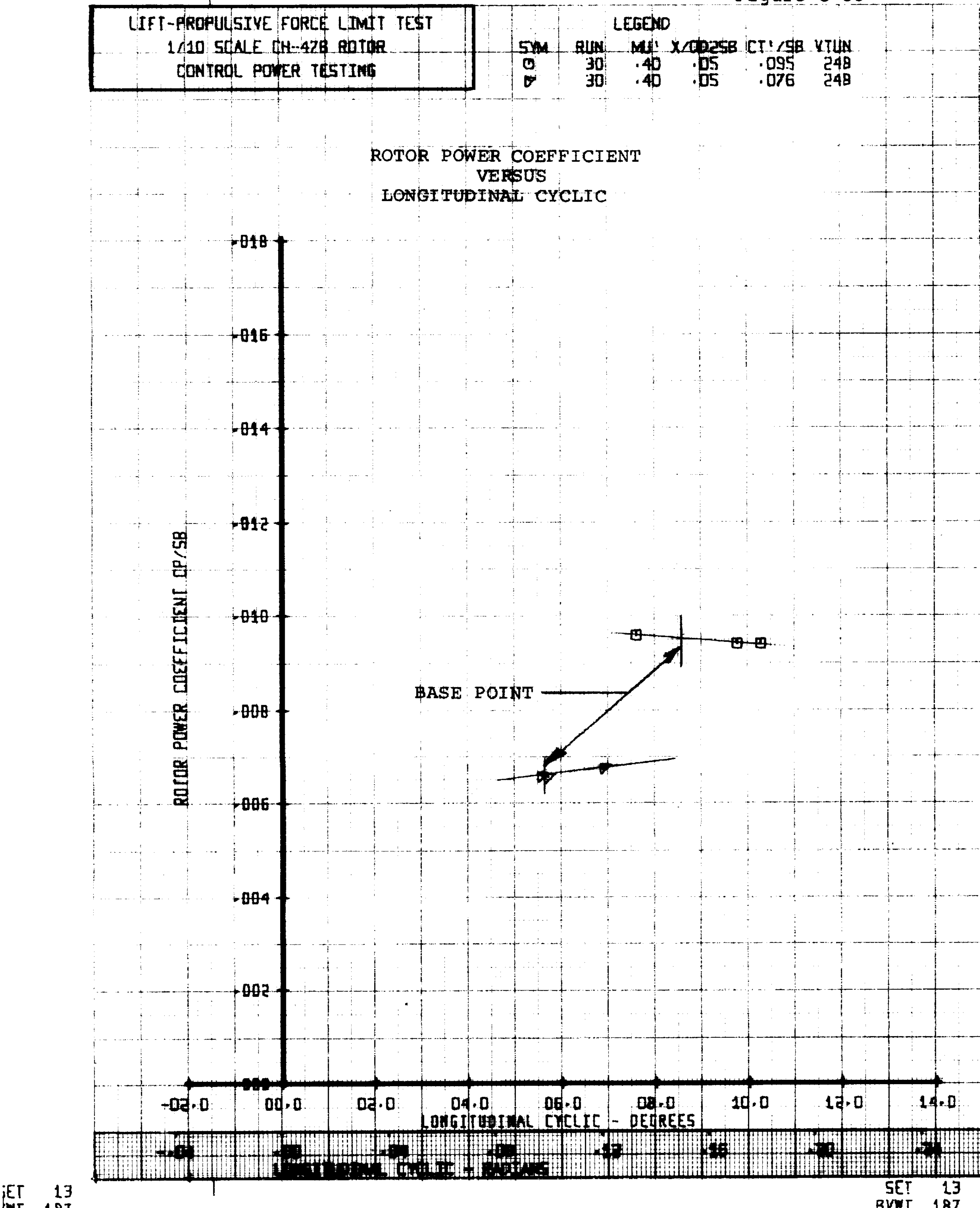
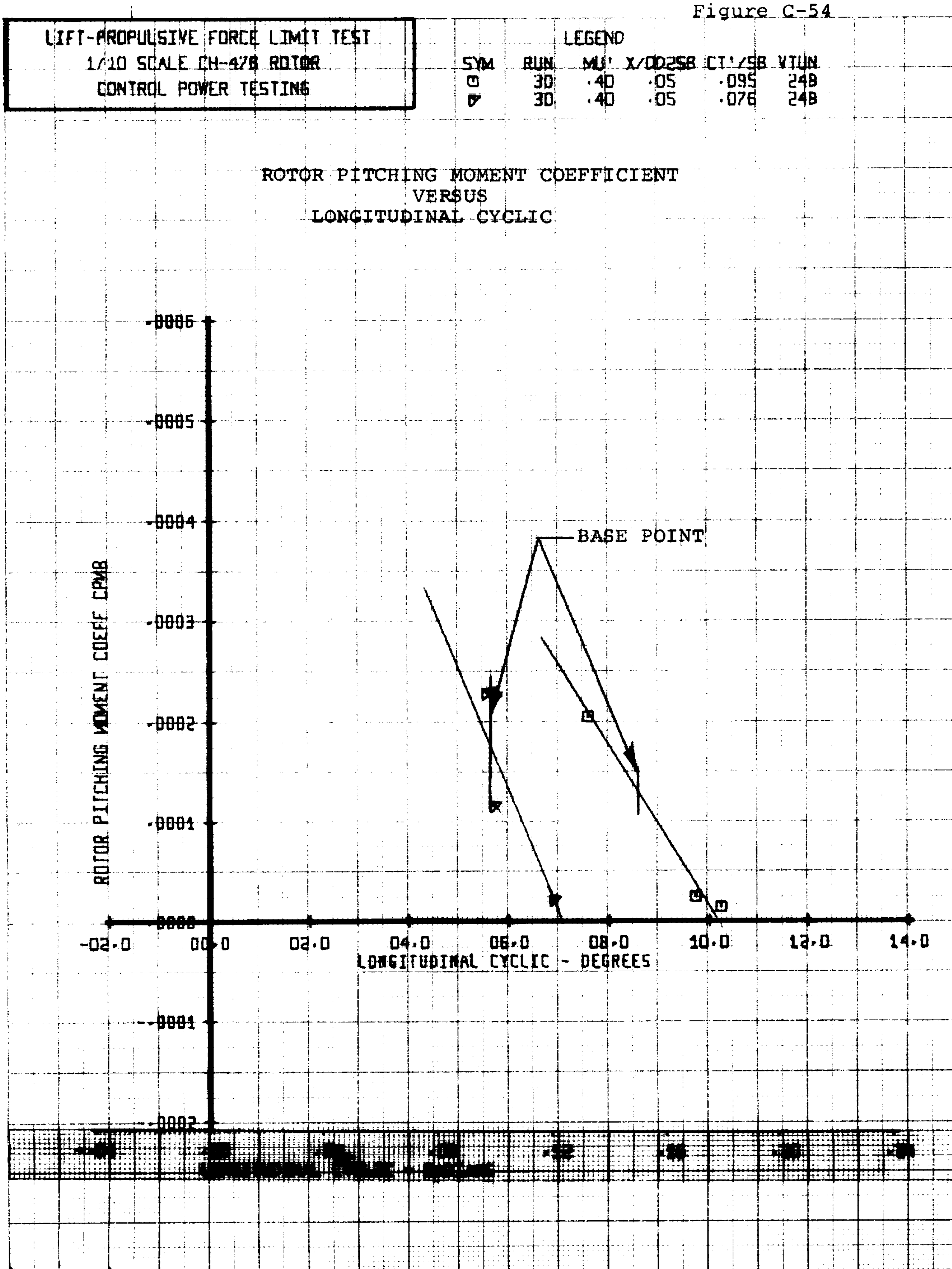

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
30 .40 .05 .095 248
30 .40 .05 .076 248
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 13
BVWT 187

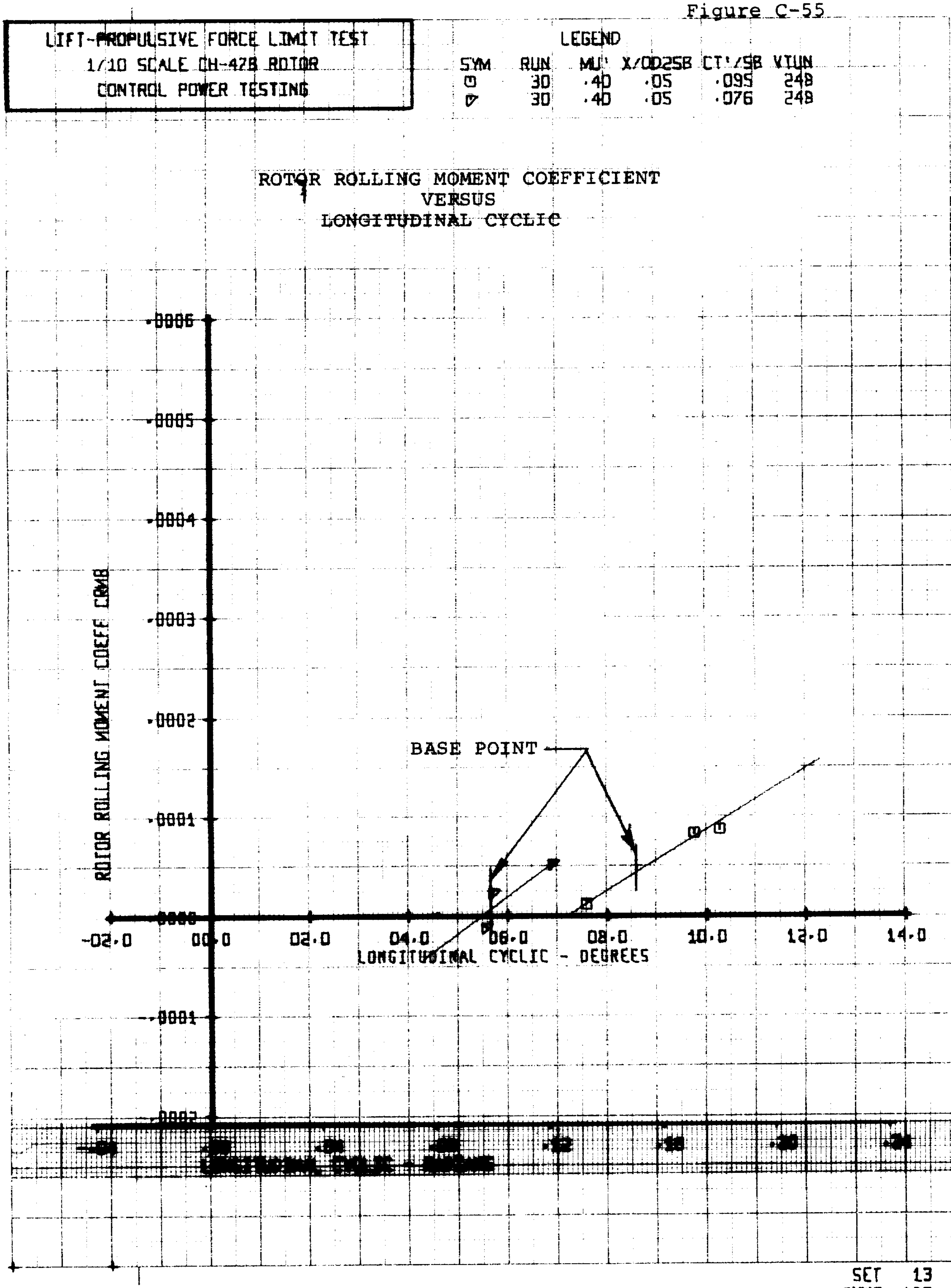
Figure C-54



SET 13
BVWT 187

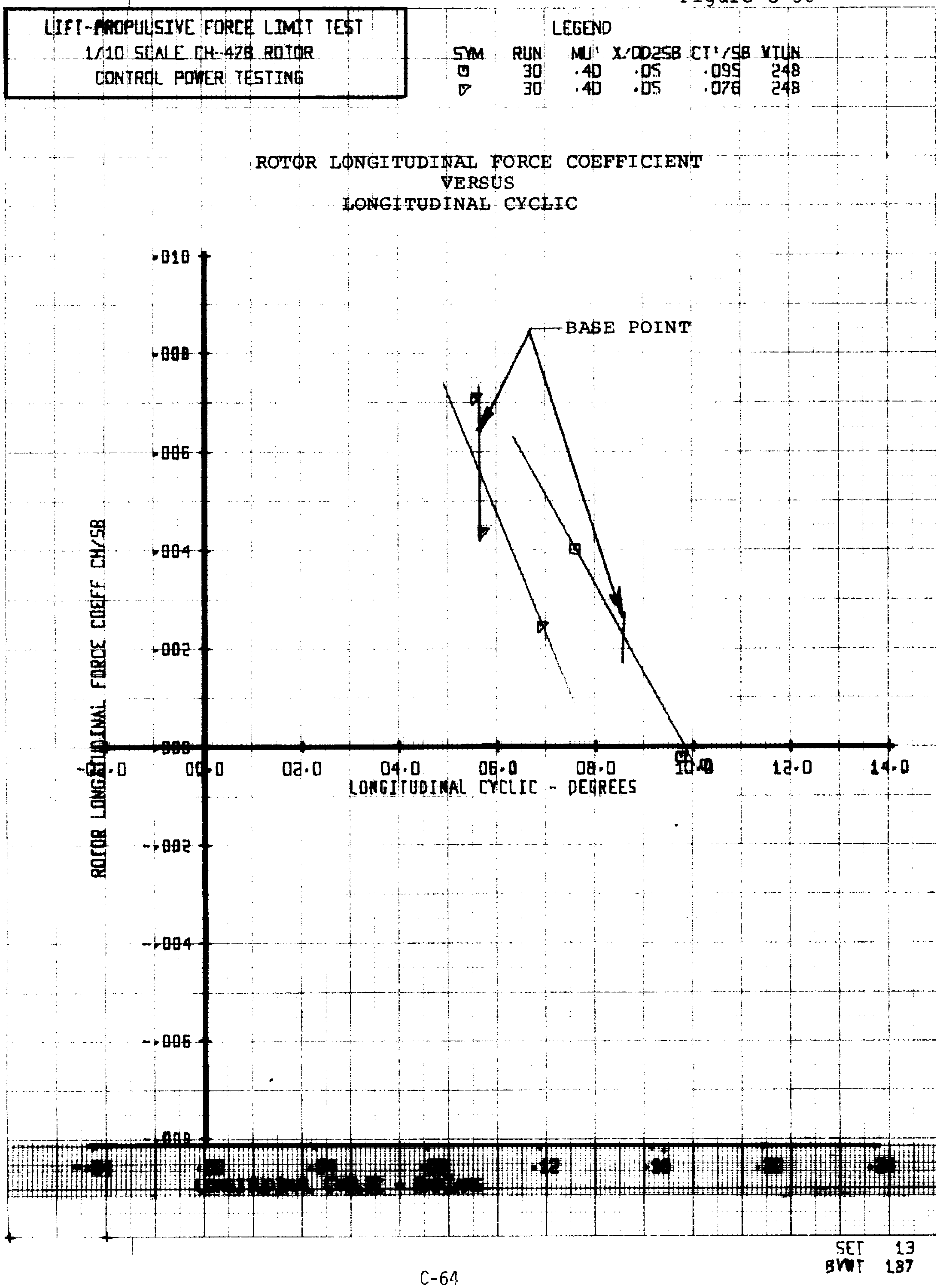
SET 13
BVWT 187

Figure C-55



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/OD25B CT'/SB VTUN
30 .40 .05 .095 248
30 .40 .05 .076 248
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR ROLLING MOMENT COEFF CRMB
LONGITUDINAL CYCLIC - DEGREES
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
SET 13
BVWT 197

Figure C-56


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
30 .40 .05 .095 248
30 .40 .05 .076 248
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
ROTOR LONGITUDINAL FORCE COEFF CH/SB
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 13
BVWT 187

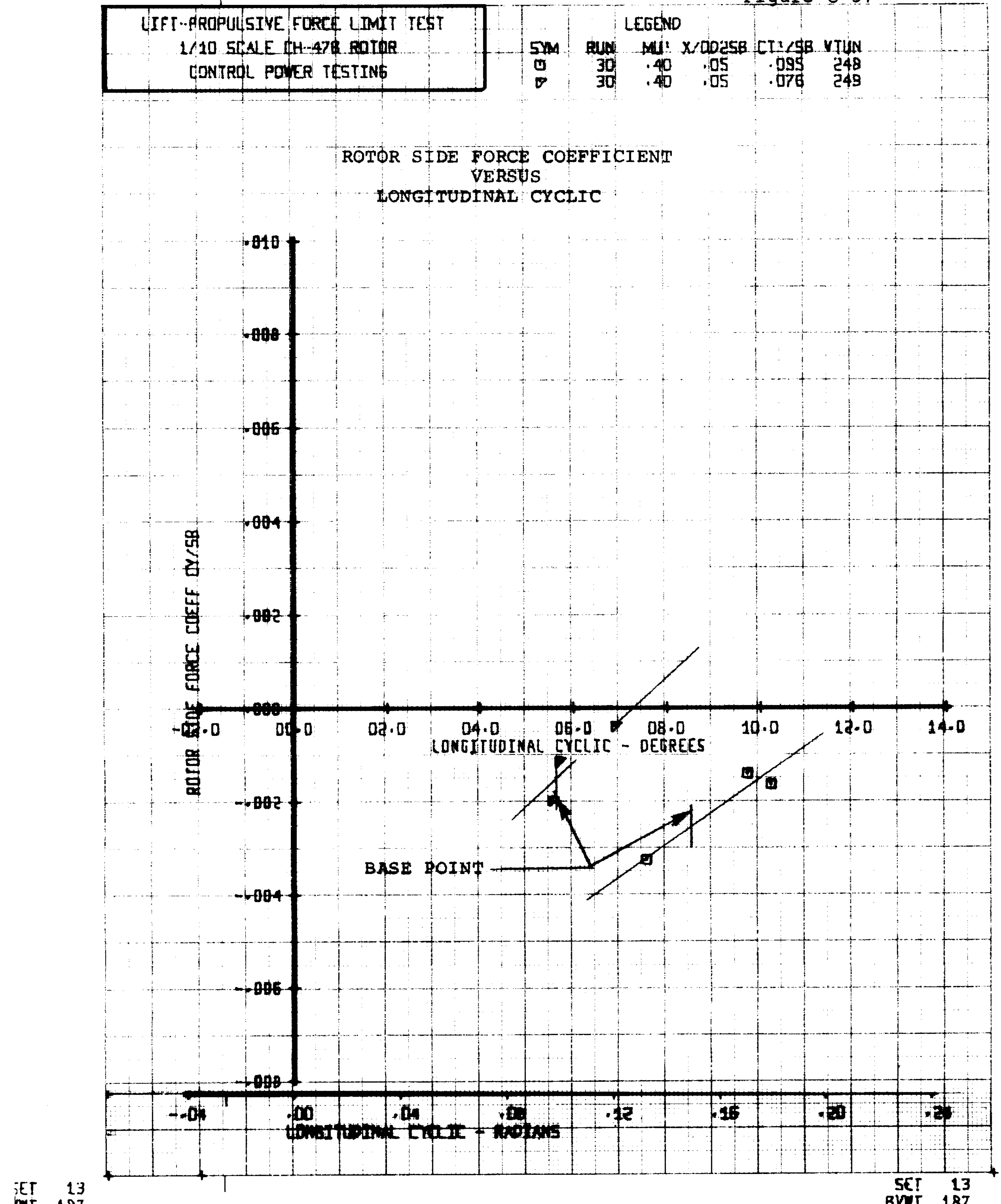
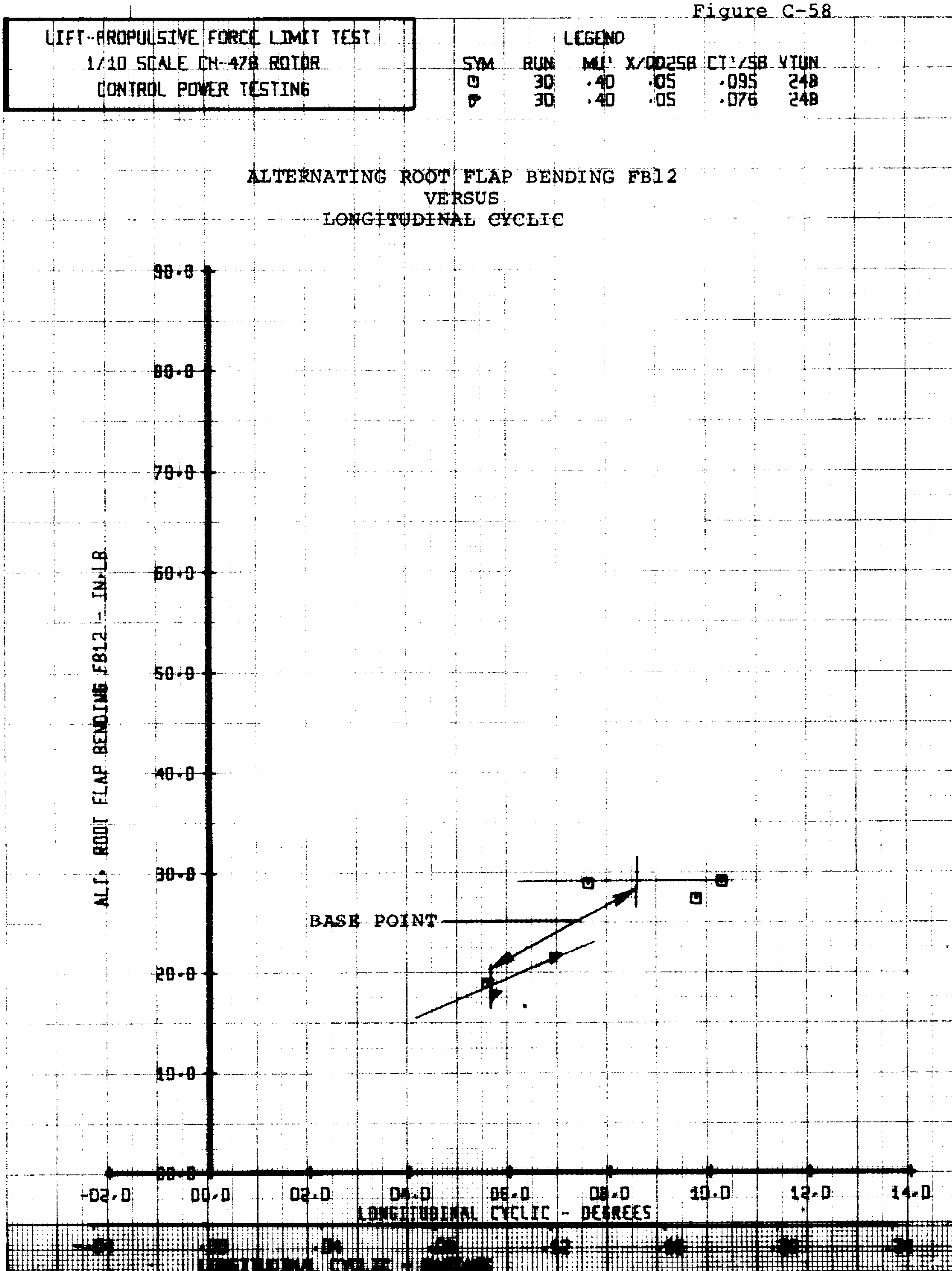

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD2SB CT'/SB VTUN
30 .40 .05 .095 248
30 .40 .05 .076 249
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR SIDE FORCE COEFF CY/SB
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
BASE POINT
-.04
.00
.04
.08
.12
.16
.20
.24
LONGITUDINAL CYCLIC - RADIANS
SET 13
BVWT 187
SET 13
BVWT 187

Figure C-58



ET 13
WT 187

SET 13
BVWT 187

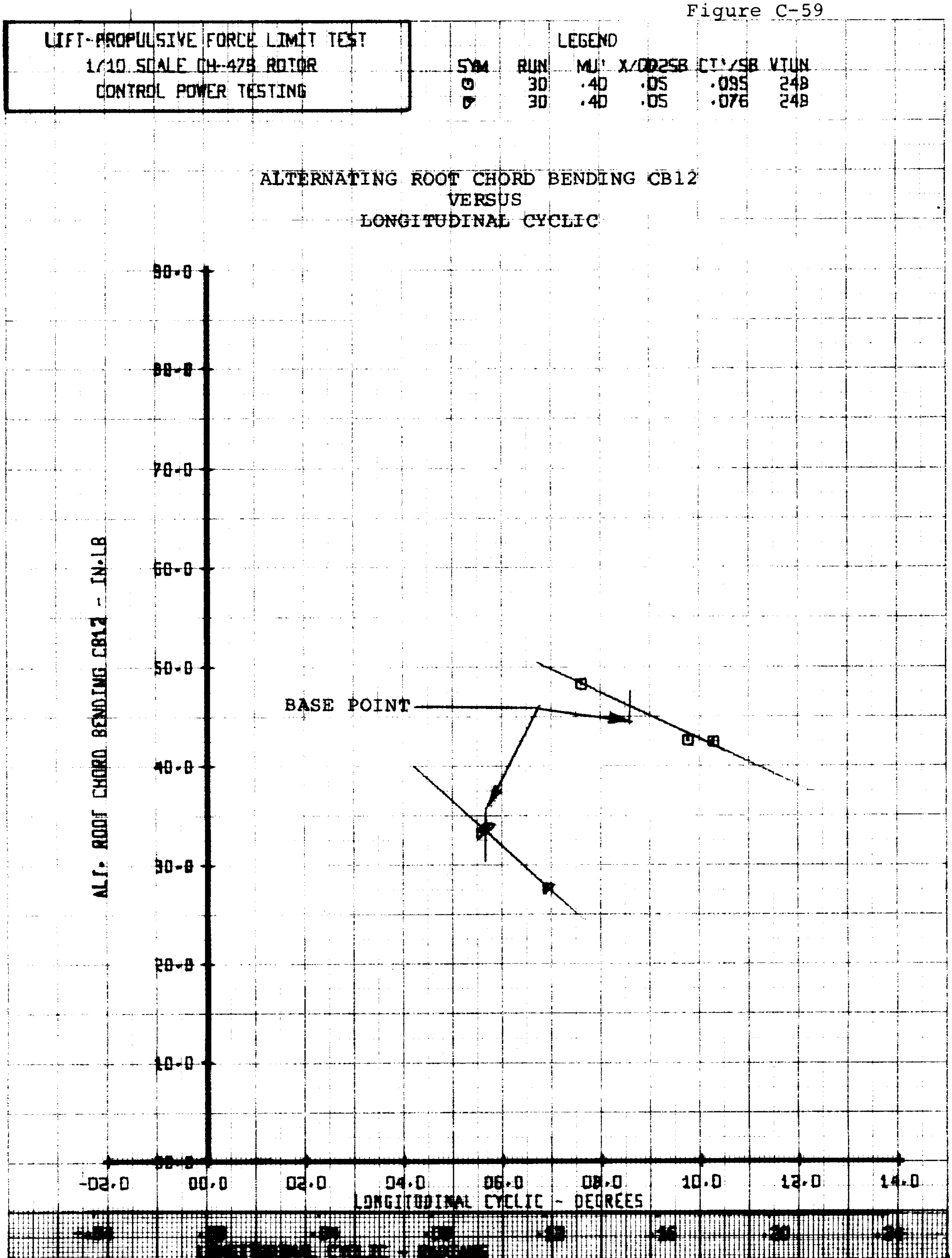
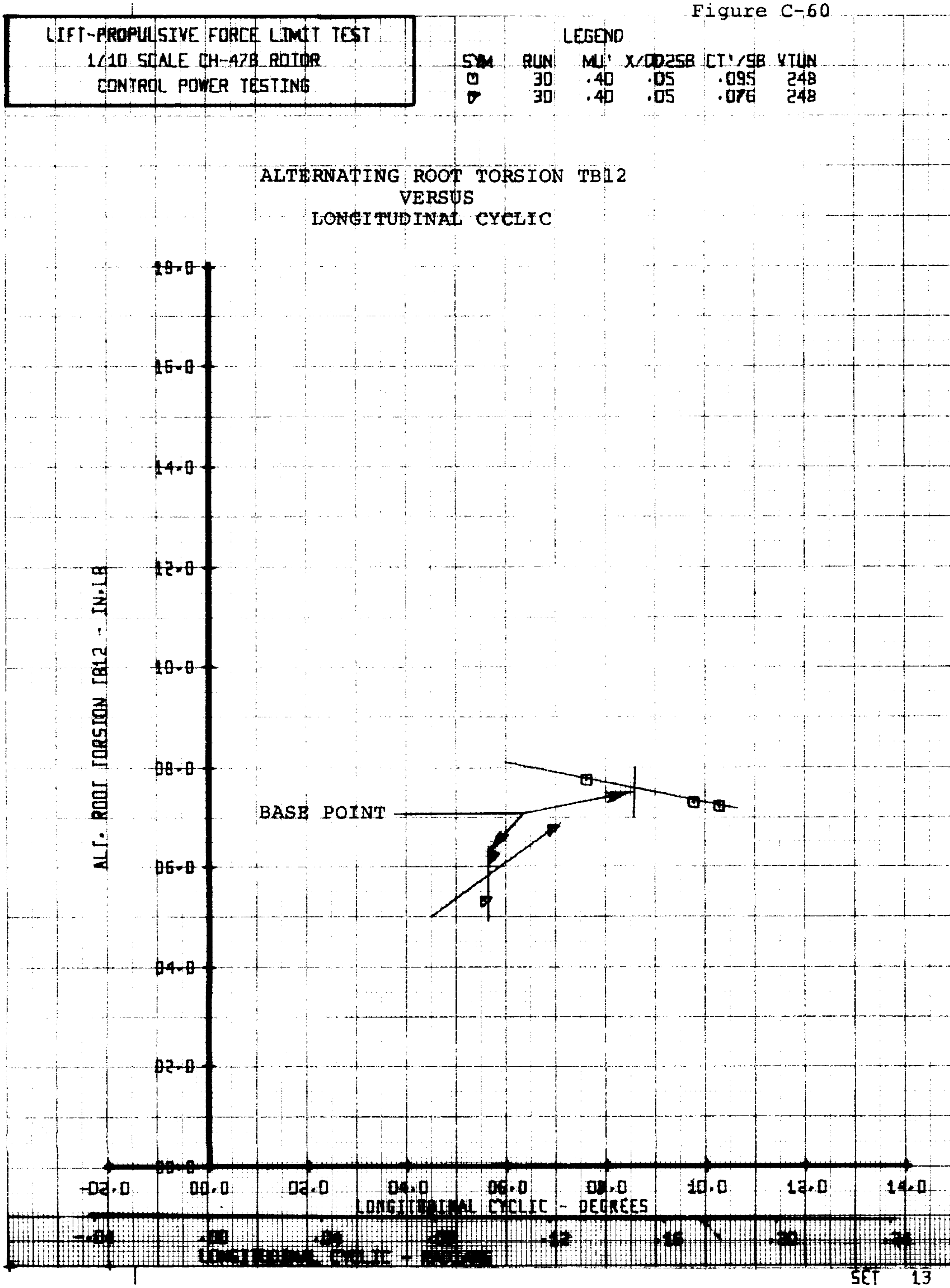
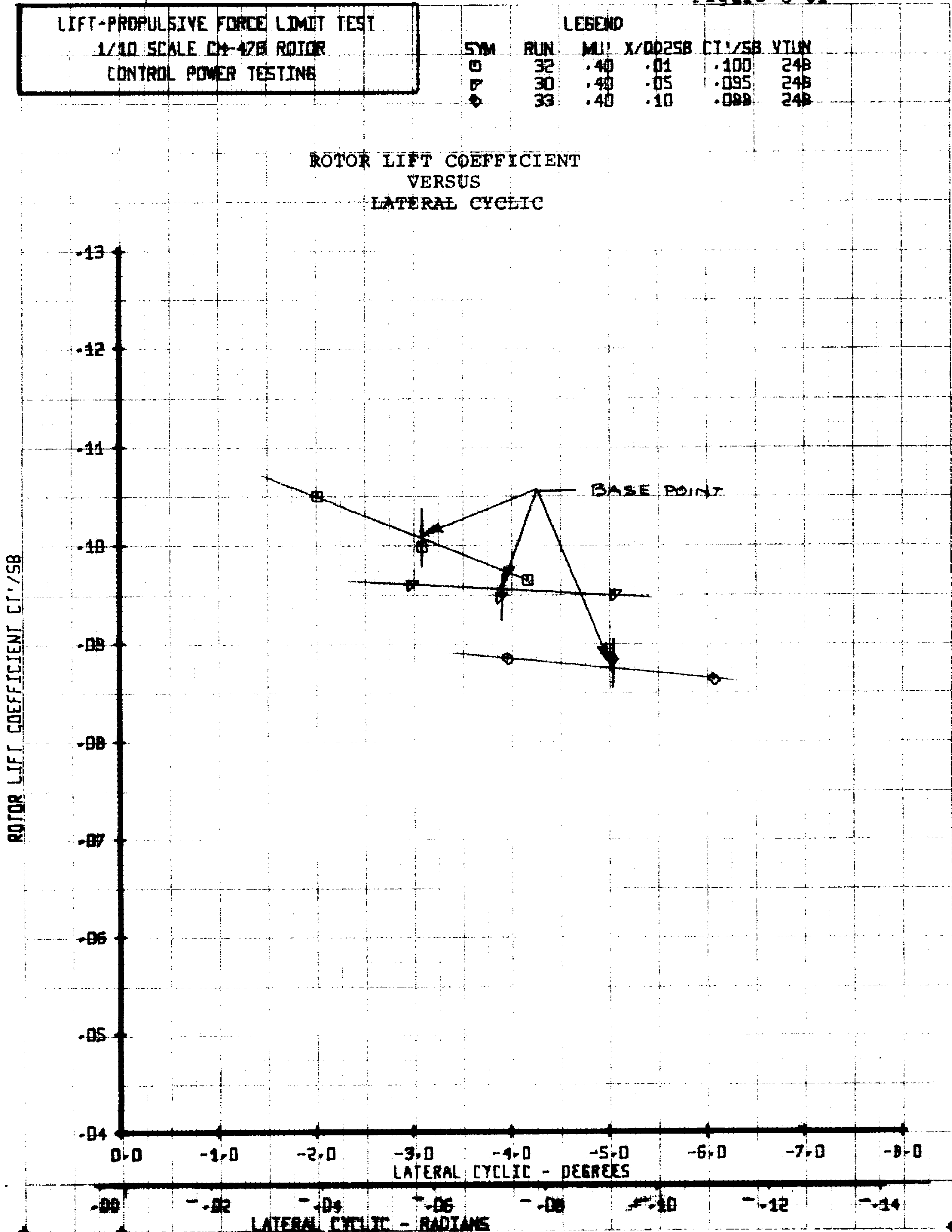

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
30 .40 .05 .095 248
30 .40 .05 .076 248
ALTERNATING ROOT CHORD BENDING CB12
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ALT. ROOT CHORD BENDING CB12 - IN-LB
LONGITUDINAL CYCLIC - DEGREES
SET 13
BYWT 187

Figure C-60



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/D025B CT'/SB VTUN
30 .40 .05 .095 248
30 .40 .05 .076 248
ALTERNATING ROOT TORSION TB12
VERSUS
LONGITUDINAL CYCLIC
ALT. ROOT TORSION TB12 - IN.LB
BASE POINT
18.0
16.0
14.0
12.0
10.0
08.0
06.0
04.0
02.0
00.0
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 13
BVWT 187

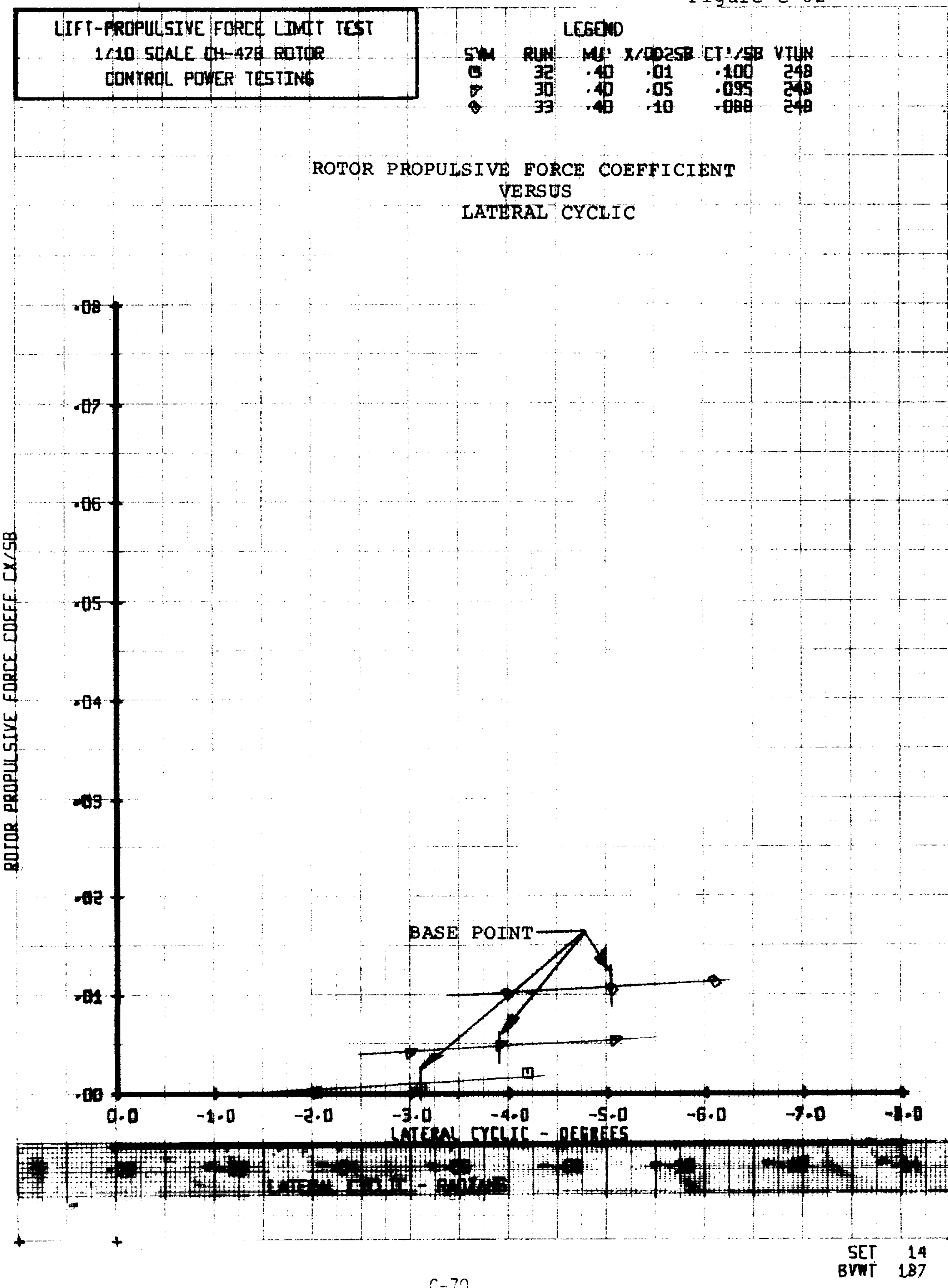
Figure C-61



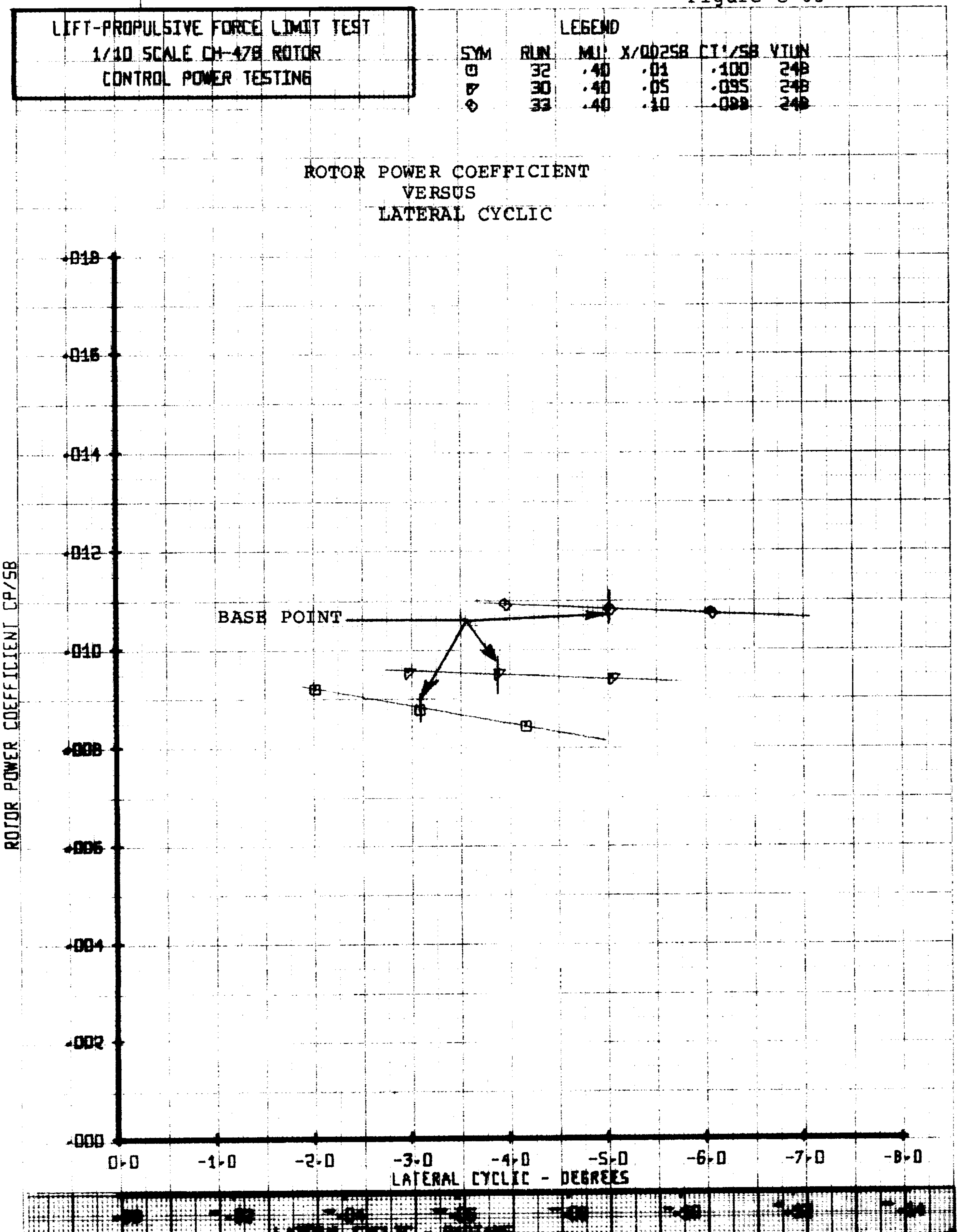
ET 14
WT 187

SET 14
BVWT 187

Figure C-62



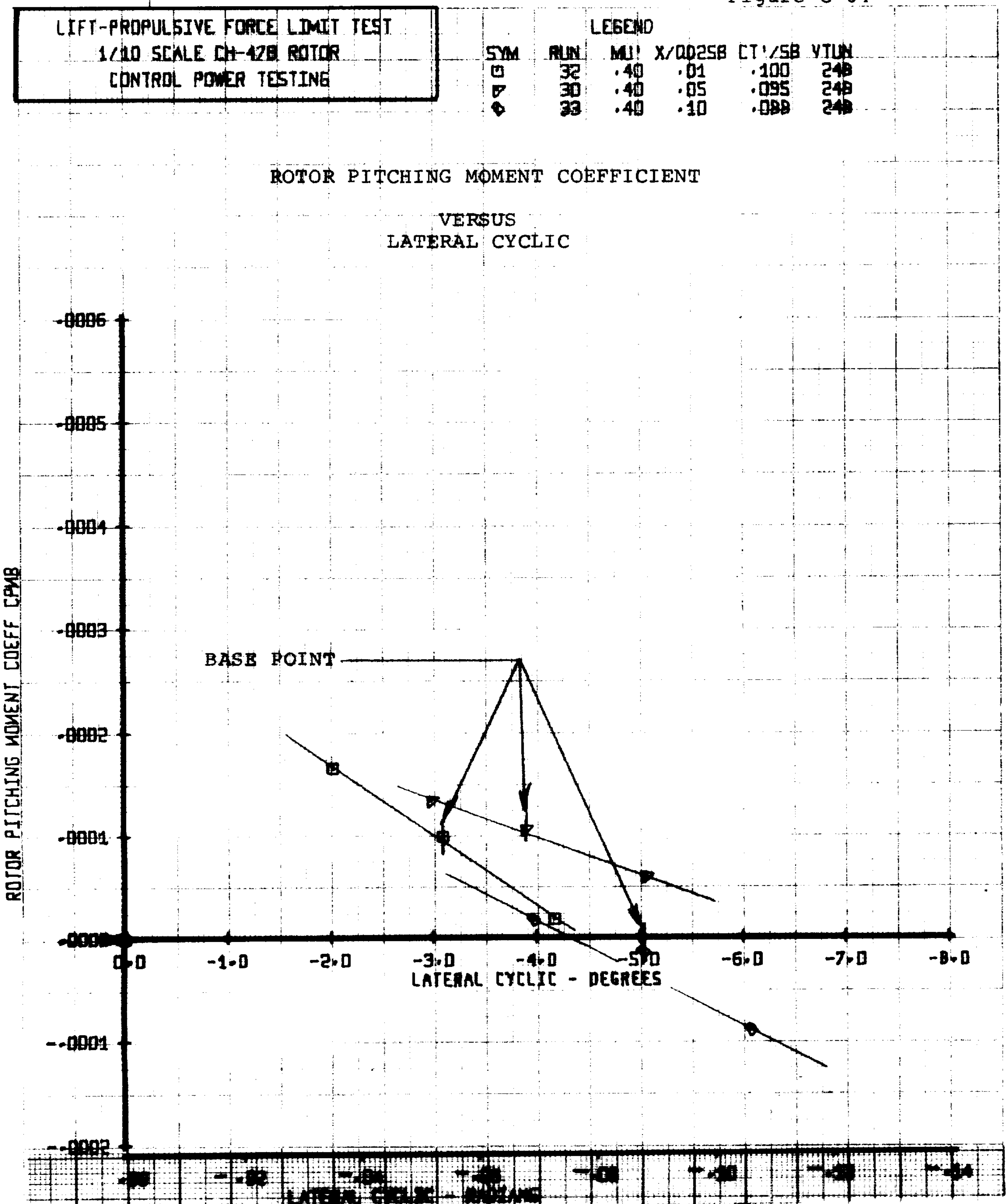
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD25B CT'/SB VTUN
32 .40 .01 .100 248
30 .40 .05 .095 248
33 .40 .10 .088 248
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PROPULSIVE FORCE COEFF CX/SB
.08
.07
.06
.05
.04
.03
.02
.01
.00
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 14
BVWT 187
SET 14
BVWT 187



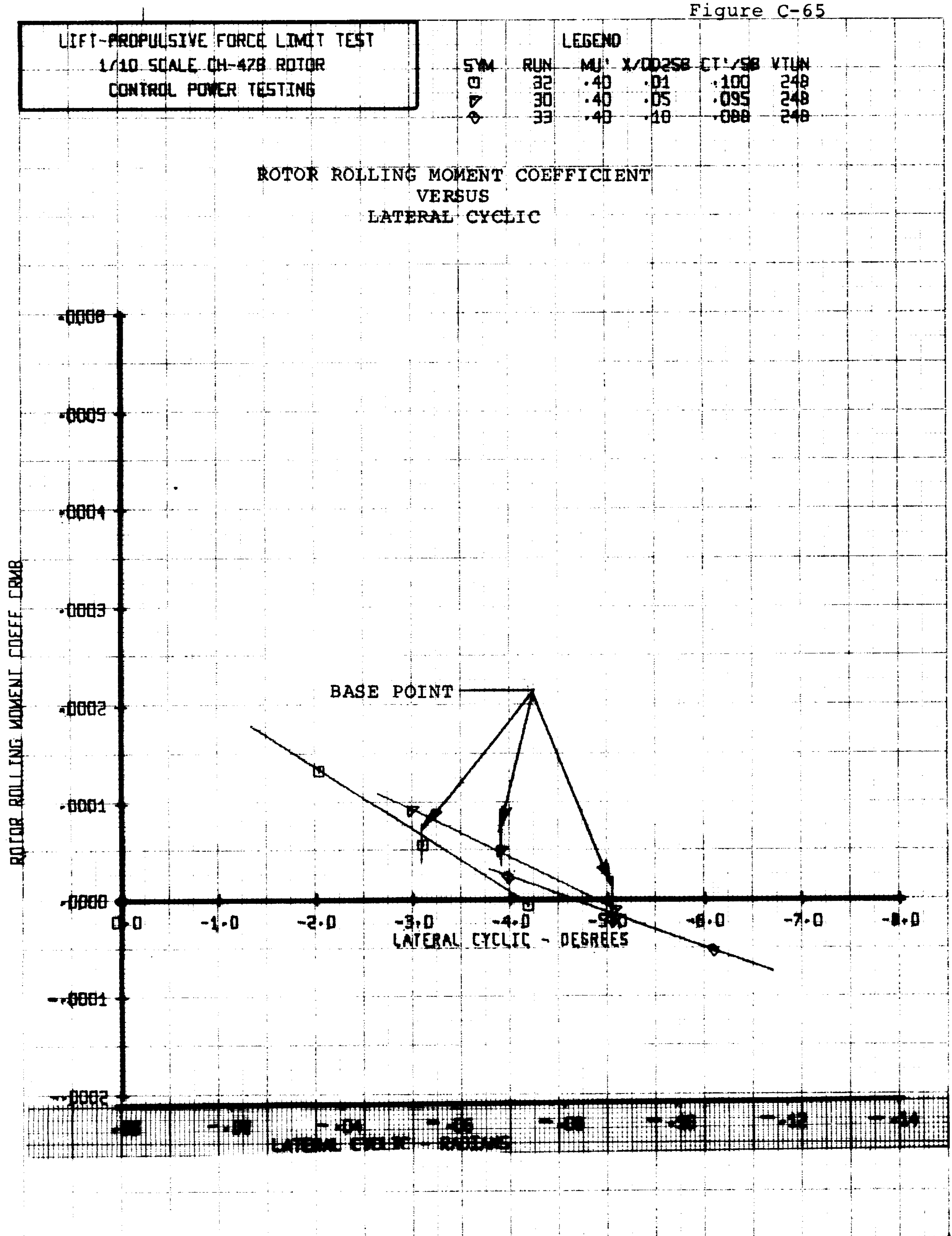
ET 14
WT 187

SET 14
BVWT 187

Figure C-64



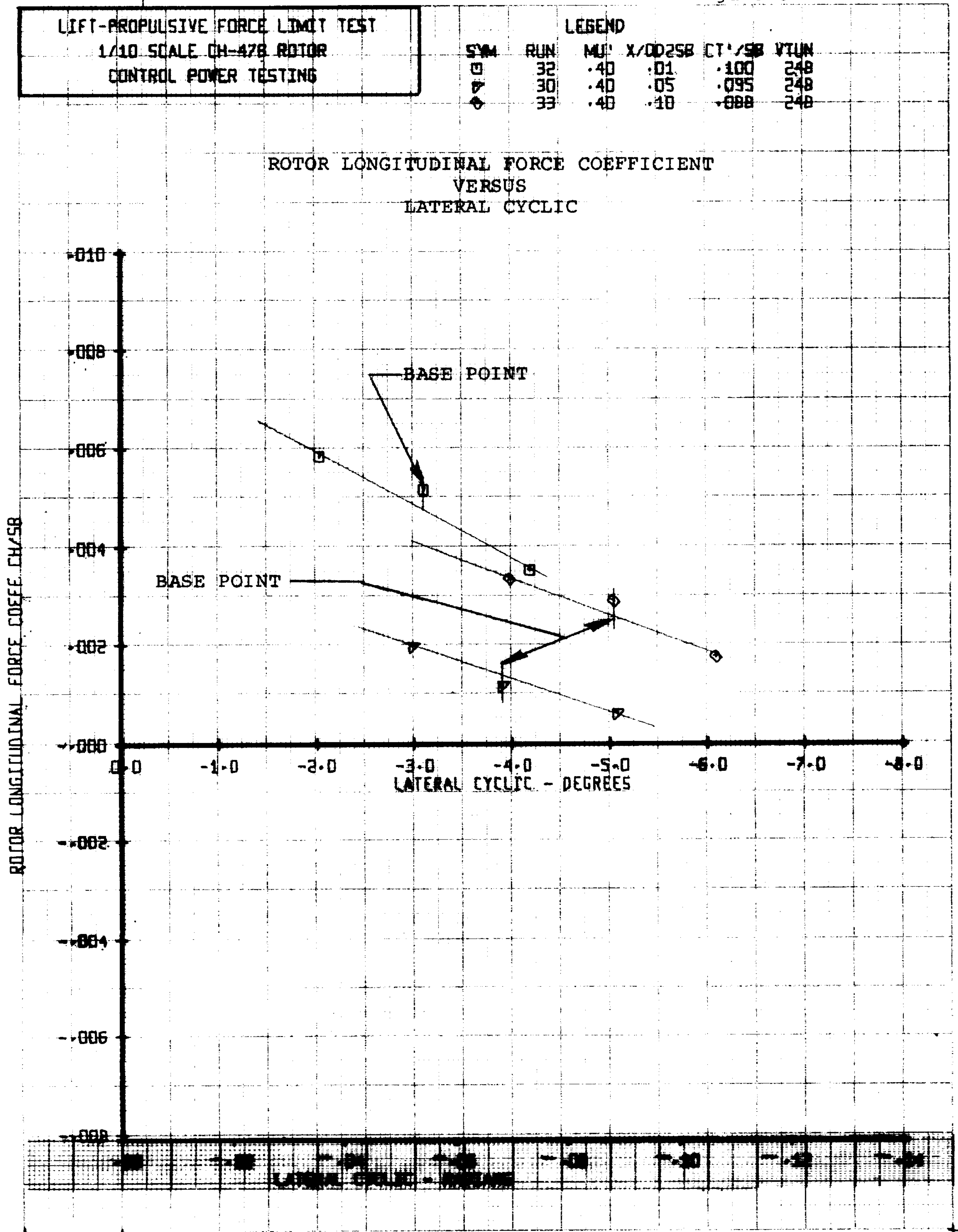
SET 14
BVWT 187



SET 14
BVWT 187

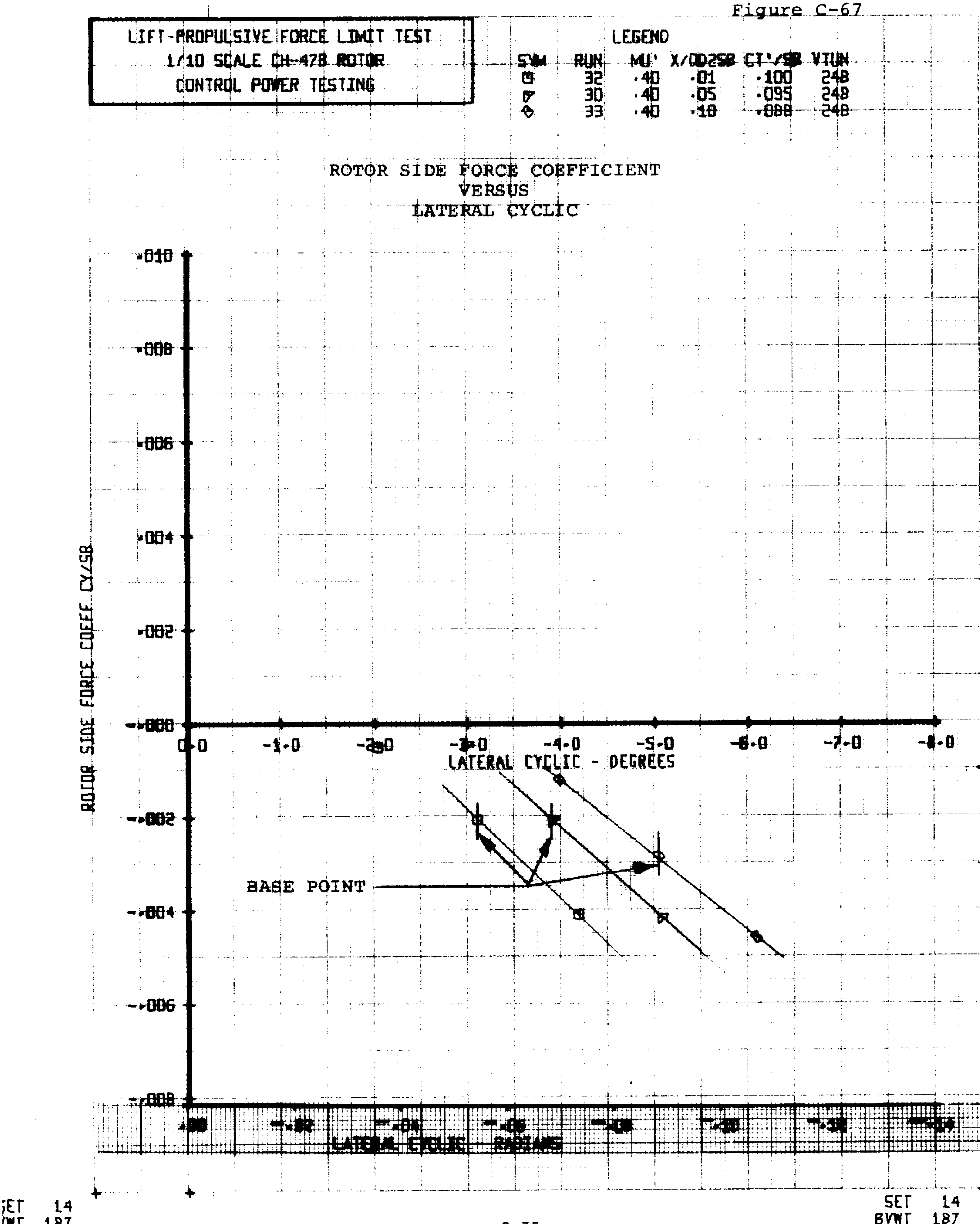
SET 14
BVWT 187

Figure C-66



SET 14
BVWT 187

SET 14
BVWT 187



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .100 248
30 .40 .05 .095 248
33 .40 .10 .088 248
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR SIDE FORCE COEFF CY/SB
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
BASE POINT
LATERAL CYCLIC - RADIANS
SET 14
BVWT 187

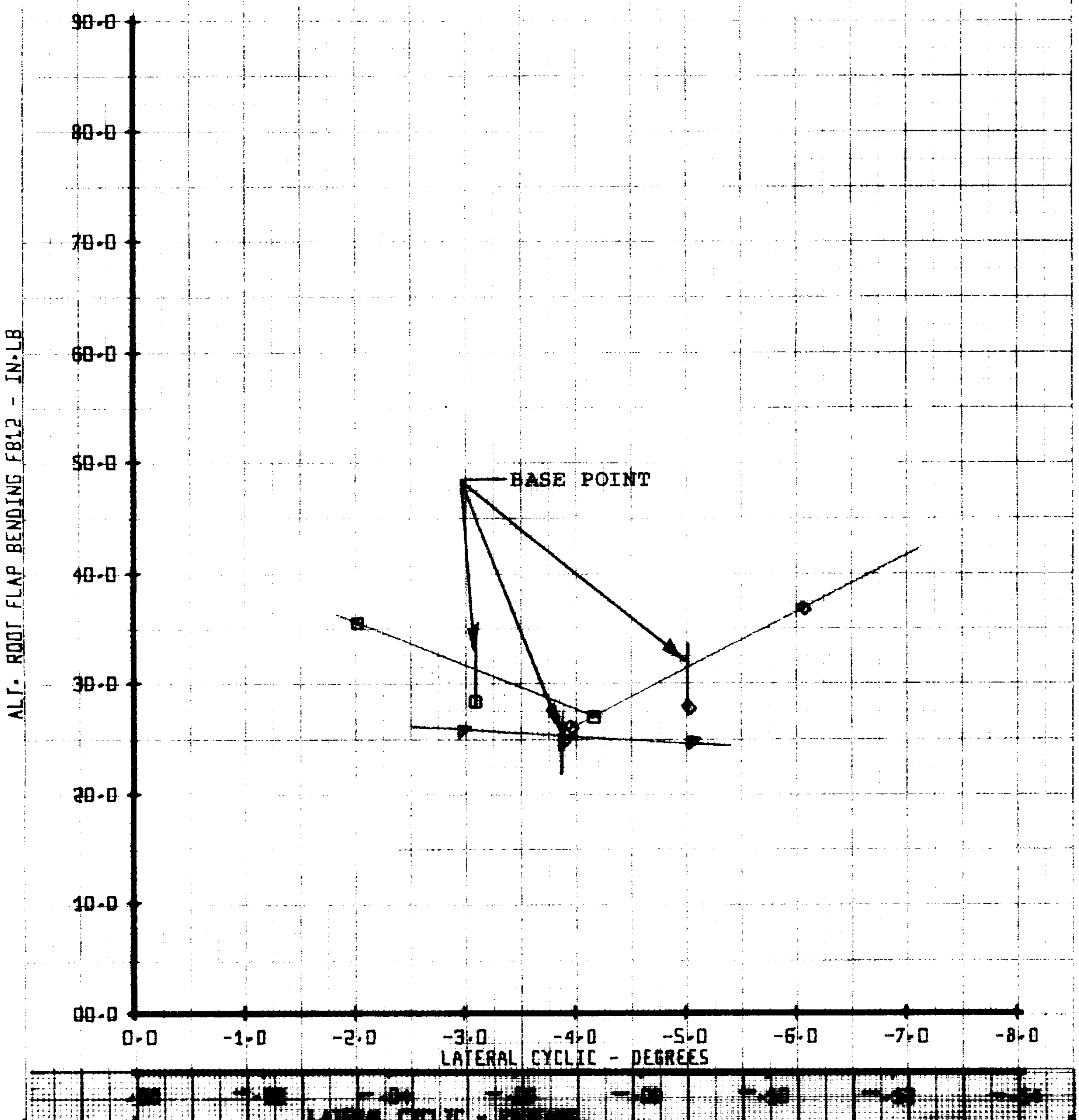
Figure C-68

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

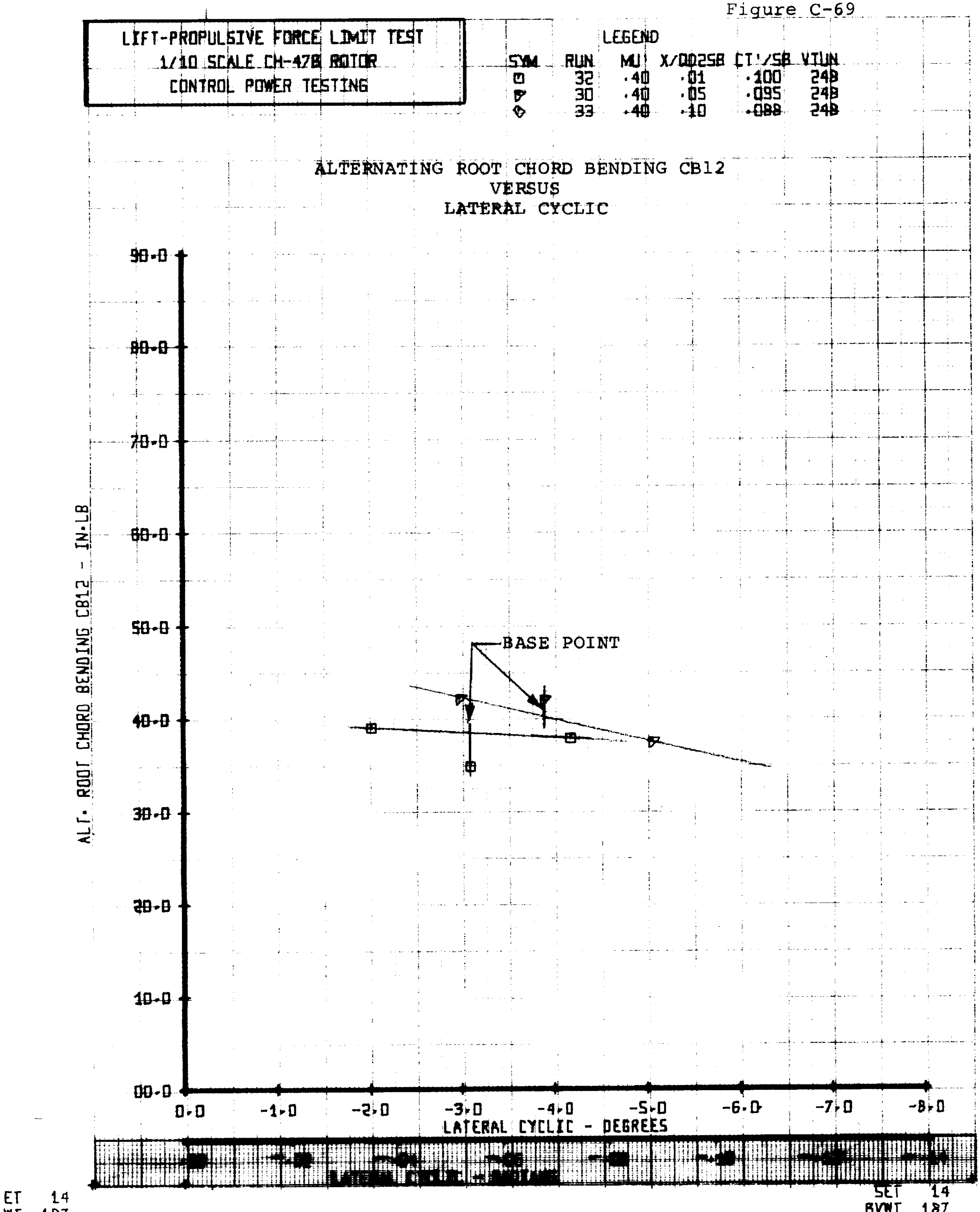
SYM	RUN	MU	X/QD2SB	CT'/SB	VTUN
□	32	.40	.01	.100	248
▽	30	.40	.05	.095	248
◇	33	.40	.10	.088	248

ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LATERAL CYCLIC



SET 14
BVWT 187

Figure C-69

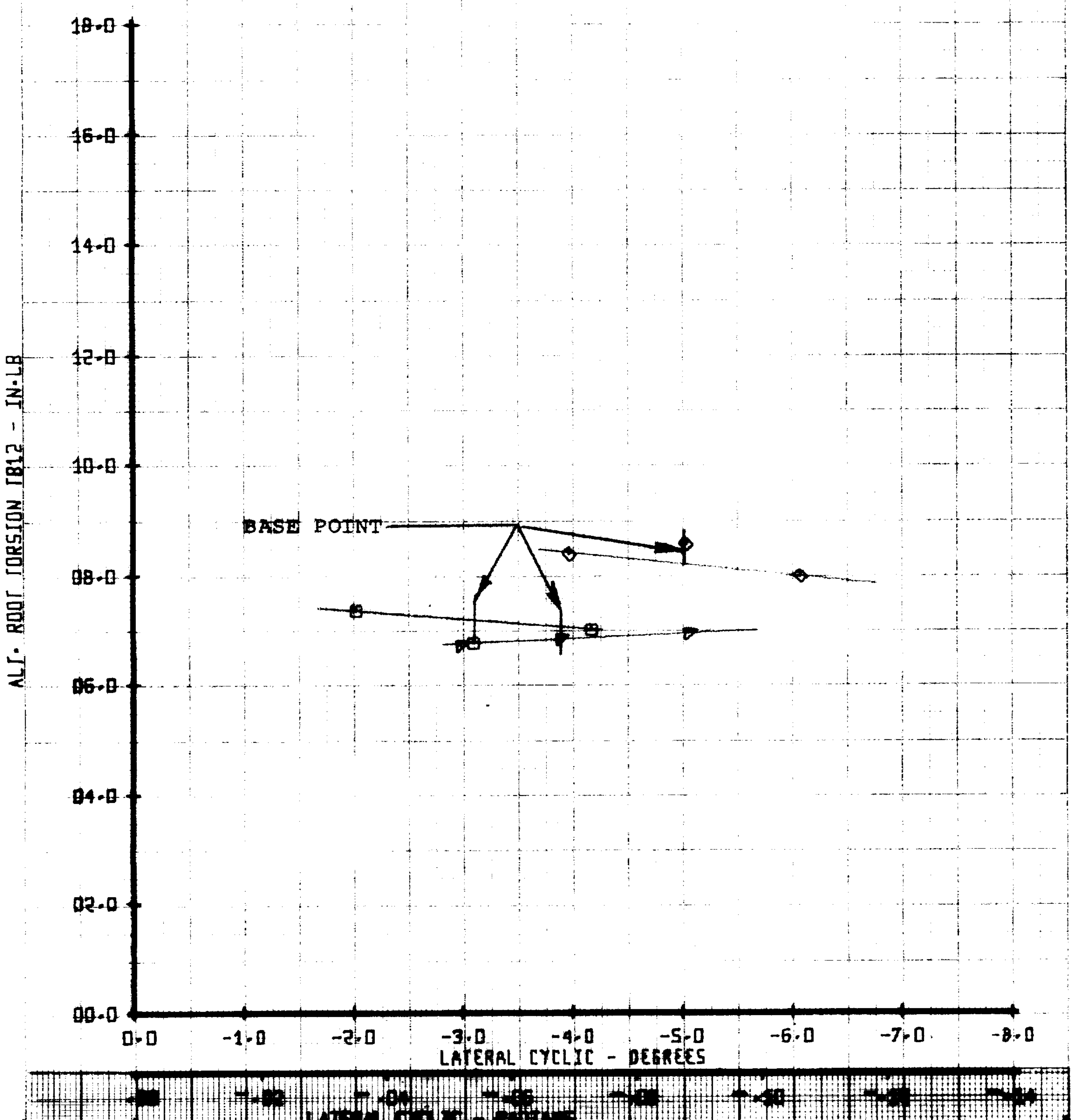

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
32 .40 .01 .100 248
30 .40 .05 .095 248
33 .40 .10 .088 248
ALTERNATING ROOT CHORD BENDING CB12
VERSUS
LATERAL CYCLIC
BASE POINT
ALT. ROOT CHORD BENDING CB12 - IN.LB
LATERAL CYCLIC - DEGREES
ET 14
WT 187
SET 14
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
□	32	.40	.01	.100	248
▽	30	.40	.05	.095	248
◇	33	.40	.10	.088	248

ALTERNATING ROOT TORSION TB12
VERSUS
LATERAL CYCLIC



ET 14
WT 187

SET 14
BVWT 187

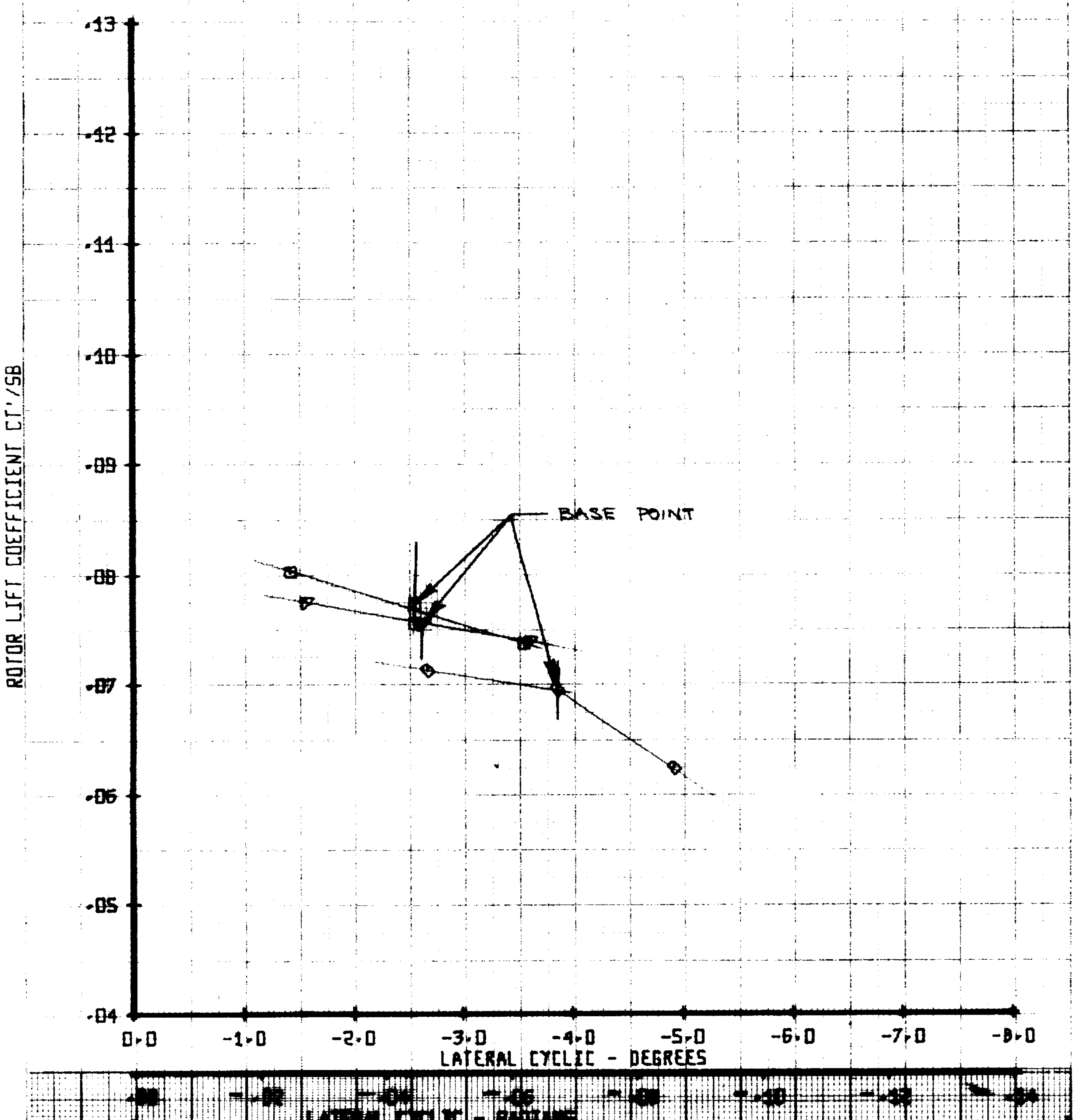
Figure C-71

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU	X/QQ2SB	CT'/SB	VTUN
⊡	32	.40	.01	.077	248
▱	30	.40	.05	.076	248
◇	33	.40	.10	.070	248

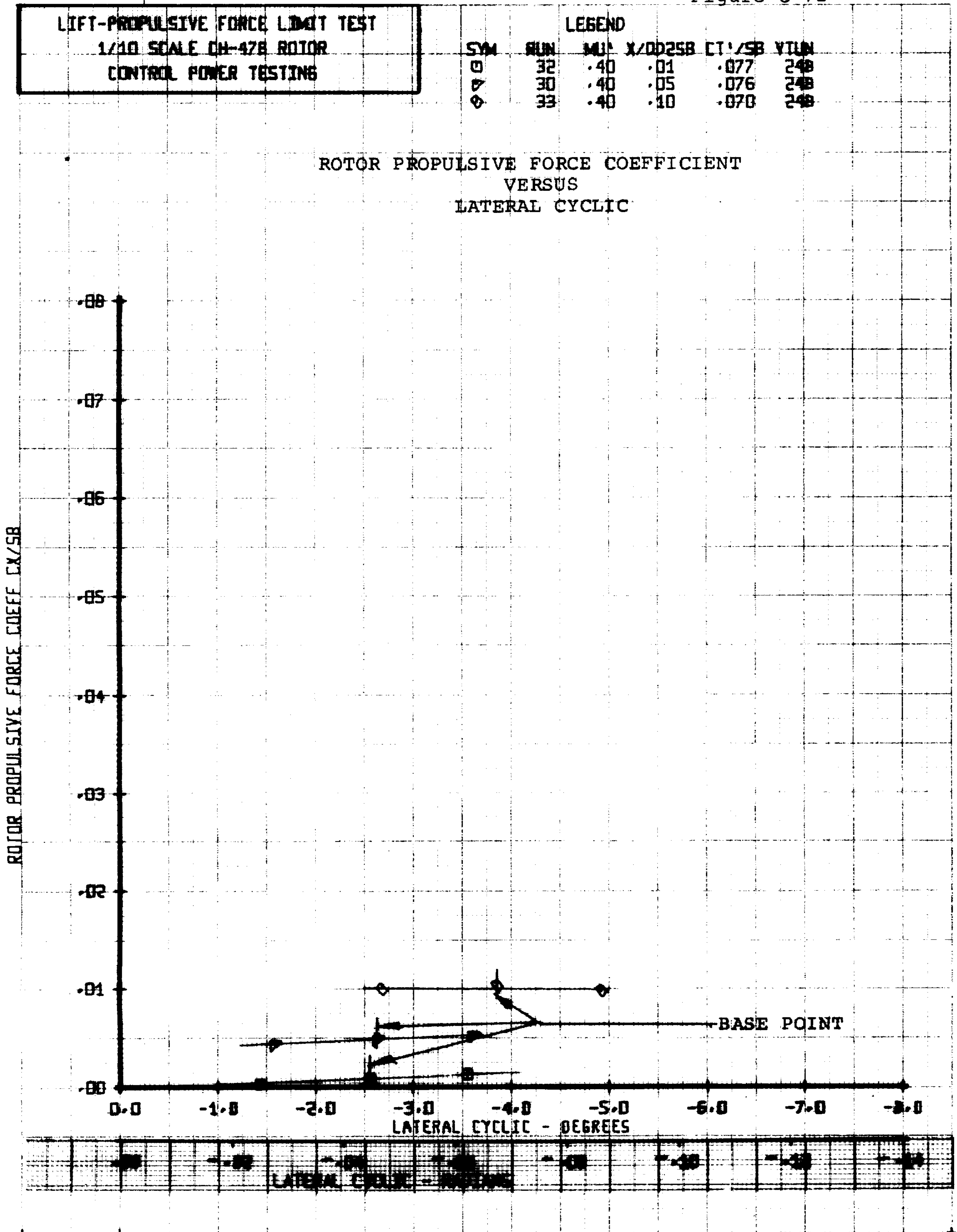
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC



ET 15
WT 187

SET 15
BVWT 187

Figure C-72



ET 15
WT 187

SET 15
BVWT 187

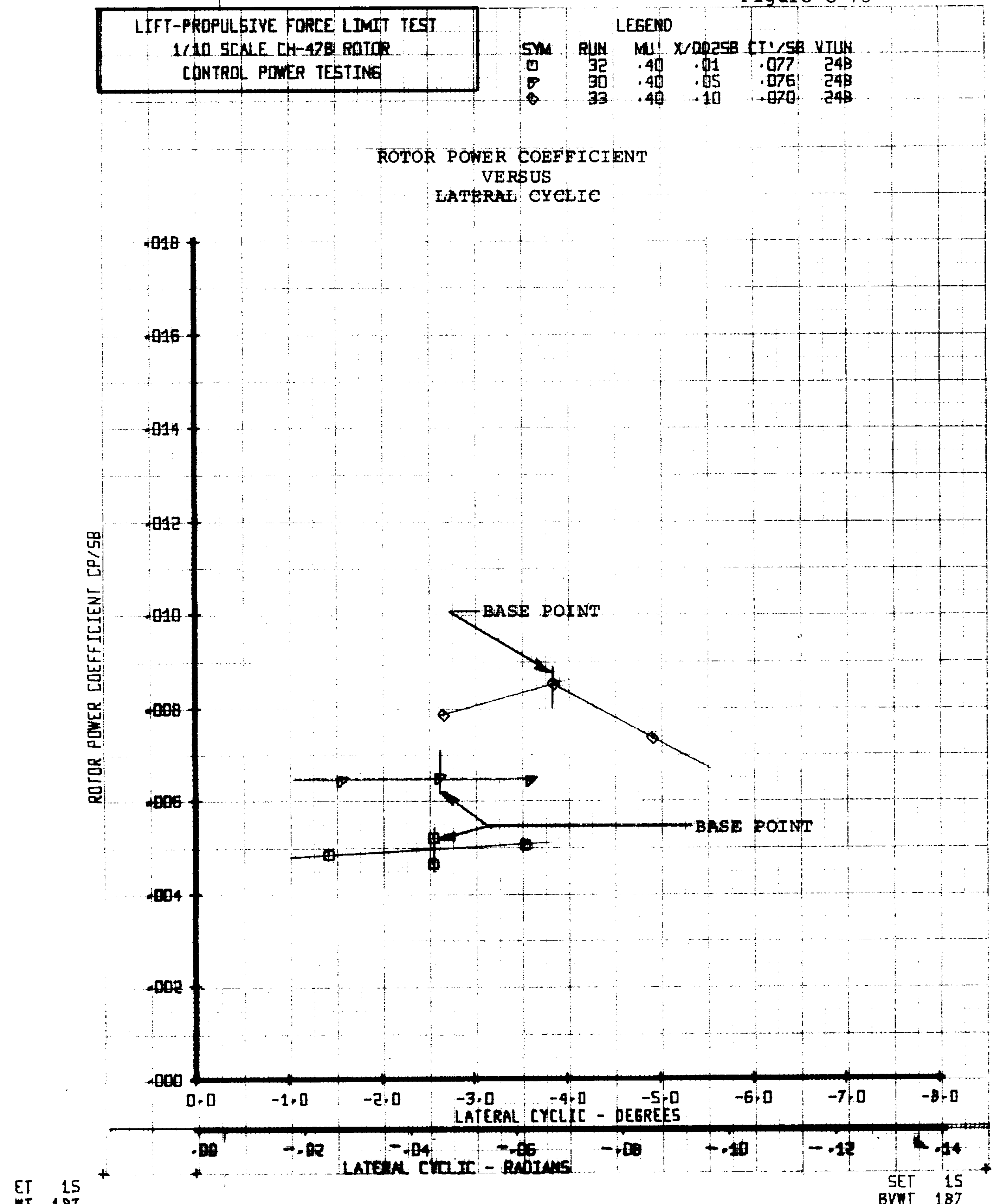
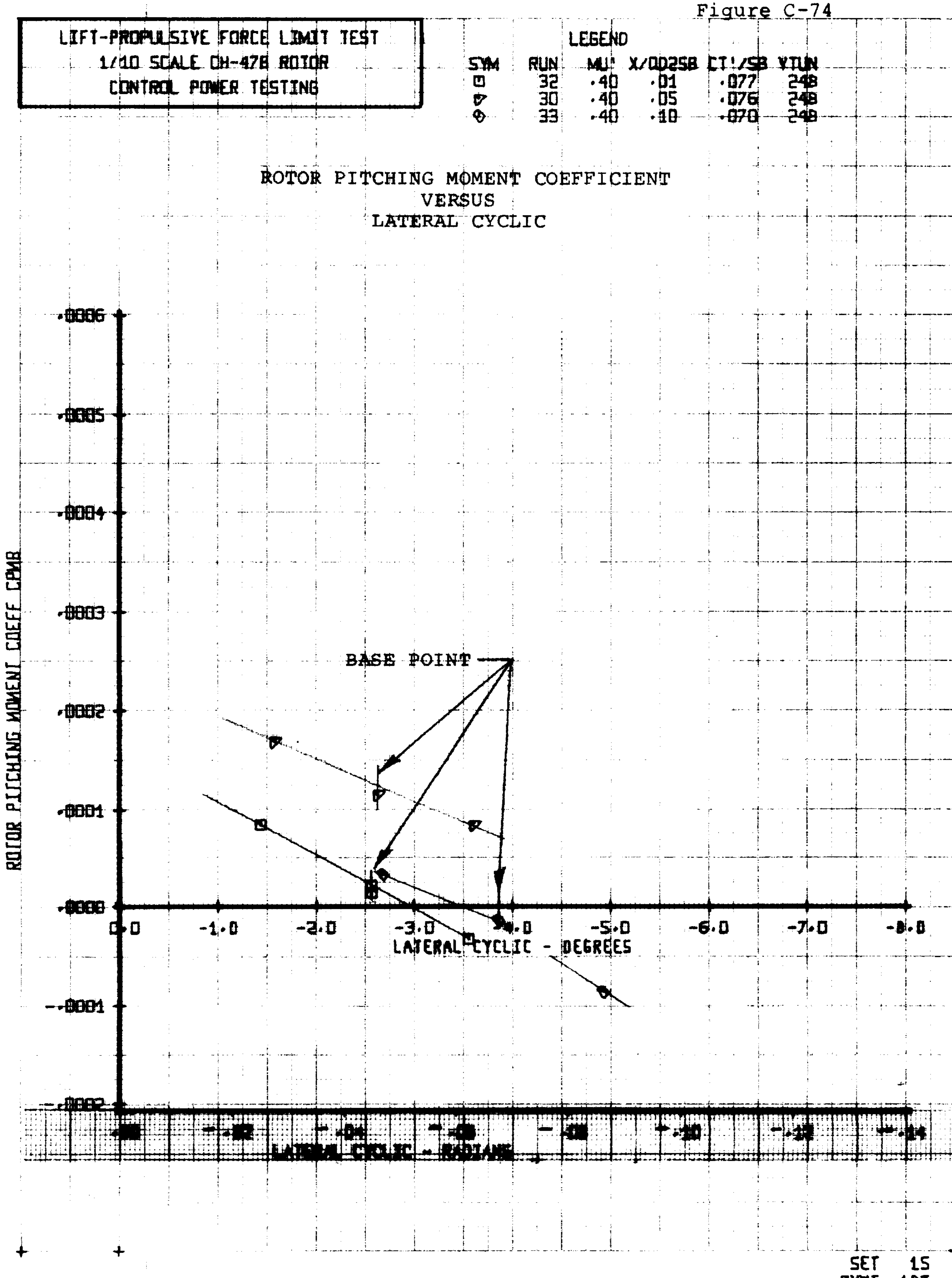
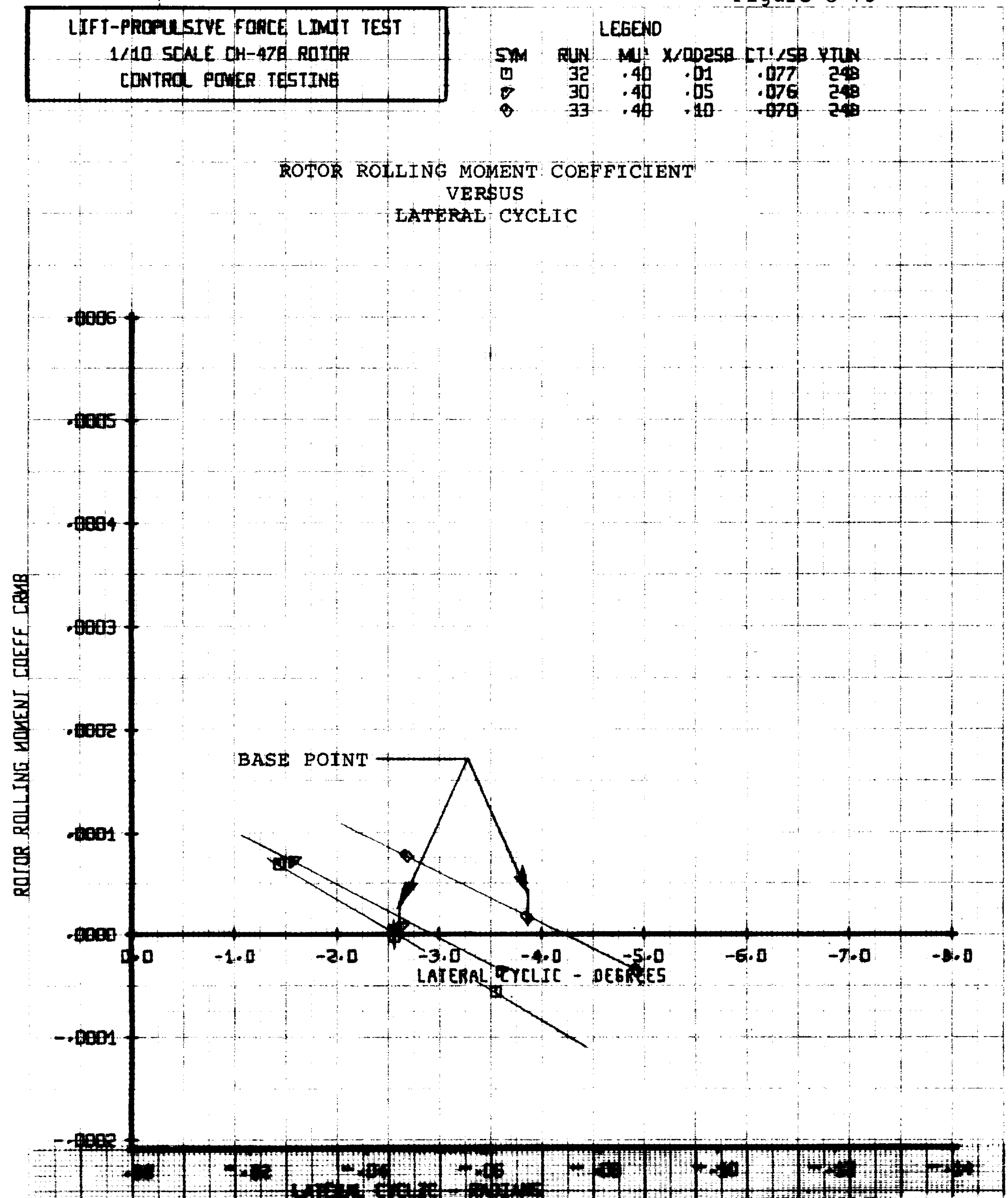

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
32 .40 .01 .077 248
30 .40 .05 .076 248
33 .40 .10 .070 248
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
.00
-.02
-.04
-.06
-.08
-.10
-.12
-.14
LATERAL CYCLIC - RADIANS
ET 1S
WT 187
SET 1S
BVWT 187

Figure C-74



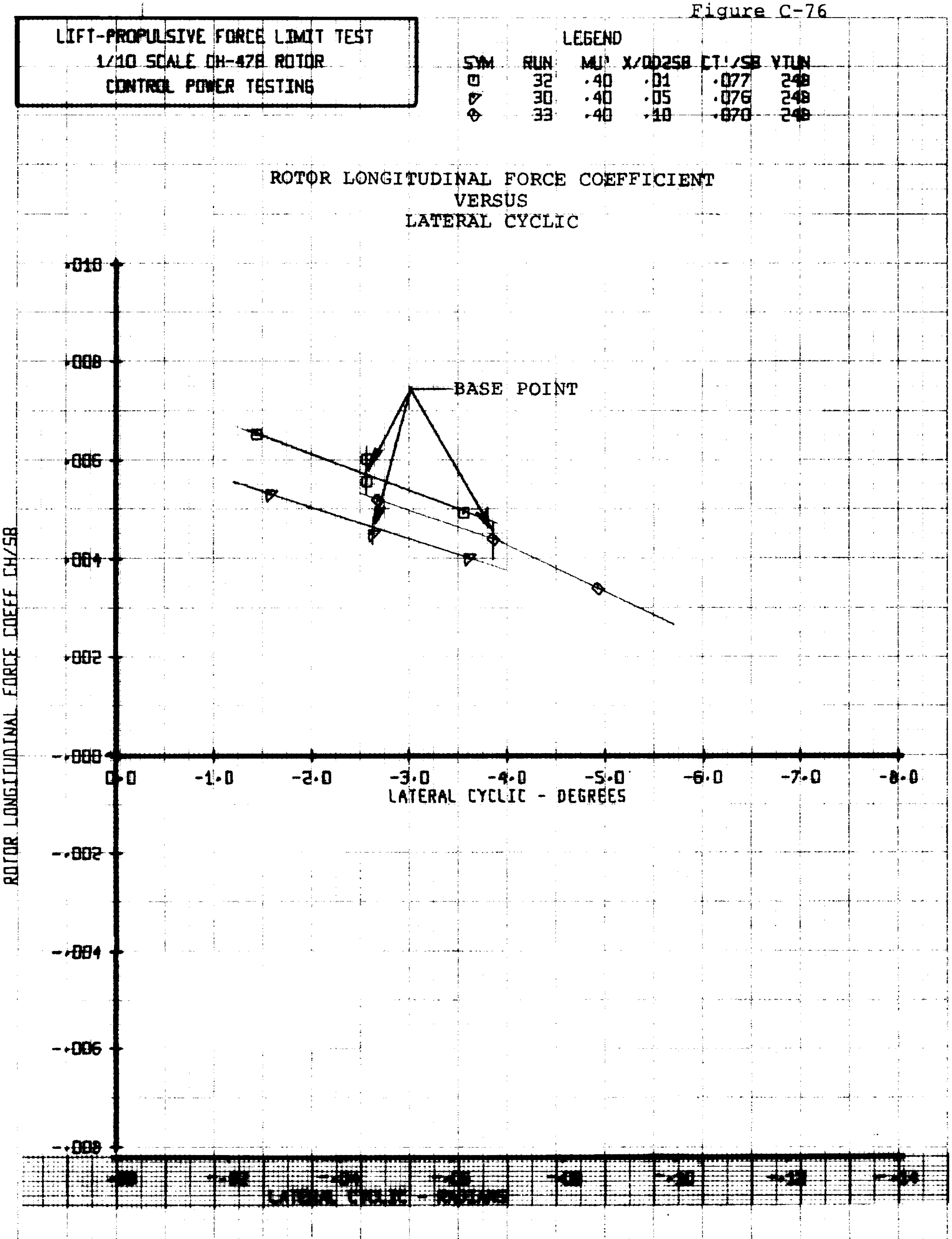
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .077 248
30 .40 .05 .076 248
33 .40 .10 .070 248
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMR
LATERAL CYCLIC - DEGREES
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0

Figure C-75



SET 15
BVWT 187

Figure C-76



ET 15
WT 187

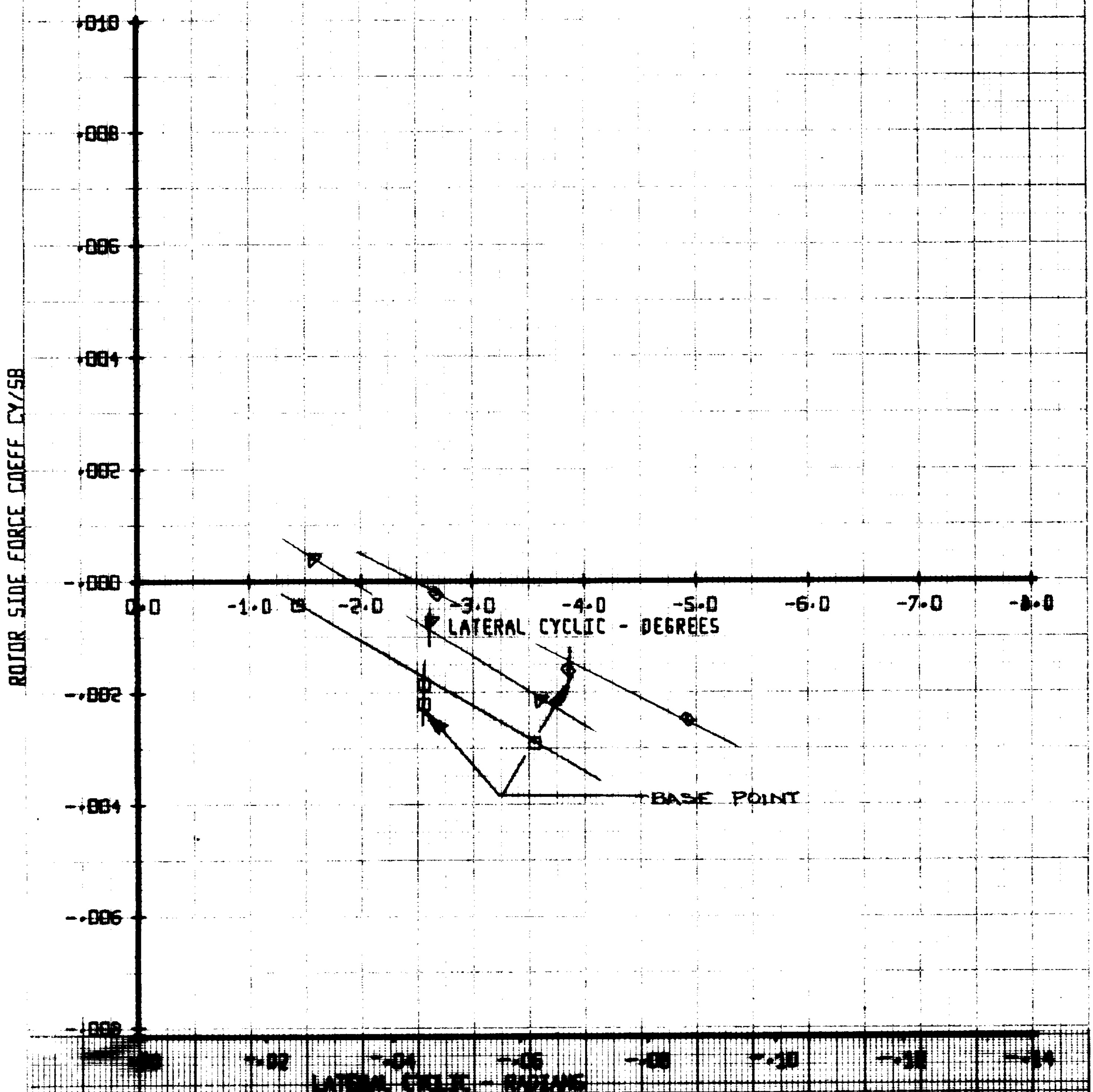
SET 15
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
□	32	.40	.01	.077	240
▽	30	.40	.05	.076	240
◇	33	.40	.10	.070	240

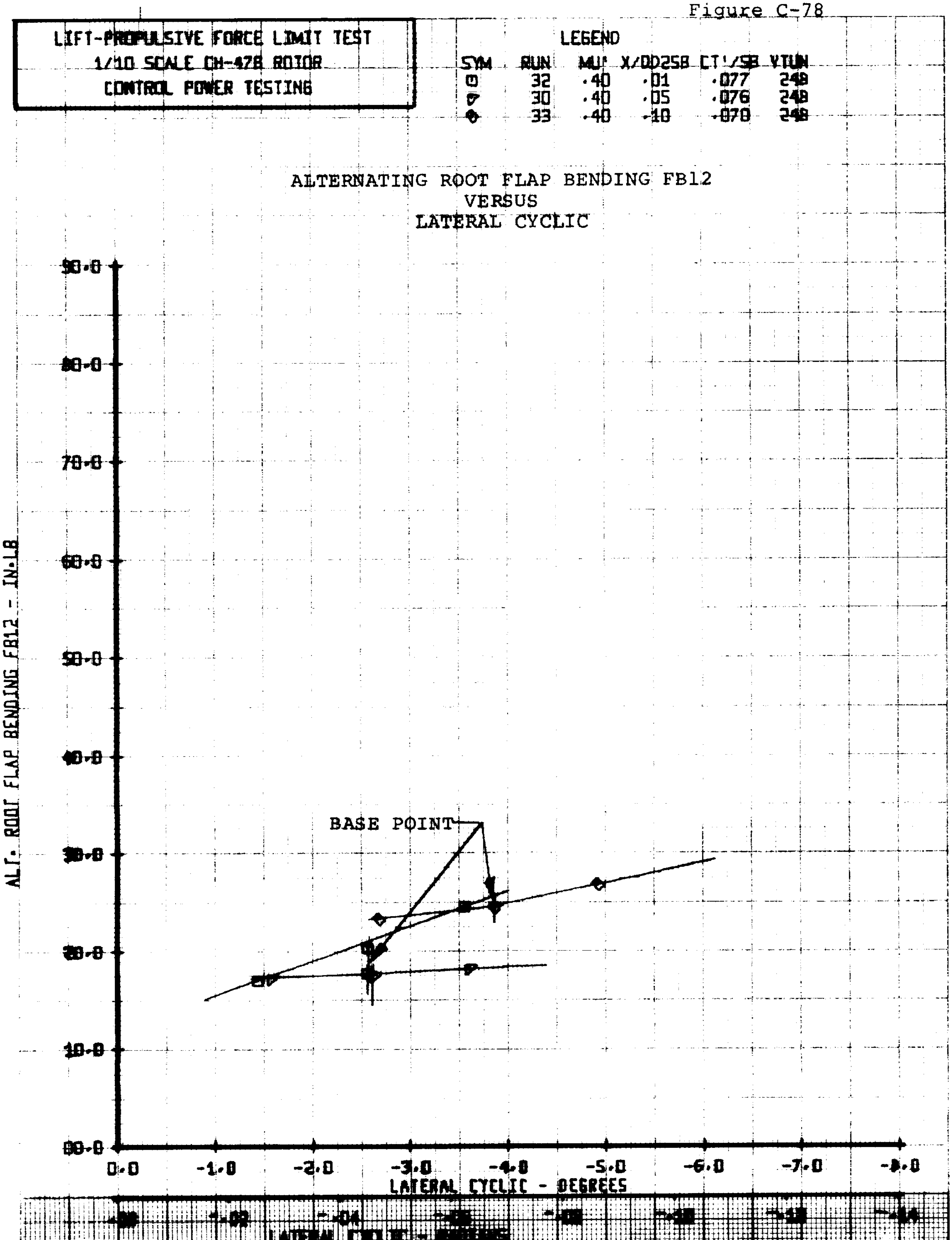
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC



ET 15
WT 187

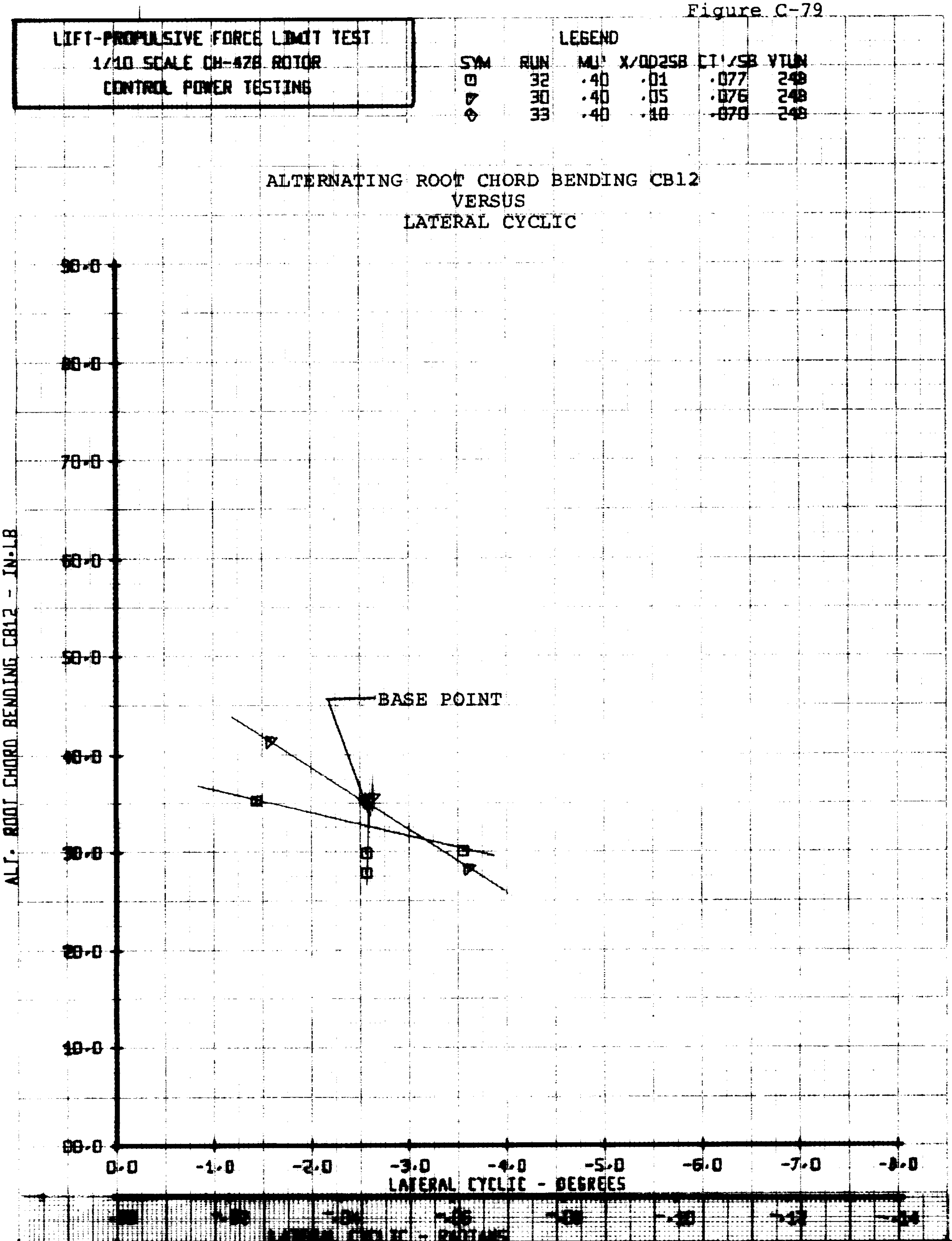
SET 15
BVWT 187

Figure C-78



SET 15
BVWT 187

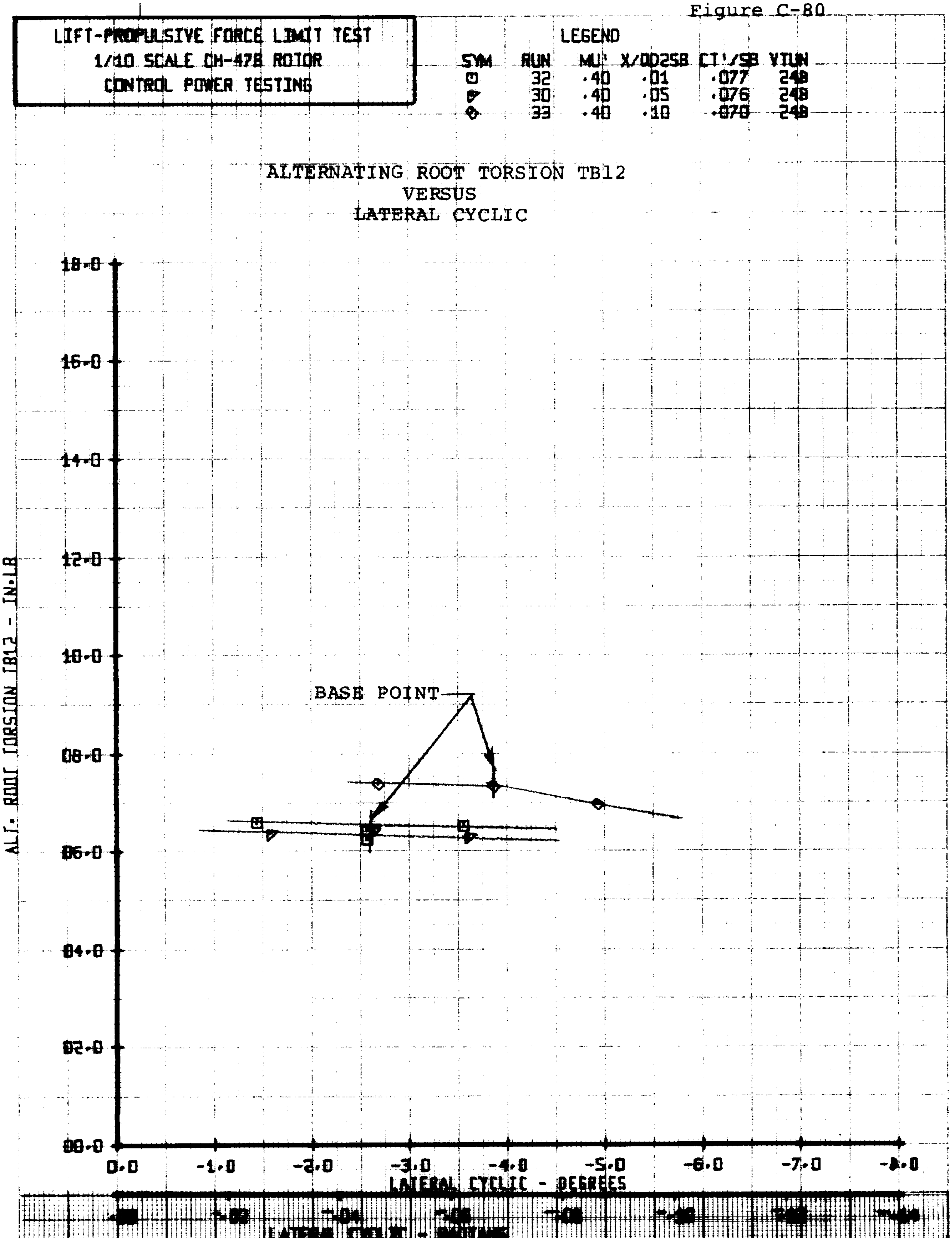
Figure C-79



SET 15
BVWT 187

SET 15
BVWT 187

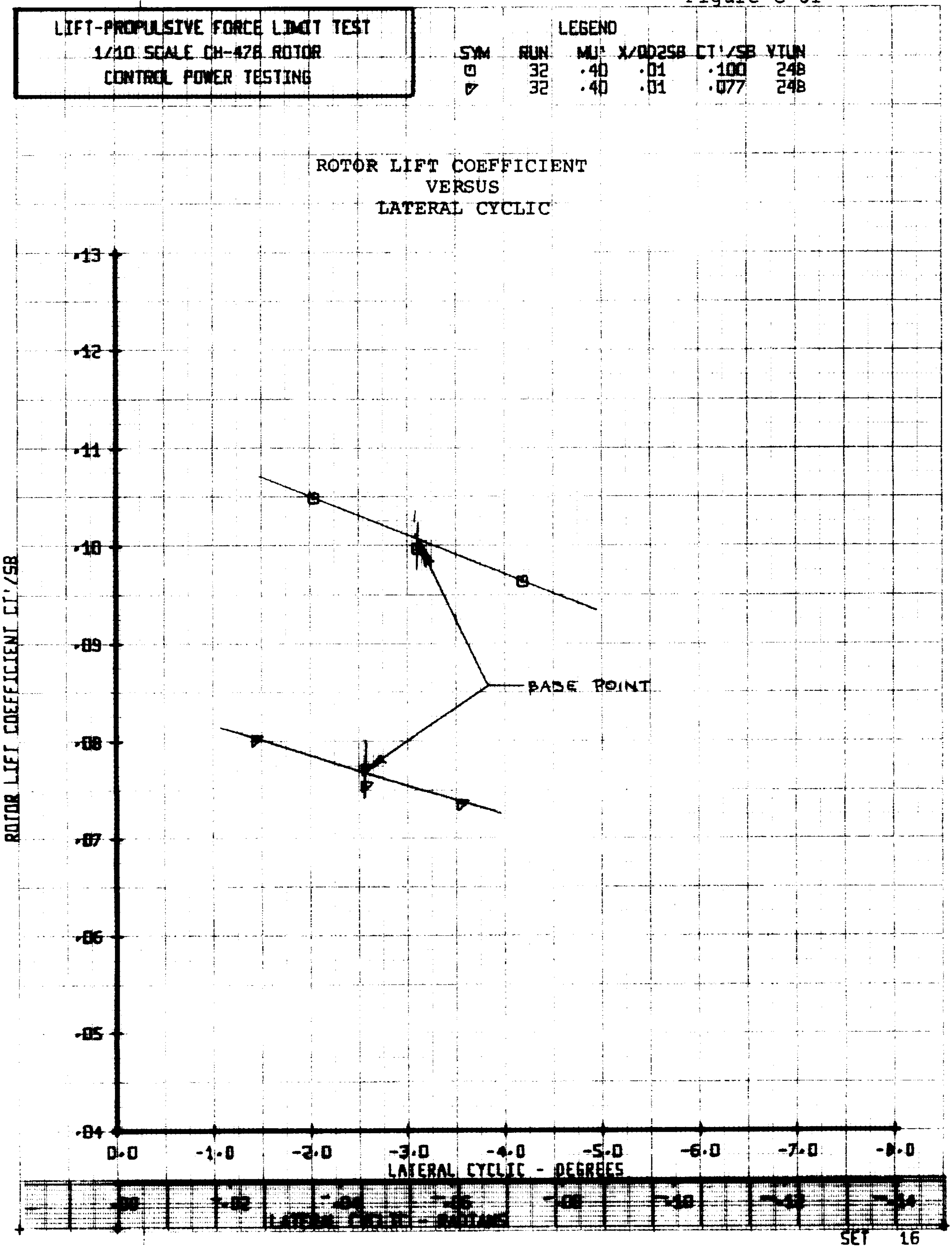
Figure C-80



ET 15
WT 187

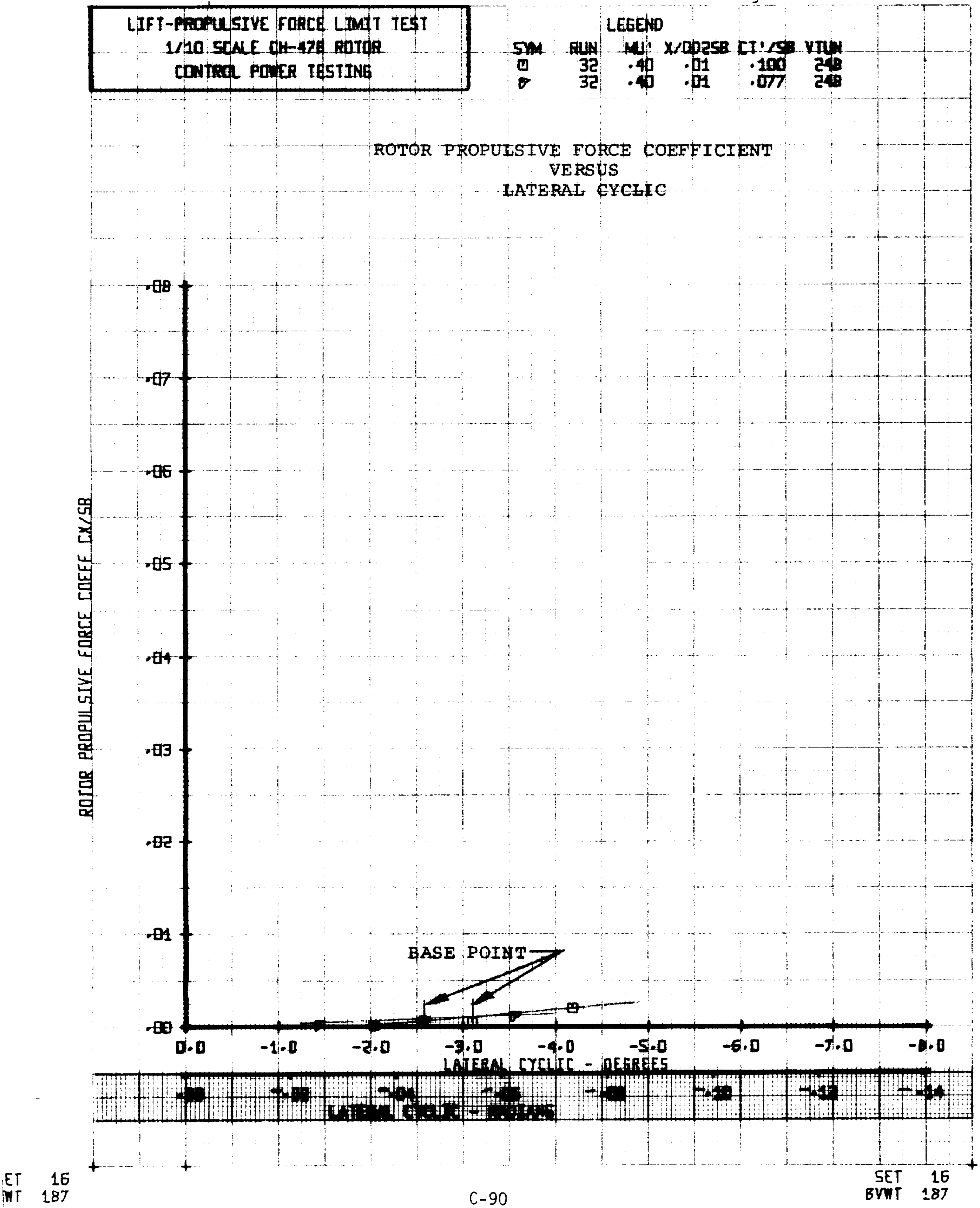
SET 15
BVWT 187

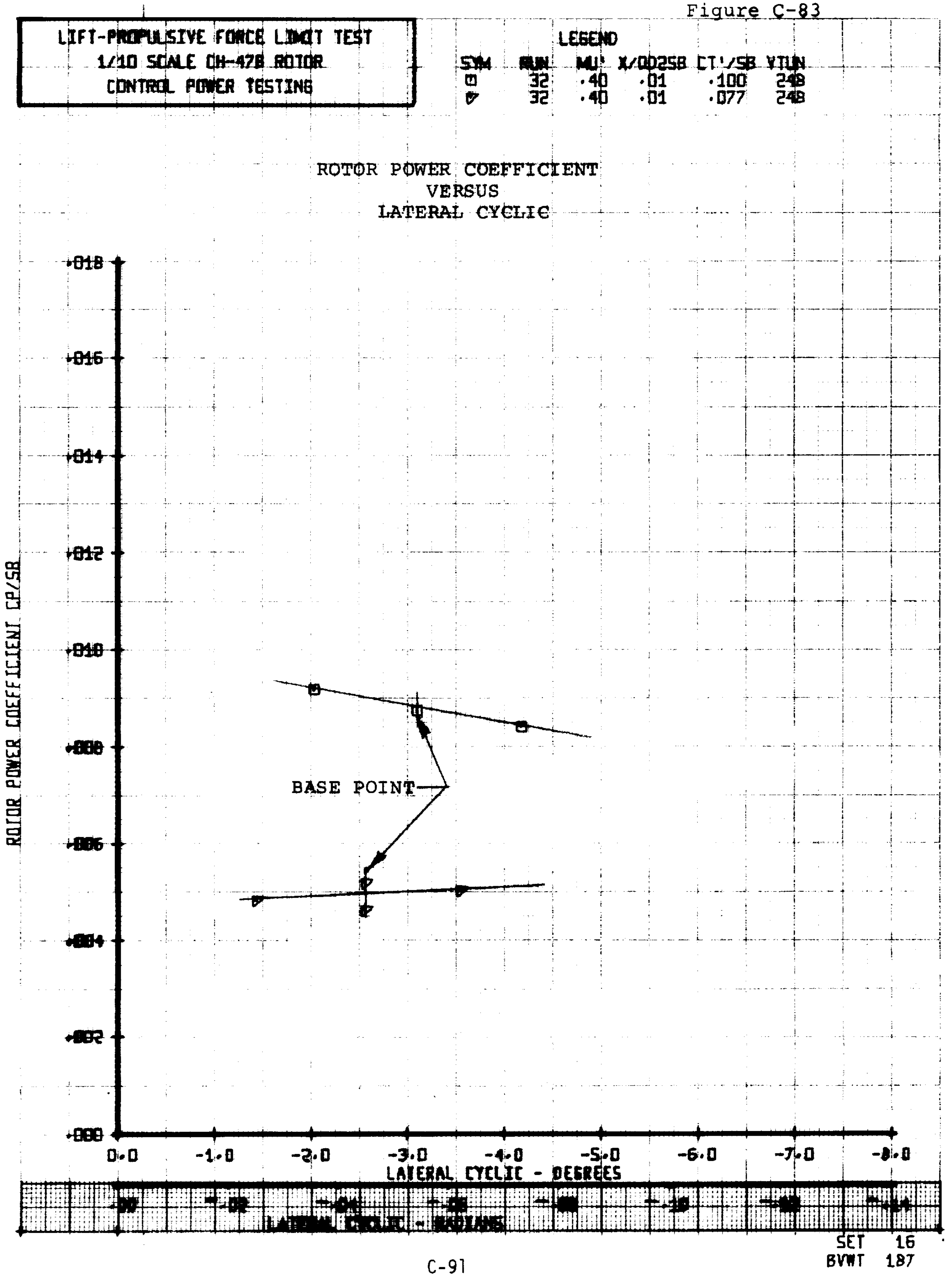
Figure C-81



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .077 248
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
BASE POINT
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
LATERAL CYCLIC - DEGREES
SET 16
BVWT 187

Figure C-82


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD25B CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .077 248
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR PROPULSIVE FORCE COEFF CX/SB
BASE POINT
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
ET 16
WT 187
SET 16
BVWT 187


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .077 248
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 16
BVWT 187

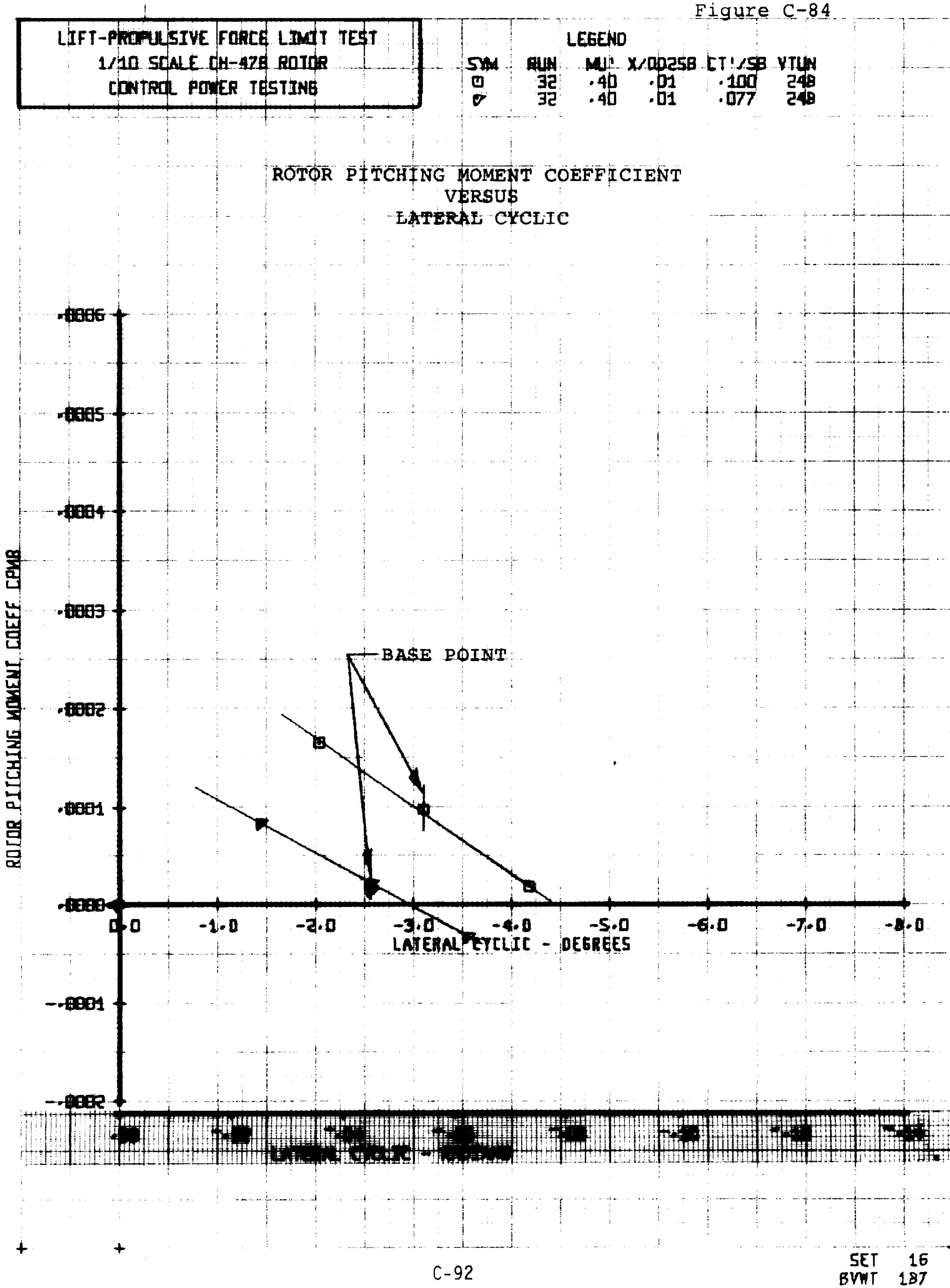
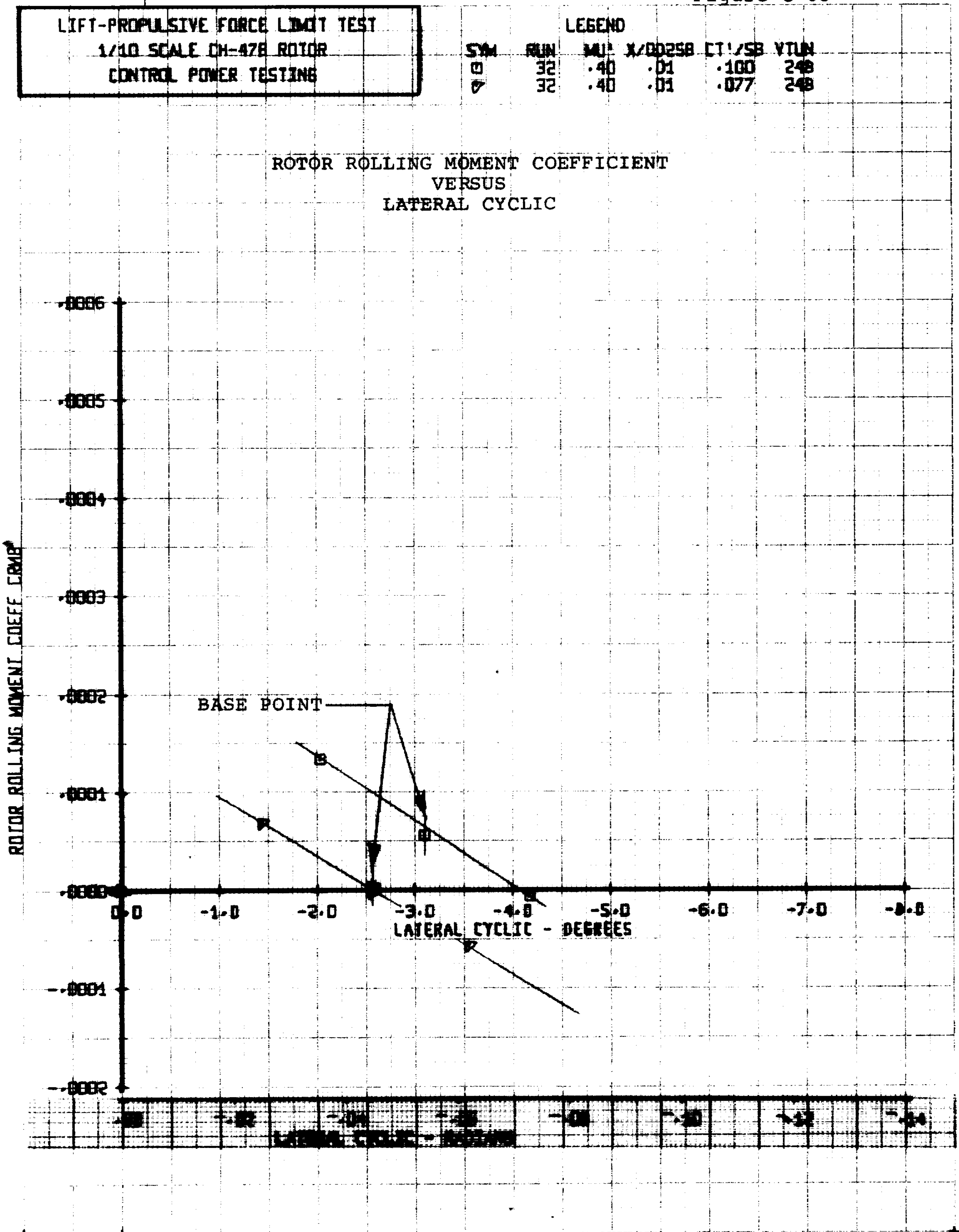

