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RDTE PROJECT NO.
AVSCOM PROJECT NO. 70-03
USAASTA PROJECT NO. 70-03

**ARMY PRELIMINARY EVALUATION II
PRODUCTION OV-1D (MOHAWK)
PERFORMANCE ADDENDUM**

FINAL REPORT

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

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ABSTRACT

Performance and stability and control testing was conducted on the production model OV-1D airplane (Mohawk) to evaluate its capability to perform the aerial surveillance mission and to determine military specification compliance. Testing was conducted by the US Army Aviation Systems Test Activity between 14 and 24 July 1970 at the Grumman Aerospace Corporation facility at Calverton, New York. Nine flights were accomplished with a total of 20.5 hours required to complete the test. The performance portion of the test results is presented in this addendum. The performance of the OV-1D was found to be satisfactory for accomplishment of the intended mission. Inadequate single-engine performance was the only shortcoming which was found in the test aircraft. Additional testing of the OV-1D is recommended in order to determine the airworthiness and flight characteristics for incorporation in the operator's manual.

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DISTRIBUTION

INTRODUCTION

BACKGROUND

1. The OV-1D airplane is a growth version of the OV-1 model manufactured for the US Army by the Grumman Aerospace Corporation (GAC), Bethpage, New York. Four preproduction aircraft were used during contractor flight testing to evaluate the performance, flying qualities, structural integrity, and electronic compatibility of the new electronic surveillance mission equipment. Army Preliminary Evaluation I (APE I) was completed on the preproduction OV-1D airplane by the US Army Aviation Systems Test Activity (USAASTA) in May 1969 (ref 1, app I). The evaluation of the production OV-1D airplane (APE II) was directed by the US Army Aviation Systems Command (AVSCOM) in Test Request No. 70-03 (ref 2).

TEST OBJECTIVES

2. The following test objectives were outlined in the test directive:
- a. To quantitatively and qualitatively evaluate the airplane's performance and handling qualities, and to verify compliance with the requirements of the military specification, MIL-F-8785(ASG), Amendment 2 (ref 3, app I) and the detail specification (ref 4).
 - b. To determine if the shortcomings reported in the preproduction APE had been adequately corrected.
 - c. To evaluate performance data provided by GAC.

DESCRIPTION

3. A production OV-1D airplane, serial number 68-16990, was tested during APE II. The OV-1D is a two-place, triple-vertical-stabilizer, mid-wing, twin-engine, turboprop airplane. The airplane is powered by two Lycoming T53-L-701 turbine engines, each rated at 1,400 shaft horsepower (shp) with Hamilton Standard 53C51-27 three-bladed propellers. Martin-Baker ejection seats are provided for the crew. The missions of the OV-1D include visual, photographic, infrared (IR), and side-looking airborne radar (SLAR) surveillance. A detailed description of both the airplane and its mission equipment is contained in reference 4, appendix I.

4. The test instrumentation which was installed in the airplane is listed in appendix II and included a photopanel, an airborne tape system, and telemetry. Calibrated engines were installed on the aircraft for the evaluation.

5. The external stores configurations are listed in table 1. The airplane configurations which were tested during the APE II performance test are listed in table 2.

Table 1. External Stores Configurations.

Configuration	Store	Location
A	ALQ-80 radar jammer LS-59A flasher pod 150-gallon drop tank ALQ-67 fuse jammer APS-94 (D) SLAR	Right wing, station 237 Right wing, station 213 Left and right wings, FS 185 Left wing, station 237 Lower right fuselage
B	ALQ-80 radar jammer 150-gallon drop tank ALQ-67 fuse jammer APS-94 (D) SLAR	Right wing, station 237 Left and right wings, FS 185 Left wing, station 237 Lower right fuselage
C	ALQ-80 radar jammer 150-gallon drop tank ALQ-67 fuse jammer	Right wing, station 237 Left and right wings, FS 185 Left wing, station 237

Table 2. Airplane Configurations.

Configuration ¹	Landing Gear Position	Flap Setting (deg)	Power
Takeoff (TO)	Down	15	Takeoff
Cruise (CR)	Up	0	Level flight
Land (L)	Down	45	Flight idle
Power approach (PA)	Down	45	Level flight ²

¹Configurations are defined in the military specification, MIL-F-8785(ASG), Amendment 2.

²Power for level flight at 1.15 times the stall speed in the landing configuration (V_{S_L}).

SCOPE OF TEST

6. The APE II testing was conducted at the GAC test facility at Peconic Airport, Calverton, New York, between 14 and 24 July 1970. Nine test flights were conducted with a total of 20.5 hours required to complete the test. Gross weight was varied between 15,750 and 17,800 pounds. Testing was conducted primarily in the maximum drag stores configuration (A). One test was conducted in the symmetrical stores configuration (C) to compare the effect of parasite drag. The evaluation was performed within the limitations of the flight envelope and the restrictions as specified in the safety-of-flight release (ref 5, app I).

7. This addendum contains the results of the performance testing. The results of the handling qualities testing were reported in the previous APE II report (ref 6, app I).

METHODS OF TEST

8. The test methods used are outlined in the test plan (ref 7, app I) and are discussed briefly in the Results and Discussion section of this report. A GAC-furnished airspeed and altimeter position error calibration was used. Data reduction procedures are discussed in appendix III.

CHRONOLOGY

9. The chronology of the OV-1D performance testing and reporting is as follows:

Test directive received	12 February	1970
Test airplane received	13 July	1970
APE testing initiated	14 July	1970
APE testing completed	24 July	1970
Performance discrepancies identified by USAASTA	28 July	1970
GAC investigation of discrepancies	September	1970
Engine recalibration	2 November	1970
AVSCOM-GAC contract negotiation on corrected data release	1 June	1971
Corrected data received	21 June	1971

RESULTS AND DISCUSSION

STABILITY AND CONTROL

10. The stability and control section of this report was published previously (ref 6, app 1).

PERFORMANCE

General

11. The performance of the OV-1D airplane is satisfactory for accomplishment of the surveillance mission. No deficiencies were noted, and inadequate single-engine performance was the only shortcoming found. Further testing to obtain current data for use in the operator's manual is recommended.

Drag Discrepancy

12. The initial performance data indicated that the aerodynamic drag of the production OV-1D airplane was 23 percent higher than the preproduction version. There were no major aerodynamic differences between the two airplanes to account for the drag increase. In an attempt to resolve the drag discrepancy, the engines were recalibrated at the completion of testing. An error was disclosed in the previous calibration, which reduced the drag discrepancy between the two airplanes. In addition, GAC conducted a series of four flights: two with production propellers, and two with the propellers used on the preproduction airplane. Based upon the results of these flights, GAC determined that the propeller efficiencies were not the same, which would account for another portion of the discrepancy. The data presented in this report have been adjusted for the engine recalibration and propeller efficiency differences. The corrected data still show a 10-percent increase in aerodynamic drag of the production airplane over that of the preproduction airplane. The GAC attributes the increase to aerodynamic differences between the two airplanes. These differences are listed in GAC report FAD-134-0-Va.151 (app IV). Further testing to obtain current data for use in the operator's manual is recommended to insure that the operator's manual performance data are correct.

Dual-Engine Level Flight Performance

13. Tests were conducted to determine airspeed, fuel flow, and power-required relationships to define the dual-engine level flight performance for various combinations of stores configuration, gross weight (grwt), and altitude. Level-flight drag polars were obtained using the constant pressure altitude technique. The level flight performance of the OV-1D was evaluated at pressure altitudes (Hp's) of 1,000, 5,000, and 10,000 feet. The testing at 5,000 feet was done in stores configuration C, while the other two tests were performed with full stores (configuration A).

14. Nondimensional plots of level flight performance are presented in figures 1 and 2, appendix V. The dual-engine level flight performance in generalized form is presented in figures 3 and 4. Specific range summaries for sea level (SL), 5,000 feet and 10,000 feet (standard-day conditions including the effects of stores) are presented in figures 5 through 7. Endurance summaries for the same conditions are presented in figures 8 through 10. Individual test results are presented graphically in figures 11 through 13.

15. The configuration with the least amount of drag (configuration C) resulted in higher long-range cruise speeds and greater specific ranges and endurances at all altitudes and gross weights. A maximum range comparison between both configurations at SL, 5,000 and 10,000 feet, standard-day conditions, and at a 16,000-pound gross weight is presented in table 3. An endurance comparison for the same conditions is presented in table 4.

Table 3. Range Summary.¹

Altitude (ft)	External Stores Configuration	Long-Range Cruise Speed (KTAS)	Specific Range (naut mi/lb)
SL	A	189	0.1598
SL	C	201	0.1642
5,000	A	198	0.1784
5,000	C	206	0.1868
10,000	A	204	0.2013
10,000	C	209	0.2115

¹A 16,000-pound gross weight.
 Standard-day conditions.
 Bleed air ON.
 Center of gravity at 27.2-percent MAC (mid).
 Propeller operating at optimum or 1,150 rpm,
 whichever is higher.

Table 4. Endurance Summary.¹

Altitude (ft)	External Stores Configuration	Maximum Endurance Speed (KTAS)	Fuel Flow For Engine (lb/hr)
SL	A	113	435
SL	C	114	430
5,000	A	134	425
5,000	C	134	420
10,000	A	128	380
10,000	C	128	370

¹A 16,000-pound gross weight.
 Standard-day conditions.
 Bleed air ON.
 Center of gravity at 27.2-percent MAC (mid).
 Propeller operating at optimum or 11,150 rpm,
 whichever is higher.

16. Figures 14 and 15, appendix V, show the variation of maximum level flight airspeed (V_H) with altitude for standard-day conditions at various gross weights. The results are based upon the power available as specified in the engine model specification (ref 8, app 1), including installation losses. Table 5 summarizes the maximum level flight airspeed obtainable at various gross weights, external stores, and engine power combinations. The altitude for the maximum level flight airspeed is also shown. The maximum level flight airspeed using military rated power (MRP) (30-minute limit) was approximately 11 percent higher than that obtained using normal rated power (NRP) with bleed air ON.

Single-Engine Performance

17. Single-engine performance was evaluated in stores configuration A under the test conditions as listed in table 6. The sawtooth climb method was used for the single-engine performance determination. All tests were conducted with the left engine operating at ground idle and the propeller feathered, while the right engine was operating at MRP. Zero sideslip was maintained for all tests. Test results are presented in figures 16 and 17, appendix V.

Table 5. Maximum Level Flight Airspeed.¹

Gross Weight (lb)	External Stores Configuration	Power Setting	Altitude for Maximum Speed (ft)	True Airspeed (kt)
14,000	A	Note ²	10,000	235
14,000	A	Note ³	12,000	260
14,000	C	Note ²	10,600	245
14,000	C	Note ²	12,500	270
16,000	A	Note ²	8,200	231
16,000	A	Note ³	9,600	256
16,000	C	Note ²	9,000	240
16,000	C	Note ³	10,200	267
18,000	A	Note ²	2,800	226
18,000	A	Note ³	7,700	253
18,000	C	Note ²	4,000	246
18,000	C	Note ³	8,000	270

¹Standard-day conditions.
Center of gravity at 27.2-percent MAC (mid).

²NRP, bleed air ON.

³MRP (30-minute limit).

Table 6. Single-Engine Climb Performance Test Conditions.¹

Aircraft Configuration	Average Gross Weight (lb)	Average Pressure Altitude (ft)	Average Temperature (°C)
TO	15,750	2,210	15.2
TO	16,345	1,780	10.0
CR	15,900	1,945	20.9
CR	15,970	9,100	11.9
CR	16,550	1,900	19.7

¹Left engine operating at ground idle with the propeller feathered.

Right engine operating at MRP.

18. Single-engine climb performance at sea level is summarized in figure 18, appendix V, as curves of rate of climb versus gross weight. Additional single-engine climb performance summaries are presented in figures 19 through 22 as curves of pressure altitude versus rate of climb.

19. A single-engine optimum climb performance summary at sea level is presented in table 7. It is noteworthy that, at a representative gross weight of 16,000 pounds, the airplane has a positive single-engine rate of climb of 120 feet per minute (ft/min) in the takeoff configuration at sea level on a standard day. This is a significant improvement over the preproduction airplane (-207 ft/min) as reported in reference 1, appendix I.

Table 7. Maximum Single-Engine Climb Performance.¹

Gross Weight (lb)	Airplane Configuration	Atmospheric Conditions	True Airspeed ² (kt)	Climb Rate (ft/min)
14,000	TO	Note ³	102	450
14,000	TO	Note ⁴	103	0
14,000	CR	Note ³	127	1,060
14,000	CR	Note ⁴	126	540
16,000	TO	Note ³	108	120
16,000	TO	Note ⁴	110	-310
16,000	CR	Note ³	131	710
16,000	CR	Note ⁴	134	220
18,000	TO	Note ³	112	-157
18,000	TO	Note ⁴	115	-573
18,000	CR	Note ³	137	408
18,000	CR	Note ⁴	140	-50

¹Engine operating at MRP (30-minute limit).
Center of gravity at 27.1-percent MAC (mid).
External stores configuration (A).

²Airspeed for maximum climb rate or minimum sink rate.

³Sea-level, standard-day (59°F) conditions.

⁴Sea-level, hot-day (103°F) conditions.

20. Figure 22, appendix V, shows that the aircraft does not have single engine climb capability in the takeoff configuration on a hot day with full stores. In the cruise configuration, as illustrated by figure 17, a positive climb rate is attainable, depending upon pressure altitude and gross weight. For example, at a 16,000-pound gross weight, the airplane has a single-engine climb capability up to an altitude of approximately 5,000 feet. Above that altitude, the airplane has no single-engine climb capability at that gross weight. An engine failure immediately after takeoff could result in the loss of an aircraft on a hot day, due to the fact that several seconds are required to retract the flaps and landing gear, and to accelerate to the optimum single-engine climb speed for the cruise configuration. Also, an engine failure while operating over terrain more than 5,000 feet above sea level could result in the loss of an aircraft on a hot day. The inadequate single-engine performance of the OV-1D is a shortcoming which should be corrected as soon as possible.

21. Single-engine specific range summaries for SL, 5,000, and 10,000 feet (standard-day conditions) are presented in figure 23, appendix V, for the cruise configuration. A maximum range summary at SL, 5,000, and 10,000 feet (standard-day conditions) is presented in table 8 for the cruise configuration at a gross weight of 16,000 pounds.

Table 8. Single-Engine Range Summary.¹

Altitude (ft)	Long-Range Cruise Speed (KTAS)	Specific Range (naut mi/lb)
SL	² 156	0.202
5,000	² 146	0.215
10,000	³ 169	0.268

¹A 16,000-pound gross weight.
Standard-day conditions.

Center of gravity at 27.2-percent MAC (mid).

²Airspeed is V_H at NRP, bleed air ON. Speed for maximum specific range unattainable in level flight using NRP with bleed air ON.

³Maximum level flight airspeed at MRP (30-minute limit). Speed for maximum specific range unattainable in level flight using MRP. Level flight using NRP with bleed air ON unattainable at any speed.

Takeoff and Landing

22. Takeoff and landing distances at different airspeeds were determined by using a Fairchild Flight Analyzer. These distances were corrected to SL, standard-day conditions.

23. The shortest takeoff distance at a 17,800-pound gross weight was achieved at a takeoff airspeed of 89 knots true airspeed (KTAS). At this airspeed, 1,398 feet were required for liftoff, and an additional 510 feet were required to clear a 50-foot obstacle. To achieve the takeoff attitude, it was necessary for the pilot to depress the nose-gear shock strut by moving the control stick forward at approximately 3 knots below the rotation speed to use the rebound from the shock strut to aid rotation as the control stick was pulled aft. Once the rotational takeoff attitude was achieved, it was necessary for the pilot to move the control stick forward in order to prevent overrotation. Although the airplane was controlled easily at 89 KTAS, the use of the nose strut rebound technique to achieve takeoff attitude is not presently recommended as an operational procedure.

24. The shortest landing distance at a 16,000-pound gross weight was achieved at an approach airspeed of 95 KTAS, with a landing sink rate of approximately 600 ft/min. Full reverse thrust was applied immediately after touchdown and held until the aircraft came to a stop. Additionally, braking was used after the ground speed had decreased to approximately 30 knots. Using this landing technique, the ground roll was 700 feet. An additional 750 feet were required from the point where a 50-foot obstacle was cleared to touchdown.

Stall Performance

25. Stall performance tests were conducted to determine the stall speed in stores configuration A in the power approach and landing configurations. The aircraft was decelerated at approximately 1 knot per second until the stall occurred. These tests were conducted at an average pressure altitude of 6,425 feet and at the mid cg loading. The variation in stall speed versus gross weight is shown in figure 24, appendix V.

26. At a representative gross weight of 16,000 pounds, the OV-1D stall speed in the landing configuration was 79 knots calibrated airspeed (KCAS) and was 68 KCAS in the power approach configuration. The stall speed decreased approximately 2.5 knots for each 1,000-pound decrease in gross weight in the landing configuration, and 2.1 knots per 1,000 pounds in the power approach configuration.

27. The shaft horsepower available and fuel-flow rate of a specification engine, including all installation losses, are illustrated in figures 25 through 27, appendix V. Figures 28 through 30 illustrate the variation of net thrust with airspeed for an installed specification engine (propeller efficiency and installation losses included) for various power settings. The variation of fuel flow with airspeed is illustrated in figures 31 through 33 for various power settings. Figure 34

presents the engine inlet pressure recovery data which were furnished by the airframe manufacturer. Figures 35 through 41 show the performance of the installed test engines.

CONCLUSIONS

GENERAL

28. The following conclusions were reached upon completion of the performance tests of the OV-1D airplane:

a. The performance of the OV-1D airplane is satisfactory for accomplishment of the surveillance mission.

b. One performance shortcoming was identified during the evaluation.

SHORTCOMING AFFECTING MISSION ACCOMPLISHMENT

29. Inadequate single-engine performance is a shortcoming, correction of which is desirable for improved aircraft operation (para 20).

RECOMMENDATIONS

30. The inadequate single-engine performance of the OV-1D should be corrected as soon as possible (para 29).
31. Further testing should be conducted on the OV-1D in order to produce current data for the operator's manual (para 12).

APPENDIX I. REFERENCES

1. Final Report, USAASTA, Project No. 68-43, *Army Preliminary Evaluation, Preproduction OV-1D (Mohawk)*, March 1970.
2. Letter, AVSCOM, 11 February 1970, subject: AVSCOM Test Request for Production OV-1D APE II, ASTA Project No. 70-03.
3. Military Specification, MIL-F-8785(ASG), Amendment 2, *Flying Qualities of Piloted Airplanes*, 17 October 1955.
4. Detail Specification, Grumman Aerospace Corporation, AMC-SS-2682, *Detail Specification for Model OV-1D Airplane (Two Turboprop Engines), Fiscal 1968 Procurement*, 10 June 1969.
5. Message, AVSCOM, AMSAV-R-F, Unclas, 13 July 1970, subject: Safety-of-Flight Release for Conduct of OV-1D APE II.
6. Final Report, USAASTA, Project No. 70-03, *Army Preliminary Evaluation II, OV-1D Airplane*, March 1971.
7. Test Plan, USAASTA, Project No. 70-03, *Army Preliminary Evaluation II, OV-1D Airplane*, May 1970.
8. Specification, Lycoming Division of Avco Corporation, No. 104.39, *T53-L-701 Turboprop Engine*, 30 September 1960, with revision, 15 February 1969.

APPENDIX II. INSTRUMENTATION

COCKPIT

Mach number (test system)
Airspeed (test system)
Altitude (test system)
Rudder pedal force
Angle of sideslip (nose boom)
Visual acceleration
Time correlation
Frame counter
Angle of attack
Fuel quantity
Outside air temperature¹
Left/right torque pressure
Left propeller rpm¹
Right propeller rpm¹
Left/right fuel flow¹
Left/right engine EGT¹
Left/right gas producer speed^{1 3}

PHOTOPANEL

Airspeed (test system)
Altitude (test system)
Time correlation
Frame counter
Fuel quantity
Outside air temperature
Left/right torque pressure
Left propeller rpm
Right propeller rpm
Left/right fuel flow
Left/right engine EGT
Left/right gas producer speed³

MAGNETIC TAPE

Rudder pedal force²
Angle of sideslip (nose boom)²
Time correlation²
Angle of attack²
Lateral stick position²

Lateral stick force²
Longitudinal stick force²
Yaw rate²
Pitch rate²
Roll rate²
Bank angle²
Pitch attitude²
Center rudder position²
Elevator position²
Left outboard aileron position²
Center-of-gravity normal acceleration²
Pilot's voice²
Fairchild camera pulse

¹ Production system.

² Recorded at the ground station when telemetry was selected. ³

³(N₁).

APPENDIX III. DATA REDUCTION PROCEDURES

INTRODUCTION

1. Flight test performance data were collected from photopanel and magnetic tape recording devices installed and maintained by GAC. Photopanel and tape data were reviewed by GAC and Army engineers to ensure that stabilized flight data were obtained. The raw data were submitted to GAC's computer facility, which generated the required performance parameters utilizing GAC's Report No. CSD-68-AV-725-039, 8 October 1968, *OV-1D Pre-Production No. 2 Aircraft Program Specifications*. The lift coefficient (C_L) is defined as:

$$C_L = \frac{L}{1/2 \rho S V_T^2} \quad (1)$$

Where: L = lift (lb)

ρ = air density (lb-sec²/ft⁴)

S = planform area (ft²)

V_T = true airspeed (ft/sec)

The coefficient of drag (C_D) is defined as:

$$C_D = \frac{D}{1/2 \rho S V_T^2} \quad (2)$$

Where: D = drag (lb)

Thrust (T) is corrected to account for ram drag (F_r), ram ejector drag (F_{rj}), slipstream drag effects (F_{ss}), and excess thrust due to acceleration and altitude variation (F_1), and is defined as:

$$T = \frac{550 \text{ ETHP}}{V_T} - F_1 - F_{ss} - F_{rj} \quad (3)$$

Where: ETHP = engine thrust horsepower (hp)

Ram drag is defined as:

$$F_r = \frac{(W_{aL} + W_{aR})}{g} V_T \quad (4)$$

Where: W_{aL} = left engine airflow at the engine's compressor inlet (lb/sec)

W_{aR} = right engine airflow at the engine's compressor inlet (lb/sec)

Ram ejector drag is defined as:

$$F_{rj} = 0.045 F_r \quad (5)$$

Slipstream drag effects are defined:

$$F_{ss} = 0.01 F_p \quad (6)$$

Where: F_p = total propeller thrust (lb)

Excess thrust due to acceleration and altitude variations is defined as:

$$F_1 = \frac{W_t \left(\frac{dV_T}{dt} \right)}{g} + \frac{W_t \left(\frac{dH_P}{dt} \right) \left(\frac{T_a}{T_{aSTD}} \right)}{V_T} \quad (7)$$

Where: W_t = test gross weight (lb)

$$\frac{dV_T}{dt} = \text{acceleration (ft/sec}^2\text{)}$$

$$\frac{dH_P}{dt} = \text{altitude variation (ft/sec)}$$

and, $\frac{T_a}{T_{aSTD}}$ = ratio of test ambient temperature (T_a) to standard-day ambient temperature (T_{aSTD}), where temperatures are degrees Kelvin ($^{\circ}K$)

LEVEL FLIGHT

2. For a steady-state level flight, lift and weight are equal. The coefficient of lift becomes:

$$C_L = \frac{W}{1/2 \rho S V_T^2} \quad (8)$$

For steady-state level flight, the drag and thrust are equal. The drag coefficient becomes:

$$C_D = \frac{T}{1/2 \rho S V_T^2} \quad (9)$$

The generalized power parameter (THP_{iw}) is defined as:

$$THP_{iw} = THP(\sigma)^{1/2} \left(\frac{W_s}{W_t} \right)^{3/2} \quad (10)$$

Where: THP = thrust horsepower required (hp)

σ = ratio of air density at test conditions to air density at standard-day conditions

W_s = standard gross weight to which THP_{iw} is being corrected (lb)

The generalized speed parameter (V_{iw}) is defined as:

$$V_{iw} = V_T(\sigma)^{1/2} \left(\frac{W_s}{W_t} \right)^{1/2} \quad (11)$$

Where: V_{iw} is in knots

The specific range in nautical air miles per pound of fuel (NAMPP) is defined as:

$$\frac{\text{Naut Mi}}{\text{lb}} = \frac{V_T}{W_f 1.689} \quad (12)$$

Where: W_f = amount of fuel used per unit of time (lb/hr)

The fairing of the curve for NAMPP versus V_T is calculated using NAMPP values for a specification engine and are conservative by 5 percent.

The fairing of the curve for THP versus V_T is calculated from the fairing of C_L^2 versus C_D . The standard gross weight, average pressure altitude, and average ambient temperatures are known, and V_T is varied to gain values of C_L^2 . Corresponding values of C_D are obtained from the C_L^2 versus C_D curve. The thrust required to maintain level, steady flight is calculated from C_D and converted to the thrust horsepower required (THP_{req}) by the equation:

$$THP_{req} = \frac{T V_T}{550} = 1/2 \rho S V_T^2 C_D \frac{V_T}{550} \quad (13)$$

The calculated values of THP_{req} and V_T are plotted to generate the curve. The maximum level flight speed (V_H) is calculated using the C_L^2 versus C_D curve and specification engine data for military rated power. A THP_{req} versus V_T curve is generated from the C_L^2 versus C_D curve. The V_T at which THP_{req} is equal to the maximum thrust horsepower available is the maximum level flight speed for the gross weight and standard-day altitude for which the calculations are made. The long-range cruise speed is the highest speed for which the specific range based on the specification engine is at 99 percent of its maximum value. A speed for maximum endurance was defined at minimum fuel flow.

