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EVALUATION OF THE OV-1D AIRCRAFT WITH THE YT53-L-704 ENGINE AND RUDDER AUGMENTATION SYSTEM PHASE II

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FINAL REPORT

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US ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523 - 5000

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A three phase (Phase I, IIA and IIB) evaluation of the OV-1D aircraft with increased power YT53-L-704 engines and a prototype rudder augmentation system (RAS) installation was performed. Phase I was conducted at Stuart, Florida between 16 December 1985 and 7 March 1986 as a joint US Army/Grumman Aerospace Corporation program. This phase involved engine build-up, initial engine and RAS installation, engine/propeller/airframe compatibilty tests, and initial flight tests. The Louvered Scarfed Shroud Suppressor (LSSS) system was removed

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following a high power ground run due to high engine nacelle temperatures which caused extensive damage to the fire shield and seal. All subsequent tests were conducted without LSSS installed. Phase IIA was conducted by the US Army Aviation Engineering Flight Activity (USAAEFA) at Stuart, Florida on 11 March 1986 as a two flight handling qualities evaluation of the OV-1D with RAS. A total of 4.0 flight hours were flown. The directional control system as designed and modified with RAS was unsatisfactory. Phase IIB was conducted by USAAEFA at Edwards Air Force Base and Paso Robles, California between 11 March 1986 and 13 May 1986 requiring 30.5 flight hours to complete. No problem of YT53-L-704 engine/ OV-1D airframe compatibility were identified with the exception of the LSSS high nacelle temperature. With YT53-L-704 engines installed, the OV-1D takeoff and single-engine climb performance were significantly improved. Dual-engine level flight range and endurance decreased approximately 5 and 4 percent, respectively. The handling qualities of the OV-1D were essentially unchanged at the higher powers attainable with the Y53-L-704. Pedal forces, although high, did not increase significantly during single-engine operation at the YT53-L-704 attainable power. The single-engine minimum control airspeed increased approximately 3/4 knot per 100 shaft horsepower. The Safe Flight Instrument Corporation stall warning system performed satisfactorily for dual-engine stall tests but failed to provide adequate warning for single-engine stall tests. The high engine noise level in the cockpit was identified as a deficiency which has existed with the standard engines.

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INTRODUCTION

BACKGROUND

1. Single-engine performance of the OV-1D at mission gross weight is very marginal even after jettisoning wing stores. Mission effectiveness is compromised when operating at airfields with a combination of high altitude and high temperature because gross weight has to be decreased to maintain single-engine climb capability. The US Army Aviation Systems Command (AVSCOM) tasked (ref 1, app A) the US Army Aviation Engineering Flight Activity (USAAEFA) to plan, conduct, and report on an evaluation of the OV-1D equipped with the increased power YT53-L-704 engine and a rudder augmentation system (RAS). A joint USAAEFA/Grumman Aerospace Corporation (GAC) feasibility evaluation was designated to determine how much additional horsepower could be used on the OV/RV-1D while maintaining adequate handling qualities and structural integrity.

TEST OBJECTIVES

2. The overall objective was to evaluate the effects of increasing the power available on the OV-1D. Specific objectives were to determine:

a. The maximum horsepower feasible while maintaining adequate handling qualities and engine-airframe compatability.

b. The variations in takeoff, climb, and cruise performance with increasing horsepower.

c. The effect of the RAS on directional flight characteristics and handling qualities.

d. The effectiveness of the Safe Flight Instrument Corporation (SFIC) stall warning system at powers higher than previously tested.

DESCRIPTION

3. The OV-1D(C) test aircraft, serial number 62-5867, is a two-place, twin engine turboprop aircraft featuring a midwing, triple vertical stabilizers, and a tricycle landing gear. Seven external store stations, including the fuselage, are used to carry a variety of surveillance pods and/or fuel tanks. For this program, the aircraft was tested in two external store configurations: two 150 gallon drop tanks (BASIC configuration) and two 150 gallon drop tanks and Side Looking Airborne Radar (SLAR) boom

installed (STORES configuration). The Louvered Scarfed Shroud Suppressor (LSSS) was removed to prevent damage in the engine compartment area due to the higher operating temperature of the YT53-L-704 engine. An airspeed/angle-of-attack and sideslip boom was mounted on the SLAR antenna attachment points or on the SLAR antenna depending on the external store configuration being tested (photo 1, app B). A more detailed description of the OV-1D aircraft is contained in appendix B and in the operator's manual (ref 2, app A). The major modifications to the test aircraft included:

a. AVCO Lycoming YT53-L-704 engines rated at 1800 shaft horsepower (shp) at sea level standard day conditions. Each engine consists of a T53-L-703 compressor and hot section, a T53-L-701 propeller gearbox, and a modified T53-L-701 fuel control.