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/OD25B CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .077 248
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 16
BVWT 187

Figure C-85



ET 16
WT 187

SET 16
BVWT 187

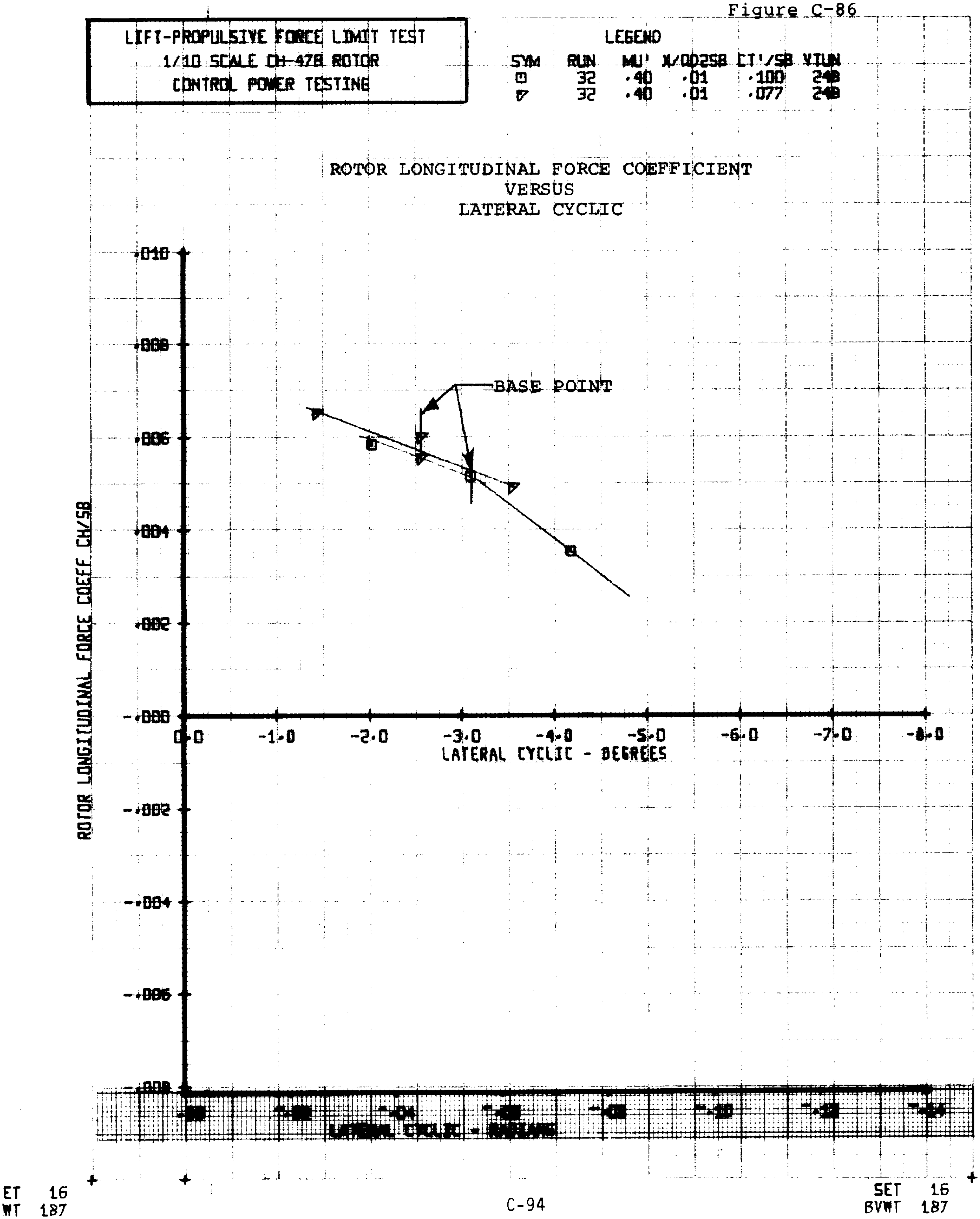
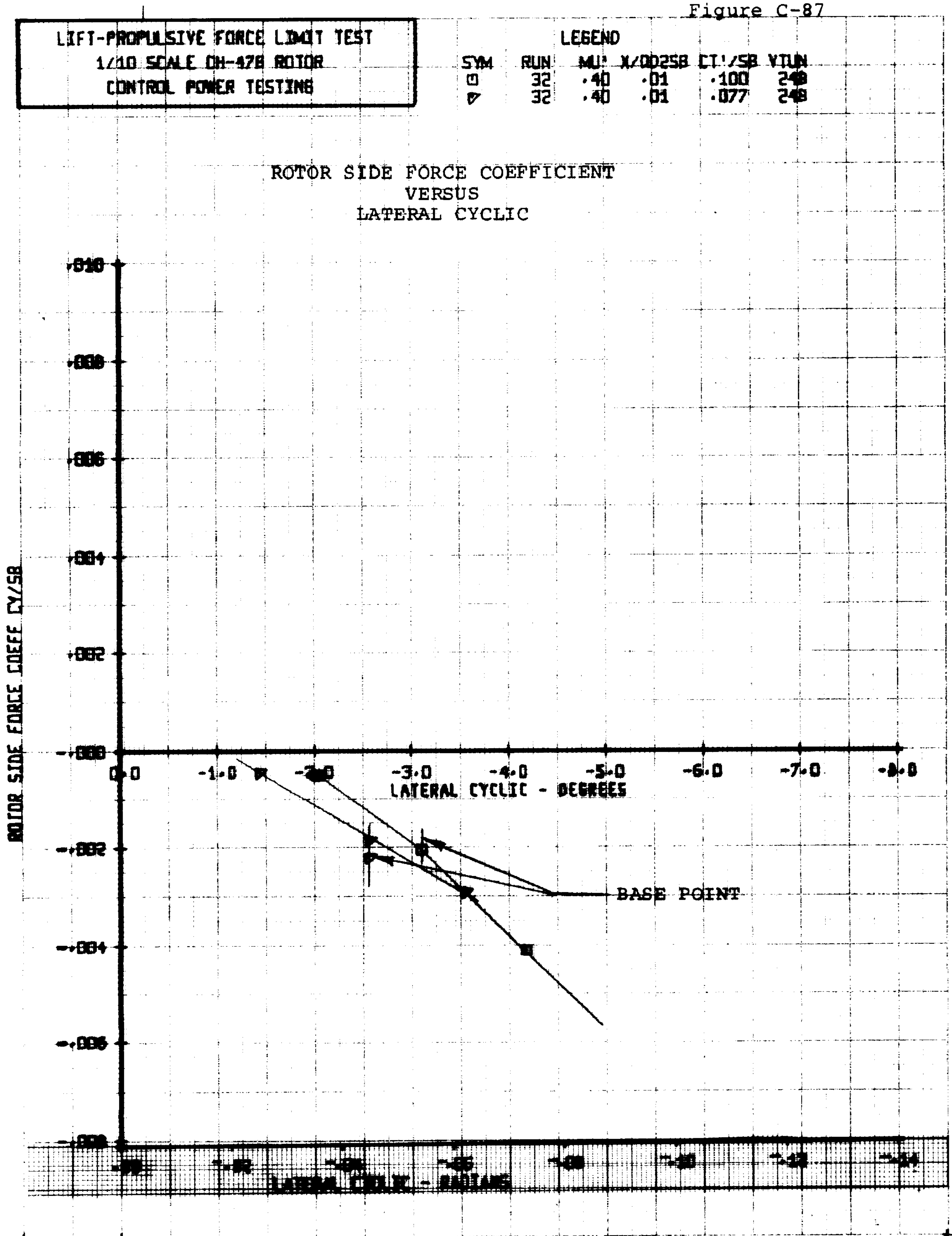

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .077 248
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR LONGITUDINAL FORCE COEFF CH/SB
LATERAL CYCLIC - DEGREES
.010
.008
.006
.004
.002
-.000
-.002
-.004
-.006
-.008
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
SET 16
BVWT 187

Figure C-87



SET 16
BVWT 187

SET 16
BVWT 187

Figure C-88

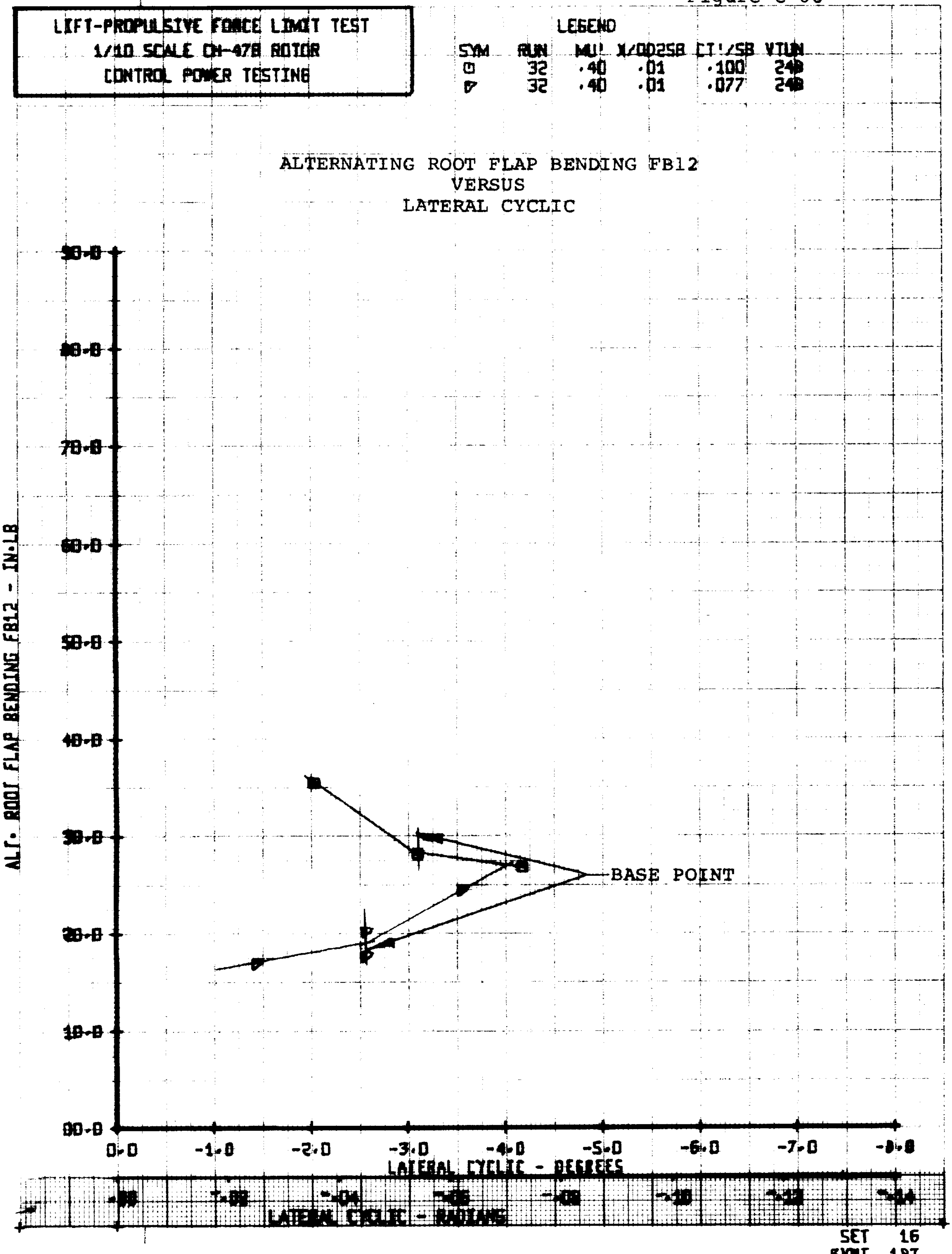

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU! X/QD2SB CT'/SB VTUN
32 .40 .01 .100 240
32 .40 .01 .077 240
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LATERAL CYCLIC
ALT. ROOT FLAP BENDING FB12 - IN-LB
BASE POINT
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 16
BVWT 187

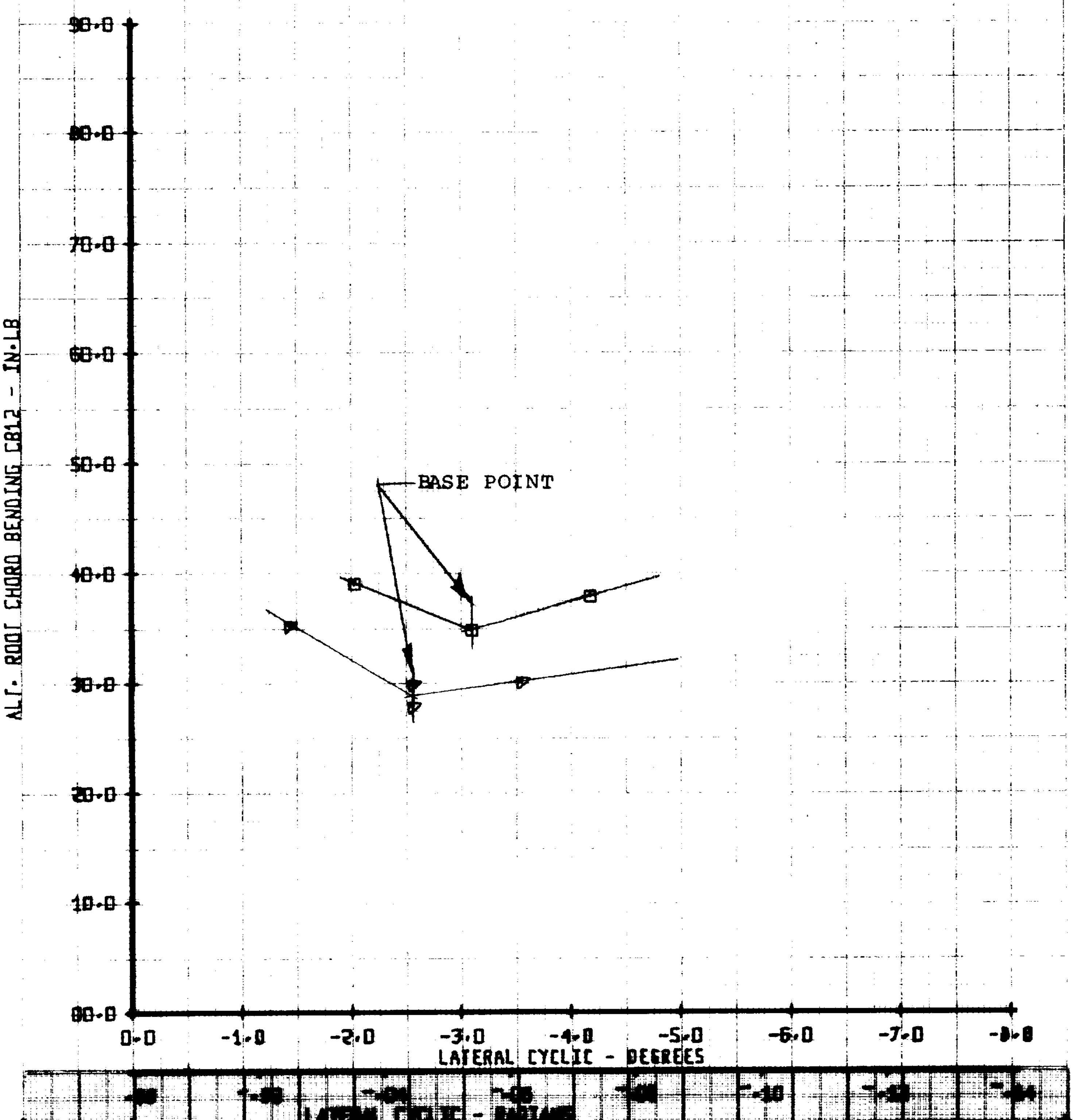
Figure C-89

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

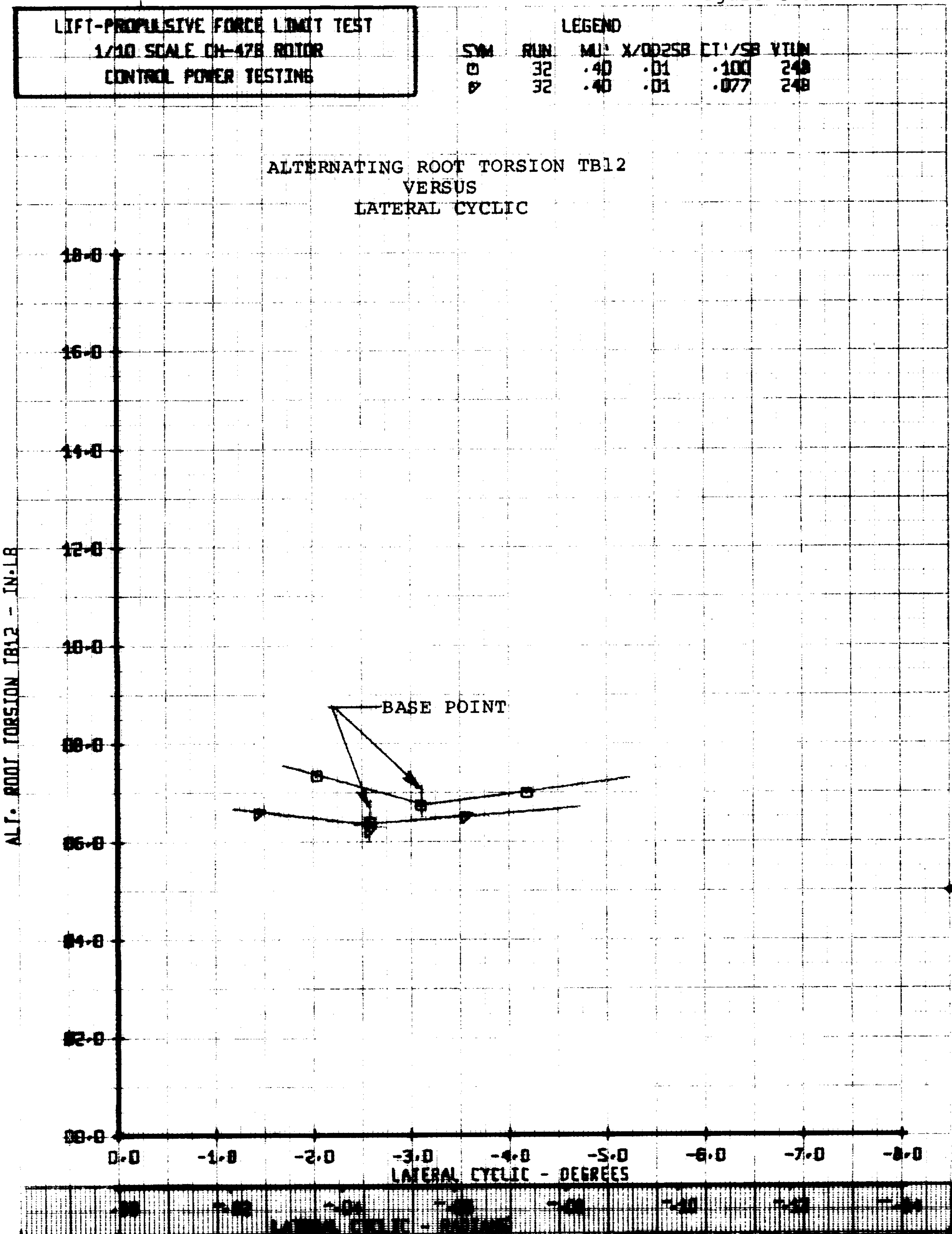
SYM	RUN	MU	X/QD2SB	CT'/SB	VTUN
⊡	32	.40	.01	.100	248
▽	32	.40	.01	.077	248

ALTERNATING ROOT CHORD BENDING CB12
VERSUS
LATERAL CYCLIC



SET 16
BVWT 187

Figure C-90



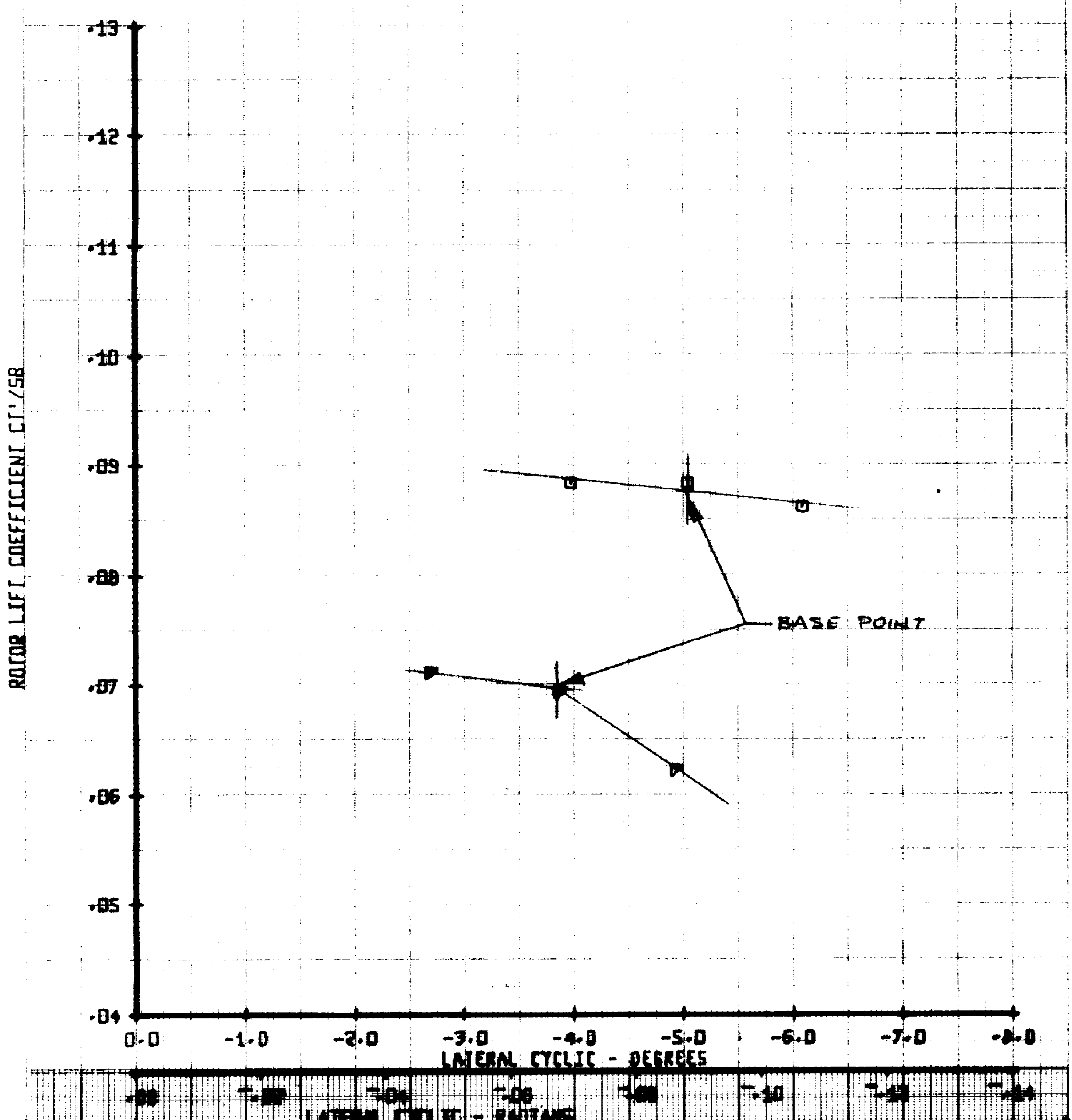
SET 16
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/DD25B	CT'/SB	VTUN
□	33	.40	.10	.088	249
▽	33	.40	.10	.070	249

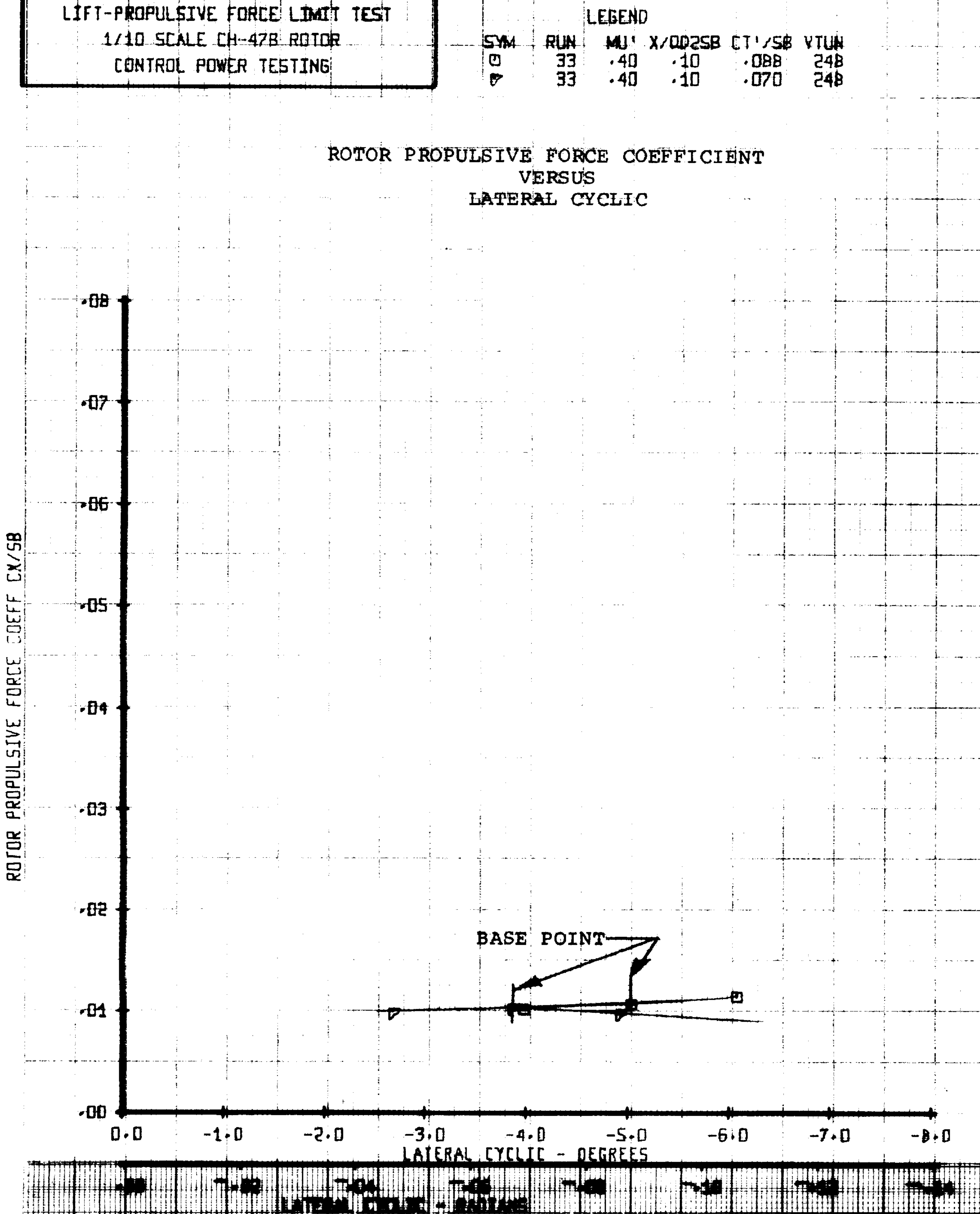
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC



SET 17
WT 187

SET 17
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING



SET 17
BVWT 187

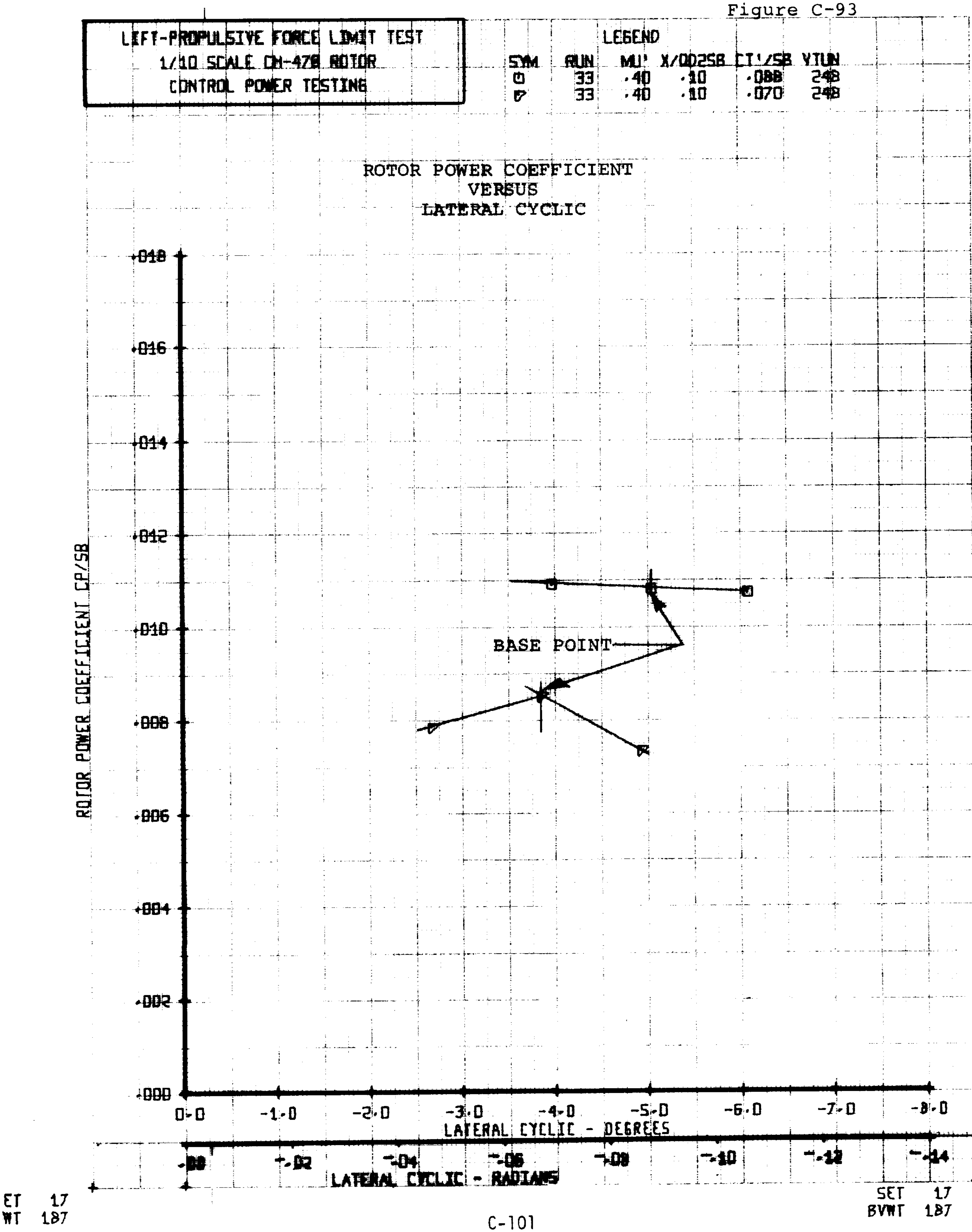
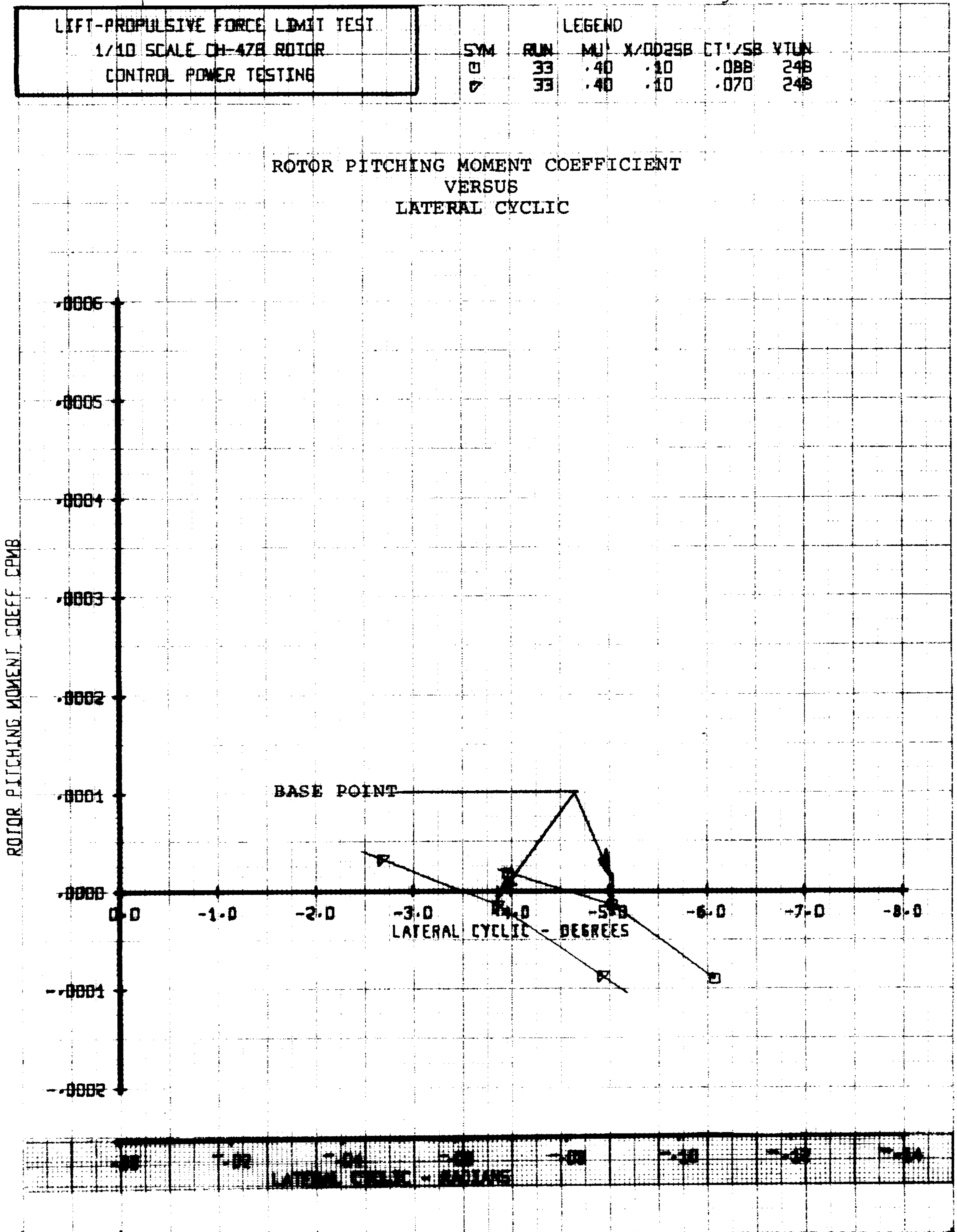
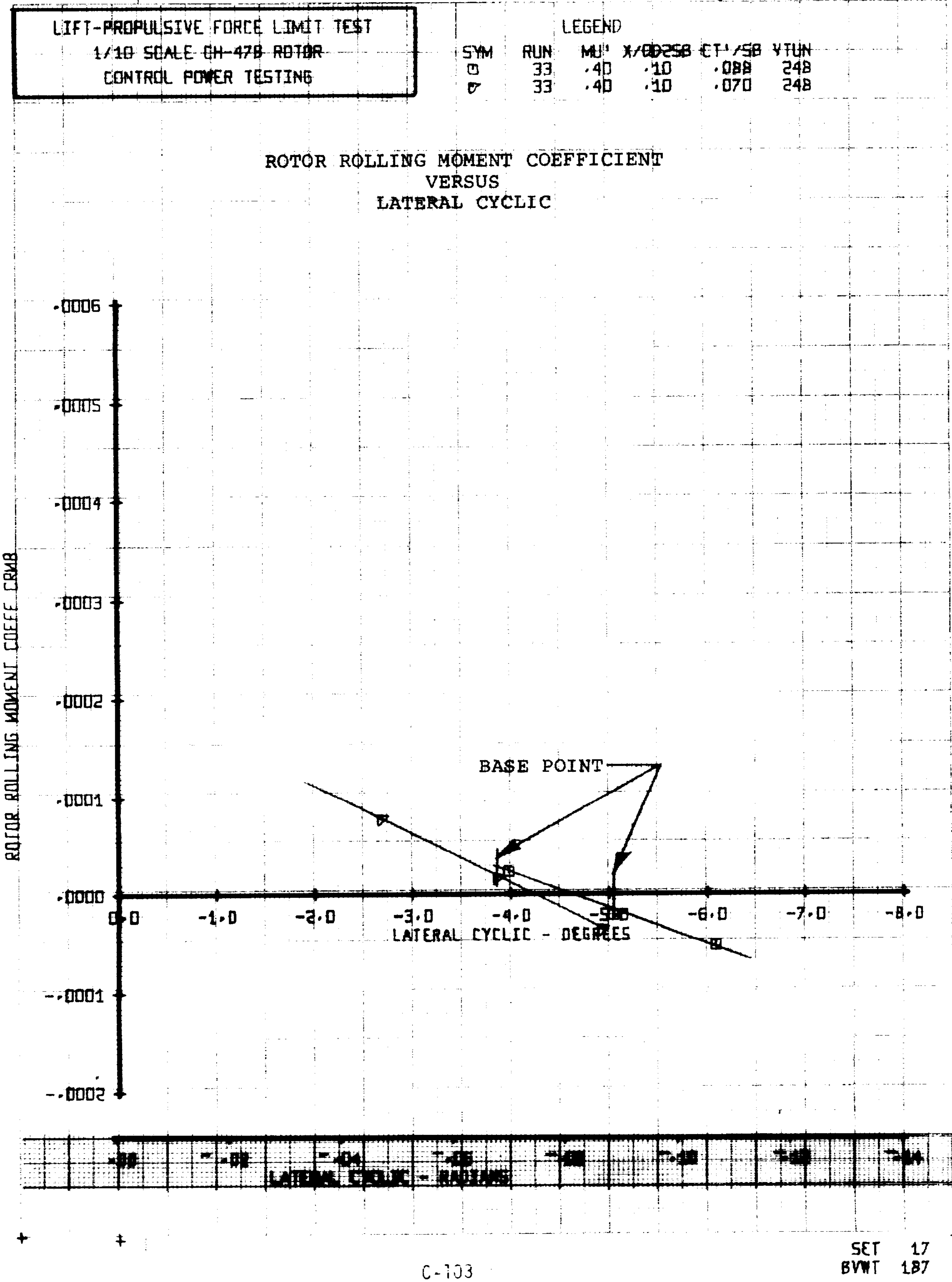

LEFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
33 .40 .10 .088 248
33 .40 .10 .070 248
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
.00
-.02
-.04
-.06
-.08
-.10
-.12
-.14
LATERAL CYCLIC - RADIANS
ET 17
WT 187
SET 17
BVWT 187

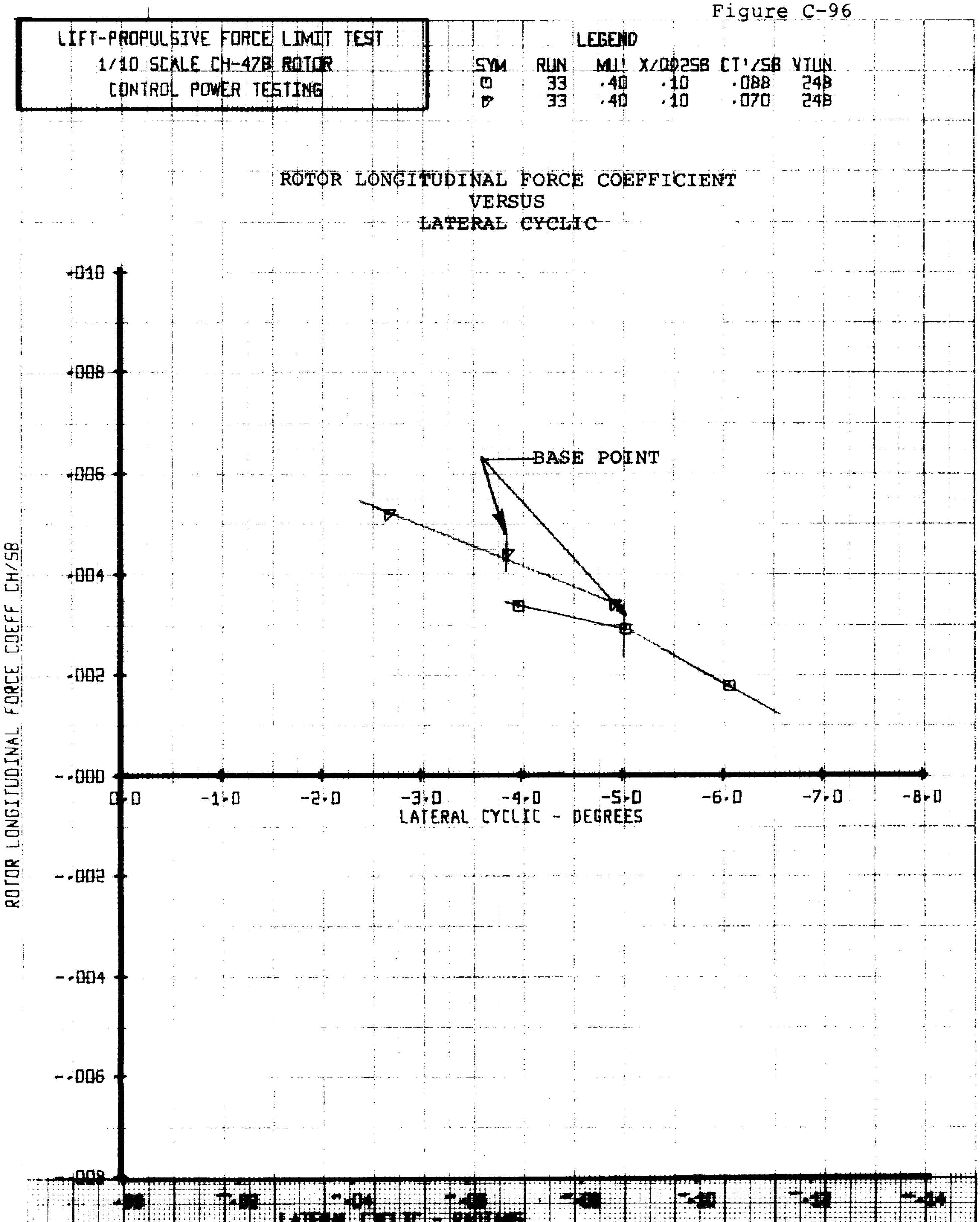
Figure C-94



ET 17
WT 187

SET 17
BVWT 187

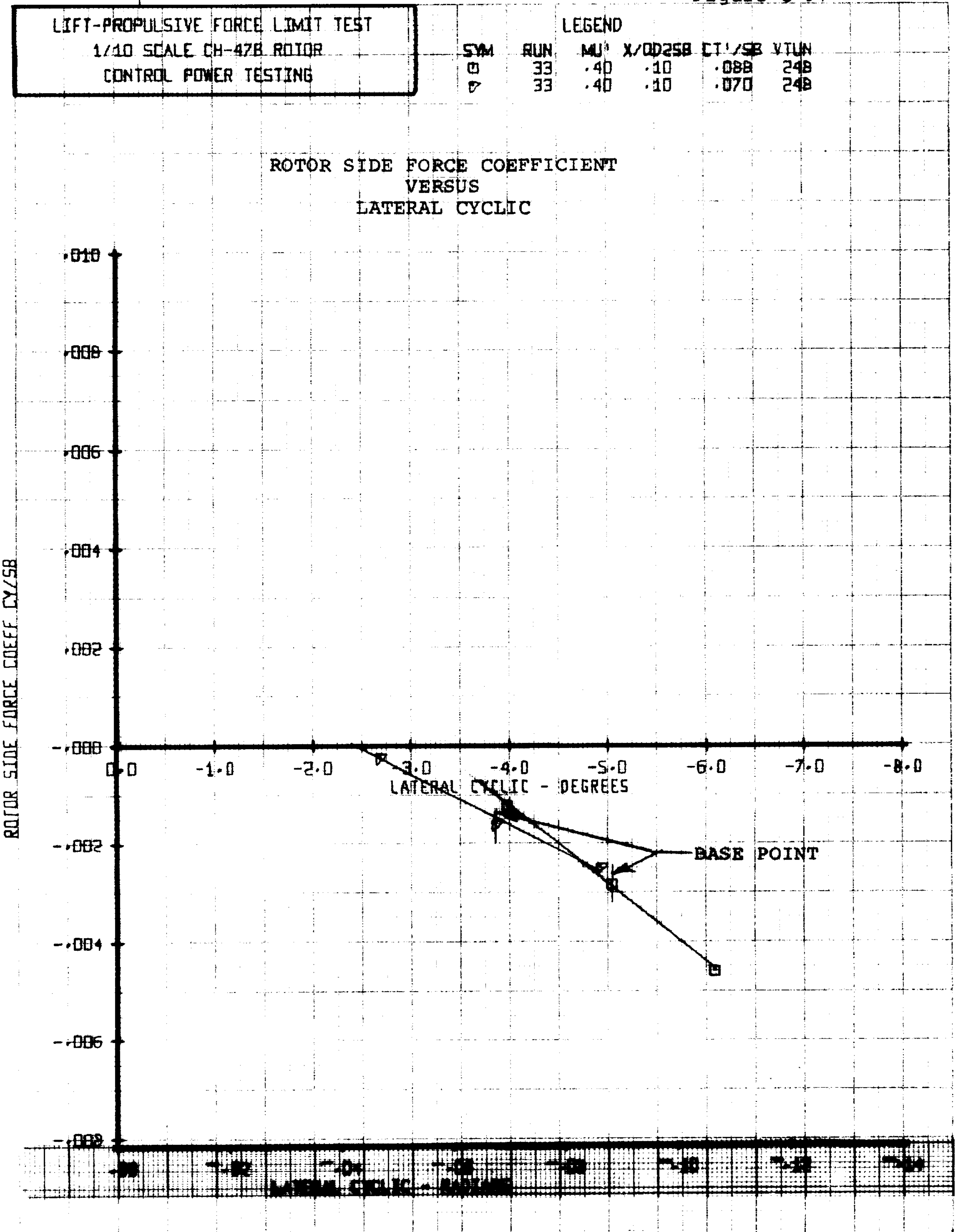

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
33 .40 .10 .088 248
33 .40 .10 .070 248
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR ROLLING MOMENT COEFF CRMB
BASE POINT
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 17
BVWT 187



ET 17
WT 187

SET 17
BVWT 187

Figure C-97



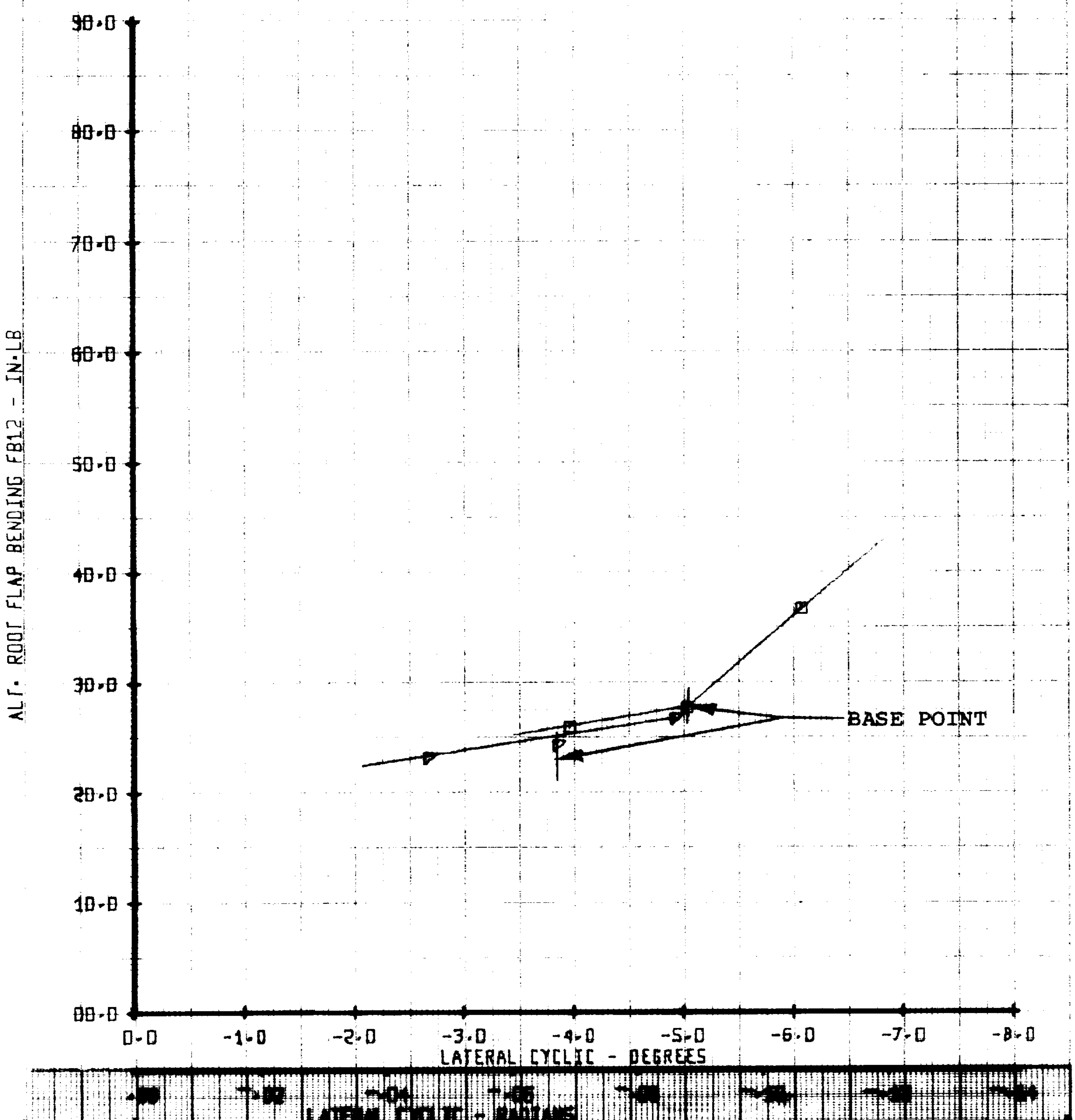
SET 17
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU	X/OD25B	CT'/SB	VTUN
□	33	.40	.10	.088	248
▽	33	.40	.10	.070	248

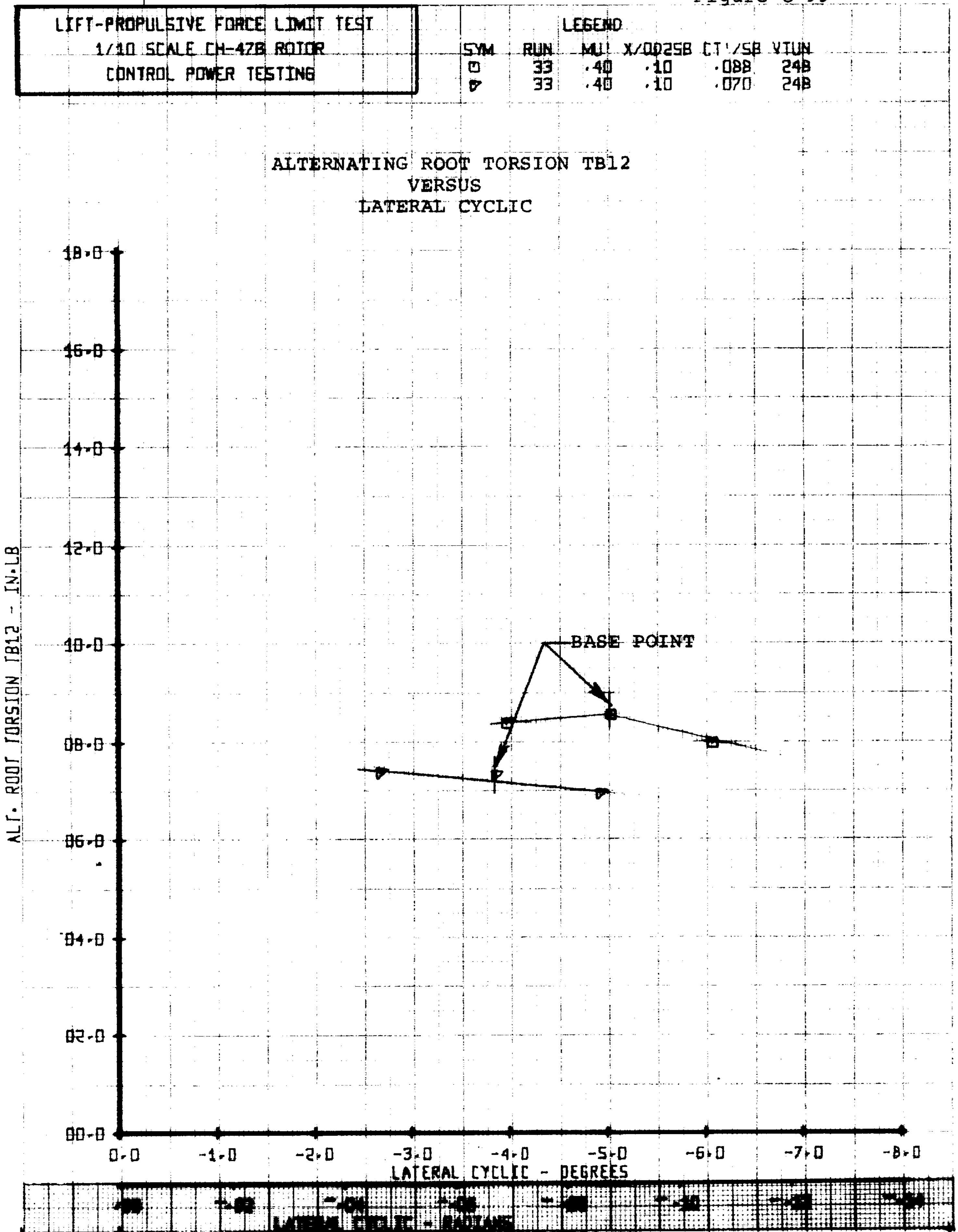
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LATERAL CYCLIC



ET 17
WT 187

SET 17
BVWT 187

Figure C-99



ET 17
WT 187

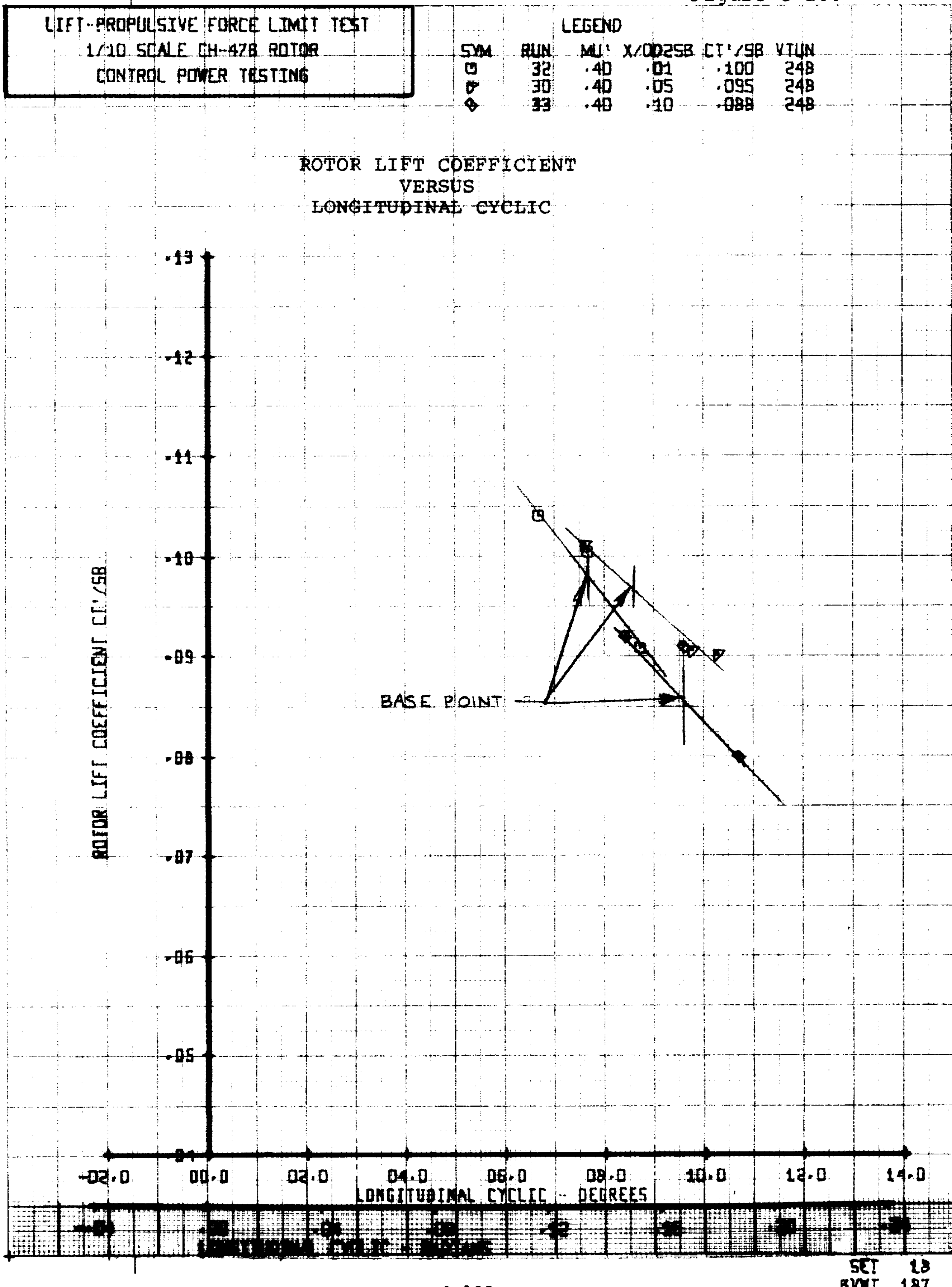
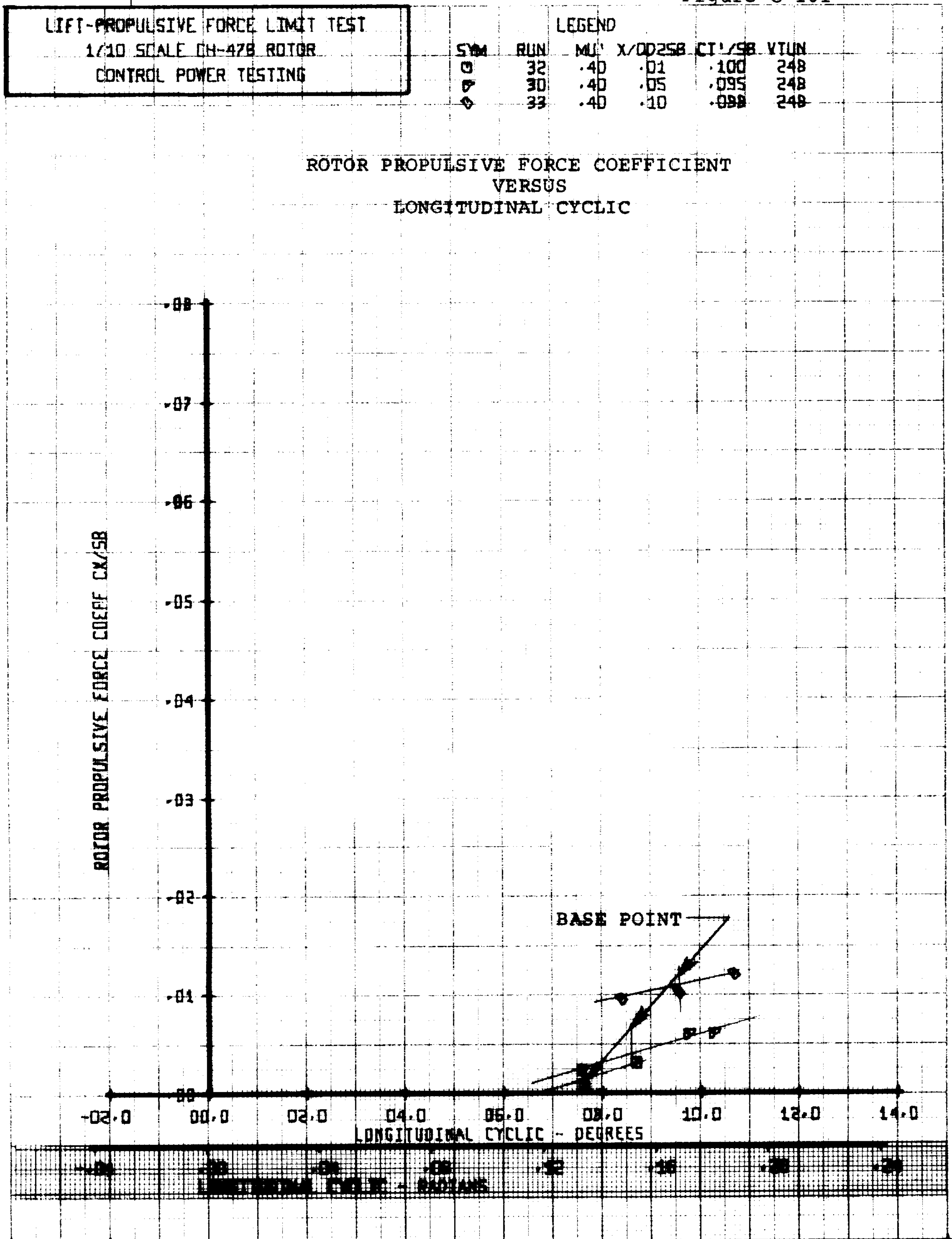
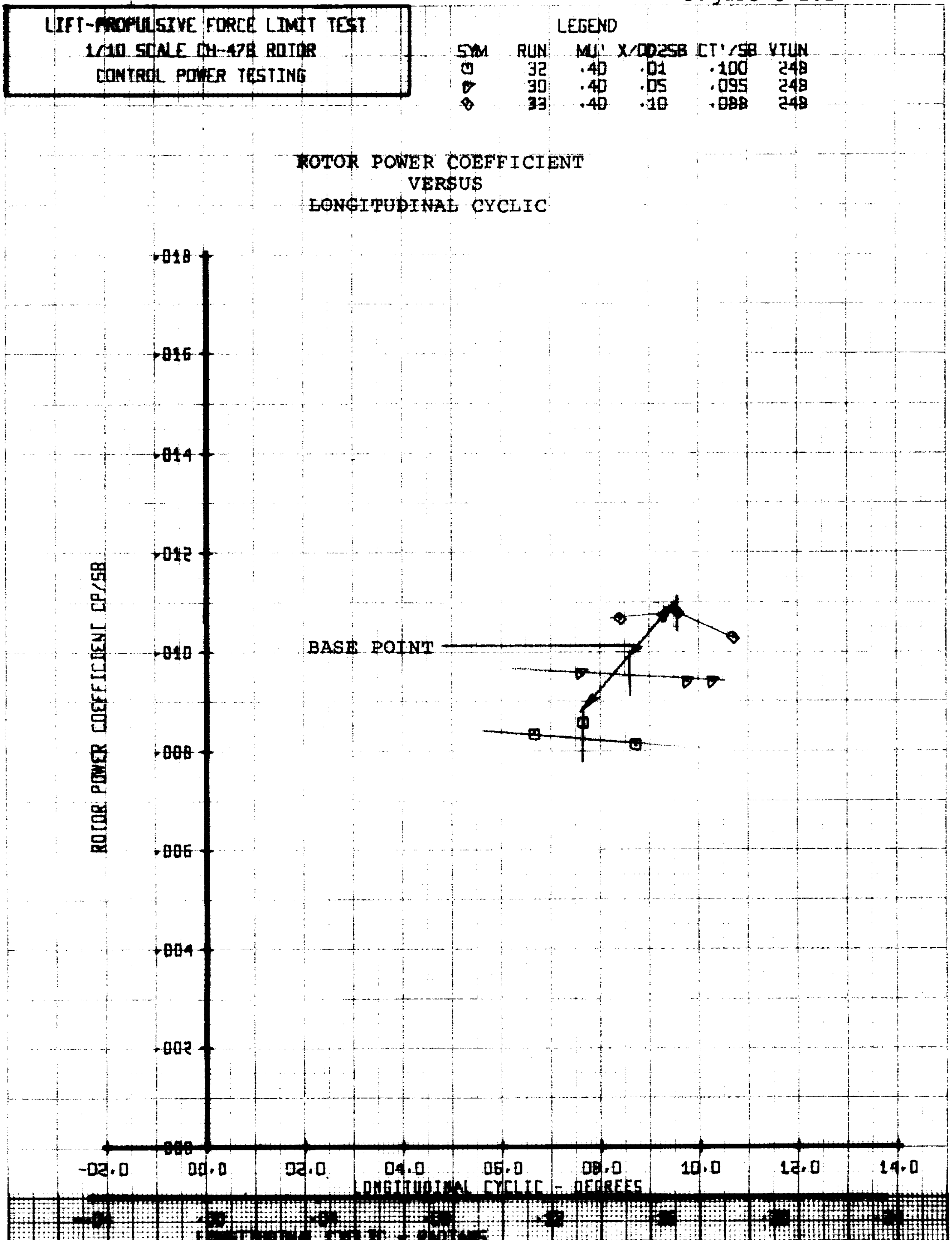

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN
32 .40 .01 .100 248
30 .40 .05 .095 248
33 .40 .10 .088 248
ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
BASE POINT
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 18
BVWT 187

Figure C-101



SET 13
BVWT 137

Figure C-102



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .100 248
30 .40 .05 .095 248
33 .40 .10 .088 248
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 18
BVWT 187

Figure C-103

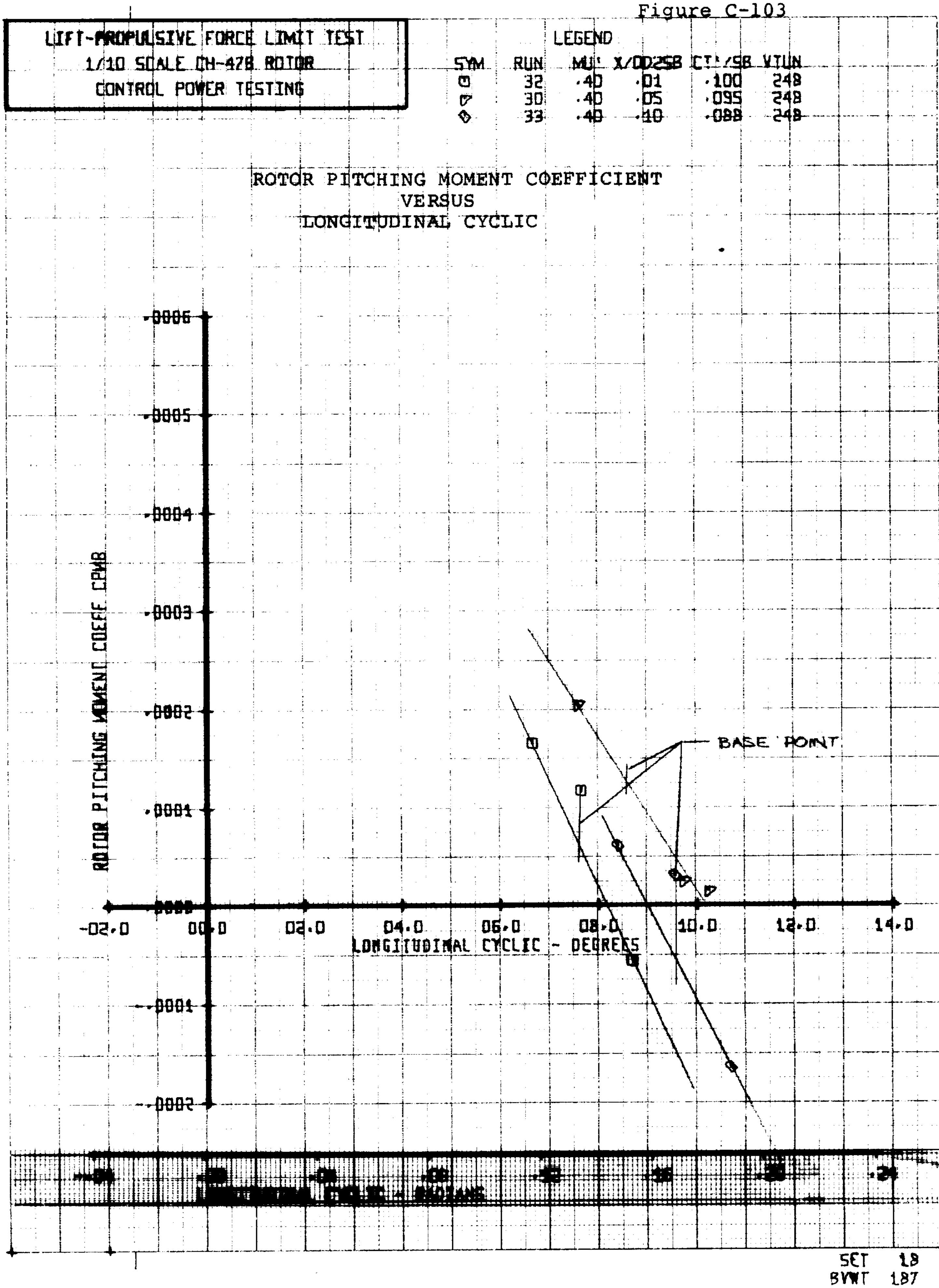
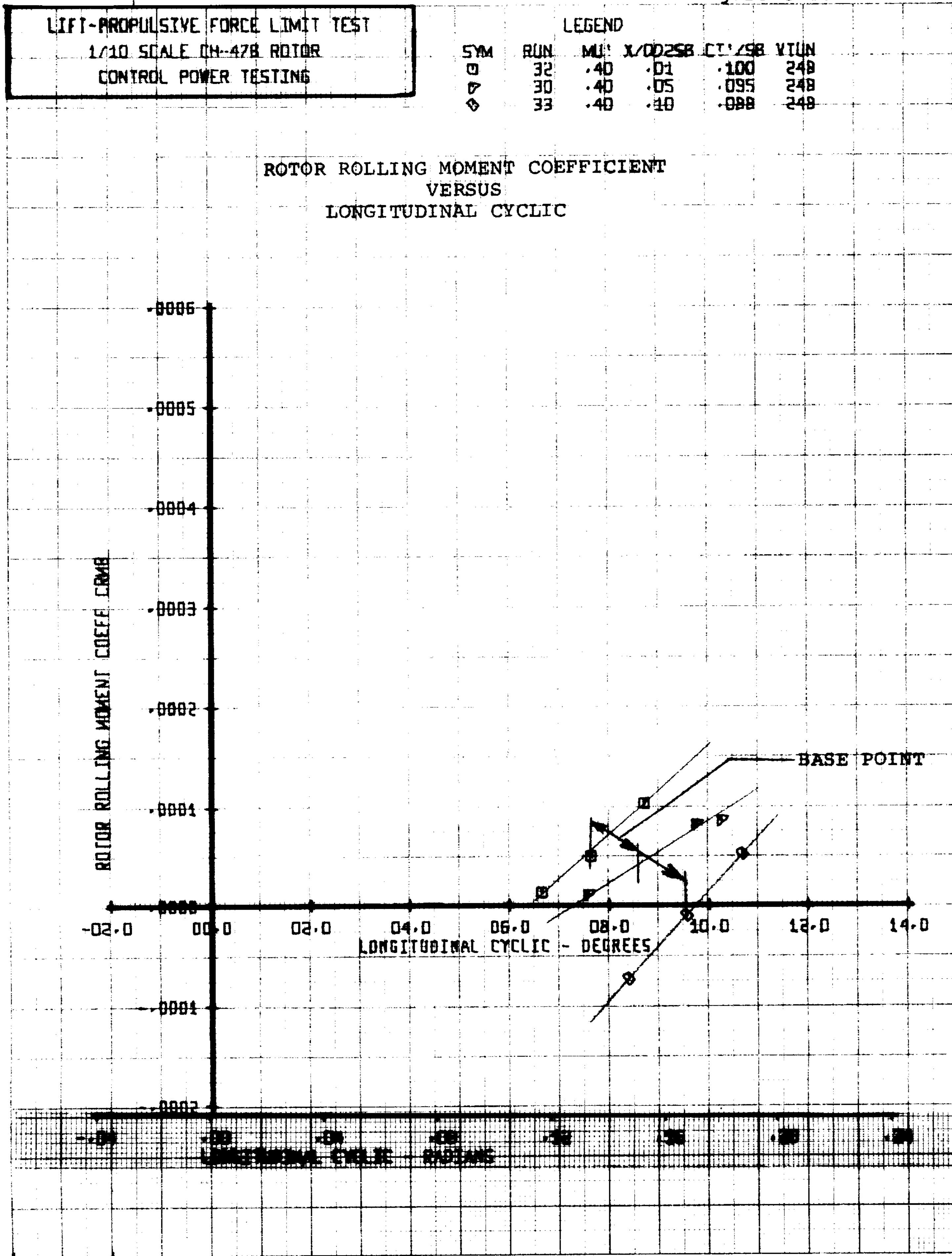

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD25B CT'/SB VTUN
32 .40 .01 .100 248
30 .40 .05 .095 248
33 .40 .10 .088 248
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR PITCHING MOMENT COEFF CPMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
BASE POINT
SET 18
BYWT 187

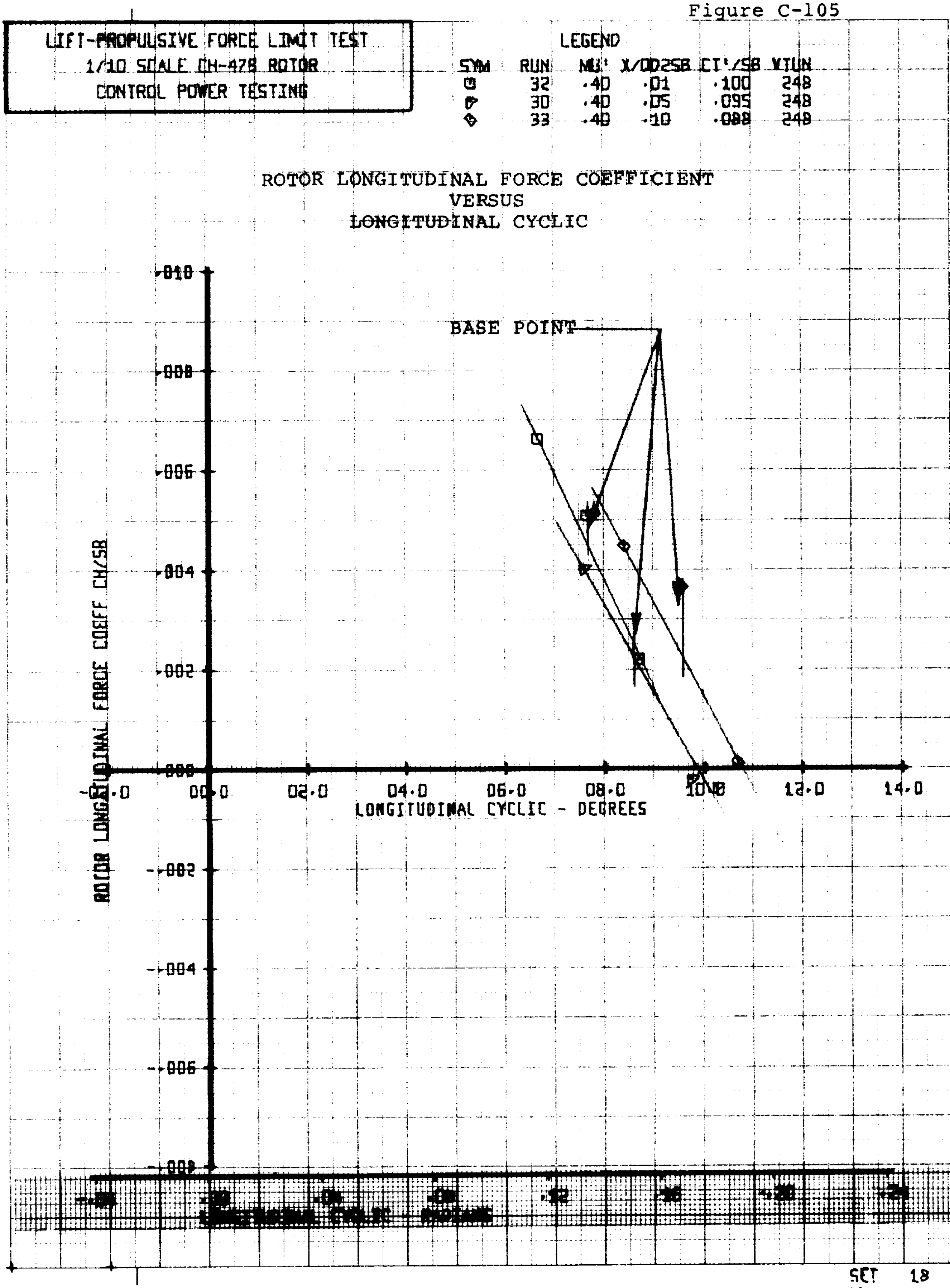
Figure C-104



SET 18
BVWT 187

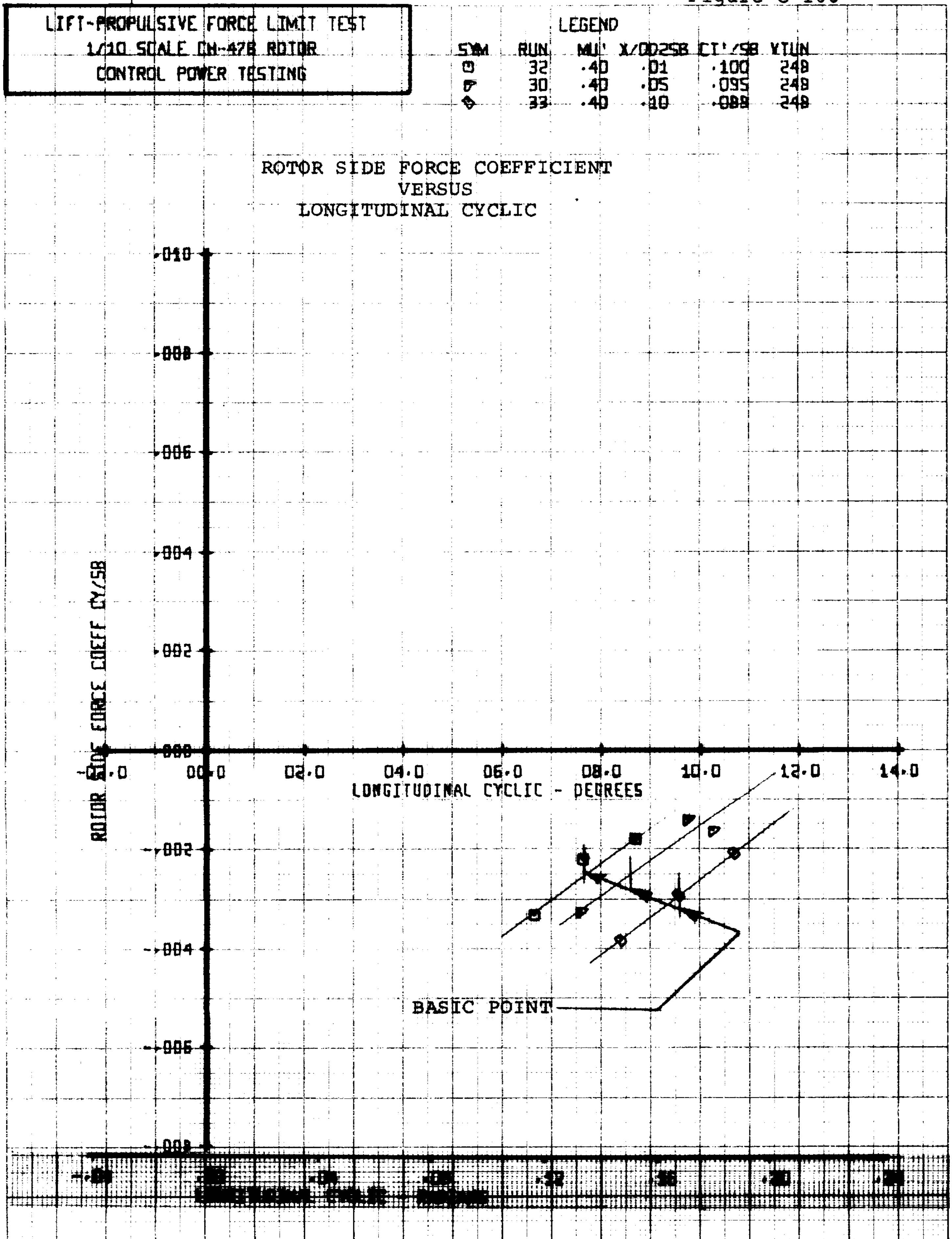
SET 18
BVWT 187

Figure C-105



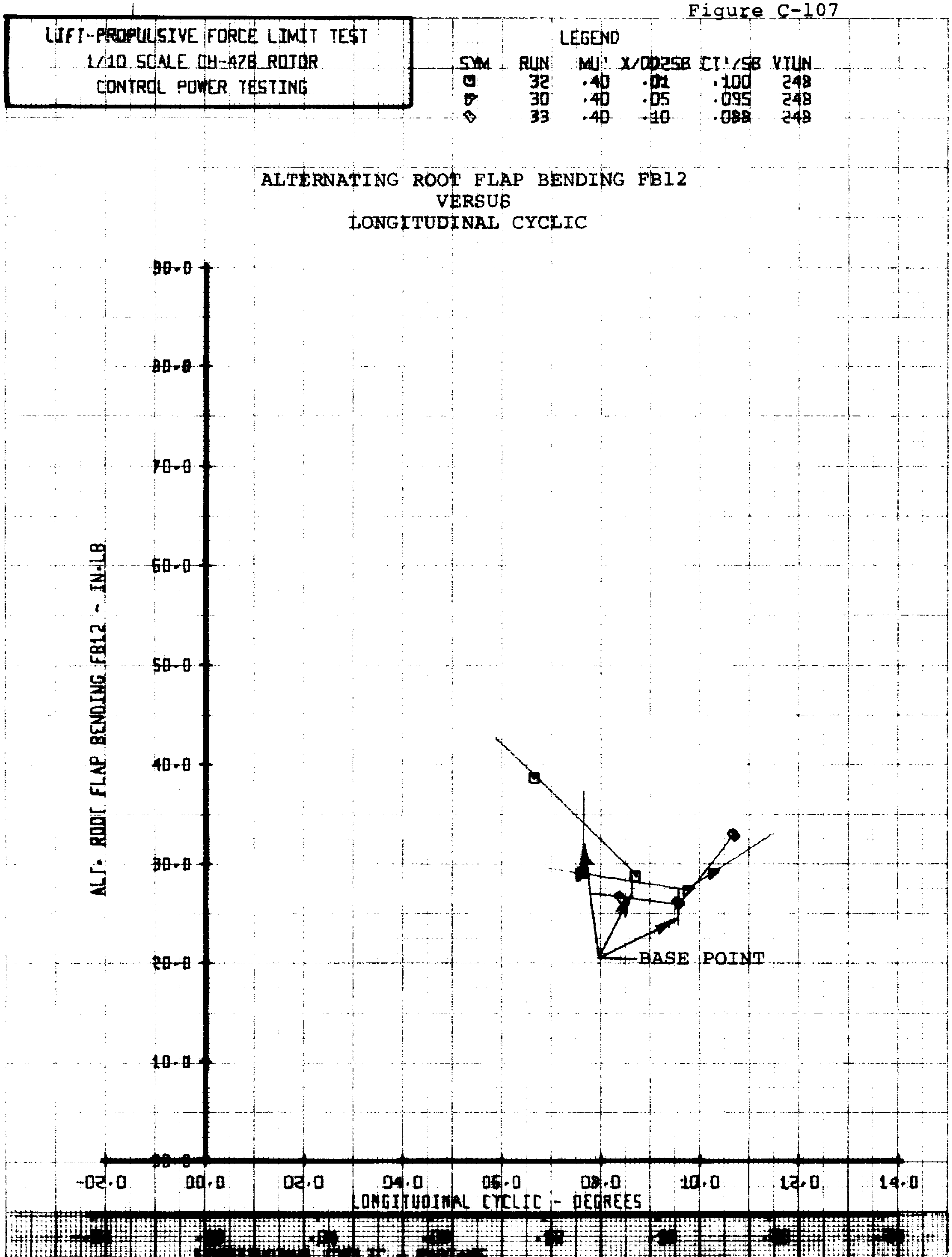
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD2SB CT'/SB VTUN
32 .40 .01 .100 248
30 .40 .05 .095 248
33 .40 .10 .088 248
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR LONGITUDINAL FORCE COEFF CH/SB
LONGITUDINAL CYCLIC - DEGREES
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
SET 18
BVWT 187

Figure C-106



SET 18
BVWT 187

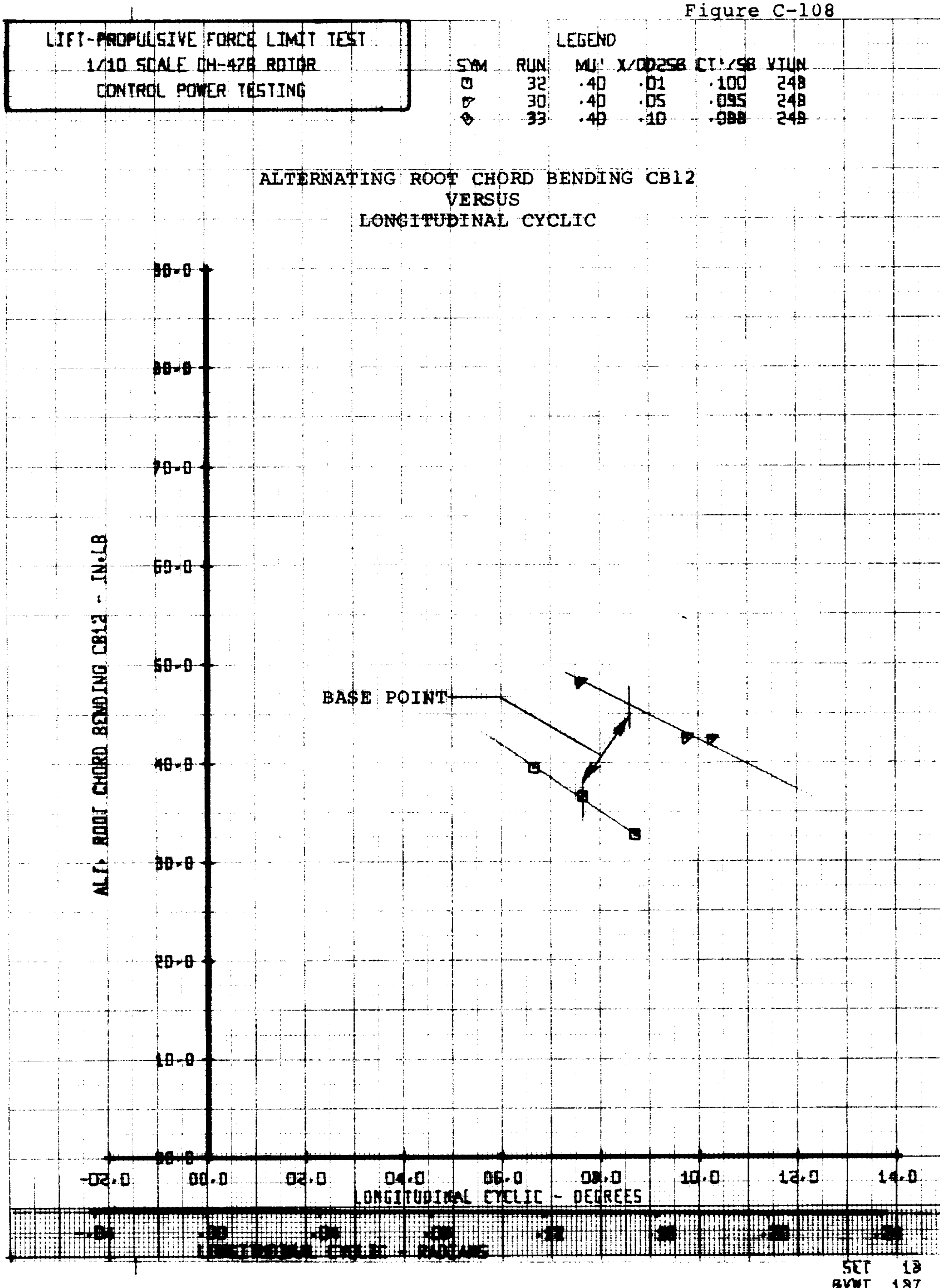
Figure C-107



ET 18
WT 187

SET 13
BYWT 187

Figure C-108


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .100 248
30 .40 .05 .095 248
33 .40 .10 .088 248
ALTERNATING ROOT CHORD BENDING CB12
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ALT. ROOT CHORD BENDING CB12 - IN.LB
LONGITUDINAL CYCLIC - DEGREES
SET 18
BVWT 187

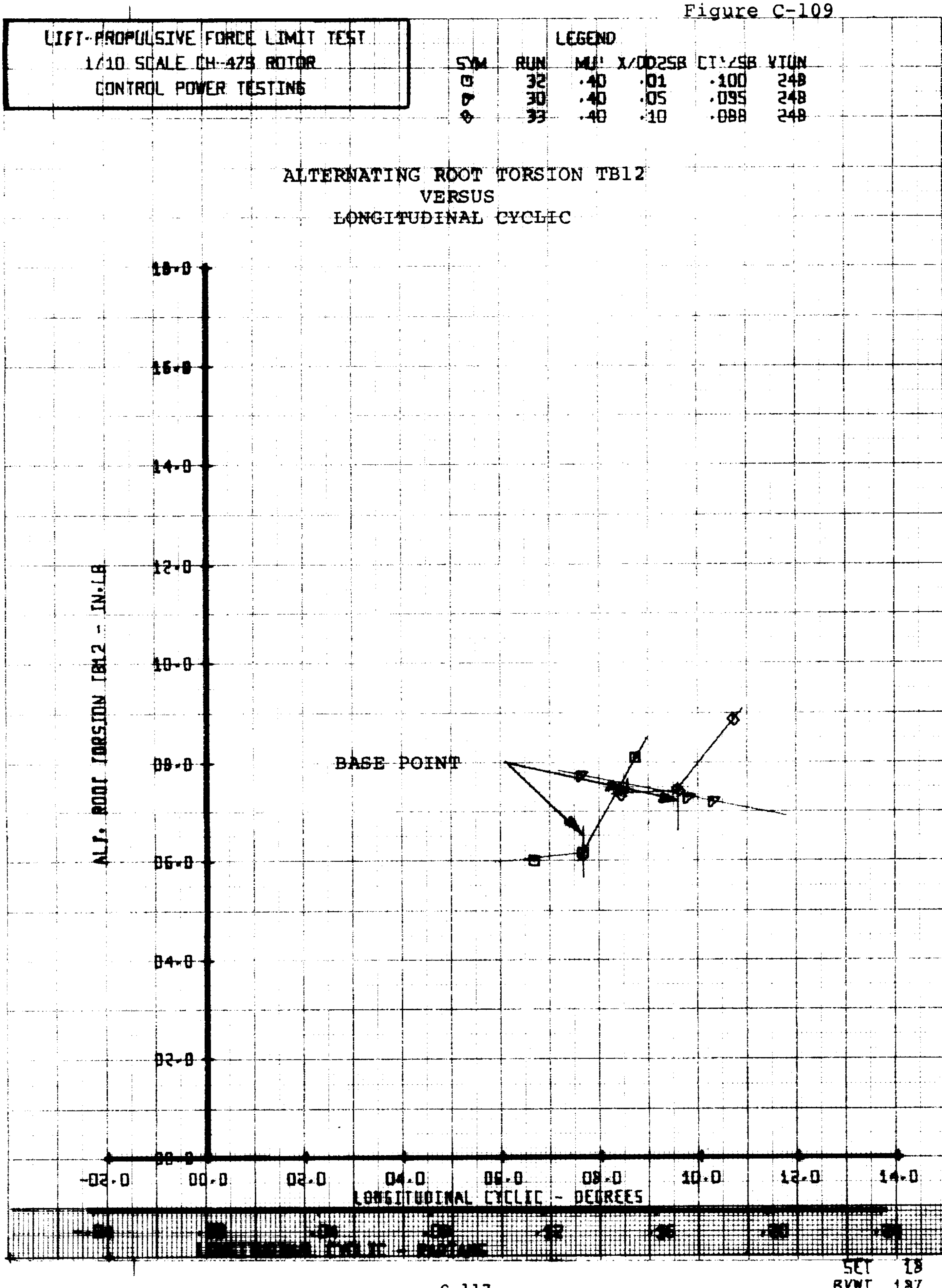
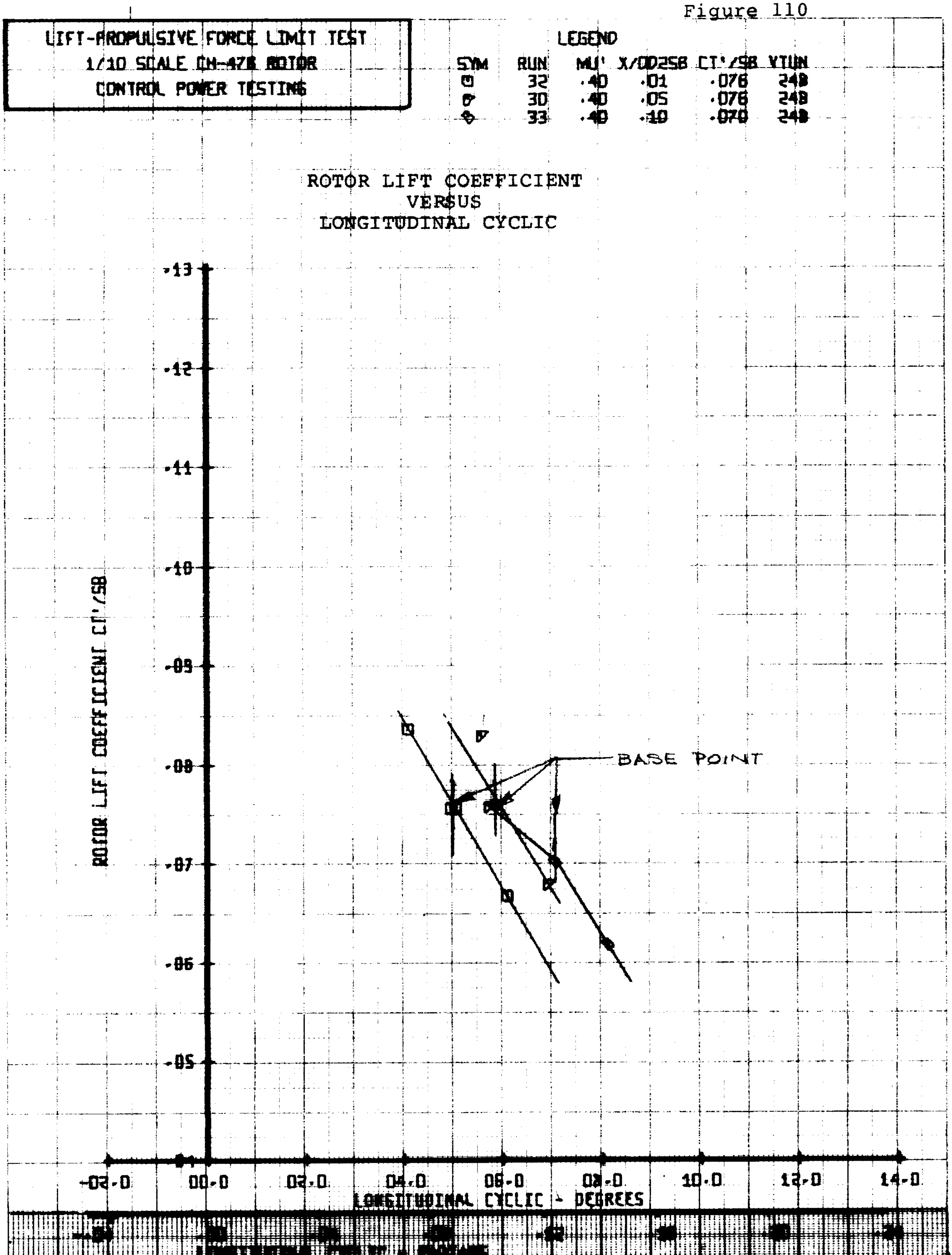

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD25B CT'/SB VTUN
32 .40 .01 .100 248
30 .40 .05 .095 248
33 .40 .10 .088 248
ALTERNATING ROOT TORSION TB12
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ALT. ROOT TORSION TB12 - IN.LB
LONGITUDINAL CYCLIC - DEGREES
SET 18
BVWT 187

Figure 110



SET 19
BVWT 187

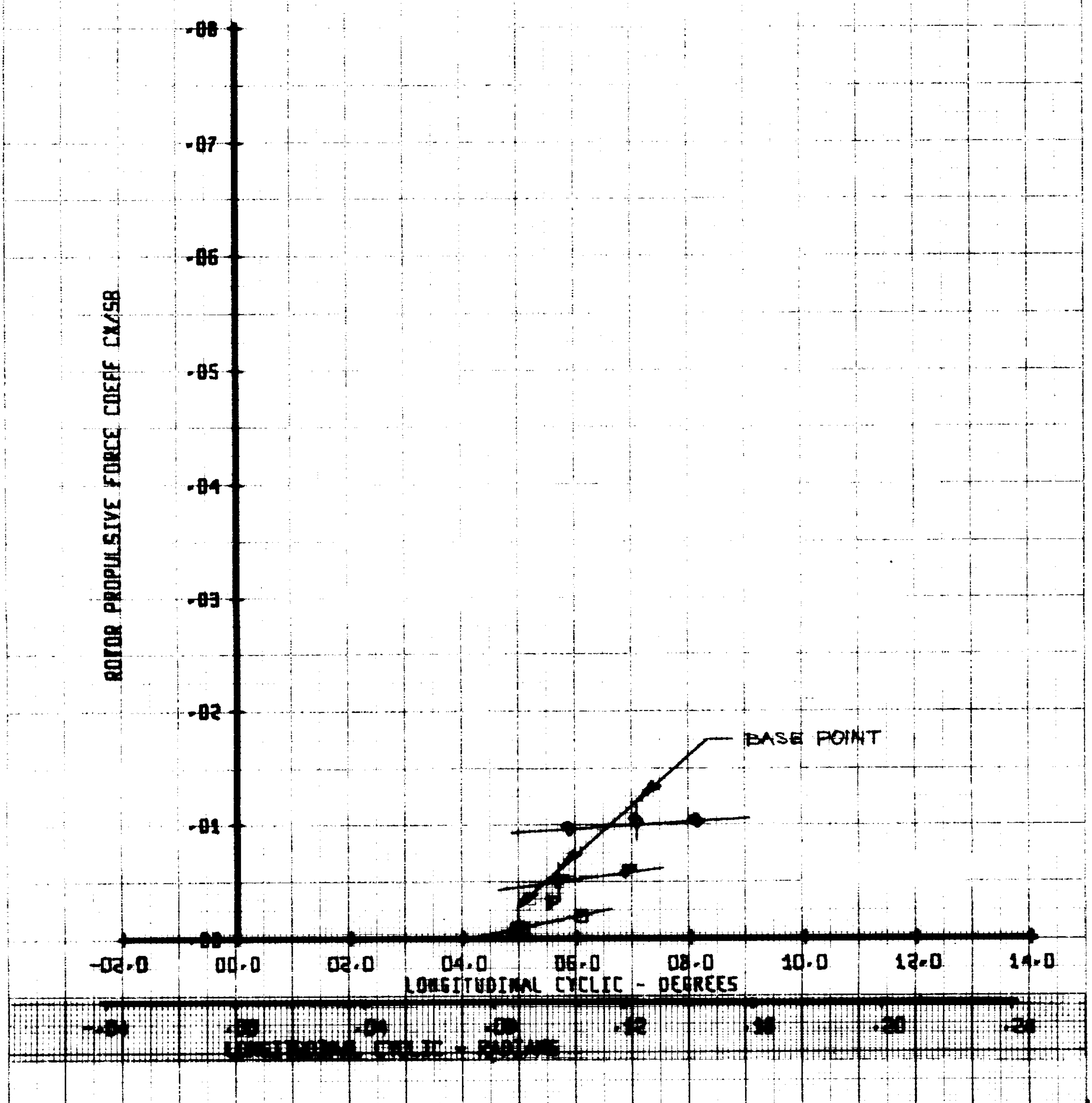
Figure C-111

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/OD25B	CT'/SB	VTUN
⊡	32	.40	.01	.076	248
⊳	30	.40	.05	.076	248
◇	33	.40	.10	.070	248

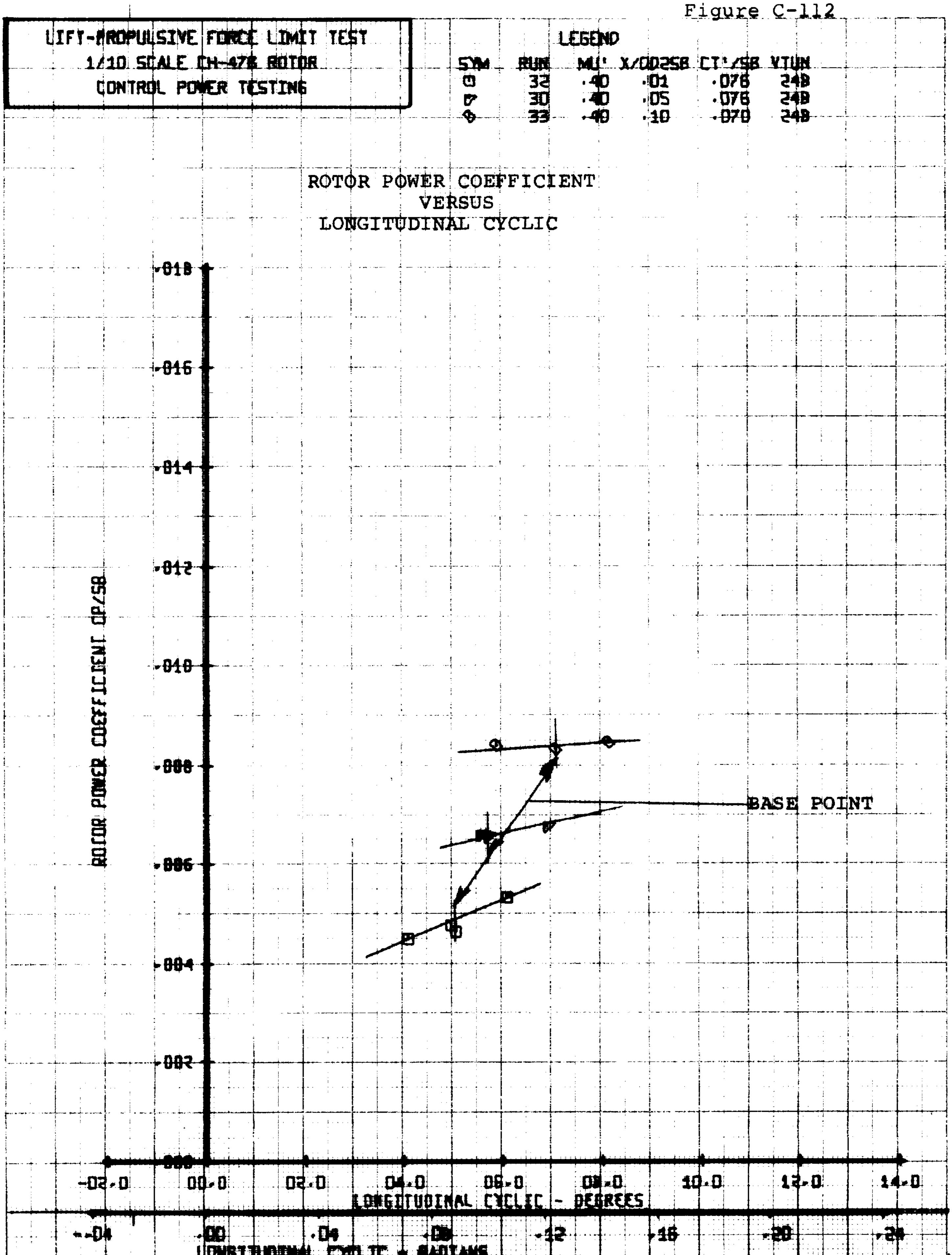
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC



SET 19
BVWT 137

SET 19
BVWT 137

Figure C-112



SET 13
BVWT 187

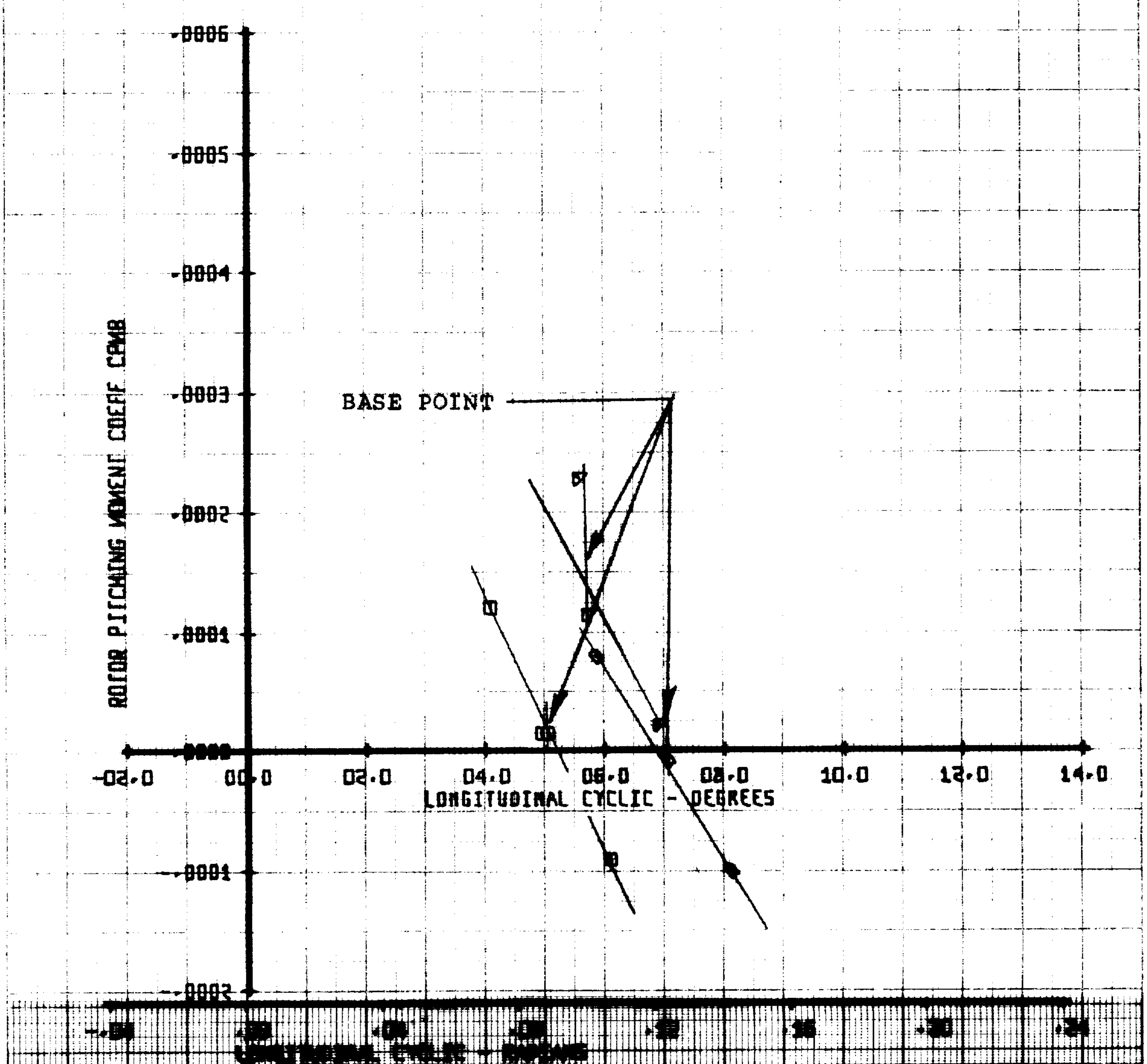
SET 13
BVWT 187

Figure C-113

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

SYM	RUN	MU'	X/DD25B	CT'/SB	VTUN
⊡	32	.40	.01	.076	248
◇	30	.40	.05	.076	248
◆	33	.40	.10	.070	248

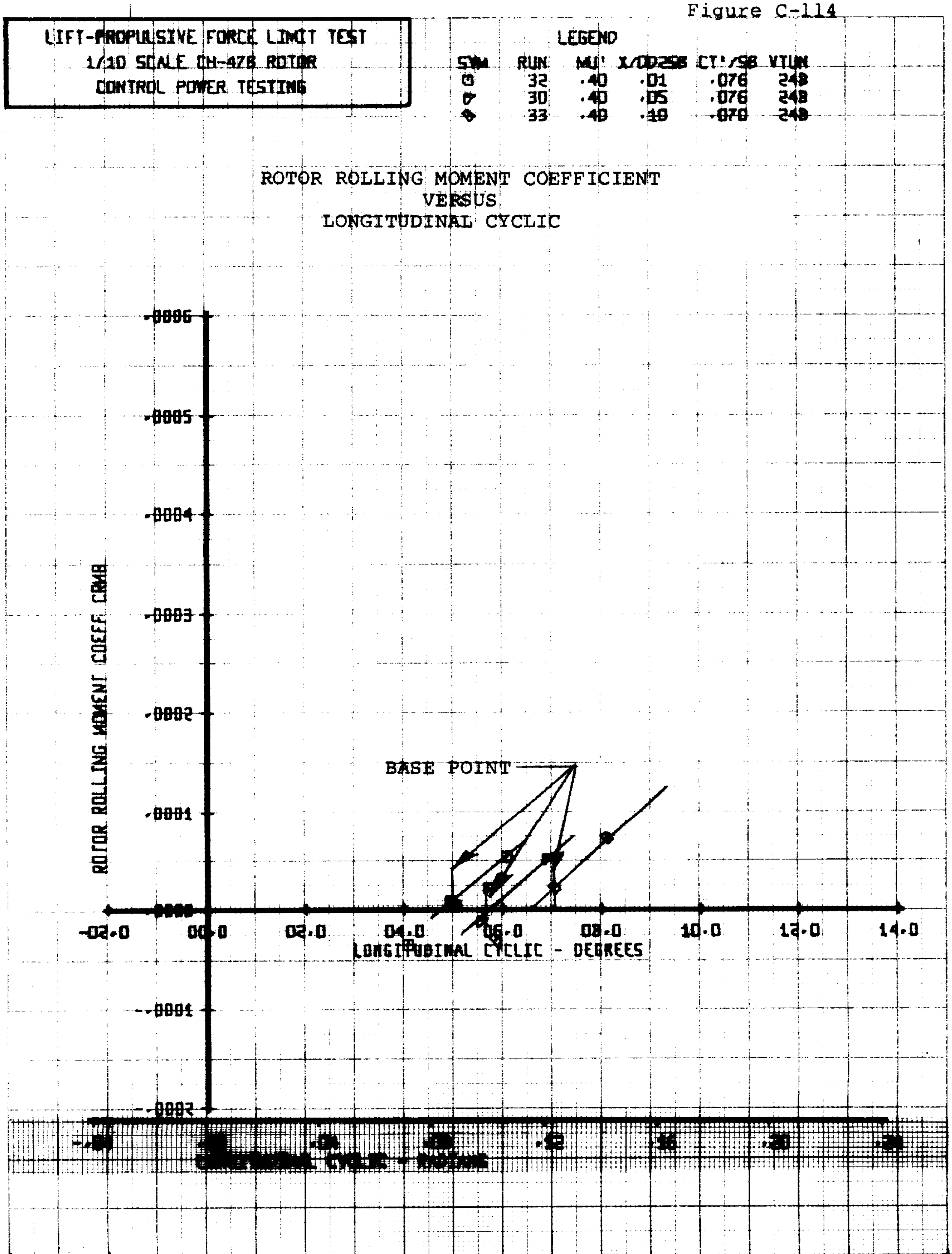
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC



SET 13
BVWT 137

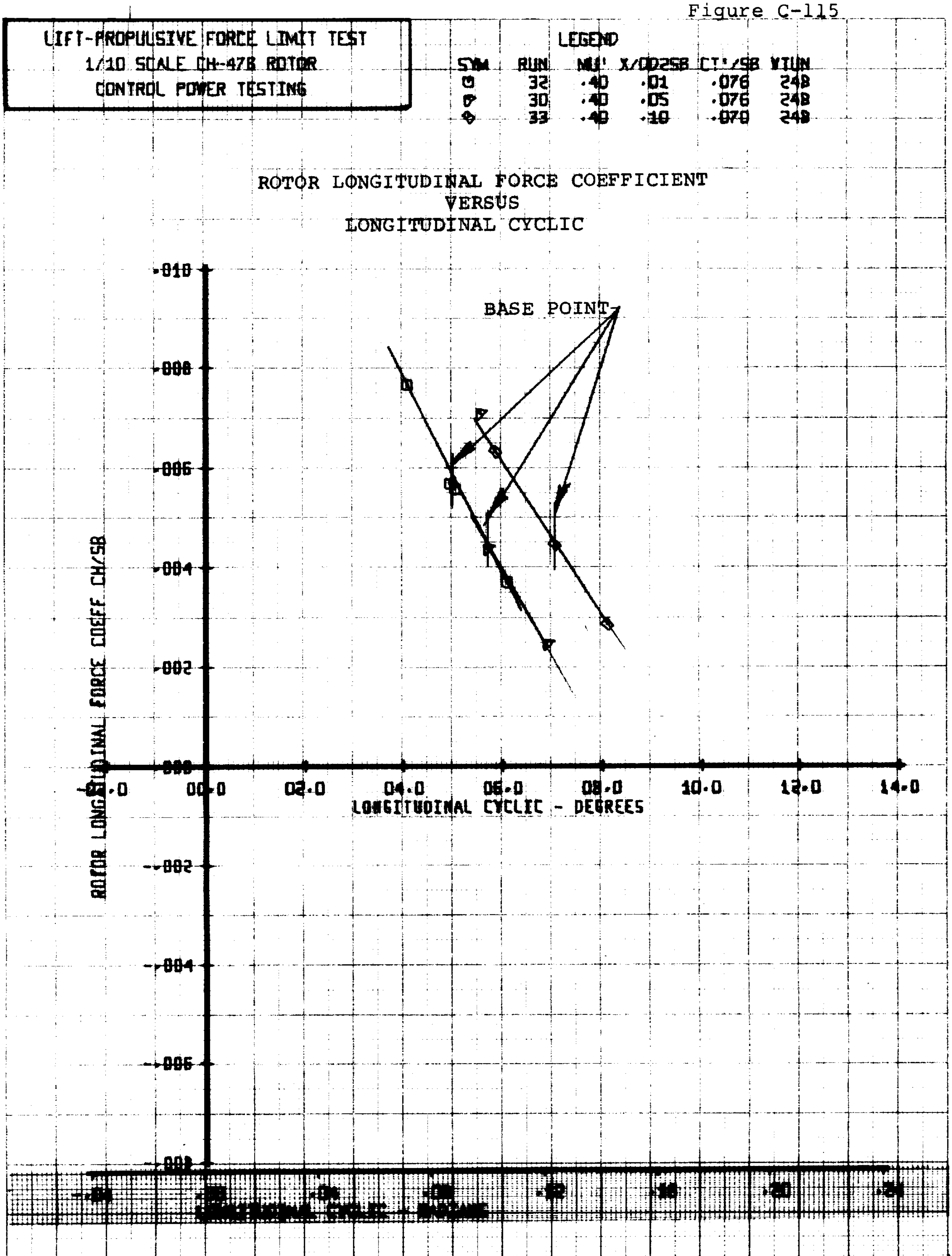
SET 13
BVWT 137

Figure C-114



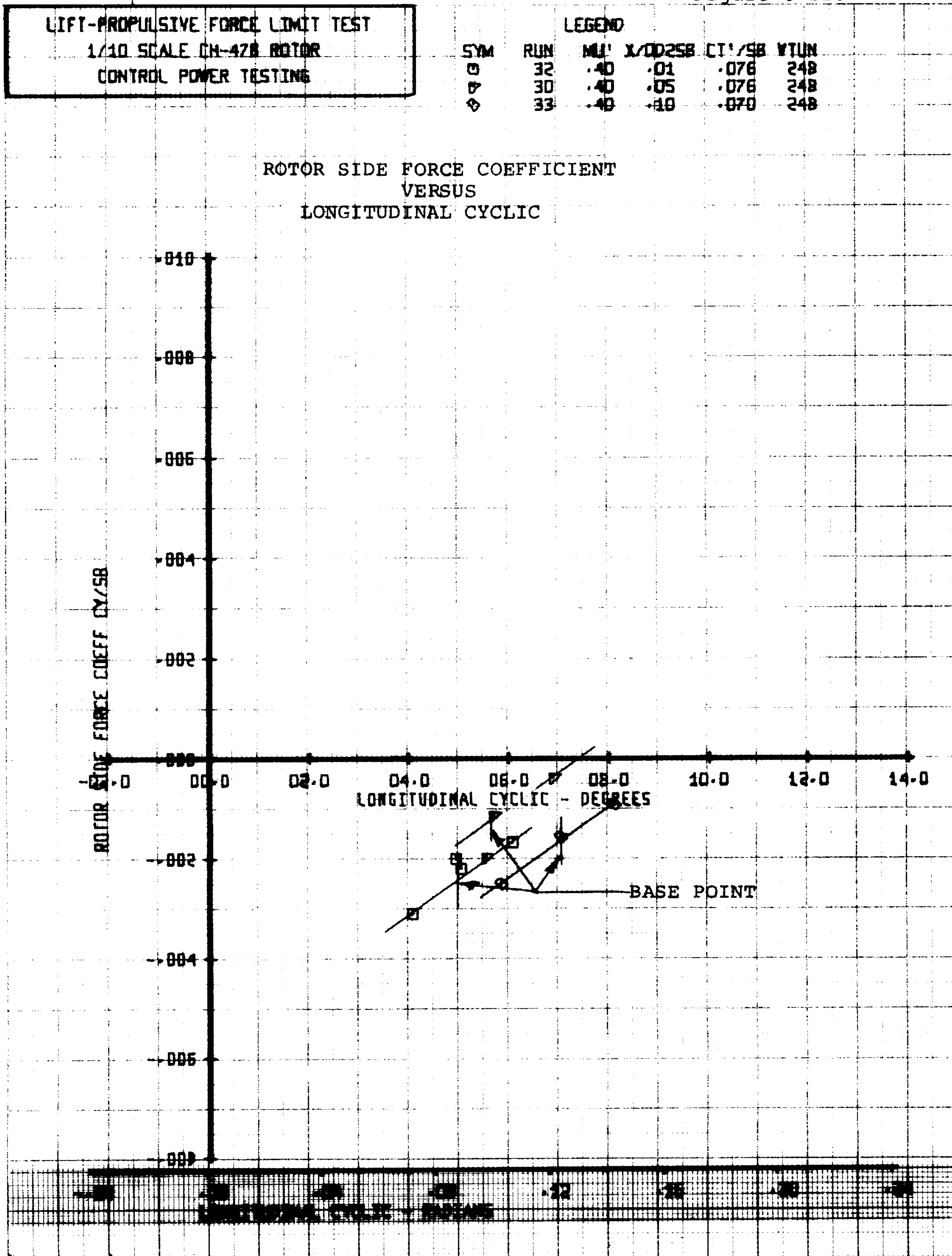
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD25B CT'/SB VTUN
32 .40 .01 .076 248
30 .40 .05 .076 248
33 .40 .10 .070 248
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR ROLLING MOMENT COEFF CRMB
BASE POINT
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 19
BVWT 187

Figure C-115



SET 19
BVWT 187

Figure C-116



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD2SB CT'/SB VTUN
32 .40 .01 .076 248
30 .40 .05 .076 248
33 .40 .10 .070 248
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR SIDE FORCE COEFF CY/SB
LONGITUDINAL CYCLIC - DEGREES
BASE POINT
SET 19
BVWT 187

Figure C-117

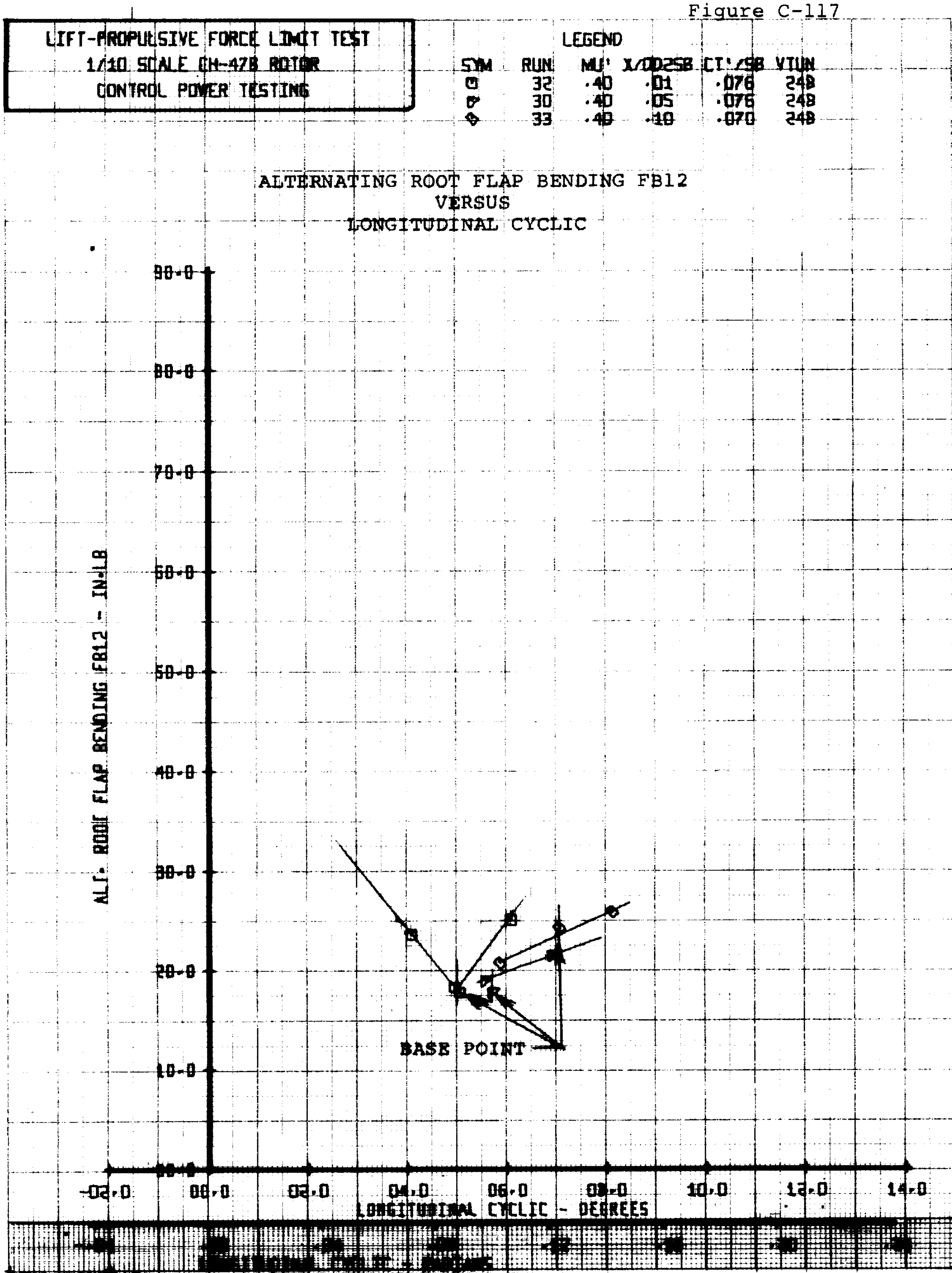

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD25B CT'/SB VTUN
32 .40 .01 .076 248
30 .40 .05 .076 248
33 .40 .10 .070 248
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LONGITUDINAL CYCLIC
ALT. ROOT FLAP BENDING FB12 - IN-LB
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 19
BVWT 187

