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USAAEFA PROJECT NO. 82-01

AIRWORTHINESS AND FLIGHT CHARACTERISTICS TEST (A&FC) OF AH-1S WITH AIRCRAFT GENERAL PURPOSE DISPENSER SYSTEM (AGPDS)

FINAL REPORT

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AUGUST 1982

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UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The United States Army Aviation Engineering Flight Activity conducted an Airworthiness and Flight Characteristics Tests (A&FC) of a production AH-1S equipped with an M130 Aircraft General Purpose Dispenser System (AGPDS). The A&FC consisted of limited performance and handling qualities tests and was conducted from 12 May through 16 June 1982 at Edwards AFB, California. The tests were conducted to obtain performance and handling qualities data for inclusion in the operator's manual. Installation of the M130 AGPDS on the AH-1S caused negligible

over

DD FORM 1473, 1 JAN 73 — EDITION OF 1 NOV 65 IS OBSOLETE

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) effect on power required for level flight. No significant changes in handling qualities were found as a result of the M130 AGPDS.

DEPARTMENT OF THE ARMY
HQ, US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND
4300 GOODFELLOW BOULEVARD, ST. LOUIS, MO 63120

DRDAV-D

SUBJECT: Directorate for Development and Qualification Position on the Final Report of USAAEFA Project No. 82-01, Airworthiness and Flight Characteristics Test (A&FC) of AH-1S with Aircraft General Purpose Dispenser System (AGPDS)

SEE DISTRIBUTION

1. The purpose of this letter is to establish the Directorate for Development and Qualification position on the subject report. The report documents the test results of the subject evaluation and substantiates that the performance and flying qualities of the AH-1S with the prototype M-130 AGPDS installation are not significantly changed from a standard configuration AH-1S. However, relocation or a different orientation of the installation could cause a degradation in performance and/or flying qualities requiring additional testing.

2. This Directorate agrees with the report's conclusions. There were no shortcomings or deficiencies.

FOR THE COMMANDER:

CHARLES C. CRAWFORD, JR.
Director of Development
and Qualification

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INTRODUCTION

BACKGROUND

1. The US Army contracted with TRACOR (the manufacturer) in 1976 to develop an XM130 chaff dispenser installation for the AH-1S. The chaff dispenser was initially mounted at the left wing stores station. This installation resulted in a large amount of chaff being ingested into engine inlet screens and recirculated by the main rotor. A new M130 location near the extreme bottom of the AH-1S vertical stabilizer on the left side was developed and tested on the AH-1S and determined to be effective. The physical size and location of the M130 installation on the AH-1S required that limited performance and stability and control testing be conducted. The US Army Aviation Research and Development Command (AVRADCOM) requested (ref 1, app A) the US Army Aviation Engineering Flight Activity (USAAEFA) conduct an Airworthiness and Flight Characteristics Test (A&FC) of the AH-1S with an M130 Aircraft General Purpose Dispenser System (AGPDS) installed.

TEST OBJECTIVE

2. The objective of this A&FC was to obtain performance and handling qualities data for inclusion in the operator's manual.

DESCRIPTION

3. The production AH-1S is a tandem seat, two-place helicopter with a two-bladed main rotor and a two-bladed Model 212 tractor tail rotor. The helicopter is powered by a Lycoming T53-L-703 turboshaft engine thermodynamically rated at 1800 shaft horsepower (SHP) at sea-level, standard-day conditions and derated by main transmission limitations to 1290 SHP for 30 minutes and 1134 SHP for continuous operation. Distinctive features of the helicopter include the narrow fuselage, stub wings with four stores stations, and a flat-plate canopy. A more complete description of the AH-1S is presented in the operator's manual (ref 2, app A) and appendix B.

4. The test aircraft AH-1S (Prod) USA Serial Number 76-22573 was configured with the K747 main rotor blades, two M65 tube-launched, optically-tracked, wire-guided (TOW) missile launchers on each outboard store station and an M159C 19-tube launcher on each of the two inboard store stations, as shown in photo A. Photo B shows the AGPDS installed on the AH-1S.

Photo A. AH-1S

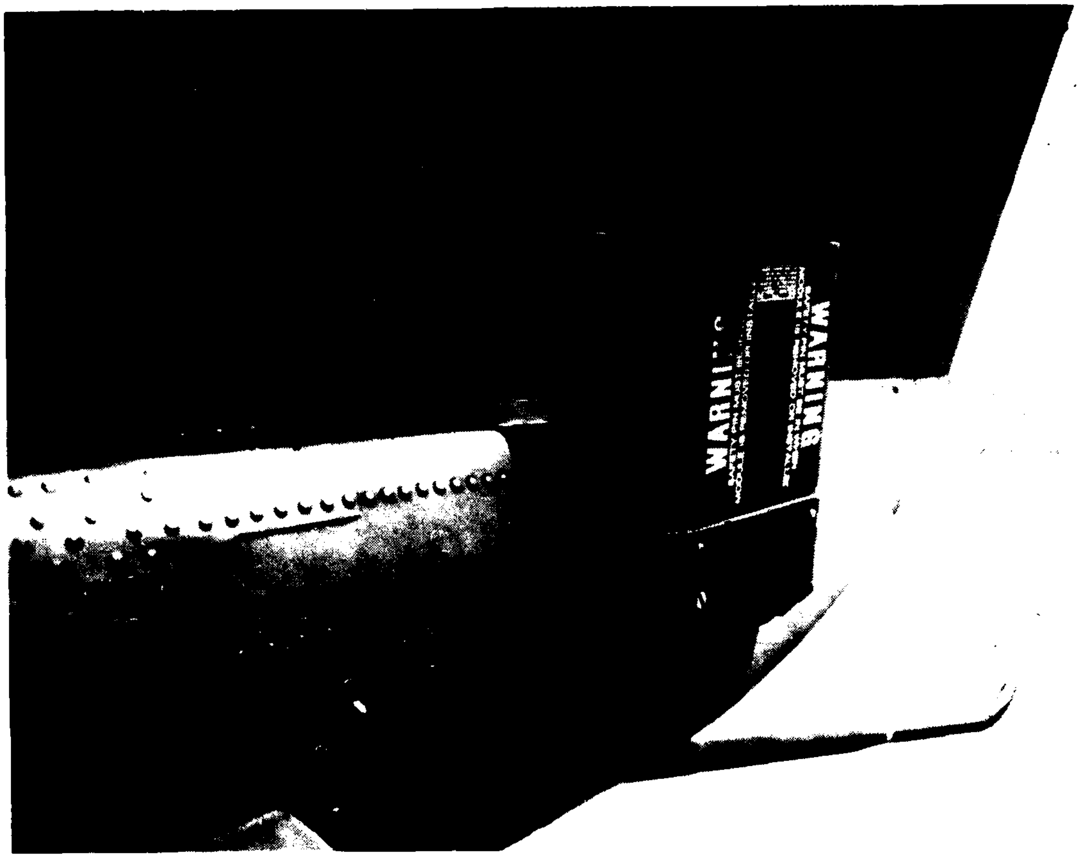


Photo B. M130 AGPDS Installation

TEST SCOPE

5. The A&FC evaluation was conducted at Edwards Air Force Base, California, from 12 May through 16 June 1982. Thirteen test flights were flown for a total of 12.1 flight hours of which 8.9 hours were productive. Flight restrictions contained in the operator's manual (ref 2, app A) and the airworthiness release (ref 3) were observed. A comparison of handling qualities and performance data with an AH-1S without M130 AGPDS installed (ref 4, app A) was also conducted. Flight conditions are summarized in table 1.

TEST METHODOLOGY

6. Established flight test techniques were used (ref 5, app A). Data were recorded by an onboard magnetic tape system. A more detailed instrumentation list is provided in appendix C. The test methods and data analysis methods are briefly described in appendix D. A Handling Qualities Rating Scale (HQRS) (fig. 1, app D) was used to augment pilot comments relative to handling qualities. The aircraft was weighed and the center of gravity (cg) was computed prior to testing. A current airspeed calibration was utilized.

Table 1. General Test Conditions[1]

Test	Gross Weight (lb)	Center of Gravity Location (FS)	Density Altitude (ft)	Calibrated Airspeed (KTS)	Flight Condition
Level Flight Performance[2]	8980	194.3 (FWD)	3840	40 to V_H[3]	C_T = 0.00494
	9380	194.9 (FWD)	8160		C_T = 0.00588
	9700	195.1 (FWD)	11,700		C_T = 0.00697
	9740	194.7 (FWD)	6500		C_T = 0.00588 M130 AGPDS Removed
Static Longitudinal Stability	9800	198.5 (AFT)	5200	108	Level
	9800	198.8 (AFT)	5220	123	
Static Lateral-Directional Stability	9620	198.8 (AFT)	5080	68,109,129,163	Level
	9860	198.6 (AFT)	5180	68	MCP[4] Climb
	9800	198.8 (AFT)	4940	87	500 ft/min Descent
	9680	199.0 (AFT)	4560	88	Autorotation
Dynamic Lateral-Directional Stability	9860	198.6 (AFT)	6580	69, 108	Level
				66	MCP Climb
	9840	198.7 (AFT)	6420	89	500 ft/min Descent
	9820	198.7 (AFT)	3500	88	Autorotation
Simulated Engine Failure	9700	199.0 (AFT)	5080	129	Level

NOTES:

[1]All tests conducted with M130 AGPDS installed except as noted.
[2]Constant referred rotor speed, $N/\sqrt{\theta}$ = 324.
[3]Maximum level flight speed at maximum continuous torque.
[4]Maximum continuous power

RESULTS AND DISCUSSION

GENERAL

7. Level flight performance and handling qualities tests were performed on an AH-1S (Prod) helicopter with an M130 AGPDS installed. The tests were conducted to obtain performance and handling qualities data for inclusion in the operator's manual and to determine the effects of installation of the M130 AGPDS on the AH-1S. There was no apparent effect on power required to maintain level flight. No change in handling qualities was caused by the installation of the M130 AGPDS. No deficiencies or shortcomings attributed to the M130 AGPDS installation were identified.

LEVEL FLIGHT PERFORMANCE

8. Level flight performance tests were conducted to determine power required and fuel flow as a function of airspeed, gross weight and density altitude. The constant referred gross weight and rotor speed (W/δ, $N/\sqrt{\theta}$) method was used to obtain data in stablized level flight at incremental airspeeds ranging from approximately 40 knots true airspeed (KTAS) to the maximum airspeed for level flight. Level flight tests were flown at zero sideslip, with the aircraft loaded to a forward cg location at near maximum gross weight. Results of these tests are presented nondimensionally in figures 1 through 3, and dimensionally in figures 4 through 6, appendix E. Baseline data were obtained with the M130 AGPDS removed. The data were compared to level flight performance with M130 installed.

9. Figure A presents a comparison of the AH-1S with and without the M130 installed. The drag effects of the M130 AGPDS were negligible.

HANDLING QUALITIES

Control Positions in Trimmed Forward Flight

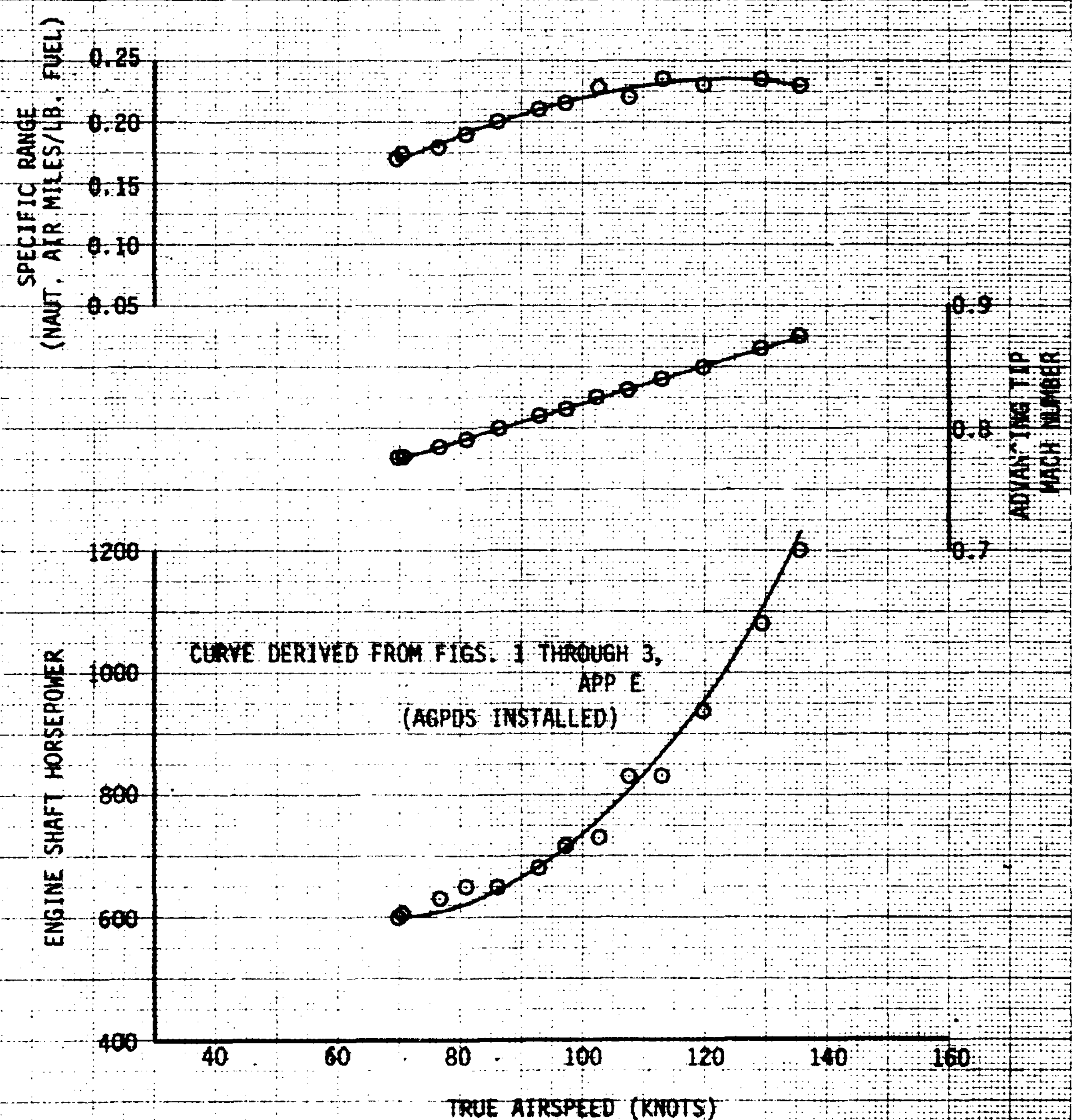
10. The control positions of the AH-1S (Prod) in trimmed forward flight were evaluated in conjunction with level flight performance testing. The test results for both M130 installed and removed configurations are presented in figures 7 and 8, appendix E, respectively.

11. During level flight, consistently increasing forward longitudinal control trim positions were required at increasing forward speeds. Trim control position variations with airspeed were

FIGURE A
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

AVG. GROSS WEIGHT (LB.)	AVG. C.G. LOCATION LONG. (FS)	AVG. C.G. LOCATION LAT. (BL)	AVG. DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	AVG. C_T
9740	194.7(FWD)	0.0(MID)	6500	14.5	324	0.00588

NOTES: 1. CIRCLED POINTS REPRESENT AGPDS REMOVED DATA
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WINGS
3. REFERRED ROTOR SPEED, $N/\sqrt{\theta}$ = 324 RPM



essentially linear, and adequate control margins were available. During level flight from 50 knots calibrated airspeed (KCAS) to 85 KCAS, a noticeable right lateral cyclic (1/2 inch) was required; however, from 85 KCAS to 130 KCAS left lateral cyclic (3/4 inch) was required. Pitch attitude varied from 4 degrees nose down to 10 degrees nose down from 50 KCAS to maximum airspeed for level flight. The control position variation with M130 AGPDS installed or removed was essentially the same.

