UNCLASSIFIED

AD NUMBER
AD865018
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution: Further dissemination only as directed by Army Aviation Systems Command, ATTN: AMSAV-R-F, PO Box 209, St. Louis, MO, 63166, NOV 1969, or higher DoD authority.**
AUTHORITY
USAAVSCOM ltr dtd 12 Nov 1973

THIS PAGE IS UNCLASSIFIED

AD
RDTE PROJECT NO. 1X141807D174
USAAVSCOM PROJECT NO. 68-31
USAASTA PROJECT NO. 68-31

ENGINEERING FLIGHT TEST

AH-1G (HUEYCOBRA) HELICOPTER EQUIPPED WITH THE XM35 ARMAMENT SUBSYSTEM (20MM AUTOMATIC GUN)

FINAL REPORT

NEAL DONALDSON
PROJECT ENGINEER

GARY C. HALL
MAJ, TC
US ARMY
PROJECT OFFICER/PILOT

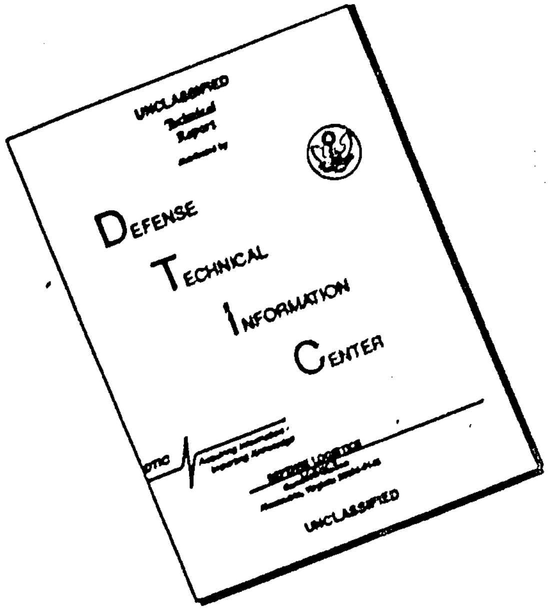
NOVEMBER 1969

DISTRIBUTION

THIS DOCUMENT MAY BE FURTHER DISTRIBUTED BY ANY HOLDER ONLY WITH SPECIFIC PRIOR APPROVAL OBTAINED THROUGH THE CG, USAAVSCOM, ATTN: AMSAV-R-F, PO BOX 209, ST. LOUIS, MISSOURI 63166.

US ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

DISCLAIMER NOTICE

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

DDC AVAILABILITY NOTICE

US military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through the Commanding General, US Army Aviation Systems Command (USAAVSCOM), ATTN: AMSAV-R-F, PO Box 209, St. Louis, Missouri 63166.

REPRODUCTION LIMITATIONS

Reproduction of this document in whole or in part is prohibited except with permission obtained through the Commanding General, USAAVSCOM, ATTN: AMSAV-R-F, PO Box 209, St. Louis, Missouri 63166. DDC is authorized to reproduce the document for United States Government purposes.

DISPOSITION INSTRUCTIONS

Destroy this report when it is no longer needed. Do not return it to the originator.

TRADE NAMES

The use of trade names in this report does not constitute an official endorsement or approval of the use of the commercial hardware and software.

RDTE PROJECT NO. 1X141807D174
USAAVSCOM PROJECT NO. 68-31
USAASTA PROJECT NO. 68-31

ARMY PRELIMINARY EVALUATION

AH-1G (HUEYCOBRA) HELICOPTER EQUIPPED WITH THE XM35 ARMAMENT SUBSYSTEM (20MM AUTOMATIC GUN)

FINAL REPORT

NEAL DONALDSON
PROJECT ENGINEER

GARY C. HALL
MAJ, TC
US ARMY
PROJECT OFFICER/PILOT

NOVEMBER 1969

DISTRIBUTION

This document may be further distributed by any holder only with specific prior approval obtained through the CG, USAAVSCOM, ATTN: AMSAV-R-F, PO Box 209, St. Louis, Missouri 63166.

US ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

ABSTRACT

The Army Preliminary Evaluation of the AH-1G (Hueycobra) helicopter equipped with the XM35 armament subsystem (20mm automatic gun) was conducted at Edwards Air Force Base, California, from 27 November to 20 December 1968 by the US Army Aviation Systems Test Activity. This evaluation consisted of performance and firing and nonfiring stability and control tests. Stability and control tests were also conducted with the turret ammunition bay doors open and loaded to simulate an evacuation mission configuration. No deficiencies were detected during this test program. The shortcomings detected during this test were: decreased range performance with the XM35 installed, fluctuation of airspeed indicator and altimeter during firing, adverse effects on the airframe during firing caused by blast pressure and/or vibration, awkward location of firing contact connector on gun, lack of a linker-delinker tool, and lack of boresighting and harmonizing instructions and equipment. The accuracy, standoff capability, dispersion, noise level and fire control system of the XM35 armament subsystem should enhance the mission capability of the AH-1G helicopter.

FOREWORD

During the conduct of this Army Preliminary Evaluation at Edwards Air Force Base, California, calibrated instrumentation and an instrumentation technician were furnished by Bell Helicopter Company. Armament technical assistance was furnished by General Electric Company.

TABLE OF CONTENTS

INTRODUCTION

BACKGROUND

1. The XM35 armament subsystem was developed jointly by Bell Helicopter Company and General Electric Company to enable the AH-1G to have greater standoff capability, better accuracy and more killing power than is available with the 2.75-inch folding fin aerial rockets (FFAR). This prototype system was evaluated during the Army Military Potential Test (MPT) in which the US Army Aviation Systems Test Activity (USAASTA) participated (ref 1, app I). The Iroquois Project Manager funded a product improvement program to qualify the subsystem on the AH-1G based upon the MPT results and the ENSURE requirement. On 14 June 1968, USAASTA was directed to conduct an Army Preliminary Evaluation (APE) of the AH-1G helicopter equipped with the XM35 armament subsystem (ref 2). During the contractor portion of the qualification program, many unanticipated problems were encountered with the high blast pressures of the SM195 gun. These problems resulted in lengthy delays in the overall qualification program. However, during the contractor portion of the program, measures were devised to overcome the blast pressure problems. On 27 November 1968, USAASTA began the APE at Edwards Air Force Base, California.

TEST OBJECTIVES

2. Test objectives were as follows:

a. To provide quantitative and qualitative engineering flight test data to serve as a basis for an estimate of the degree to which the aircraft is suitable for its intended mission.

b. To assist in determining the flight envelope to be used by Army pilots for future weapons subsystem development tests, service tests and operational usage.

c. To detect and allow early correction of deficiencies, as well as to provide a basis for evaluation of changes incorporated to correct deficiencies.

d. To provide aircraft performance data for operational use.

DESCRIPTION

3. The test aircraft, S/N 67-15532, is a FY 67 procurement production AH-1G tactical helicopter produced by Bell Helicopter Company and was designed specifically for the armed role. It is a tandem, two-place, high-speed helicopter with a two-bladed, door-hinge type main rotor and conventional antitorque rotor. A three-axes stability and control augmentation system (SCAS) is used in lieu of the stabilizer bar to improve helicopter stability and handling qualities. The test helicopter is powered by a Lycoming T53-L-13 turboshaft engine with a military power rating of 1400 shaft horsepower (shp) at sea level (SL), standard day, static conditions. The power plant is limited to 1100 shp at 314 rpm rotor speed due to maximum torque limits of the main transmission.

4. The distinctive features of the helicopter are the narrow fuselage (36 in.), the stub mid-wings (with four external stores stations) and the integral XM28 chin turret. The armament configurations are changed by varying wing stores and/or turret weapons. The pilot can fire all weapons in the stowed position. The copilot/gunner operates the flexible turret and can also fire the wing stores in an emergency by use of the pilot override. For this test, the XM195 automatic 20 millimeter (mm) six-barrel gun was installed on the left-hand inboard wing stores station. The cyclic rate of fire is 650 to 850 shots per minute (spm). Ammunition is housed in bays one on each side of the lower fuselage extending from the aft cross tube rearward. The ammunition capacity is approximately 1000 rounds. With the armament system installed, the lateral center of gravity (cg) is approximately 2 inches left of center. This weapon system has been designated the XM35.

5. The flight control system is a positive mechanical type with conventional helicopter controls located in the pilot's aft cockpit. The copilot/gunner's forward cockpit is provided with conventional directional controls, sidearm collective and cyclic controls. Control forces are reduced by hydraulic servo cylinders connected to the control system mechanical linkage. The hydraulic system is powered by dual transmission driven pumps. A synchronized elevator is used to improve longitudinal characteristics. The electrically operated mechanical force trim system, connected to the cyclic and directional controls, is used to induce artificial control feel and to provide positive control centering. Ausform armor protection is provided for the crew, engine fuel control and engine compressor section. A detailed description of the helicopter is contained in references 3 and 4, appendix I.

SCOPE OF TEST

6. This test program consisted of limited quantitative performance tests and qualitative and quantitative firing and nonfiring stability and control tests. Limited qualitative and quantitative stability and control tests were conducted at speeds up to 100 knots indicated airspeed (KIAS) with the turret ammunition bay doors open and loaded with ballast to simulate an evacuation mission. During the doors-open portion of the test, the doors were secured by a rigid brace in lieu of the standard flexible cable. Test conditions for each test are discussed briefly in the Results and Discussion section of this report, and the data are presented in appendix II.

7. The flight restrictions which governed this test are presented in appendix IV. A safety-of-flight release for these flight restrictions was issued by the US Army Aviation Systems Command (USAAVSCOM) (ref 5, app I).

8. Thirty-six flights were conducted during this test at Edwards Air Force Base, California, for a total of 31 test hours during an elapsed calendar time of 24 days utilizing 17 working days.

METHODS OF TEST

9. The engineering flight test methods used are described briefly for each test in the Results and Discussion section of this report.

CHRONOLOGY

10. The chronology of this test program is as follows:

Test directive received	14 June 1968
Test aircraft received	18 November 1968
Tests started	27 November 1968
Tests completed	20 December 1968
Draft report submitted	29 January 1969

RESULTS AND DISCUSSION

GENERAL

11. Quantitative level flight performance tests were conducted in both the clean and the XM35 configurations. The clean configuration range data on this production model test aircraft were compared with clean configuration data on a prototype AH-1G undergoing Phase D testing. There was no significant difference in the performance characteristics of these two test aircraft. When compared with the clean configuration AH-1G, the XM35 equipped AH-1G presented a loss in specific range (average 7.5 percent). Optimum cruise speed was reduced approximately 15 knots for the conditions tested.

12. Firing and nonfiring stability and control tests were conducted in the XM35 configuration. Nonfiring stability and control tests were conducted with the turret ammunition bay doors open and loaded with 200 pounds of ballast each to simulate an evacuation mission (hereafter in this report referred to as the doors-open configuration.) No significant deterioration in AH-1G stability and control characteristics was noted except for an increase in vibration levels during firing tests. High vibration blast pressures during firing tests caused airframe cracks and loosened screws. The standard ship's system airspeed indicator and altimeter fluctuated during firing. The firing contact connector on the gun is located in an awkward position. A linker-delinker tool should be provided with the kit. No boresighting and harmonizing instructions or equipment was provided. Standoff capability, accuracy, reliability and dispersion appeared to be excellent.

PERFORMANCE

General

13. Level flight performance tests were conducted in both the clean and the XM35 configurations to determine the change in helicopter performance caused by the XM35 armament subsystem installation.

Level Flight Performance

14. Level flight performance tests were conducted to cover a range of selected thrust coefficients (C_T) which had been flown in previous performance tests on a prototype AH-1G helicopter,

S/N 66-15247. Two speed-power polars were flown in the clean configuration and three in the XM35 configuration. The nominal conditions for these tests were a 324 rpm rotor speed, a 5000- to 10,000-foot density altitude (H_D), a forward and aft cg and an 8000- to 9100-pound gross weight (grwt). A level flight summary plot showing a comparison of the clean and the XM35 equipped helicopter is illustrated by figure 1, appendix II. Nondimensional summary plots are presented in figures 2 and 3, appendix II. The clean speed-power polars are presented in figures 4 and 5. The XM35 speed-power polars are presented in figures 6 through 8. Fuel flow information was obtained from the fuel flow specification chart, figure 9.

15. Data show that there is no difference between performance characteristics of the clean production and the prototype AH-1G helicopter.

16. The XM35 configuration produced a significant decrease in level flight performance when compared with the clean configuration. Specific range was reduced 8.8 percent; and cruise airspeed was reduced 16.2 knots at 9000 pounds, a 5000-foot H_D and a 324 rpm rotor speed. A comparison summary is presented in table 1.

Table 1. Performance Comparison.

Gross Weight (lb)	Specific Range Nautical Air Miles Per Pound of Fuel Configuration (Clean)	(XM35)	Cruise Airspeed Knots True Airspeed Configuration (Clean)	(XM35)	Specific Range Performance Decrease (Percent)
7800	.2272	.2145	140.2	124.3	5.6
8400	.2206	.2050	139.2	123.0	7.1
9000	.2132	.1945	136.3	120.1	8.8

Airspeed Calibration

17. Airspeed calibration flights were conducted at an 8500-pound grwt, a cg location of 194.1 inches and a rotor speed of 324 rpm to determine the position error of the test (boom) and ship's standard airspeed systems. The ground speed course method was used up to 121

KIAS. From 95 to 168 KIAS, a US Army T-28B pacer aircraft with a calibrated airspeed system was used as an airspeed reference. The test results are presented in figure 10, appendix II.

18. The standard ship's system was not calibrated with the airspeed boom removed. Calibration is not considered to be valid for a standard production AH-1G without airspeed boom and is not presented. All data are based on the test airspeed boom calibration.

STABILITY AND CONTROL

General

19. Stability and control tests were conducted to define the effects of the XM35 armament subsystem and of open ammunition bay doors on the various stability and control characteristics of the helicopter.

Static Longitudinal Stability

20. The approximate conditions for these tests were a 324 rpm rotor speed, a 5000-foot H_D, a forward cg location and an 8100- to 9200-pound grwt. The control position requirements were determined as a function of airspeed during level flight performance tests. The helicopter was stabilized at various trim airspeeds in level flight, and data were recorded to determine the control positions. A constant thrust coefficient (C_T) was maintained during these tests by increasing altitude with fuel burn-off. The results of these tests are presented in figures 11 and 12, appendix II, for the clean configuration and in figures 13 through 15 for the XM35 configuration. The collective-fixed static longitudinal stability was determined by maintaining the fixed collective pitch control at a trim condition and then recording control position requirements at stabilized increased and decreased airspeeds from the trim airspeed. The results of these tests are presented in figures 16 through 18.

21. For all conditions tested, longitudinal cyclic stick position gradients were stable. Forward cyclic displacement was required to maintain a higher airspeed, and aft cyclic displacement was required to maintain a lower airspeed. There was a trend noted which indicated that static longitudinal stick gradients decreased with increasing airspeed, but this trend was not objectionable to the pilot. No significant adverse effects on the static longitudinal stability characteristics were caused by either the installation of the XM35 armament subsystem or by the open ammunition bay doors.

Static Lateral-Directional Stability

22. The approximate conditions for these tests were a 324 rpm rotor speed, a 5000-foot H_D and an 8100- to 9000-pound grwt. These tests were conducted by stabilizing the helicopter at a trim airspeed in balanced, zero sideslip flight with collective pitch control fixed at the required trim setting. While maintaining a straight flight path with a trim airspeed, the sideslip angle was increased in increments. At each increment of sideslip, the control positions, helicopter attitudes and the sideslip angle were recorded. The test results are presented in figures 19 through 22, appendix II, for the XM35 configuration and in figures 23 and 24 for the doors-open configuration.

23. Static directional stability was determined to be positive from the directional control position gradients with sideslip angle (left pedal required for right sideslip and vice versa) at all conditions tested. Neither the XM35 nor the doors-open configurations caused adverse effects on the static directional stability characteristics of the helicopter.

24. The effective dihedral, as indicated by lateral control position gradients with sideslip angle, was positive for all conditions tested. Neither the XM35 nor the doors-open configuration caused significant adverse effects on the effective dihedral of the helicopter.

25. When operating the AH-1G with the XM35 installed and no balancing store on the right wing, large bank angles were required to maintain zero sideslip at low airspeeds; and attempts to fly with the ball of the turn and bank indicator centered resulted in large sideslip angles. This situation could become a problem in low visibility or night operations. It is recommended that a caution note pertaining to the sideslip angles at low airspeeds be placed in the operator's manual (TM 55-1520-221-10).

Dynamic Stability

26. The approximate test conditions for these tests were a 324 rpm rotor speed, a 5000-foot H_D, a forward cg and an 8500- to 9100-pound grwt. These tests were conducted by disturbing the helicopter from trimmed stable flight with a 1-inch, 1-second control pulse to simulate a gust input and by recording the resulting helicopter motions. The results of these tests are presented as typical time histories in figures 25 through 27, appendix II, for the XM35 configuration and in figure 29 for the doors-open configuration.

27. Analysis of these time histories indicates that neither of these configurations has any adverse effect on the short period damping characteristics of the helicopter for the conditions tested.

Controllability

28. The approximate test conditions for these tests were a 324 rpm rotor speed, a 5000-foot H_D, a forward cg and an 8500- to 9000-pound grwt. These tests were conducted about all axes by recording the resulting helicopter motions following an abrupt step-type control displacement from trim. Response characteristics are summarized in figures 30 and 31, appendix II.

29. No significant change in the AH-1G response characteristics was noted during this test.

XM35 FIRING

30. Firing tests were conducted to determine the stability and control characteristics of the helicopter while firing the XM35 armament subsystem. The approximate test conditions for these tests were a 324 rpm rotor speed, a 3500-foot H_D, a forward cg and a 9100-pound grwt. The helicopter was stabilized on the desired trim conditions, and the controls held fixed while firing the gun and recording resultant helicopter motions. Two typical time histories of aircraft reactions to XM35 firing are presented in figures 32 and 33, appendix II.

31. Reactions of the helicopter about the pitch, roll and yaw axes during 3- to 5-second firing bursts were small and had a negligible effect on the helicopter. This negligible effect applied to all flight conditions tested. The physical location of the 20mm gun on the left inboard wing stores station caused a linear rearward acceleration on the aircraft rather than significant pitching, rolling or yawing reactions. At no time were control margins inadequate or aircraft reactions objectionable due to the weapons firing.

32. During attempts to accurately engage a target, a very slight left yawing tendency was noted. However, the yaw SCAS adequately corrected this tendency, and this characteristic did not significantly detract from the excellent system accuracy. Targets were accurately and consistently engaged from a 1000- to 3000-meter slant range at altitudes from 500 to 3500 feet above the ground. No

detailed accuracy tests were conducted. Subsystem accuracy appears to depend solely on pilot proficiency and ability to accurately estimate ranges. A discussion of other aspects of the 20mm armament subsystem are included in paragraphs 34 through 44.

Velocity Never Exceed (V_{NE}) Evaluation

33. Tests were conducted to evaluate the contractor established V_{NE}. These tests were conducted by climbing the helicopter to an approximate 11,500-foot H_p and diving at V_{NE} until recovery was necessary. Vibration data were recorded throughout the dive. These tests were conducted at a forward cg, a 9000-pound grwt and a 324 rpm rotor speed. The results of these tests, for various trim V_{NE} points where vibrations were highest, are presented in figures 34 through 36, appendix II. At no point were the vibration levels considered excessive. The V_{NE} established by the contractor appeared to be realistic.

MISCELLANEOUS

Airspeed and Altimeter Fluctuations

34. The ship's standard airspeed indicator and altimeter fluctuated considerably during firing due to either blast pressures or vibration. These fluctuations should be reduced to a minimum.

Reliability of the XM35

35. The XM35 appeared to be very reliable. No stoppages occurred during the test. Only two incidents occurred during firing of 4900 rounds. The first incident occurred at 1964 rounds fired when the ammunition inspection door retainer spring on the left ammunition can vibrated loose (either from blast effect during firing or from ammunition feeding through the ammunition can during firing). This incident did not cause a malfunction of the weapon. The second incident occurred at 3921 rounds fired when one end of the housing cover lock pin broke off and lodged in the bolt-clearing well causing the bolt to drag as the weapon cleared. This incident did not cause a stoppage and was discovered during reloading operations.

Blast Deflectors

36. The blast deflectors had been previously used for approximately 6670 rounds. Prior to firing tests, they were inspected in accordance with reference 5, appendix I, and found to be satisfactory.

Three blast deflector clamping bolts were replaced at 1964 rounds at the request of the General Electric representative. The armament subsystem was inspected upon completion of the test program, and no discrepancies were noted.

Standoff Capability

37. Qualitatively, standoff capability with XM35 is increased considerably over the 2.75-inch rockets. Targets were consistently engaged accurately at the 3000-meter slant range at altitudes up to 3500 feet above the ground.

Accuracy

38. Although detailed accuracy tests were not conducted, it appears that subsystem accuracy depends solely on pilot flying proficiency and ability to accurately estimate ranges; and it is much more accurate than the 2.75-inch rockets.

Dispersion

39. Qualitatively, dispersion of rounds on the target appeared to be good.

Noise Levels

40. Qualitatively, the noise levels in the pilot's and copilot/gunner's cockpits are comparable to those levels experienced in firing the XM28/XM129 twin 40mm grenade launchers. The noise levels are considered acceptable.

Vibration and Blast Pressure

41. Vibration and blast pressure during firing appeared to adversely affect the airframe and instrumentation of the aircraft. After 1964 rounds of ammunition were fired, the left wing tip fairing assembly, S/N 1560-560-1471, came off in flight during firing. It is believed that vibration during firing had caused the hinge pin to wear out. Action should be taken to eliminate the cause of these adverse effects on the aircraft.

42. Upon completion of firing 4900 rounds, the following discrepancies were noted on the aircraft:

a. Plug wires were broken off the gas producer N_1 tachometer indicator.

b. The rpm warning light was found to have four broken wires.

c. The fuel quantity circuit breaker had popped.

d. Two rivets were missing in the left-hand side fuselage panel below the cockpit.

e. Numerous loose rivets were found in the left-hand side fuselage panel below the cockpit.

f. Two cracks were found in the left-hand side panel below the pilot's cockpit.

g. The accelerometer plug and wires were broken off (located behind the left-hand side panel below the cockpit).

h. The friction assembly on the cyclic stick had vibrated completely loose. No torque was evident on the pilot's cyclic stick friction assembly.

i. Numerous screws in the forward canopy door hinges had vibrated loose.

j. The nut plate on the left-hand side fuselage panel had broken off.