SINGLE-ENGINE CLIMB PERFORMANCE

3. For climb performance, lift and weight are assumed to be equal. The coefficient of lift becomes:

$$C_L = \frac{W}{1/2 \rho S V_T^2} \quad (14)$$

For climb performance the drag and thrust are equal. The drag coefficient becomes:

$$C_D = \frac{T}{1/2 \rho S V_T^2} \quad (15)$$

Rate of climb (R/C) is defined as:

$$R/C = \frac{(THP_a - THP_{req}) \times 33,000}{W_t} \text{ (ft/min)} \quad (16)$$

Where: THP_a = thrust horsepower available from a specification engine

THP_{req} = thrust horsepower required for level flight computed from the single-engine C_L^2 versus C_D curve

STALL PERFORMANCE

4. Stall performance is evaluated in terms of the maximum C_L obtained at stall corrected to a standard deceleration rate of 0.5 knot per second. The corrected lift coefficient ($C_{L0.5}$) is defined as:

$$C_{L0.5} = C_L - \frac{dC_L}{d\left(\frac{dV_i}{dt}\right)} \left[\left(\frac{dV_i}{dt}\right)_{test} - 0.5 \right] \quad (17)$$

Where: $\frac{dC_L}{d\left(\frac{dV_i}{dt}\right)} = 0.13 \text{ (1/kt/sec)}$

C_L = calculated using V_T

V_i = indicated airspeed (kt)

$\left(\frac{dV_i}{dt}\right)_{test}$ = absolute value of the time rate of change of the test indicated airspeed (kt/sec)

TAKEOFF AND LANDING

5. Takeoff and landing data were collected from photopanel film and Fairchild Flight Analyzer photographs. Airspeeds were obtained from the photopanel data and distances from the Fairchild Flight Analyzer photographs.

APPENDIX IV. DRAG INVESTIGATION

GRUMMAN AEROSPACE CORPORATION

FLIGHT ACCEPTANCE DEPARTMENT

VEHICLE FLIGHT TEST

FLIGHT SCIENCES DATA RELEASE NO. FAD-134-0-Va.151

19 November 1970

From: Vehicle Flight Test

To: W. Bedell F. Gauch
V. Crafa L. Keer
N. Danneffer J. Lueck
G. Dery A. Pugliese
F. Finnerty A. Ridley

Subject: OV-1D NO. 5 POST APE AERODYNAMIC PERFORMANCE DRAG INVESTIGATION

Reference: (a) OV-1D No. 5 Performance Investigation Briefing
FAD-70-06-732-10M-167, dated 29 September 1970.

Summary:

Results from GAC aerodynamic performance flight tests and the Army Preliminary Evaluation (APE) of OV-1D No. 5 showed a 23% drag rise when compared to previous FY-67/OV-1C and Pre-Production OV-1D test aircraft in similar store configurations. Since the estimated drag difference is negligible between these aircraft, a series of specific performance flights were flown to investigate this anomaly.

Results of these flights showed that basic OV-1D aerodynamic performance has changed 7.5% over FY-67/OV-1C and Pre-Production OV-1D test aircraft.

Apparent variations in the magnetostrictive torque indicating system, and inconsistencies within the Hamilton Standard 53C51/7125 propeller efficiency chart for a Hamilton Standard 53C51-27/7157C-6 propeller, caused the remaining 15.5% drag rise encountered during the OV-1D No. 5 aerodynamic performance flight test evaluation and the Army Preliminary Evaluation.

Discussion:

The test vehicle was OV-1D No. 5 (S/N 68-16990). For the post APE drag investigation, the aircraft was flown in the FY-67 configuration (two (2)-150 gallon tanks). Airspeed and altitude were obtained from the production airspeed system. Calibrated Lycoming T53-L-701 engines were used incorporating the "magnetostrictive" torque system.

A total of four flights were flown during the post APE drag investigation. Flights 92 and 93 were flown with Hamilton Standard 53C51-27 propellers with 715C-6 blades incorporating new anti-erosion propeller sheaths located on the outer blade span at the leading edge of the blade airfoil. These are production OV-1D propellers except the right hand propeller was strain gaged for the Hamilton Standard propeller stress survey conducted early in the production flight evaluation program. Flights 94 and 95 were flown with Hamilton Standard 53C51-23/7125-6 propellers. These propellers are representative of the propellers used during the FY-67/OV-1C and Pre-Production OV-1D flight programs.

The mission requirements for the post APE drag investigation consisted of dual engine, cruise configuration drag polars at 1000 ft and 15000 ft, engine calibrations at 5000 ft and power-off glide polars with the new Hamilton Standard 53C51-27/7157C-6 propeller. The dual engine drag polars at 1000 ft and 15000 ft were repeated with the 53C51-23/7125-6 propeller. Engine ground calibrations were performed at the start of the flight series and a torque system checkout ground run was conducted by Lycoming at the end of the investigation.

Engineering Coordination:

Vehicle Flight Test conducted a series of briefings to coordinate the planned technical approach to the problem. Briefings were held with GAC Engineering (representing Stuart engineering), AVCO Lycoming Division and Hamilton Standard Division of United Aircraft. Reference (a) delineated the results of the engineering briefing. The results of the Lycoming and Hamilton Standard briefings are as follows.

A. AVCO Lycoming (October 1, 1970)

1. Technical agreement was sought with Lycoming on correction methodology employed when comparing GAC installed ground run data to the un-installed Lycoming calibration. Lycoming agreed that the GAC data appeared to indicate a torquemeter calibration shift. However, their final position would be made after the re-calibration of the test engines in their test cell.

B. Hamilton Standard (October 2, 1970)

1. Hamilton Standard agreed that the area of the 53C51-23/7125-6 propeller efficiency map which shows the largest drag polar variation is hard to define and extremely sensitive to horsepower coefficient change.
2. Hamilton Standard also indicated that:
 - o The propeller anti-erosion sheath should give no more than a 0.5% to 1.0 % efficiency degradation.
 - o Manufacturing tolerances could result in another $\pm 0.5\%$ to $\pm 1.0\%$ efficiency variation.
 - o They had experienced as much as a 3% to 10% efficiency degradation with a similar strain gaged propeller (not a 53C51-27) during tunnel tests.

Test Results:

The enclosed data are broken into three categories:

1. Engine Summary
11. Propeller Summary
111. Drag and Range Summary

CATEGORY 1: ENGINE SUMMARY

Figures 1 and 2 present referred shaft horsepower vs. referred gas producer speed relationships for engines S/N's 30001 and 30003 respectively. These data show Lycoming's initial water-brake uninstalled S.L./Static calibrations at an optimum power turbine speed. The data show an unexplained 10% shaft horsepower variation between Lycoming's calibration and GAC's calibration at low power levels.

Because of the apparent shift in engine calibration, Lycoming was asked to perform a torque system checkout. This is accomplished with a unique Lycoming "breakout box" specifically designed to test their magnetostrictive system. The equipment consists of a digital voltmeter incorporating a Lycoming-designed indicator filter network and a power supply unit. Results of this checkout showed no measurable errors within the electrical torque indicating system. However, this checkout does not rule out the possibility of a torquemeter calibration shift within the engines. The torque system checkout can only check the components of the torque indicating system, i.e., power supply and indicator. The equipment cannot checkout the waterbrake torque vs. milliamp signal relationship which represents the torquemeter calibration.

CATERORY 1: (continued)

On the basis of the torquemeter calibration being the only undefined area of the torque system checkout, the test data showing a shift in the shaft horsepower vs. gas producer speed relationship, and Lycoming's technical agreement that the data appeared to indicate a torquemeter calibration shift, VFT proceeded to generate an adjusted torquemeter calibration for both test engines.

Figures 1 and 2 show the high horsepower values indicated in the installed engine calibrations as compared with the Lycoming dynamometer calibrations. The errors were applied to the original Lycoming calibrations to correct torquemeter indicated values.

Figures 3 and 4 present the adjusted torquemeter calibrations. These curves were input into the GAC computer program and applicable GAC and Army APE performance data were rerun. Figures 5 through 10 present the corrected (and expected) gas generator performance characteristics for the T53-L-701 test engines.

Figures 5 and 6 present referred shaft horsepower vs. referred gas producer speed relationships for each test engine. Comparisons of Lycoming uninstalled optimum power turbine speed calibration and the GAC installed ground run data are shown. The GAC data are shown at Max increase prop. RPM with power extraction at 4900 ft. altitude and 0.293 Mach No. The Lycoming Sea Level calibration is shown for reference, as well as a correction of the calibration to flight conditions using a "Model Spec" adjustment. The Mach effect increment is in good agreement with the "Model Spec" at high gas producer speeds. At low gas producer speeds, "Model Spec" agreement no longer occurs since flight power turbine speeds were off optimum.

Figures 7 and 8 present referred fuel flow vs. referred gas producer speed relationships for both test engines. Also shown in the data is a Lycoming "Model Spec" adjustment to the test cell calibration data. Examination of both the "Model Spec" corrected data and the test data suggest the Mach effect is insignificant.

Figures 9 and 10 present the test engines shaft horsepower vs. observed fuel flow characteristics. Because of left engine flow meter problems having occurred during the test program, right engine fuel flow was used for the calculation of aircraft specific range in the drag and range section of this report (Figures 18 and 19).

CATERORY II: PROPELLER SUMMARY

All data in this section have been corrected for the torquemeter variations.

All propeller efficiencies have been calculated through the HSD 53C51/7125-6 propeller efficiency map (HSD curve No. 27769 dated March 10, 2960).

Figures 11 through 14 present dual engine drag polars at 1000 ft and 15000 ft, respectively, for two different sets of propellers. These flight conditions were selected to produce diverse power coefficient/advance ratio combinations. This technique allows relative comparisons of accuracy in the propeller efficiency map.

Figures 11 and 12 are presented for the purpose of verifying the existence of relative inaccuracies in the propeller efficiency map. Figure 11 presents data flown with the Hamilton Standard 53C51-27 propeller at two test altitudes. The data show a significant "altitude" variation. Inconsistencies within the propeller efficiency map for the HSD 53C51-27/7157C-6 propellers result in 7% to 14% differences in apparent drag with the same propeller.

Figure 12 presents the HSD 53C51-23/7125 propeller at the two test altitudes. A slight efficiency variation exists with this propeller.

Figure 13 shows two distinct drag polars at approximately the same flight conditions. The high drag polar was flown with (HSD 53C51-27/7157C-6 (with blade sheaths and strain gages). The low drag line was flown with the HSD 53C51-23/7125 propellers. The differences between the drag polars are attributed to propeller efficiency variation between the -27 and -23 propellers. The HSD 53C51-27/7157C-6 propellers are 6% less efficient when operating in the same area of the 53C51/7125-6 propeller efficiency map (approximately 1000 ft) as compared to the HSD 53C51-23/7125-6 propellers. This is consistent with what Hamilton Standard quotes as a possible maximum percent variation.

Figure 14 presents the same relationship as shown in Figure 13. However, these polars were flown at 15000 ft which also means a distinctly different area of the propeller efficiency map. The data show good agreement between the two sets of propellers.

Apparently the drag data at 15000 ft for both sets of propellers correspond to a region of the propeller efficiency map which is more accurately defined than the region corresponding to the 1000 ft drag polar data.

CATEGORY II: (Continued)

It can be concluded at this time that the HSD 53C51/7125 propeller efficiency map is not representative of the OV-1D/HSD 53C51/7157C-6 production propellers at all flight conditions.

Figure 15 presents a relationship of drag coefficient vs. true pressure altitude as a function of lift coefficient squared, for the HSD 53C51-27 and the HSD 53C51-23 propellers.

Figure 16 presents the apparent change in drag coefficient (ΔC_D) between the HSD 53C51-23 propellers and the HSD 53C51-27 propeller vs. true pressure altitude as a function of lift coefficient squared. This propeller correction is used to correct HSD 53C51-27 drag data to the HSD 53C51-23 propeller drag levels.

Figure 17 presents a power-off glide polar for reference purposes. This polar was generated by flying at flight idle power with the propellers feathered. Propeller windmilling drag and flight jet thrust have been accounted for. The data show good agreement with the FY-67 power-on polar at low lift coefficients. At C_L^2 values above 0.8, power effects become apparent. These data present the power-off polar based on aerodynamic pressure drag only (no power effects). The good agreement with FY-67 data suggests little aerodynamic difference between OV-1D and OV-1C test aircraft.

CATEGORY III: DRAG AND RANGE SUMMARY

Figure 18 compares the OV-1D No. 5 and FY-67/OV-1C dual engine drag polars computed at 5000 ft altitude. Army APE flight 72 is used as an example. Drag polar "A" presents the as-flown OV-1D drag polar with no corrections incorporated (25% difference). Drag polar "B" incorporates the adjusted torquemeter calibrations (13%). Drag polar "C" incorporates the HSD-53C51-27 propeller correction (see Figure 16) (2.5%). Drag polar "D" accounts for the AN/ALQ-67 and AN/ALQ-80 store drag and presents itself in the FY-67 two (2) - 150 gallon drop tank configuration (2%). The difference between drag polar "D" and drag polar "E" represents the measureable differences between the OV-1C S/N 67-18897 aircraft (7.5% difference). All comparisons are made at a lift coefficient squared of 1.0.

CATEGORY III: (Continued)

The external differences between the FY67/OV-1C and Production OV-1D aircraft are as follows:

ITEM	DESCRIPTION	LOCATION
1	Two (2) IR Fairings (Bubbles)	Lower-Fwd-R.H. Side Fuselage
2	KA-60 Camera Fairing (Blister)	Bottom-Aft-Fuselage
3.	Larger Nacelle Airscoops (Two)	Top-Mid-Nacelles
4.	Larger Oil Cooler Inlets	Bottom-Fwd-Nacelles
5.	Engine Compartment Discharge Probes (Four per Nacelle)	Bottom-Fwd-Nacelle
6.	T53-L-701 Propeller Shaft Extension - (One inch due to gear box)	Prop Spinner
7.	ARC 114 (VHF-FM) Antenna	Top-Fwd Fuselage
8.	ARC 115 (VHF/UHF) Antenna	Bottom-Aft-Fuselage
9.	ARC 116 (VHF/UHF) Antenna	Bottom-Aft-Fuselage
10.	APR-26 Antenna	Bottom-Aft-Fuselage
11.	AN/APN 39 Loop Antenna	Top-Mid-Fuselage
12.	Two AN/APR-25 Antenna	Fuselage Tailcone

Figure 19 presents aircraft cruise performance for the symmetrical store configuration (2-150 gallon drop tanks plus ALQ-67 and ALQ-80) in the form of specific range for a gross weight of 16500 lbs at 5000 ft altitude. The calculated cruise performance line is based on power required developed from drag polar "B" of Figure 18 and the right engine referred fuel flow vs. referred shaft horsepower relationship. The scatter of the test data corresponds to a possible reading error of the production fuel flow indicator of about 25 Lbs/Hr. The data indicate good agreement between the specific range calculated from the drag polar and engine data, and the directly observed test data (test fuel flow and test airspeed). Figure 20 shows a similar comparison for FY-67/OV-1C data. Note that similar "data scatter" exists. While the drag polar comparison of Figure 18 yields a 5.5% increase in fuel flow, the range data of Figures 19 and 20 show a range decrement of 6.3%. This is considered to be excellent agreement between drag and range data.

Conclusions

- 1) Basic OV-1D aerodynamic performance has changed 7.5% over FY-67/OV-1C and Pre-Production OV-1D test aircraft.
- 2) Variations in the magnetostrictive torque system produce up to 15% difference in shaft horsepower when compared to Lycoming's original engine calibrations.
- 3) Inconsistencies within the HSD 53C51/7125 propeller efficiency map produce up to 14% drag polar variations at low altitudes.
- 4) With engine corrections incorporated, OV-1D aircraft performance has been determined within acceptable test accuracy.
- 5) Propeller efficiency inconsistencies can be compensated for if aircraft "drag" is defined as a function of altitude.

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APPENDIX V. TEST DATA

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Figure 1. Dual-Engine Level Flight Performance.

OV-10 USA S/N 68-16990

Symbol:	○	□
Average Gross Weight:	17,130 lb	17,190 lb
Average Pressure Altitude:	1,000 ft	10,000 ft
Average Outside Air Temperature:	21.1°C	11.0°C
External Store Configuration:	A	↑
Average Center of Gravity:	27.4% MAC (mid)	27.2% MAC (mid)
Propeller Speed:	1500 rpm	1500 rpm

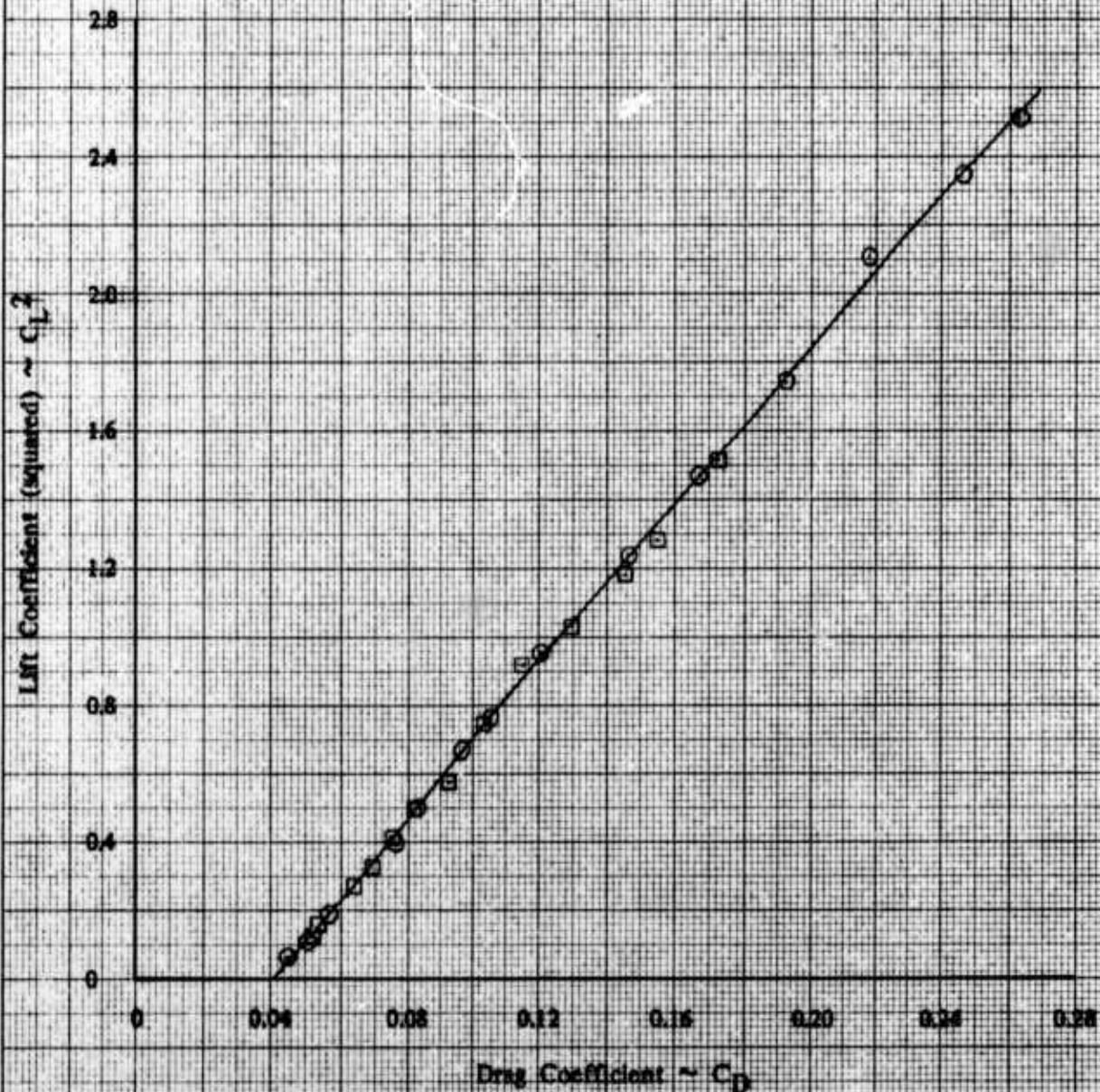
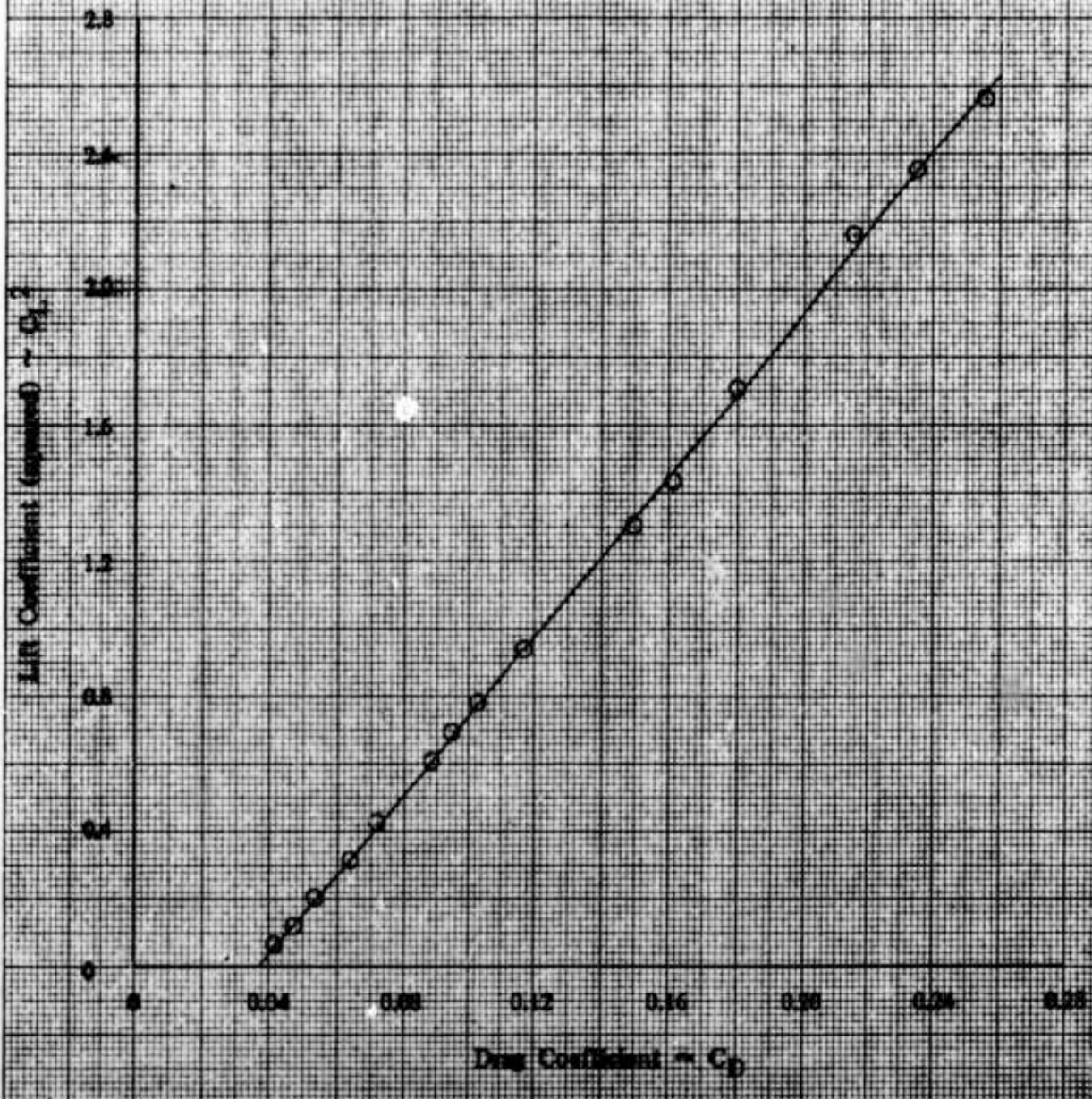


Figure 2. Dual-Engine Level Flight Performance

OV-10 USA S/N 68-16990

Symbol:	○
Average Gross Weight:	16,650 lb
Average Pressure Altitude:	5,000 ft
Average Outside Air Temperature:	11.8°C
External Store Configuration:	C
Average Center of Gravity:	17.2% MAC (mid)
Propeller Speed:	1,600 rpm



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Figure 3. Dual-Engine Level Flight Performance.

OY-10 USA S/N 68-16990

Standard Weight: 16,000 lb

Symbol	○	◐
Average Gross Weight	17,138 lb	17,199 lb
Average Pressure Altitude	1,000 ft	10,000 ft
Average Center of Gravity	27.4% MAC (mid)	27.2% MAC (mid)
External Store Configuration	A	A
Average Outside Air Temperature	21.1°C	11.0°C
Propeller Speed	1,600 rpm	1,600 rpm

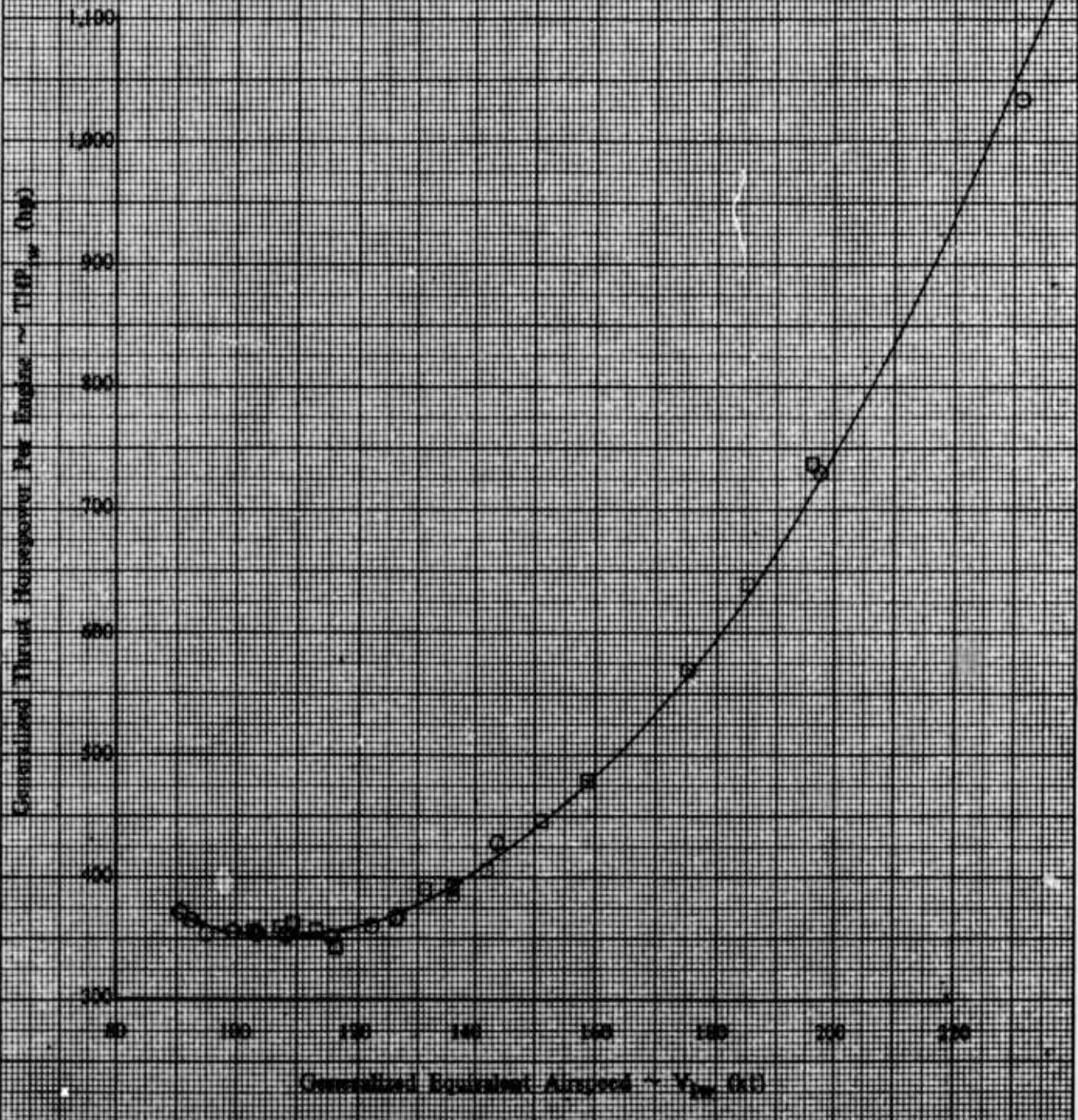


Figure 4. Dual-Engine Level Flight Performance.