Static Longitudinal Stability

12. The static longitudinal stability characteristics of the AH-1S were evaluated in level flight with M130 AGPDS installed at the conditions presented in table 1, and data are presented in figures 9 and 10, appendix E. The variation of longitudinal control position and control force with airspeed were essentially linear and indicated weak positive static stability (forward control displacement and an accompanying push force for higher airspeeds). The weak static stability required increased pilot effort to establish and maintain a desired airspeed and resulted in a ±3 knot airspeed excursion when trying to maintain 110 KCAS (HQRS 4). Pitch attitude varied ±1 1/2 degrees from trim and provided weak cues for maintaining desired airspeed. The weak static longitudinal stability with M130 AGPDS installed is essentially unchanged from the standard AH-1S (ref 4, app A).

Static Lateral-Directional Stability

13. Static lateral-directional stability characteristics of the AH-1S were evaluated at the conditions presented in table 1 in level flight, climbs, partial power descents, and autorotations with M130 AGPDS installed and data are presented in figures 11 through 14, appendix E. At all airspeeds tested, the helicopter exhibited positive directional stability (increased left directional control for increase in right sideslip), and positive dihedral effect (increased right lateral control with increased right sideslip). The gradient of directional control position with change in sideslip angle was approximately 1 inch of pedal displacement per 20 degrees of sideslip at 68 KCAS. These gradients became larger at the higher airspeeds tested. Sideforce cues were weak about trim as evidenced by the small change in roll attitude. The static lateral-directional stability characteristics of the AH-1S with the M130 AGPDS installed were essentially unchanged from those of a standard AH-1S (ref 4, app A).

Dynamic Stability

14. Lateral-directional short-term response (figs. 15 through 21, app E) was evaluated during level flight, climbs, descents and autorotations at the conditions shown in table 1. The aircraft was flown with stablity and control augmentation system (SCAS) ON. Short-term response characteristics for directional controls were evaluated following single-axis, 1/2 second, 1 inch pulse inputs and during 1 inch control doublets. Following the inputs all controls were held fixed until the motion subsided.

15. A lateral-directional oscillation (dutch roll) was the principle aircraft response following pedal pulses and doublets. An easily excitable 3 second period oscillation occurred for all control inputs and damped out within 6 to 8 seconds. The lateral directional short-term response of the AH-1S with M130 AGPDS installed appears to be unchanged from the standard AH-1S (ref 4, app A).

Simulated Engine Failures

16. Sudden engine failures were simulated by trimming the aircraft at the test condition and abruptly closing the throttle to the flight-idle position. The flight controls were held fixed until the minimum transient rotor speed of 91 percent was approached or until 2 seconds had elapsed. The delay in moving the controls was to simulate the normal delay in pilot reaction time following an actual engine failure. A typical time history of the test is presented in figure 22, appendix E.

17. The response of the AH-1S following simulated sudden engine failure in level flight was characterized by rapid rotor speed decay, moderate left yaw, and slight left roll. The aircraft response to sudden engine failure was unaffected by the addition of the M130 AGPDS installation.

CONCLUSIONS

18. Installation of the M130 AGPDS on the AH-1S caused negligible effect on power required for level flight. No significant changes in handling qualities were found as a result of the installation of the M130 AGPDS. No deficiencies or shortcomings related to the M130 AGPDS were identified.

RECOMMENDATION

19. The following note should be added to the AH-1S operator's manual:

NOTE

The AH-1S (Prod) performance and handling qualities remain unchanged with the M130 AGPDS installed at fuselage station 490.8.

APPENDIX A. REFERENCES

1. Letter, AVRADCOM, DRDAV-I, 18 March 1982, subject: Airworthiness and Flight Characteristics (A&FC) of AH-1S with M130 Aircraft General Purpose Dispenser System (AGPDS) Installed.

2. Technical Manual, TM 55-1520-236-10, *Operator's Manual, Army Model AH-1S (Prod), AH-1S (ECAS), AH-1S (Modernized Cobra) Helicopter*, 11 January 1980, with change 2, May 1980.

3. Letter, AVRADCOM, DRDAV-D, 7 May 1982, subject: Airworthiness Release for AH-1S (Prod) S/N 76-22573 Airworthiness and Flight Characteristics (A&FC) Test with M130 Aircraft General Purpose Dispenser System (AGPDS) Installed.

4. Final Report, USAAEFA Project No. 79-08, *AH-1S (Prod) Airworthiness and Flight Characteristics for Instrument Flight*, November 1980.

5. Flight Test Manual, Naval Air Test Center, USNTPS-FTM-No. 101, *Helicopter Stability and Control*, June 1968.

APPENDIX B. AIRCRAFT DESCRIPTION

GENERAL

1. The test helicopter, S/N 76-22573, was a production AH-1S with the K747 main rotor blades installed. Wing stores configuration for all tests were two-M65 tube launched, optically tracked, wire guided (TOW) launchers on each of the outboard wing stores stations and one 19-tube M159C launcher pod on each of the inboard wing stores stations.

MAIN ROTOR BLADES

2. The K747 main rotor blades utilize a multicell filament wound fiberglass spar, a nomex honeycomb core afterbody, and a Kevlar trailing edge spline, all enclosed by fiberglass skin. At the inboard end, checkplates carry loads to an aluminum adapter which is attached to the hub with a pin.

3. The K747 blade airfoil shape is based on a family of airfoils developed by Boeing Vertol. The airfoil shape varies from blade tip to root as follows:

r/R(Blade Radius Station)	Airfoil Design
From tip to 0.85	K747 8% thick Boeing Vertol VR-8
From 0.85 to 0.67	Linear transition to 12% thick VR-7
From 0.67 to 0.25	12% thick Boeing Vertol VR-7
From 0.25 to 0.18	Gradual buildup to 25% thick by cheekplates

ENGINE AND TRANSMISSION/TAIL ROTOR DRIVE

4. The T53-L-703 turboshaft engine is installed in the AH-1S (Prod) helicopter. This engine employs a two-stage, axial-flow free power turbine; a separate two-stage, axial flow turbine driving a five stage axial and one stage centrifugal compressor; variable inlet guide vanes; and an external annular combustor. A 3.2105:1 reduction gear box located in the air inlet housing reduces power turbine speed to a nominal output shaft speed of 6600 RPM at 100 percent N_2. The engine reduction gear box is limited to 1175 foot-pounds (ft-lb) torque for 30 minutes and 1110 ft-lb torque for continuous operation. A T_7 interstage turbine temperature sensor harness measures interstage turbine temperatures and displays this information in the cockpit as turbine gas temperature on the cockpit instruments.

5. The main transmission has a 1290 shaft horsepower (SHP) limit for 30 minutes and a 1134 SHP limit for continuous operation at a rotor speed of 324 RPM (100 percent N_R). The aircraft is further limited to 88 percent torque above 100 knots indicated airspeed (KIAS). The tail rotor drive system has a 260 SHP transient limit for 4 seconds and a 187 SHP limit for continuous operation.

PRINCIPAL DIMENSIONS AND GENERAL DATA

6. The principal dimensions and general data concerning the AH-1S (Prod) helicopters are as follows:

Overall Dimensions

Length, rotor turning	53 feet, 1 inch
Height, tail rotor vertical	13 feet, 9 inches
Length, rotors removed	44 feet, 7 inches

Main Rotor

Diameter	44 feet
Disc area	1520.5 $feet^2$
Number of blades	2
Blade twist	-0.556 degrees/foot
Airfoil	(See paragraph 3)

Tail Rotor

Diameter	8 feet, 6 inches
Disc area	56.75 $feet^2$
Solidity	0.1436
Number of blades	2
Blade chord, constant	11.5 inches
Blade twist	0.0 degrees
Airfoil	NACA 0010 modified

Fuselage

Length:	44 feet, 7 inches
Height:	
To tip of tail fin	10 feet, 8 inches
Ground to top of mast	12 feet, 3 inches
Ground to top of transmission fairing	10 feet, 2 inches

Width:

Fuselage Only	3 feet
Wing span	10 feet, 9 inches
Skid gear tread	7 feet

Stabilator:

Span	6 feet, 11 inches
Airfoil	Inverted Clark Y

Vertical Fin:

Area	18.5 $feet^2$
Airfoil	Special cambered
Height	5 feet, 6 inches

Wing:

Span	10 feet, 9 inches
Incidence	17 degrees
Airfoil (root)	NACA 0030
Airfoil (tip)	NACA 0024

Weight and Balance

7. The aircraft weight, longitudinal center of gravity (CG) location and lateral CG location were determined prior to testing. A fuel cell calibration was also performed prior to testing. All weighings were accomplished with instrumentation installed without external stores or chin turret weapon installed.

APPENDIX C. INSTRUMENTATION

1. In addition to the standard aircraft instruments, calibrated instruments were displayed on the pilot and gunner cockpit panels. Data were obtained from cockpit instruments and from the test instrumentation system. The test instrumentation system was installed, calibrated, and maintained by USAAEFA personnel. All test instrumentation parameters are encoded pulse code modulation (PCM) and recorded on magnetic tape aboard the test aircraft. Sideslip vane, angle-of-attack vane, total temperature sensor, and pivoting pitot-static head are located on a test boom extending 89 inches from the nose of the aircraft.

2. The parameters recorded on magnetic tape are:

<u>PCM Parameters</u>

Time code
Event
Record number
Main rotor speed
Fuel used
Engine fuel flow rate
Engine gas producer speed
Engine power turbine speed
Airspeed (boom system)
Airspeed (ship's system)
Altitude (boom system)
Altitude (ship's system)
Total air temperature
Angle of attack
Angle of sideslip
Engine torque
Engine exhaust gas temperature
Control positions
- Longitudinal
- Lateral
- Directional
- Collective
- Throttle

Aircraft attitudes
- Pitch
- Roll

Aircraft angular rates
- Pitch
- Roll
- Yaw

Main rotor shaft torque
Main rotor blade angle

3. The parameters displayed in the cockpit are:

Pilot Panel

Pressure altitude (boom system)
Pressure altitude (ship's system)
Airspeed (boom system)
Airspeed (ship's system)
Main rotor speed
Engine torque
Engine turbine gas temperature
Engine gas producer speed
Angle of sideslip

Copilot Panel

Pressure altitude (boom system)
Airspeed (boom system)
Main rotor speed
Engine torque
Engine gas producer speed
Total air temperature
Fuel used
Time code display
Data system control

APPENDIX D.
TEST TECHNIQUES AND DATA ANALYSIS METHODS

GENERAL

1. Established test techniques and data analysis methods were used in the handling qualities tests. Descriptions of the test techniques are contained in this appendix. The Handling Qualities Rating Scale, presented in figure 1, was used to augment pilot comments relative to handling qualities. All test flights were conducted with zero sideslip trim condition.

WEIGHT AND BALANCE

2. The aircraft weight, longitudinal CG location, and lateral CG location were determined prior to testing. The weighing was accomplished with instrumentation installed. The aircraft was ballasted as necessary to achieve the desired takeoff gross weight and CG.

Level Flight Performance

3. Helicopter performance test data were generalized by use of nondimensional coefficients. The purpose of this generalization was to accurately interpolate performance at aircraft gross weight/ambient air condition combinations not specifically tested. The following coefficients were used:

a. Coefficient of power (C_P):

$$C_P = \frac{SHP \times 550}{\rho A (\Omega R)^3}$$

b. Coefficient of thrust (C_T):

$$C_T = \frac{GW}{\rho A (\Omega R)^2}$$

c. Advance ratio (μ):

$$\mu = \frac{1.6878 \times V_T}{\Omega R}$$

d. Advancing tip mach number (M_{TIP}):

$$M_{TIP} = \frac{1.6878\ V_T + \Omega R}{a}$$

Where:

SHP = Engine output shaft horsepower

550 = Conversion factor (ft-lb/sec/shp)

ρ = Air density ($lb\text{-}sec^2/ft^4$)

A = Main rotor disc area (ft^2)

Ω = Main rotor angular velocity (rad/sec)

R = Main rotor radius

GW = Gross weight (lb)

1.6878 = Conversion factor (ft/sec/kt)

V_T = True airspeed (kt)

a = Speed of sound (ft/sec)

For N_R = 324 RPM

Ω = 33.93

ΩR = 746.442

$(\Omega R)^2$ = 557176.28

$(\Omega R)^3$ = 415900007.

4. Engine output SHP was determined from the engine torque pressure. Torque pressure as a function of engine torque output of the engine was obtained from the engine manufacturer's test cell calibration. Shaft horsepower was determined by the following equation:

$$SHP = \frac{2\pi \times N_p \times T_q}{33{,}000}$$

Where:

N_p = Engine output speed (RPM)

T_q = Engine output shaft torque (ft-lb)

33,000 = Conversion factor (ft-lb/min/shp)

SHP = Shaft horsepower

5. Each level flight performance flight was designed to obtain one curve of C_P versus μ at a constant value of C_T. The flight technique was to stabilize at zero sideslip at incremental airspeeds from approximately 40 KIAS to the maximum attainable. At each airspeed, torque, altitude, airspeed, and rotor speed were held constant for at least 1 minute prior to recording data. Altitude was increased between data points as a function of fuel burnoff in order to maintain a constant ratio of gross weight to air pressure ratio (W/δ). Also, rotor speed (N) was varied as a function of ambient air temperature in order to maintain a constant ratio of rotor speed to square root of the air temperature ratio ($N/\sqrt{\theta}$). The reason for maintaining constant $N/\sqrt{\theta}$ was to minimize the difference in compressibility effects between flights. Target $N/\sqrt{\theta}$ was 324 RPM for all level flight performance tests.

6. The C_P versus μ curves were cross plotted as C_P versus C_T with lines of constant μ. From these curves level flight performance at any combination of gross weight, rotor speed, pressure altitude, and air temperature can be determined.

7. Specific range was calculated using measured values of V_T and fuel flow as follows:

$$NAMPP = \frac{V_T}{W_f}$$

Where:

NAMPP = Specific range (nautical air miles per pound of fuel)

V_T = True airspeed (kt)

W_f = Fuel flow (lb/hr)

Control Positions in Trimmed Forward Flight

8. Control positions in trimmed forward flight at zero sideslip were determined by stabilizing the helicopter on a constant heading and airspeed. Data were recorded on magnetic tape. Control positions were plotted as a function of calibrated airspeed.

Static Longitudinal Stability

9. Static longitudinal stability was evaluated in level, climbing, and autorotational flight. The aircraft was trimmed at the desired trim airspeed. With collective fixed, the aircraft was stabilized at approximately 5-knot increments ±20 knots from trim airspeed, allowing altitude, rate of climb, or rate of descent to vary as necessary. Control positions and airspeeds were recorded on magnetic tape. The control positions were then plotted as a function of calibrated airspeed.

