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FUEL CONSERVATION EVALUATION OF US ARMY HELICOPTERS, PART 5, AH-1S FLIGHT TESTING

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FINAL REPORT

Approved for public release, distribution unlimited

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

USAAEFA

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The United States Army Aviation Engineering Flight Activity conducted level flight performance tests of the AH-1S (Prod) helicopter to provide data to determine the most fuel efficient operating conditions. Hot and cold weather test sites were used to extend the range of the advancing tip Mach number data to supplement existing AH-1S performance data. Preliminary analysis of non-dimensional data identifies the effects of compressibility on performance and shows a power penalty of as much as 6% at a high $N_R/\sqrt{\theta}$. The power

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required characteristics determined by these tests can be combined with engine performance to determine the most fuel efficient operating conditions.

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. 81-01-5, Fuel Conservation Evaluation of US Army Helicopters, Part 5, AH-1S Flight Testing

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1. The purpose of this letter is to establish the Directorate for Development and Qualification position on the subject report. The report documents part 5 of a 5 part effort which involves performance flight testing of the AH-1S to obtain performance data and determine the most efficient operating characteristics. Part 1 involved conducting a flight operation improvement analysis. Part 2 was initiated to develop and evaluate flight manual data designed for optimizing fuel conservation. Parts 3, 4 and 5 entail flight testing of the UH-1H, OH-58C, and AH-1S which is specifically oriented towards obtaining performance data applicable to fuel conservation. The part 5 evaluation conducted by the US Army Aviation Engineering Flight Activity (USAAEFA) consisted of obtaining detailed comprehensive performance data for the AH-1S in both hot and cold temperatures. Future major revisions to the AH-1S Operator's Manual will consider incorporation of changes in performance data or optimum performance operating procedures resulting from this evaluation.

2. This Directorate agrees with the report conclusions and recommendations.

FOR THE COMMANDER:

Ronald E. Gormont

RONALD E. GORMONT
Acting Director of
Development and Qualification

A

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INTRODUCTION

BACKGROUND

1. The US Army is placing emphasis on achieving fuel conservation relative to the operation of Army aircraft. The Deputy Chief of Staff for Logistics (DCSLOG), Aviation Logistics Office/Special Assistant (DALO-AV) supports a program that will investigate ways to minimize fuel consumption. The Directorate for Development and Qualification of the US Army Aviation Research and Development Command (AVRADCOM) and the US Army Aviation Engineering Flight Activity (USAAEFA) have jointly developed a fuel conservation program for helicopters which was briefed to Headquarters, US Army Materiel Development and Readiness Command (DARCOM) and DCSLOG on 28 January 1981. Both DCSLOG and DARCOM agreed to implement the program. DSCLOG additionally agreed to provide necessary Operation and Maintenance - Army (OMA) funding. AVRADCOM directed USAAEFA to conduct the Cobra portion of the fuel conservation program on the AH-1S (Prod) (ref 1, app A).

TEST OBJECTIVE

2. The objective of this test program was to obtain flight test data to determine the most fuel efficient operating characteristics of the AH-1S (Prod).

DESCRIPTION

3. The test aircraft, a production AH-1S serial number (S/N) 76-22573 (photo 1, app B) is a tandem seat, two-place helicopter with two-bladed main and tail rotors. 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 but limited by the main transmission to 1290 SHP for 30 minutes at airspeeds below 100 KIAS and 1134 SHP for continuous operation at any airspeed within the flight envelope. Distinctive features of this helicopter include the narrow fuselage, a modified flat plate canopy, stub wings with four stores stations, a model 212 tractor tail rotor and the K747 improved main rotor blades (K747 IMRB). A more complete description of the aircraft is presented in the operator's manual (ref 2, app A).

TEST SCOPE

4. Level flight performance tests of the AH-1S (Prod) helicopter were conducted in the vicinity of Edwards Air Force Base, California, El Centro, California, and St. Paul, Minnesota.

Project flying included 41 test flights which yielded 37.2 hours of productive test time from the 77.8 total hours flown. Of this total, there were 18.1 hours of ferry flight. The test aircraft and the test instrumentation were maintained by USAAEFA.

5. Flight restrictions and operating limitations contained in the operator's manual (ref 2, app A) and the airworthiness release issued by AVRADCOM (ref 3, app A) were observed. For this evaluation, maximum power-on main rotor speed was increased above the handbook limit of 324 RPM to 329 RPM. All tests were conducted at a mid longitudinal center of gravity (cg) location, a slightly right lateral cg, and with the engine bleed air OFF. Twenty-eight data sets (level flight speed-power polars) were flown in the clean configuration. Eight additional data sets were flown with XM-159/C rocket pods installed (photo 1, app B). Four sets were flown with the pods empty and the other four sets with the pods fully loaded.

6. The evaluation consisted of level flight performance tests using referred rotor speed ($N_R/\sqrt{\theta}$) and thrust coefficient, C_T, as the major variables to supplement the range of currently available data. General test conditions are shown in table 1.

TEST METHODOLOGY

7. Established engineering flight test techniques and data reduction procedures were used and are described in appendix C. Test methods are also briefly discussed in the Results and Discussion section of this report. Test parameters were recorded from calibrated instrumentation by an onboard magnetic tape system installed and maintained by USAAEFA (photo 1, app D). Aircraft weight and balance measurements and fuel cell calibrations were conducted by USAAEFA prior to the start of performance testing. Airspeed and engine torquemeter calibrations utilized are presented in figures 39 through 42, appendix E. Performance data were not corrected for drag changes caused by addition of the nose boom system.

Table 1. Level Flight Performance Test Conditions[1]

Average $N_R/\sqrt{\theta}$ ~RPM	Average $C_T \times 10^4$	Average Gross WT ~lb	Average Density Alt ~ft	Average Air Temperature ~°C	App E Fig. No.
293	50.54	7860	3080	26.0	3
293	54.43	8400	3560	26.5	4
293	58.98	8440	5840	24.5	5
293	64.39	7840	10,180	17.0	6
293	68.25	8500	9460	16.0	7
304	49.92	8240	4160	30.5	8
303	54.66	8440	5720	27.0	9
303	58.38	7960	9120	20.5	10
303	62.51	8540	9060	21.0	11
303	68.81	8060	12,880	11.0	12
314	49.97	8860	3460	26.5	13
314	53.82	9080	4900	24.0	14
314	57.52	8880	7600	22.0	15
313	62.04	8980	9260	20.0	16
314	68.26	9180	11,400	17.5	17
324	50.03	8140	5060	-3.0	18
324	53.94	9220	3420	-2.5	19
324	58.13	8760	6940	-6.5	20
324	62.44	9020	8100	-8.0	21
325	67.70	9300	9920	-9.5	22
334	50.37	8780	4440	-4.0	23
334	54.22	9220	5260	-5.5	24
334	57.87	9160	7400	-8.0	25
334	62.01	8900	10,140	-10.0	26
336	67.57	9360	11,460	-11.5	27
339	50.57	9080	4480	-6.5	28
341	54.63	9360	5820	-9.0	29
340	58.79	9340	8280	-9.0	30
323[2]	54.42	8960	7520	24.0	31
323[2]	58.39	8840	9820	19.5	32
324[2]	62.25	8380	12,940	13.0	33
323[2]	68.50	8960	13,640	12.5	34
323[3]	54.42	9430	5680	24.5	35
323[3]	58.51	9580	7500	22.5	36
324[3]	62.21	9520	9480	19.5	37
323[3]	68.41	9620	11,380	13.0	38

NOTES:

[1]Clean configuration, zero sideslip, mid longitudinal cg, constant thrust coefficient and referred rotor speed method unless otherwise noted.
[2]Flown with empty XM-159/C pods.
[3]Flown with full XM-159/C pods.

RESULTS AND DISCUSSION

GENERAL

8. This evaluation of the AH-1S (Prod) helicopter obtained level flight performance data to determine power required and fuel flow as a function of airspeed from approximately 20 knots true airspeed (KTAS) to the maximum level flight airspeed. The constant referred gross weight and rotor speed (W/δ, $N_R/\sqrt{\theta}$) method was used to obtain data at zero sideslip and a mid longitudinal cg location. Additional data were obtained by addition of two XM-159/C pods mounted inboard in the empty and fully loaded configurations. The power required characteristics determined by these tests can be combined with engine performance data to determine the most fuel efficient operating conditions.

POWER REQUIRED

9. The power required for level flight data were analyzed using nondimensional power, thrust, and advance ratio (C_P, C_T, and μ), as described in appendix C. The matrix flown, shown in table 1, consisted of 35 sets of speed-power data that covered a range of $C_T \times 10^4$ from 50 to 68, and $N_R/\sqrt{\theta}$ from 294 to 342 RPM. The baseline data in this evaluation were flown at a target $N_R/\sqrt{\theta}$ of 294 RPM at Edwards AFB. Increased $N/\sqrt{\theta}$ (324 RPM through 342 RPM) were flown at cold temperatures in St. Paul, Minnesota, where the maximum permitted power-on main rotor speed was raised for test purposes from the handbook limit of 324 RPM to 329 RPM. The lower limit of 294 RPM remained unchanged.

10. A nondimensional summary of the results is shown in figures 1 and 2, appendix E, and dimensional data for the individual tests (clean configuration) are presented in figures 3 through 30. Table 1 provides a cross-reference of test conditions with figure number.

11. For all values of μ, the fairings of C_P versus C_T in figures 1 and 2, appendix E, do not vary with referred rotor speeds between $N_R/\sqrt{\theta} = 294$ through 314 RPM. However, for increasing values of μ, a divergent trend from this baseline appears for the highest $N_R/\sqrt{\theta}$ flown (342 RPM) starting at $\mu = 0.22$. As μ increases above 0.22, the fairings for $N_R/\sqrt{\theta} = 342$ eventually form a separate family of curves with higher values of C_P than those of the baseline. This same separate family of curves for $N_R/\sqrt{\theta} = 342$ also begin to appear at $\mu = 0.12$ and is more pronounced for decreasing values of μ. Similar trends emerge for other referred rotor speeds with increasing μ: $N_R/\sqrt{\theta} = 334$ separates from the

baseline at $\mu = 0.24$ and 324 at $\mu = 0.26$. As μ increases, the divergent trends generally appear at lower C_{T_S} for the higher values of $N_R/\sqrt{\theta}$ and produce larger C_P increases at higher values of C_T. From $\mu = .14$ to $\mu = .20$ the curves are identical for all values of $N_R/\sqrt{\theta}$. Power required is affected by compressibility above $N_R/\sqrt{\theta} = 314$ RPM in amounts which vary with C_T and μ. The difference attributed to compressibility effects between baseline and high $N_R/\sqrt{\theta}$ amounted to 1.0% at $C_T \times 10^4 = 50$ and varied to as much as 6.0% at $C_T \times 10^4 = 58$.

ROTOR SPEED

12. The nondimensional summary shows a C_P penalty for $N_R/\sqrt{\theta}$ above 314 RPM as a function of C_T and μ. The dimensional data must be used to determine whether performance for varying gross weights, altitudes, temperature, and airspeeds can be maximized by reducing rotor speeds to operate at lower $N_R/\sqrt{\theta}$. It should be noted that there is the possibility that decreasing $N_R/\sqrt{\theta}$ beyond some condition will incur a C_P penalty due to the increase of C_T and μ.

CONFIGURATION VARIATION

13. Eight sets of data were flown to compare performance of the clean configuration with two XM-159/C pods installed inboard empty and fully loaded with dummy rockets (ten pound warheads). The data indicate an increase in drag of 3.3 square feet for the empty pods and 5.5 square feet for the pods fully loaded. Figures 31 through 38 show the data acquired in these configurations for various values of C_T. This data compares favorably with data taken in USAAEFA Project No. 66-06 (ref 4, app A).

ENGINE CHARACTERISTICS

14. Fuel flow characteristics of the Lycoming T53-L-703 engine were derived from Lycoming Engine Model Specification computer program, US Army Model T53-L-703, Model Spec 104.43, dated 1 May 1974 (ref 5, app A) using installation losses described in para 11, appendix D. Representative engine characteristics are shown in figures 40 through 42, appendix E. The consistency of these data indicate that engine power, based on the engine torquemeter system, did not change throughout the program. The engine, S/N LE12158Z was calibrated at Corpus Christi Army Depot on 30 June 1981.

FUEL EFFICIENCY

15. Specific range (nautical air miles per pounds of fuel) was calculated for an installed specification engine for each of the level flight performance tests and is shown in figures 3 through 38. The fuel flow data for the cold weather tests were unreliable and therefore not presented. Specification values agree closely with the measured data.

16. Maximum endurance occurs at minimum fuel flow rate, and best range at maximum nautical miles per pound fuel (specific range). Fuel efficiency for level cruise flight can be maximized at any temperature by flying at the right combination of airspeed, altitude and rotor speed. These conditions can be determined by examining the dimensional performance calculatd by combining the engine characteristics with the power required from the summary in figures 1 and 2, appendix E. Aircraft performance and engine specification data from this report should be combined with existing data and presented in the operator's handbook in a format suitable for use by the aviator.

CONCLUSIONS

17. The power required characteristics determined by these data tests can be combined with engine performance to determine the most fuel efficient operating conditions. Specific conclusions were:

a. Power required is effected by compressibility above $N_R/\sqrt{\theta}$ = 314 RPM in amounts which vary with C_T and μ (para 11).

b. Empty XM-159/C pods increase the flat plate area of the AH-1S (Prod) by 3.3 square feet; fully loaded pods increase the flat plate area by 5.5 square feet (para 13).

RECOMMENDATION

18. Aircraft performance and engine specification data from this report should be combined with existing data and presented in the operator's handbook in a format suitable for use by the aviator (para 16).

APPENDIX A. REFERENCES

1. Letter, AVRADCOM, DRDAV-DI, 30 June 1981, subject: Fuel Conservation Evaluation of US Army Helicopters, Part 5, AH-1S Flight Testing.

2. Technical Manual, TM 55-1520-2 36-10, *Operator's Manual, Army Model AH-1S (Prod) Helicopter,* change 3, 14 April 1982.

3. Letter, AVRADCOM, DRDAV-D, 7 August 1981, subject: Airworthiness Release for AH-1S (Prod) S/N 76-22573, Fuel Conservation Evaluation, Revision 2, 9 August 1982.

4. Final Report, USAAEFA, Project No. 66-06, *Engineering Flight Test AH-1G Helicopter (Hueycobra)* April 1970.

5. Engine Specification, Lycoming Divison, No. T53-L-703, *Turboshaft Engine*, Model No. 104.43, 1 May 1974.

6. Engineering Design Handbook, Army Material Command AMC Pamphlet 706-204, *Helicopter Performance Testing,* 1 August 1974.

APPENDIX B. AIRCRAFT DESCRIPTION

GENERAL

1. The test helicopter, S/N 76-22573, was an AH-1S (Prod) (photo 1) with no modifications other than test instrumentation. The external configuration was slightly modified by the installation of a pitot-static boom incorporating angle-of-attack, angle-of-sideslip vanes and a total air temperature probe. The boom was mounted below the telescope sighting unit at fuselage station (FS) 45. It extended forward of the nose 89 inches. The air temperature probe was mounted aft of the boom mounts at FS 57.

POWER PLANT

2. The T53-L-703 turboshaft engine is installed in the AH-1S helicopter. This engine employs a two-stage, axial-flow free power turbine; a 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 located in the air inlet housing reduces power turbine speed to a nominal output shaft speed of 6604.3 RPM at 100 percent N_2. A T_7 interstage turbine temperature sensor harness measures interstage turbine temperatures and displays this information in the cockpit as TGT on the cockpit instruments.

Principal Dimensions

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

Overall Dimensions	
Length, rotor turning	53 ft, 1 in.
Width, rotor turning	44 ft
Height, tail rotor vertical	13 ft, 9 in.

Main Rotor	K747 IMRB
Diameter[1]	44 ft
Disc area	1520.53 ft^2
Solidity	0.0625
Number of blades	2
Planform	Trapezoidal chord 30.0" tapering to 10.0" at tip.
Blade twist	-0.556 deg/ft
Main rotor speed	324 RPM (100%)

[1]Blade tie-down fixture is not included in the diameter.

Tail Rotor

Diameter	8 ft, 6 in.
Disc area	56.75 ft^2
Solidity	0.1436
Number of blades	2
Blade chord, constant	11.5 in.
Blade twist	0.0 deg/ft
Airfoil	NACA 0018 at the blade root changing linearly to a special cambered section at 8.27 percent of the tip
Tail rotor speed	1655.1 RPM (100%)

Fuselage

Length, rotor removed	44 ft, 7 in.
Height:	
To tip of tail fin	10 ft, 8 in.
Ground to top of mast	12 ft, 3 in.
Ground to top of transmission fairing	10 ft, 2 in.
Width:	
Fuselge only	3 ft
Wing span	10 ft, 9 in.
Skid gear tread	7 ft
Elevator:	
Span	6 ft, 11 in.
Airfoil	Inverted Clark Y
Vertical Fin:	
Area	18.5 ft^2
Airfoil	Special cambered
Height	5 ft, 6 in.
Wing:	
Span	10 ft, 9 in.
Incidence	17.0 deg
Airfoil (root)	NACA 0030
Airfoil (tip)	NACA 0024
Airfoil	Inverted Clark Y

Photo 1. Test Aircraft, AH-1S (Prod) S/N 76-22573

APPENDIX C. TEST TECHNIQUES AND DATA ANALYSIS METHODS

General

1. Conventional level flight performance test techniques were used to conduct this evaluation (ref 6, app A). Speed-power data were obtained in increasing increments of airspeed from 20 KIAS until reaching an operating limitation (either V_{NE}, transmission torque, TGT, or gas producer speed). Specific points would be repeated as judged appropriate by using an onboard plot of indicated torque versus airspeed for each point taken. All tests were conducted under nonturbulent atmospheric conditions to preclude uncontrolled disturbances influencing the results. Data were recorded on magnetic tape once a stable condition was achieved, and each point used was held for 60 seconds.

Weight and Balance

2. Prior to testing, the aircraft gross weight and center-of-gravity location were determined with calibrated scales (electrical load cells placed under the aircraft jack points). The aircraft was weighed in the configurations flown with instrumentation installed. The empty gross weight including full oil and trapped fuel was determined to be 6647 pounds with a longitudinal center-of-gravity (cg) at FS 201.6 inches and lateral cg at 0.1 inches right.

3. A manometer-type external sight gauge was calibrated and used to determine fuel volume. Fuel specific gravity was measured with a hydrometer. The fuel loading for each test flight was determined both prior to engine start and following engine shutdown. Fuel used in flight was recorded by a totalizer and verified with the pre- and post flight sight gauge reading. Fuel cg based on fuel volume contained in the fuel cell (259 gallon capacity) had been previously determined, and this measurement was used as a basis to calculate aircraft cg for each test point. Aircraft gross weight and cg were also controlled by ballast installed at various locations in the aircraft. All tests were flown at a mid longitudinal cg location.

Level Flight Performance and Specific Range

4. The helicopter level flight performance data were generalized by the following nondimensional coefficients:

a. Coefficient of power (C_P):

$$C_P = \frac{SHP\ (550)}{\rho\ A(\Omega R)^3} = 0.02958 \quad \frac{SHP}{\rho (RPM)^3} \qquad (1)$$

b. Coefficient of thrust (C_T):

$$C_T = \frac{W}{\rho A(\Omega R)^2} = 0.00012 \frac{W}{\rho(RPM)^2} \tag{2}$$

c. Advance ratio (μ):

$$\mu = \frac{1.6878\ V_T}{\Omega R} = 0.7326 \frac{V_T}{RPM} \tag{3}$$

d. Advancing blade tip Mach number (M_{tip}):

$$M_{tip} = \frac{1.6878\ V_T + (\Omega R)}{a} = \frac{1.6878 V_T + 2.3038\ (RPM)}{a} \tag{4}$$

Where:

SHP = Engine output shaft horsepower
550 = Conversion factor (ft-lb/sec/shp)
ρ = Air density (slug/ft^3)
ρ_o = Standard day sea level density (0.0023769 slugs/ft^3)
δ = Ambient pressure ratio (test point to sea level standard)
A = Main rotor disc area (ft^2) = 1520.53
Ω = Main rotor angular velocity (radian/sec) = $\frac{2\pi}{60}$ x RPM
R = Main rotor radius (ft) = 22.0
W = Gross weight (lb)
θ = Temperature ratio = (T + 273.15)/288.15
T = Ambient air temperature (°C)
1.6878 = Conversion factor (ft/sec/knot)
V_T = True airspeed (knot)
a = Speed of sound (ft/sec) = $1116.45\sqrt{\theta}$

5. Each speed power was flown at a predetermined constant C_T by maintaining a constant referred gross weight (W/δ) and referred rotor speed ($N_R/\sqrt{\theta}$). A constant W/δ was maintained by increasing altitude to decrease ambient pressure ratio (δ) as aircraft gross gross weight decreased due to fuel burnoff. Rotor speed was also varied to maintain a constant $N_R/\sqrt{\theta}$ as the ambient air temperature varied.

6. Standard iterative carpet and cross-plotting techniques were applied to each set of data to provide smooth fairings in non-dimensional format and develop consistent families of curves continuous with each dimension (C_P, C_T, and μ). Sets of data for

each configuration and $N_R/\sqrt{\theta}$ were independently processed in this way, followed by comparison with each other to identify trends with referred rotor speed. Final adjustments to the fairings were made using combined data to arrive at a family of nondimensional curves (fig. 1 and 2, app E) that summarize the entire matrix of test results and include effects of each parameter varied.

7. Test-day (measured) level flight power was corrected to presentation flight conditions for each speed-power data point by assuming the test-day dimensionless parameters C_{P_t}, C_{T_t}, and μ_t are identical to C_{P_s}, C_{T_s}, and μ_s respectively.

From equation 1, the following relationship can be derived:

$$SHP_s = SHP_t \frac{(\rho_s)}{\rho_t} \qquad (5)$$

Where:

Subscript t = test day (measured for each data point)
Subscript s = presentation day for each set of speed power data point

8. Test specific range was calculated using level flight performance data and the measured fuel flow.

$$SR = \frac{V_T}{W_f} \qquad (6)$$

Where:

SR = Specific range (nautical air miles per pound of fuel)
V_T = True airspeed (knot)
W_f = Fuel flow (lb/hr)

<u>Shaft Horsepower Required</u>

9. The engine output shaft torque was determined from the engine manufacturer's torque system using a calibration obtained at Corpus Christi Army Depot on 30 June 1981 (para 14). The output shp was determined from the engine output shaft torque and rotational speed by equation (7).

$$SHP = \frac{2\pi \times N_P \times Q}{33,000} \qquad (7)$$

Where :

N_p = Engine output shaft rotational speed (rpm)
Q = Engine output shaft torque (ft-lb)
33,000 = Conversion factor (ft-lb/min/shp)

Changes in Equivalent Flat Plate Area

10. Changes in the equivalent flat plate area due to change in aircraft configuration were calculated from the following equation.

$$\Delta F_e = \frac{2\Delta C_p A}{\mu^3} \qquad (8)$$

Where:

ΔF_e = Change in equivalent flat plate area (ft^2)
ΔC_P = Differential power coefficient (based on engine power)
A = Main rotor disc area (ft^2) = 1520.53
μ = Advance ratio

No power corrections were made to the data to account for nose boom drag.

Specification Fuel Flow and Shaft Horsepower

11. Specification fuel flow and shaft horsepower were obtained from Lycoming Engine Model Specification computer program, US Army Model T53-L-703, Model Spec 104.43, dated 1 May 1974 (ref 4, app A). The installation losses used are described in reference 4, appendix A (USAAEFA Project No. 66-06). Engine accessory shp losses were assumed to be a constant 4 shp with customer bleed air losses computed at 0.9%. All computations were made for a bleed air OFF condition.

Indicated Airspeed and Pressure Altitude

12. Airspeed and pressure altitude were measured from sensors mounted on a flight test boom installed on the nose of the aircraft. The output signals were recorded on magnetic tape, and the following expressions were used to calculate the parameters:

a. Instrument corrected airspeed (V_{ic}):

$$V_{ic} = a_o \left\{ 5 \left[\left(\frac{qc_{ic}}{Pa_o} + 1 \right)^{2/7} -1 \right] \right\}^{1/2} \tag{9}$$

b. Instrument corrected pressure altitude (HP_{ic}):

$$HP_{ic} = \left[1-\left(\frac{Pa_{ic}}{Pa} \right)^{1/5.255863} \right] \div (6.8755856 \times 10^{-6}) \tag{10}$$

Where:

V_{ic} = Indicated airspeed corrected for instrument error (kt)
a_o = Speed of sound at standard day, sea level = 661.479 kt
qc_{ic} = Indicated differential pressure corrected for instrument error (in. Hg)
Pa_o = Atmospheric pressure at standard day, sea level = 29.92125 in. Hg
HP_{ic} = Indicated pressure altitude corrected for instrument error (ft)
Pa_{ic} = Indicated pressure altitude corrected for instrument error (in. Hg)
Pa = Atmospheric pressure at corrected altitude (in. Hg)

Airspeed Calibration

13. The boom pitot-static system was calibrated using the trailing bomb method to determine the airspeed position error. This calibration is shown in figure 1, appendix D. Calibrated airspeed (V_{cal}) was obtained by correcting indicated airspeed (V_i) using instrument (ΔV_{ic}) and position (ΔV_{pc}) error corrections.

$$V_{cal} = V_i + \Delta V_{ic} + \Delta V_{pc} \tag{11}$$

14. True airspeed (V_t) was calculated from the calibrated airspeed and density ratio.

$$V_T = \frac{V_{cal}}{\sqrt{\sigma}} \tag{12}$$

Where:

σ = Density ratio $\left(\frac{\rho}{\rho_o}\right)$

Corrected Pressure Altitude and Altitude Position Error

15. HP_{ic} was corrected for altimeter position error by using ΔV_{pc}. The assumption was made that a pressure position error (ΔP_p) was produced entirely at the static source. Since both airspeed and altitude systems utilize the same static source, the following relationships were used:

$$qc = \left\{ \left[0.2 \left(\frac{V_{cal}}{a_o} \right)^2 + 1 \right]^{3.5} - 1 \right\} Pa_o \tag{13}$$

$$\Delta P_p = qc - qc_{ic} \tag{14}$$

$$Pa = Pa_{ic} - \Delta P_p \tag{15}$$

$$H_p = \left[1.0 - \left(\frac{Pa}{Pa_o} \right)^{1/5.255863} \right] \div (6.8755856 \times 10^{-6}) \tag{16}$$

Where:

qc = Differential pressure corrected for position and instrument error (in. Hg)
qc_{ic} = Indicated differential pressure corrected for instrument error (in. Hg)
V_{cal} = Calibrated airspeed (knots)
a_o = Speed of sound at standard day sea level = 661.479 knots
Pa_o = Atmospheric pressure at standard day, sea level = 29.92125 in. Hg
ΔP_p = Pressure position error (in. Hg)
Pa = Atmospheric pressure at corrected altitude (in. Hg)
Pa_{ic} = Indicated pressure altitude corrected for instrument error (in. Hg)
H_p = Corrected pressure altitude (ft)

Static Temperature

16. Static temperature was obtained by correcting the measured total temperature for temperature rise due to compressibility. The assumption was made that the temperature probe recovery factor is equal to 1.