Figure C-118

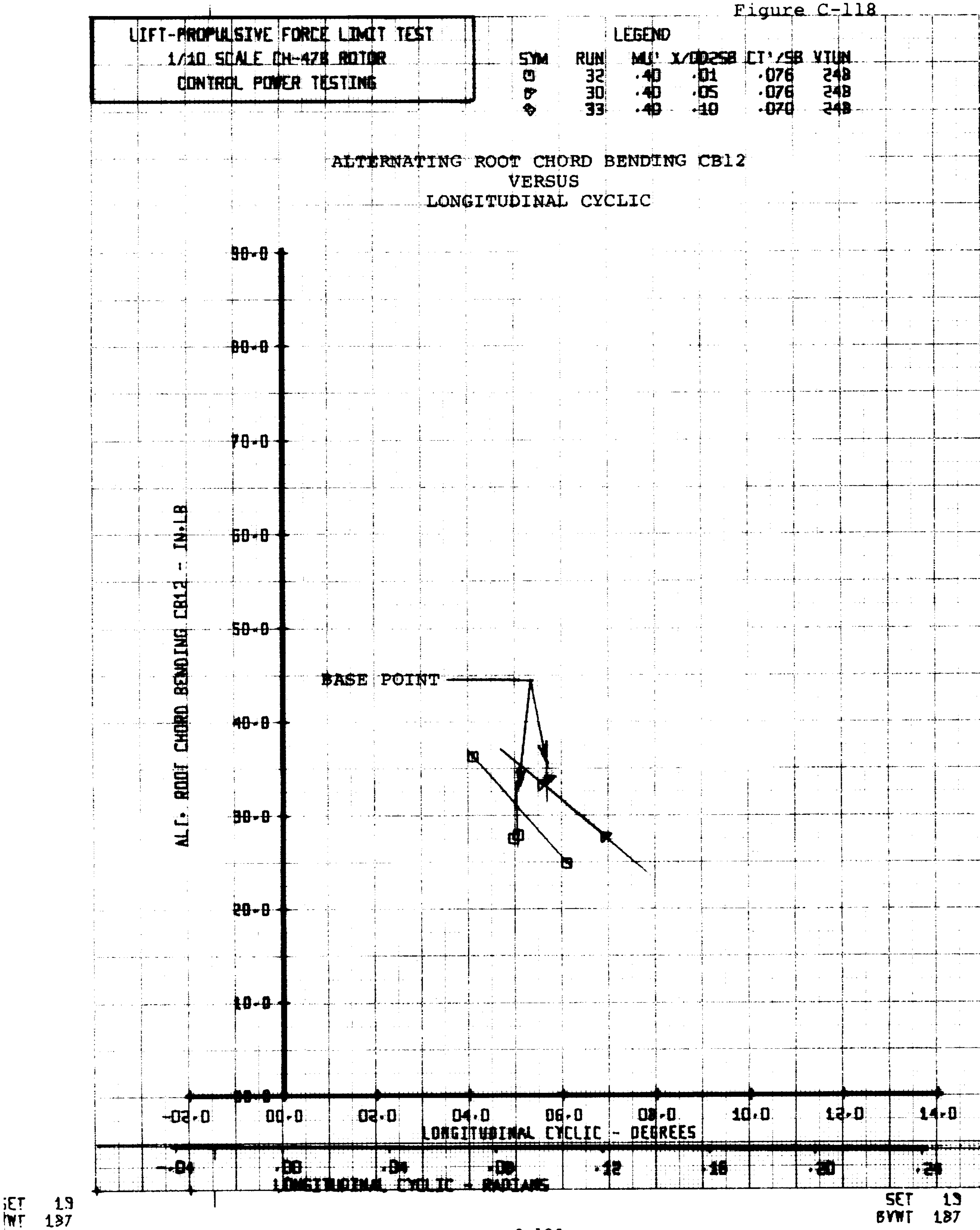
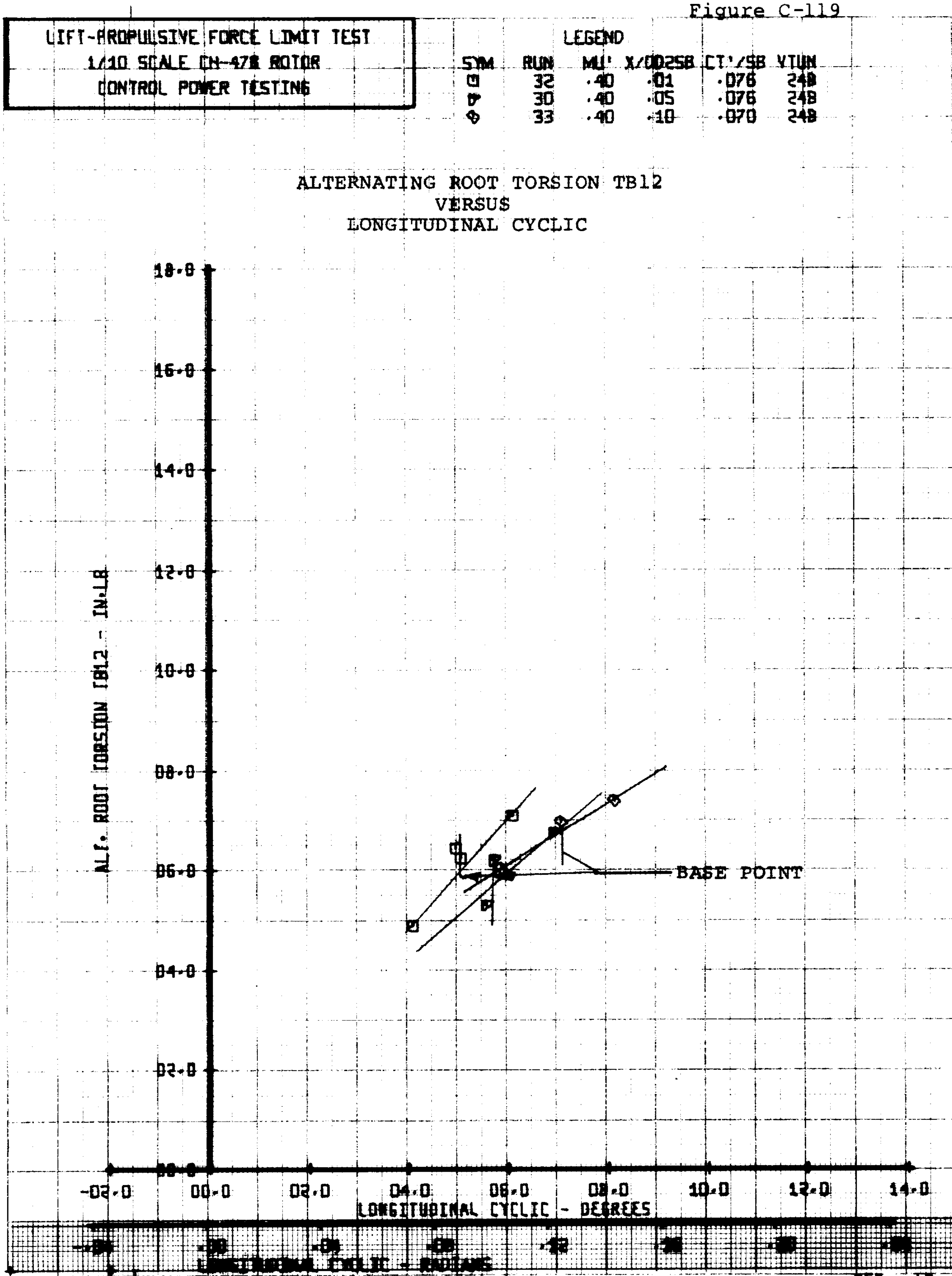
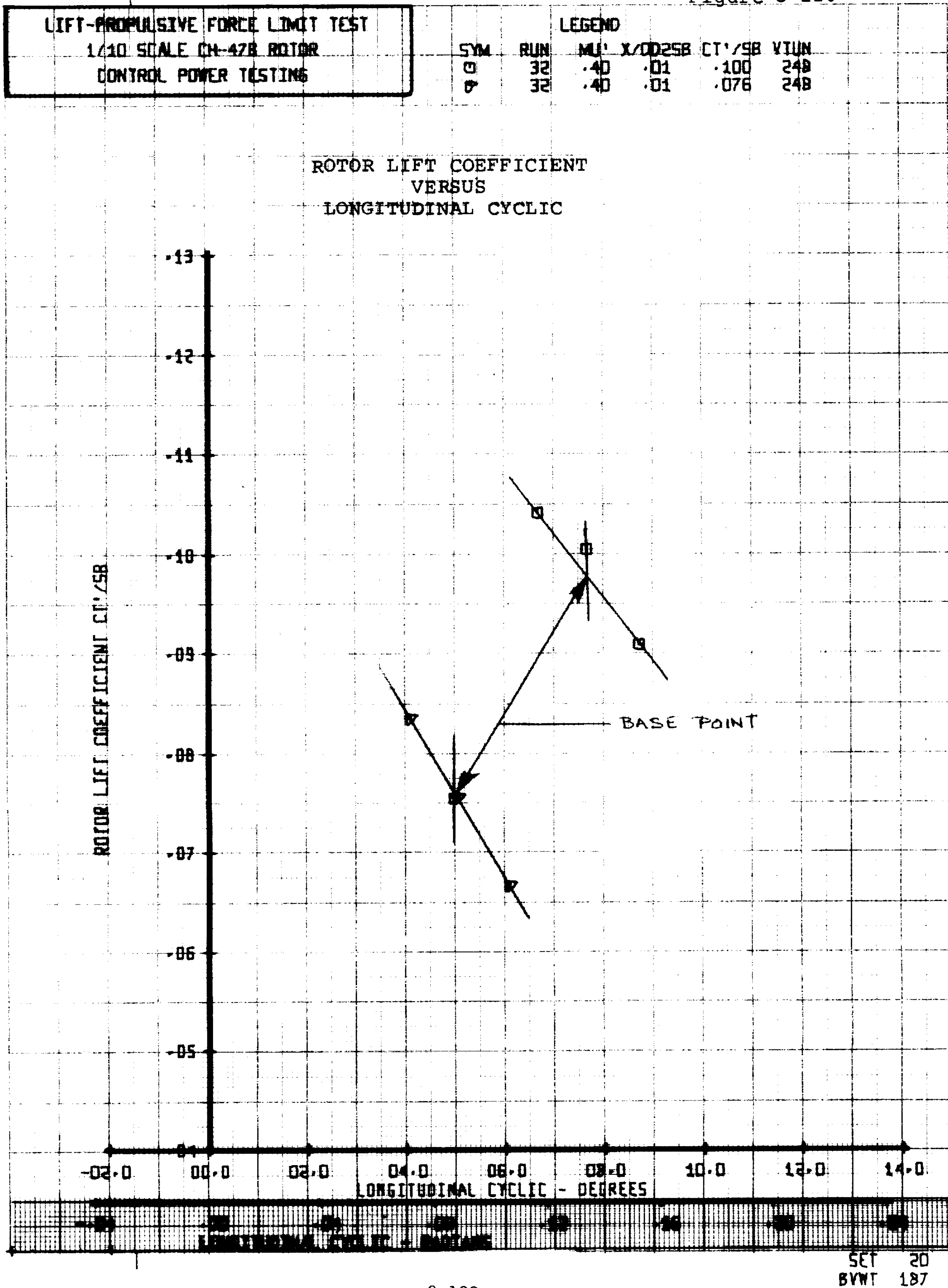

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .076 248
30 .40 .05 .076 248
33 .40 .10 .070 248
ALTERNATING ROOT CHORD BENDING CB12
VERSUS
LONGITUDINAL CYCLIC
ALT. ROOT CHORD BENDING CB12 - IN.LB
BASE POINT
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 13
BYWT 187

Figure C-119



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .076 248
30 .40 .05 .076 248
33 .40 .10 .070 248
ALTERNATING ROOT TORSION TB12
VERSUS
LONGITUDINAL CYCLIC
ALT. ROOT TORSION TB12 - IN.LB
18.0
16.0
14.0
12.0
10.0
08.0
06.0
04.0
02.0
00.0
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 19
BVWT 187


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .076 248
ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
ROTOR LIFT COEFFICIENT CT'/SB
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 20
BVWT 187

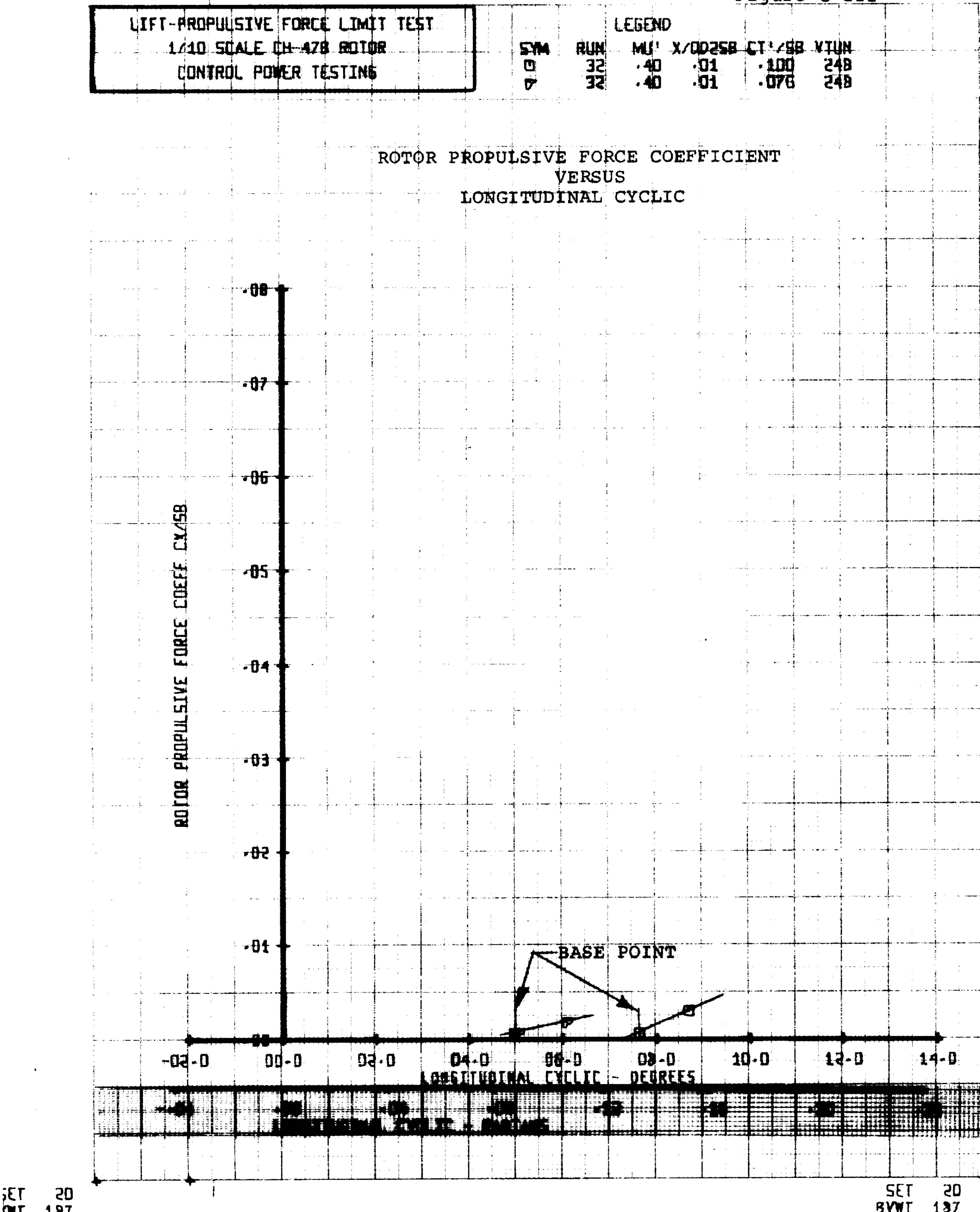
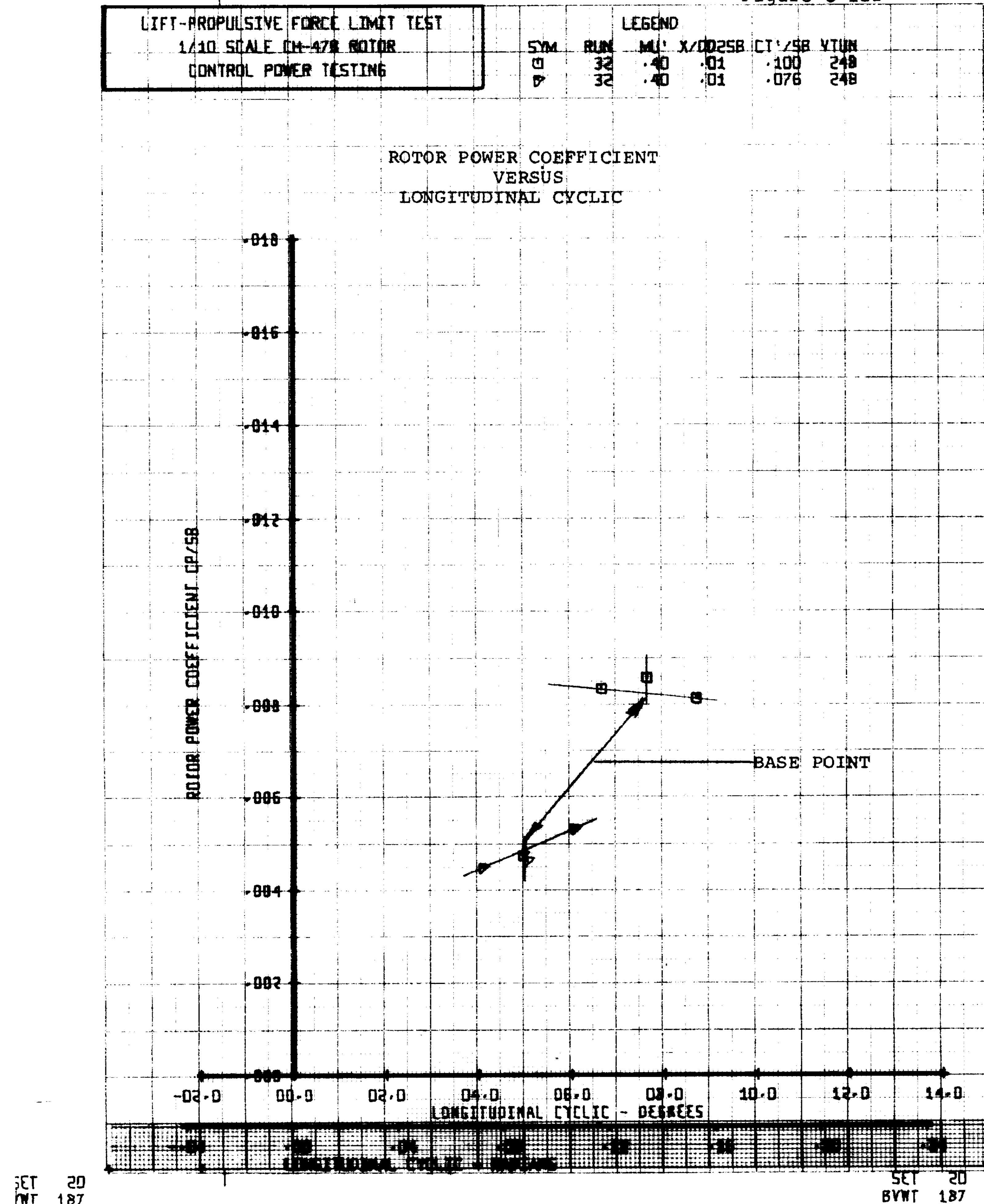
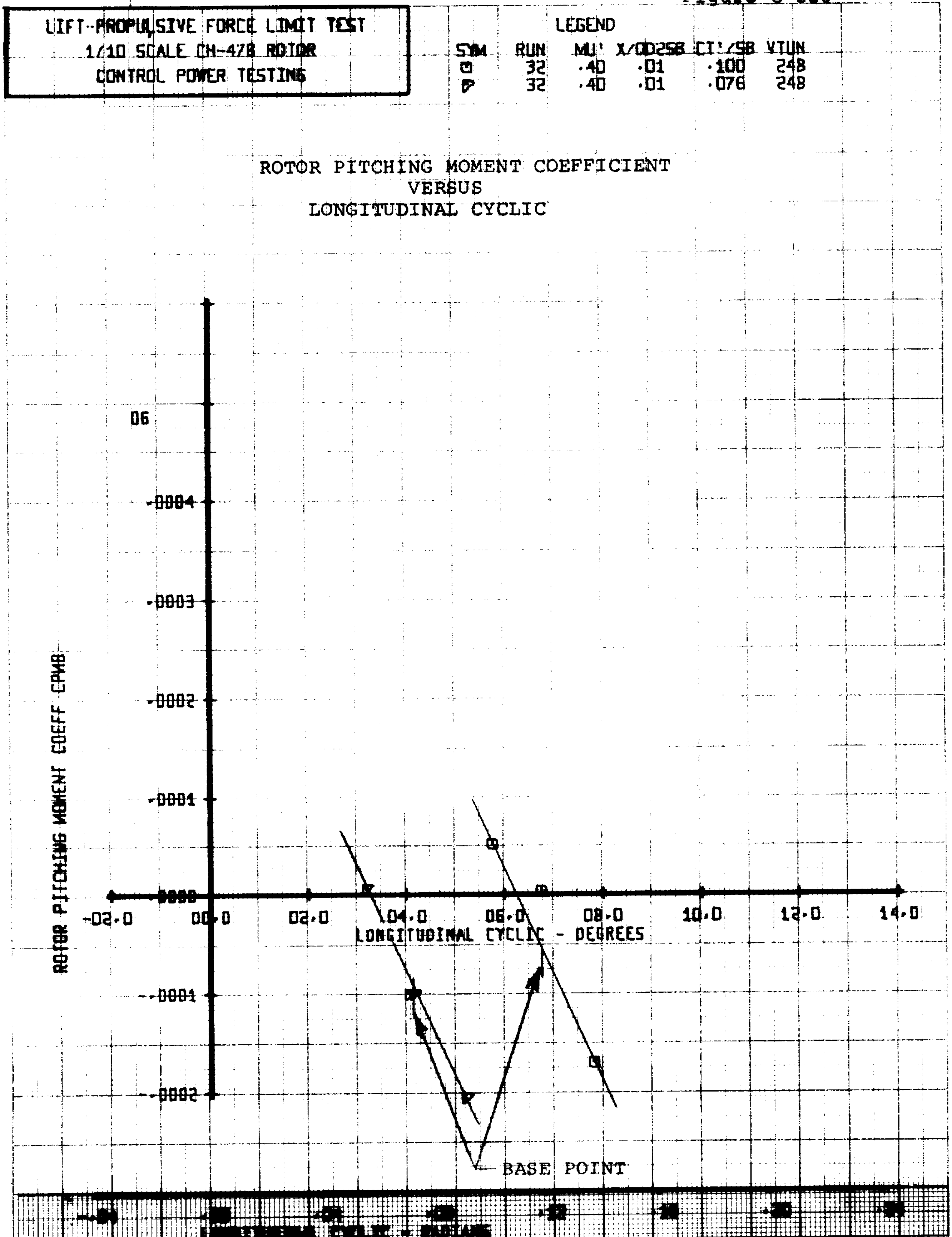

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/OD25B CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .076 248
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR PROPULSIVE FORCE COEFF CX/SB
.08
.07
.06
.05
.04
.03
.02
.01
.00
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 20
BVWT 137

Figure C-122



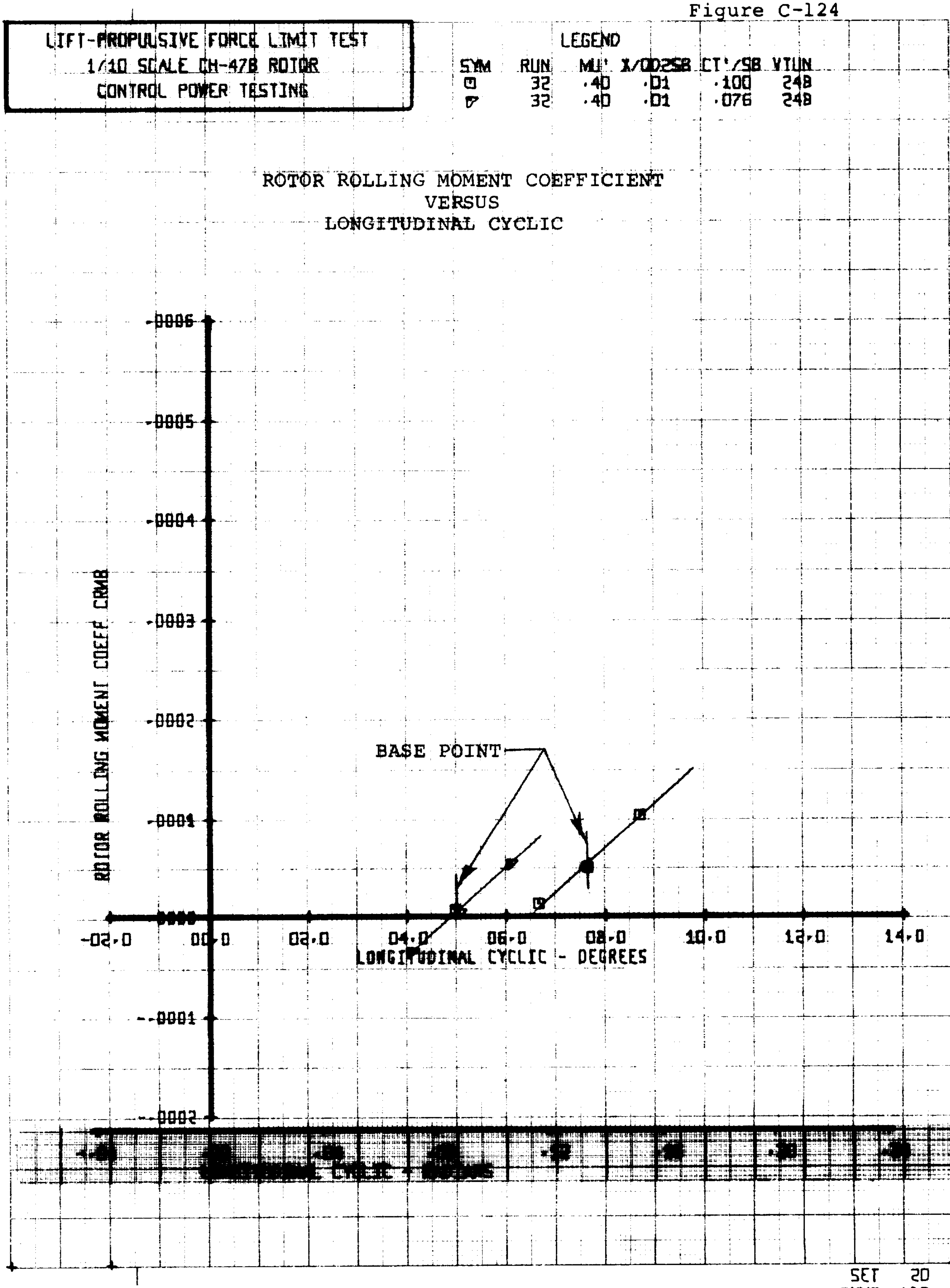
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .076 248
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 20
BVWT 187

Figure C-123



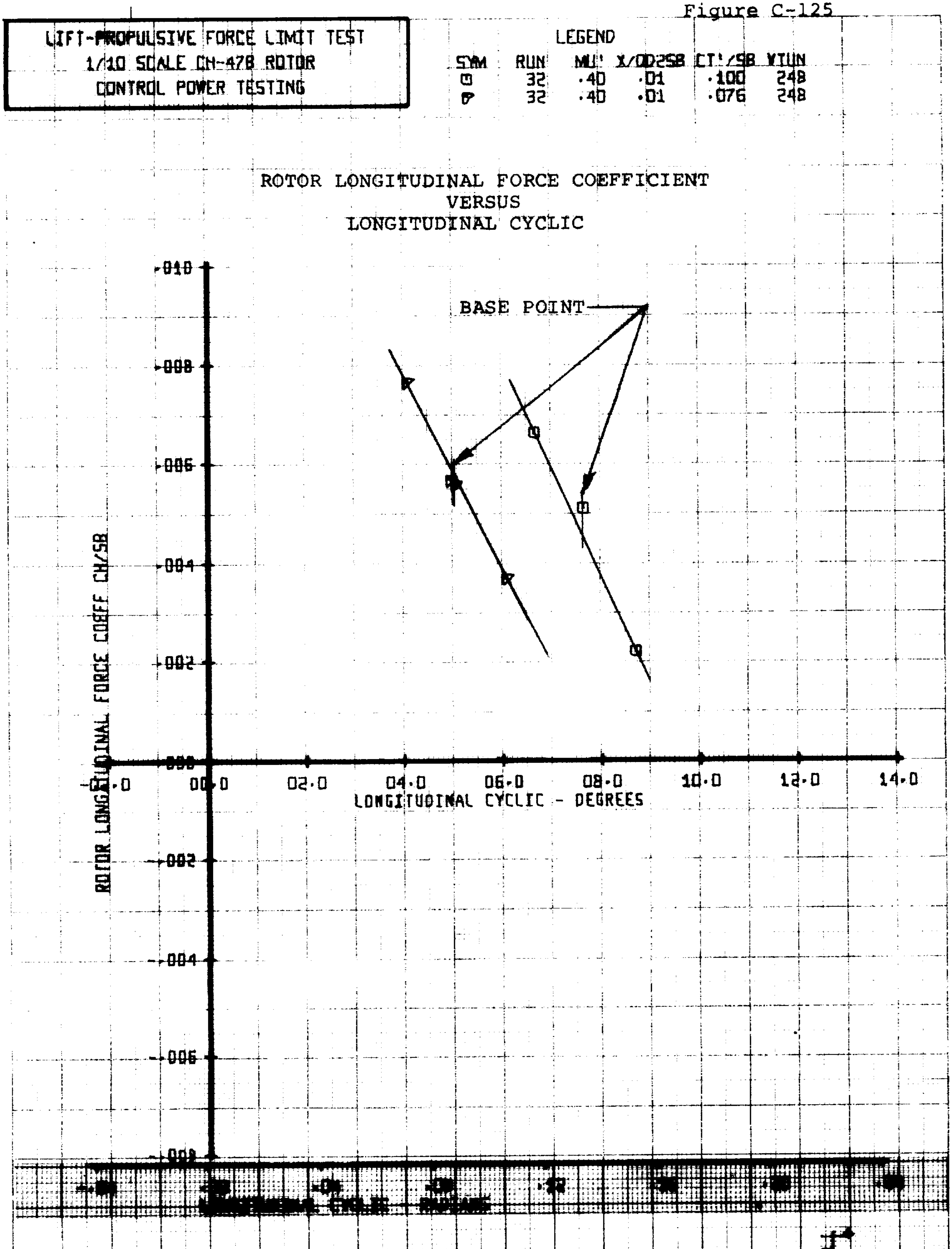
SET 20
TWT 187

Figure C-124



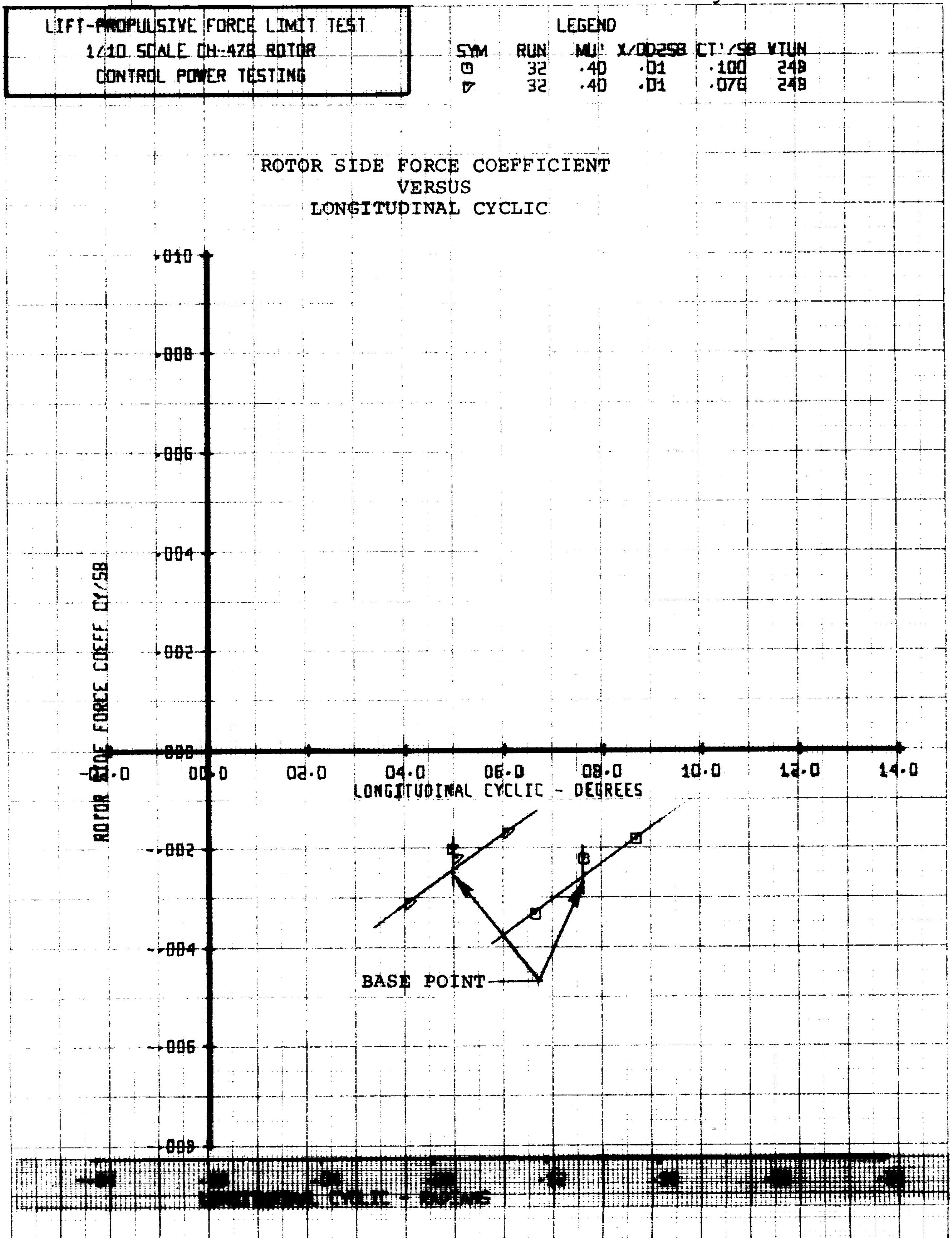
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .076 248
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR ROLLING MOMENT COEFF CRMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 20
BVWT 187

Figure C-125



SET 20
WT 197

Figure C-126



SET 20
BVWT 187

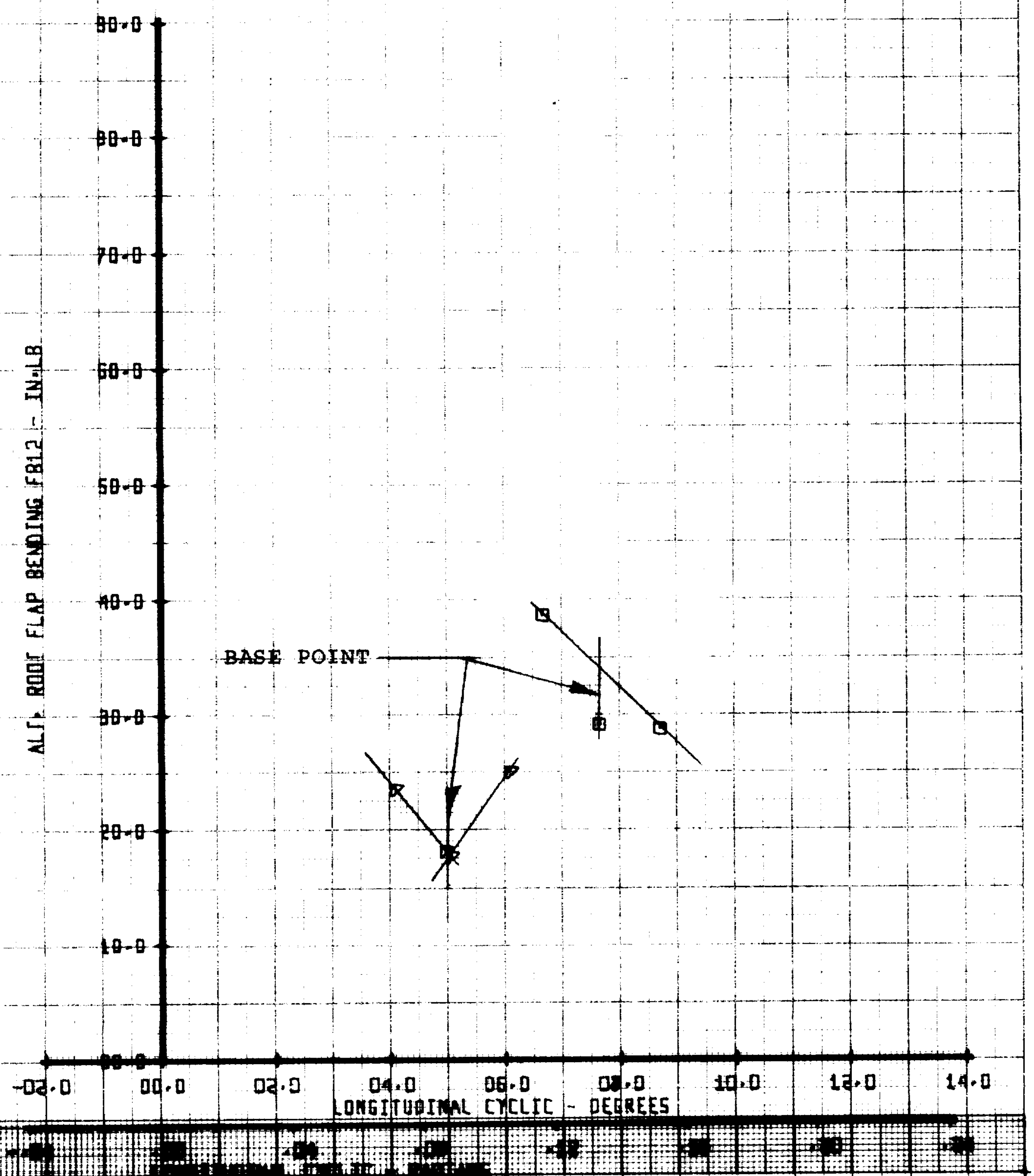
SET 20
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/DD25B	CT'/SB	VTUN
□	32	.40	.01	.100	248
▽	32	.40	.01	.076	248

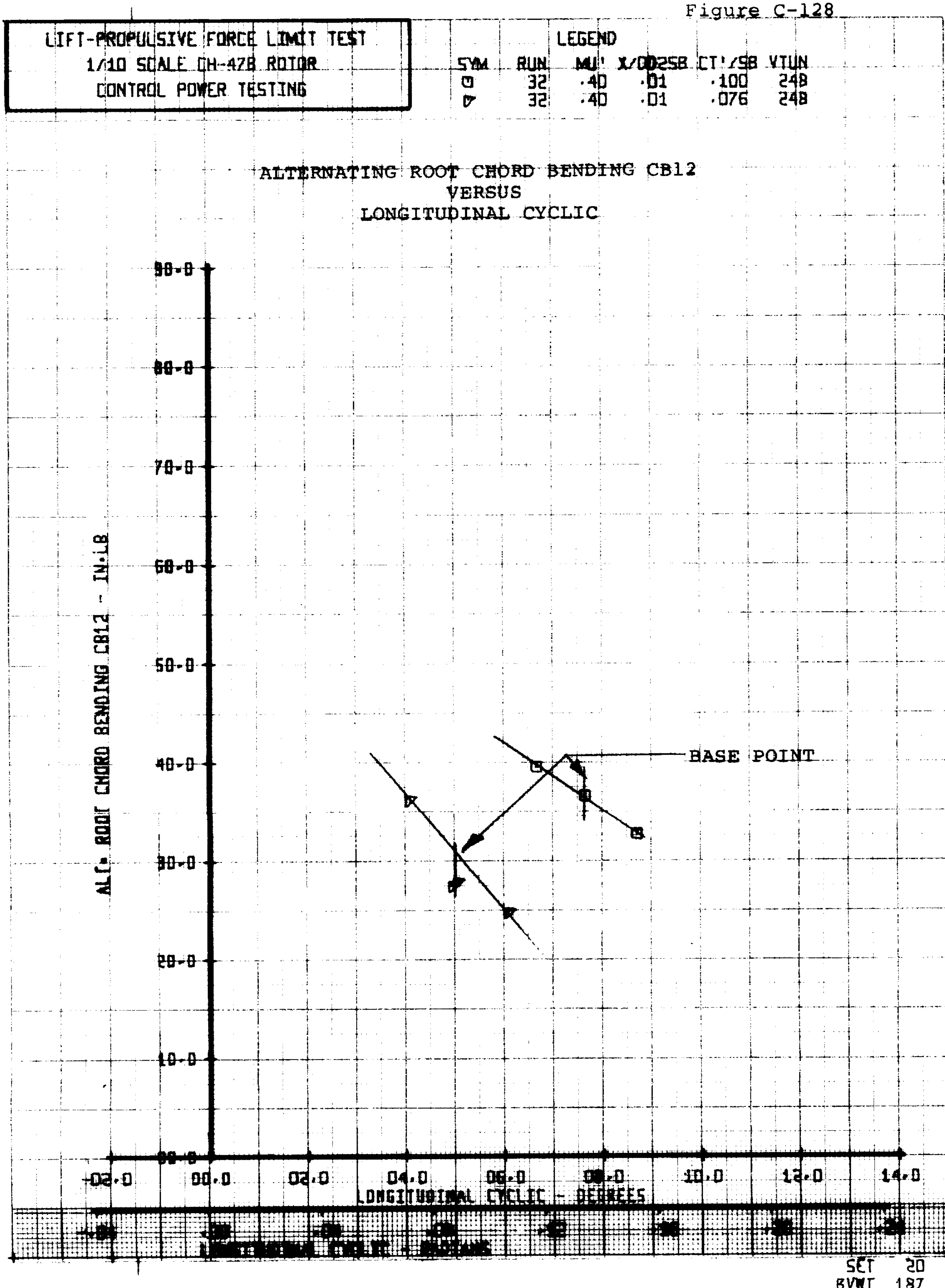
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LONGITUDINAL CYCLIC



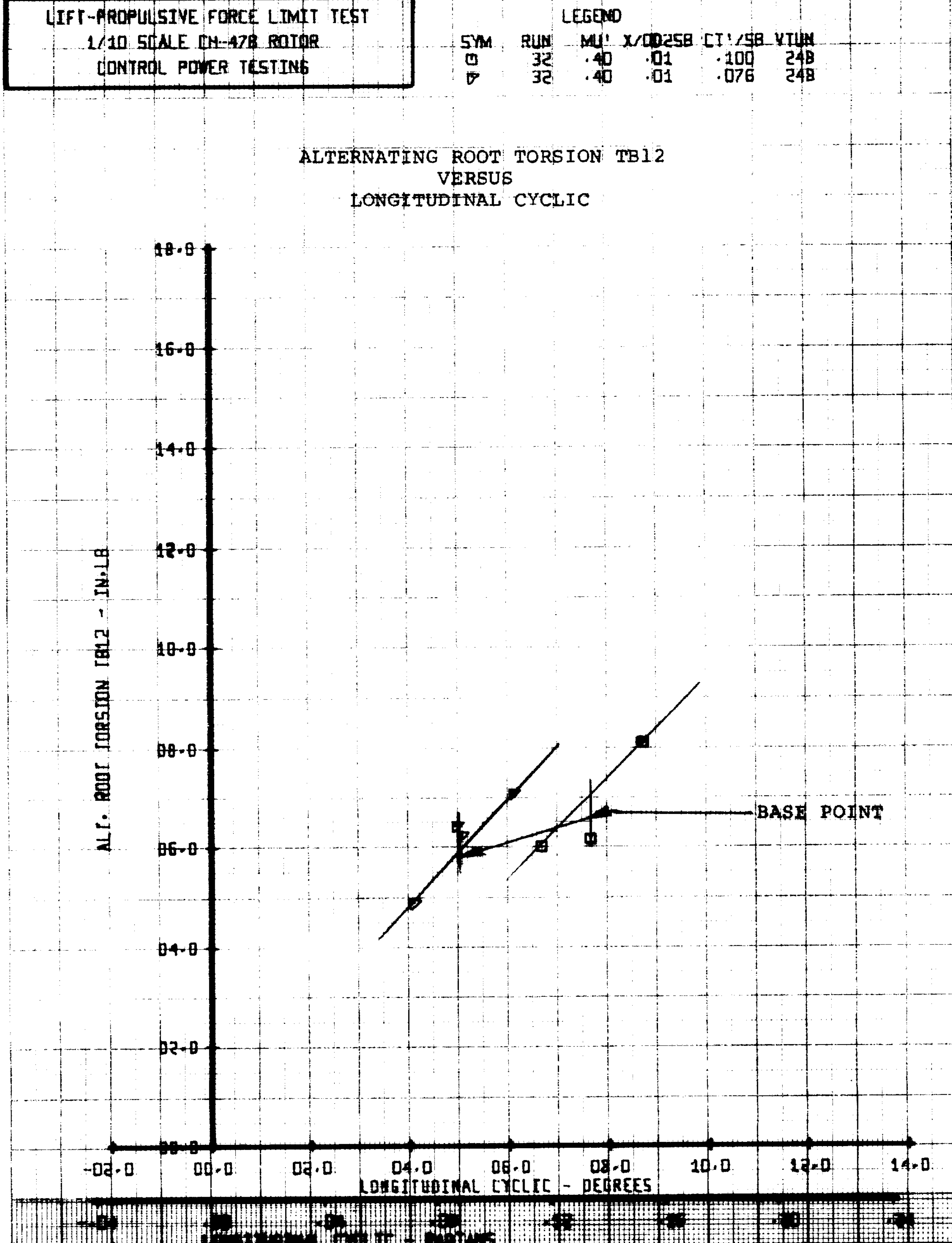
SET 20
BVWT 187

SET 20
BVWT 187

Figure C-128


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD2SB CT'/SB VTUN
32 .40 .01 .100 248
32 .40 .01 .076 248
ALTERNATING ROOT CHORD BENDING CB12
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ALT. ROOT CHORD BENDING CB12 - IN.LB
LONGITUDINAL CYCLIC - DEGREES
SET 20
BVWT 187

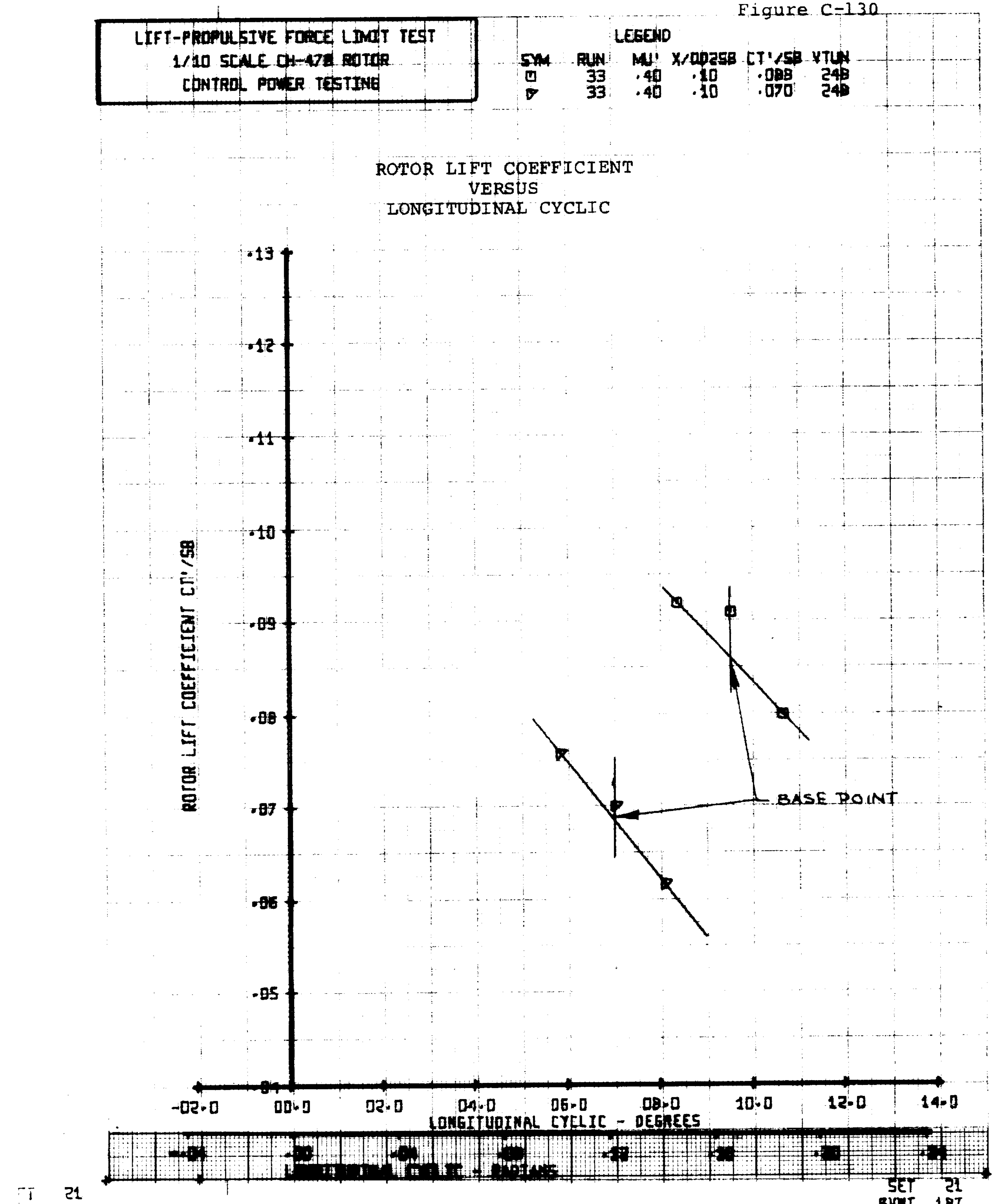
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

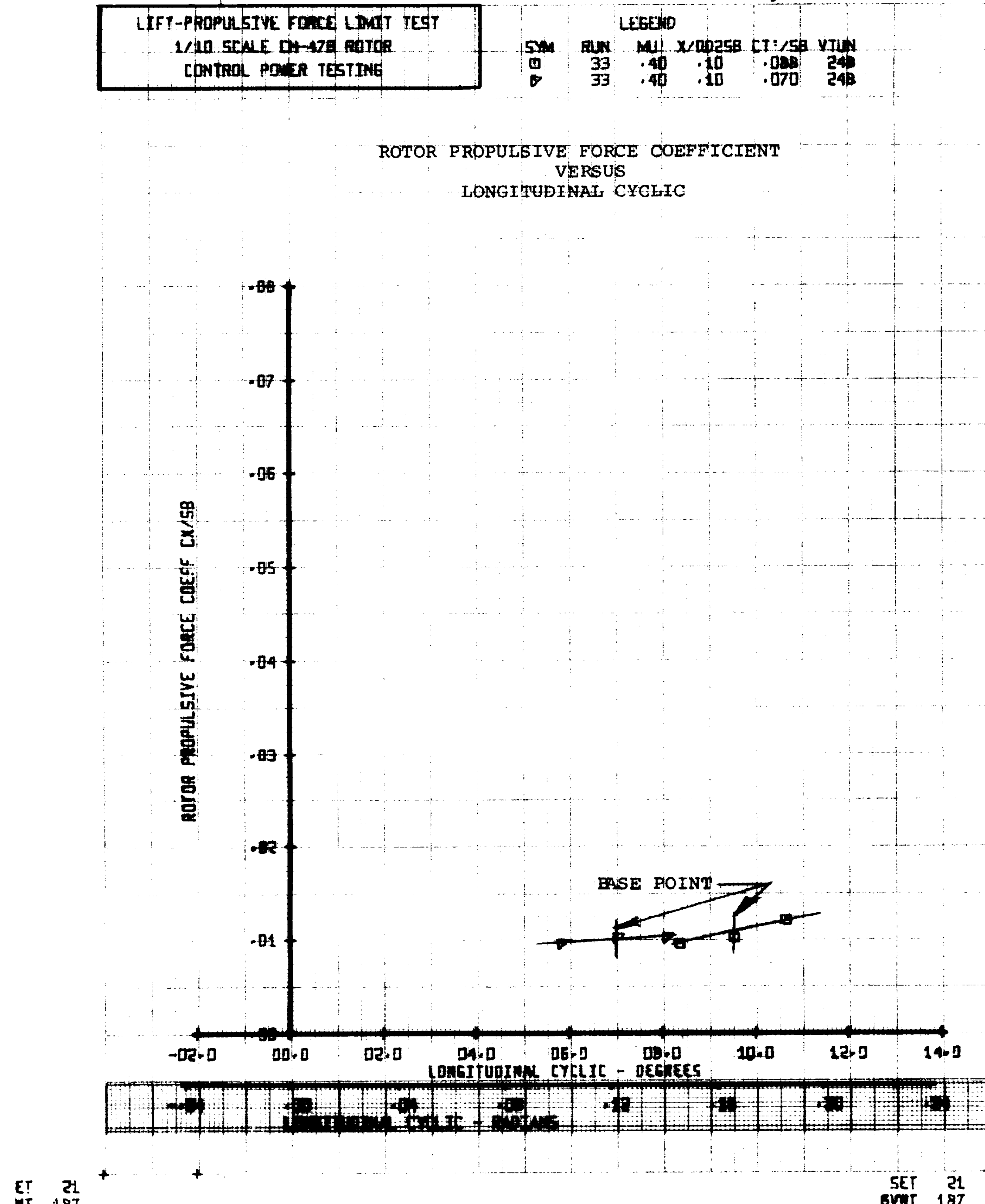


SET 20
BVWT 187

SET 20
BVWT 187

Figure C-130


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
33 .40 .10 .088 248
33 .40 .10 .070 248
ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 21
BVWT 187



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
33 .40 .10 .088 248
33 .40 .10 .070 248
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR PROPULSIVE FORCE COEFF CX/SB
.08
.07
.06
.05
.04
.03
.02
.01
.00
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 21
BVWT 187

Figure C-132

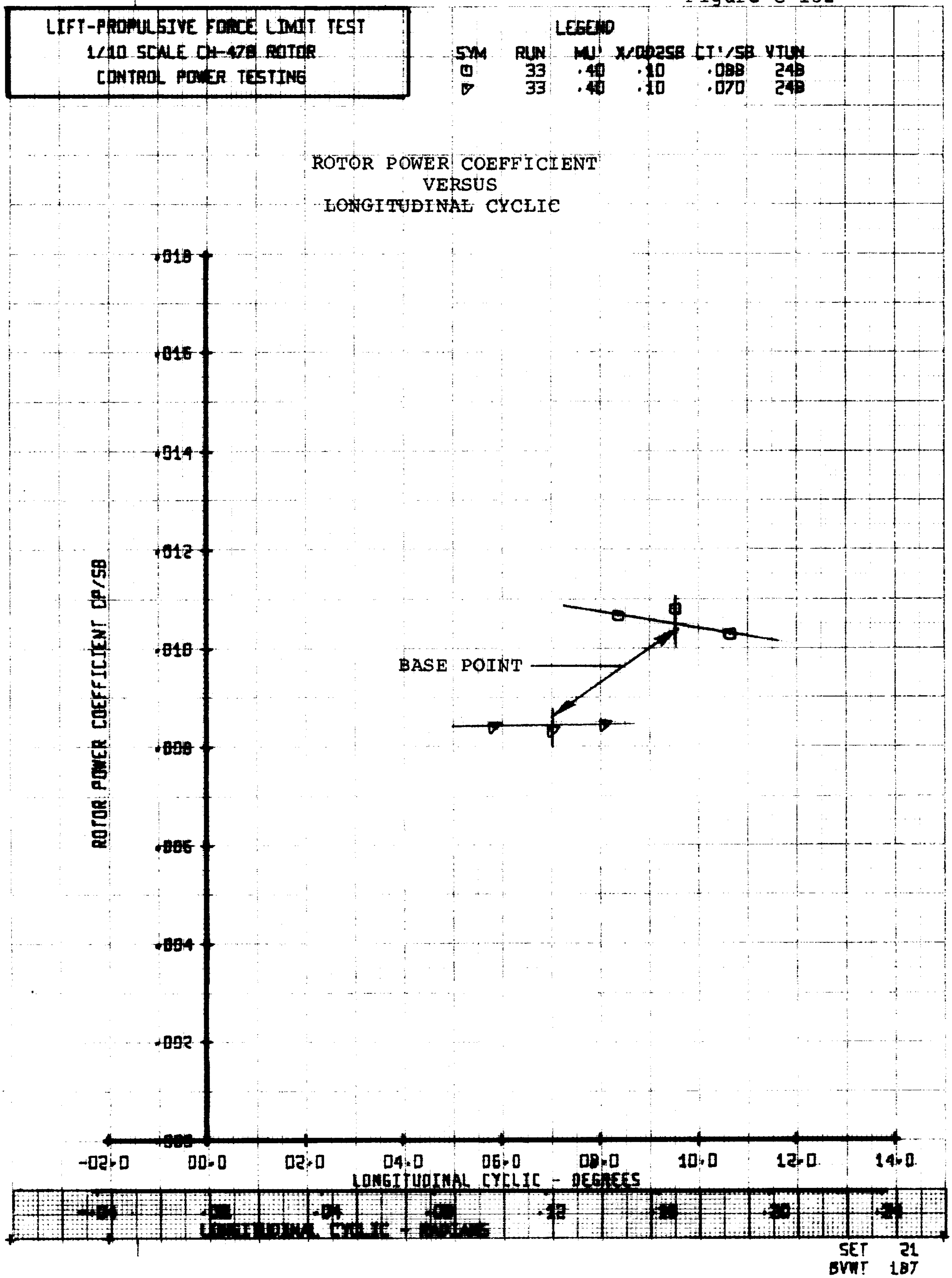

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/Q02SB CT'/SB VTUN
33 .40 .10 .088 248
33 .40 .10 .070 248
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 21
BVWT 187

Figure C-133

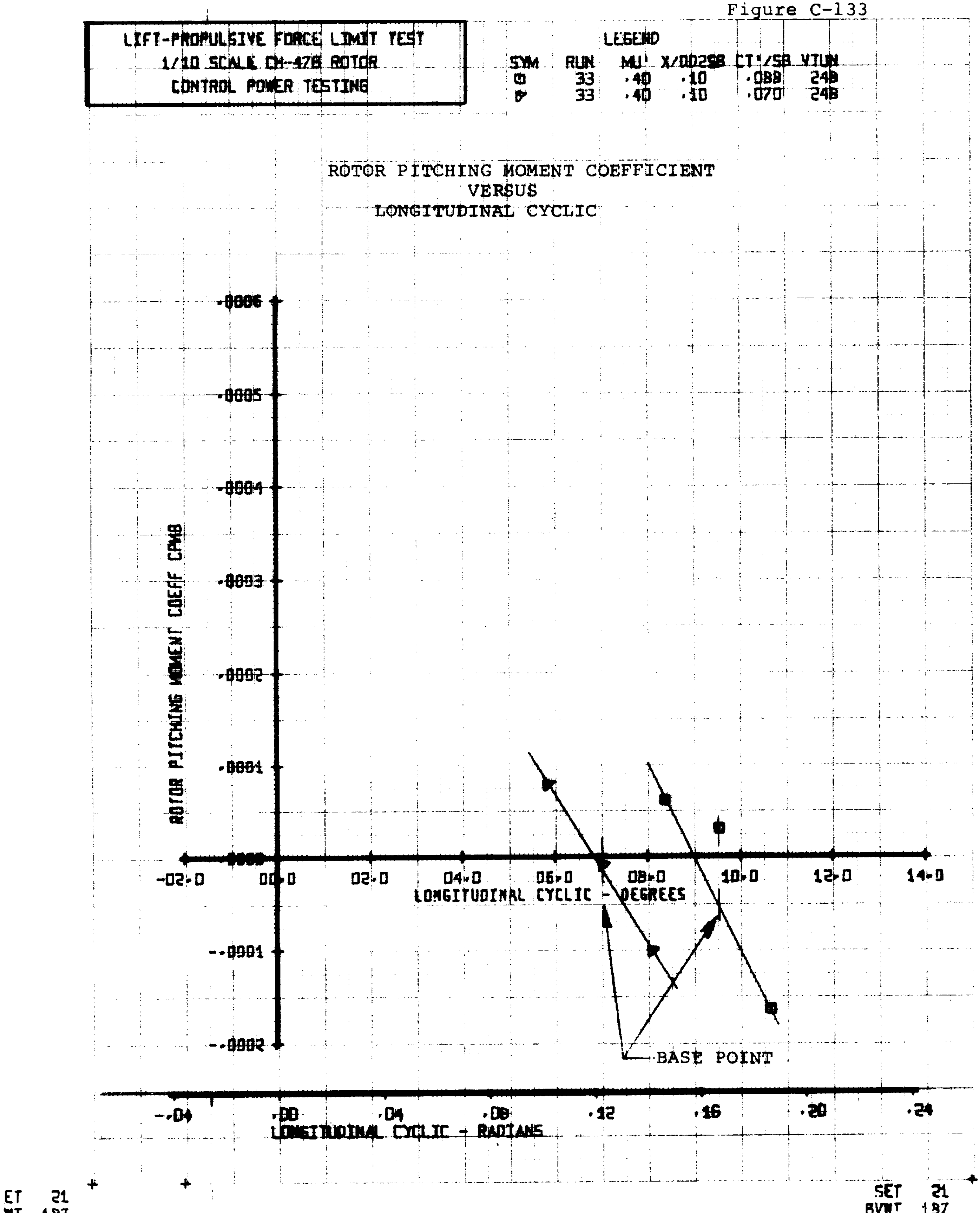

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD2SB CT'/SB VTUN
33 .40 .10 .088 248
33 .40 .10 .070 248
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR PITCHING MOMENT COEFF CPMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
BASE POINT
-.04
.00
.04
.08
.12
.16
.20
.24
LONGITUDINAL CYCLIC - RADIANS
ET 21
WT 187
SET 21
BVWT 187

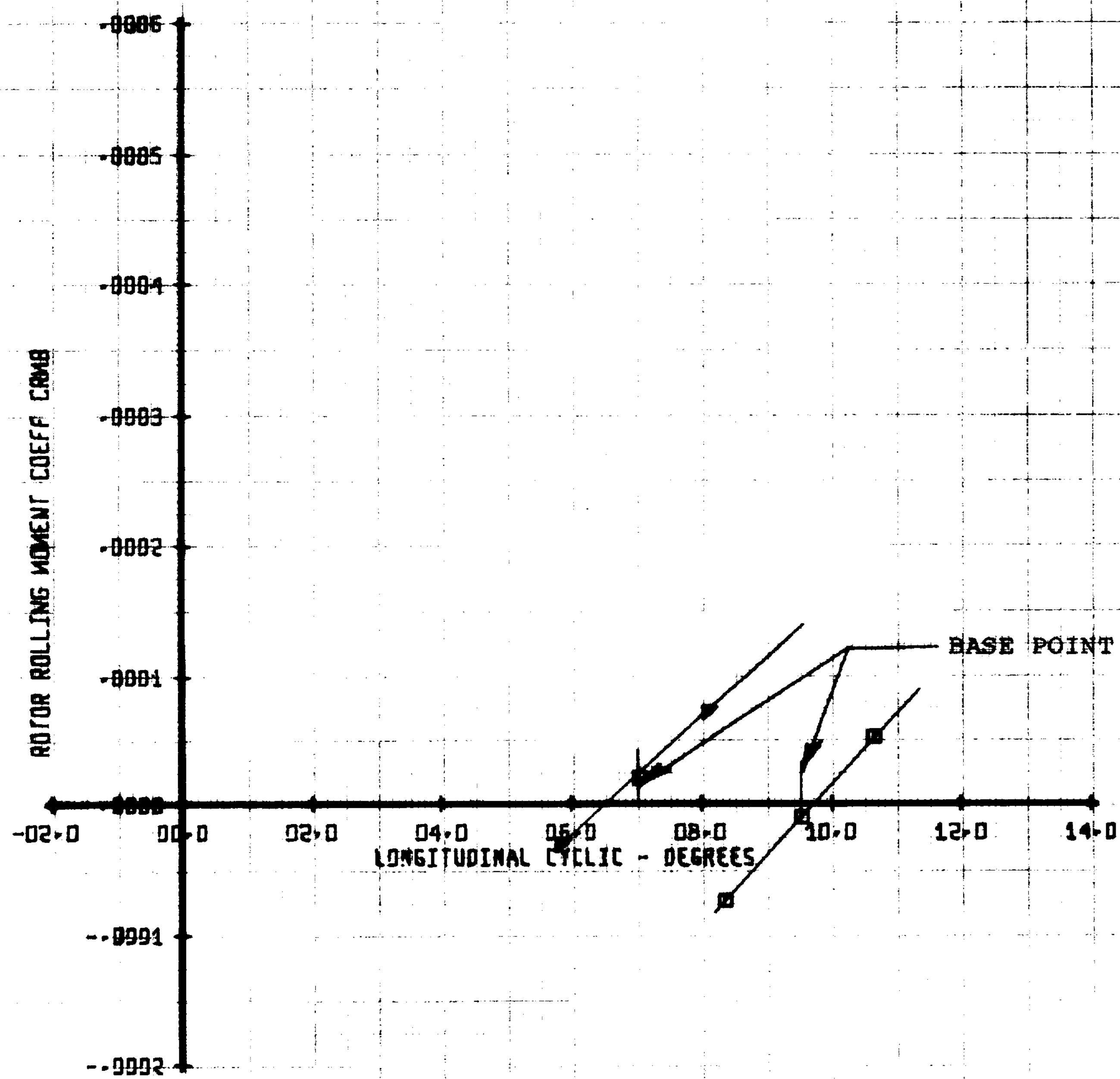
Figure C-134

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU	X/OD25B	CT'/SB	VTUN
⊡	33	.40	.10	.098	248
▷	33	.40	.10	.070	248

ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC



ET 21
WT 187

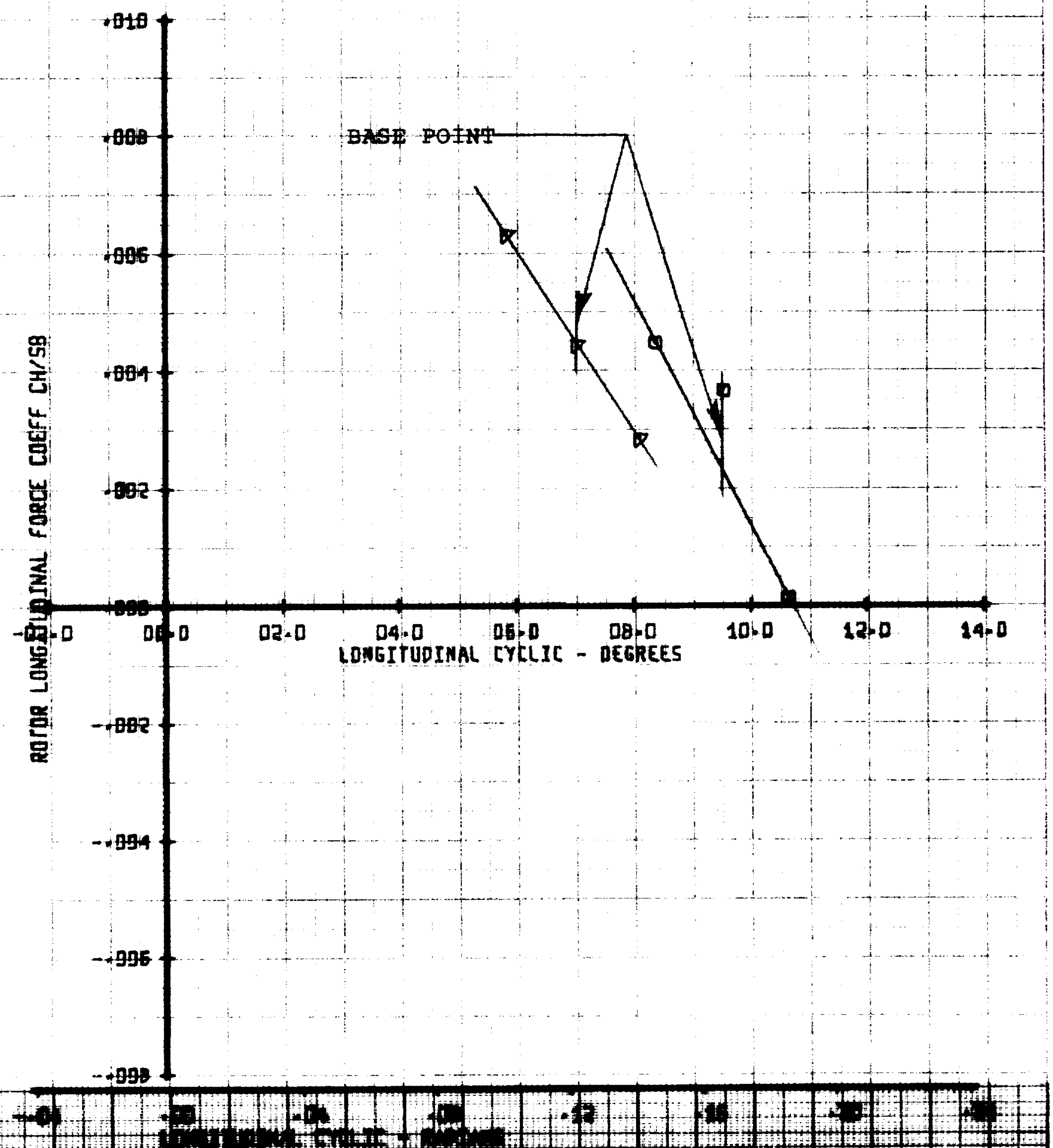
SET 21
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU	X/QD2SB	CT'/SB	VTUN
⊡	33	.40	.10	.089	248
▽	33	.40	.10	.070	248

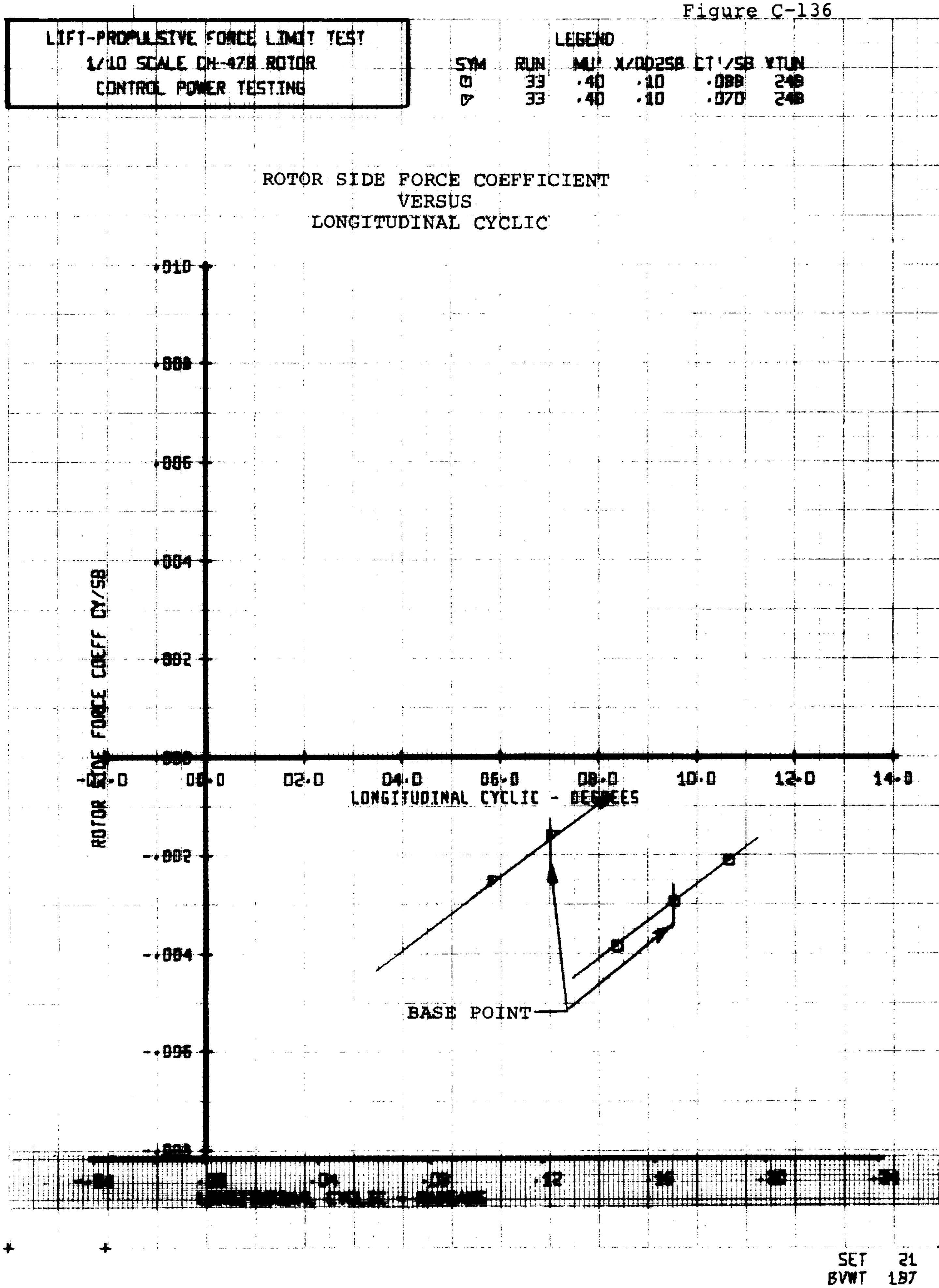
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC



ET 21
WT 137

SET 21
BVWT 137

Figure C-136



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD258 CT'/SB VTUN
□ 33 .40 .10 .080 240
▽ 33 .40 .10 .070 240
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR SIDE FORCE COEFF CY/SB
LONGITUDINAL CYCLIC - DEGREES
BASE POINT

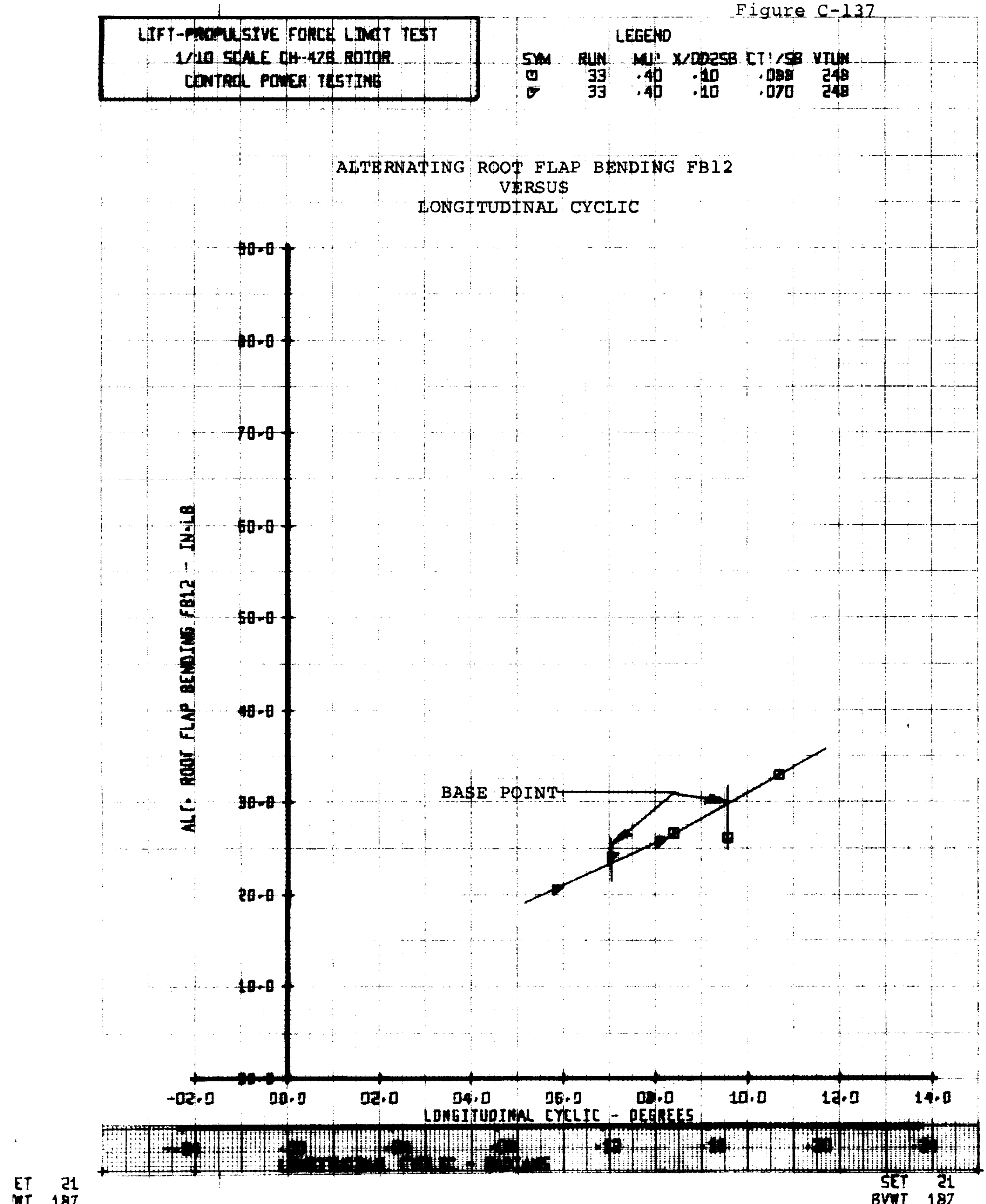
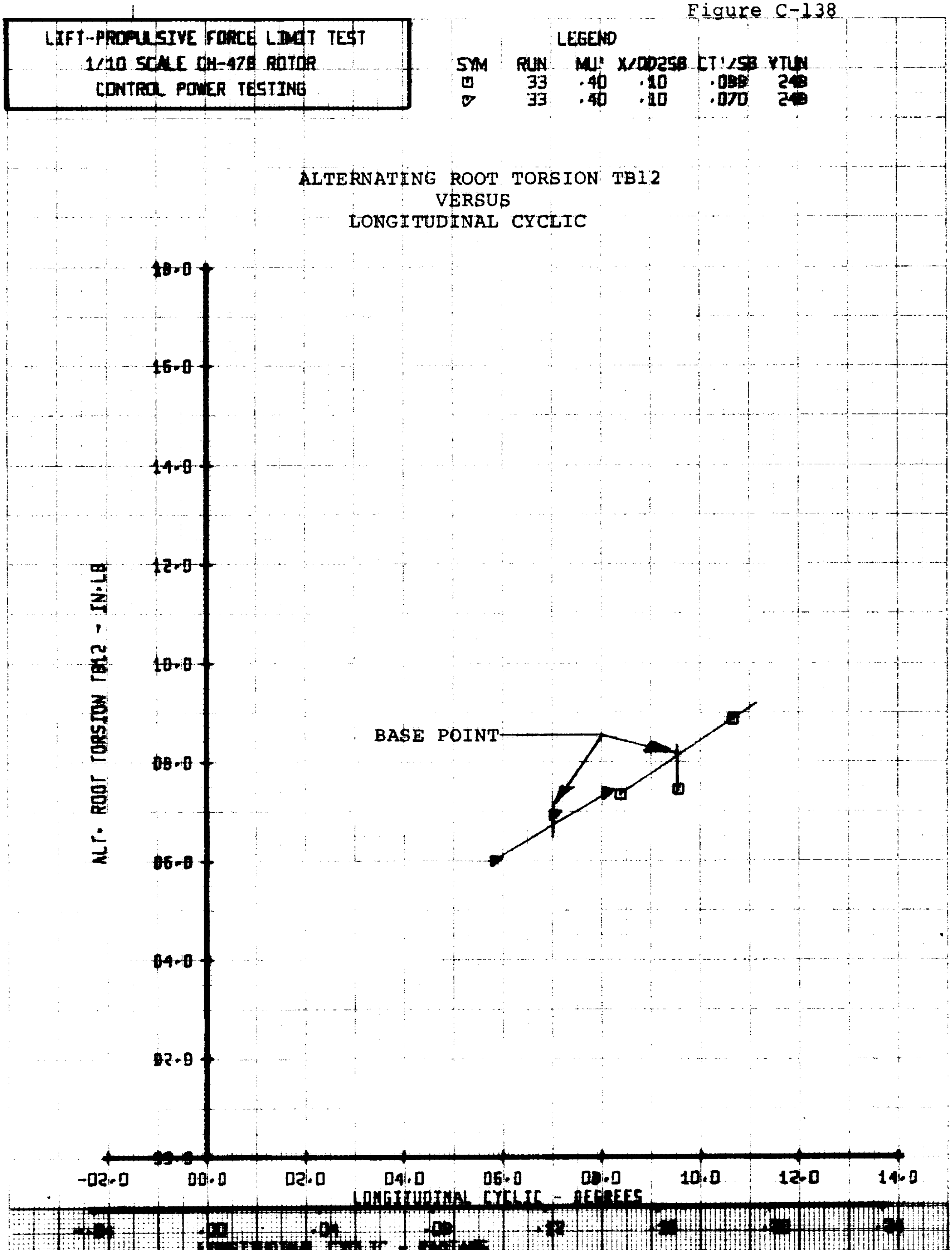

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN
33 .40 .10 .088 248
33 .40 .10 .070 248
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ALT. ROOT FLAP BENDING FB12 - IN-LB
LONGITUDINAL CYCLIC - DEGREES
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
00.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
ET 21
WT 187
SET 21
BVWT 187

Figure C-138



SET 21
BVWT 187

SET 21
BVWT 187

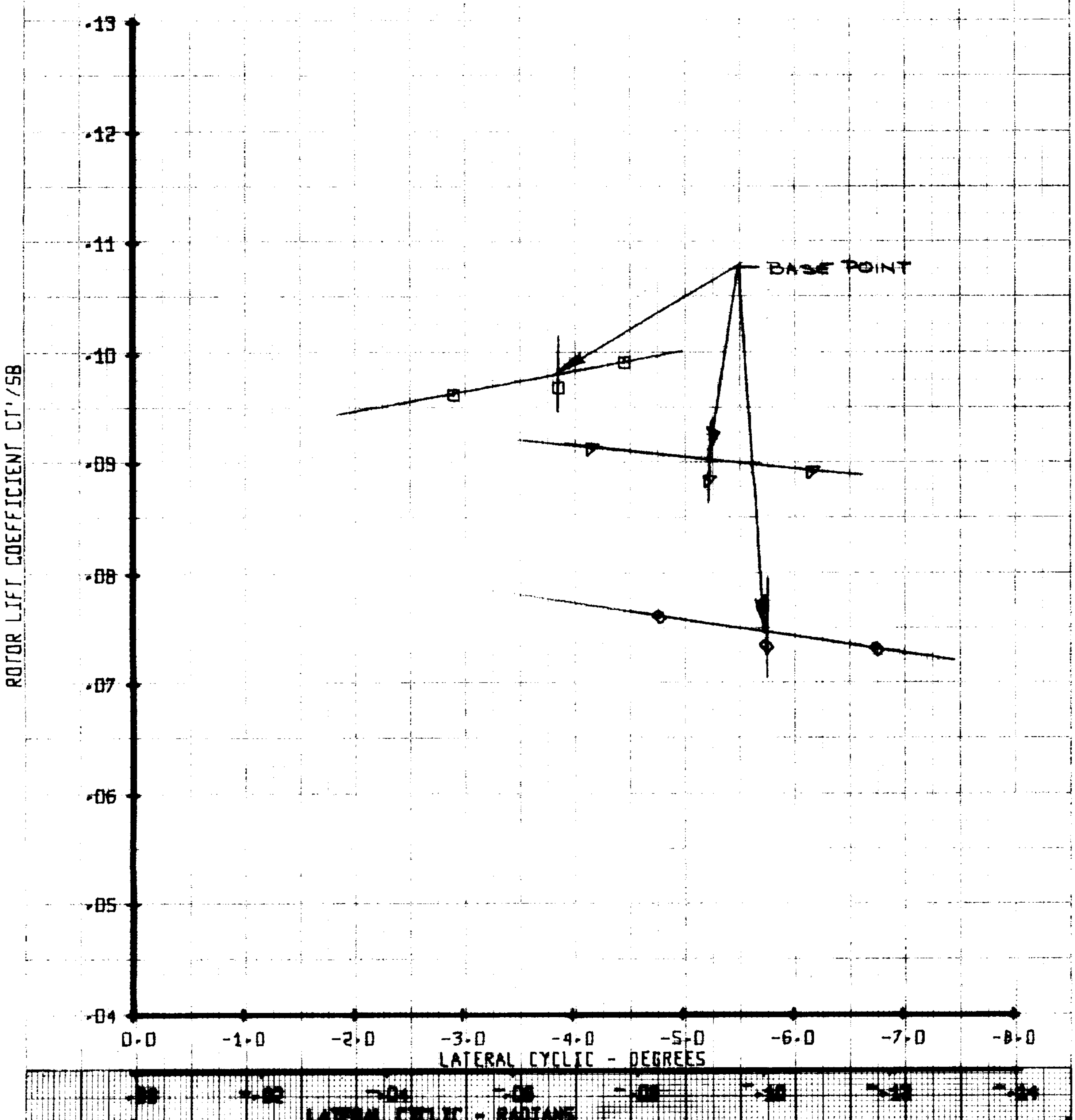
Figure C-139

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
□	39	.50	.05	.098	310
▽	41	.50	.10	.090	310
◇	42	.50	.20	.073	310

ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC



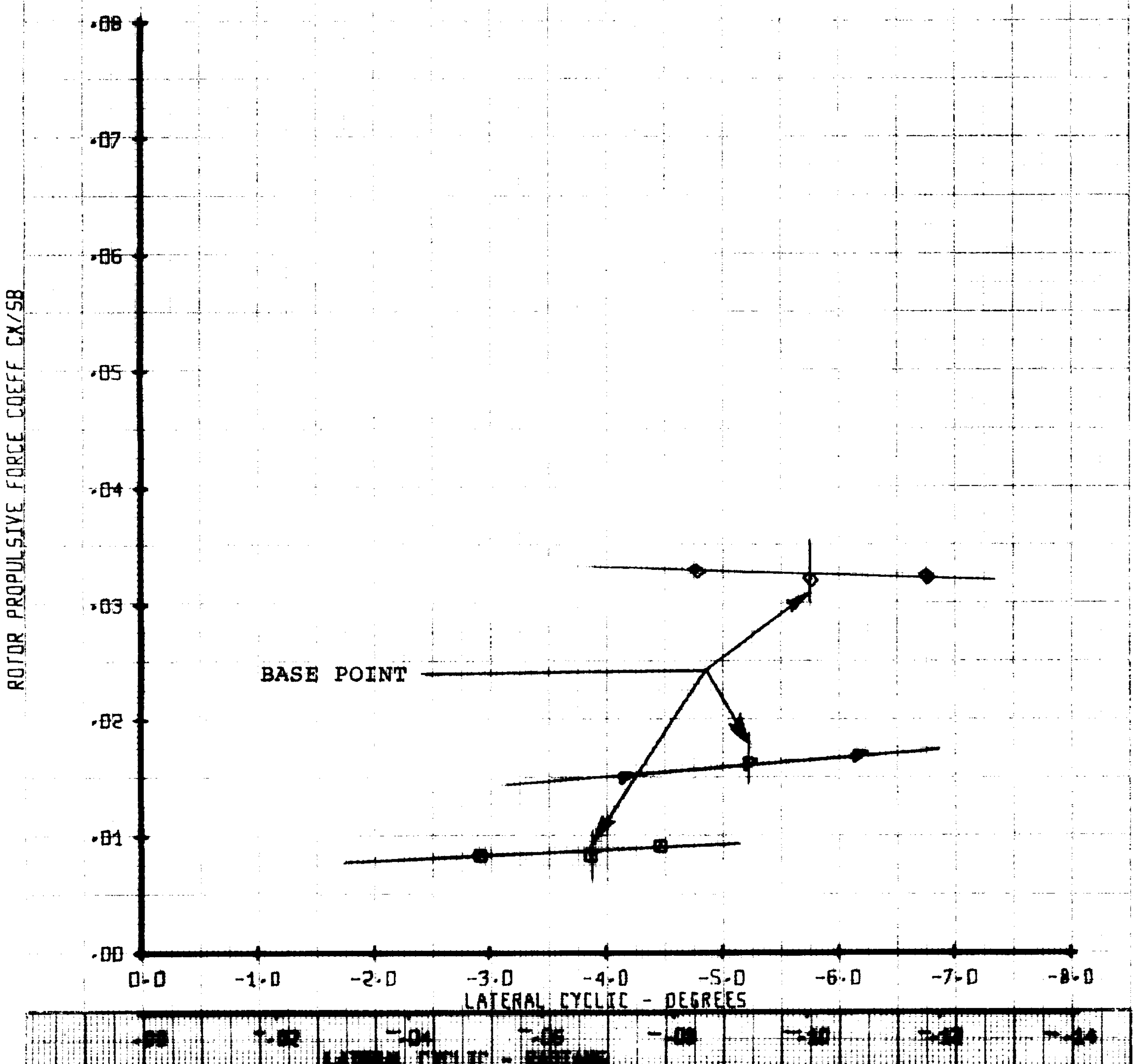
SET 22
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
□	39	.50	.05	.098	310
◸	41	.50	.10	.090	310
◇	42	.50	.20	.073	310

ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC



ET 22
WT 187

SET 22
BVWT 187

Figure C-141

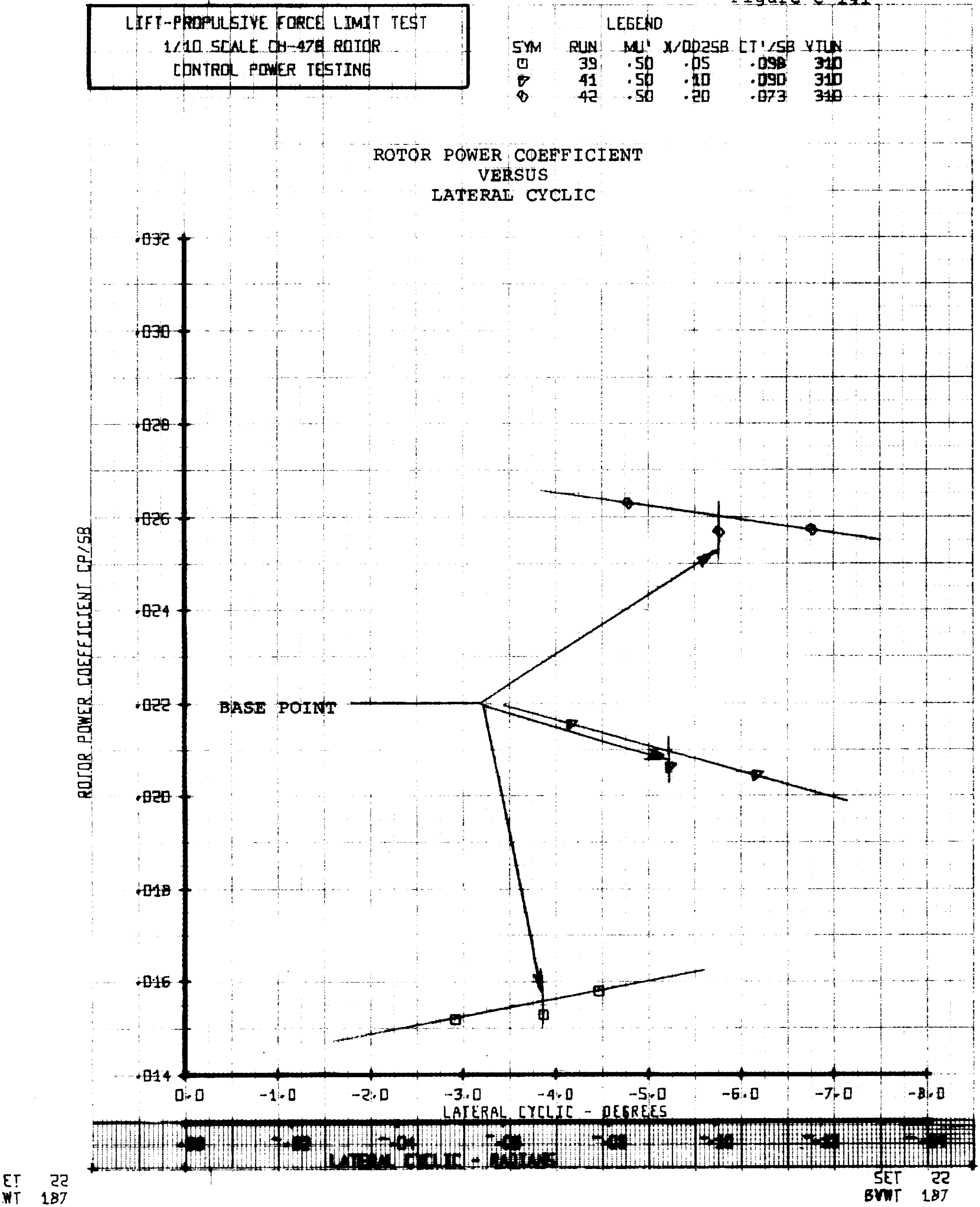
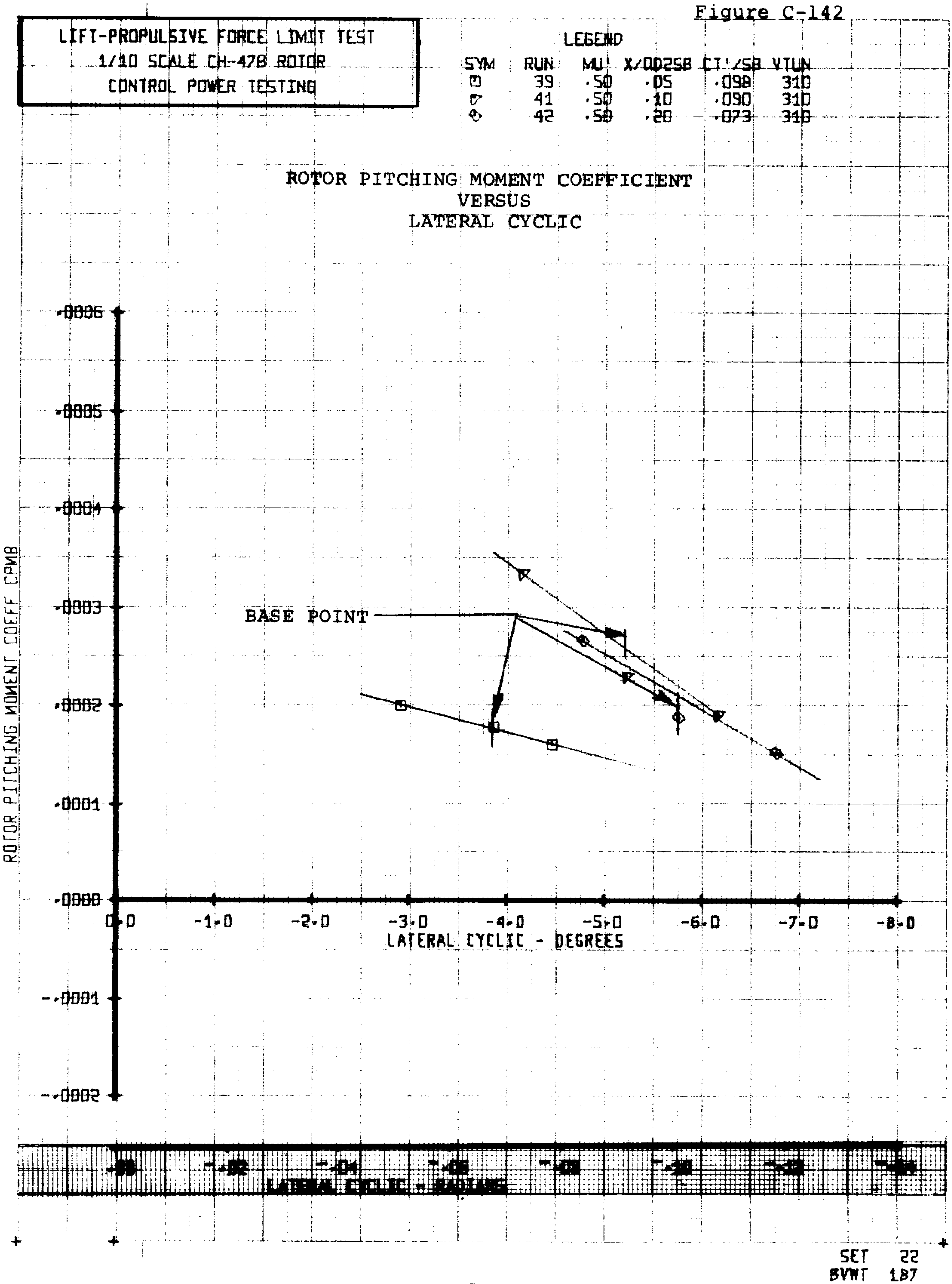

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN
39 .50 .05 .098 310
41 .50 .10 .090 310
42 .50 .20 .073 310
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.032
.030
.028
.026
.024
.022
.020
.018
.016
.014
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
ET 22
WT 187
SET 22
BVWT 187

Figure C-142



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD258 CT'/SB VTUN
39 .50 .05 .098 310
41 .50 .10 .090 310
42 .50 .20 .073 310
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 22
BVWT 187

Figure C-143

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU	X/QD2SB	CT'/SB	VTUN
□	39	.50	.05	.098	310
▽	41	.50	.10	.090	310
◇	42	.50	.20	.073	310

ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC

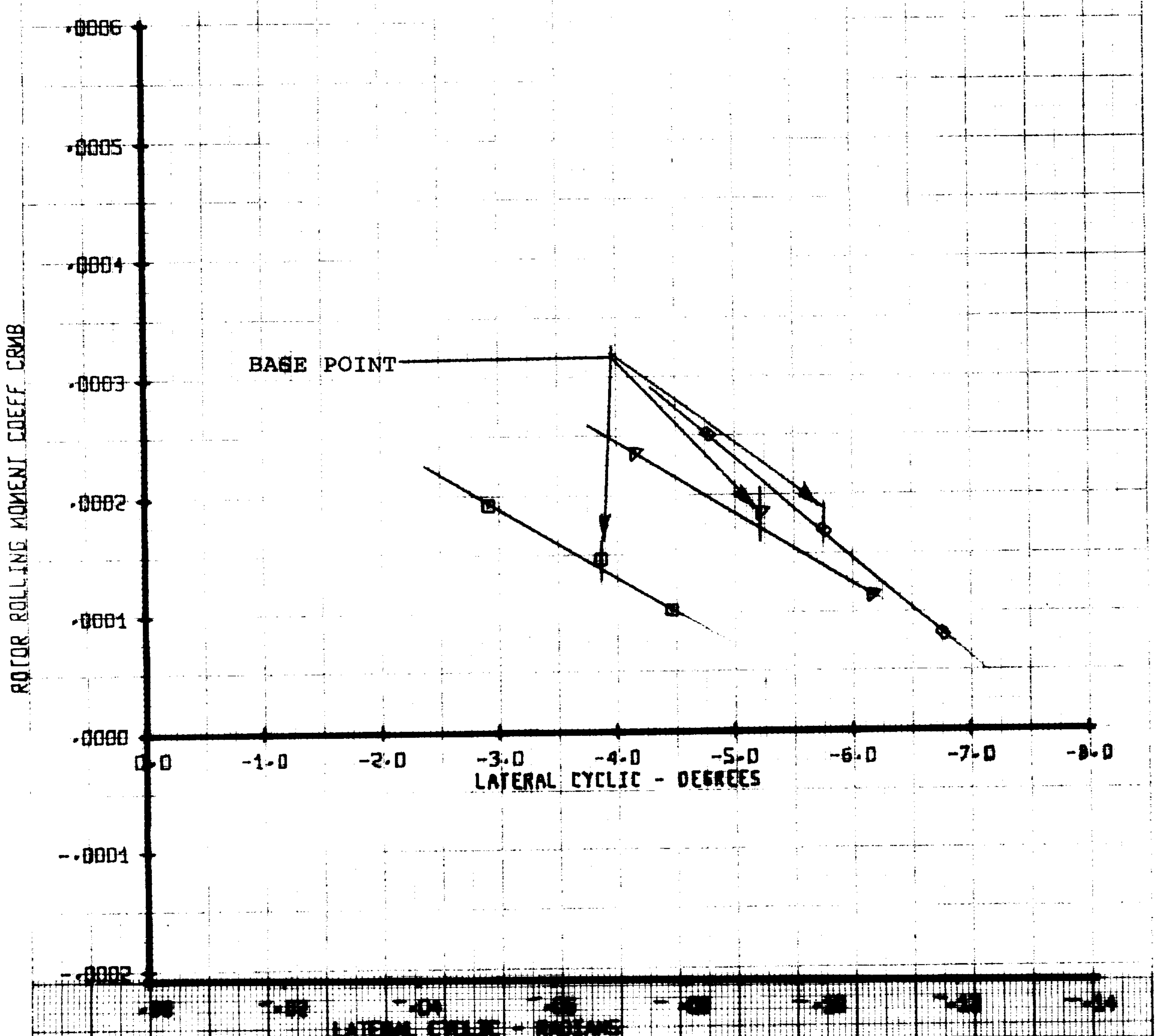
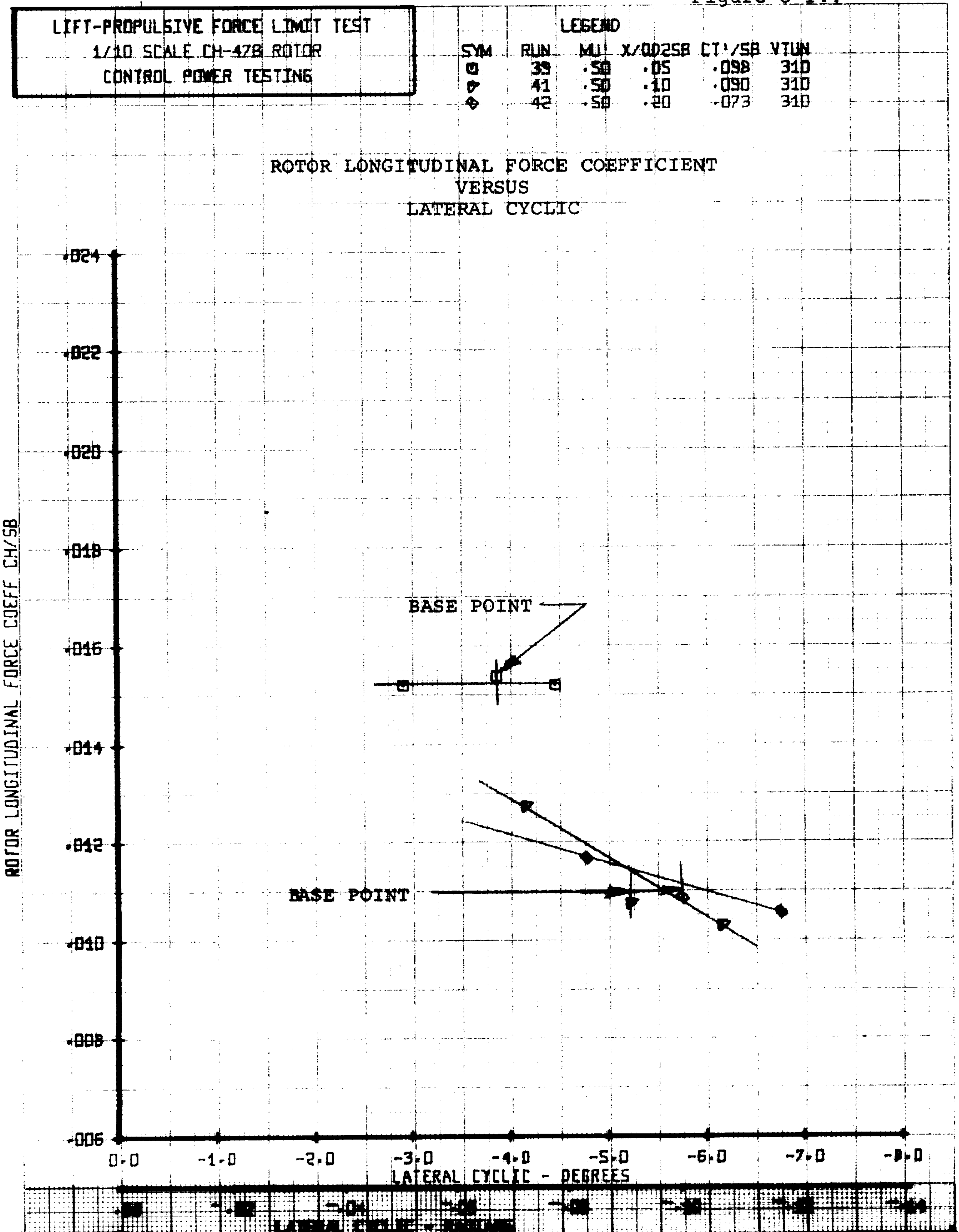


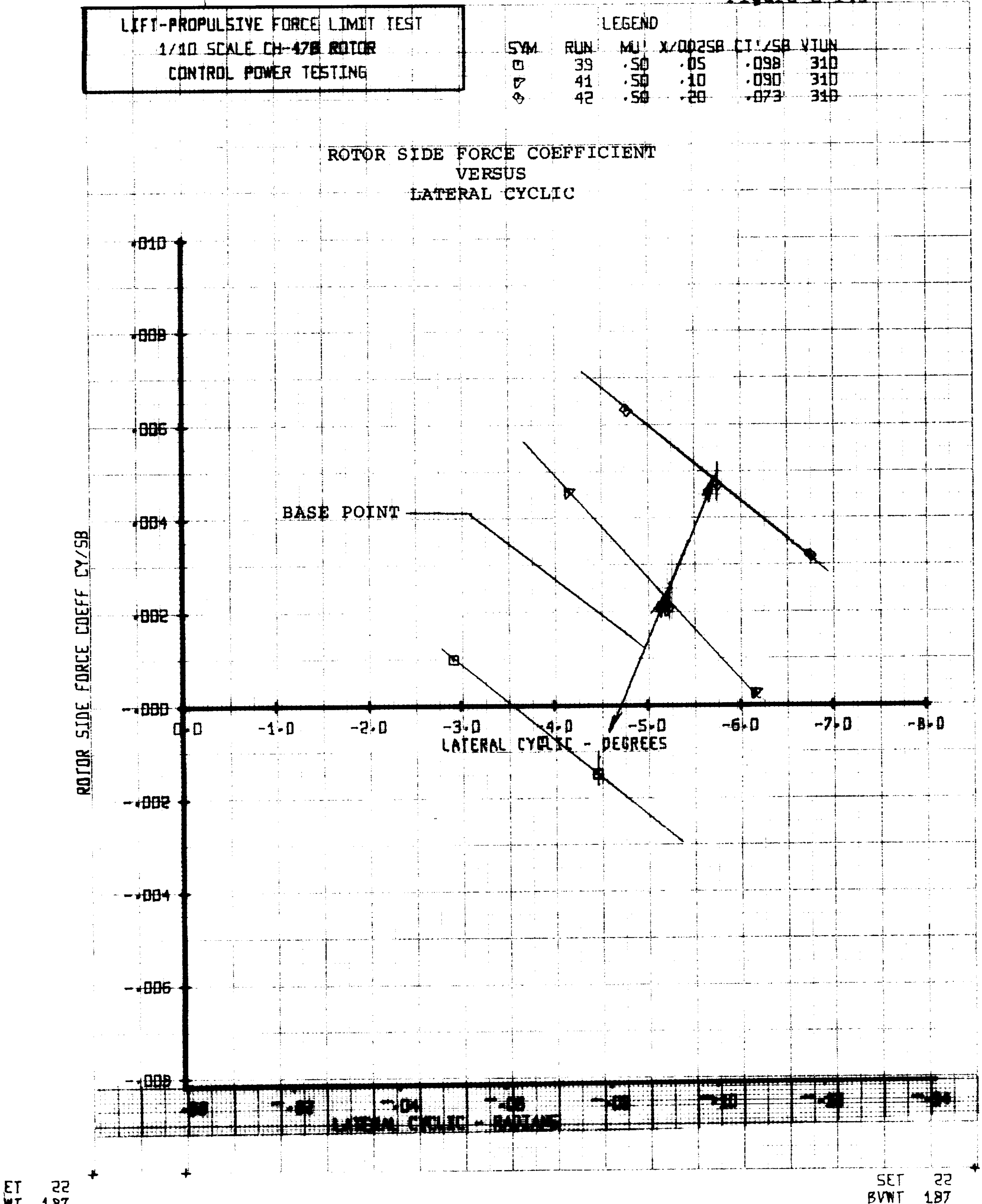
Figure C-144

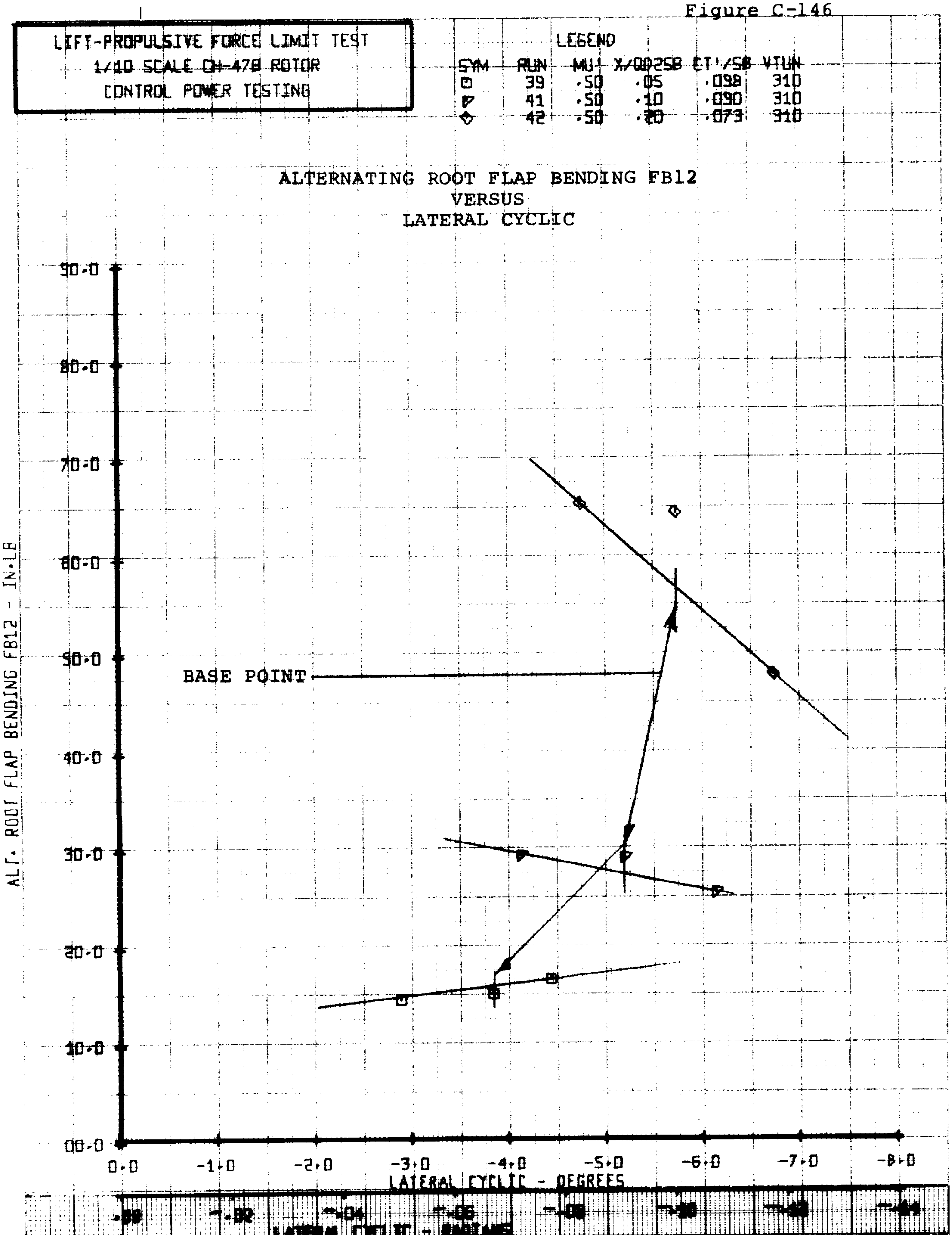


ET 22
WT 187

SET 22
BVWT 187

Figure C-145

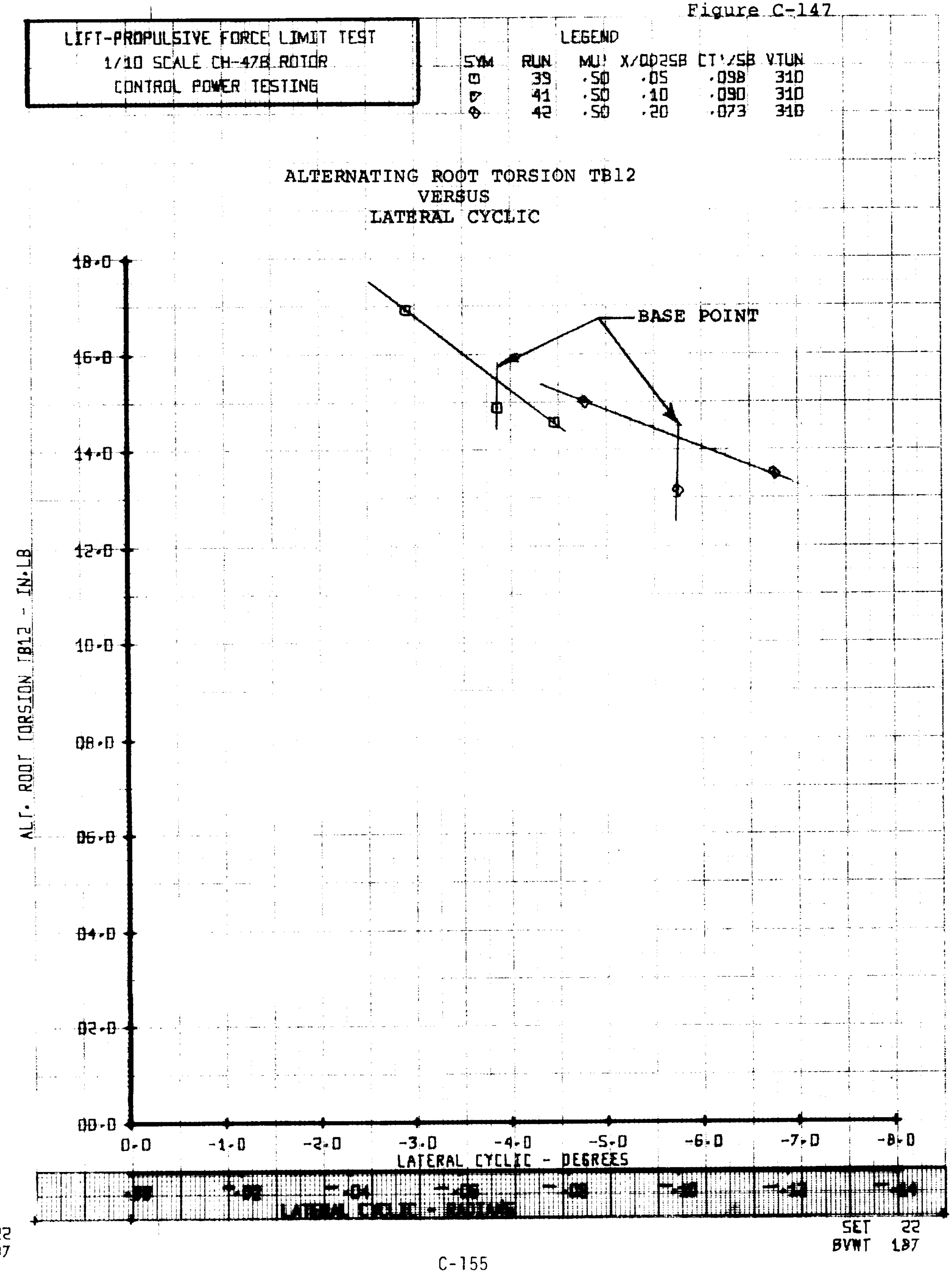

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
39 .50 .05 .098 310
41 .50 .10 .090 310
42 .50 .20 .073 310
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR SIDE FORCE COEFF CY/SB
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 22
BVWT 187



ET 22
WT 187

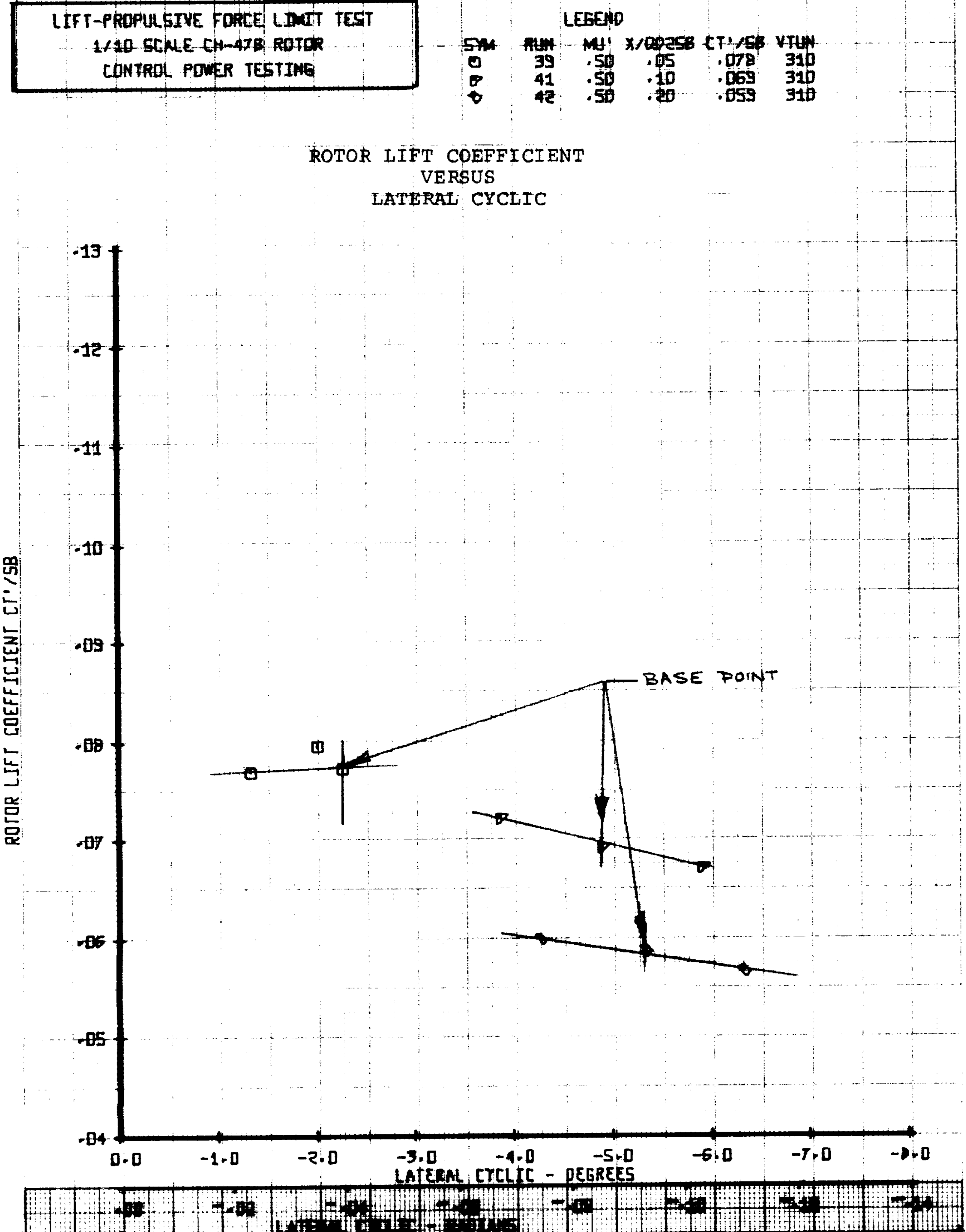
SET 22
BVWT 187

Figure C-147



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
39 .50 .05 .098 310
41 .50 .10 .090 310
42 .50 .20 .073 310
ALTERNATING ROOT TORSION TB12
VERSUS
LATERAL CYCLIC
BASE POINT
ALT. ROOT TORSION TB12 - IN.LB
18.0
16.0
14.0
12.0
10.0
08.0
06.0
04.0
02.0
00.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 22
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING



ET 23
WT 187

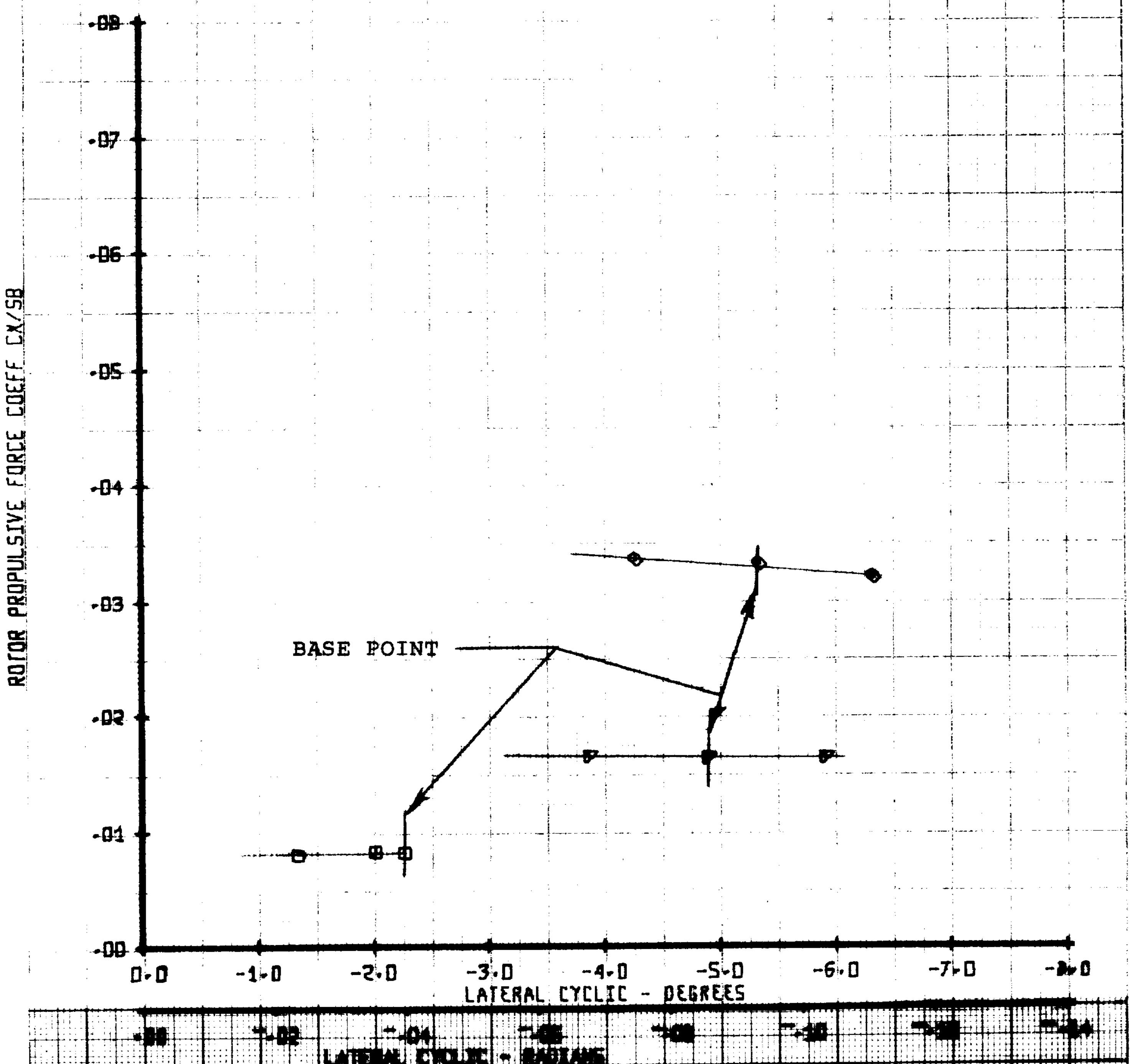
SET 23
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
⊡	39	.50	.05	.078	310
▽	41	.50	.10	.069	310
◇	42	.50	.20	.059	310

ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC



ET 23
WT 187

SET 23
BVWT 187

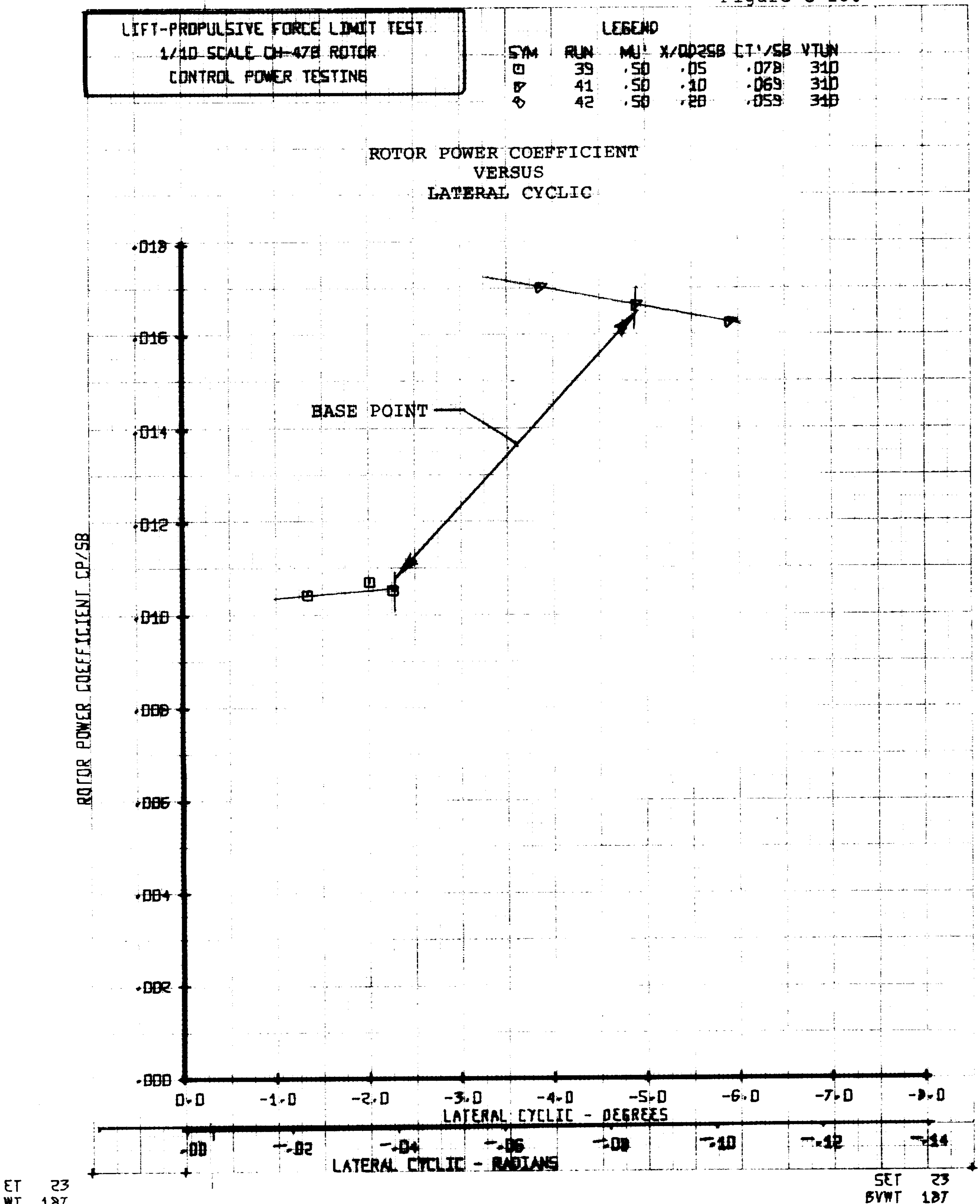
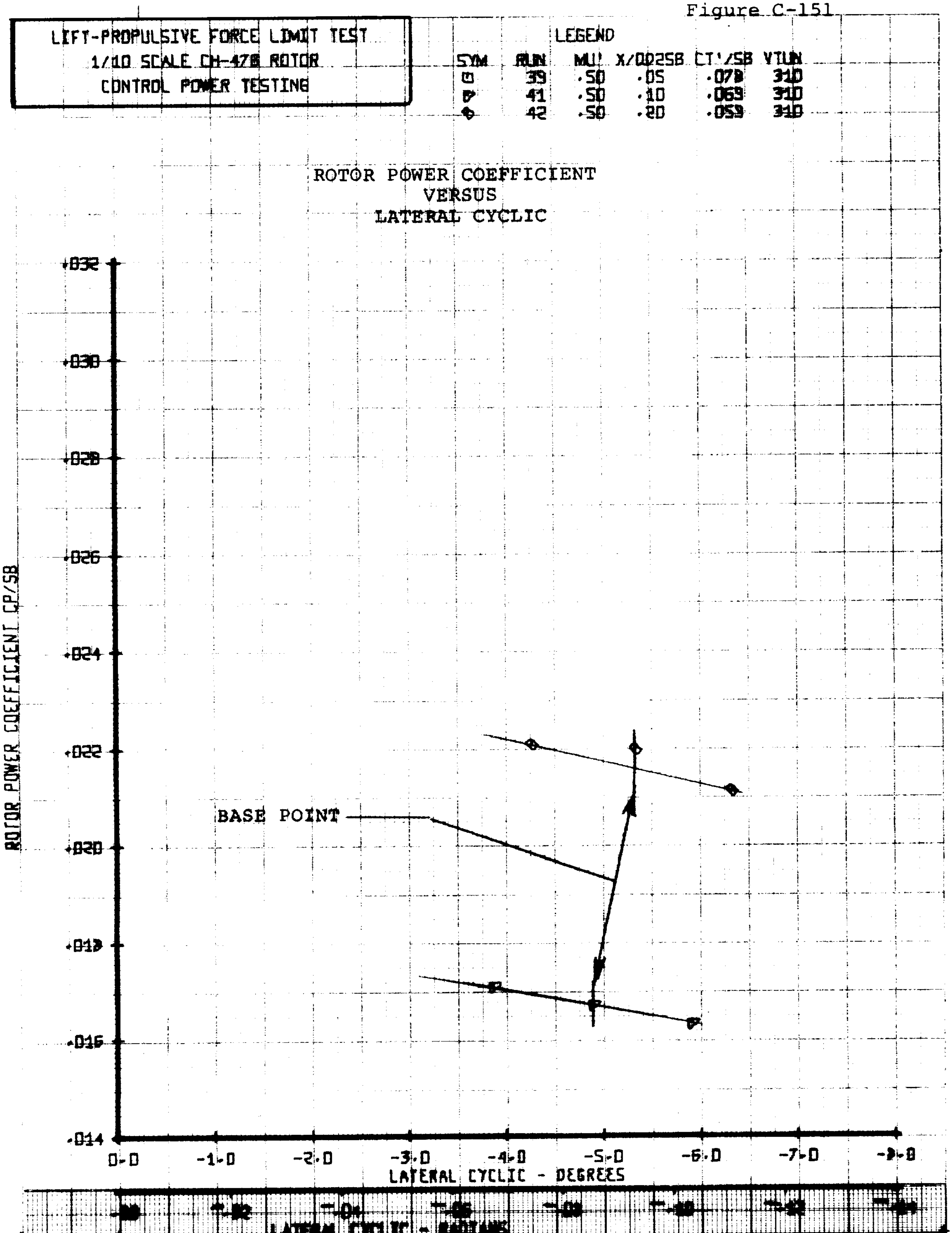

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
39 .50 .05 .079 310
41 .50 .10 .069 310
42 .50 .20 .059 310
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
.00
-.02
-.04
-.06
-.08
-.10
-.12
-.14
LATERAL CYCLIC - RADIANS
ET 23
WT 187
SET 23
BVWT 187

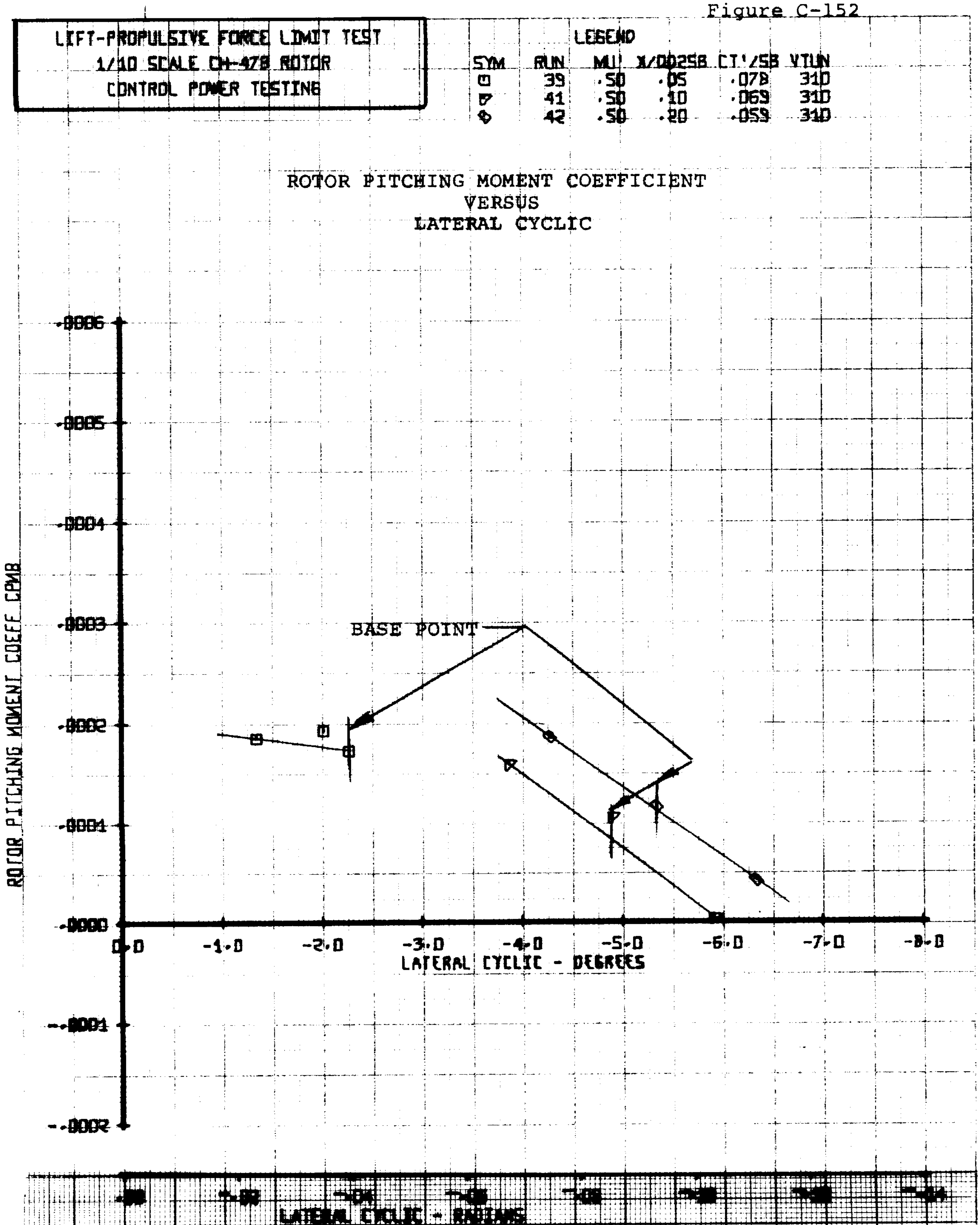
Figure C-151



ET 23
WT 137

SET 23
BVWT 137

Figure C-152



ET 23
WT 137

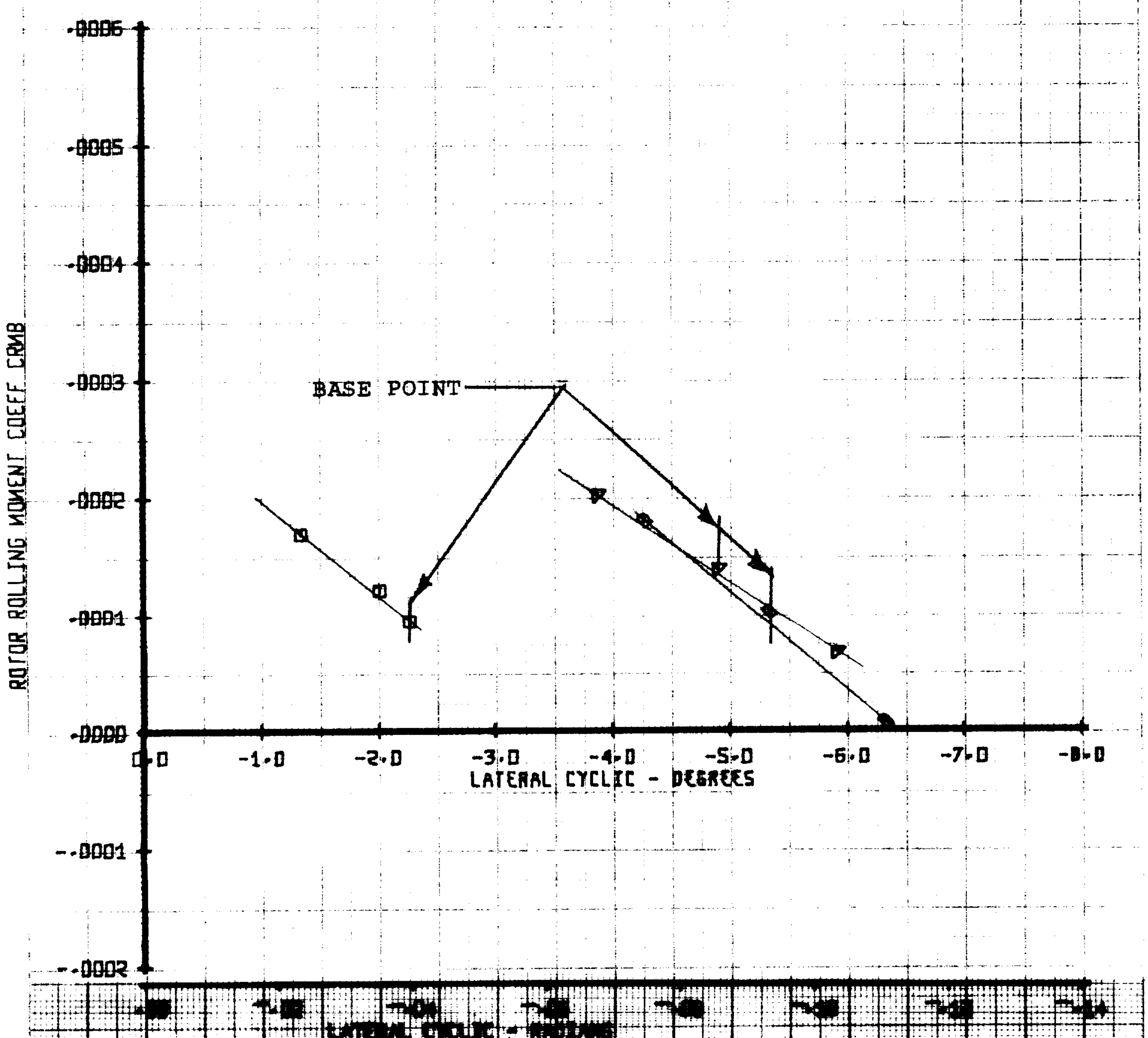
SET 23
BVWT 137

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/DD2SB	CT'/SB	VTUN
□	39	.50	.05	.078	310
▽	41	.50	.10	.069	310
◇	42	.50	.20	.059	310

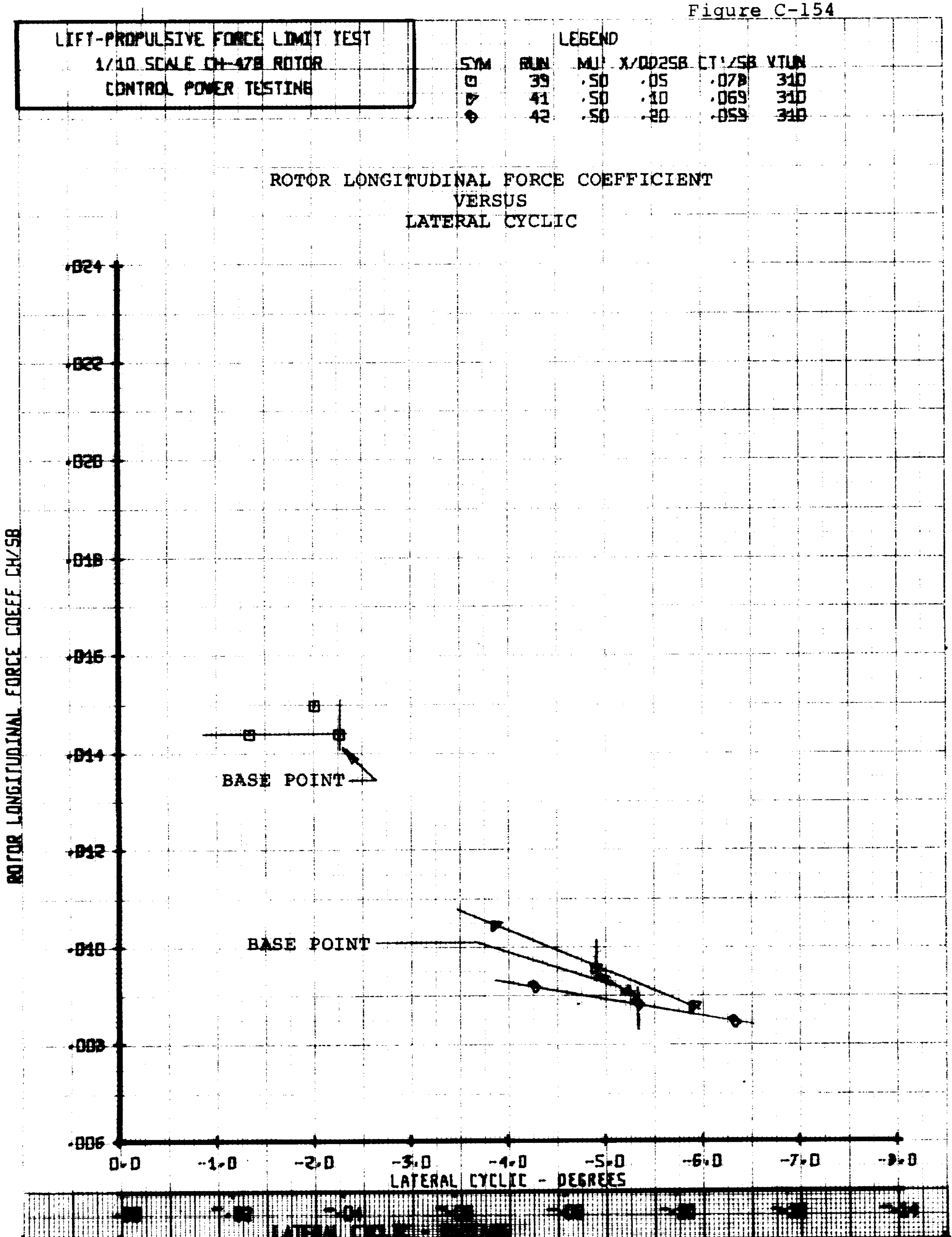
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC



ET 23
WT 187

SET 23
BVWT 187

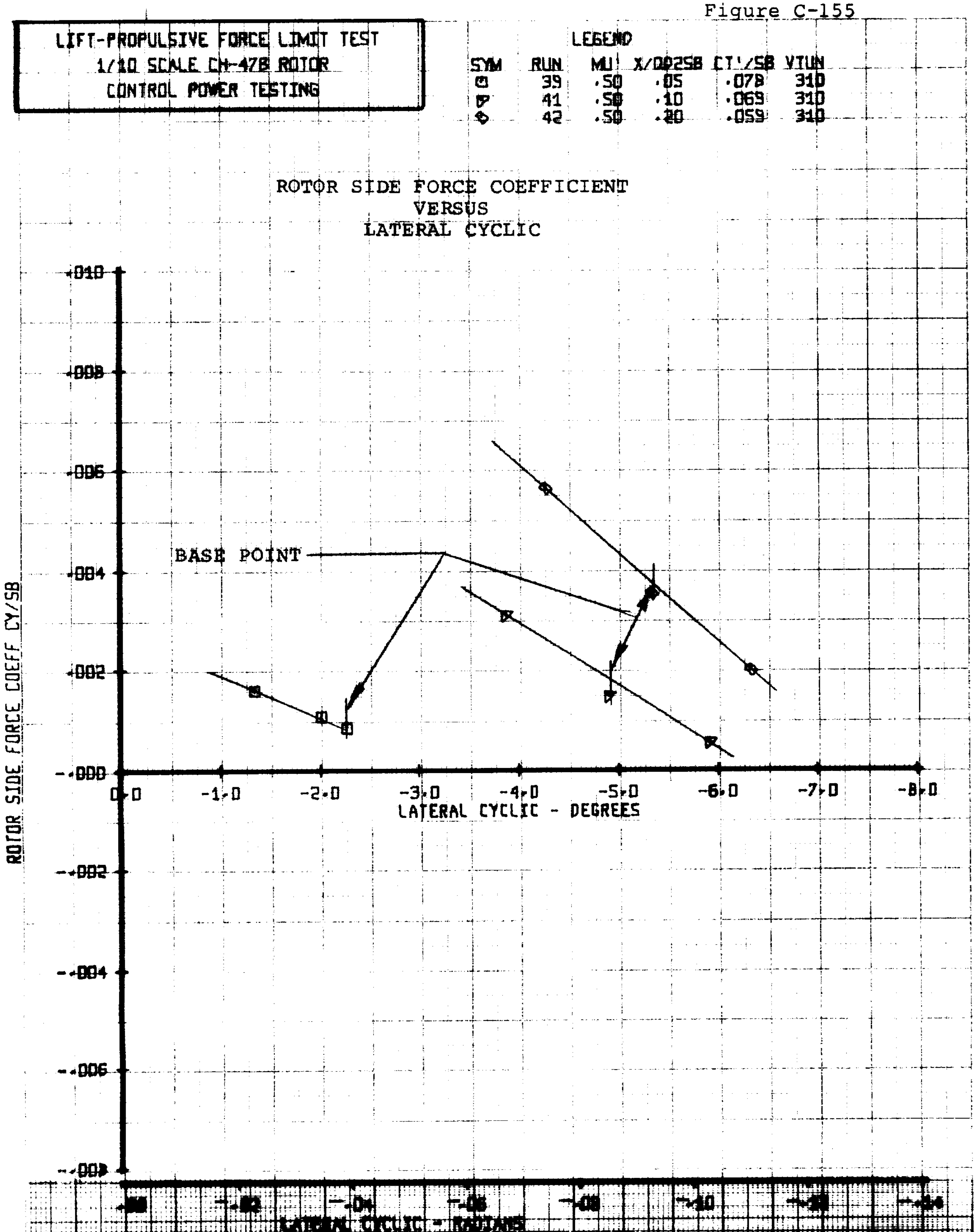
Figure C-154



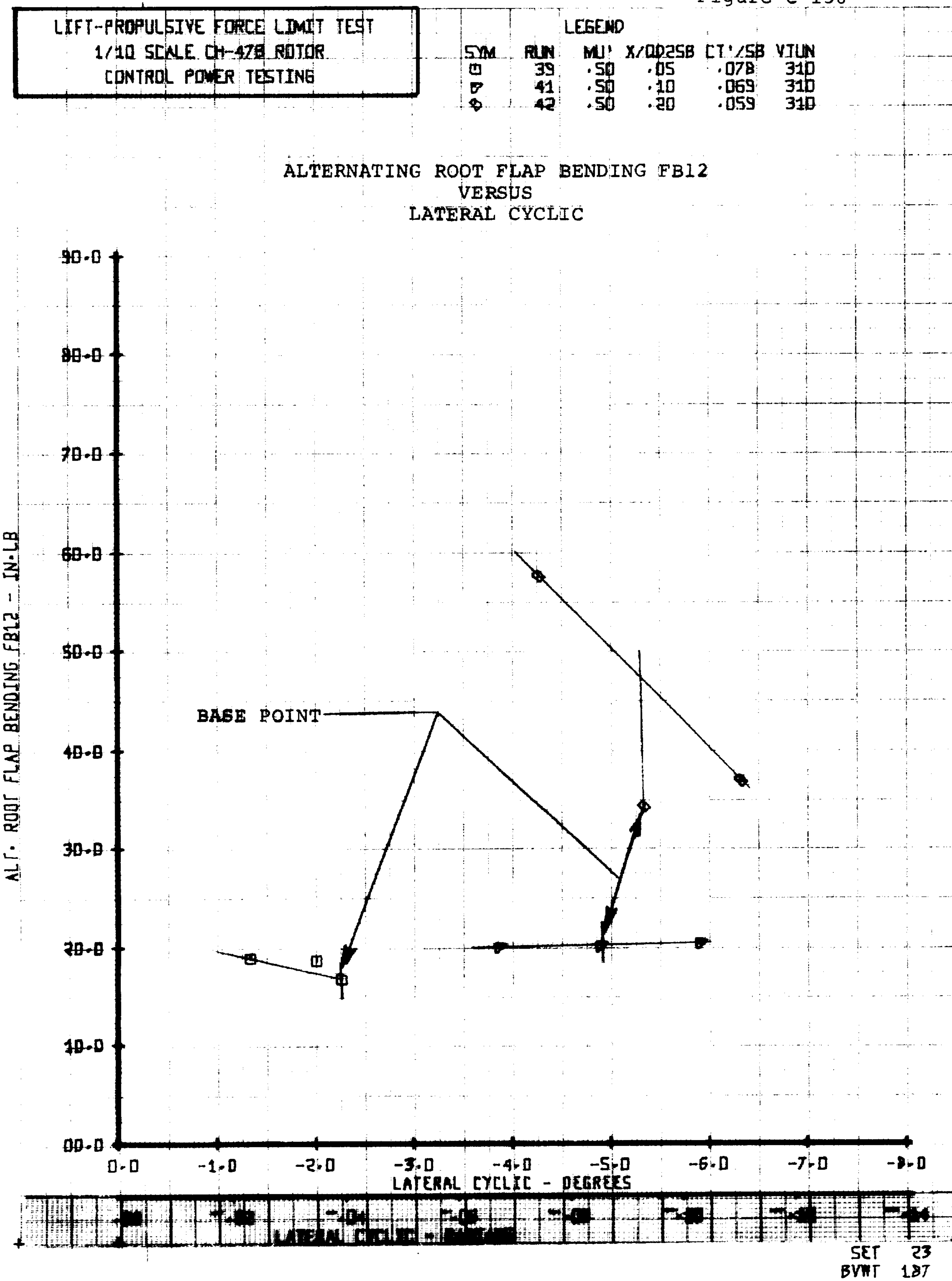
ET 23
WT 187

SET 23
BVWT 187

Figure C-155

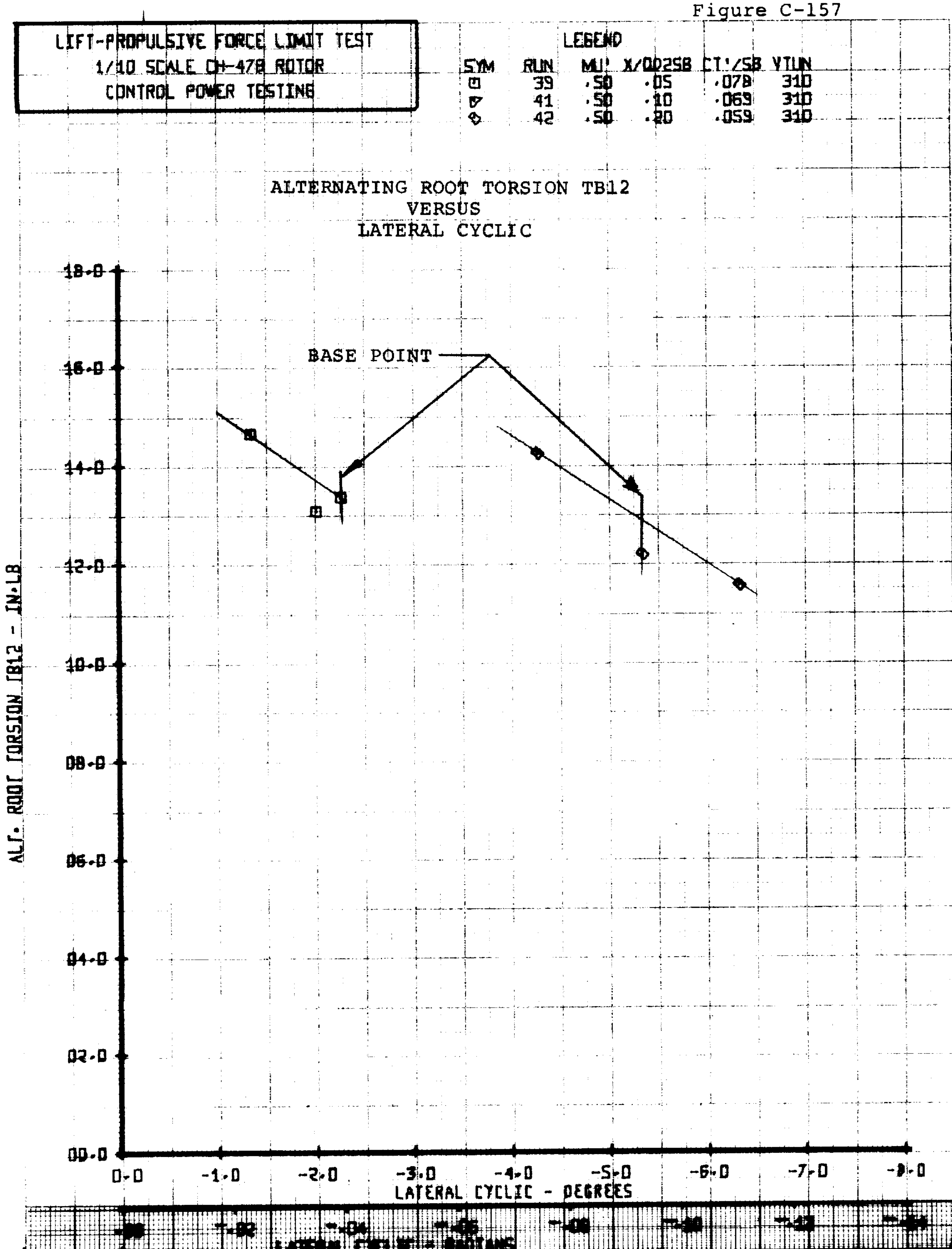


SET 23
BVWT 137



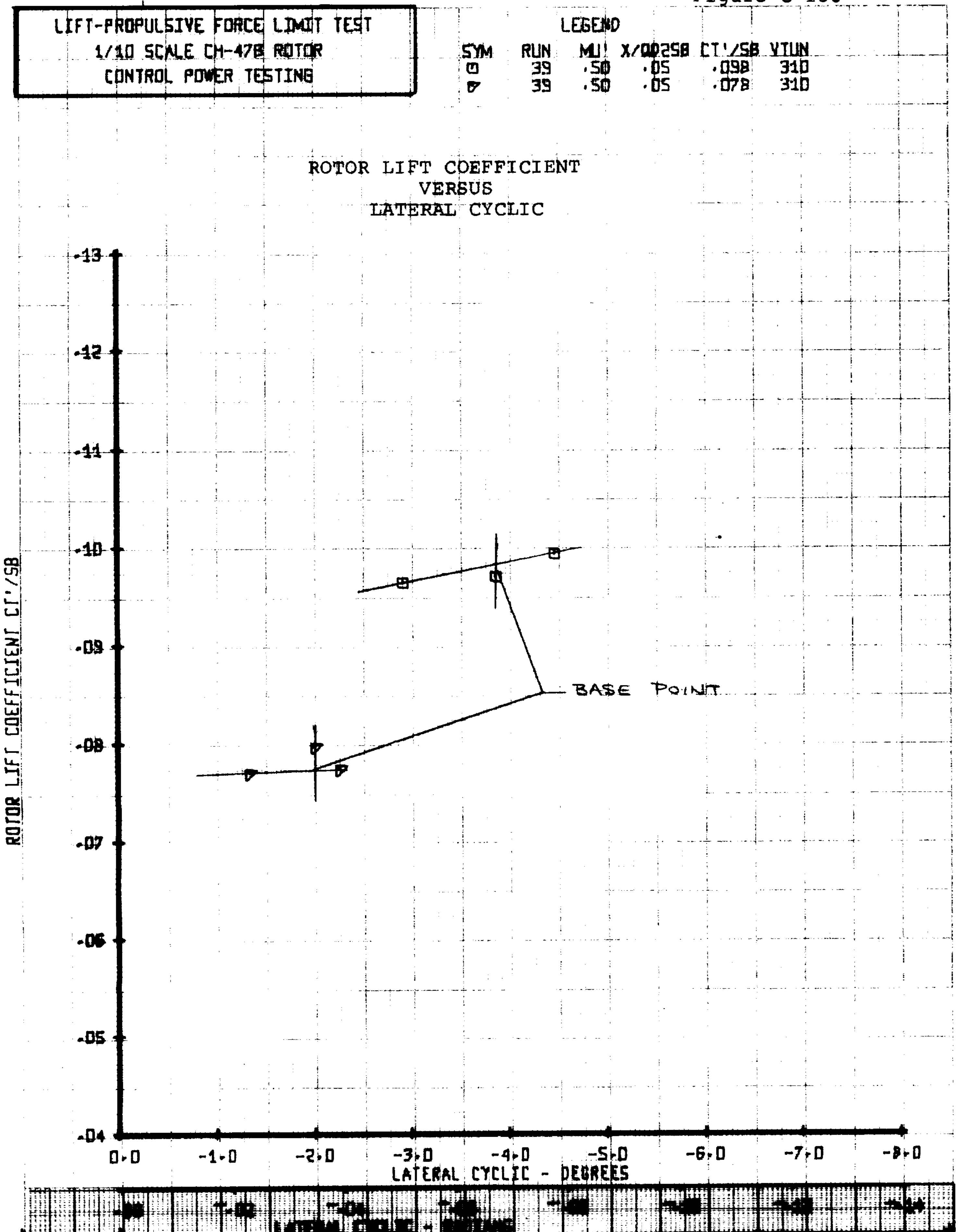
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
39 .50 .05 .078 310
41 .50 .10 .069 310
42 .50 .20 .059 310
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LATERAL CYCLIC
BASE POINT
ALT. ROOT FLAP BENDING FB12 - IN.LB
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
00.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 23
BVWT 187

Figure C-157



ET 23
WT 137

SET 23
BVWT 137



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
39 .50 .05 .098 310
39 .50 .05 .078 310
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
BASE POINT
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 24
BVWT 187

ET 24
WT 187

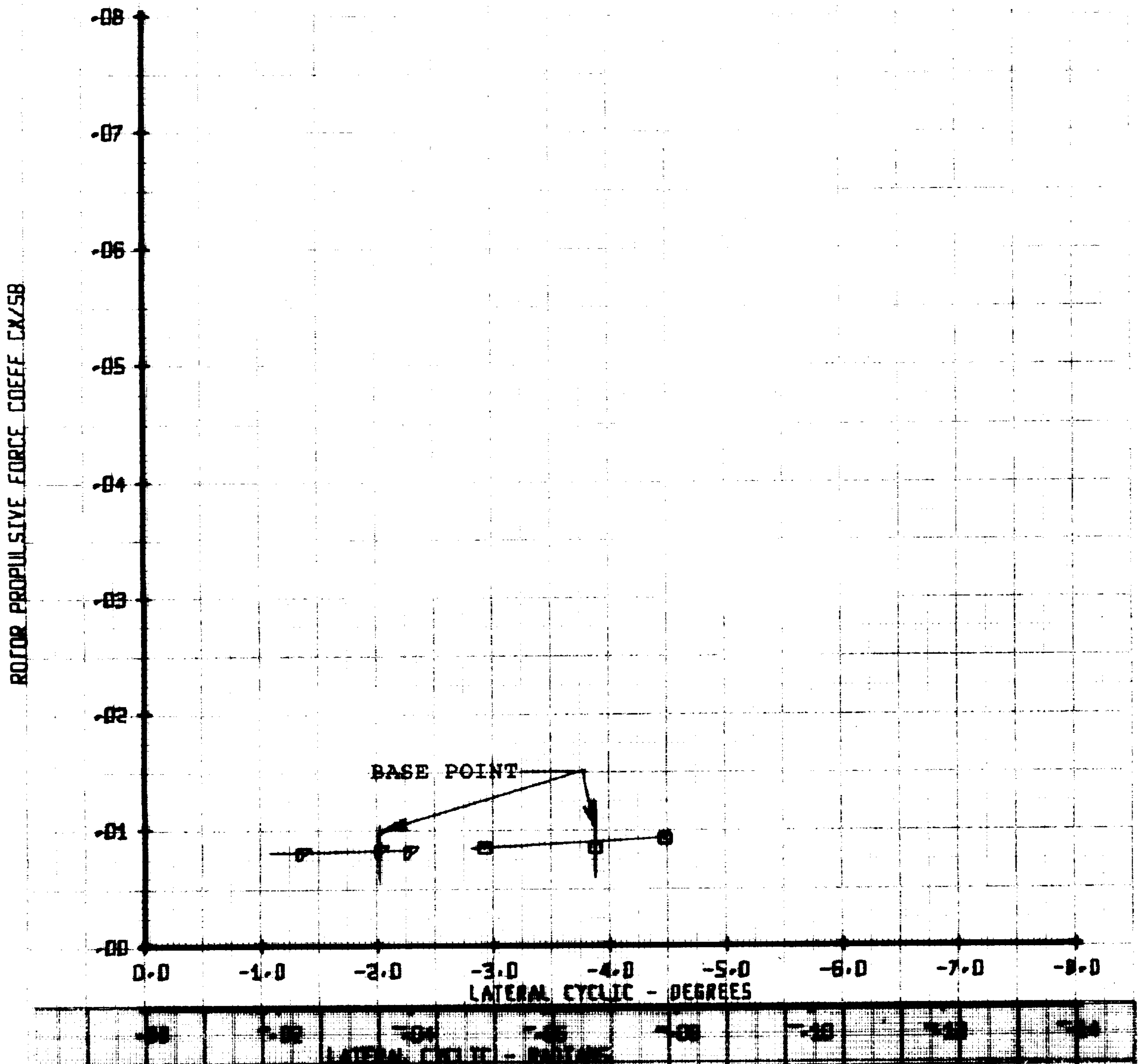
Figure C-159

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

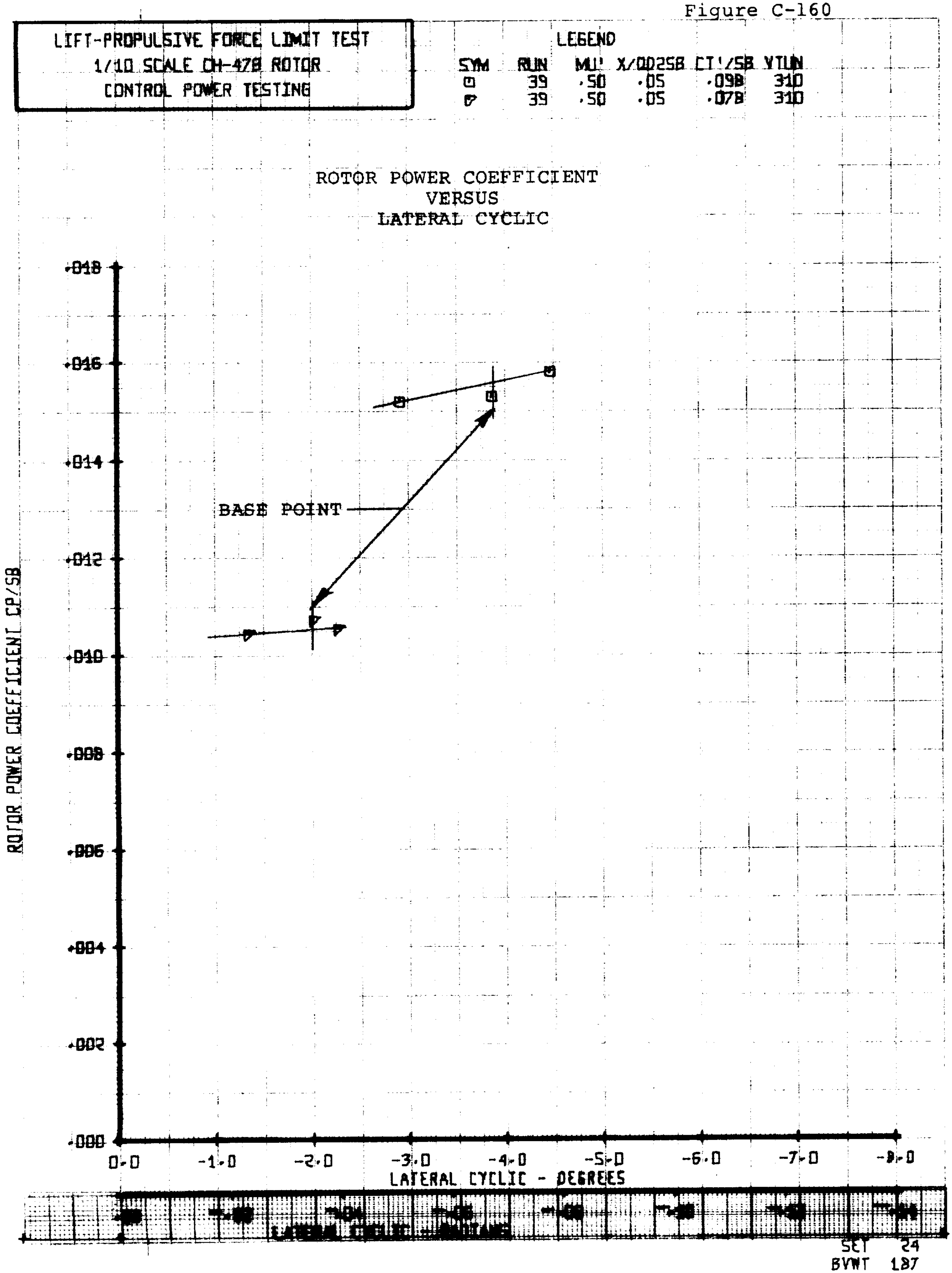
SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
⊡	39	.50	.05	.098	310
▽	39	.50	.05	.078	310

ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC



ET 24
WT 187

SET 24
BVWT 187



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
39 .50 .05 .098 310
39 .50 .05 .078 310
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 24
BVWT 187

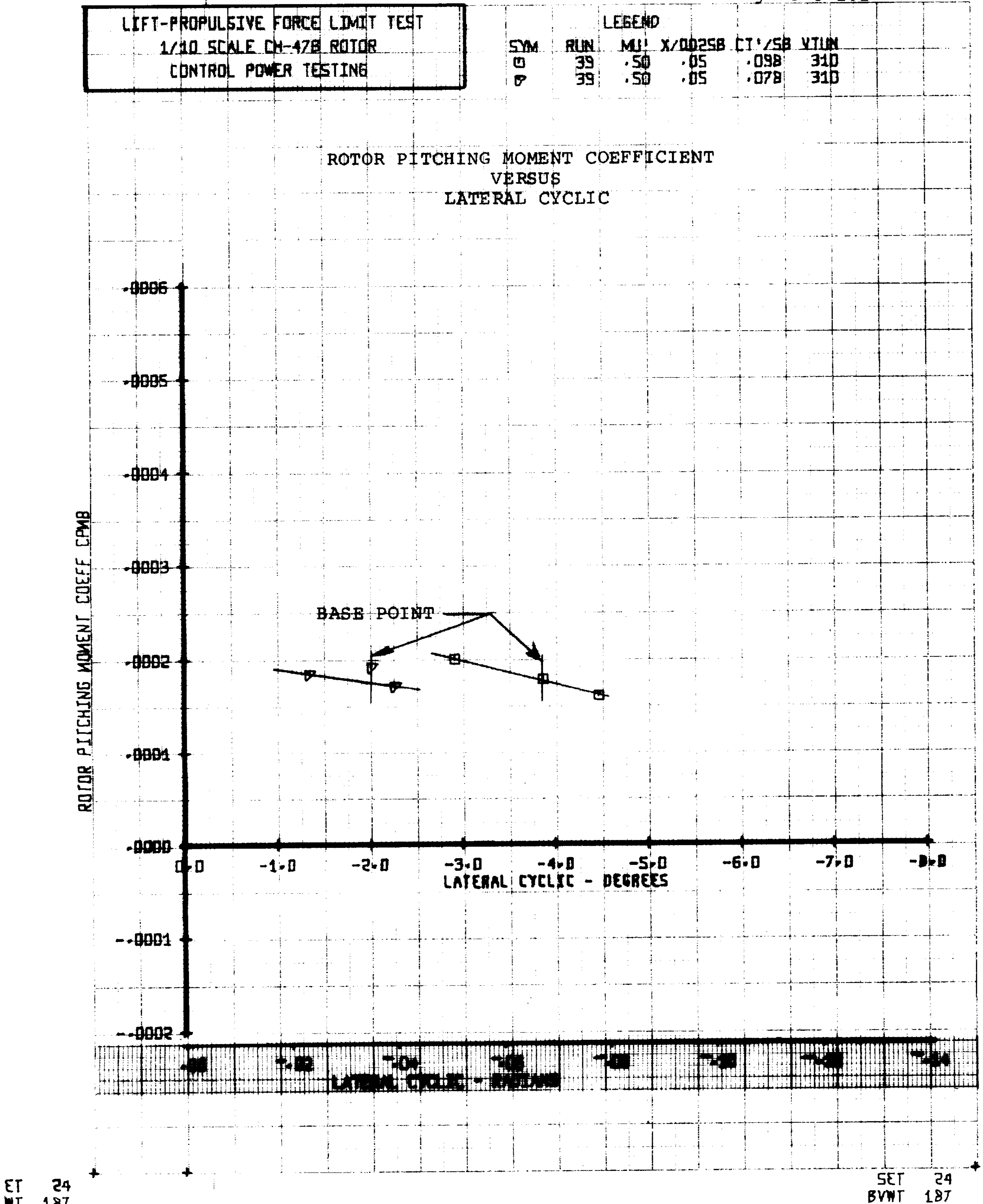
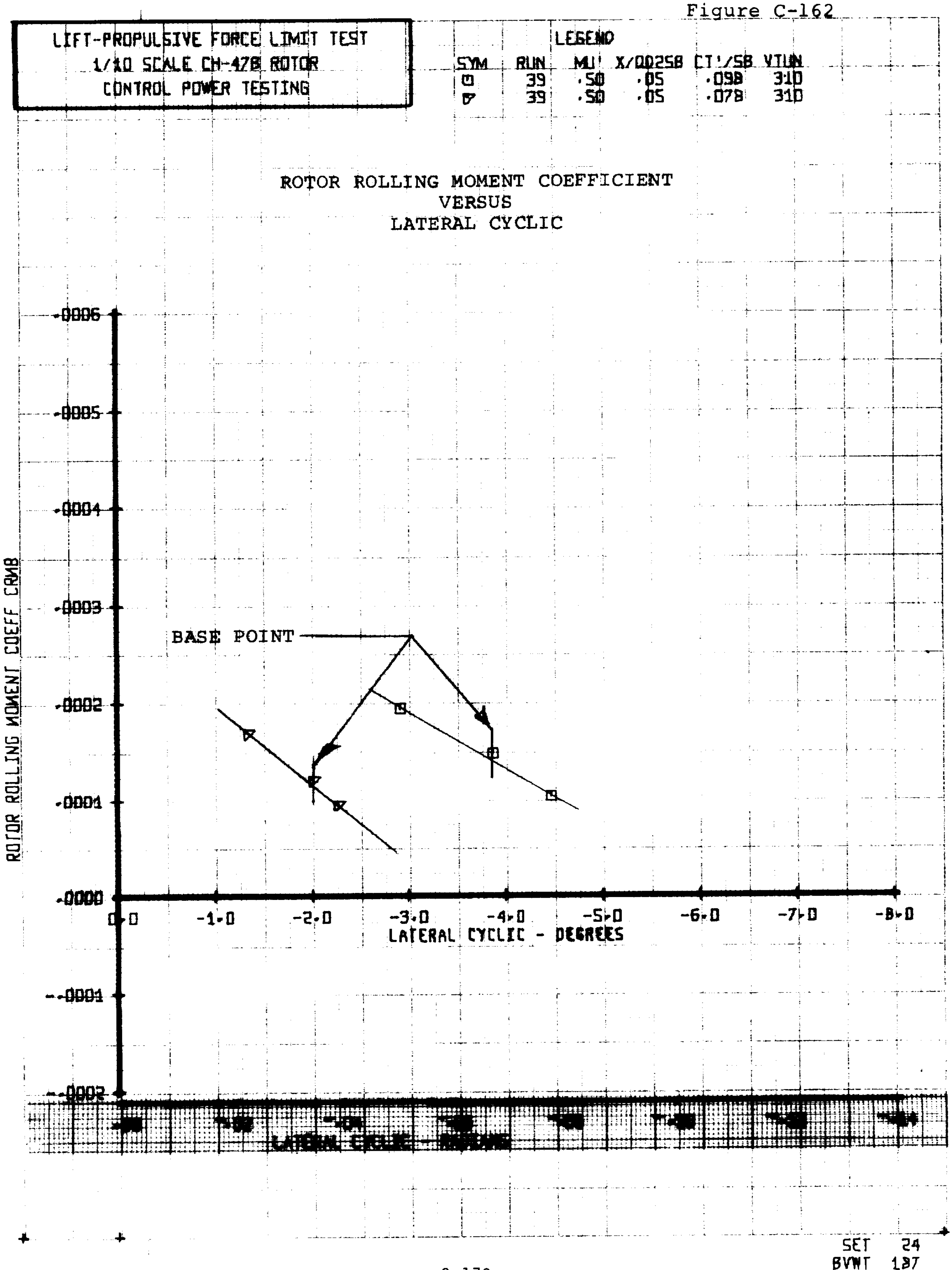
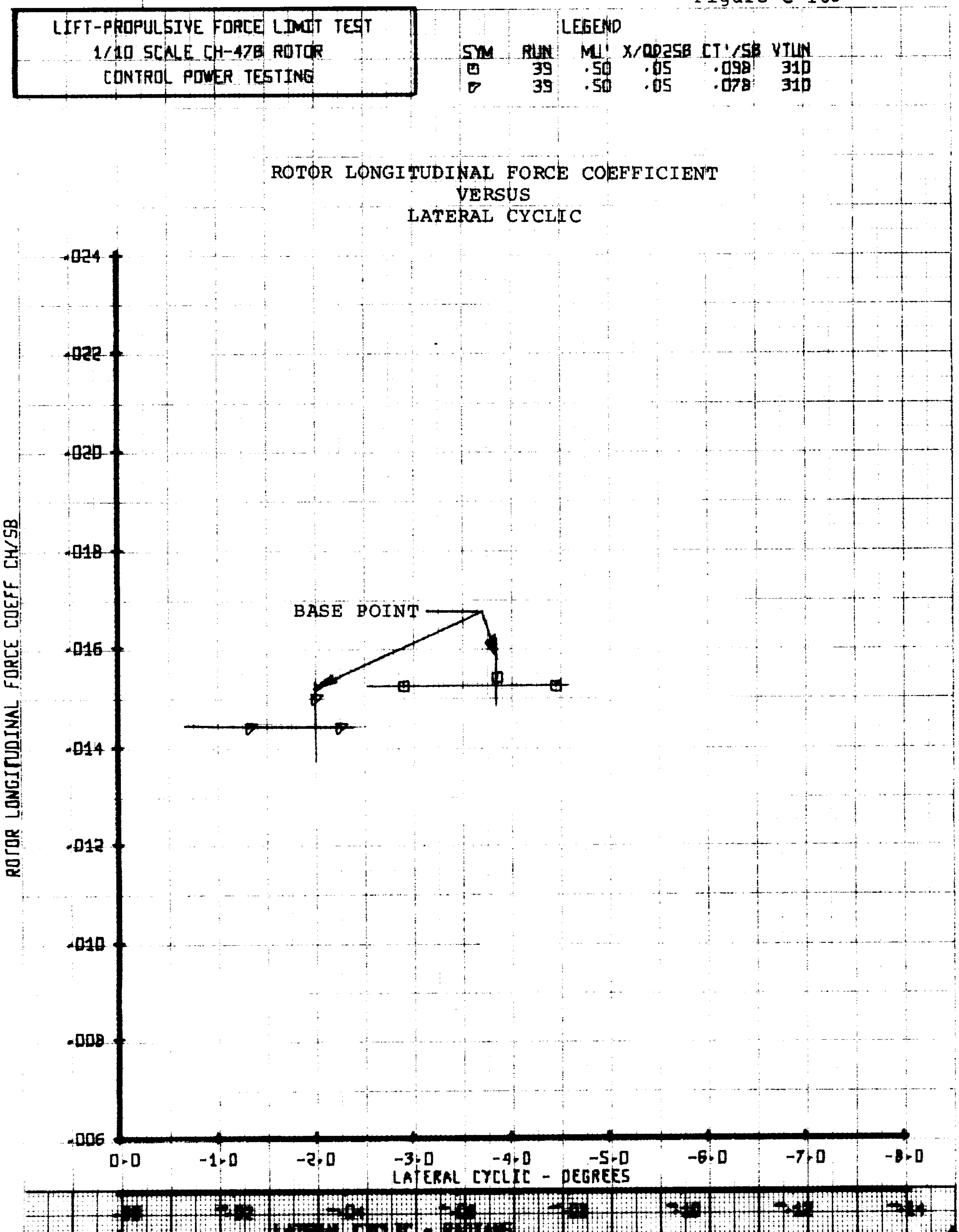

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
39 .50 .05 .098 310
39 .50 .05 .078 310
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
ET 24
WT 187
SET 24
BVWT 187

Figure C-162



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
□ 39 .50 .05 .098 310
▽ 39 .50 .05 .078 310
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR ROLLING MOMENT COEFF CRMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 24
BVWT 187

Figure C-163



ET 24
WT 187

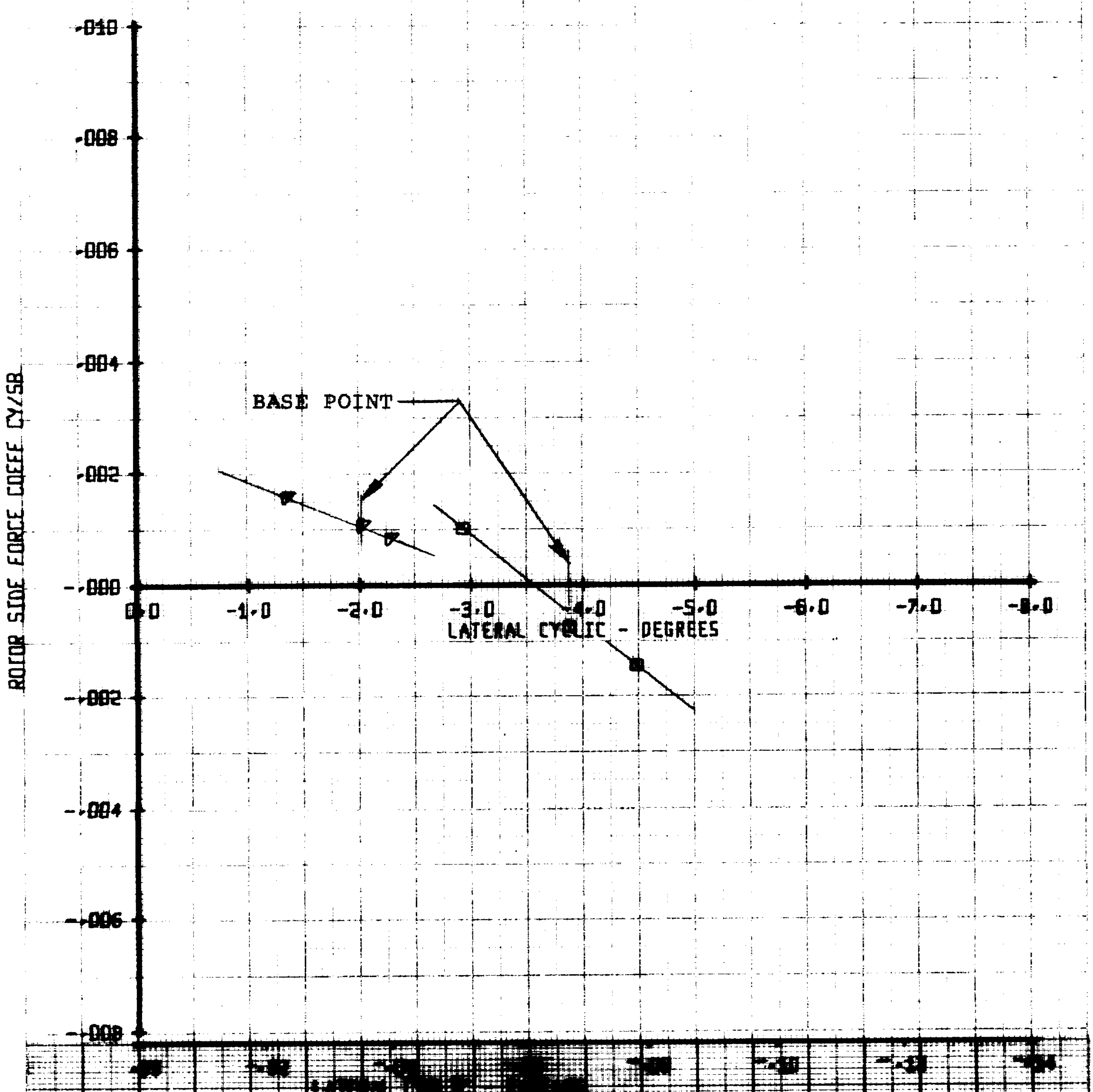
SET 24
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU	X/D0258	CT'/SB	VTUN
⊡	39	.50	.05	.098	310
▽	39	.50	.05	.078	310

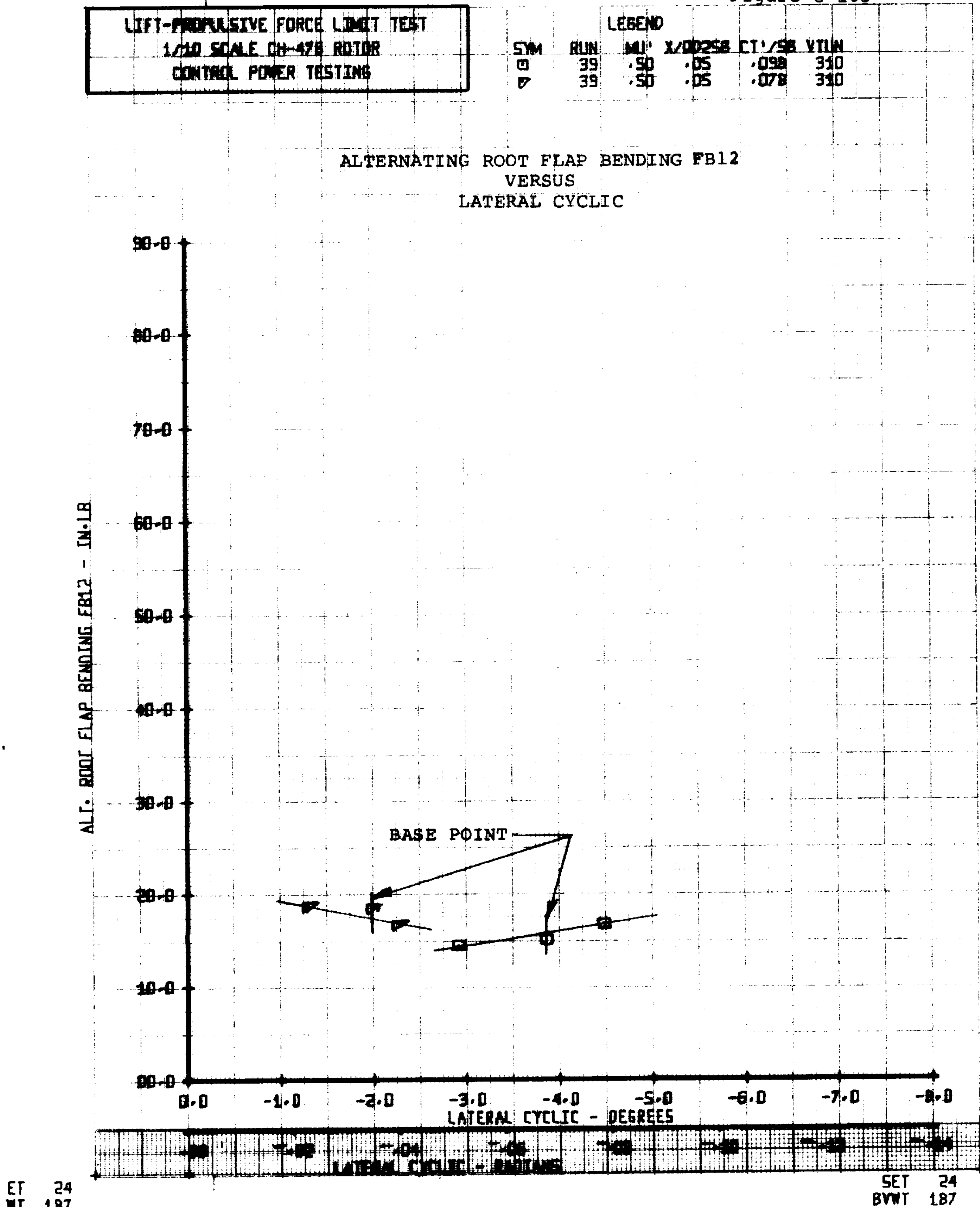
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC

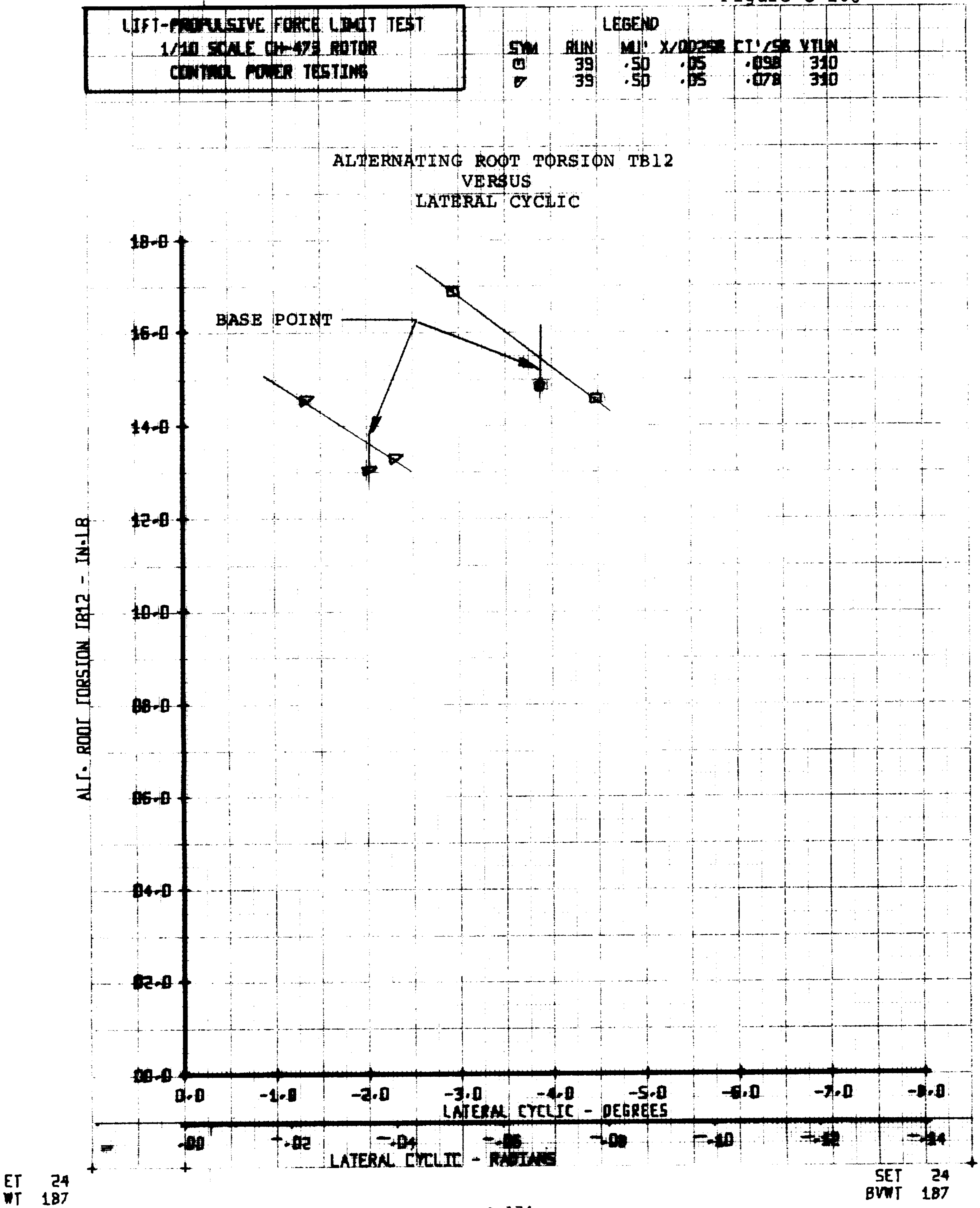


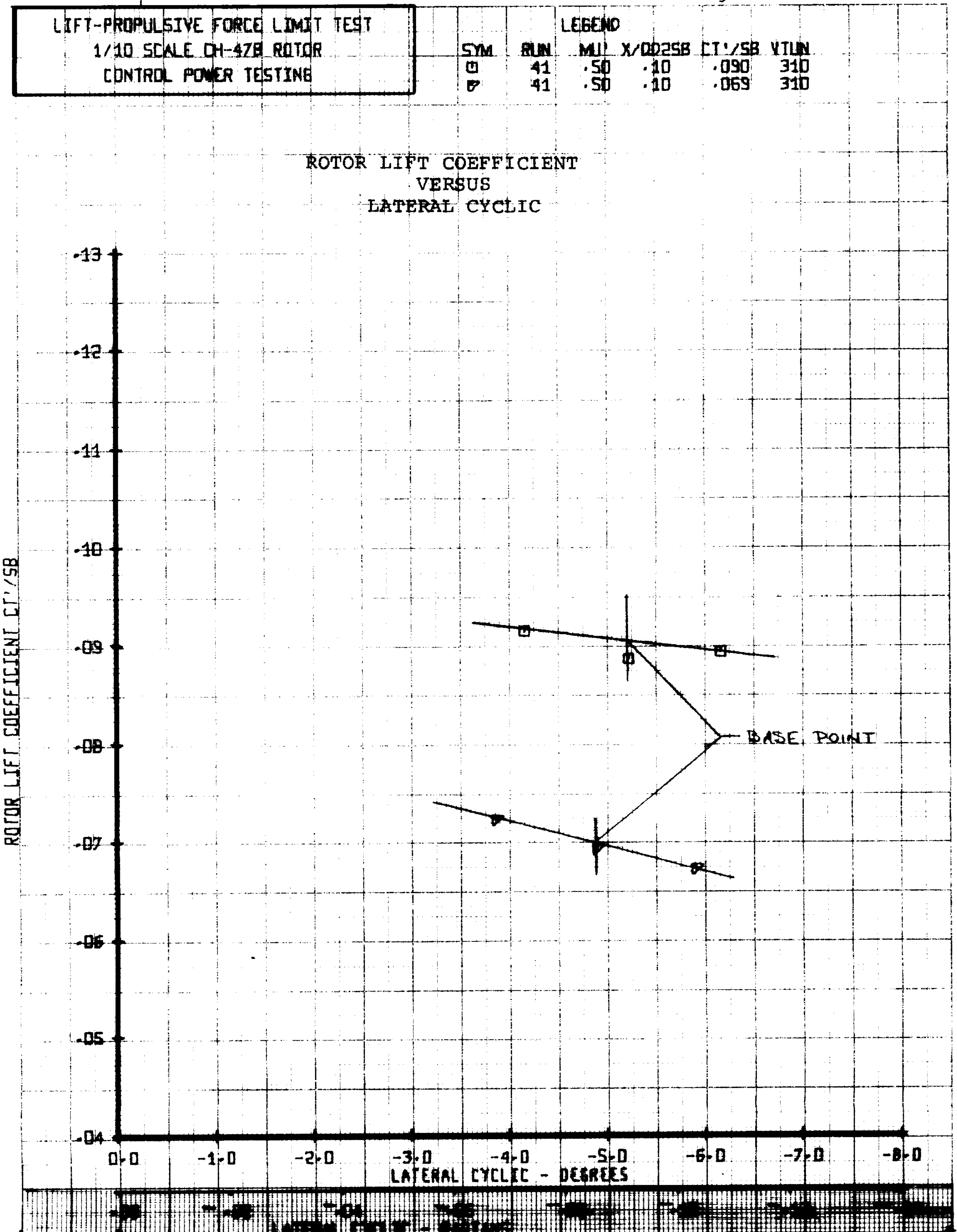
SET 24
BVWT 187

SET 24
BVWT 187

Figure C-165

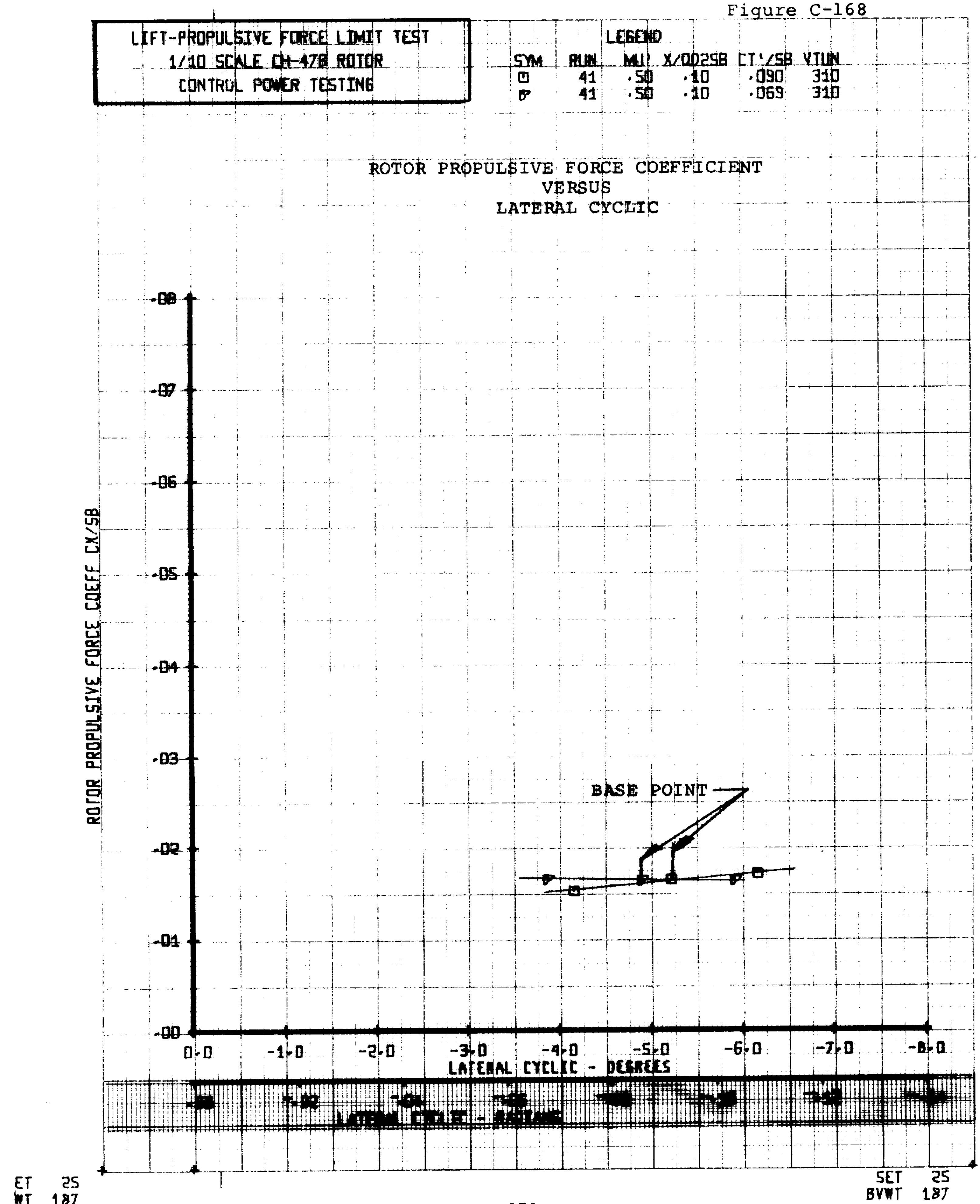

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2S8 CT'/S8 VTUN
39 .50 .05 .098 310
39 .50 .05 .078 310
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LATERAL CYCLIC
BASE POINT
ALT. ROOT FLAP BENDING FB12 - IN.LB
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 24
BVWT 187


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
39 .50 .05 .098 310
39 .50 .05 .078 310
ALTERNATING ROOT TORSION TB12
VERSUS
LATERAL CYCLIC
BASE POINT
ALT. ROOT TORSION TB12 - IN-LB
18.0
16.0
14.0
12.0
10.0
08.0
06.0
04.0
02.0
00.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
.00
-.02
-.04
-.06
-.08
-.10
-.12
-.14
LATERAL CYCLIC - RADIANS
ET 24
WT 187
SET 24
BVWT 187


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
41 .50 .10 .090 310
41 .50 .10 .069 310
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 25
BVWT 187

ET 25
WT 187

Figure C-168



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
41 .50 .10 .090 310
41 .50 .10 .069 310
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PROPULSIVE FORCE COEFF CX/SB
.08
.07
.06
.05
.04
.03
.02
.01
.00
0.0 -1.0 -2.0 -3.0 -4.0 -5.0 -6.0 -7.0 -8.0
LATERAL CYCLIC - DEGREES
SET 25
BVWT 187

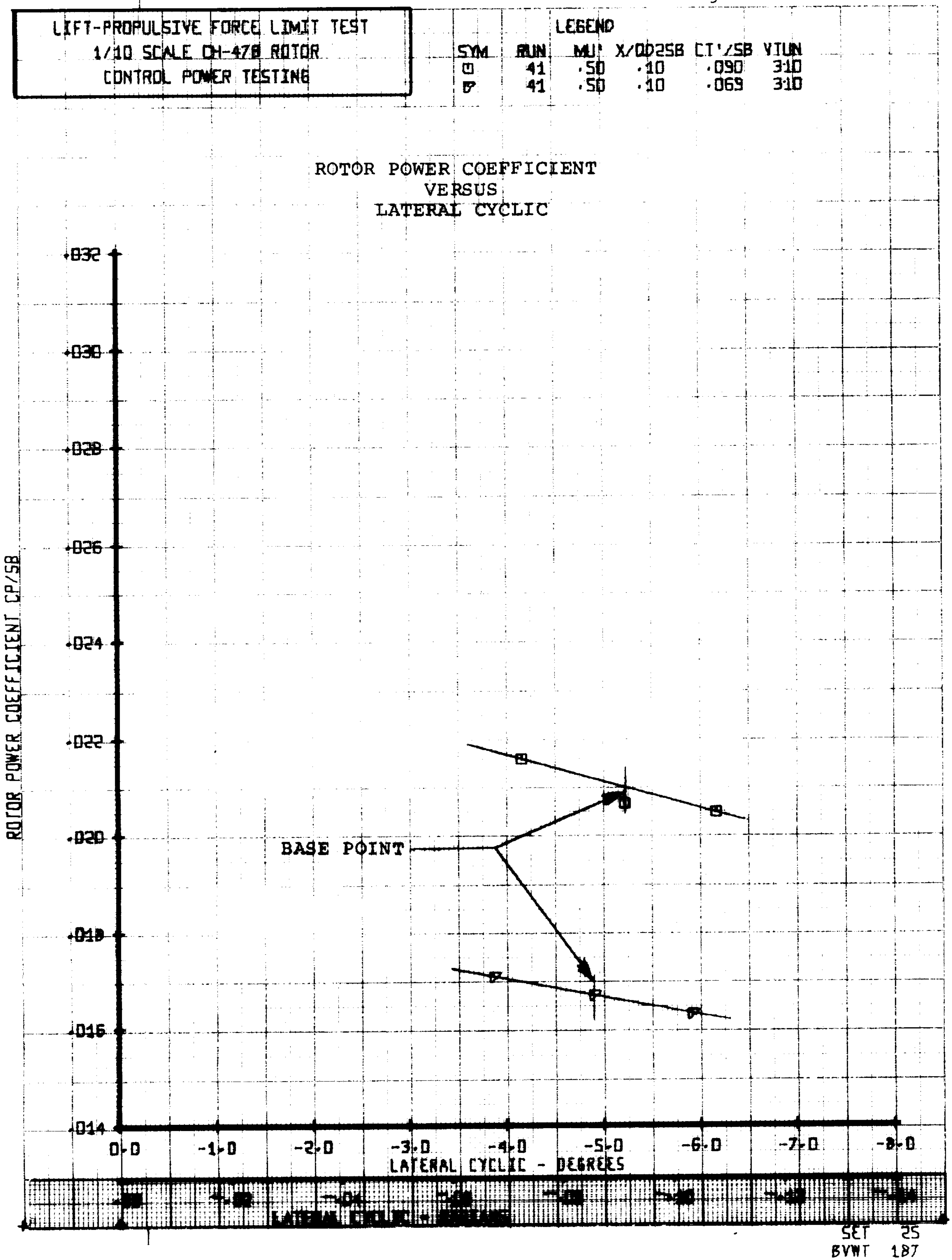
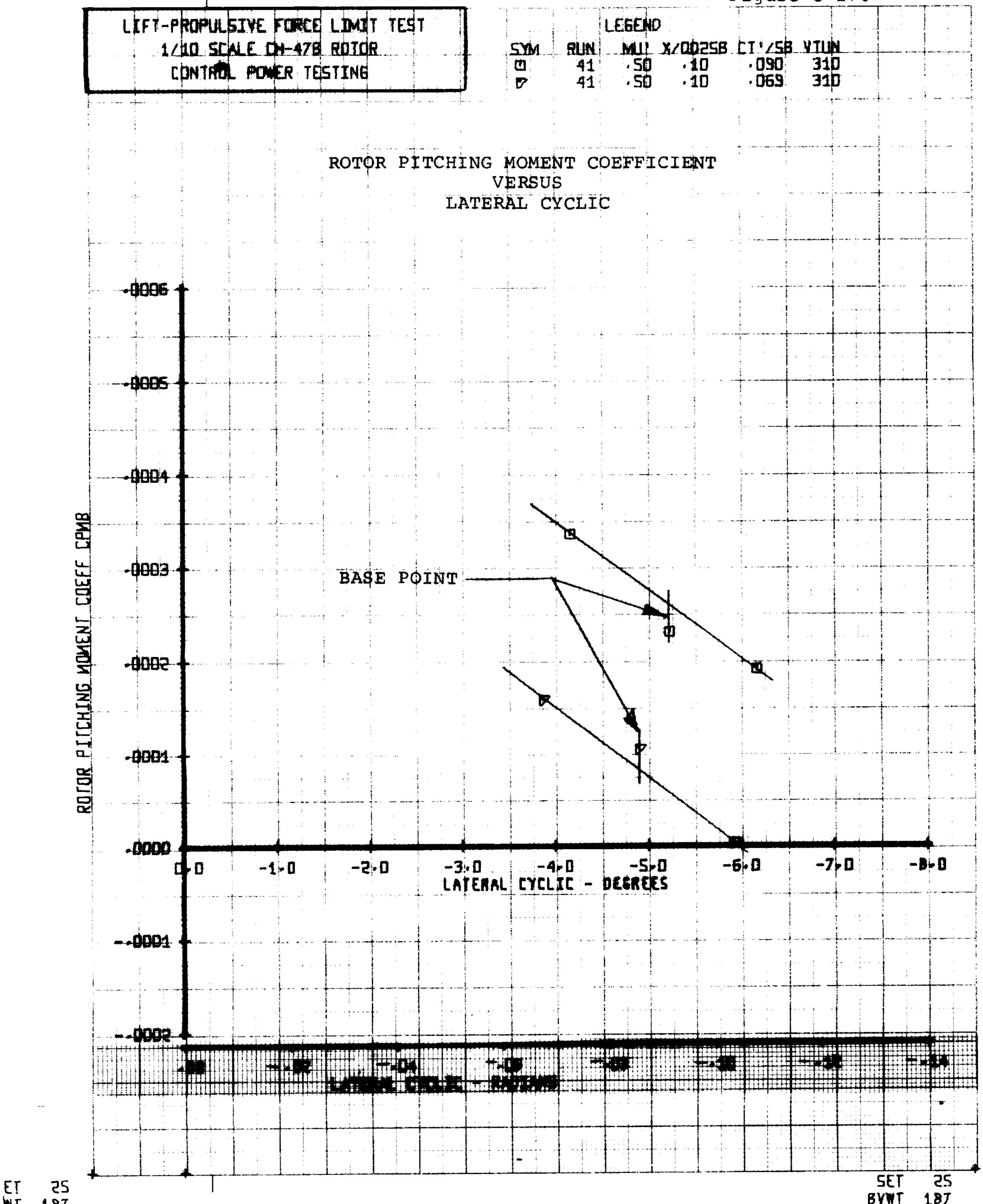

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
41 .50 .10 .090 310
41 .50 .10 .069 310
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.032
.030
.028
.026
.024
.022
.020
.018
.016
.014
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 25
BVWT 187

Figure C-170



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/OD2SB CT'/SB VTUN
□ 41 .50 .10 .090 310
▽ 41 .50 .10 .069 310
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
ET 25
WT 187
SET 25
BVWT 187

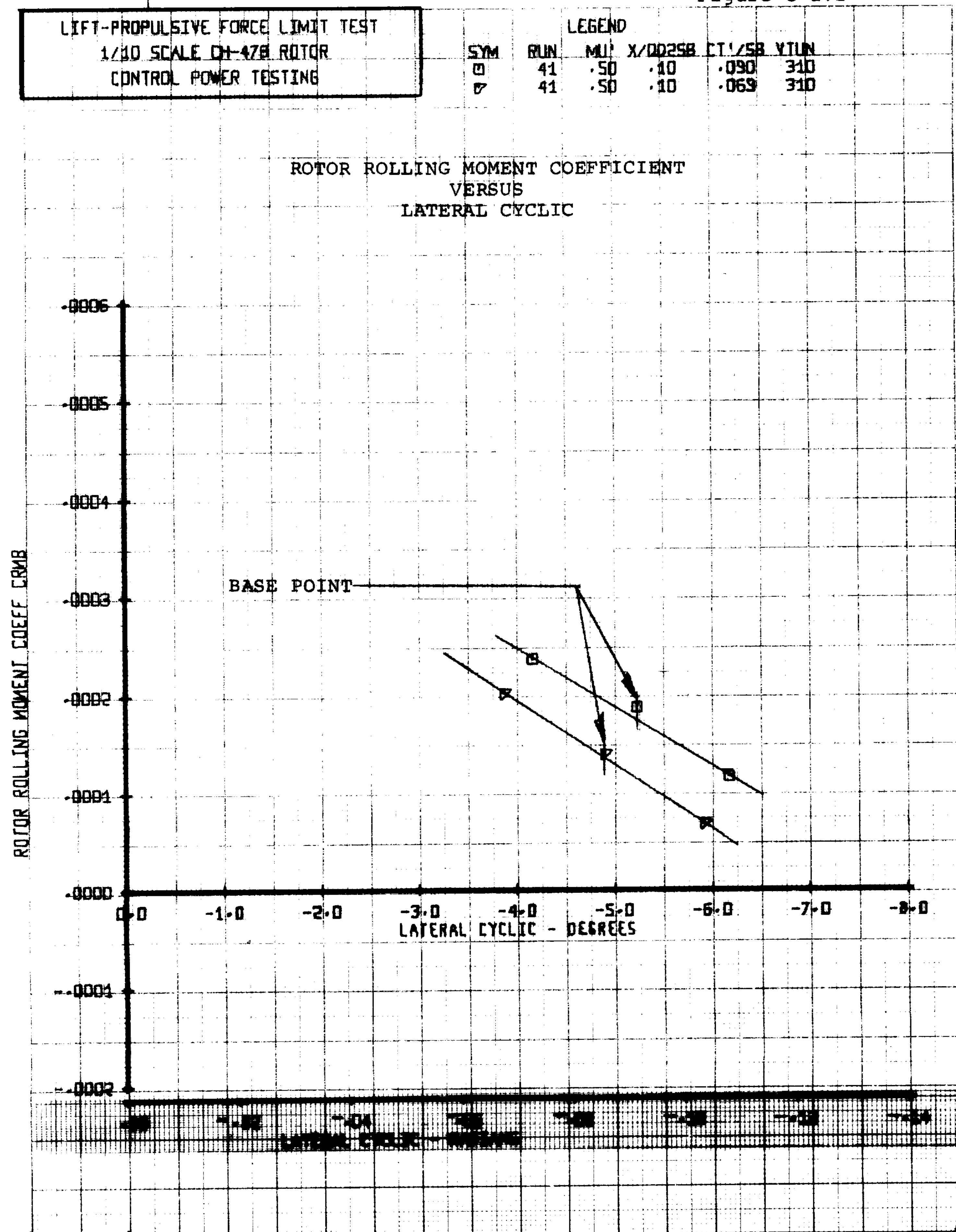
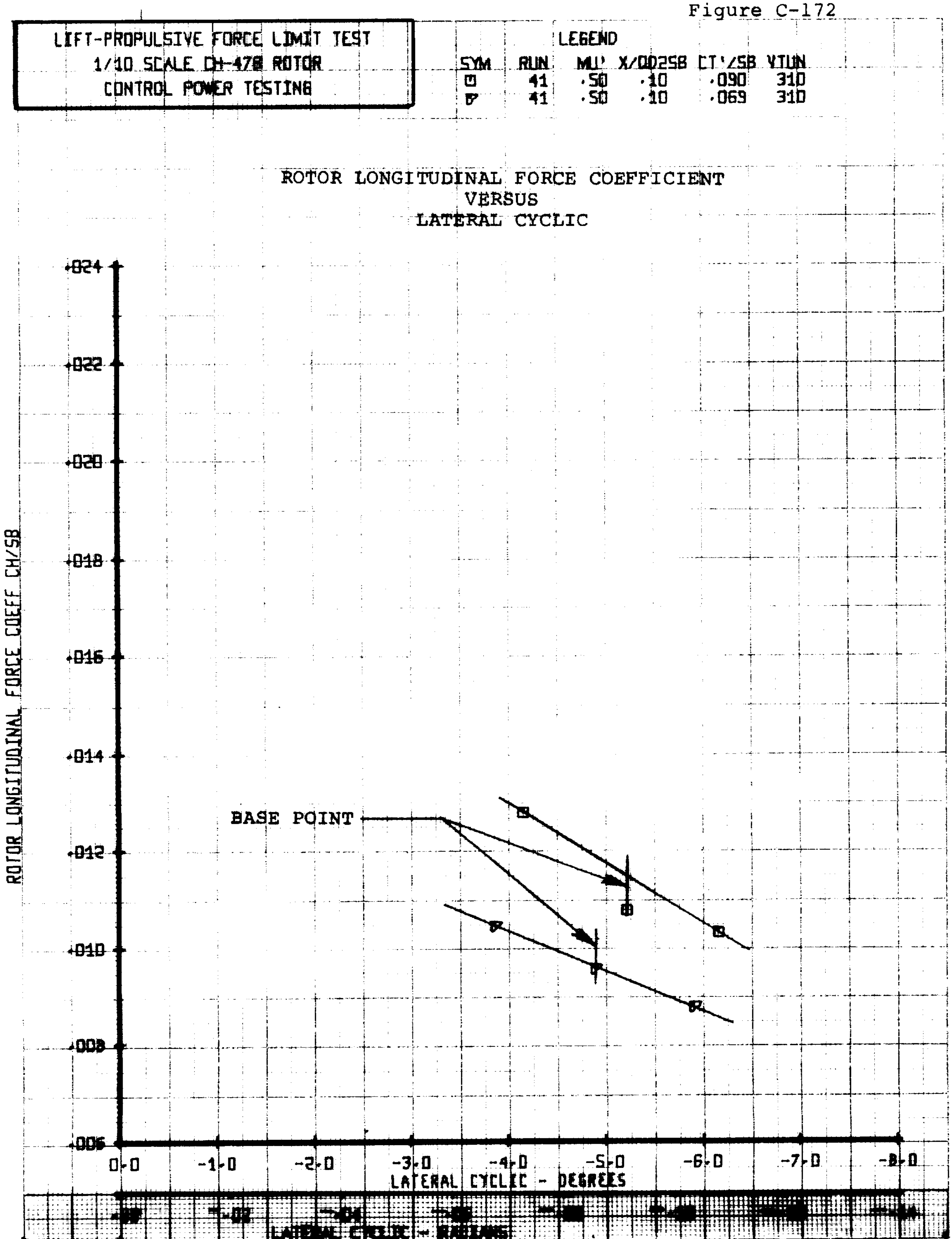
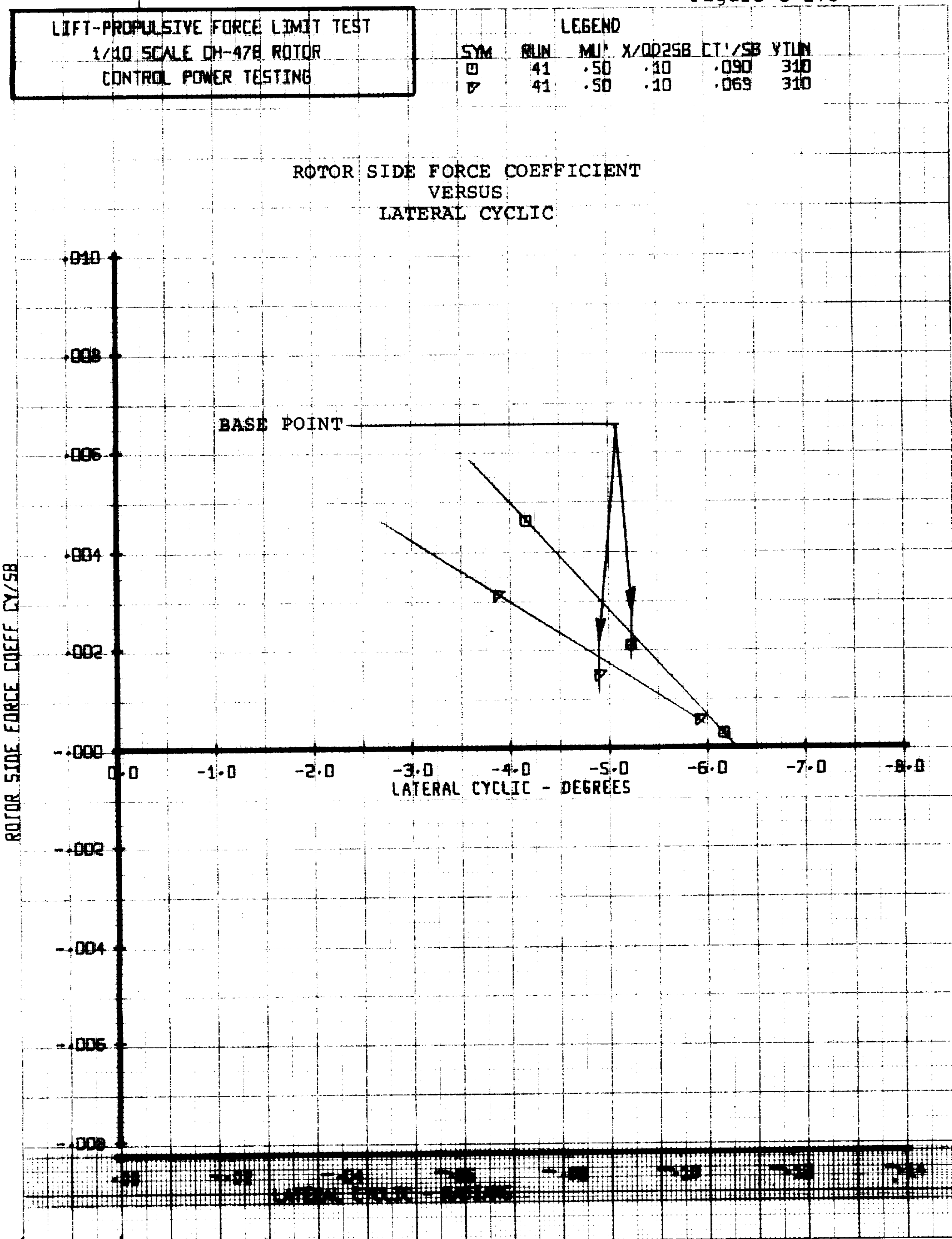

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
□ 41 .50 .10 .090 310
▽ 41 .50 .10 .069 310
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR ROLLING MOMENT COEFF CRMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES

Figure C-172



SET 25
BVWT 187

Figure C-173



ET 25
WT 187

SET 25
BVWT 187

Figure C-174

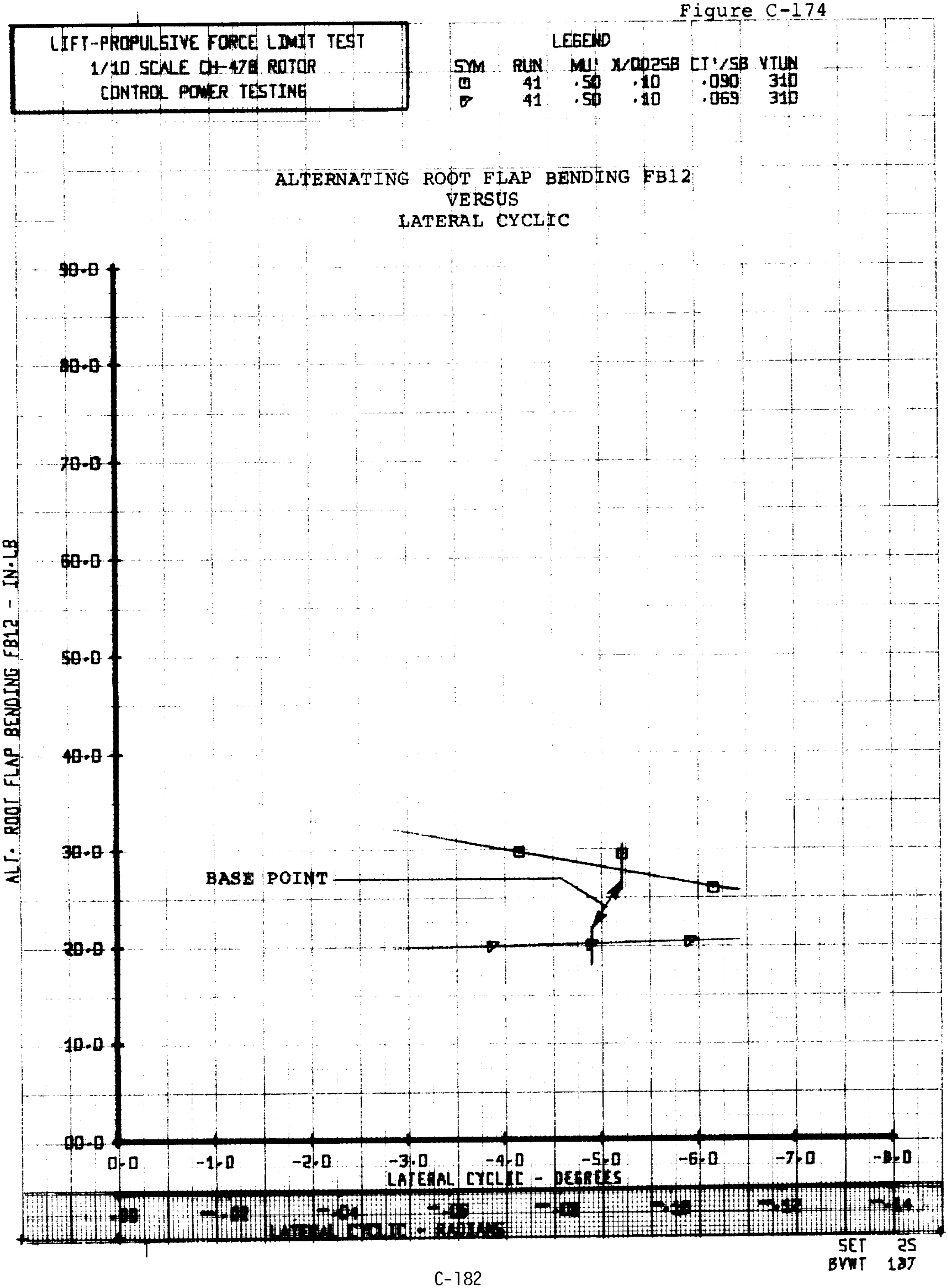
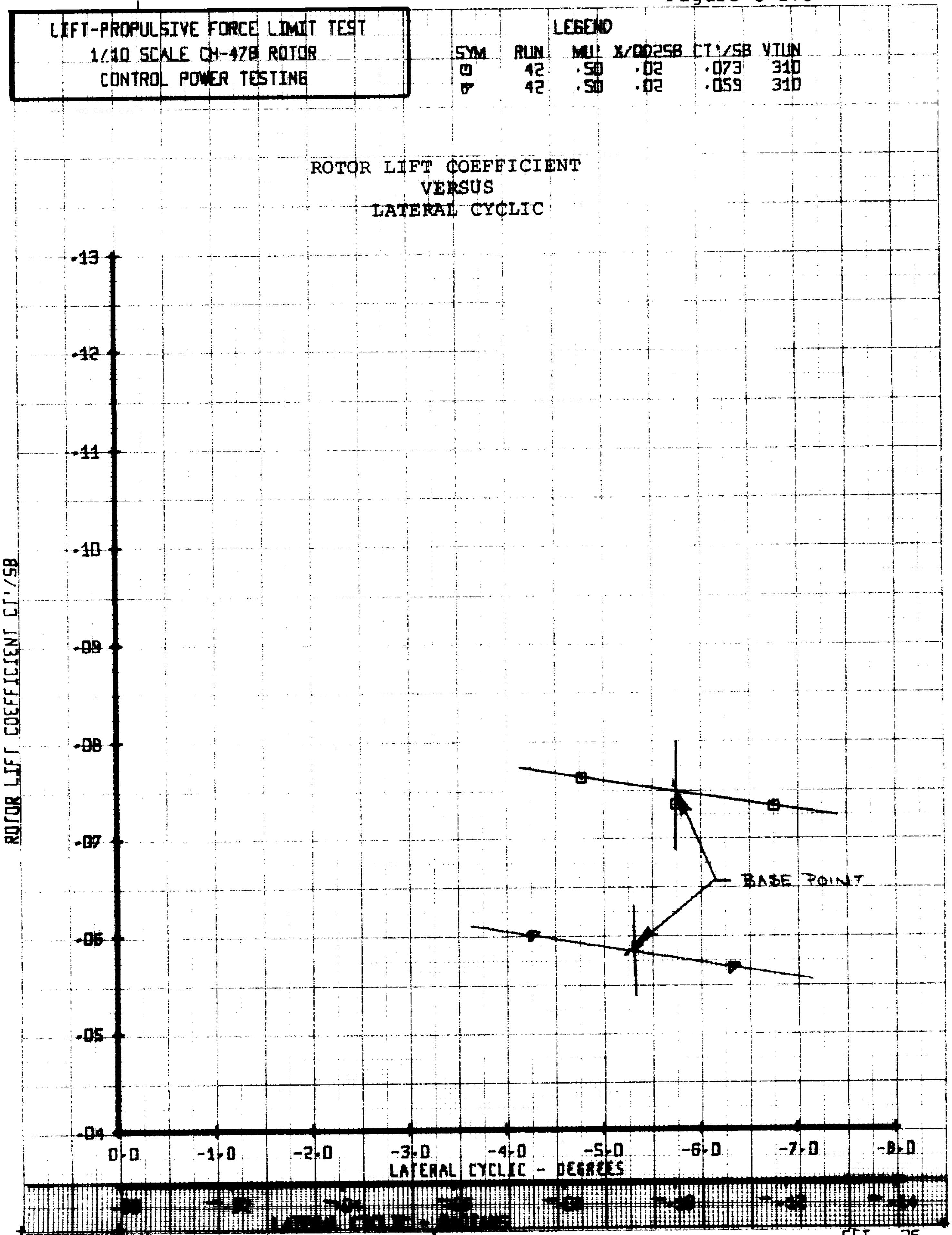
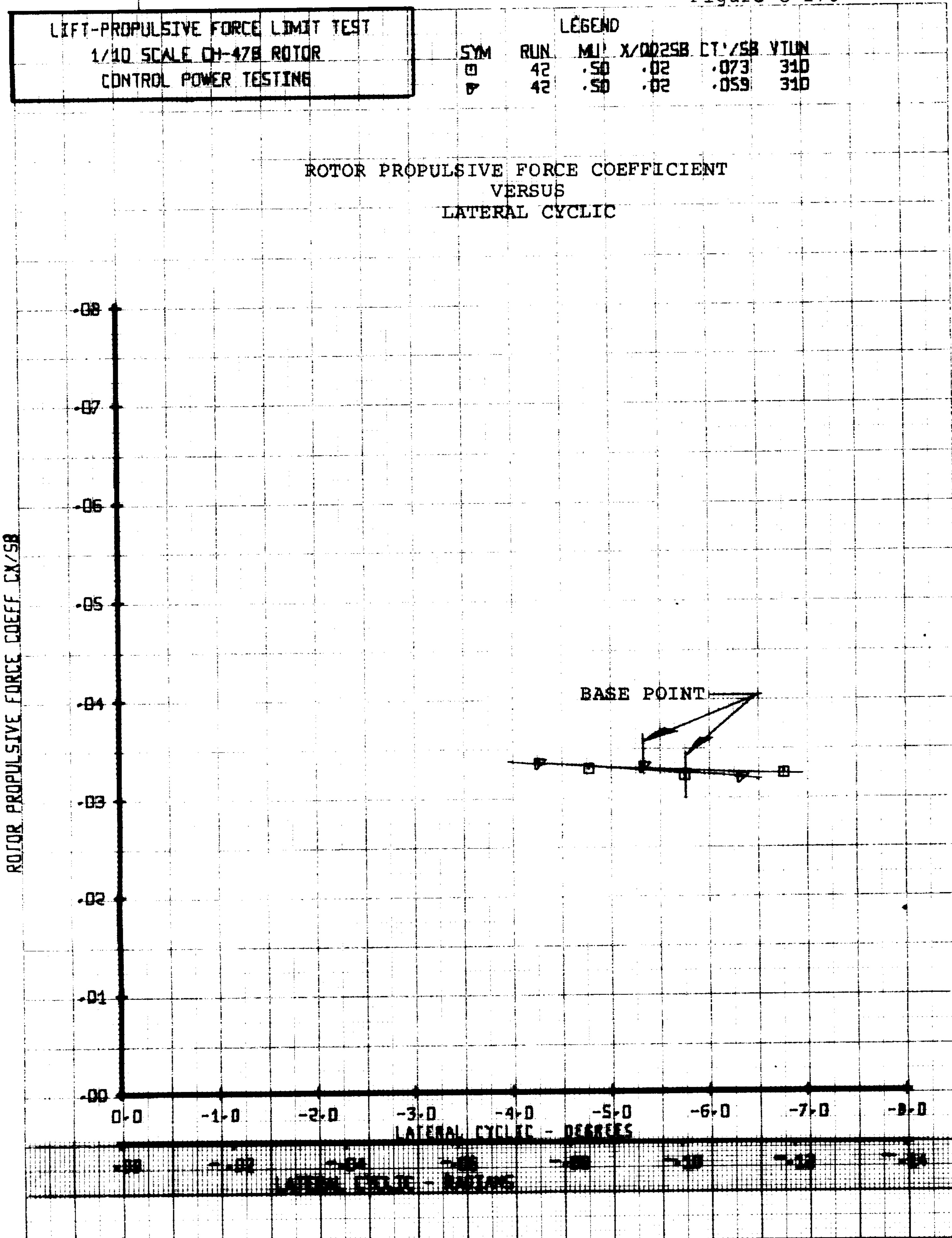

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
41 .50 .10 .090 310
41 .50 .10 .069 310
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LATERAL CYCLIC
ALT. ROOT FLAP BENDING FB12 - IN-LB
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
00.0
BASE POINT
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
SET 25
BVWT 137

Figure C-175

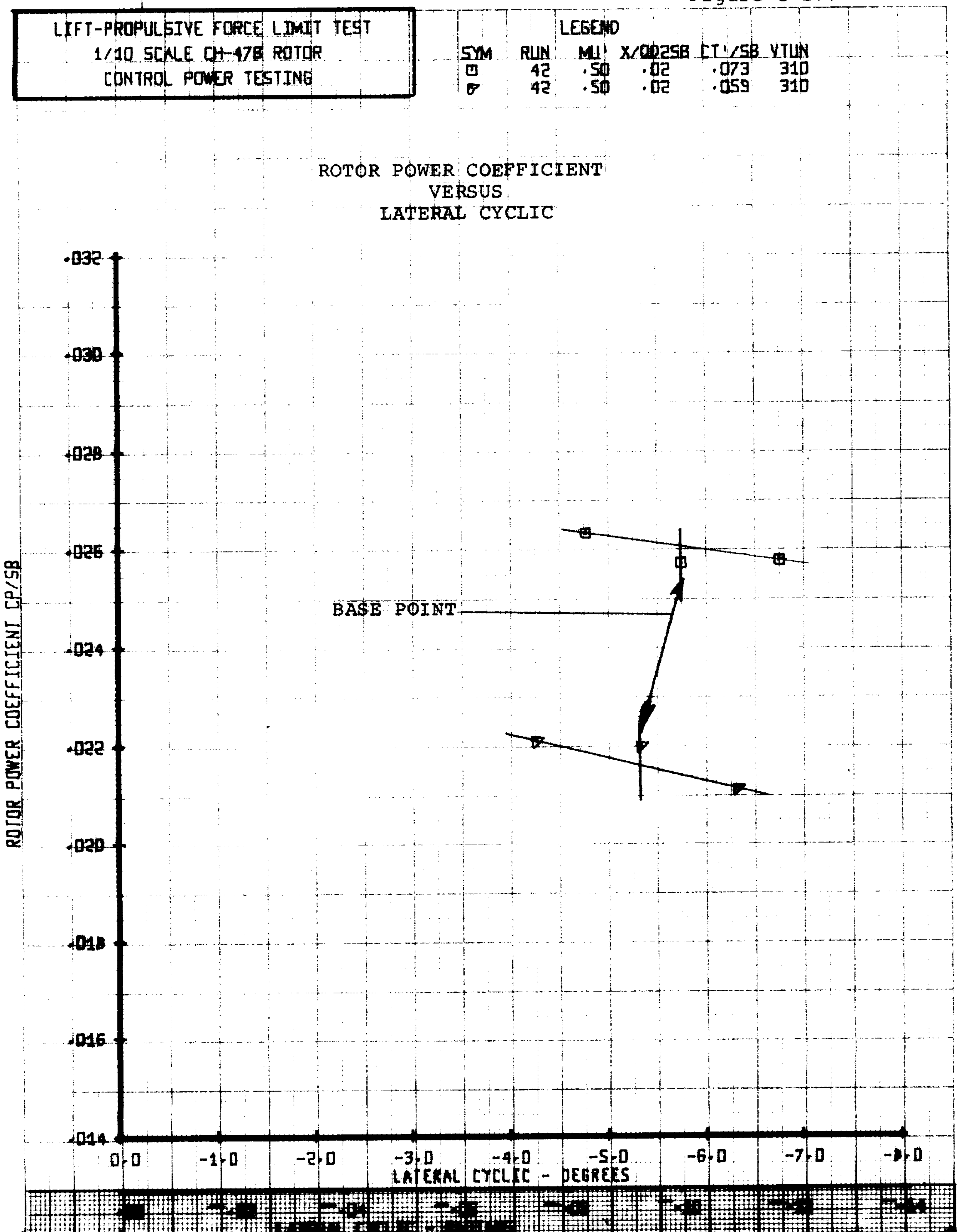


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
42 .50 .02 .073 310
42 .50 .02 .059 310
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
BASE POINT
ET 26
WT 187
SET 26
BVWT 187

Figure C-176



ET 26
WT 187


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
42 .50 .02 .073 310
42 .50 .02 .059 310
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.032
.030
.028
.026
.024
.022
.020
.018
.016
.014
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 26
BVWT 187

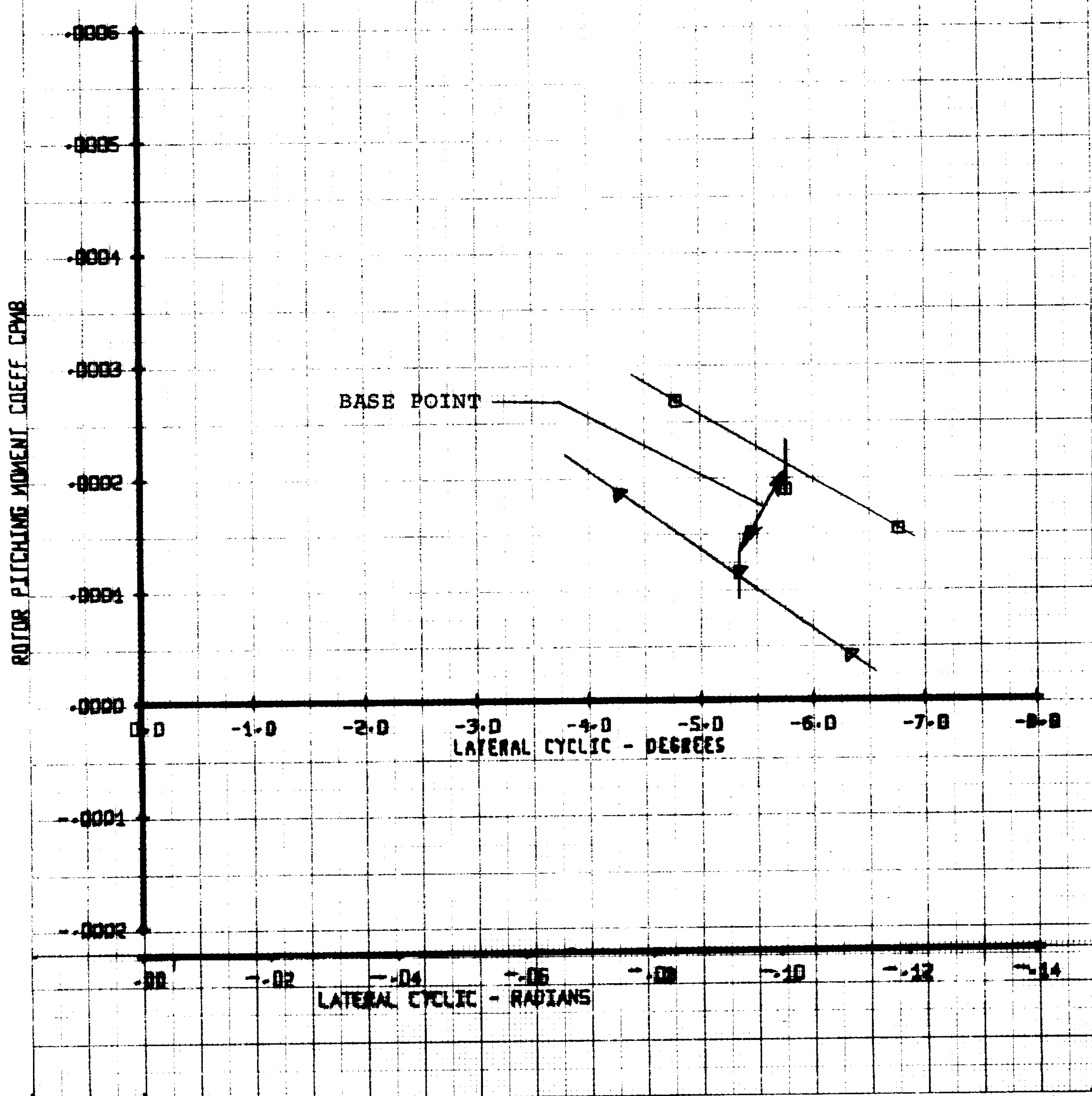
ET 26
WT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

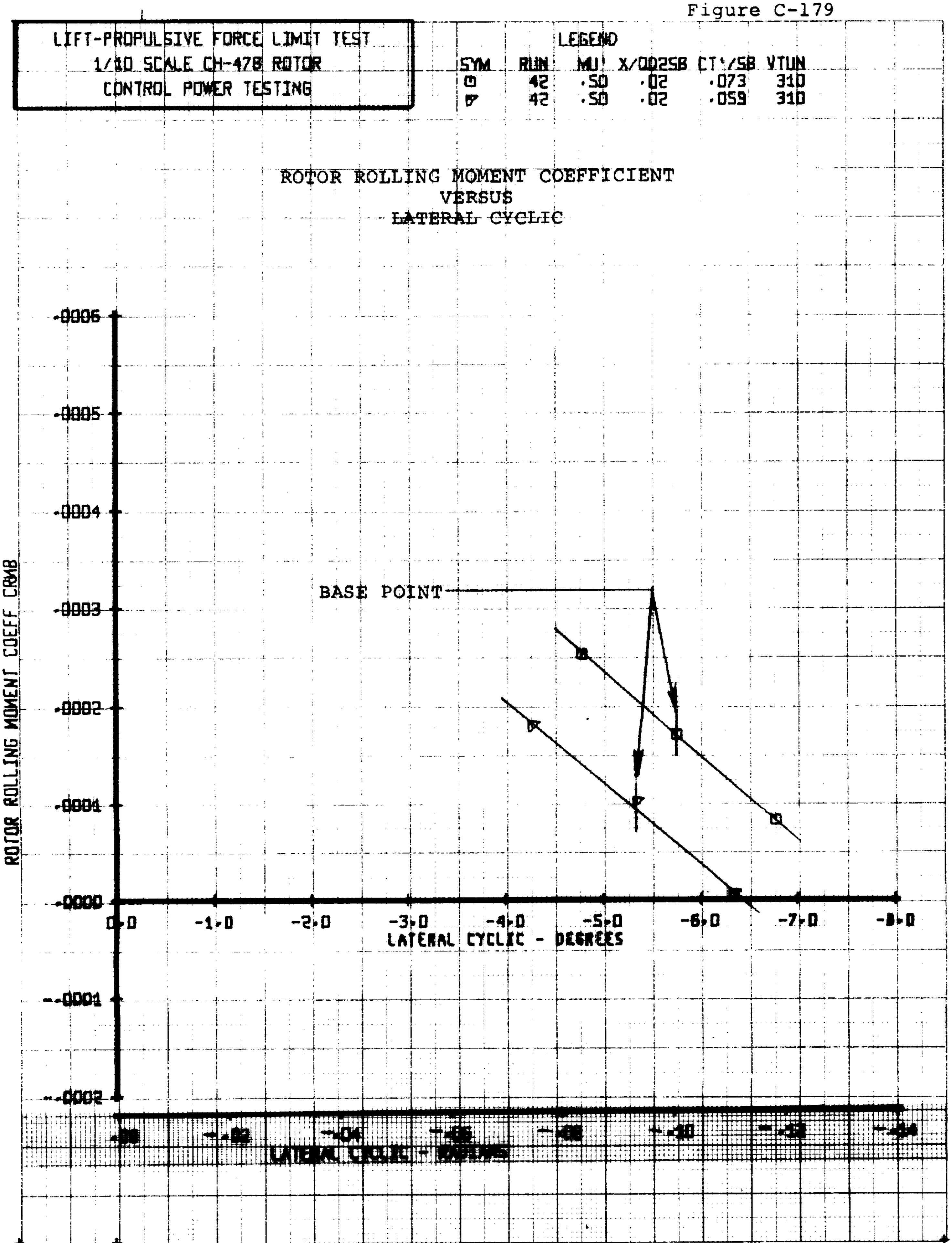
SYM	RUN	MU	X/DD2SB	CT'/SB	VTUN
□	42	.50	.02	.073	310
▽	42	.50	.02	.059	310

ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC



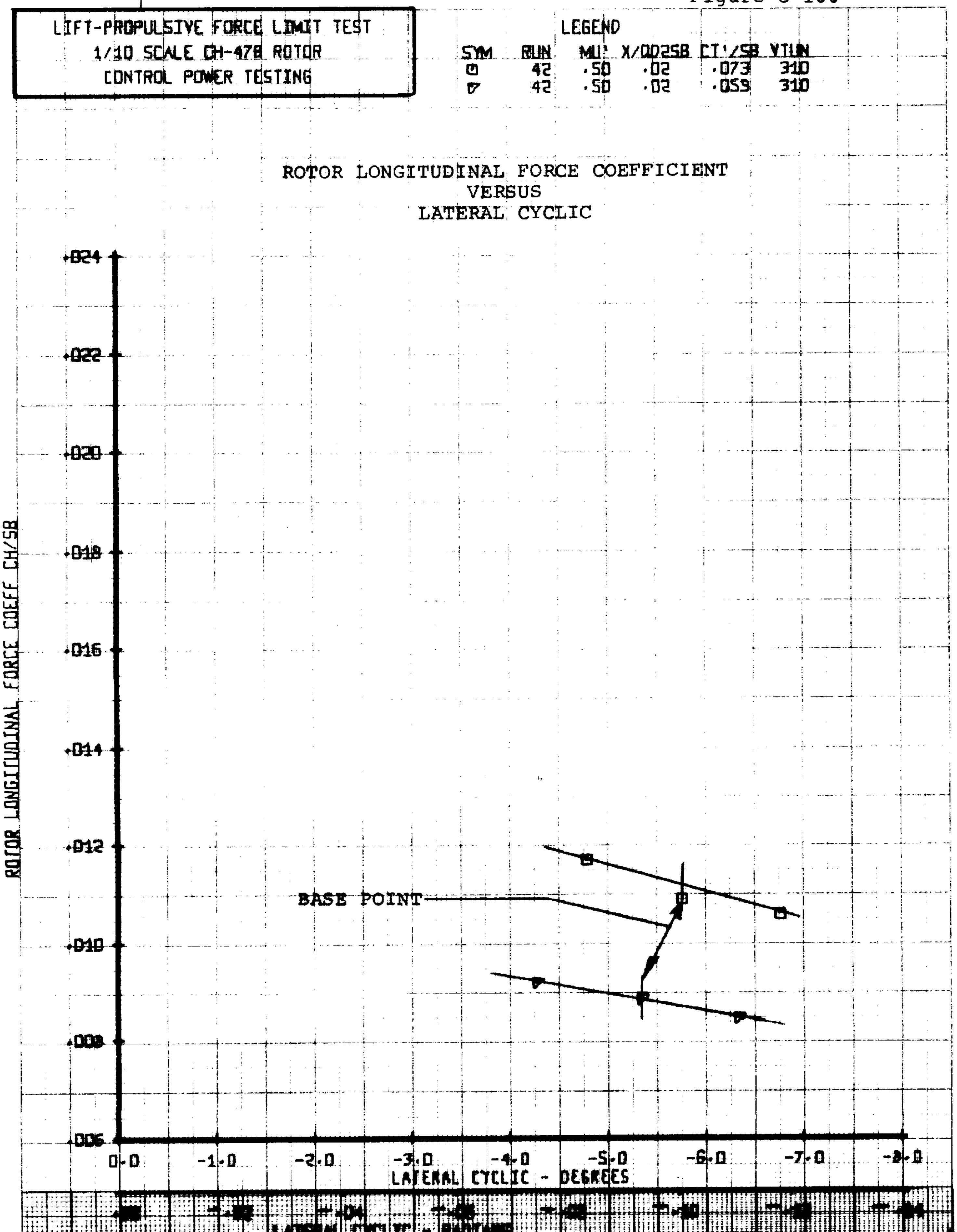
ET 26
WT 187

SET 26
BVWT 187



SET 26
BVWT 187

Figure C-180



ET 26
WT 187

SET 26
BVWT 187

Figure C-181

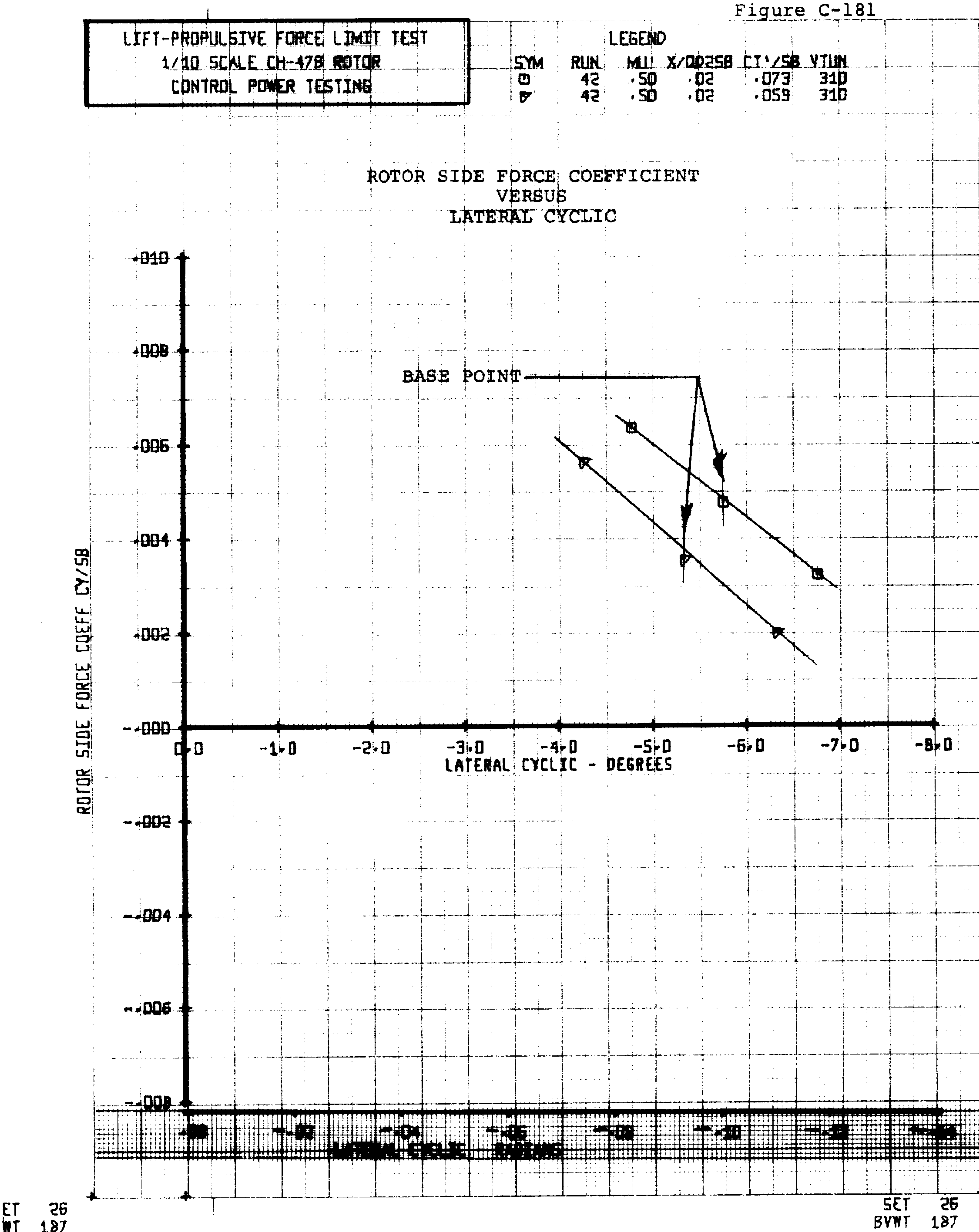
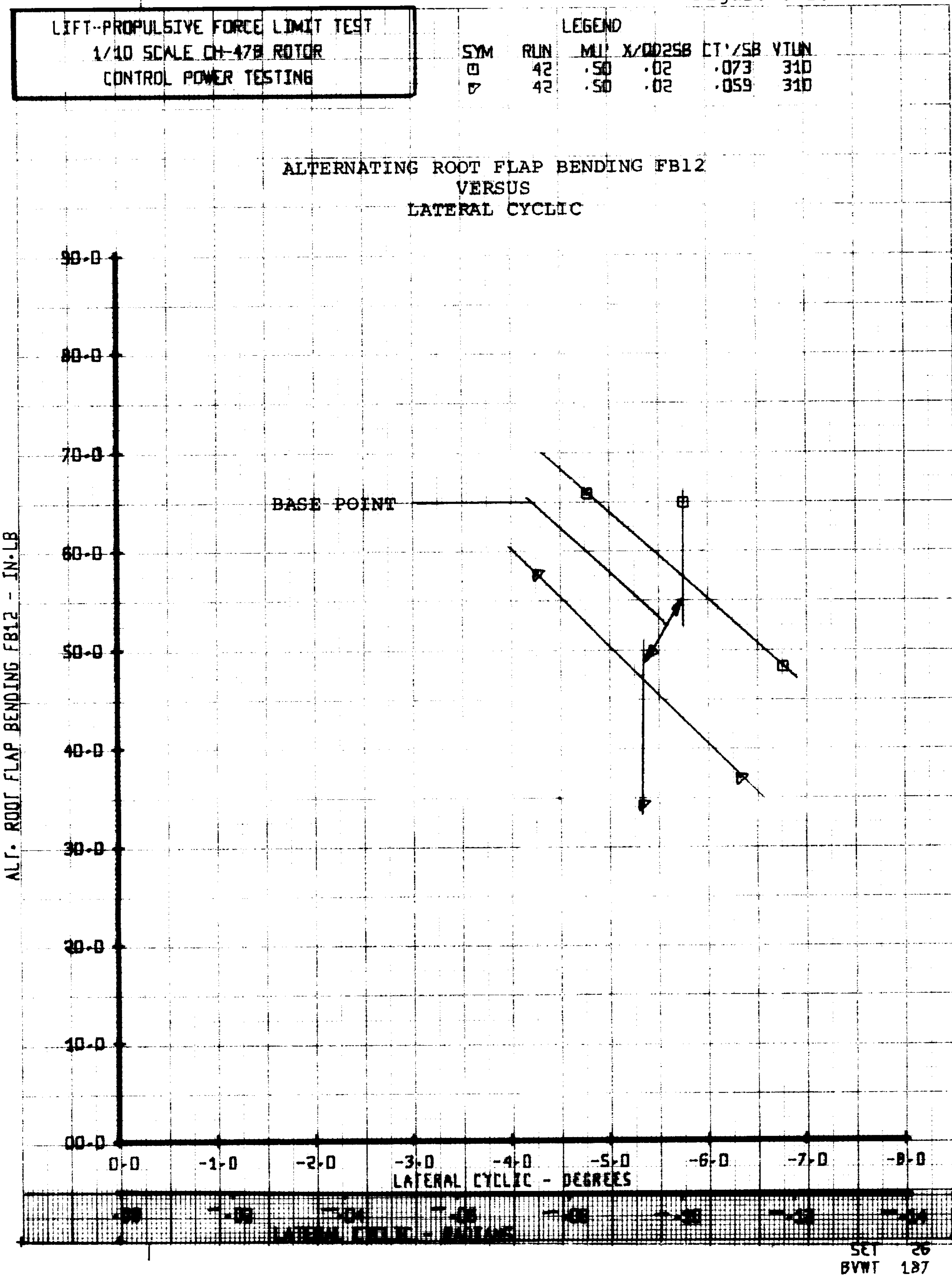
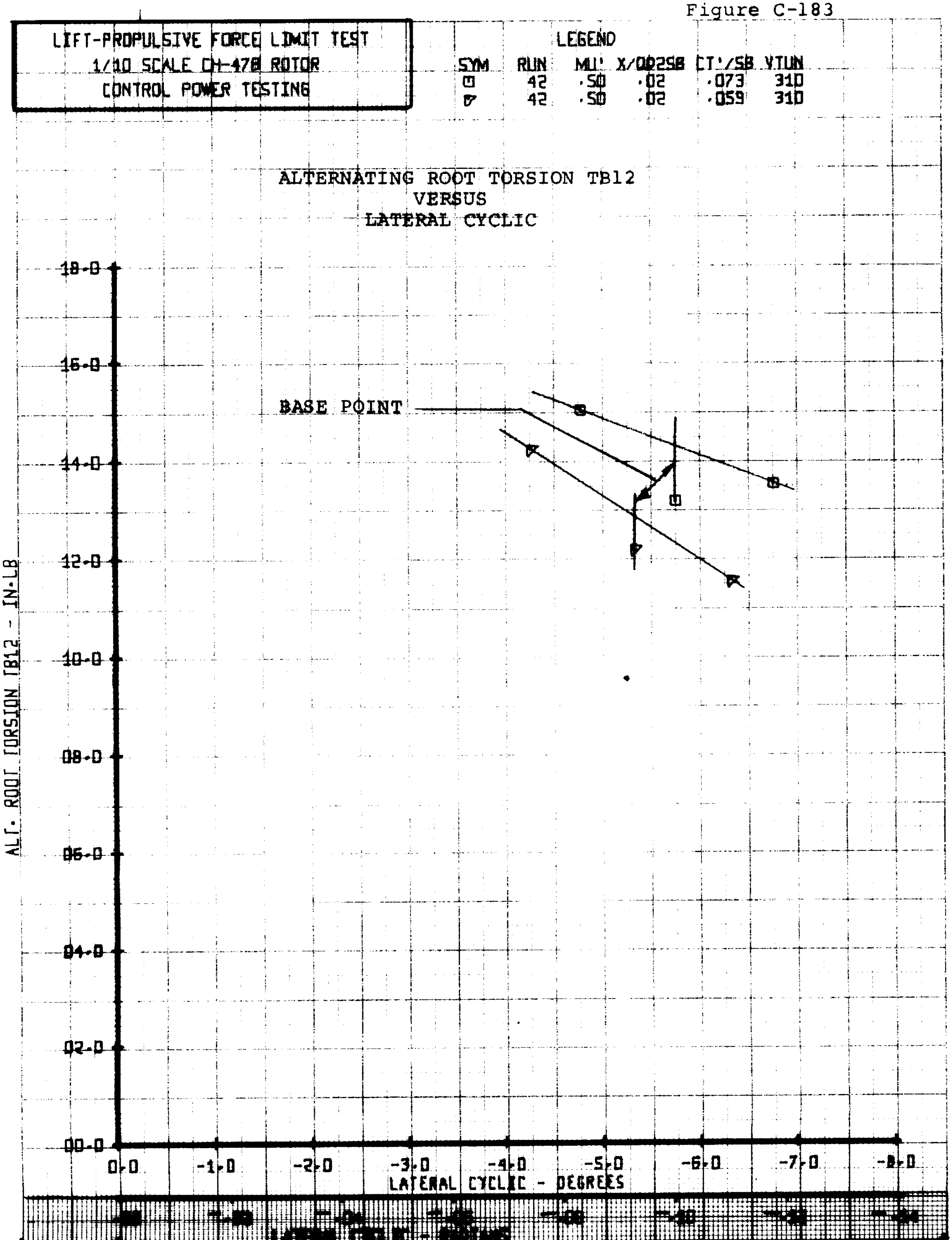