OY-1D USA S/N 68-16990

Standard Weight: 16,500 lb

Average Gross Weight:	16,650 lb
Average Pressure Altitude:	5,000 ft
Average Center of Gravity:	27.3% MAC (mid)
External Store Configuration:	C
Average Outside Air Temperature:	11.8°C
Propeller Speed:	1,600 rpm

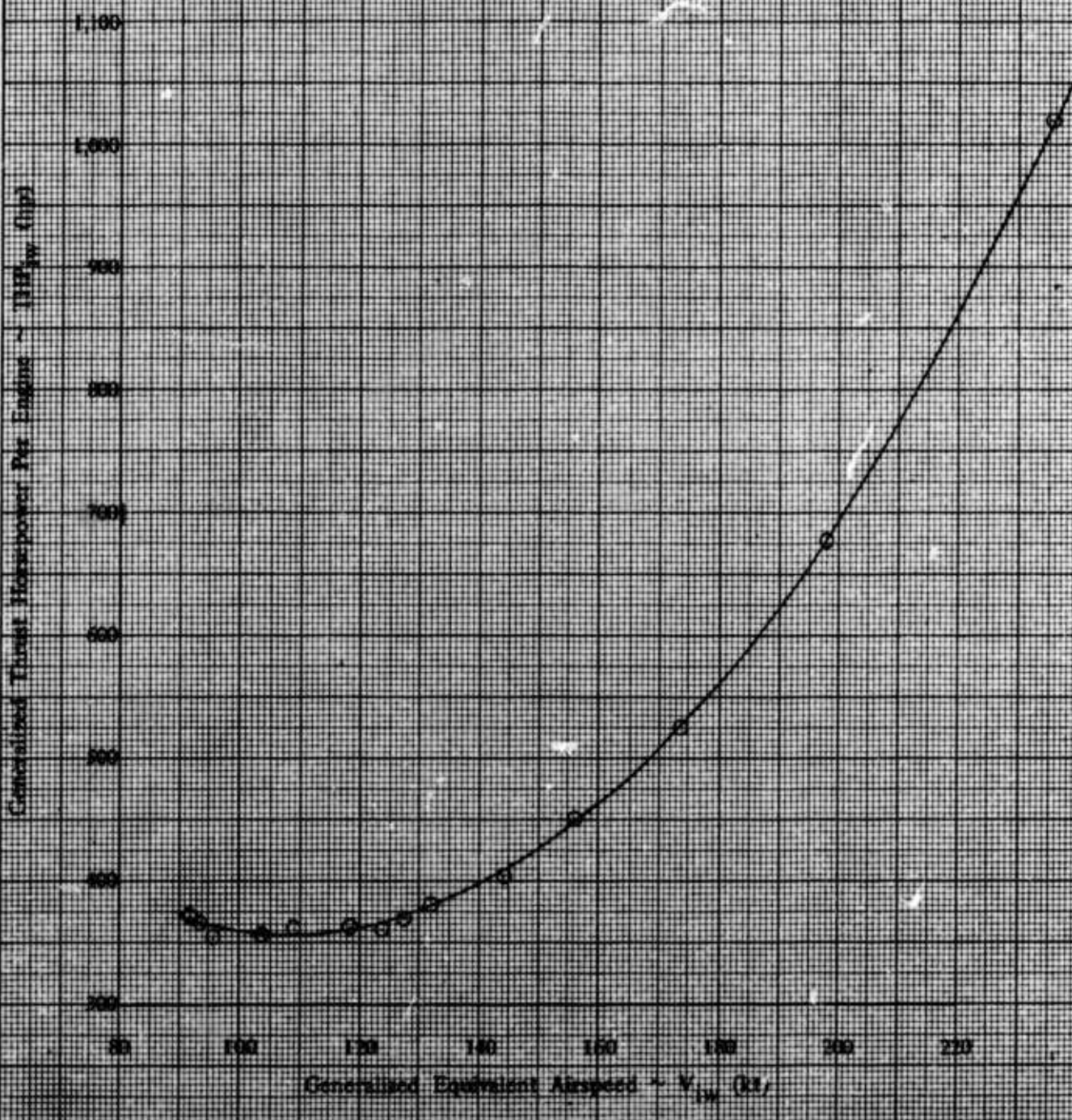


Figure 3. Level-Flight Range Summary.

Dual-Engine OV-10 USA S/N 68-16990

Standard-Day Conditions

Sea Level

Center of Gravity: 27.2% MAC (mid)

- Note:
1. Curves derived from figures 1, 2, and 31.
 2. Specific range based on 1.05 x fuel-flow specification (Fig 28).
 3. Bleed air ON.
 4. Long-Range cruise speed defined at 0.99 maximum nautical miles per pound of fuel.
 5. Specification fuel flow based on optimum power turbine speed off optimum at propeller speed less than 1,500 rpm.

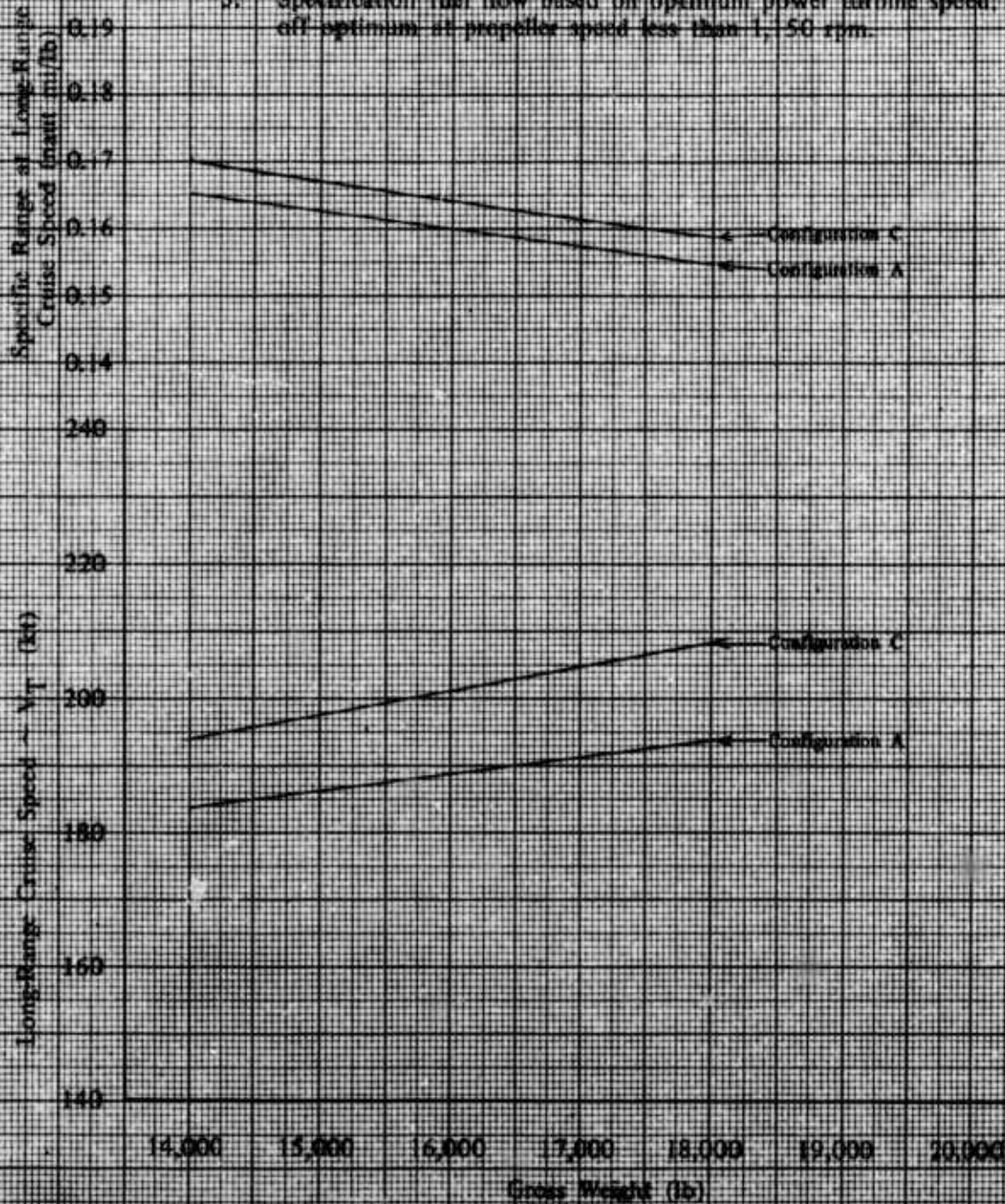


Figure 6. Level-Flight Range Summary.

Two-Engine OV-10 USA SN 68-16990

Standard-Day Conditions

Pressure Altitude: 5,000 ft
 Center of Gravity: 27.2% MAC (mid)

- Note:
1. Curves derived from figures 1, 2, and 32.
 2. Specific range based on 1.05 x fuel-flow specification. (fig. 29).
 3. Bleed air ON.
 4. Long-Range cruise speed defined at 0.99 maximum nautical miles per pound of fuel.
 5. Specification fuel flow based on optimum power turbine speed; off optimum at propeller speed less than 1,150 rpm.

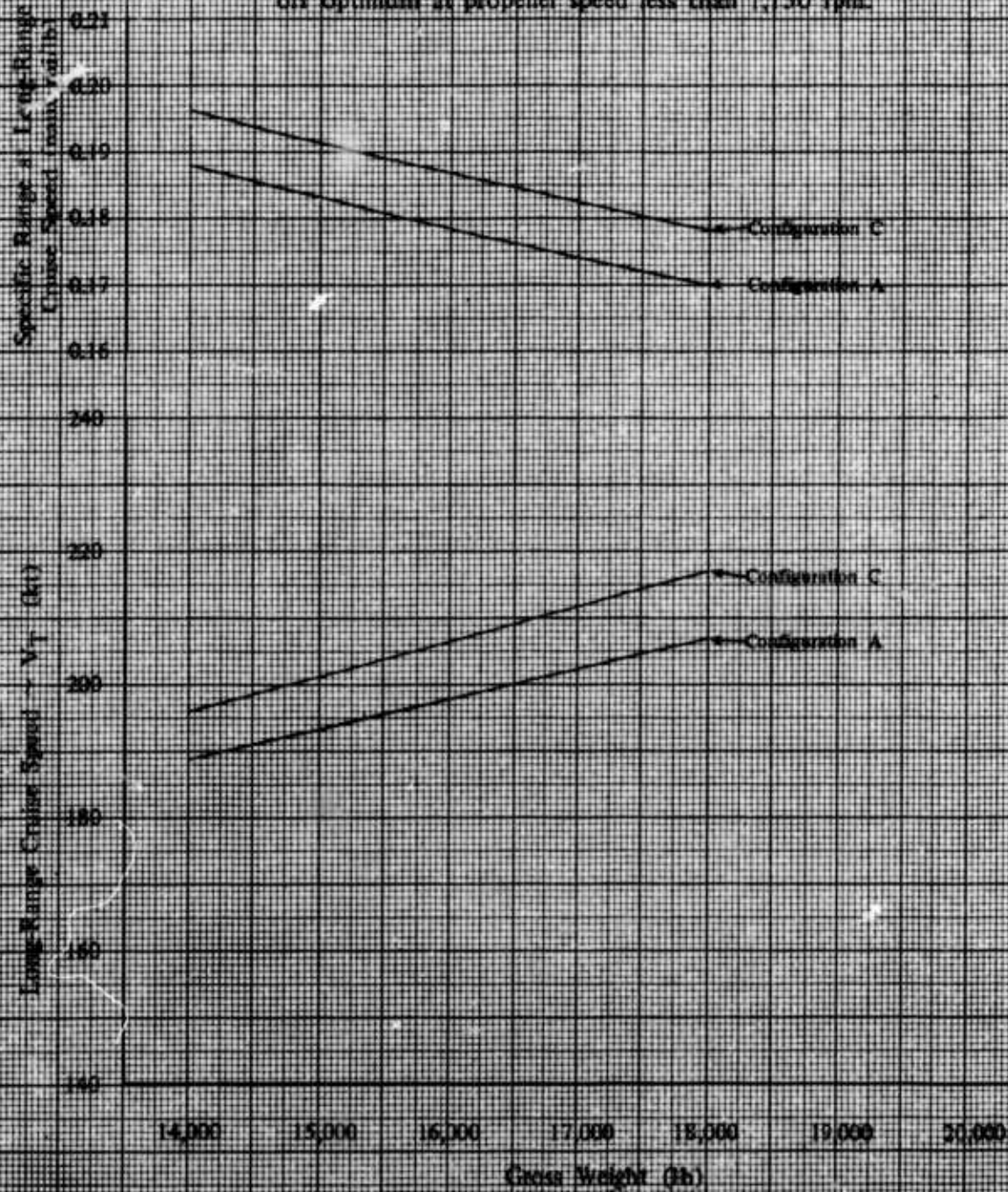


Figure 7. Level-Flight Range Summary

Dual-Engine OV-10 USA S/N 68-16990

Standard-Day Conditions

Pressure Altitude:

10,000 ft

Center of Gravity:

27.2% MAC (mid)

Note

1. Curves derived from figures 1, 2, and 33.
2. Specific range based on 1.05 x fuel-flow specification. (fig. 30).
3. Bleed air ON.
4. Long-Range cruise speed defined at 0.99 maximum nautical miles per pound of fuel.
5. Specification fuel flow based on optimum power turbine speed; off optimum at propeller speed less than 1,500 rpm.

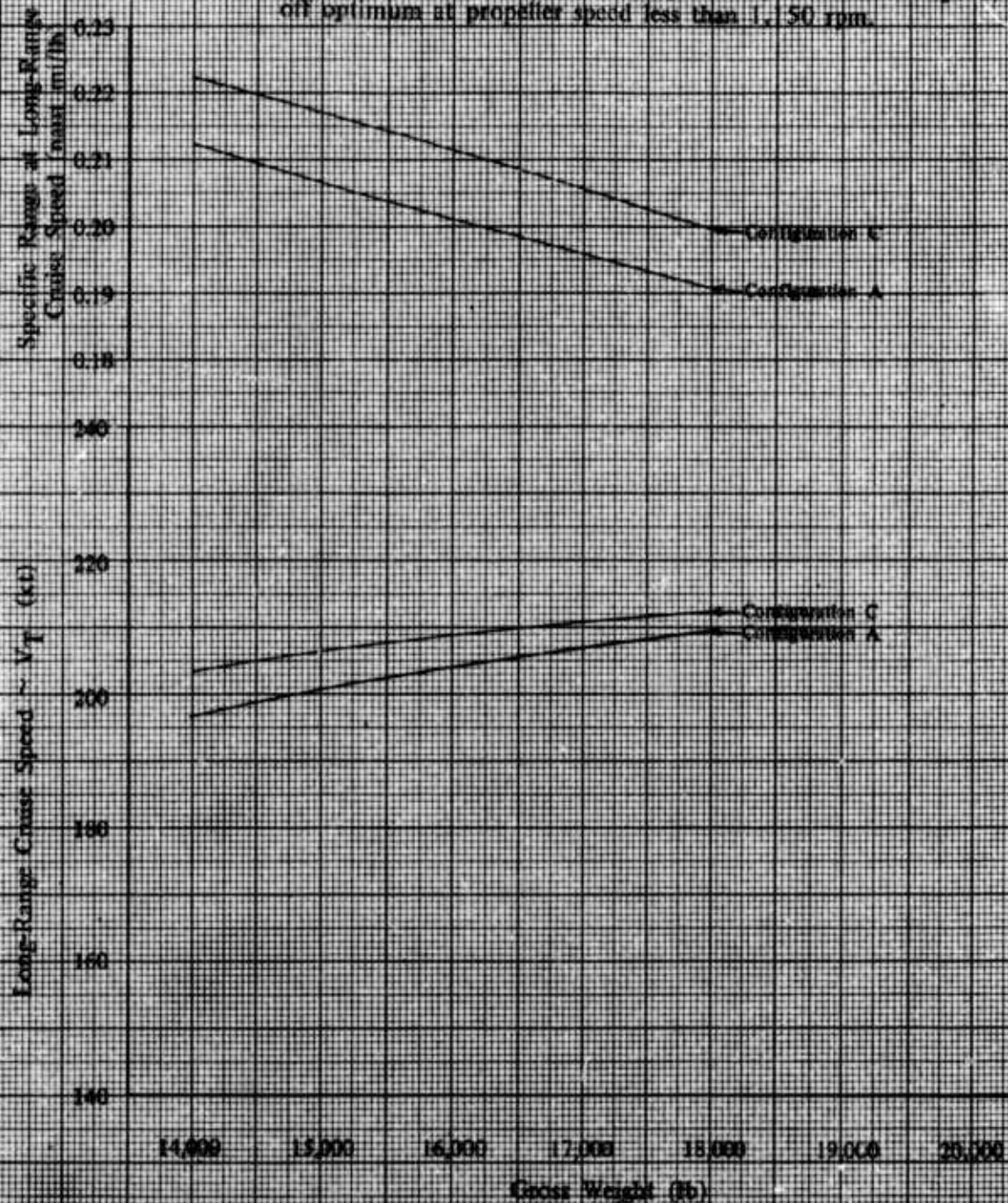


Figure 8. Maximum Endurance Summary.

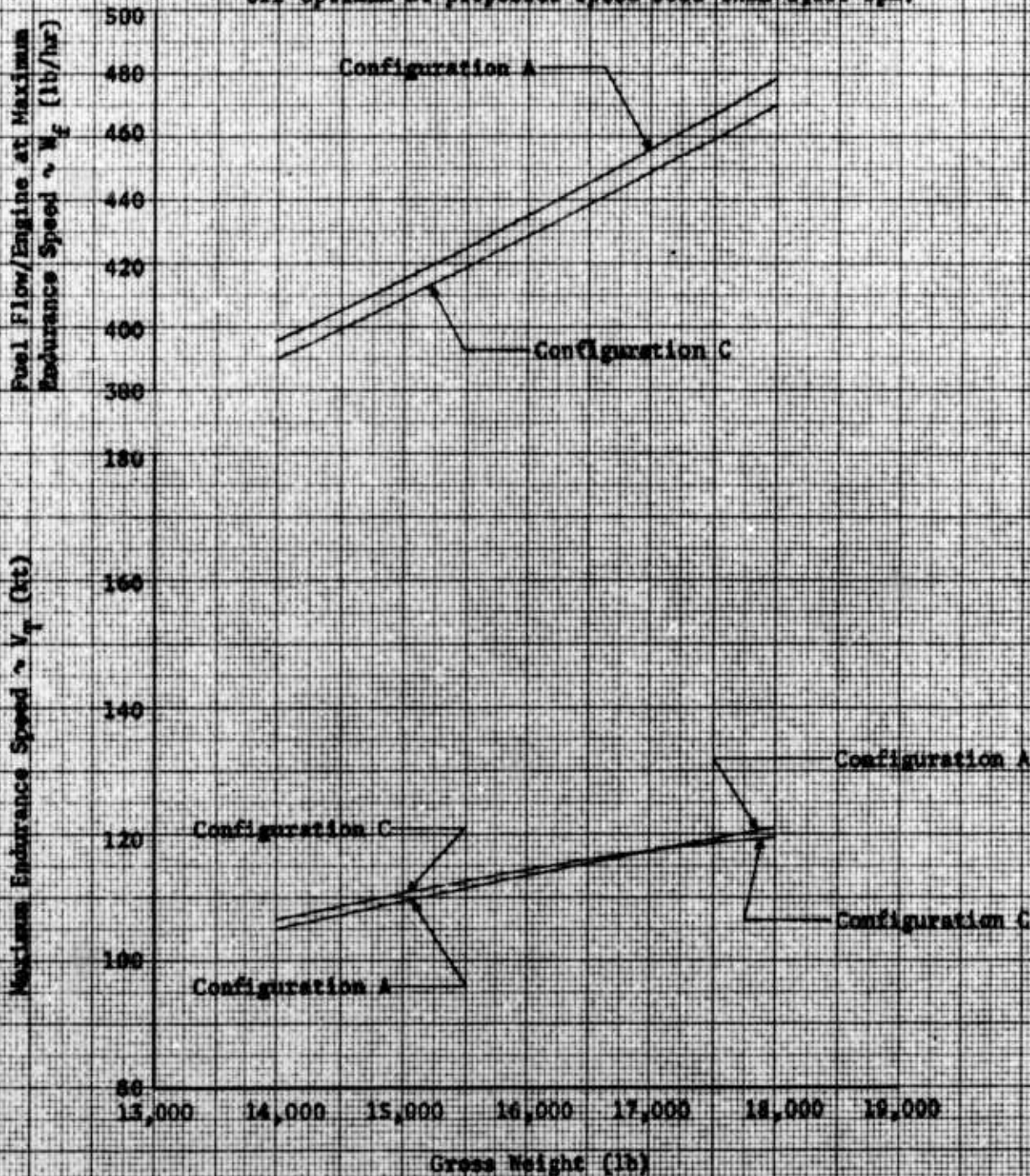
OV-10 USA S/N 68-16990

Standard-Day Conditions:

Pressure Altitude:
Center of Gravity:

Sea Level
27.2% MAC (mid)

- Note:
1. Curves derived from figures 1, 2, and 31.
 2. Fuel flow based on 1.65 x fuel-flow specification (fig. 28).
 3. Bleed air ON.
 4. Maximum endurance speed defined at minimum fuel flow.
 5. Specification fuel flow based on optimum power turbine speed; off optimum at propeller speed less than 1,150 rpm.



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Figure 9. Maximum Endurance Summary.

OV-10 USA S/N 68-16990

Standard-Day Conditions:

Pressure Altitudes

5,000 ft

Center of Gravities

27.2% MAC (mid)

- Note:
1. Curves derived from Figures 1, 2, and 12.
 2. Fuel flow based on 1.05 x fuel-flow specification (Fig. 29).
 3. Bleed air ON.
 4. Maximum endurance speed defined at minimum fuel flow.
 5. Specification fuel flow based on optimum power turbine speed; off optimum at propeller speed less than 1,150 rpm.