The following expressions were used:

$$T_{Tic} = OAT_{ic} + 273.15 \tag{17}$$

$$Ta = \frac{T_{Tic}}{\left(\frac{qc}{Pa} + 1\right)^{2/7}} \qquad (18)$$

$$OAT = Ta - 273.15 \qquad (19)$$

Where:

OAT_{ic} = Indicated ambient temperature corrected for instrument error (C°)

T_{Tic} = Indicated temperature corrected for instrument error (K°)

Ta = Static temperature (K°)

P_a = Atmospheric pressure at corrected altitude (in. Hg)

qc = Differential pressure corrected for position and instrument error (in. Hg)

OAT = Static temperature (C°)

APPENDIX D. INSTRUMENTATION

1. The test instrumentation system was designed, calibrated, installed, and maintained by USAAEFA (photo 1). Digital and analog data were obtained from calibrated instrumentation and were recorded on magnetic tape and/or displayed in the cockpit. The digital instrumentation system consisted of various transducers, signal conditioning units, a ten-bit pulse coded modulation (PCM) encoder, and the Ampex AR 700 tape recorder. The digital data were telemetered to a ground station for in-flight monitoring. Time correlation was accomplished with a pilot/engineer event switch and on-board recorded and displayed Inter-Range Instrumentation Group (IRIG) B time. Various specialized test indicators displayed data to the pilot and engineer continuously during the flight. A boom with the following sensors was mounted on the nose of the aircraft: swiveling pitot-static head, sideslip vane, angle-of-attack vane, and total-temperature sensor (photo 1, app B). Boom airspeed system calibration is shown in figure 1C. The ship's airspeed calibration is shown in figure 39.

2. Calibrated cockpit monitored parameters and special equipment are listed below.

<u>Pilot Station</u>

Airspeed (boom)
Airspeed (ship's system)
Altitude (boom)
Altitude (ship's system)
Rate of climb (ship's system)
Rotor speed (sensitive)
Engine torque
Measured gas temperature (TGT)
Gas generated speed (N_1)
Power turbine speed (N_2)
Angle of sideslip
Outside air temperature (ship's system)
Event switch

<u>Copilot/Engineer Station</u>

Airspeed (boom)
Altitude (boom)
Engine torque
Event switch
Fuel used (totalizer)
Gas generated speed (ship's system)
Instrumentation controls and displays

Measured gas temperature
Record Counter
Rotor speed
Time of day
Total air temperature (boom)

3. Parameters recorded on magnetic tape were as follows:

<u>PCM Parameters</u>

Airspeed (boom)
Airspeed (ship's system)
Altitude (boom)
Altitude (ship's system)
Angle of attack
Angle of sideslip
Control position
  Longitudinal
  Lateral
  Directional
  Collective
Engine speed (N_2)
Fuel used
Gas generator speed
Pilot/engineer event
Rotor speed
Time of day
Fuel flow
T_4T
Q

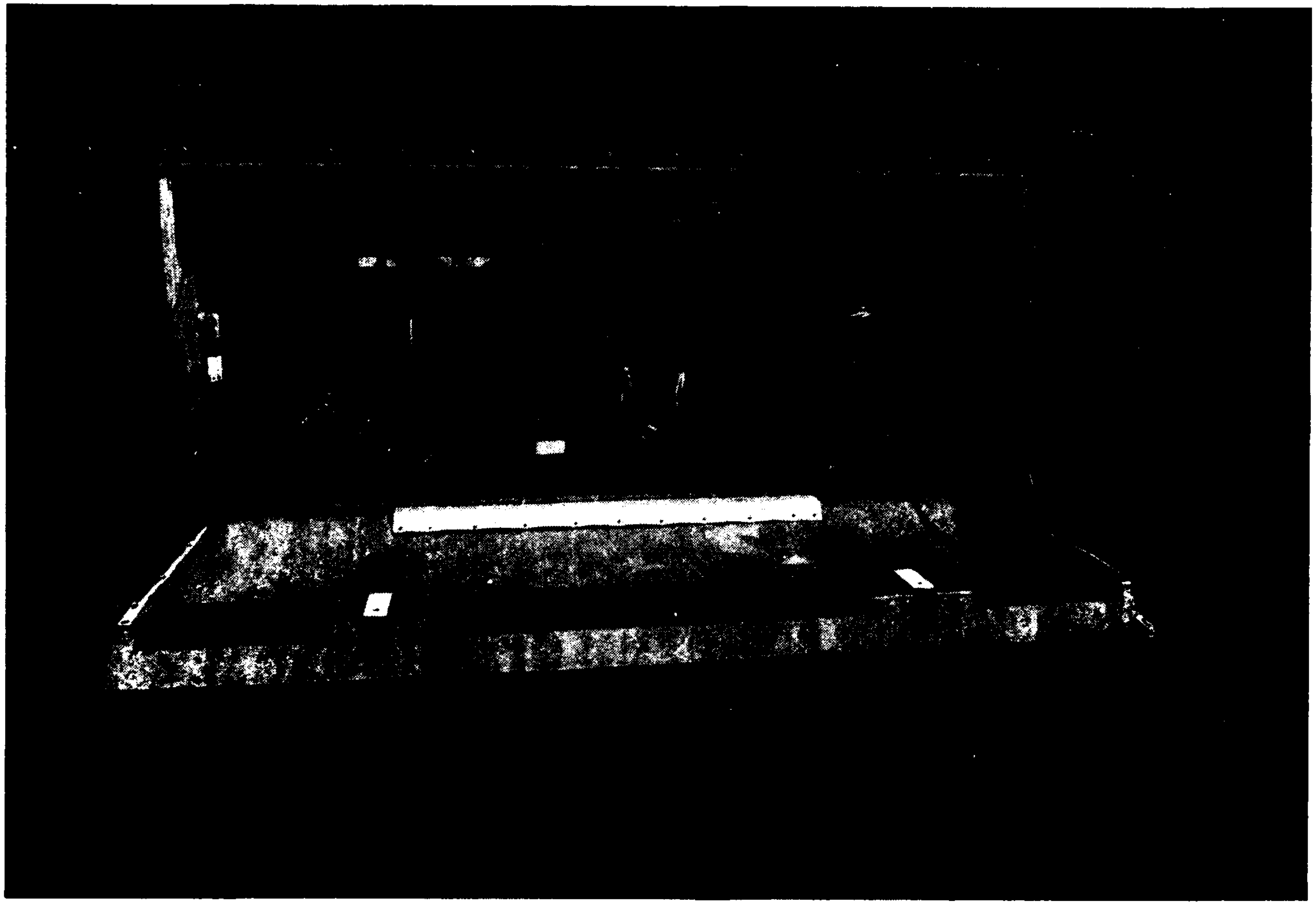
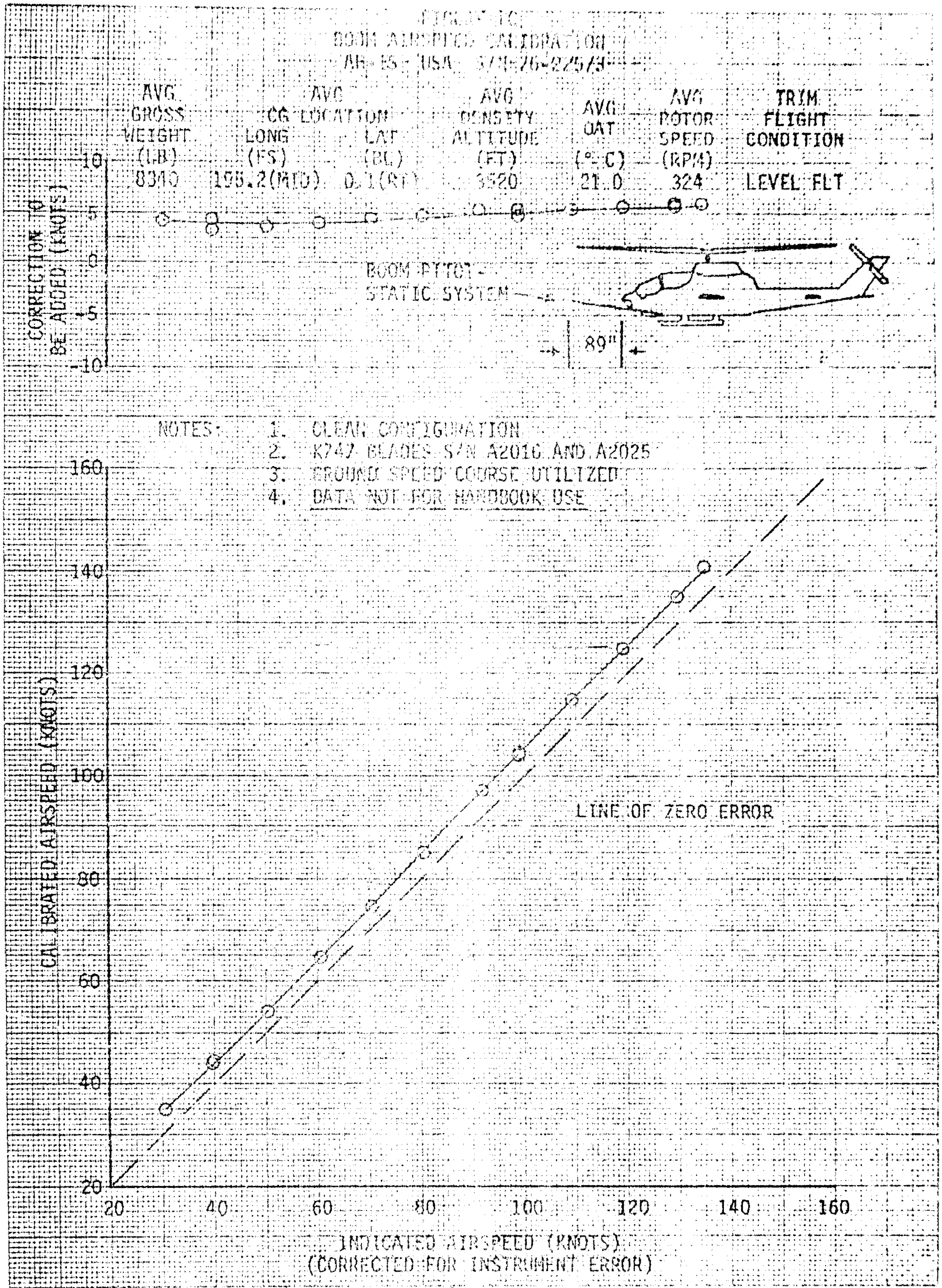


Photo 1. Instrumentation System



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APPENDIX E. TEST DATA

INDEX

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

NOTES: 1. CONFIGURATION: CLEAN
2. AVG LONG CG = 195.3 MID
3. ZERO SIDESLIP
4. CURVES ARE DERIVED FROM FIGURES 3 THROUGH 30
5. SYMBOLS $N_R/\sqrt{\Theta}$

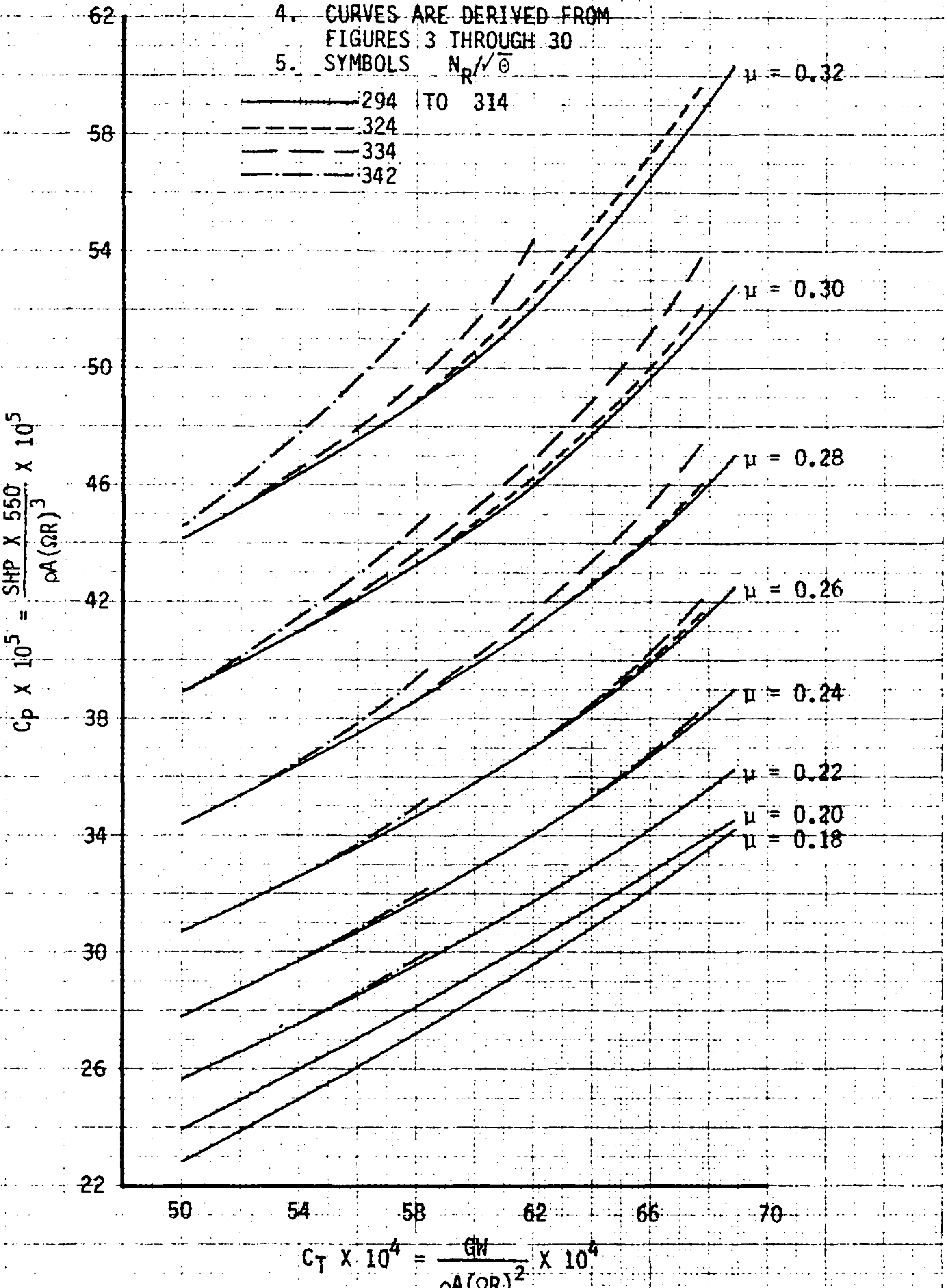
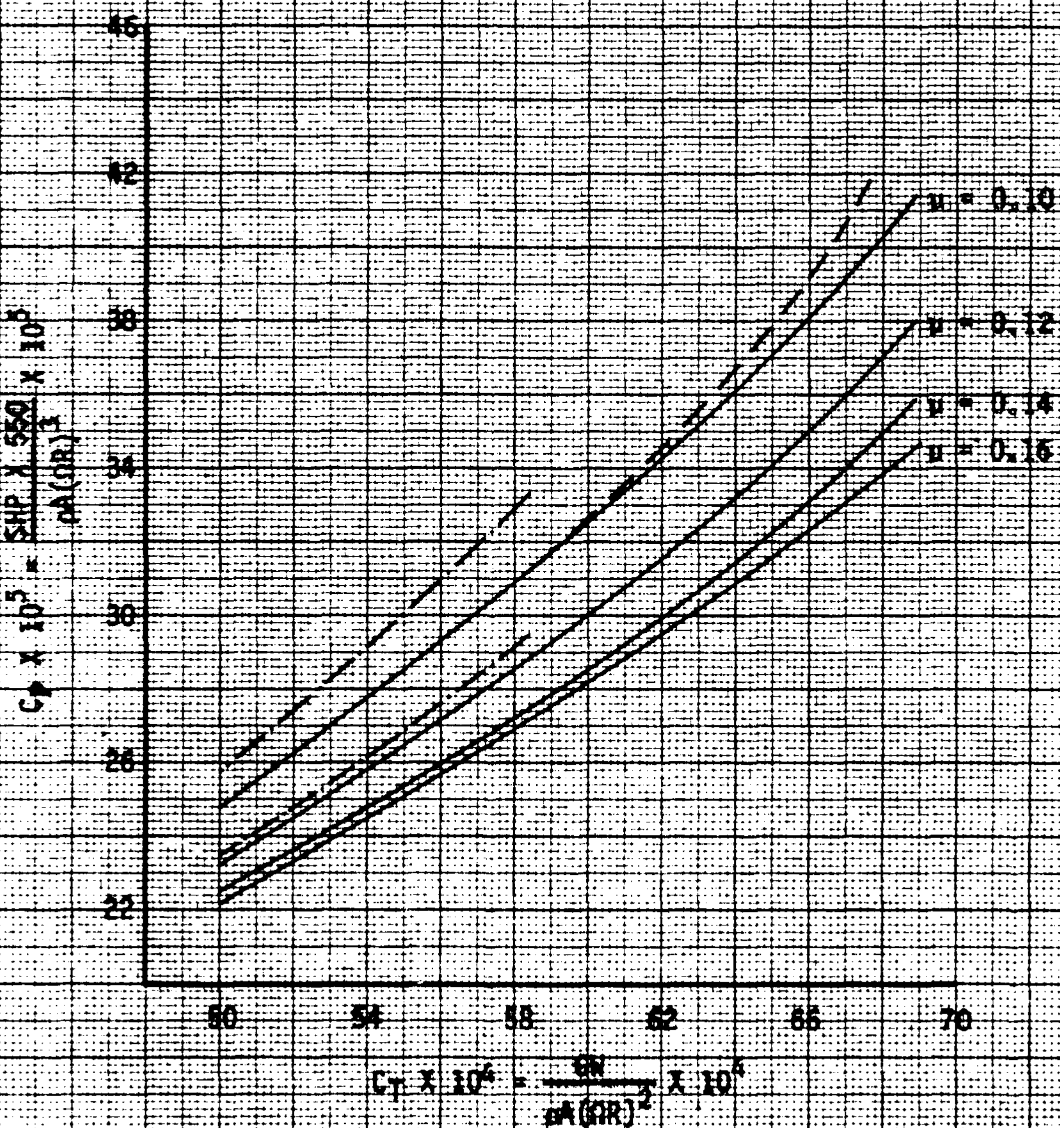


FIGURE 2
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

NOTES: 1. CONFIGURATION: CLEAN
2. AVG LONG CG = 195.3 MID
3. ZERO SIDESLIP
4. CURVES ARE DERIVED FROM FIGURES 3 THROUGH 30
5. SYMBOLS $N_R/\sqrt{\theta}$

294 TO 314
324
334
342



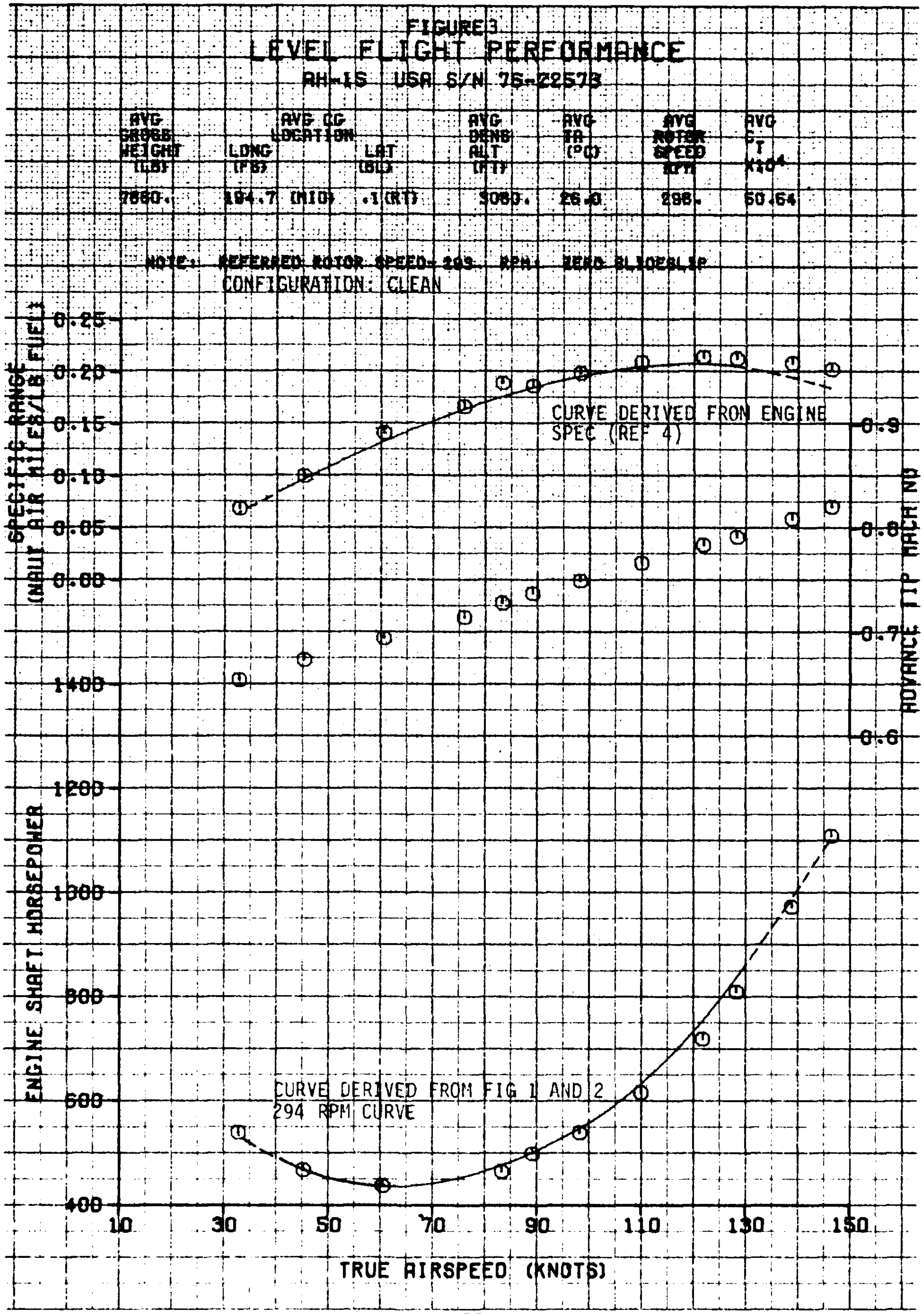


FIGURE 3
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (°C)
AVG ROTOR SPEED RPM
AVG C_T $\times10^4$
7660.
194.7 (MID)
.1 (RT)
5060.
26.0
298.
50.64
NOTE: REFERRED ROTOR SPEED= 293 RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
0.25
0.20
0.15
0.10
0.05
0.00
CURVE DERIVED FROM ENGINE SPEC (REF 4)
ADVANCE TIP MACH NO
0.9
0.8
0.7
0.6
ENGINE SHAFT HORSEPOWER
1400
1200
1000
800
600
400
CURVE DERIVED FROM FIG 1 AND 2
294 RPM CURVE
10
30
50
70
90
110
130
150
TRUE AIRSPEED (KNOTS)

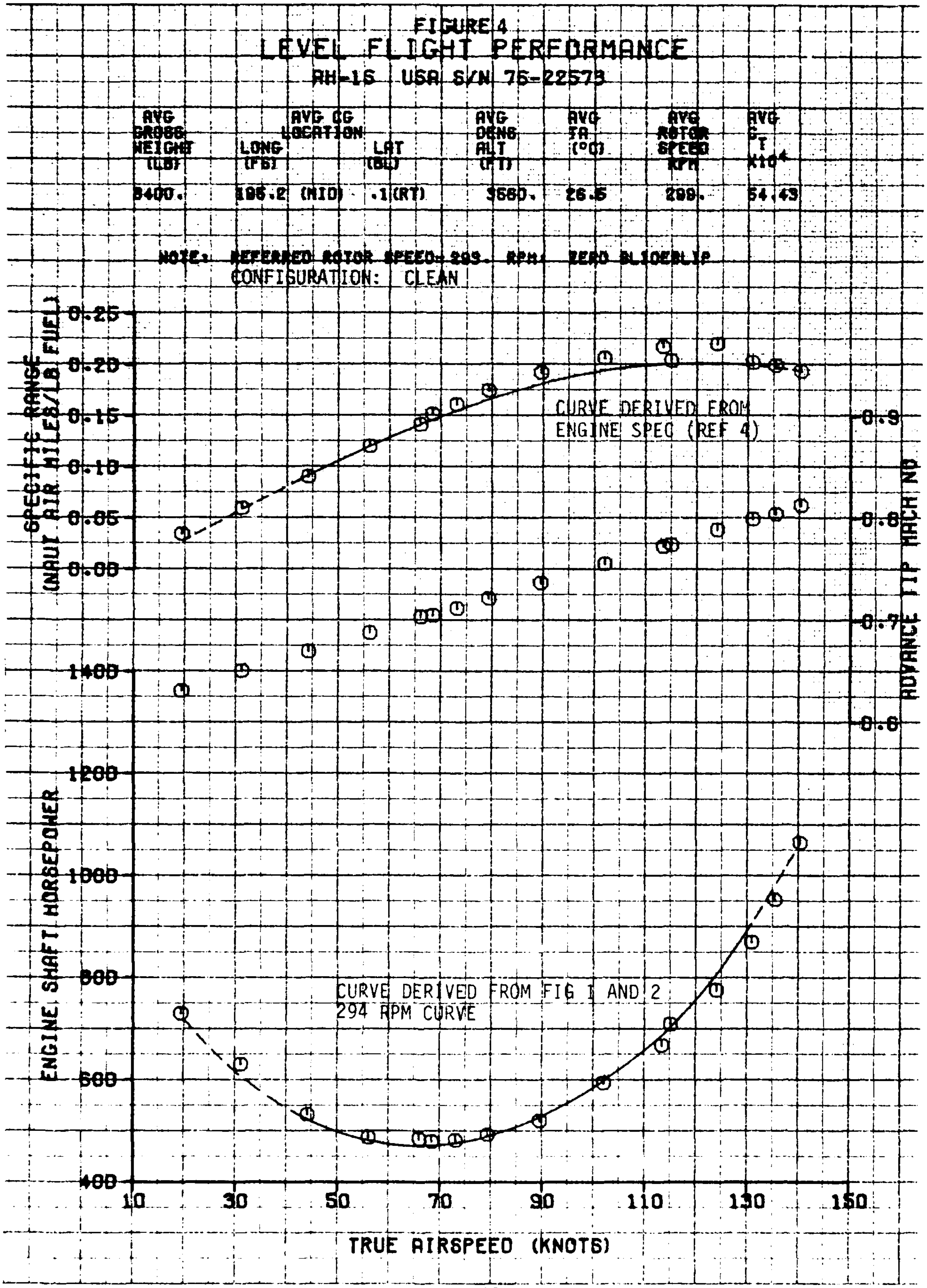


FIGURE 4
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (°C)
AVG ROTOR SPEED RPM
AVG CT X10^4
8400.
196.2 (MID)
.1 (RT)
3660.
26.5
299.
54.43
NOTE: REFERRED ROTOR SPEED=293. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
CURVE DERIVED FROM ENGINE SPEC (REF 4)
ADVANCE TIP MACH NO
ENGINE SHAFT HORSEPOWER
CURVE DERIVED FROM FIG 1 AND 2 294 RPM CURVE
TRUE AIRSPEED (KNOTS)