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
□ 42 .50 .02 .073 310
▽ 42 .50 .02 .059 310
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR SIDE FORCE COEFF CY/SB
.010
.008
.006
.004
.002
-.000
-.002
-.004
-.006
-.008
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
ET 26
WT 187
SET 26
BVWT 187

Figure C-182



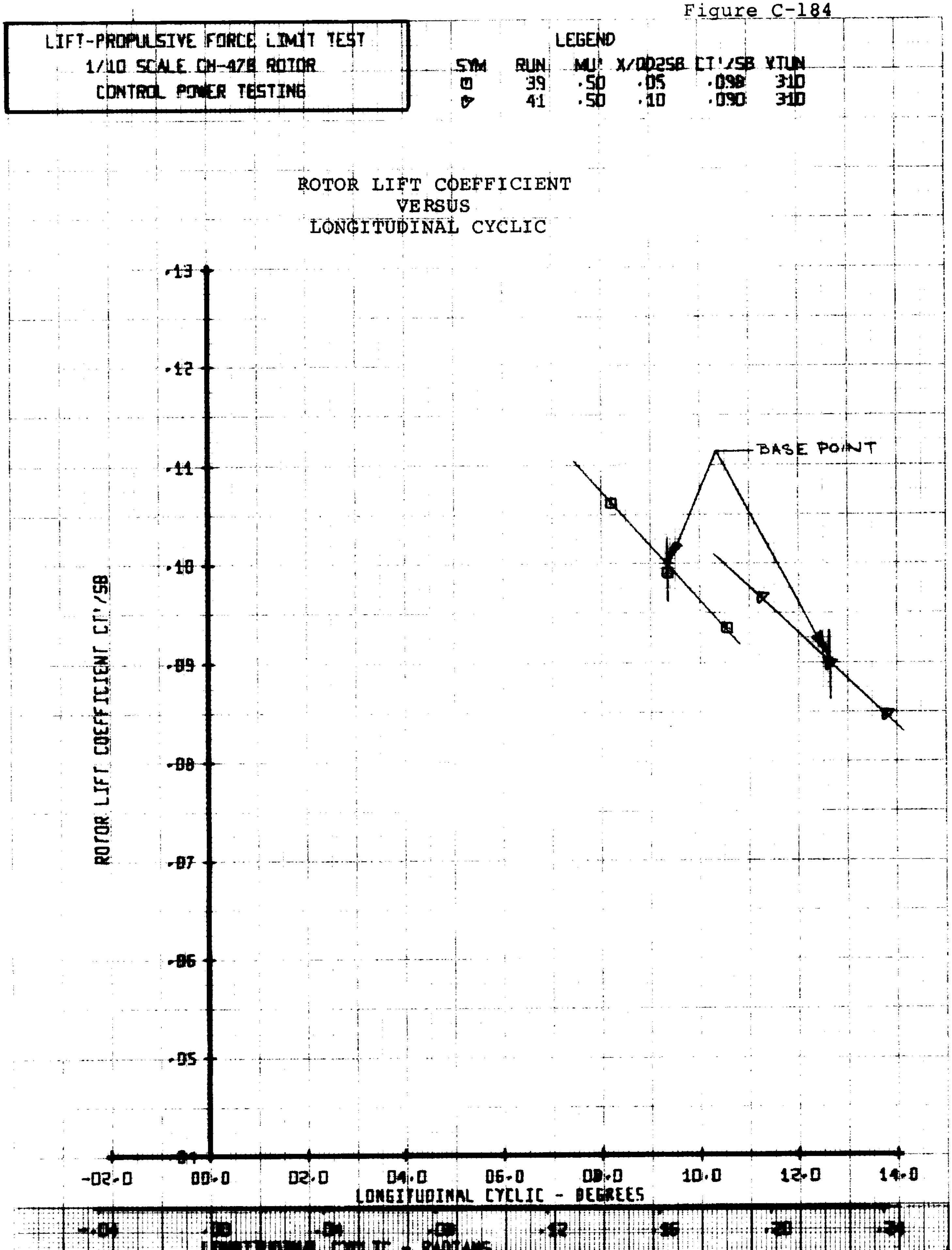
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
□ 42 .50 .02 .073 310
▽ 42 .50 .02 .059 310
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LATERAL CYCLIC
BASE POINT
ALT. ROOT FLAP BENDING FB12 - IN.LB
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
00.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
ET 26
WT 187
SET 26
BVWT 187

Figure C-183



SET 26
BVWT 187

Figure C-184



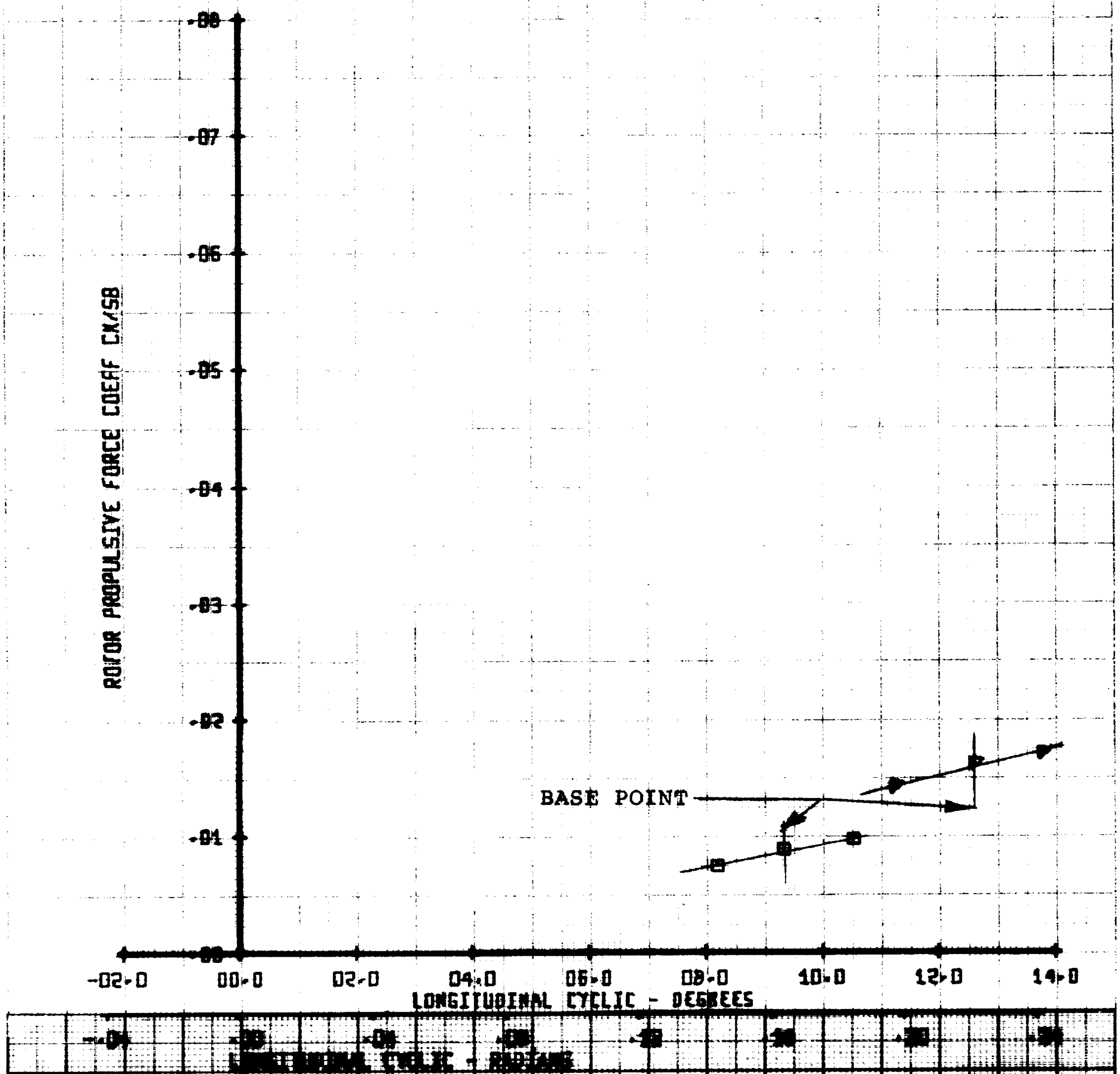
SET 27
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QQ2SB	CT'/SB	VTUN
□	39	.50	.05	.090	310
▷	41	.50	.10	.090	310

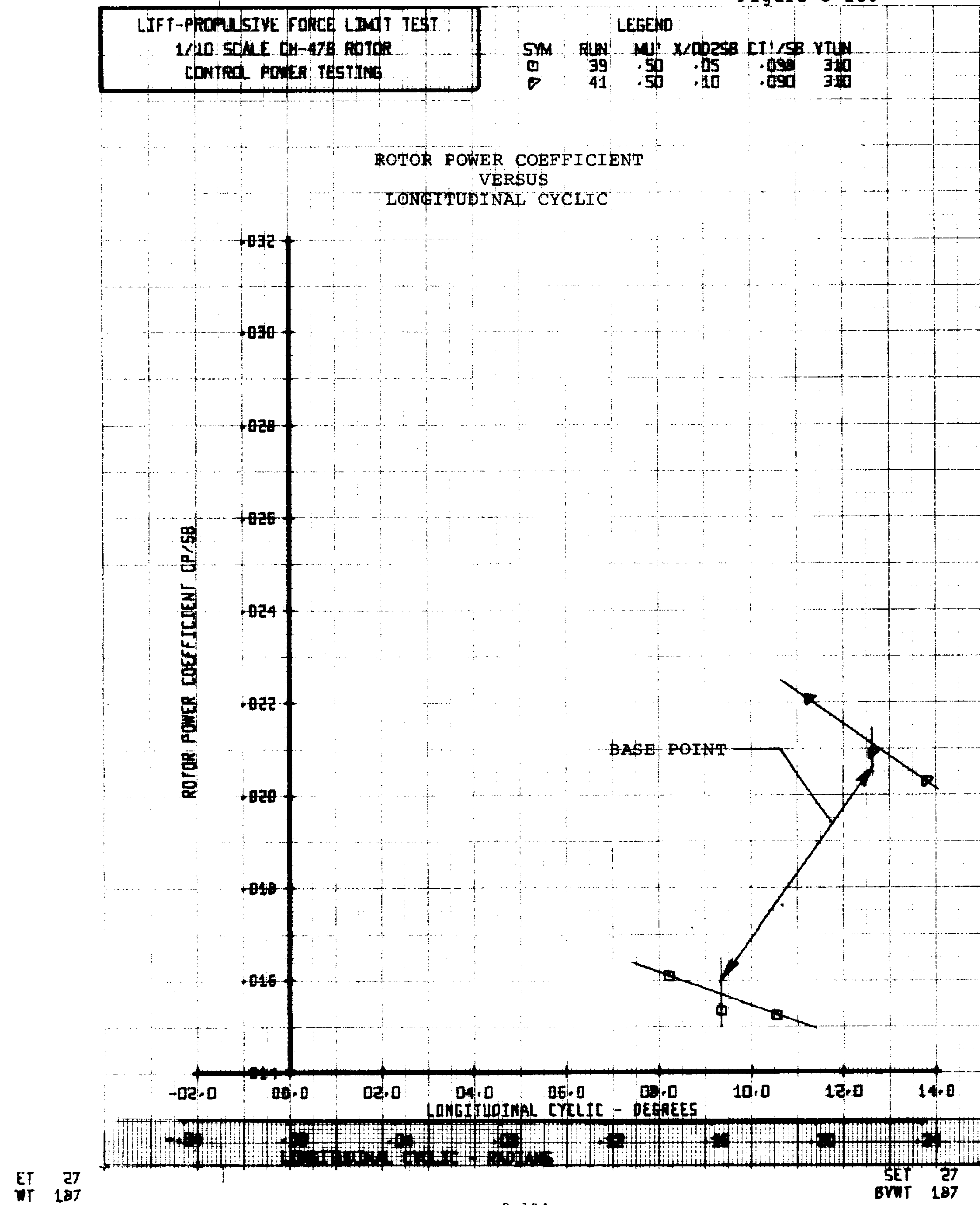
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC

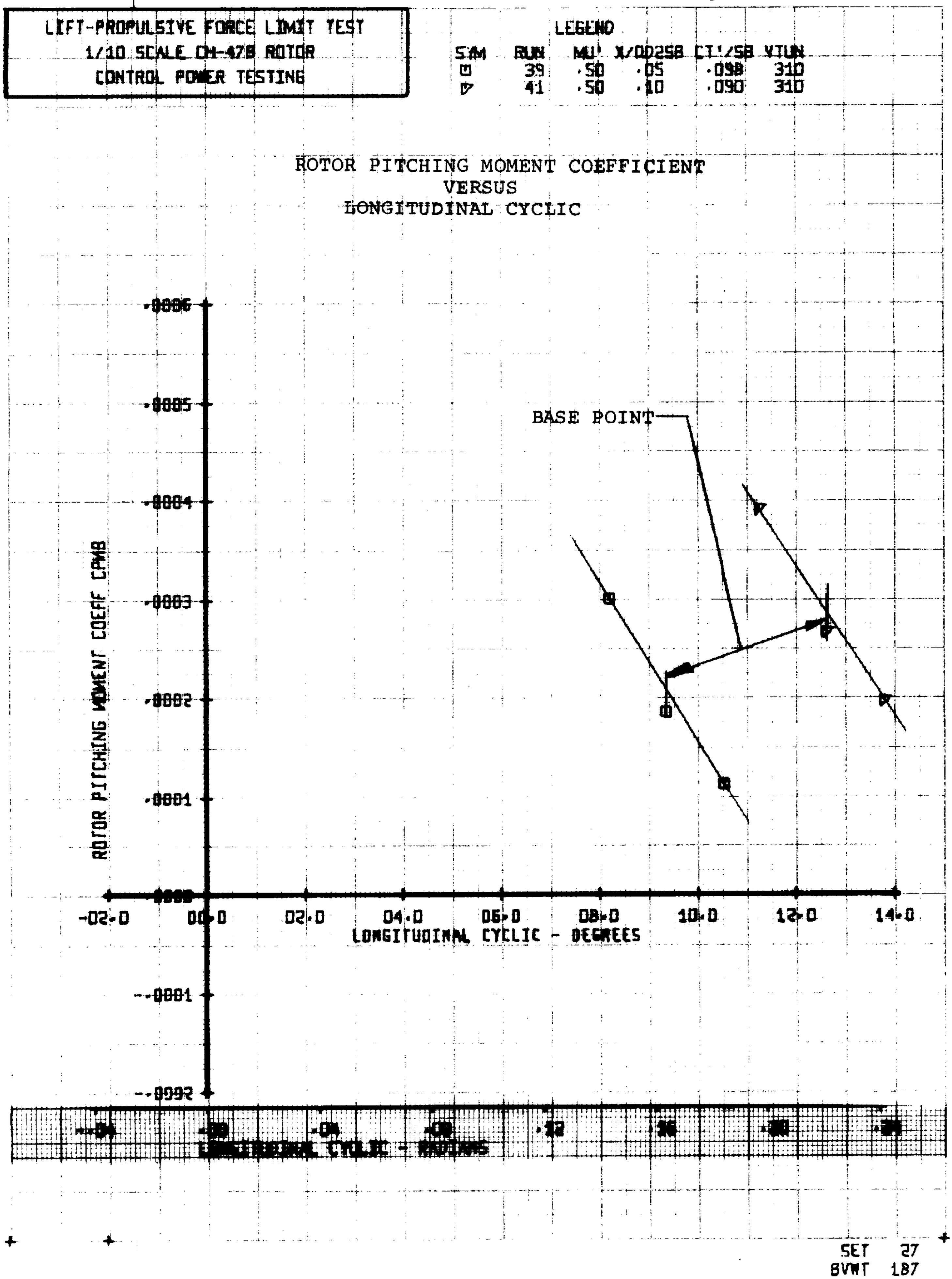


ET 27
WT 187

SET 27
BVWT 187

Figure C-186


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/OD25B CT'/SB VTUN
39 .50 .05 .090 310
41 .50 .10 .090 310
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR POWER COEFFICIENT CP/SB
BASE POINT
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 27
BVWT 187

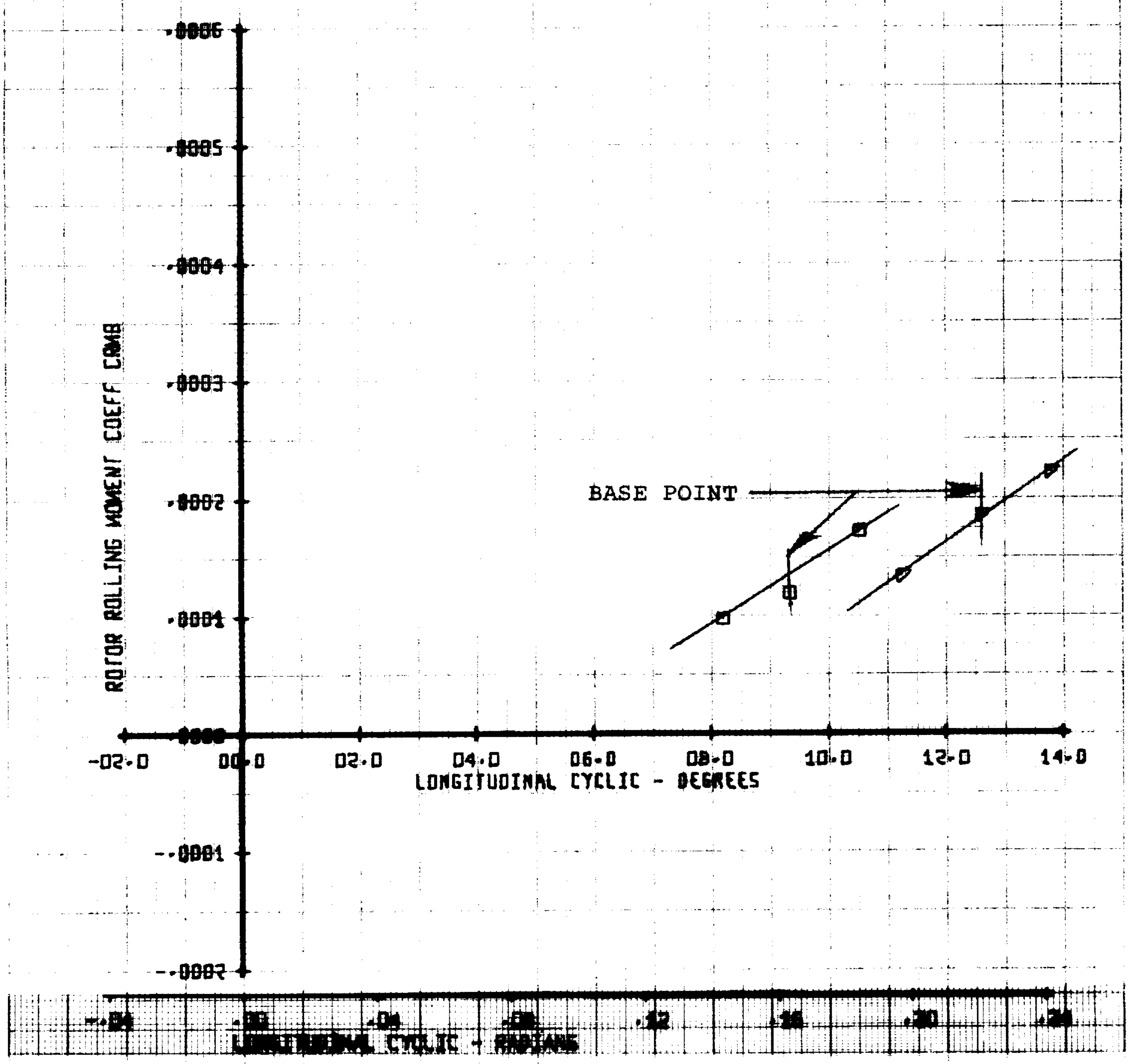

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
39 .50 .05 .090 310
41 .50 .10 .090 310
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMB
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU	X/QD2SB	CT/SB	VTUN
⊡	39	.50	.05	.098	310
▽	41	.50	.10	.090	310

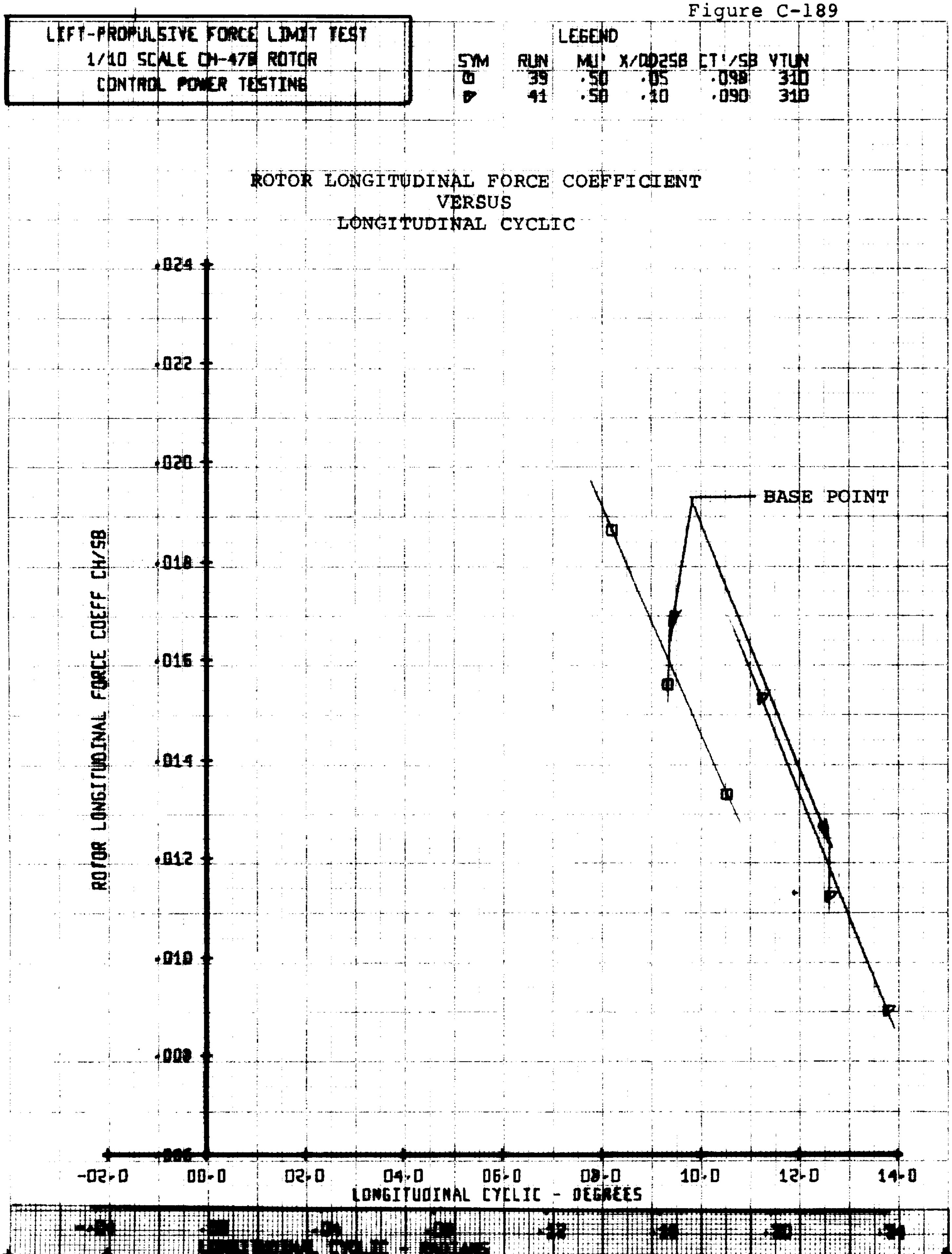
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC



ET 27
WT 1B7

SET 27
BVWT 1B7

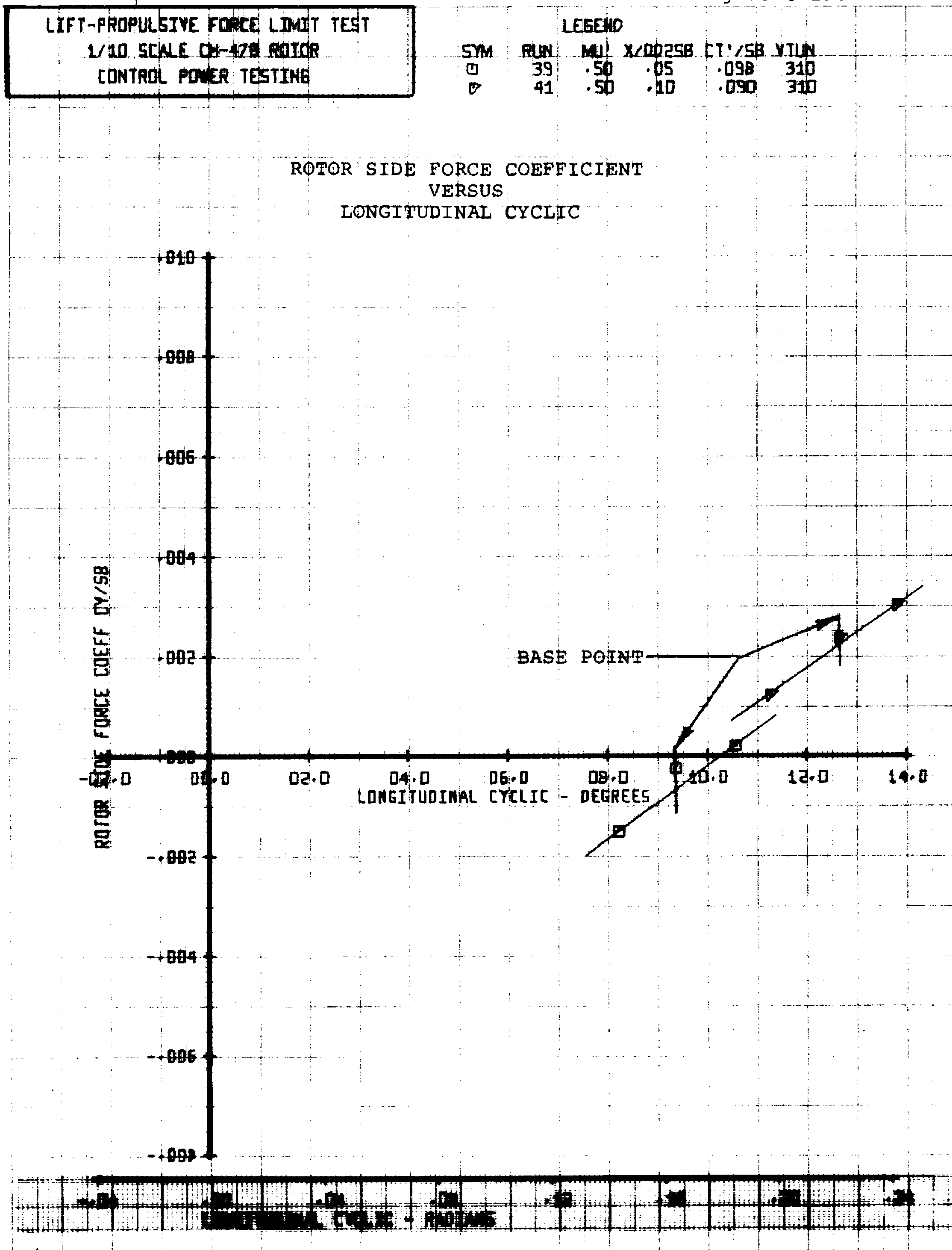
Figure C-189



ET 27
WT 187

SET 27
BVWT 187

Figure C-190



ET 27
WT 187

SET 27
BVWT 187

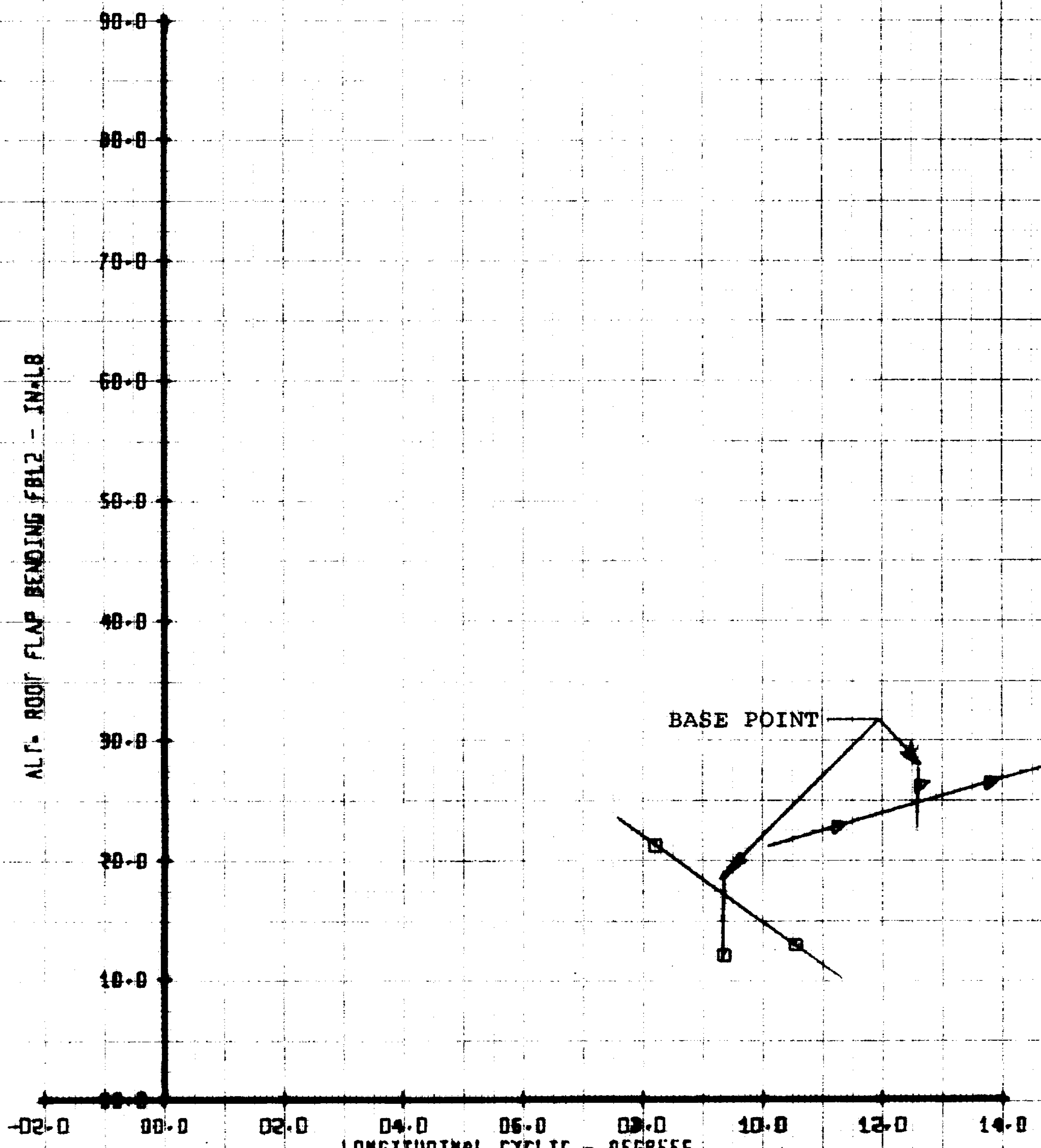
Figure C-191

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/DD25B	CT'/SB	VTUN
□	39	.50	.05	.098	310
▽	41	.50	.10	.090	310

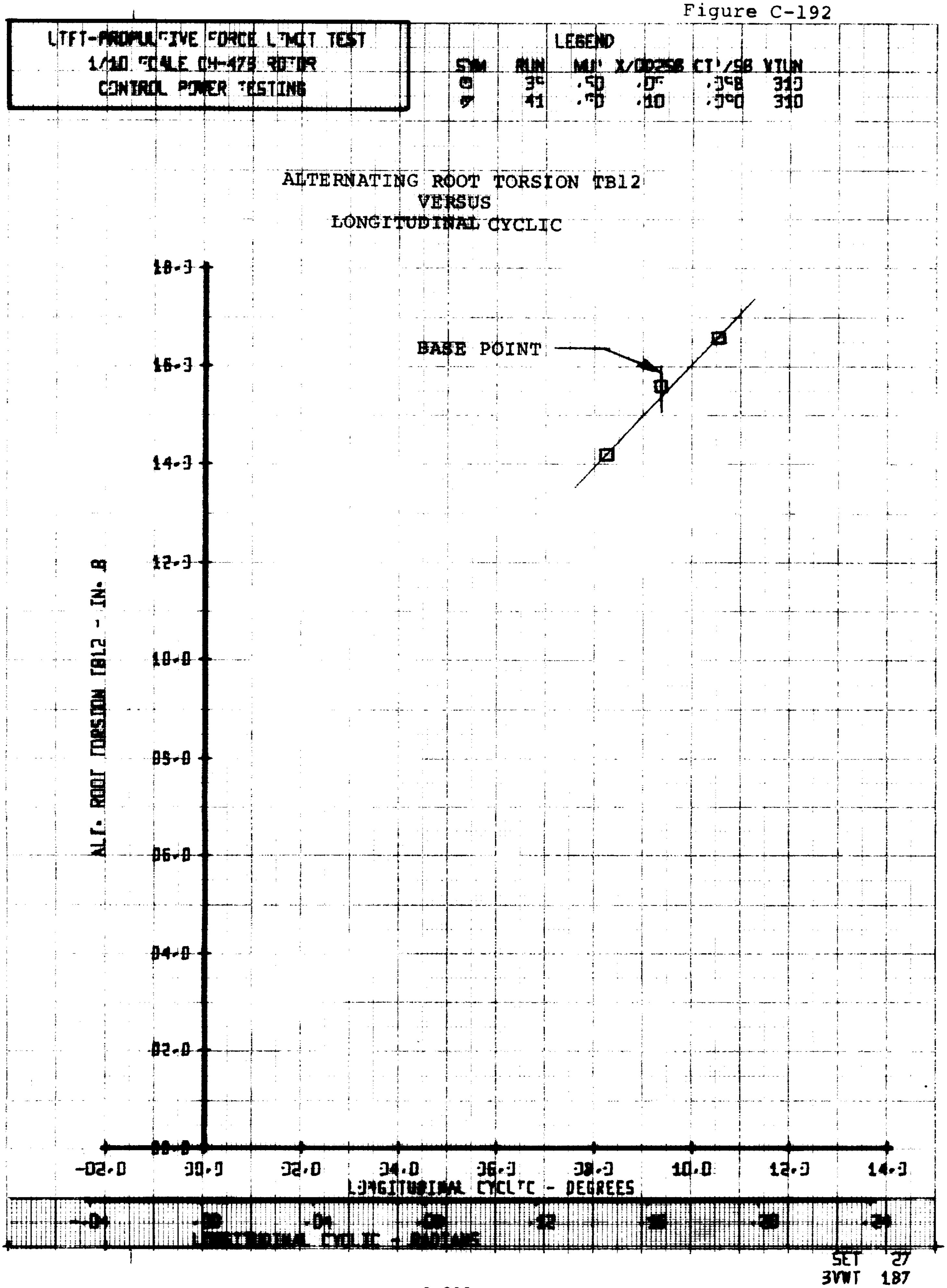
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LONGITUDINAL CYCLIC



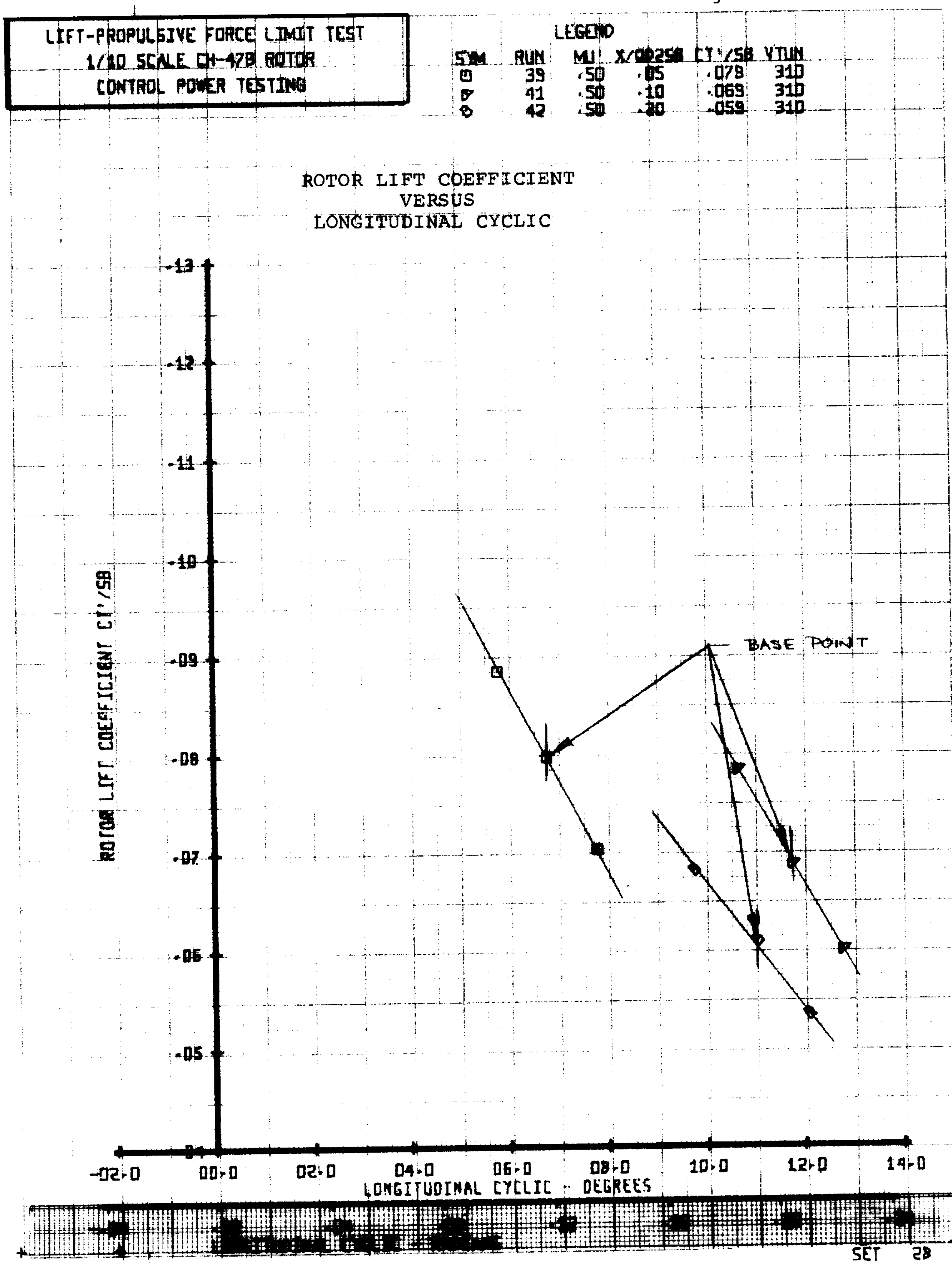
SET 27
BVWT 187

SET 27
BVWT 187

Figure C-192

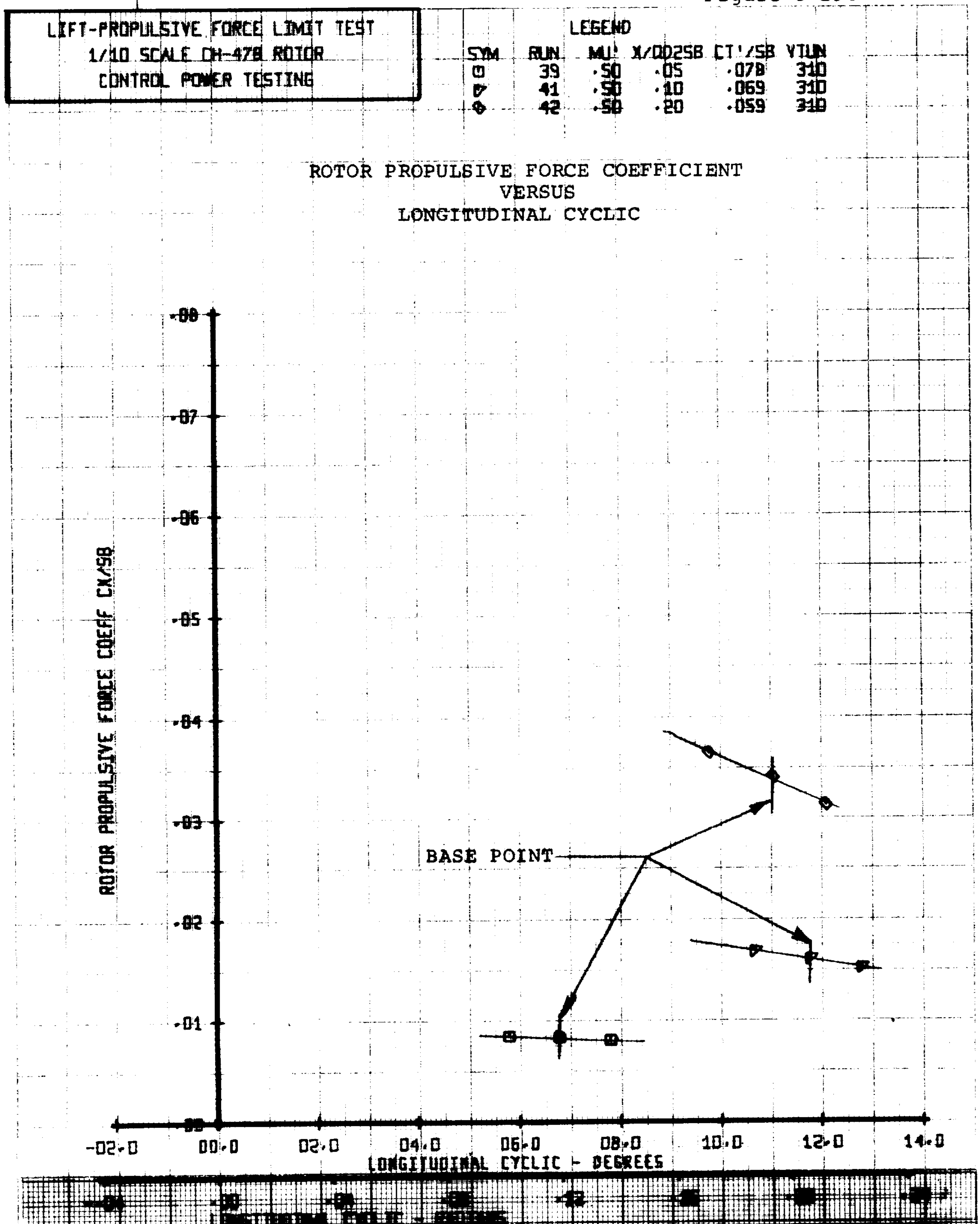


LTFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/D ... CT/SB VTUN
41 .10 310
ALTERNATING ROOT TORSION TB12
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ALT. ROOT TORSION TB12 - IN. B
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 27
3VWT 187

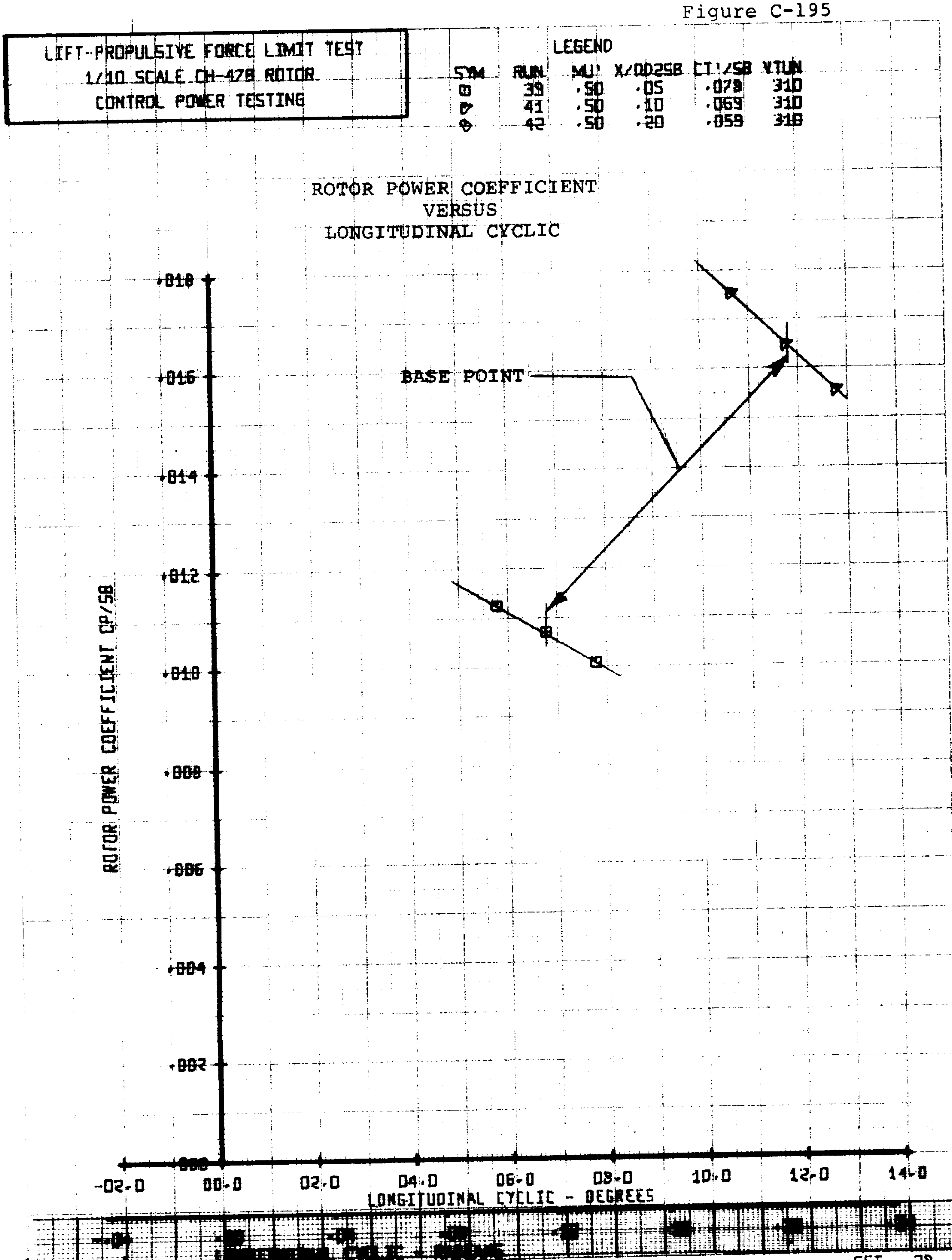

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QQ2SB CT'/SB VTUN
39 .50 .05 .078 310
41 .50 .10 .069 310
42 .50 .20 .059 310
ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 28
BVWT 187

ET 28
WT 187

Figure C-194



SET 28
BVWT 187



ET 29
WT 187

SET 29
BVWT 187

Figure C-196

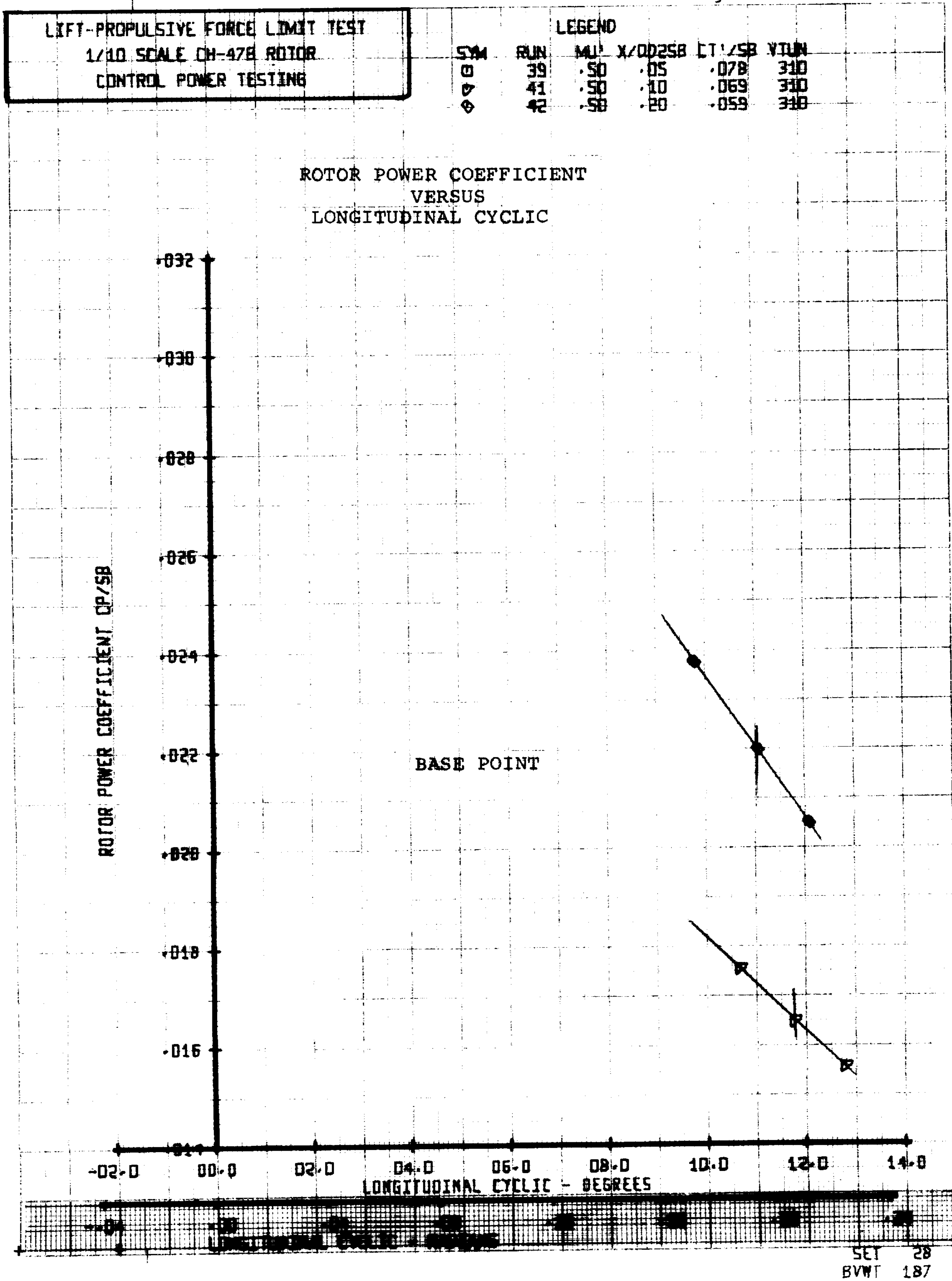
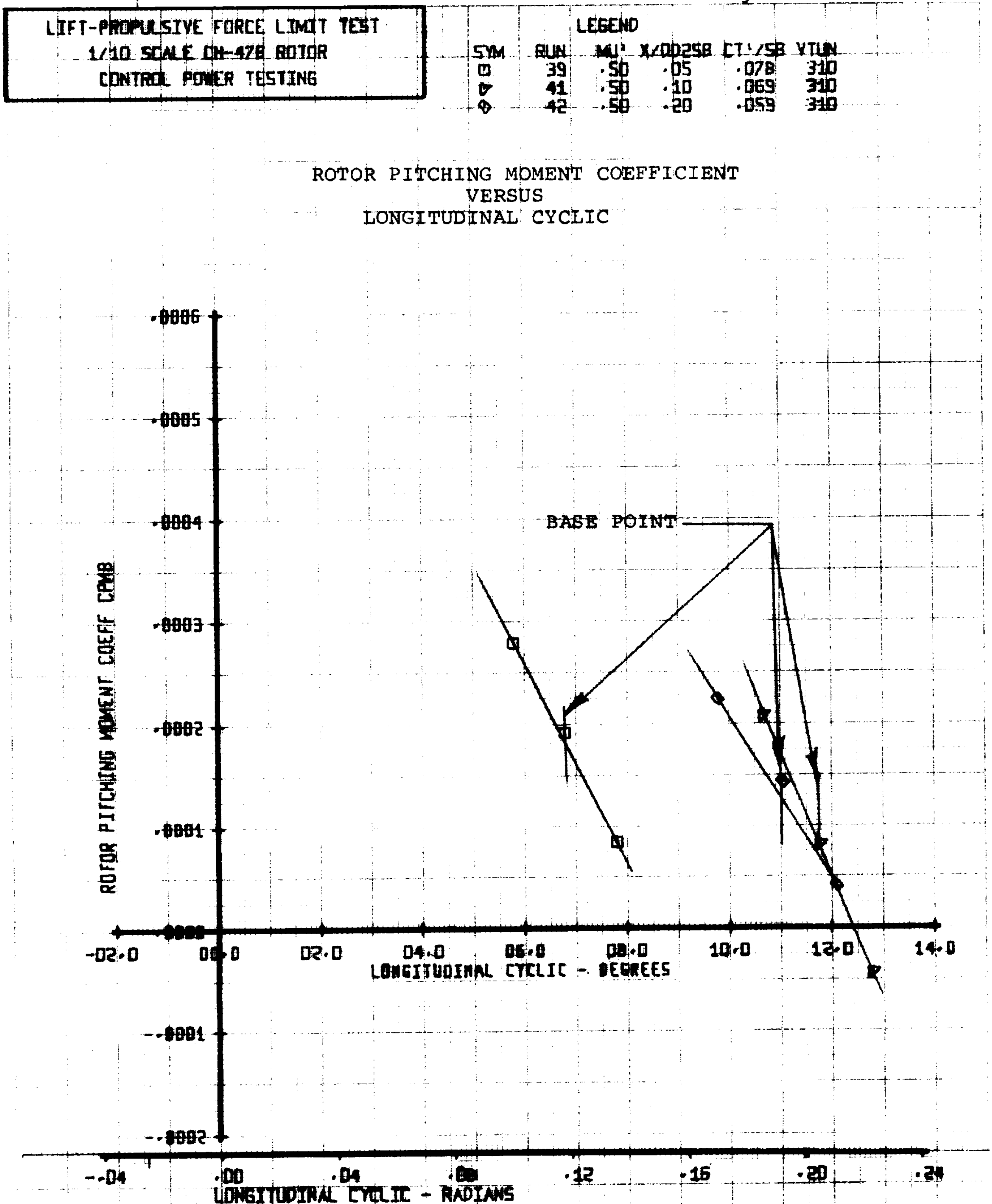
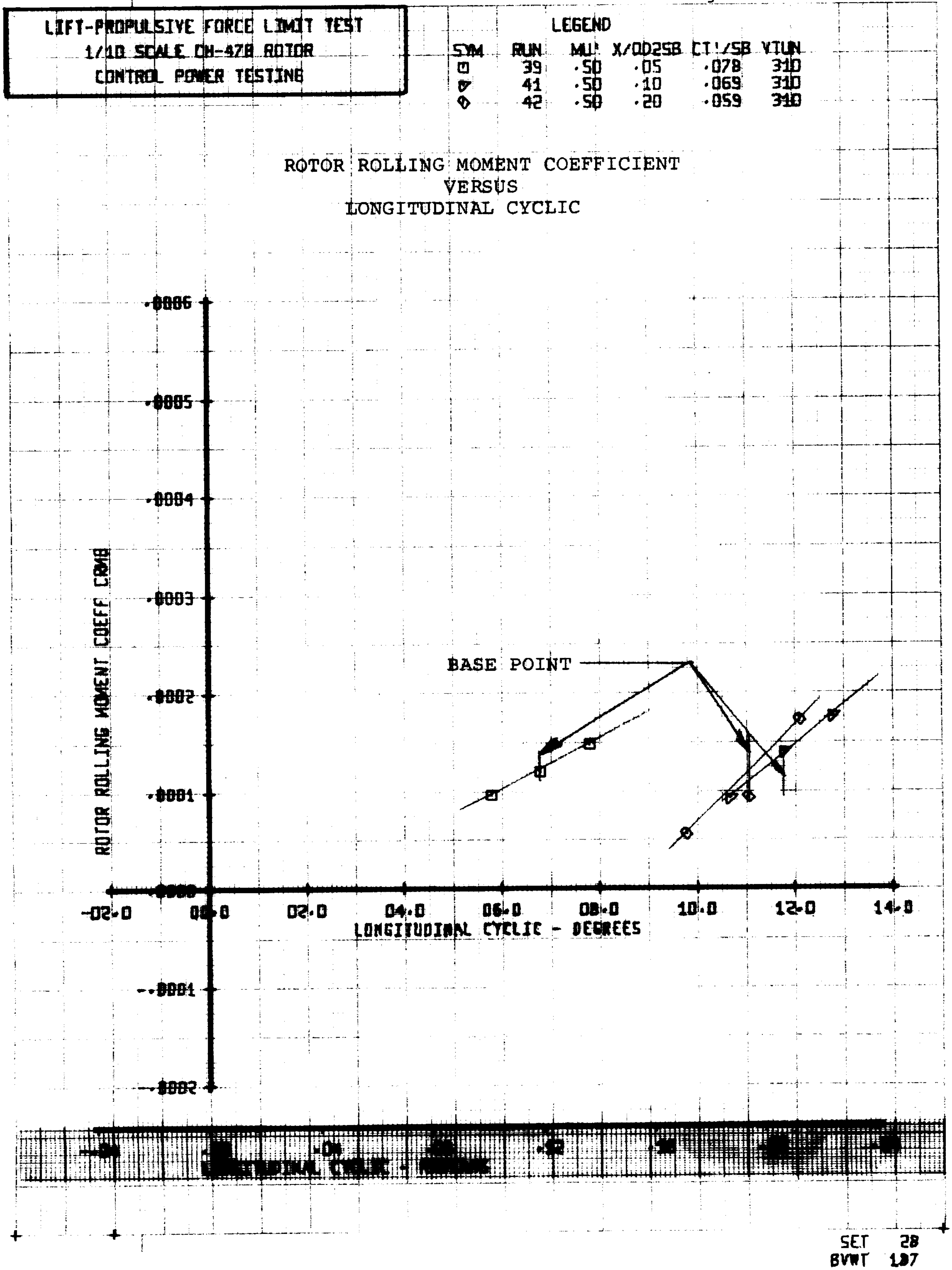

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD2SB CT'/SB VTUN
39 .50 .05 .078 310
41 .50 .10 .069 310
42 .50 .20 .059 310
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR POWER COEFFICIENT CP/SB
.032
.030
.028
.026
.024
.022
.020
.018
.016
.014
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 28
BVWT 187

Figure C-197



ET 28
WT 187

SET 28
BVWT 187



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
39 .50 .05 .078 310
41 .50 .10 .069 310
42 .50 .20 .059 310
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR ROLLING MOMENT COEFF CRMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 28
BVWT 187

Figure C-199

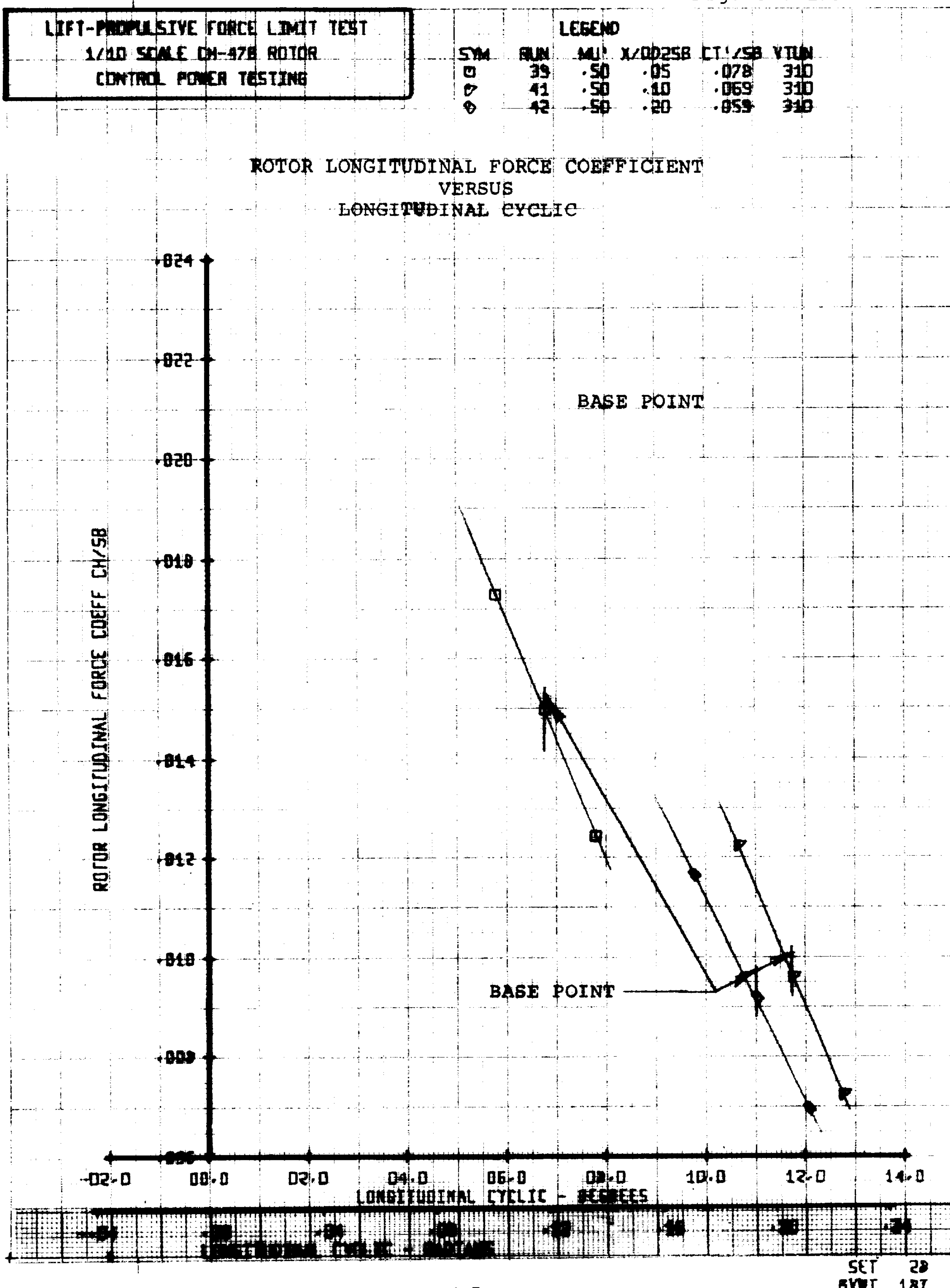
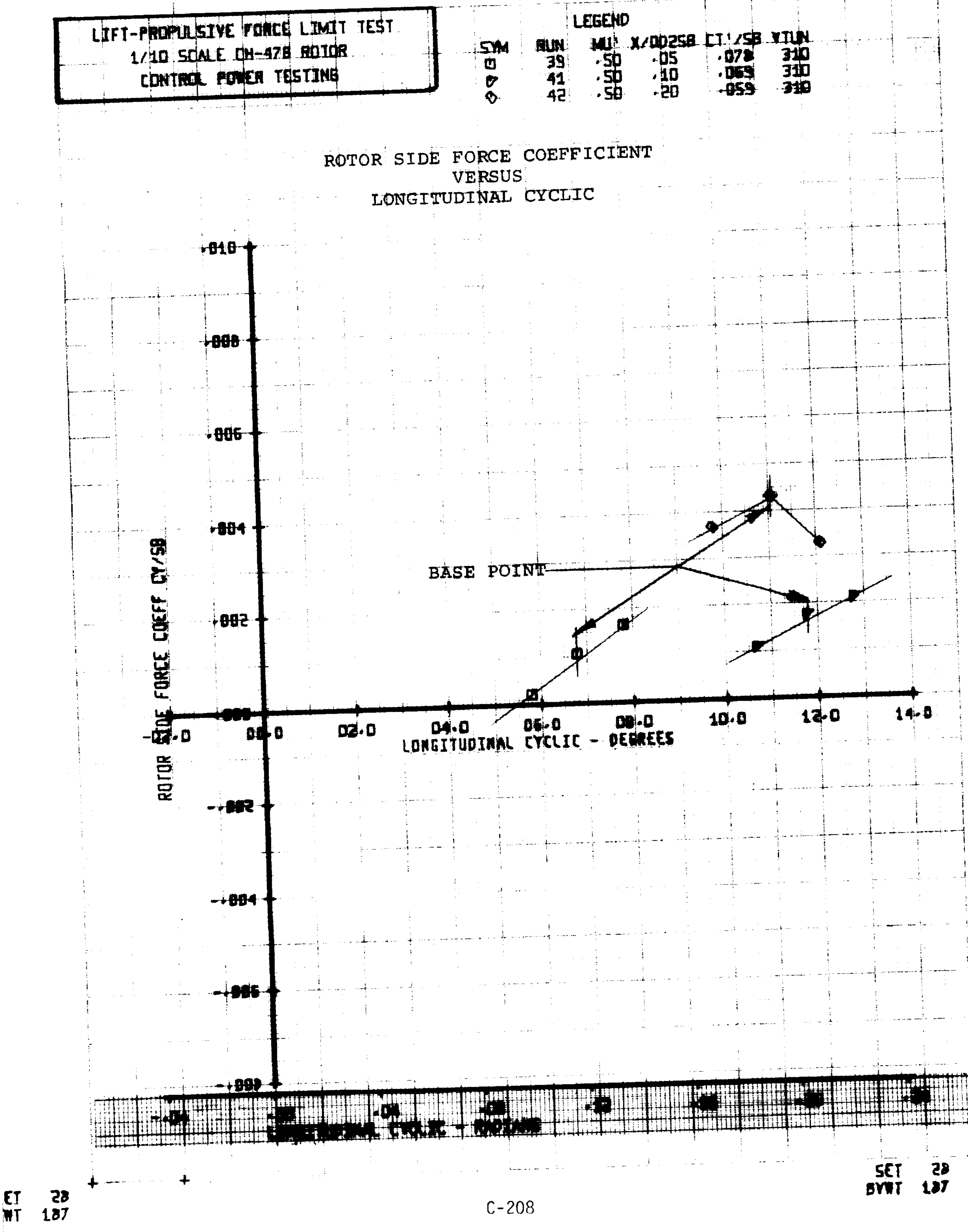
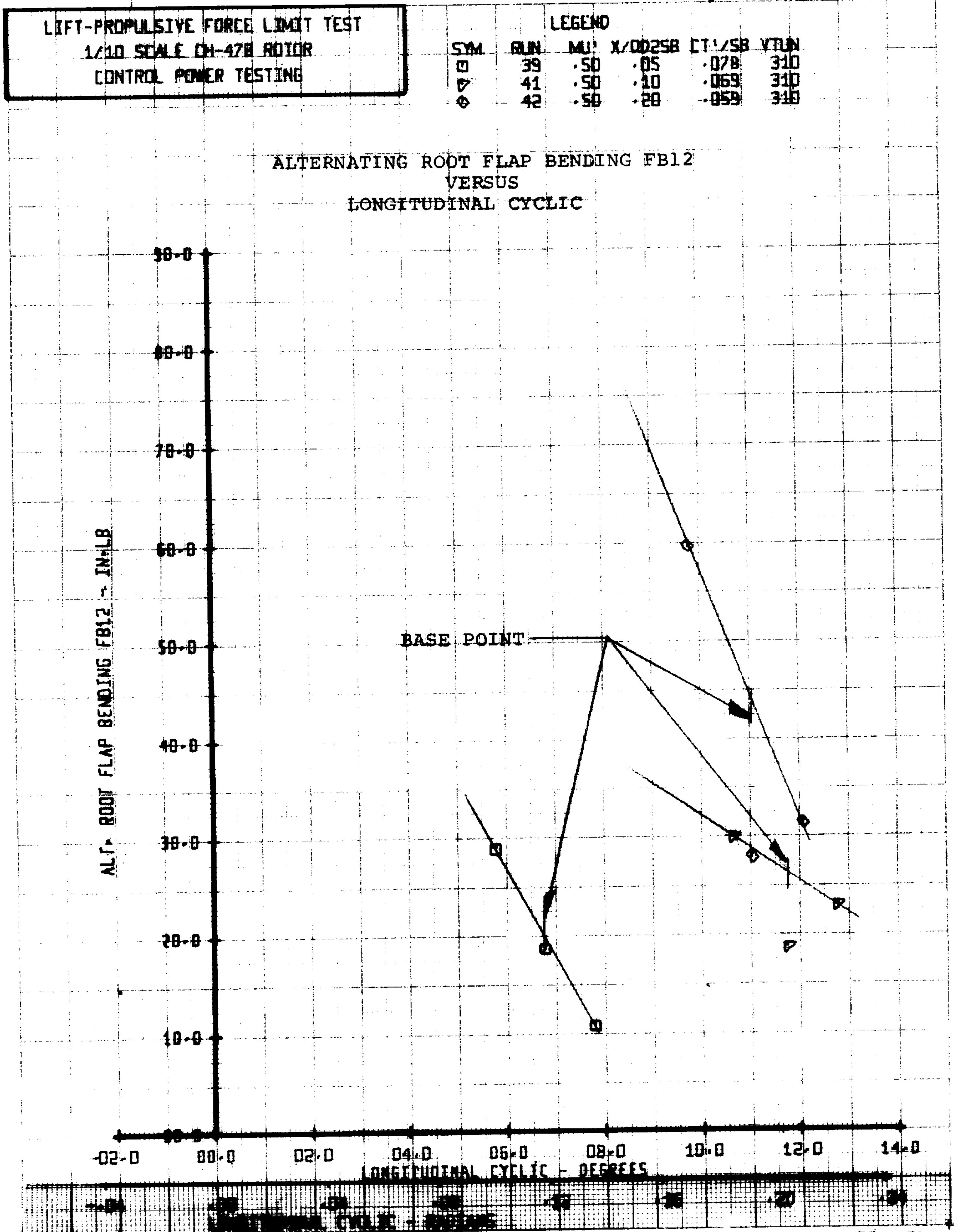

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD25B CT'/SB VTUN
39 .50 .05 .078 310
41 .50 .10 .069 310
42 .50 .20 .059 310
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
BASE POINT
ROTOR LONGITUDINAL FORCE COEFF CH/SB
.024
.022
.020
.018
.016
.014
.012
.010
.008
.006
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
ET 28
WT 187
SET 28
BVWT 187

Figure C-200



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD258 CT'/SB VTUN
39 .50 .05 .078 310
41 .50 .10 .069 310
42 .50 .20 .059 310
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR SIDE FORCE COEFF CY/SB
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 28
BYWT 187
ET 28
WT 187

Figure C-201



ET 28
WT 187

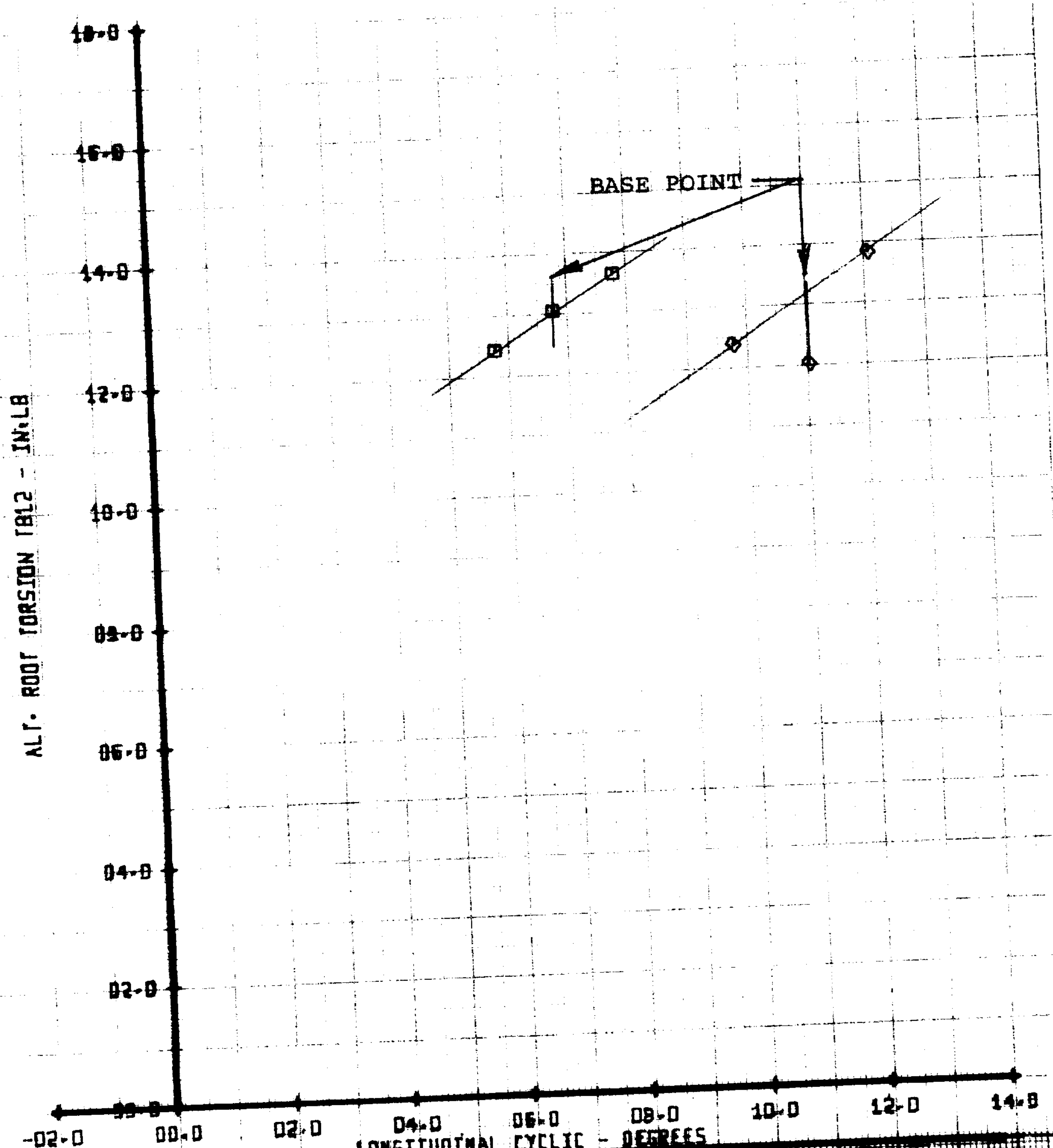
SET 28
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

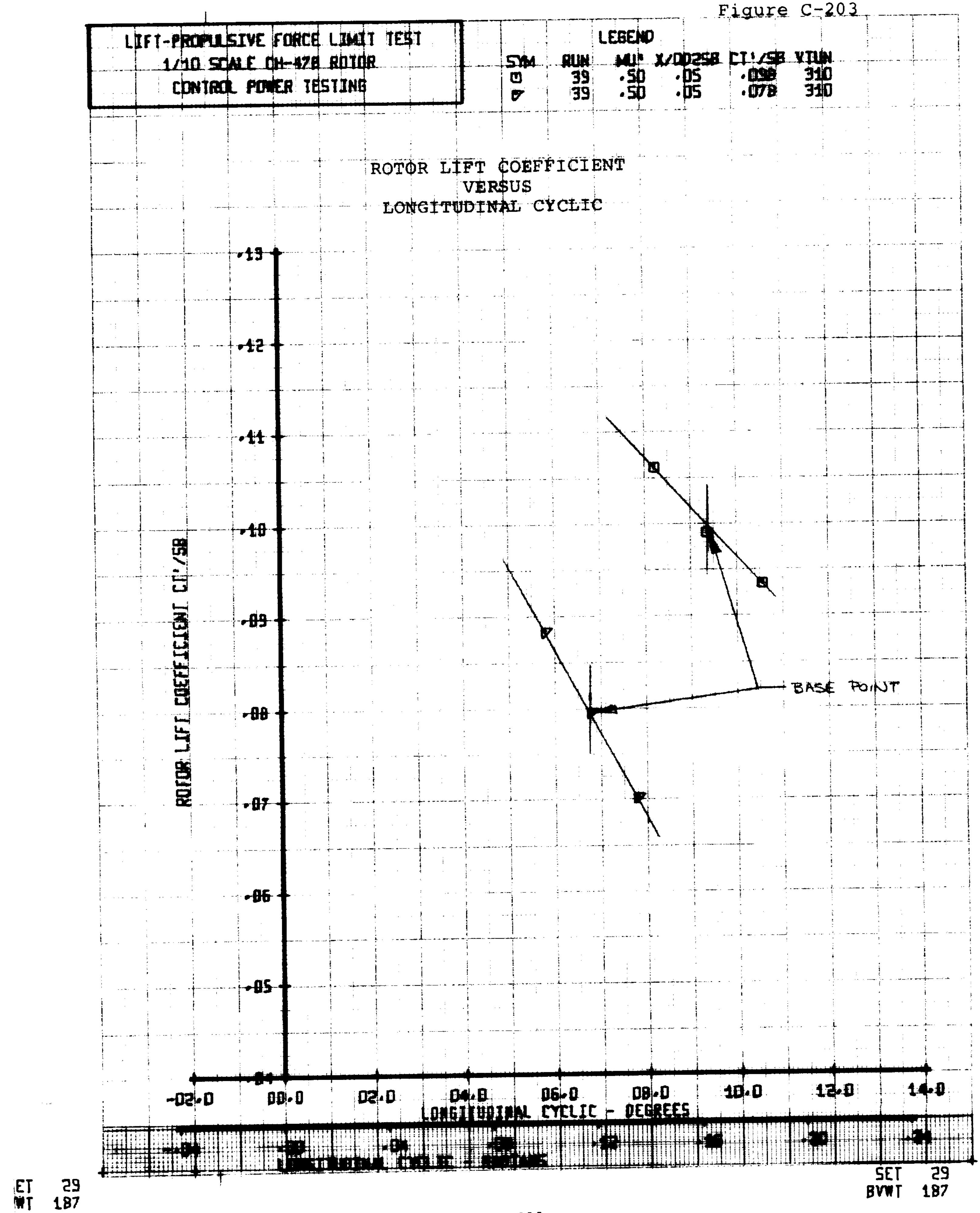
SYM	RUN	MU	X/QD2SB	CT/SB	VTUN
□	39	.50	.05	.078	310
▽	41	.50	.10	.069	310
◇	42	.50	.20	.059	310

ALTERNATING ROOT TORSION TB12
VERSUS
LONGITUDINAL CYCLIC

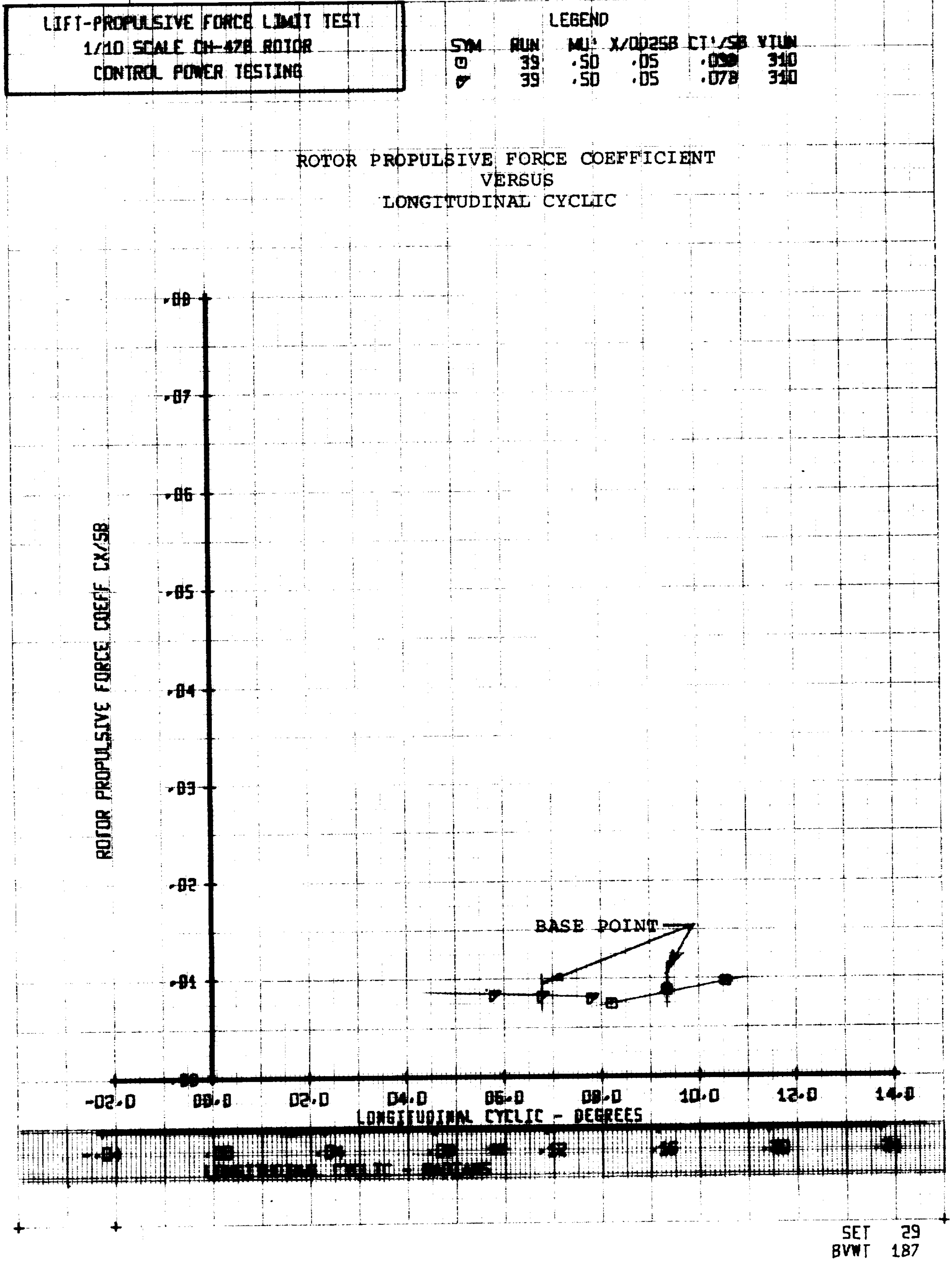


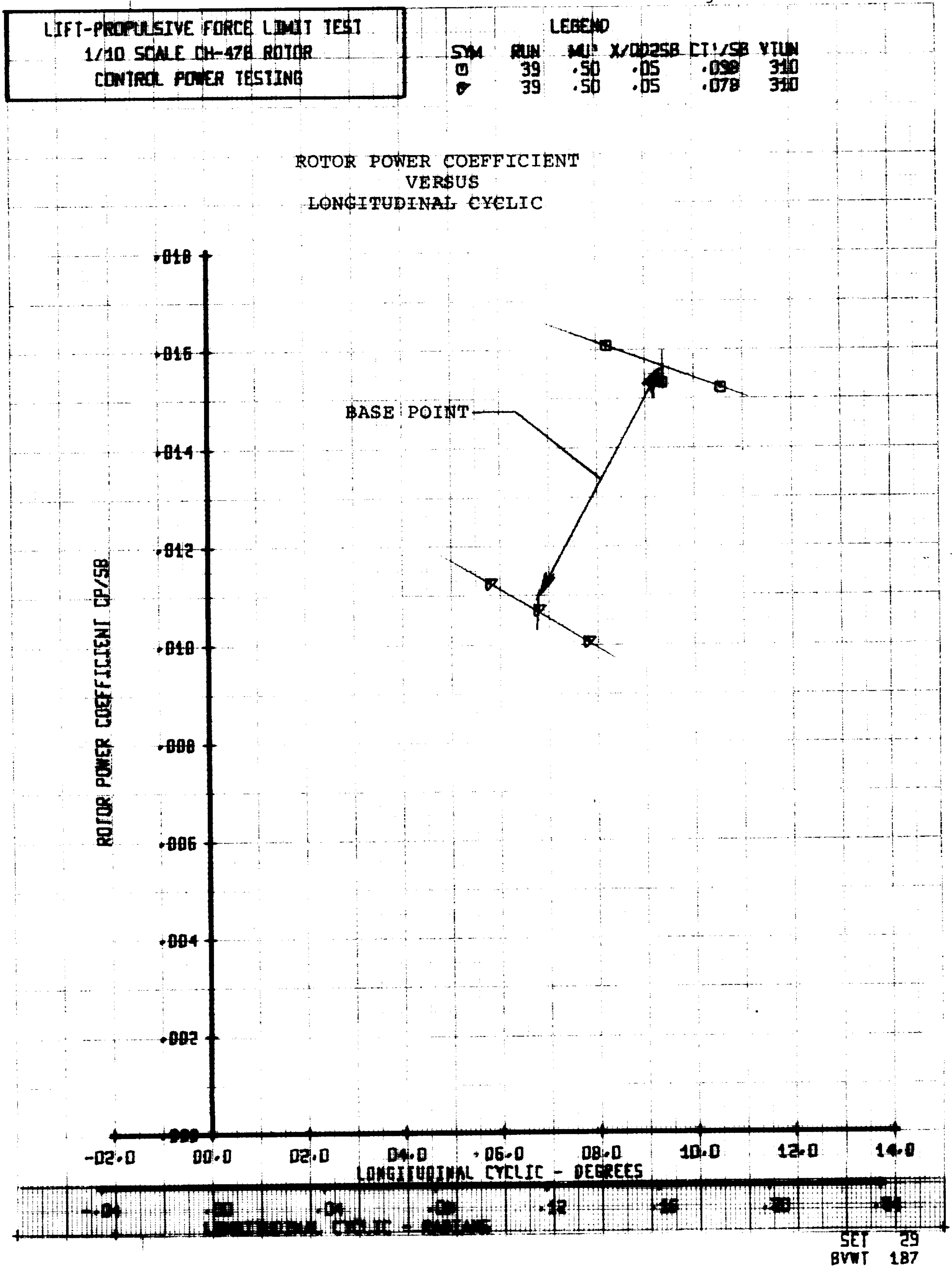
SET 28
BVWT 187

ET 28
WT 187


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD2SB CT'/SB VTUN
39 .50 .05 .098 310
39 .50 .05 .078 310
ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 29
BVWT 187
ET 29
WT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING



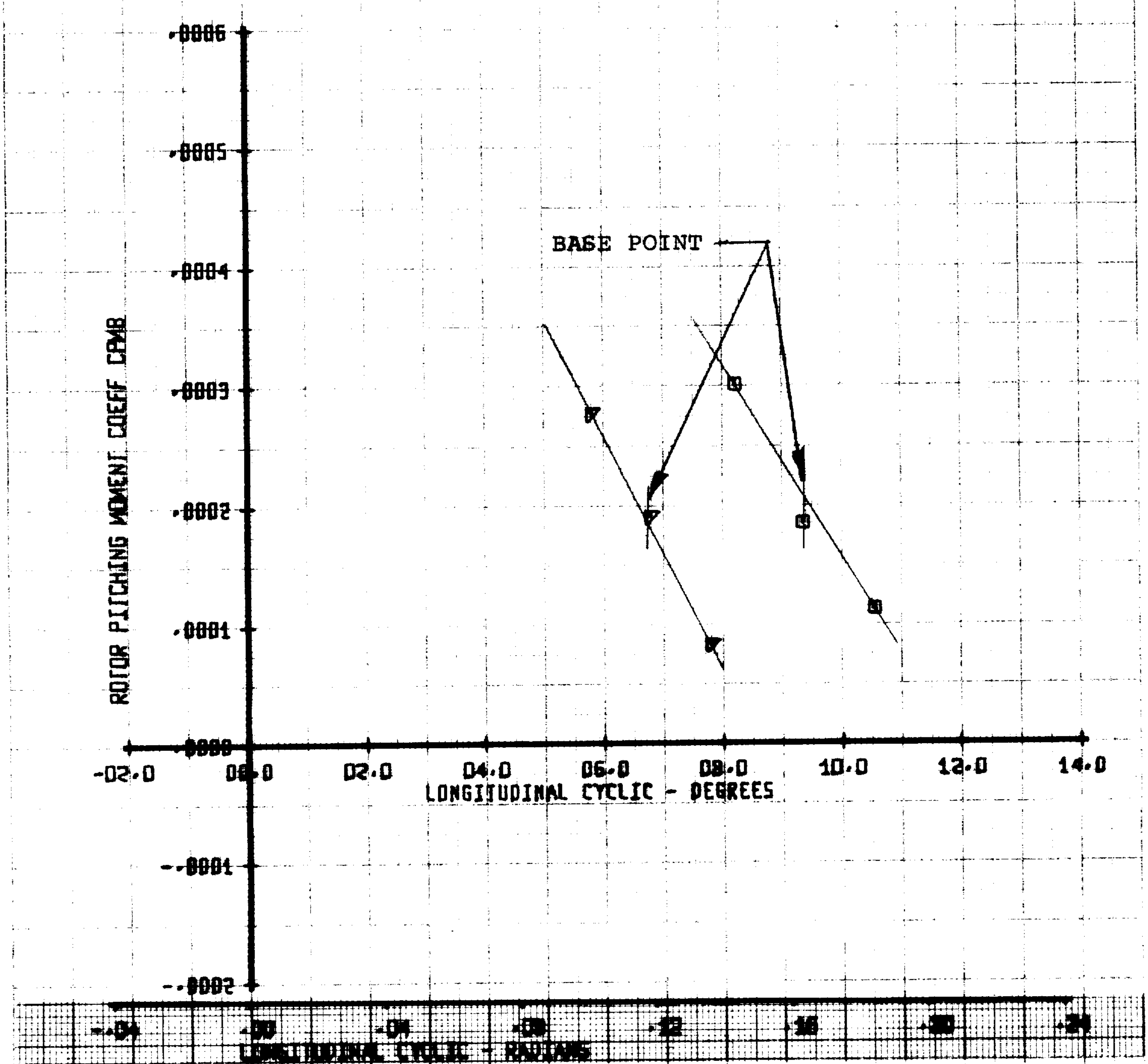

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
39 .50 .05 .098 310
39 .50 .05 .078 310
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
ROTOR POWER COEFFICIENT CP/SB
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 29
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

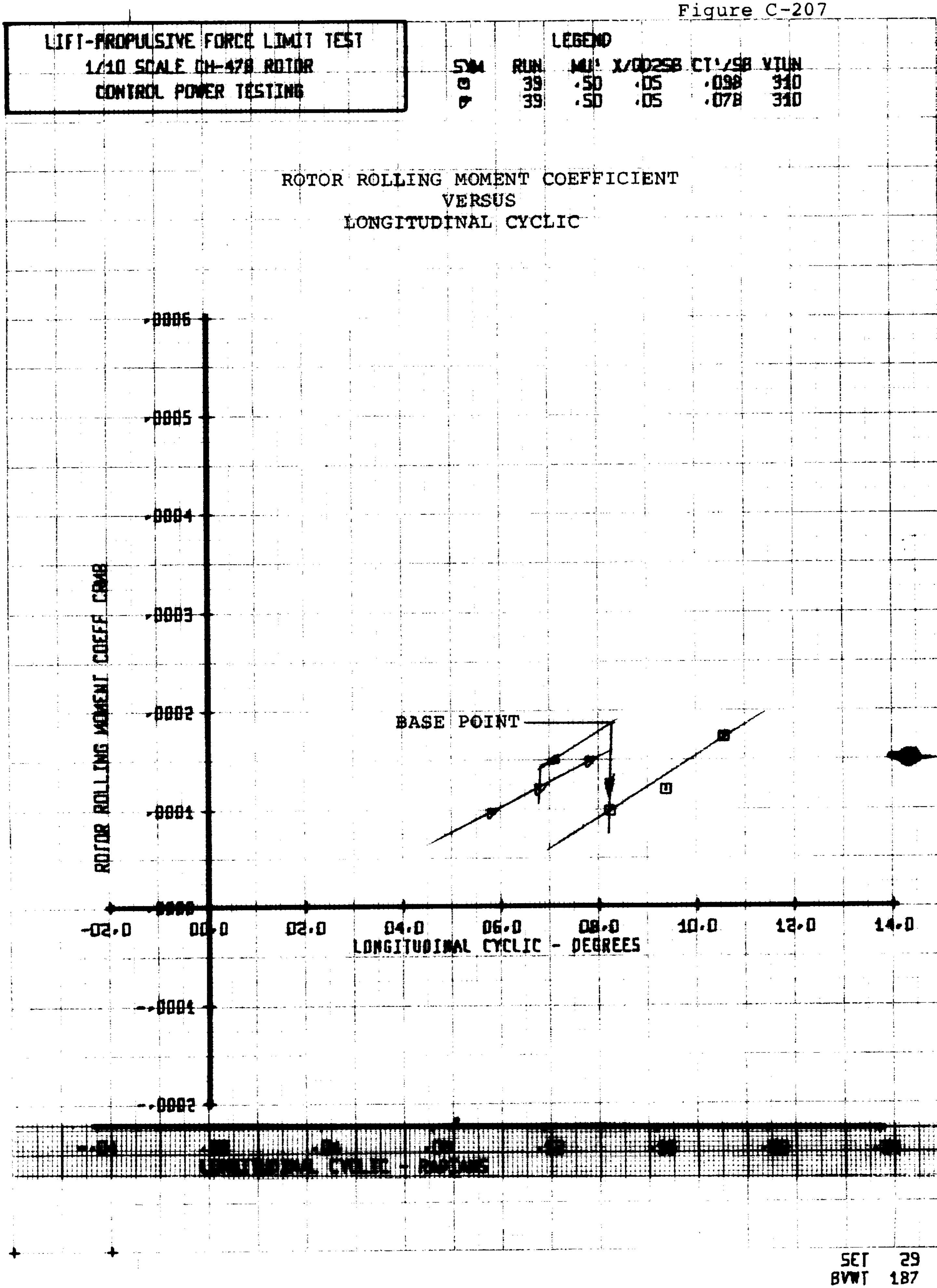
SYM	RUN	MU	X/QD2SB	CT'/SB	VTUN
⊡	39	.50	.05	.098	310
▽	39	.50	.05	.078	310

ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC



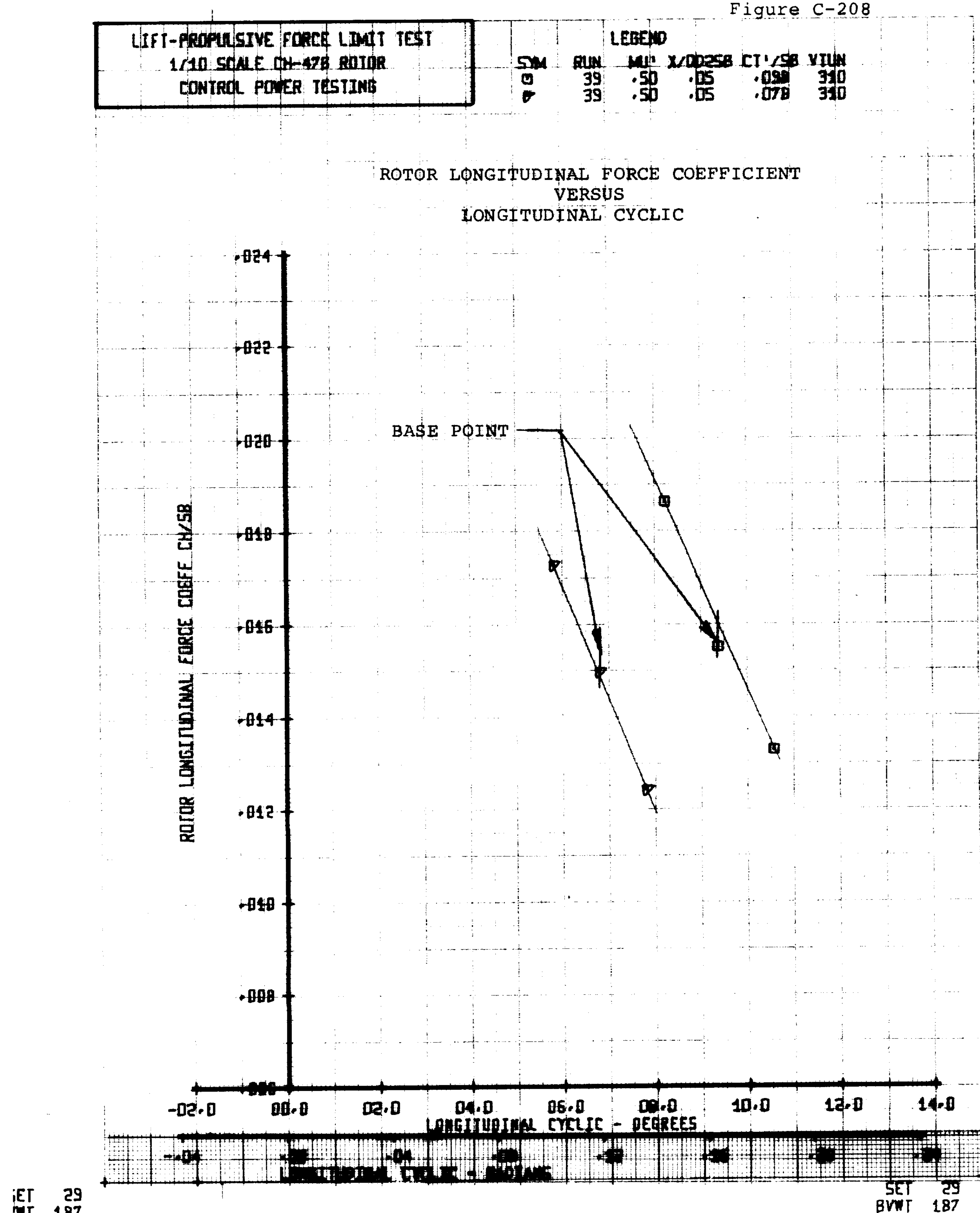
SET 29
BVWT 187

Figure C-207



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
39 .50 .05 .098 310
39 .50 .05 .078 310
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR ROLLING MOMENT COEFF CRMR
LONGITUDINAL CYCLIC - DEGREES
SET 29
BVWT 187

Figure C-208



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN
39 .50 .05 .098 310
39 .50 .05 .078 310
ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR LONGITUDINAL FORCE COEFF CH/SB
.024
.022
.020
.018
.016
.014
.012
.010
.008
.006
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 29
BVWT 187

Figure C-209

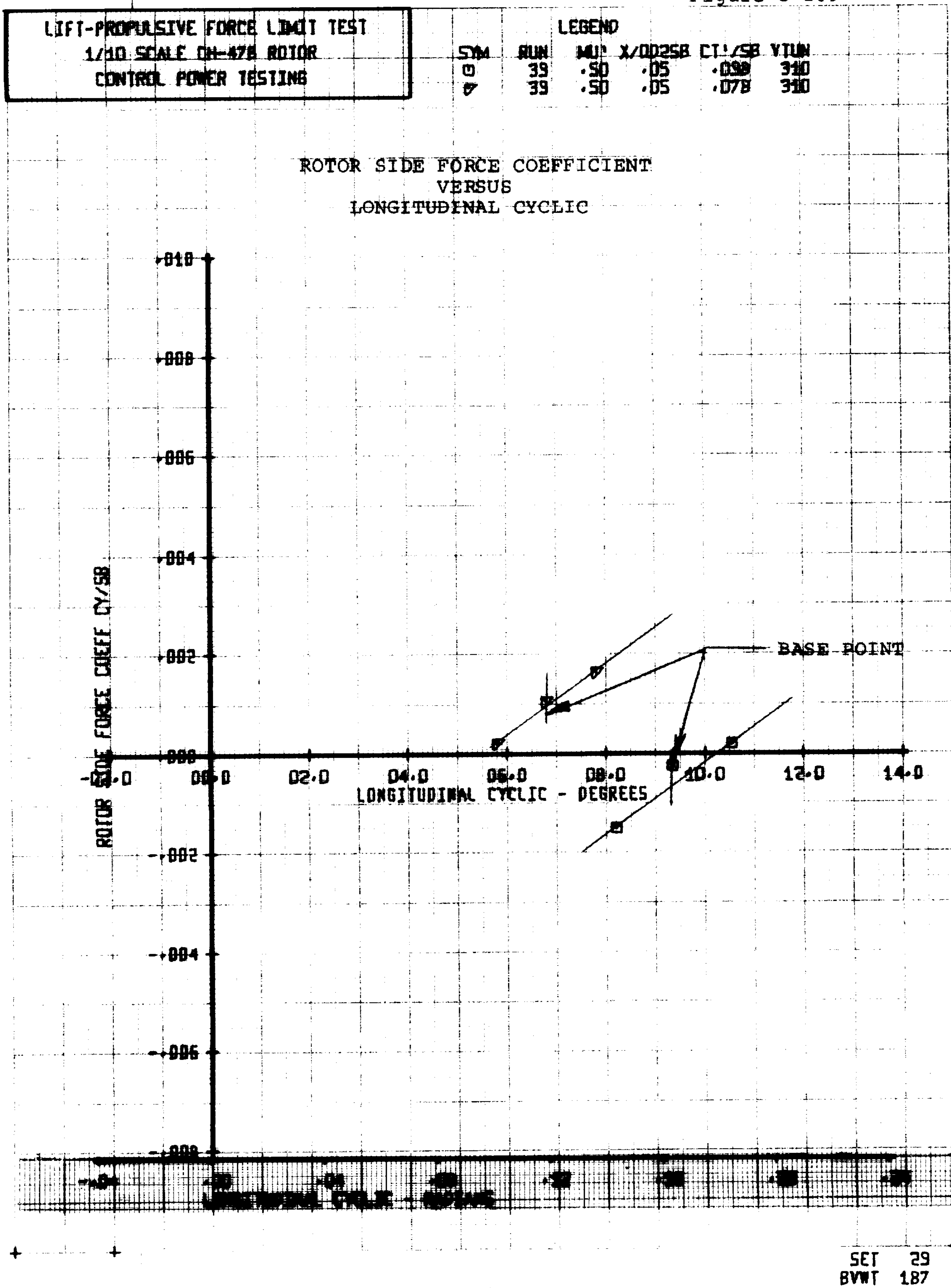

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/OD25B CT'/SB VTUN
39 .50 .05 .090 310
39 .50 .05 .078 310
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR SIDE FORCE COEFF CY/SB
LONGITUDINAL CYCLIC - DEGREES
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
SET 29
BVWT 187

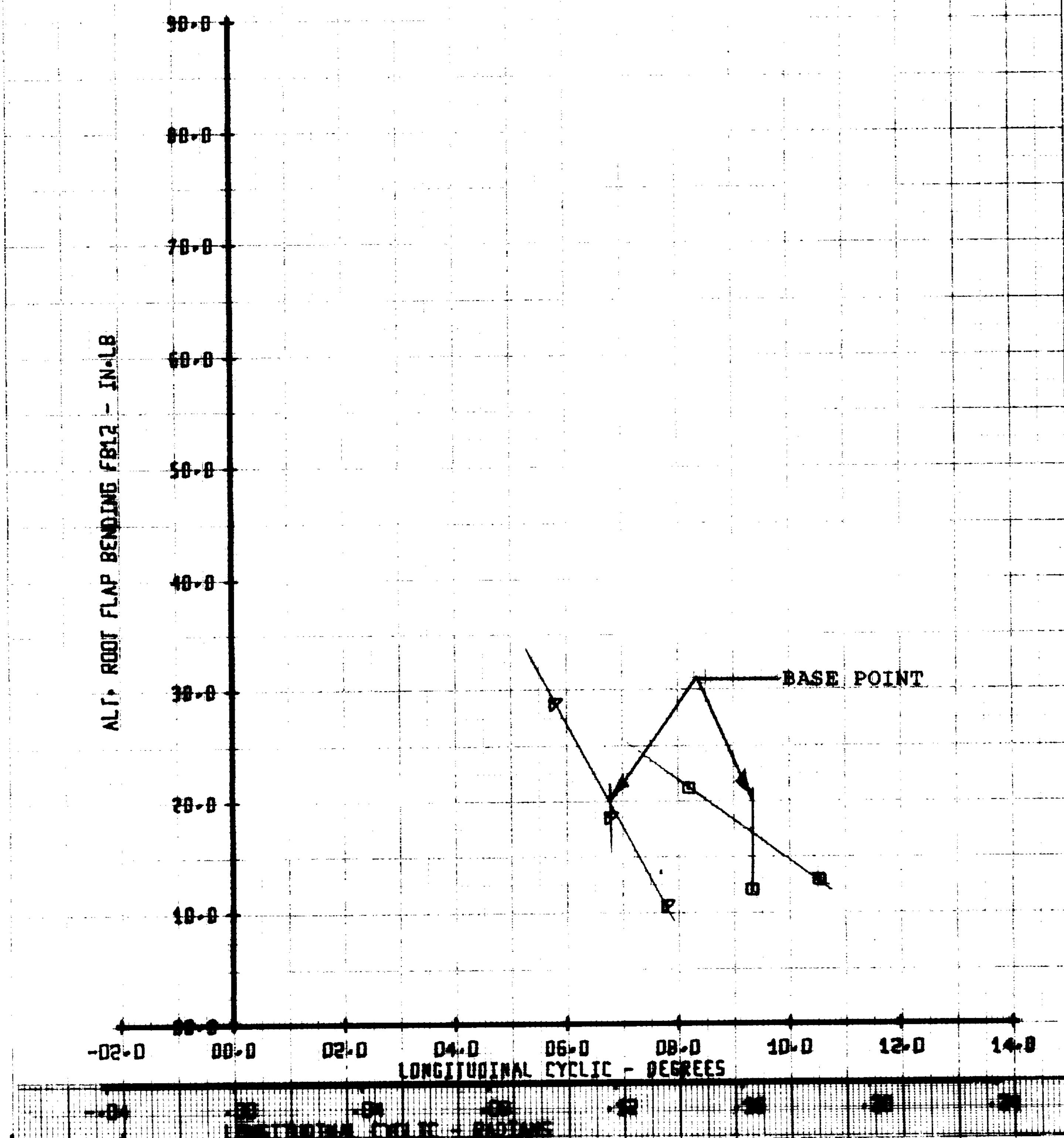
Figure C-210

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
⊡	39	.50	.05	.098	310
▽	39	.50	.05	.078	310

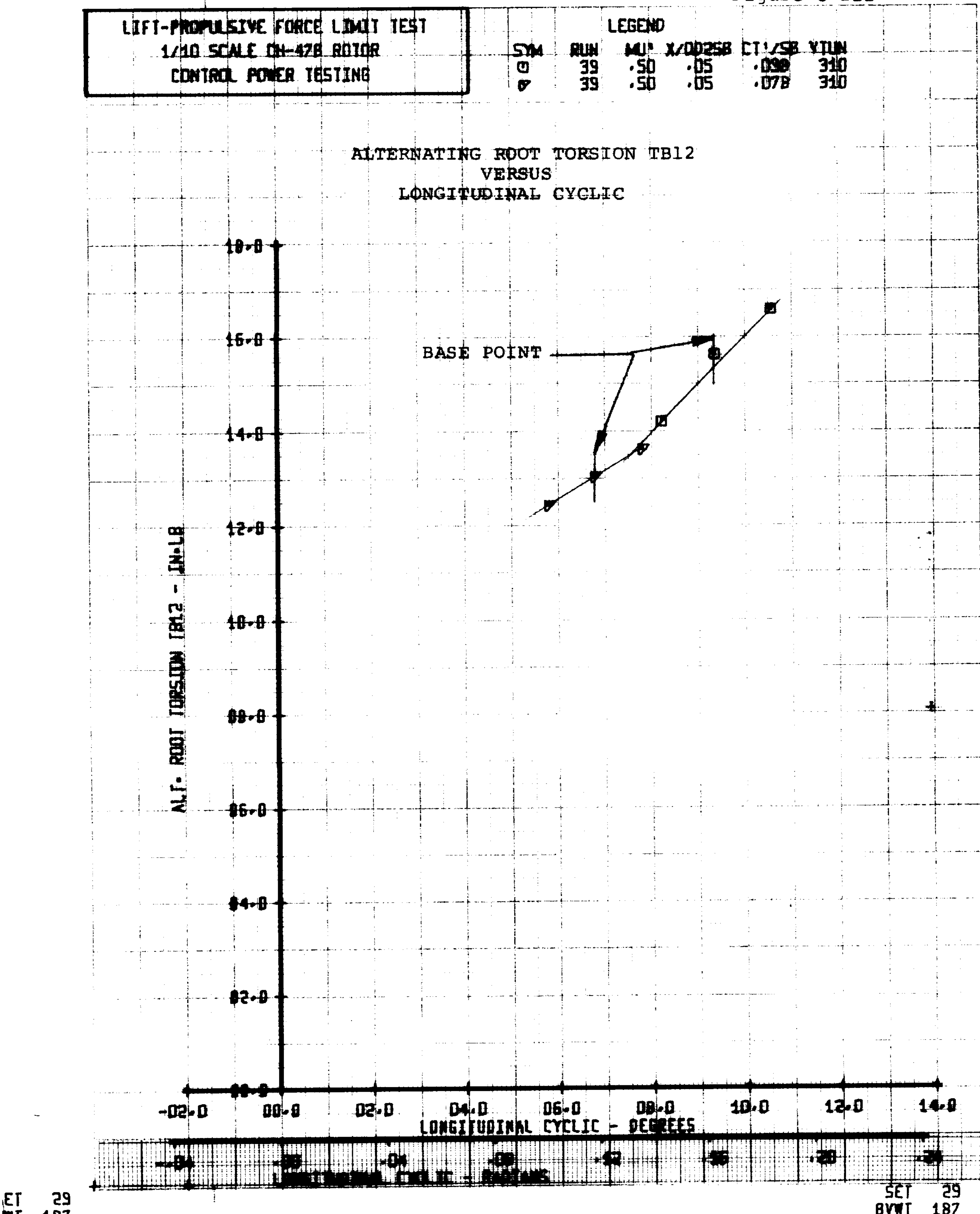
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LONGITUDINAL CYCLIC



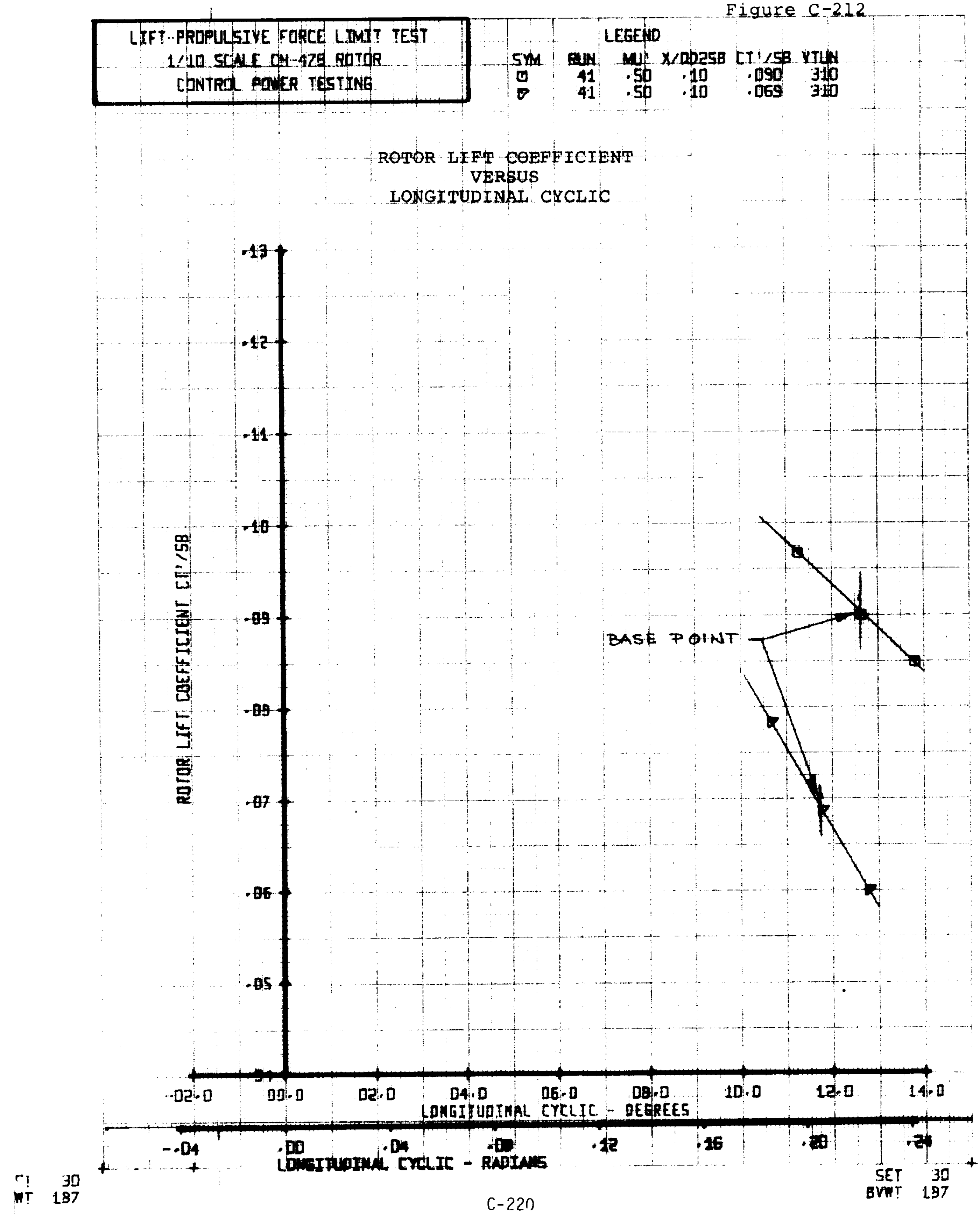
ET 29
WT 187

SET 29
BVWT 187

Figure C-211


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/OD25B CT'/SB VTUN
39 .50 .05 .090 310
39 .50 .05 .078 310
ALTERNATING ROOT TORSION TB12
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ALT. ROOT TORSION TB12 - IN-LB
18.0
16.0
14.0
12.0
10.0
08.0
06.0
04.0
02.0
00.0
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 29
BVWT 187

LIFT PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC

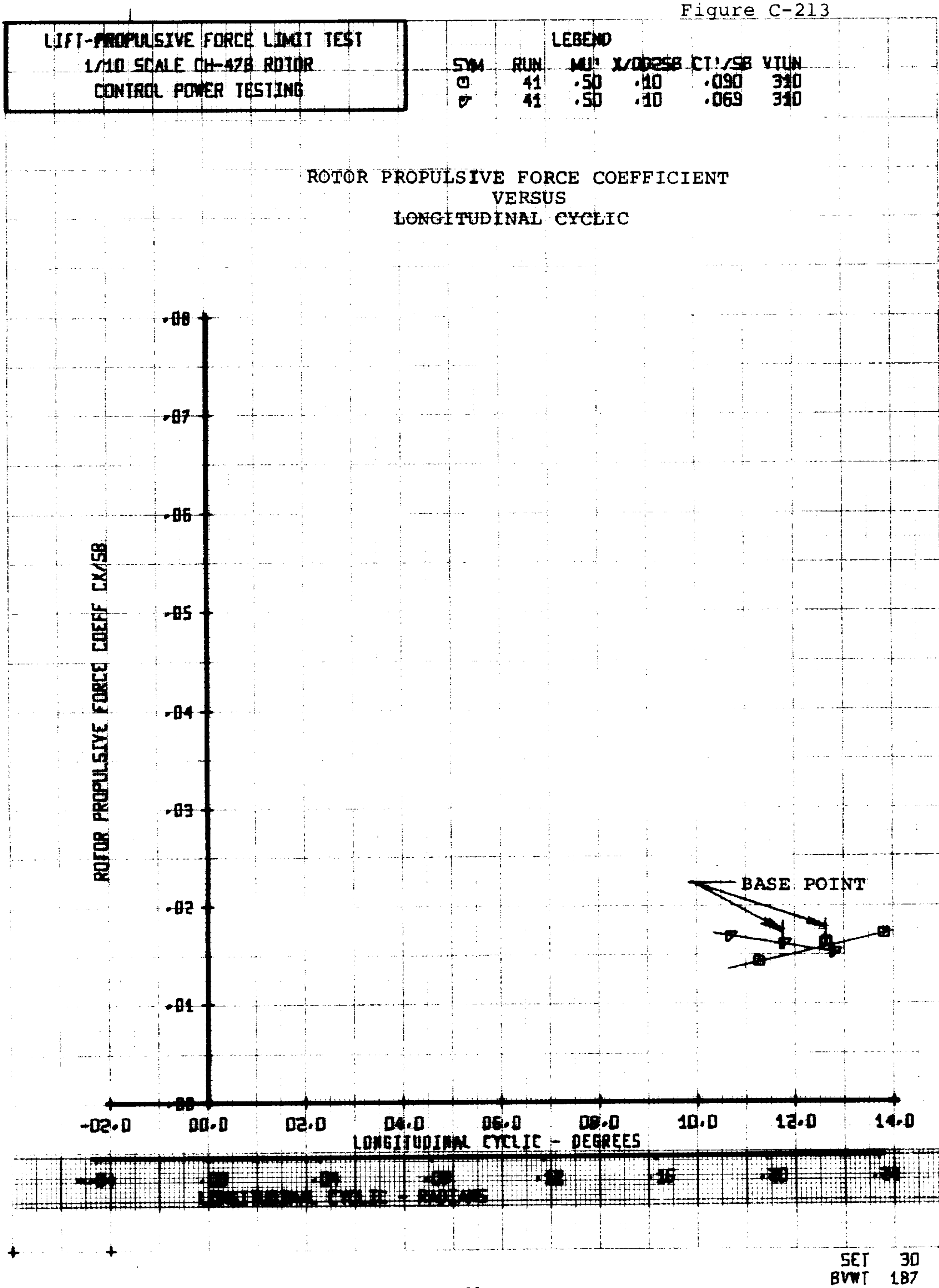


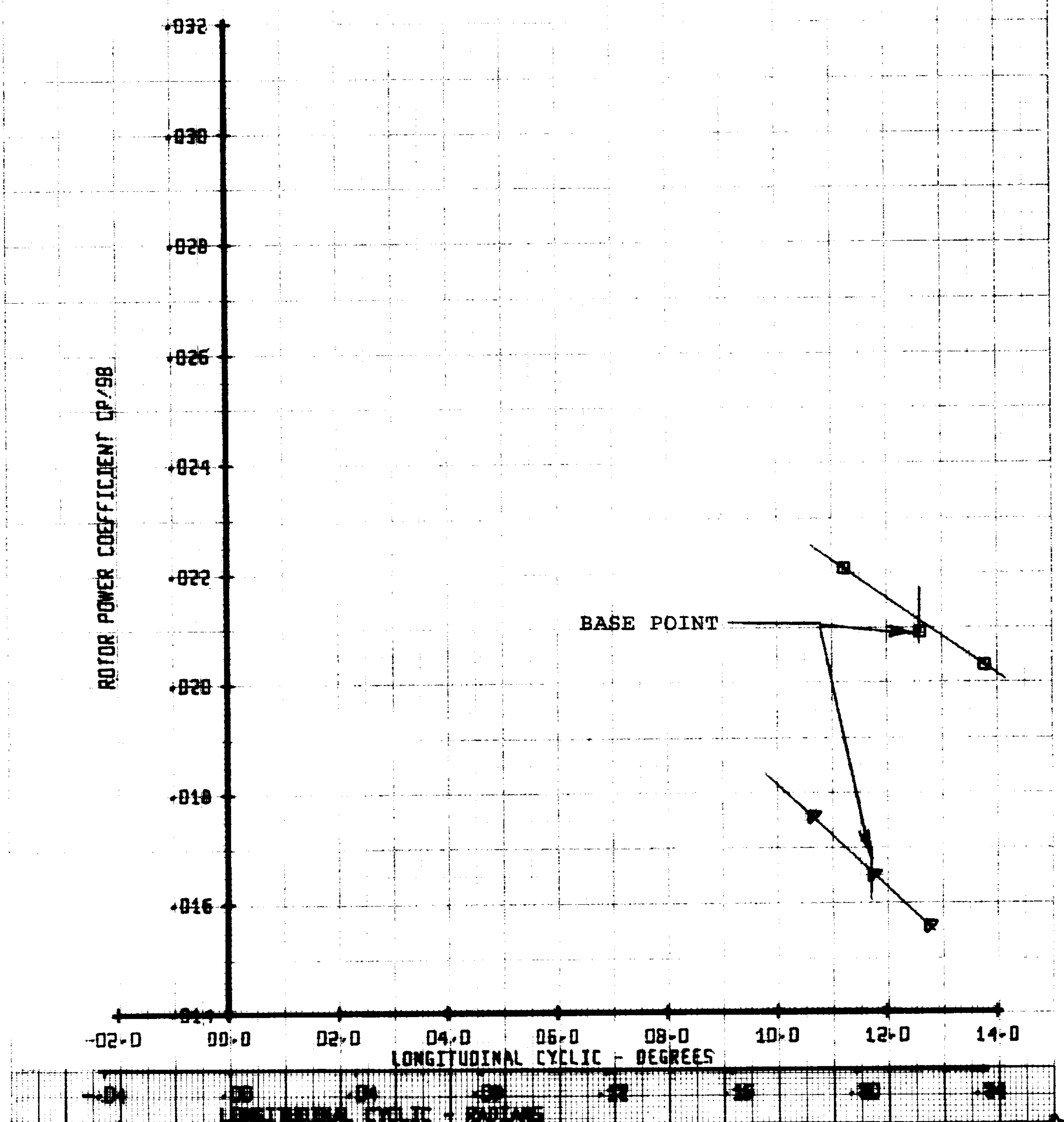
Figure C-214

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU	X/QD2SB	CT'/SB	VTUN
□	41	.50	.10	.090	310
▽	41	.50	.10	.069	310

ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC



ET 30
WT 187

SET 30
BVWT 187

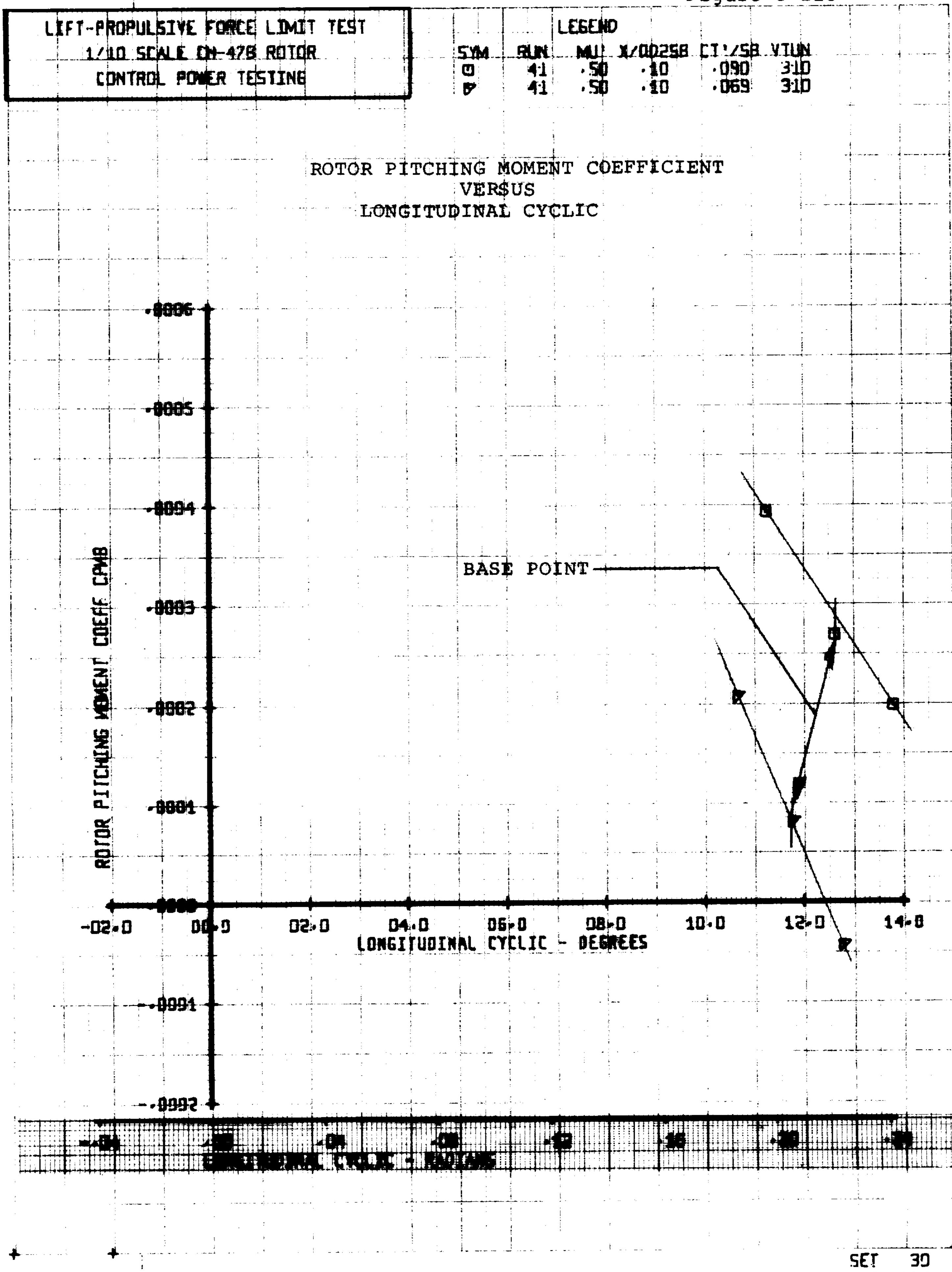
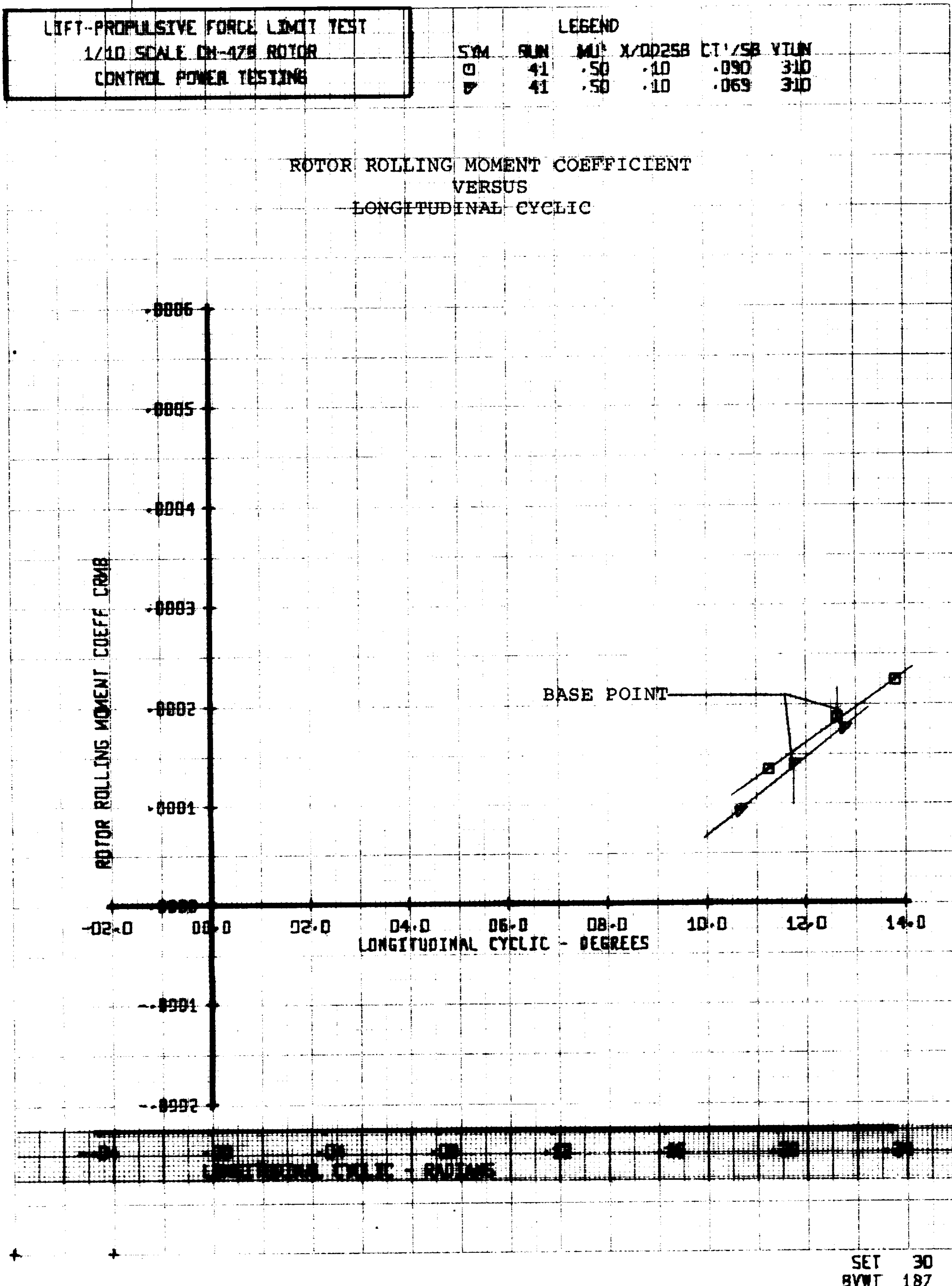
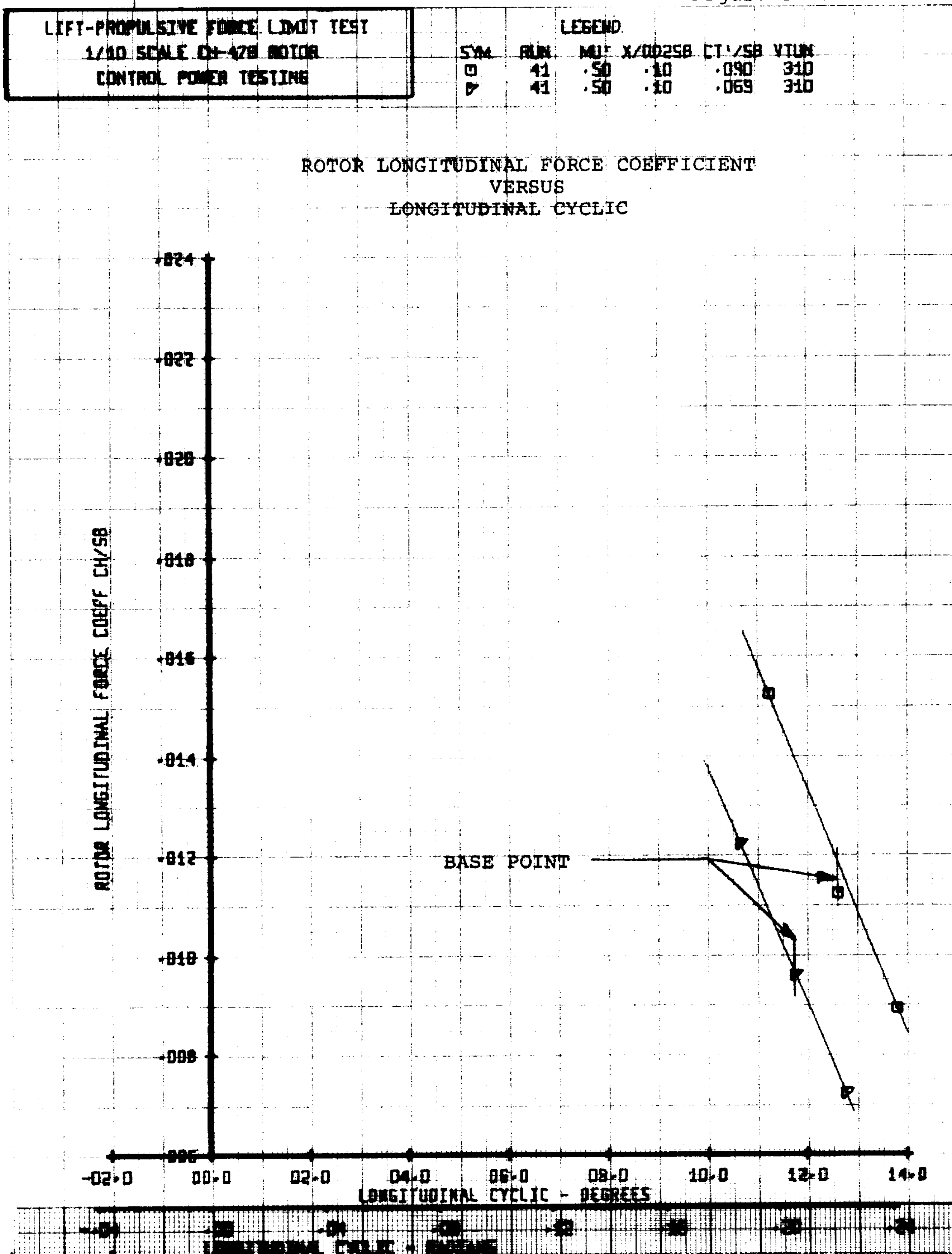

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/00258 CT'/SB VTUN
41 .50 .10 .090 310
41 .50 .10 .069 310
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR PITCHING MOMENT COEFF CPMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
ET 30
WT 187
SET 30
BVWT 187

Figure C-216



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/D0258 CT'/SB VTUN
41 .50 .10 .090 310
41 .50 .10 .069 310
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR ROLLING MOMENT COEFF CRMB
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 30
BVWT 187

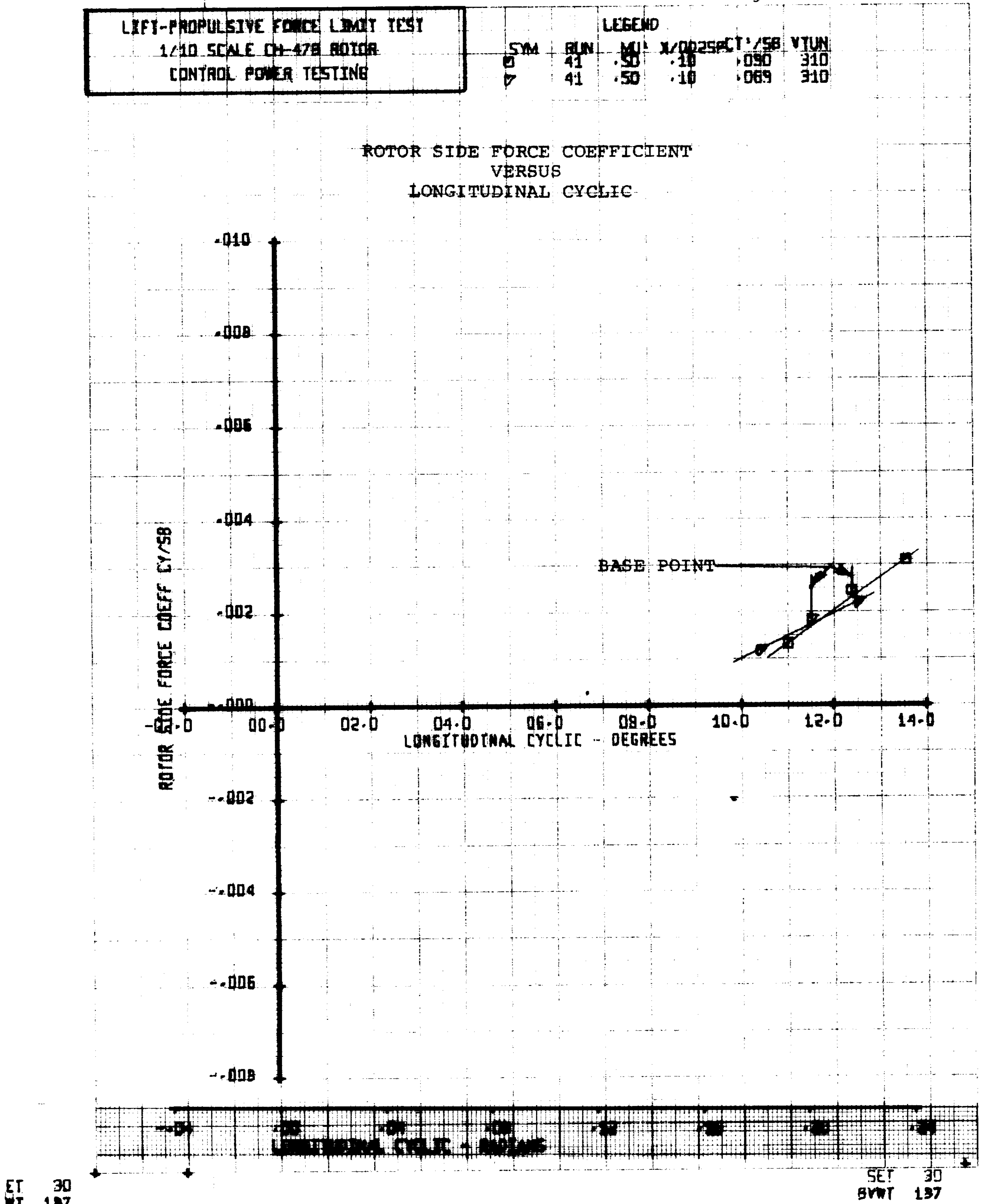
Figure C-217



ET 30
WT 187

SET 30
BVWT 187

Figure C-218



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SP CT'/SB VTUN
41 .50 .10 .090 310
41 .50 .10 .069 310
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ROTOR SIDE FORCE COEFF CY/SB
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
ET 30
WT 187
SET 30
SVWT 137

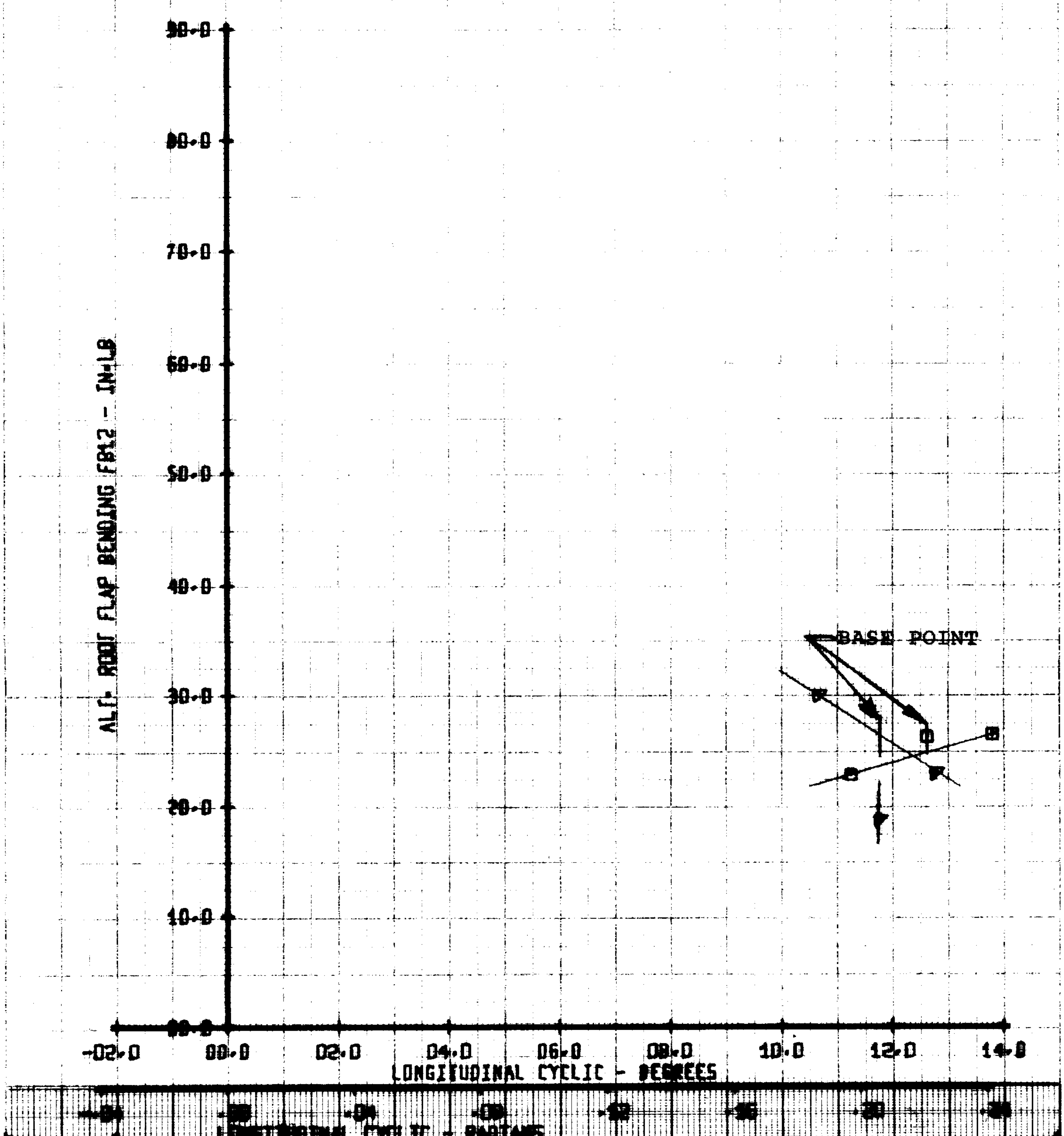
Figure C-219

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	CT'/SB	VTUN
□	41	.50	.10	.090	310
▽	41	.50	.10	.069	310

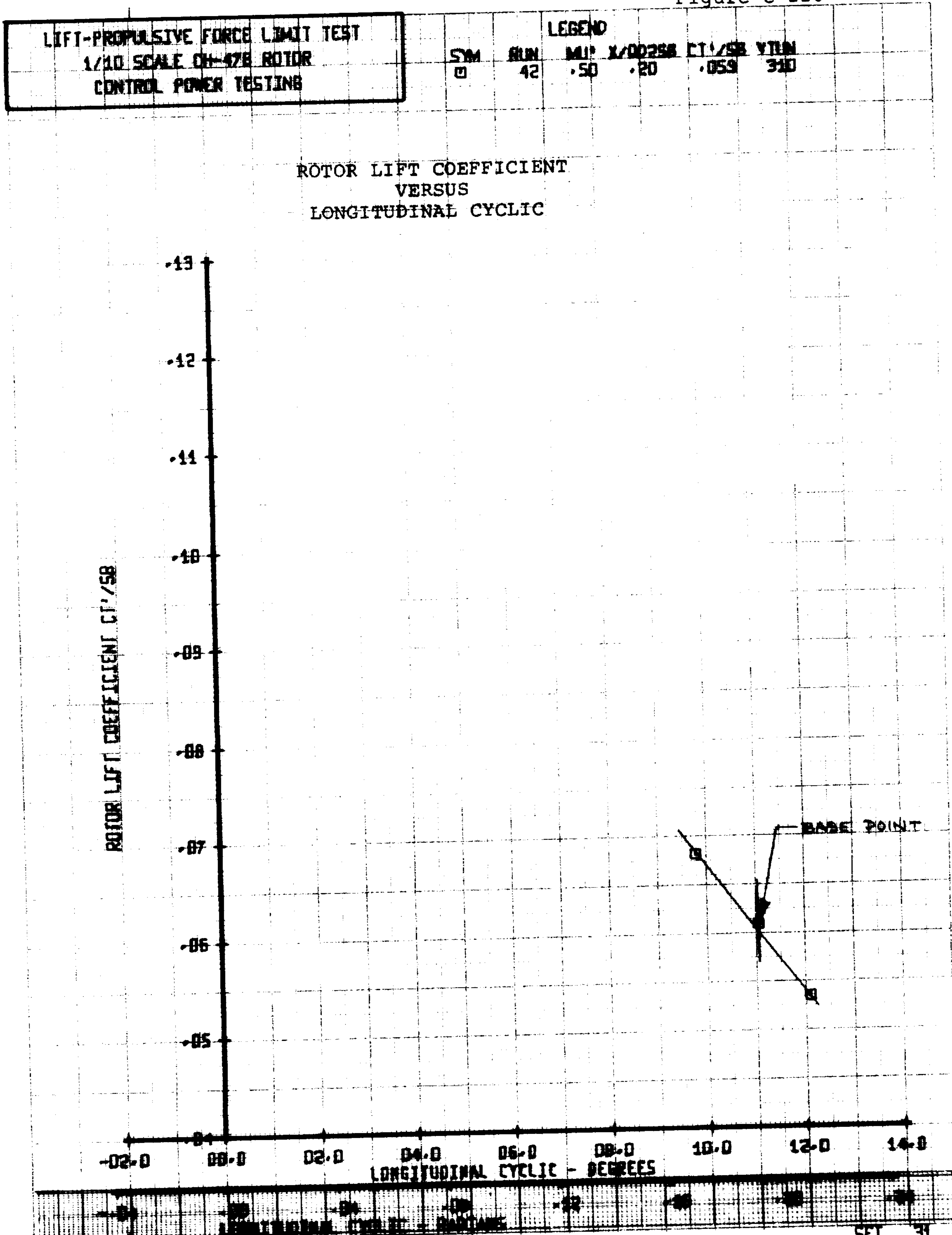
ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LONGITUDINAL CYCLIC



ET 30
WT 187

SET 30
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING



ET 31
WT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

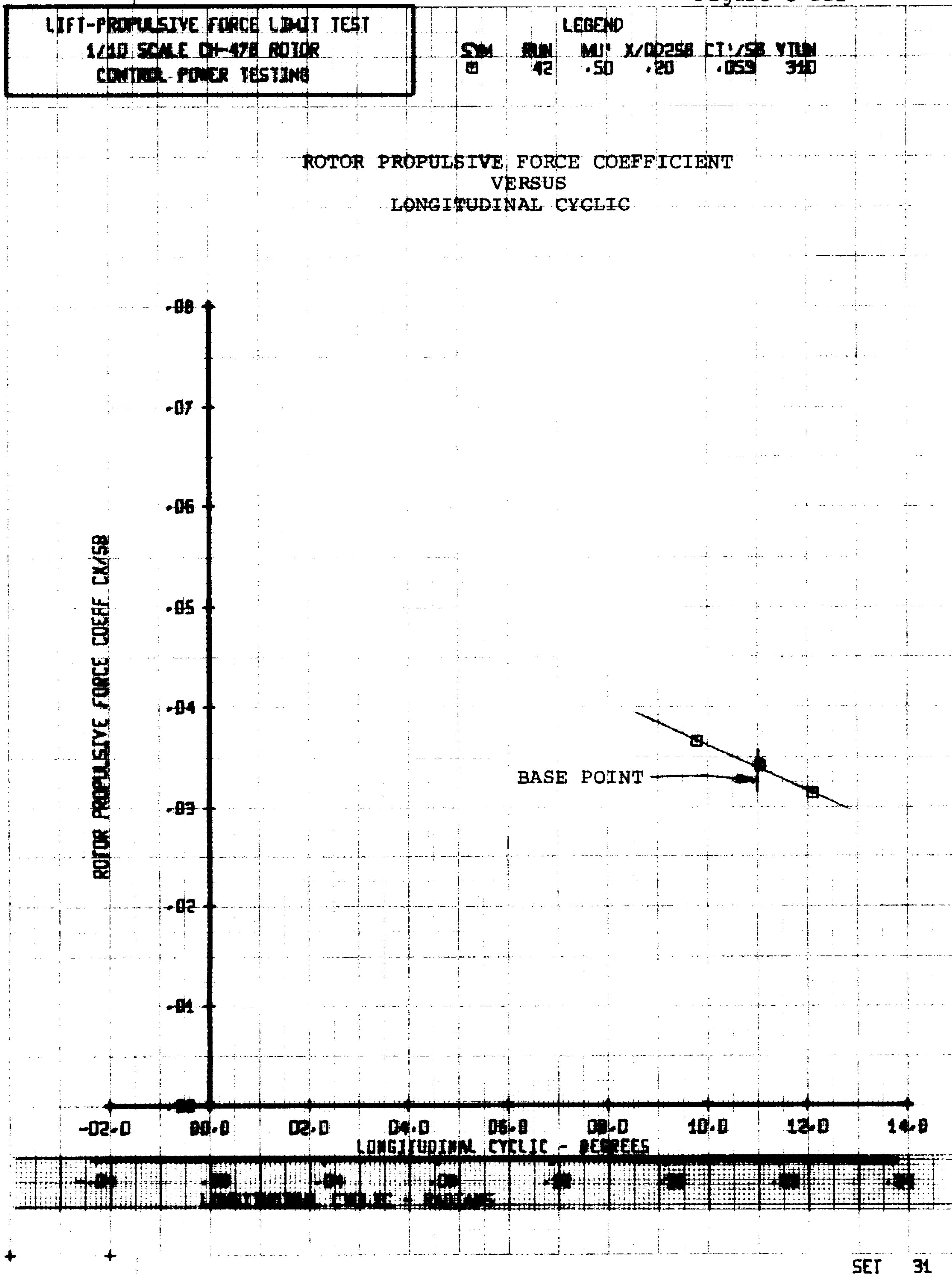
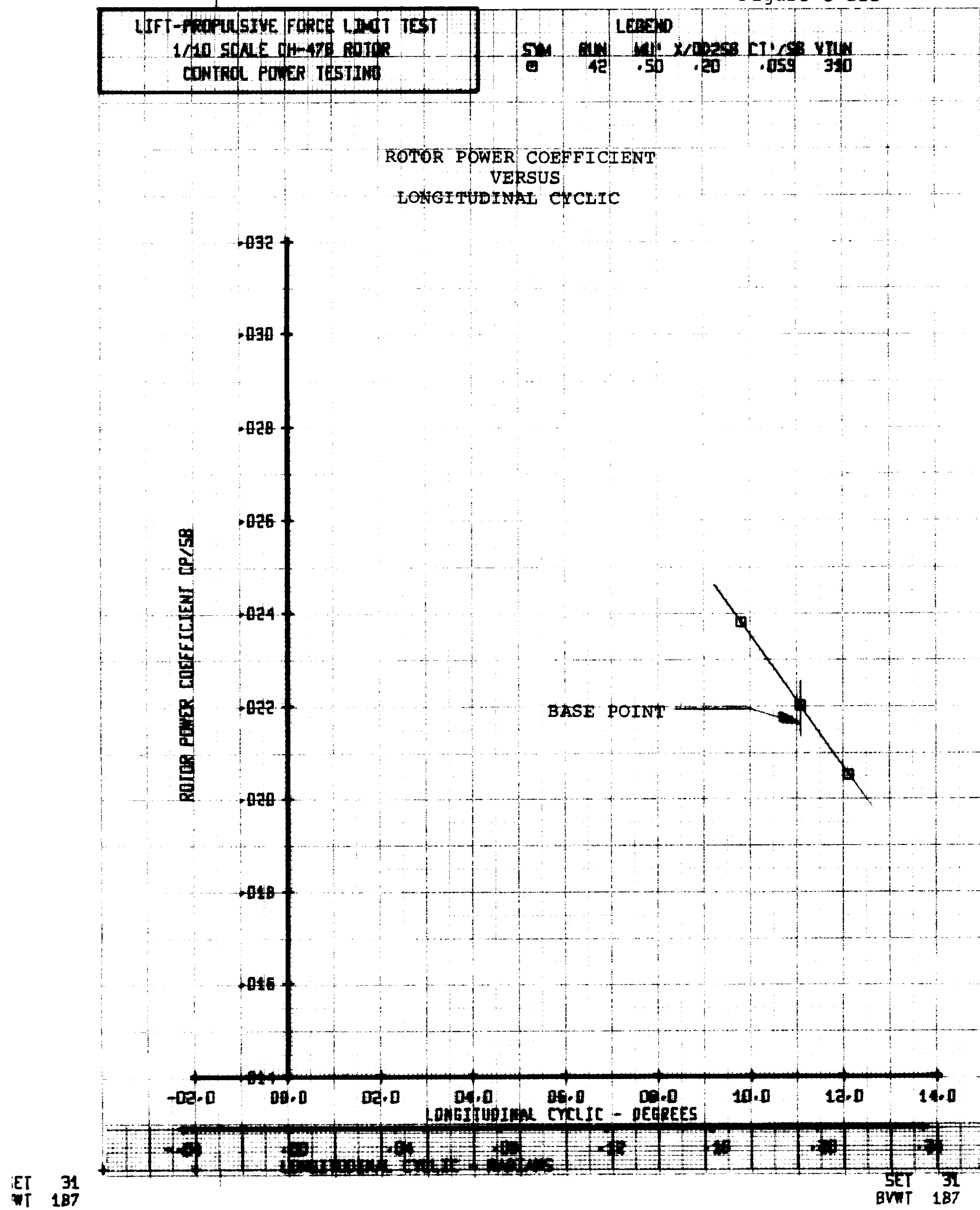
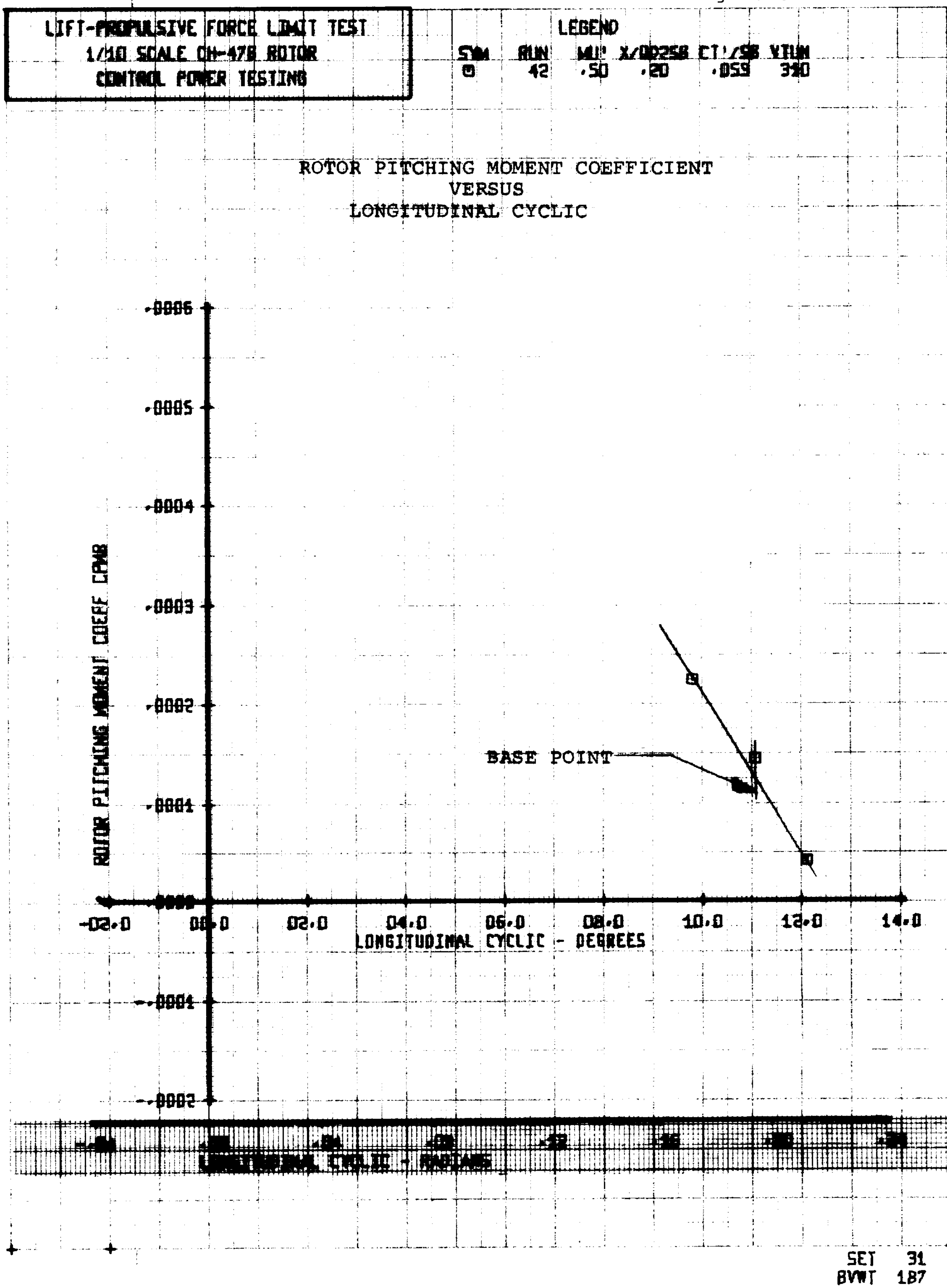
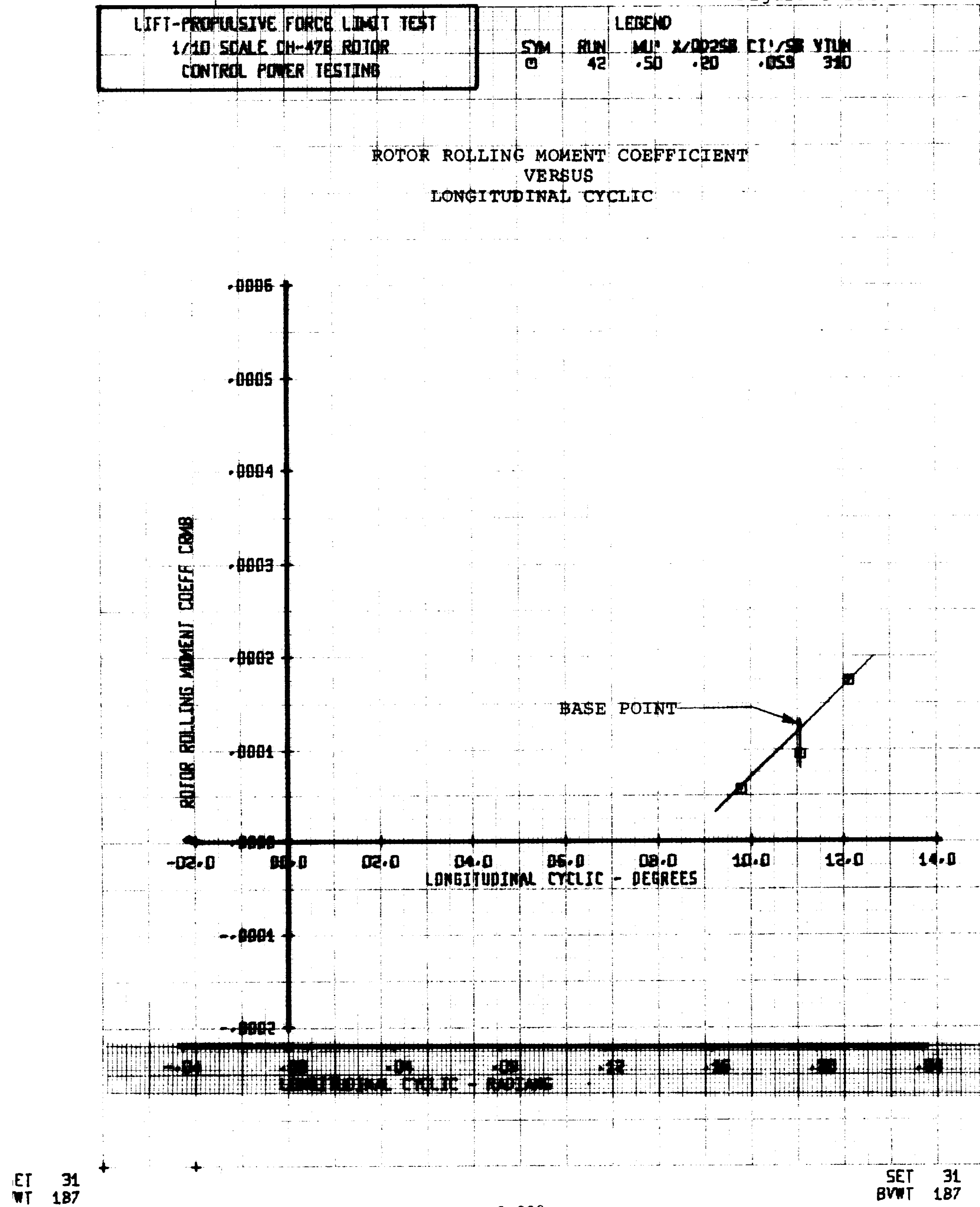


Figure C-222

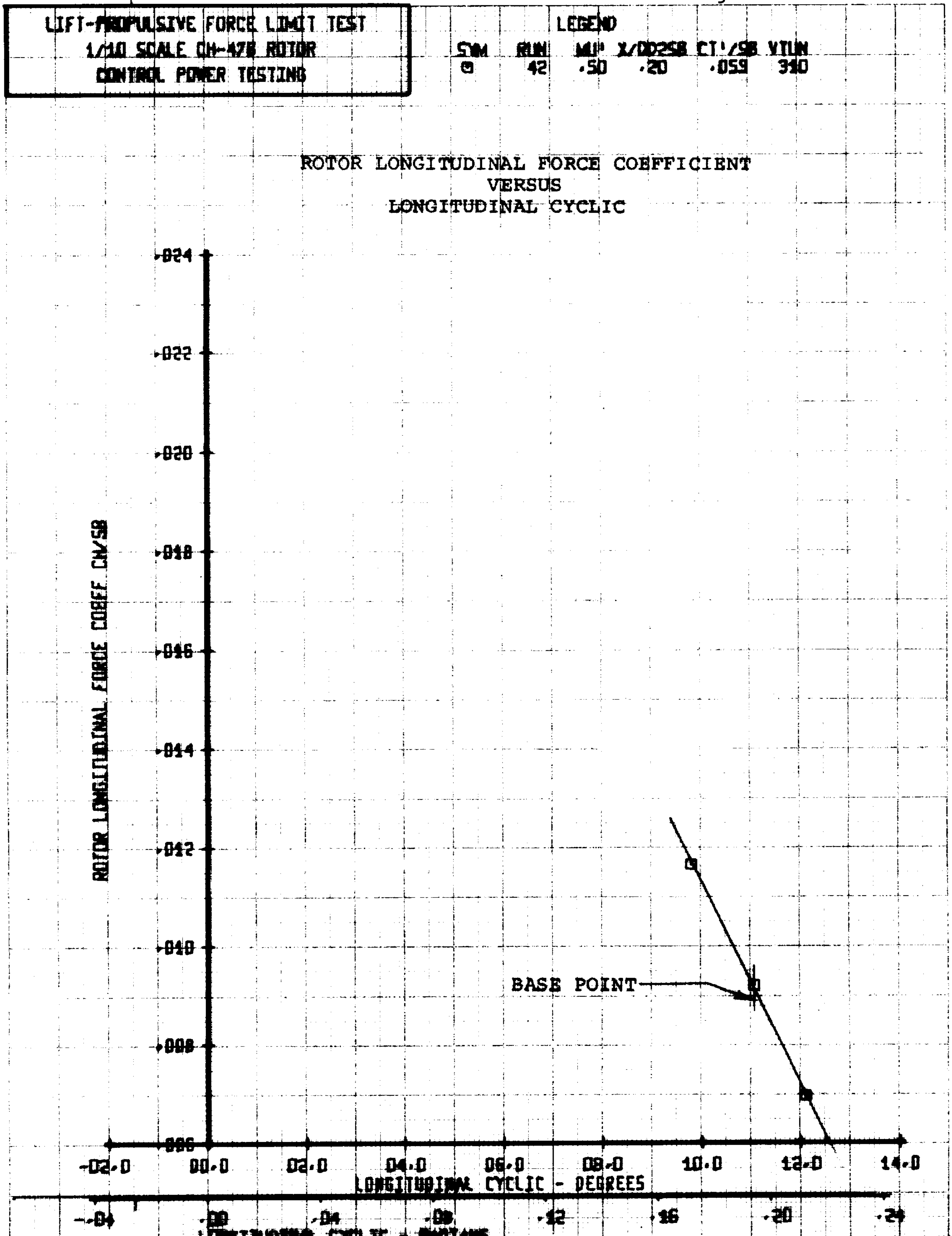


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/QD2SB CT'/SB VTUN
42 .50 .20 .059 310
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
.032
.030
.028
.026
.024
.022
.020
.018
.016
.014
ROTOR POWER COEFFICIENT CP/SB
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 31
BVWT 187


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN
42 .50 .20 .059 390
ROTOR PITCHING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
.0006
.0005
.0004
.0003
.0002
.0001
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
-.0001
-.0002
ROTOR PITCHING MOMENT COEFF CPMB
LONGITUDINAL CYCLIC - RADIANS
SET 31
BVWT 187

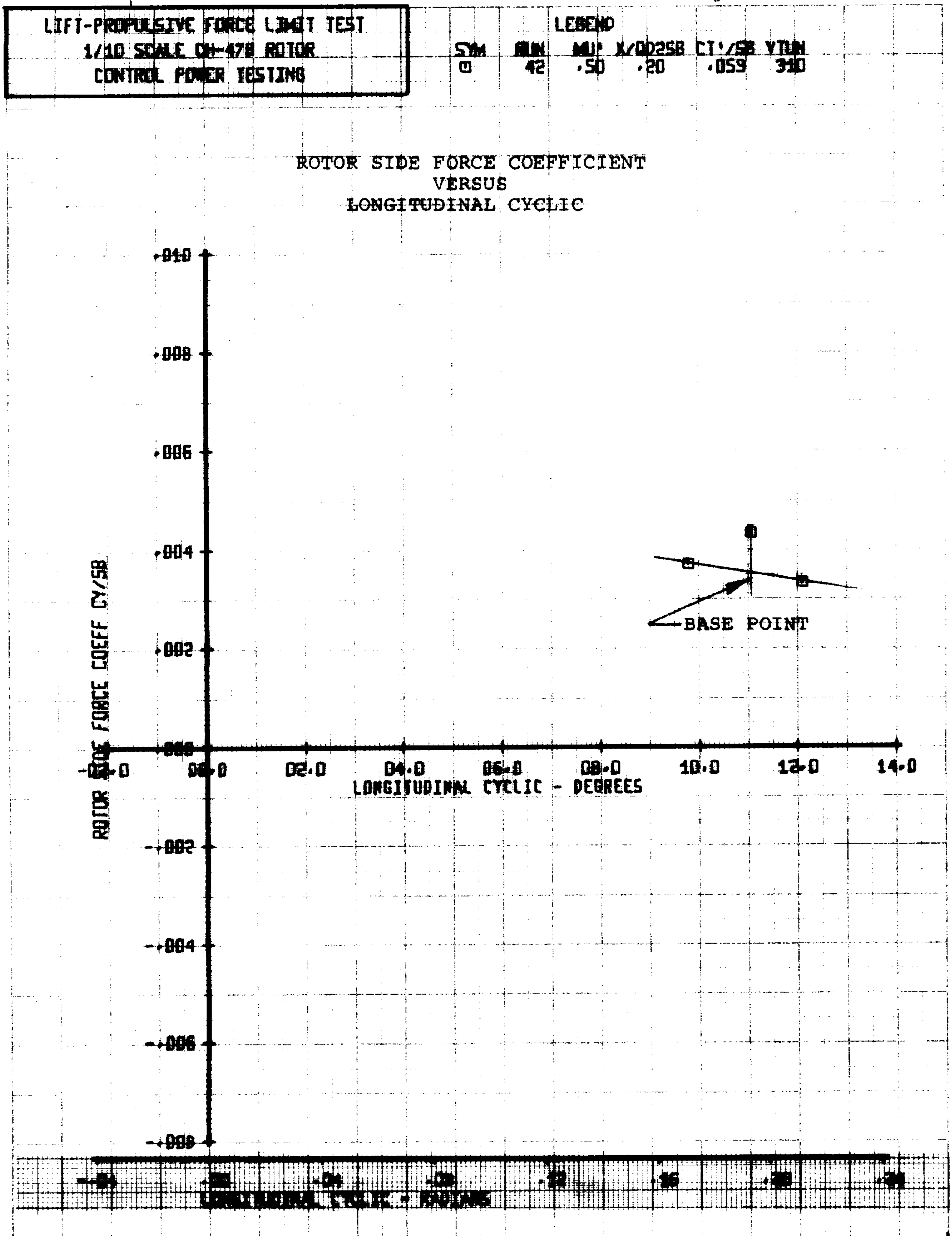

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
42 .50 .20 .059 310
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR ROLLING MOMENT COEFF CRMB
.0006
.0005
.0004
.0003
.0002
.0001
-.0001
-.0002
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 31
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING



SET 31
BVWT 187

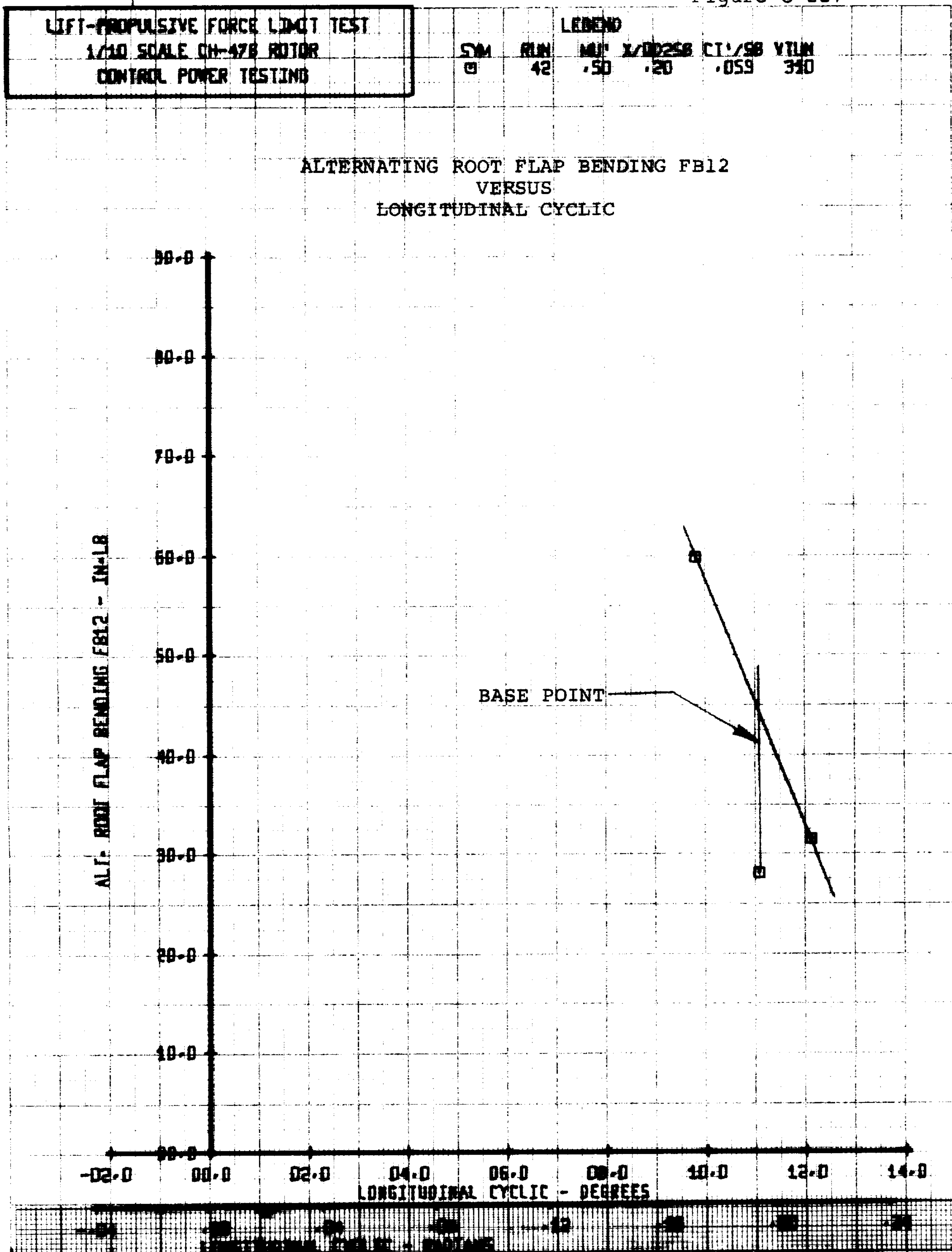
Figure C-226



ET 31
WT 187

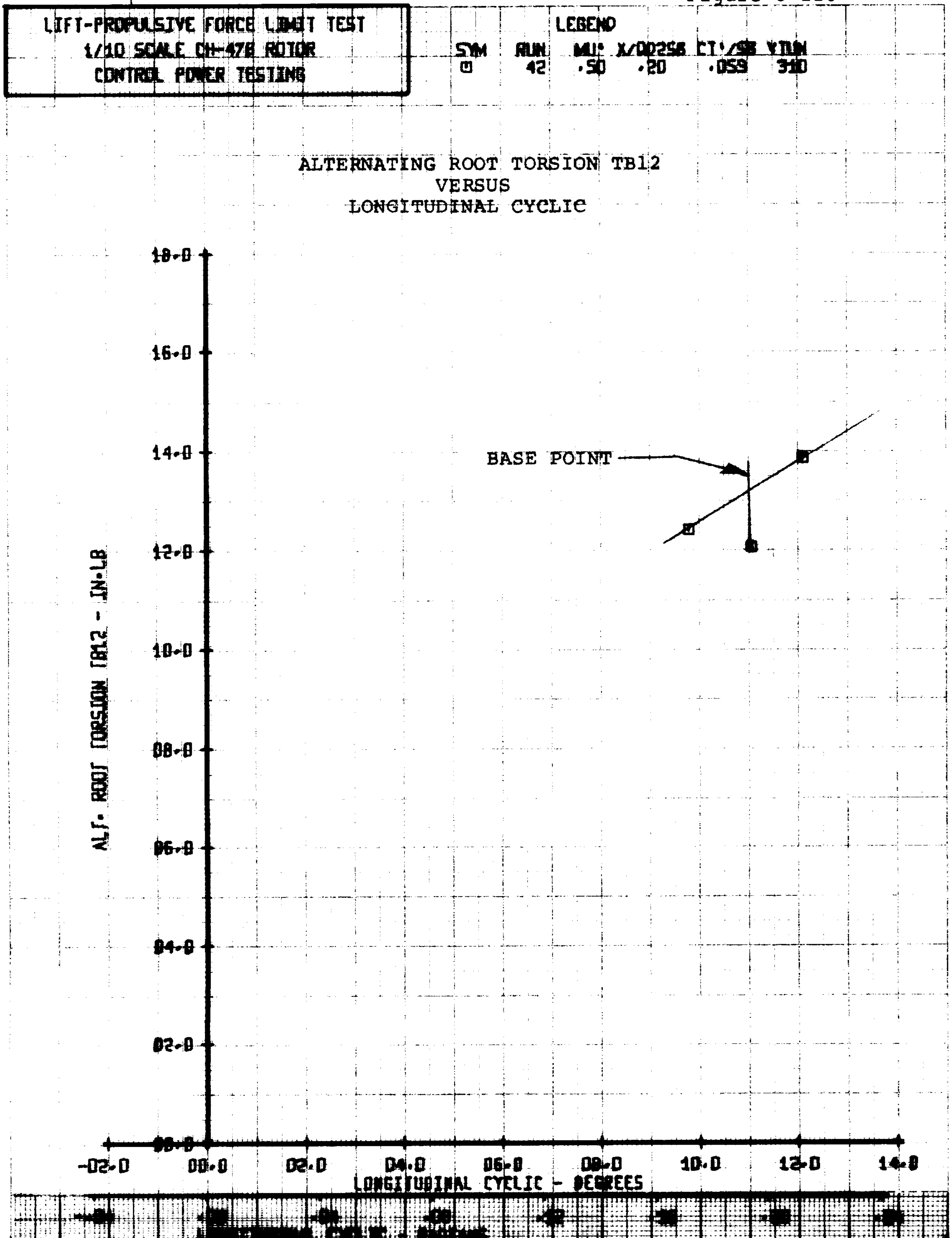
SET 31
BVWT 187

Figure C-227



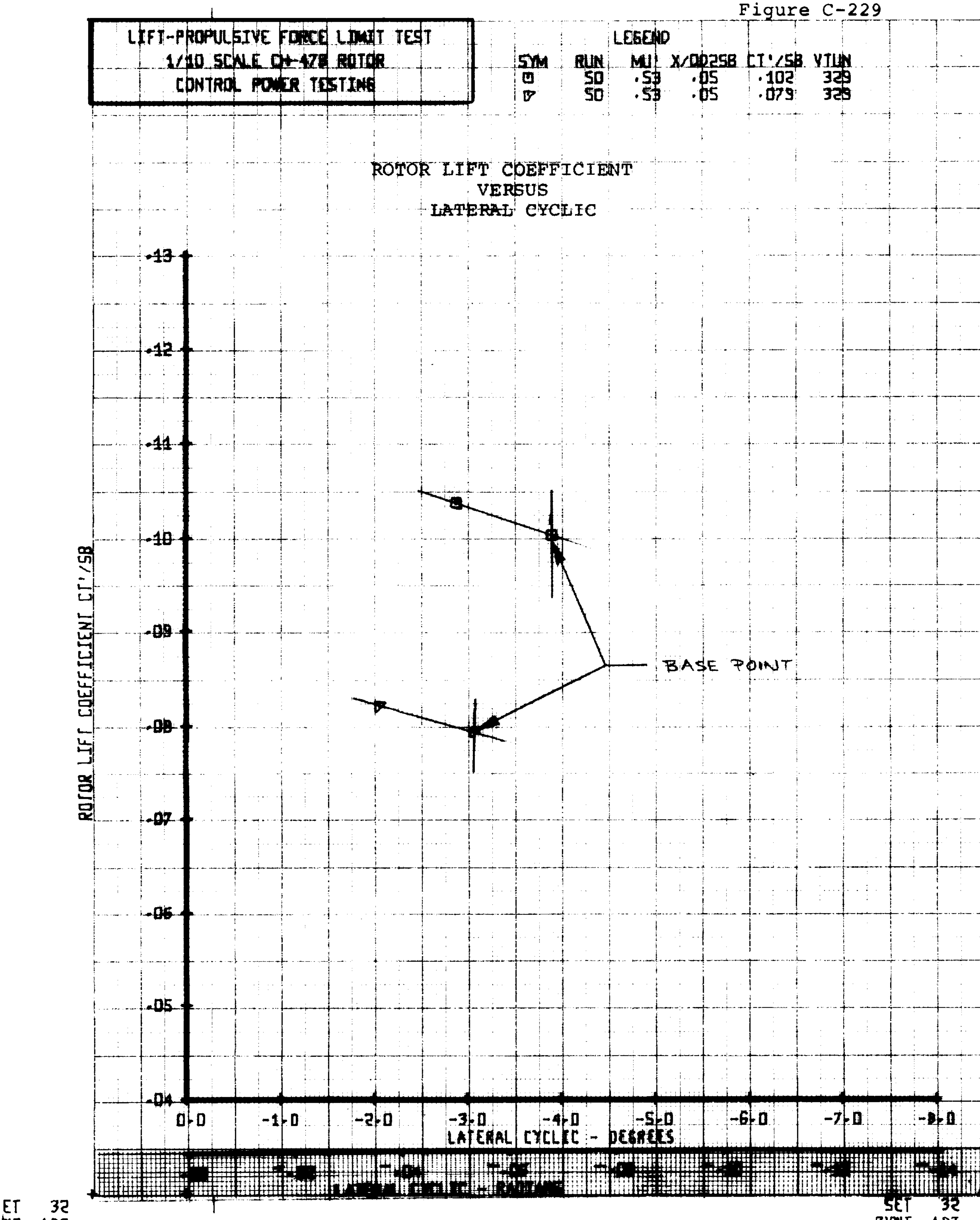
SET 31
BVWT 187

Figure C-228



ET 31
WT 187

SET 31
BVWT 187



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/D02SB CT'/SB VTUN
50 .53 .05 .102 329
50 .53 .05 .079 329
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
BASE POINT
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
LATERAL CYCLIC - RADIANS
ET 32
WT 187
SET 32
BVWT 187

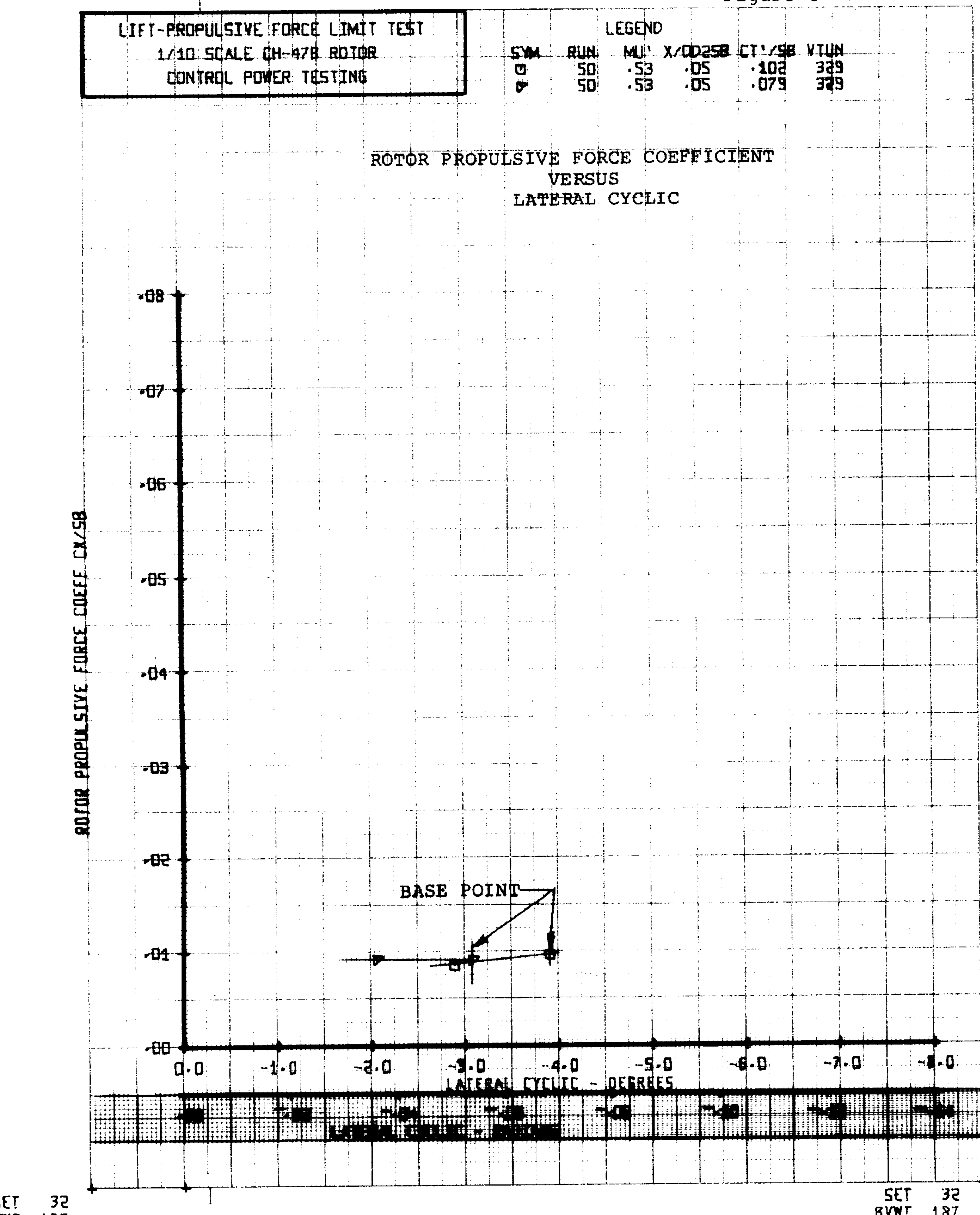
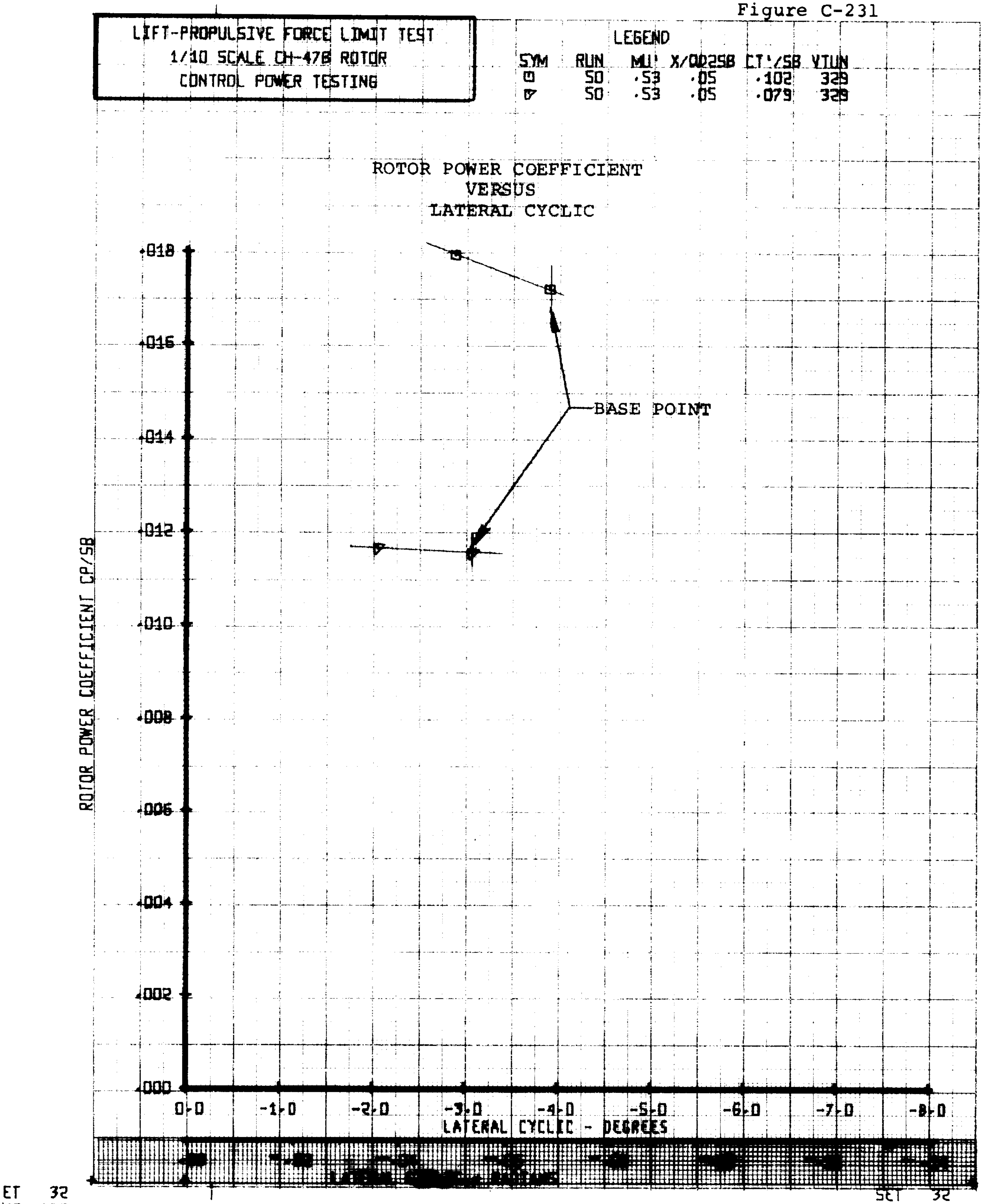

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD25B CT'/SB VTUN
50 .53 .05 .102 329
50 .53 .05 .079 329
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR PROPULSIVE FORCE COEFF CX/SB
.08
.07
.06
.05
.04
.03
.02
.01
.00
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 32
BVWT 137
SET 32
BVWT 137

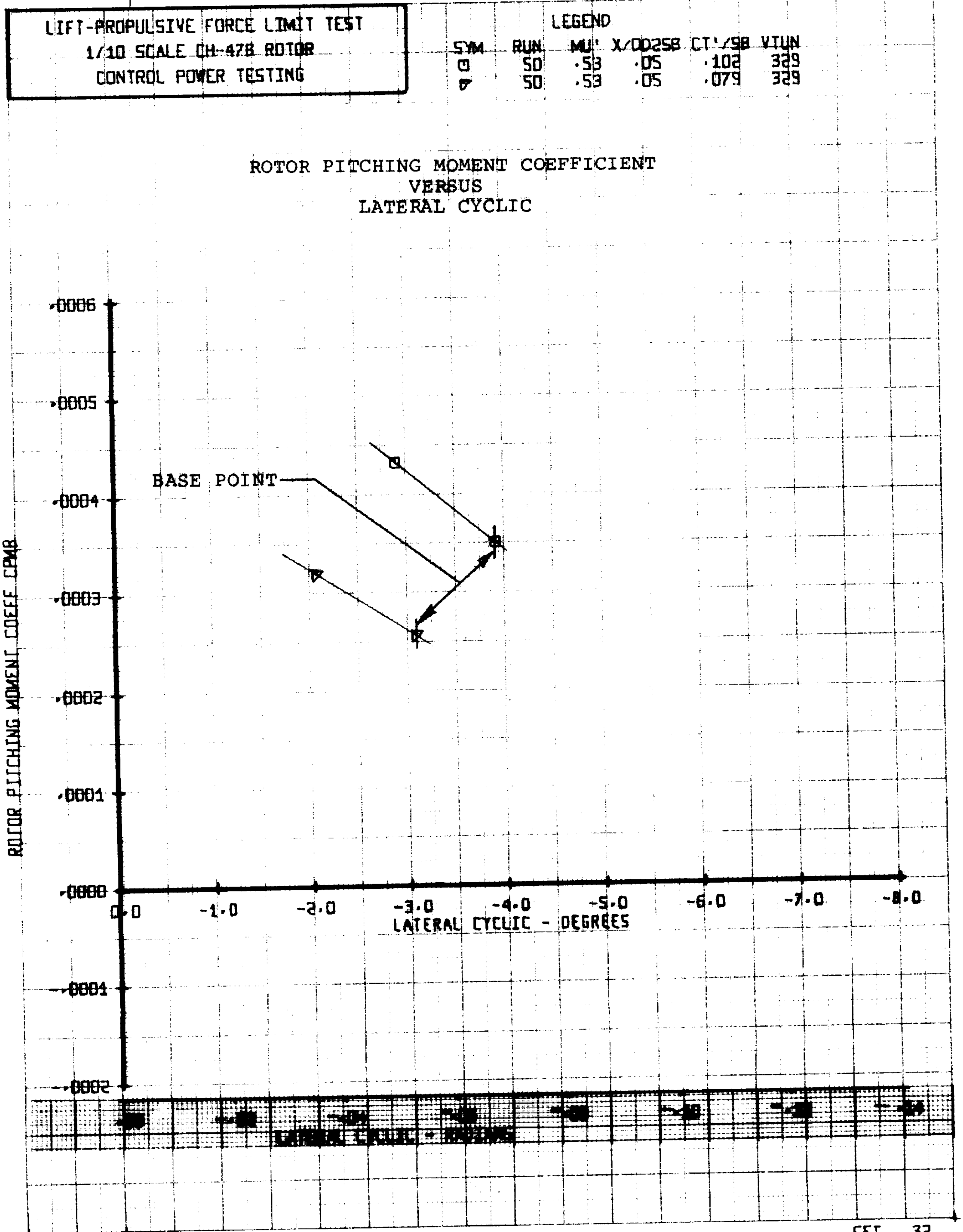
Figure C-231



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD25B CT'/SB VTUN
50 .53 .05 .102 329
50 .53 .05 .079 329
ROTOR POWER COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
.018
.016
.014
.012
.010
.008
.006
.004
.002
.000
ROTOR POWER COEFFICIENT CP/SB
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
ET 32
WT 187
SET 32
BVWT 187

Figure 232

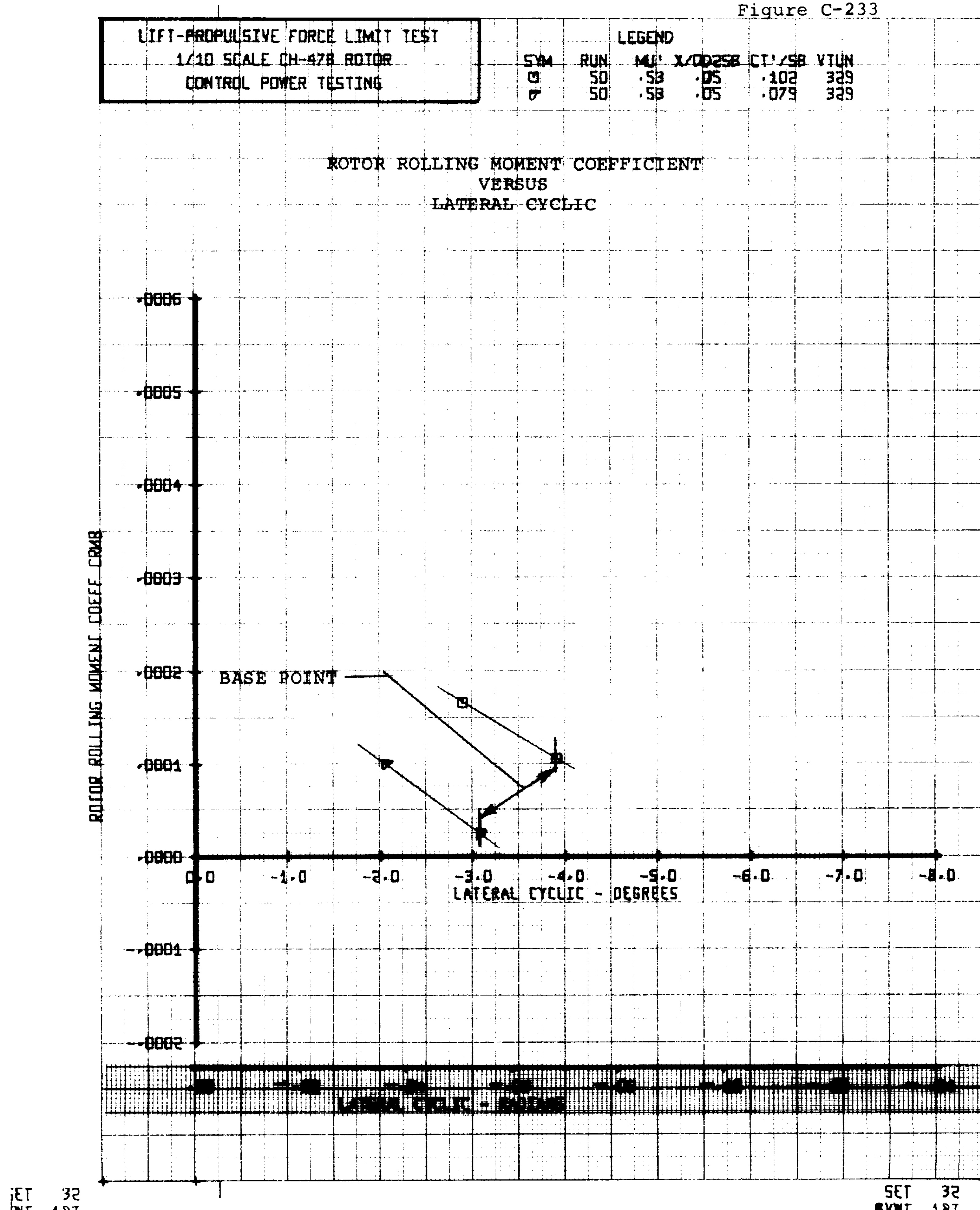
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING



SET 32
BVWT 187

SET 32
BVWT 187

Figure C-233



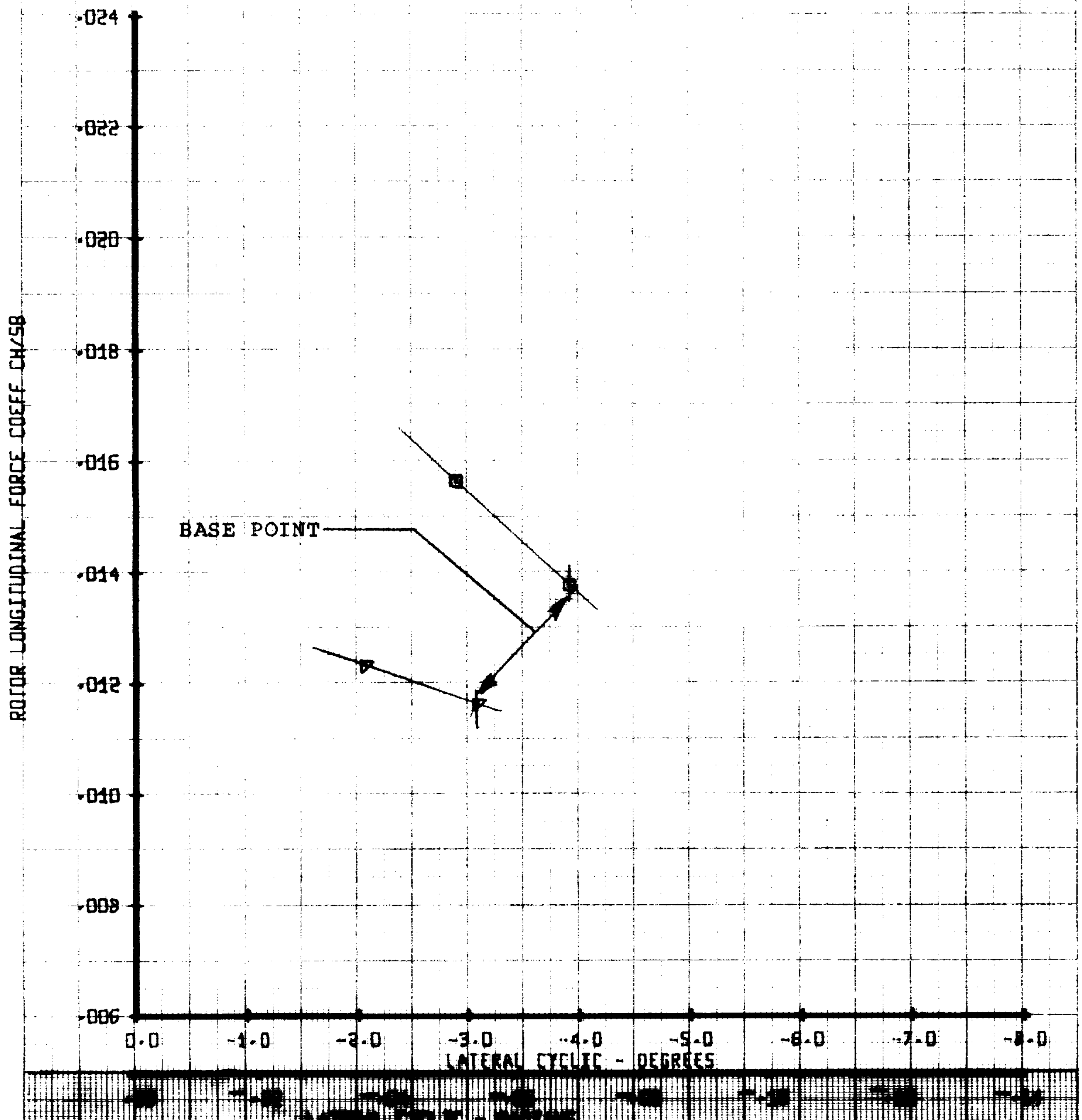
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
50 .58 .05 .102 329
50 .58 .05 .079 329
ROTOR ROLLING MOMENT COEFFICIENT
VERSUS
LATERAL CYCLIC
BASE POINT
ROTOR ROLLING MOMENT COEFF CRMB
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0001
-.0002
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 32
BVWT 187

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/QD25B	CT'/SB	VTUN
⊡	50	.53	.05	.102	329
▽	50	.53	.05	.079	329

ROTOR LONGITUDINAL FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC



SET 32
BVWT 187

SET 32
BVWT 187

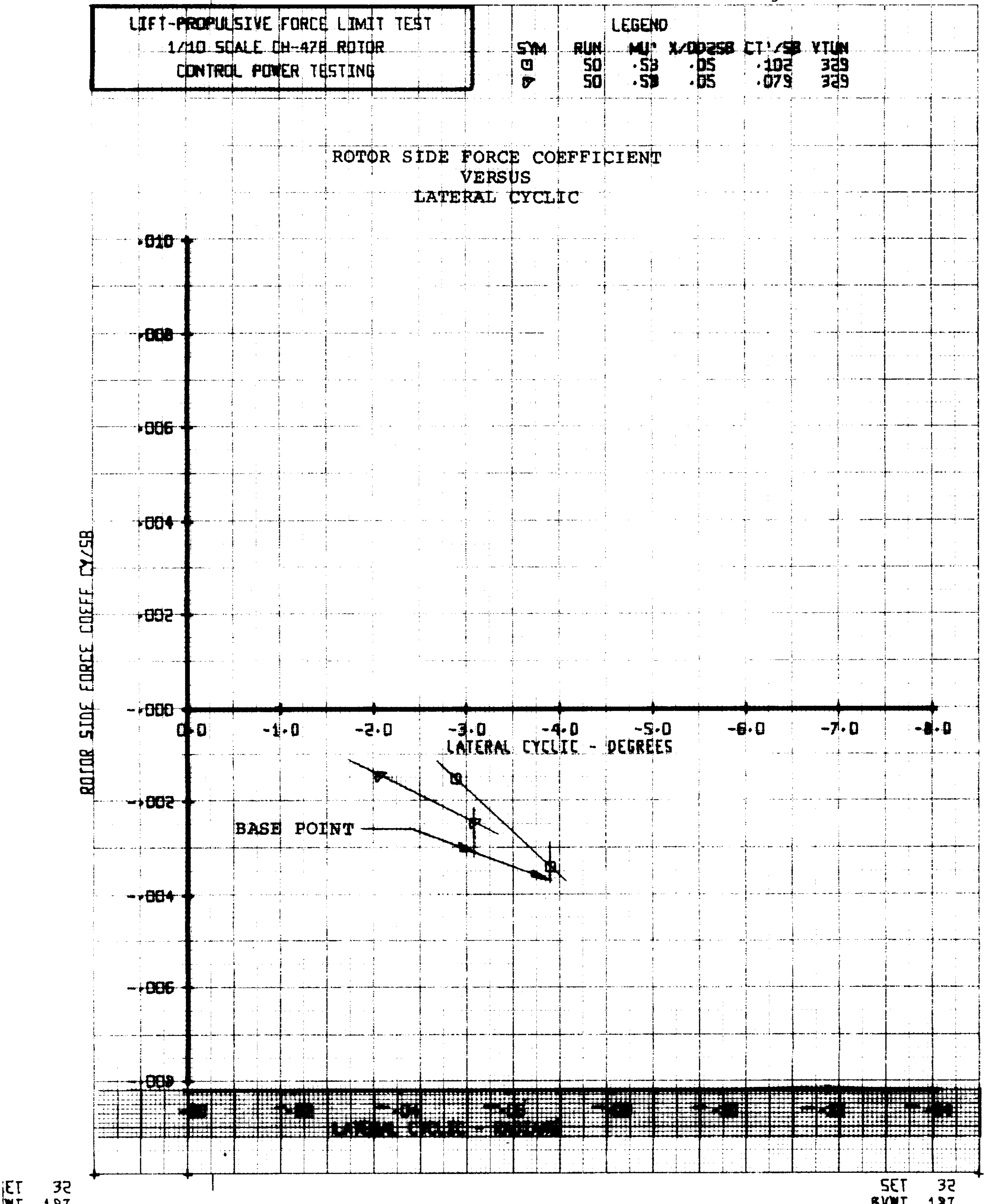

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD2SB CT'/SB VTUN
50 .58 .05 .102 329
50 .58 .05 .079 329
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR SIDE FORCE COEFF CY/SB
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
BASE POINT
SET 32
BVWT 137

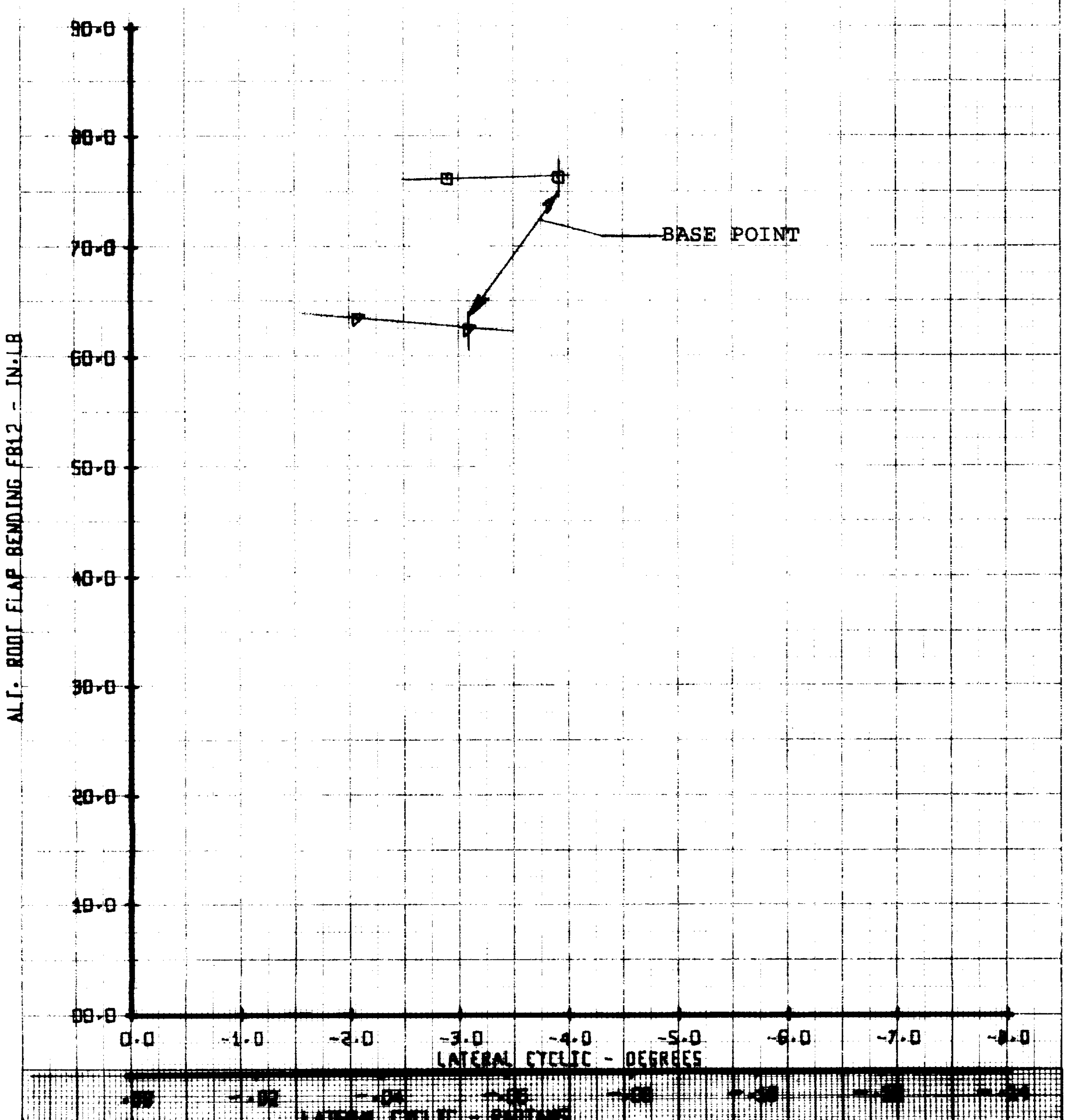
Figure C-236

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

SYM	RUN	MU'	X/DD258	CT'/S8	VTUN
⊡	50	.53	.05	.102	329
▽	50	.53	.05	.079	329

ALTERNATING ROOT FLAP BENDING FB12
VERSUS
LATERAL CYCLIC



SET 32
BVWT 187

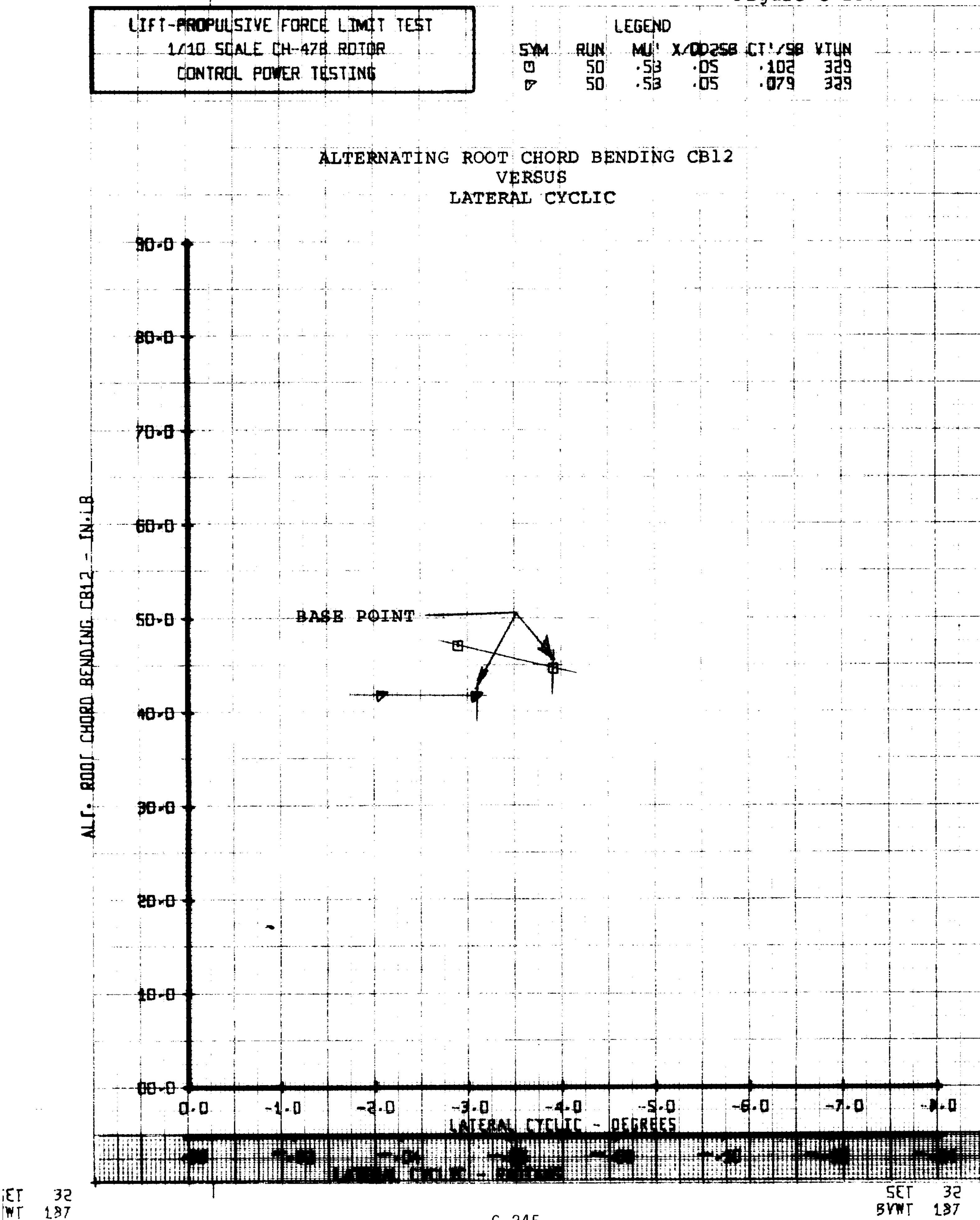

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD258 CT'/S8 VTUN
50 .53 .05 .102 329
50 .53 .05 .079 329
ALTERNATING ROOT CHORD BENDING CB12
VERSUS
LATERAL CYCLIC
BASE POINT
ALT. ROOT CHORD BENDING CB12 - IN.LB
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
00.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
LATERAL CYCLIC - DEGREES
SET 32
BVWT 137

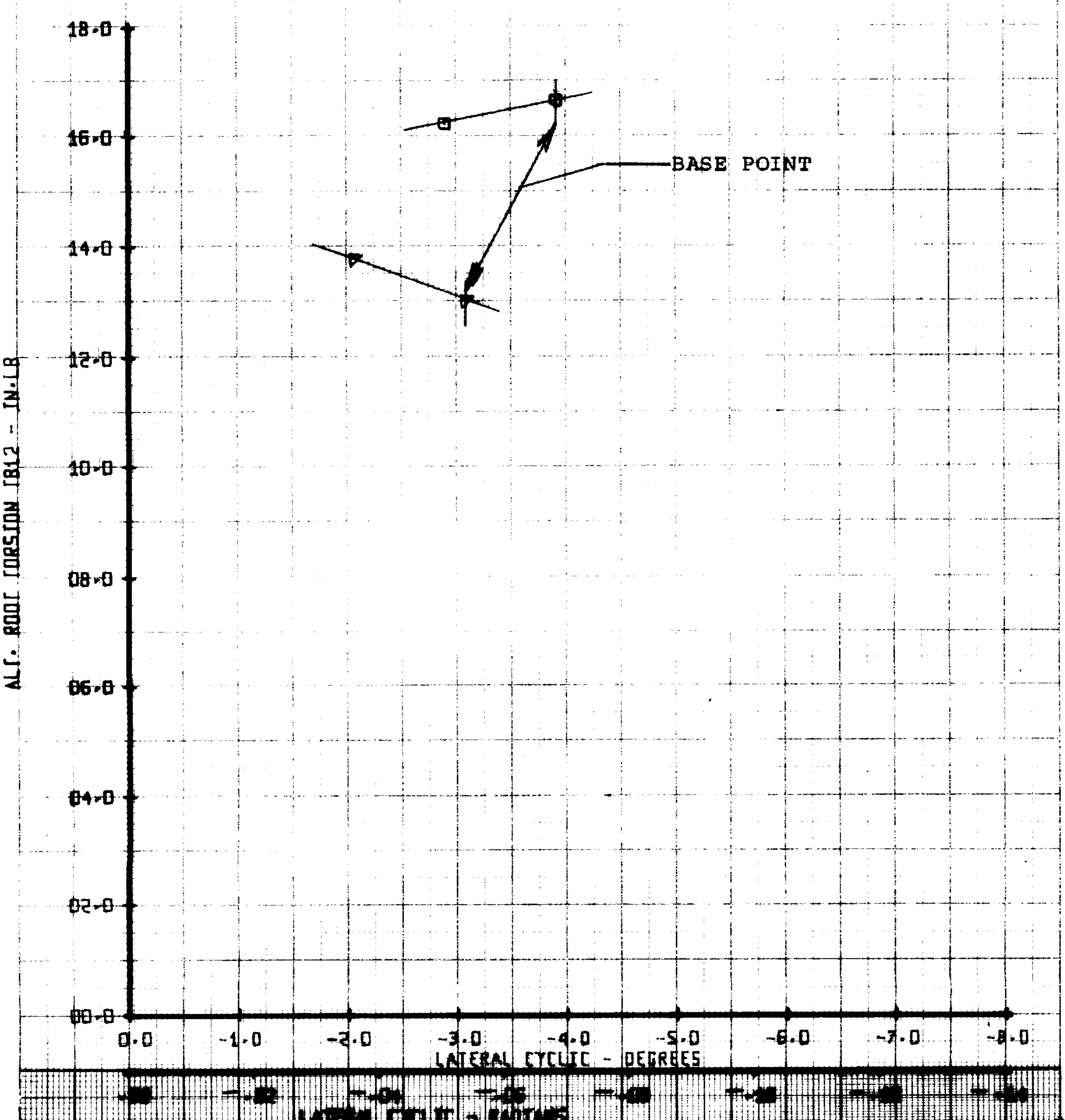
Figure C-238

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING

LEGEND

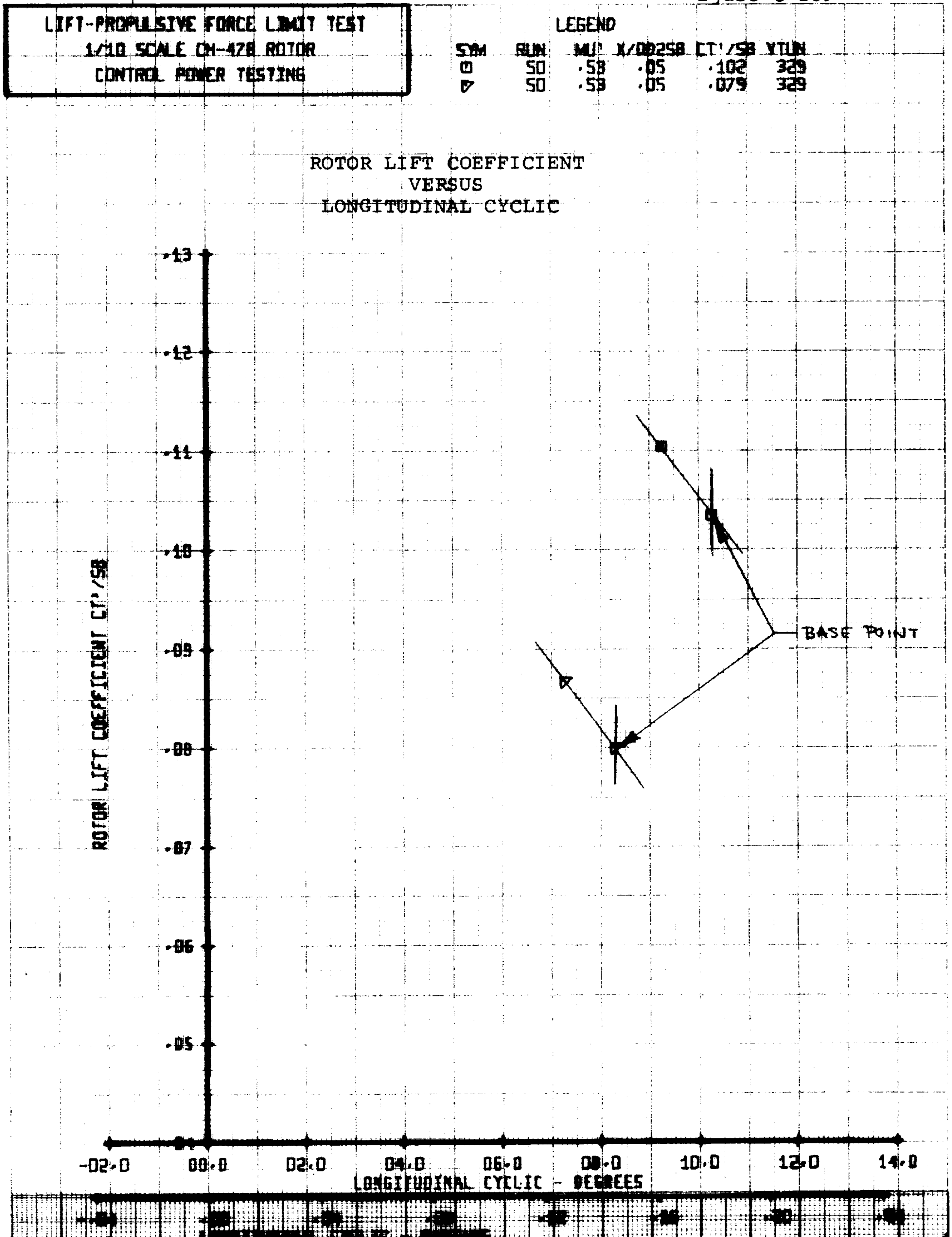
SYM	RUN	MU'	X/QD25B	CT'/SB	VTUN
⊡	50	.53	.05	.102	329
▽	50	.53	.05	.079	329

ALTERNATING ROOT TORSION TB12
VERSUS
LATERAL CYCLIC



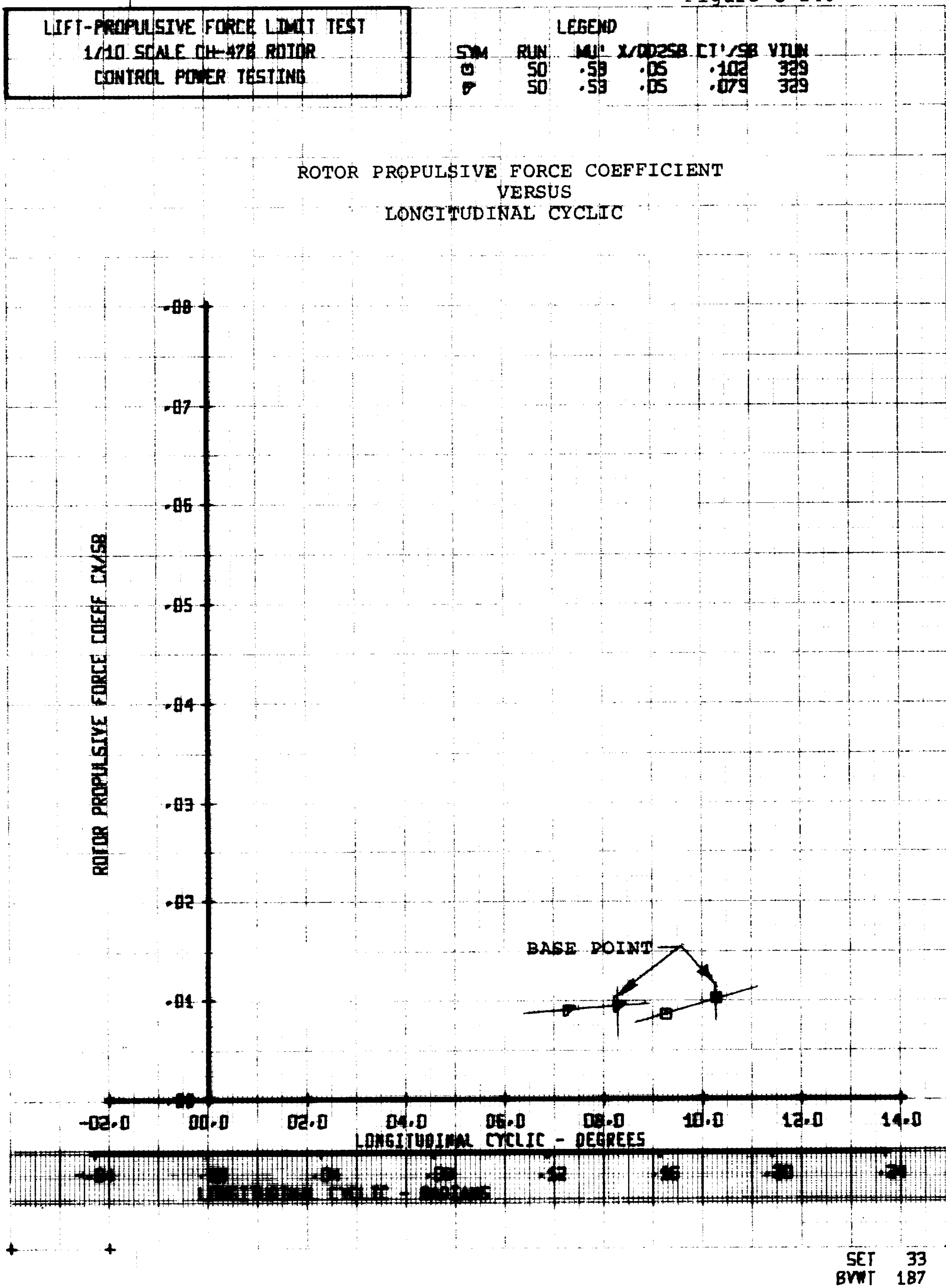
SET 32
BVWT 187

Figure C-239



ET 33
WT 187

SET 33
BVWT 187



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
50 .59 .05 .102 329
50 .59 .05 .079 329
ROTOR PROPULSIVE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR PROPULSIVE FORCE COEFF CX/SB
.08
.07
.06
.05
.04
.03
.02
.01
BASE POINT
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 33
BVWT 187

Figure C-241

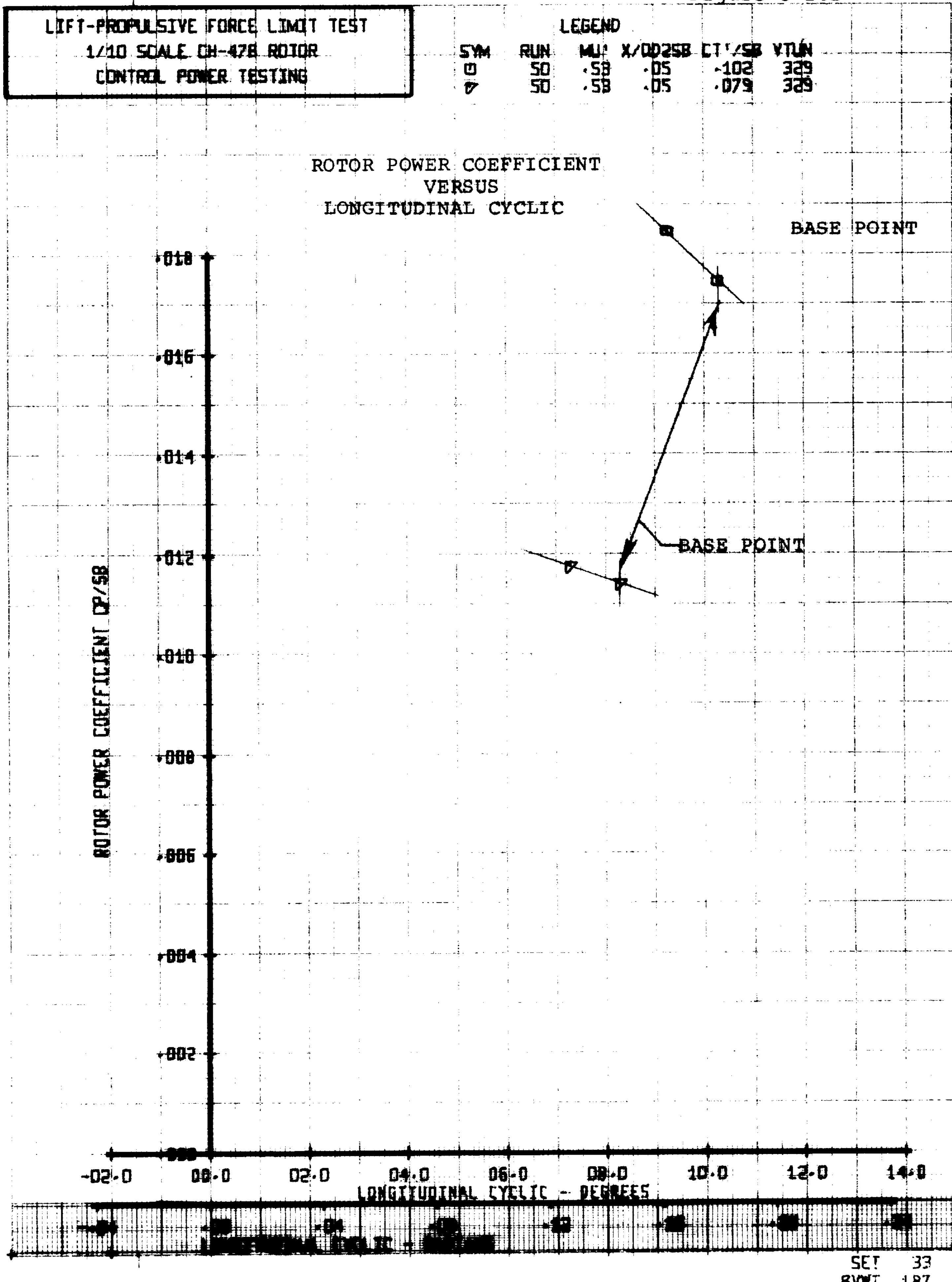
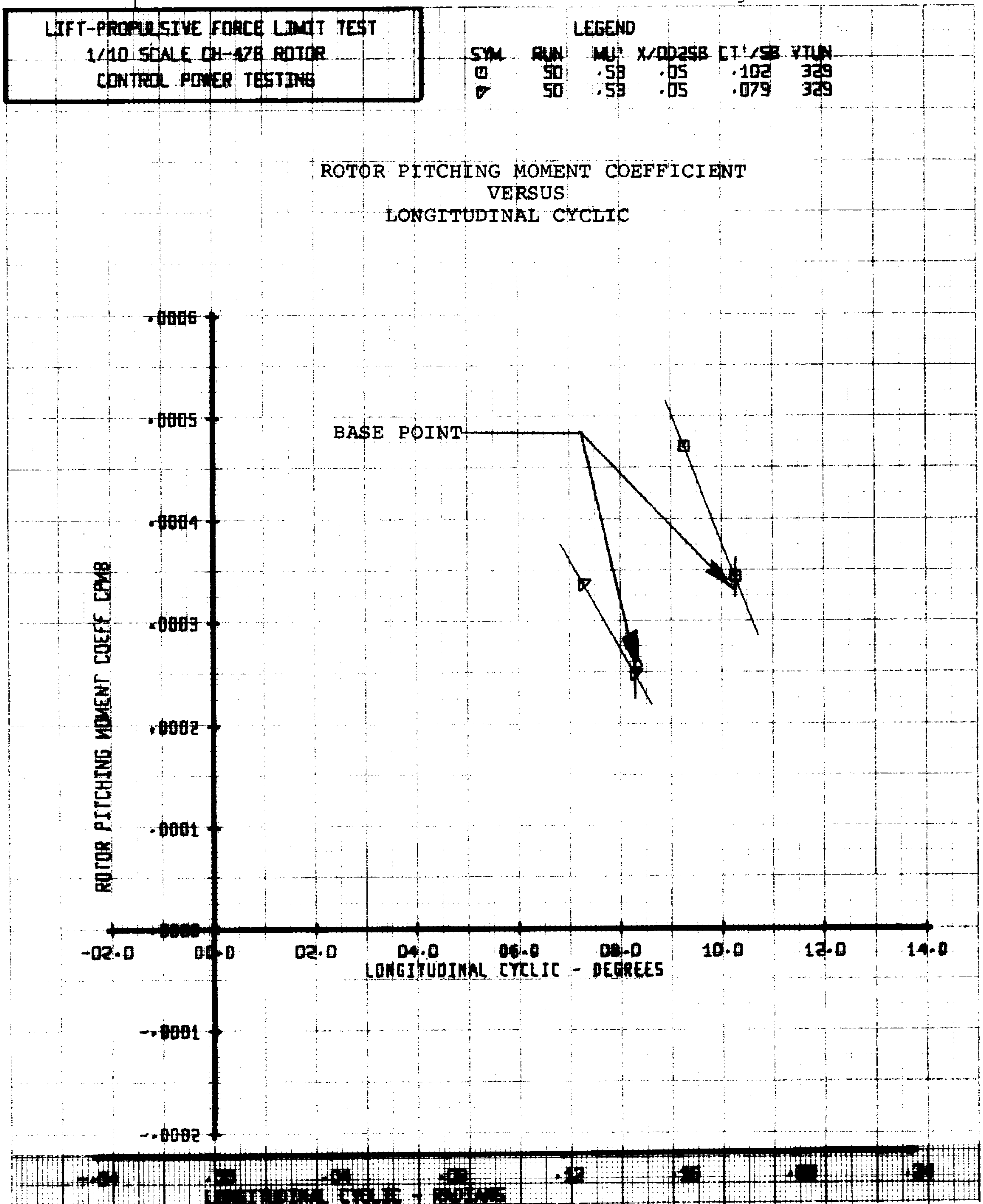
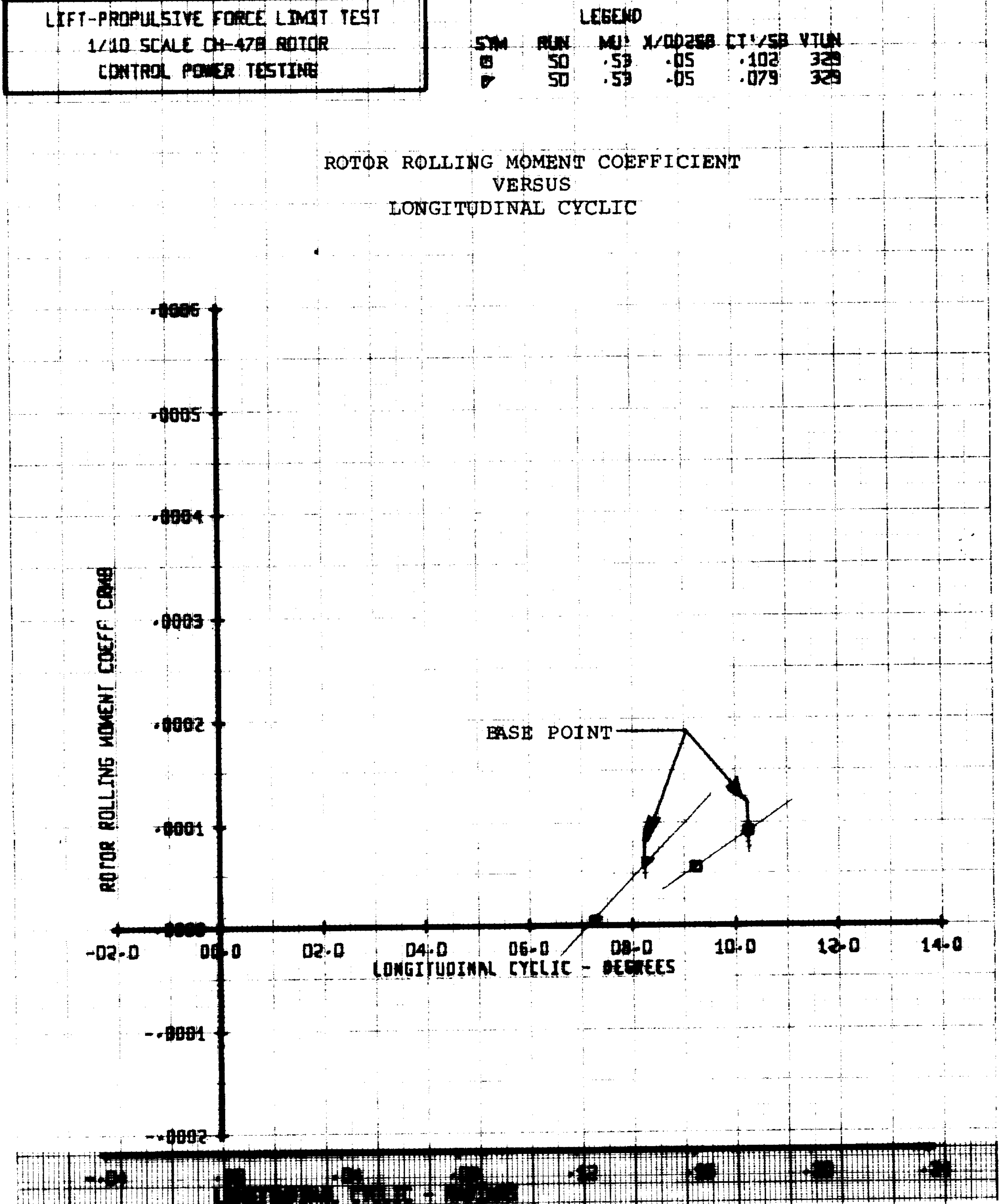

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU X/DD2SB CT'/SB VTUN
50 .58 .05 .102 329
50 .58 .05 .079 329
ROTOR POWER COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
BASE POINT
ROTOR POWER COEFFICIENT CP/SB
.018
.016
.014
.012
.010
.008
.006
.004
.002
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
SET 33
BVWT 187

Figure C-242



SET 33
BVWT 187

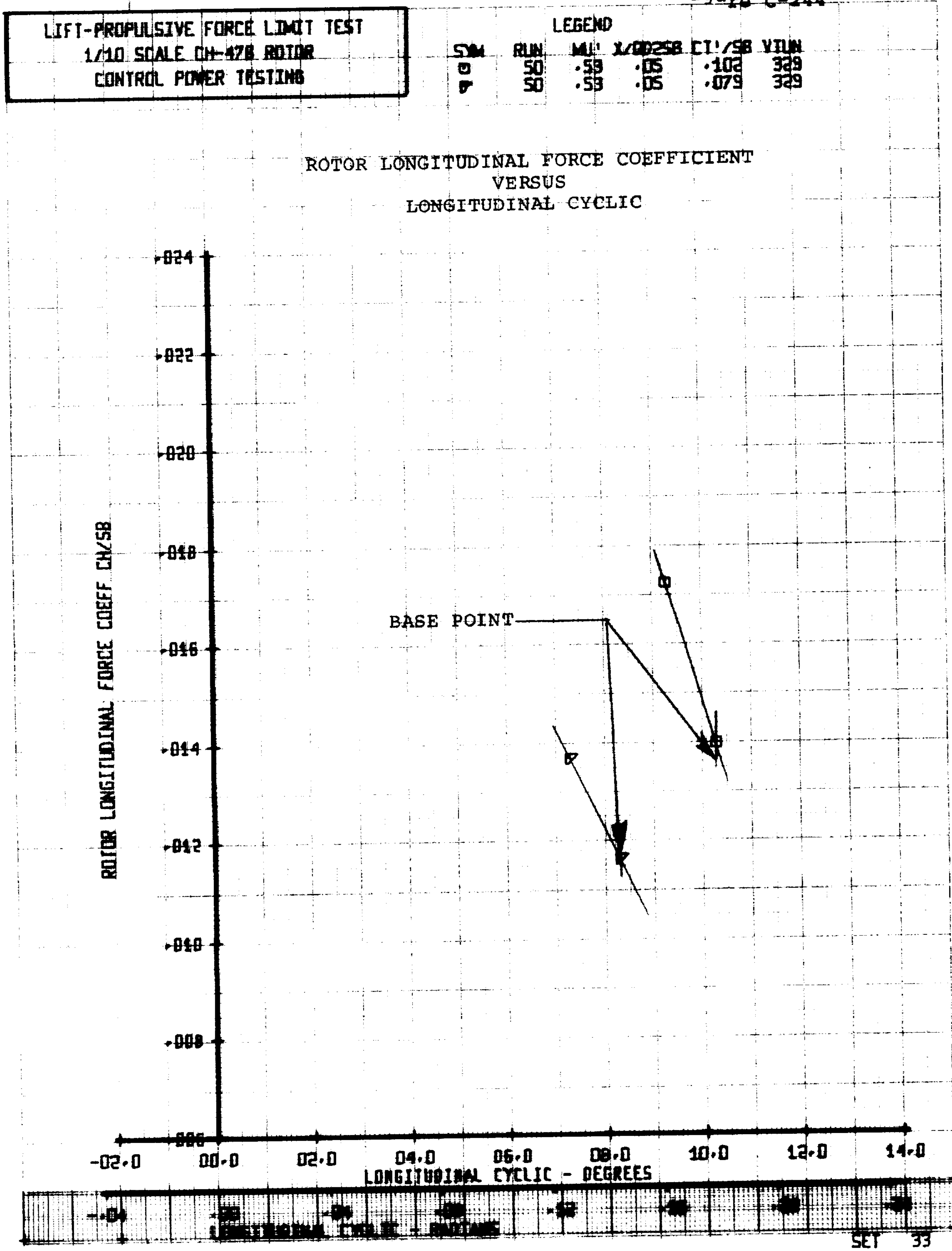
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING



ET 33
WT 187

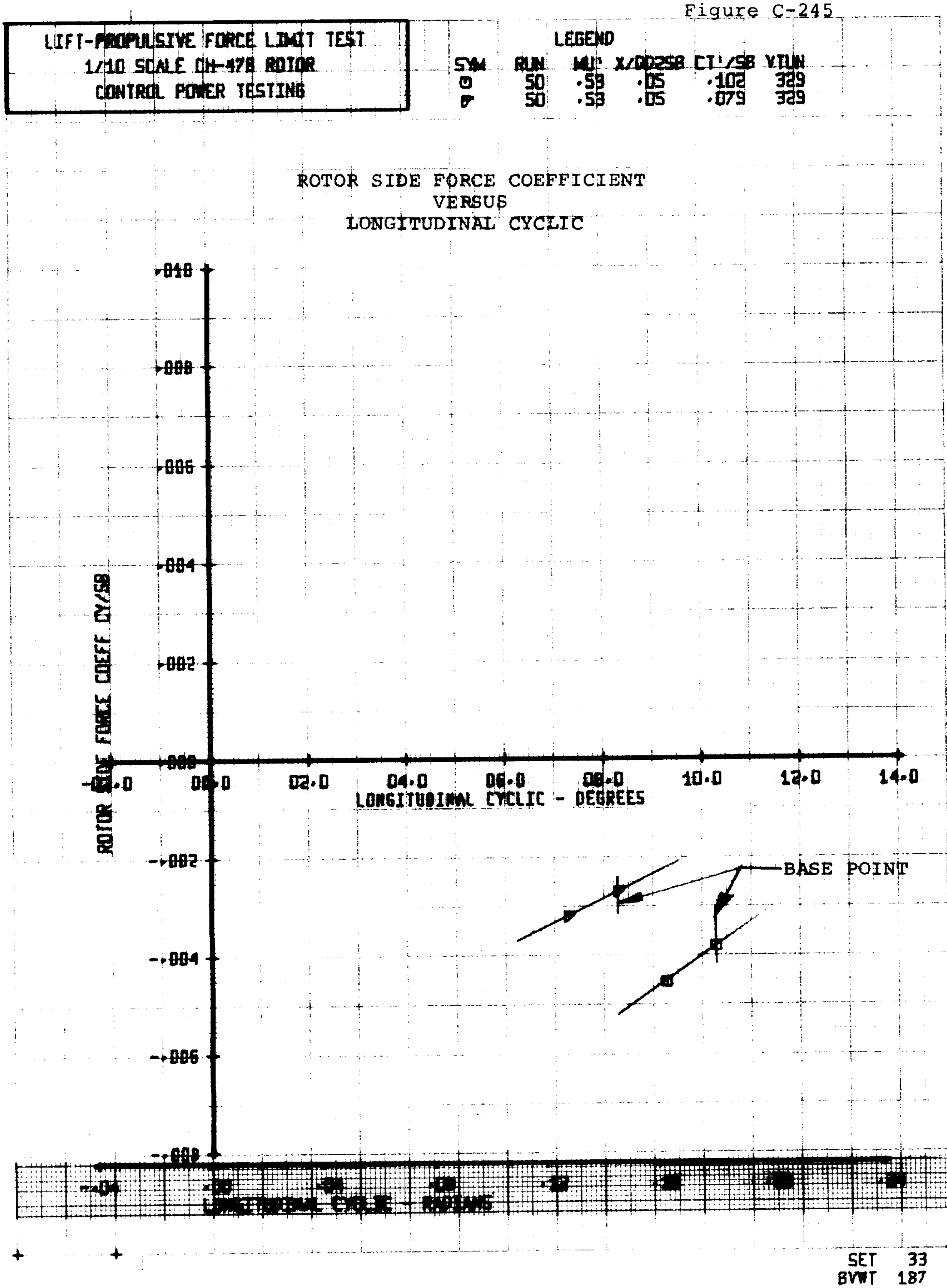
SET 33
BVWT 187

Figure C-244



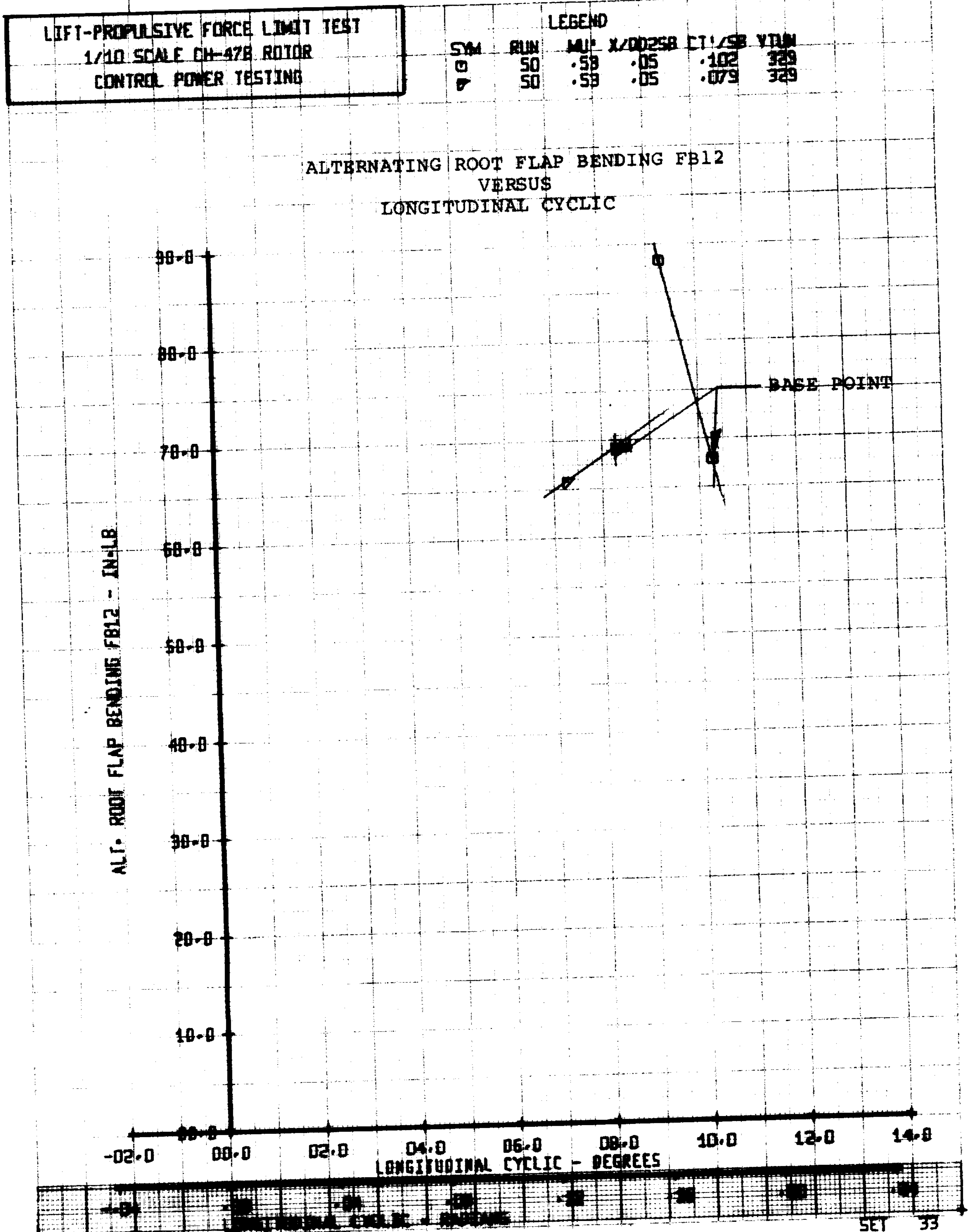
SET 33
BVWT 187

Figure C-245

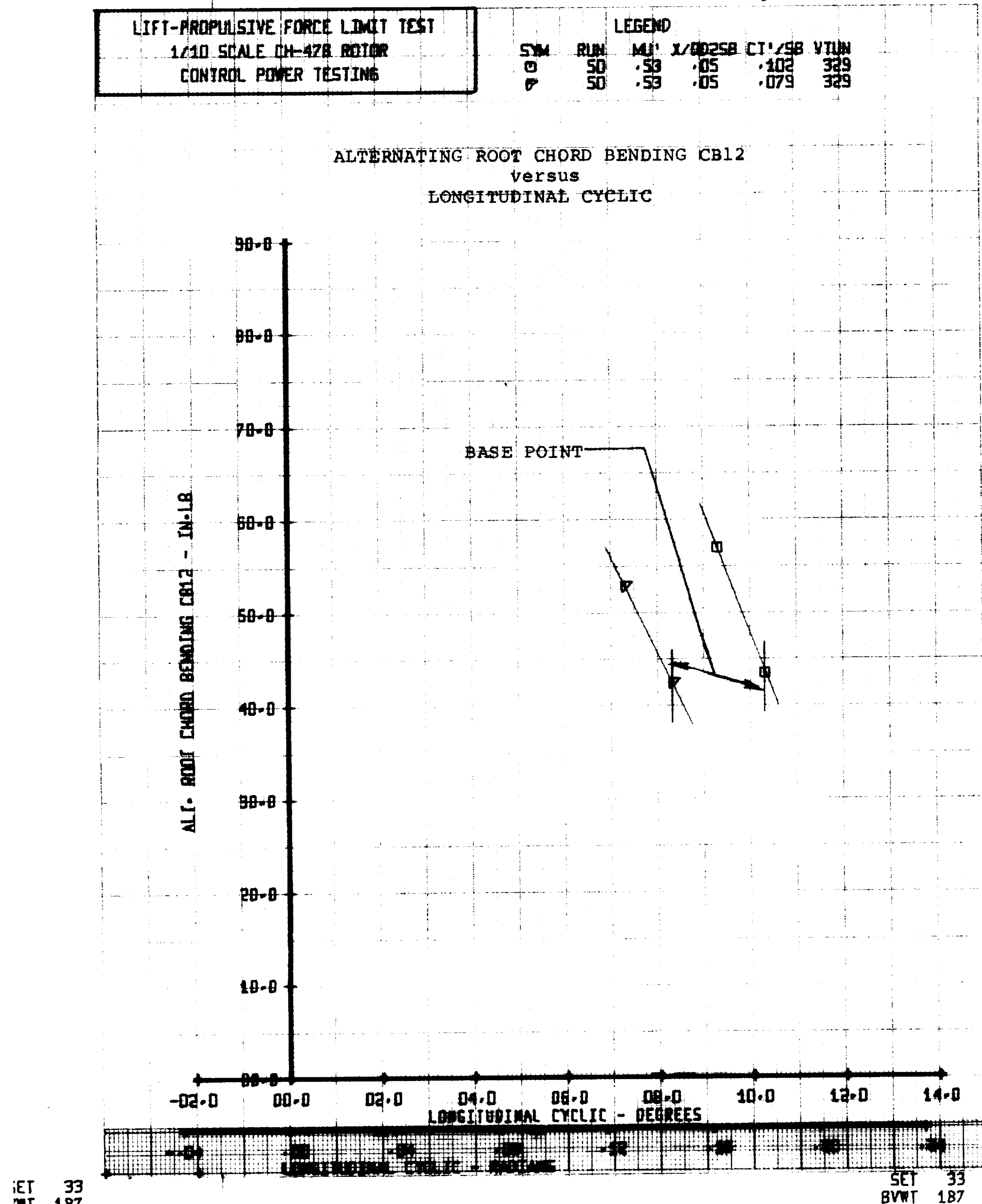


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/DD2SB CT'/SB VTUN
50 .58 .05 .102 329
50 .58 .05 .079 329
ROTOR SIDE FORCE COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR SIDE FORCE COEFF CY/SB
.010
.008
.006
.004
.002
.000
-.002
-.004
-.006
-.008
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
BASE POINT
LONGITUDINAL CYCLIC - RADIANS
SET 33
BVWT 187

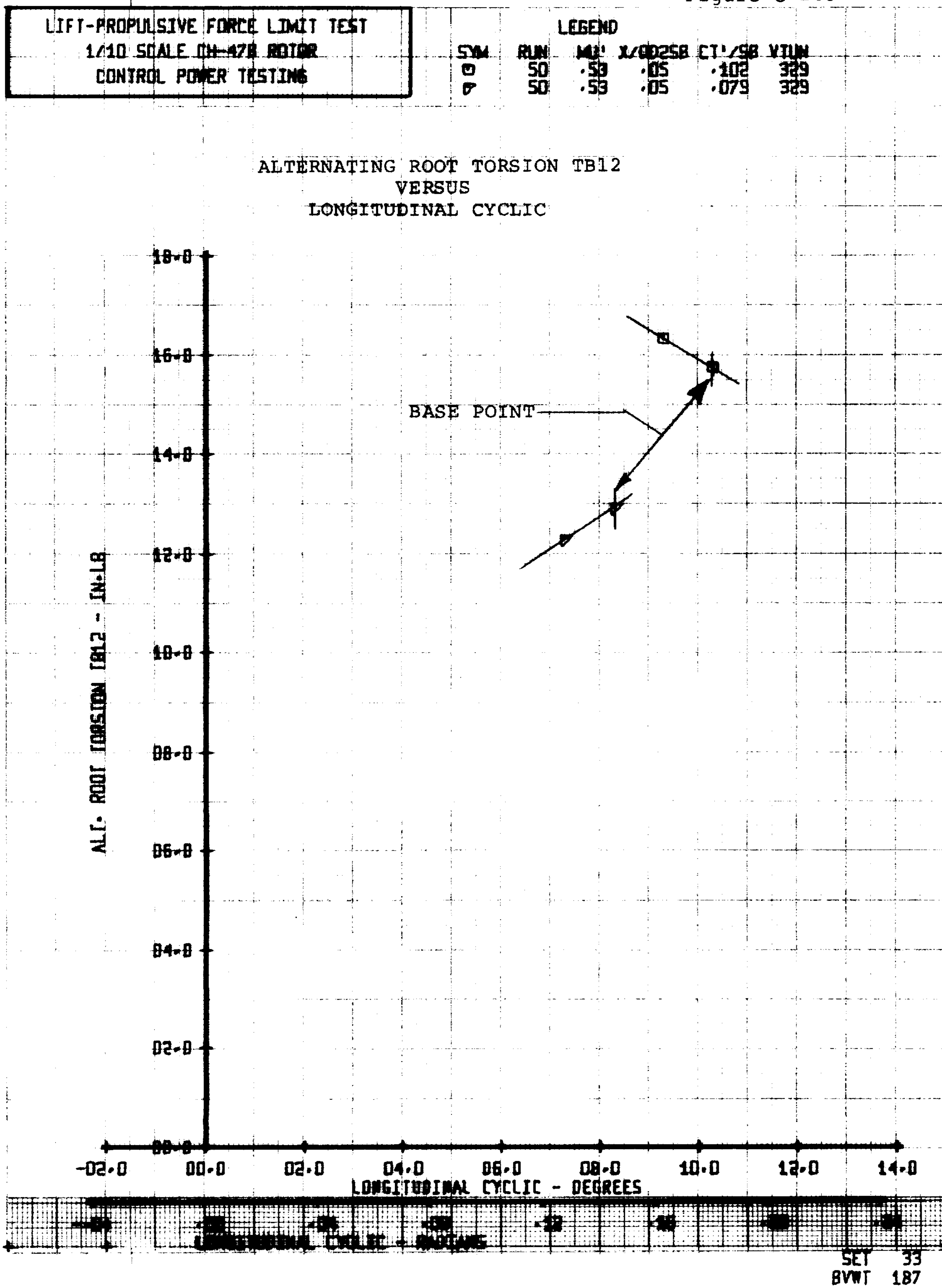
Figure C-246



ET 33
WT 187



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/Q0258 CT'/S8 VTUN
50 .53 .05 .102 329
50 .53 .05 .079 329
ALTERNATING ROOT CHORD BENDING CB12
versus
LONGITUDINAL CYCLIC
BASE POINT
ALT. ROOT CHORD BENDING CB12 - IN-LB
LONGITUDINAL CYCLIC - DEGREES
SET 33
BVWT 187


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
CONTROL POWER TESTING
LEGEND
SYM RUN MU' X/QD2SB CT'/SB VTUN
50 .53 .05 .102 329
50 .53 .05 .079 329
ALTERNATING ROOT TORSION TB12
VERSUS
LONGITUDINAL CYCLIC
BASE POINT
ALT. ROOT TORSION TB12 - IN-LB
18.0
16.0
14.0
12.0
10.0
08.0
06.0
04.0
02.0
00.0
-02.0
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
LONGITUDINAL CYCLIC - DEGREES
LONGITUDINAL CYCLIC - RADIANS
SET 33
BVWT 187

D. Performance Summary

Performance data obtained during the definition of the lift limit is shown in Appendix A at individual advance ratio for a variation of propulsive force or for a limited range of advance ratios for one propulsive force level. This section presents a summary of rotor performance, the rotor and control positions required and the alternating blade root torsion load produced. This data is presented for one level of propulsive force coefficient, $X/qd^2\sigma = 0.05$, at the basic tip speed of 620 ft/sec and the reduced tip speed of 570 ft/sec. During the testing two distinct levels of performance were observed; one without stall at the retreating tip and the other with stall present throughout the sweep in lift coefficient. Both sets of performance are included to delineate the two levels of performance and specify which runs are in each category.