Maintainability and Turn-around Time

43. The following items were noted regarding maintainability and turn-around time:

a. Firing contact connector: Considerable difficulty and delay in turn-around time was experienced by the awkward location of the firing contact connector on the right top side of the gun. This connector should be relocated to the left side of the weapon in an easily accessible location.

b. Inspection port: An inspection port should be provided to observe that the ammunition is seated properly in the feeder.

c. Linker-delinker: A hand operated linker-delinker, 20mm, M26, P/N 77080853, should be provided with the subsystem to assist in linking and delinking ammunition during weapon system loading. This will decrease turn-around time.

Fire Control System

44. The fire control system (switching functions) in the test aircraft appeared to be adequate. It was not known if this control arrangement was the production configuration.

Boresighting and Harmonizing

45. No boresighting and harmonizing procedures are currently available. These should be provided in addition to any special equipment that may be required.

CONCLUSIONS

GENERAL

46. The following general conclusions were reached upon the completion of the Army Preliminary Evaluation of the XM35 equipped AH-1G helicopter:

a. The level flight performance characteristics of clean production and prototype AH-1G helicopters are essentially the same (para 15).

b. The level flight performance of the clean AH-1G helicopter is reduced by the installation of the XM35 armament subsystem (para 16).

c. The XM35 armament subsystem does not significantly affect the stability and control characteristics of the AH-1G during firing or nonfiring flight (paras 19 through 32).

d. The stability and control characteristics of the AH-1G helicopter equipped with the XM35 armament subsystem are not adversely affected for the conditions tested with the turret ammunition bay doors open and loaded to simulate an evacuation mission configuration (paras 19 through 29).

e. The operation of the XM35 armament subsystem causes adverse effects on the airframe structural integrity and instrumentation of the aircraft during firing (paras 41 and 42).

f. The V_{NE} established by the contractor for the XM35 equipped AH-1G helicopter appears to be realistic (para 33).

DEFICIENCIES AND SHORTCOMINGS AFFECTING MISSION ACCOMPLISHMENT

47. No deficiencies were detected which would preclude acceptance of the aircraft in the XM35 configuration or in the doors-open configuration within the tested flight envelopes.

48. Correction of the following shortcomings is desirable for improved operation and mission capabilities:

a. Reduced performance due to installation of the XM35 armament subsystem (para 16).

b. Adverse effects on the airframe structure and instrumentation of the aircraft while firing the XM35 (paras 41 and 42).

RECOMMENDATIONS

49. The following recommendations are made to improve the XM35 equipped AH-1G helicopter for operational use:

a. Action be taken to reduce the adverse effects on the airframe structure and instrumentation of the aircraft caused by firing of the XM35 armament subsystem (paras 41 and 42).

b. The possibility of increasing performance capabilities by incorporating a fairing on the XM159 gun be explored (para 16).

c. The firing contact connector on the gun be relocated to the left-hand side to facilitate ease of maintenance and reduce turn-around time for reloading (para 43a).

d. An inspection port be provided to allow observation of proper seating of ammunition in the feeder (para 43b).

e. A linker-delinker tool be provided to facilitate loading of ammunition and reduce turn-around time (para 43c).

f. Adequate boresighting and harmonizing instructions and equipment be provided (para 45).

g. A caution note pertaining to the sideslip angles at low airspeeds be placed in the operator's manual (para 25).

APPENDIX I. REFERENCES

1. Letter Report, US Army Aviation Test Activity (USAAVNTA), Project No. 68-09, *Engineering Flight Test of the AH-1G Helicopter Equipped with the XM20 Armament Subsystem Automatic 20mm Cannon*, March 1968.

2. Test Directive, USAAVSCOM, No. 68-31, "AH-1G/XM35 Army Preliminary Evaluation," June 1968.

3. Technical Manual, TM 55-1420-221-10, *Operator's Manual, Army Model, AH-1G Helicopter*, April 1967.

4. Specification, 209-947-030, Bell Helicopter Company, *Detail Specification for Model AH-1G Helicopter, Fiscal Year 67 Procurement*, 1 August 1966.

5. Messages, USAAVSCOM, AMSAV-R-EF, 12-1313 and 12-1328, subjects: Flight Release for AH-1G Flight with Ammunition Doors Open, and Safety of Flight Release for the AH-1G/XM35 Configuration ATA PROJECT 68-31, 11 December 1968 (unclassified).

APPENDIX II. TEST DATA

FIGURE NO. 1
LEVEL FLIGHT SUMMARY

AH-1G/XM-35 U.S.A. S/N 67-15532

DENSITY ALTITUDE= 5000 FEET
ROTOR SPEED= 324 RPM

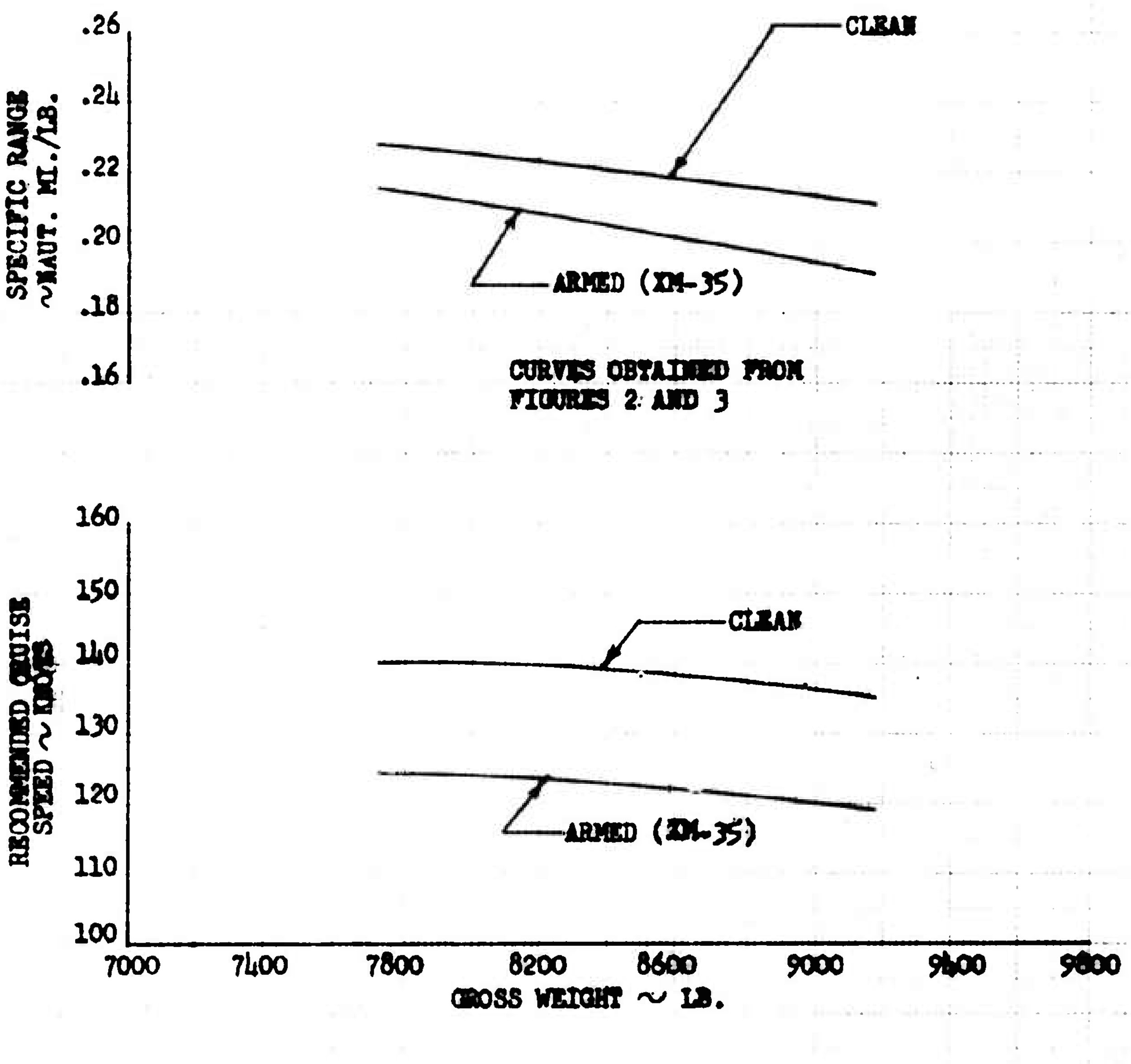


FIGURE NO. 2
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE
AH-1G/XM-35 USA S/N 67-15532

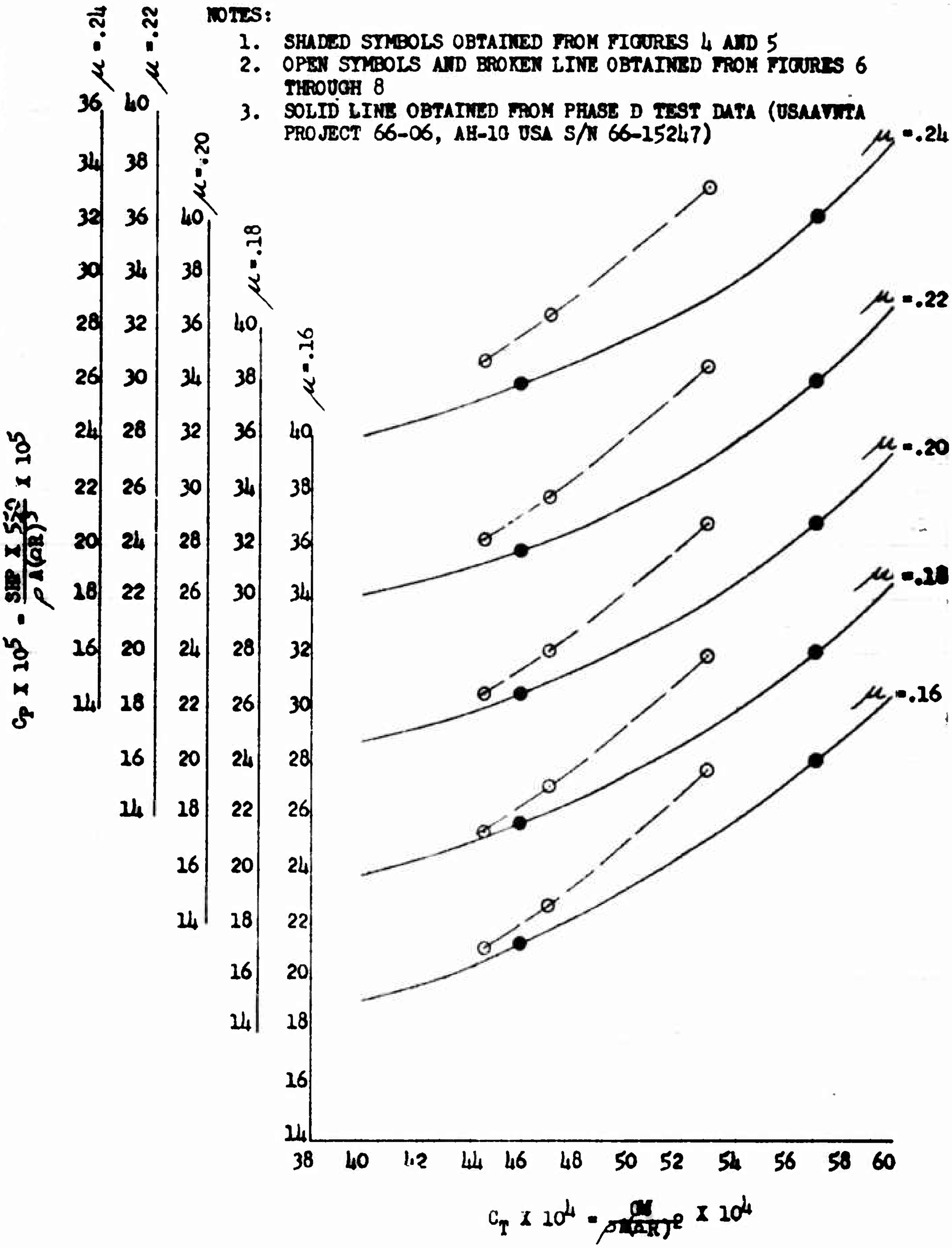


FIGURE NO. 3
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE
AH-1G/XM-35 USA S/N 67-15532

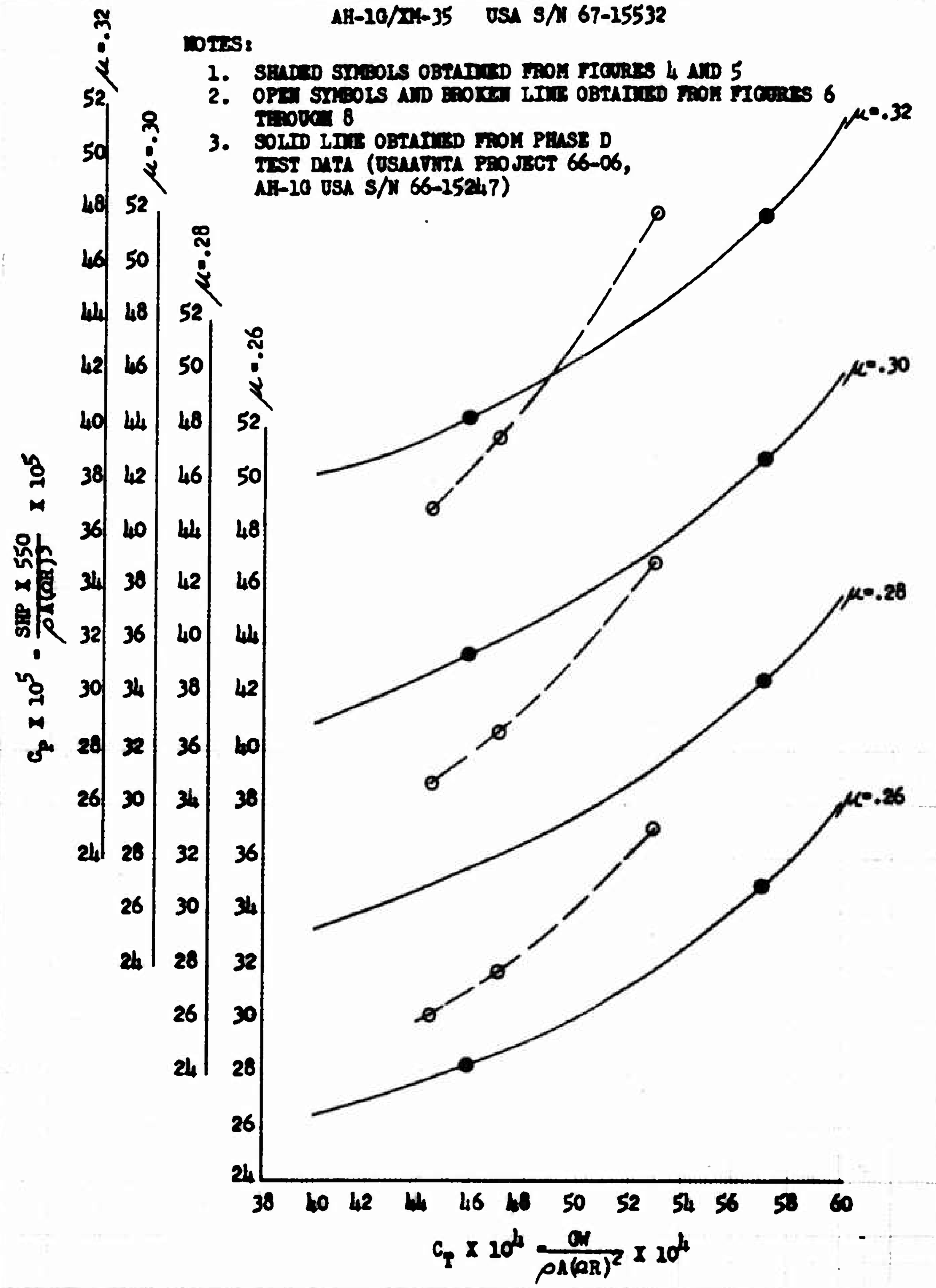


FIGURE NO. 4
LEVEL FLIGHT PERFORMANCE
AH-1G/XM-35 U.S.A. S/N 67-15532

GROSS WEIGHT= 7925
LONG. C.G. STATION= 199.6 IN (AFT)
LAT. C.G. STATION= 0.04 IN (LT)
DENSITY ALTITUDE= 5160 FEET
THRUST COEFFICIENT= 0.004590
CONFIGURATION= CLEAN

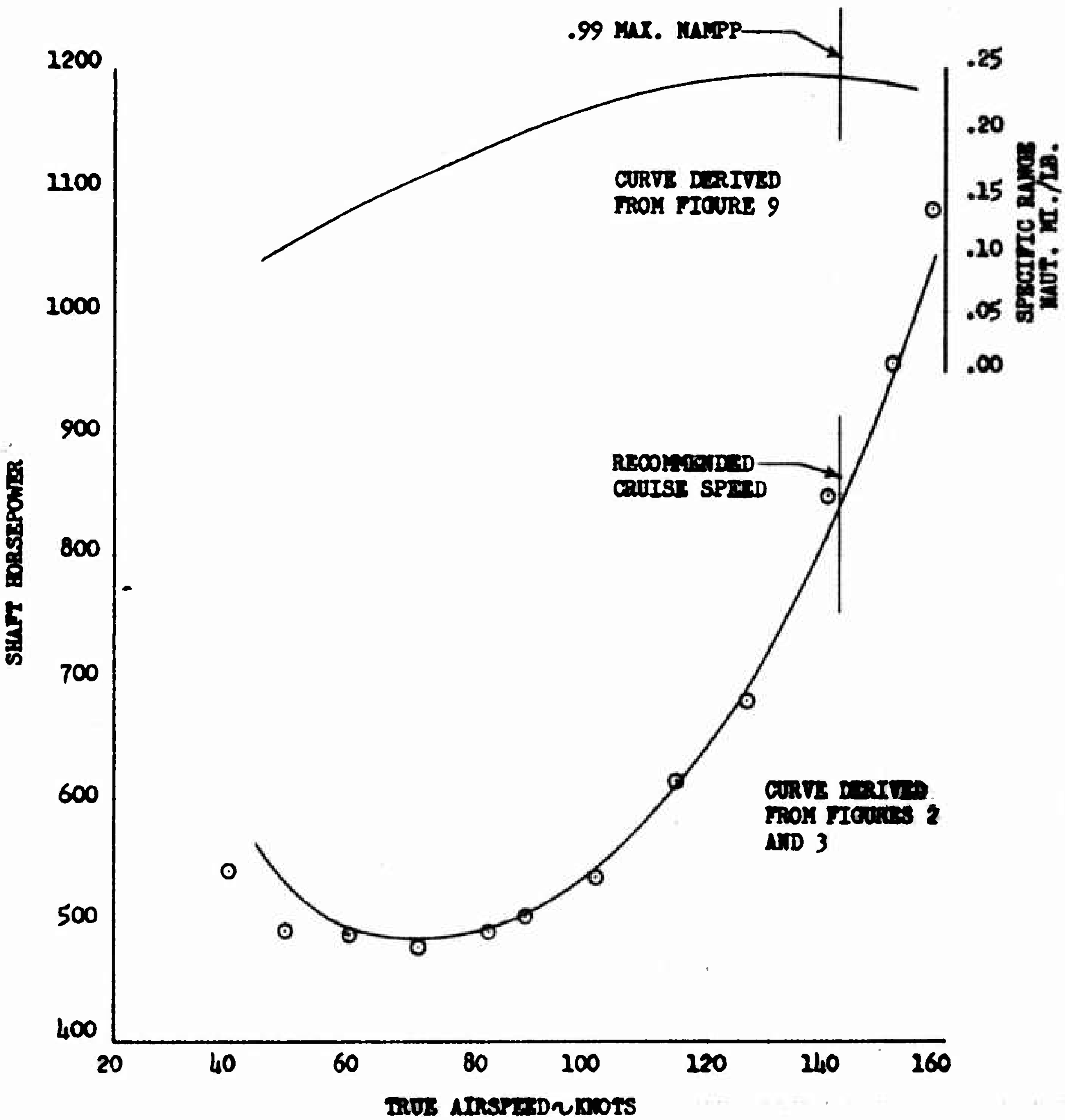


FIGURE NO. 5
LEVEL FLIGHT PERFORMANCE
AH-1G/XM-35 U.S.A. S/N 67-15332

GROSS WEIGHT= 8317 LB
LONG. C.G. STATION= 194.2 IN. (FWD)
LAT. C.G. STATION= 0.04 IN. (LT)
DENSITY ALTITUDE= 10657 FEET
ROTOR SPEED= 324 RPM
THRUST COEFFICIENT= 0.005710
CONFIGURATION= CLEAN