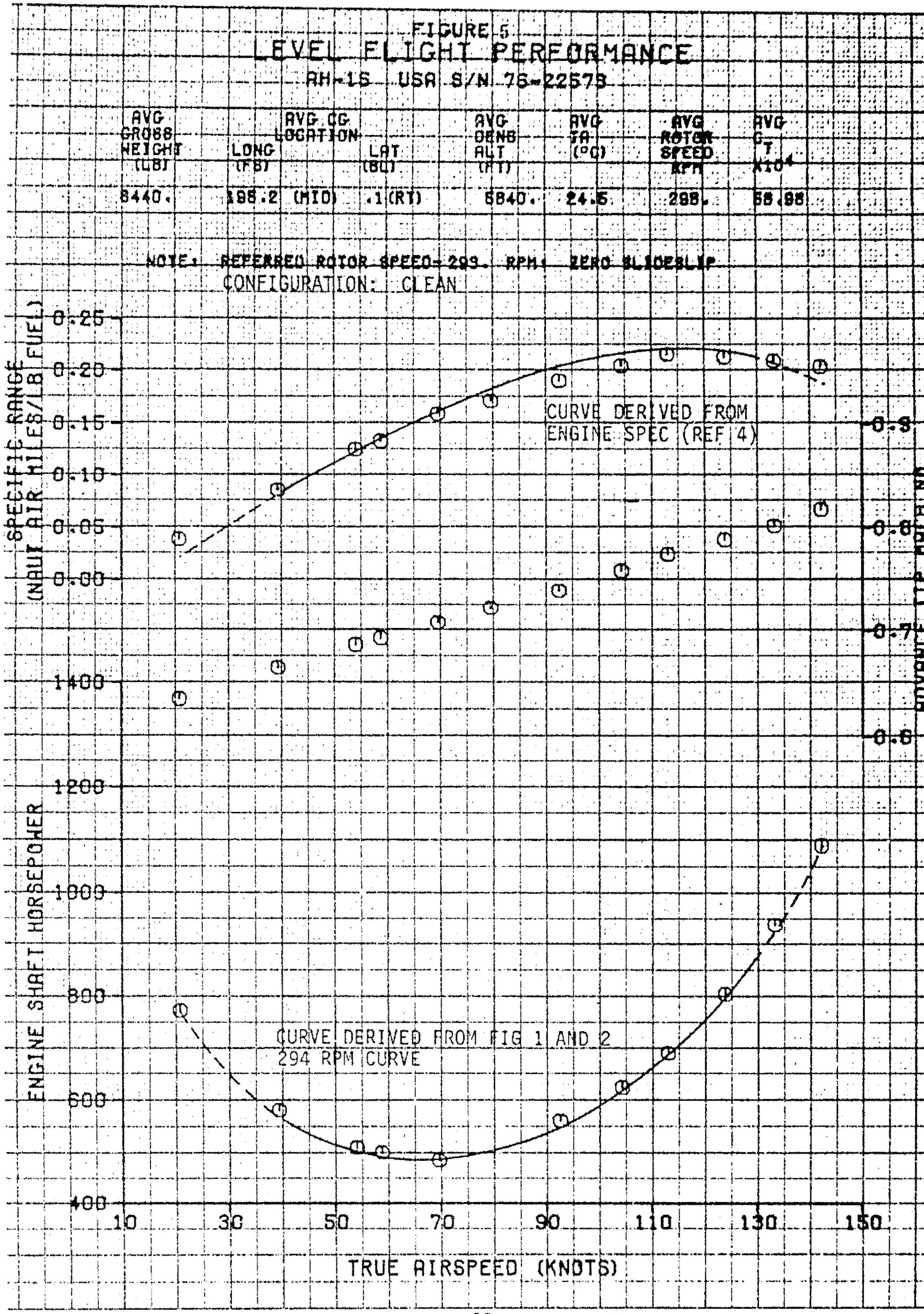
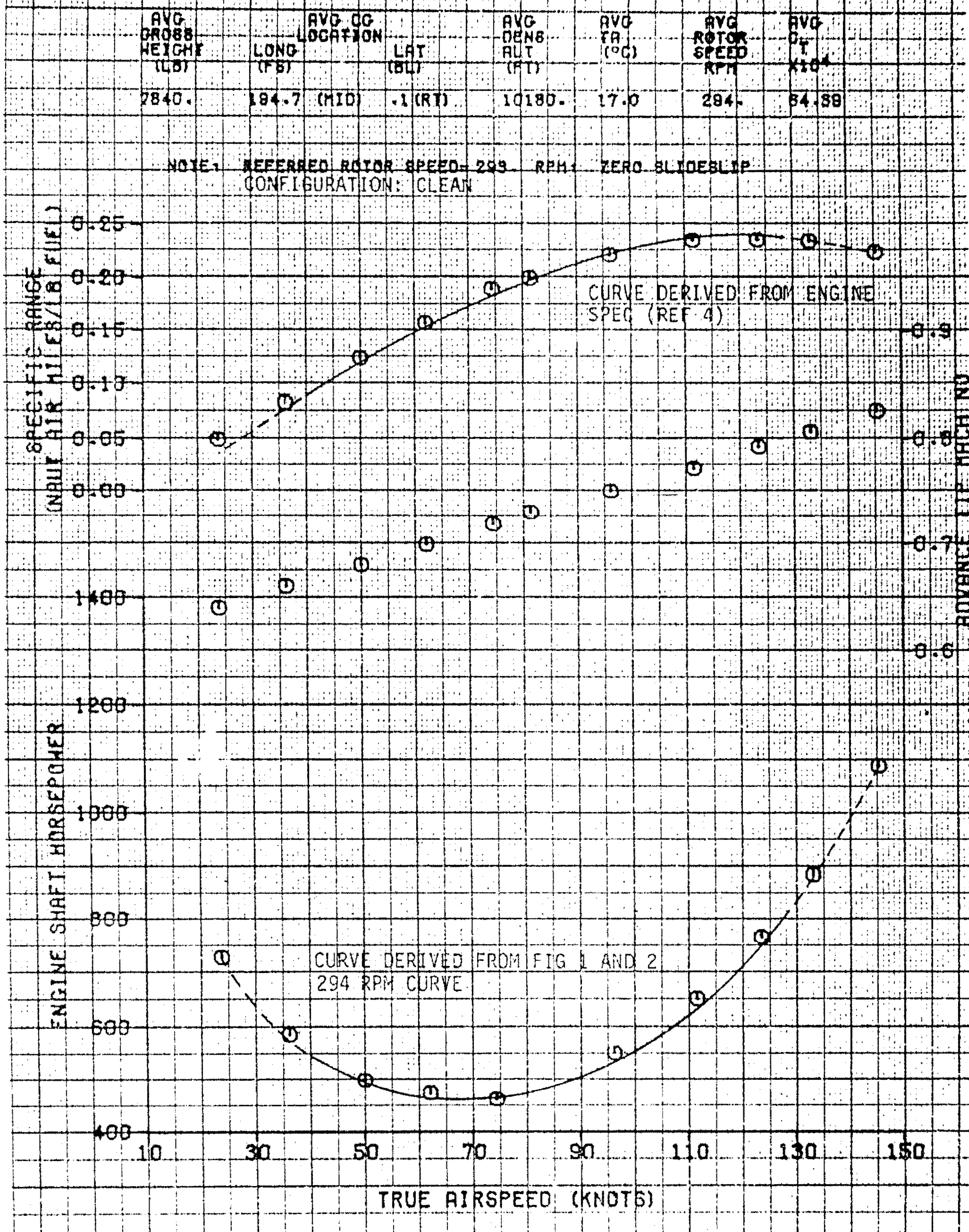


FIGURE 5
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (°C)
AVG ROTOR SPEED RPM
AVG C_T X10[4]
8440.
198.2 (MID)
.1 (RT)
5840.
24.5
298.
58.98
NOTE: REFERRED ROTOR SPEED=293. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
0.25
0.20
0.15
0.10
0.05
0.00
CURVE DERIVED FROM ENGINE SPEC (REF 4)
ADVANCING TIP MACH NO
0.9
0.8
0.7
0.6
ENGINE SHAFT HORSEPOWER
1400
1200
1000
800
600
400
CURVE DERIVED FROM FIG 1 AND 2
294 RPM CURVE
10
30
50
70
90
110
130
150
TRUE AIRSPEED (KNOTS)

FIGURE 6
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22578



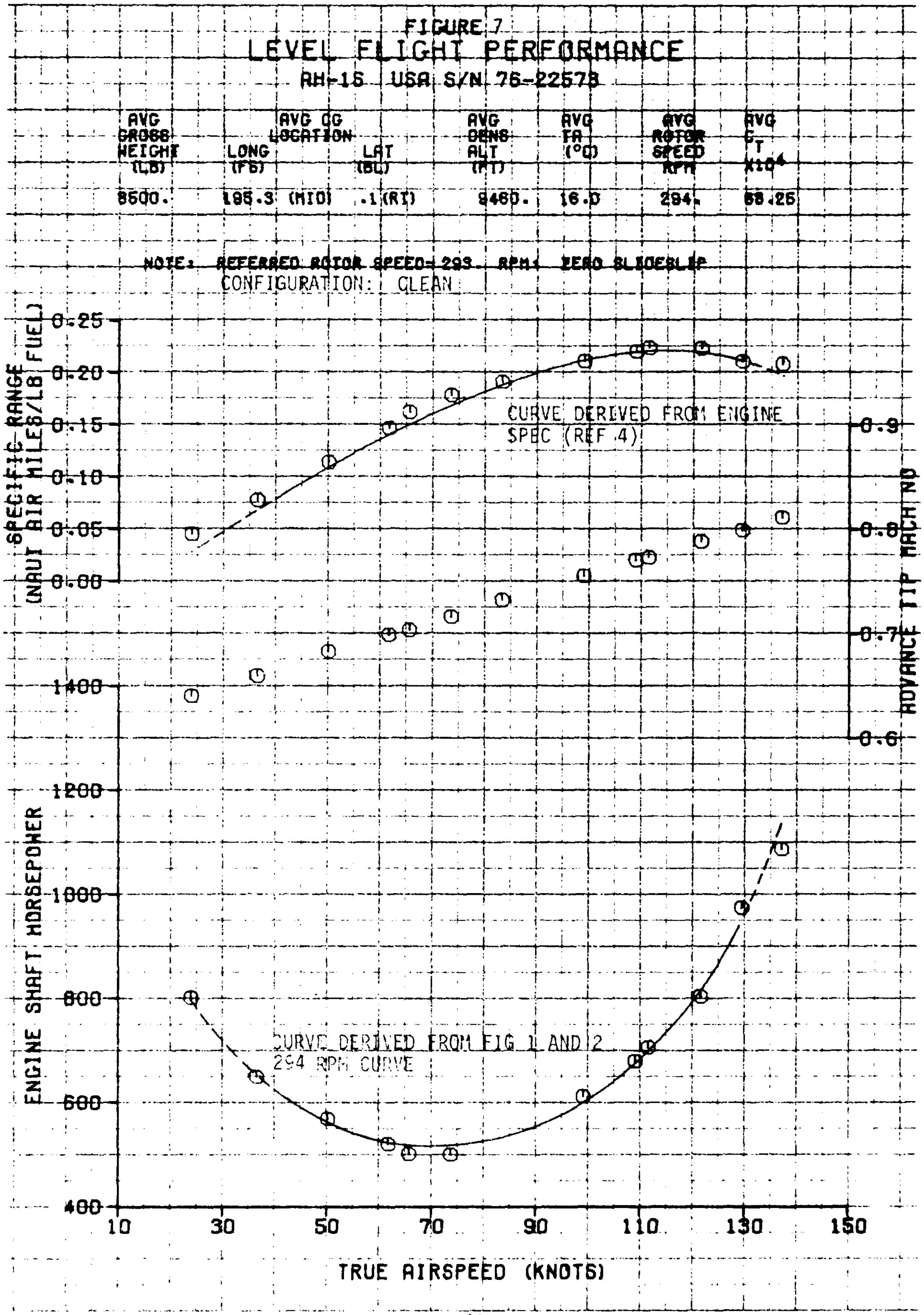


FIGURE 7
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG TA (°C)
AVG ROTOR SPEED RPM
AVG C_T $X10^4$
8500.
195.3 (MID)
.1 (RT)
9460.
16.0
294.
68.25
NOTE: REFERRED ROTOR SPEED = 293 RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
CURVE DERIVED FROM ENGINE SPEC (REF 4)
ADVANCE TIP MACH NO
ENGINE SHAFT HORSEPOWER
CURVE DERIVED FROM FIG 1 AND 2
294 RPM CURVE
TRUE AIRSPEED (KNOTS)

FIGURE 8

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG TA (°C)	AVG ROTOR SPEED RPM	AVG C_T $\times 10^4$
8240.	294.7 (MID)	.1 (RT)	4160.	30.5	312.	49.92

NOTE: REFERRED ROTOR SPEED= 304. RPM; ZERO SIDESLIP
CONFIGURATION: CLEAN

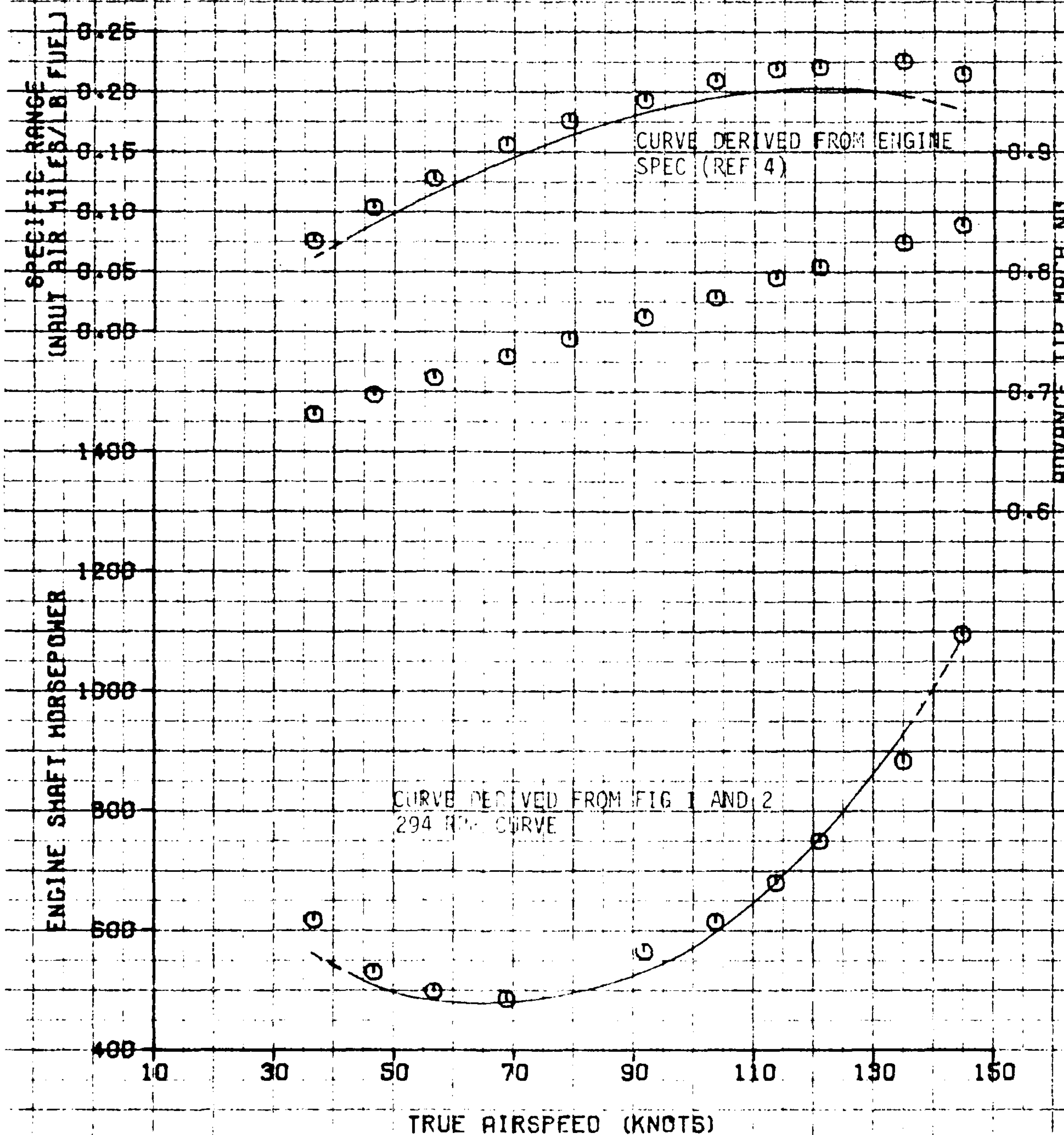


FIGURE 9
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENS ALT (FT)	AVG OAT (°C)	AVG ROTOR SPEED RPM	AVG C_T X10^4
8440.	195.3 (MID)	-1 (RT)	5720.	27.0	309.	54.66

NOTE: REFERRED ROTOR SPEED= 303. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN

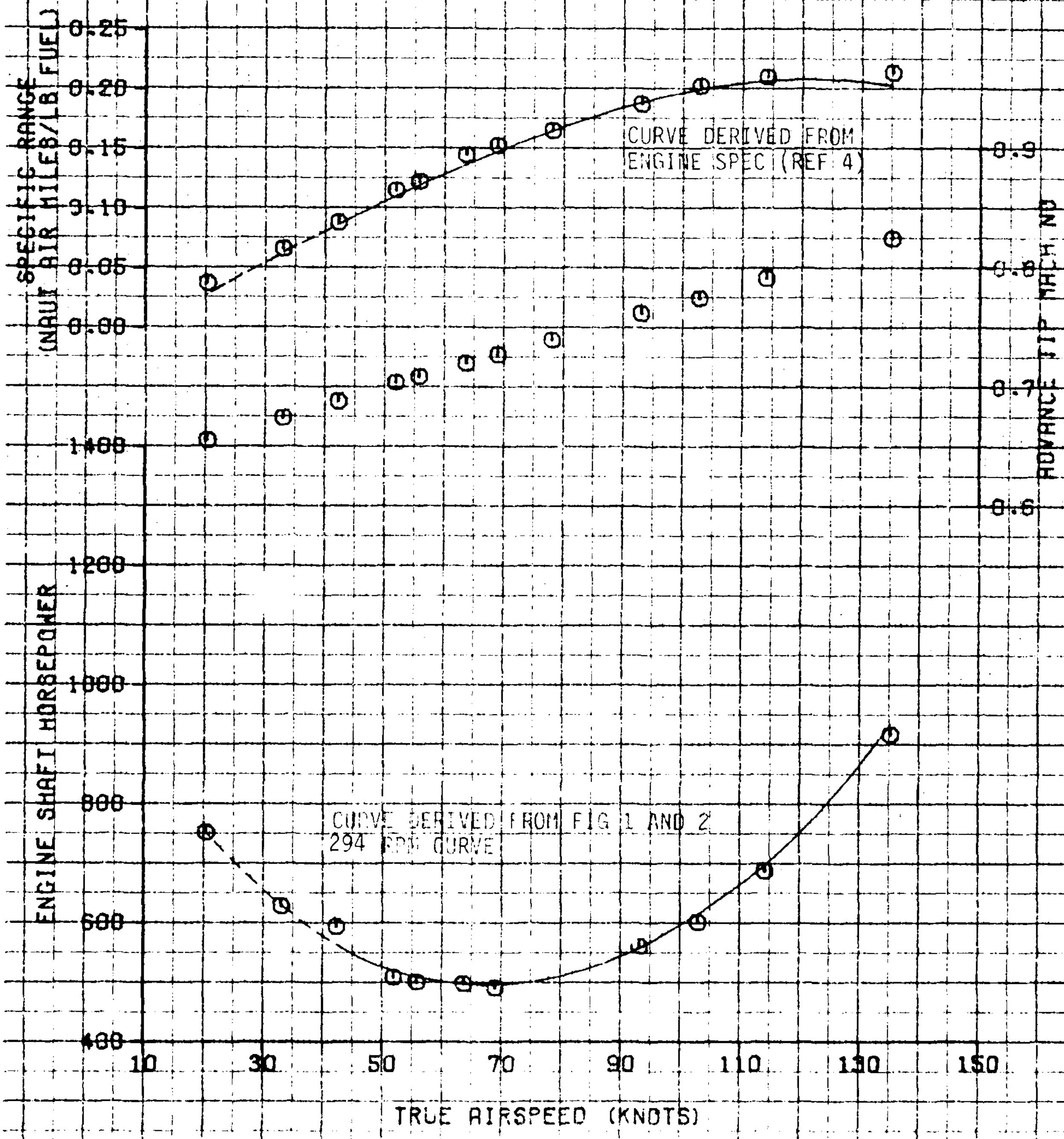


FIGURE 10

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22578

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENS ALT (FT)	AVG OAT (°C)	AVG ROTOR SPEED RPM	AVG C_T $\times 10^4$
7960.	194.8 (MID)	.1 (RT)	9120.	20.5	308.	68.38

NOTE: REFERRED ROTOR SPEED = 303. RPM; ZERO SIDESLIP

CONFIGURATION: CLEAN

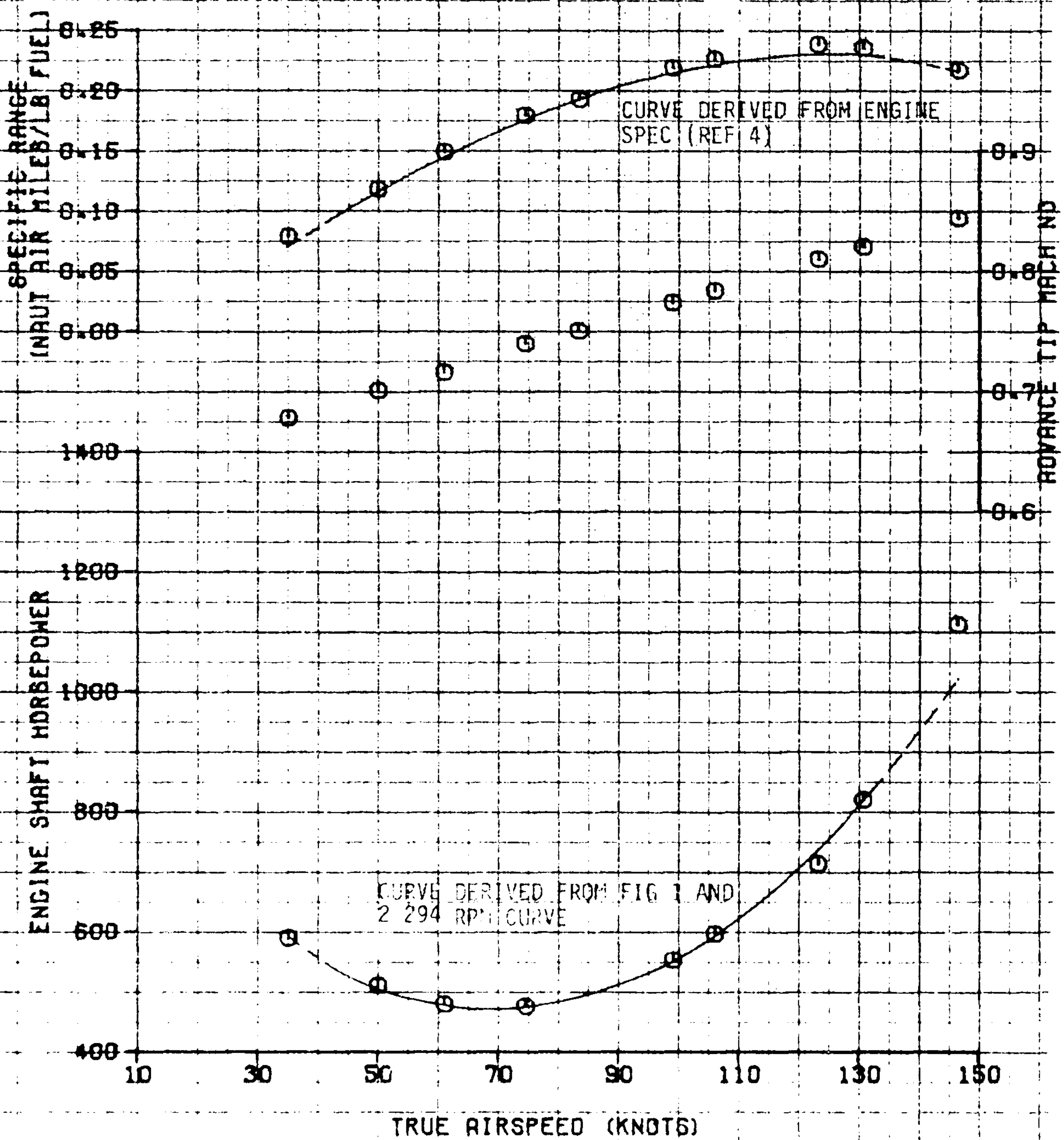


FIGURE 11
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG TA (°C)	AVG ROTOR SPEED RPM	AVG C_T $\times 10^4$
8540.	195.5 (MID)	.1 (RT)	8060.	21.0	306.	82.51