The test data obtained for each of these test runs of Appendix A have been combined to show the effect of advance ratio only. The combinations, identified as plot sets are defined in Table D-1 and are marked on the bottom of each sheet. Within each plot set are a series of graphs presenting the variation of the major components of measured data with rotor lift coefficient. The sequence of these graphs are as follows:

Rotor Lift Coefficient versus Shaft Angle of Attack

Rotor Lift Coefficient versus Collective Pitch

Rotor Lift Coefficient versus Longitudinal Cyclic

Rotor Lift Coefficient versus Lateral Cyclic

Rotor Lift COefficient versus Rotor Power Coefficient

Rotor Lift Coefficient versus Alternating Root Torsion TB12

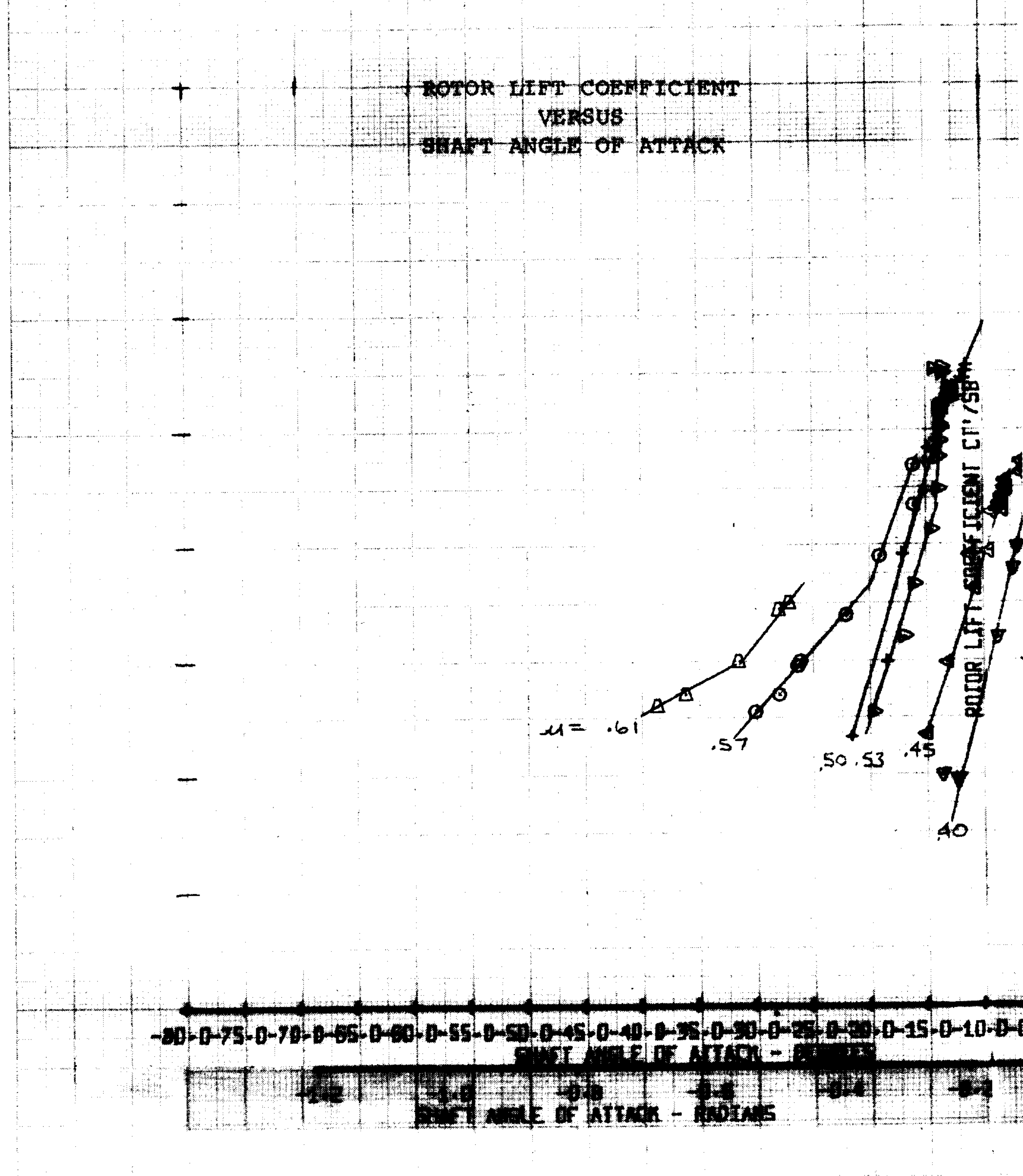
TABLE D-1 DATA PLOTTING SUMMARY FOR PERFORMANCE SUMMARY

PLOT SET	RUN NO.	ROTOR TIP SPEED V_T	ADVANCE RATIO μ	ROTOR LIFT COEFF. C_T^1/σ	ROTOR PROPULSIVE FORCE COEFF. $X/qd^2\sigma$	TUNNEL SPEED V	COMMENTS
44	23 25 27 30 36 39 50 228 229	620 FPS	0 .10 .20 .40 .45 .50 .53 .57 .61	Range	.05	0 62 FPS 124 FPS 248 FPS 279 FPS 310 FPS 329 FPS 353 FPS 378 FPS	Performance at baseline tip speed
46	256 255 254 257 258 259 260	570 FPS	.40 .45 .50 .53 .57 .61 .64	Range	.05	228 FPS 256 FPS 285 FPS 302 FPS 325 FPS 348 FPS 368 FPS	Performance at reduced tip speed
43	23 25 28 29 227 225 224 273 274	620 FPS	0 .10 .20 .30 .45 .50 .53 Range Range	Range	.05	0 65 FPS 124 FPS 186 FPS 279 FPS 310 FPS 328 FPS Range Range	Performance at baseline tip speed with tip stall throughout C_T^1/σ sweep
45	250 251 252 253	570 FPS	.40 .45 .50 .53	Range	.05	228 FPS 256 FPS 285 FPS 302 FPS	Performance at reduced tip speed with tip stall throughout C_T^1/σ sweep

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

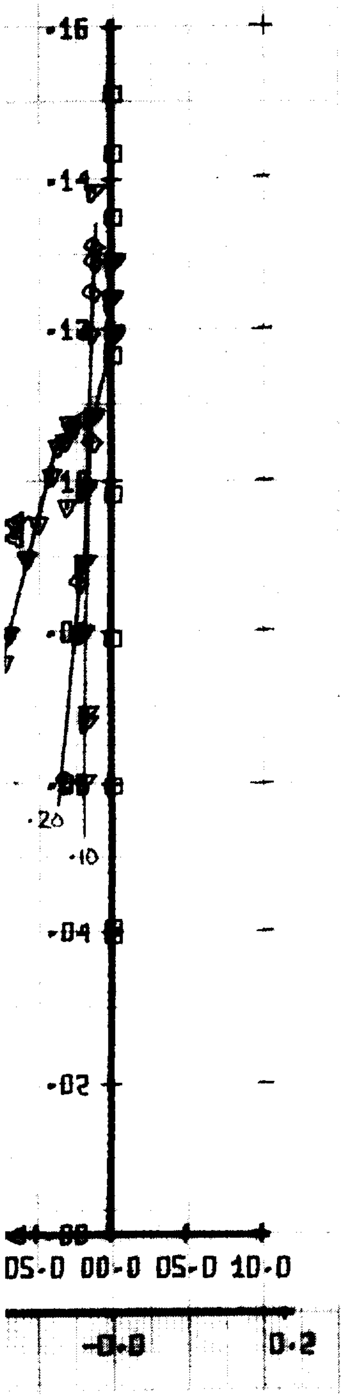
LEGEND

SYM	RUN	MU'	X/QD2SB	VTUN
⊡	23	0	.05	0
▽	25	.10	.05	62
◇	27	.20	.05	124
▽	30	.40	.05	248
◁	36	.45	.05	279
+	39	.50	.05	310
▷	50	.53	.05	329
⊙	228	.57	.05	353
△	229	.61	.05	378



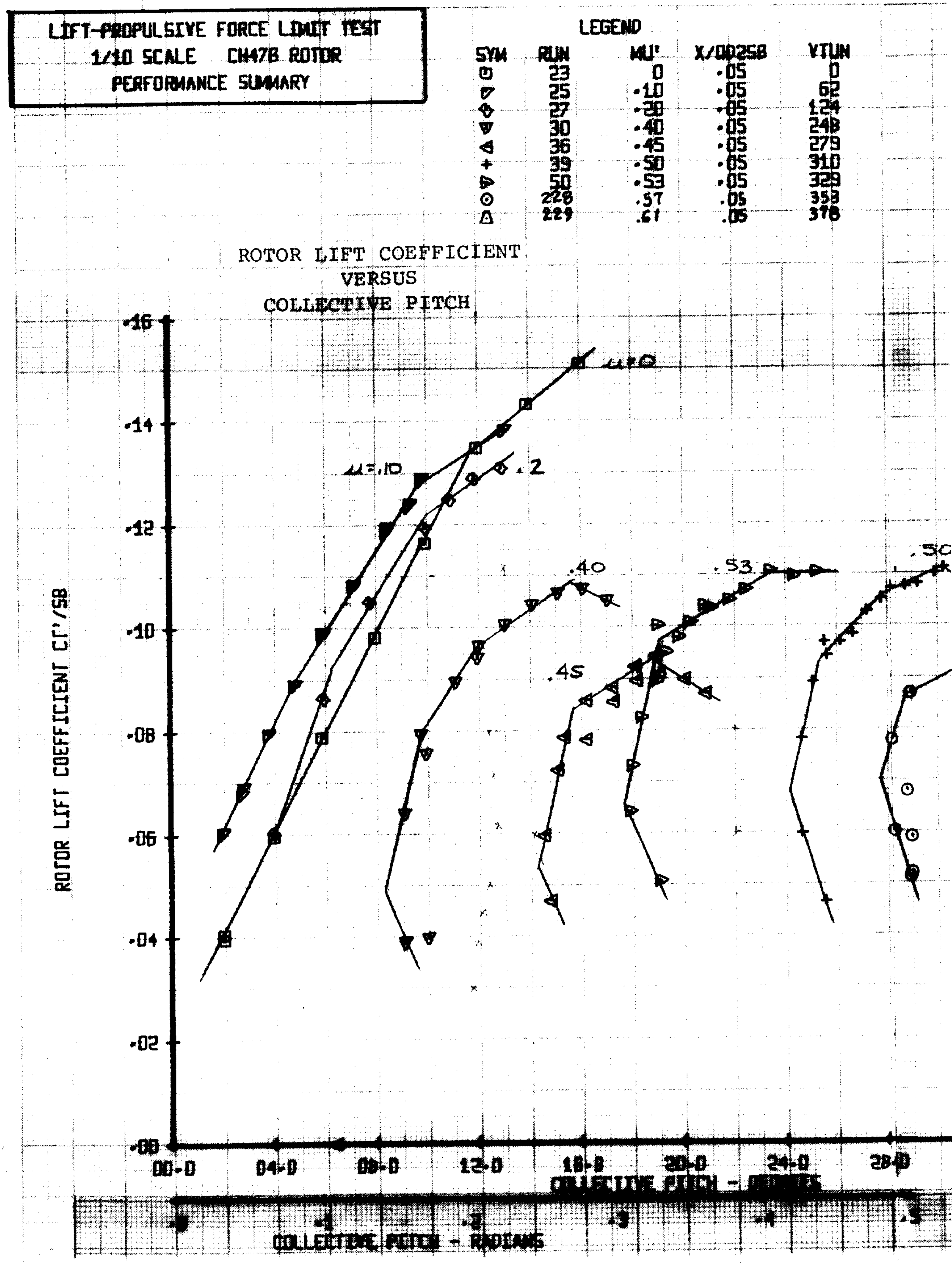
SET 44
BVWT 193

FOLDOUT FRAME 1



FOLDOUT FRAME 2

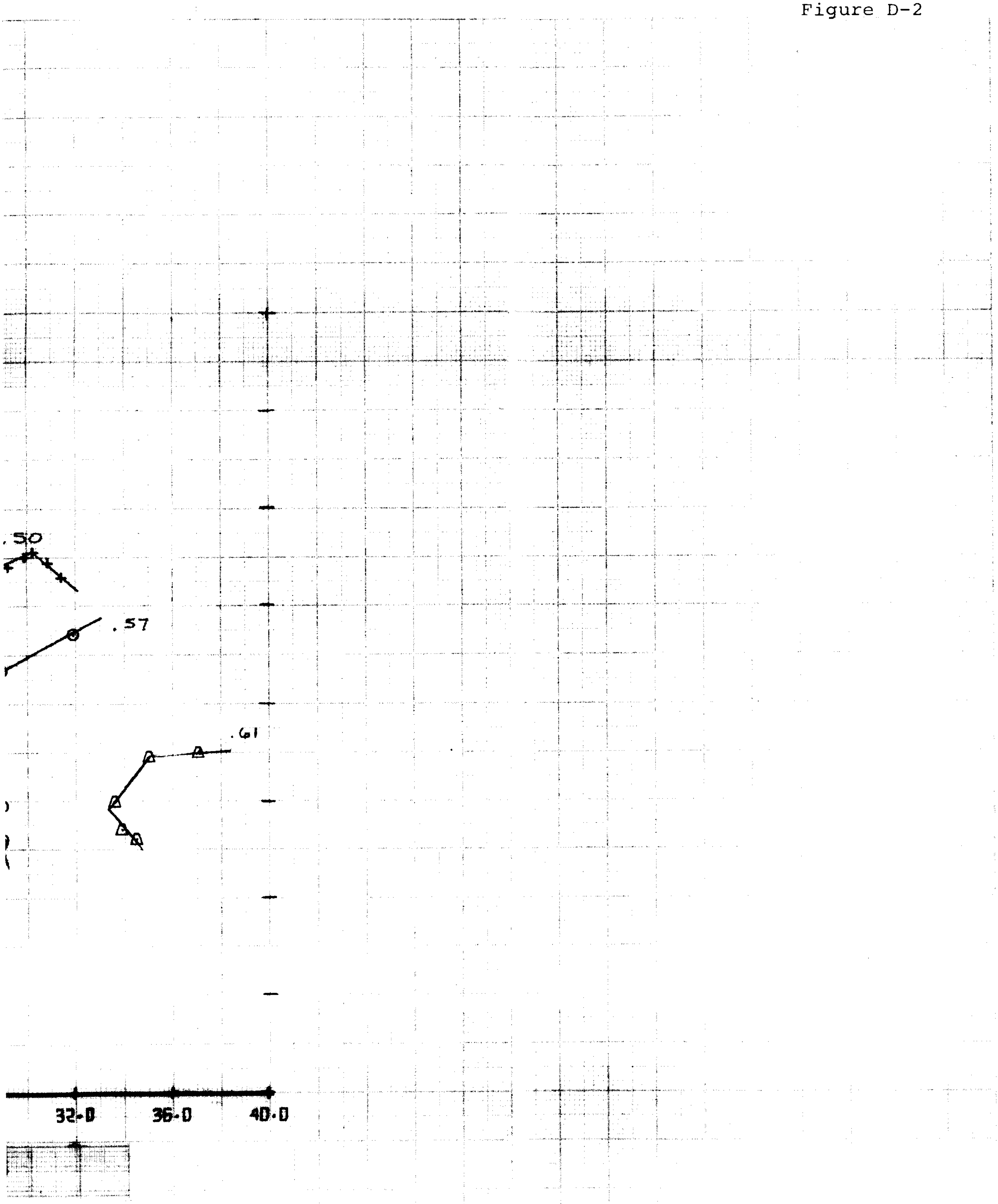
SET 44
BVWT 193



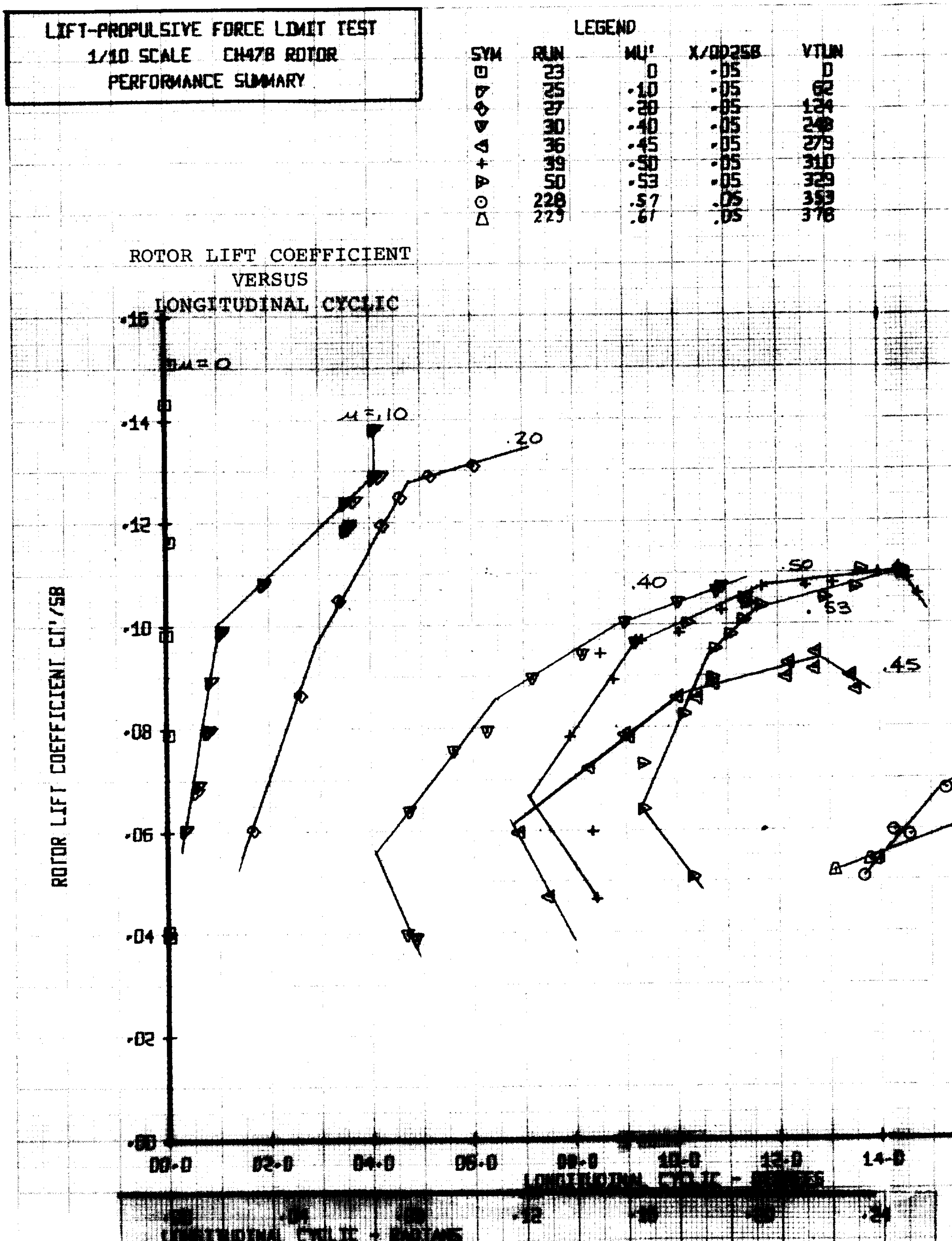
SET 44
BVWT 193

FOLDOUT FRAME 1

Figure D-2



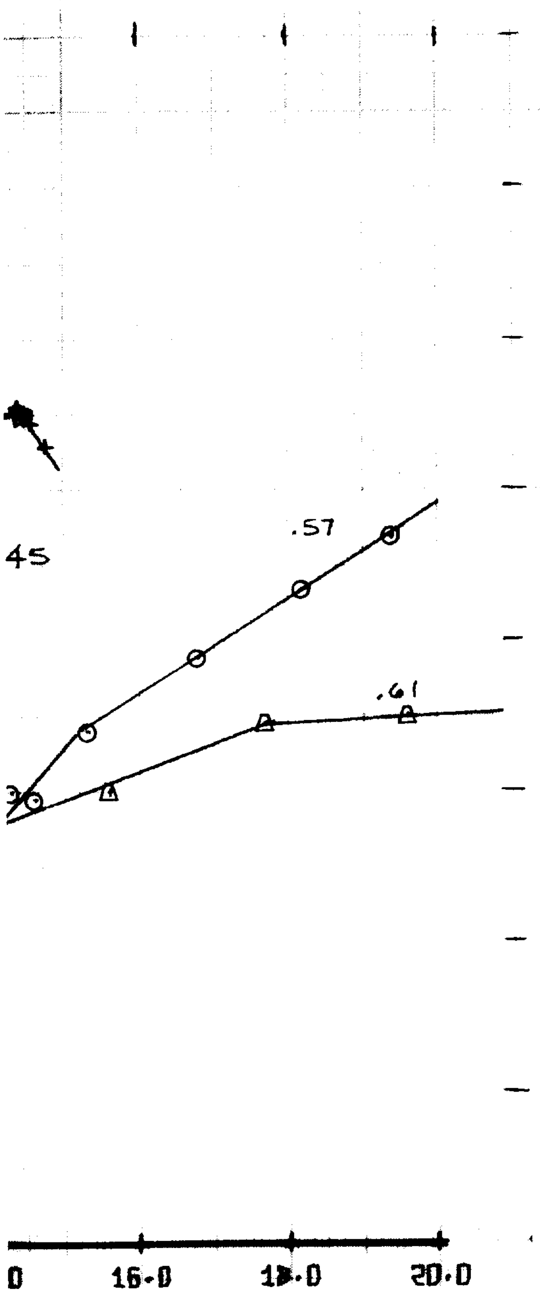
SET 44
BVWT 193



SET 44
BVWT 193

FOLDOUT FRAME 1

Figure D-3



FOLDOUT FRAME D-5 2

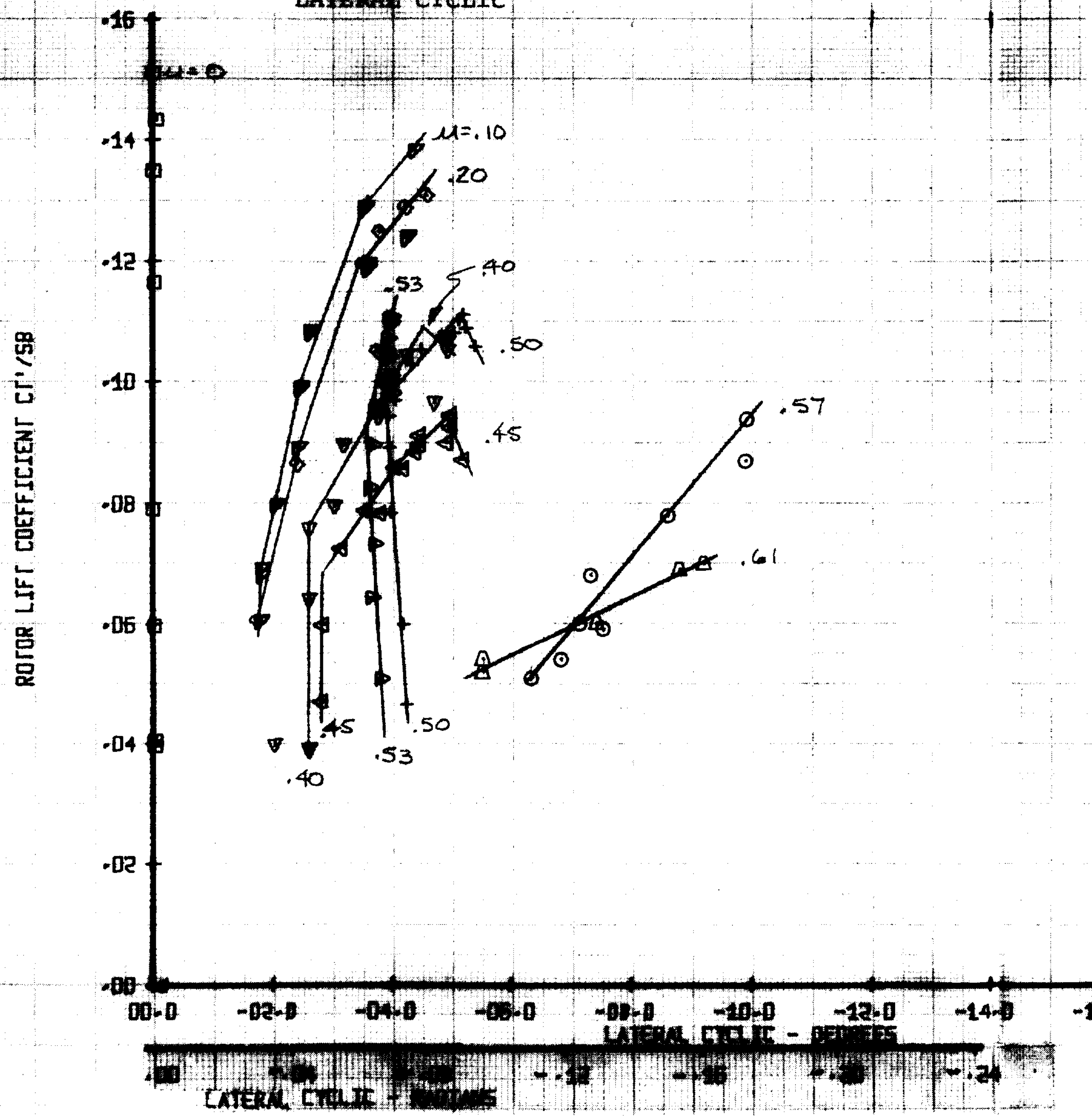
SET 44
BVWT 193

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

SYM	RUN	MU'	X/QD2SB	VTUN
⊡	23	0	.05	0
▽	25	.10	.05	62
◇	27	.20	.05	124
▽	30	.40	.05	248
◁	36	.45	.05	279
+	39	.50	.05	310
▷	50	.53	.05	329
⊙	228	.57	.05	353
Δ	229	.61	.05	378

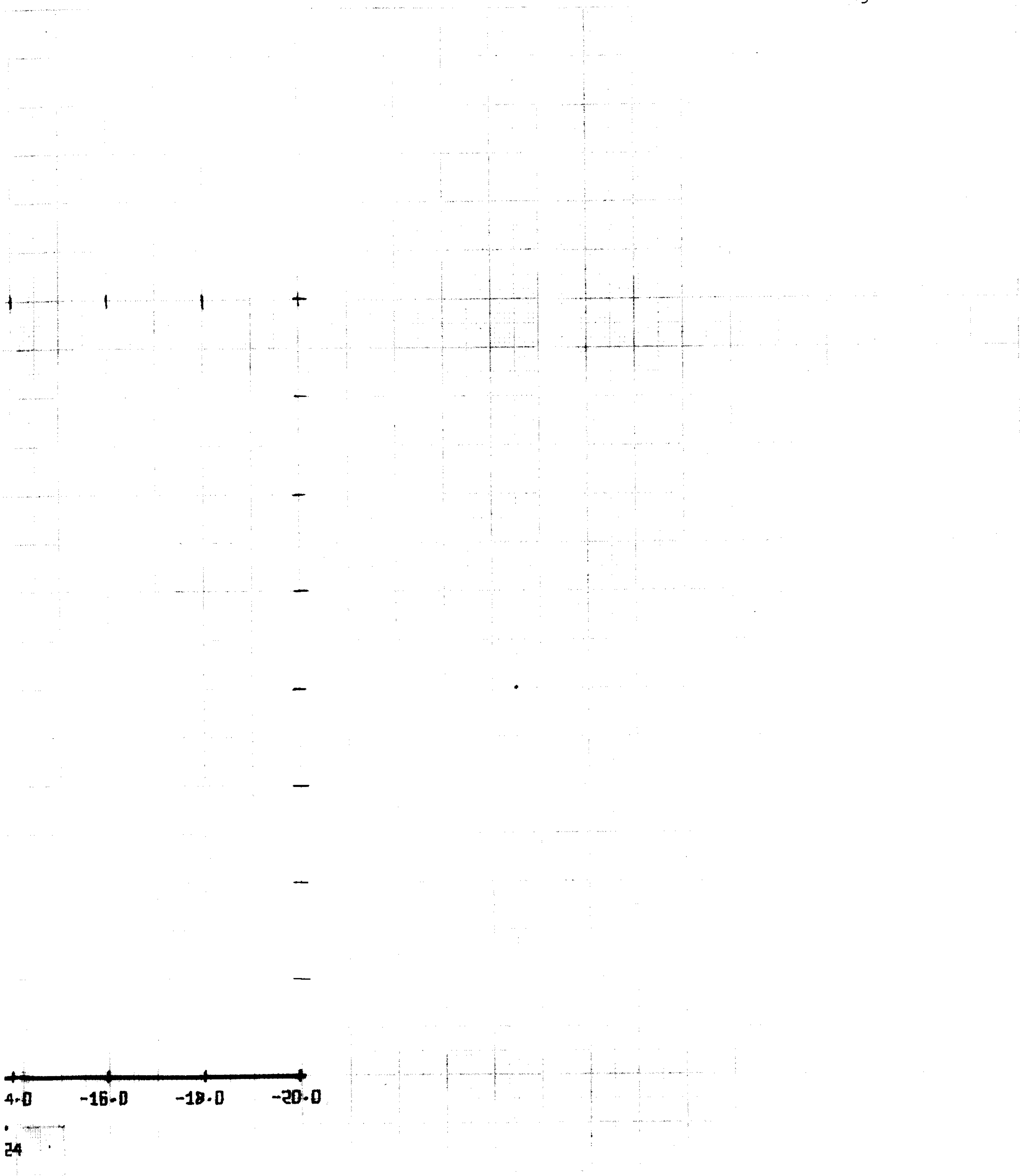
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC



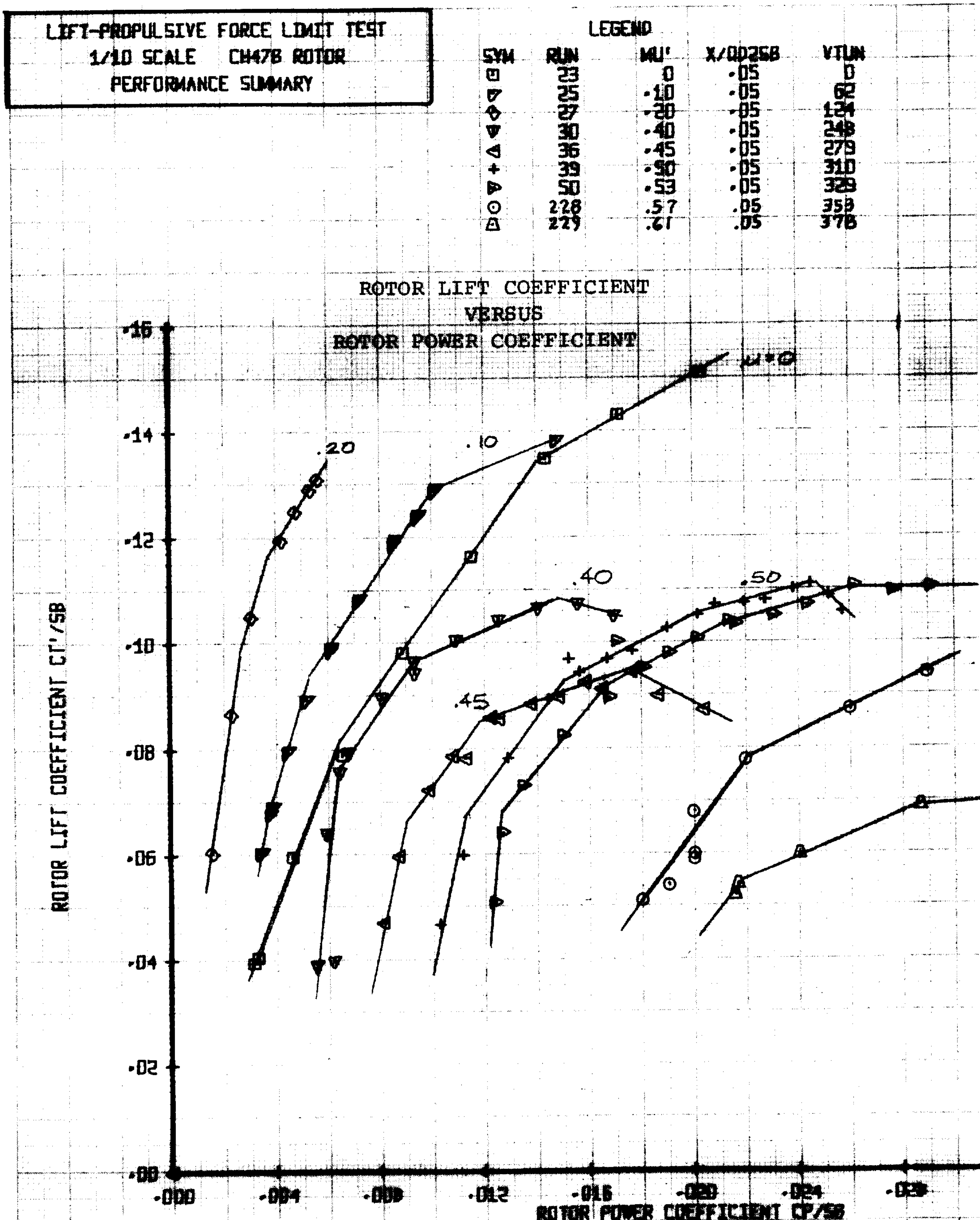
SET 44
BVWT 193

FOLDOUT FRAME

Figure D-4

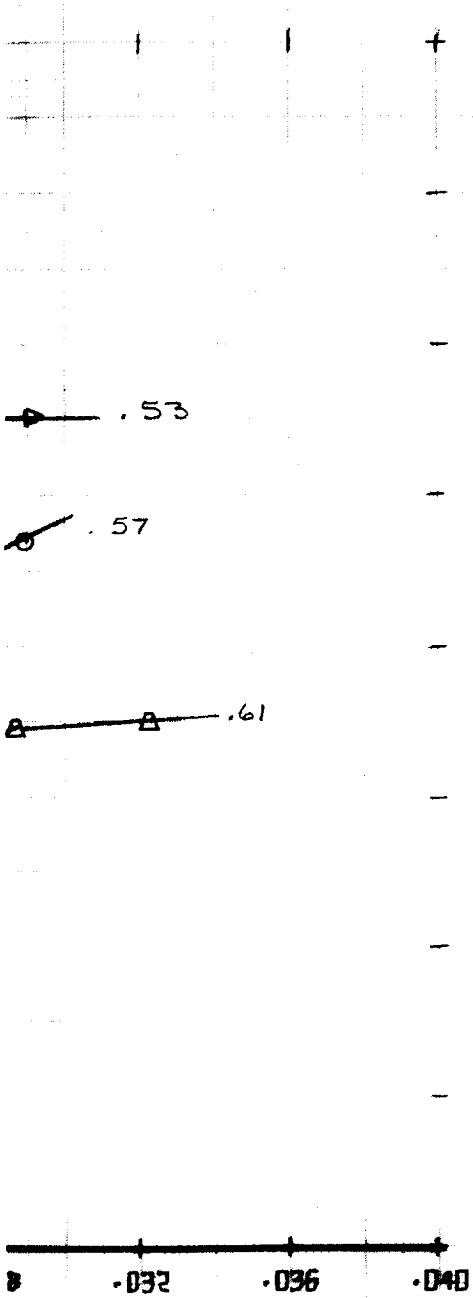


SET 44
BVWT 193

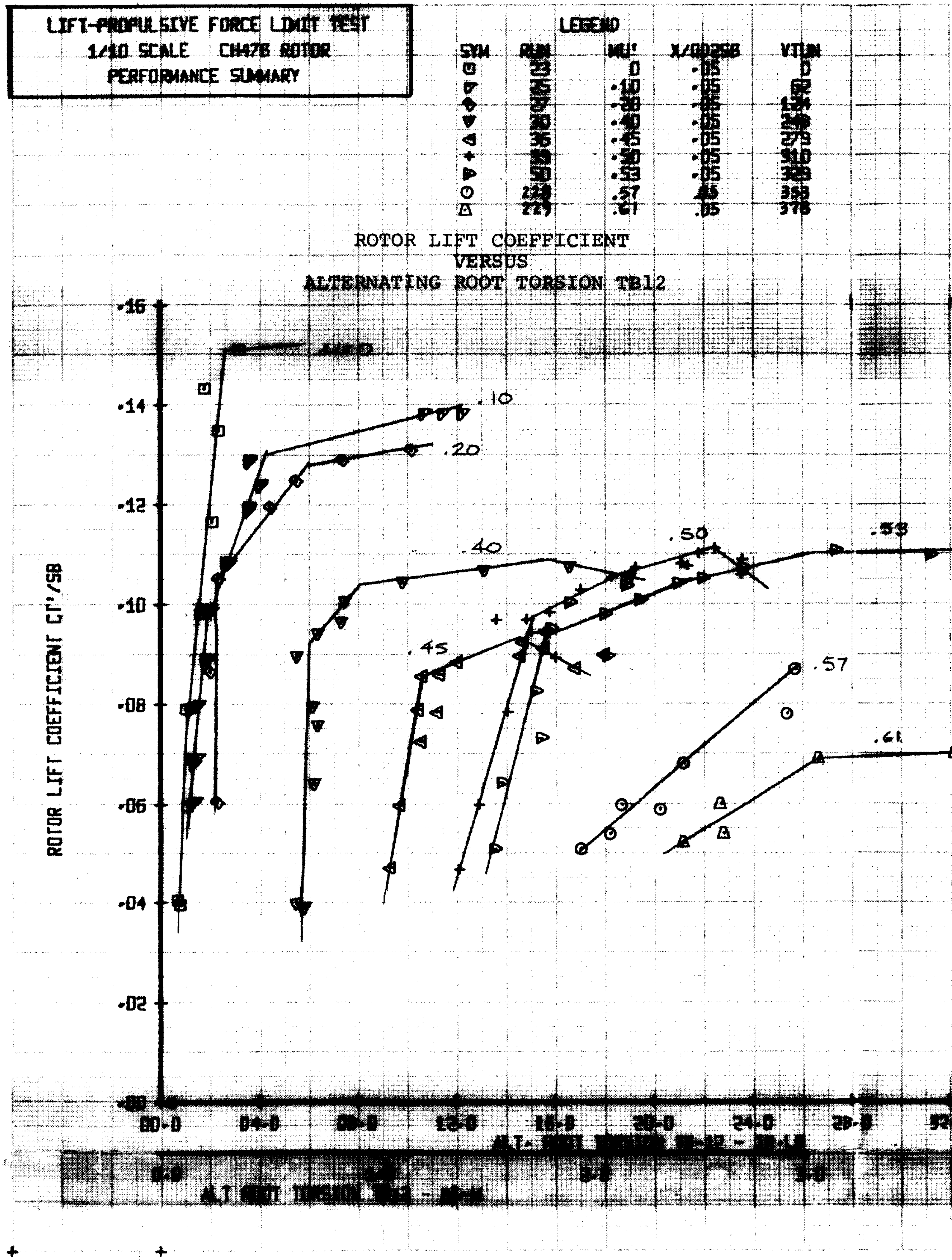


SET 44
BVWT 193

FOLDOUT FRAME 1



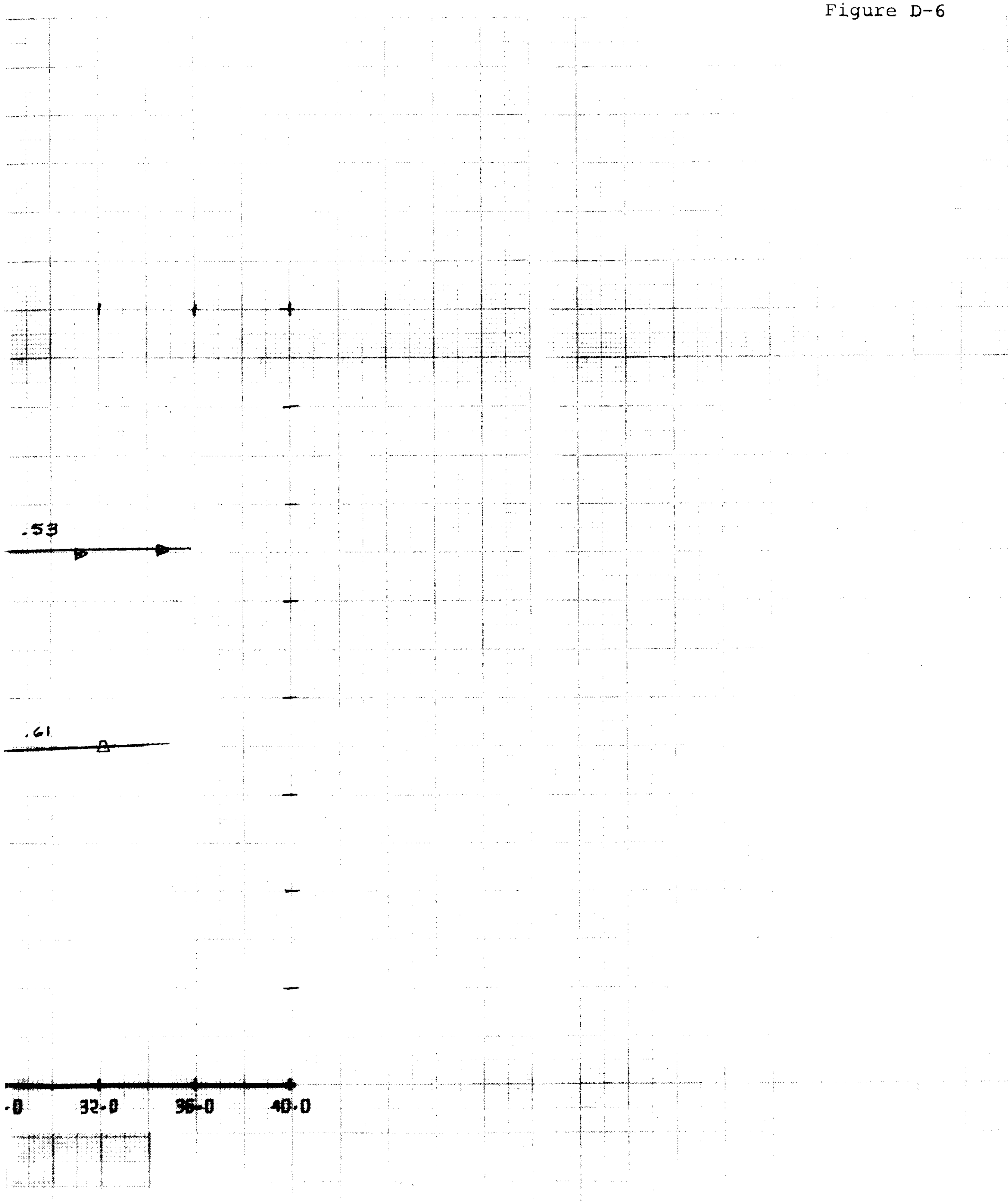
SET 44
BVWT 133



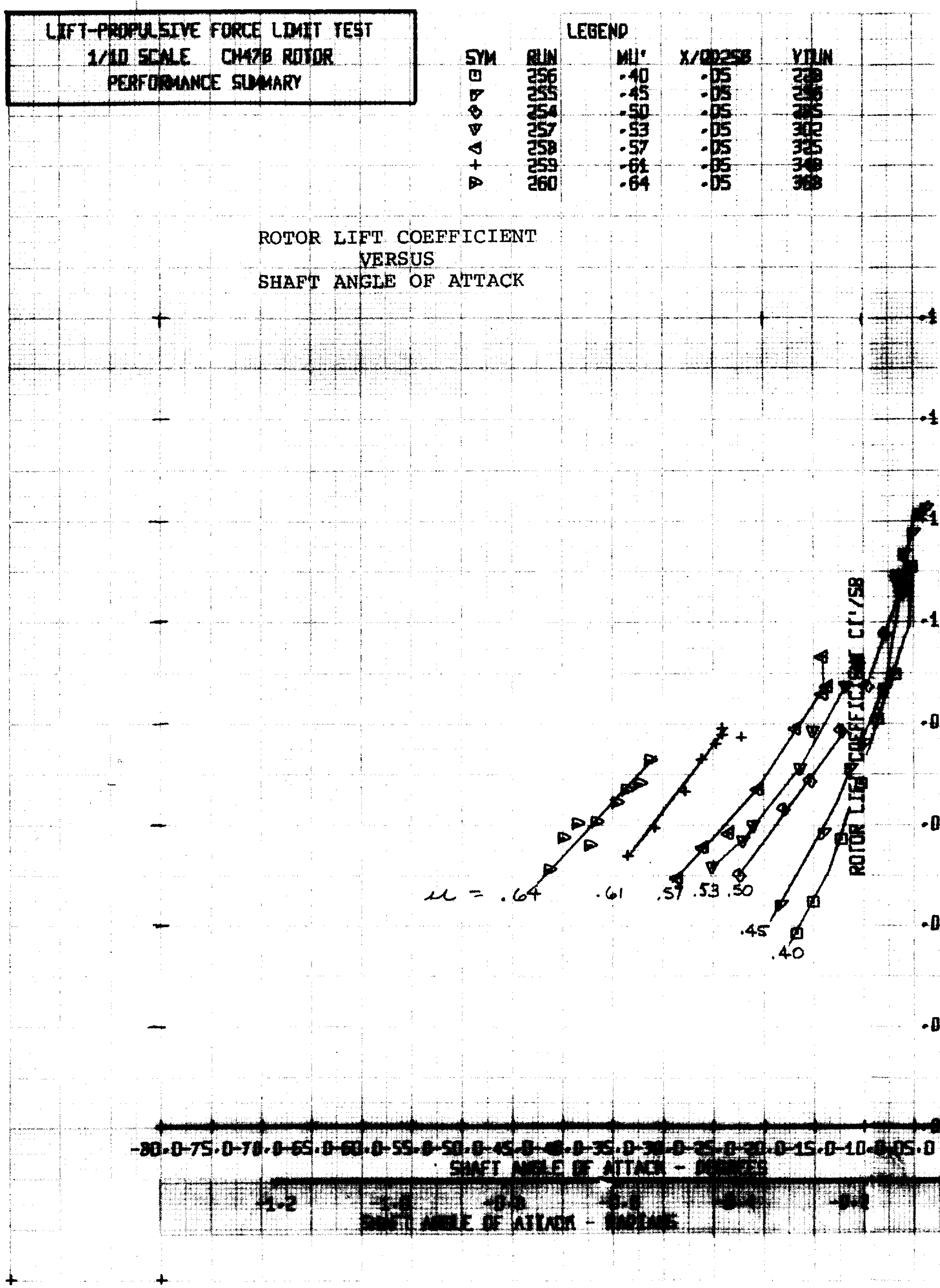
SET 44
VWT 193

FOLDOUT FRAME

Figure D-6

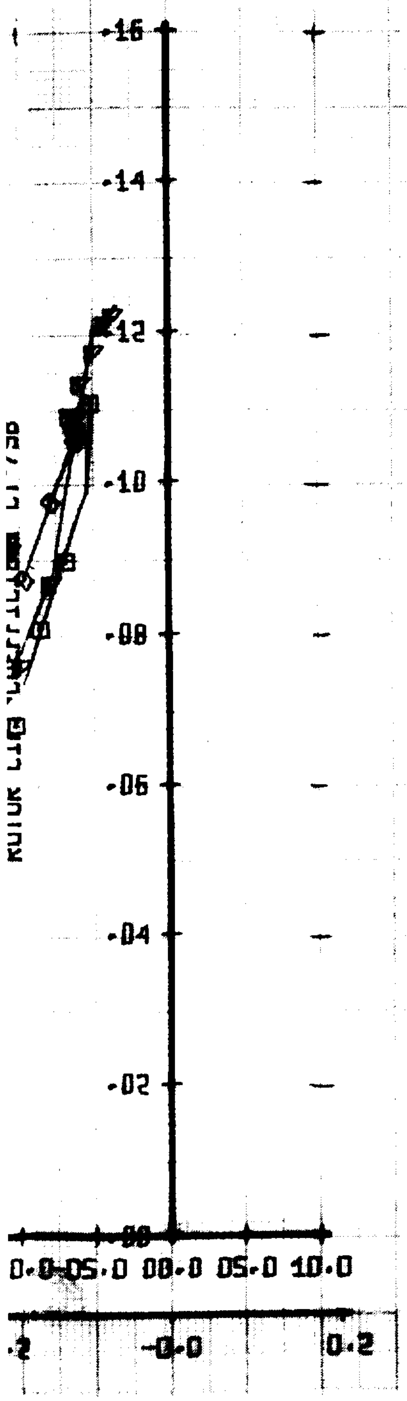


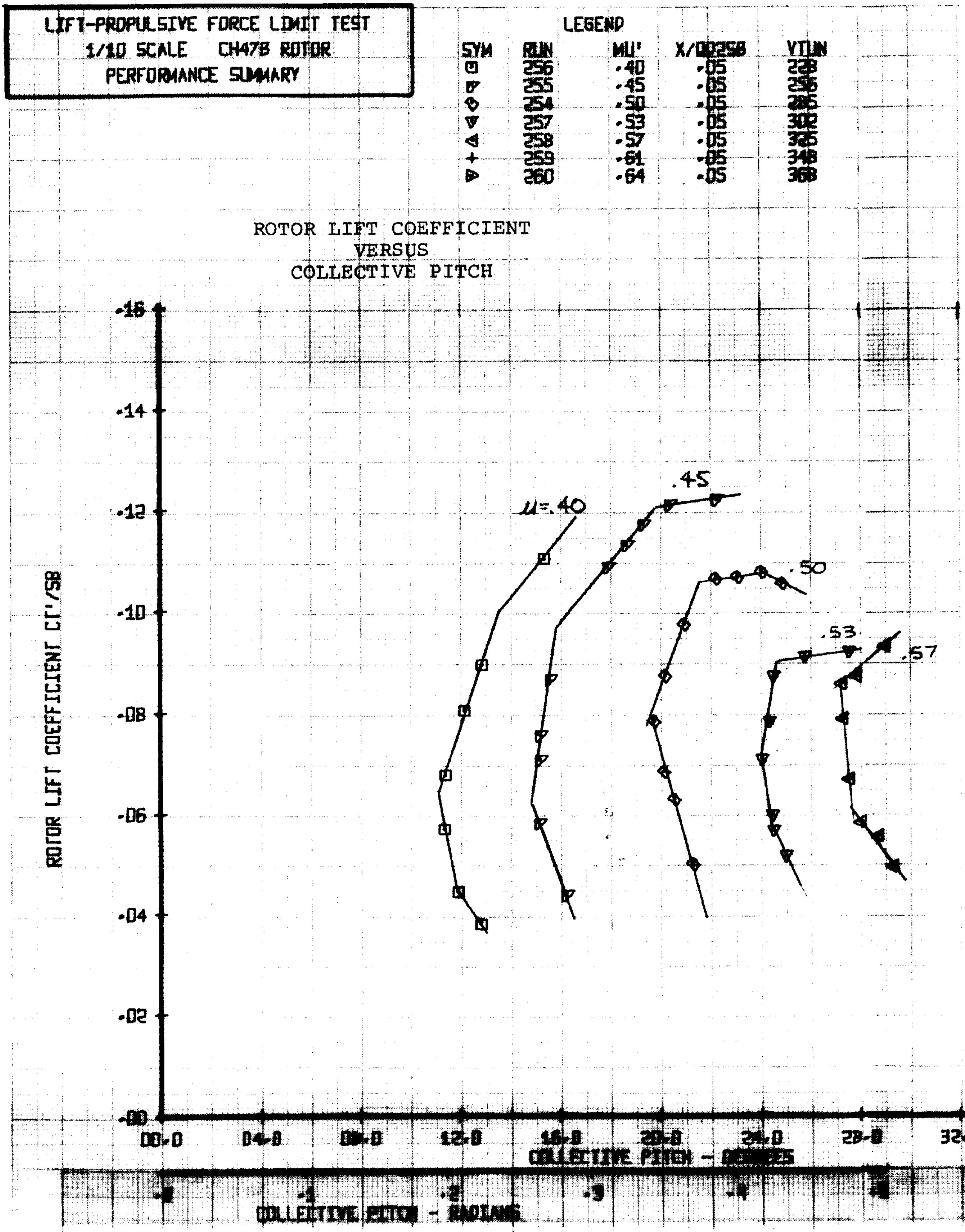
SET 44
BVWT 193



SET 46
BVWT 193

FOLDOUT FRAME 1

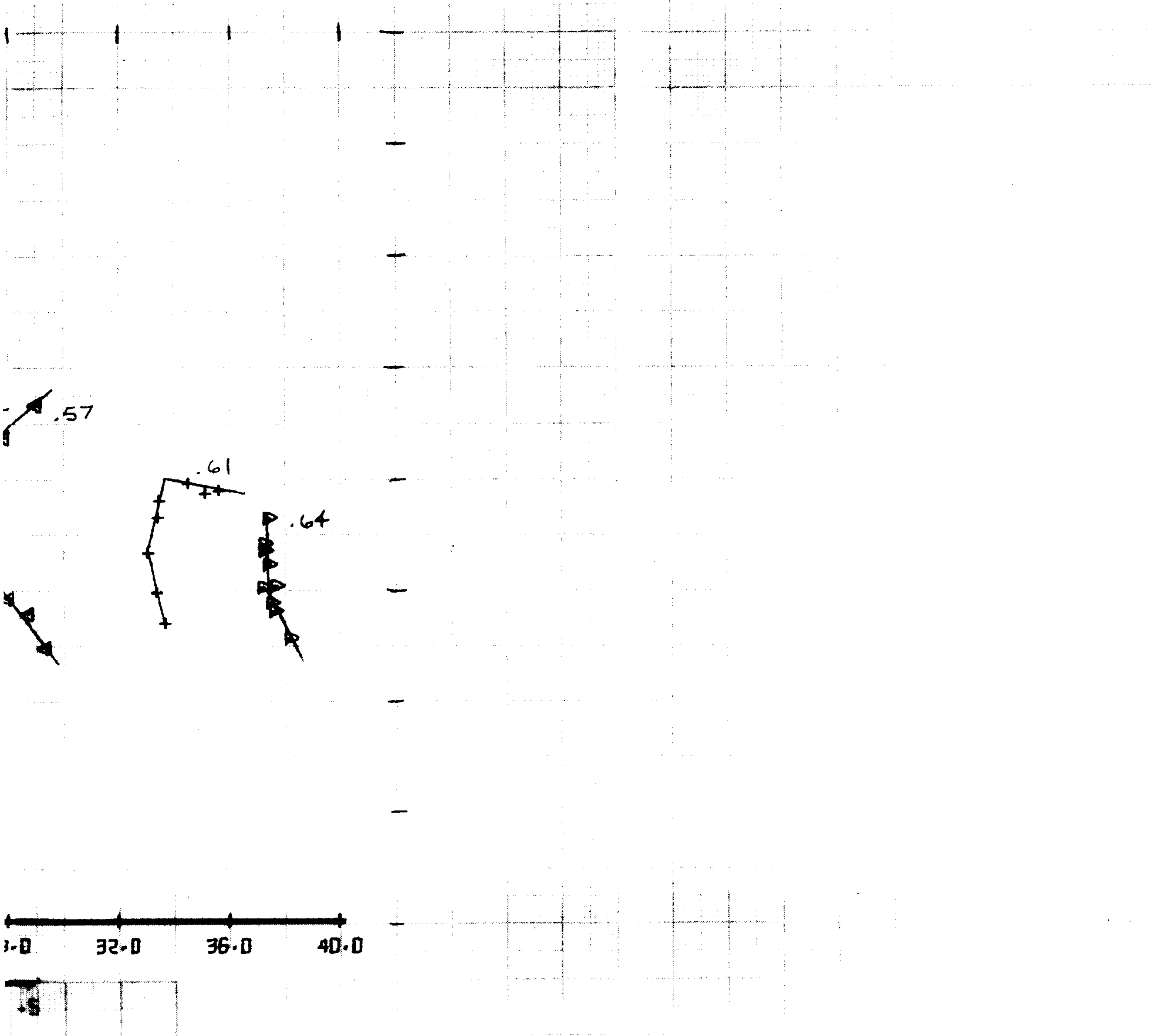

.16
.14
.12
.10
.08
.06
.04
.02
.00
0.0 .05 0.00 0.05 0.10
-0.0
0.2



SET 46
VWT 193

FOLDOUT FRAME 1

Figure D-8



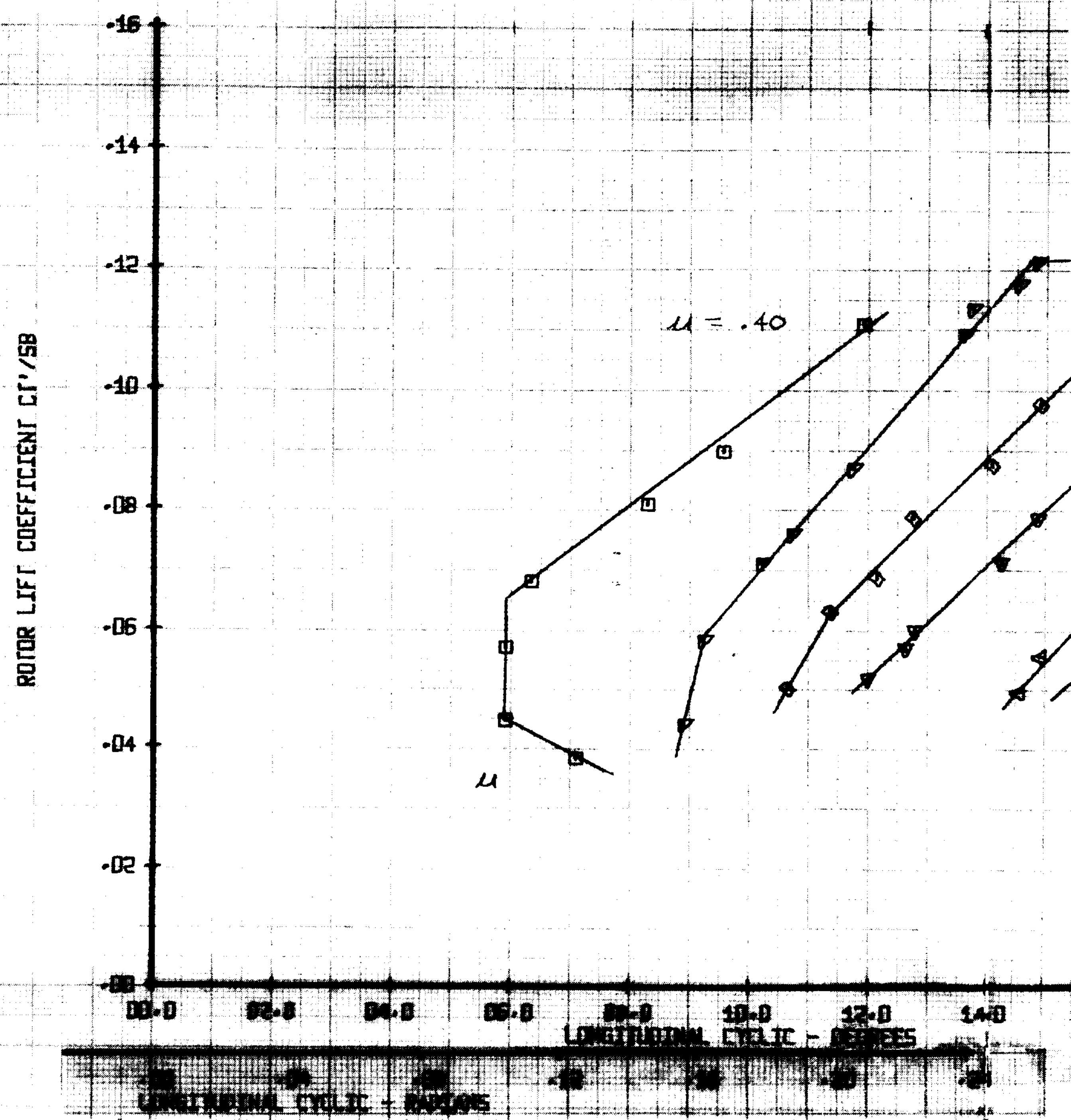
SET 46
BVWT 193

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

SYM	RUN	MU'	X/QD2SB	YTIN
□	256	.40	.05	[illegible]
▽	255	.45	.05	[illegible]
◇	254	.50	.05	[illegible]
▽	257	.53	.05	302
◁	258	.57	.05	325
+	259	.61	.05	[illegible]
▷	260	.64	.05	[illegible]

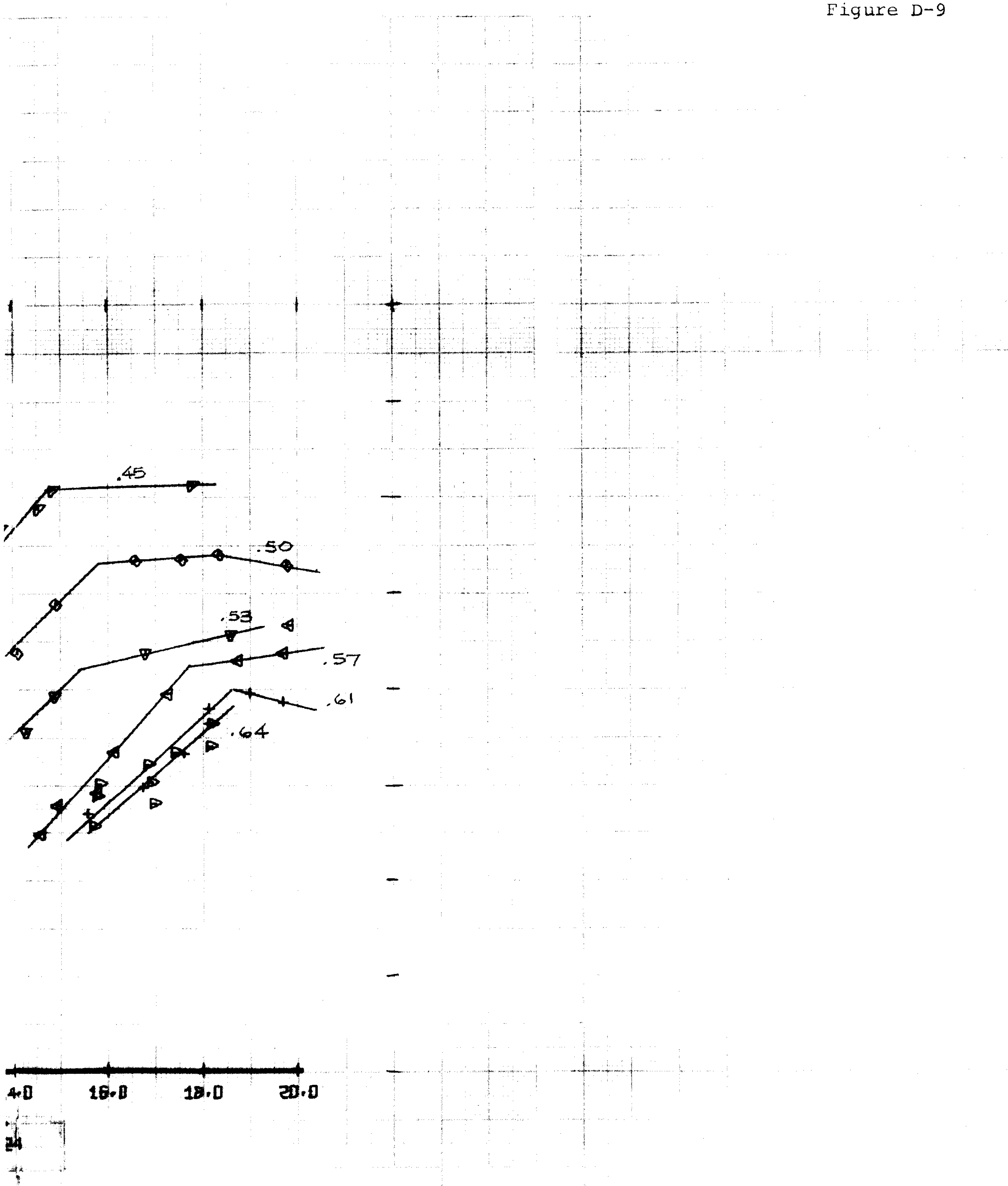
ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC

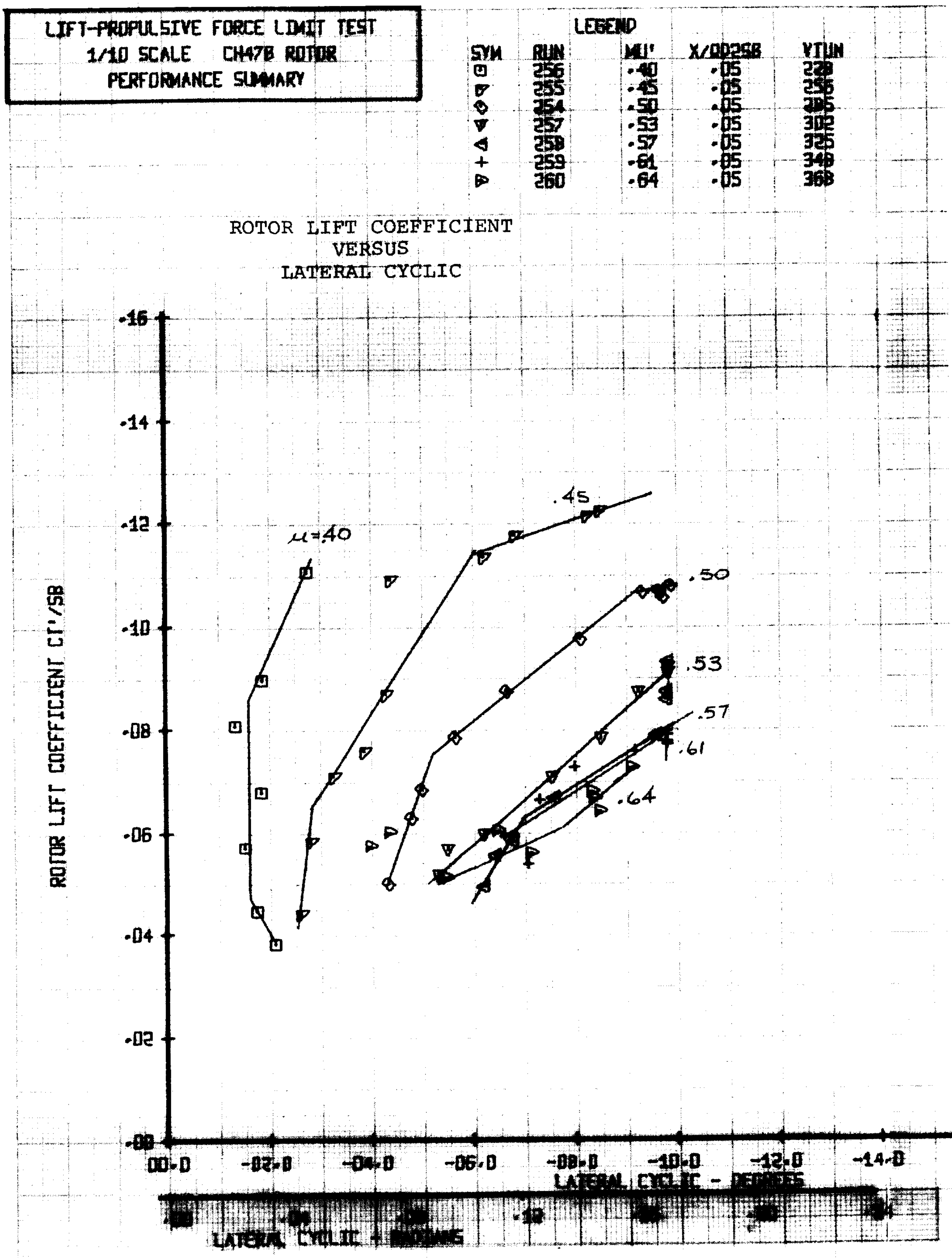


SET 46
BVWT 193

FOLDOUT FRAME /

Figure D-9

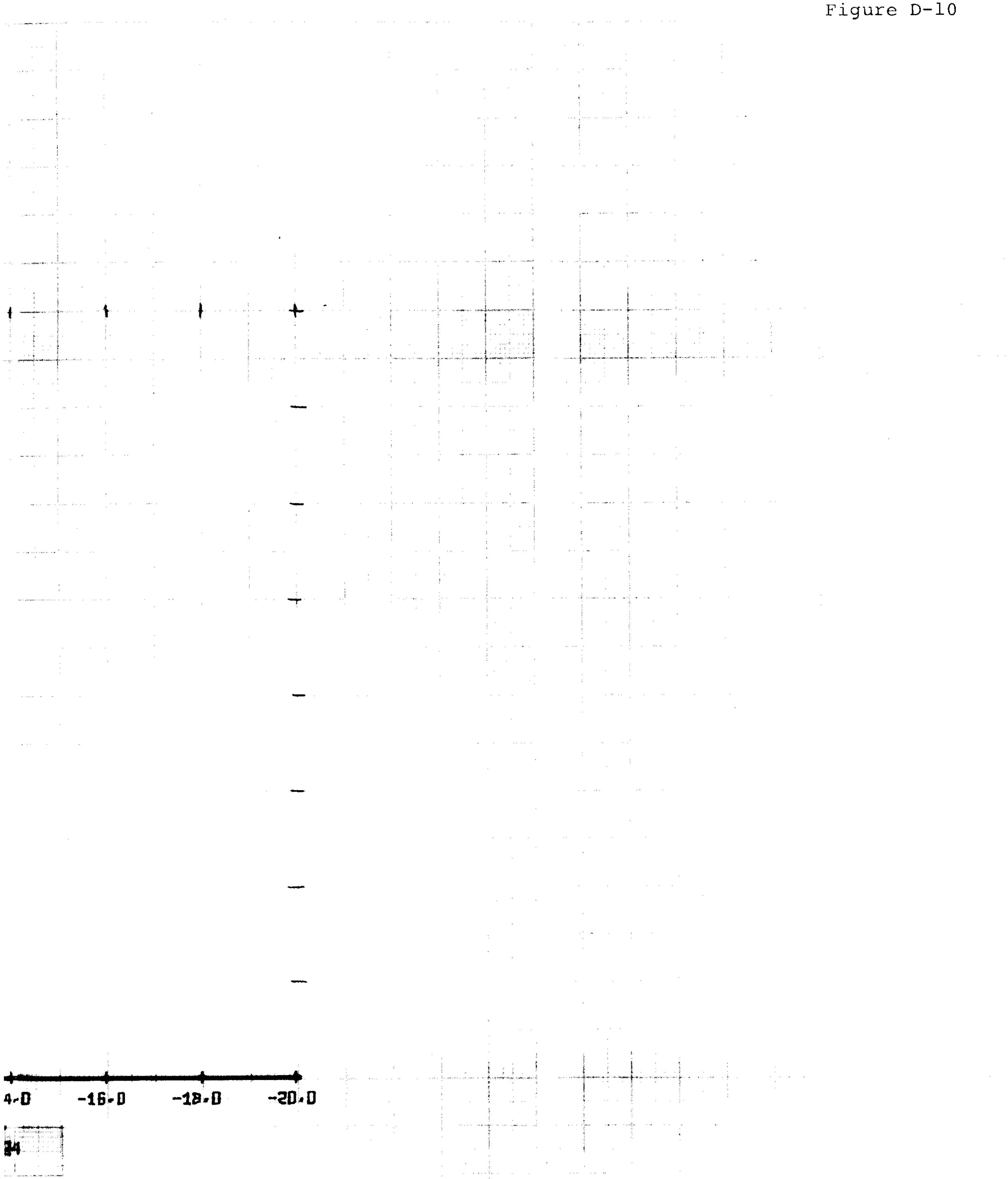




SET 46
BVWT 193

FOLDOUT FRAME 1

Figure D-10

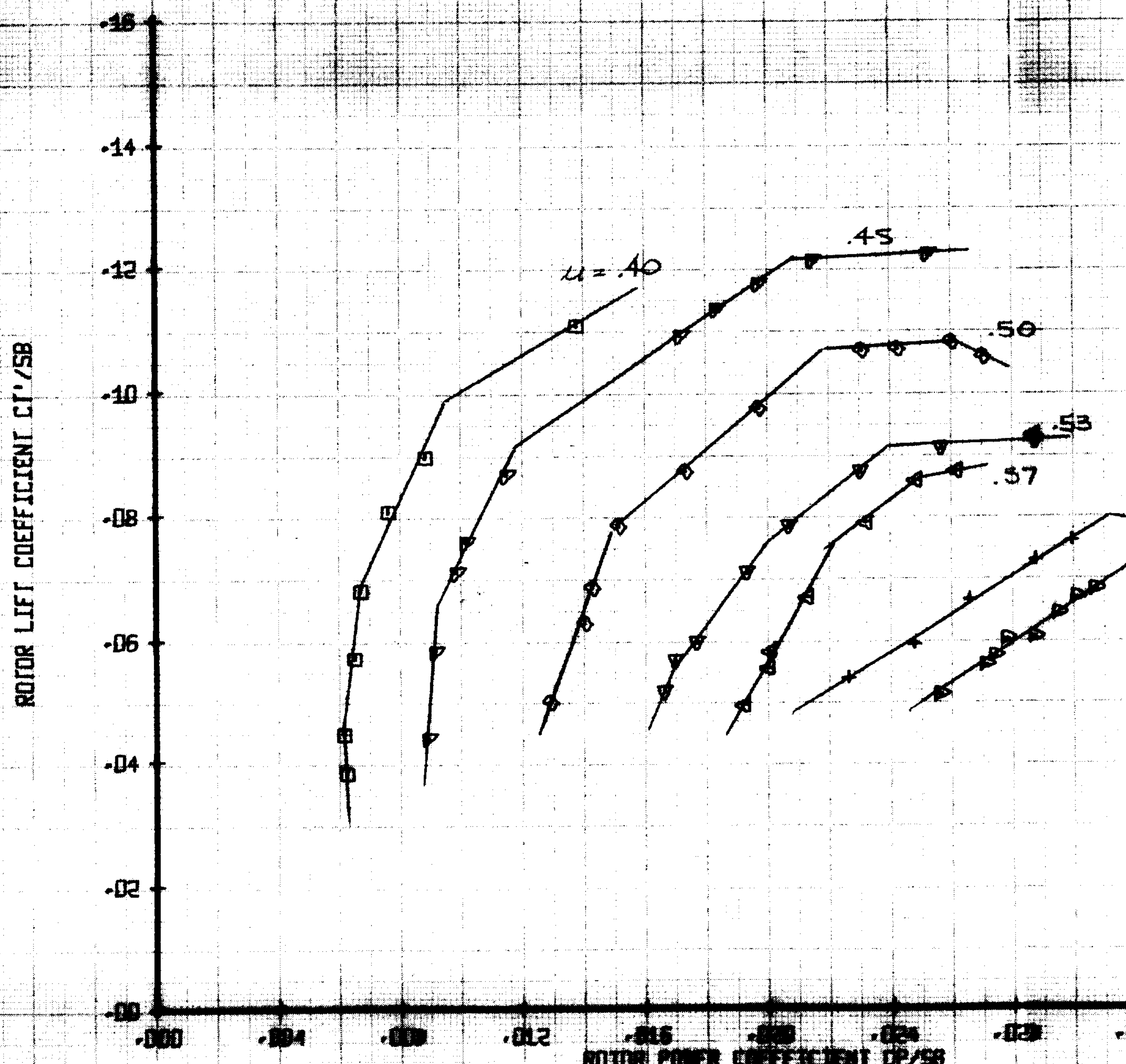


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

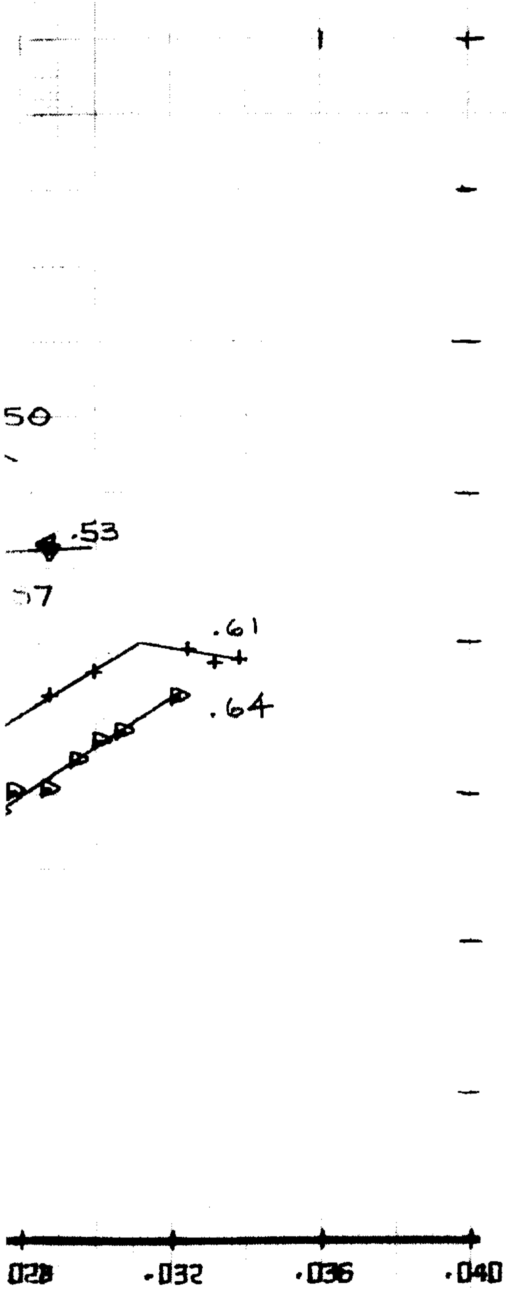
SYM	RUN	MU'	X/QD25B	YTUN
□	256	.40	.05	228
▽	255	.45	.05	256
◇	254	.50	.05	285
▽	257	.53	.05	302
◁	258	.57	.05	325
+	259	.61	.05	348
▷	260	.64	.05	368

ROTOR LIFT COEFFICIENT
VERSUS
ROTOR POWER COEFFICIENT



SET 46
BVWT 193

FOLDOUT FRAME 1



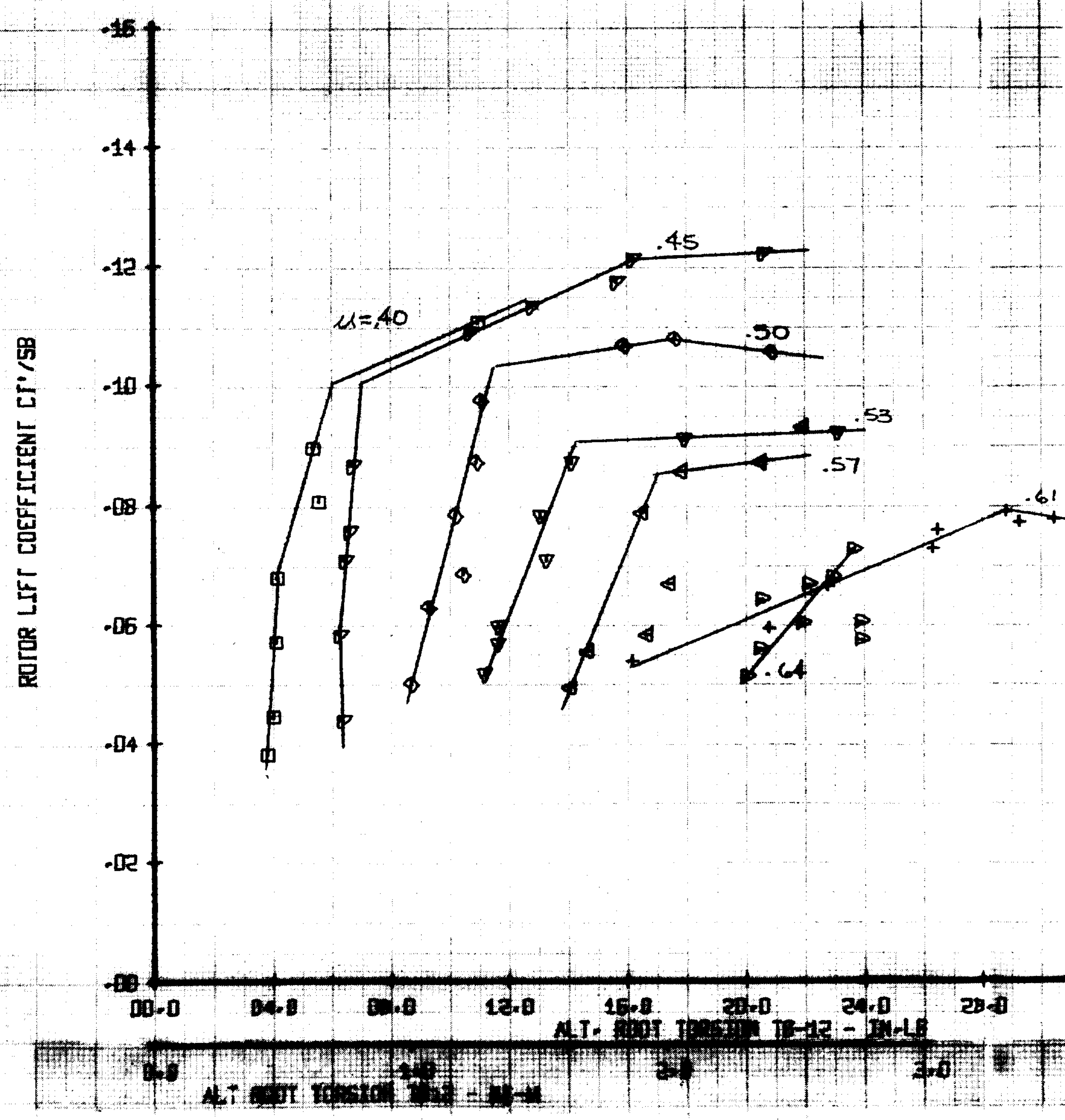
SET 46
BVWT 193

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

SYM	RUN	MU'	X/QQ2SB	YTUN
□	256	.40	.05	228
◸	255	.45	.05	256
◇	254	.50	.05	285
▽	257	.53	.05	302
◁	258	.57	.05	325
+	259	.61	.05	340
▷	260	.64	.05	360

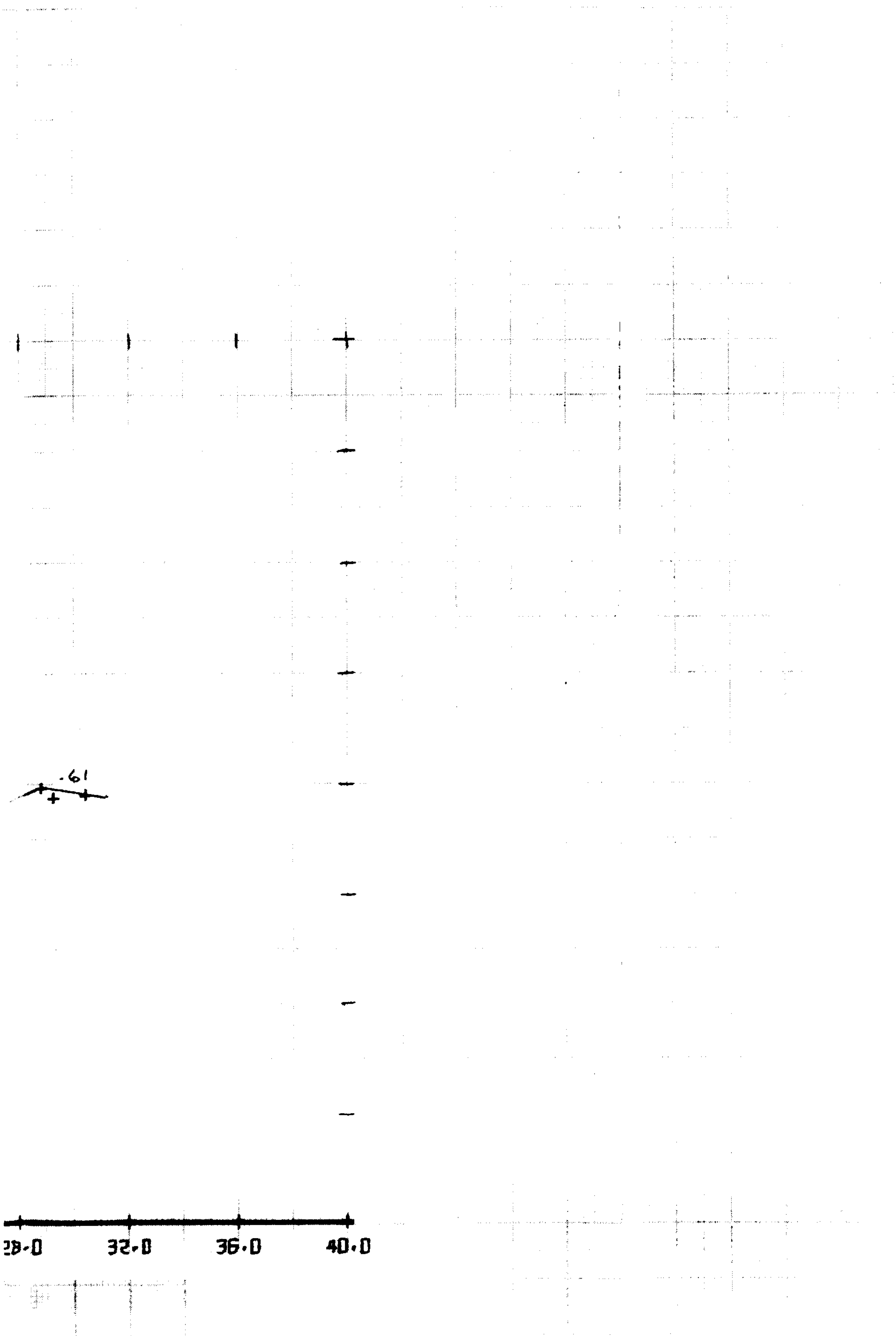
ROTOR LIFT COEFFICIENT
VERSUS
ALTERNATING ROOT TORSION TB12



SET 46
BVWT 193

FOLDOUT FRAME 1

Figure D-12



 FOLDOUT FRAME 2

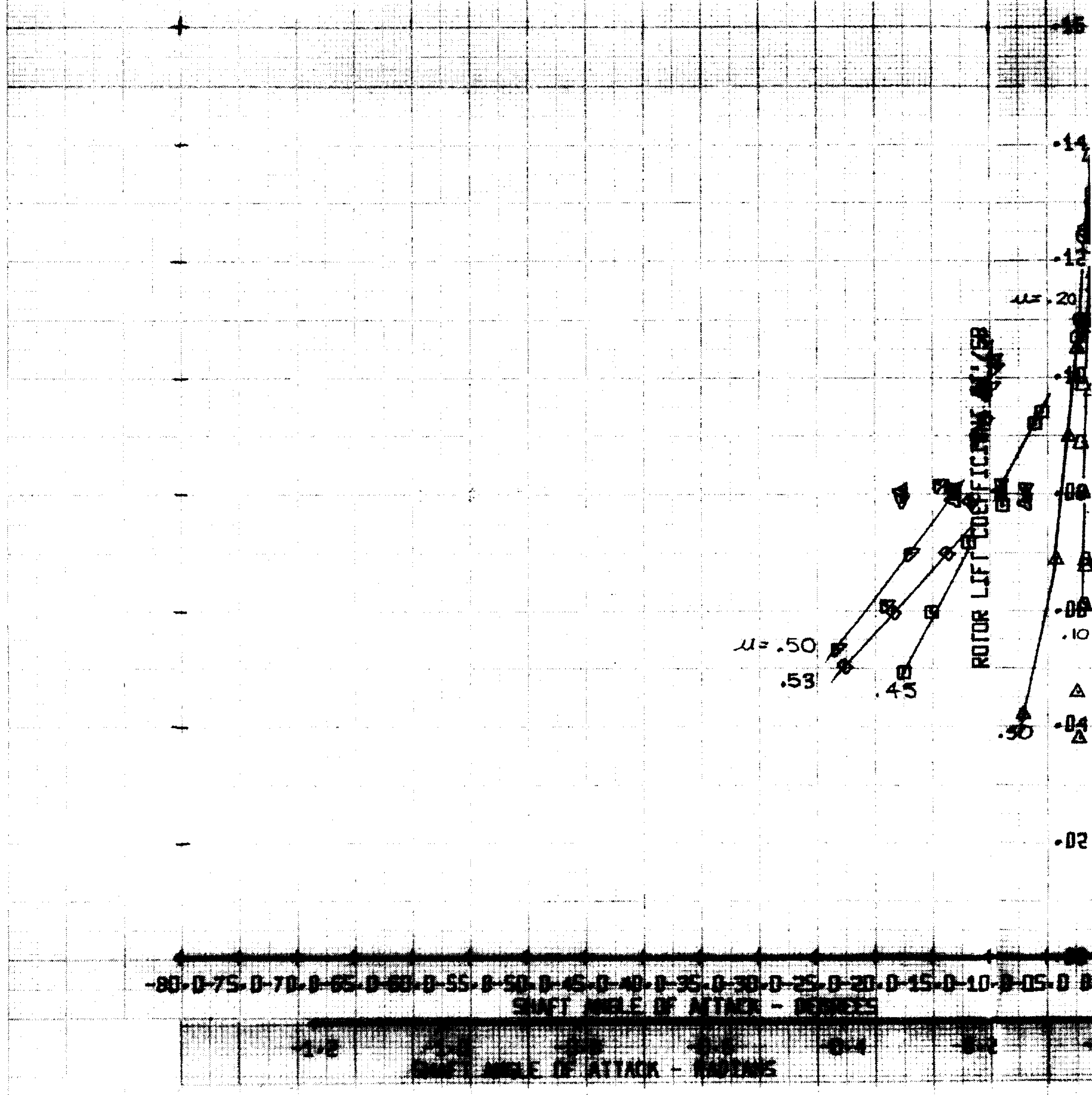
SET 46
BVWT 193

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

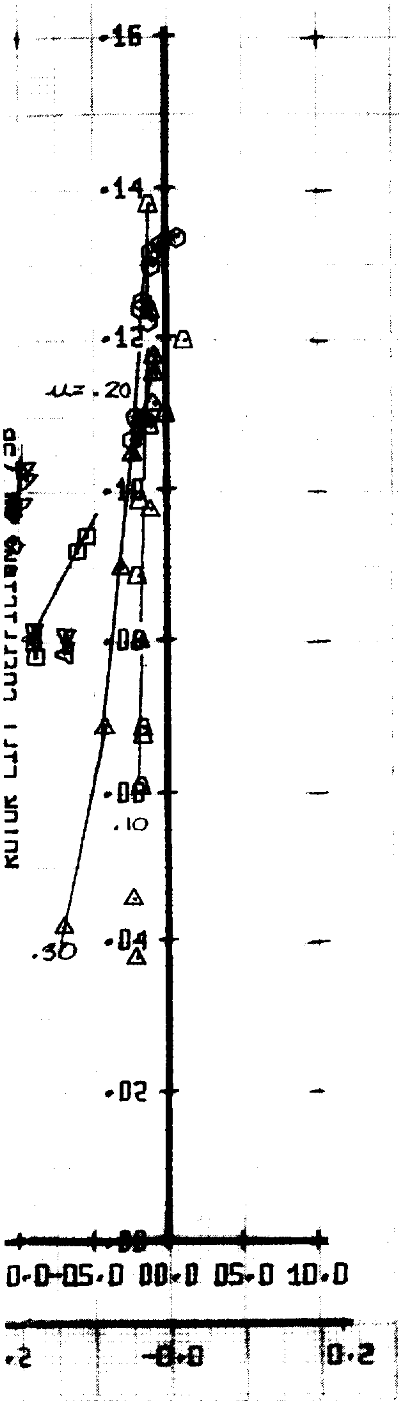
SYM	RUN	MU'	X/QD2SB	VTUN
⊡	227	.45	.05	279
◸	225	.50	.05	310
◇	224	.53	.05	328
▽	273	RANGE	.05	RANGE
◁	274	RANGE	.05	RANGE
△	25	.10	.05	62
○	28	.20	.05	124
△	29	.30	.05	186

ROTOR LIFT COEFFICIENT
VERSUS
SHAFT ANGLE OF ATTACK

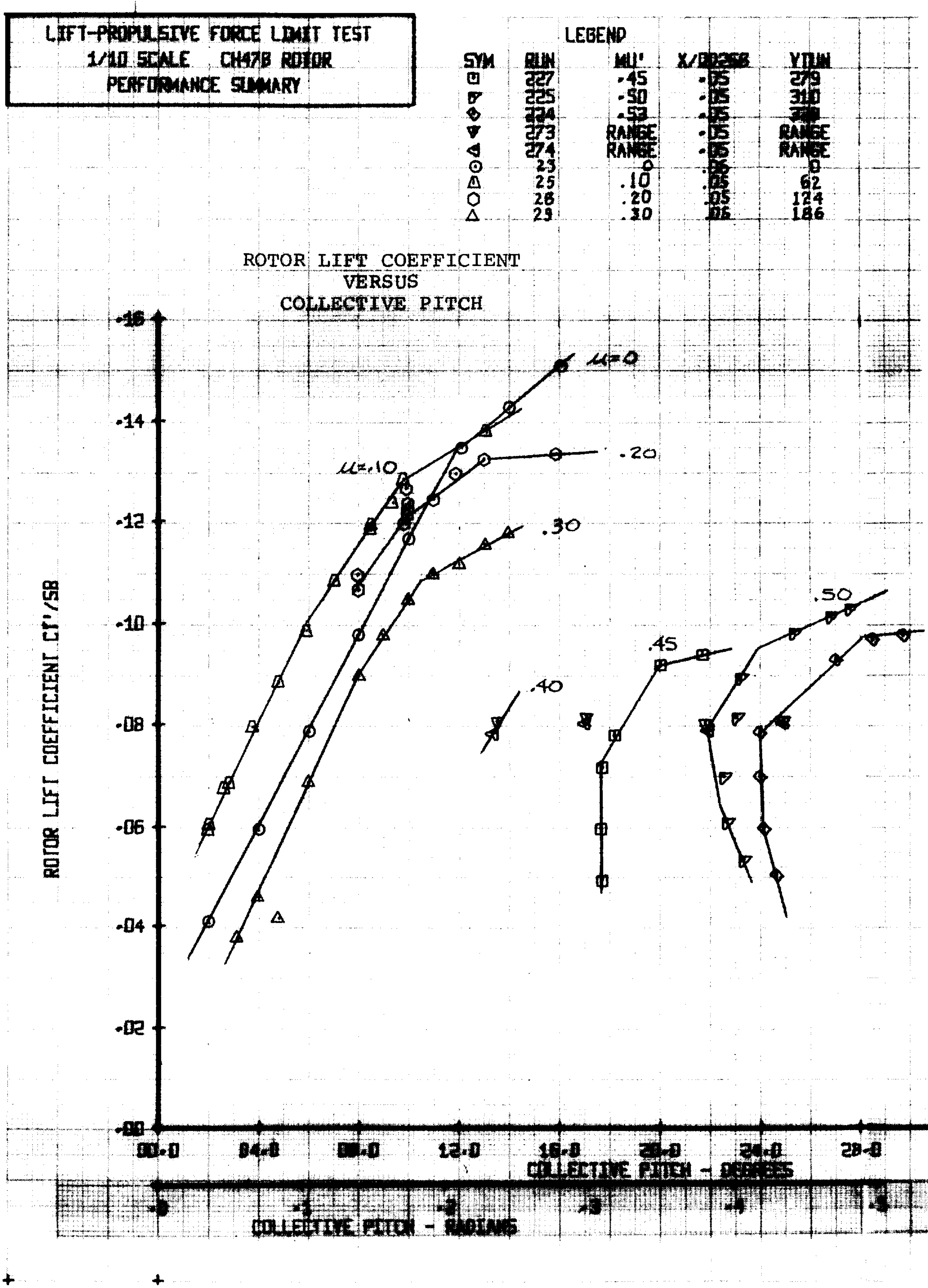


SET 43
BVWT 193

FOLDOUT FRAME /

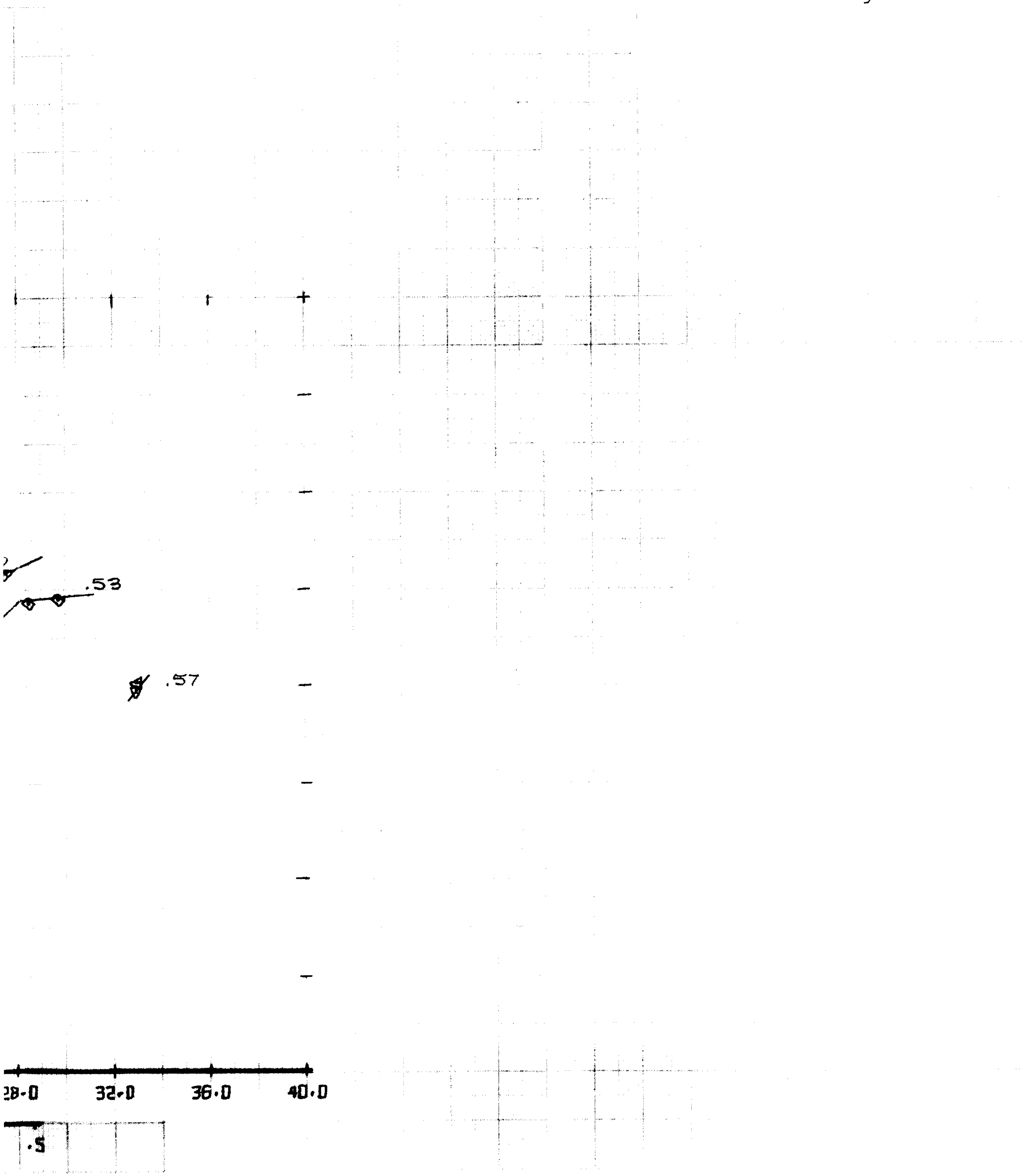


SET 43
BVWT 193



SET 43
BVWT 193

FOLDOUT FRAME 1

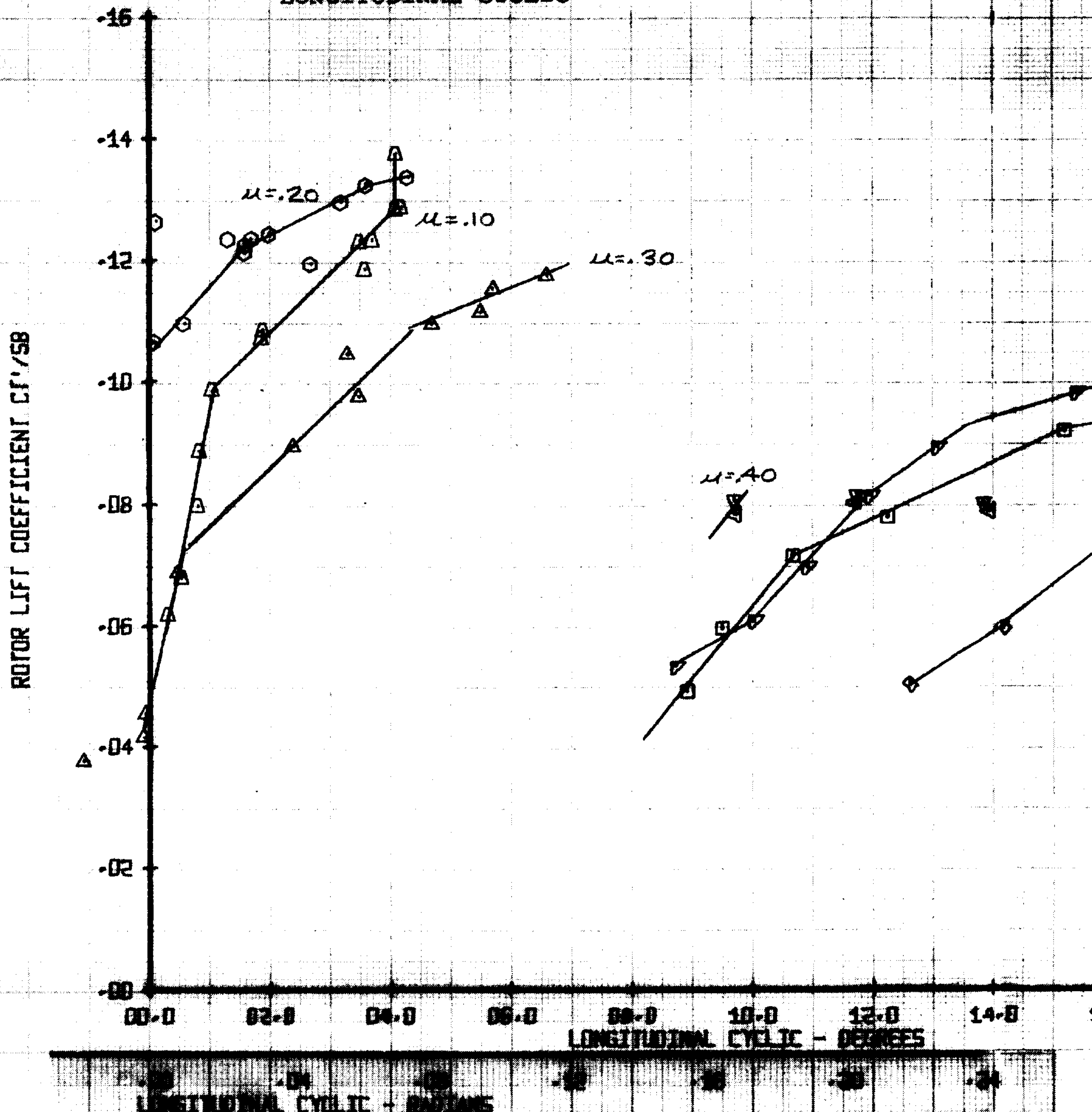

.53
.57
28.0
32.0
36.0
40.0
.5

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

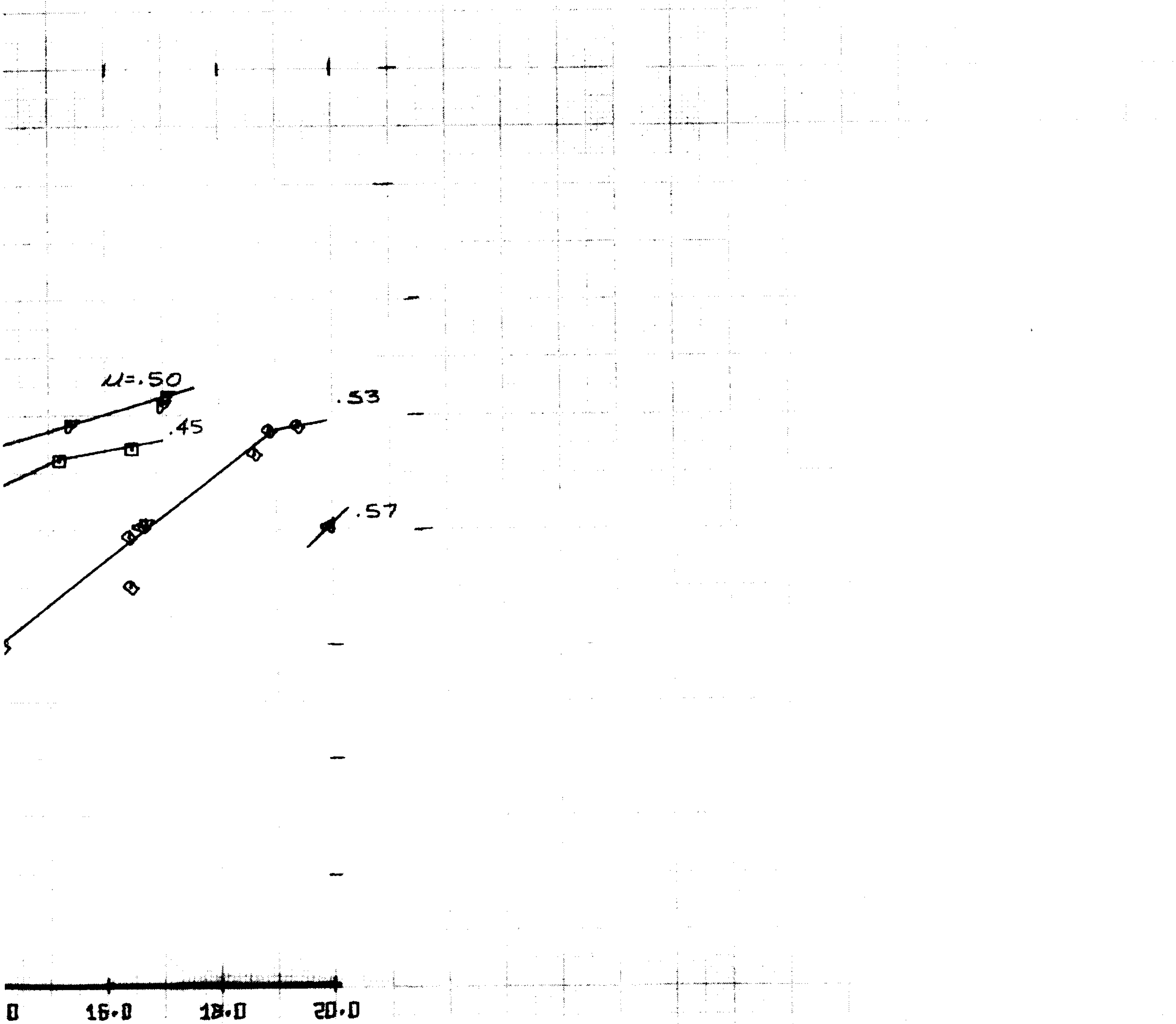
SYM	RUN	MU'	X/QQ2SB	YTUN
□	227	.45	.05	279
▽	225	.50	.05	310
◇	224	.53	.05	[illegible]
▽	273	RANGE	.05	RANGE
◁	274	RANGE	.05	RANGE
△	25	.10	.05	62
⬡	28	.20	.05	124
△	29	.30	.05	186

ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC



SET 43
BVWT 193

FOLDOUT FRAME 1



μ=.50
.45
.53
.57
0
16.0
18.0
20.0

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

SYM	RUN	MU'	X/DD25B	YTUN
□	227	.45	.05	279
▽	225	.50	.05	310
◇	224	.53	.05	328
▽	273	RANGE	.05	RANGE
◁	274	RANGE	.05	RANGE
△	25	.10	.05	62
○	28	.20	.05	124
△	29	.30	.05	186

ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC

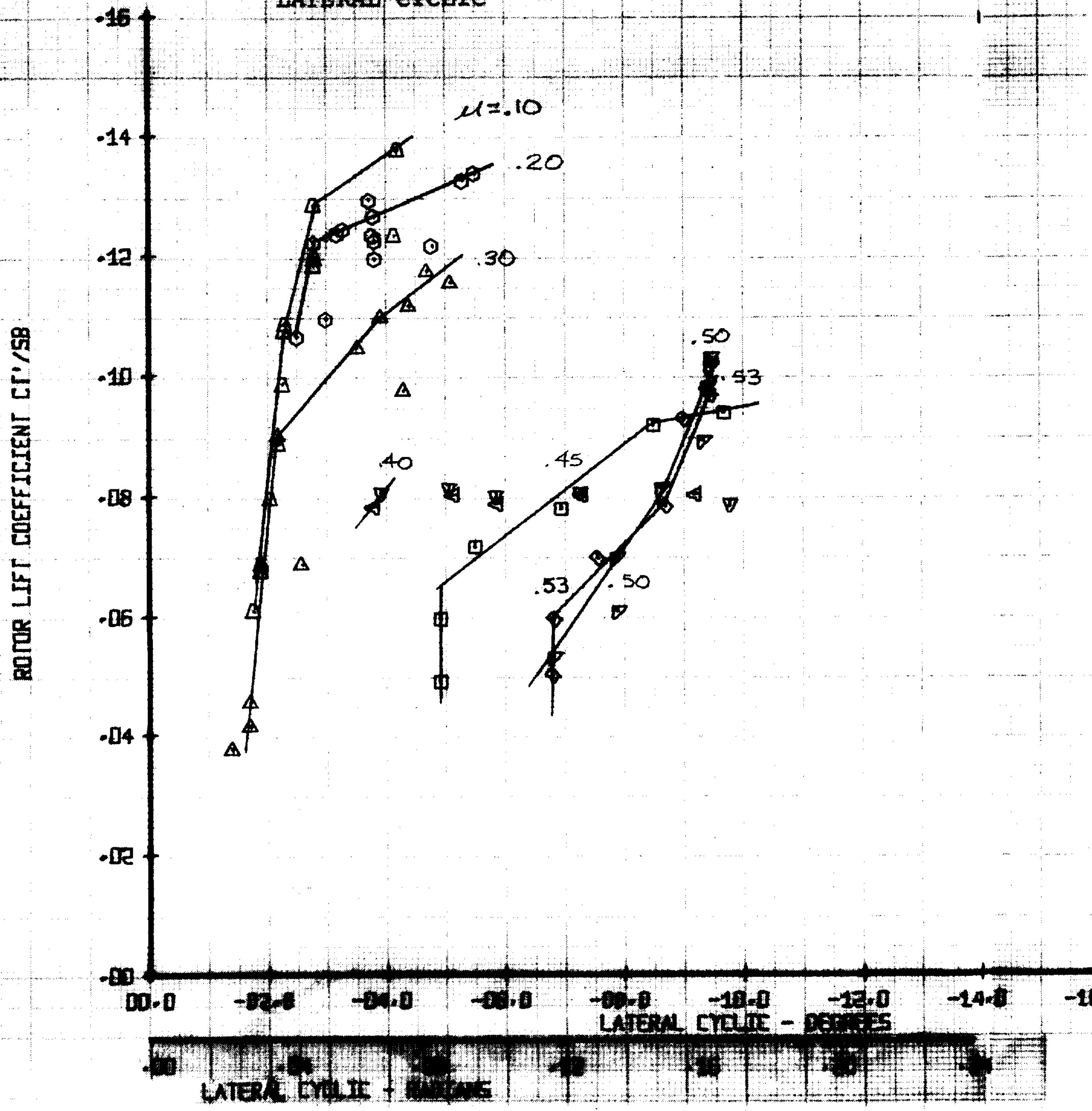
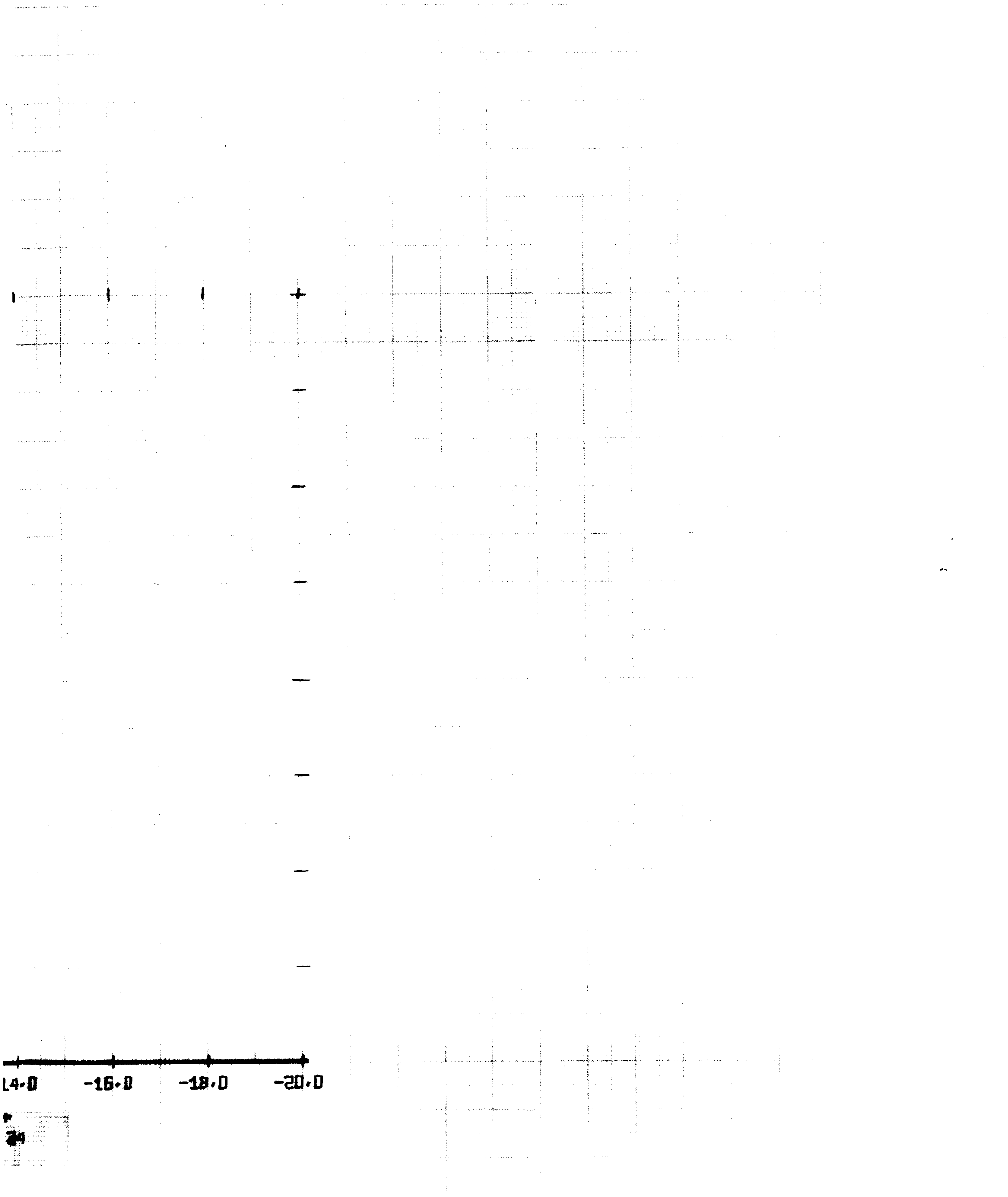