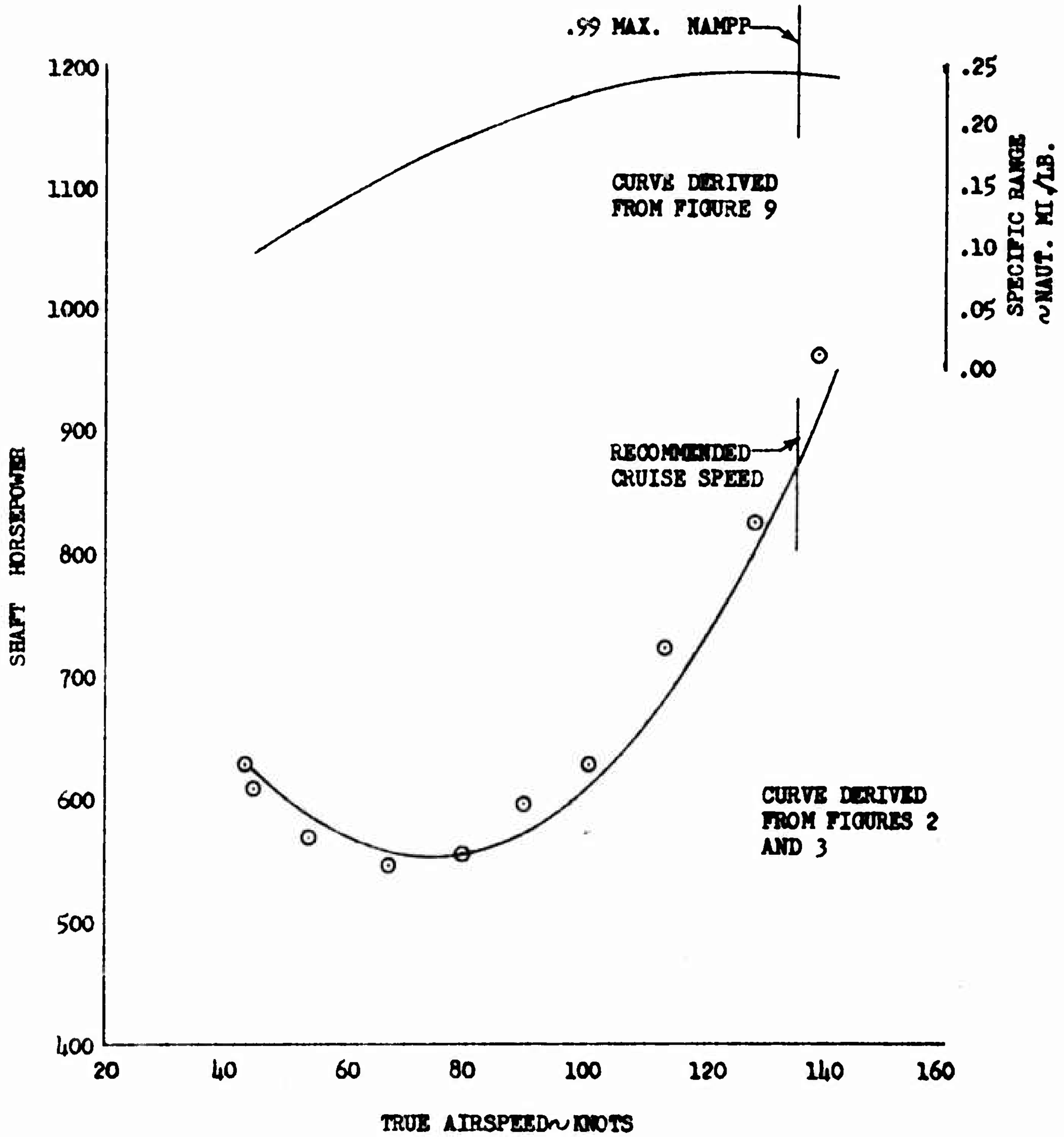


FIGURE NO. 6
LEVEL FLIGHT PERFORMANCE
AH-1G/XM-35 U.S.A. S/N 67-15532

GROSS WEIGHT= 8205 LB
LONG. C.G. STATION= 193.7 IN (FWD)
LAT. C.G. STATION= 1.76 IN (LT)
DENSITY ALTITUDE= 2975 FEET
ROTOR SPEED= 324 RPM
THRUST COEFFICIENT= 0.004450
CONFIGURATION=XM-35

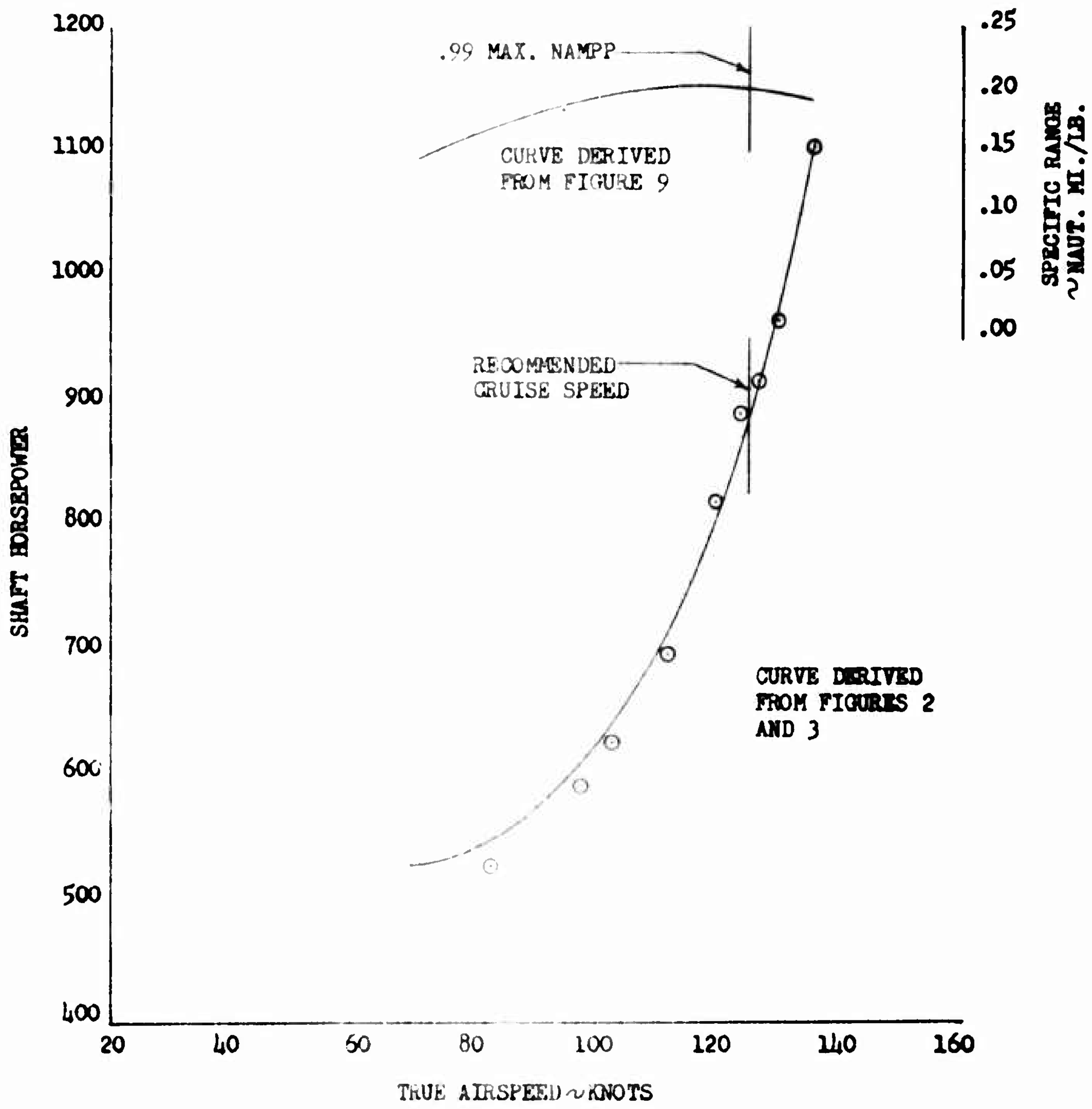


FIGURE NO. 7
LEVEL FLIGHT PERFORMANCE
AH-1G/XM-35 U.S.A. S/N 67-15532

GROSS WEIGHT= 8181 LB
LONG. C.G. STATION= 194.2 IN (FWD)
LAT. C.G. STATION= 1.77 IN (LT)
DENSITY ALTITUDE= 4895 FEET
ROTOR SPEED= 324 RPM
THRUST COEFFICIENT= 0.004700
CONFIGURATION=XM-35

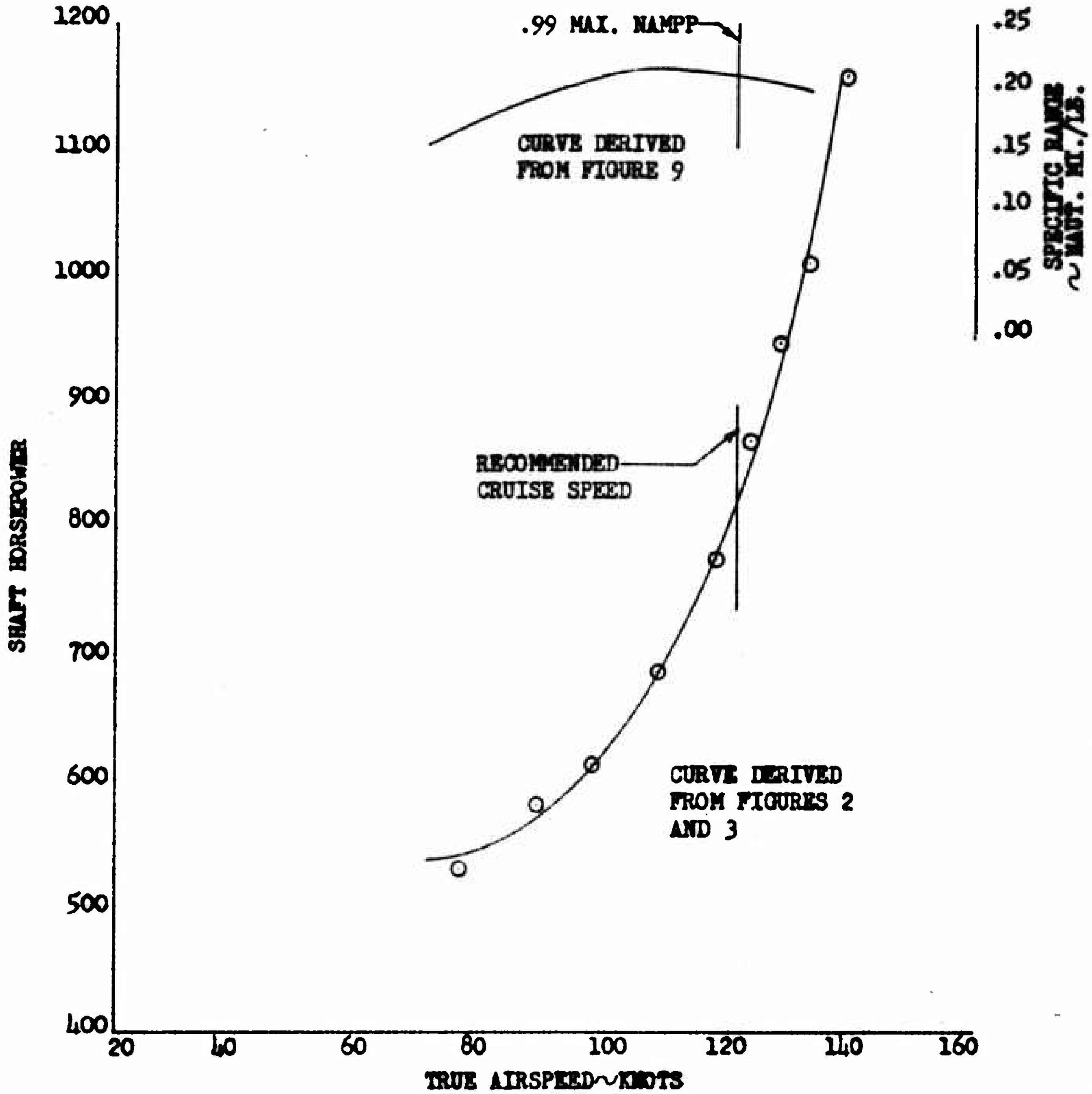


FIGURE NO. 8
LEVEL FLIGHT PERFORMANCE
AH-1G/XM-35 U.S.A. S/N 67-15532

GROSS WEIGHT= 8394
LONG. C.G. STATION= 191.9 IN (FWD)
LAT. C.G. STATION= 1.72 IN (LT)
DENSITY ALTITUDE= 7918 FEET
ROTOR SPEED= 324 RPM
THRUST COEFFICIENT= 0.005290
CONFIGURATION= XM-35

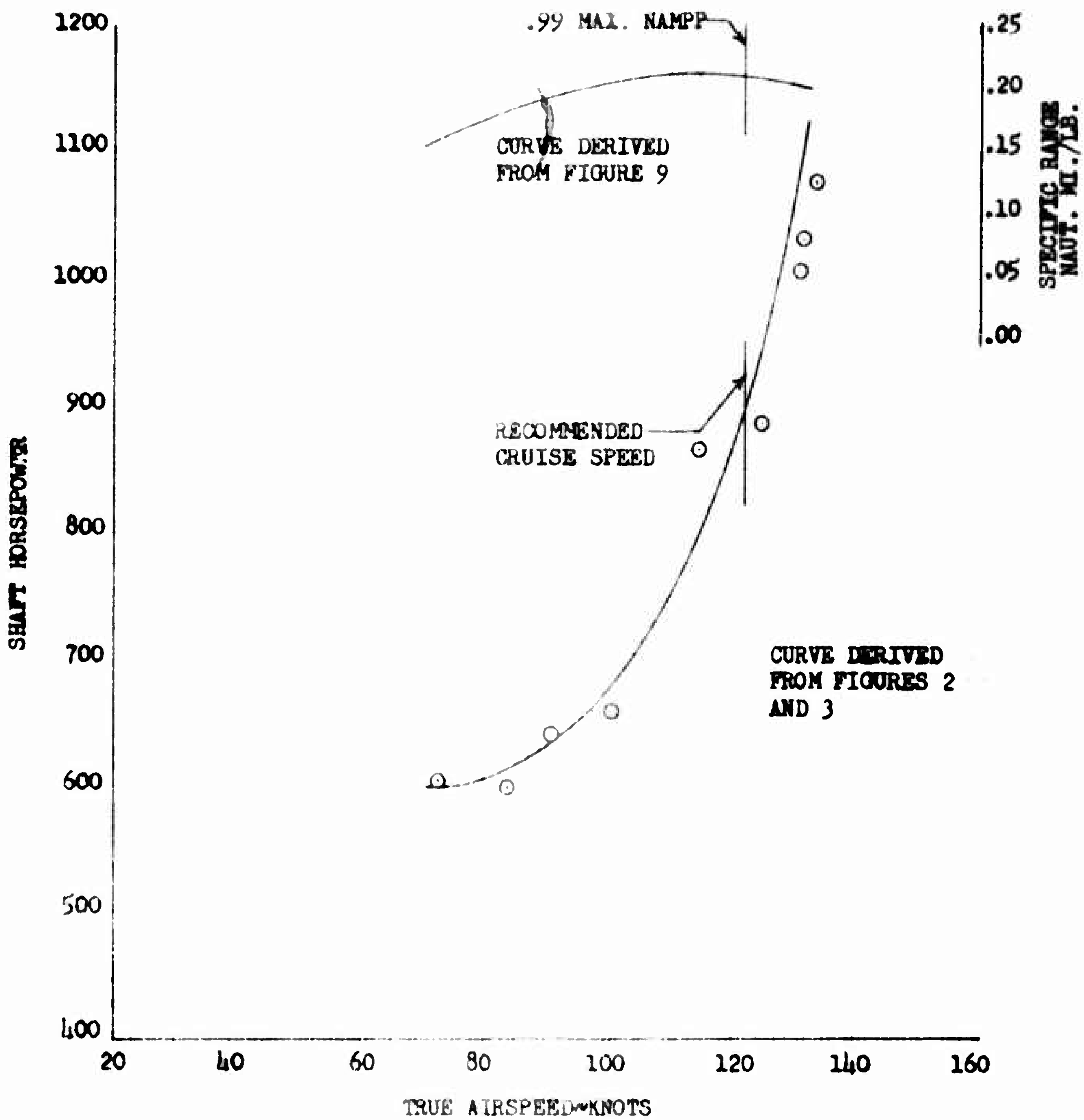


FIGURE NO. 9
SPECIFICATION FUEL FLOW

AH-1G/XM-35 U.S.A. S/N 67-15532

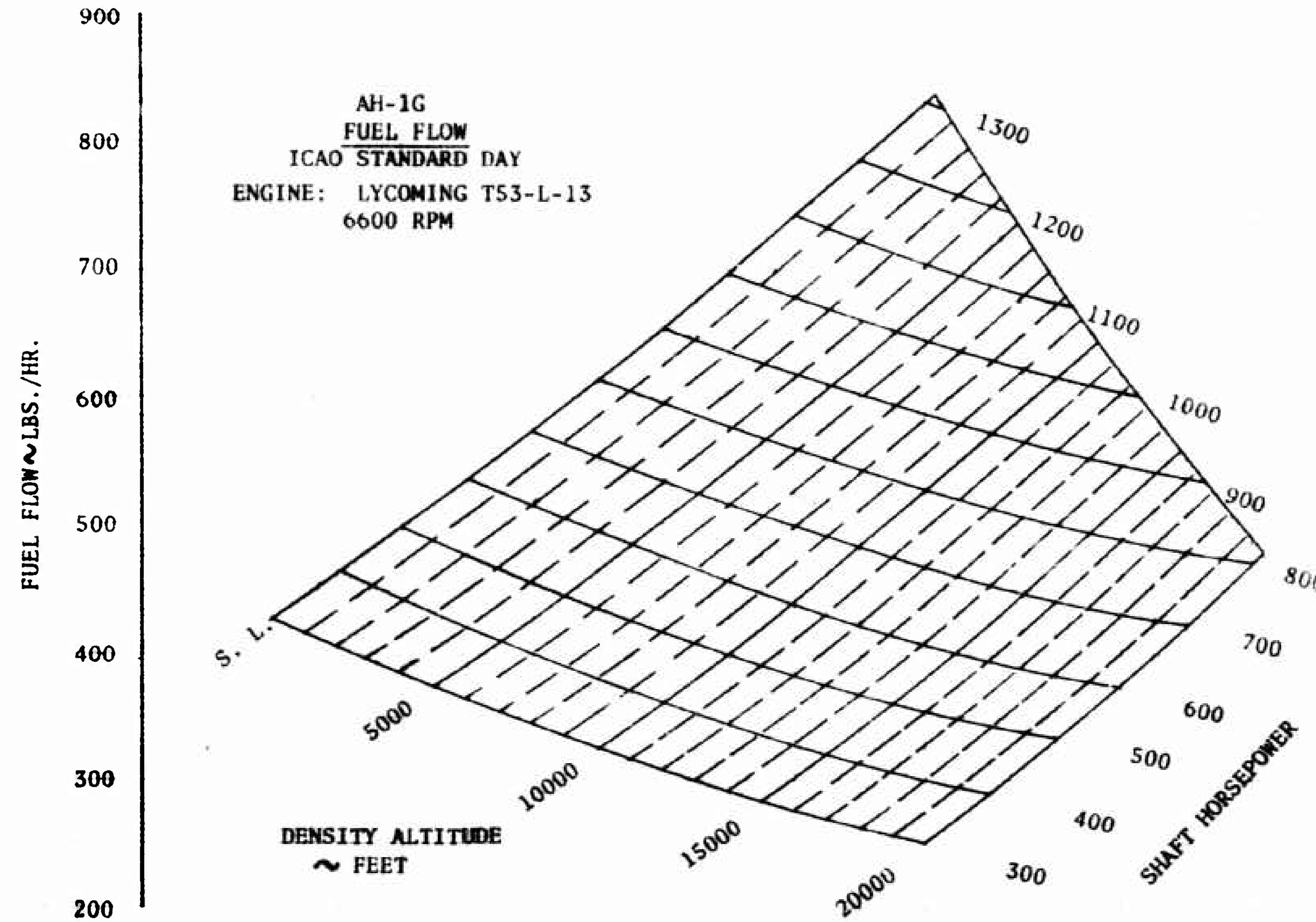


FIGURE NO. 10
AIRSPEED CALIBRATION
AH-1G/XM-35 USA S/N 67-15532

	GROSS WEIGHT	LONG. C.G.	LAT. C.G.	DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
GROUND	8435	194.0	0.801	1309	324	XM-35
PACED	8635	194.2	0.782	5999	324	XM-35

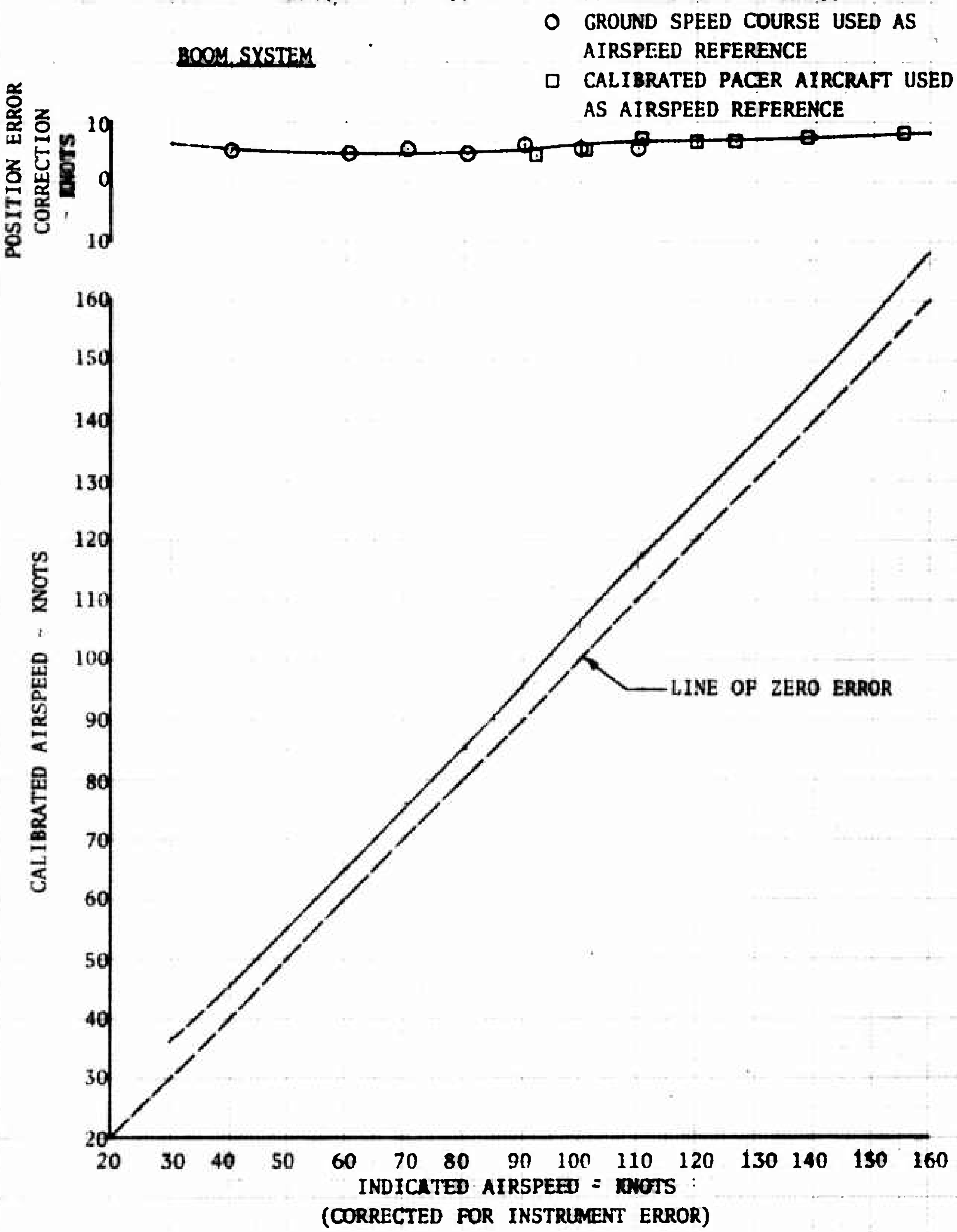


FIGURE NO. 11
CONTROL POSITIONS IN LEVEL FLIGHT
AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	CONFIGURATION	C_T
7988	199.5	0.4 LEFT	4934	CLEAN	0.004593