b. A RAS (one for each outboard rudder) consisting of new cranks and support brackets, new pushrods, T-46 rudder actuators and support fittings, local rib structure reinforcements, larger access covers, and hydraulic lines to the actuators.

c. A SFIC stall warning system consisting of a lift transducer on the leading edge of the right wing, flap position transmitter, lift computer, rudder pedal shaker, stall warning tone generator, and a weight on wheels switch. A detailed description of the SFIC stall warning system and its operation is contained in reference 3.

TEST SCOPE

4. The evaluation was conducted in three phases: Phase I, IIA and IIB. Phase I was an initial evaluation of the OV-1D with YT53-L-704 engines and a prototype RAS installation. This phase was performed at Stuart, Florida between 16 December 1985 and 7 March 1986 as a joint US Army/GAC program which included engine build-up, initial engine and RAS installation, engine/propeller/airframe compatibility tests, and initial flight tests. GAC planned, conducted, and reported on Phase I with USAAEFA providing a test pilot, an instrumented aircraft, and data reduction support. USAAEFA submitted a letter of effort on Phase I (ref 4).

5. Phase IIA was a handling qualities evaluation with YT53-L-704 engines and RAS installed and was conducted by USAAEFA at Stuart, Florida on 11 March 1986 requiring two flights totaling 4.0 flight hours. Phase IIB which included tests with the RAS removed was conducted at Edwards Air Force Base and Paso Robles, California.

A total of 16 flights and 30.5 flight hours (25.2 productive flight hours) were conducted between 12 April and 13 May 1986. The SFIC stall warning system installed for a previous program (USAAEFA Project No. 85-16) remained in the aircraft for a continuing evaluation of its effectiveness at higher engine thrust. All tests were conducted in accordance with the test plan (ref 5) in day visual meteorological conditions and within the limits of the operator's manual and airworthiness releases (refs 6 and 7). The handling qualities were compared to the requirements of Military Specification MIL-F-8785C (ref 8). Performance and handling qualities tests were conducted over a range of takeoff gross weights, pressure altitudes, flap and power settings, at a mid longitudinal center of gravity location, and mainly in the BASIC external store configuration. The LSSS was not installed. The aircraft configurations are listed in table 1 with the test conditions shown in tables 2 and 3.

TEST METHODOLOGY

6. Established engineering flight test techniques and data reduction procedures were used during this evaluation (refs 9 and 10, app A). The test methods are described briefly in the Results and Discussion section of this report. A more detailed description of the test techniques and data analysis methods may be found in appendix D. Data was recorded on magnetic tape onboard the aircraft and via telemetry to the Real Time Data Acquisition and Processing System (RDAPS). A detailed listing of the test instrumentation is included in appendix C.

Table 1. Airplane Configurations

Airplane Configuration	Landing Gear Position	Flap Setting (deg)	Power Setting
Takeoff (TO)	Down	15	Takeoff
Climb (CL)	Up	0	Takeoff
Cruise (CR)	Up	0	Power for Level Flight
Go-Around (GA)	Down	45	Takeoff

Table 2. Performance Test Conditions

Test	Average Gross Weight (lb)	Average Longitudinal Center of Gravity Location (FS)	Average Density Altitude (ft)	Trim Calibrated Airspeed (kt)	Power Setting (shp)	Airplane Configuration	External Stores Configuration
Takeoff[1]	16,400	160.0 (mid)	-520	92[3]	1680 1700 1770 1800	TO	Basic[2]
	18,200		840		1800		Stores[4]
Dual-Engine Level Flight	15,600	160.8 (mid)	3040	96 to 263	321 to 1677	CR	Basic
Single-Engine Level Flight	15,600	160.9 (mid)	4980	101 to 200	819 to 1789	CR	Basic
	17,570	161.4 (mid)	10,060	113 to 167	1137 to 1454		
Single-Engine Climb	15,580	160.1 (mid)	5320	117 to 180	1560	CL	Basic
	15,840	160.9 (mid)	5060	109 to 189	1700		
	17,590	159.7 (mid)	5900	116 to 179	1752		Stores

NOTES:

[1]Ground roll measurement only.
[2]Basic: 150-gallon drop tank at wing station 3 and 4.
[3]Rotation airspeed.
[4]Stores: SLAR, 150-gallon drop tank wing station 3 and 4.