NOTE: REFERRED ROTOR SPEED= 303. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN

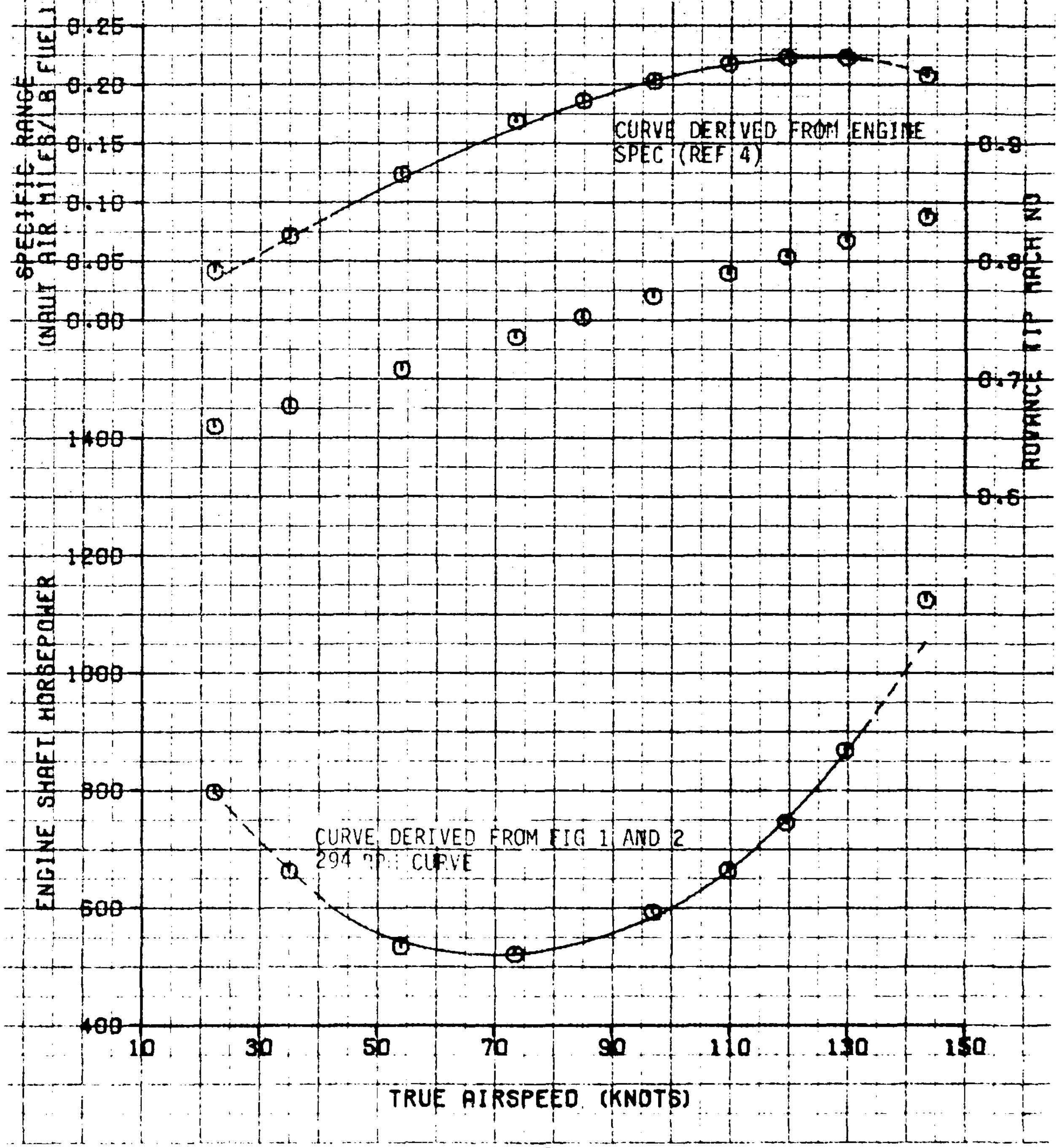


FIGURE 12

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENS ALT (FT)	AVG FA (°C)	AVG ROTOR SPEED RPM	AVG C_T $\times 10^4$
8060.	198.0 (MID)	.1(RT)	12680.	11.0	301.	68.81

NOTE: REFERRED ROTOR SPEED= 303. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN

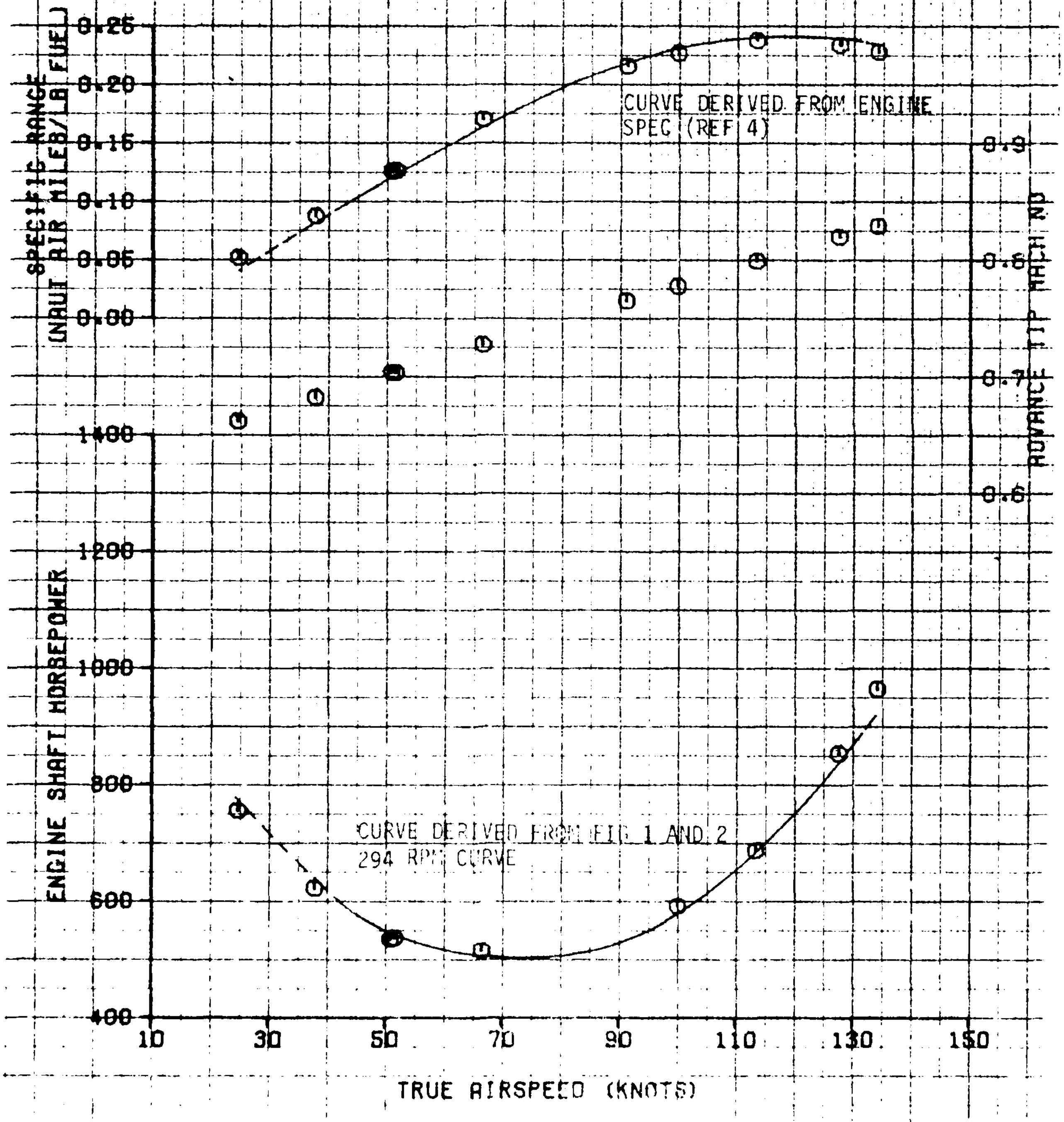


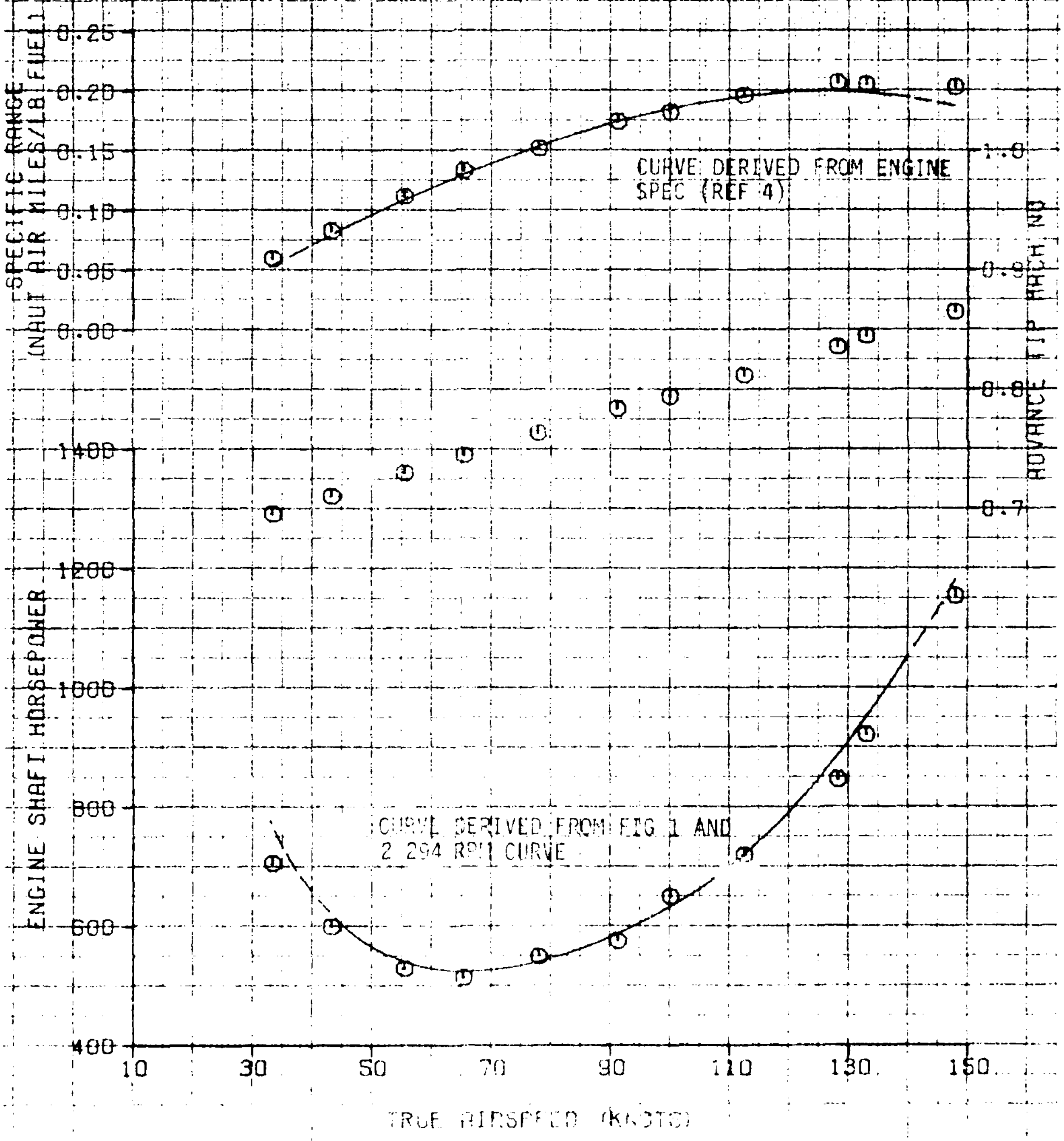
FIGURE 13

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)		AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (°C)	AVG ROTOR SPEED RPM	AVG C_T $X10^4$
8860.	195.0	(MID)	.1(RT)	3460.	26.5	320.	49.97

NOTE: REFERRED ROTOR SPEED = 314 RPM ZERO SIDESLIP
CONFIGURATION: CLEAN



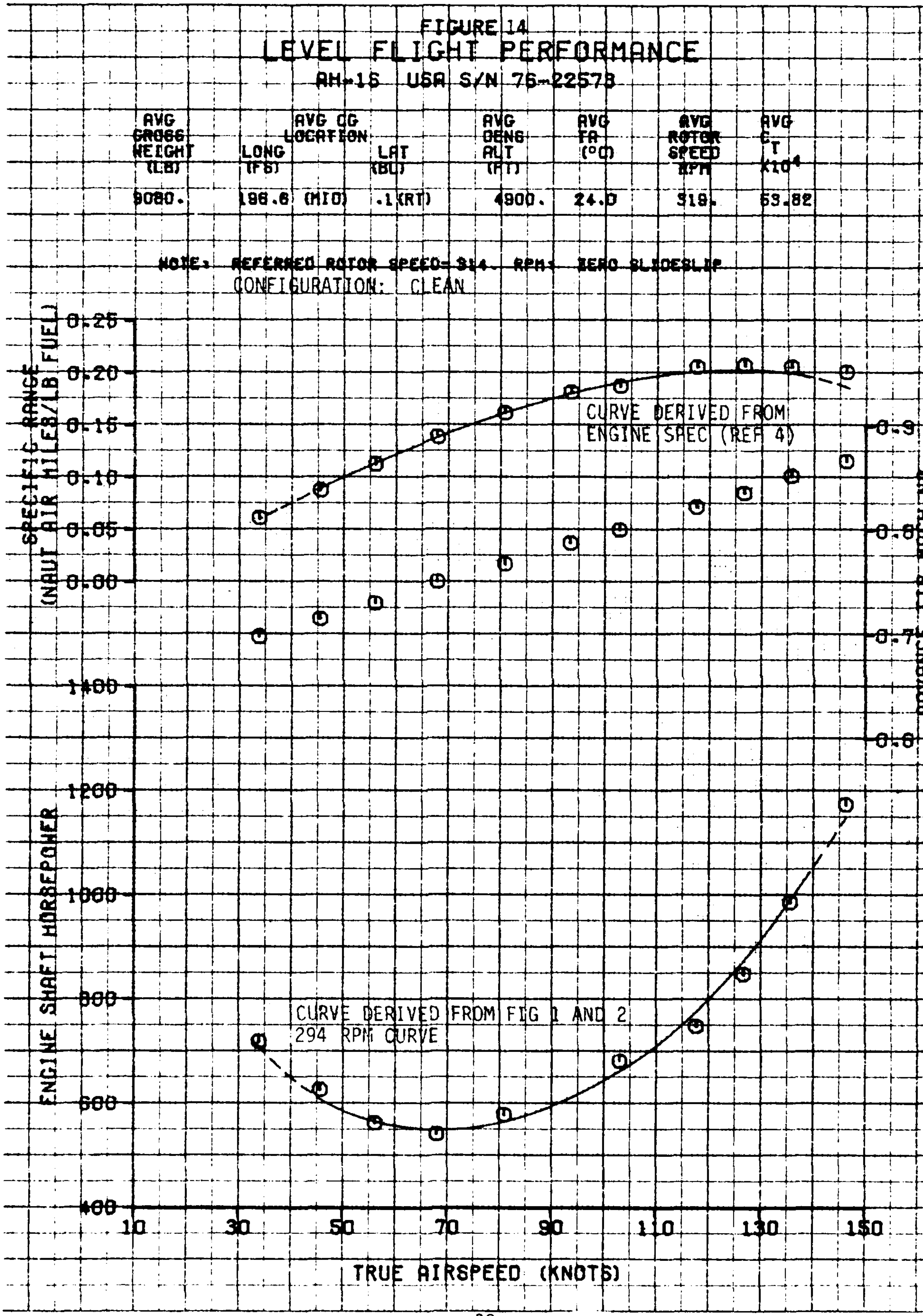


FIGURE 14
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22578
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (°C)
AVG ROTOR SPEED RPM
AVG C T X10^4
9080.
196.6 (MID)
.1 (RT)
4900.
24.0
319.
53.82
NOTE: REFERRED ROTOR SPEED=314. RPM; ZERO SIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
0.25
0.20
0.15
0.10
0.05
0.00
CURVE DERIVED FROM ENGINE SPEC (REF 4)
ADVANCE TIP MACH NO
0.9
0.8
0.7
0.6
ENGINE SHAFT HORSEPOWER
1400
1200
1000
800
600
400
CURVE DERIVED FROM FIG 1 AND 2
294 RPM CURVE
10
30
50
70
90
110
130
150
TRUE AIRSPEED (KNOTS)

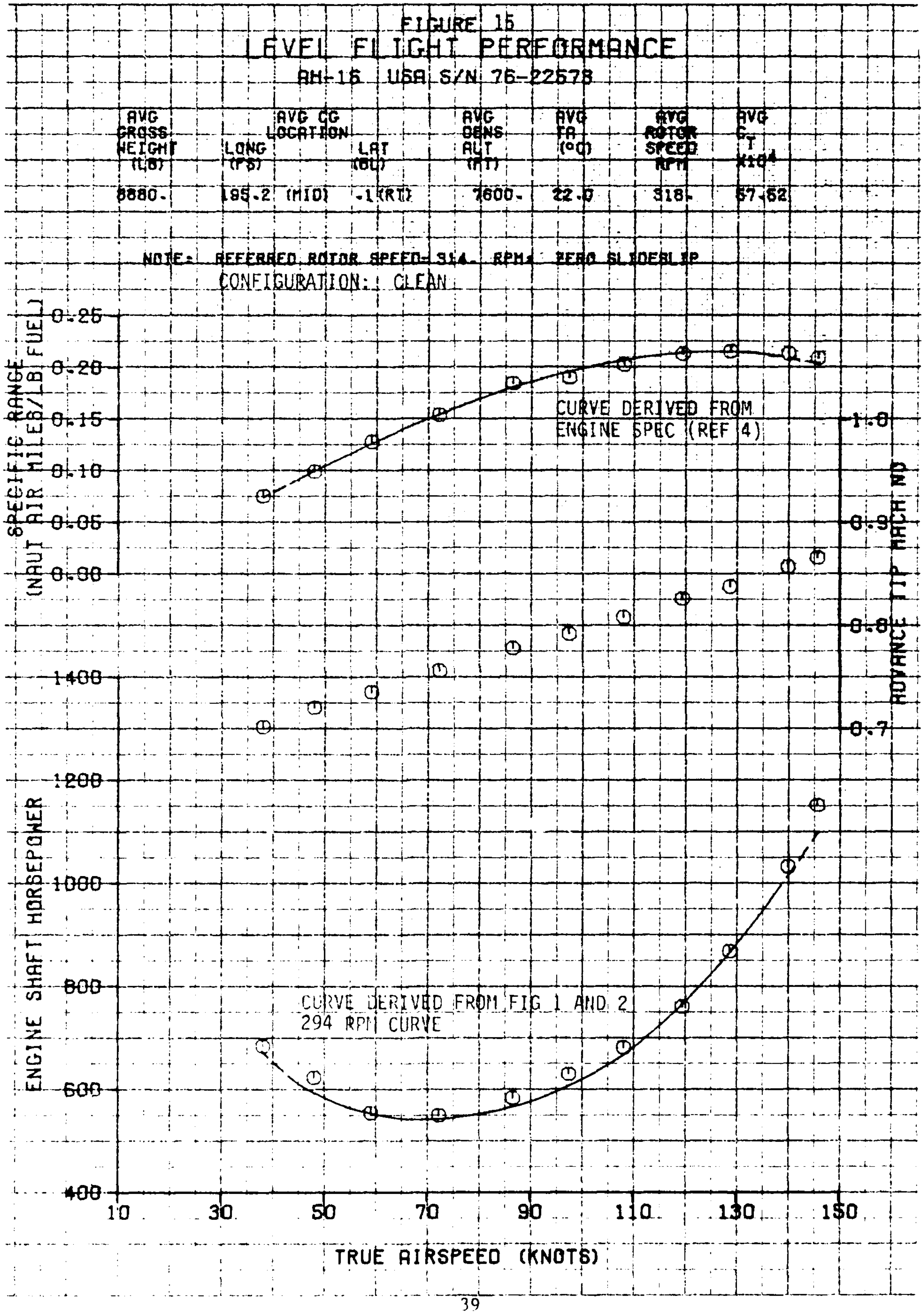


FIGURE 15
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22578
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG FA (°C)
AVG ROTOR SPEED RPM
AVG C_T X10⁴
8880.
195.2 (MID)
-1 (RT)
7600.
22.0
318.
57.52
NOTE: REFERRED ROTOR SPEED=314. RPM, ZERO SIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
0.25
0.20
0.15
0.10
0.05
0.00
CURVE DERIVED FROM ENGINE SPEC (REF 4)
1.0
0.9
0.8
0.7
ADVANCE TIP MACH NO
1400
1200
1000
800
600
400
ENGINE SHAFT HORSEPOWER
CURVE DERIVED FROM FIG 1 AND 2
294 RPM CURVE
10
30
50
70
90
110
130
150
TRUE AIRSPEED (KNOTS)

FIGURE 16
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG TA (°C)	AVG ROTOR SPEED RPM	AVG C_T $X10^4$
8980.	195.2 (MID)	.1 (RT)	9260.	20.0	316.	62.04

NOTE: REFERRED ROTOR SPEED: 313. RPM; ZERO SIDESLIP
CONFIGURATION: CLEAN

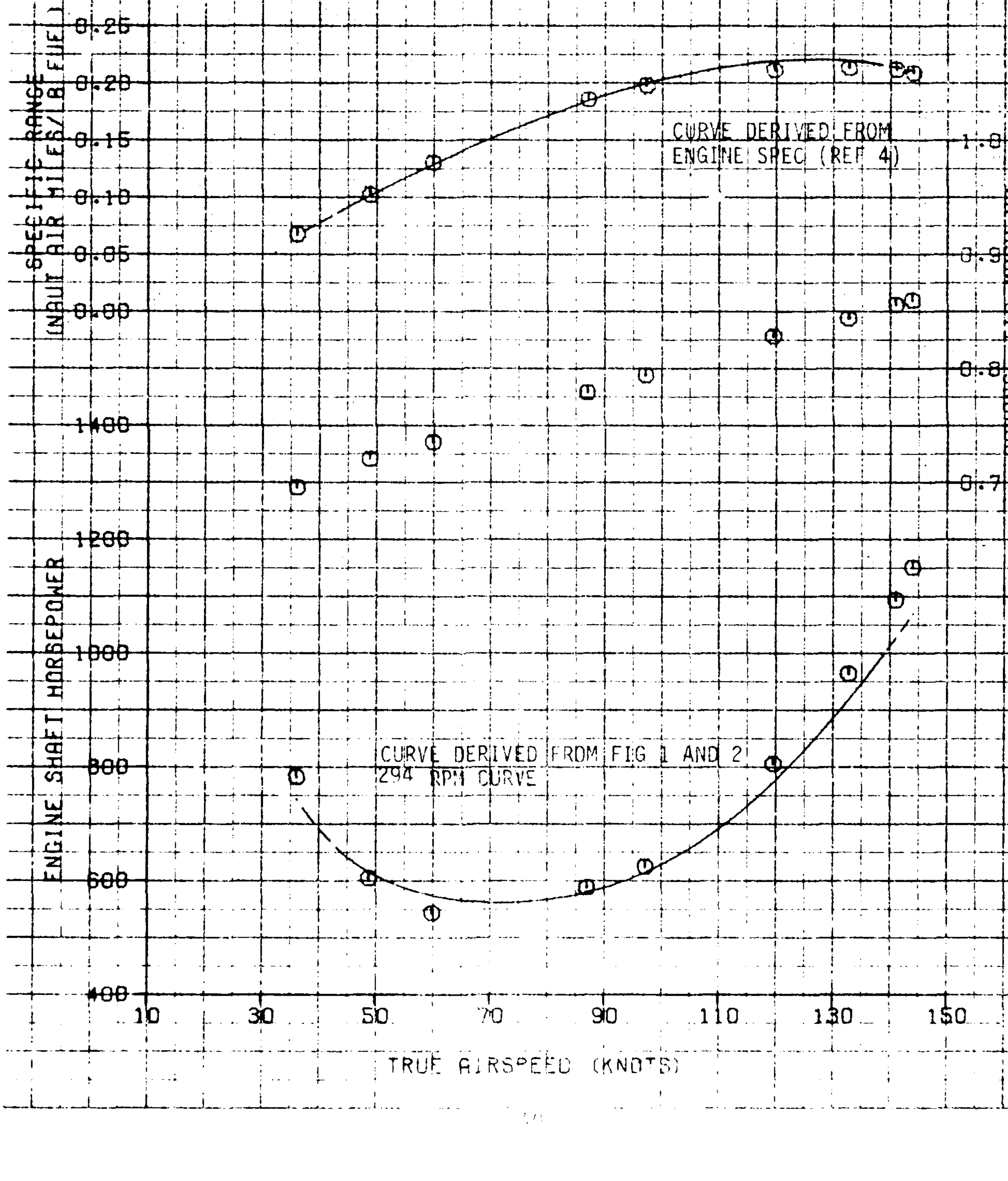


FIGURE 17
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENS ALT (FT)	AVG FA (°C)	AVG ROTOR SPEED RPM	AVG C_T $\times 10^4$
9180.	195.4 (MID)	.1 (RT)	11400.	17.5	315.	58.26