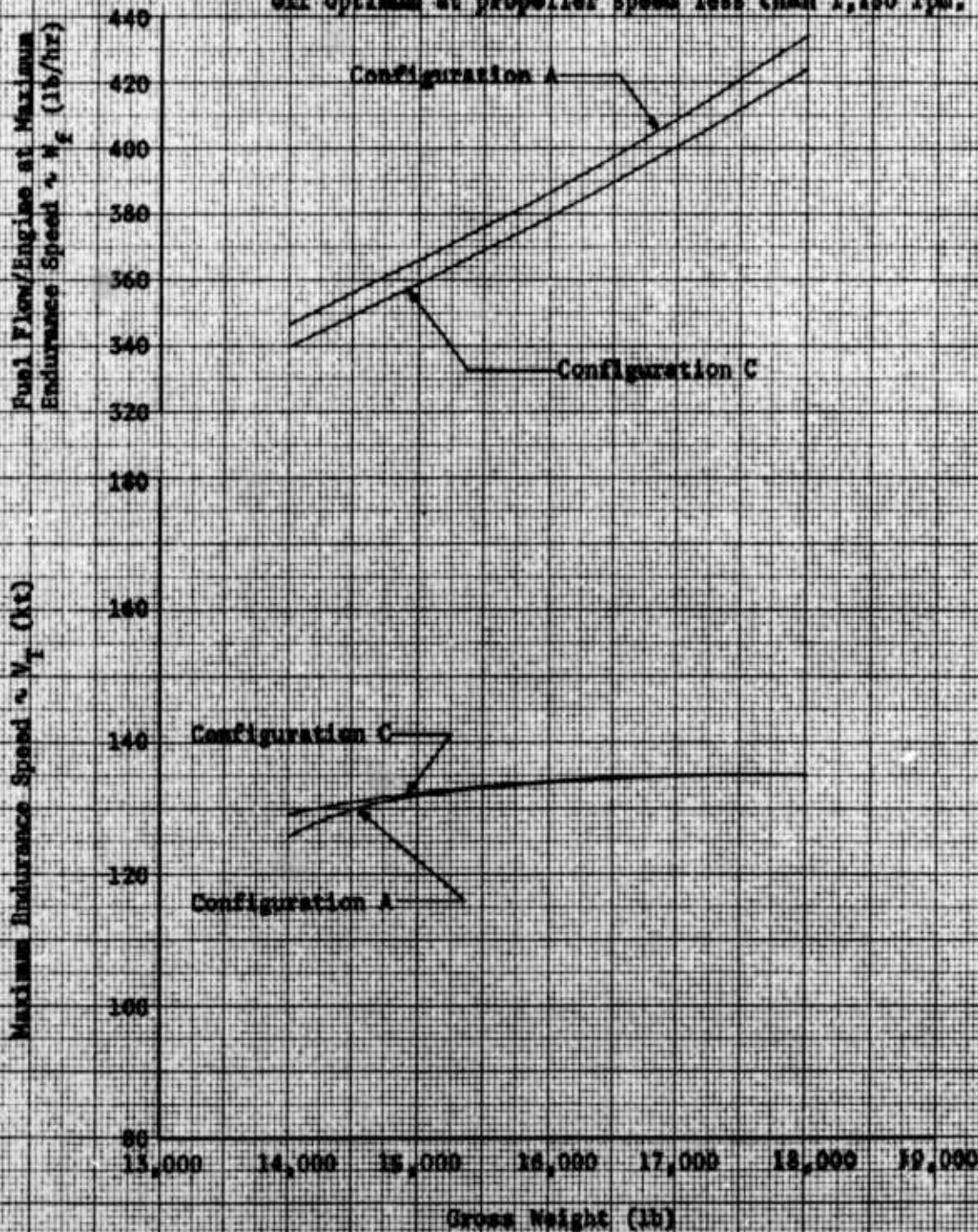


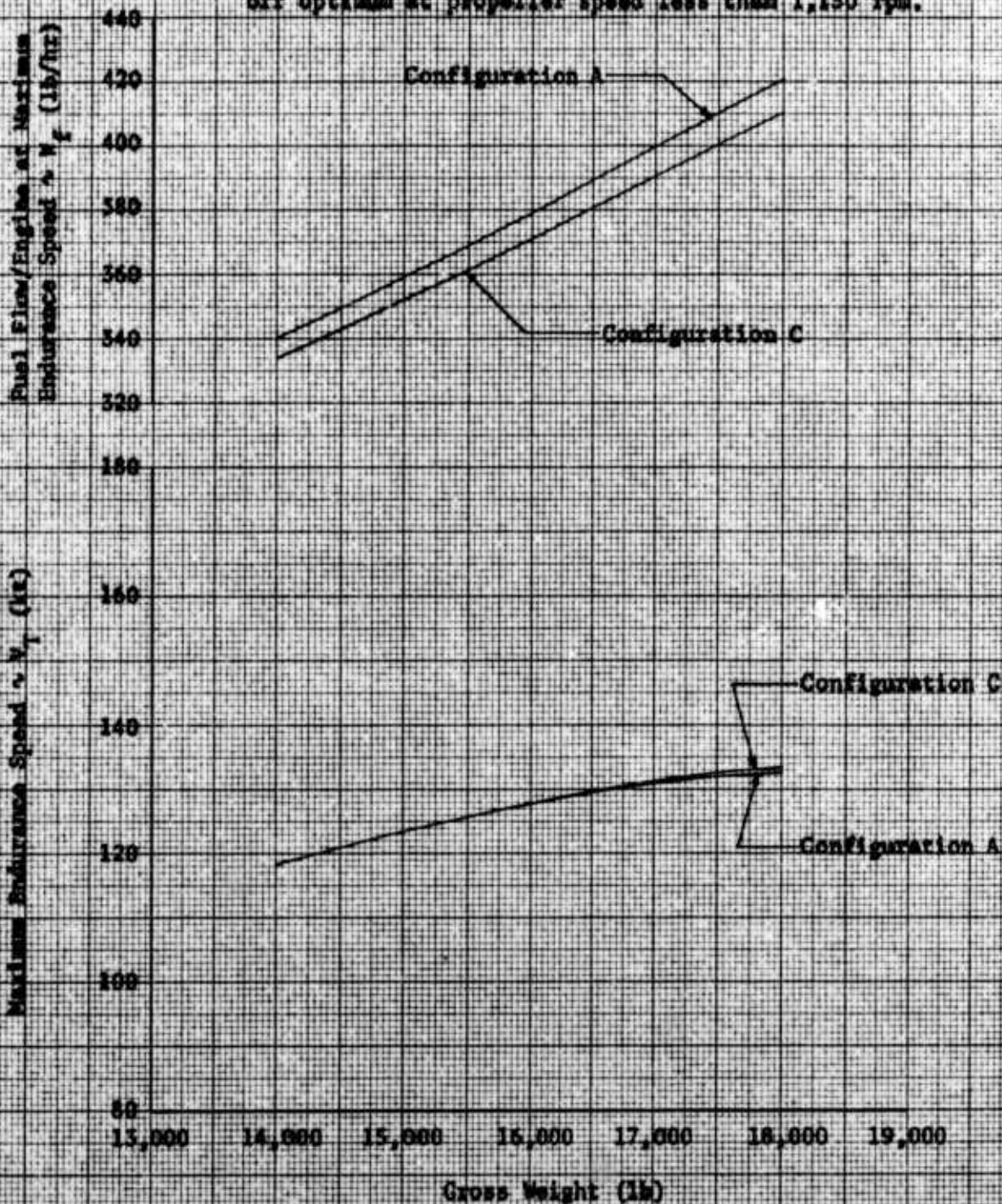
Figure 10. Maximum Endurance Summary

OV-10 USA S/N 68-16990

Standard-Day Conditions

Pressure Altitude: 10,000 ft
 Center of Gravity: 27.2% MAC (mid)

- Note:
1. Curves derived from figures 1, 2, and 33.
 2. Fuel flow based on 1.05 x fuel-flow specification (fig. 30).
 3. Bleed air ON.
 4. Maximum endurance speed defined at minimum fuel flow.
 5. Specification fuel flow based on optimum power turbine speed; off optimum at propeller speed less than 1,150 rpm.



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Figure 11. Dual-Engine Level Flight Performance

OVID USA S/N 68-16990

Average Gross Weight:	17,130 lb
Average Pressure Altitude:	1,000 ft
Average Center of Gravity:	27.4% MAC (mid)
External Store Configuration:	A
Average Outside Air Temperature:	21.1°C
Propeller Speed:	1,600 rpm

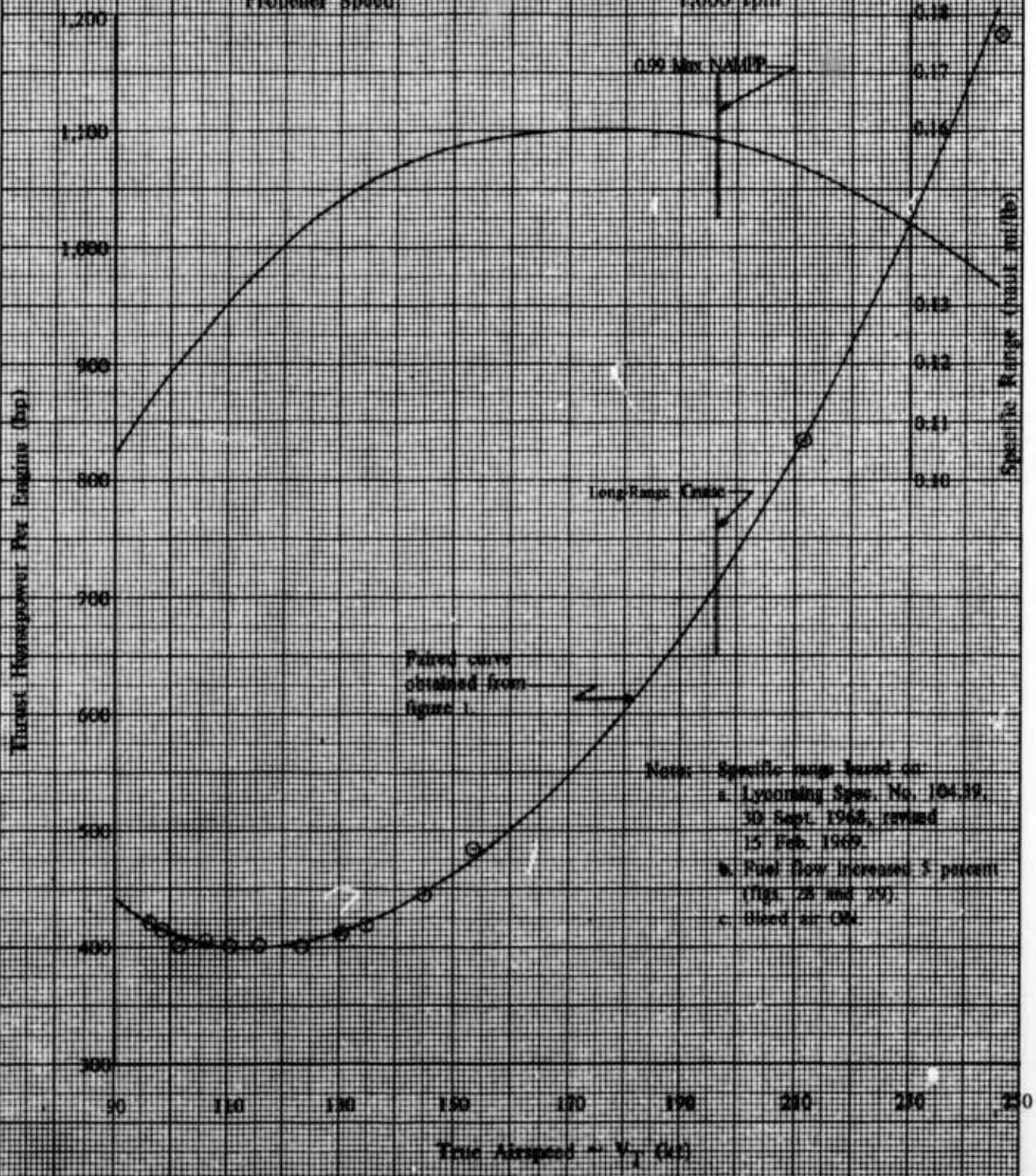


Figure 12. Dual-Engine Level Flight Performance

OV-10 USA S/N 68-16990

Average Gross Weight: 17,190 lb
 Average Pressure Altitude: 10,000 ft
 Average Center of Gravity: 27.2% MAC (mid)
 External Store Configuration: A
 Average Outside Air Temperature: 11.0°C
 Propeller Speed: 1,600 rpm
 0.99 Max NAMP

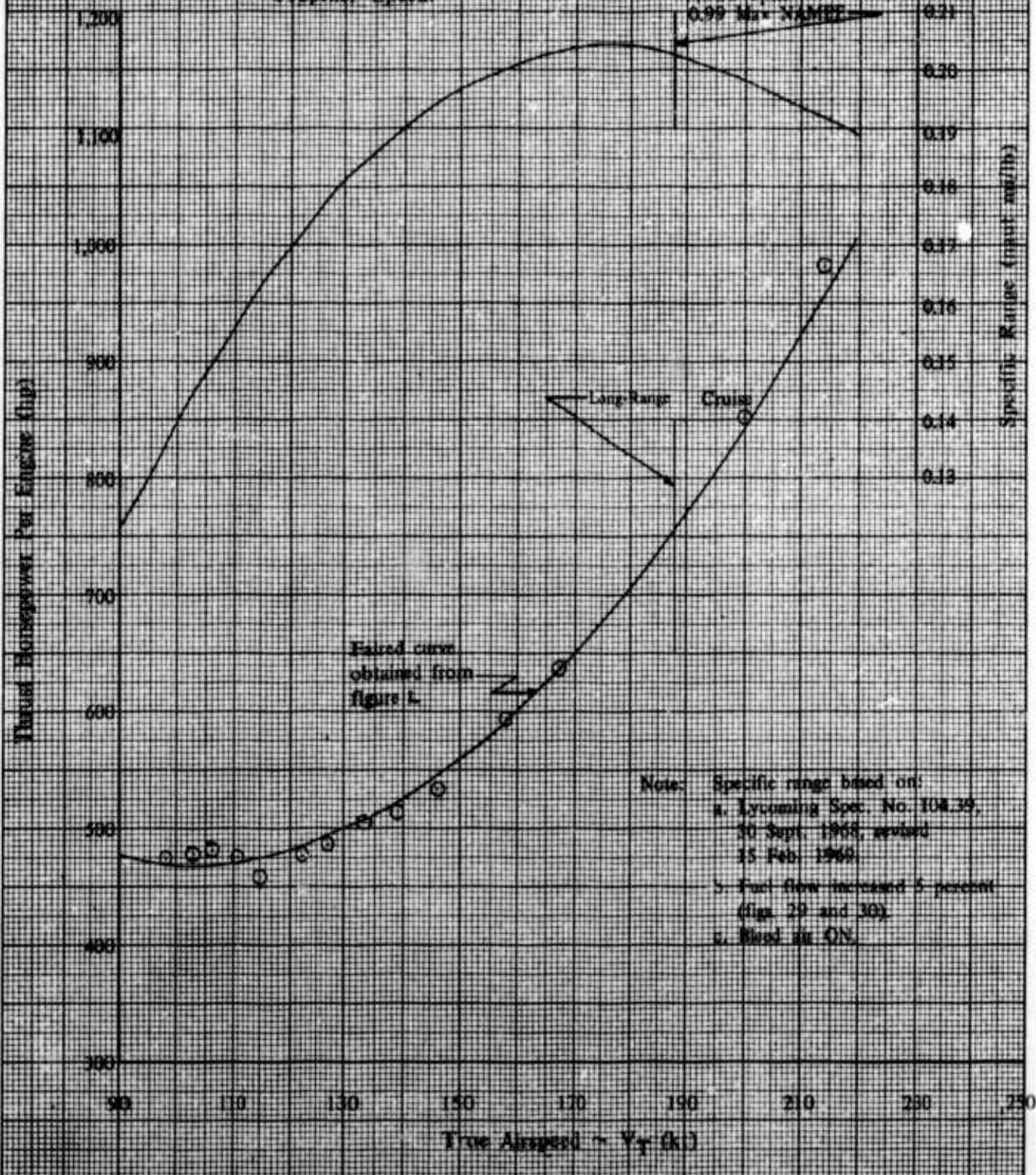
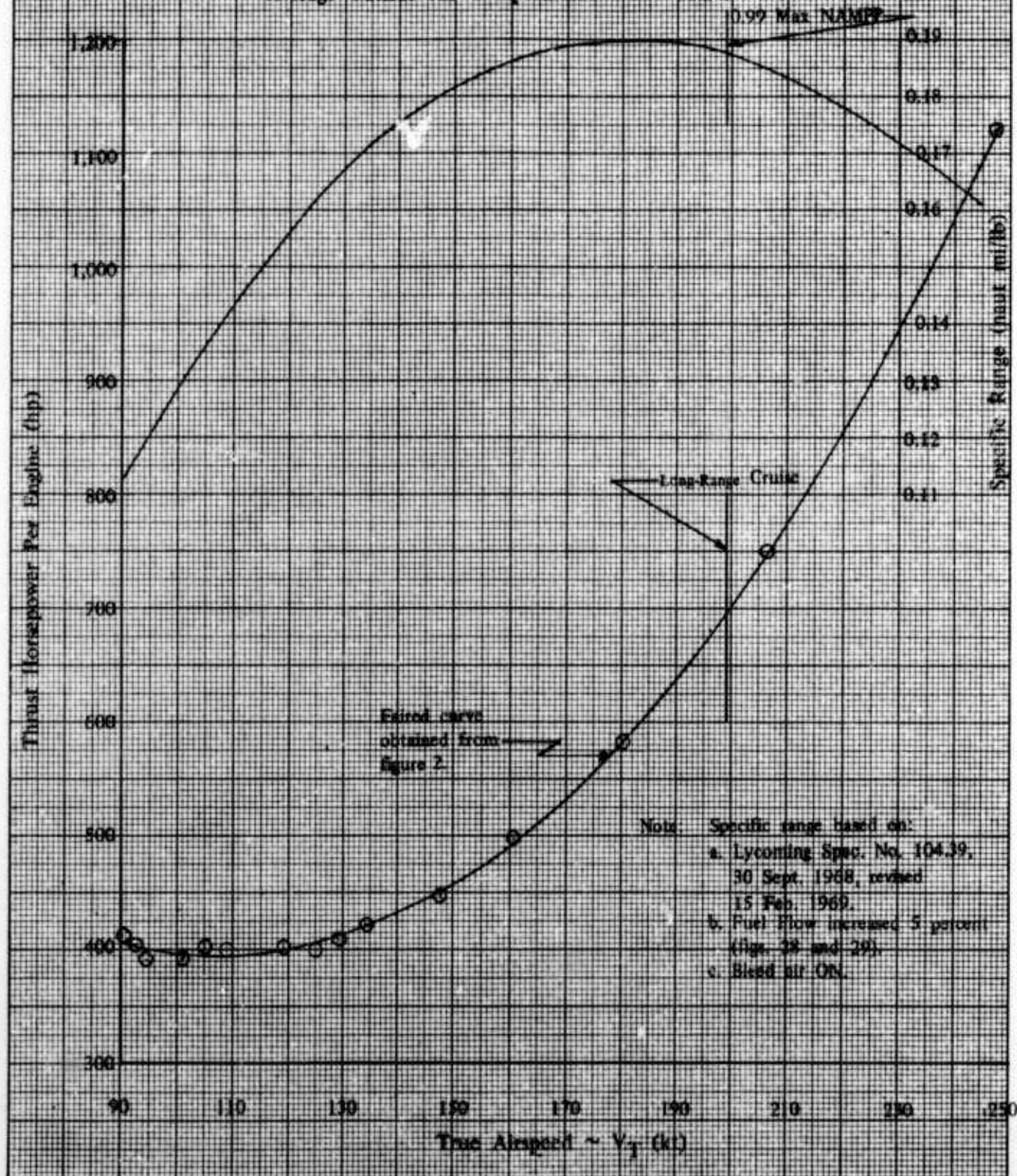


Figure 13. Dual-Engine Level Flight Performance.

OV-10 USA S/N 68-16990

Propeller Speed:	1,500 rpm
Average Gross Weight:	16,650 lb
Average Pressure Altitude:	5,000 ft
Average Center of Gravity:	27.2% MAC
External Store Configuration:	C
Average Outside Air Temperature:	11.8°C



Note: Specific range based on:
 a. Lycoming Spec. No. 104.39,
 30 Sept. 1968, revised
 15 Feb. 1969.
 b. Fuel flow increased 5 percent
 (figs. 28 and 29).
 c. Bleed air ON.

Figure 14. Maximum Level Flight Airspeed (V_{gr}).

OV-1D USA S/N 16990

Standard-Day Conditions:
Center of Gravity:

27.2% MAC (mid)

- Notes: Maximum level flight airspeed based on:
- a. Lycoming specification No. 104.39, 30 Sep. 1968, revised 15 Feb. 1969.
 - b. Normal rated power (figs. 31 through 33) based on optimum power turbine speed.
 - c. Bleed air ON.
 - d. Power required derived from figures 1 and 2.

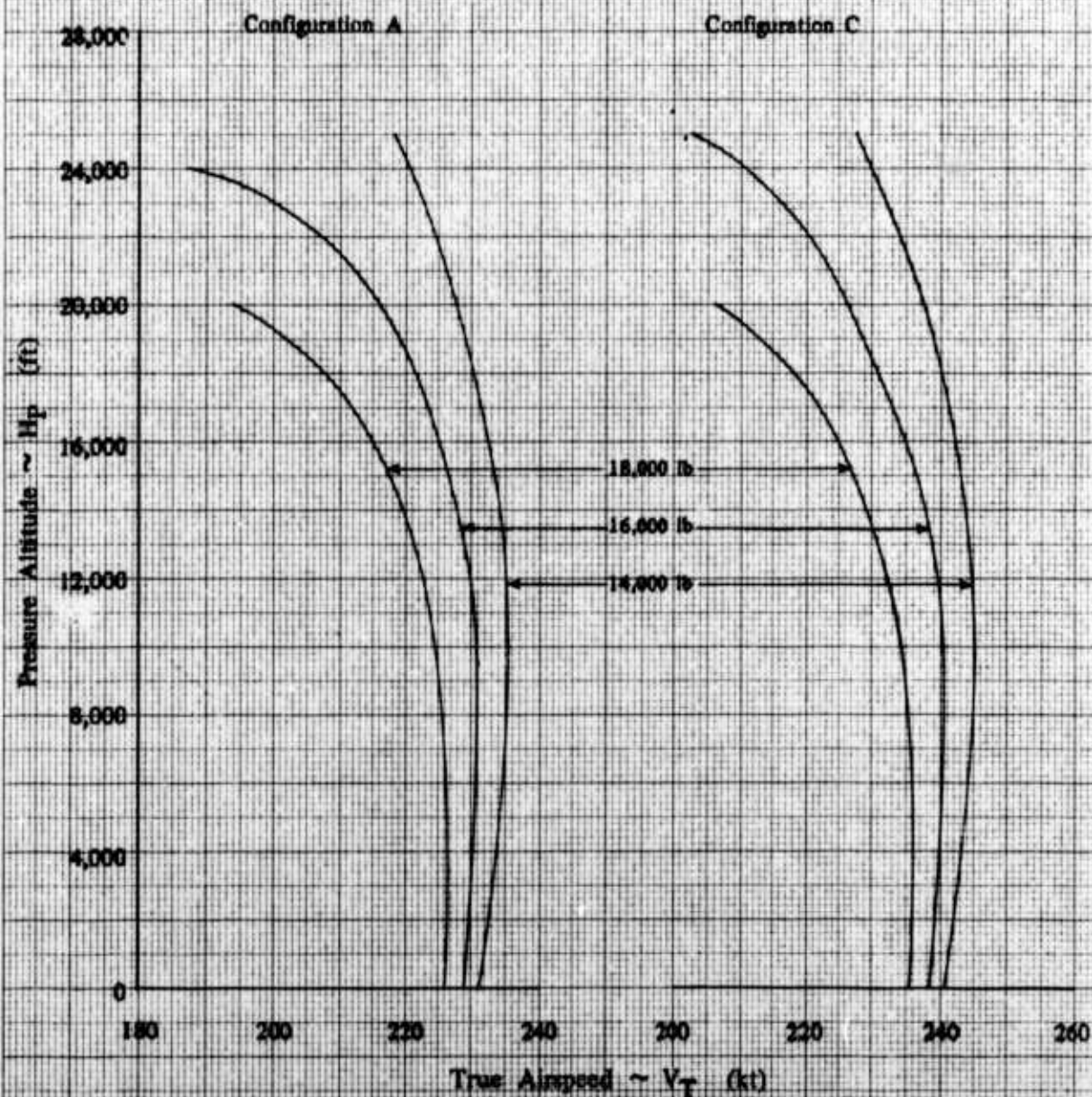


Figure 15. Maximum Level Flight Airspeed (V_{FF}).

OV-1D USA S/N 16990

Standard-Day Conditions*

Center of Gravity:

27.2% MAC (mid)

Note:

Maximum level flight airspeed based on:

- Lycoming specification No. 104.39, 30 Sep. 1968, revised 15 Feb. 1969.
- Military rated power (fig. 26) based on optimum power turbine speed.
- Bleed air OFF.
- Power required derived from figures 1 and 2.