Table 3. Handling Qualities Test Conditions[1]

Test	Average Gross Weight (lb)	Average Density Altitude (ft)	Trim Calibrated Airspeed (kt)	Average Power Settings (shp)	Airplane Configuration	External Stores Configuration
Static Longitudinal Stability	14,380	5540	119	1606	CL	
	14,100	4820	107	1656	TO	Basic[2]
	16,980	5580	183	1721	CL	Stores[3]
Static Lateral-Directional Stability	17,500	6400	133, 180	1705	CL	
	15,200	7500	132, 160	1603	CL[4]	
	16,600	6400	118, 150	1665	TO	Basic
	14,500	5000	120, 150	1599	TO[4]	
	16,200	6400	118, 150	1627	GA	
	14,500	5500	102, 150	1561	GA[4]	
Dynamic Longitudinal Stability	14,240	5600	117	1639	CL	Basic
	15,780	5840	127	1642	TO	
Dynamic Lateral-Directional Stability	15,040	5820	133, 157	1614	CL	
	14,680	5820	119, 149	1624	TO	Basic
	14,280	5540	102, 146	1600	GA	
Dual-Engine Stall Characteristics			105	1500, 1600	CL	
	15,200	5300	TO trim[5]	1600	TO	Basic
			105	1600	GA	
			114	1700	CL	
	17,700	4600	TO trim	1700	TO	Stores
			106	1650	GA	
Single-Engine Stall Characteristics	16,120	4200		1350-1800	CL	
	15,740	4600	130	1500-1700	CL[4]	Basic
	15,050	8900		1300-1500	CL	
	15,200	7200		1350-1400	CL[4]	
	15,740	4200		1400-1650	TO	
	15,600	4600	TO trim	1600-1700	TO[4]	Basic
	15,100	7200		1350-1400	TO[4]	
	15,660	4200		1400-1650	GA	
	15,600	4600	114	1600	GA[4]	Basic
	15,100	7200		1400-1500	GA[4]	
	17,600		134	1600-1750	CL	
	17,660	4800	TO trim	1350-1650	TO	Stores
	17,340		105	1300-1700	GA	
Static Single-Engine Minimum Control Airspeed	16,120	4200		1350-1800	CL	
	15,740	4600	130	1500-1700	CL[4]	Basic
	15,050	8900		1300-1500	CL	
	15,200	7200		1350-1400	CL[4]	
	15,740	4200		1400-1650	TO	
	15,600	4600	TO trim	1600-1700	TO[4]	Basic
	15,100	7200		1350-1400	TO[4]	
	15,660	4200		1350-1800	GA	
	15,550	4600	114	1600	GA[4]	Basic
	15,100	7200		1400-1500	GA[4]	
	17,600		134	1600-1750	CL	
	17,660	4800	TO trim	1350-1650	TO	Stores
	17,340		105	1300-1700	GA	
Dynamic Single-Engine Minimum Control Airspeed	15,980	4200		1400-1800	CL	
	15,200	7200		1350-1400	CL[4]	
	15,440	4200	V_{mc}[6]	1400-1650	TO	Basic
	15,100	7200		1350-1400	TO[4]	
	15,520	4200		1350-1700	GA	
	15,100	7200		1400-1500	GA[4]	
	18,000			1750	CL	
	17,600	4800	V_{mc}	1650	TO	Stores
	17,400			1700	GA	
Engine Failure	17,460	7040	120-197	1537-1773	CL	
	17,310	7013	116-140	1551-1690	TO	Basic
	17,200	7040	117-145	1573-1609	GA	
Engine Acceleration/Deceleration	17,780	15,880	108	586-1116	GA	Basic
Trimmability	16,960	2640	97	1402-1601	GA	Basic

NOTES:

[1]All tests conducted with RAS removed except as noted and at a mid center of gravity.
[2]Basic: 150-gallon drop tank at wing stations 3 and 4.
[3]Stores: SLAR, 150-gallon drop tank at wing stations 3 and 4.
[4]RAS installed.
[5]Operator's manual recommended takeoff trim setting.
[6]V_{mc}: Static minimum control airspeed.