Static Lateral-Directional Stability

10. This test was conducted using the steady-heading sideslip method and was accomplished by establishing a trimmed flight condition and then stabilizing at sideslip angles, in 5-degree increments, to the limit of the flight envelope or until full control deflection was reached, whichever occurred first. Collective control position was fixed at the trim value and altitude was allowed to vary. The trim airspeed and desired heading were maintained. All pertinent parameters were recorded on magnetic tape. The static directional stability, dihedral effect, and side-force characteristics of the aircraft were evaluated by plotting the variation of control position and aircraft attitude as a function of sideslip angle.

Dynamic Stability

11. Dynamic stability tests were conducted to evaluate the short-period response characteristics of the aircraft. Short-period characteristics were evaluated to determine aircraft response to sudden wind gusts. Short period response characteristics were simulated by rapidly displacing the cyclic control approximately one inch, holding the input for 0.5 second, then rapidly returning the control to the trim position while recording the resulting aircraft responses on magnetic tape. Lateral-directional short-term response was further evaluated by directional control doublets.

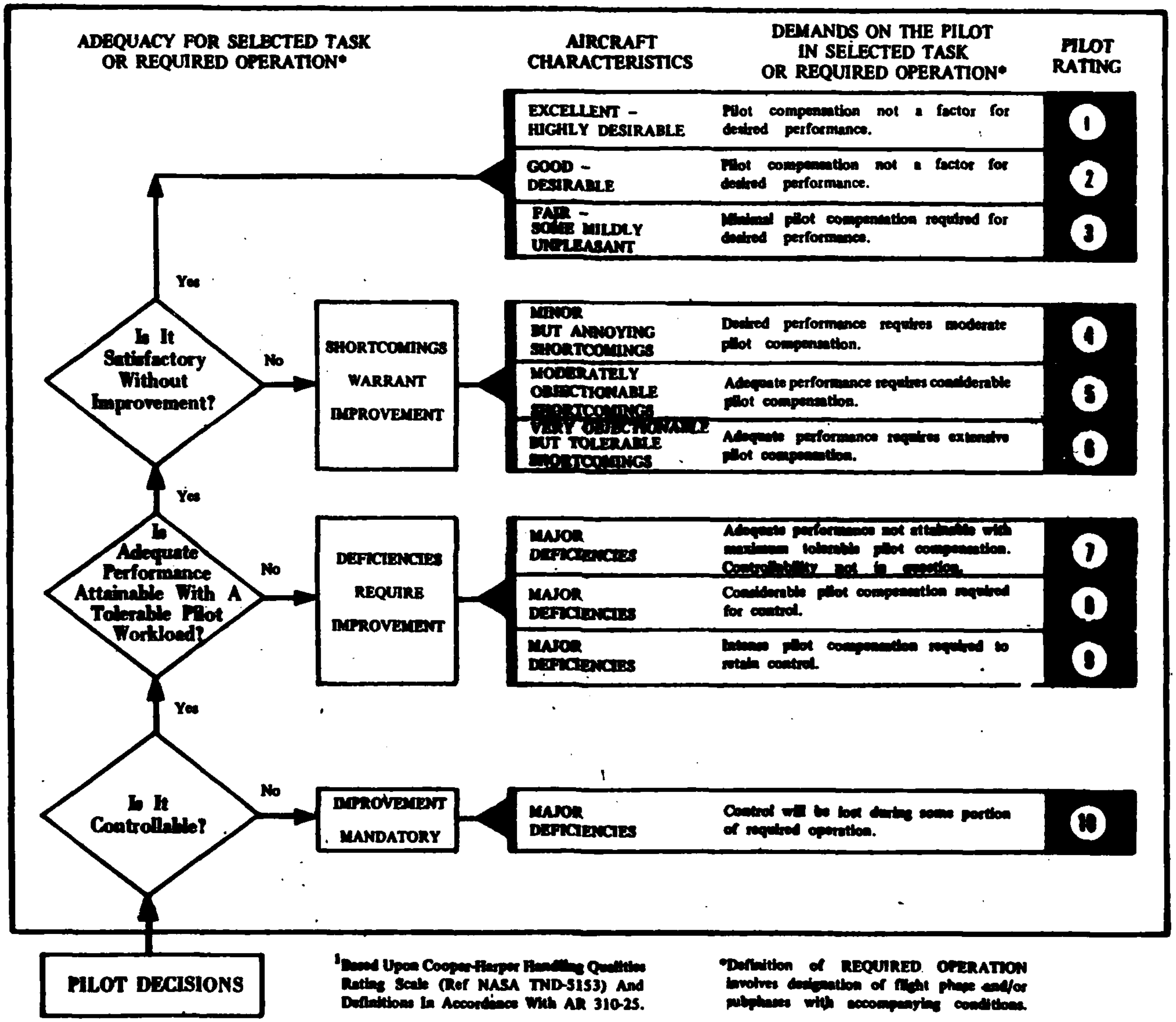


Figure 1. Handling Qualities Rating Scale

APPENDIX E. TEST DATA

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FIGURE 1
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

NOTES:
1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WINGS
3. LONGITUDINAL CENTER OF GRAVITY = FS 194.8(FWD)
4. CONSTANT $N/\sqrt{\theta}$ = 324 RPM
5. ZERO SIDESLIP TRIM CONDITION
6. CURVES OBTAINED FROM FIGS 4-6

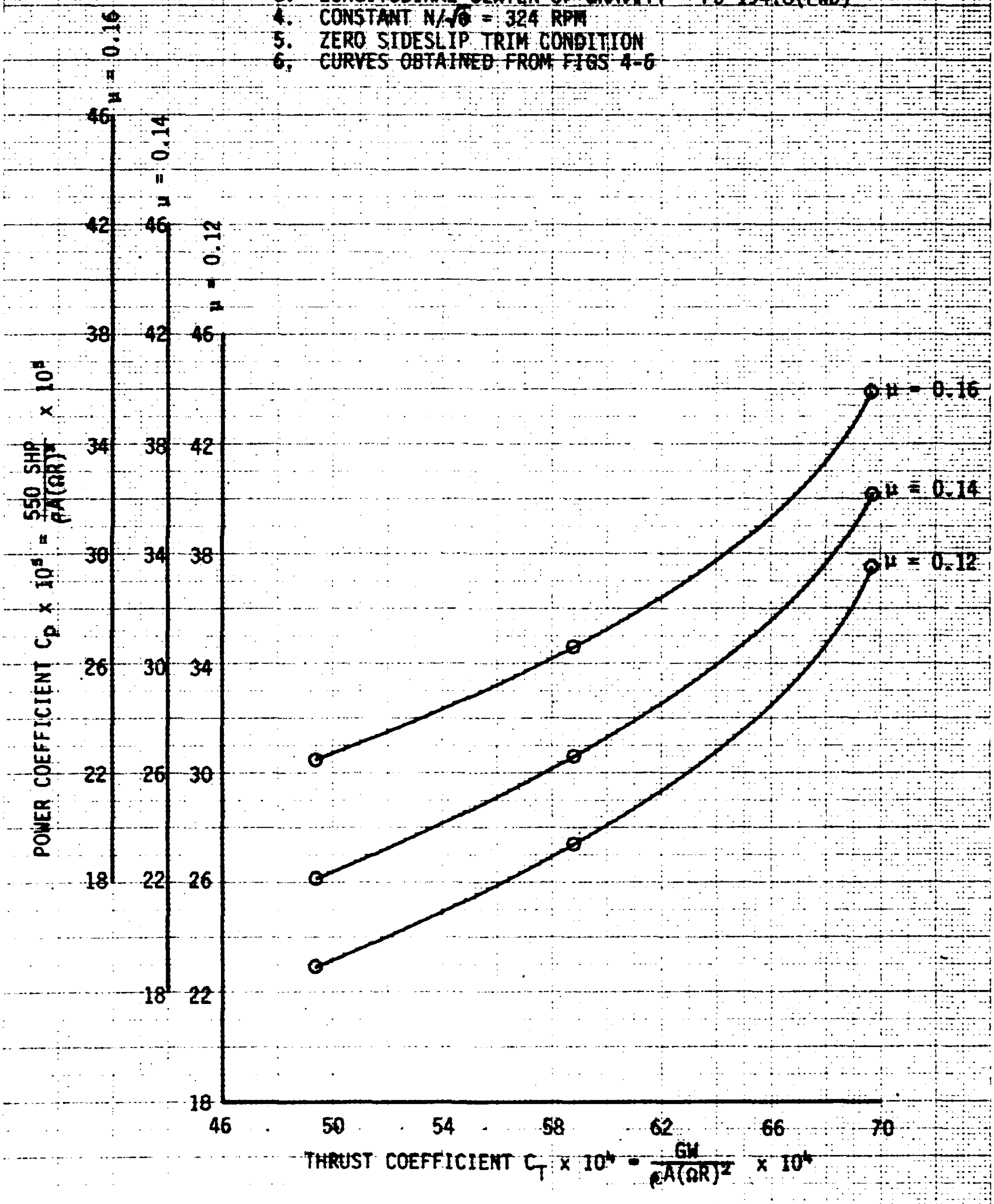
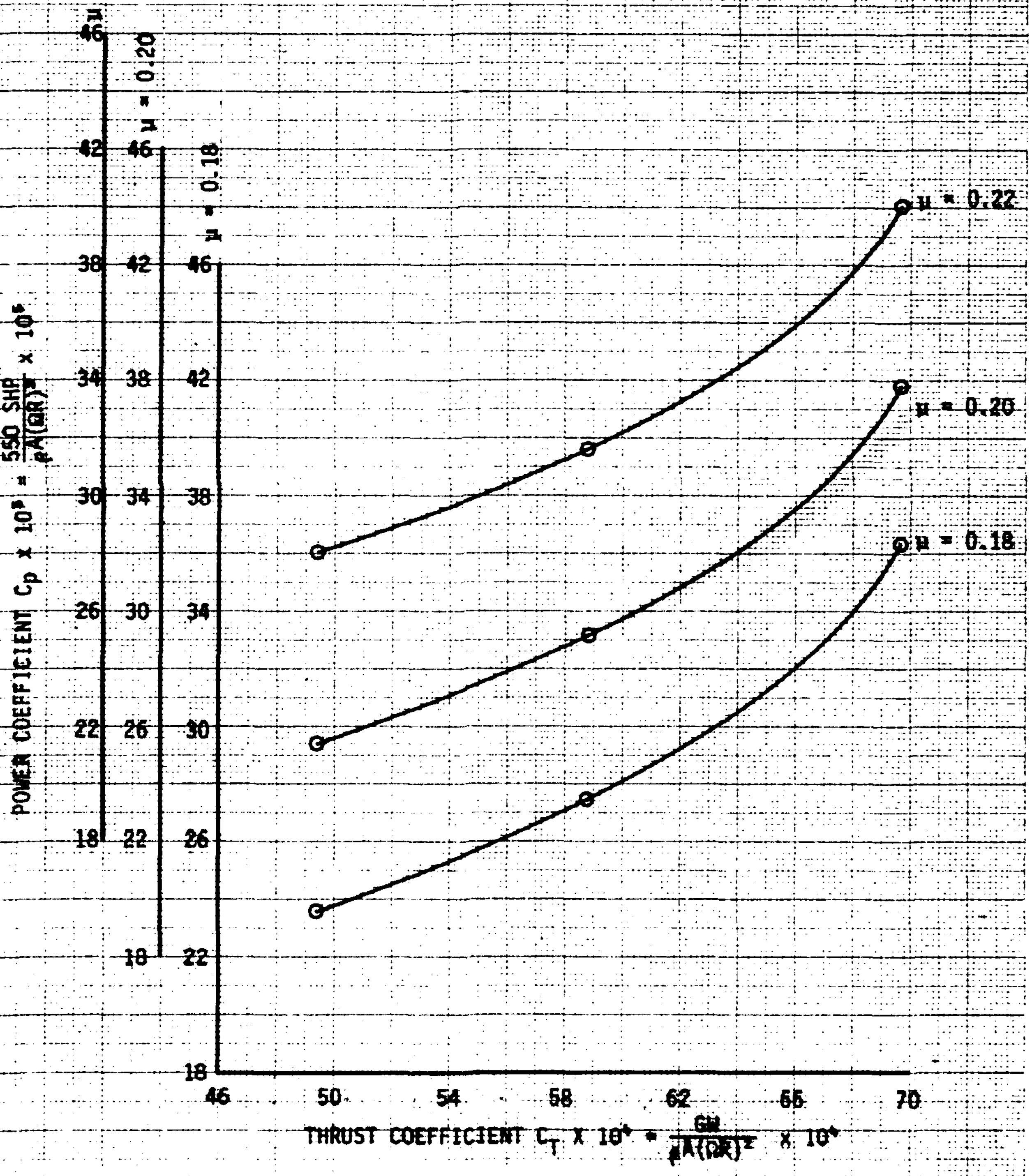


FIGURE 2
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

NOTES:
1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WING
3. LONGITUDINAL CENTER OF GRAVITY = FS194.8(FWD)
4. CONSTANT $N/\sqrt{\theta}$ = 324 RPM
5. ZERO SIDESLIP TRIM CONDITION
6. CURVES OBTAINED FROM FIGS. 4-6



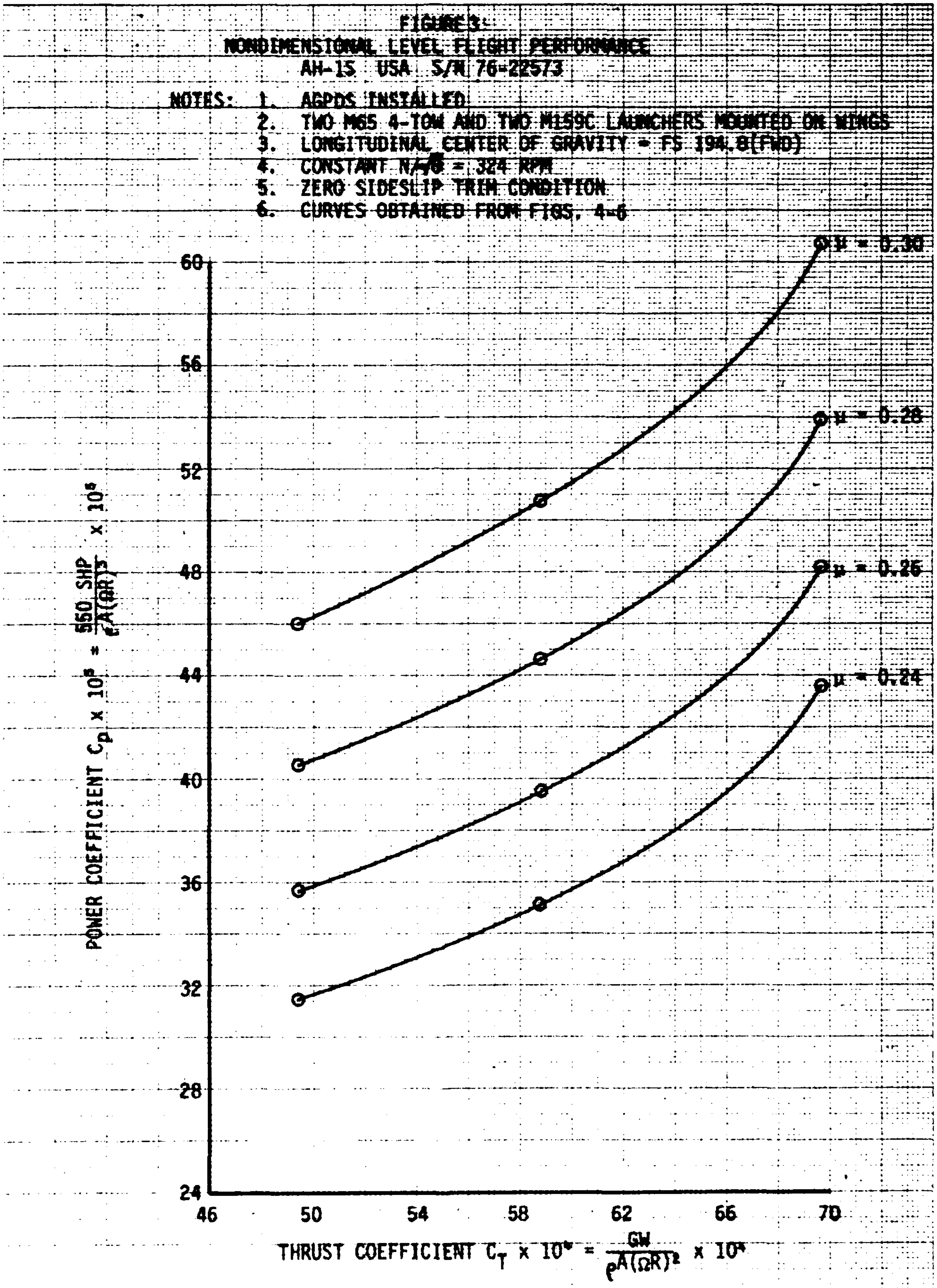


FIGURE 3
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
NOTES: 1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WINGS
3. LONGITUDINAL CENTER OF GRAVITY = FS 194.8(FWD)
4. CONSTANT N/√θ = 324 RPM
5. ZERO SIDESLIP TRIM CONDITION
6. CURVES OBTAINED FROM FIGS. 4-6
μ = 0.30
μ = 0.28
μ = 0.26
μ = 0.24
60
56
52
48
44
40
36
32
28
24
46
50
54
58
62
66
70
POWER COEFFICIENT C_P x 10^5 = 550 SHP / ρA(ΩR)^3 x 10^5
THRUST COEFFICIENT C_T x 10^4 = GW / ρA(ΩR)^2 x 10^4