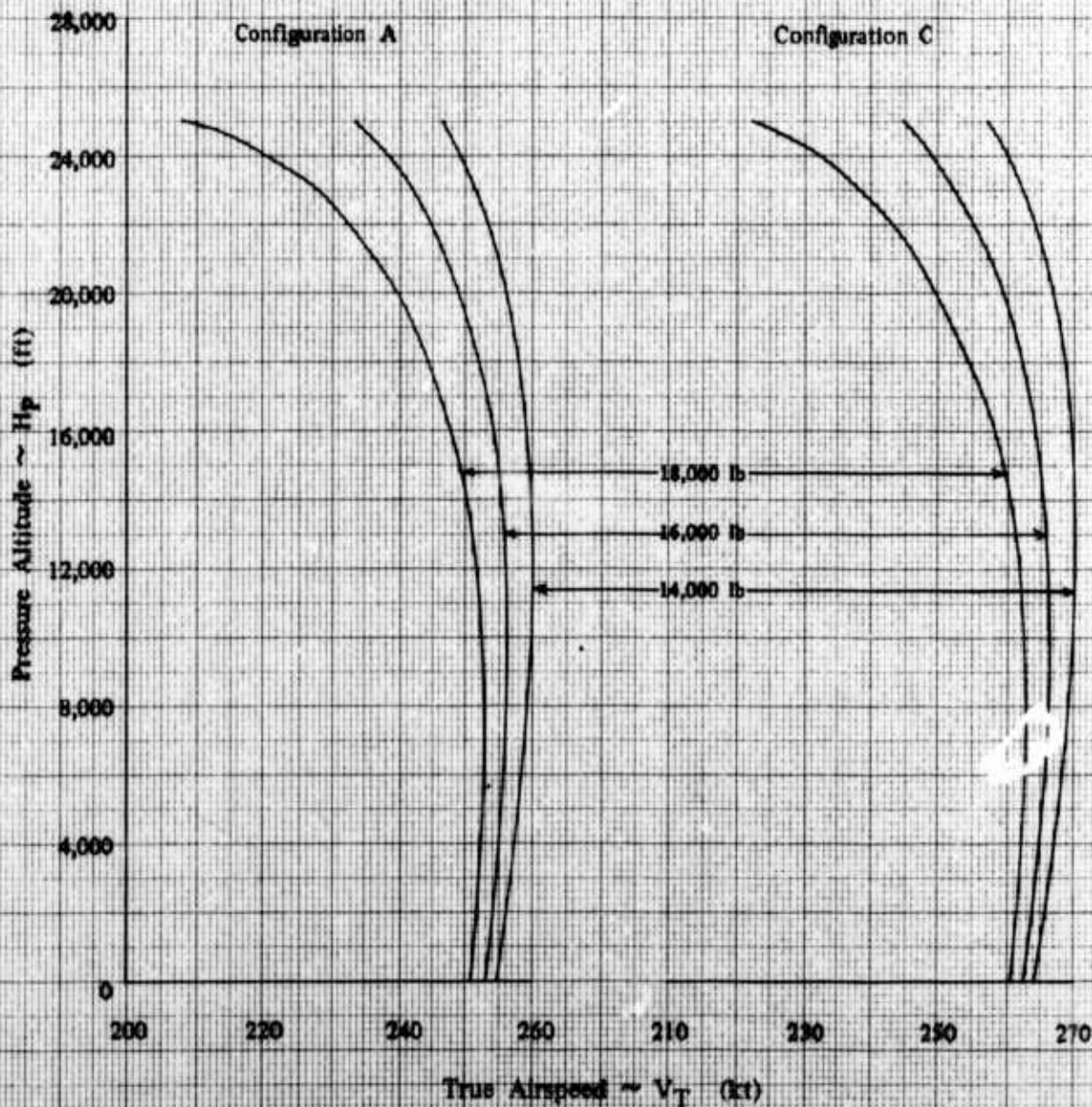


Figure 15 Single-Engine Performance

OV-10 USA S/N 68-16990

Cruise Configuration:

Symbol	○	⊙	△
Average Gross Weight:	15,900 lb	15,970 lb	16,550 lb
Average Pressure Altitude:	1,945 ft	9,100 ft	1,900 ft
Average Outside Air Temperature:	20.9°C	11.9°C	19.7°C
External Store Configuration:	A	A	A
Average Center of Gravity:	27.0% MAC (msd)	27.1% MAC (msd)	27.1% MAC (msd)
Propeller Speed:	1,600 rpm	1,600 rpm	1,600 rpm

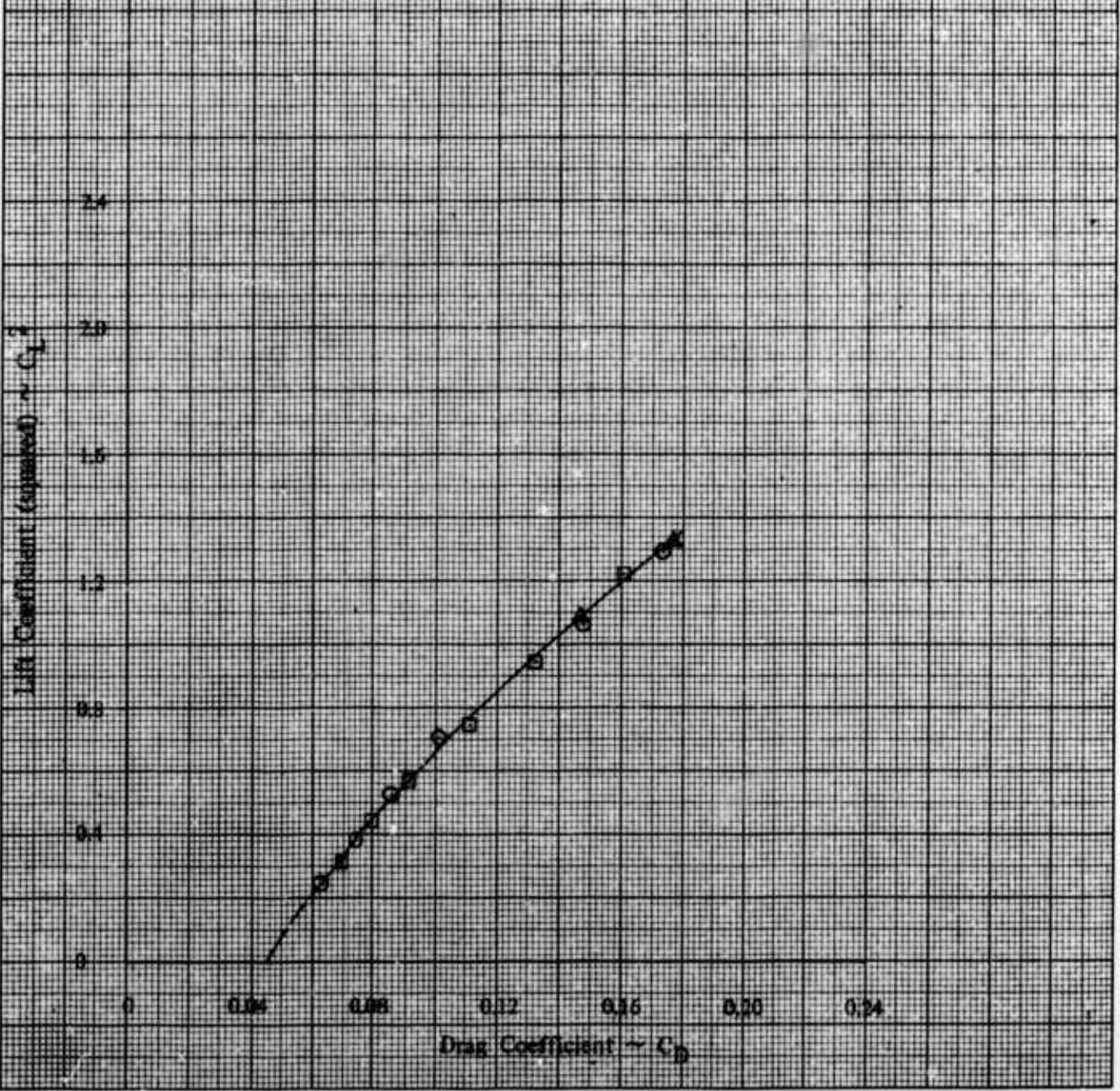


Figure 17. Single-Engine Performance

OV-10 USA S/N 68-16990

Takeoff Configuration

Symbol:	○	□
Average Gross Weight:	15,750 lb	16,345 lb
Average Pressure Altitude:	2,210 ft	1,780 ft
Average Outside Air Temperature:	15.2°C	10.0°C
External Store Configuration:	▲	▲
Average Center of Gravity:	26.9% MAC (mid)	26.9% MAC (mid)
Propeller Speed:	1,600 rpm	1,600 rpm

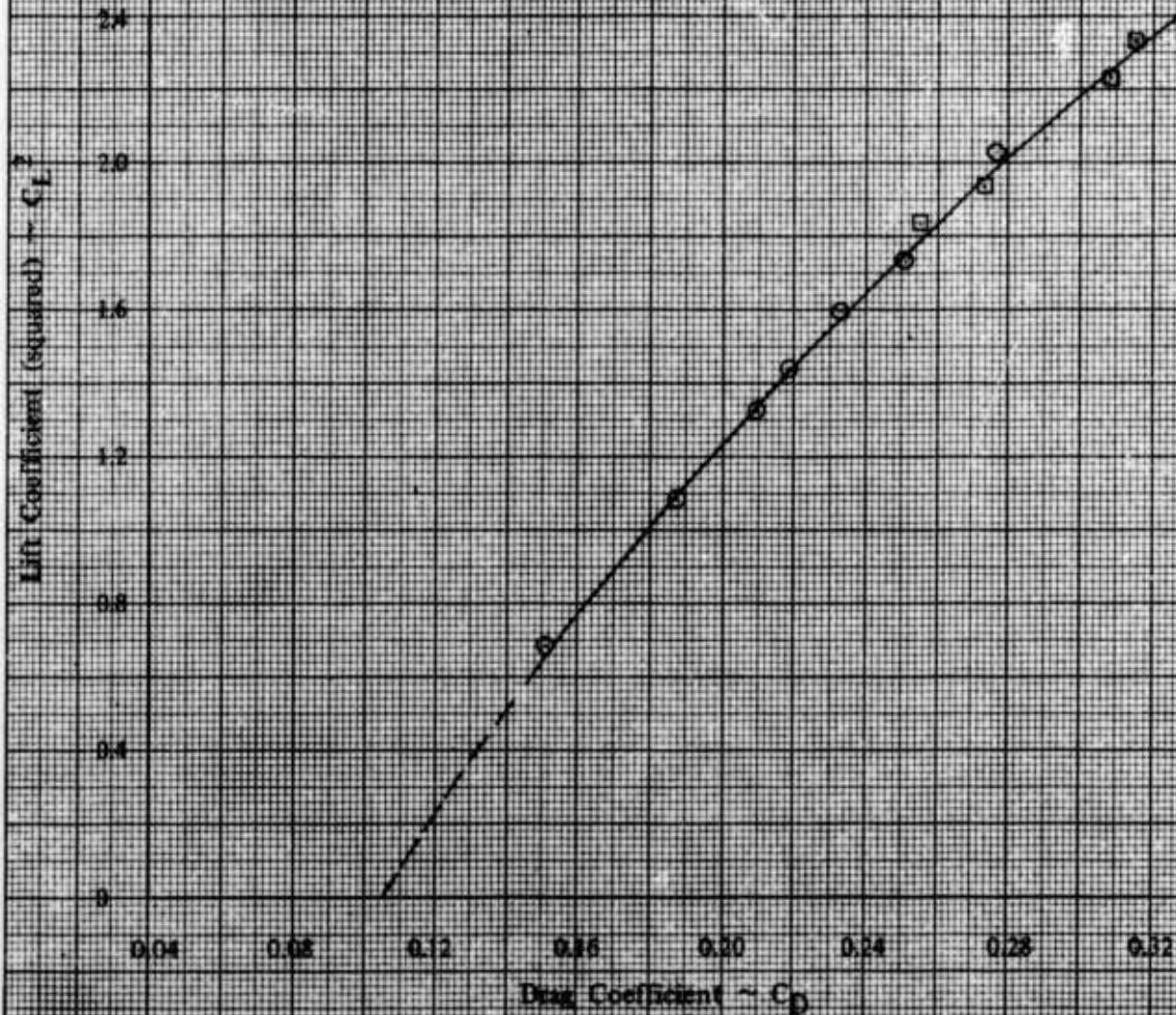


Figure 18. Single-Engine Climb Performance.

OV-10 USA S/N 68-16990

Sea Level

Center of Gravity:

27.0% MAC (mid)

Note:

1. Power available based on TS3-L-70 specification engine. (Fig. 25)
2. Bleed air OFF at MRP.
3. Curves derived from figures 16 and 17.
4. Optimum propeller speed.

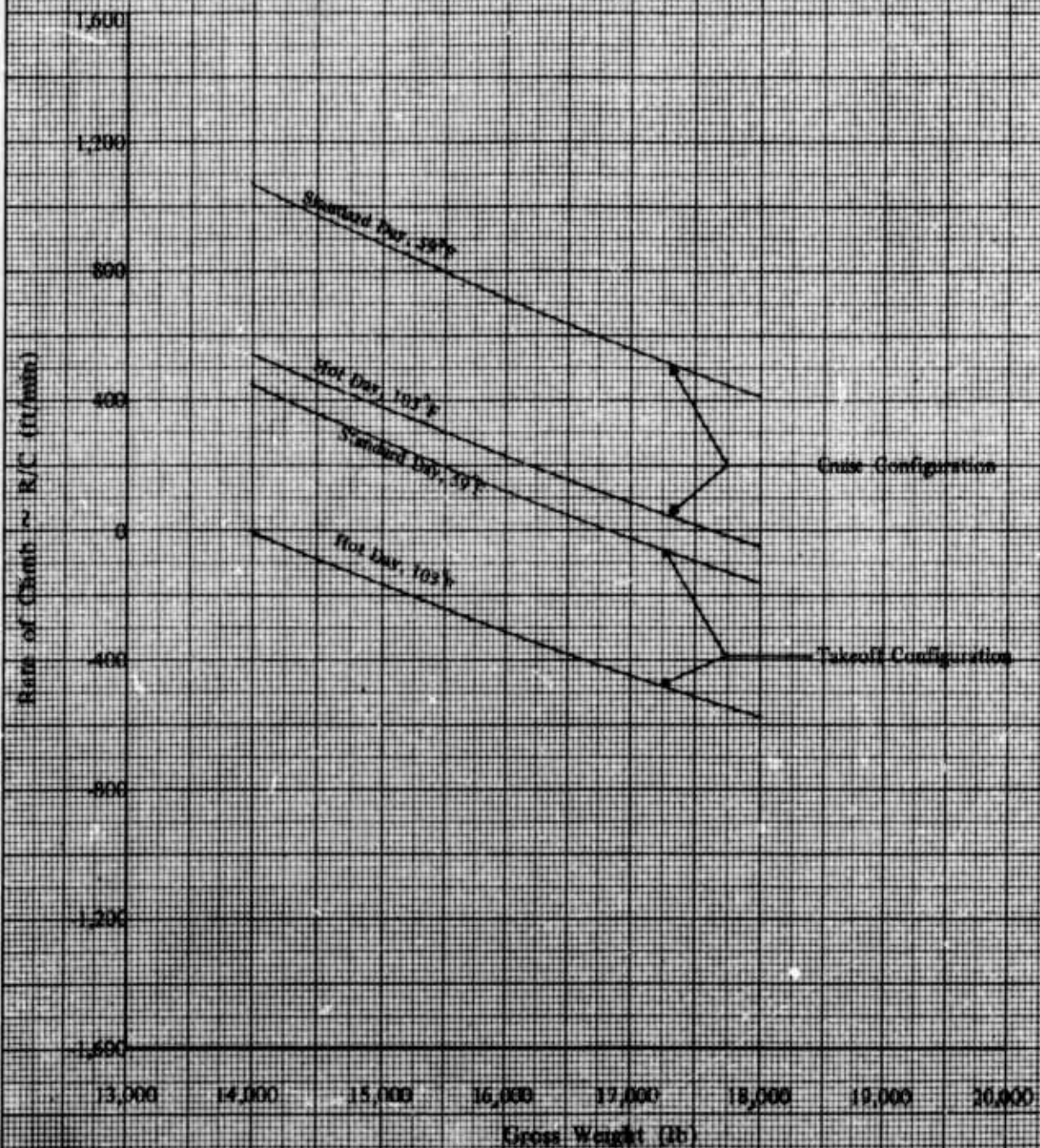


Figure 19. Single-Engine Climb Performance Summary.

OV-10 USA S/N 68-16990

Cruise Configuration

Standard-Day Conditions

Configuration A

Center of Gravity:

27.1% MAC (mid)

- Note:
1. Power available based on T53-L-701 specification engine (fig. 25).
 2. Bleed air OFF at MRP.
 3. Curves derived from figure 16.
 4. Optimum propeller speed.

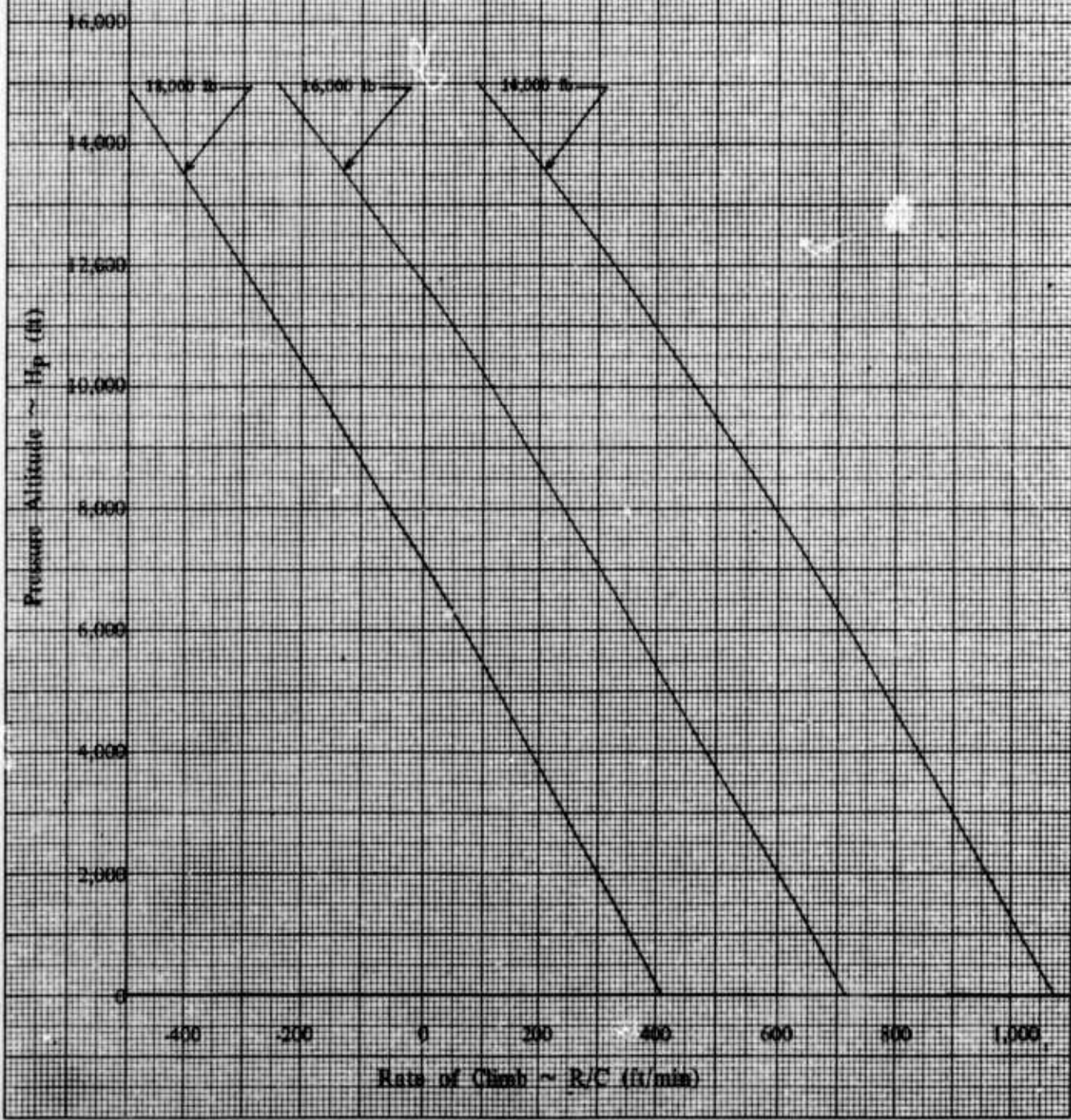


Figure 20. Single-Engine Climb Performance Summary.

OV-1D USA S/N 68-16990

Takeoff Configuration
Standard Day Conditions
Configuration A

Center of Gravity: 26.9% MAC (mid)

- Note:
1. Power available based on T53-L701 specification engine (Fig. 25).
 2. Bleed air OFF at MRP.
 3. Curves derived from Figure 17.
 4. Optimum propeller speed.

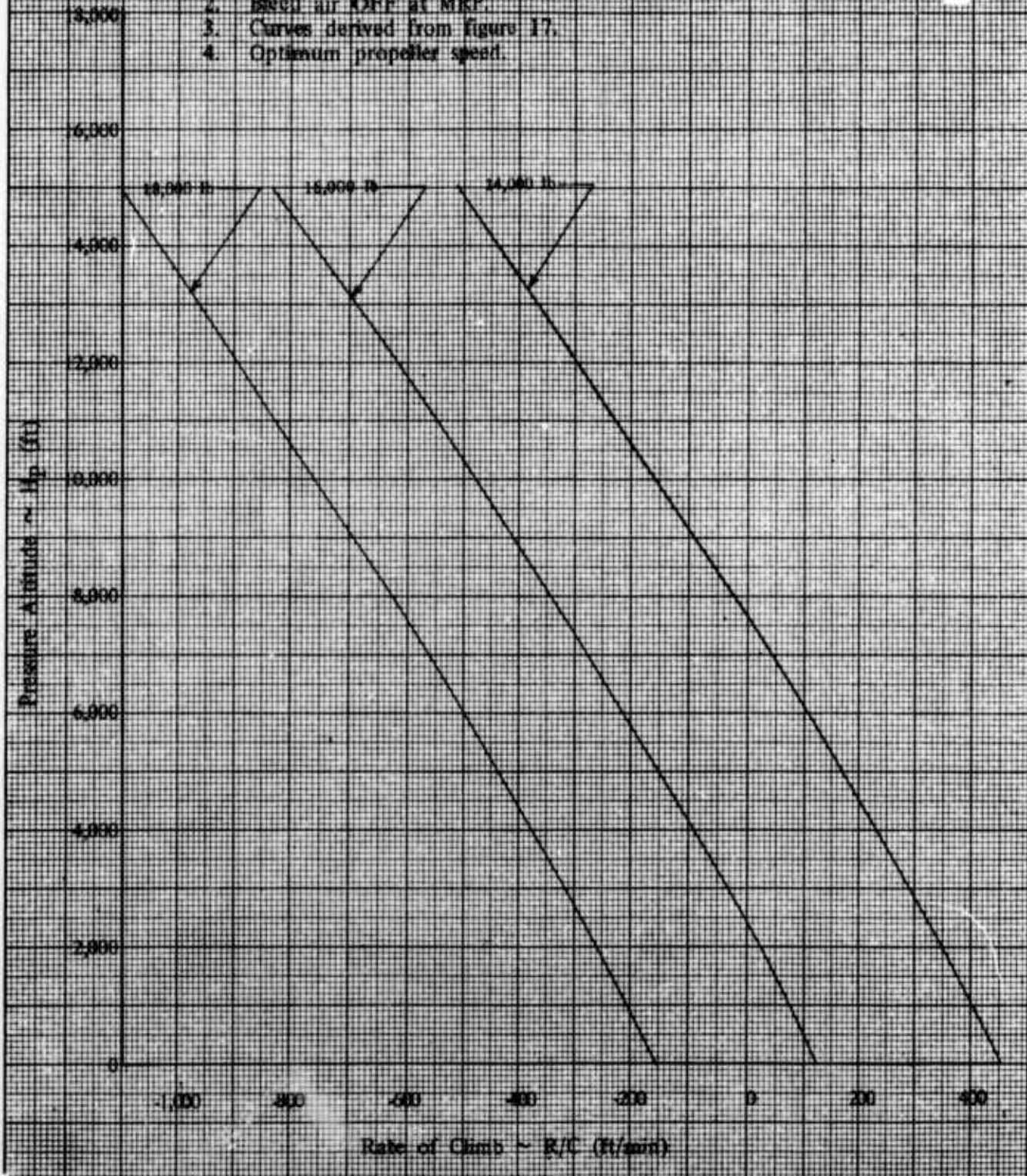


Figure 21. Single-Engine Climb Performance Summary.

OV-10 USA S/N 68-16990

Cruise Configuration

Hot Day Conditions

Configuration A

Center of Gravity:

27.1% MAC (mid)

Note:

1. Power available based on T53-L-701 specification engine (fig. 25).
2. Bleed air ODFP at MRP.
3. Curves derived from Figure 16.
4. Optimum propeller speed.
5. ANA hot day: 103°F at sea level.

Pressure Altitude - Hp (ft)

18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0

Rate of Climb - R/C (ft/min)

-500 -400 -300 -200 -100 0 100 200 300 400 500 600 700 800

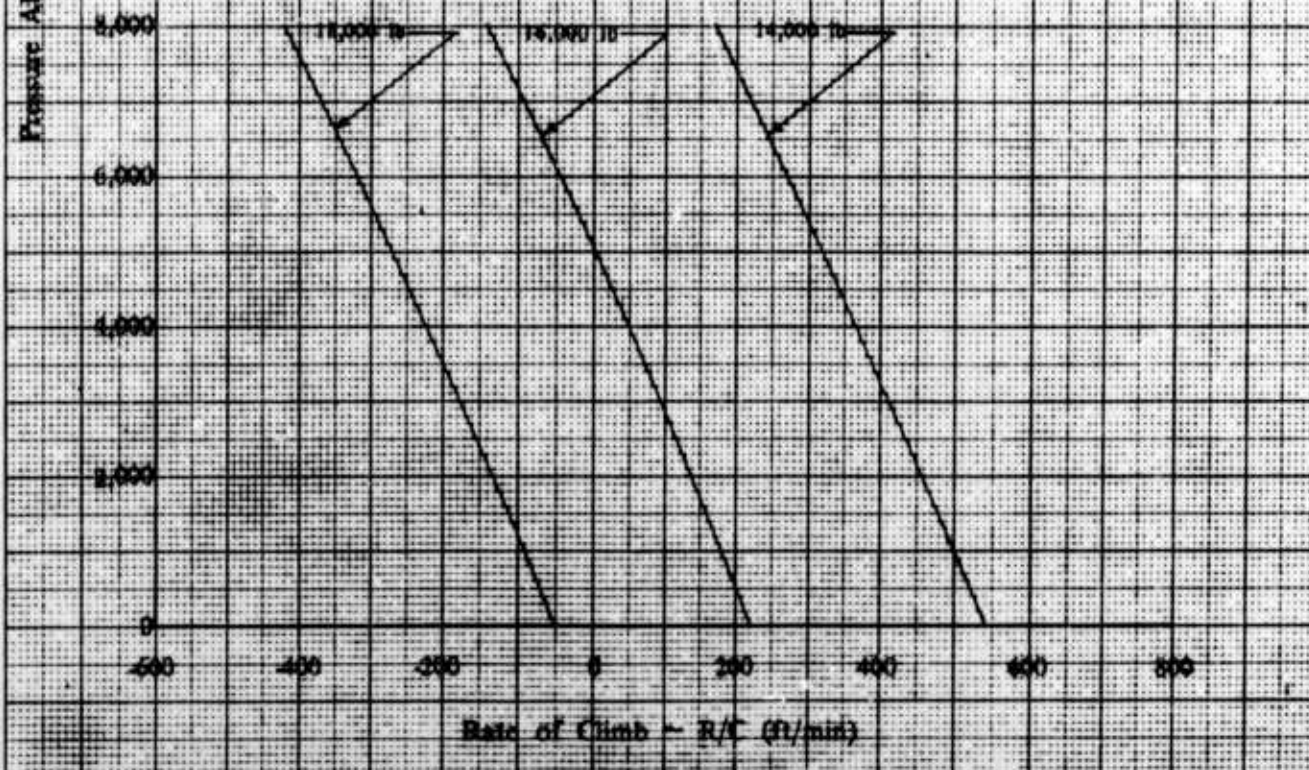


Figure 22. Single-Engine Climb Performance Summary.

OY-1D USA S/N 68-16990

Takeoff Configuration

Hot Day Conditions

Configuration A

Center of Gravity

26.9% MAC (mid)

Note

1. Power available based on T53-L-701 specification engine (fig. 25)
2. Bleed air OFF at MRP
3. Curves derived from Figure 17.
4. Optimum propeller speed.
5. ANA hot day; 103°F at sea level.