RESULTS AND DISCUSSION

GENERAL

7. Performance and handling qualities characteristics of the OV-1D with YT53-L-704 engines installed were evaluated in the BASIC and STORES configurations. All tests were conducted with LSSS removed. Limited handling qualities tests of the OV-1D with RAS installed were performed, and the SFIC stall warning system was evaluated at the higher output power of the YT53-L-704 engines. The OV-1D with the YT53-L-704 engines installed showed significant improvement in single-engine climb performance. The flaps up single-engine minimum control airspeed (V_{mc}) increased slightly with the higher powers attainable with the YT53-L-704, however, pedal force during single-engine operation remained unchanged. The SFIC stall warning system provided inadequate warning at the higher thrust levels during single-engine operation, however, full pedal deflection was always encountered at least 10 knots prior to stall which provided an adequate cue of impending stall. The engine noise level in the cockpit during high power/propeller speed settings preclude cockpit and radio communication and is a deficiency. The handling qualities of the OV-1D with the YT53-L-704 engines were essentially unchanged from the standard OV-1D aircraft.

PERFORMANCE

General

8. The performance capabilities of the OV-1D aircraft with YT53-L-704 engines were evaluated to provide data for comparison with an OV-1D aircraft with the standard T53-L-701 engines installed. All tests were conducted at the test conditions outlined in table 2. Takeoff performance and single-engine climb performance showed significant improvements. Range and endurance decreased due to the increase in fuel consumption of the YT53-L-704 engines.

Takeoff Performance

9. Takeoff performance was conducted at the test conditions shown in table 2. Handbook takeoff trim settings were used with the aircraft positioned on the runway centerline. The desired power was applied prior to brake release; however, if the wheels started to slide prior to brake release, the desired power was applied during the ground roll. All takeoff runs were started at a known point and ground observers were used to determine ground roll distance to the lift-off point. Lift-off airspeed was the handbook recommended airspeed or V_{mc} plus 5 knots indicated airspeed (KIAS), whichever was higher. The takeoff data are

presented in table 4. Takeoff distance was approximately 500 feet less at 1800 shp than at 1400 shp for 18,200 lb gross weight. Takeoff performance with flaps at zero should be evaluated to determine if the single-engine best rate of climb airspeed (V_{yse}) can be safely attained sooner without excessive ground run than with flaps at the 15 degree setting. Additional takeoff performance tests with the YT53-L-704 engines and LSSS installed should be evaluated.

10. Ambient cockpit engine noise levels during takeoff performance tests were measured using a model 1933 sound audiometer manufactured by General Radio. The noise levels were high (111 decibels) and precluded intelligible cockpit intercommunications and external radio reception. The high noise levels can be alleviated by wearing earplugs but communications cannot be understood. If earplugs are not worn, communications can be heard but the noise level is painful and damaging to the ears. The high ambient cockpit engine noise levels at high power settings is a deficiency. This deficiency is not only associated with the YT53-L-704 engine but also with the T53-L-701 engines.

Single-Engine Climb Performance

11. Single-engine climb performance was evaluated at the test conditions shown in table 2. The sawtooth climb method was used with the left engine shutdown and propeller feathered and the right engine operating at the desired power setting. The test aircraft was stabilized with the flight control trim tabs set for minimum control force. Figure 1, appendix E, presents the drag polar at all conditions tested. Single-engine climb performance at standard day and hot day atmospheric conditions are summarized in figures 2 and 3. A comparison of the single-engine climb performance at 200 feet per minute (fpm) climb capability with either engine installed is presented in figure 4.