FIGURE 4
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

AVG. GROSS WEIGHT (LB.)	AVG. C.G. LOCATION LONG. (FS)	AVG. C.G. LOCATION LAT. (BL)	AVG. DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	AVG. CT
8980	194.3(FWD)	0.0(MID)	3840	19.0	326	0.00494

NOTES:
1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO 159C LAUNCHERS MOUNTED ON WINGS
3. REFERRED ROTOR SPEED, $N/\sqrt{\theta}$ = 324 RPM

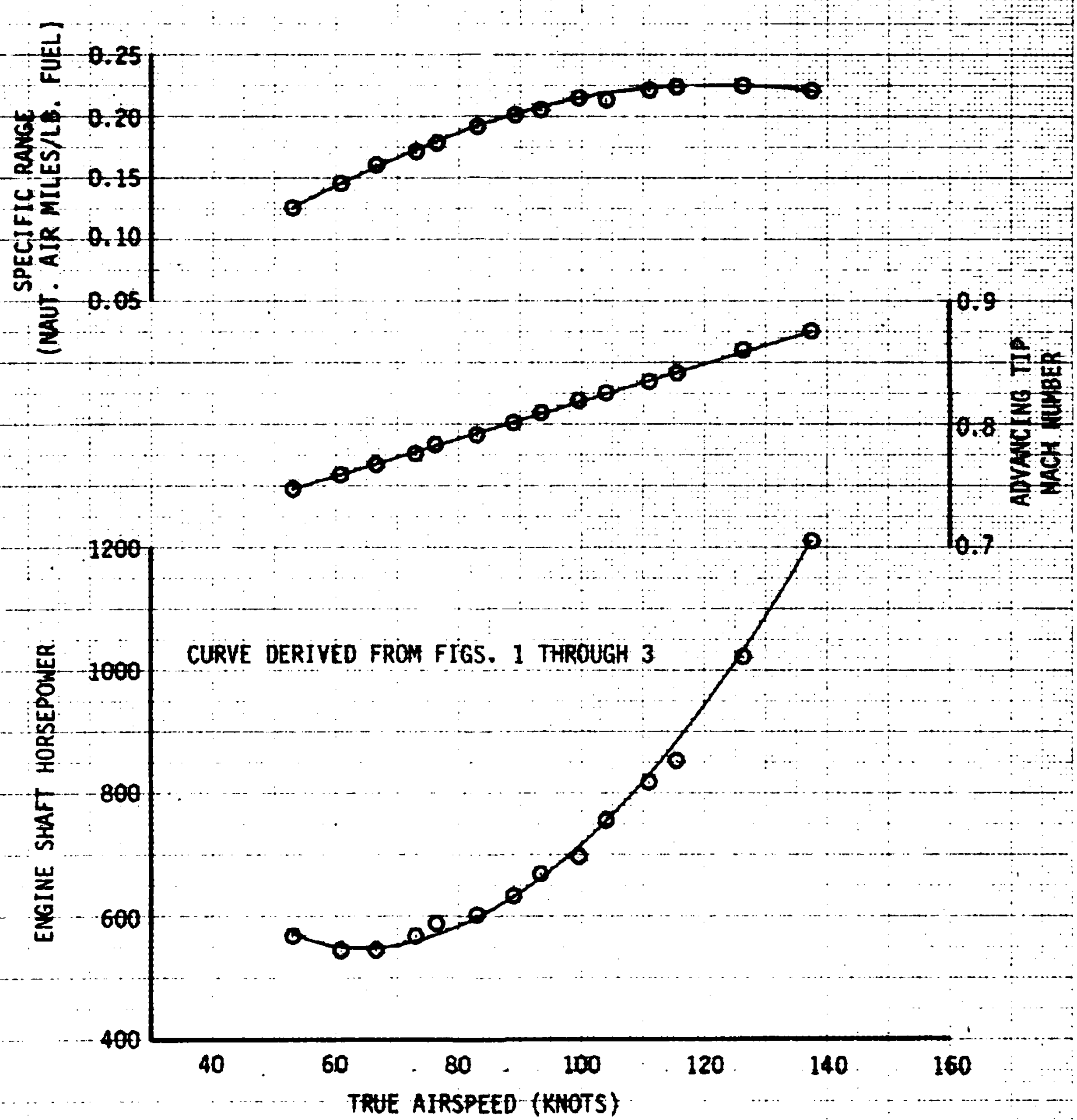


FIGURE 5

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG. GROSS WEIGHT (LB.)	AVG. C.G. LOCATION LONG. (FS)	LAT. (BL)	AVG. DENSITY ALTITUDE (FT)	AVG. OAT (^{o}C)	AVG. ROTOR SPEED (RPM)	AVG. CT
9380	194.9(FWD)	0.0(MID)	8160	18.5	326	0.00588

NOTES:
1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO 159C LAUNCHERS MOUNTED ON WINGS
3. REFERRED ROTOR SPEED, $N/\sqrt{\theta}$ = 324 RPM

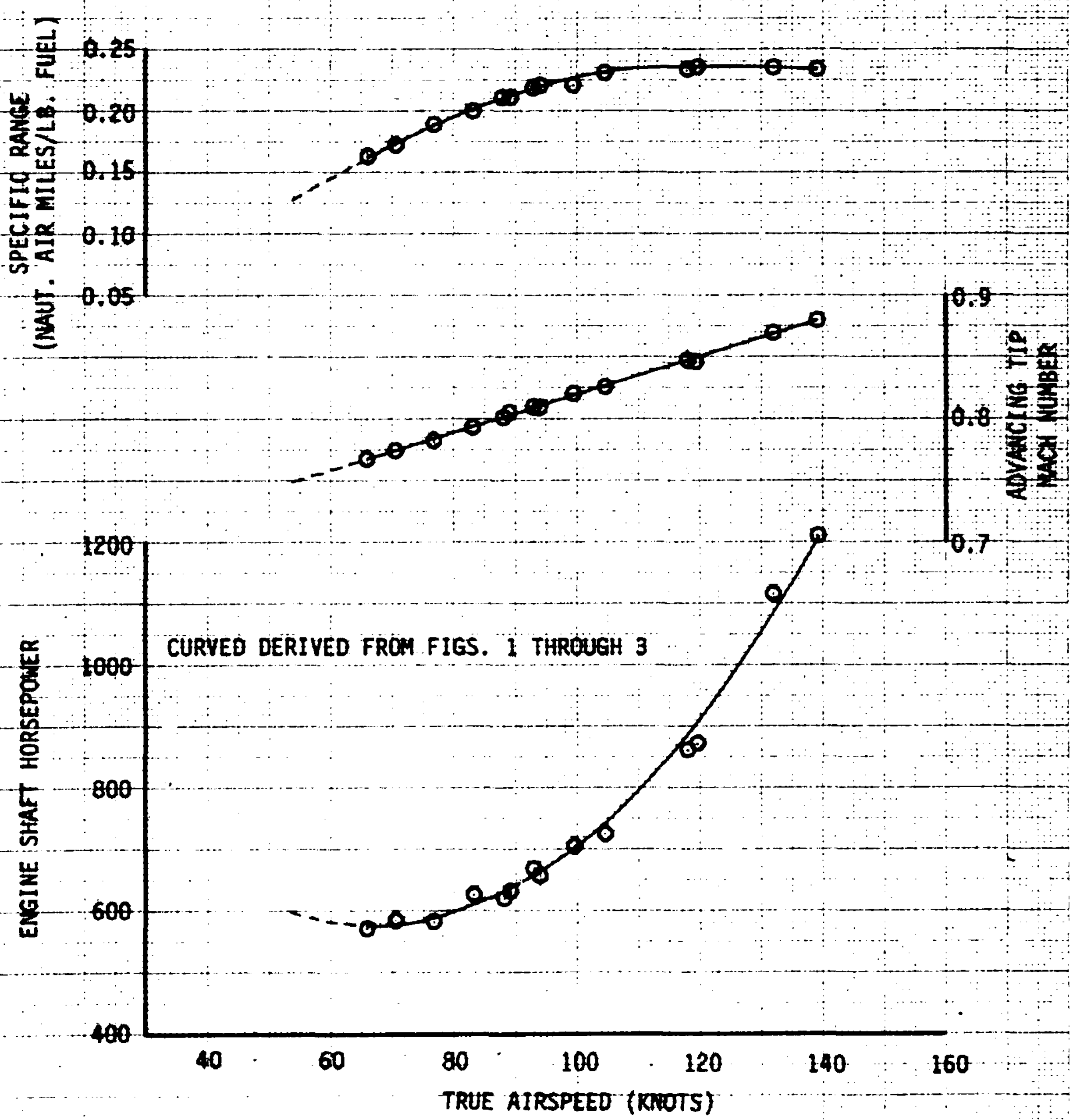


FIGURE 6
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

AVG. GROSS WEIGHT (LB.)	AVG. C.G. LOCATION LONG. (FS)	AVG. C.G. LOCATION LAT. (BL)	AVG. DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	AVG. CT
9700	195.1(FWD)	0.0(MID)	11700	10.5	322	0.00697

NOTES: 1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO 159C LAUNCHERS MOUNTED ON WINGS
3. REFERRED ROTOR SPEED, $N/\sqrt{\theta}$ = 324 RPM

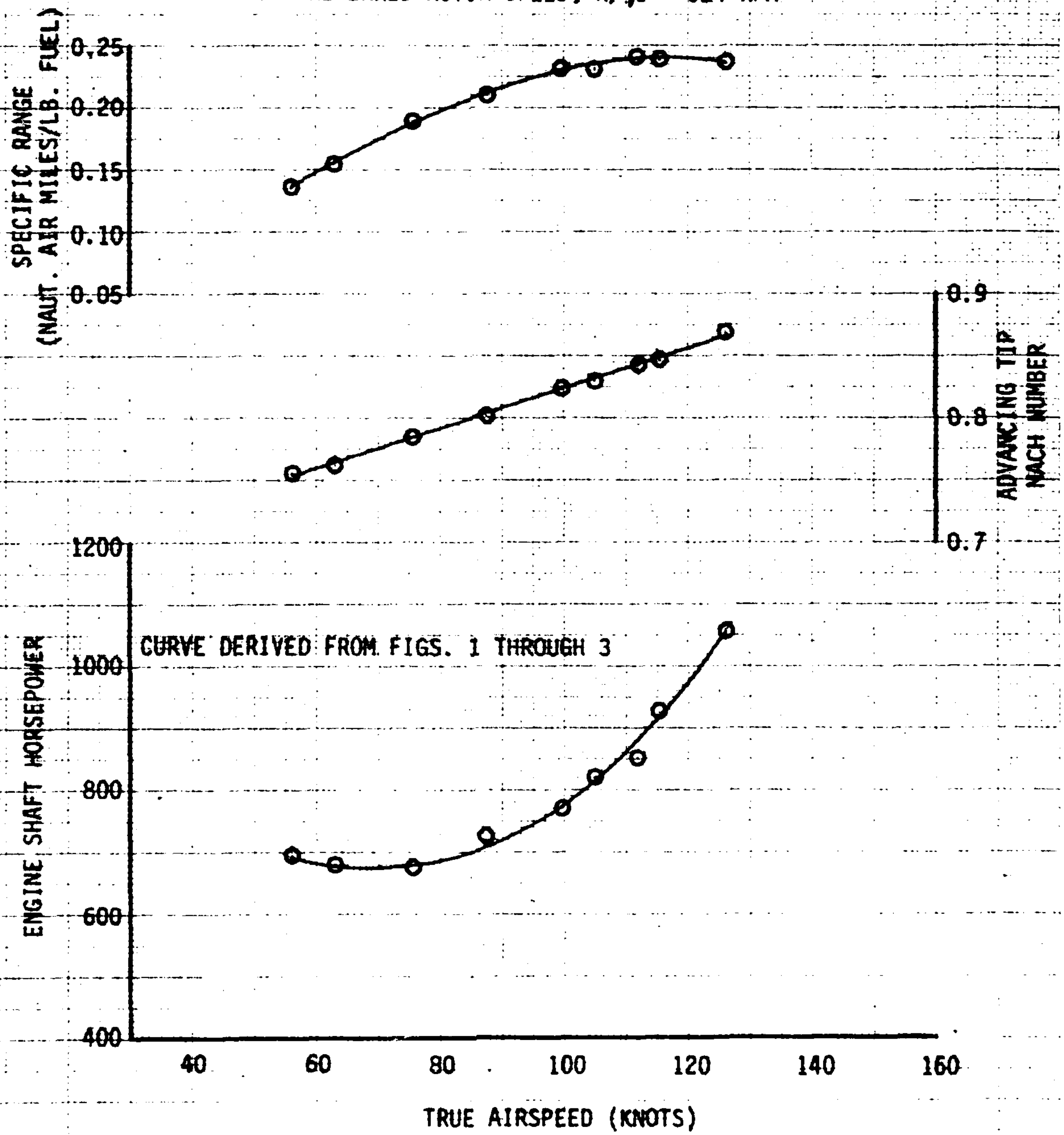


FIGURE 7
CONTROL POSITIONS IN TRIMMED FLIGHT
AH-1S USA S/N 76-22573

AVG. GROSS WEIGHT (LB.)	AVG. C.G. LOCATION LONG. (FS)	AVG. C.G. LOCATION LAT. (BL)	AVG. DENSITY ALTITUDE (FEET)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	FLIGHT CONDITION
9300	194.9(FWD)	0.0(MID)	3840	19.0	324	LEVEL

NOTES: 1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WINGS
3. ZERO SLIDESLIP