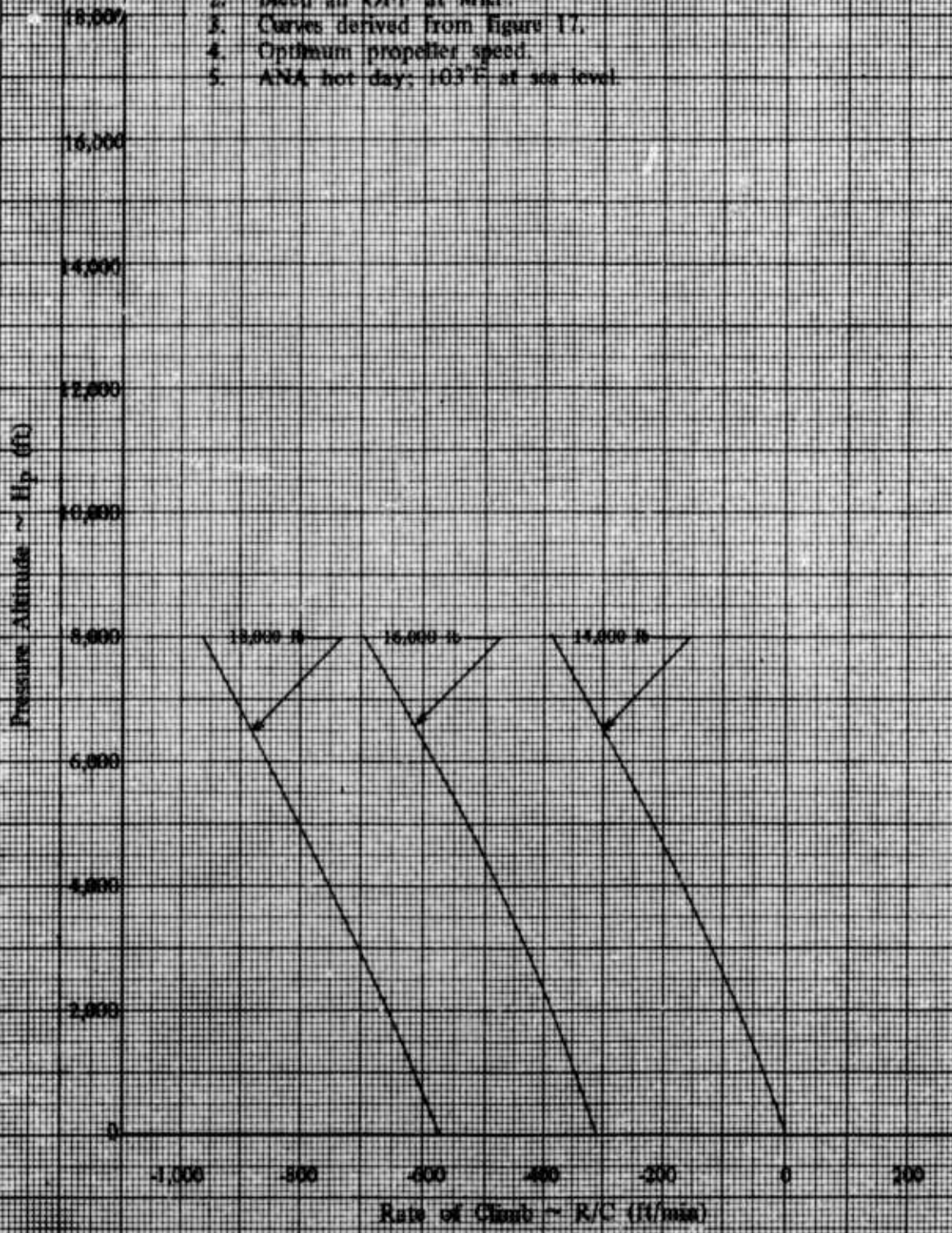


Figure 23. Single-Engine Level-Flight Range Summary.

OV-10 USA S/N 16990

Cruise Configuration

Standard-Day Conditions:

Center-of-Gravity:

Optimum Propeller Speed

26.9% MAC (mid)

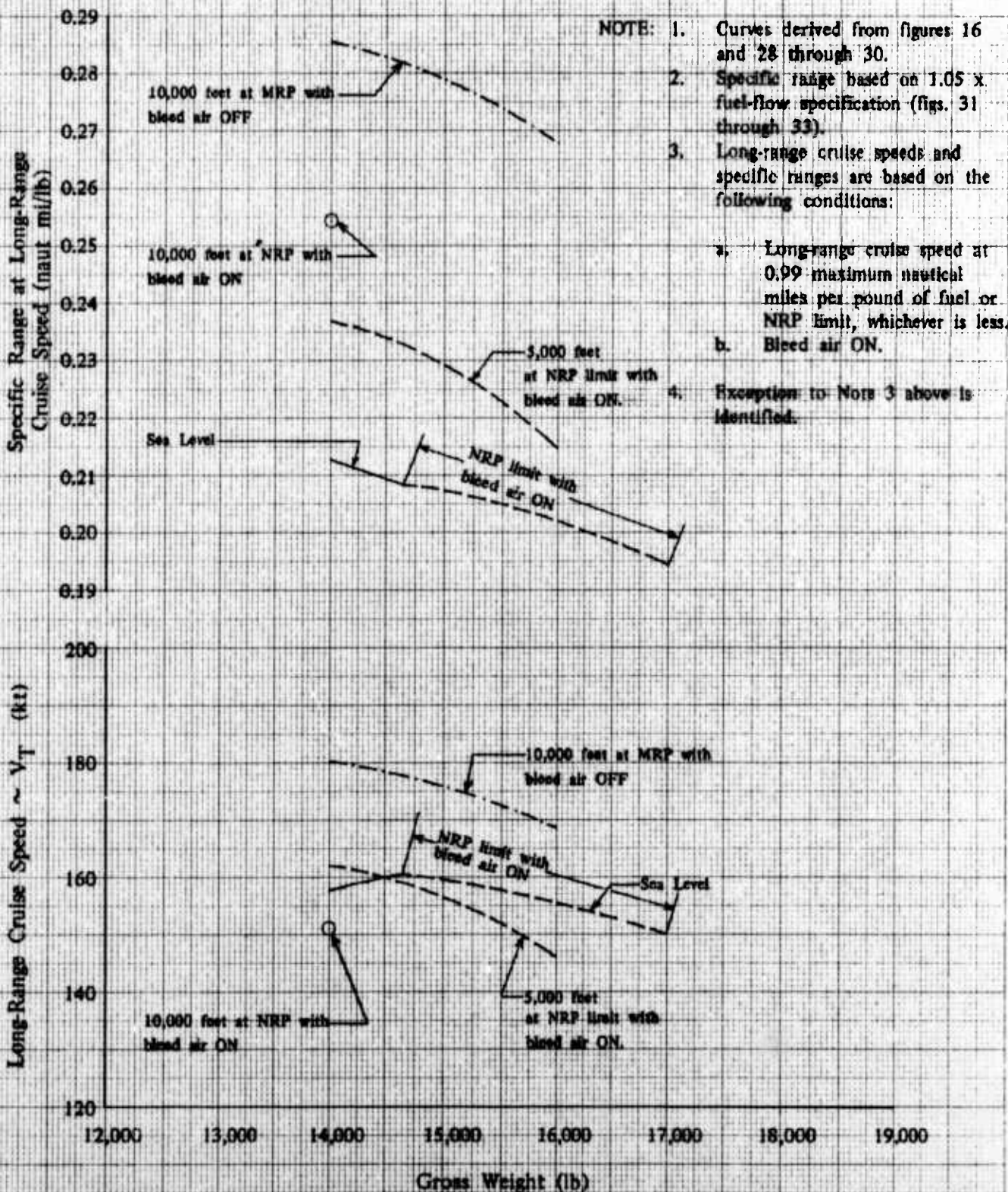


Figure 24. Stall Performances.

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Symbol:	○	□
Average Pressure Altitude:	6,130 ft	6,920 ft
Average Center of Gravity:	27.1% MAC (mid)	27.0% MAC (mid)
External Store Configuration:	A	A
Average Outside Air Temperature:	10.3°C	9.5°C
Propeller Speed:	1,600 rpm	1,600 rpm

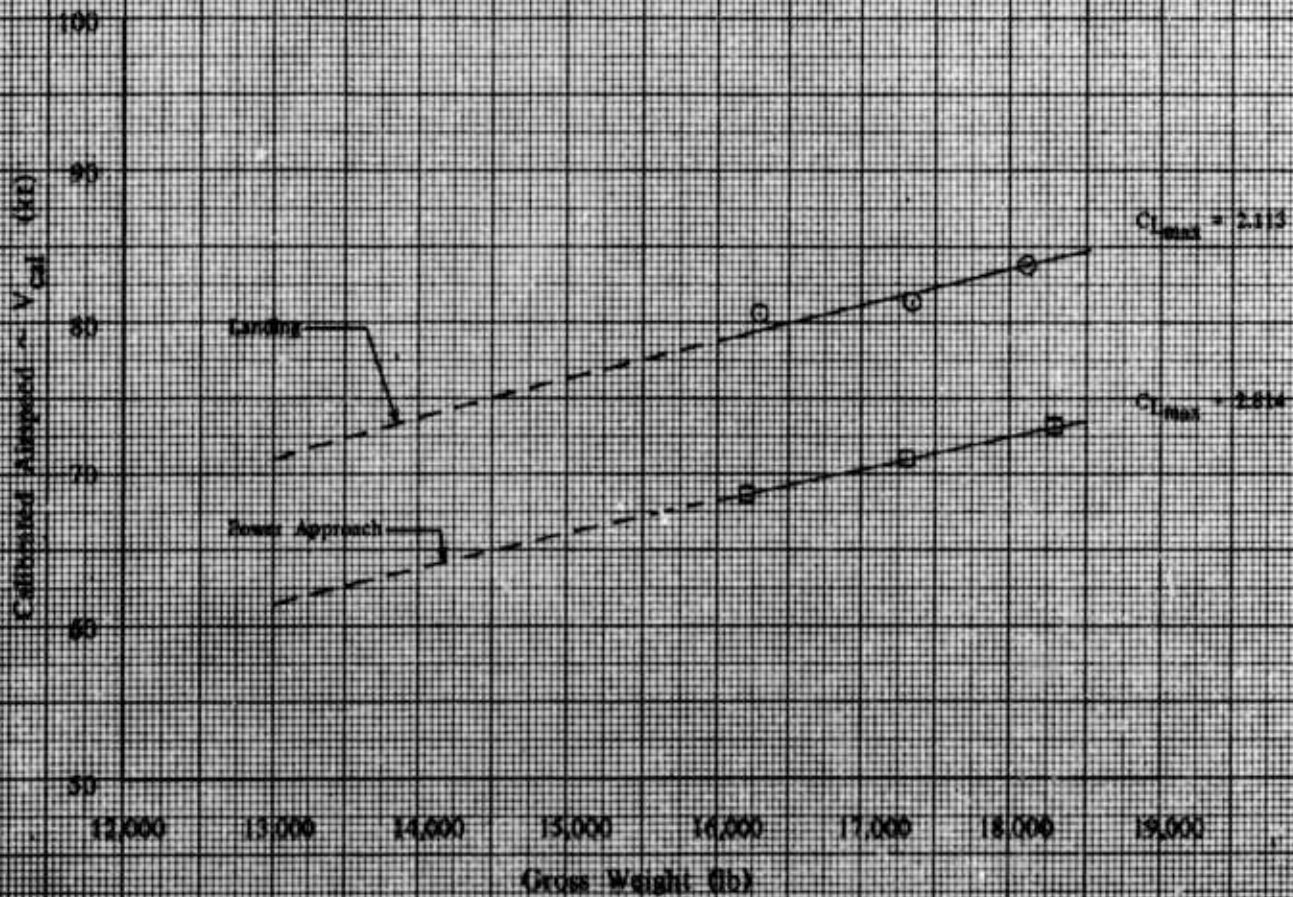


Figure 25. Engine Characteristics.

T53-L-701

Military Power Available.
 Specifications Engine Based on IBM Data
 Static Conditions

- Note:
1. Environmental Control System bleed air OFF.
 2. Fifteen-horsepower extraction.
 3. One-percent exhaust pressure loss.
 4. Hot-day definition obtained from Air Force-Navy Aeronautical (ANA) Bulletin 421 (ref MIL-C-8678(AER)).
 5. Cold-day definition obtained from Air Force-Navy Aeronautical (ANA) Bulletin 432 (ref MIL-C-8678(AER)).
 6. Engine inlet recovery curve (Fig. 34).
 7. US Standard Atmosphere 1962.
 8. Optimum power turbine speed.

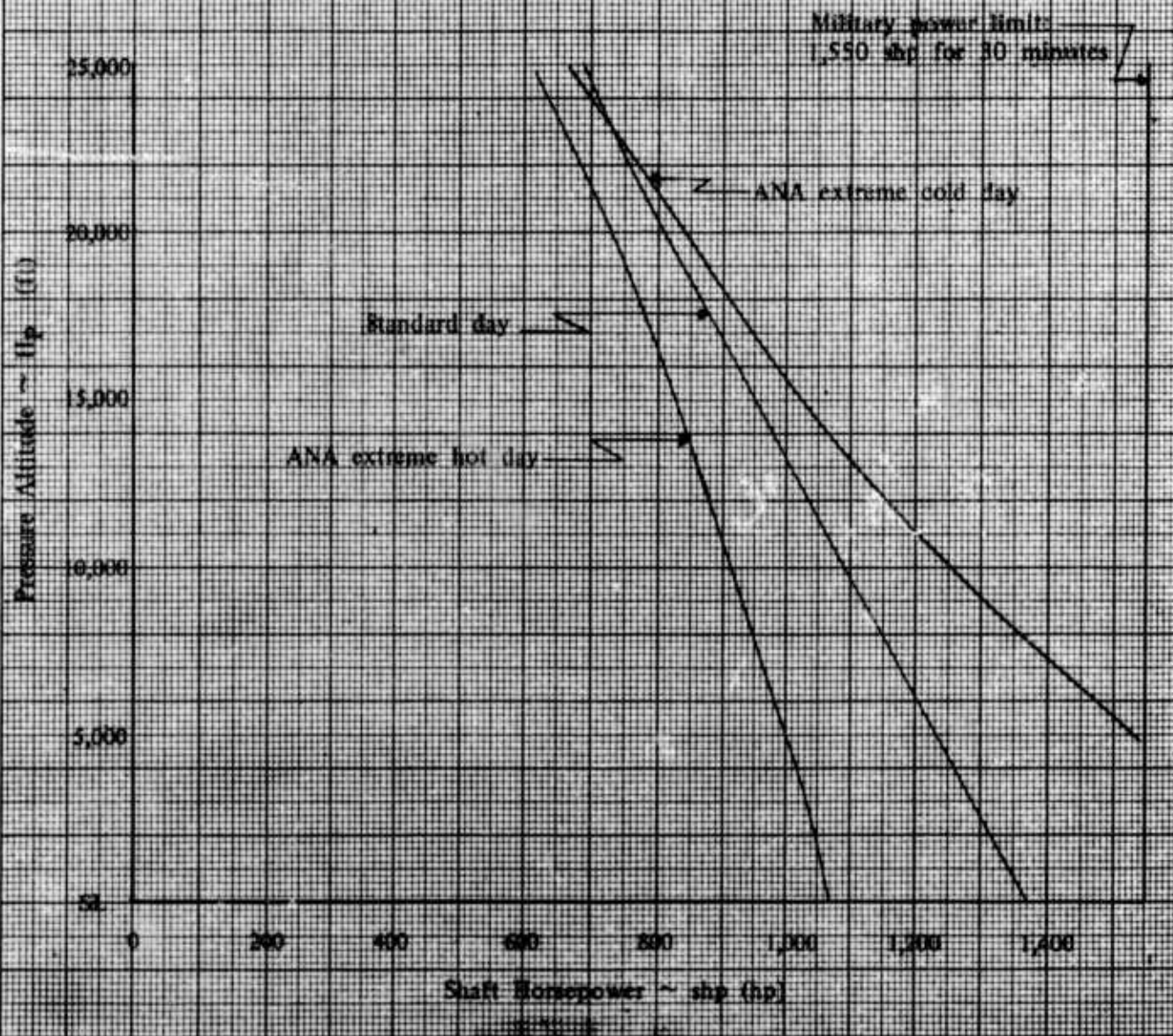


Figure 26. Engine Characteristics

Military Power Available
Standard Day Conditions

- Note:
1. Environmental Control System Bleed Air OFF.
 2. Fifteen-horsepower extraction.
 3. One-percent exhaust pressure loss.
 4. Specification engine based on IBM data.
 5. Engine inlet recovery curve (fig. 34).
 6. Optimum power turbine speed.

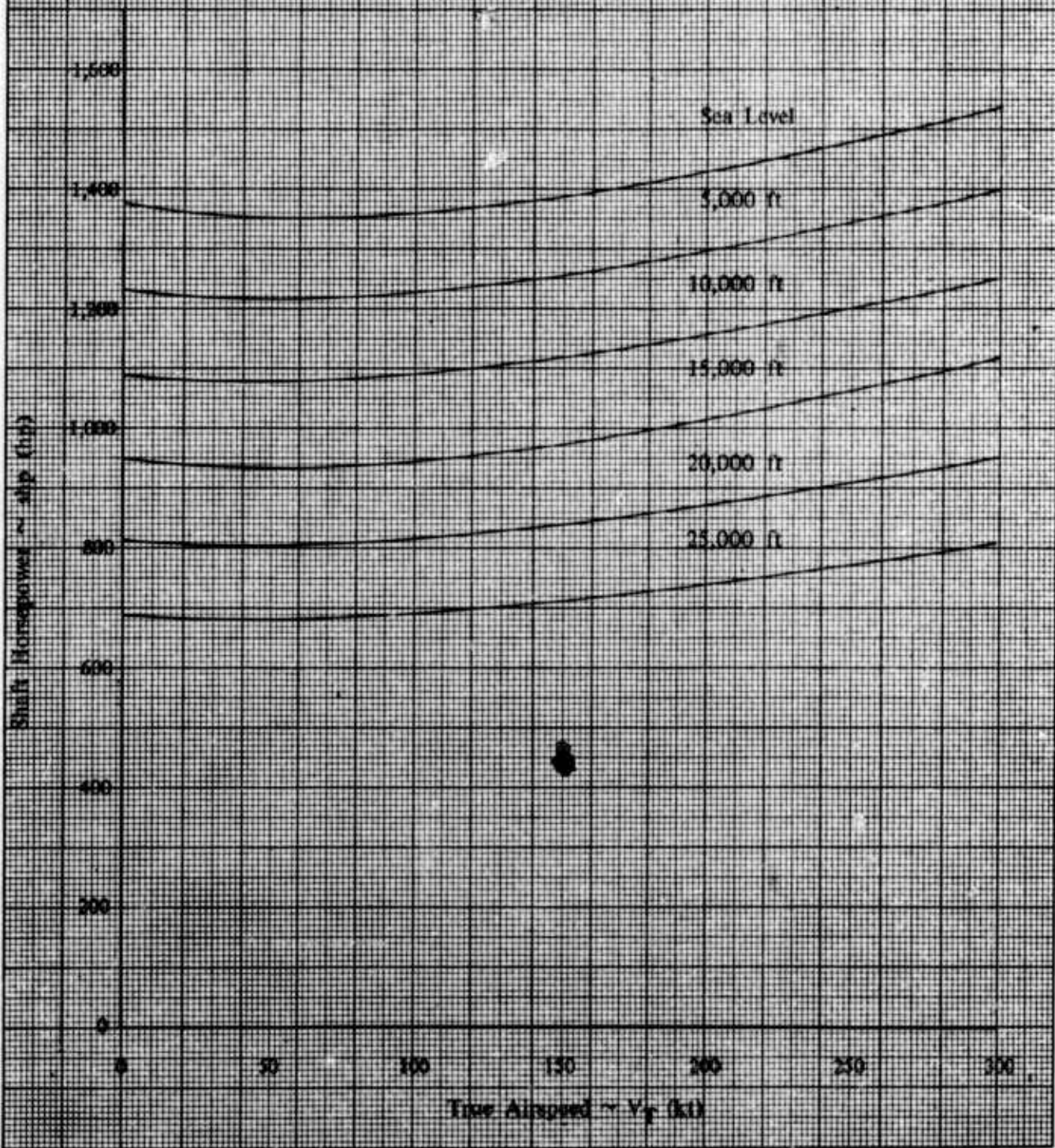


Figure 27. Engine Characteristics

Military Power Available
Standard-Day Conditions

- Note:
1. Environmental Control System Bleed Air OFF.
 2. Fifteen-horsepower extraction.
 3. One-percent exhaust pressure loss.
 4. Specification engine based on IBM data.
 5. Engine inlet recovery curve (fig. 34).
 6. Optimum power turbine speed.

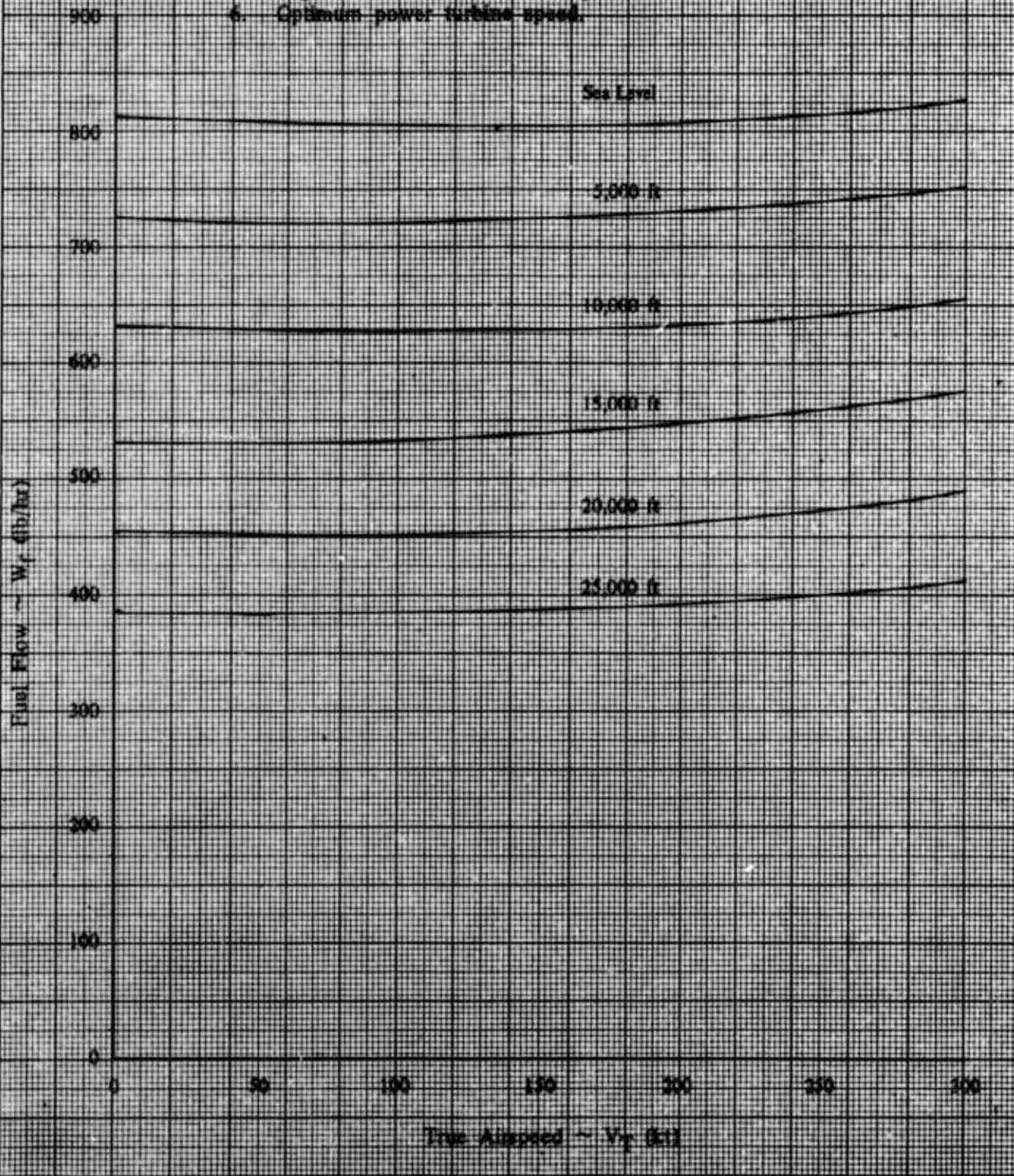
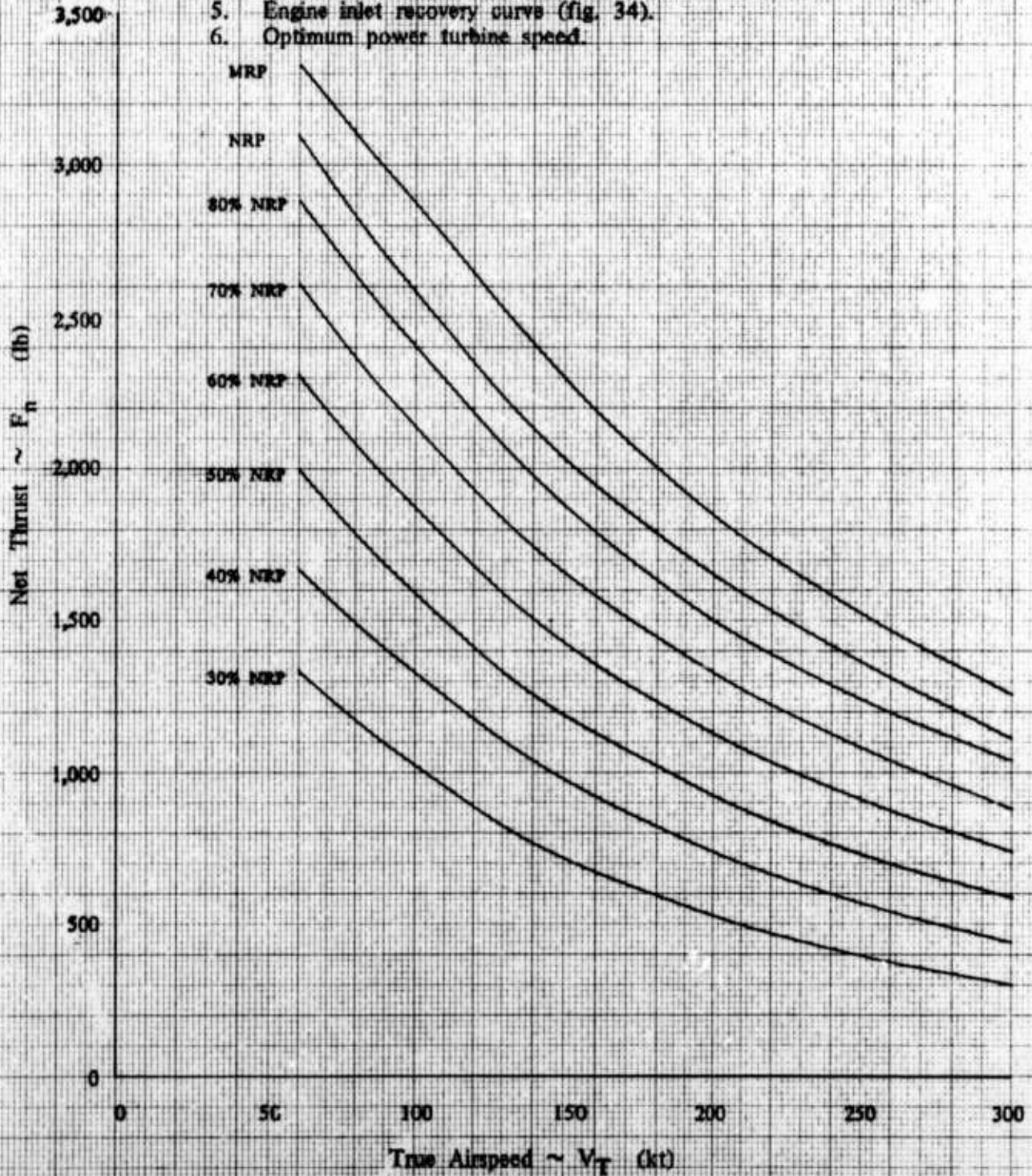


Figure 28, Engine Characteristics.