NOTE: REFERRED ROTOR SPEED = 314. RPM: ZERO SLIDESLIP
CONFIGURATION: CLEAN

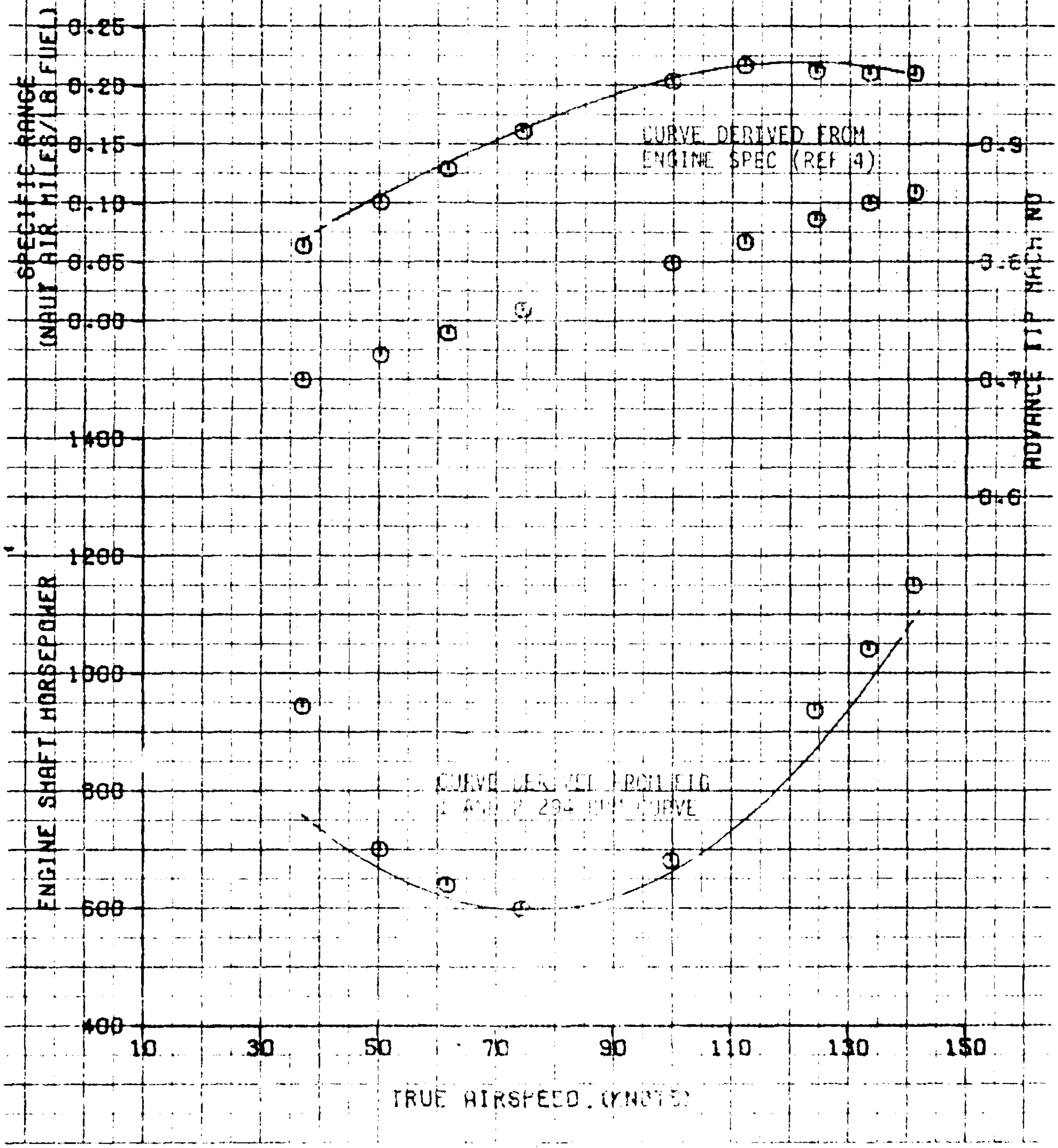
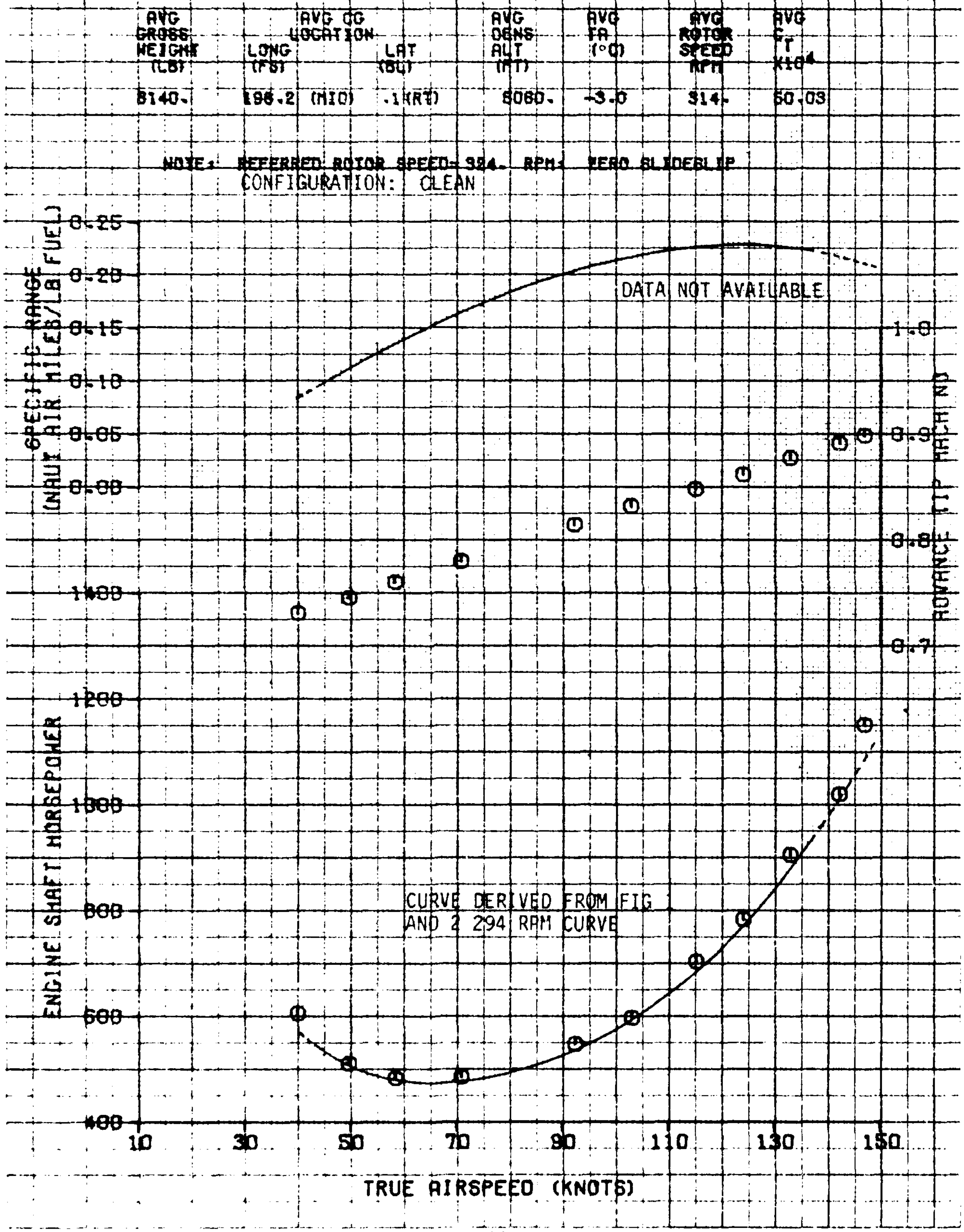


FIGURE 18
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573



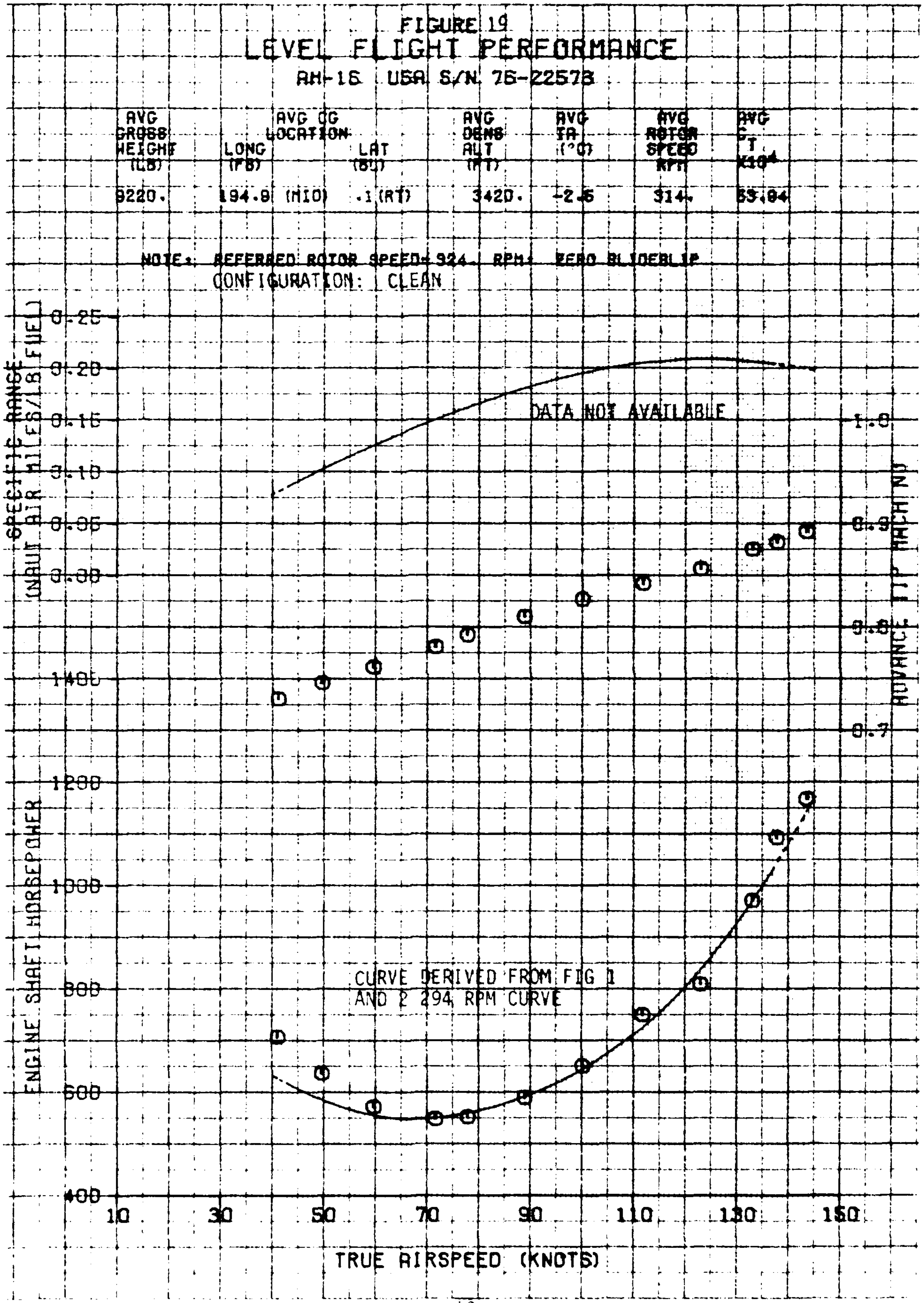


FIGURE 19
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (°C)
AVG ROTOR SPEED RPM
AVG C_T $X10^4$
9220.
194.9 (MID)
.1 (RT)
3420.
-2.5
314.
53.94
NOTE: REFERRED ROTOR SPEED = 324. RPM; ZERO SIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
DATA NOT AVAILABLE
ADVANCE TIP MACH NO
ENGINE SHAFT HORSEPOWER
CURVE DERIVED FROM FIG 1 AND 2 294 RPM CURVE
TRUE AIRSPEED (KNOTS)
0.25
0.20
0.15
0.10
0.05
0.00
1.0
0.9
0.8
0.7
1400
1200
1000
800
600
400
10
30
50
70
90
110
130
150

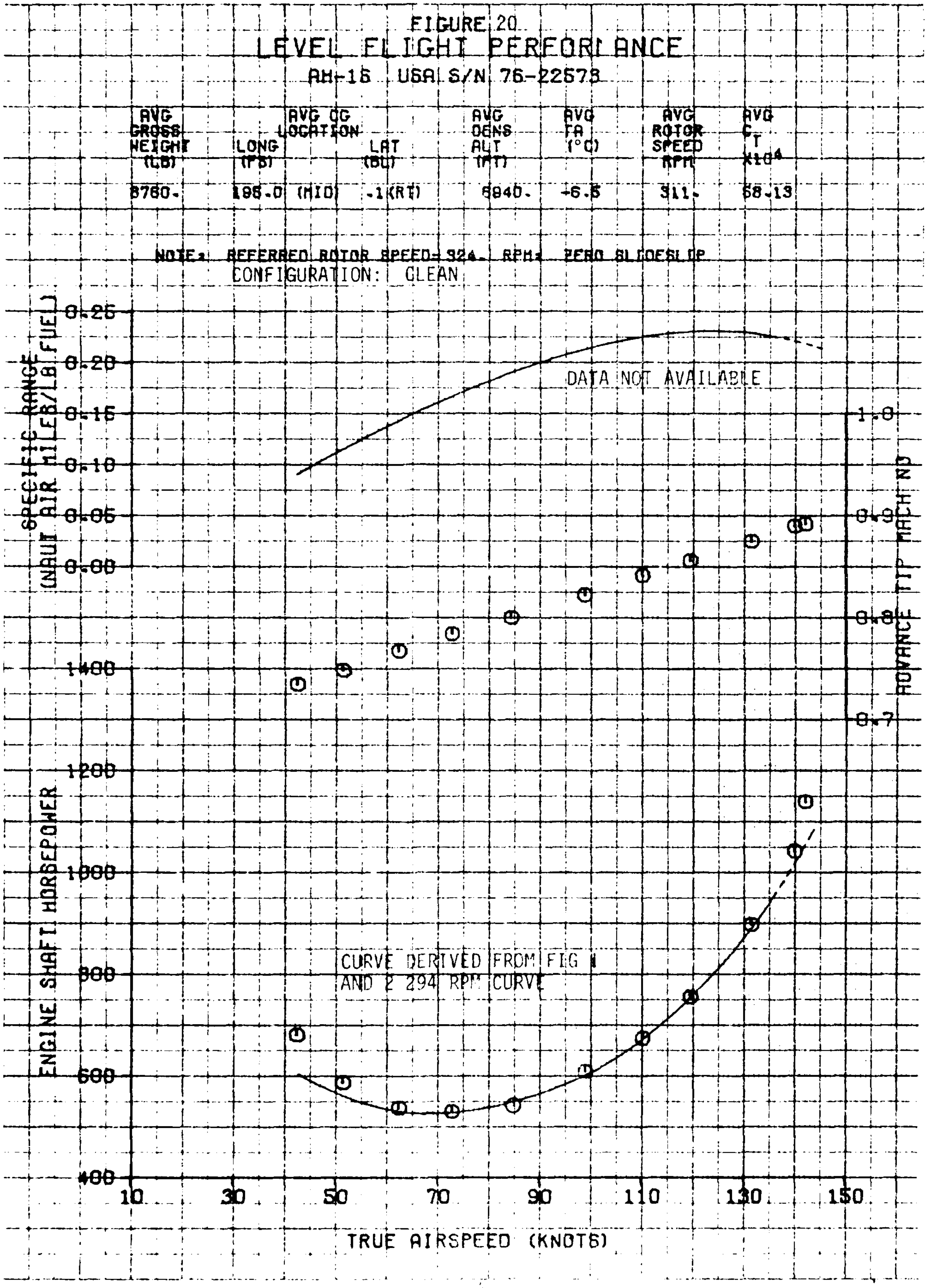


FIGURE 20
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (°C)
AVG ROTOR SPEED RPM
AVG C_T X10^4
8760.
195.0 (MID)
.1(RT)
5840.
-6.5
311.
58.13
NOTE: REFERRED ROTOR SPEED=324. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
0.25
0.20
0.15
0.10
0.05
0.00
DATA NOT AVAILABLE
ADVANCE TIP MACH NO
1.0
0.9
0.8
0.7
ENGINE SHAFT HORSEPOWER
1400
1200
1000
800
600
400
CURVE DERIVED FROM FIG
AND 294 RPM CURVE
10
30
50
70
90
110
130
150
TRUE AIRSPEED (KNOTS)

FIGURE 21
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG TA (°C)	AVG ROTOR SPEED RPM	AVG C_T X10^4
9020.	196.2 (MID)	.1 (RT)	8100.	-8.0	310.	62.44

NOTE: REFERRED ROTOR SPEED=324. RPM: ZERO SLIDESLIP
CONFIGURATION: CLEAN

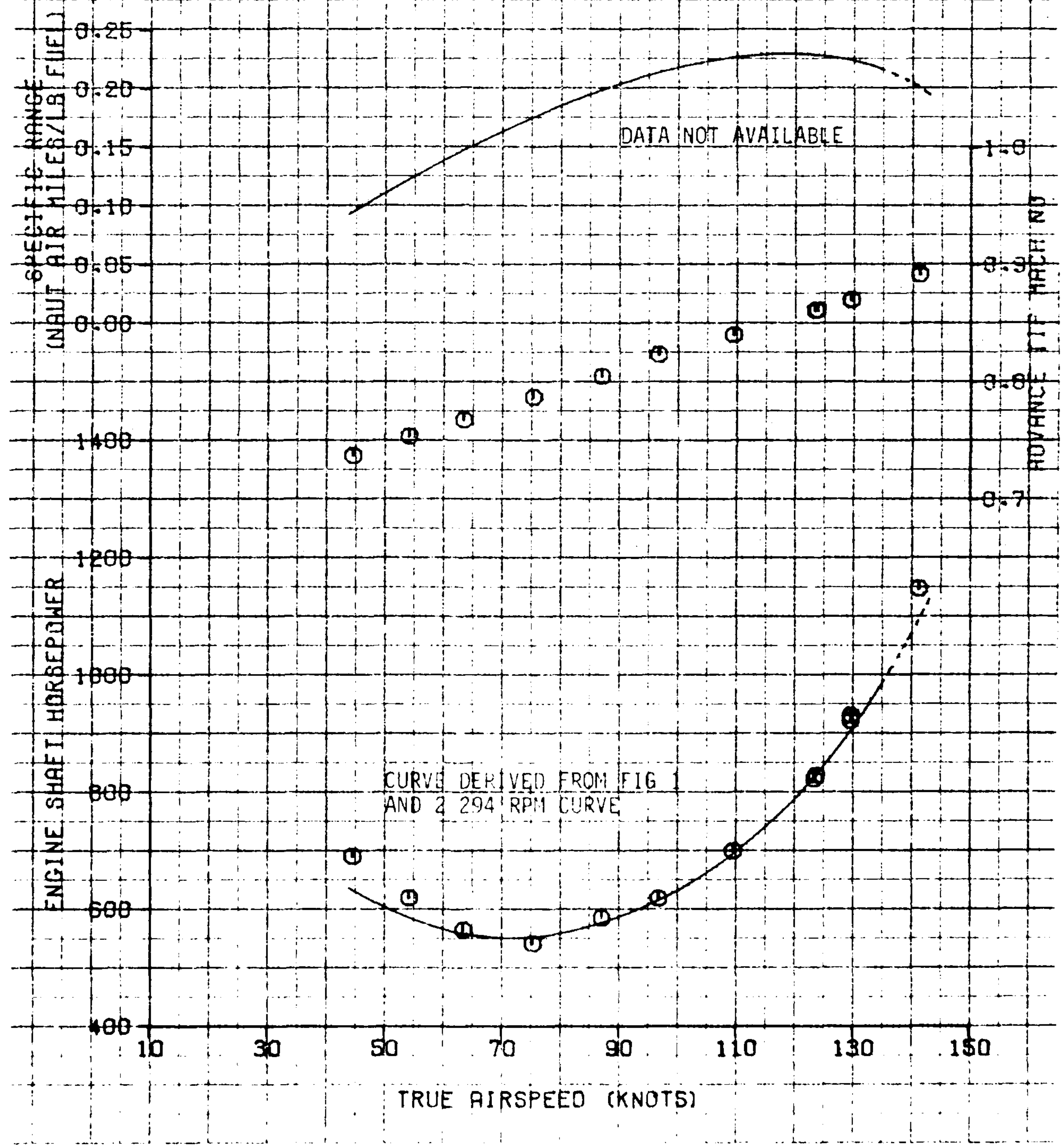


FIGURE 22

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG TA (°C)	AVG ROTOR SPEED RPM	AVG C_T X10⁴
8300.	195.5 (MID)	-.1 (RT)	8820.	-9.5	311.	57.70

NOTE: REFERRED ROTOR SPEED= 325. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN

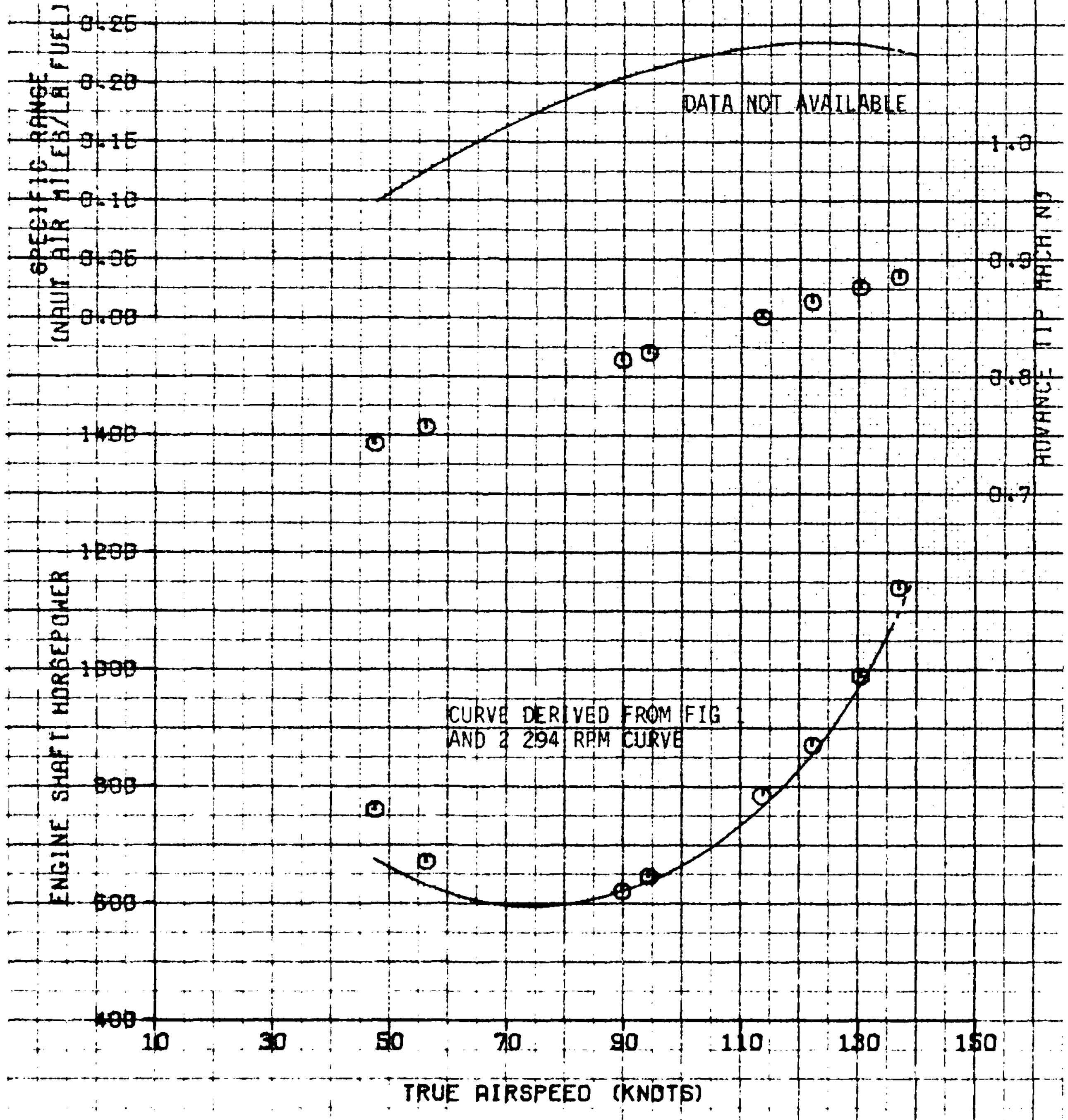


FIGURE 23
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG OAT (°C)	AVG ROTOR SPEED RPM	AVG C_T X10^4
8780.	196.0 (MID)	.1 (RT)	4440.	-4.0	322.	80.37