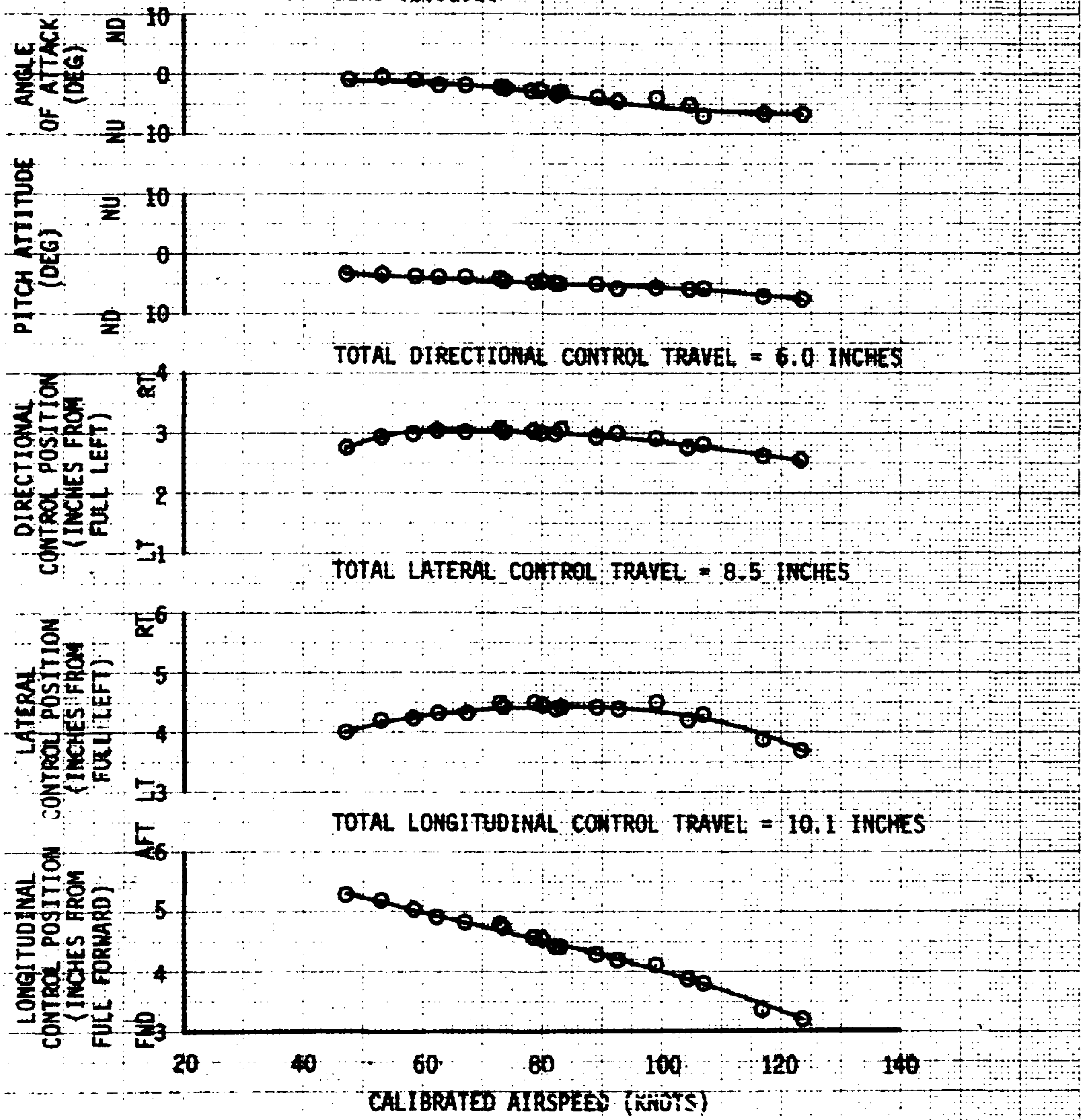


FIGURE 8
CONTROL POSITIONS IN TRIMMED FLIGHT
AH-1S USA S/N 76-22573

AVG. GROSS WEIGHT (LB.)	AVG. C.G. LOCATION LONG. (FS)	AVG. C.G. LOCATION LAT. (BL)	AVG. DENSITY ALTITUDE (FEET)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	FLIGHT CONDITION
9740	194.7(FWD)	0.0(MID)	6500	14.5	324	LEVEL

NOTES: 1. AGPDS REMOVED
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WING
3. ZERO SIDESLIP

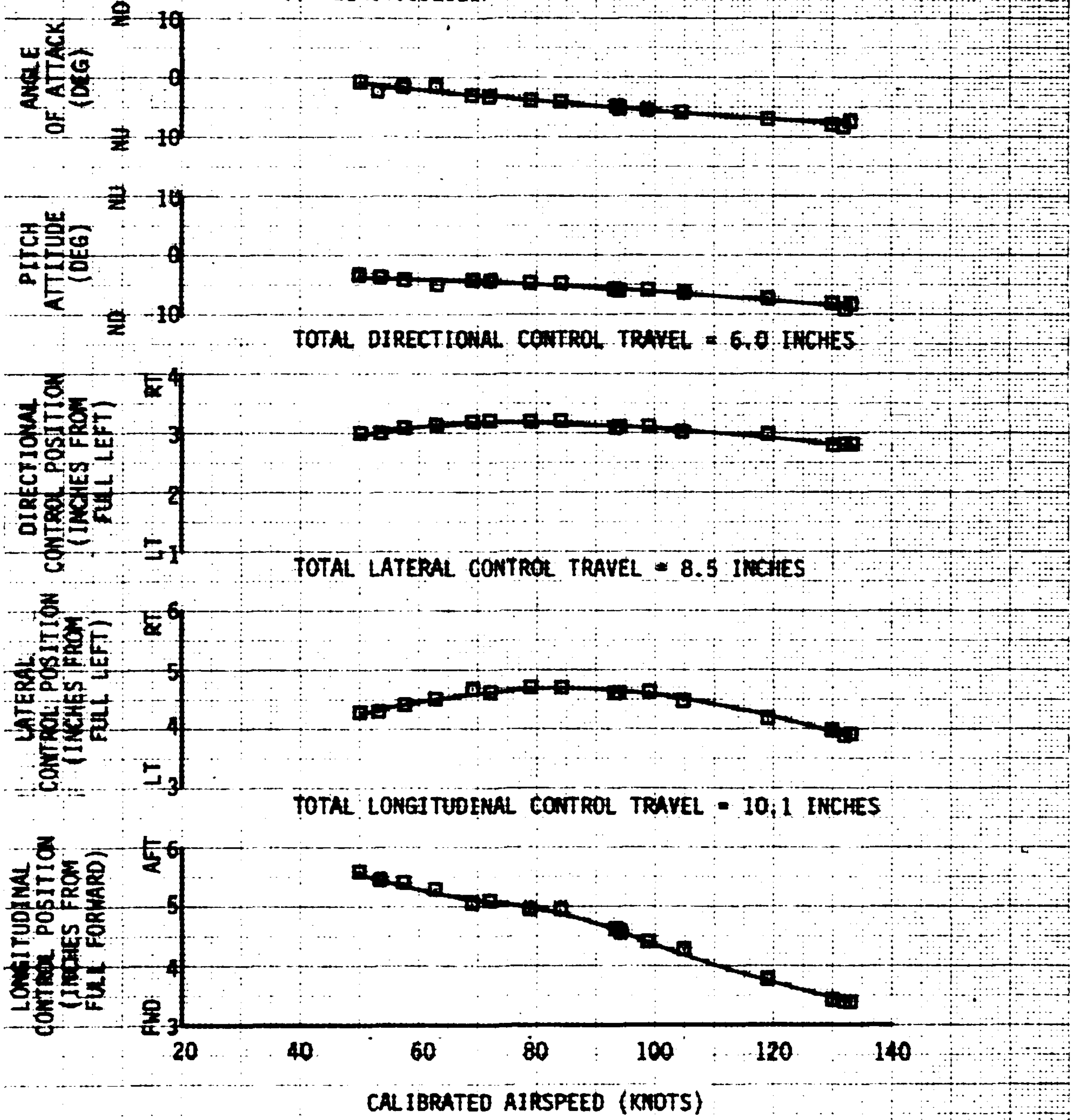


FIGURE 9
STATIC LONGITUDINAL STABILITY
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG C.G. LOCATION LONG (FS)	AVG C.G. LOCATION LAT. (BL)	AVG DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	FLIGHT CONDITION
9800	198.5(AFT)	0.0(MID)	5200	20.0	324	LEVEL

NOTES: 1. AGPOS INSTALLED
2. TWO M65 4-TWO AND TWO M159C LAUNCHERS MOUNTED ON WINGS
3. SHADED SYMBOLS DENOTE TRIM

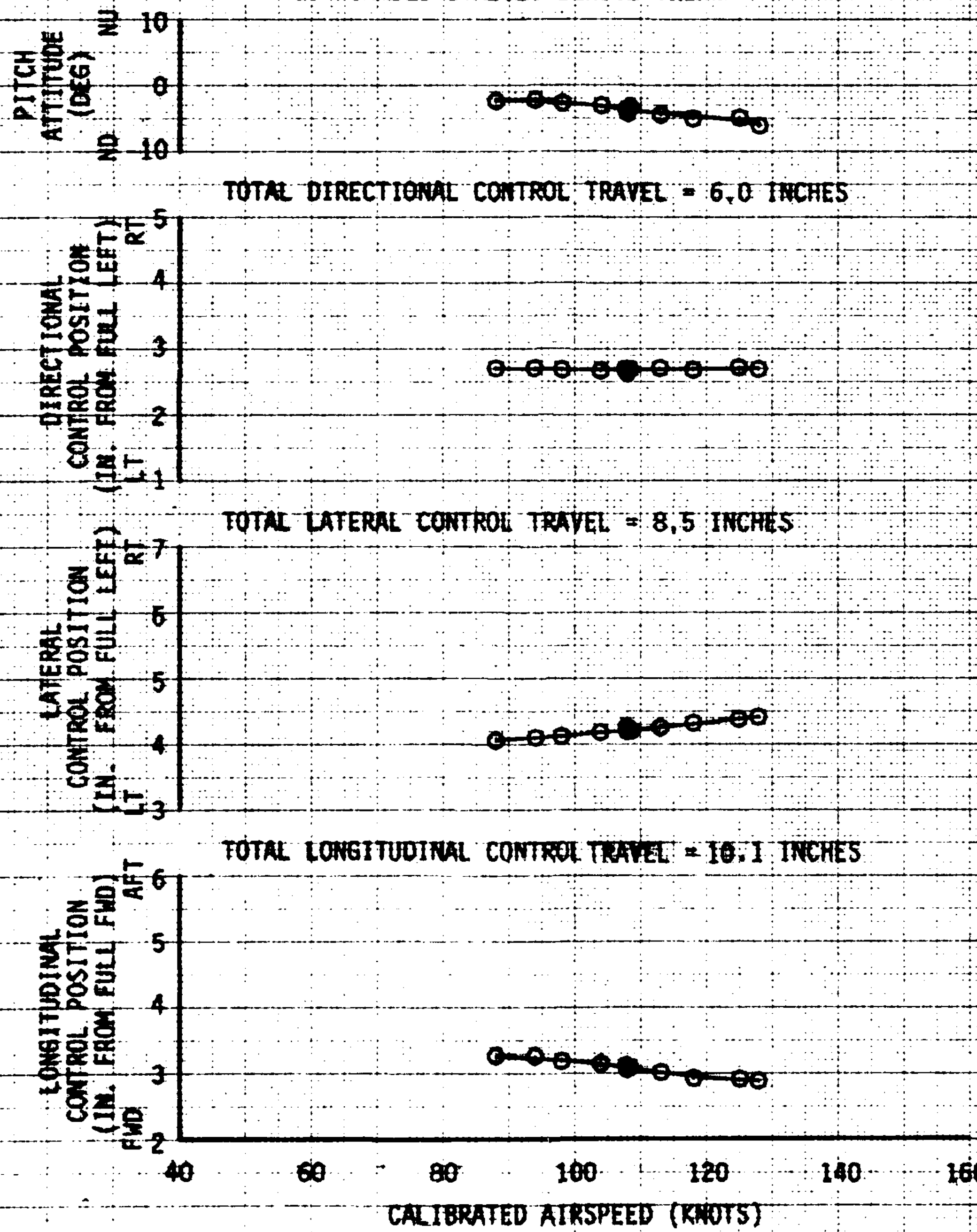


FIGURE 10

STATIC LONGITUDINAL STABILITY
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG C.G. LOCATION LONG (FS)	AVG C.G. LOCATION LAT. (BL)	AVG DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	FLIGHT CONDITION
9800	198.8(AFT)	0.0(MID)	5220	20.0	324	LEVEL

NOTES:
1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WINGS
3. SHADED SYMBOLS DENOTE TRIM

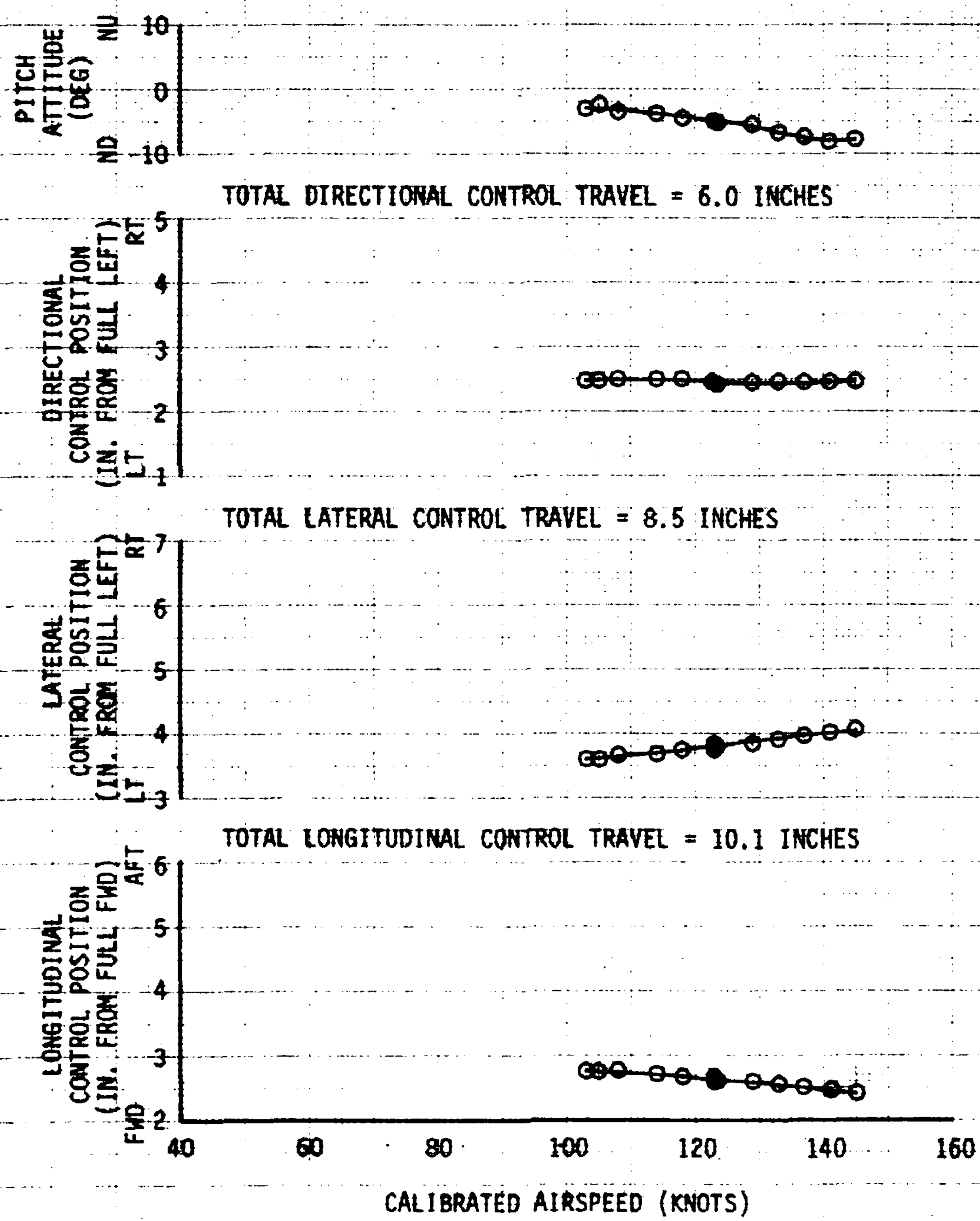


FIGURE 11

STATIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG C.G. LOCATION LONG. (FS)	AVG C.G. LOCATION LAT. (BL)	AVG DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	FLIGHT CONDITION
9780	198.5(AFT)	0.0(MID)	5220	14.5	324	LEVEL 68 KCAS