Lycoming T53-L-701

Standard-Day Conditions:
Sea Level

- Note:
1. Environmental control system bleed air ON.
 2. Fifteen-horsepower extraction.
 3. One-percent exhaust pressure loss.
 4. Specification engine based on IBM data.
 5. Engine inlet recovery curve (fig. 34).
 6. Optimum power turbine speed.



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Figure 29. Engine Characteristics

Lycoming T53-L-701

Standard Day Conditions:

Pressure Altitude

5,000 ft

- Notes:
1. Environmental Control System Bleed Air ON.
 2. Fifteen-horsepower extraction.
 3. One-percent exhaust pressure loss.
 4. Specification engine based on IBM data.
 5. Engine inlet recovery curve (Fig. 34).
 6. Optimum power turbine speed.

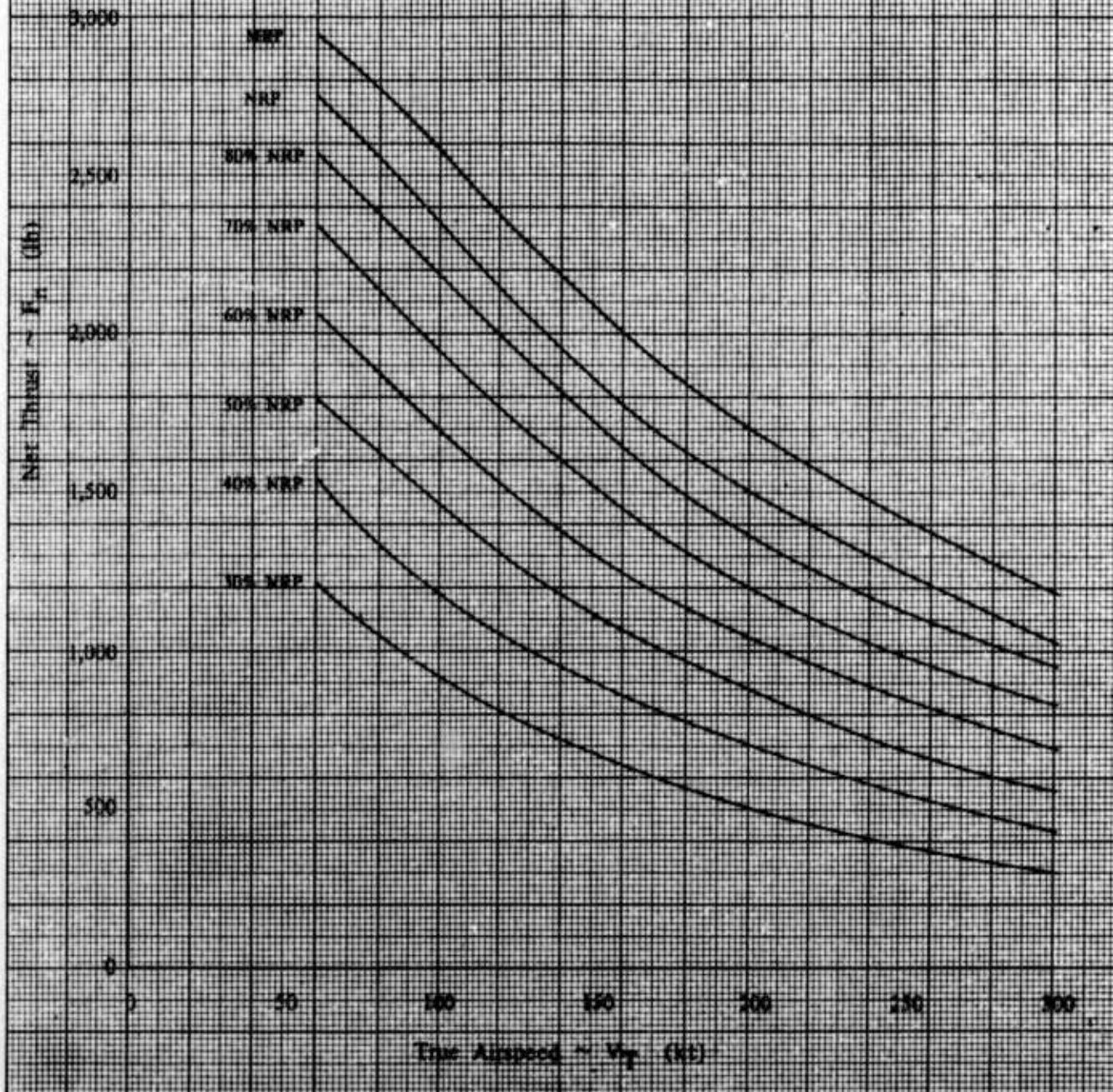


Figure 30. Engine Characteristics

Lycoming TS3-L-701

Standard-Day Conditions

Pressure Altitude

10,000 ft

- Note:
1. Environmental Control System Bleed Air ON.
 2. Fifteen-horsepower extraction.
 3. One-percent exhaust pressure loss.
 4. Specification engine based on IBM data.
 5. Engine inlet recovery curve (Fig. 34).
 6. Optimum power turbine speed.

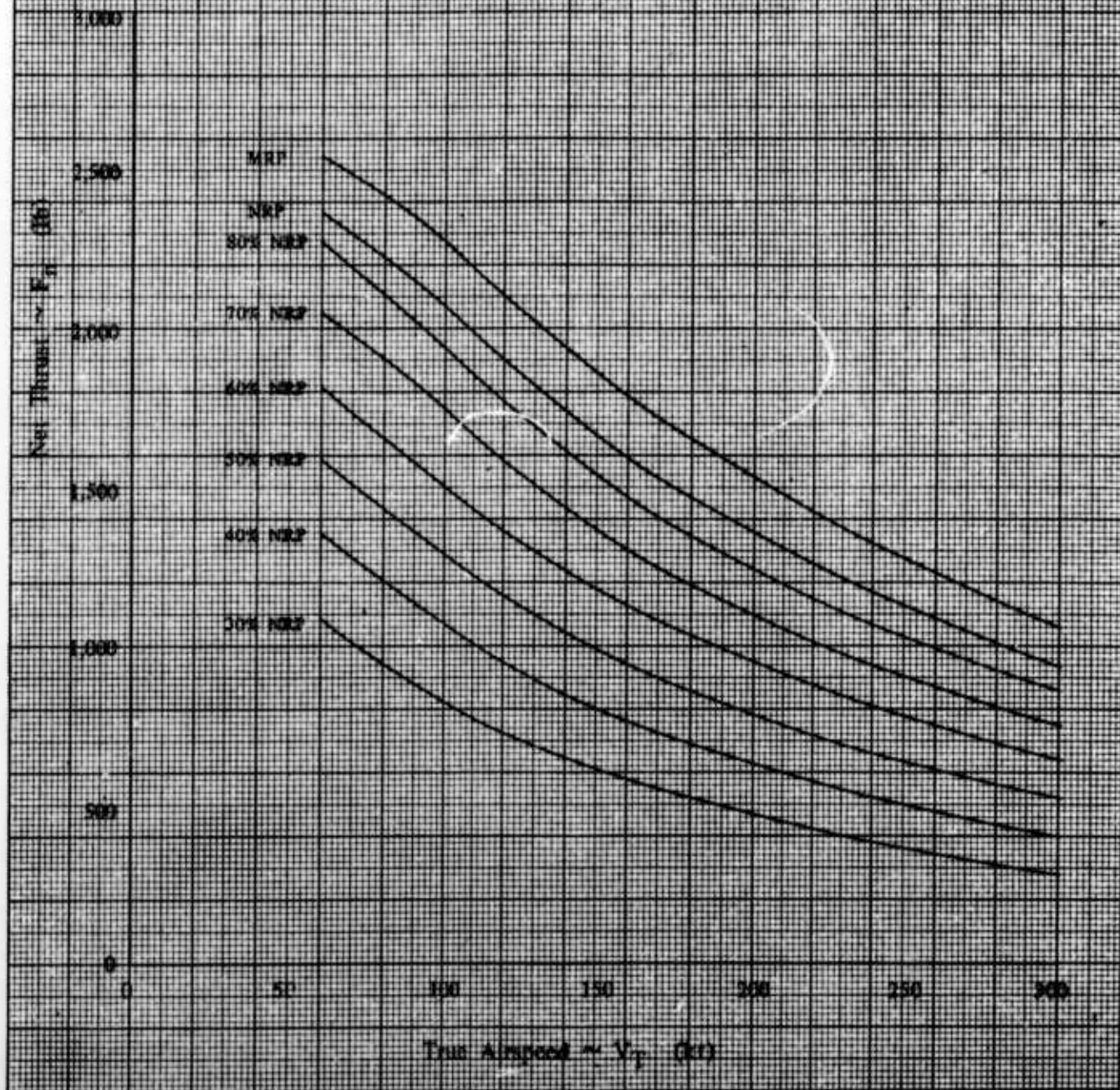


Figure 31. Engine Characteristics

Lycosine T55-1-701

Standard-Day Conditions:
Sea Level

- Note:
1. Environmental Control System bleed air ON.
 2. Fifteen-horsepower extraction.
 3. One-percent exhaust pressure loss.
 4. Specification engine based on IOM data.
 5. Engine inlet recovery curve (Fig. 34).
 6. Fuel flow increased 5 percent.
 7. Optimum power turbine speed.

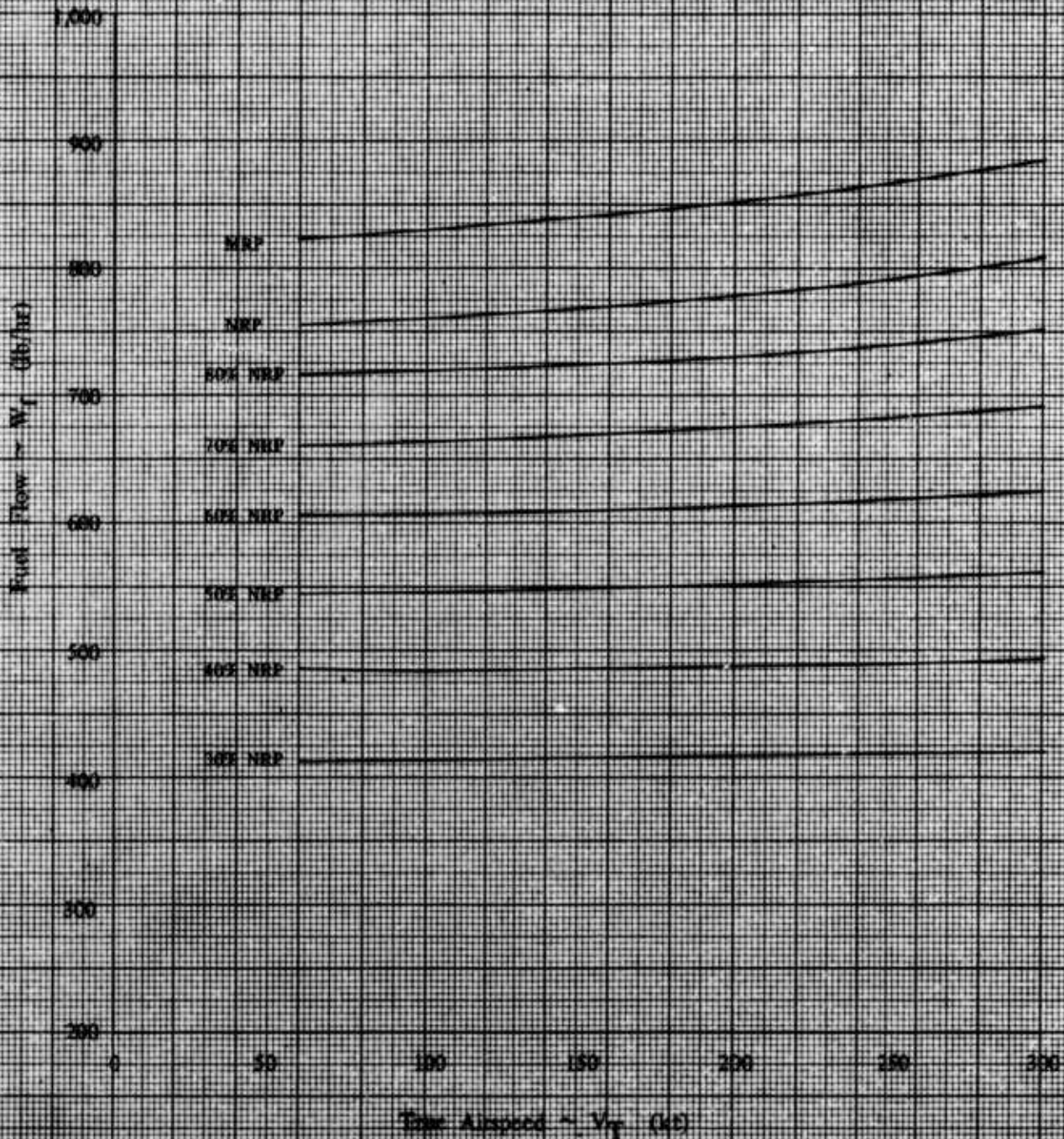


Figure 32. Engine Characteristics

Locking 200 L 70

Standard Day Conditions

Pressure Altitude

5,000 ft

Note:

1. Environmental Control System Used Air ON.
2. Fifteen horsepower extraction.
3. One-percent exhaust pressure loss.
4. Specification engine based on 1984 data.
5. Engine inlet recovery curve (Fig. 34).
6. Fuel flow increased 1 percent.
7. Optimum power turbine speed.

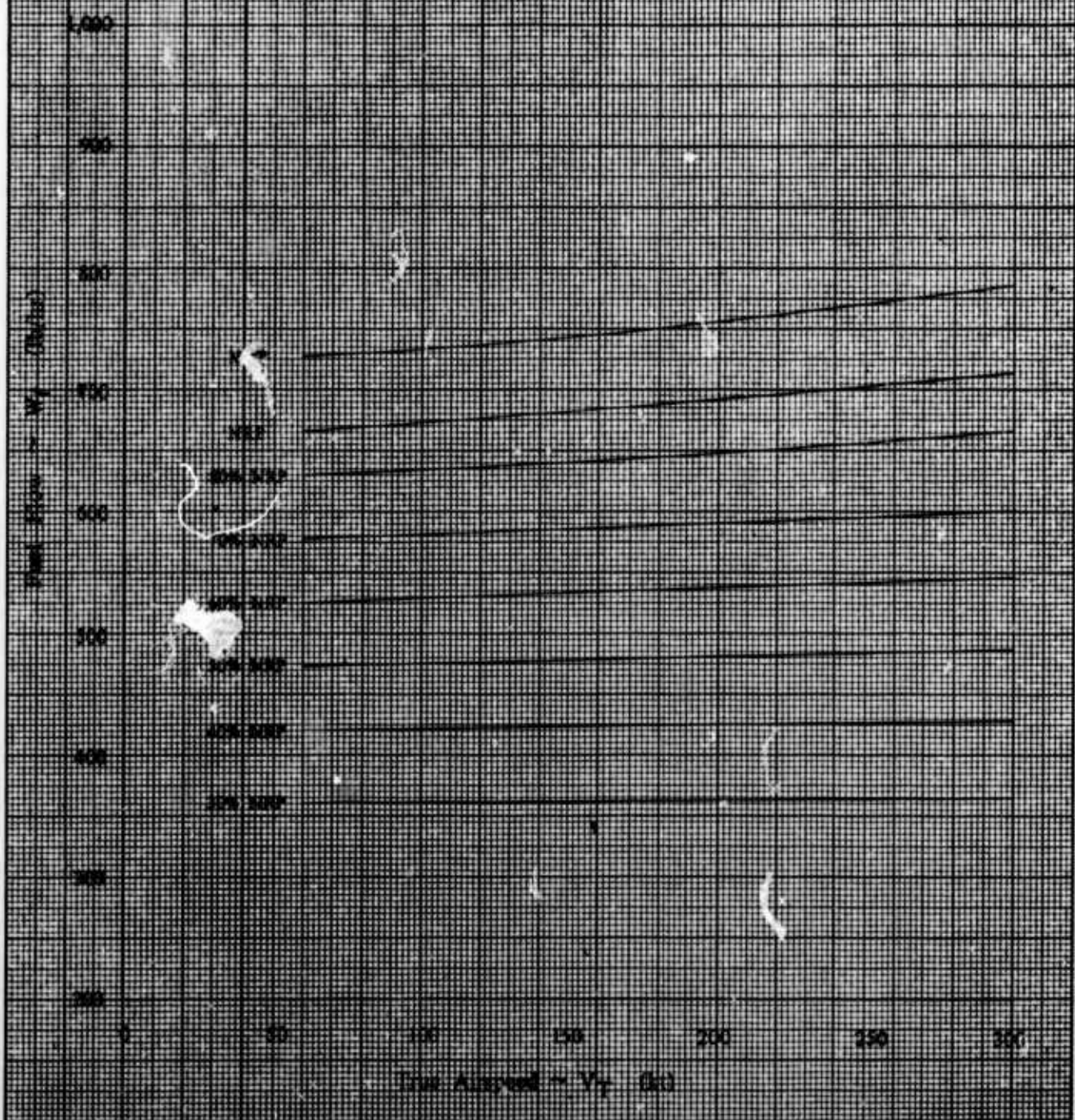


Figure 23. Engine Characteristics
Lycoming T55-L-701

Standard-Day Conditions:

Pressure Altitude: 10,000 ft

- Note:
1. Environmental Control System Bleed Air ON.
 2. Fifteen-horsepower extraction.
 3. One-percent exhaust pressure loss.
 4. Specification engine based on 1800 data.
 5. Engine inlet recovery curve (Fig. 34).
 6. Fuel flow increased 5 percent.
 7. Optimum power turbine speed.

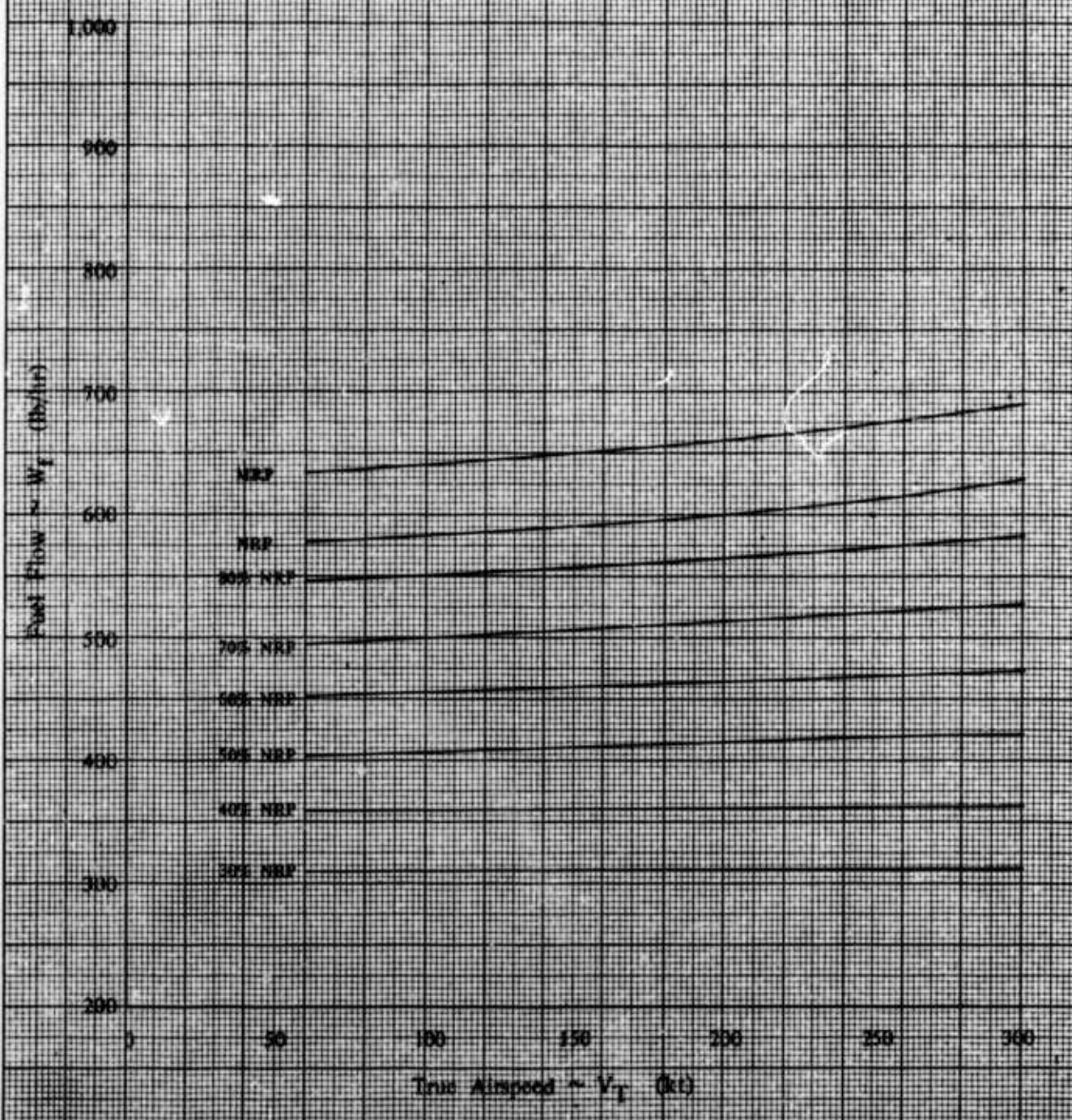


Figure 34. Inlet Total Pressure Recovery.

OY-1D USA S/N 68-16990

- Notes:
1. Data furnished by Grumman Aircraft Corporation.
 2. M_T is defined as Mach number.
 3. PT_1 is defined as total pressure at engine compressor face.
 4. PT_0 is defined as free stream total pressure.
 5. M_1 is defined as mass flow at engine compressor face.
 6. M_0 is defined as free stream mass flow.

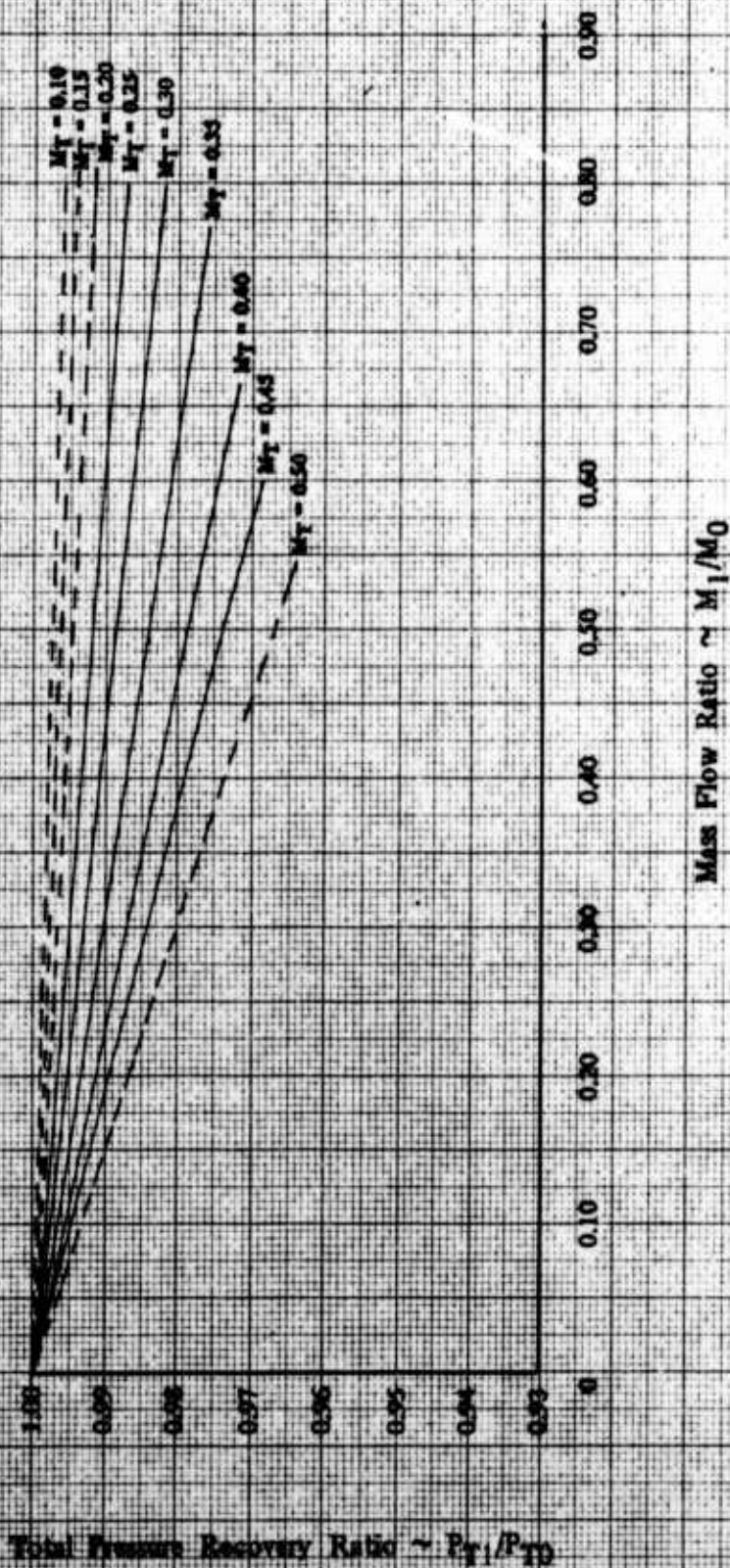


Figure 35. Engine Characteristics.