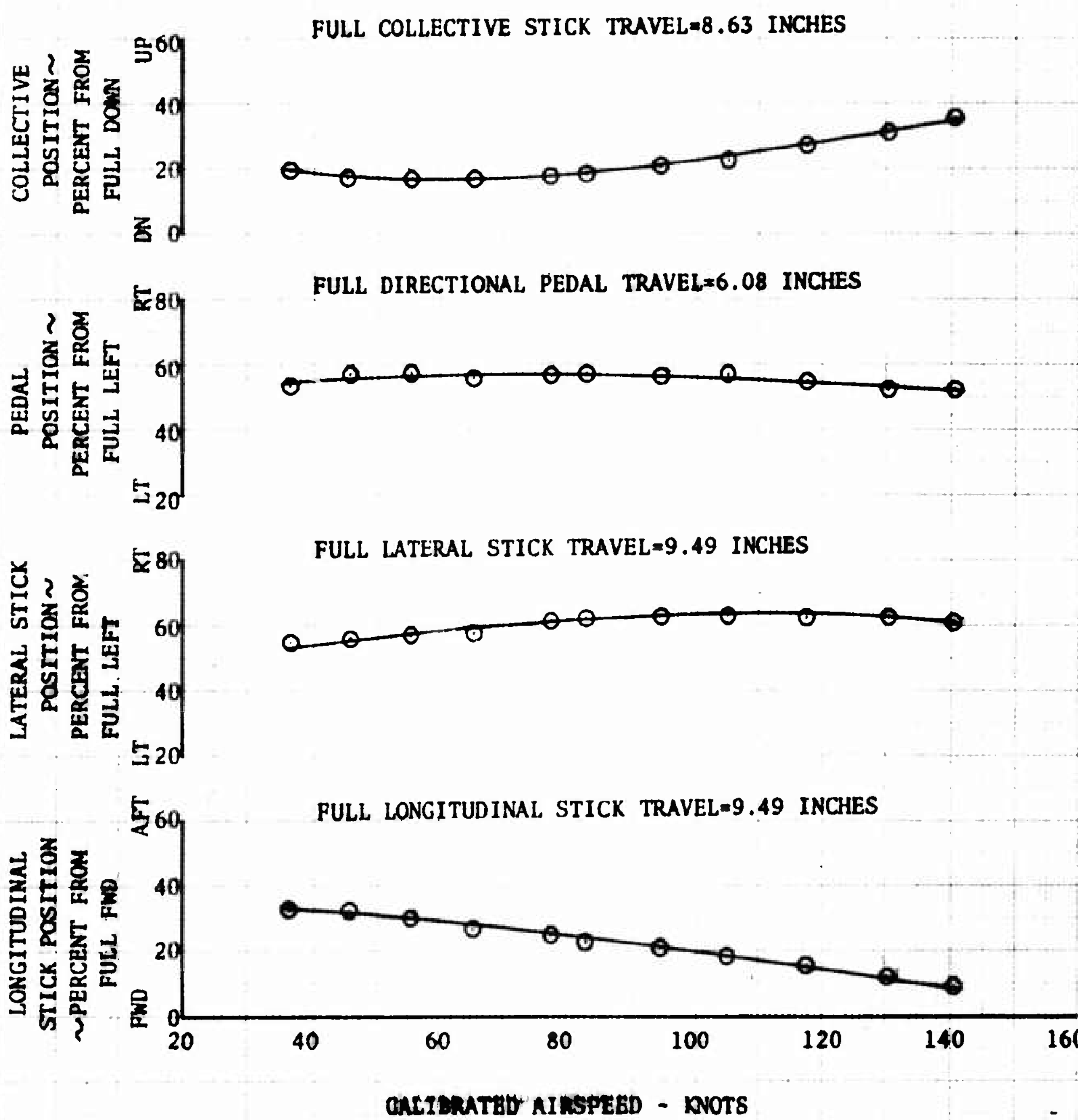


FIGURE NO. 12
CONTROL POSITIONS IN LEVEL FLIGHT
AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	CONFIGURATION	C_T
8066	194.9	0.4 LEFT	6613	CLEAN	0.00488

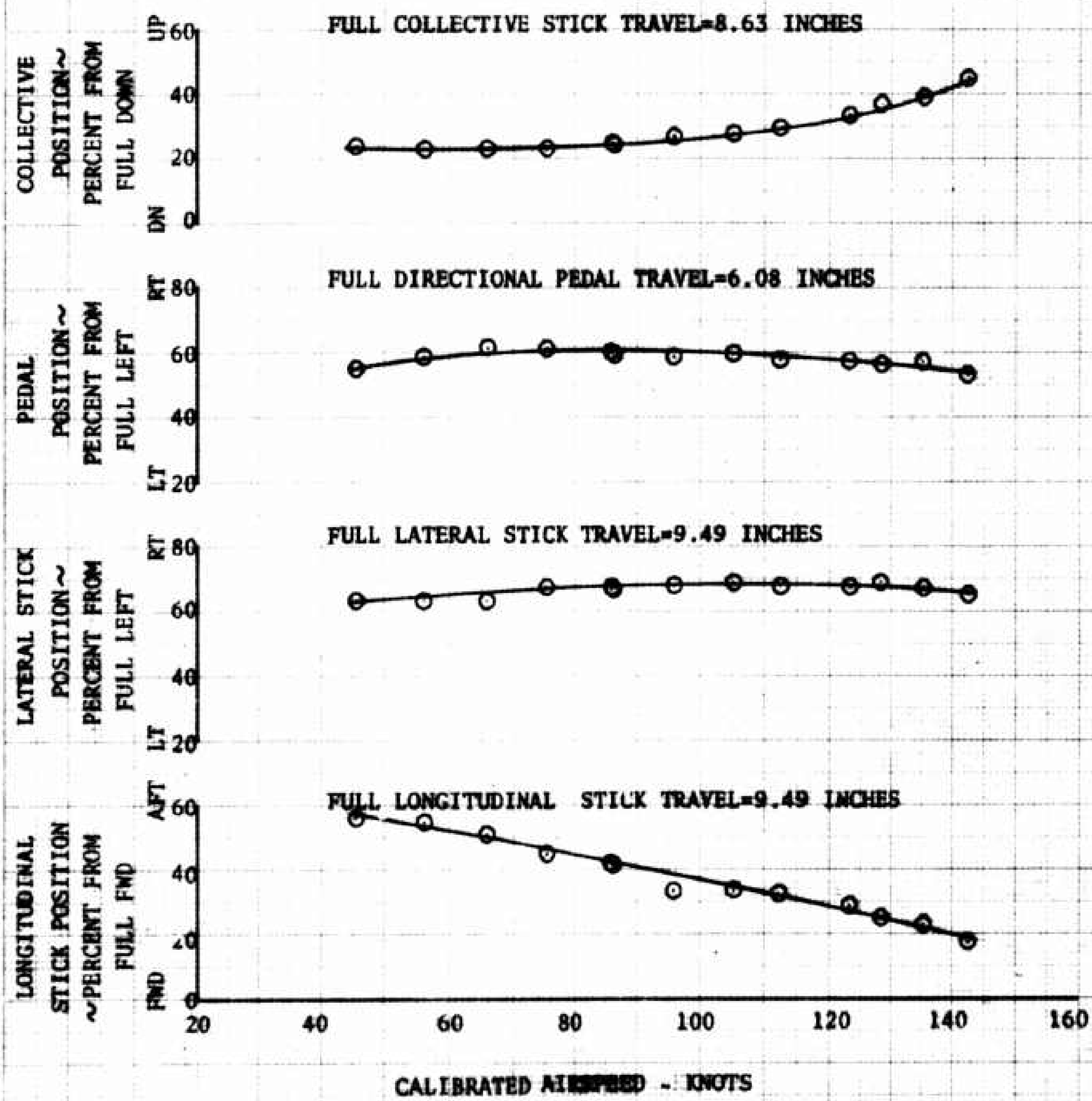


FIGURE NO. 13
CONTROL POSITIONS IN LEVEL FLIGHT
AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	CONFIGURATION	C_T
8169	194.0	1.70 LEFT	4940	XM-35	0.00470

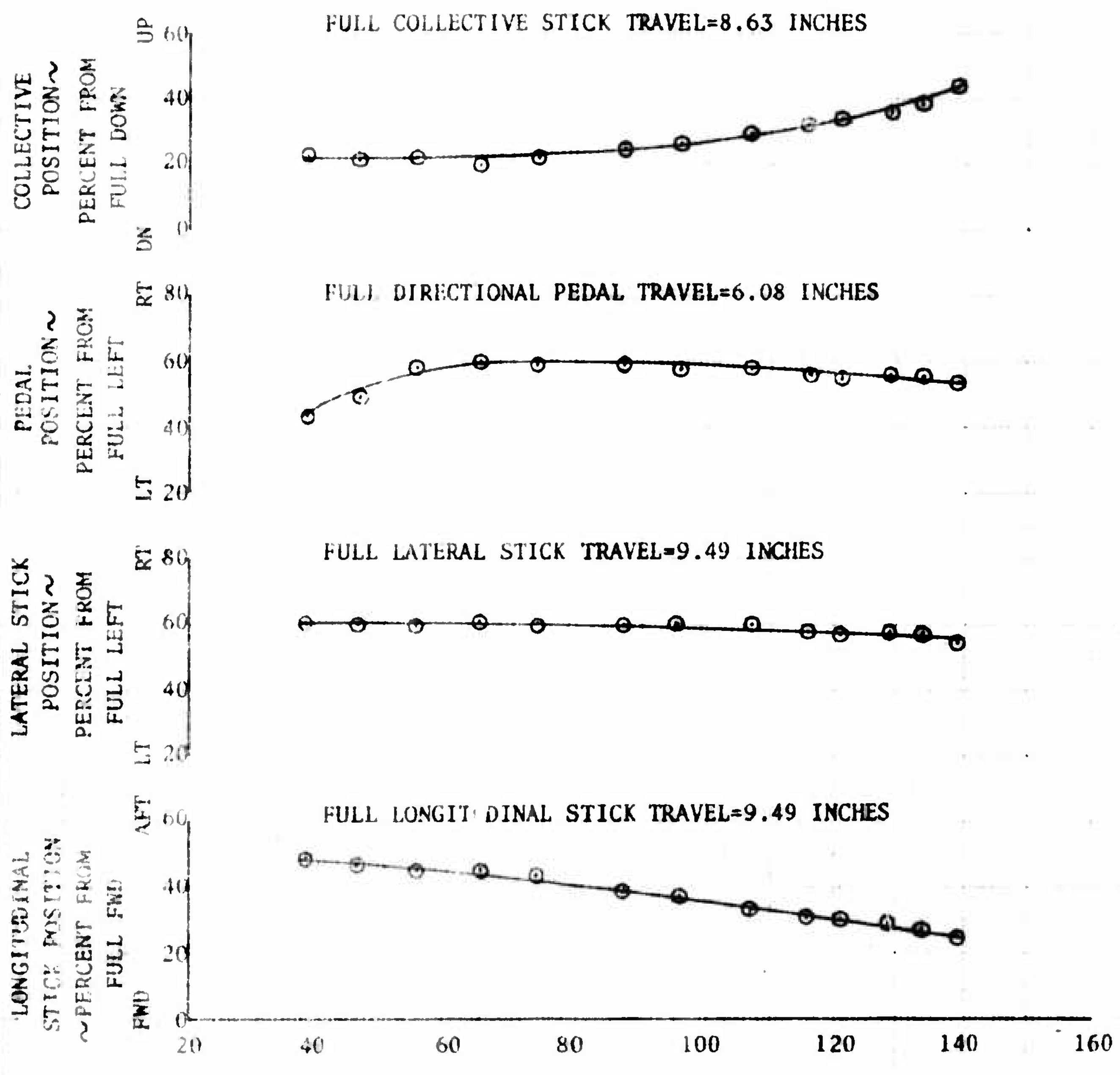


FIGURE NO. 14

CONTROL POSITIONS IN LEVEL FLIGHT

AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	CONFIGURATION	C_T
8190	193.5	1.71 LEFT	3038	XM-35	0.00445

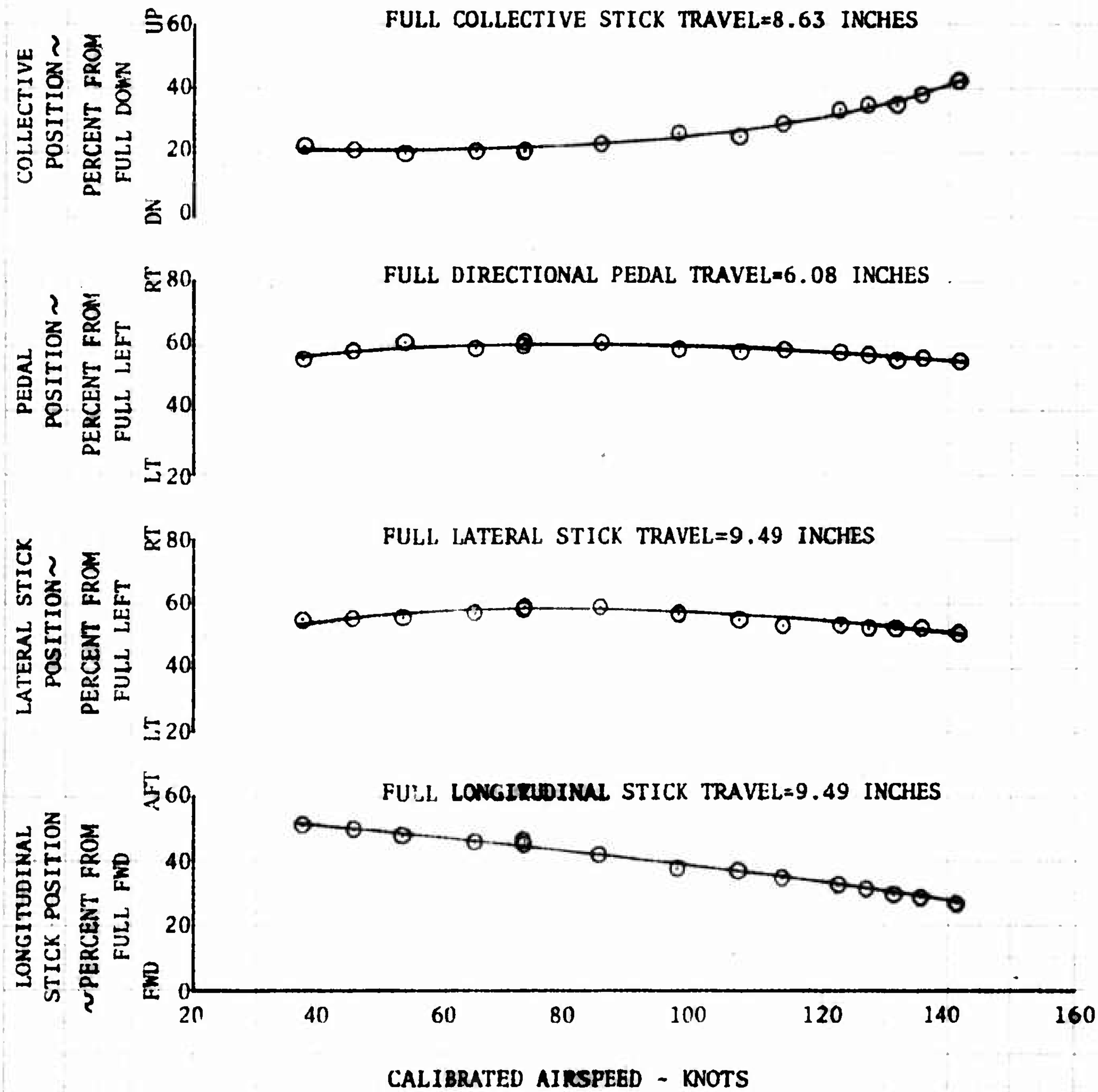


FIGURE NO. 15
CONTROL POSITIONS IN LEVEL FLIGHT
AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	CONFIGURATION	C_T
8409	191.5	1.64 LEFT	7857	XM-35	0.00529

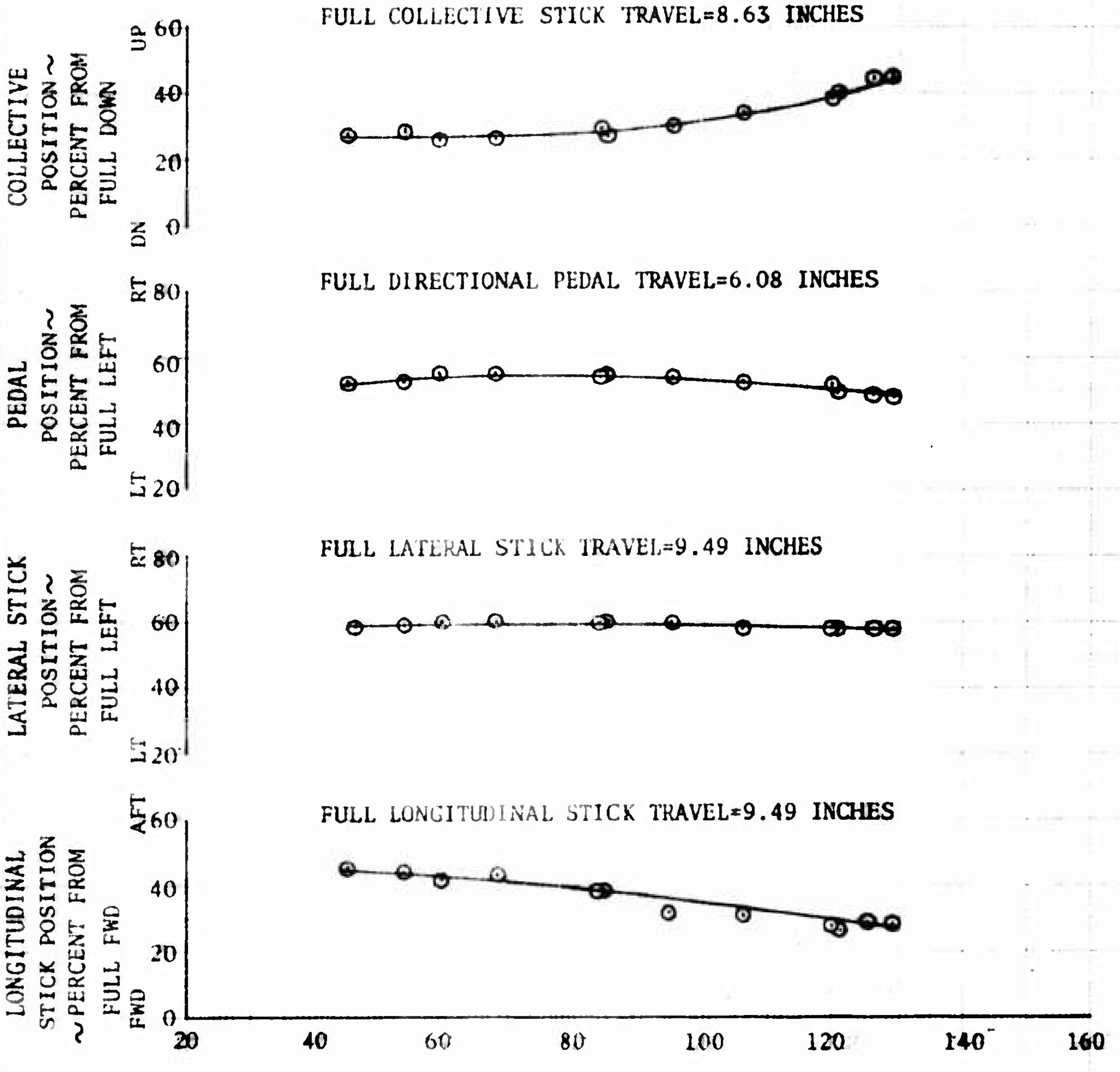


FIGURE NO. 16
STATIC LONGITUDINAL STABILITY
AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG C.G. STATION INCHES	LAT C.G. STATION INCHES	DENSITY ALTITUDE FEET	CONFIGURATION	C_T
8728	194.5	1.66 LEFT	5322	XM-35	0.00473