NOTE: REFERRED ROTOR SPEED = 334. RPM; ZERO SIDESLIP
CONFIGURATION: CLEAN

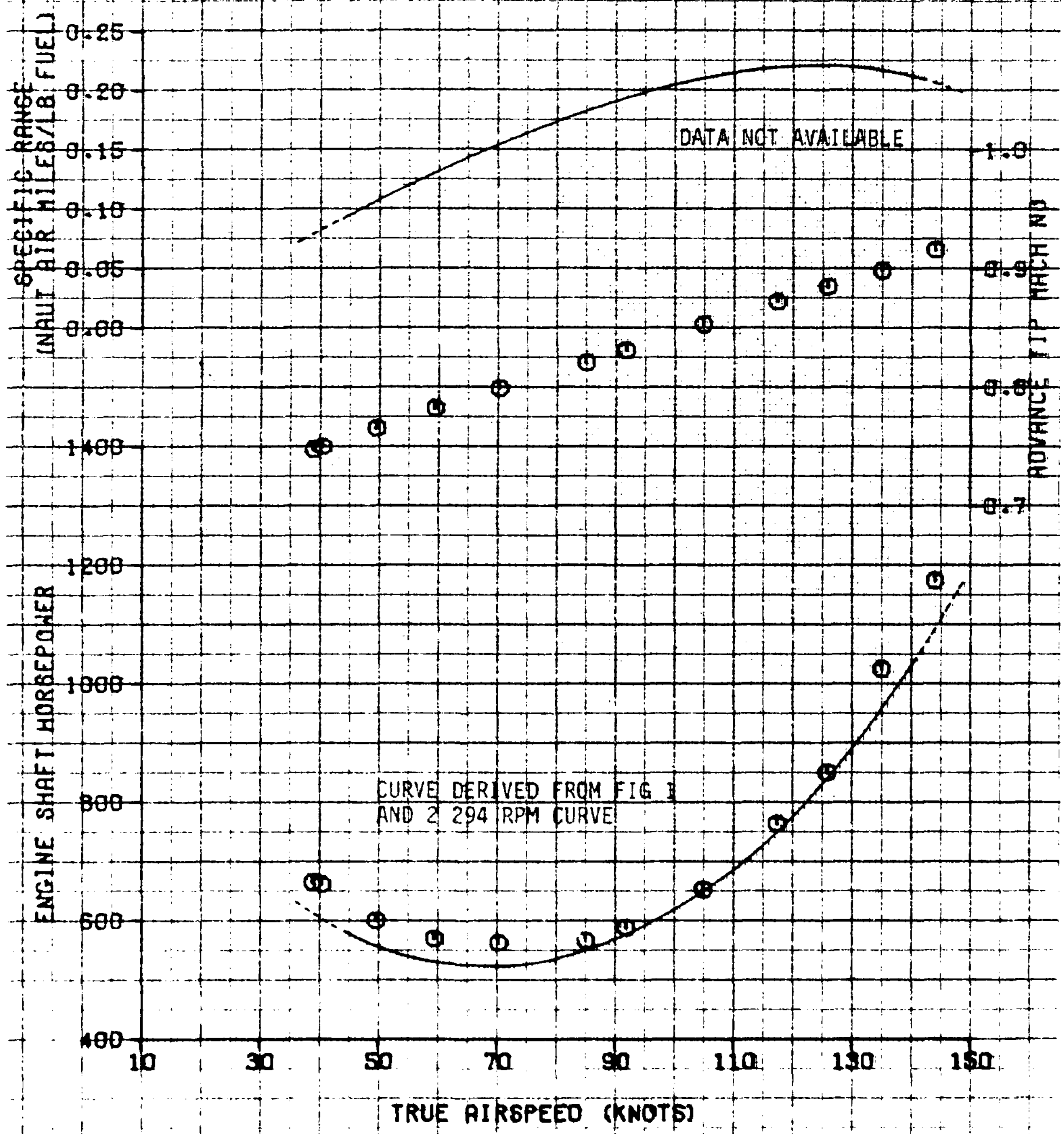
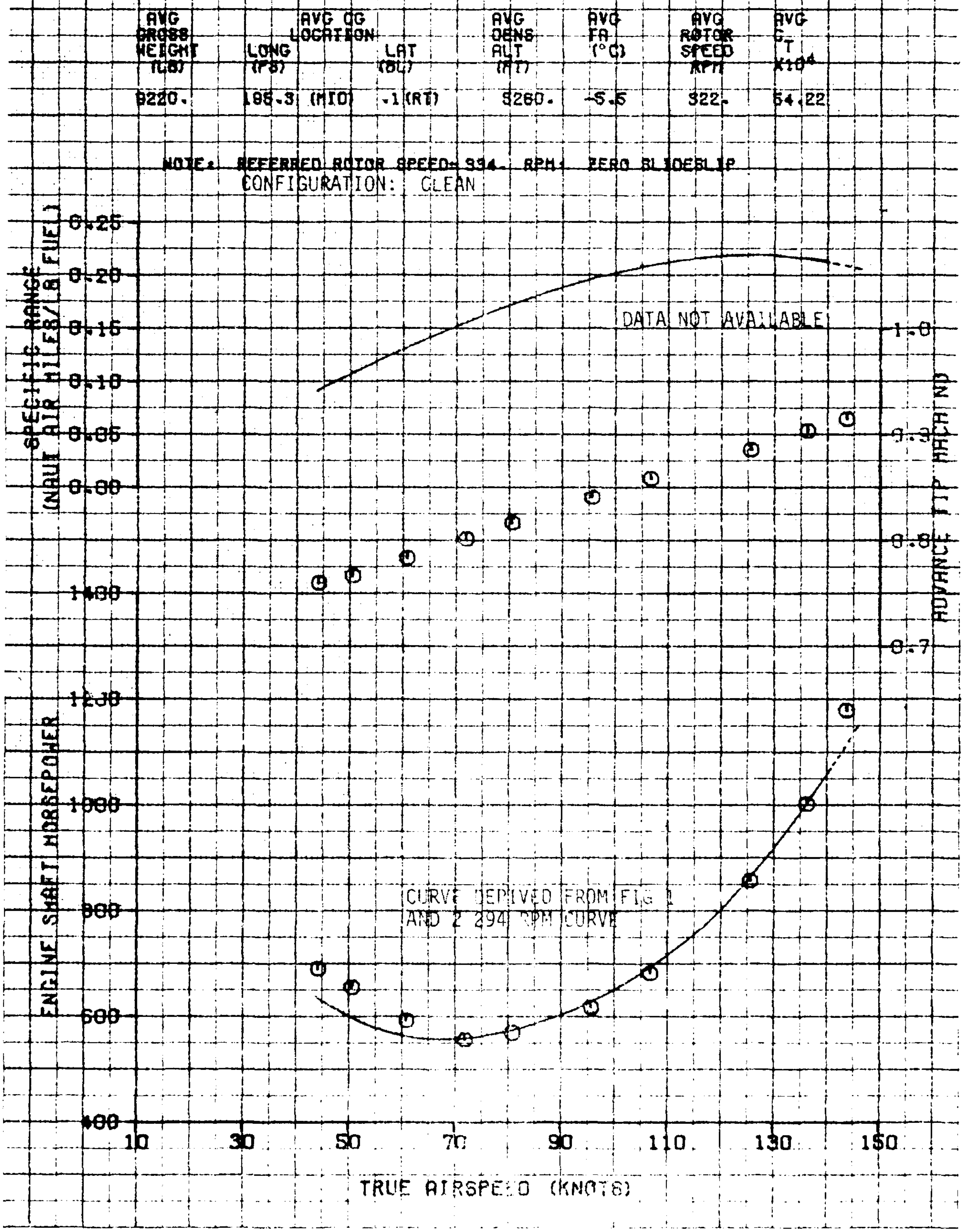


FIGURE 24
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573



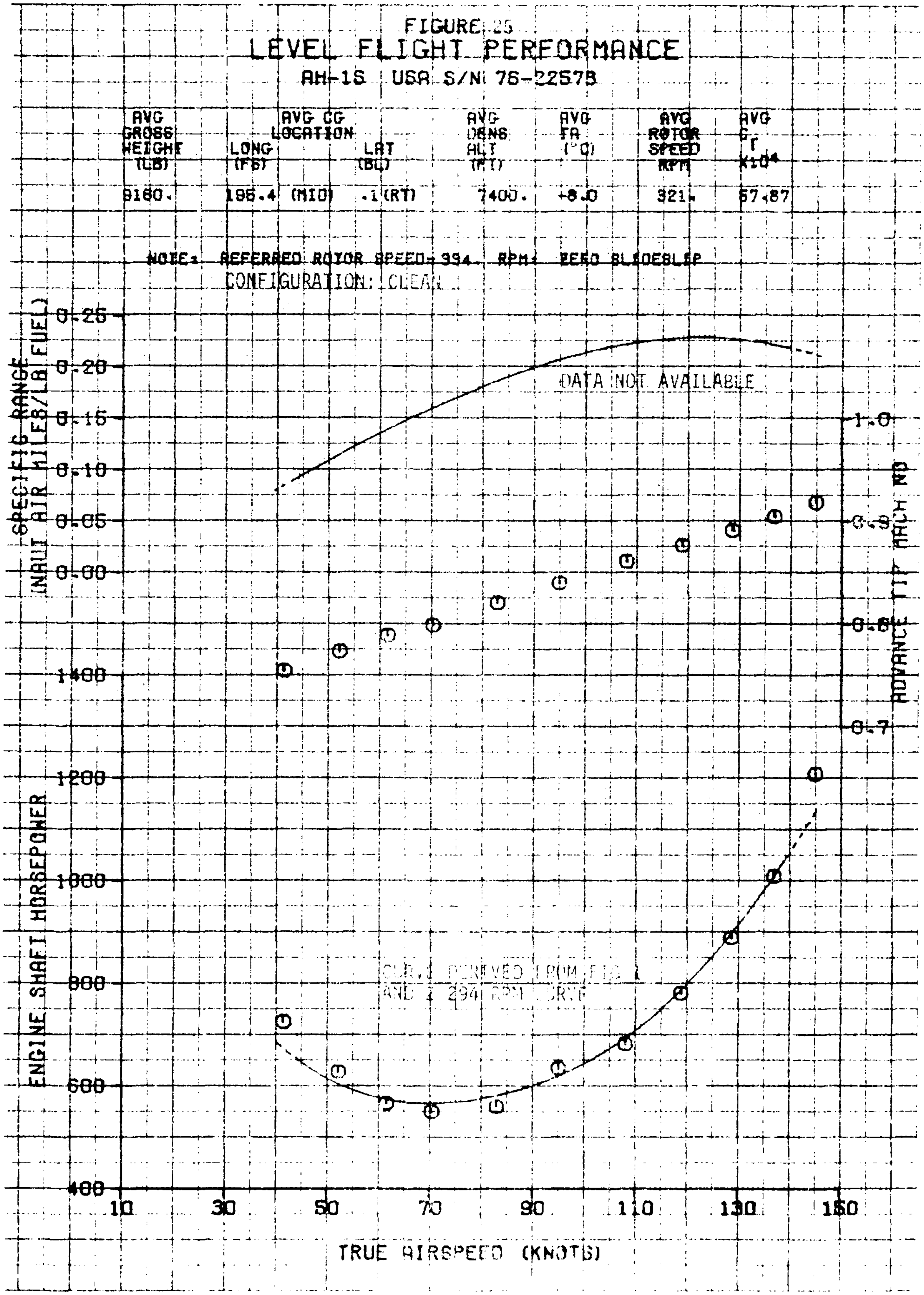


FIGURE 25
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (°C)
AVG ROTOR SPEED RPM
AVG C_T $x10^4$
9160.
196.4 (MID)
.1 (RT)
7400.
-8.0
321.
67.87
NOTE: REFERRED ROTOR SPEED=394. RPM; ZERO SIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
0.25
0.20
0.15
0.10
0.05
0.00
DATA NOT AVAILABLE
ADVANCE TIP MACH NO
1.0
0.9
0.8
0.7
ENGINE SHAFT HORSEPOWER
1400
1200
1000
800
600
400
CURVE DERIVED FROM FIG
AND 294 RPM CURVE
10
30
50
70
90
110
130
150
TRUE AIRSPEED (KNOTS)

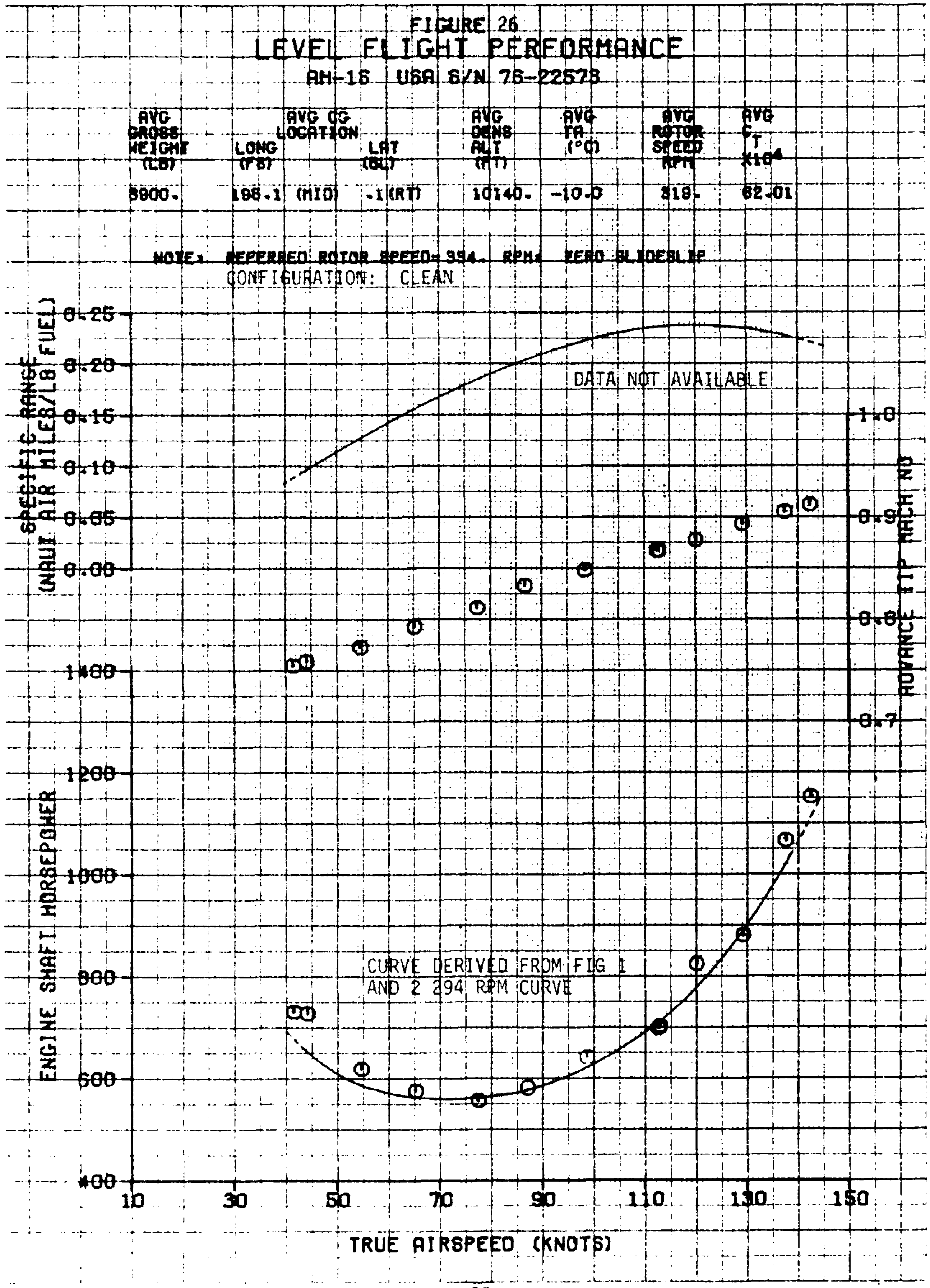


FIGURE 26
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG FA (°C)
AVG ROTOR SPEED RPM
AVG C T X10^4
8900.
198.1 (MID)
.1 (RT)
10140.
-10.0
318.
62.01
NOTE: REFERRED ROTOR SPEED=334. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
DATA NOT AVAILABLE
ADVANCE TIP MACH NO
ENGINE SHAFT HORSEPOWER
CURVE DERIVED FROM FIG 1 AND 2 294 RPM CURVE
TRUE AIRSPEED (KNOTS)

FIGURE 27
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

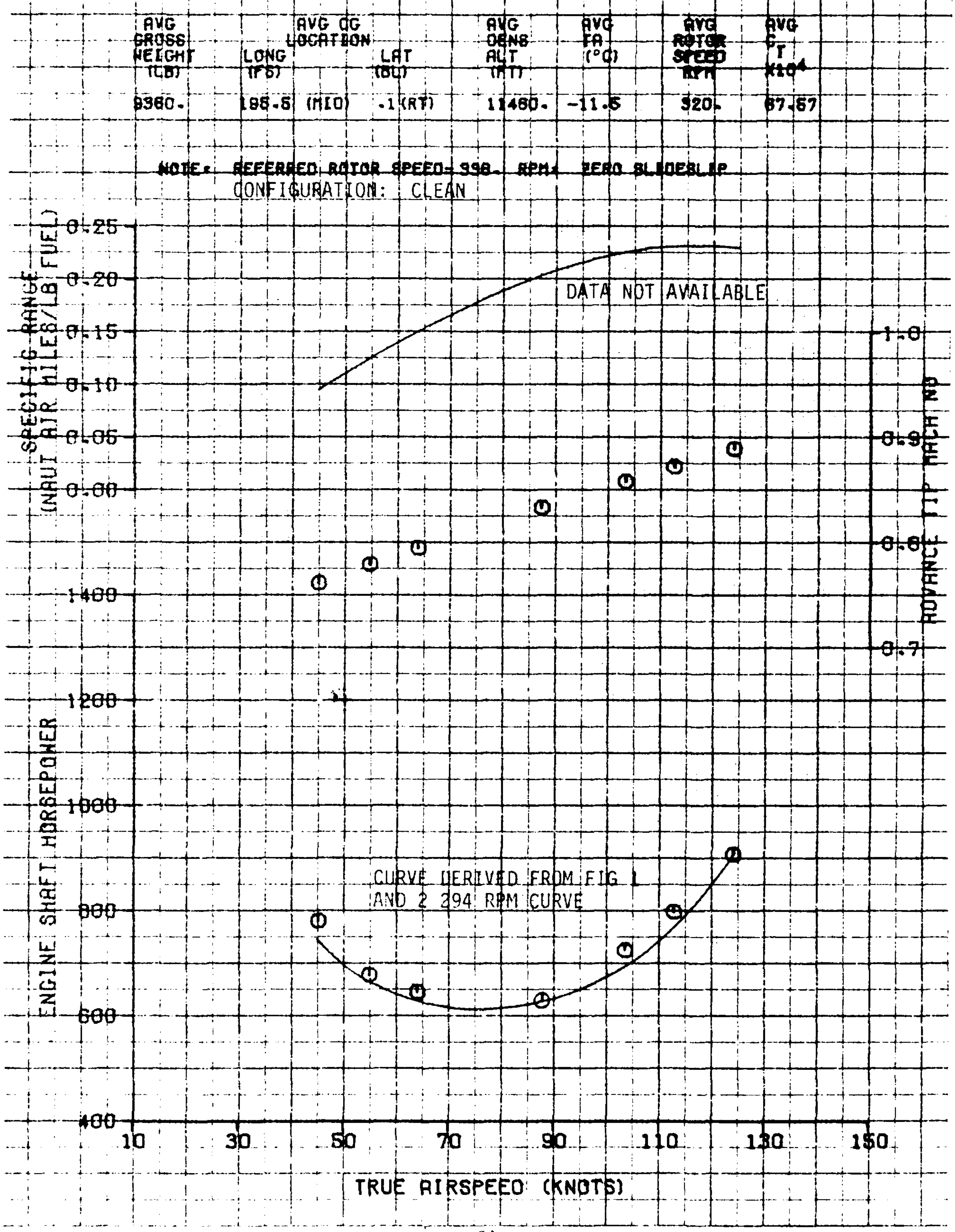


FIGURE 28

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG FA (°C)	AVG ROTOR SPEED RPM	AVG C_T $\times 10^4$
9080.	195.2 (MID)	.1 (RT)	4450.	-6.5	327.	60.57

NOTE: REFERRED ROTOR SPEED: 339. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN

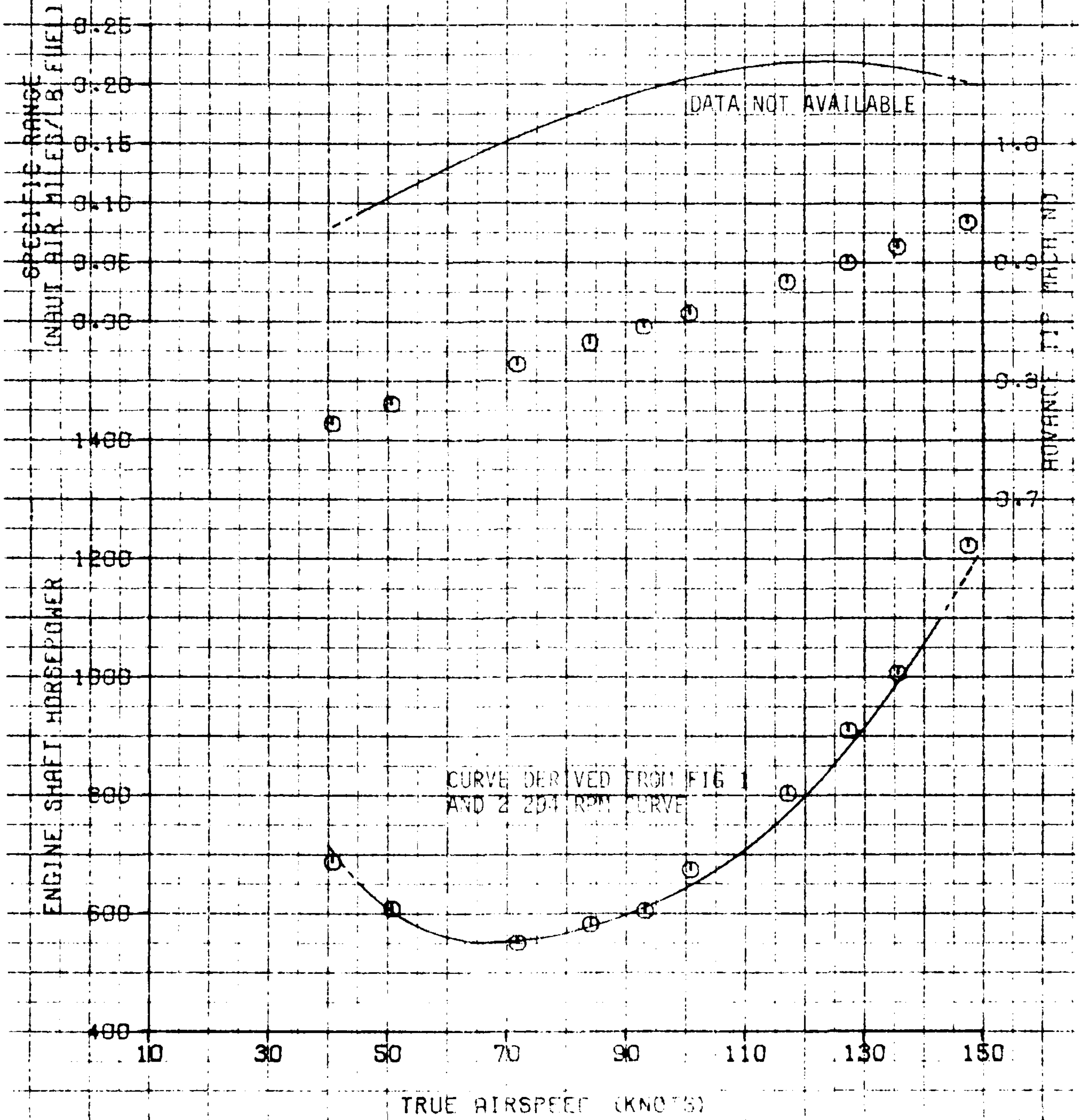


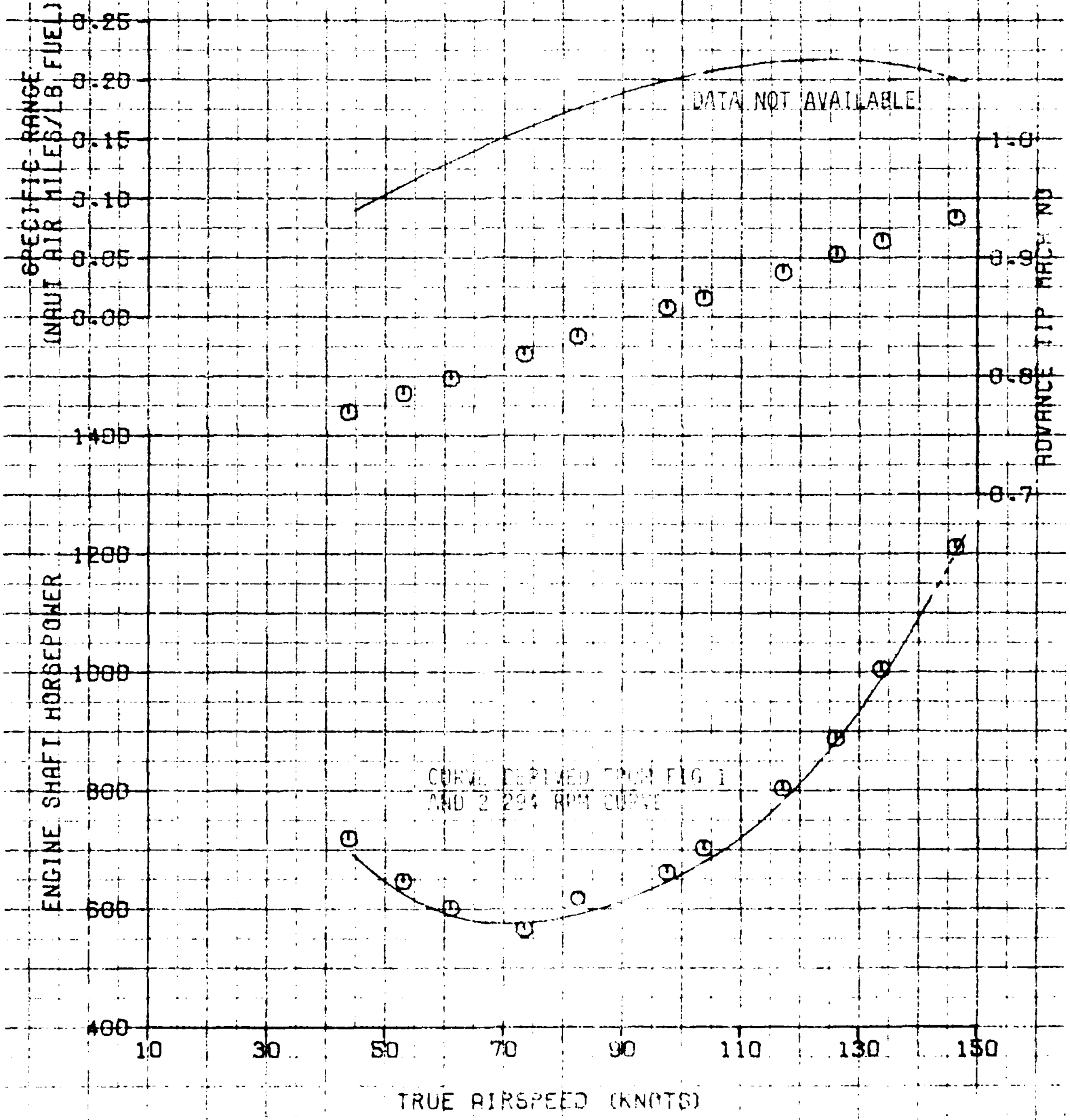
FIGURE 29.