12. Significant single-engine climb capability is gained with the YT53-L-704 engines. Figure 4 shows the OV-1D aircraft with YT53-L-704 engines installed is able to obtain 200 fpm rate of climb up to a gross weight of 16,760 lb on a 4000 feet 35 degree C day. Where as with T53-L-703 engine at the same ambient conditions, 200 fpm can be attained only up to 14,320 lb. The OV/RV-1D aircraft with its various equipment operates satisfactorily at 1400 shp. If a need exists to provide to the field an improved single-engine climb capability immediately, then the T53-L-704 engine can be flat rated at 1400 shp, which will still provide the hot day single-engine climb capability. The increase in hot day power available and single-engine climb performance provided by the YT53-L-704 engines enhances safe mission accomplishment.

Table 4. Takeoff Performance[1]

Average Gross Weight (lb)	Average Pressure Altitude (ft)	Average Air Temperature (deg C)	Average Shaft Horsepower Per Engine	Rotation Airspeed (KCAS)	Lift-Off Distance (ft)
16,400[2]	600	5.0	1680		980
16,400	550	9.0	1700		1070
16,400	550	6.0	1770		800
16,400	800	10.0	1800	92	1150
18,200[3]	750	15.0	1800		1490
18,200	700	14.0	1800		1500

NOTES:

[1]All tests conducted at longitudinal center of gravity of 160.0 FS.
[2]150-gallon drop tanks at wing stations 3 and 4.
[3]SLAR, and 150-gallon drop tanks at wing stations 3 and 4.

The YT53-L-704 engines should be installed on operational aircraft. Additional single-engine climb performance with YT53-L-704 engines and LSSS installed should be performed.

Level Flight Performance

13. Dual and single-engine level flight performance was evaluated at the test conditions shown in table 2. The constant pressure altitude technique was used. The test aircraft was stablized and trimmed (ball-centered) at 10 knots incremental airspeeds from minimum obtainable to the maximum level flight airspeed at military rated power. During single-engine level flight test the left engine was shutdown and propeller feathered and the right engine operated at the required power setting. The drag polars are presented in figures 5 and 6, appendix E. Figures 7 through 9 present the dimensional level flight performance data gathered during this test. Dual-engine range and endurance summaries at standard and hot day atmospheric conditions are presented in figures 10 through 13. A comparison of dual-engine level flight range and endurance at 14,000 feet pressure altitude with either engine installed are summarized in figures 14 and 15.

14. The fuel consumption of the YT53-L-704 engine increased with increase in shaft horsepower available. In order for the YT53-L-704 to produce the higher power, the engine had to operate at a higher temperature and bleed air for cooling had to be introduced in the first stage gas producer turbine blades and nozzle. The effects of the increased fuel consumption are reflected in decreased maximum range and endurance as shown in table 5. Comparatively, at 14,000 feet pressure altitude, the maximum range and endurance time of the OV-1D with the YT53-L-704 installed decreased by 5.1 and 4.3 percent respectively. Additional level flight performance tests with the YT53-L-704 engine and LSSS installed should be performed.

HANDLING QUALITIES

General

15. A limited handling qualities evaluation was conducted to determine stability and control characteristics of the OV-1D aircraft with the YT53-L-704 engines installed. Selective test for comparative purposes were also conducted with RAS installed. Emphasis was placed on the higher power settings of the YT53-L-704 engines to determine its effect on the handling qualities of the aircraft. Engine/airframe compatability was also evaluated. The handling qualities of the OV-1D aircraft with the YT53-L-704

Table 5. Dual-Engine Level Flight Maximum Range and Endurance

	Range Performance			Endurance Performance		
Engine	Long Range Cruise Airspeed (kts)	Specific Range (naut. mi/lb)	Range (naut. mi)	Airspeed (kts)	Fuel Flow (lb/hr)	Mission Time (hr)
L701	215	0.274	822	143	615	4.88
L704	215	0.260	780	143	642	4.67

NOTES:

[1]Gross weight range: 18,000 lb to 15,000 lb.
[2]Fuel used: 3,000 lb.
[3]14,000 feet pressure altitude, standard day
[4]Data obtained from figures 14 and 15, appendix E.

engines installed were essentially unchanged from the standard OV-1D aircraft. Pedal forces although high did not increase significantly during single-engine operation at the YT53-L-704 attainable powers. The directional control system as designed and modified with RAS was unsatisfactory. The engine/airframe compatibility and response characteristics were satisfactory with the exception of LSSS high nacelle temperatures.