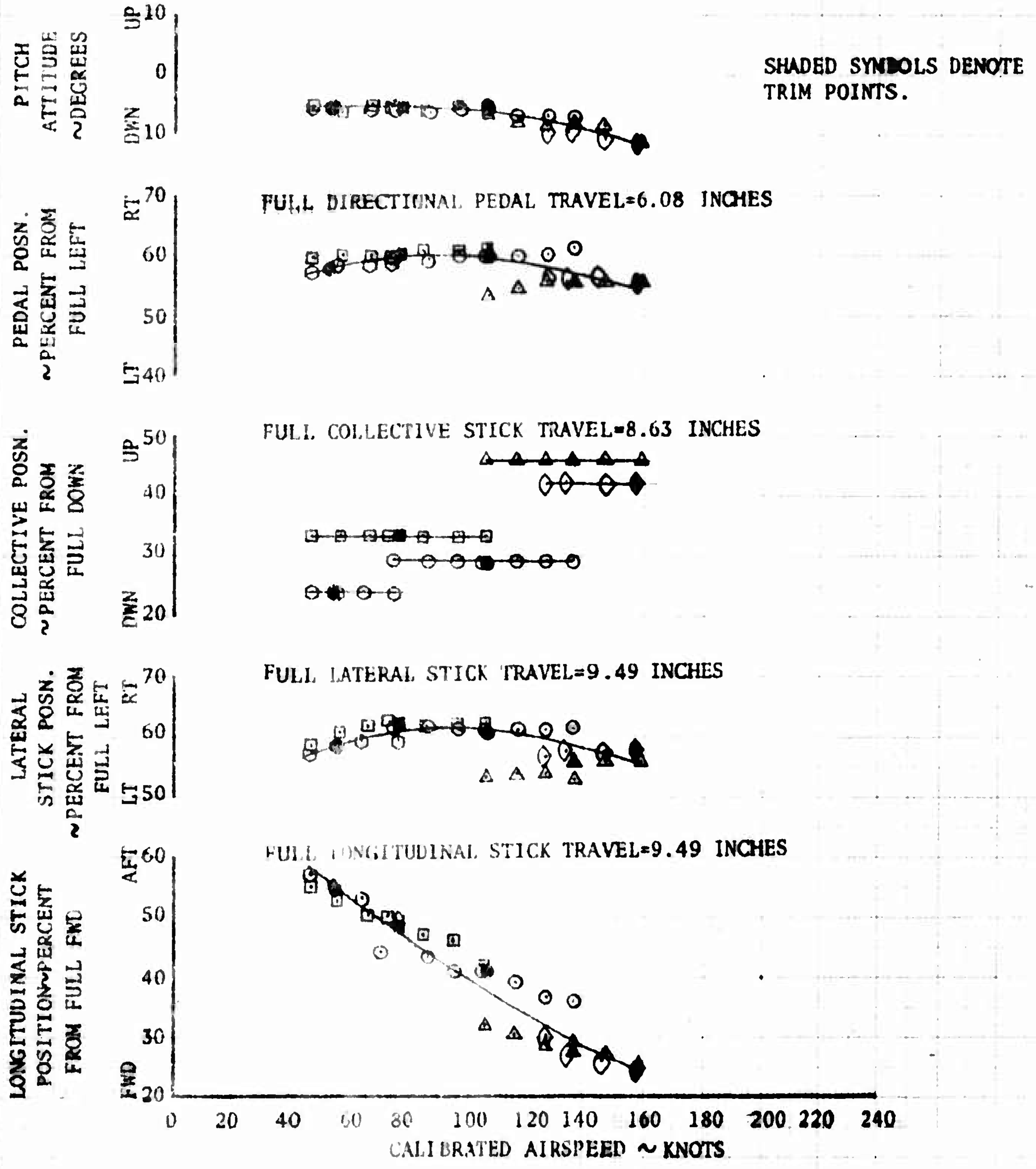


FIGURE NO. 17
STATIC LONGITUDINAL STABILITY
AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG C.G. STATION INCHES	LAT C.G. STATION INCHES	DENSITY ALTITUDE FEET	CONFIGURATION	C_T
8927	192.2	0.730 LEFT	4135	XM-35	0.00501

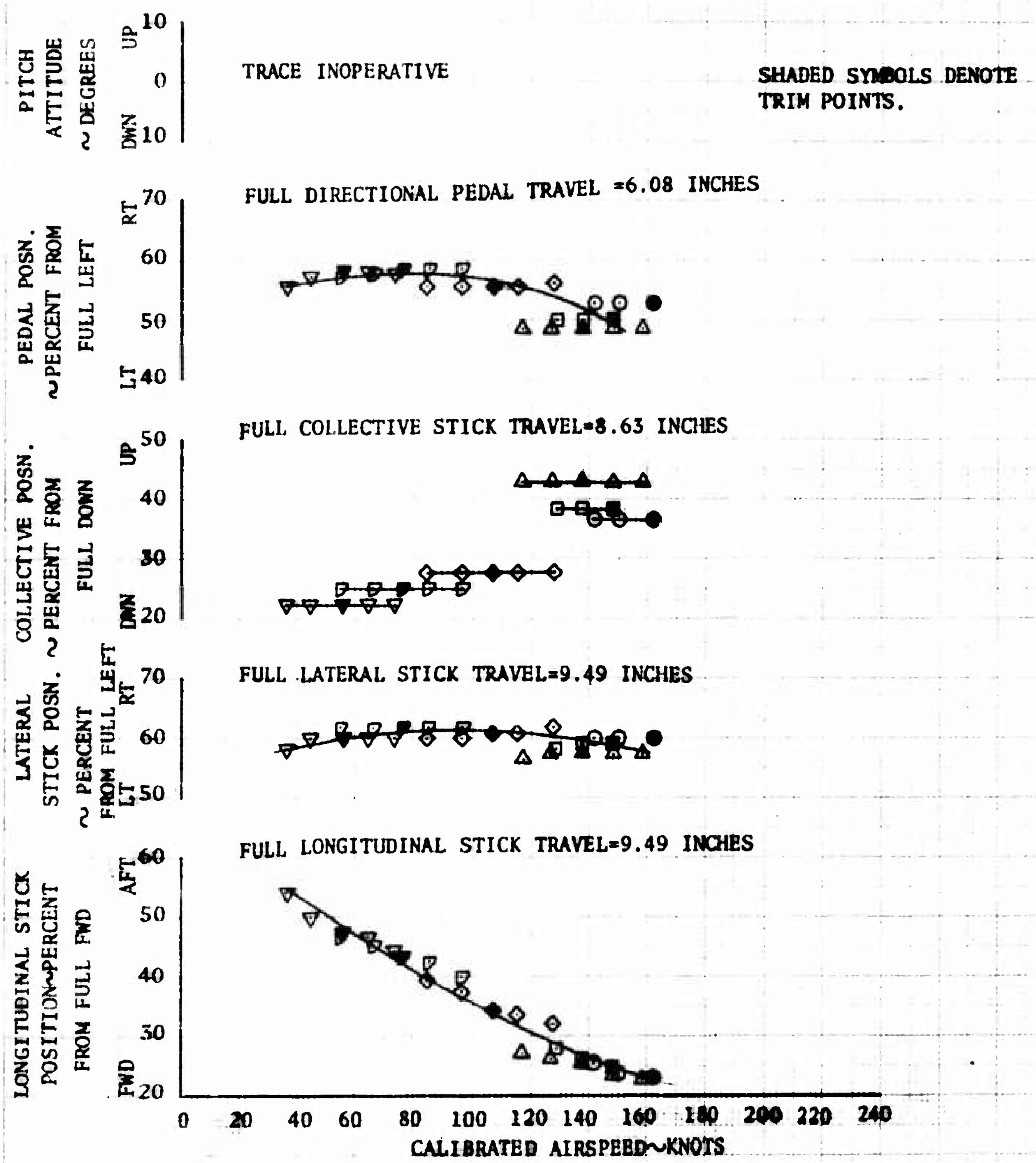


FIGURE NO. 18

STATIC LONGITUDINAL STABILITY

AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG C.G. STATION INCHES	LAT C.G. STATION INCHES	DENSITY ALTITUDE FEET	CONFIGURATION	C_T
9253	194.4	0.73 LEFT	3010	XM-35 DOORS OPEN	0.00502

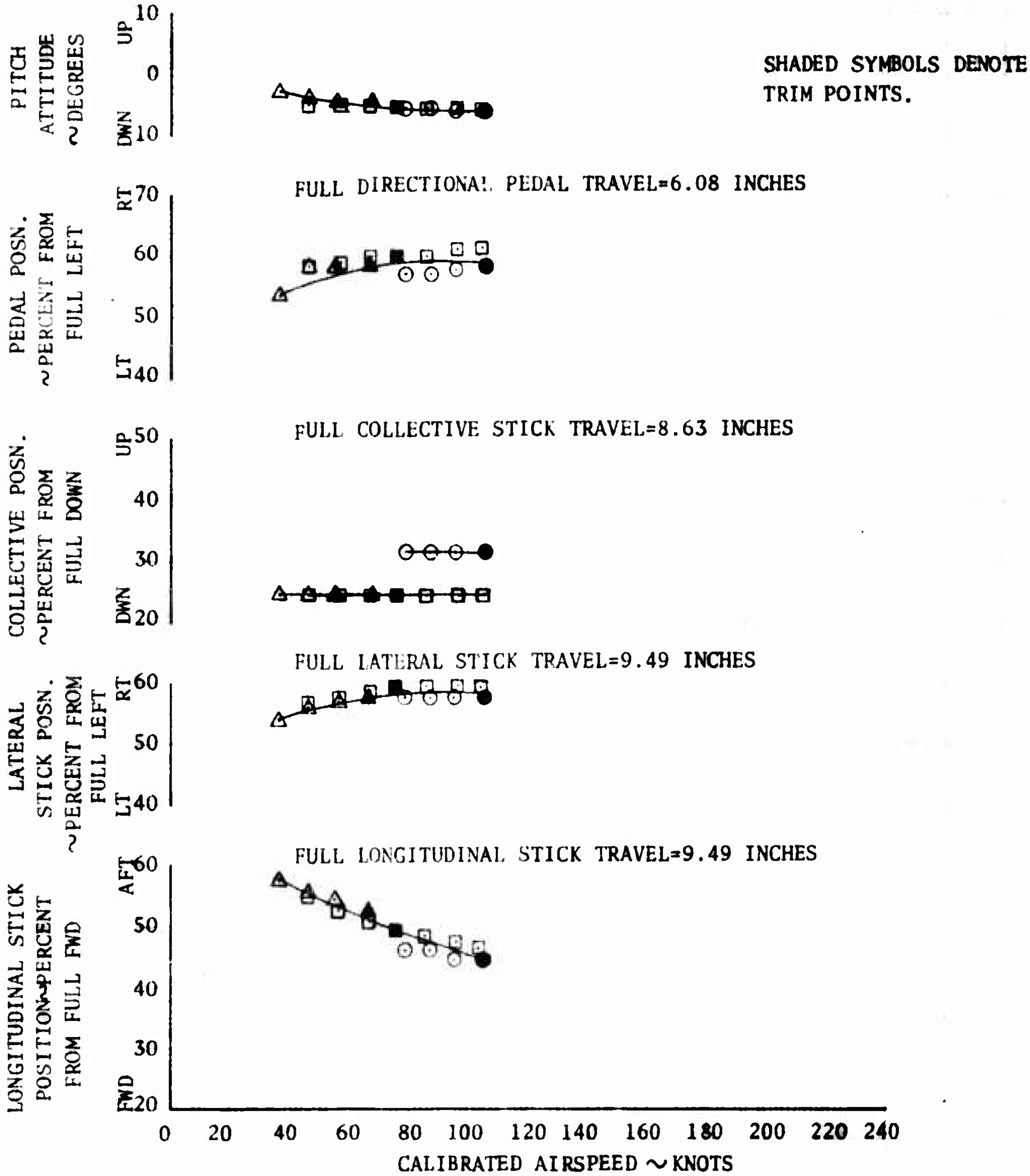


FIGURE NO. 19

STATIC LATERAL-DIRECTIONAL STABILITY

AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	ROTOR SPEED RPM	CALIBRATED AIRSPEED KNOTS	CONFIGURATION
8183	193.9	1.78	5173	324	107.0	XM-35

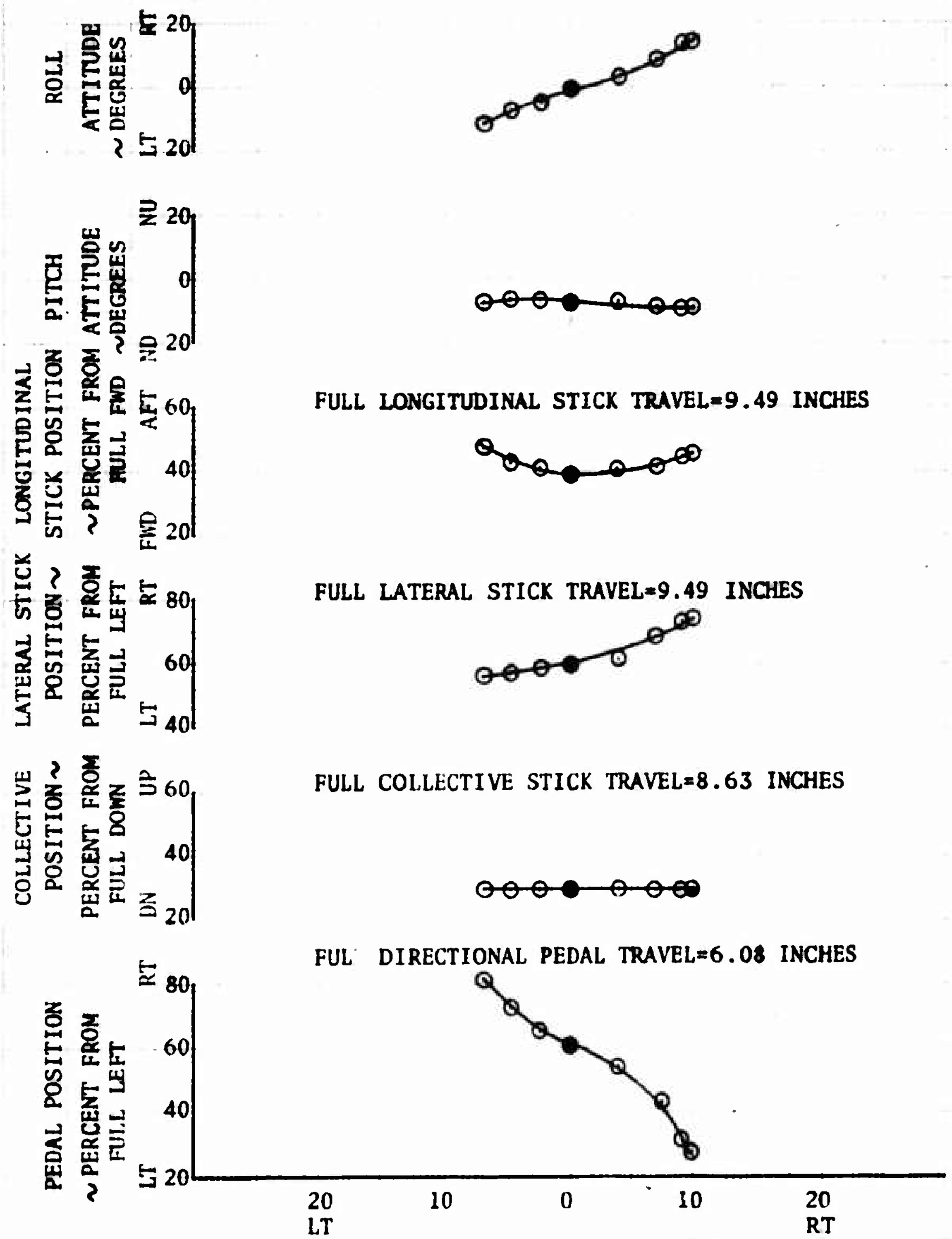


FIGURE NO. 20
STATIC LATERAL-DIRECTIONAL STABILITY
AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	ROTOR SPEED RPM	CALIBRATED AIRSPEED KNOTS	CONFIGURATION
8378	193.5	1.73 LEFT	5178	324	158.0	XM-35

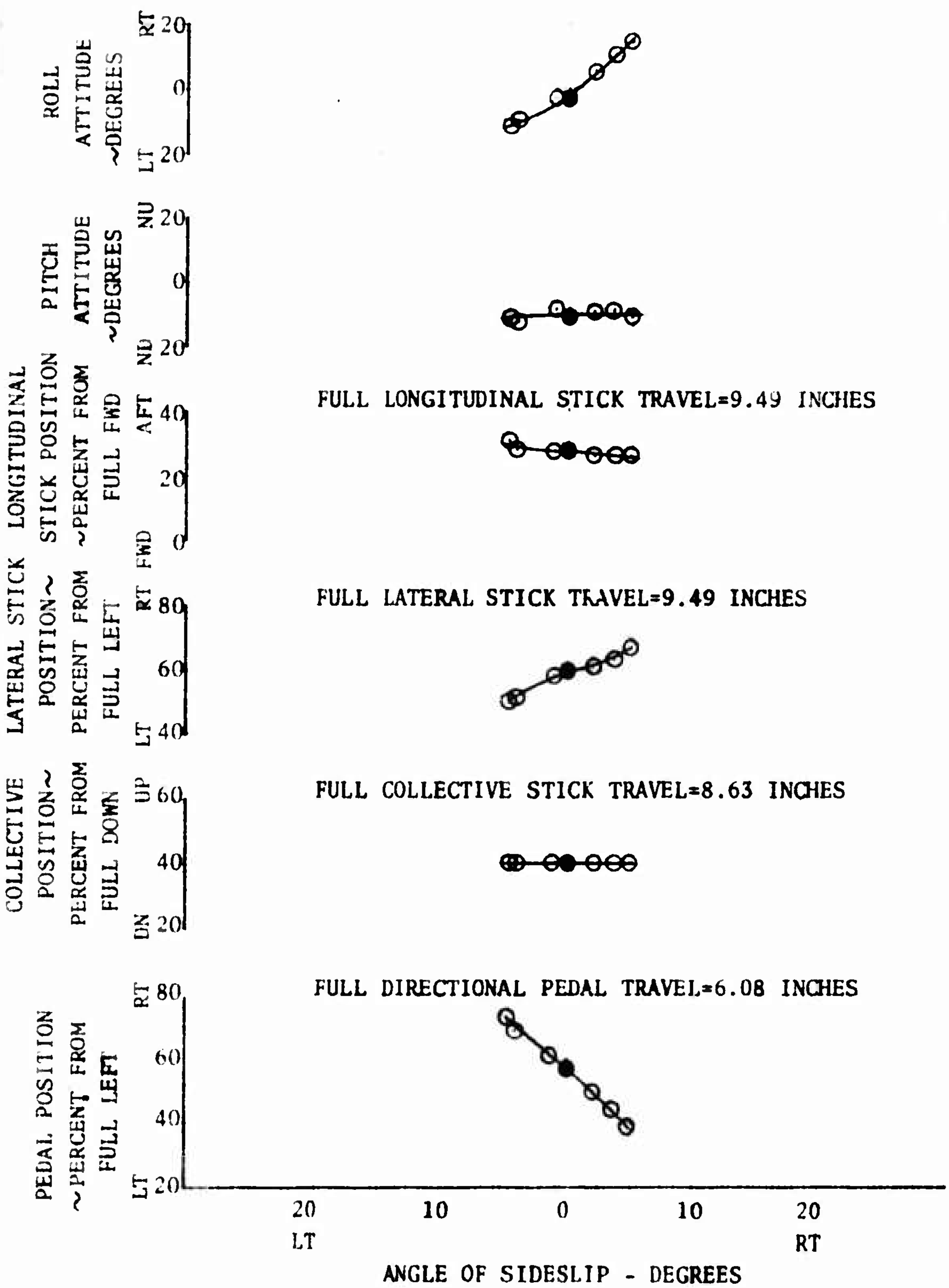


FIGURE NO. 21
STATIC LATERAL-DIRECTIONAL STABILITY
AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	ROTOR SPEED RPM	CALIBRATED AIRSPEED KNOTS	CONFIGURATION
9182	195.0	1.54 LEFT	9167	324	107.0	XM-35

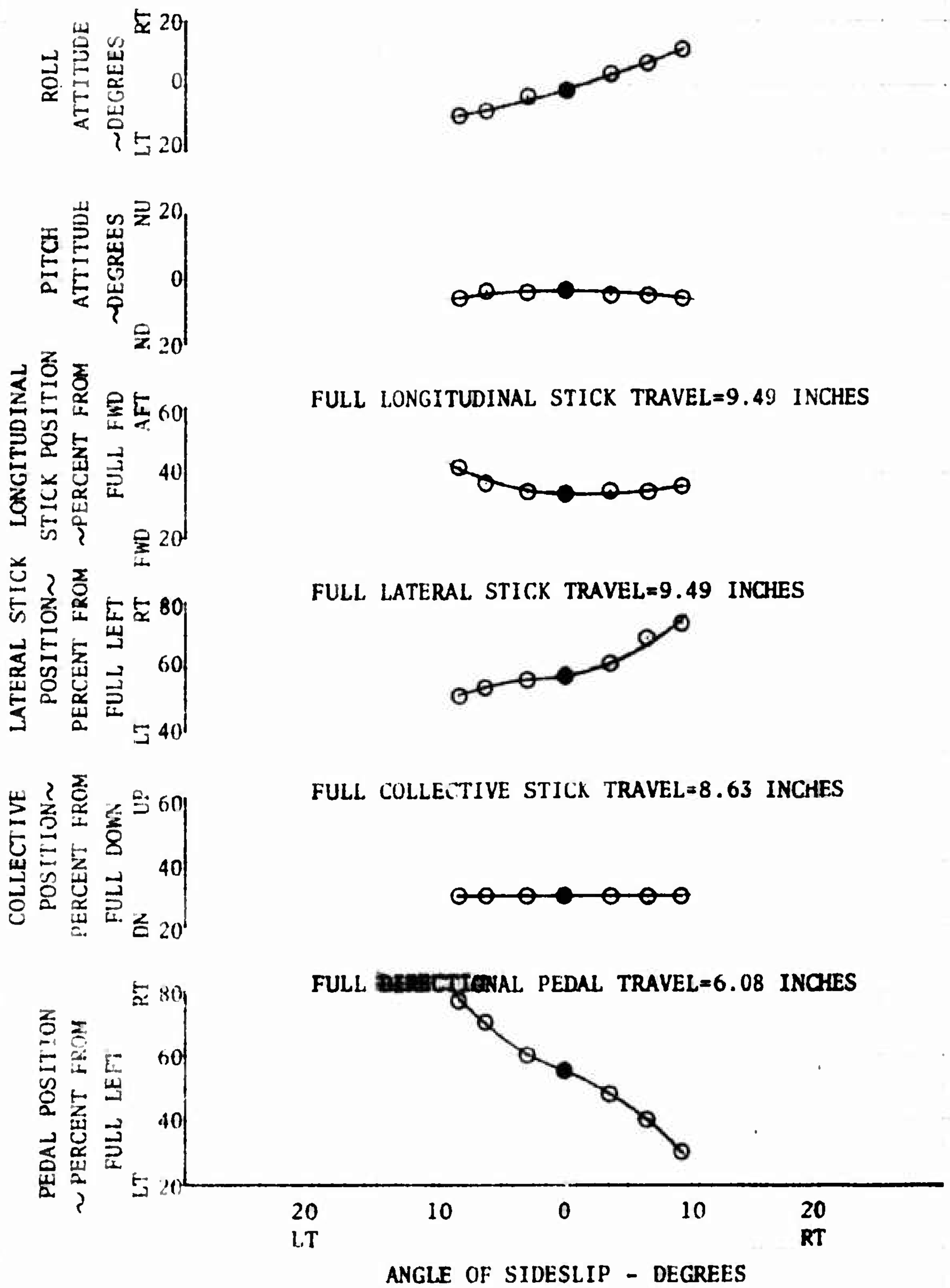


FIGURE NO. 22

STATIC LATERAL-DIRECTIONAL STABILITY

AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	ROTOR SPEED RPM	CALIBRATED AIRSPEED KNOTS	CONFIGURATION
8982	195.3	1.58 LEFT	9167	324	156.0	XM-35