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22578

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)		AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG TA (°C)	AVG ROTOR SPEED RPM	AVG C_T $X10^4$
9980.	195.4	(MID)	.1 (RT)	5820.	-9.0	326.	54.63

NOTE: REFERRED ROTOR SPEED= 341. RPM; ZERO SIDESLIP
CONFIGURATION: CLEAN



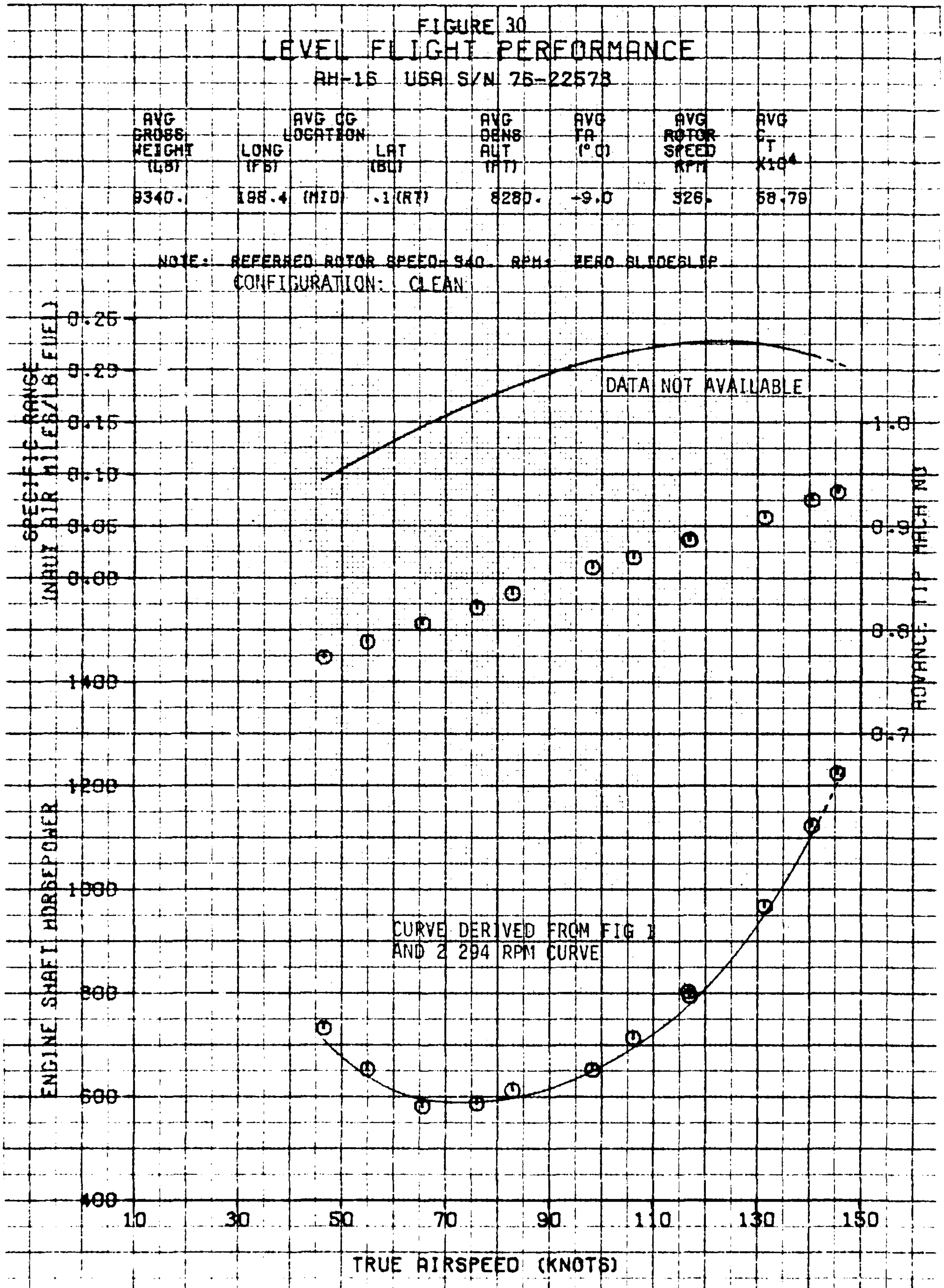


FIGURE 30
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG FA (°C)
AVG ROTOR SPEED RPM
AVG C T X10^4
9340.
198.4 (MID)
.1 (RT)
8280.
-9.0
326.
58.79
NOTE: REFERRED ROTOR SPEED= 340. RPM; ZERO SLIDESLIP
CONFIGURATION: CLEAN
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
0.25
0.20
0.15
0.10
0.05
0.00
DATA NOT AVAILABLE
ADVANCE TIP MACH NO
1.0
0.9
0.8
0.7
ENGINE SHAFT HORSEPOWER
1400
1200
1000
800
600
400
CURVE DERIVED FROM FIG 1 AND 2 294 RPM CURVE
10
30
50
70
90
110
130
150
TRUE AIRSPEED (KNOTS)

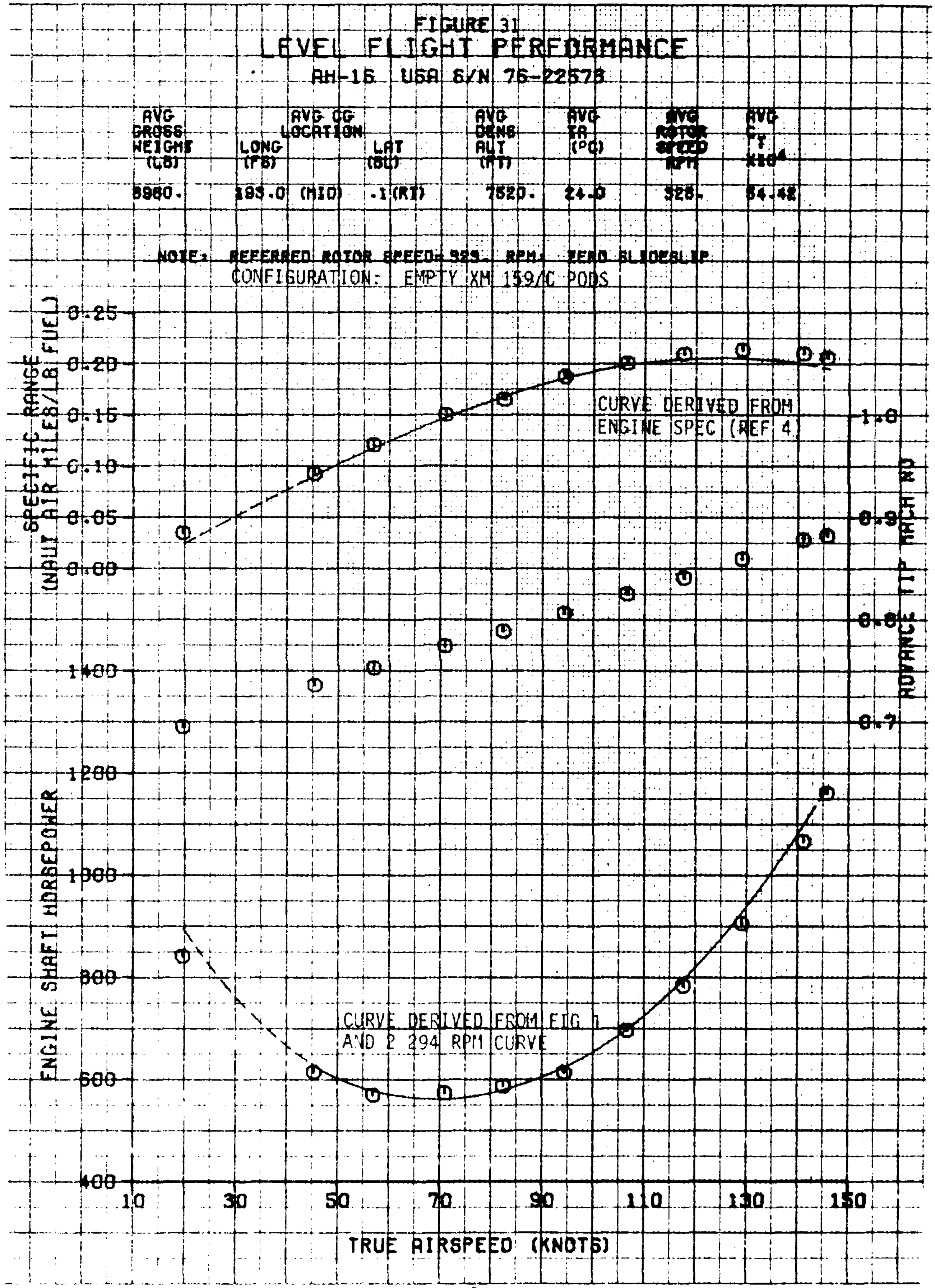


FIGURE 31
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (°C)
AVG ROTOR SPEED RPM
AVG C_T $\times 10^4$
8960.
193.0 (MID)
-.1 (RT)
7520.
24.0
325.
54.42
NOTE: REFERRED ROTOR SPEED=325. RPM; ZERO SIDESLIP
CONFIGURATION: EMPTY XM 159/C PODS
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
CURVE DERIVED FROM ENGINE SPEC (REF 4)
ADVANCE TIP MACH NO
ENGINE SHAFT HORSEPOWER
CURVE DERIVED FROM FIG 1 AND 2 294 RPM CURVE
TRUE AIRSPEED (KNOTS)

FIGURE 32

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG TA (°C)	AVG ROTOR SPEED RPM	AVG C_T $X10^4$
8840.	192.9 (MID)	.1 (RT)	9820.	19.5	328.	58.39

NOTE: REFERRED ROTOR SPEED = 323. RPM; ZERO SIDESLIP

CONFIGURATION: EMPTY XM 159/C PODS

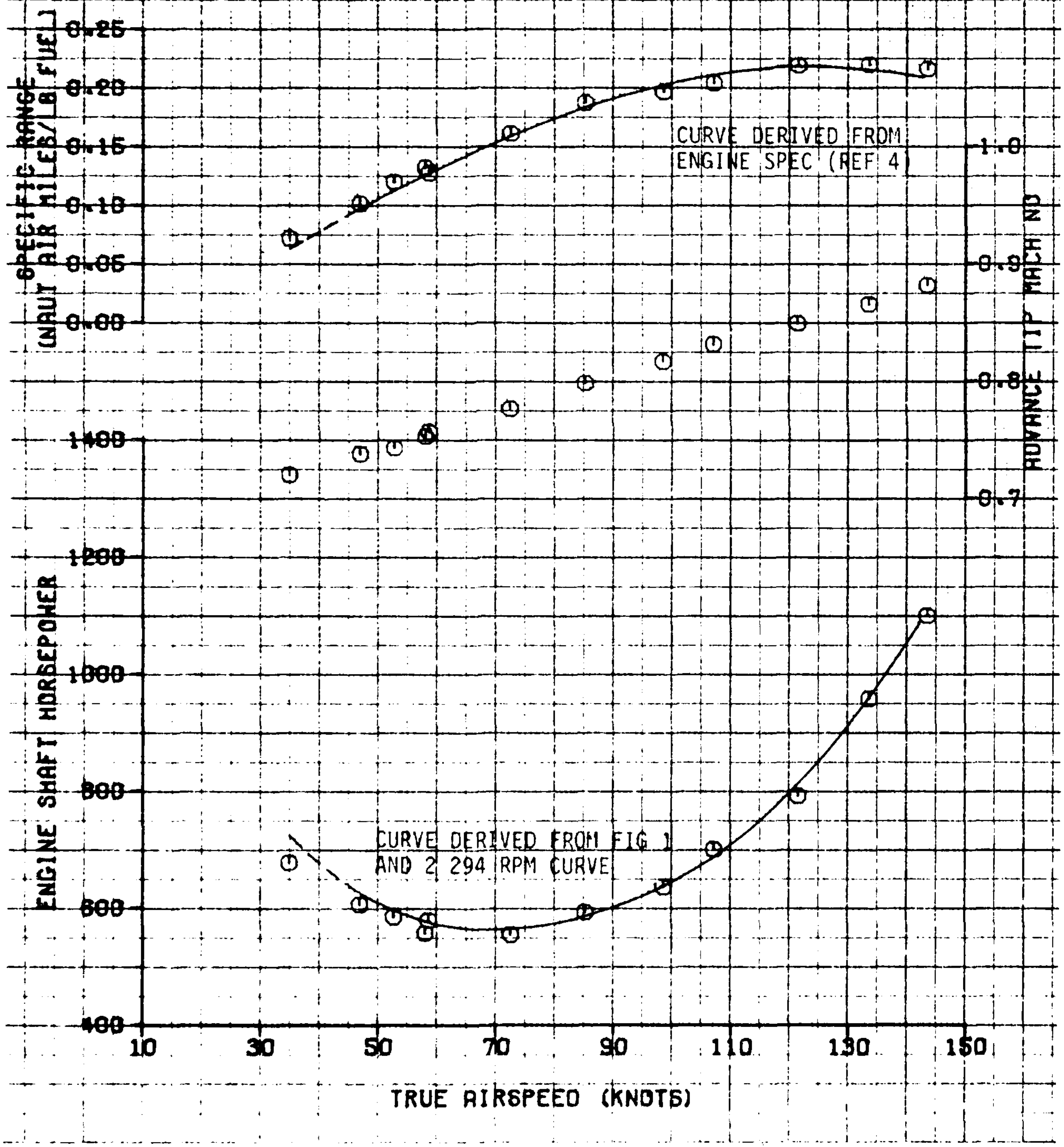


FIGURE 33
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22578

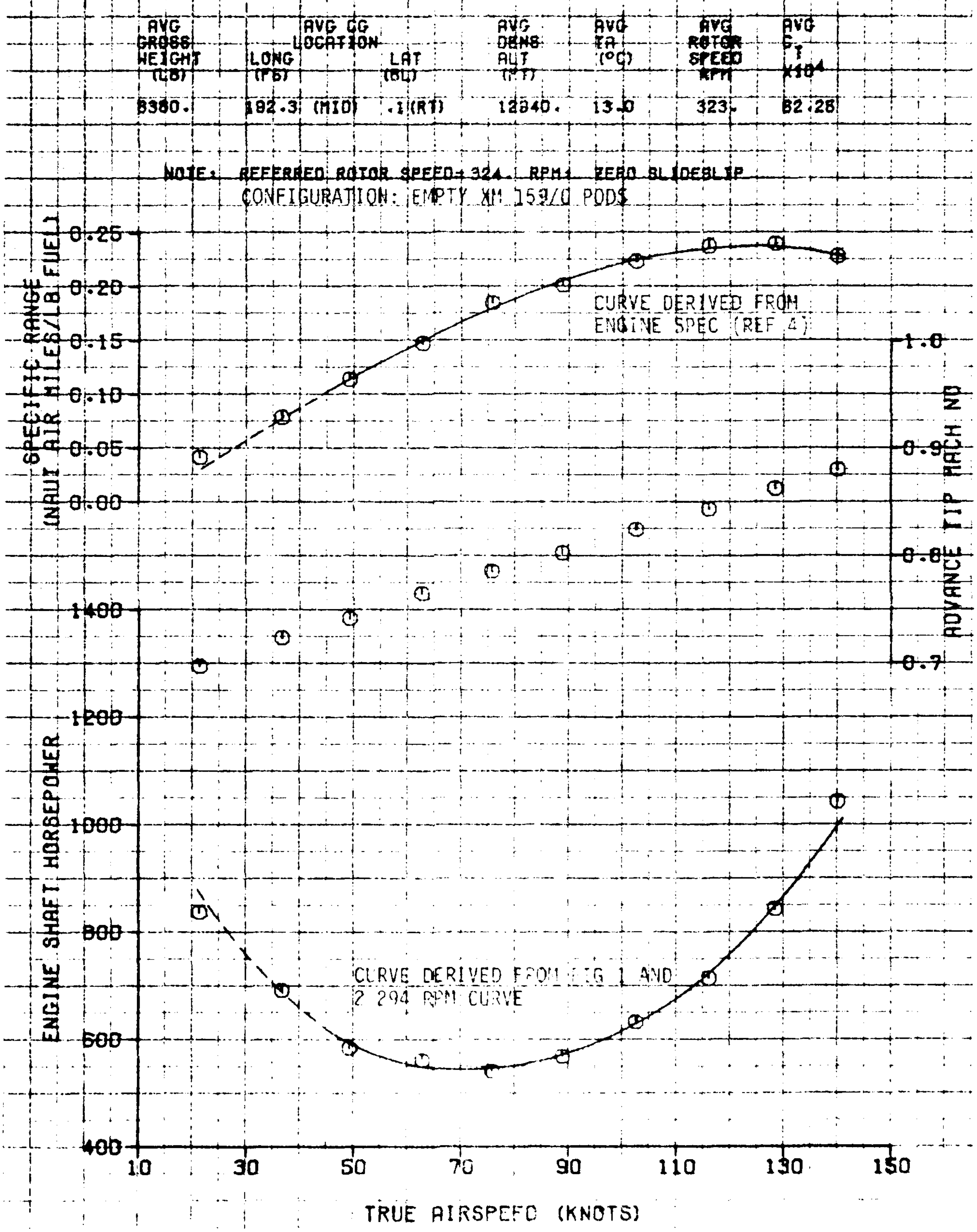


FIGURE 34

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG FA (°C)	AVG ROTOR SPEED RPM	AVG C_T $X10^4$
8960.	193.0 (MID)	.1 (RT)	13640.	12.5	322.	88.60

NOTE: REFERRED ROTOR SPEED= 323 RPM; ZERO SLIDESLIP

CONFIGURAGION: EMPTY XM 159/C PODS

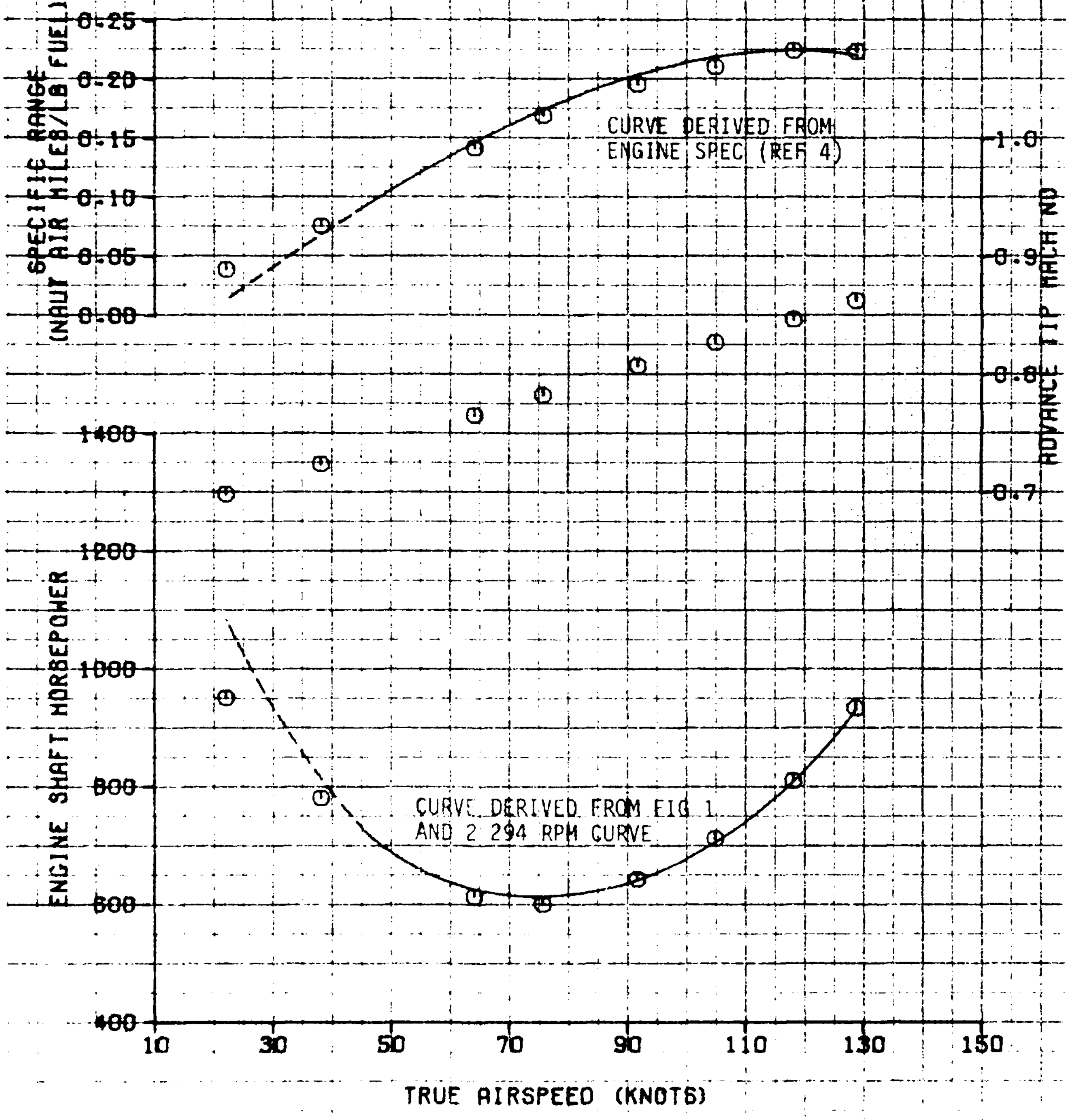


FIGURE 35

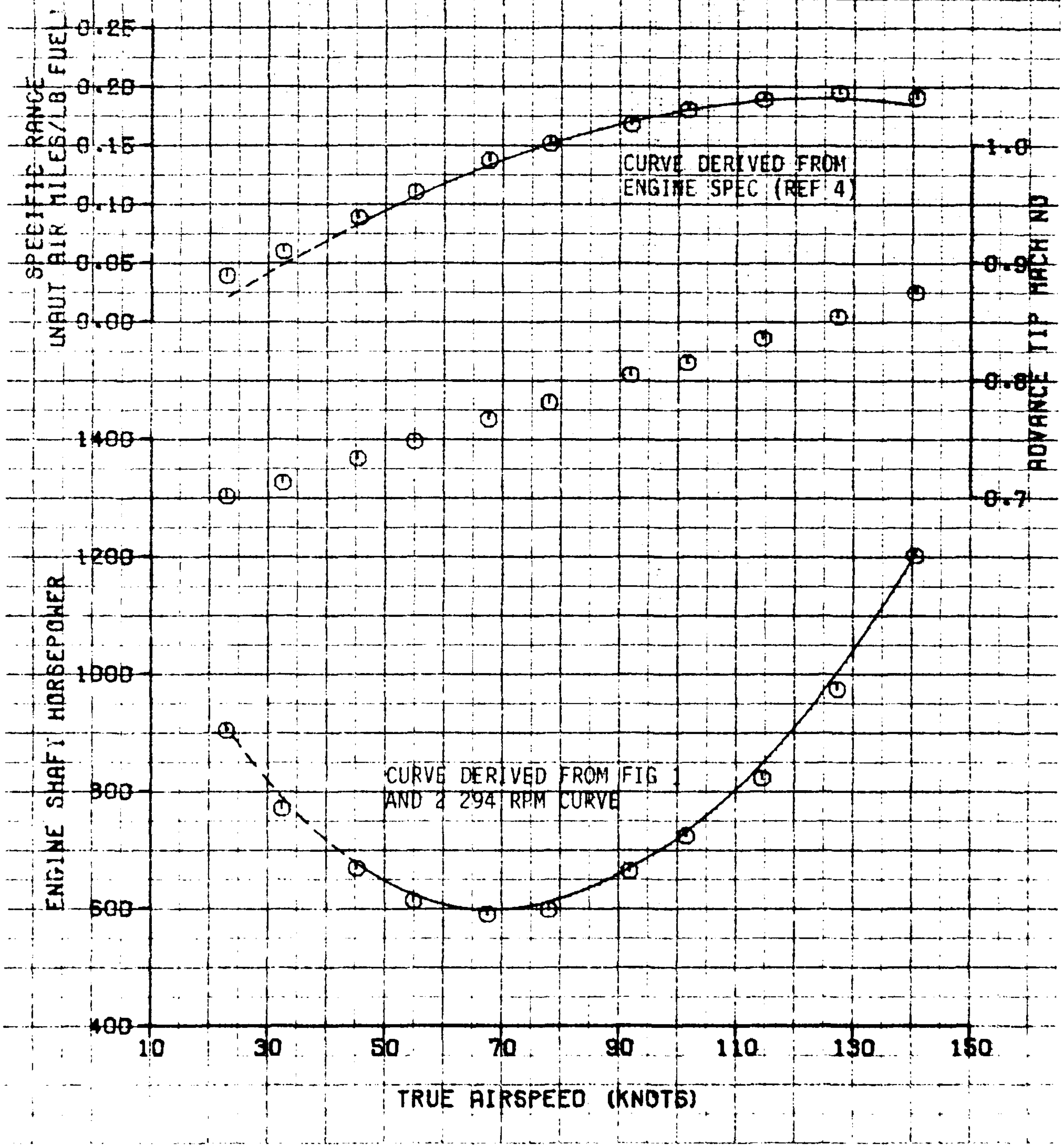
LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG TA (°C)	AVG ROTOR SPEED RPM	AVG C_T $\times 10^4$
9480.	192.1 (MID)	.1 (RT)	5680.	24.5	32[illegible].	54.42