NOTES:
1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WINGS
3. SHADED SYMBOLS DENOTE TRIM

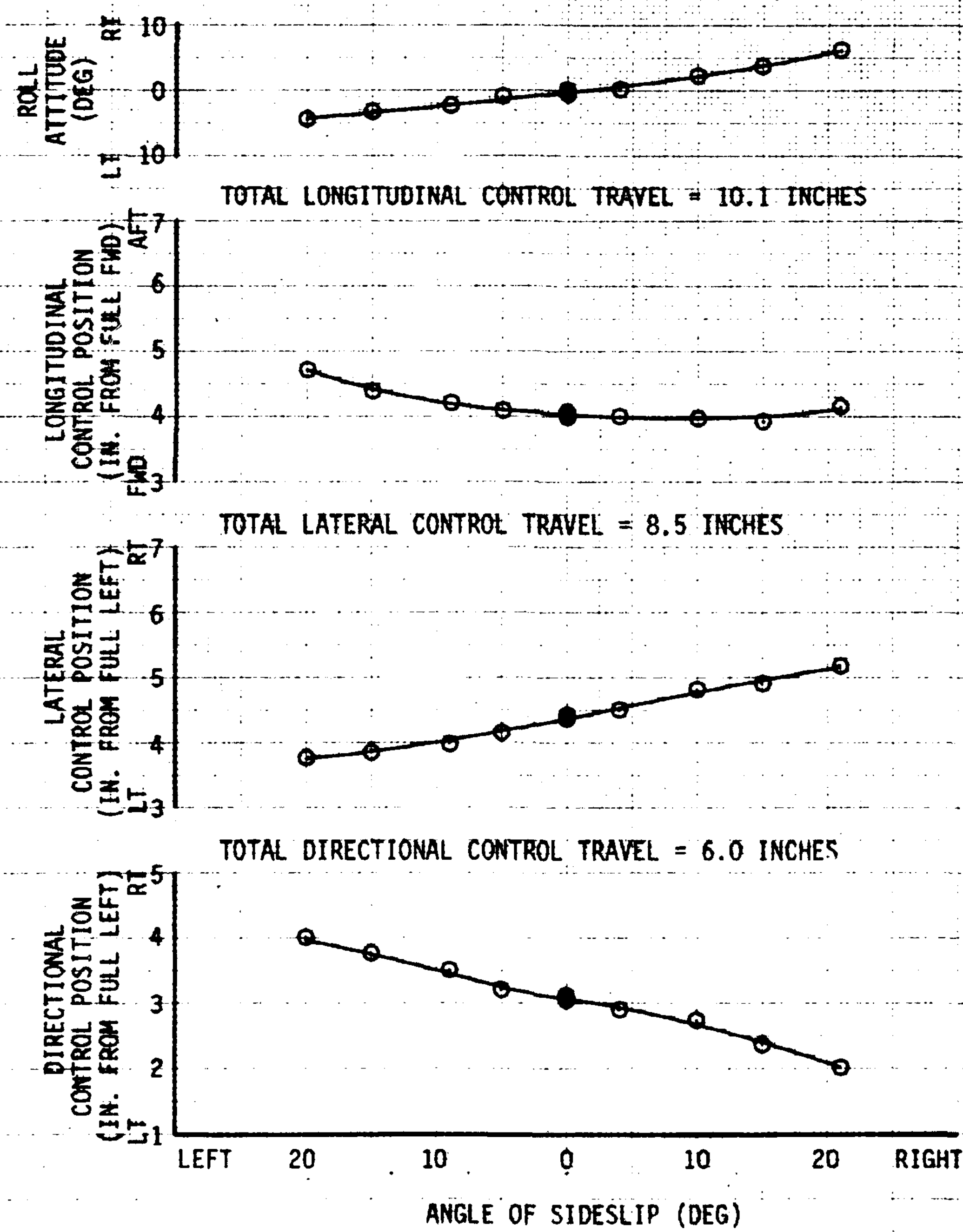


FIGURE 12

STATIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG C.G. LOCATION LONG. (FS)	LAT. (BL)	AVG DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	FLIGHT CONDITION
9650	198.7(AFT)	0.0(MID)	5240	15.0	324	LEVEL 109 KCAS

NOTES:
1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WINGS
3. SHADED SYMBOLS DENOTE TRIM

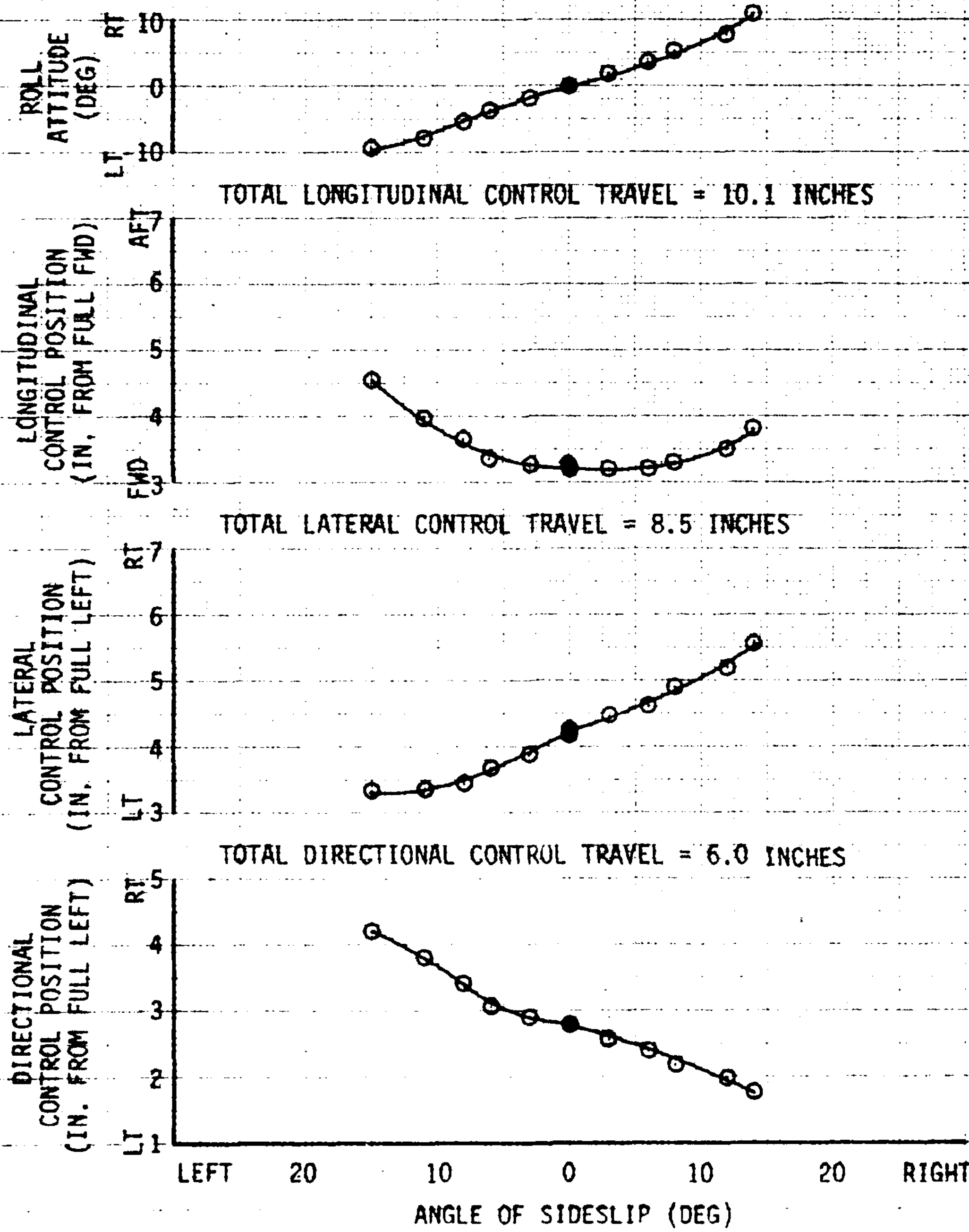


FIGURE 13

STATIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG C.G. LOCATION LONG (FS)	AVG C.G. LOCATION LAT. (BL)	AVG DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	FLIGHT CONDITION
○ 9460	198.9(AFT)	0.0(MID)	4780	14.5	324	LEVEL 129 KCAS
□ 9560	198.9(AFT)	0.0(MID)	5060	16.0	324	LEVEL 163 KCAS

NOTES: 1. AGPDS INSTALLED
2. TWO M65 4-TWO AND TWO M159C LAUNCHERS MOUNTED ON WINGS
3. SHADED SYMBOLS DENOTE TRIM

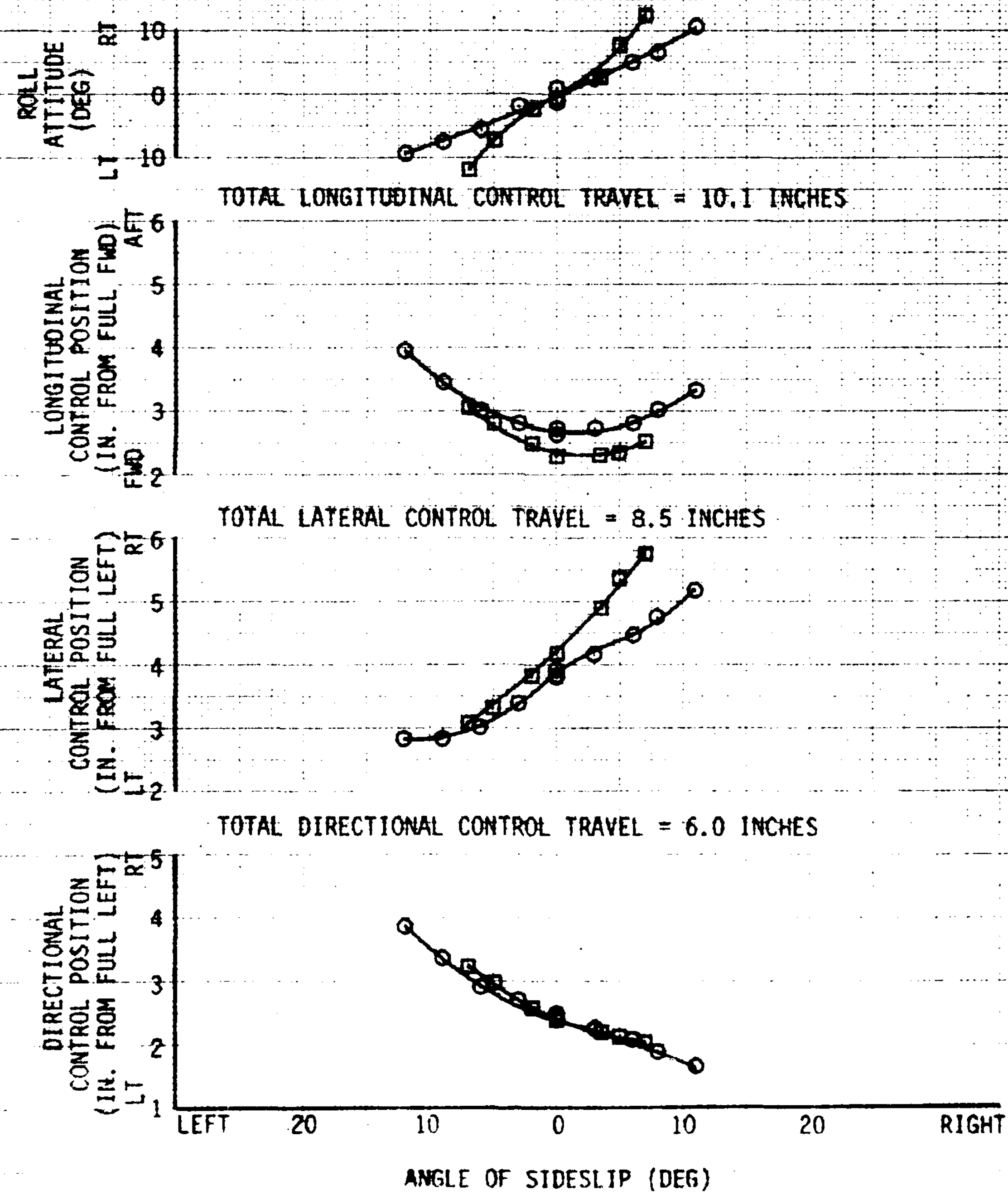
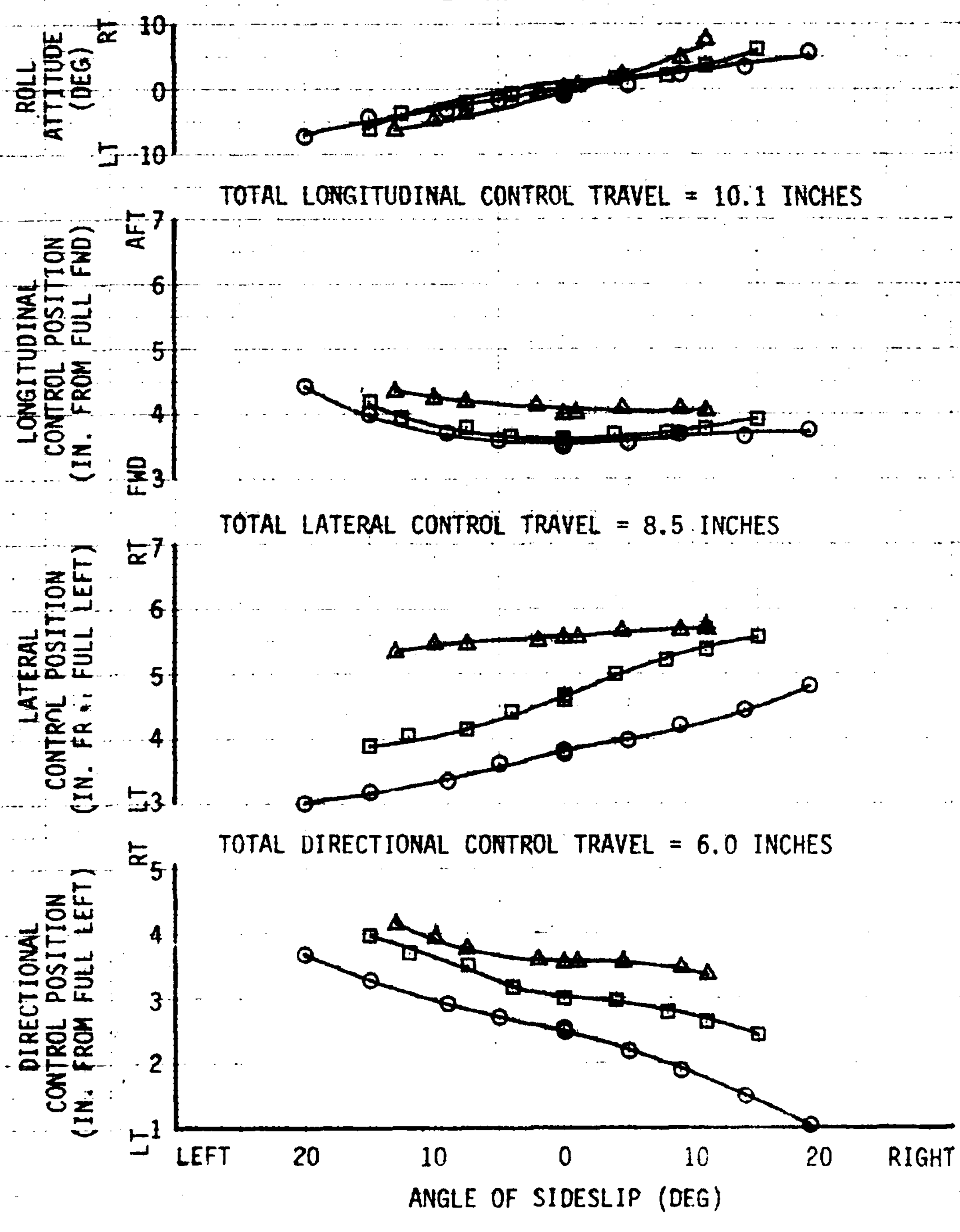