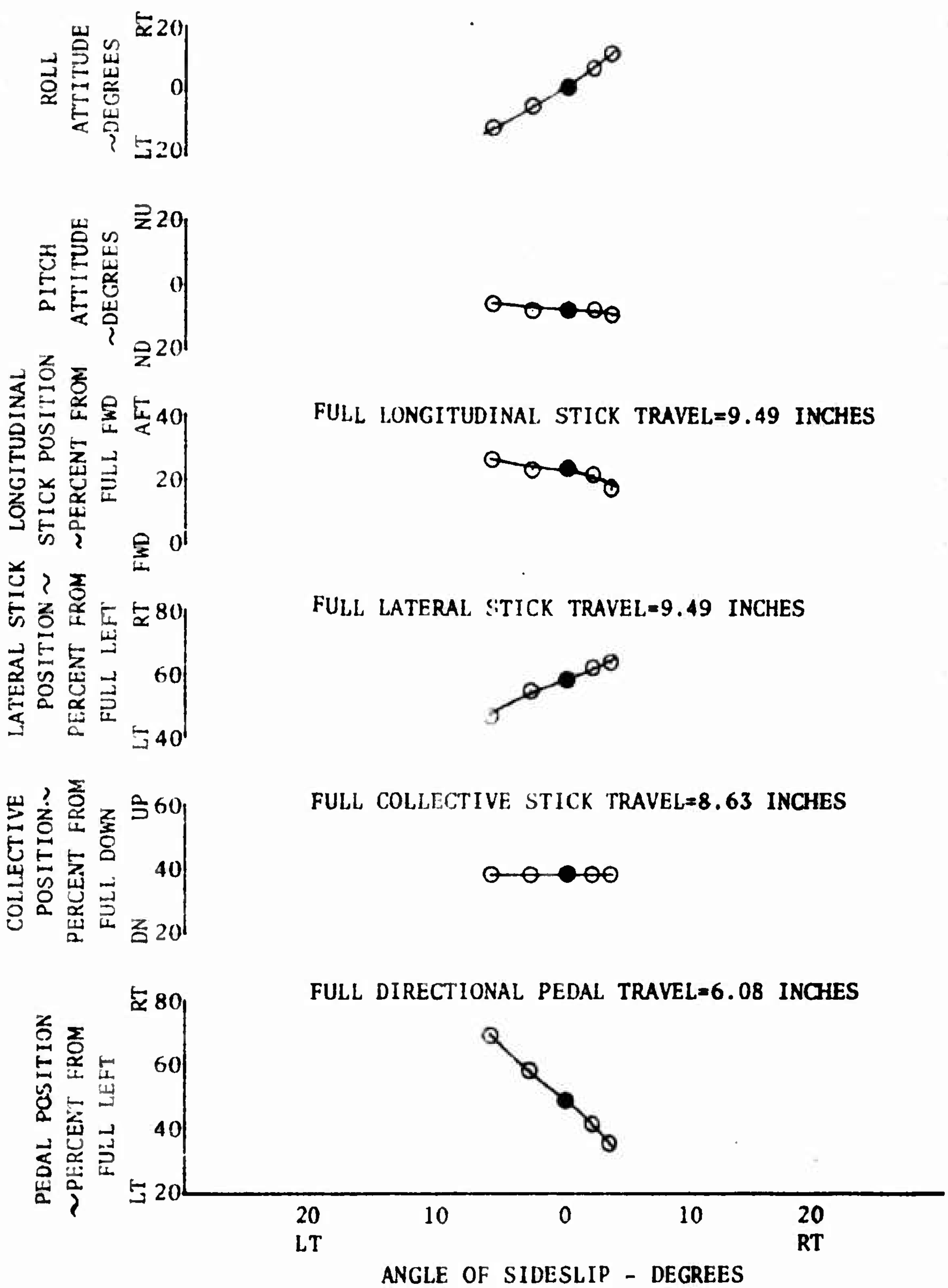


FIGURE NO. 23
STATIC LATERAL-DIRECTIONAL STABILITY
AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	ROTOR SPEED RPM	CALIBRATED AIRSPEED KNOTS	CONFIGURATION
9219	192.9	0.914	4850	324	74.8	XM-35 DOORS OPEN

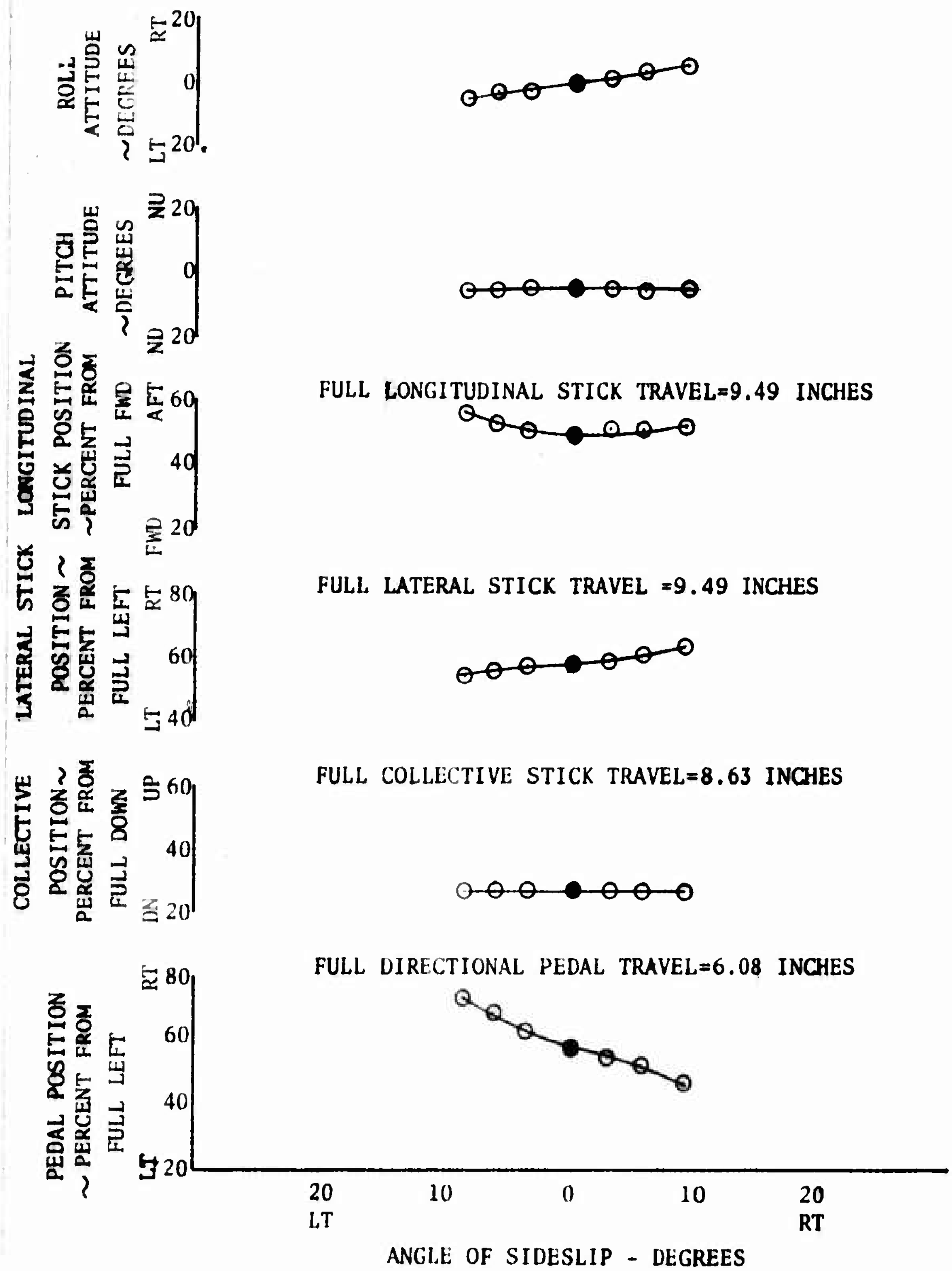


FIGURE NO. 24

STATIC LATERAL-DIRECTIONAL STABILITY

AH-1G/XM-35 USA S/N 67-15532

GROSS WEIGHT LB	LONG. C.G. STATION INCHES	LAT. C.G. STATION INCHES	DENSITY ALTITUDE FEET	ROTOR SPEED RPM	CALIBRATED AIRSPEED KNOTS	CONFIGURATION
8940	193.4	0.75 LEFT	4850	324	106.1	XM-35 DOORS OPEN

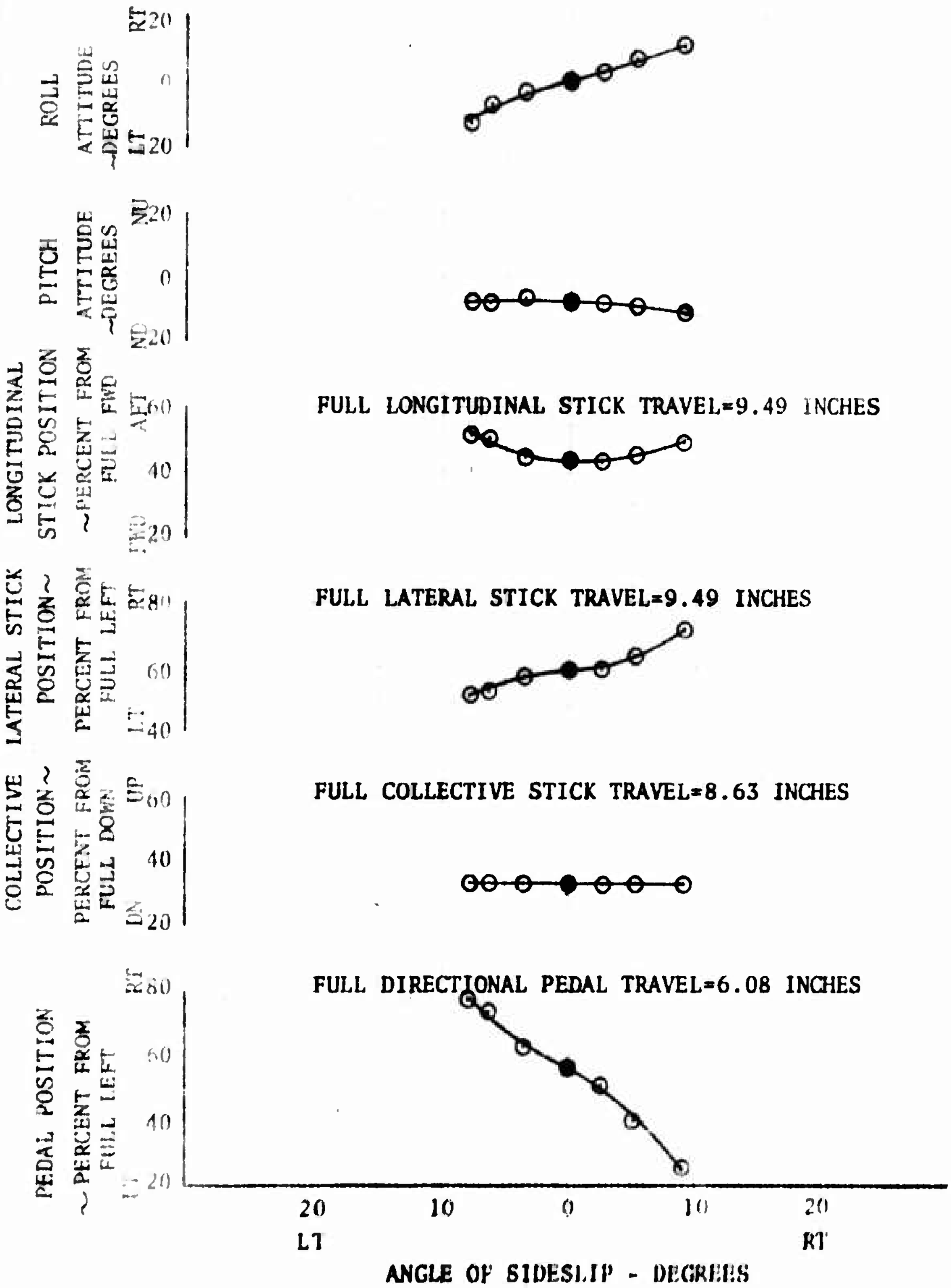


FIGURE NO. 25
AFT LONGITUDINAL PULSE
AH-1G/XM-35 USA S/N 67-15532

AIRSPEED CALIB	GROSS WEIGHT (lb)	LONG. C.G. STATION (in.)	LATERAL C.G. STATION (in.)	DENSITY ALTITUDE (ft)	ROTOR SPEED (rpm)	CONFIGURATION
106.0	9070	194.6	1.61 LEFT	5000	324	XM-35

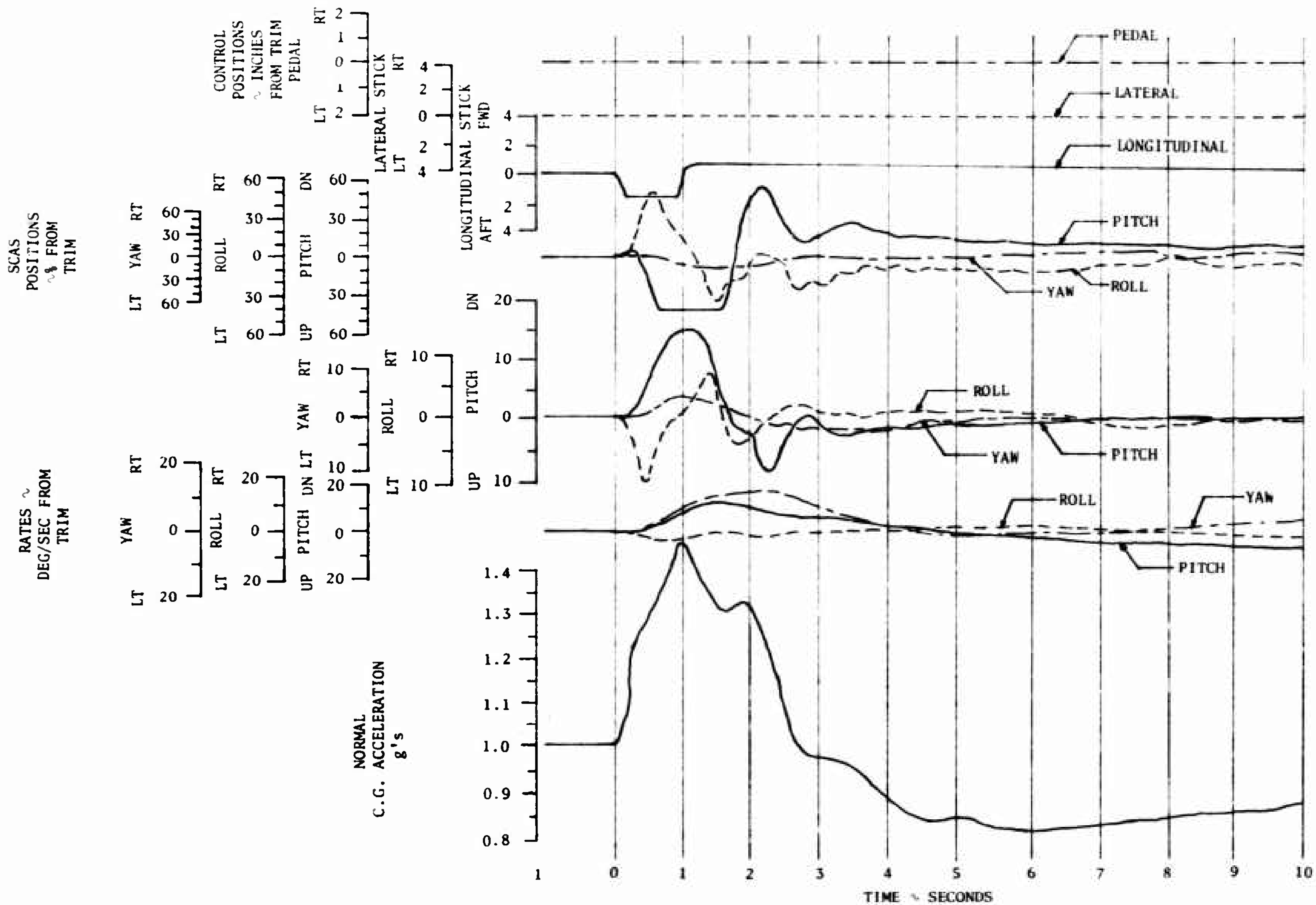


FIGURE NO. 26
LEFT LATERAL PULSE
AH-1G/XM-35 USA S/N 67-15532

AIRSPEED CALIB	GROSS WEIGHT (lb)	LONG. C.G. STATION (in.)	LATERAL C.G. STATION (in.)	DENSITY ALTITUDE (ft)	ROTOR SPEED (rpm)	CONFIGURATION
106.0	8890	194.4	1.64 LEFT	5000	324	XM-35

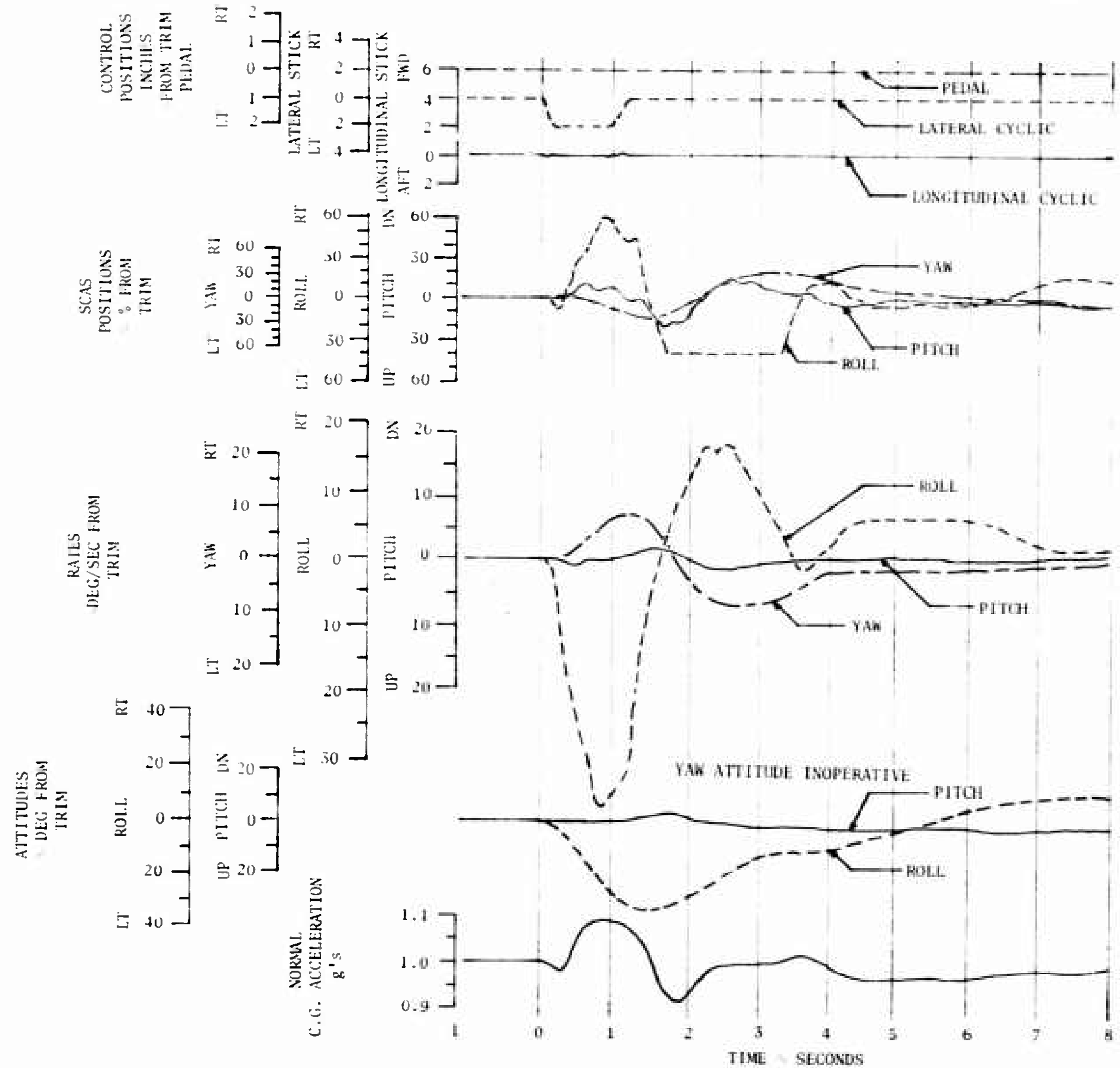


FIGURE NO. 27
LEFT LATERAL PULSE
AH-1G/SM-35 USA S/N 67-15532

AIRSPEED	GROSS WEIGHT	LONG. C.G. STATION	LATERAL C.G. STATION	DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
158.0	8676	191.5	0.98 LEFT	4970	324	XM-35