Figure D-16



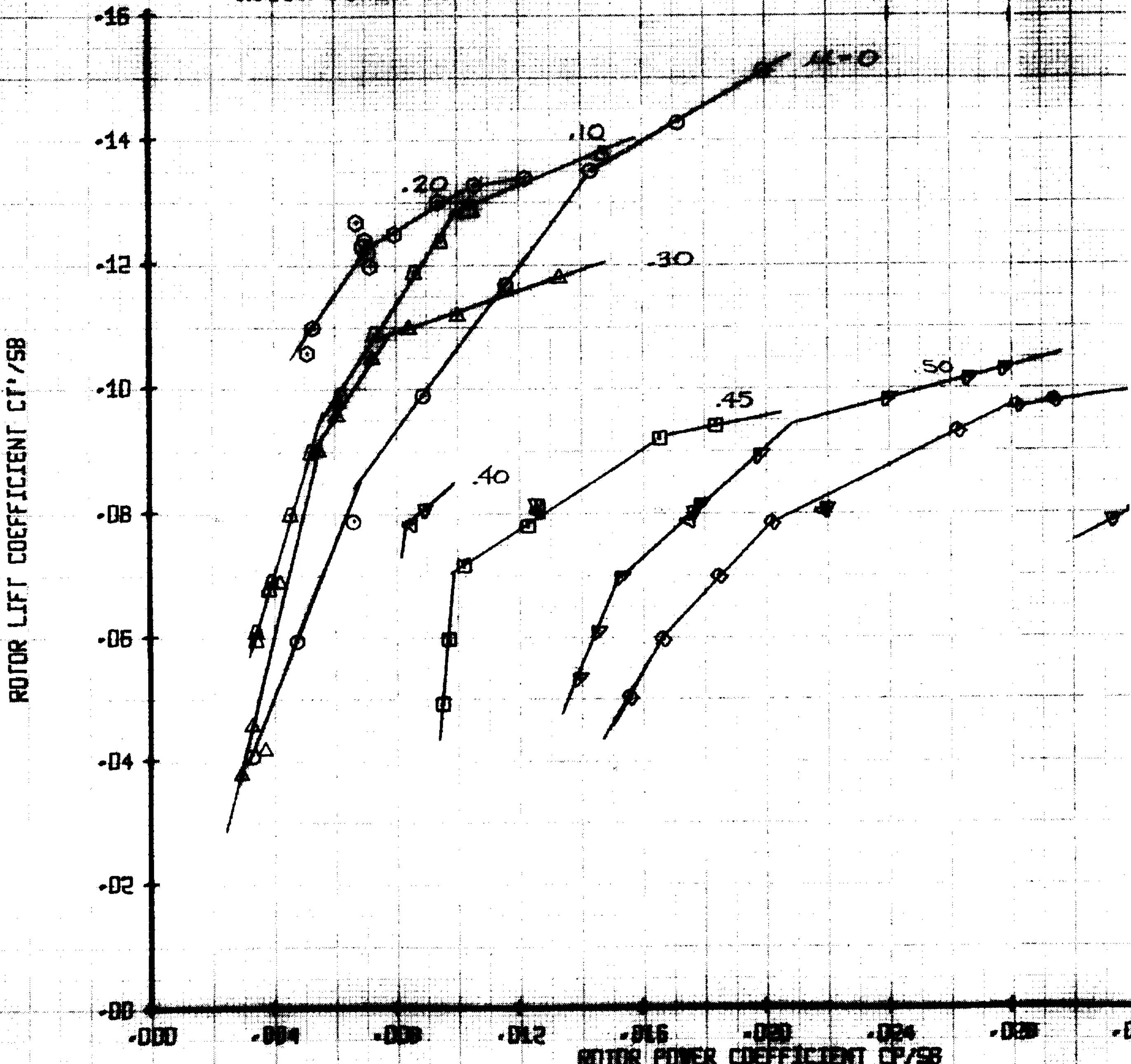
SET 43
BVWT 193

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

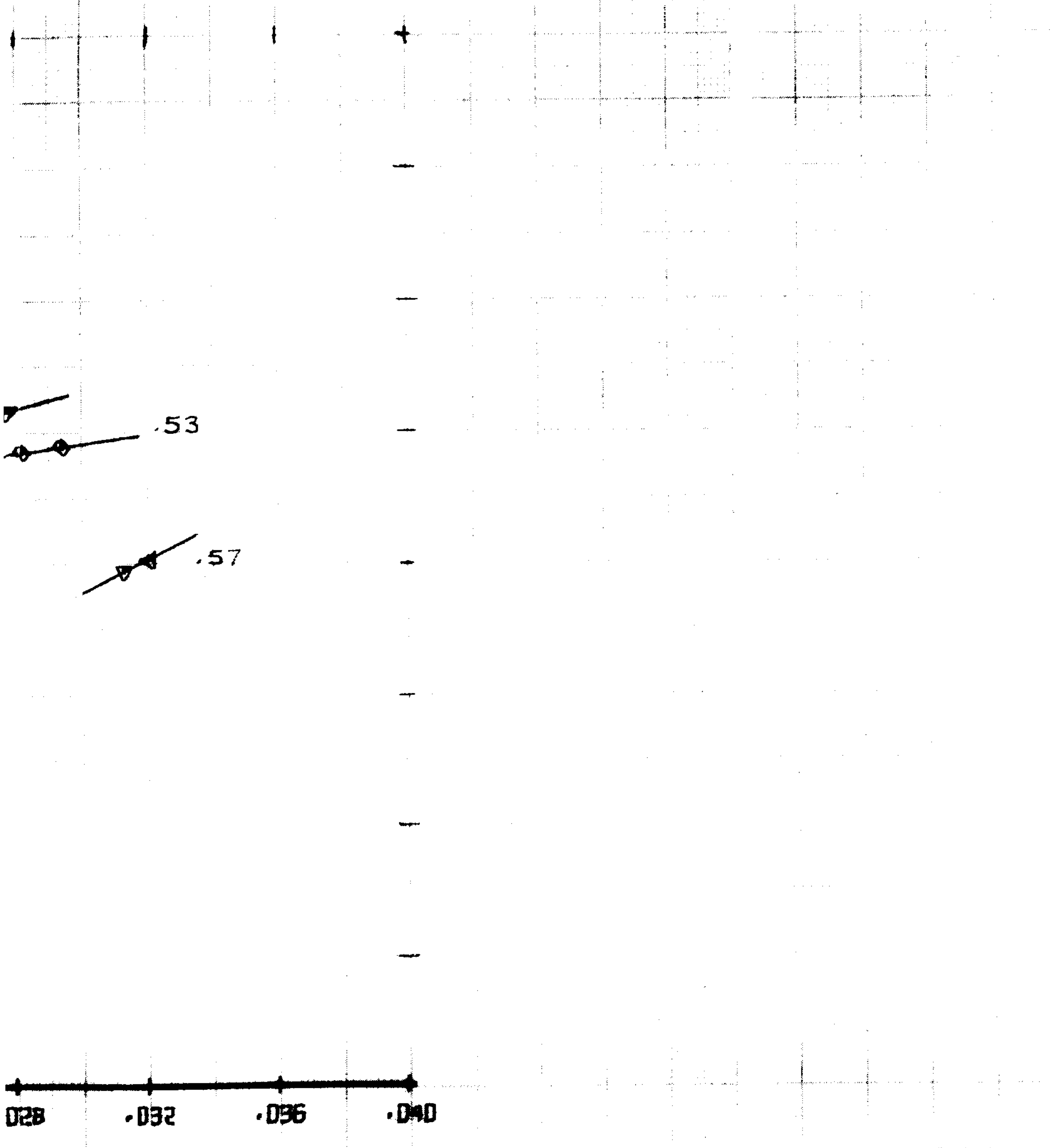
SYM	RUN	MU'	X/QD2SB	VTUN
⊡	227	.45	.05	279
▽	225	.50	.05	310
◇	224	.53	.05	328
▼	273	RANGE	.05	RANGE
◁	274	RANGE	.05	RANGE
⊙	23	0	.05	0
△	25	.10	.05	62
○	28	.20	.05	124
△	29	.30	.05	186

ROTOR LIFT COEFFICIENT
VERSUS
ROTOR POWER COEFFICIENT



SET 43
BVWT 193

FOLDOUT FRAME

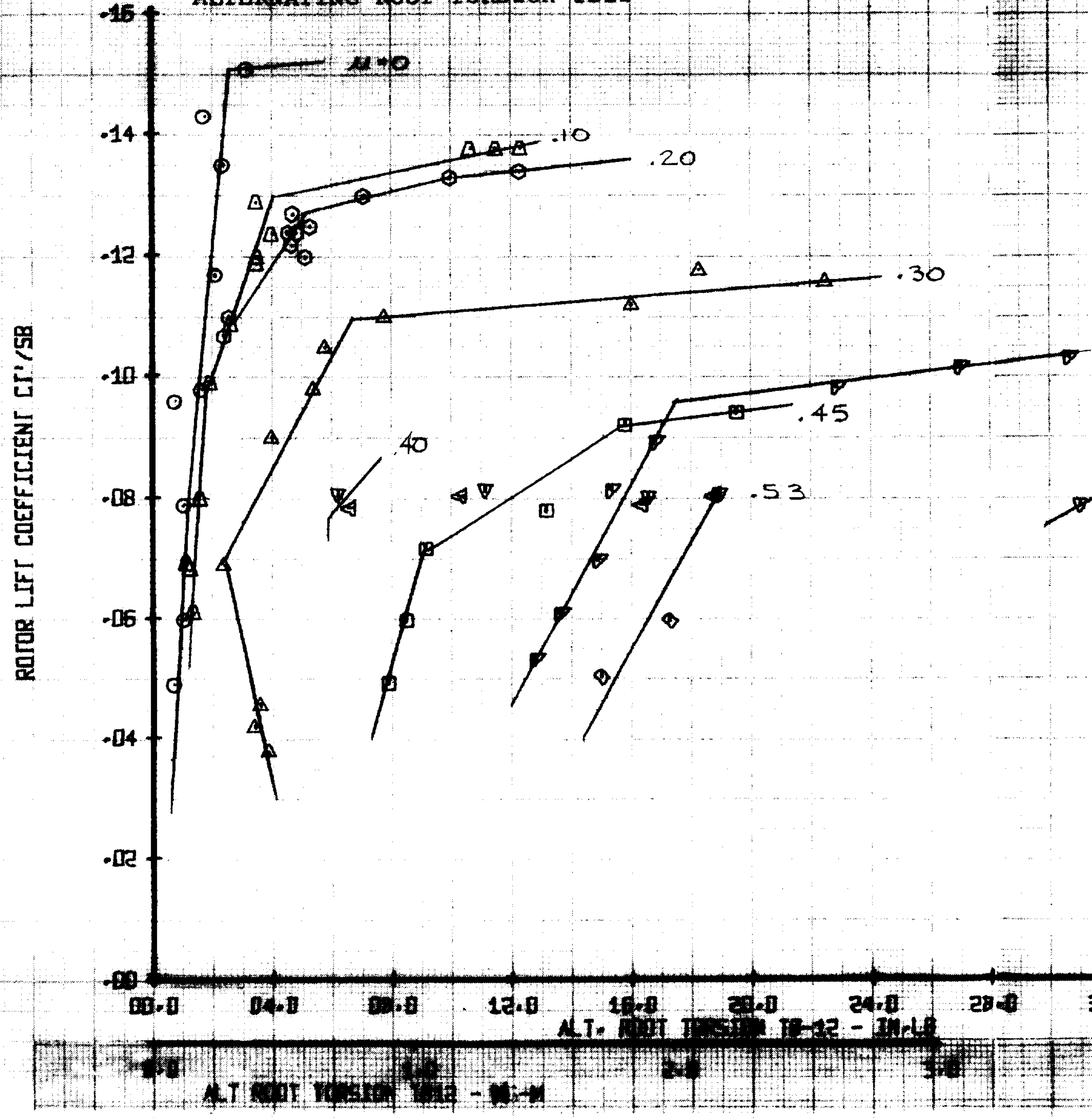

.53
.57
.028
.032
.036
.040

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

SYM	RUN	MU'	X/QD2SB	VTUN
⊡	227	.45	.05	279
▽	225	.50	.05	310
◇	224	.53	.05	329
▽	273	RANGE	.05	RANGE
◁	274	RANGE	.05	RANGE
⊙	23	0	.05	0
△	25	.10	.05	62
⬡	28	.20	.05	124
△	29	.30	.05	186

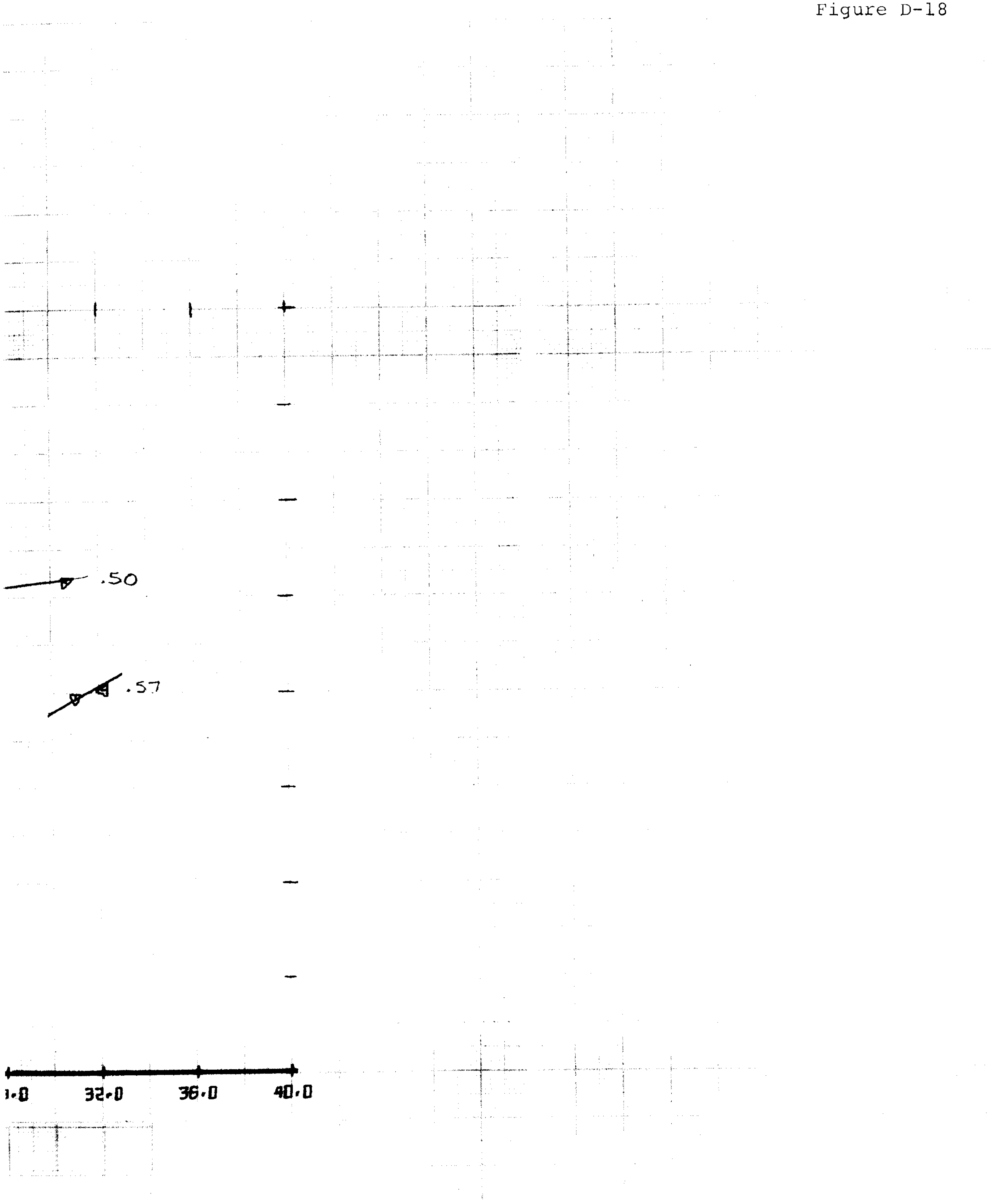
ROTOR LIFT COEFFICIENT
VERSUS
ALTERNATING ROOT TORSION TB12



SET 43
BVWT 193

FOLDOUT FRAME

Figure D-18

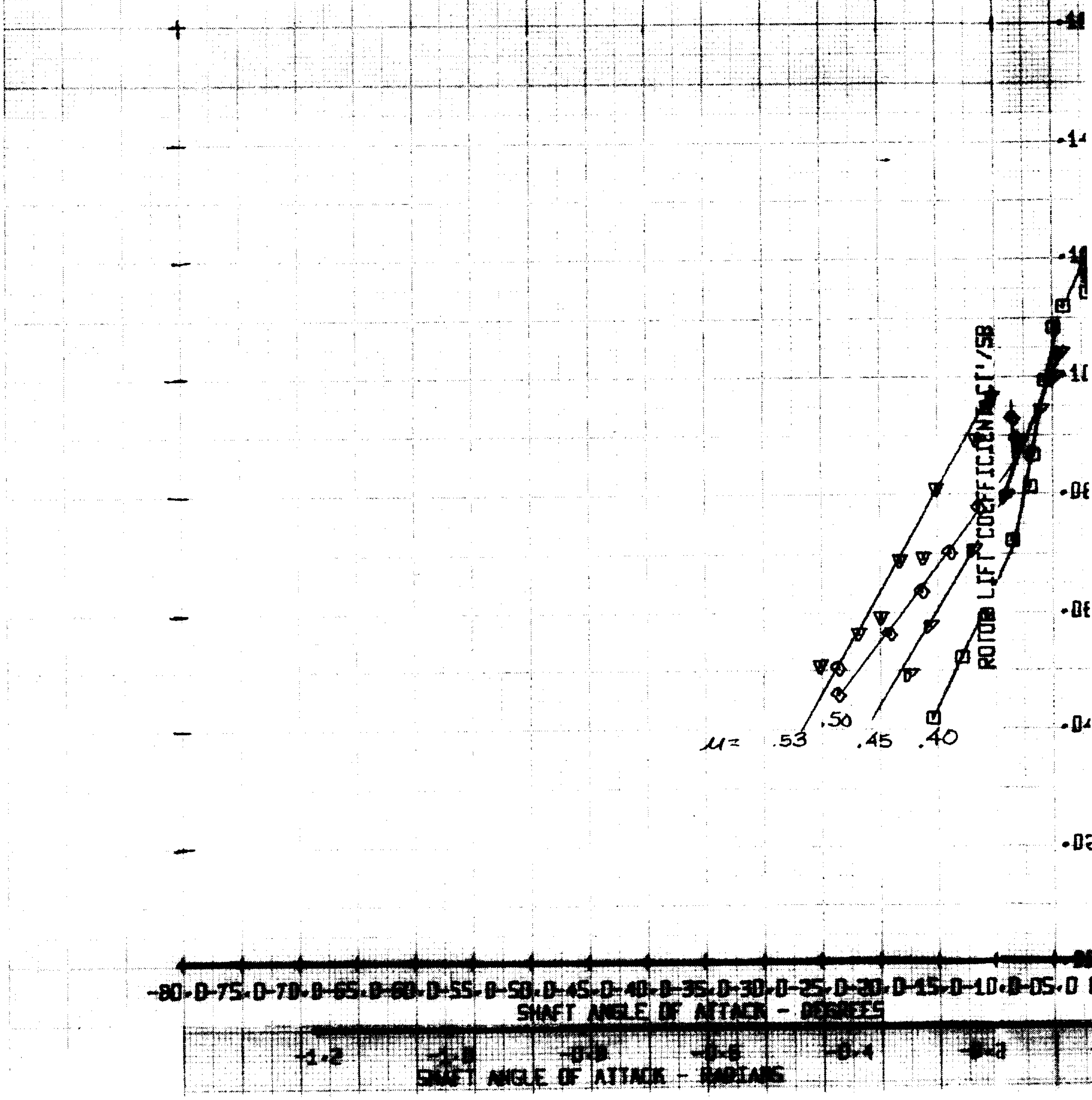


LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

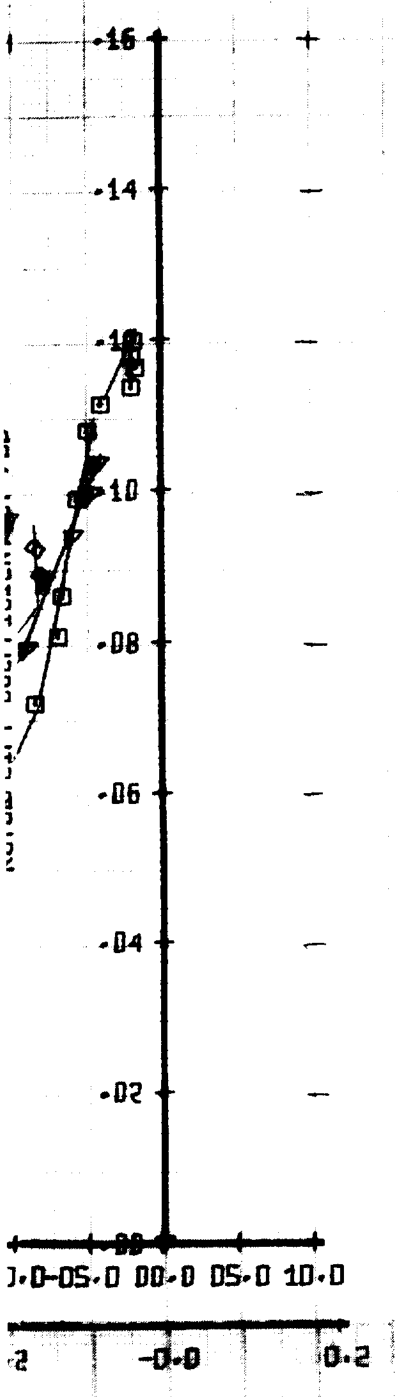
SYM	RUN	MU'	X/QD2SB	VTUN
⊡	250	.40	.05	228
▽	251	.45	.05	256
◇	252	.50	.05	285
▽	253	.53	.05	302

ROTOR LIFT COEFFICIENT
VERSUS
SHAFT ANGLE OF ATTACK



SET 45
BVWT 193

FOLDOUT FRAME

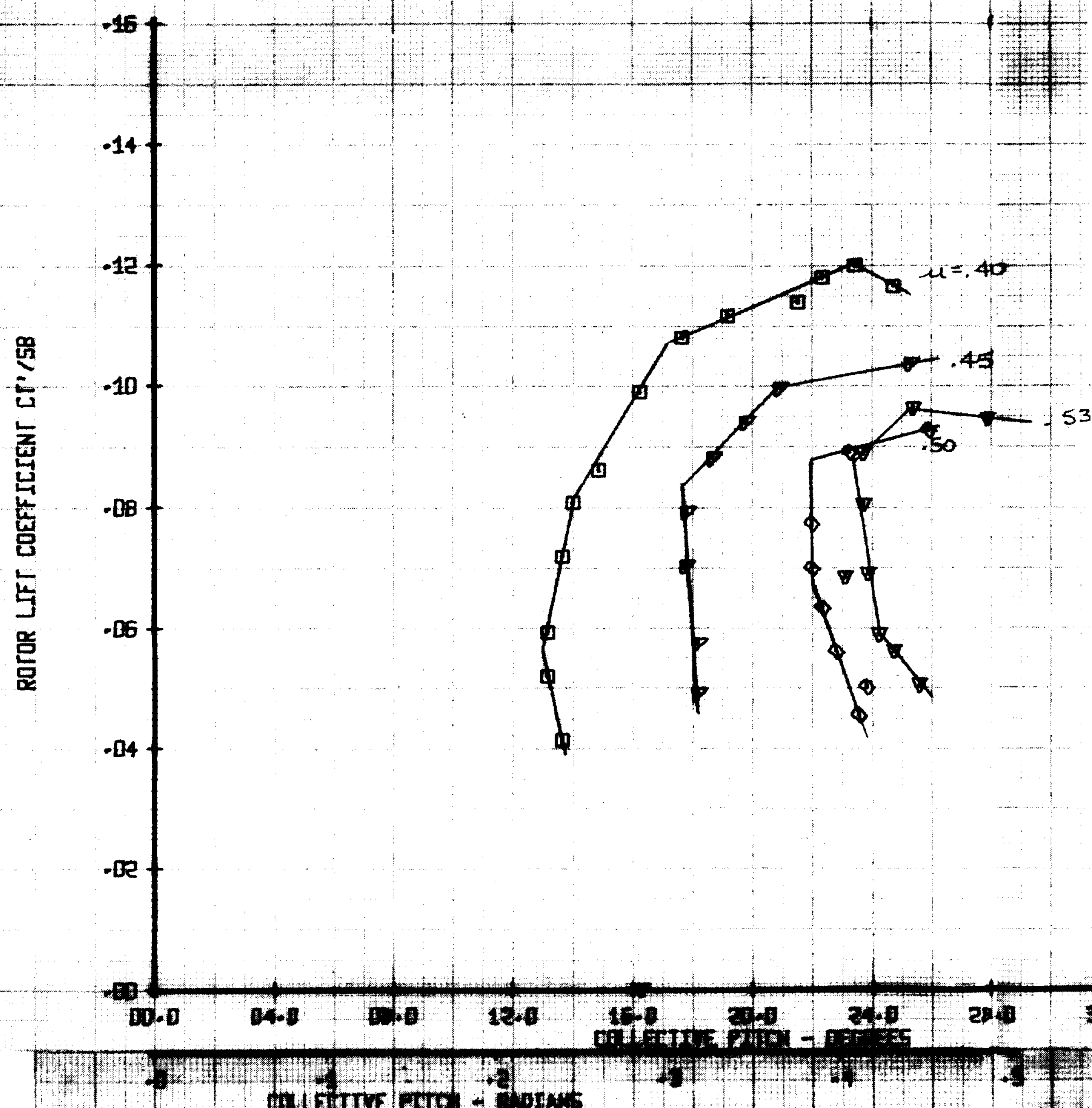

.16
.14
.12
.10
.08
.06
.04
.02
.00
0.0-05.0 00.0 05.0 10.0
-0.0
0.2

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

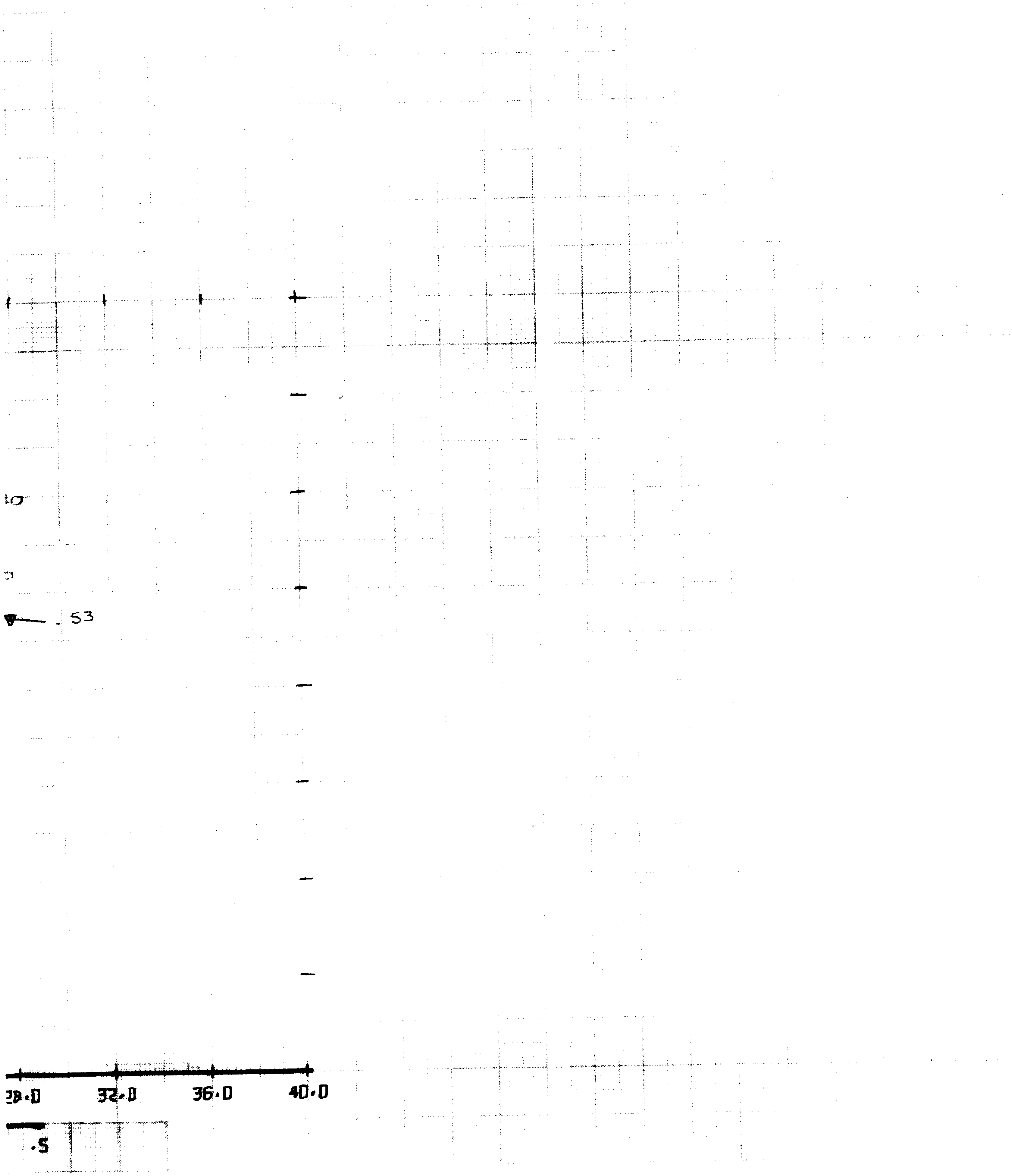
SYM	RUN	MU'	X/QD25B	VTUN
⊡	250	.40	.05	280
▽	251	.45	.05	296
◇	252	.50	.05	305
▼	253	.53	.05	302

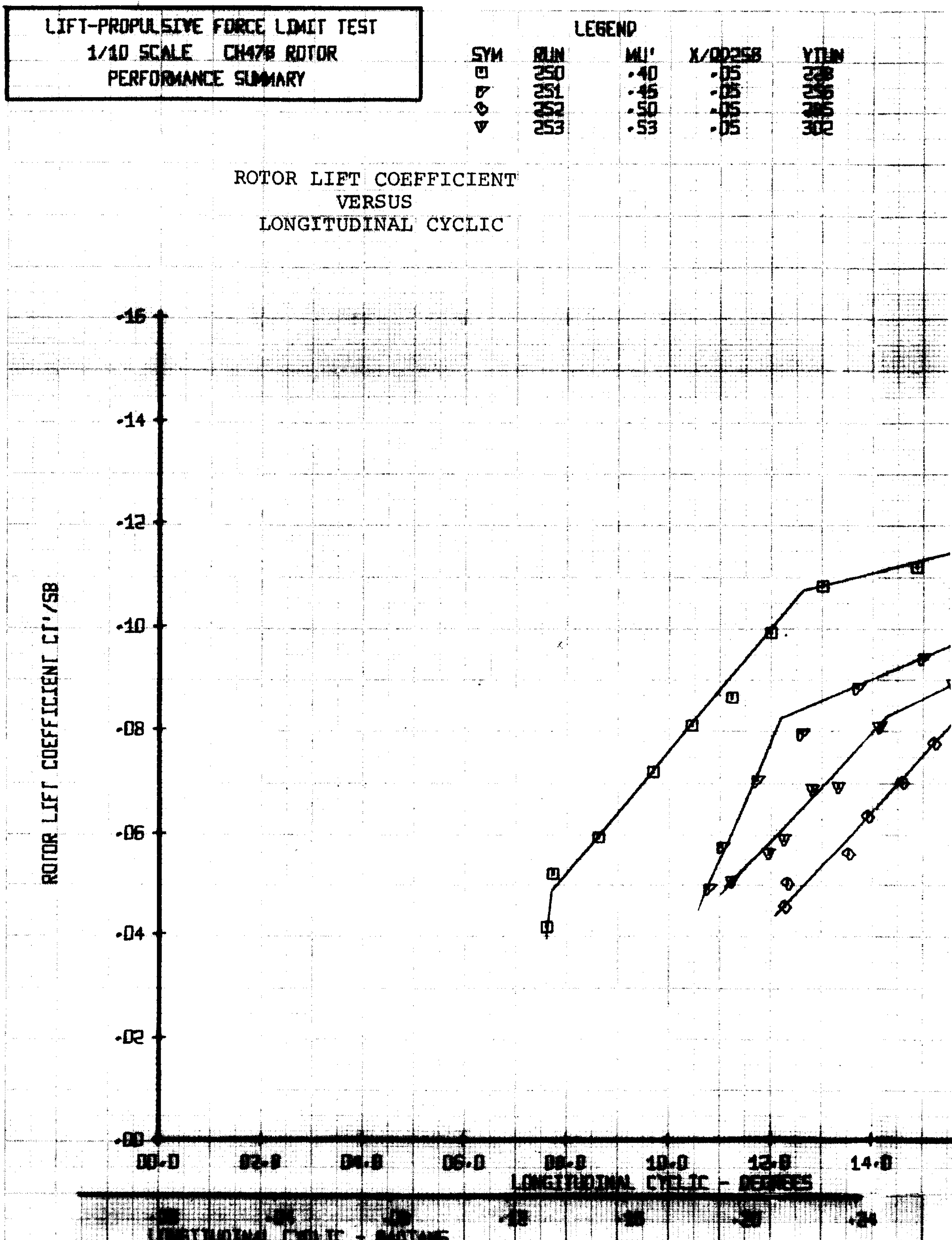
ROTOR LIFT COEFFICIENT
VERSUS
COLLECTIVE PITCH



SET 45
BVWT 193

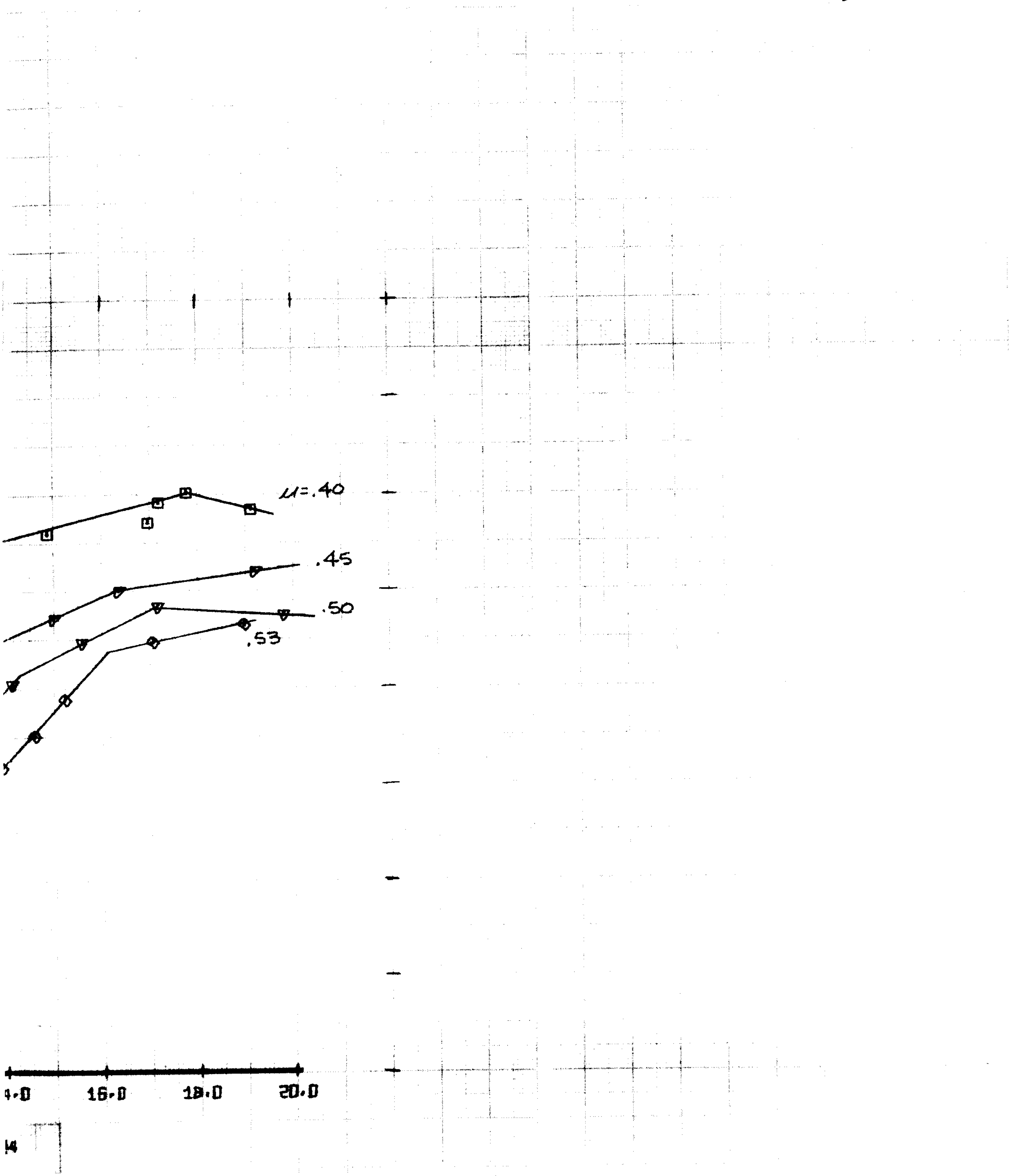
FOLDOUT FRAME


10
5
.53
28.0
32.0
36.0
40.0
.5



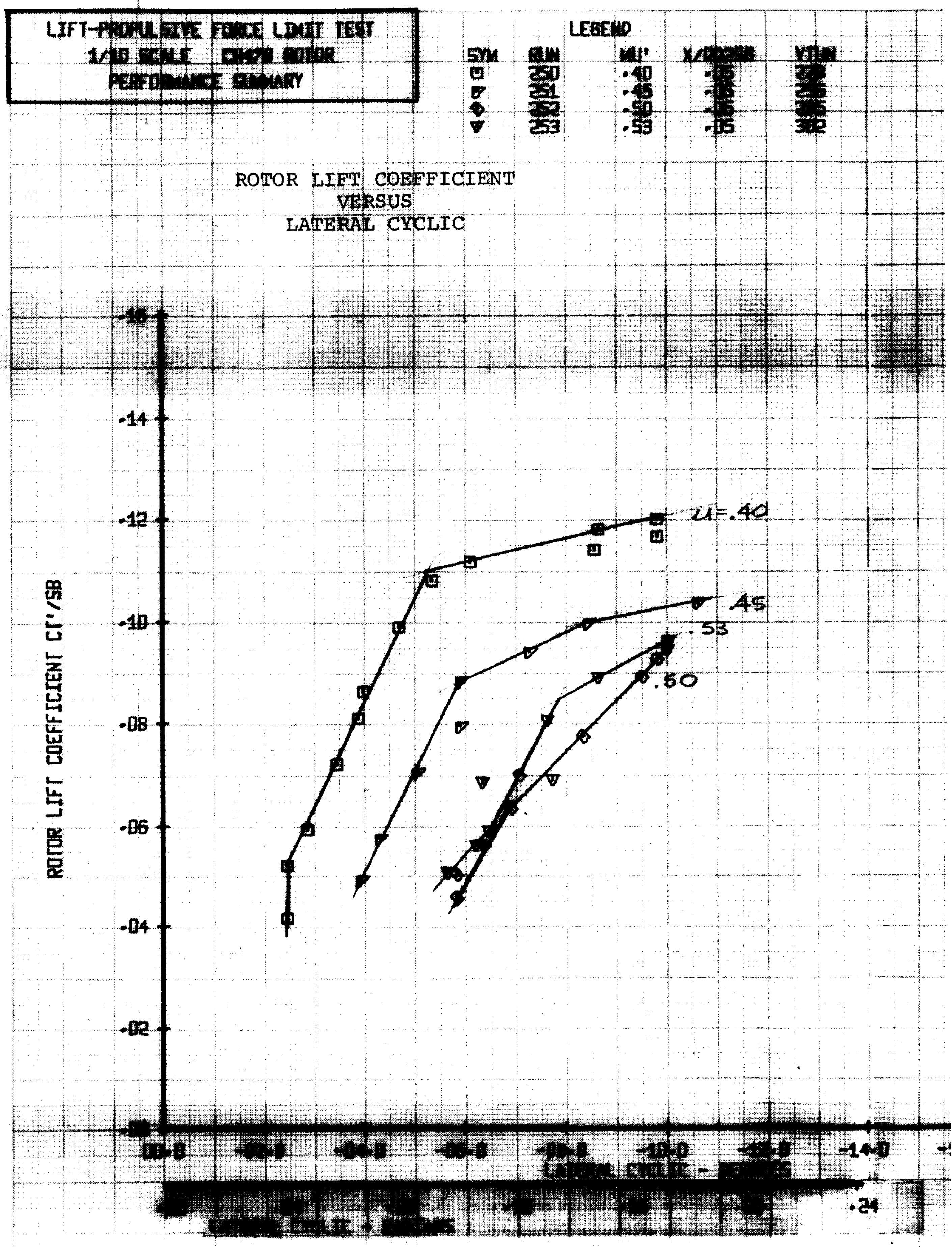
SET 45
BVWT 193

FOLDOUT FRAME



μ=.40
.45
.50
.53
4.0
16.0
18.0
20.0

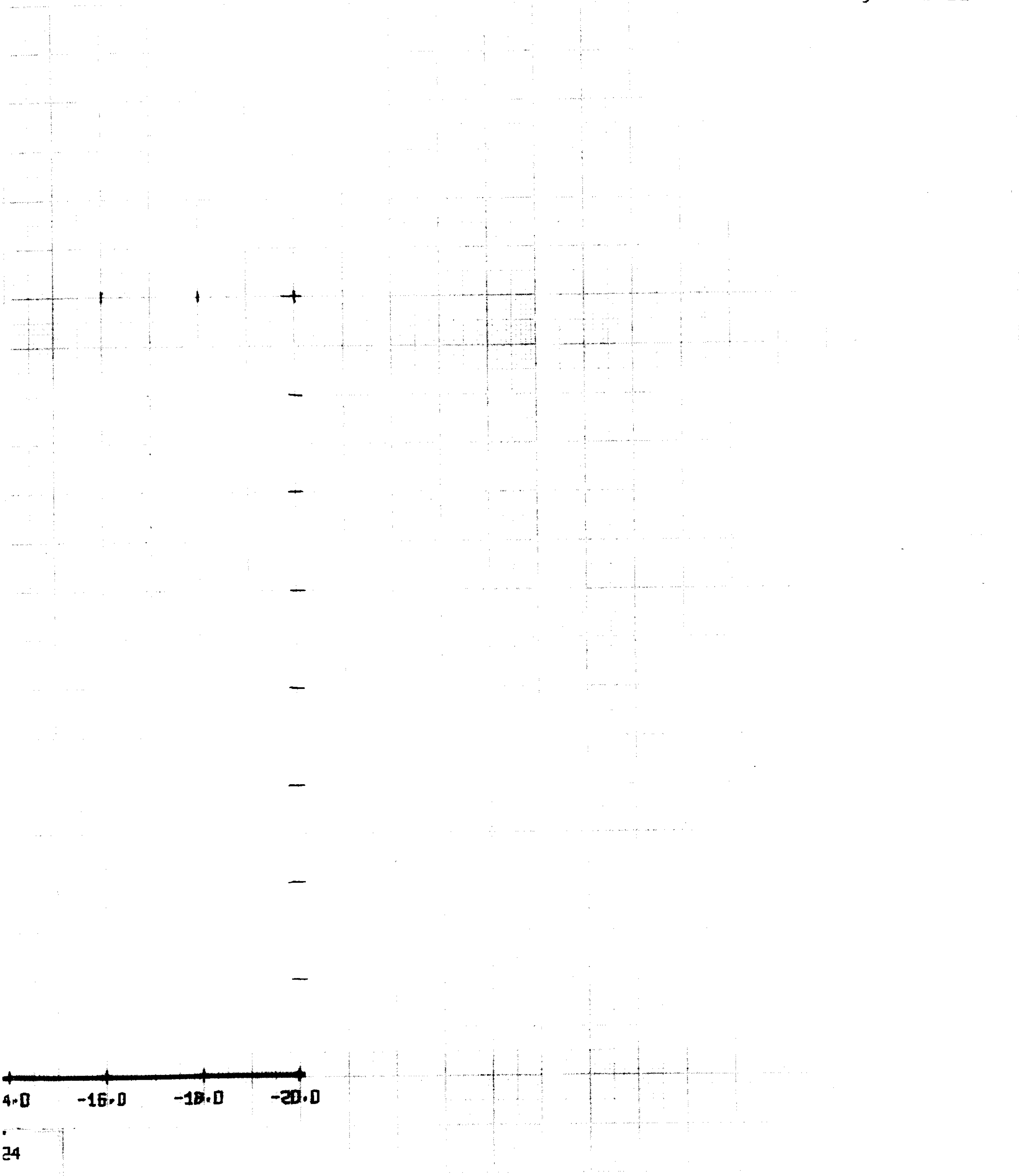
LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH47B ROTOR
PERFORMANCE SUMMARY



SET 45
BVWT 193

FOLDOUT FRAME /

Figure D-22



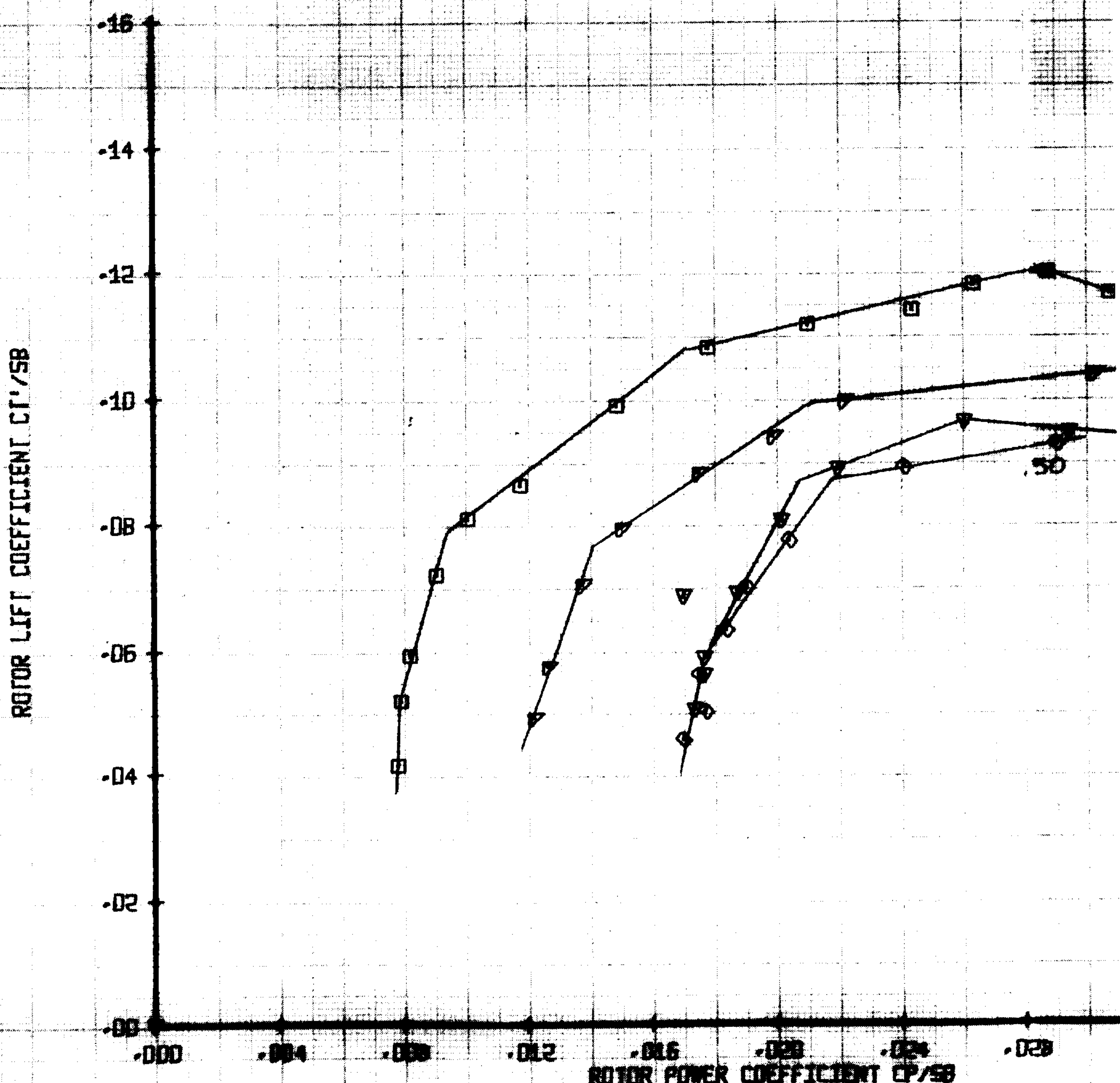
 FOLDOUT FRAME 2 SET 45 BVWT 193

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE   CH47B ROTOR
PERFORMANCE SUMMARY

LEGEND

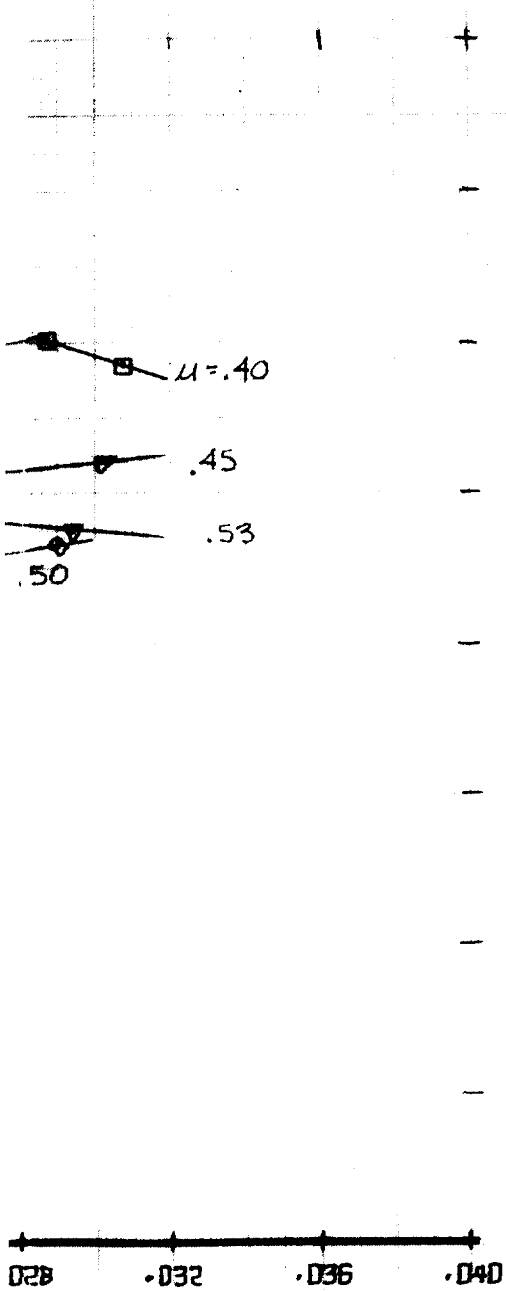
SYM	RUN	MU'	X/QQ2SB	VTUN
□	250	.40	.05	220
◸	251	.45	.05	256
◇	252	.50	.05	285
▽	253	.53	.05	302

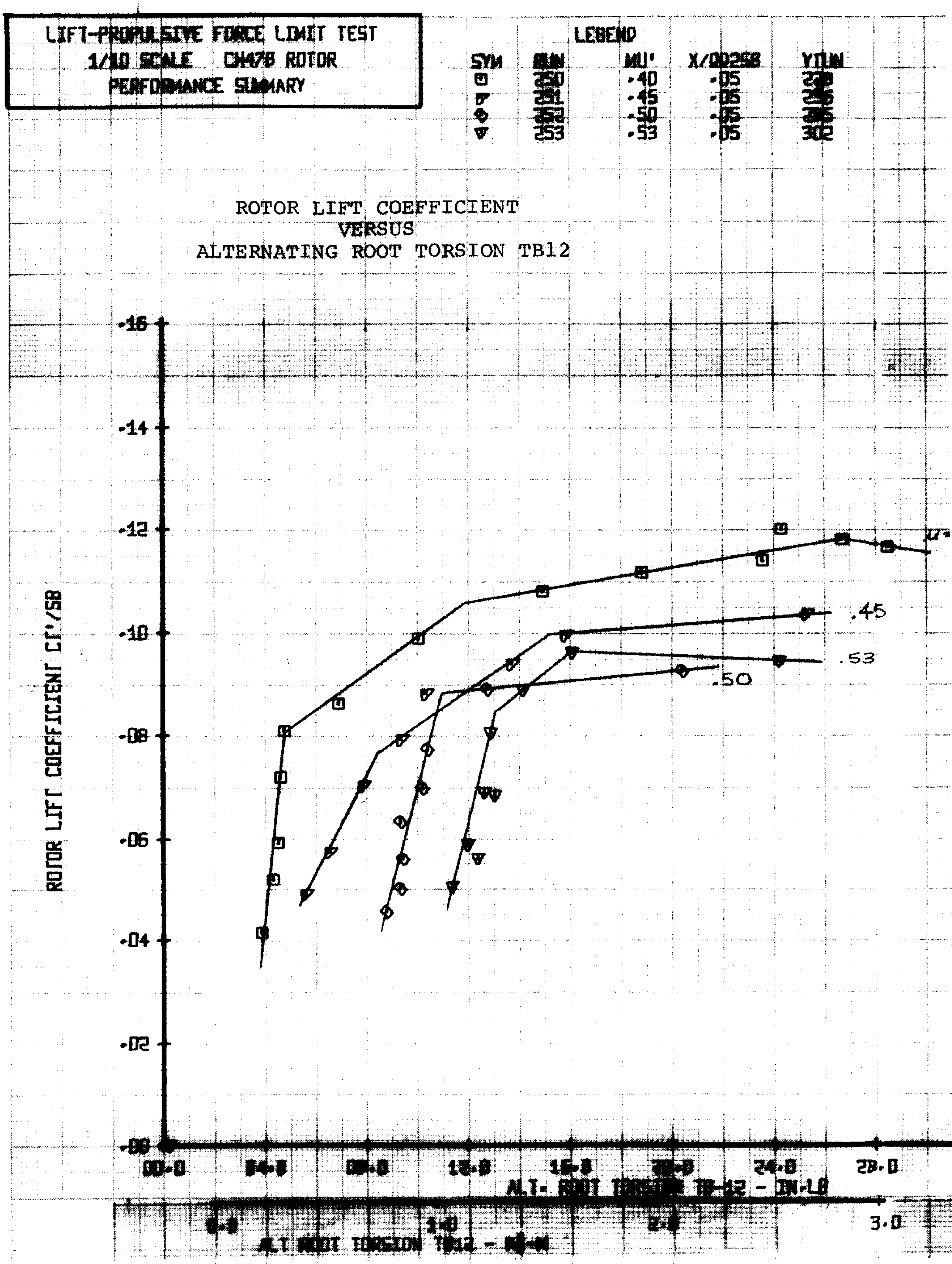
ROTOR LIFT COEFFICIENT
VERSUS
ROTOR POWER COEFFICIENT



SET 45
BVWT 193

FOLDOUT FRAME

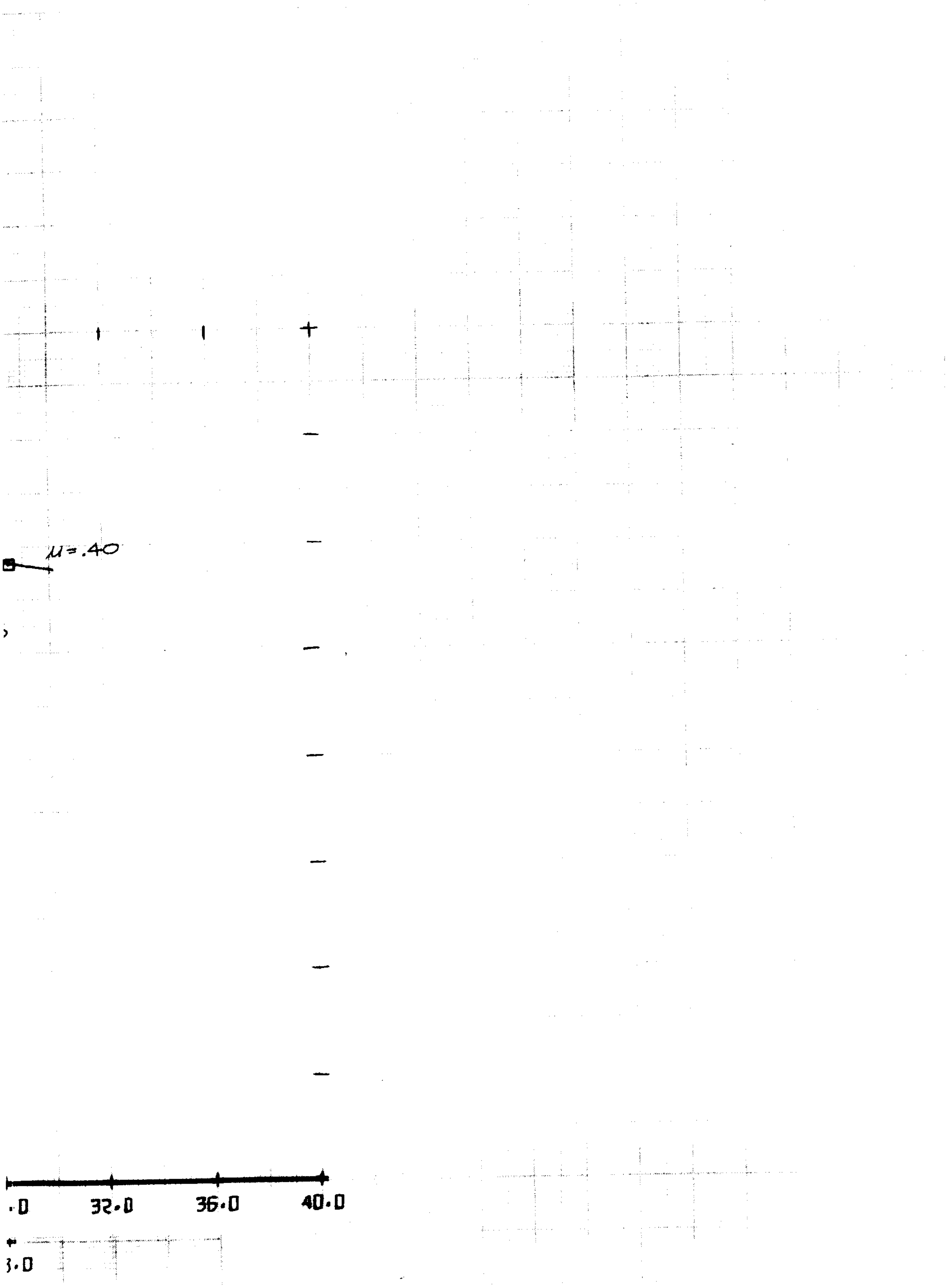

μ=.40
.45
.53
.50
.028
.032
.036
.040



SET 45
BVWT 193

FOLDOUT FRAME /

Figure D-24



SET 45
BVWT 193

E. Effect of Torsional Stiffness

At the end of the first portion of the test program, a model control system problem caused the destruction of a set of standard blades. A set of rotor blades that were geometrically the same but with a reduced torsional stiffness were selected for interim testing. These soft GJ blades had a torsional stiffness that was reduced by 45 percent of the standard blades. After installing these blades on the model, a run was conducted to determine the frequency spectrum, shown in Figure E-1, at an advance ratio of 0.30 and a rotor lift coefficient of 0.06. Following this run, a forward flight run was made at an advance ratio of 0.57 to determine the lift limit. This data obtained is presented in Figures E-2 through E-17. A second forward flight run was attempted but a severe model problem was encountered which finished Part 1 of the test program.

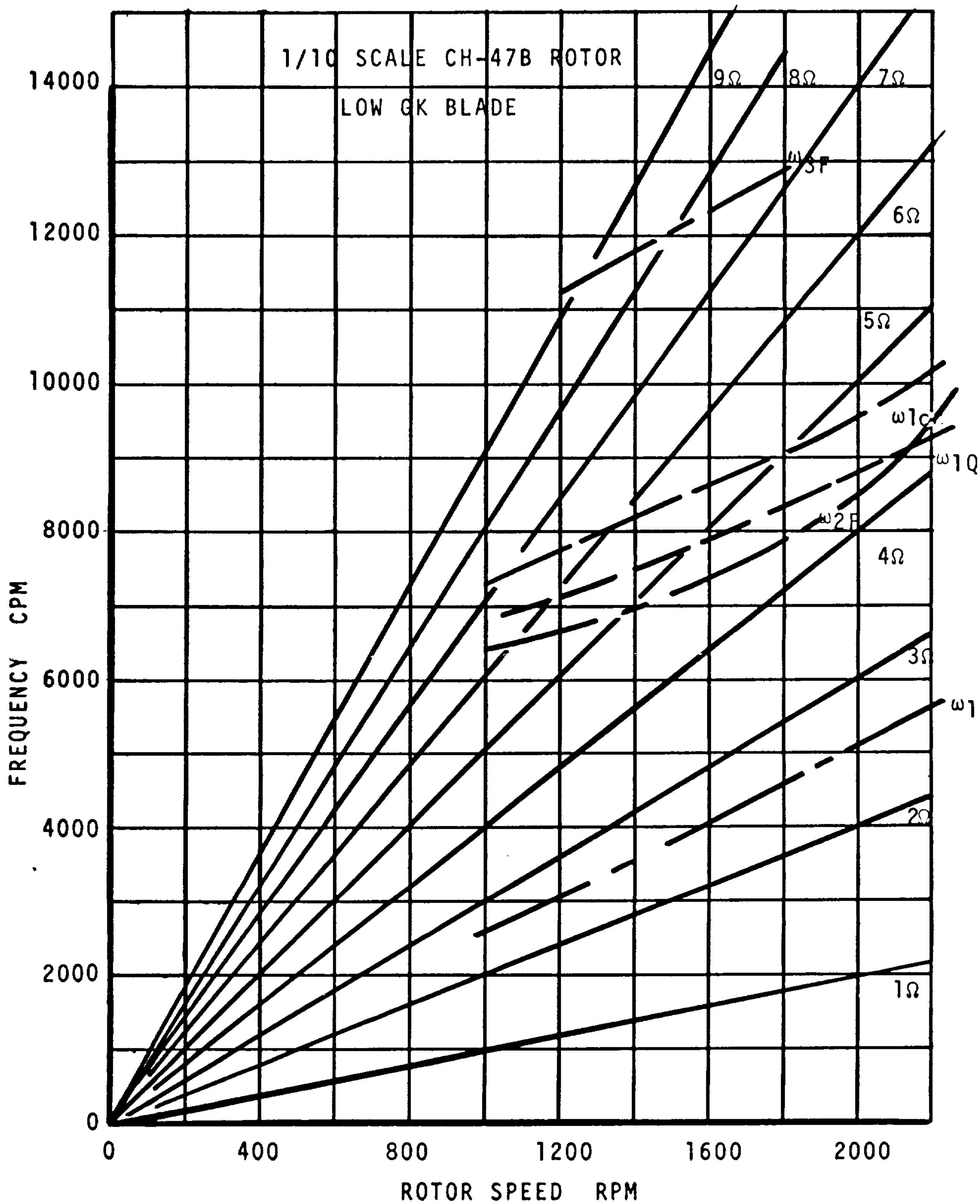
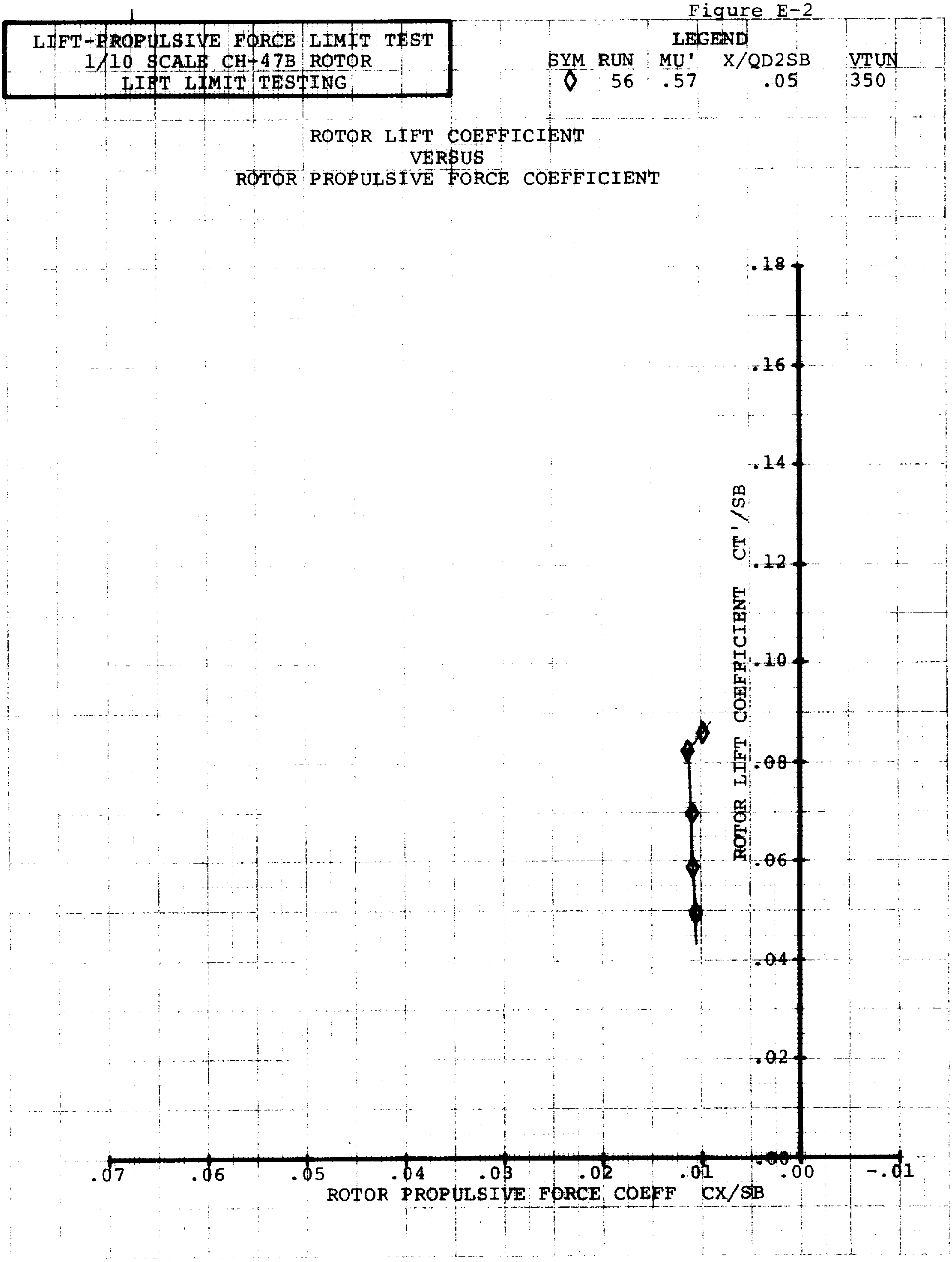
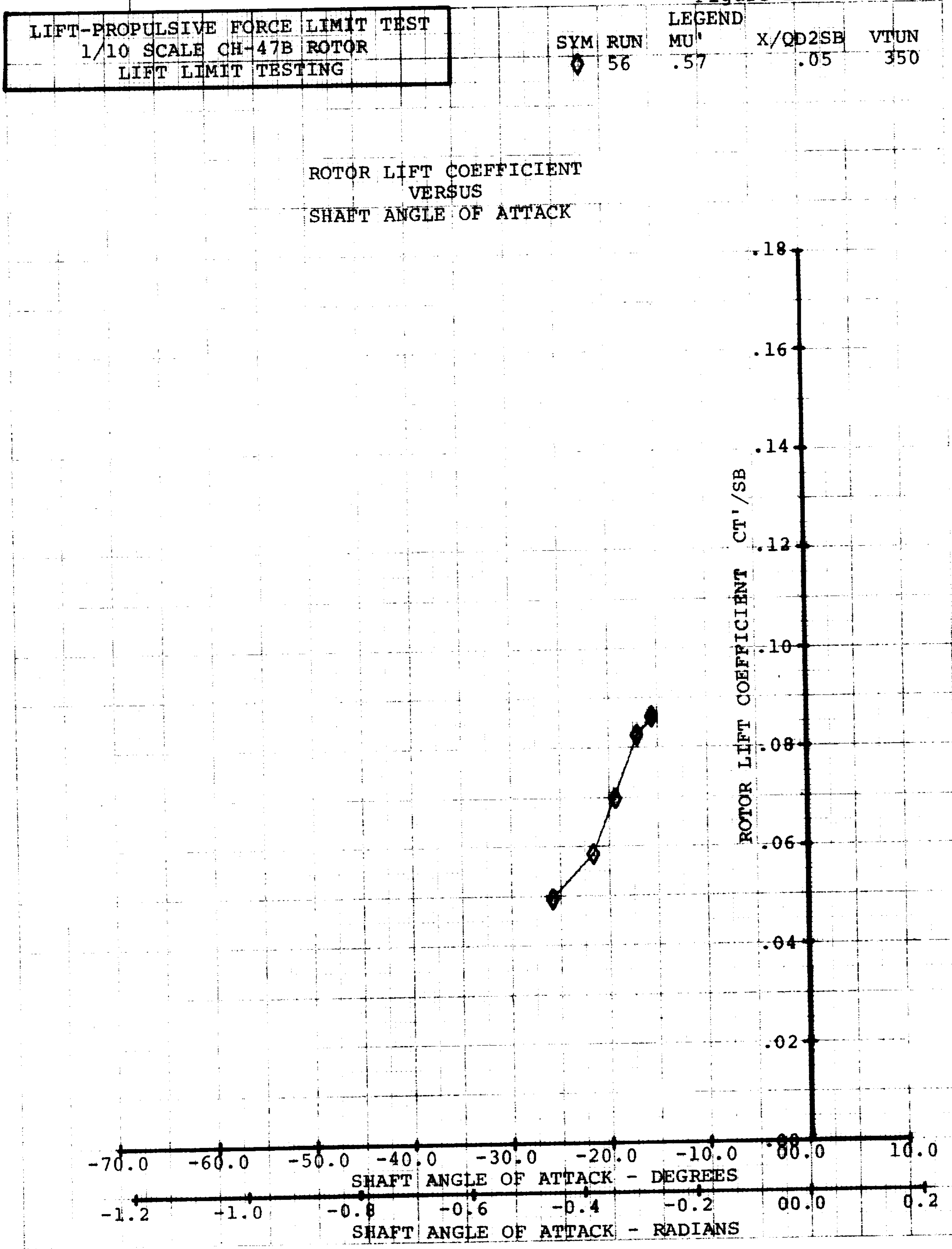


FIGURE E-1 FREQUENCY SPECTRUM FOR TORSIONALLY SOFT BLADE

Figure E-2



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
ROTOR PROPULSIVE FORCE COEFFICIENT
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
.07
.06
.05
.04
.03
.02
.01
.00
-.01
ROTOR PROPULSIVE FORCE COEFF CX/SB



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
SHAFT ANGLE OF ATTACK
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
-70.0 -60.0 -50.0 -40.0 -30.0 -20.0 -10.0 00.0 10.0
SHAFT ANGLE OF ATTACK - DEGREES
-1.2 -1.0 -0.8 -0.6 -0.4 -0.2 00.0 0.2
SHAFT ANGLE OF ATTACK - RADIANS

Figure E-4

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	VTUN
◊	56	.57	.05	350

ROTOR LIFT COEFFICIENT
VERSUS
COLLECTIVE PITCH

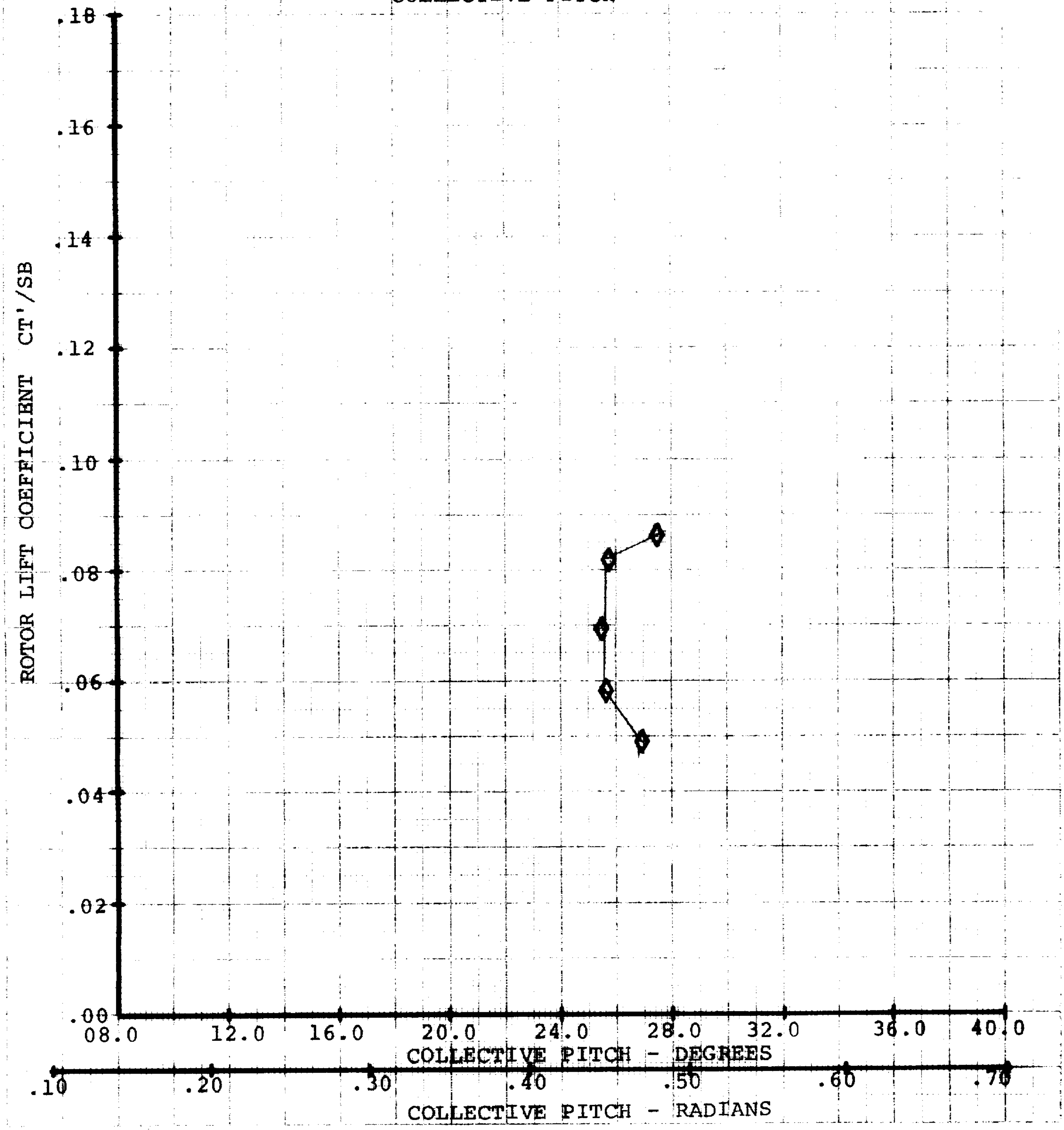


Figure E-5

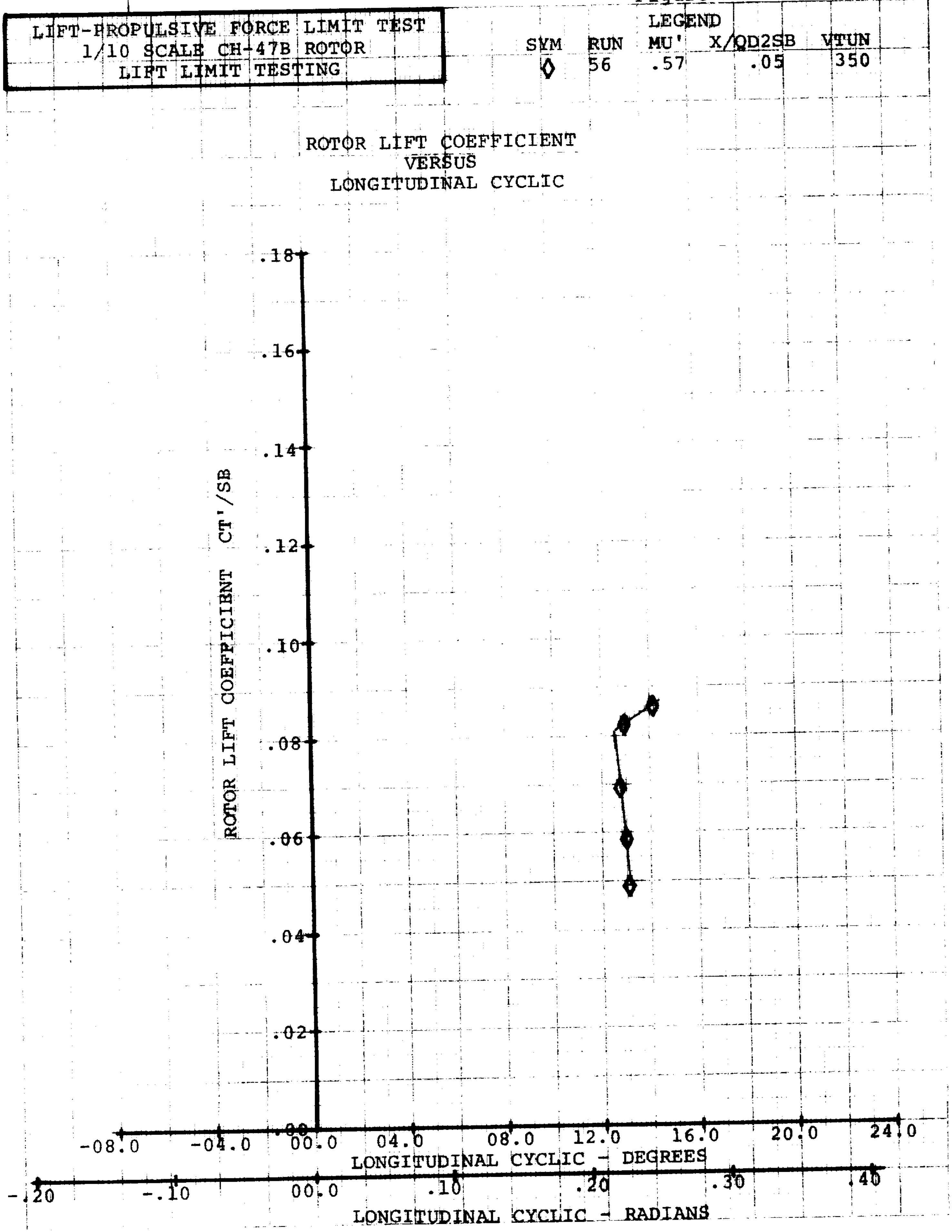

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
LONGITUDINAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
-08.0
-04.0
00.0
04.0
08.0
12.0
16.0
20.0
24.0
LONGITUDINAL CYCLIC - DEGREES
-.20
-.10
00.0
.10
.20
.30
.40
LONGITUDINAL CYCLIC - RADIANS

Figure E-6

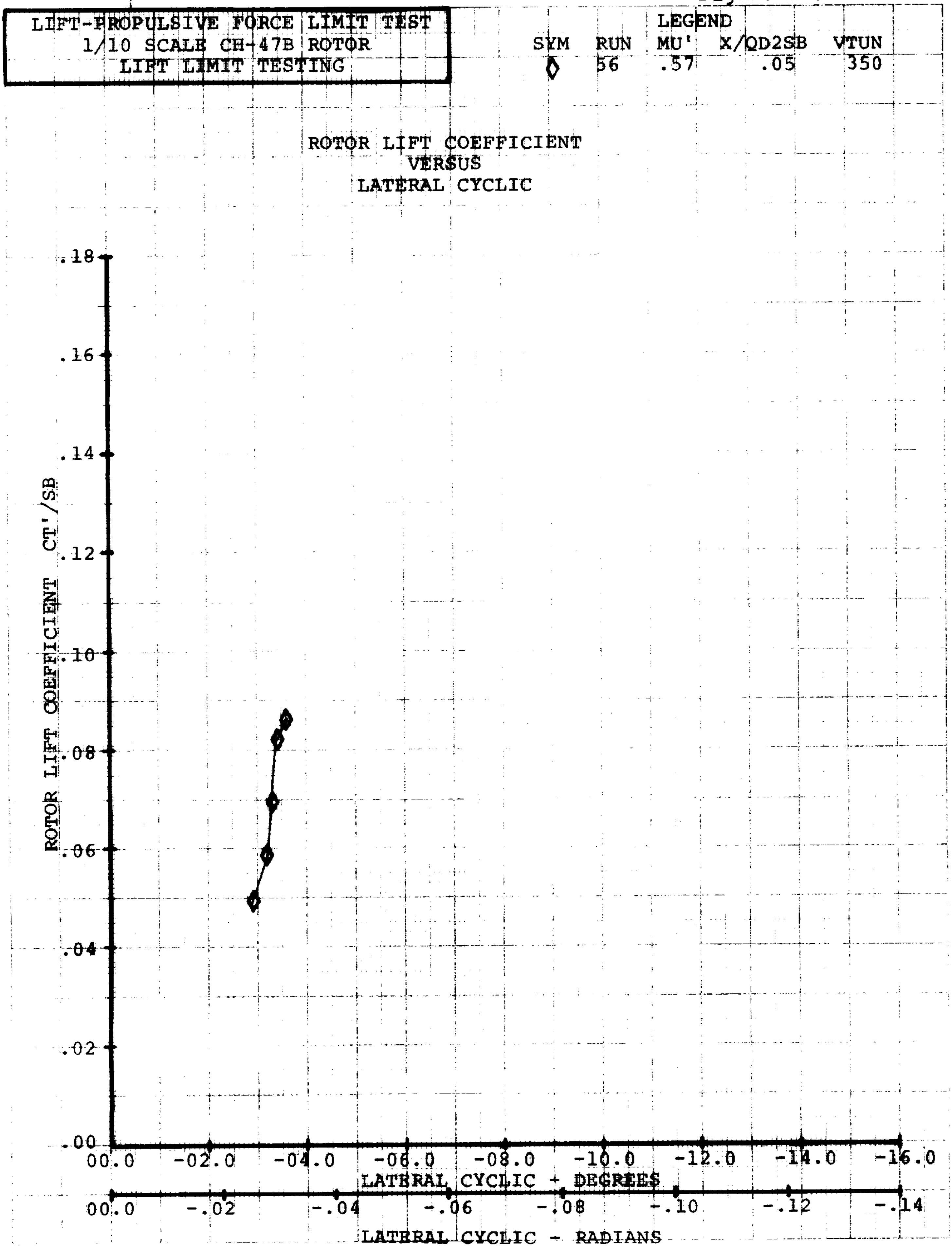
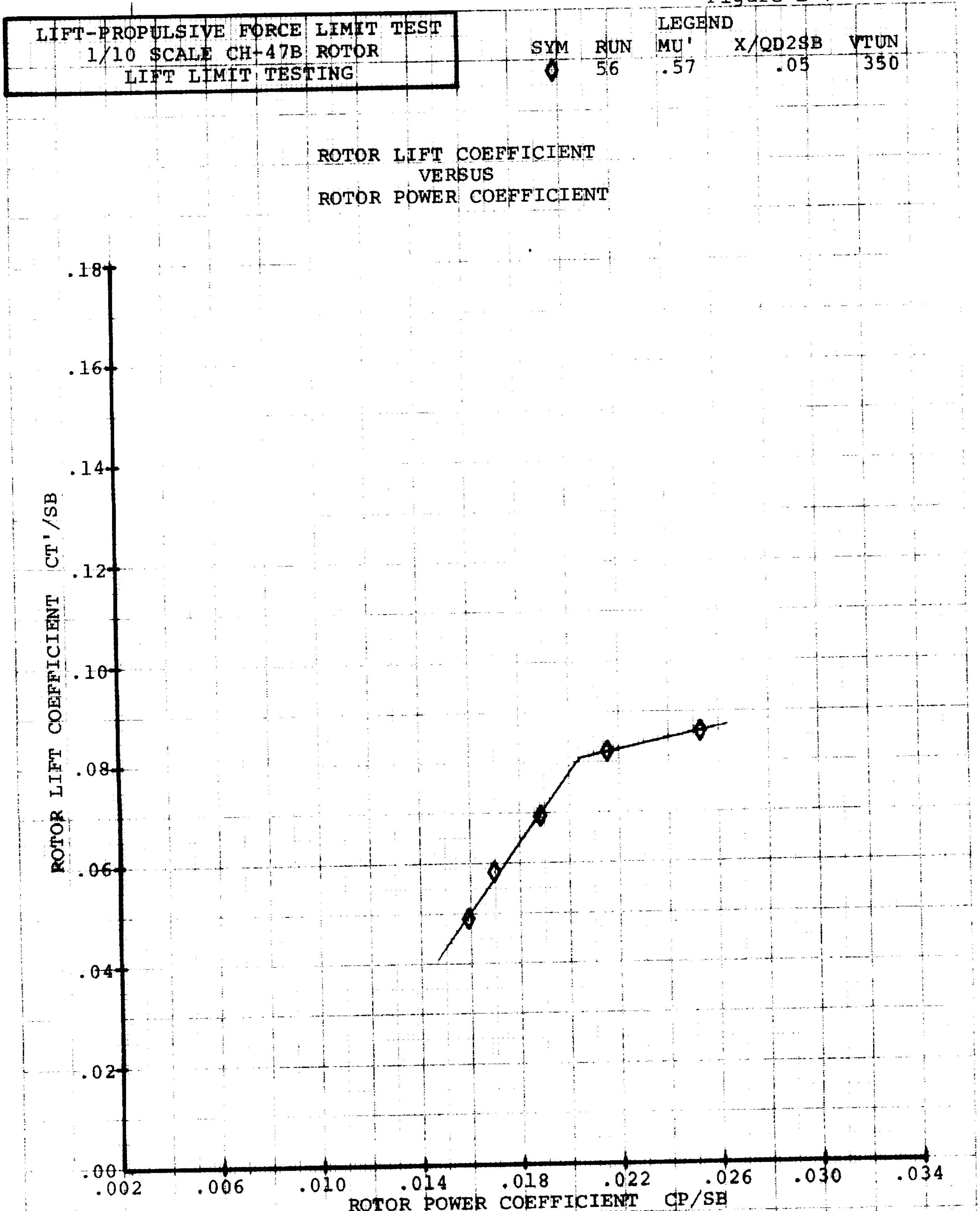

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
LATERAL CYCLIC
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
00.0 -02.0 -04.0 -06.0 -08.0 -10.0 -12.0 -14.0 -16.0
LATERAL CYCLIC - DEGREES
00.0 -.02 -.04 -.06 -.08 -.10 -.12 -.14
LATERAL CYCLIC - RADIANS

Figure E-7



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
ROTOR POWER COEFFICIENT
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
ROTOR LIFT COEFFICIENT CT'/SB
.002
.006
.010
.014
.018
.022
.026
.030
.034
ROTOR POWER COEFFICIENT CP/SB

Figure E-8

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	VTUN
◊	56	.57	.05	350

ROTOR LIFT COEFFICIENT
VERSUS
ROTOR EFFECTIVE DRAG COEFFICIENT

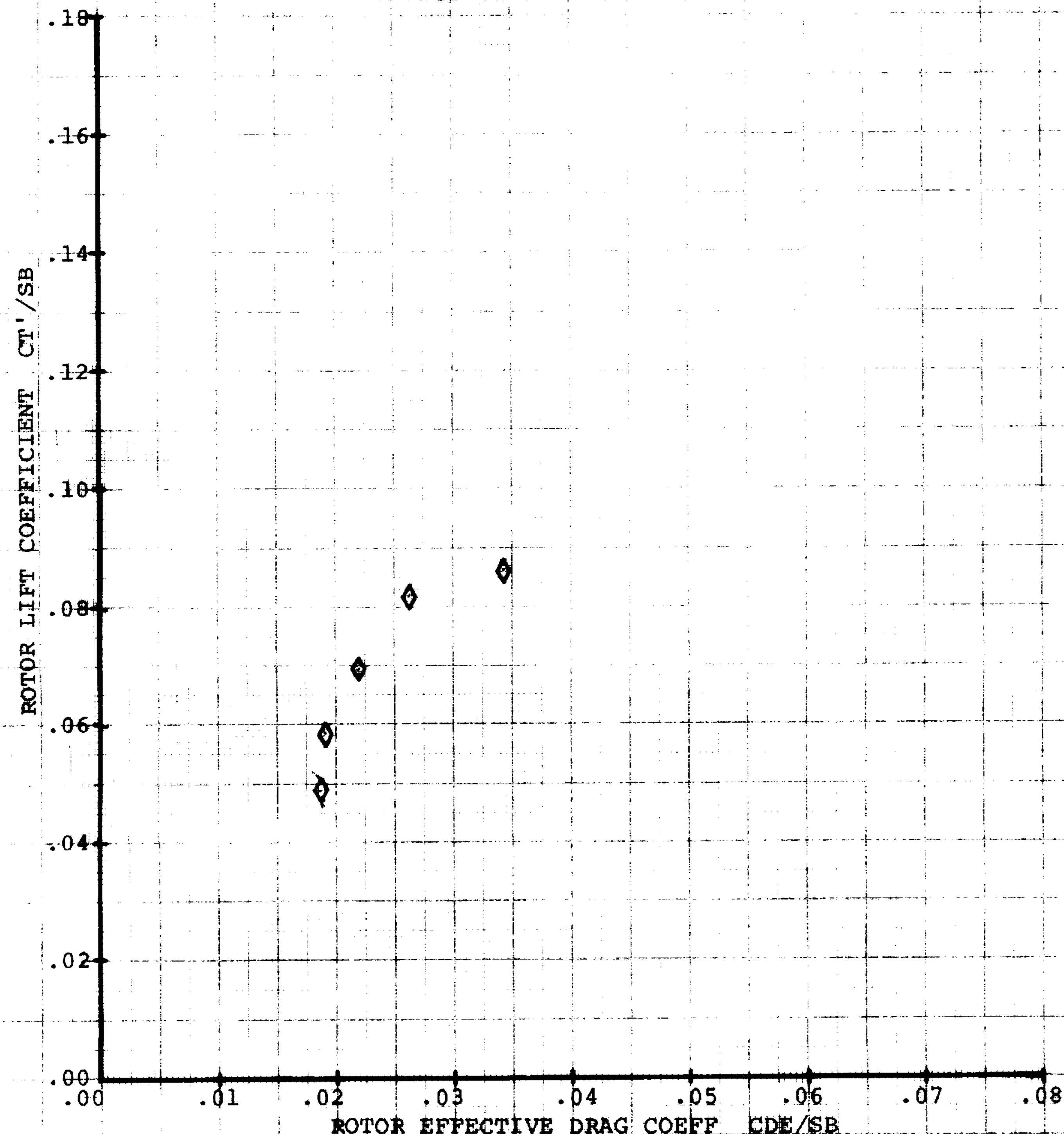


Figure E-9

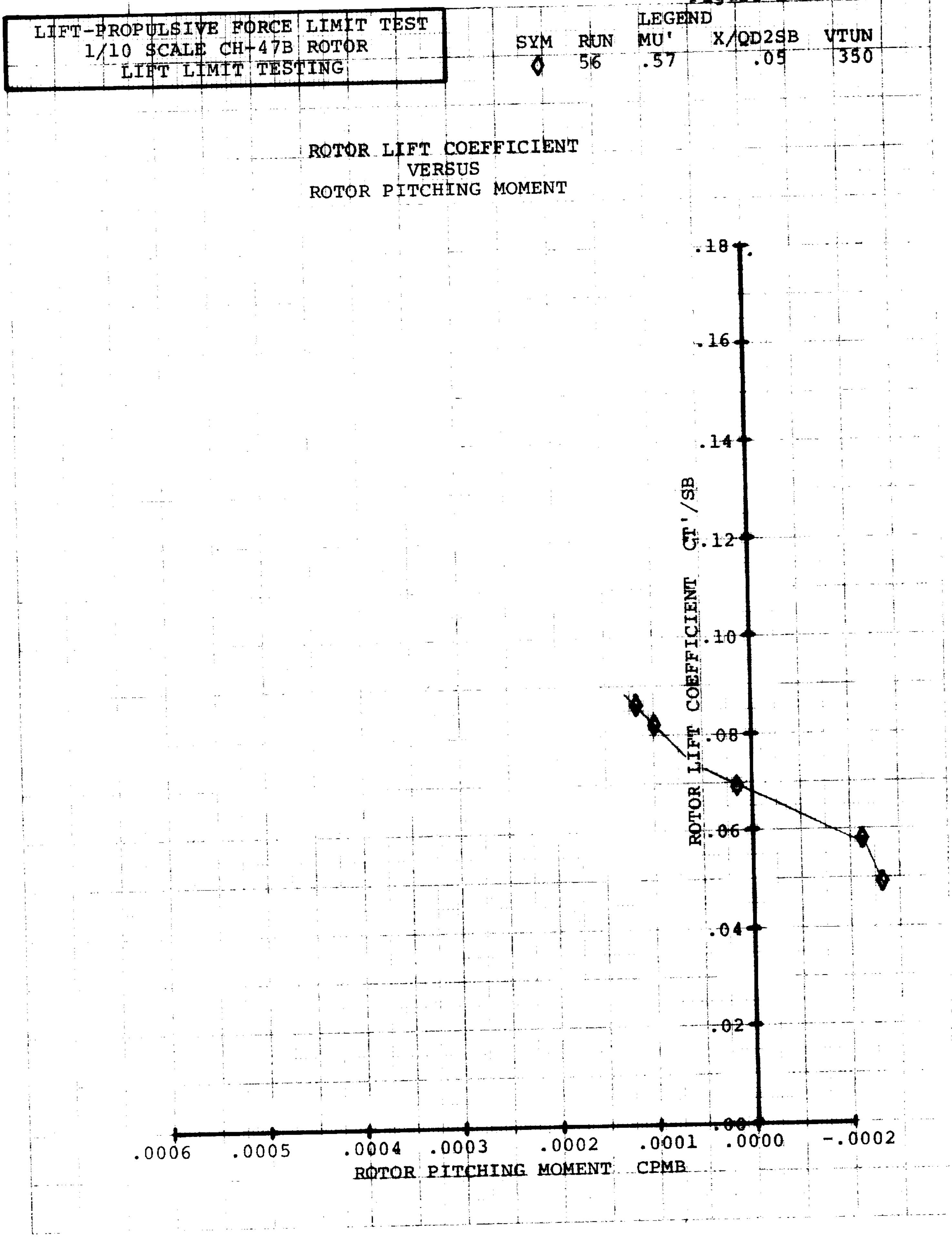
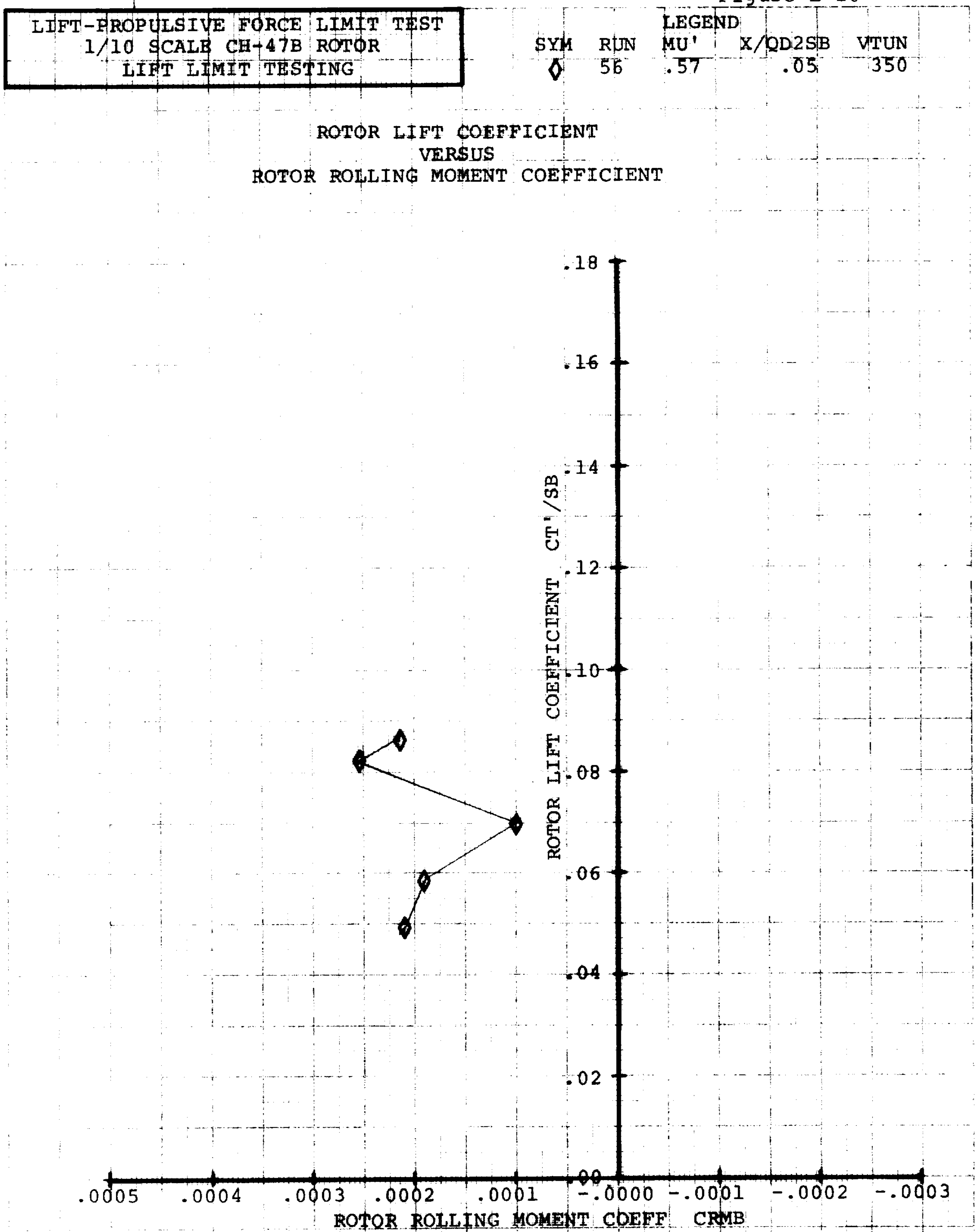

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
◊ 56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
ROTOR PITCHING MOMENT
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
.0006
.0005
.0004
.0003
.0002
.0001
.0000
-.0002
ROTOR PITCHING MOMENT CPMB

Figure E-10



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
ROTOR ROLLING MOMENT COEFFICIENT
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
.0005
.0004
.0003
.0002
.0001
-.0000
-.0001
-.0002
-.0003
ROTOR ROLLING MOMENT COEFF CRMB

Figure E-11

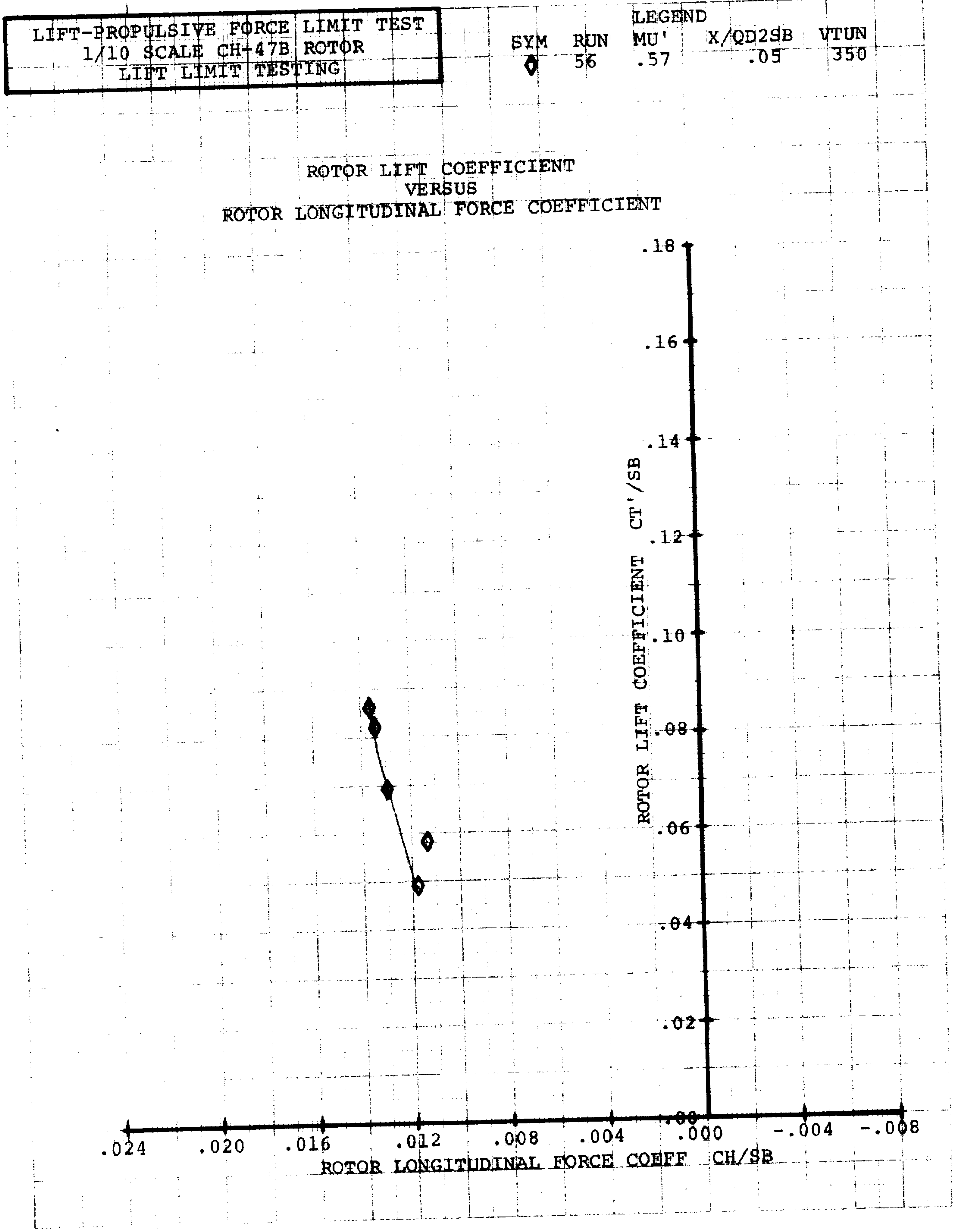

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
ROTOR LONGITUDINAL FORCE COEFFICIENT
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
ROTOR LIFT COEFFICIENT CT'/SB
.024
.020
.016
.012
.008
.004
.000
-.004
-.008
ROTOR LONGITUDINAL FORCE COEFF CH/SB

Figure E-12

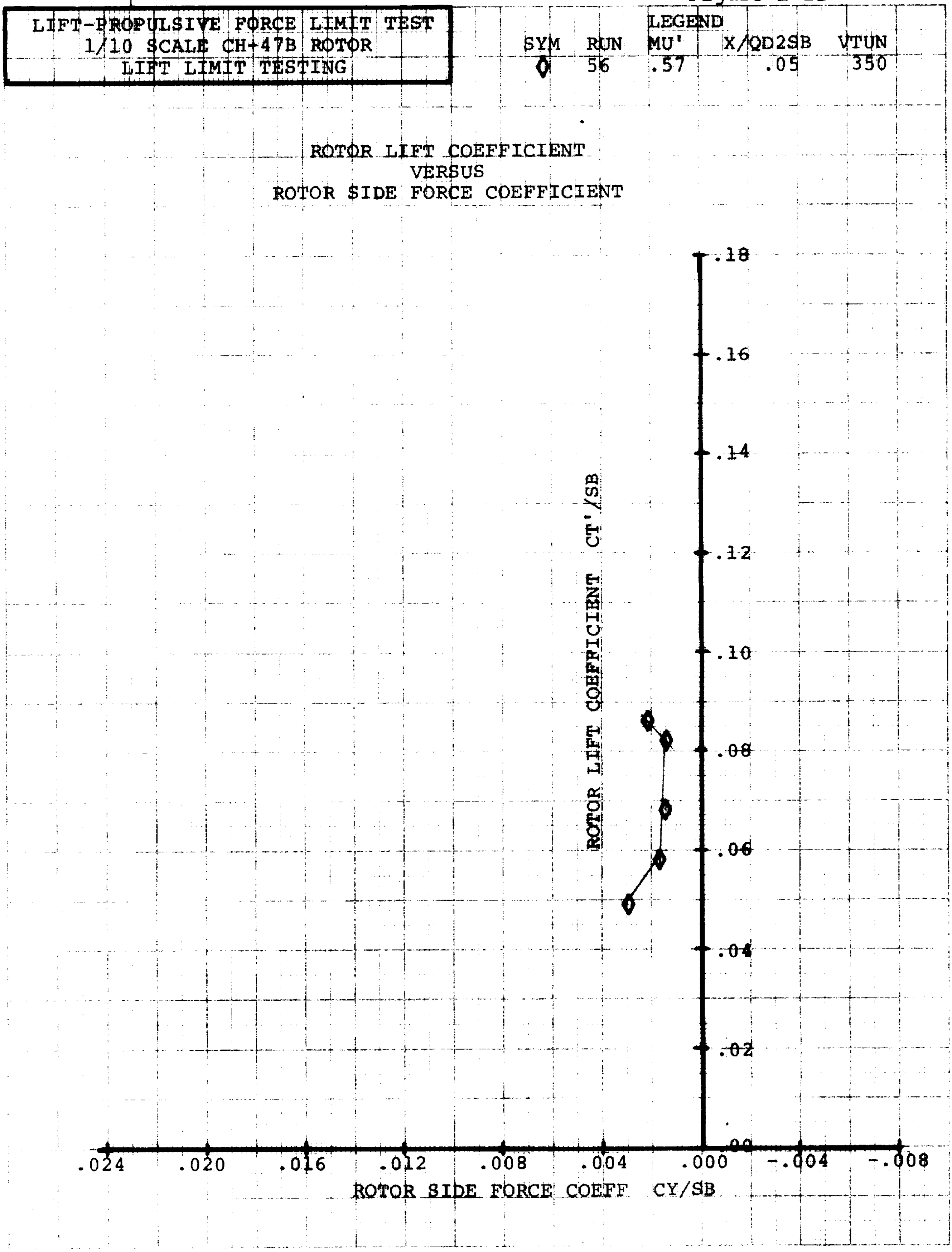

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
ROTOR SIDE FORCE COEFFICIENT
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
.024
.020
.016
.012
.008
.004
.000
-.004
-.008
ROTOR SIDE FORCE COEFF CY/SB

Figure E-13

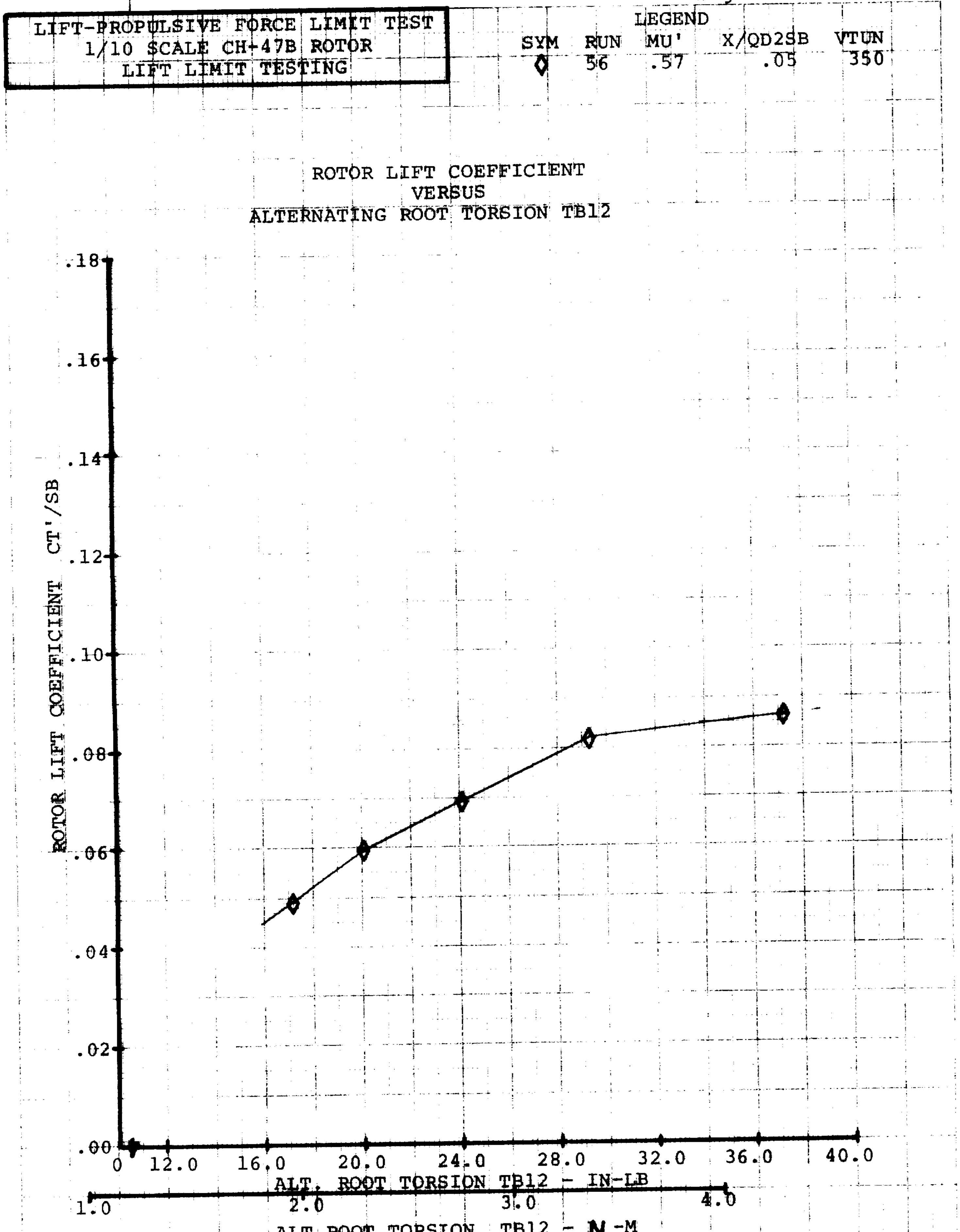

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
◊ 56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
ALTERNATING ROOT TORSION TB12
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
0
12.0
16.0
20.0
24.0
28.0
32.0
36.0
40.0
ALT. ROOT TORSION TB12 - IN-LB
1.0
2.0
3.0
4.0
ALT ROOT TORSION TB12 - N-M

Figure E-14

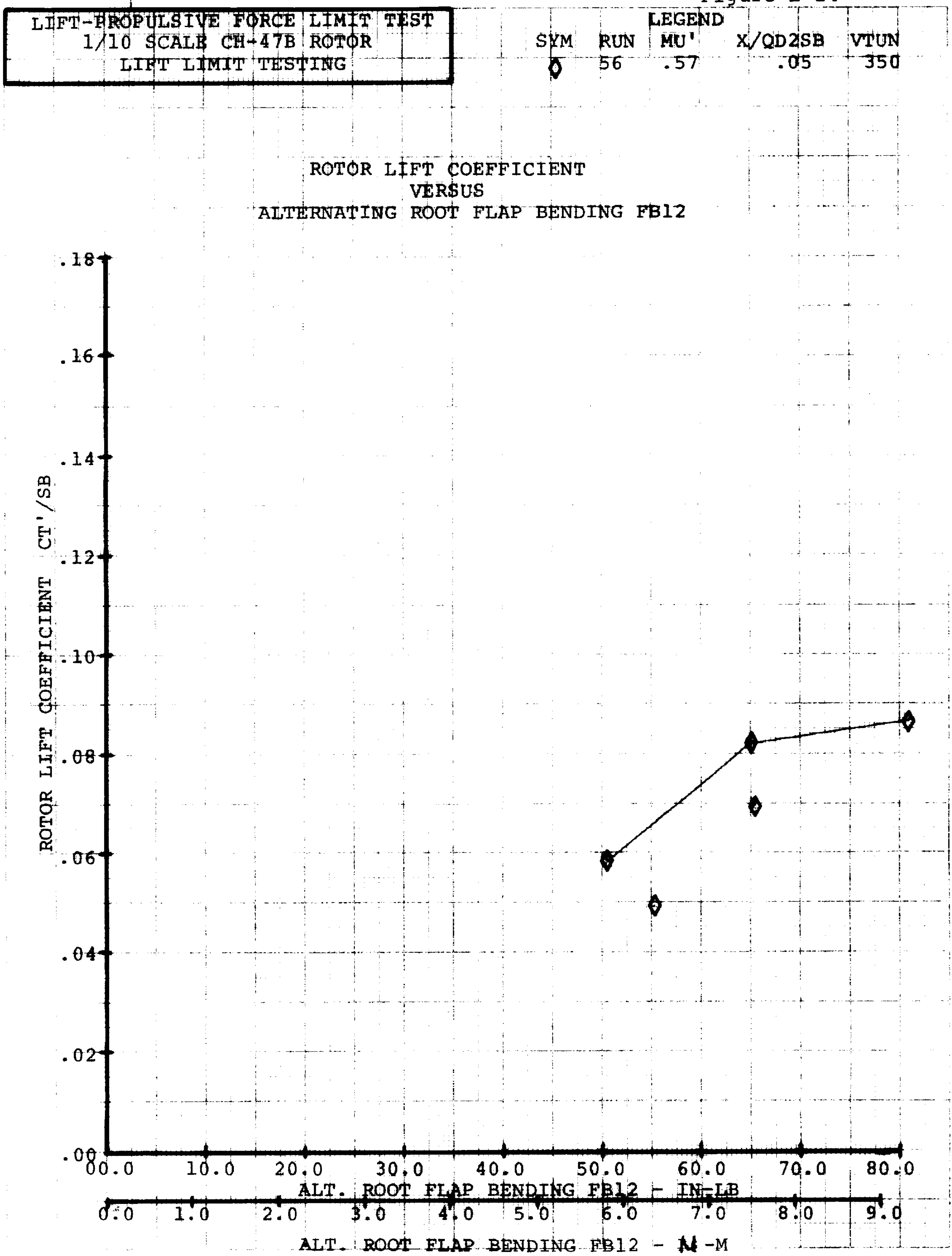

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
ALTERNATING ROOT FLAP BENDING FB12
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
00.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0
ALT. ROOT FLAP BENDING FB12 - IN-LB
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0
ALT. ROOT FLAP BENDING FB12 - N-M

Figure E-15

LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING

LEGEND

SYM	RUN	MU'	X/QD2SB	VTUN
◊	56	.57	.05	350

ROTOR LIFT COEFFICIENT
VERSUS
ALTERNATING ROOT FLAP BENDING FB35

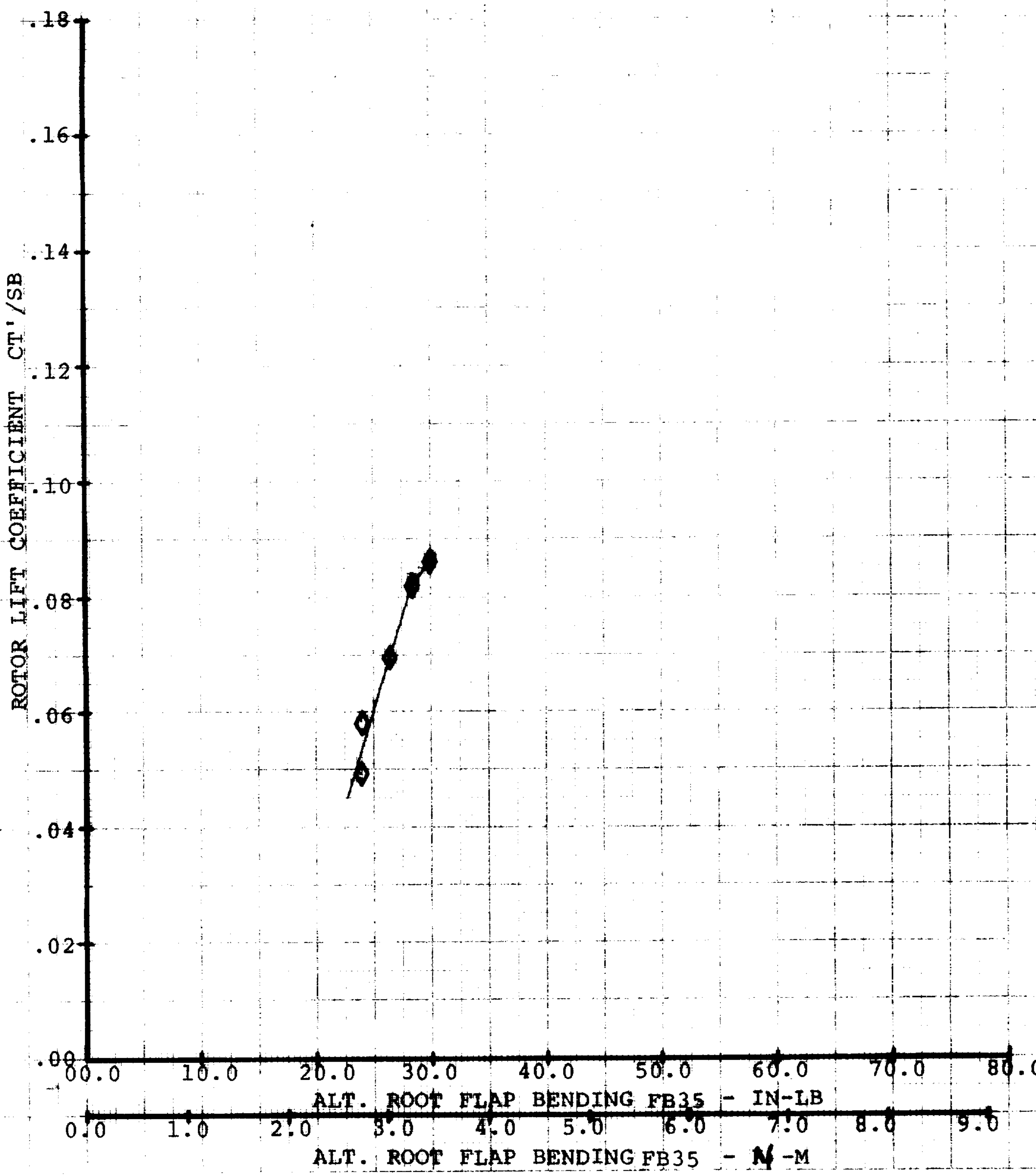
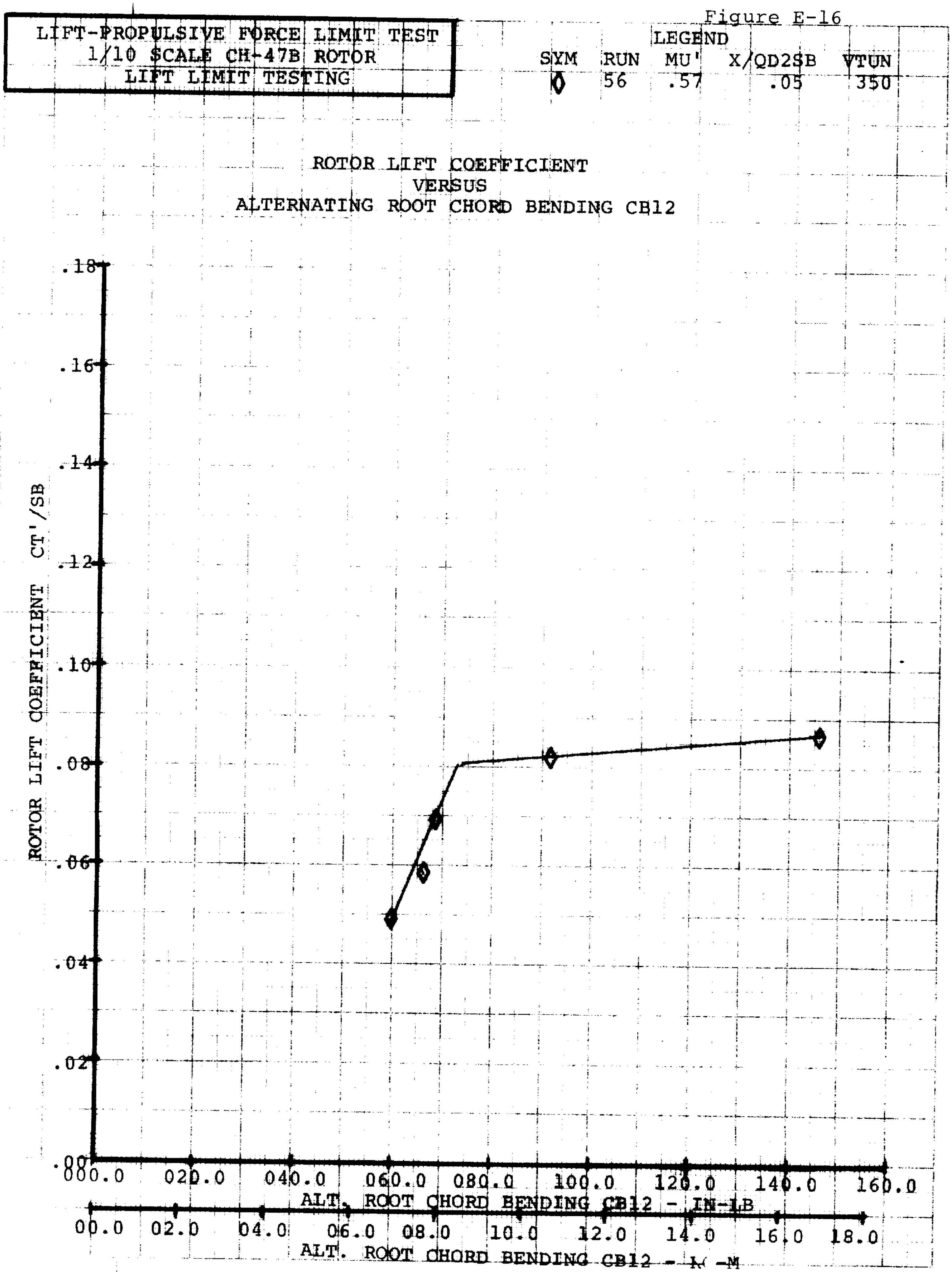


Figure E-16



LIFT-PROPULSIVE FORCE LIMIT TEST
1/10 SCALE CH-47B ROTOR
LIFT LIMIT TESTING
LEGEND
SYM RUN MU' X/QD2SB VTUN
56 .57 .05 350
ROTOR LIFT COEFFICIENT
VERSUS
ALTERNATING ROOT CHORD BENDING CB12
ROTOR LIFT COEFFICIENT CT'/SB
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
000.0
020.0
040.0
060.0
080.0
100.0
120.0
140.0
160.0
ALT. ROOT CHORD BENDING CB12 - IN-LB
00.0
02.0
04.0
06.0
08.0
10.0
12.0
14.0
16.0
18.0
ALT. ROOT CHORD BENDING CB12 - N-M