FIGURE 14
STATIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG C.G. LOCATION LONG. (FS)	LAT. (BL)	AVG DENSITY ALTITUDE (FT)	AVG. OAT (°C)	AVG. ROTOR SPEED (RPM)	FLIGHT CONDITION
○9860	198.6(AFT)	0.0(MID)	5180	14.0	324	MCP CLIMB 68 KCAS
□9800	198.8(AFT)	0.0(MID)	4940	14.5	324	500 FT/MIN DESCENT 87 KCAS
△9680	199.0(AFT)	0.0(MID)	4560	14.5	324	AUTOROTATION 88 KCAS

NOTES: 1. AGPDS INSTALLED
2. TWO M65 4-TOW AND TWO M159C LAUNCHERS MOUNTED ON WINGS



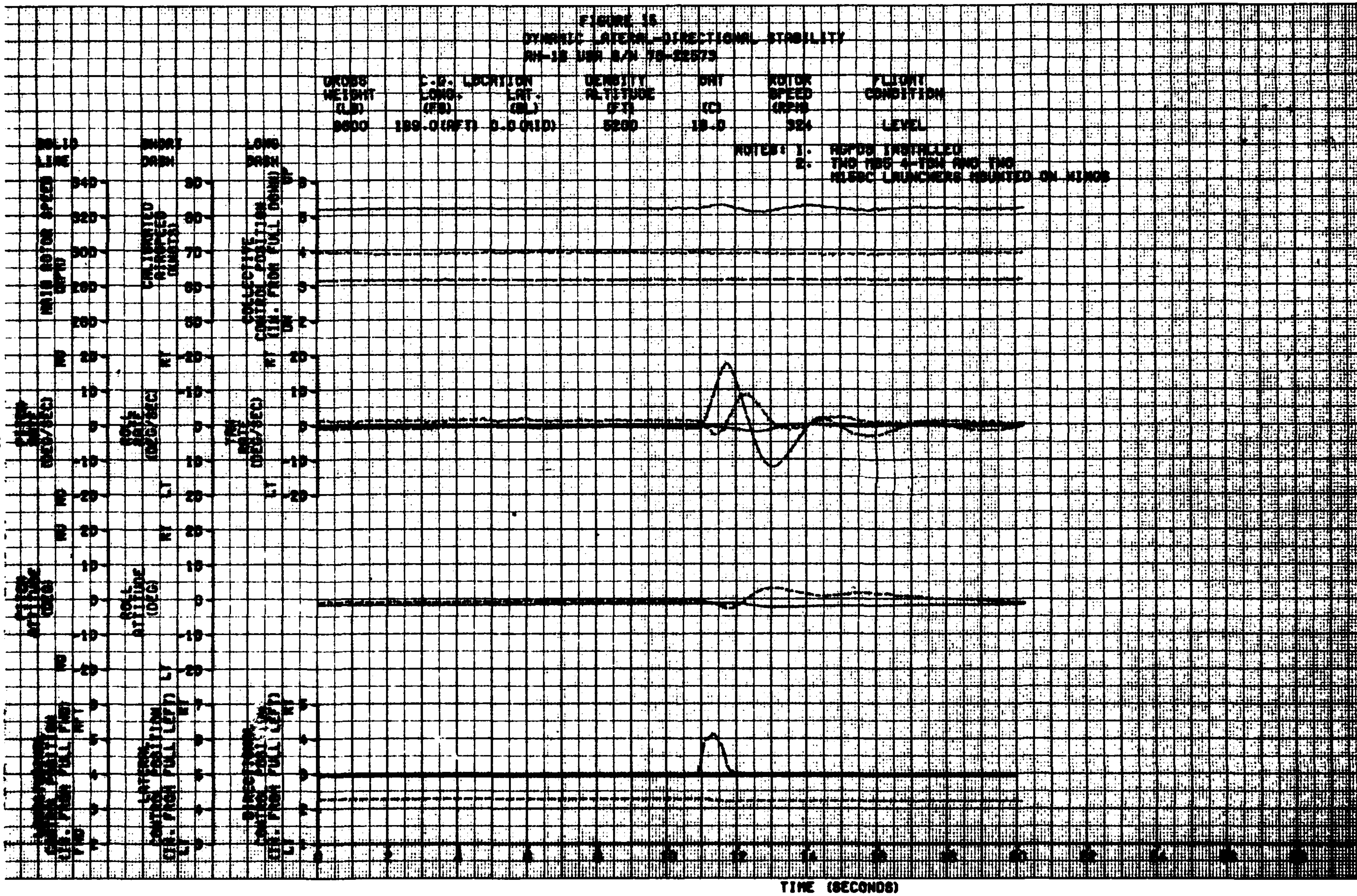
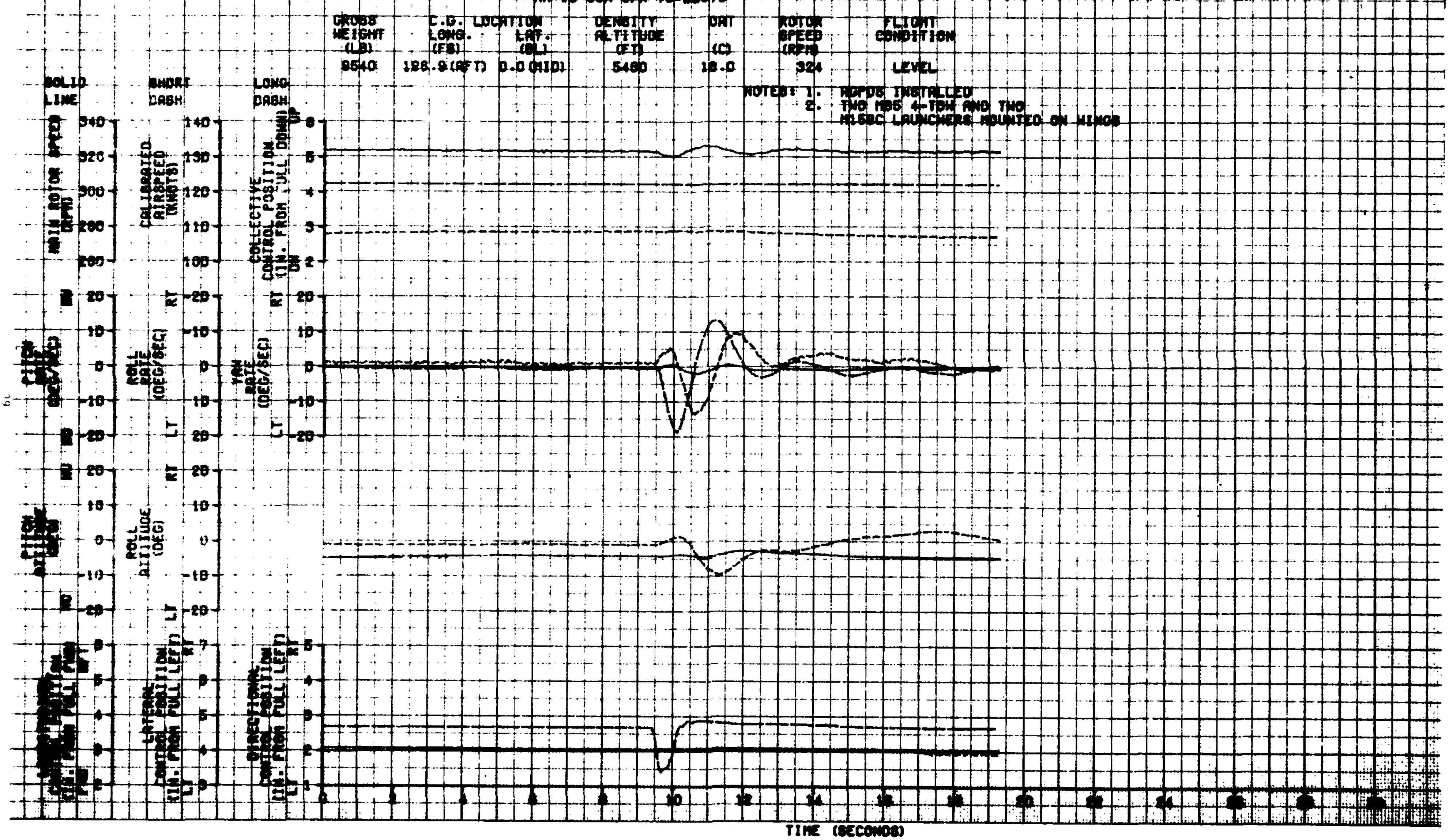
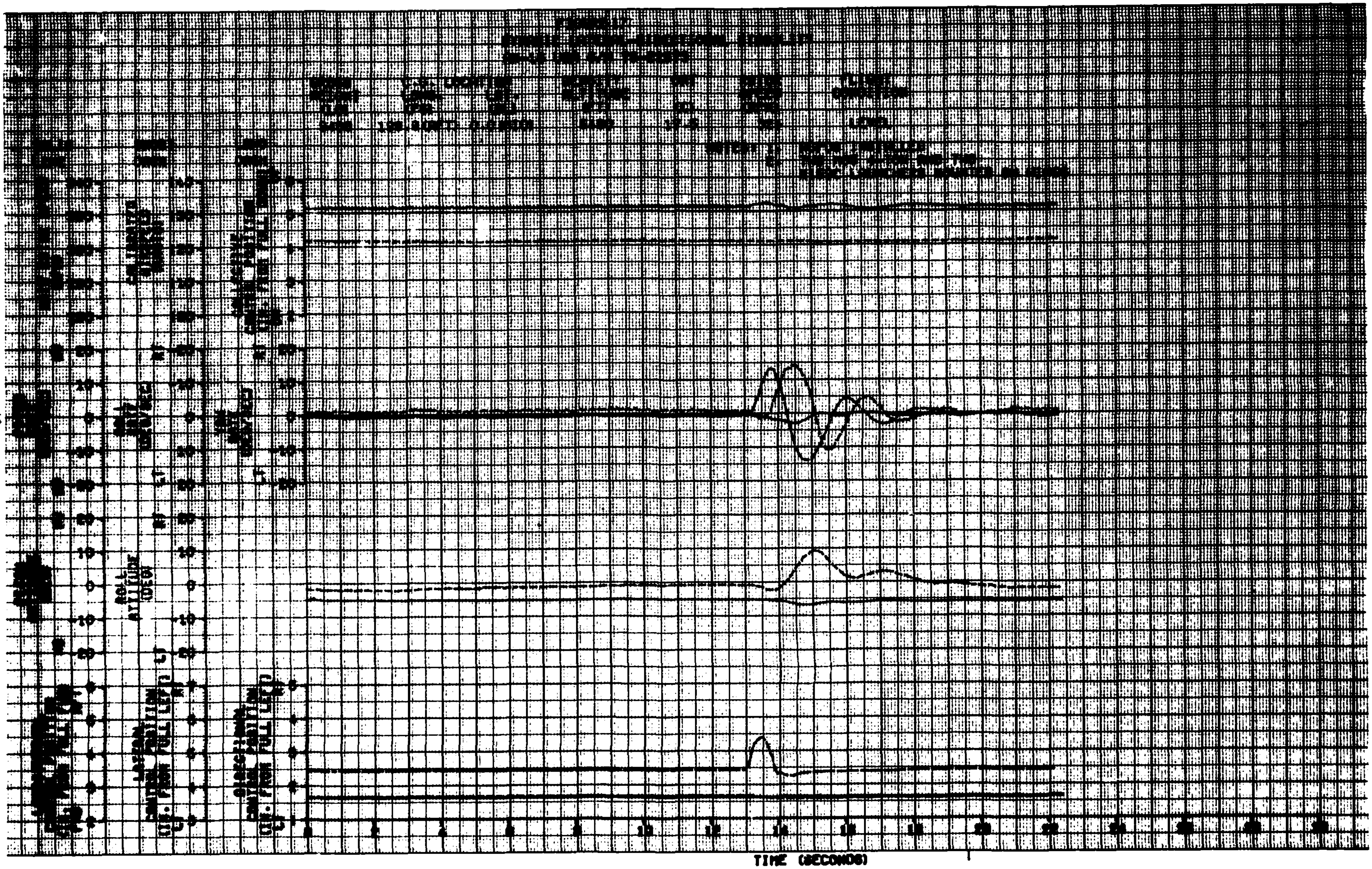


FIGURE 15
DYNAMIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 76-22573

FIGURE 16
DYNAMIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 78-22573




TIME (SECONDS)