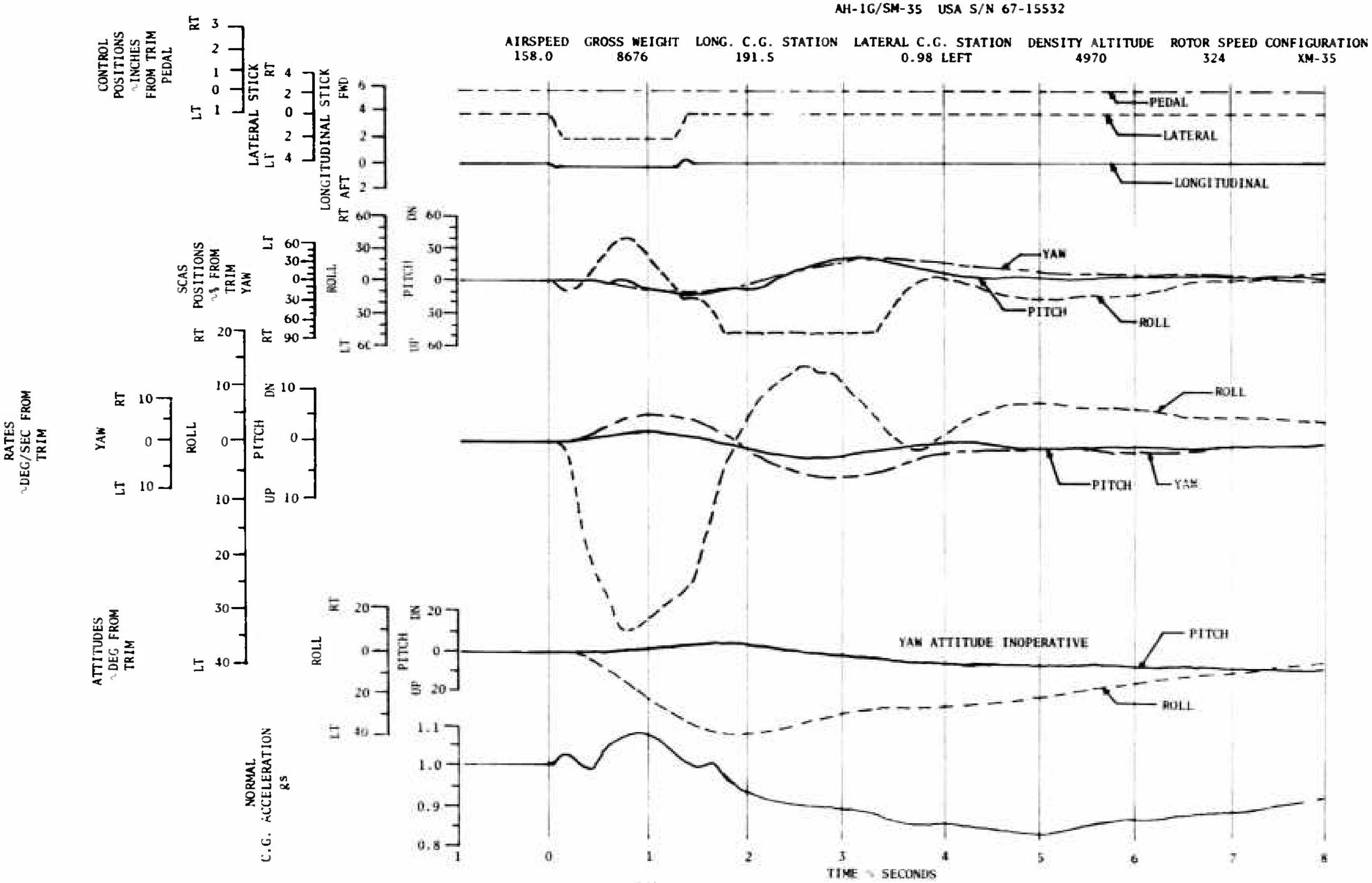


FIGURE NO. 28
RIGHT PEDAL PULSE
AH-1G/SM-35 USA S/N 67-15532

AIRSPEED CALIB	GROSS WEIGHT (lb)	LONG. C.G. STATION (in.)	LATERAL C.G. STATION (in.)	DENSITY ALTITUDE (ft)	ROTOR SPEED (rpm)	CONFIGURATION
106.0	8798	194.4	1.66 LEFT	5000	324	XM-35

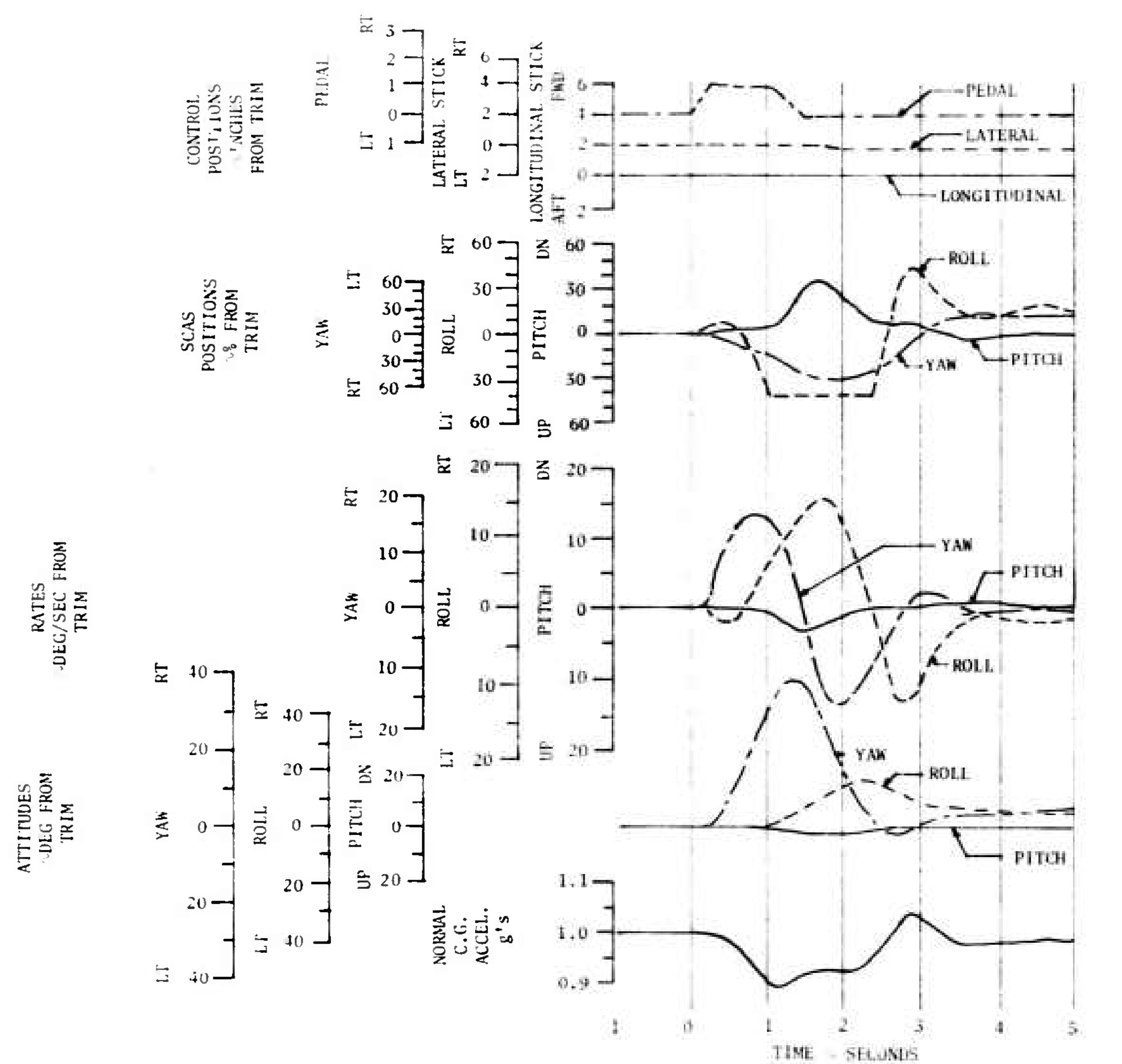


FIGURE NO. 29
LEFT LATERAL PULSE
AH-1G/XM-35 USA S/N 67-15532

CALIBRATED AIRSPEED	GROSS WEIGHT (lb)	LONG. C.G. STATION (in.)	LATERAL C.G. STATION (in.)	DENSITY ALTITUDE (ft)	ROTOR SPEED (rpm)	CONFIGURATION
106.0	8913	192.2	0.87 LEFT	4970	324	XM-35 DOORS OPEN

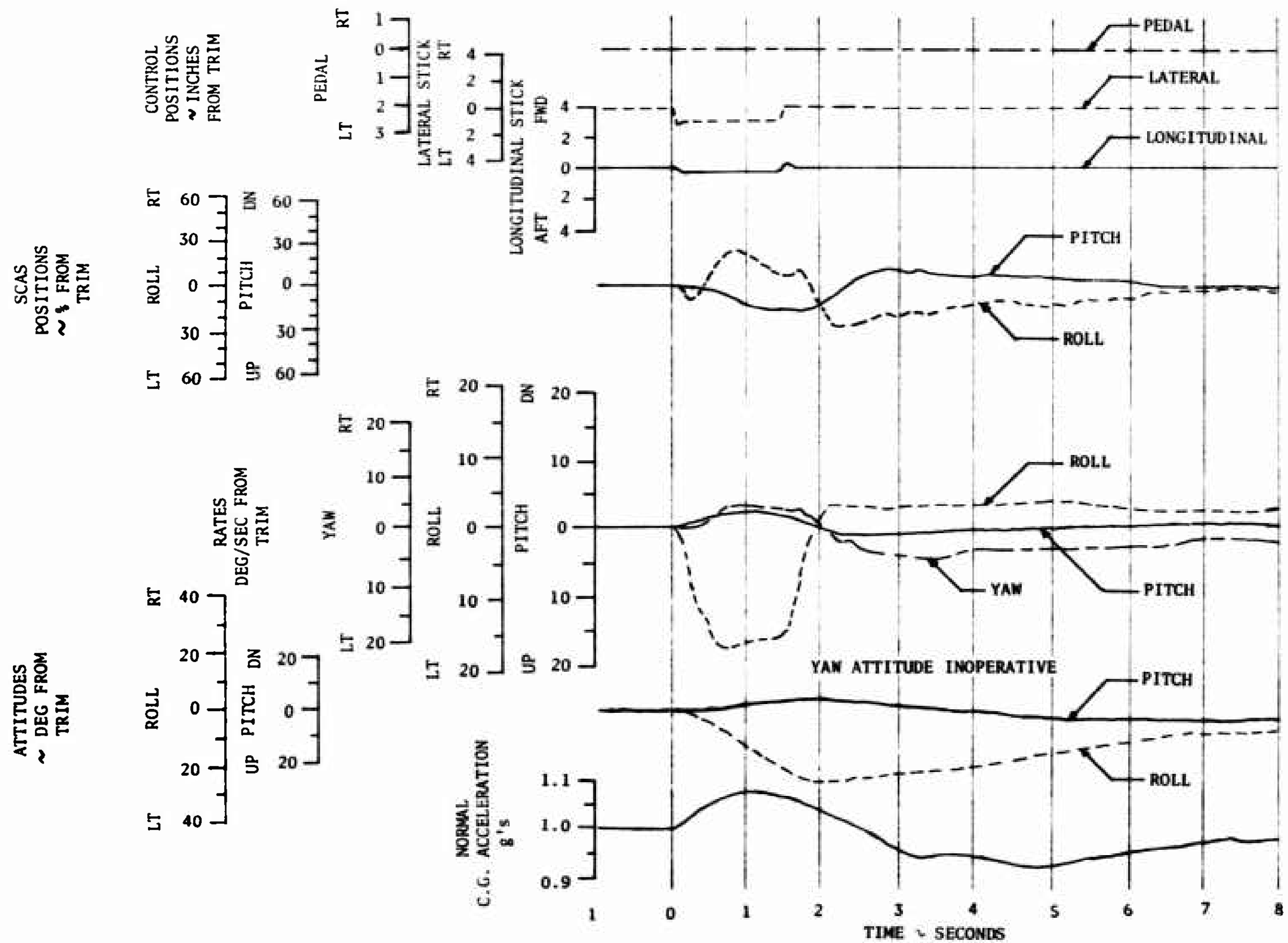
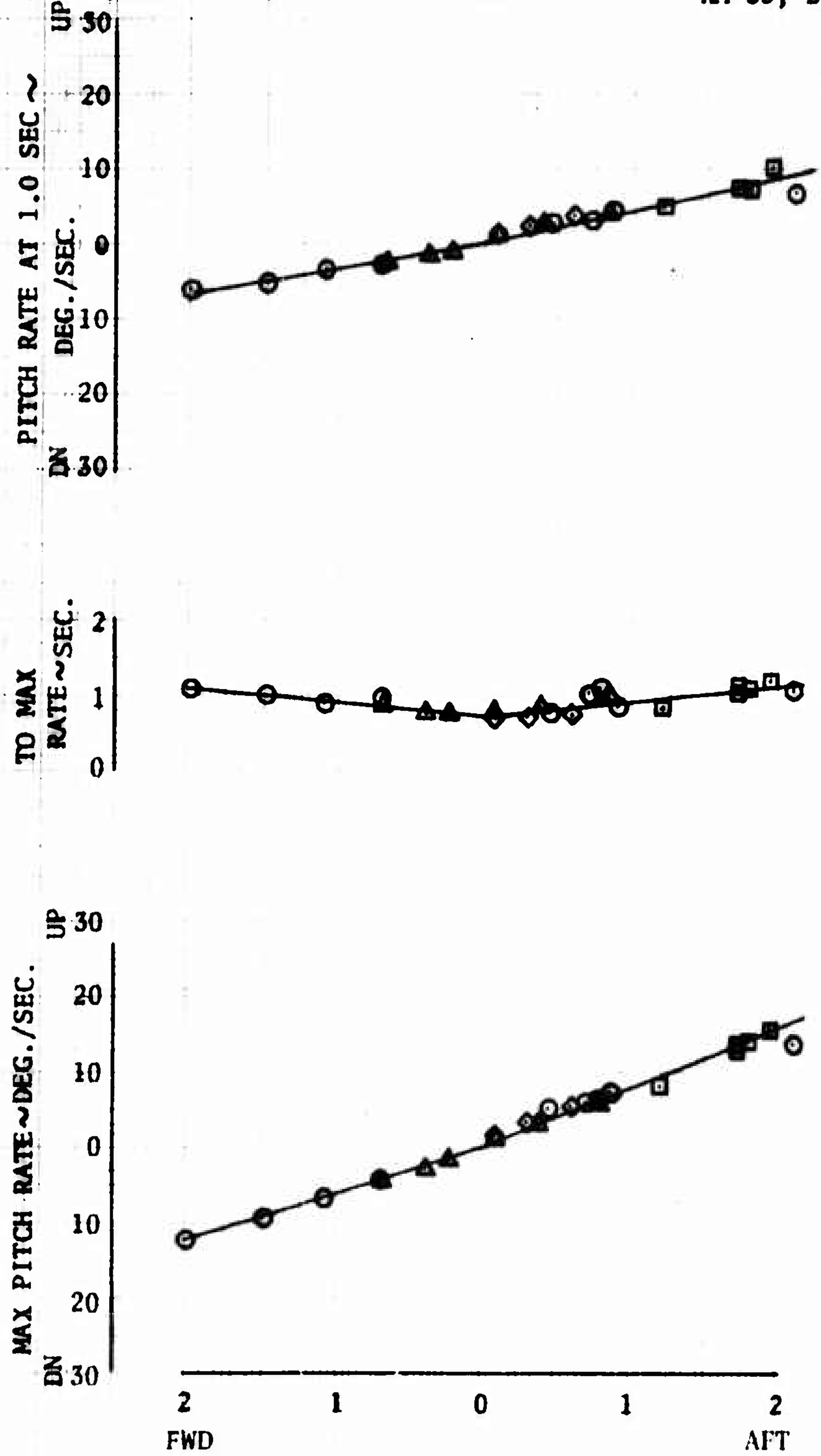


FIGURE NO. 30
LONGITUDINAL RESPONSE
AH-1G/XM-35 USA S/N 67-15532

SYMB.	GROSS WEIGHT	LONG. C.G.	LAT. C.G.	DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
○	9091	195.1	1.56	4755	324	XM-35
□	9052	191.5	0.75	5000	324	XM-35
△	9231	191.7	0.84	4690	324	XM-35, DOORS OPEN
◇	8965	191.4	0.87	5280	324	XM-35, DOORS OPEN

SYMBOL	CALIBRATED AIRSPEED ~ KNOTS
○	75.5
□	158.5
△	77.0
◇	106.5



LONGITUDINAL CYCLIC STICK DISPLACEMENT
~ INCHES FROM TRIM

FIGURE NO. 31

LATERAL RESPONSE

AH-1G/XM-35 USA S/N 67-15532

SYMB.	GROSS WEIGHT	LONG. C.G.	LAT. C.G.	DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
○	8779	194.8	1.62	4300	324	XM-35
□	8675	191.5	0.78	5000	324	XM-35
△	9032	191.5	0.96	4690	324	XM-35, DOORS OPEN
◇	[illegible]	191.2	0.88	4570	324	XM-35, DOORS OPEN