Control System Characteristics

16. During Phase IIA testing, the directional control system was modified as discussed in appendix B. The directional control breakout plus friction force with RAS installed but turned off was 18 lb, slightly greater than the 12 lb RAS uninstalled configuration. The 18 lb breakout plus friction force increased nonlinearly to 46 lb at the maximum pedal deflection on the ground (no air load). Positive pedal centering was provided and was satisfactory. The directional control system characteristics during operation in a failure mode caused an increase in V_{mc}, degraded single-engine handling qualities, increased pilot workload, and increased pedal forces above those that would be experienced with the current directional control system. The directional control system as designed and modified with RAS for Phase IIA was unsatisfactory. Because the handling qualities characteristics of the OV-1D with the RAS installed could not be compared with the operational OV/RV-1D (RAS uninstalled) characteristics, the RAS was replaced with the conventional directional control system for Phase IIB.

Static Longitudinal Stability

17. Static longitudinal stability was evaluated at the test conditions shown in table 3. The aircraft was trimmed at the desired airspeed then stabilized in 5 knot increments up to 20 knots faster or slower than the trim airspeed while maintaining constant throttle and trim settings. Test results are shown in figures 16 through 18, appendix E. The stick-free (variation of longitudinal control force with airspeed) and stick-fixed (variation of longitudinal control position with airspeed) static longitudinal stability was positive, and unchanged from OV-1D with T53-L-701 engines installed. The static longitudinal stability characteristics of the OV-1D with RAS installed or uninstalled, and with YT53-L-704 engines installed is satisfactory and met the requirements of MIL-F-8785C.

Static Lateral-Directional Stability

18. Static lateral-directional stability tests were conducted at the test conditions shown in table 3. Tests were conducted by

trimming the aircraft (ball-centered) and then stabilizing at various sideslip angles up to the limits of the sideslip envelope (15 degrees) at a constant airspeed and engine power while maintaining zero turn rate. Plots of pedal force versus sideslip and rudder deflection versus link loads are presented in figures 19 through 28, appendix E. Static lateral-directional stability, dihedral effect, and sideforce characteristics were positive both RAS ON and OFF (installed) and uninstalled. Although pedal force lightening was encountered in the takeoff and landing configurations, lateral-directional stability remained positive and the force lightening was not objectionable. The static lateral-directional stability characteristics of the OV-1D with YT53-L-704 engines installed and with RAS installed and uninstalled are satisfactory and met the requirements of MIL-F-8785C.

Dynamic Longitudinal Stability

19. Dynamic longitudinal stability tests were conducted at the test conditions shown in table 3. The long-term (phugoid) dynamic characteristics were evaluated by varying airspeed 10 knots above and below the trim airspeed, then returning the longitudinal control to the trim position. Representative time histories are presented in figures 29 and 30, appendix E. The phugoid was unstable, at maximum power (1800 shp) in the takeoff (TO) configuration. The period was approximately 30 seconds and was not objectionable. The short-period longitudinal stability (gust response) was evaluated by introducing longitudinal control pulses. Typical short-period simulated gust response time histories are presented in figures 31 and 32. Longitudinal short-term characteristics were essentially deadbeat for all test conditions. The dynamic longitudinal stability characteristics of the OV-1D with YT53-L-704 engines is satisfactory, essentially unchanged from the standard OV-1D aircraft and met the requirements of MIL-F-8785C.

Dynamic Lateral-Directional Stability

20. Dynamic lateral-directional stability tests were conducted at the test conditions shown in tables 3. Dutch roll mode oscillations were excited by releases from steady heading sideslips and from rudder doublets. Typical time histories for releases from steady heading sideslips and rudder doublet excitations are presented in figures 33 through 40, appendix E. The roll to sideslip ratio of 1:2 was well damped with approximately three overshoots. The dynamic lateral-directional stability of the OV-1D with YT53-L-704 engines is satisfactory both RAS installed and not installed and met the requirements of MIL-F-8785C.