Lycoming T53-L-701 Engines, S/N 30001 and S/N 30000
 Military Rated Power Check Curve

Symbol	Test Conditions
⊙	Constant Mach Climb at 0.22 M _∞ (furnished by GAC)
△	Constant Mach Climb at 0.24 M _∞ (furnished by GAC)
◇	Single-Engine Climb at 2,000 feet (APE data)
⊠	Single-Engine Climb at 9,000 feet (APE data)

- Note: 1. Flagged symbols denote engine S/N 30000.
 2. Curve obtained from Lycoming Specification No. 10434, 30 Sep. 1968, revised 15 Feb. 1969.
 3. Bleed air OFF.

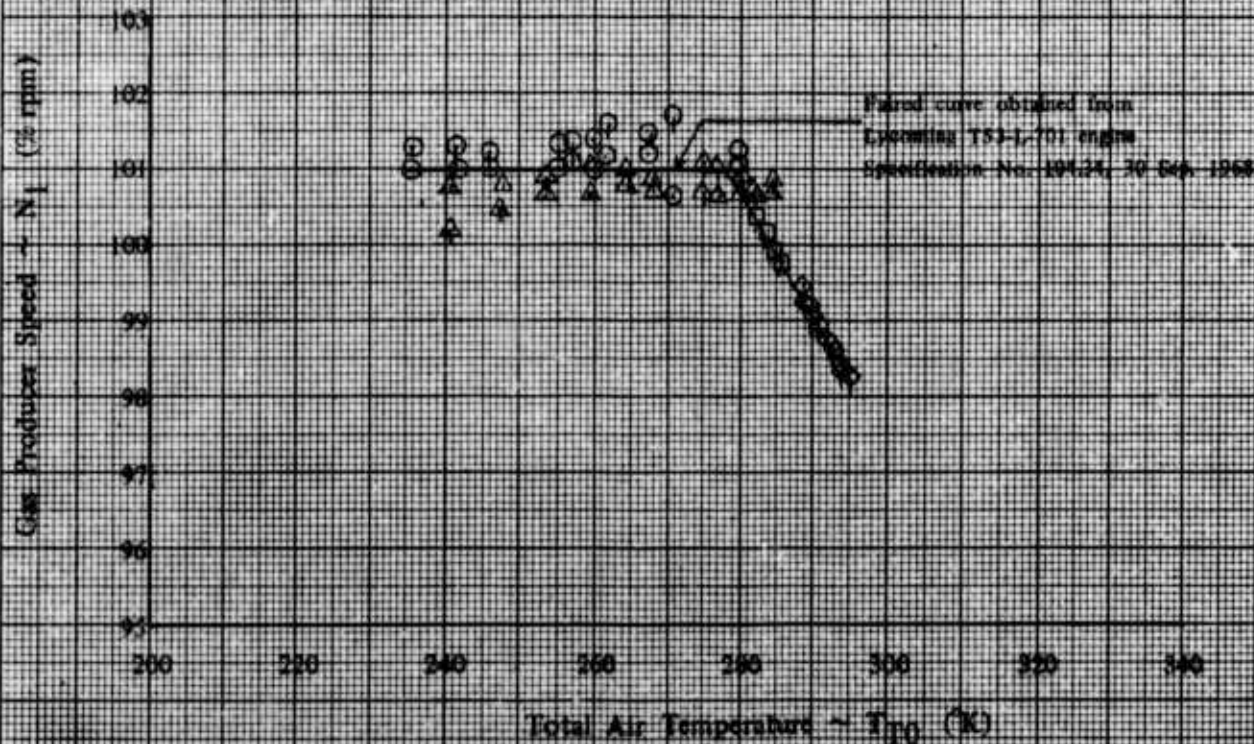


Figure 36. Engine Characteristics.

Lycoming T53-L-10E Engine 578 3000E

Symbol	Flight Condition	Average Pressure Altitude
○	Level flight	5,000 feet
◊	Level flight	1,000 feet
□	Level flight	10,000 feet

- Note: 1. Rating for specification engine at static, sea-level conditions.
 2. δ_1 based on engine inlet total pressure recovery presented in Figure 34.
 3. θ_1 based on ambient temperature.
 4. Bleed air OFF.
 5. Propeller speed: 1,600 rpm.

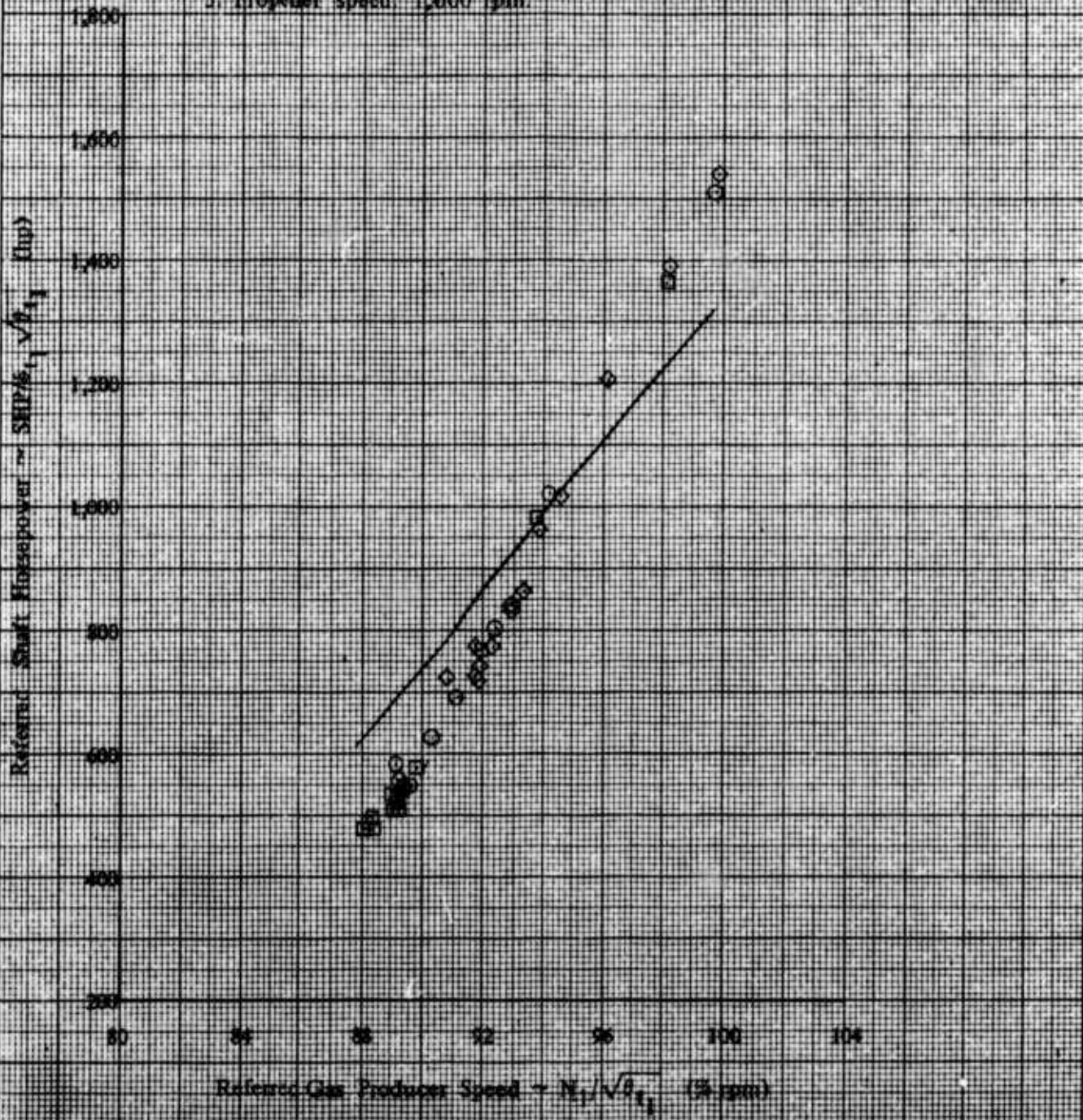


Figure 37. Engine Characteristics

Lycoming T53-L-701 Engine S/N 30001

Symbol	Flight Condition	Average Pressure Altitude
○	Level flight	5,000 feet
◊	Level flight	1,000 feet
○	Level flight	10,000 feet

- Note:
1. Fairing for specification engine at static sea-level conditions.
 2. δ_{T1} based on engine inlet total pressure recovery presented in figure 34.
 3. δ_{T1} based on ambient temperature.
 4. Bleed air OFF.
 5. Propeller speed: 1,600 rpm.

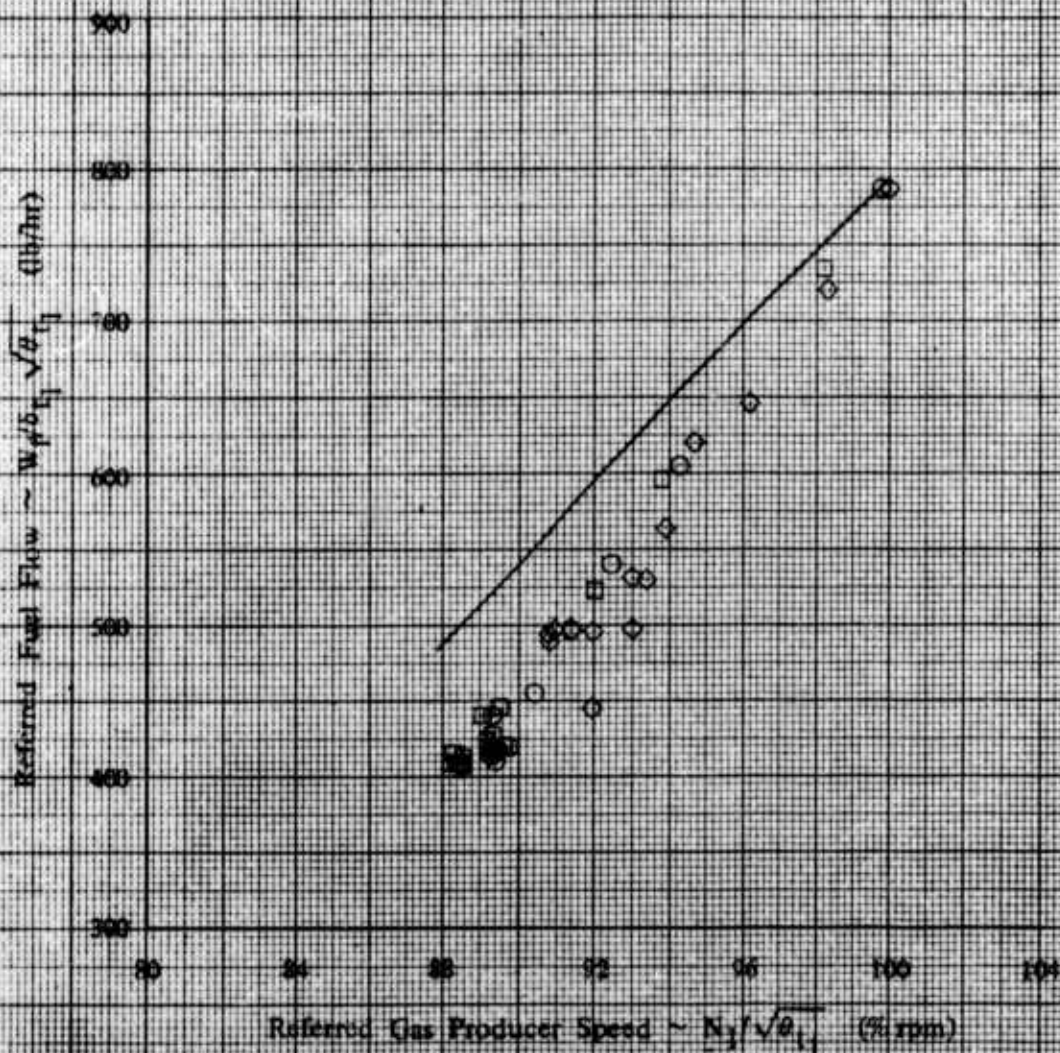


Figure 33. Engine Characteristics.

Lycoming TS3-L-701 Engine S/N 30993

Symbol	Flight Condition	Average Pressure Altitude
○	Level Flight	5,000 feet
□	Level Flight	1,000 feet
○	Level Flight	10,000 feet
△	Climb	9,000 feet

- Note:
1. Fairing for specification engine at static, sea-level conditions.
 2. σ_1 Based on engine inlet total pressure recovery presented in figure 34.
 3. θ_1 based on ambient temperature.
 4. Bleed air OFF.
 5. Propeller speed: 1,600 rpm.

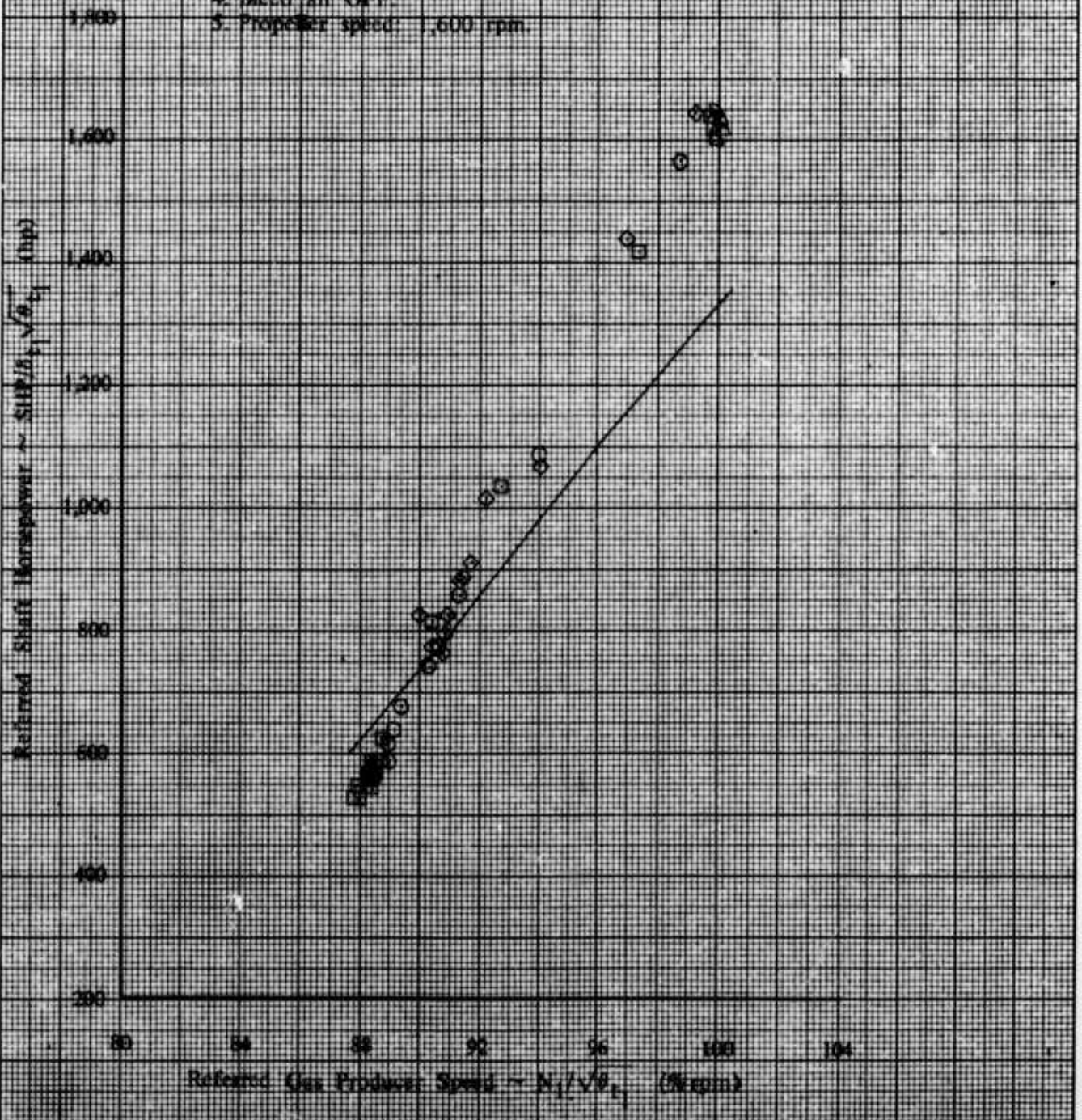


Figure 19 Engine Characteristics
 Lycoming T53-L-70 Engine S/N 30003

Symbol	Flight Condition	Average Pressure Altitude
○	Level flight	5,000 feet
□	Level flight	1,000 feet
◇	Level flight	10,000 feet
○	Climb	9,000 feet

- Note: 1. Fairing for specification engine at static, sea-level conditions.
 2. δ_{t1} based on engine inlet total pressure recovery presented in figure 34.
 3. θ_{t1} based on ambient temperature.
 4. Bleed air OFF.
 5. Propeller speed: 1,600 rpm.

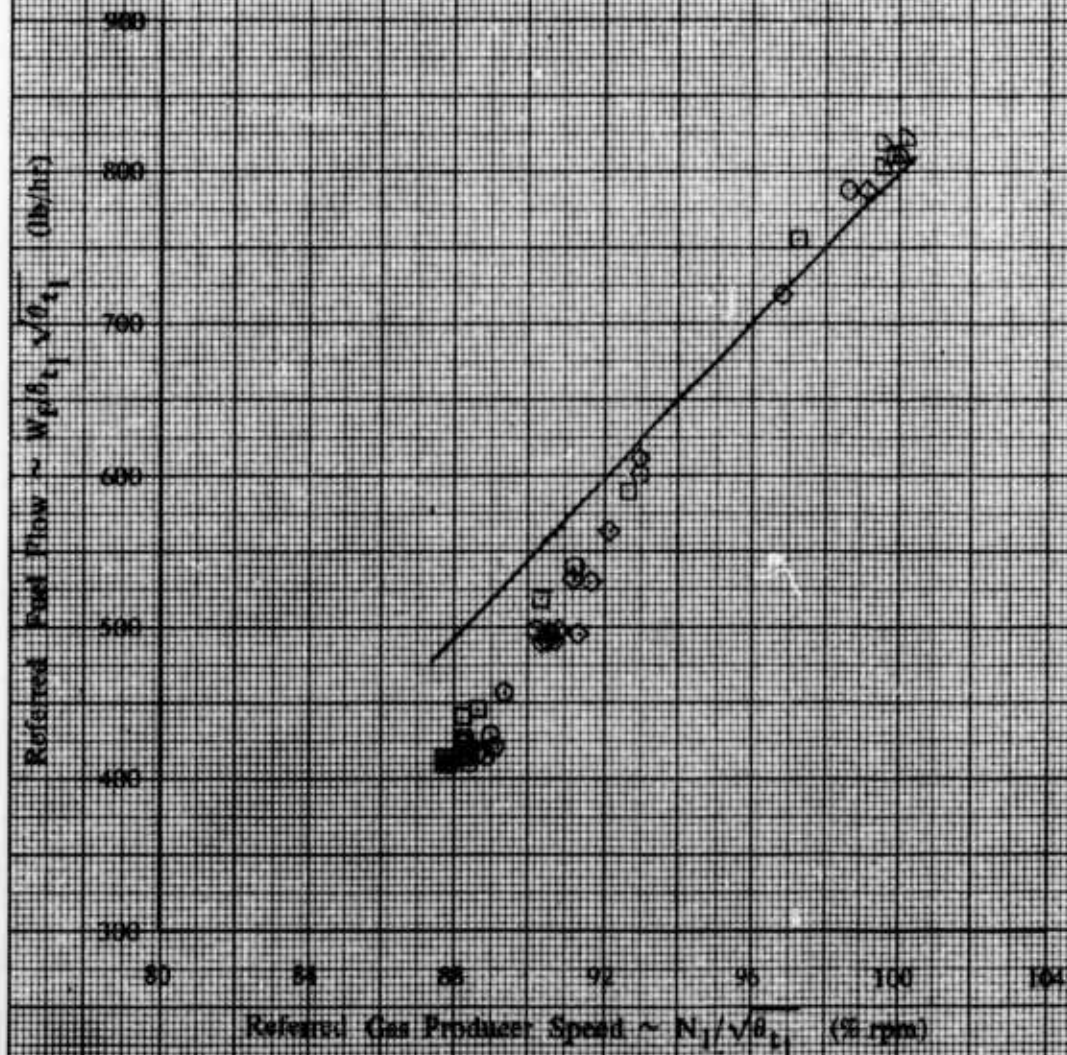
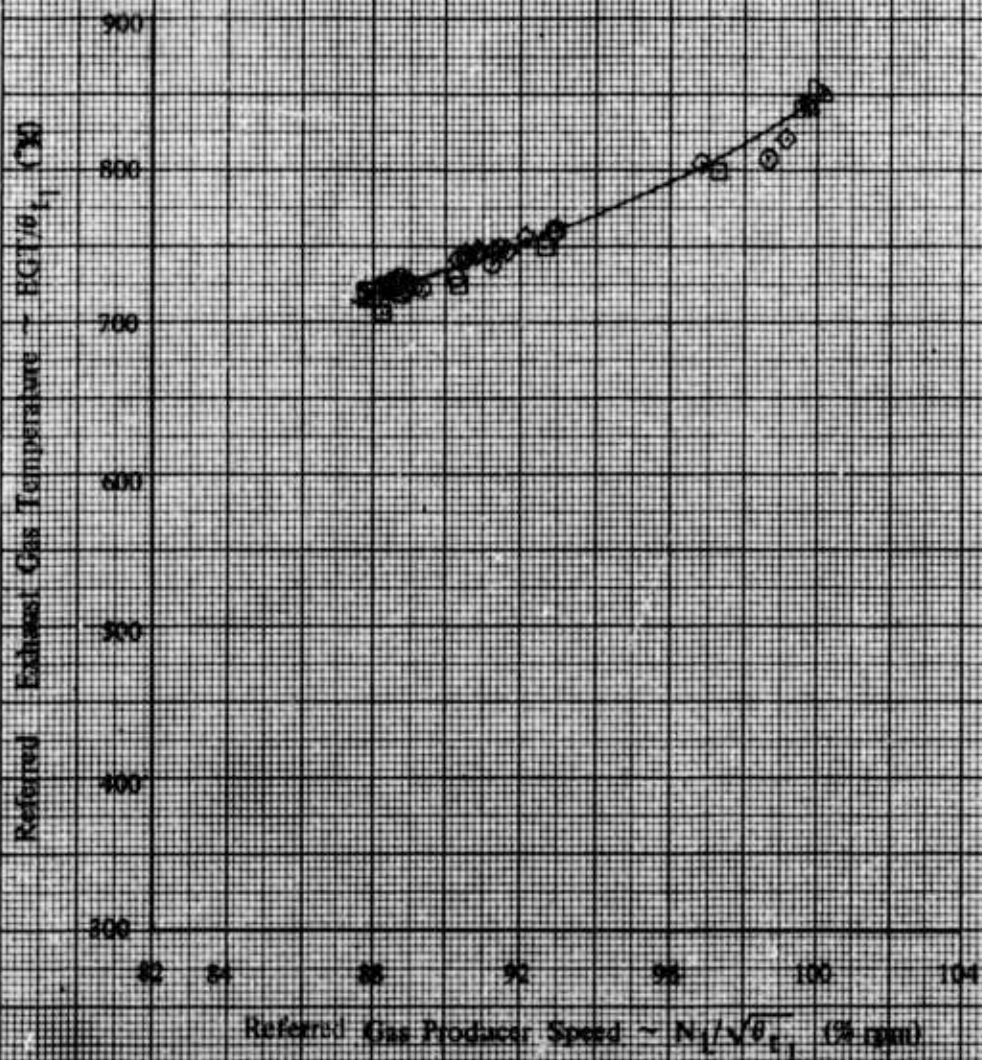


Figure 40. Engine Characteristics

Lycoming T53-L-701 Engine S/N 30003

Symbol	Flight Condition	Average Pressure Altitude
○	Level Flight	5,000 feet
□	Level Flight	1,000 feet
◇	Level Flight	10,000 feet
◊	Climb	9,000 feet

- Note:
1. Fixing for specification engine at static, sea-level conditions.
 2. P_{E1} based on ambient temperature.
 3. Bleed air OFF.
 4. Propeller speed: 1,600 rpm.



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13. ABSTRACT			
<p>Performance and stability and control testing was conducted on the production model OV-1D airplane (Mohawk) to evaluate its capability to perform the aerial surveillance mission and to determine military specification compliance. Testing was conducted by the US Army Aviation Systems Test Activity between 14 and 24 July 1970 at the Grumman Aerospace Corporation facility at Calverton, New York. Nine flights were accomplished with a total of 20.5 hours required to complete the test. The performance portion of the test results is presented in this addendum. The performance of the OV-1D was found to be satisfactory for accomplishment of the intended mission. Inadequate single-engine performance was the only shortcoming which was found in the test aircraft. Additional testing of the OV-1D is recommended in order to determine the airworthiness and flight characteristics for incorporation in the operator's manual.</p>			

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Performance and stability and control Production Model OV-1D Addendum Satisfactory for Intended mission Inadequate single-engine performance Additional testing recommended						