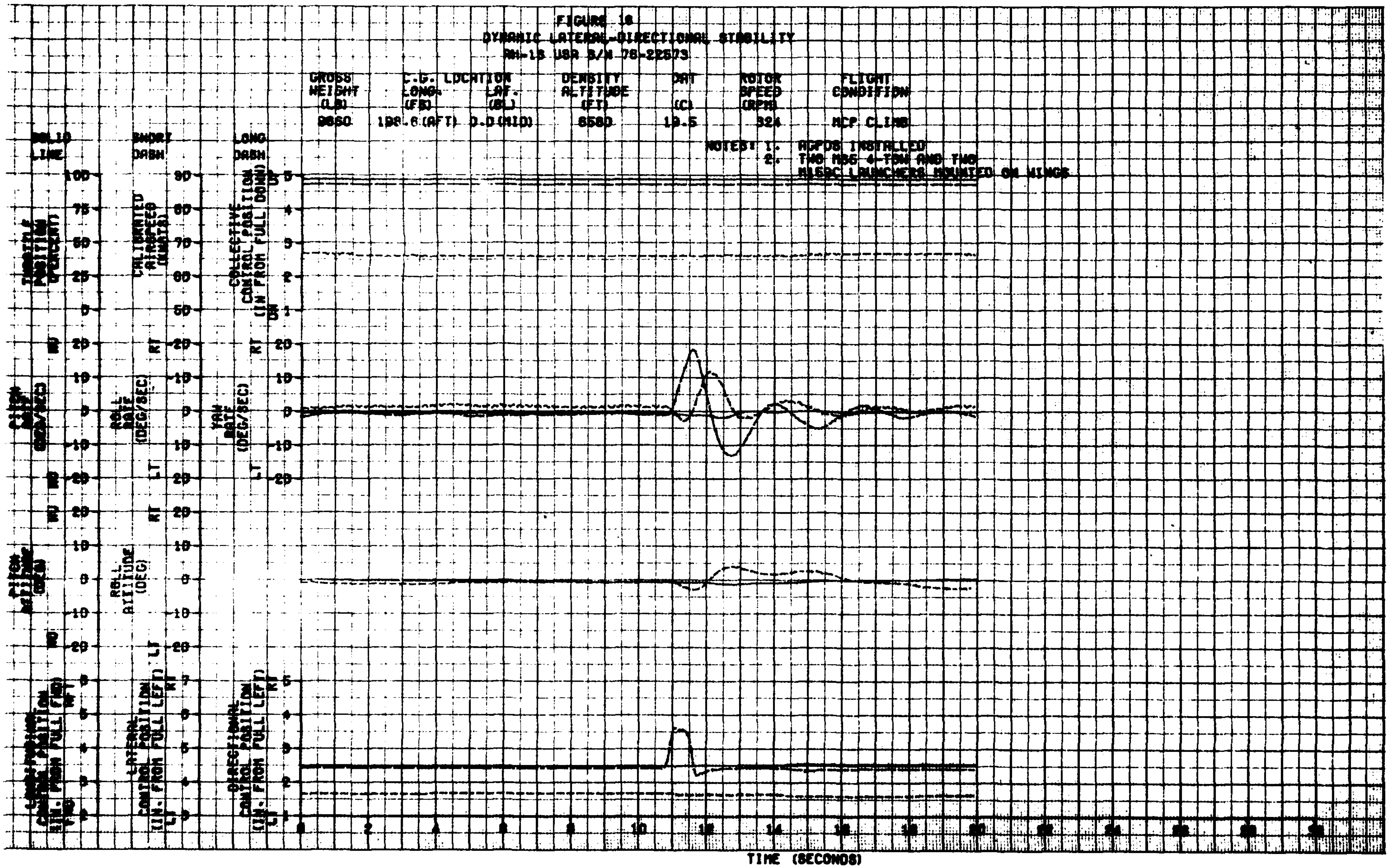


FIGURE 18
DYNAMIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 76-22573

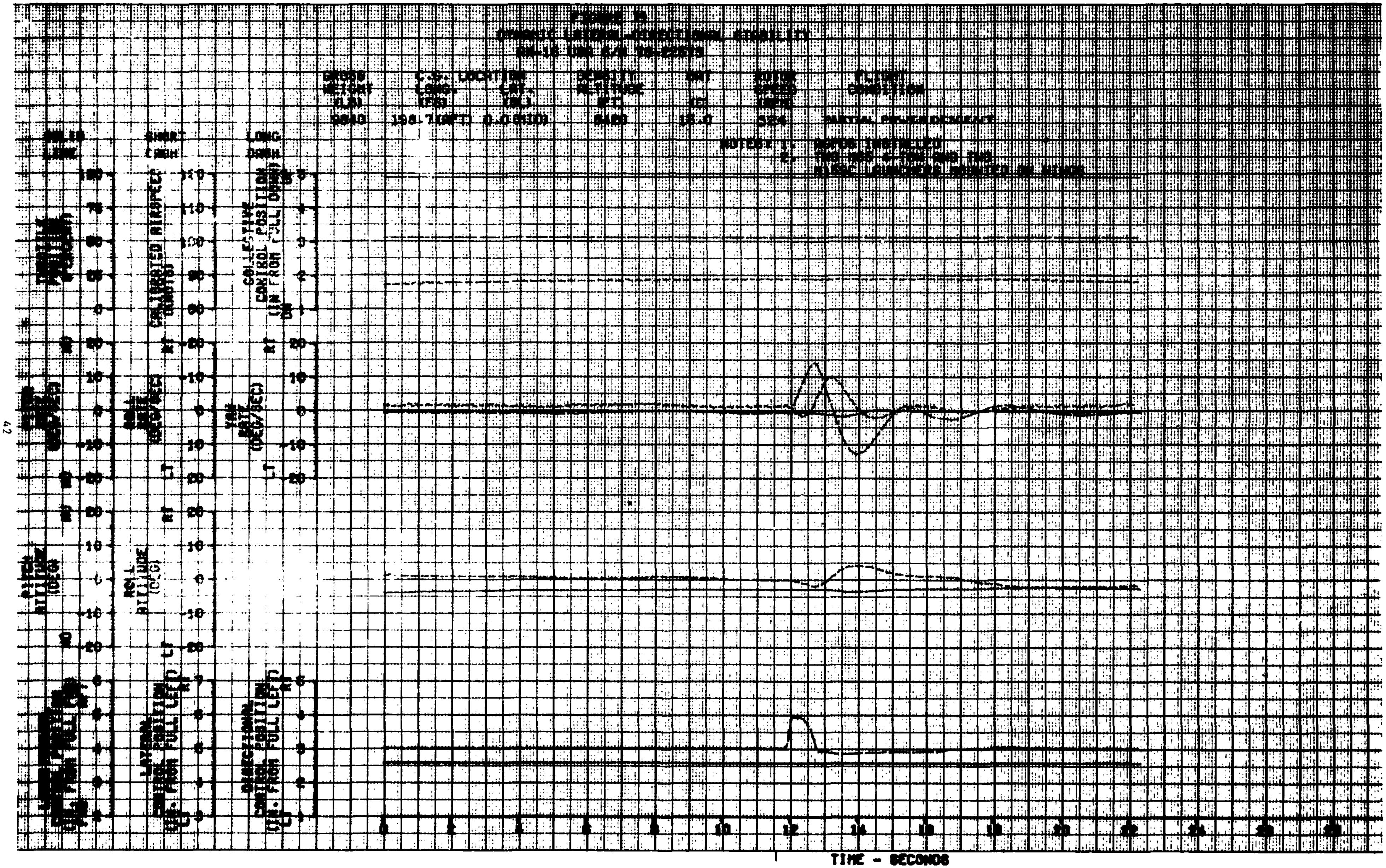

GROSS WEIGHT
C.G. LOCATION
NOTES:
CALIBRATED AIRSPEED (KNOTS)
COLLECTIVE CONTROL POSITION (IN FROM FULL DOWN)
ROLL RATE (DEG/SEC)
YAW RATE (DEG/SEC)
PITCH ATTITUDE (DEG)
ROLL ATTITUDE (DEG)
LATERAL CONTROL POSITION (IN. FROM FULL LEFT)
DIRECTIONAL CONTROL POSITION (IN. FROM FULL LEFT)
TIME - SECONDS

FIGURE 20.
DYNAMIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 76-22673

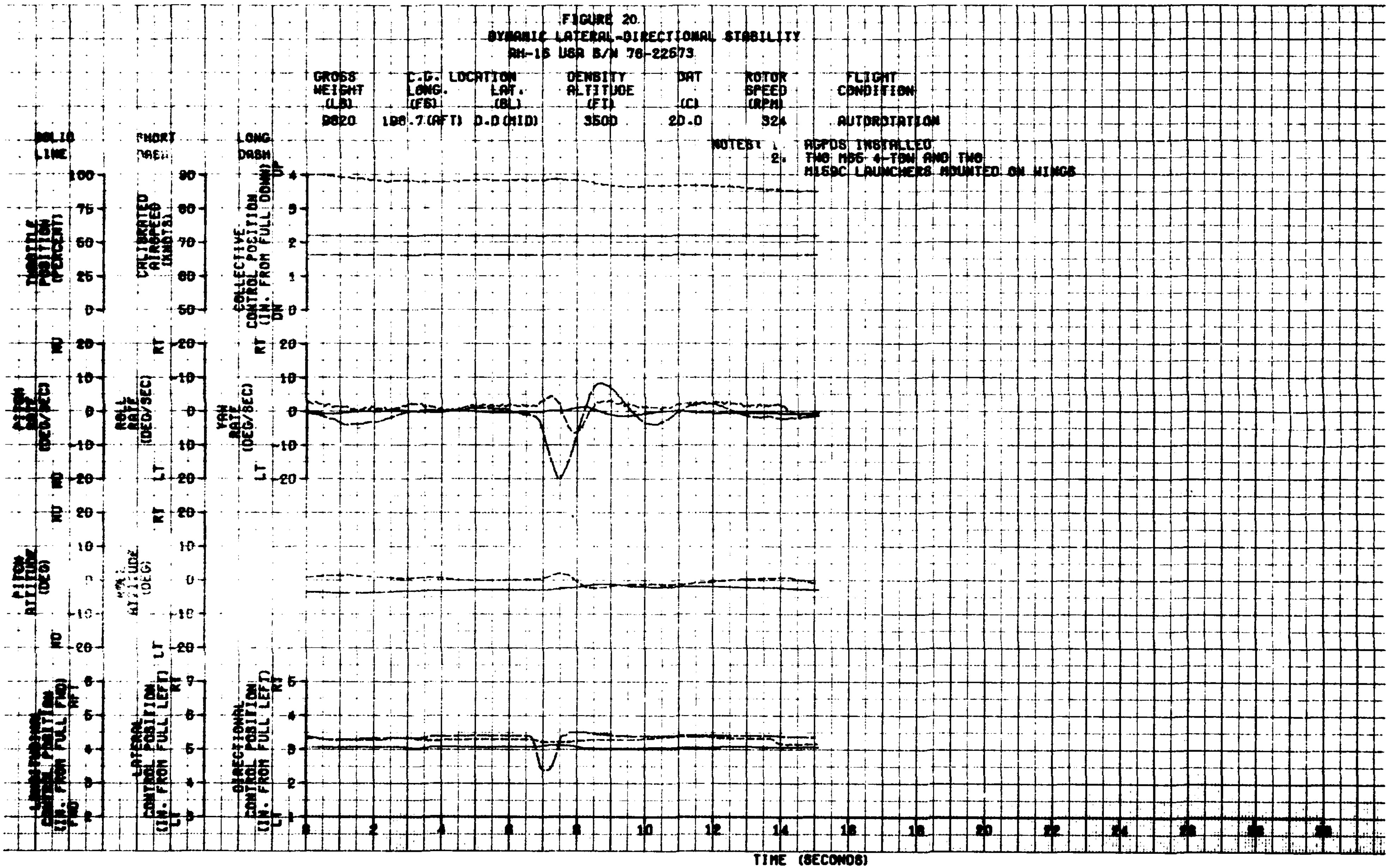
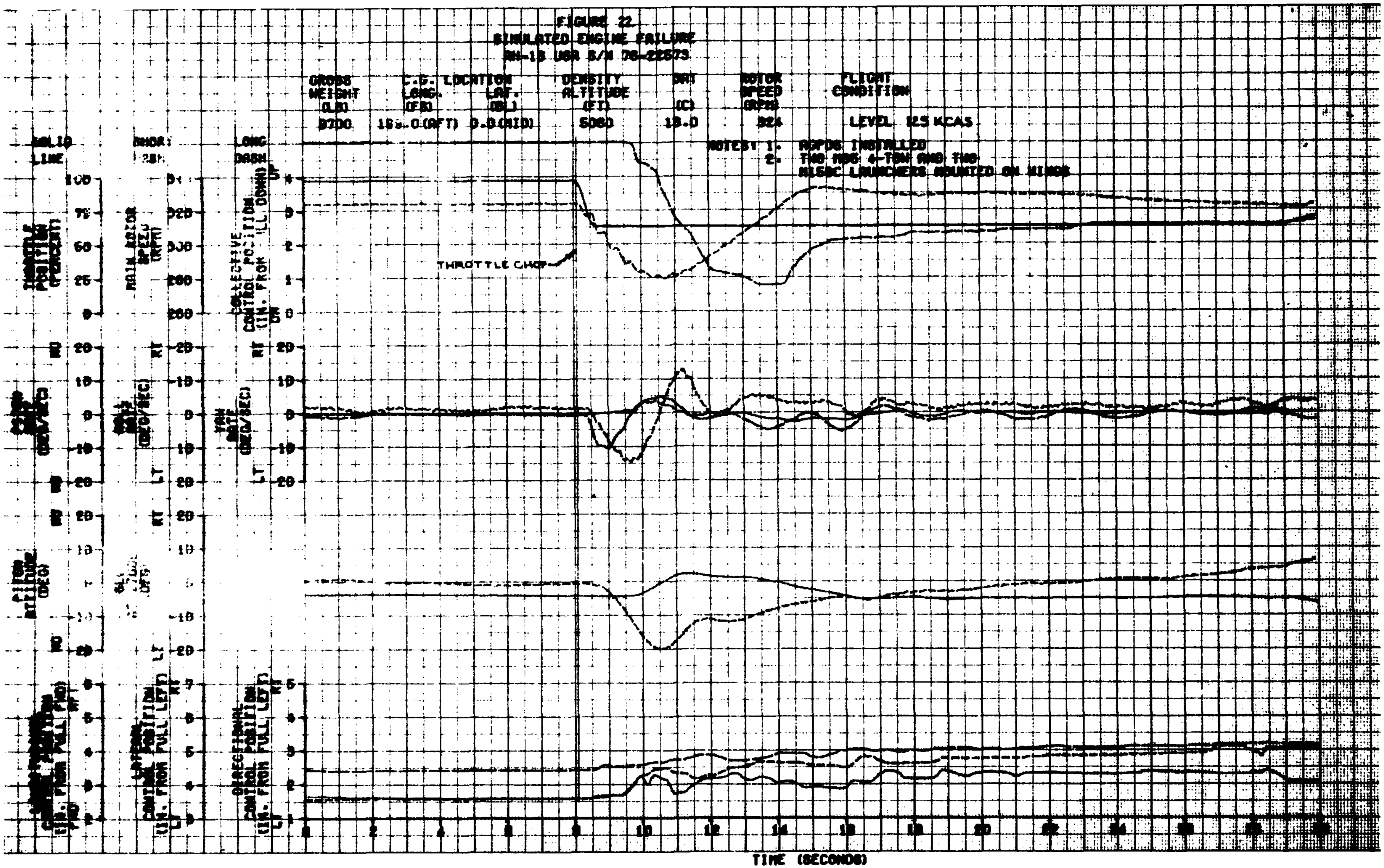


FIGURE 21.
DYNAMIC LATERAL-DIRECTIONAL STABILITY
AH-1S USA S/N 76-22573

GROSS WEIGHT (LB)	C.G. LOCATION LONG. (FS)	C.G. LOCATION LAT. (BL)	DENSITY ALTITUDE (FT)	OAT (C)	ROTOR SPEED (RPM)	FLIGHT CONDITION
9580	198.9(AFT)	0.0(MID)	5240	18.0	324	LEVEL

NOTES: 1. RCPDS INSTALLED
2. TWO M65 4-TOW AND TWO M158C LAUNCHERS MOUNTED ON WINGS

FIGURE 22
SIMULATED ENGINE FAILURE
AH-1S USA S/N 76-22573



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