Stall Characteristics

21. Dual and single-engine unaccelerated stalls were conducted at the test conditions shown in table 3. Flight control trim tabs were set for each aircraft configuration as defined in paragraph 9, appendix D. The aircraft was decelerated at a rate of one knot or less per second until stall occurred. Stall warning airspeeds, stall airspeeds, and handling qualities associated with the stalls were evaluated. Dual and single-engine stall airspeeds and stall warning airspeeds as a variation with power and configuration are presented in tables 6 through 8. The dual and single-engine stalls were preceded by roll and pitch oscillations with increased nose drop and wing roll off at the stall. Recovery was easily effected by releasing stick back pressure and allowing the aircraft to increase airspeed. The dual and single-engine stall characteristics of the OV-1D with the YT53-L-704 engines installed were satisfactory and met the requirements of MIL-F-8785C. The dual-engine stall warning margins were satisfactory and met the requirements of MIL-F-8785C. Single-engine stall warning margins at T53-L-701 power levels were satisfactory. The single-engine stall warning margins with higher power settings (1300 shp to 1800 shp) were unsatisfactory (as little as one knot warning) and did not meet the requirements of MIL-F-8785C. However, during all single-engine stalls where warning was inadequate, full pedal deflection occurred at least 10 knots prior to the stall which provided adequate cue to the pilot of impending stall. When the SFIC stall warning system is installed in operational unit aircraft, the following warning should be incorporated in chapter 8 of the operator's manual.

WARNING

> During single-engine operations at high power, the stall warning system does not provide adequate stall warning. Airspeed should not be decreased below the point where full rudder pedal deflection is required to maintain balanced (ball-centered) flight. Simultaneous stall and V_{mc} with resultant loss of control may occur without warning (neither buffet nor artificial warning).

Single-Engine Minimum Control Airspeed

22. Static and dynamic V_{mc} evaluations were conducted at the conditions shown in table 3. A definition of static and dynamic V_{mc} and trim tab settings for each configuration is contained

Table 6. Dual-Engine Stall[1]

Aircraft/SLAR Configuration	Average Shaft Horsepower (shp)	Average Gross Weight (lb)	Average Density Altitude (ft)	SFIC Warning Airspeed (KCAS)	Stall Airspeed (KCAS)
CL/OFF	1700	17,700	4600	84	76
CL/ON	1500	15,200	5300	81	75
CL/ON	1600	15,200	5300	82	75
TO/OFF	1700	17,700	4600	83	72
TO/ON	1600	15,200	5300	84	70
GA/OFF	1650	17,700	4600	75	67
GA/ON	1600	15,200	5300	80	66

NOTE:

[1]All tests conducted at longitudinal center of gravity of FS 160.5, RAS removed, and externally configured with two 150 gallon drop tanks.

Table 7. Single-Engine Stall with Right Engine Shutdown[1]

Aircraft/SLAR Configuration	Rudder Augmentation System	Average Shaft Horsepower (shp)	Average Gross Weight (lb)	Average Density Altitude (ft)	SFIC Warning Airspeed (KCAS)	Stall Airspeed (KCAS)
CL/OFF	Removed	1500	15,000	8900	96	86
CL/OFF	Removed	1700	15,500	4200	97	90
CL/OFF	Installed	1350	15,100	7200	102	92
CL/OFF	Installed	1650	15,500	4600	99	87
CL/ON	Removed	1600	17,200	4800	98	92
TO/OFF	Removed	1650	15,400	4200	89	86
TO/OFF	Installed	1350	15,000	7200	92	83
TO/OFF	Installed	1700	15,500	4600	90	81
TO/ON	Removed	1600	17,300	4800	90	87
GA/OFF	Removed	1700	15,300	4200	87	80
GA/OFF	Installed	1400	15,000	7200	85	79
GA/OFF	Installed	1600	15,400	4600	87	78
GA/ON	Removed	1600	16,600	4800	87	81

NOTE:

[1]All tests conducted at longitudinal center of gravity of FS 160.5, and externally configured with two 150 gallon drop tanks.

Table 8. Single-Engine Stall with Left Engine Shutdown[1]

Aircraft/SLAR Configuration	Average Shaft Horsepower (shp)	Average Gross Weight (lb)	Average Density Altitude (ft)	SFIC Warning Airspeed (KCAS)	Stall Airspeed (KCAS)
CL[2]	--	--	--	--	--
TO/OFF	1400	15,900	4200	92	87
TO/OFF	1550	15,900	4200	93	91
TO/ON	1350	17,900	4800	94	88
TO/ON	1450	17,800	4800	92	91
TO/ON	1500	17,700	4800	92	90
TO/ON	1650	17,600	4800	91	89
GA/OFF	1350	15,800	4200	89	87
GA/OFF	1450	15,700	4200	87	86
GA/OFF	1500	15,700	4200	87	86
GA/OFF	1650	15,600	4200	87	86
GA/OFF	1700	15,600	4200	87	86
GA/OFF	1800	15,600	4200	87	86
GA/ON	1300	17,600	4800	87	83
GA/ON	1450	17,500	4800	87	86
GA/ON	1500	17,500	4800	87	86
GA/ON	1700	17,400	4800	86	85
GA/ON	1700	17,400	4800	87	86