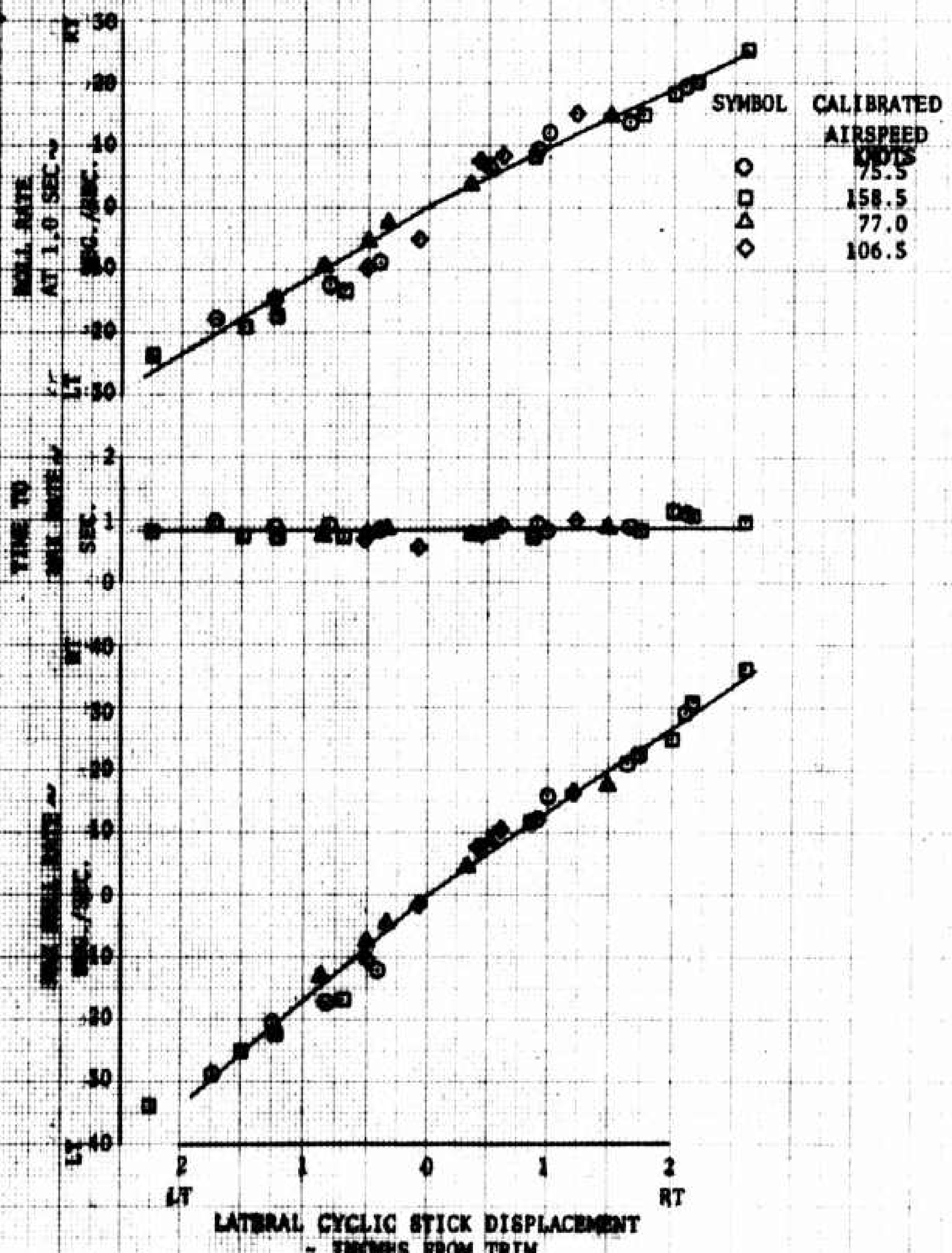


FIGURE NO. 32

XM-35 (20MM CANNON) FIRING

LEVEL FLIGHT

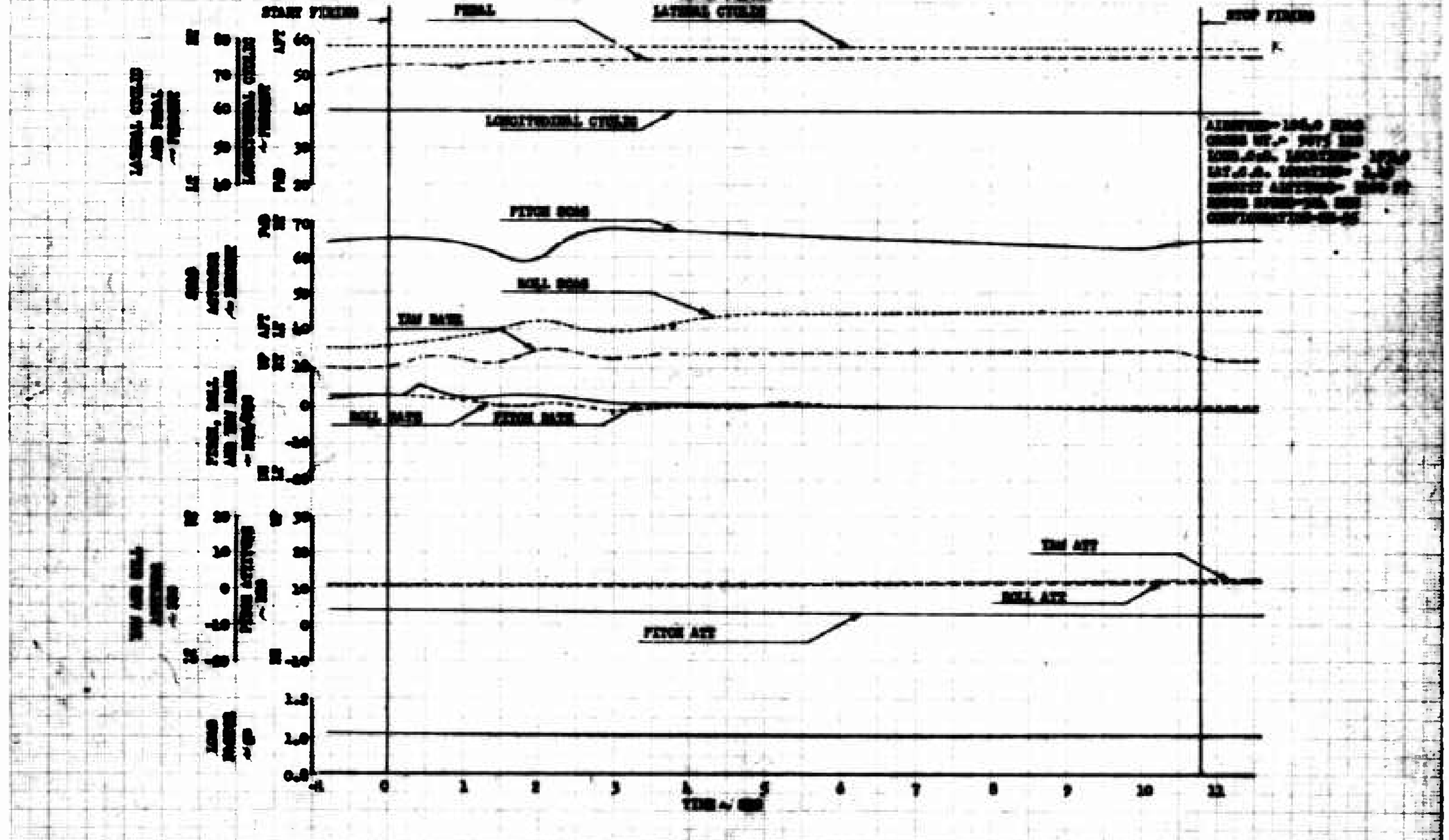
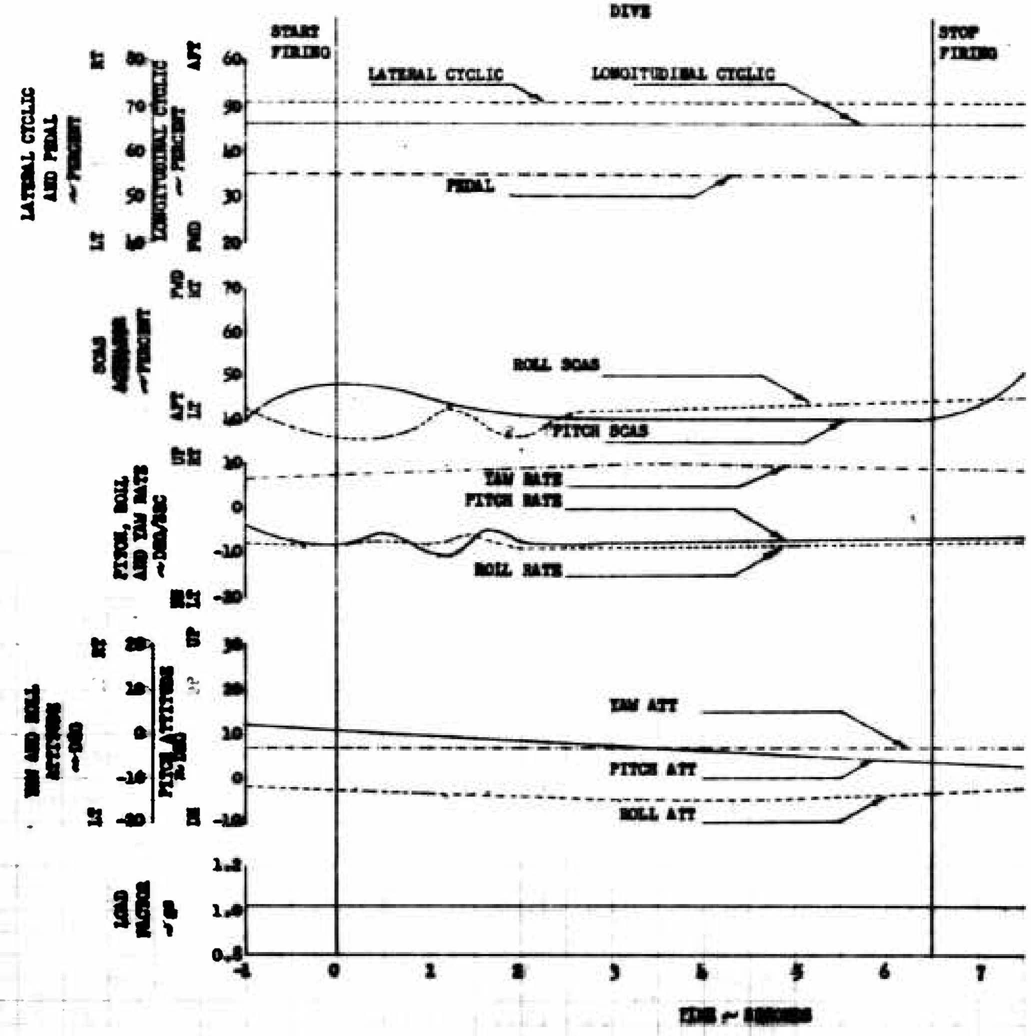


FIGURE NO. 33
XM-35 (20MM CANNON) FIRING
AH-1G/XM-35 USA S/N 67-15532
DIVE



AIRSPEED = 274.8 KCAS
GROSS WT. = 8603 LBS
LONG C.G. LOCATION = 193.5
LAT C.G. LOCATION = 1.65 LEFT
DENSITY ALTITUDE = 4700 FT
ROTOR SPEED = 324
CONFIGURATION = XM-35

FIGURE NO. 34

V_{NE} EVALUATION

AH-1G/XM-35 USA S/N 67-15532

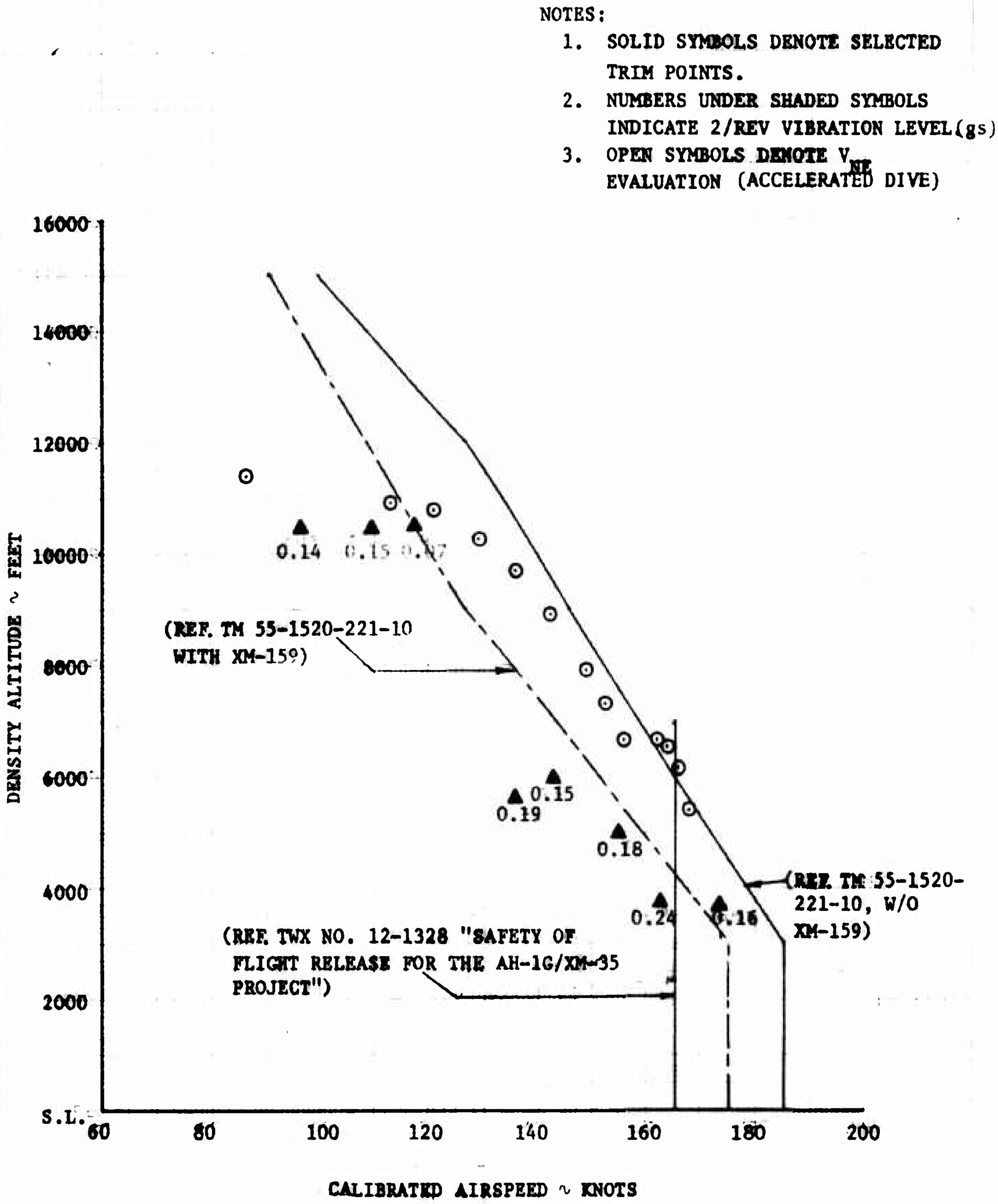


FIGURE NO. 35

V_{NE} EVALUATION

AH-1G/XM-35 U.S.A. S/N 67-15532

COPILOT VERTICAL

AVG. GROSS WEIGHT=9270 LB.
LONG. C.G. STATION=193.8 IN. (FWD)
LAT. C.G. STATION=1.57 IN (LT)
AVG. DENSITY ALTITUDE=8480 FEET
ROTOR SPEED=324 RPM

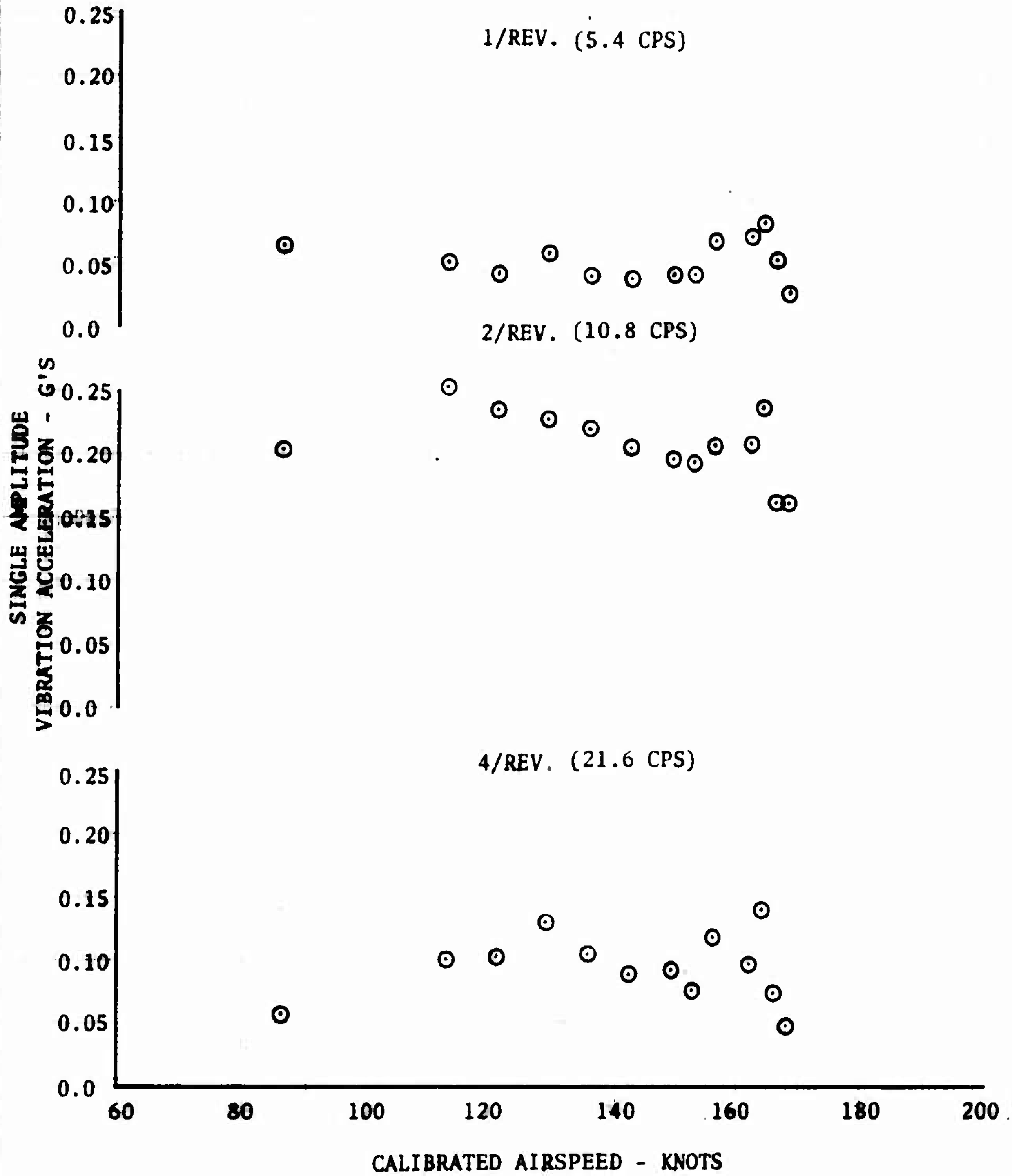
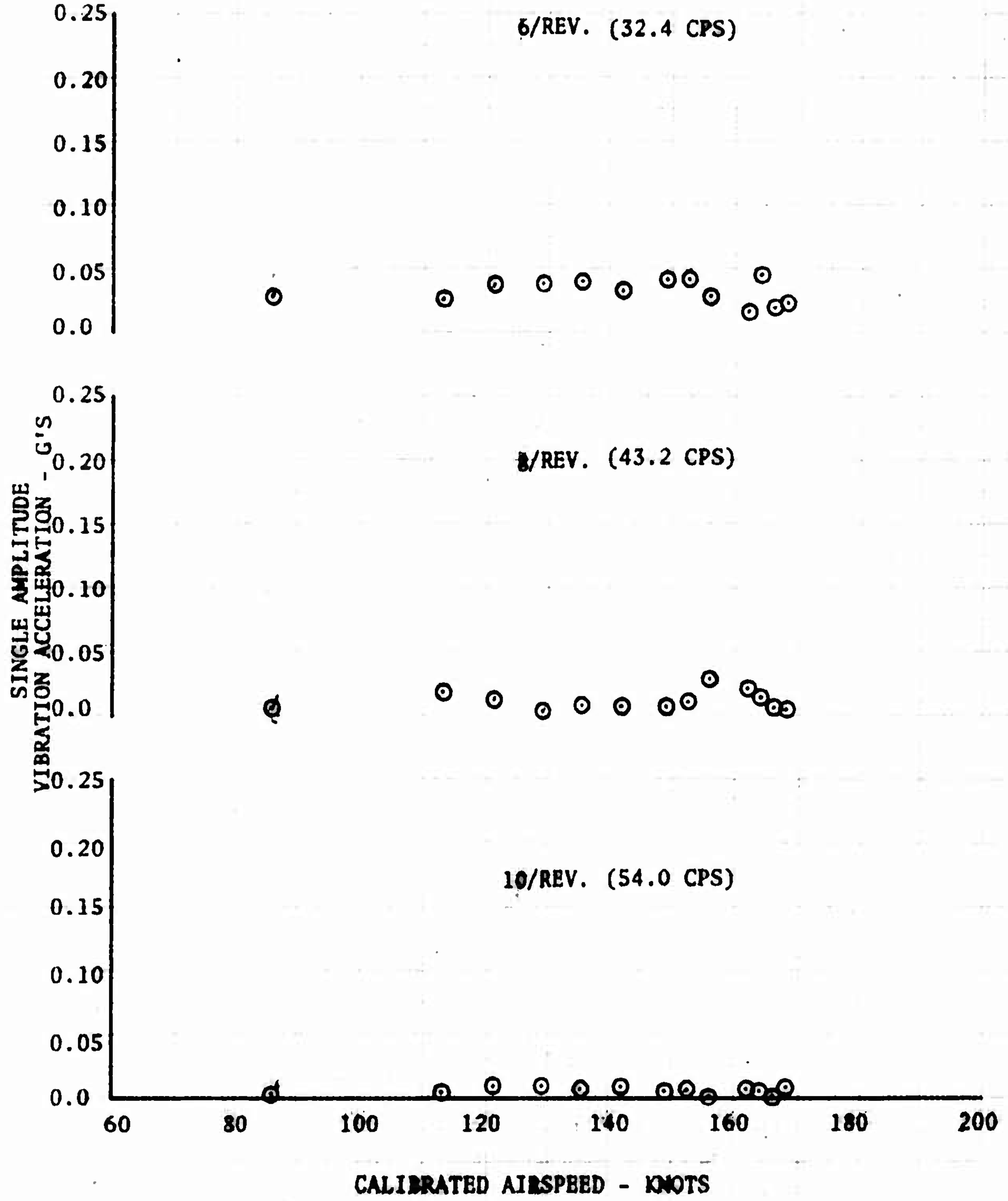


FIGURE NO. 36

V_{NE} EVALUATION

AH-1G/XM-35 U.S.A. S/N 67-15532

COPILOT VERTICAL



APPENDIX III. TEST INSTRUMENTATION

ENGINEER'S PANEL

Free air temperature
Fuel counter
Oscillograph counter
Oscillograph switch
Standard system airspeed
Standard system altitude

PILOT'S PANEL

Angle of sideslip
Boom airspeed
Boom altitude
Control positions
Normal acceleration
Oscillograph counter
Sensitive rotor tachometer

OSCILLOGRAPH

Angle of attack
Angle of sideslip
Collective stick position
Copilot/gunner's vertical acceleration
Delta torque
Directional control position
Lateral cyclic stick position
Rotor blip
Longitudinal, lateral and directional SCAS actuator position
Longitudinal stick position
Pitch, roll and yaw attitude
Pitch, roll and yaw rates
Rate of fire
Throttle position
Vertical cg acceleration

APPENDIX IV. AH-IG OPERATING LIMITATIONS

LIMIT AIRSPEED (V_L)

XM35 Configuration

Zero to 170 KIAS at 6000-foot H_D or below

Above a 6000-foot H_D, the V_L reduced 6.7 knots per thousand feet to 12,000 feet

Ammunition Bay Doors Open

Zero to 100 KIAS

GROSS WEIGHT/CENTER OF GRAVITY ENVELOPE

Do not exceed 9500 pounds

Forward center of gravity limit:

Fuselage station (FS) 190 at 7000 pounds or less

FS 192 at 9500 pounds with linear decrease to FS 190 at 7000 pounds

Aft center of gravity limit:

FS 201.0 up to 8270 pounds with linear decrease to FS 200.0 at 9500 pounds

SIDESLIP LIMITS

Eight degrees at 170 KCAS with linear increase to 20 degrees at 60 KCAS

NORMAL ACCELERATION

Maximum	3.5 g
Minimum	-0.5 g

RPM LIMITS (Steady State)

Power on:

Engine rpm	6000 to 6600
Rotor rpm	294 to 339

TEMPERATURE AND PRESSURE LIMITS

Engine oil temperature	93°C
Transmission oil temperature	110°C
Engine oil pressure	25 to 100 psi
Transmission oil pressure	30 to 70 psi
Fuel pressure	5 to 20 psi
Torque pressure	50 psi

T53-L-13 ENGINE LIMITS - INSTALLED

Normal rated (maximum continuous)	400 to 625°C
Military rated (30-minute limit)	625 to 645°C
Starting and acceleration (5-second limit)	675°C
Maximum for starting and acceleration	760°C
Torque pressure	50 psi

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
US Army Aviation Systems Test Activity (USAASTA)
Edwards Air Force Base, California 93523

2a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

2b. GROUP

3. REPORT TITLE
ARMY PRELIMINARY EVALUATION
AH-1G (HUEYCOBRA) HELICOPTER EQUIPPED
WITH THE XM35 ARMAMENT SUBSYSTEM (20 MM AUTOMATIC GUN)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
FINAL REPORT, June 1968 through November 1969

5. AUTHOR(S) (First name, middle initial, last name)
NEAL DONALDSON, Project Engineer
GARY C. HALL, Maj, TC, US Army, Project Officer/Pilot

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1969	59	5

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.
RDTE Project No. 1X141807D174

c.
USAAVSCOM Project No. 68-31

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
USAASTA Project No. 68-31

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
N/A

10. DISTRIBUTION STATEMENT
This document may be further distributed by any holder only with specific prior approval obtained through the Commanding General, USAAVSCOM, ATTN: AMSAV-R-F, PO Box 209, St. Louis, Missouri 63166.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Commanding General
US Army Aviation Systems Command, ATTN:
AMSAV-R-F, PO Box 209, St. Louis, Missouri 63166

13. ABSTRACT

The Army Preliminary Evaluation of the AH-1G (Hueycobra) helicopter equipped with the XM35 armament subsystem (20 mm automatic gun) was conducted at Edwards Air Force Base, California, from 27 November to 20 December 1968 by the US Army Aviation Systems Test Activity. This evaluation consisted of performance and firing and nonfiring stability and control tests. Stability and control tests were also conducted with the turret ammunition bay doors open and loaded to simulate an evacuation mission configuration. No deficiencies were detected during this test program. The shortcomings detected during this test were: decreased range performance with the XM35 installed, fluctuation of airspeed indicator and altimeter during firing, adverse effects on the airframe during firing caused by blast pressure and/or vibration, awkward location of firing contact connector on gun, lack of a linker-delinker tool, and lack of boresighting and harmonizing instructions and equipment. The accuracy, standoff capability, dispersion, noise level and fire control system of the XM35 armament subsystem should enhance the mission capability of the AH-1G helicopter.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Army Preliminary Evaluation						
AH-1G (Hueycobra) helicopter						
XM35 armament subsystem (20mm automatic gun)						
Performance						
Firing and nonfiring stability and control						
Ammunition bay doors open and loaded						
Simulate evacuation mission						
No deficiencies detected						
Shortcomings detected						