NOTE: REFERRED ROTOR SPEED=323. RPM; ZERO SIDESLIP

CONFIGURATION: FULL XM 159/C PODS



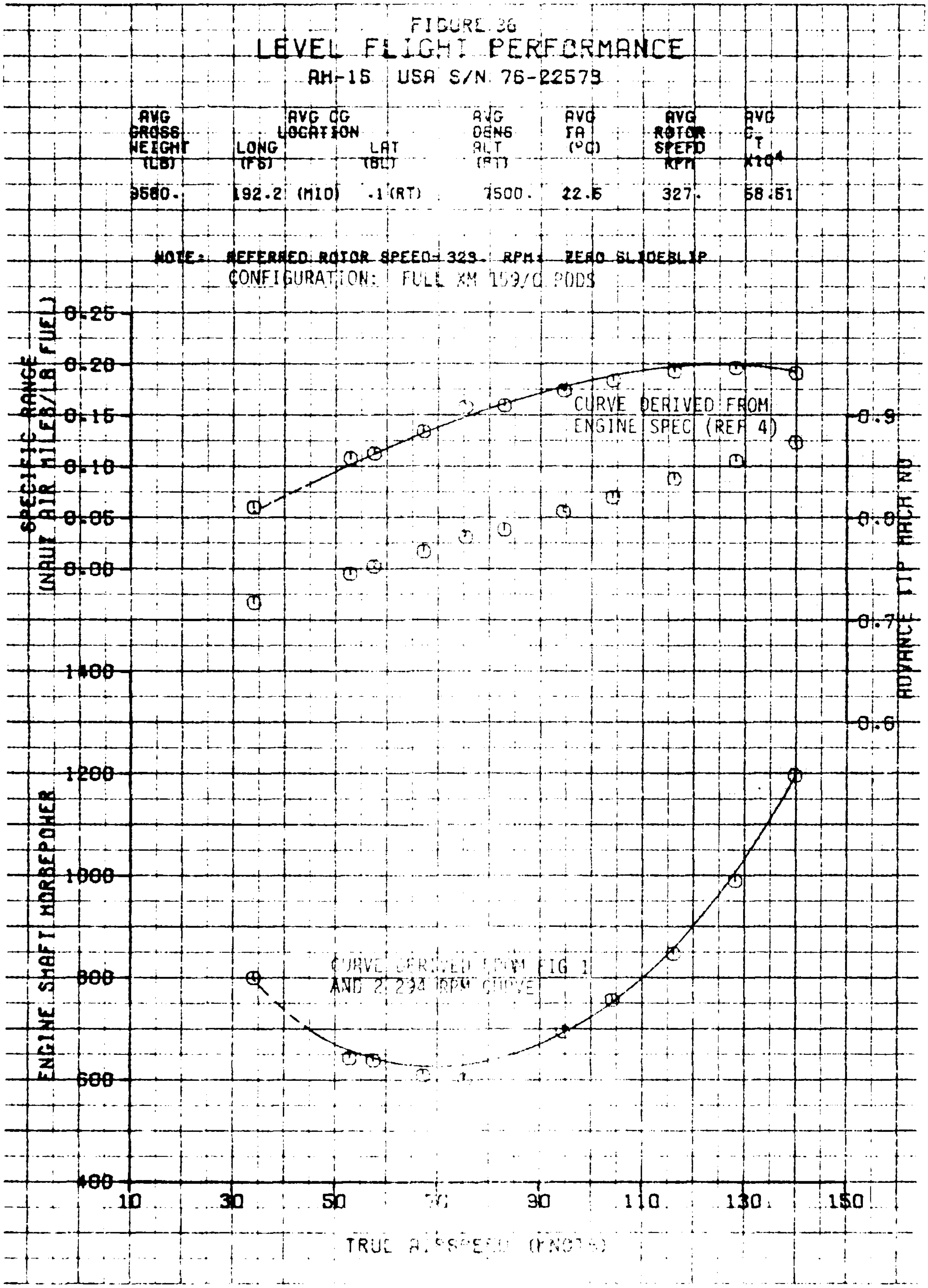


FIGURE 36
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573

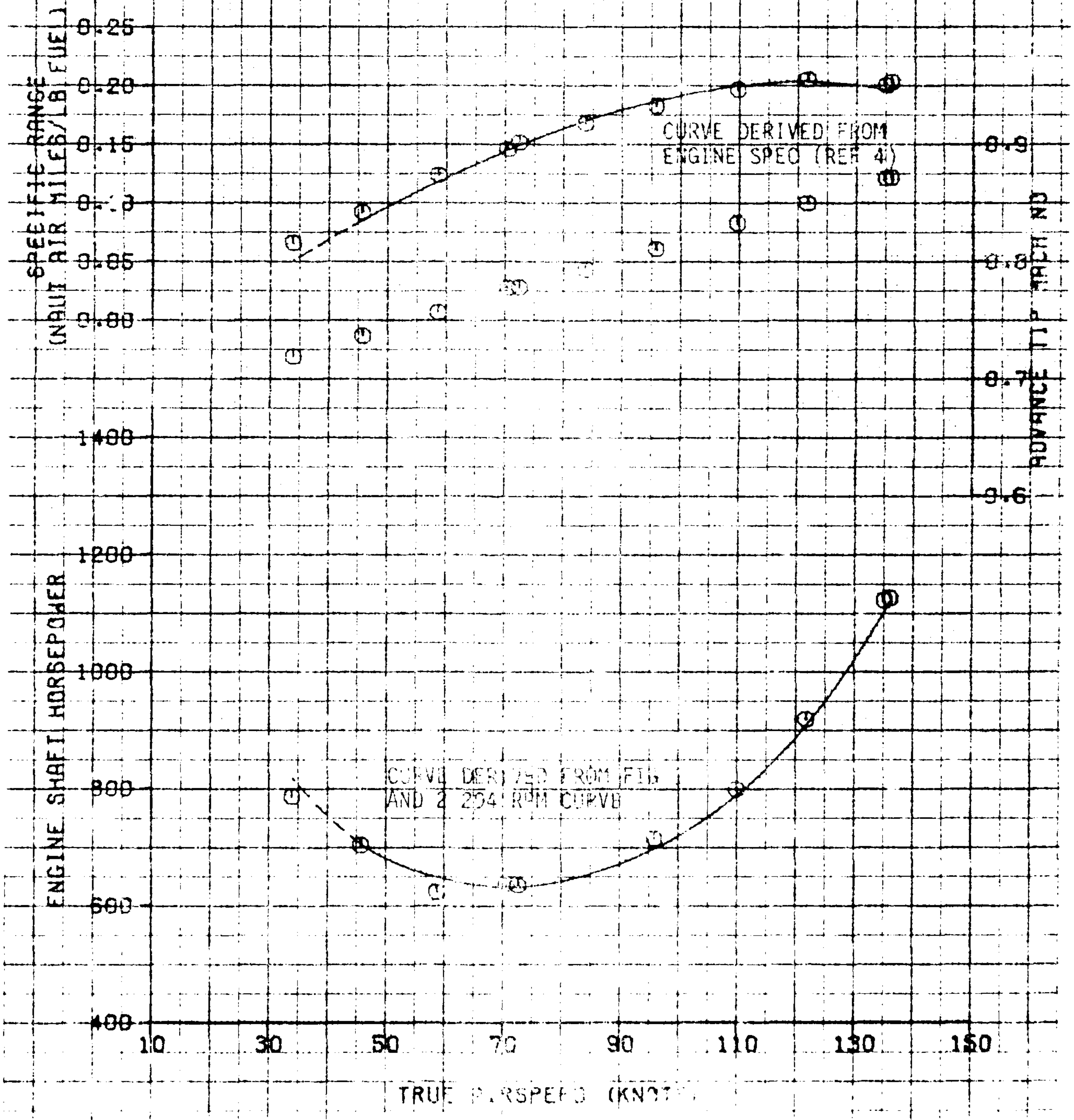
FIGURE 5

LEVEL FLIGHT PERFORMANCE

AH-1S USA S/N 76-22573

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENS ALT (FT)	AVG TA (°C)	AVG ROTOR SPEED RPM	AVG C_T X10[4]
9520.	192.1 (MID)	.1 (RT)	6460.	19.5	326.	82.21

NOTE: REFERRED ROTOR SPEED=324. RPM; ZERO SIDESLIP
CONFIGURATION: FULL XM 159/C PODS



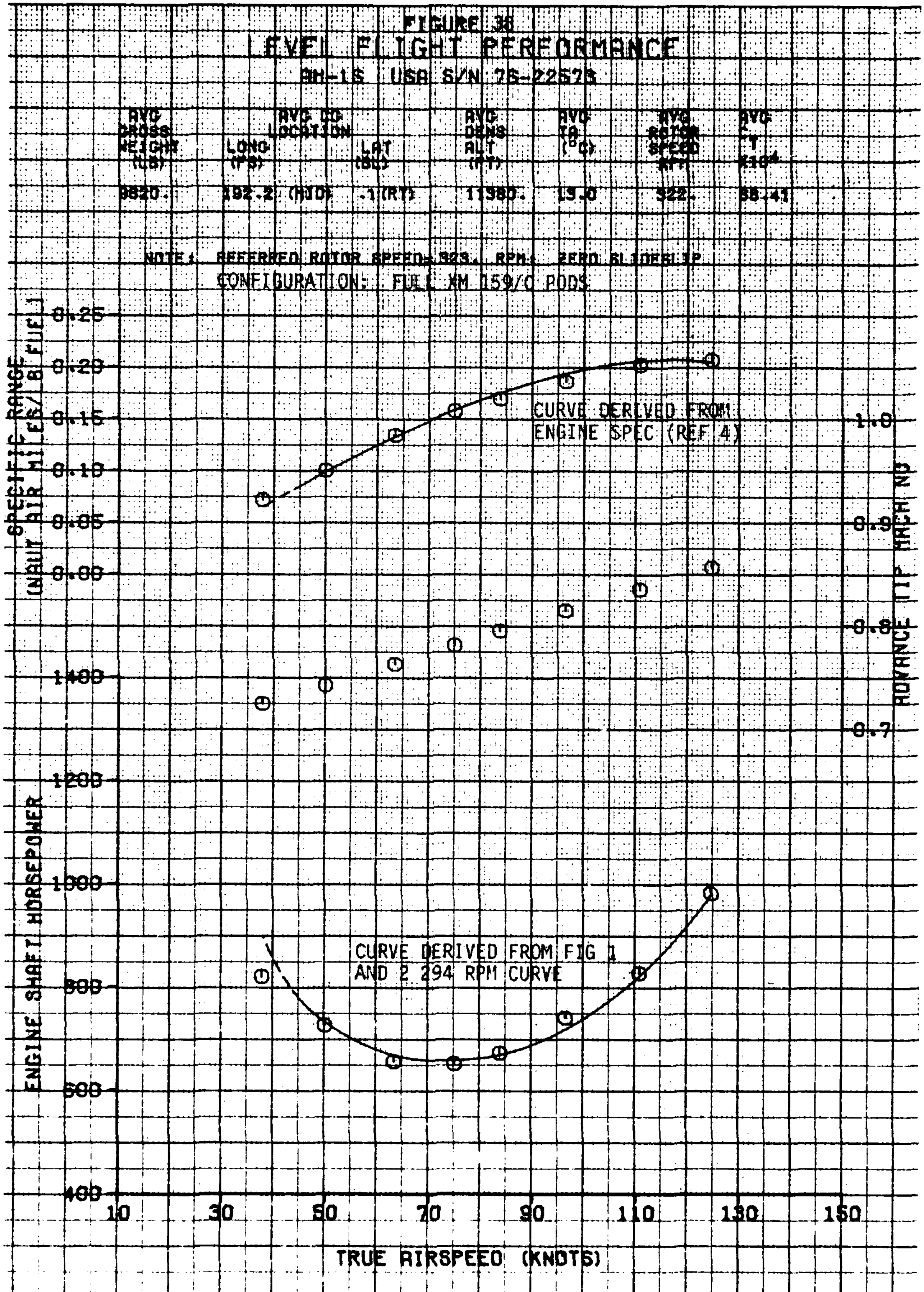


FIGURE 38
LEVEL FLIGHT PERFORMANCE
AH-1S USA S/N 76-22573
AVG GROSS WEIGHT (LB)
AVG CG LOCATION
LONG (FS)
LAT (BL)
AVG DENS ALT (FT)
AVG OAT (°C)
AVG ROTOR SPEED RPM
AVG C_T X10^4
9820.
192.2 (MID)
.1 (RT)
11380.
13.0
322.
88.41
NOTE: REFERRED ROTOR SPEED= 323. RPM; ZERO SLIDESLIP
CONFIGURATION: FULL XM 159/C PODS
SPECIFIC RANGE (NAUT AIR MILES/LB FUEL)
0.25
0.20
0.15
0.10
0.05
0.00
CURVE DERIVED FROM ENGINE SPEC (REF 4)
ADVANCE TIP MACH NO
1.0
0.9
0.8
0.7
ENGINE SHAFT HORSEPOWER
1400
1200
1000
800
600
400
CURVE DERIVED FROM FIG 1 AND 2 294 RPM CURVE
10
30
50
70
90
110
130
150
TRUE AIRSPEED (KNOTS)

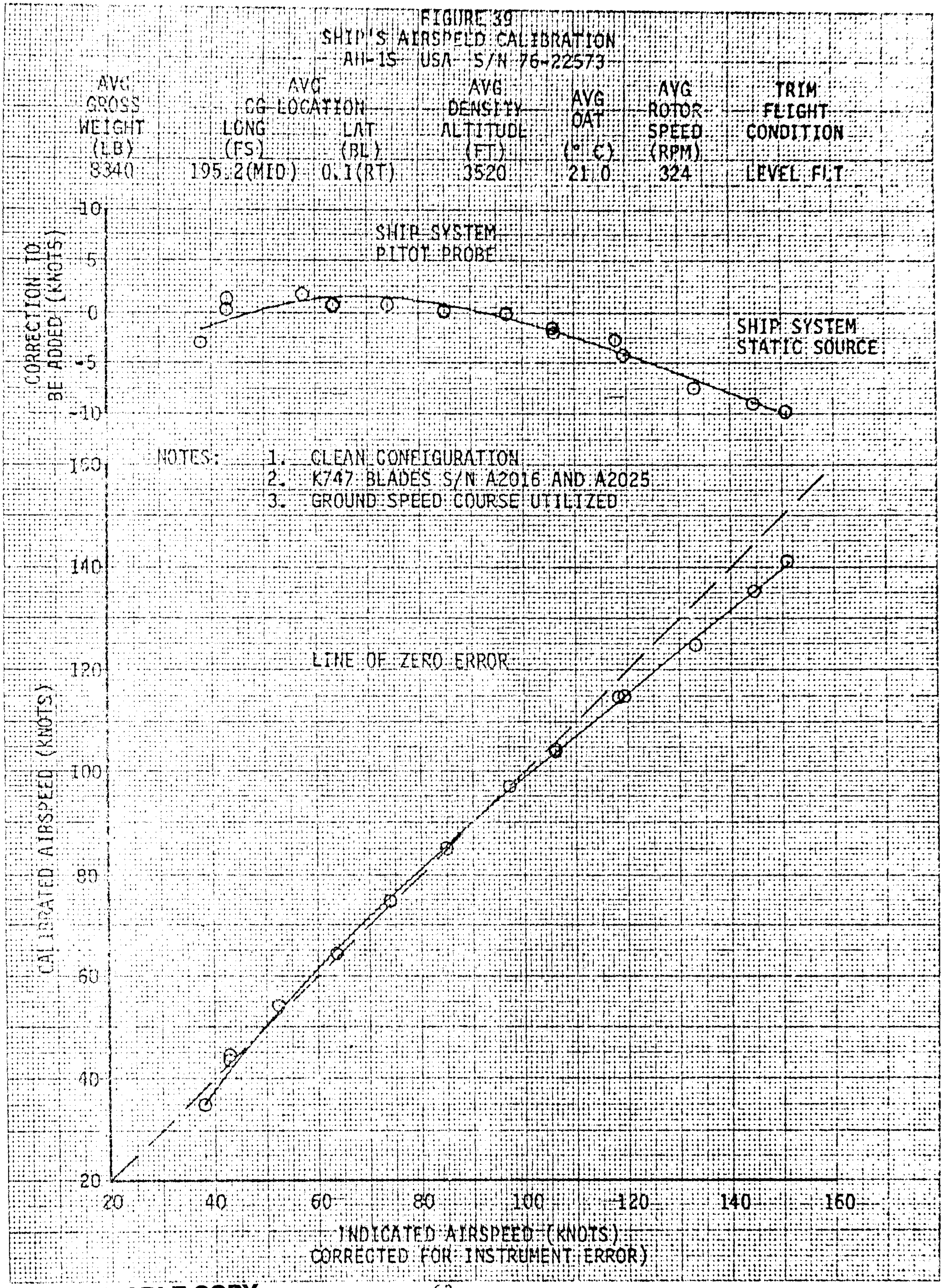


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FIGURE 40
REFERRED ENGINE CHARACTERISTICS

SYM	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	TEST LOCATION
○	4180	25.0	EL CENTRO, CA
□	6280	21.0	EDWARDS, CA
△	5050	-3.0	MINNEAPOLIS, MN

NOTE: 1. CURVE DERIVED FROM ENGINE CALIBRATION, 30 JUN 81

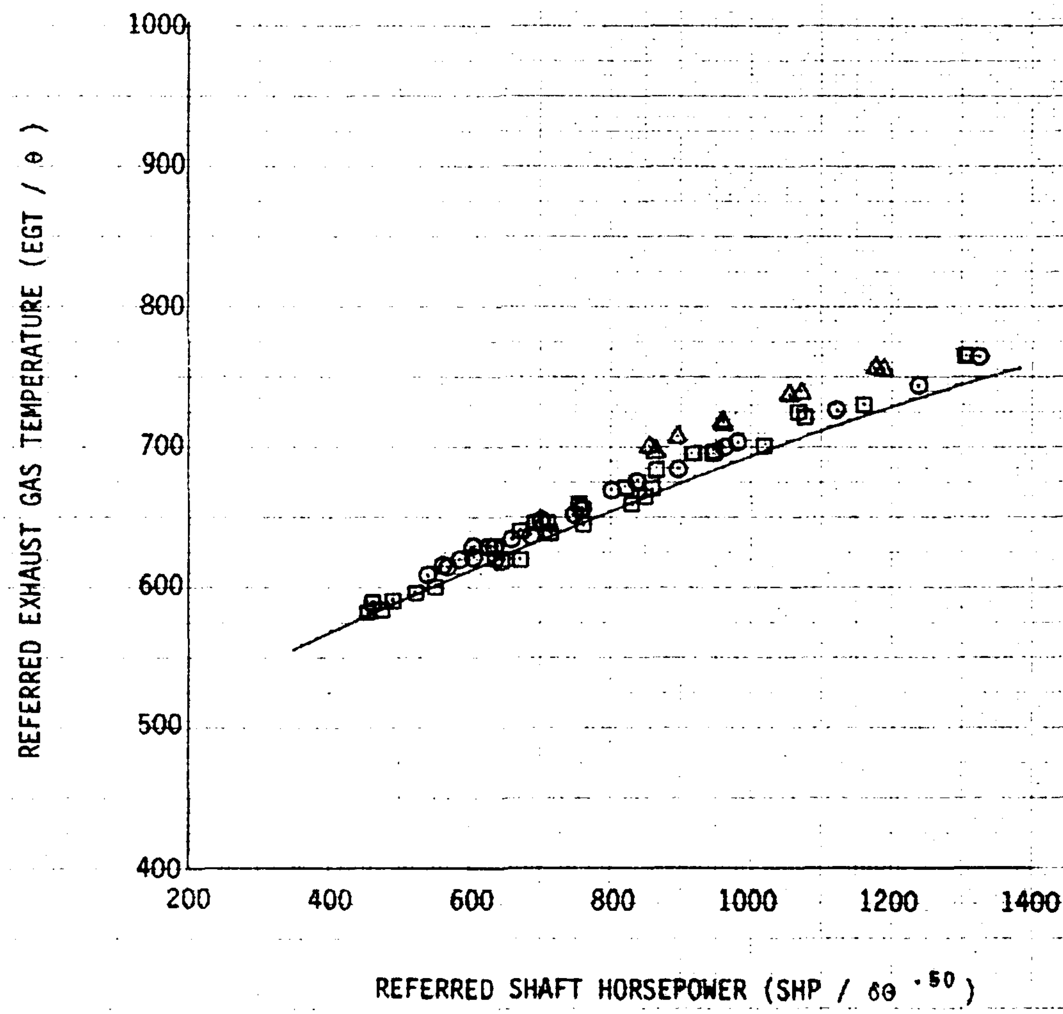


FIGURE 41
REFERRED ENGINE CHARACTERISTICS

SYM	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	TEST LOCATION
○	4180	25.0	EL CENTRO, CA
□	6280	21.0	EDWARDS, CA
△	5050	-3.0	MINNEAPOLIS, MN

NOTE: 1. CURVE DERIVED FROM ENGINE CALIBRATION, 30 JUN 82.

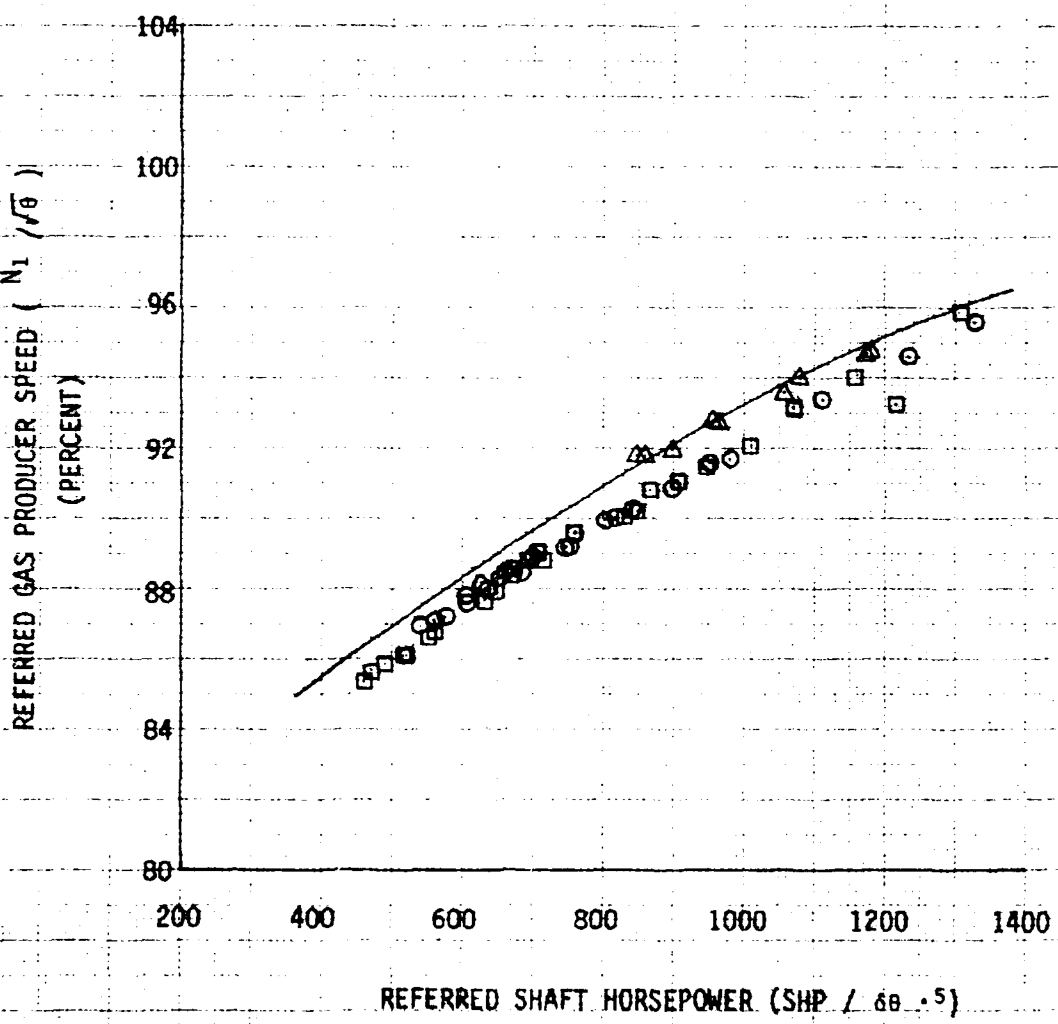
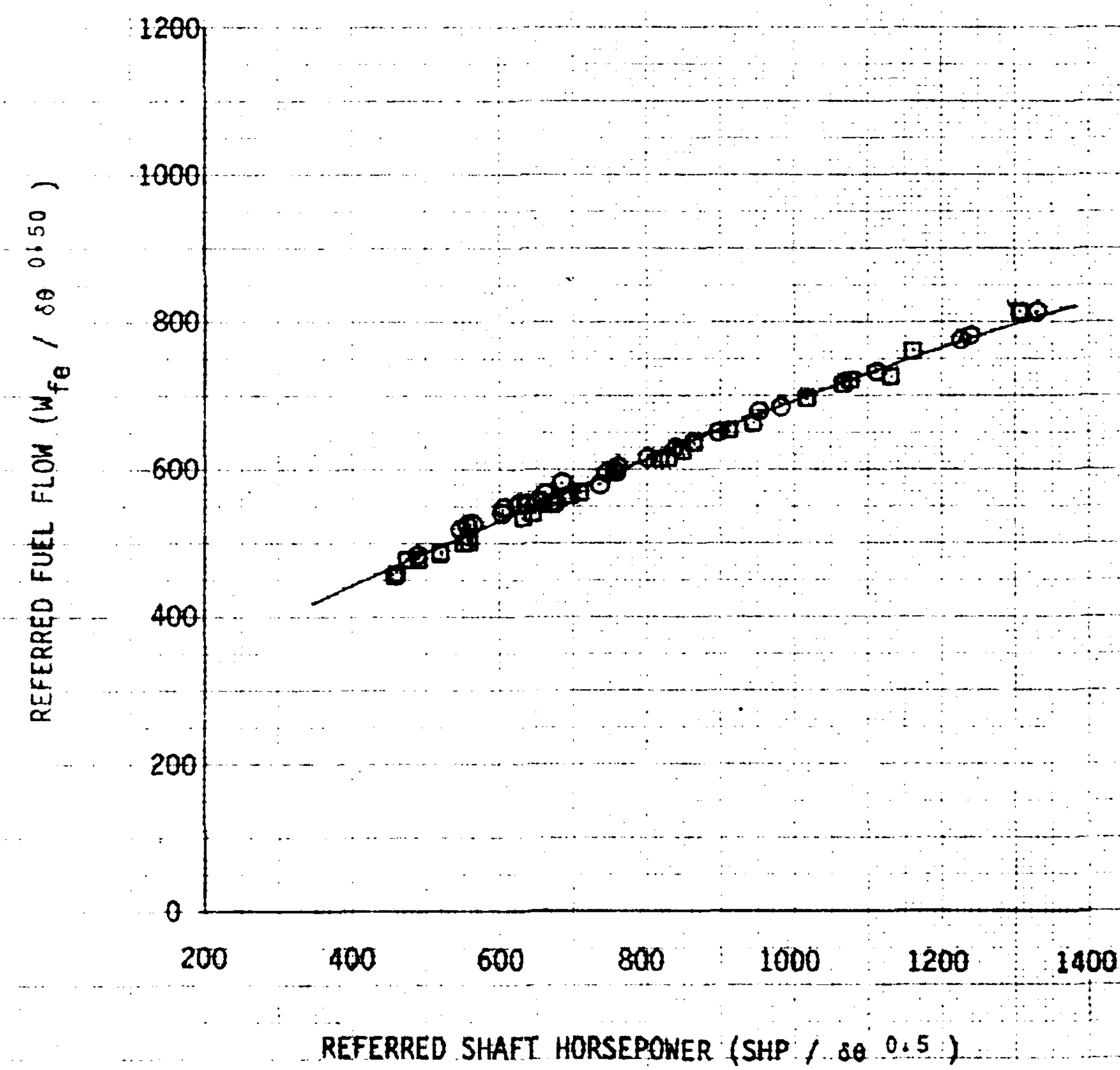


FIGURE 42
REFERRED ENGINE CHARACTERISTICS

SYM	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	TEST LOCATION
○	4180	25.0	EL CENTRO, CA
□	6280	23.0	EDWARDS, CA

NOTE: 1. CURVE DERIVED FROM ENGINE CALIBRATION, 30 JUN 81



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