NOTES:

[1]All tests conducted at longitudinal center of gravity of FS 160.5, RAS removed, and externally configured with two 150 gallon drop tanks.
[2]V_{mc} achieved instead of stall. See table 9.

in paragraph 10, appendix D. Static V_{mc} tests were conducted with the critical (left) engine shutdown and the propeller feathered. Airspeed was decreased at one knot per second while maintaining up to 5 degrees of bank into the operating engine. Dynamic V_{mc} tests were performed by rapidly reducing the critical (left) engine power lever to idle. For the TO configuration, the propeller control was reduced to minimum propeller speed simulating the operation of the autofeather. Flight control inputs were delayed for one second following the simulated engine failure to allow for pilot reaction time. This procedure was repeated at successively slower airspeeds until the minimum airspeed was reached when a straight flight path could no longer be reestablished and maintained. Static and dynamic V_{mc} variations with power and configuration are presented in table 9. V_{mc} airspeeds for the TO and go-around (GA) configurations were essentially unchanged with the higher power settings. V_{mc} for the climb (CL) configuration increased approximately 3/4 knot per 100 shp. Time histories of typical dynamic V_{mc} tests are presented in figures 41 and 42, appendix E. Dynamic V_{mc} was identical to static V_{mc} for all configurations and power settings. Static and dynamic V_{mc} with the left engine operating at maximum power were spot checked for all configurations and results show that the aircraft always stalled prior to reaching V_{mc}. The variation of pedal force with power during V_{mc} tests is summarized in figure 43. RAS installed V_{mc} pedal forces were approximately 50 lb less than RAS removed pedal forces. Pedal force at the higher power available with the YT53-L-704 engine was essentially the same as that available with T53-L-701 engines during static and dynamic V_{mc} tests.

Engine Failure

23. Simulated single-engine failure tests were conducted at the test conditions shown in table 3. The aircraft was stabilized at the desired trim condition and engine failure was simulated by rapidly reducing the selected power lever to flight idle. Following the engine failure, all flight controls were held fixed for 2 seconds. A time history of an engine failure at 1800 shp at 290 knots calibrated airspeed is presented in figure 44, appendix E. The aircraft was easily controllable when recovery inputs were made. The most critical airspeed for engine failure at 1800 shp was near V_{mc}. At higher airspeeds, the aircraft response to single-engine failure was a slow roll into the failed engine. The sudden engine failure characteristics of the OV-1D with the YT53-L-704 engine installed are satisfactory and met the requirements of MIL-F-8785C.

Table 9. Single-Engine Minimum Control Airspeed (V_{mc})

Aircraft/SLAR Configuration	Rudder Augmentation System	Average Shaft Horsepower (shp)	Average Gross Weight (lb)	Average Density Altitude (ft)	V_{mc} Airspeed (KCAS)
CL/OFF	Removed	1300	15,100	8900	91
CL/OFF	Removed	1350	15,200	4200	97
CL/OFF	Removed	1400	15,100	8900	92
CL/OFF	Removed	1400	15,200	4200	97
CL/OFF	Removed	1450	15,000	8900	92
CL/OFF	Removed	1500	16,100	4200	97
CL/OFF	Removed	1650	16,100	4200	99
CL/OFF	Removed	1800	16,000	4200	100
CL/OFF	Installed	1400	15,300	7200	95
CL/OFF	Installed	1500	15,900	4600	94
CL/OFF	Installed	1700	15,800	4600	95
CL/ON	Removed	1750	18,000	4800	95
TO/OFF	Installed	1400	15,200	7200	82
TO/OFF	Installed	1600	15,700	4600	85
GA/OFF	Installed	1500	15,200	7200	83
GA/OFF	Installed	1600	15,700	4600	84

NOTES:

[1]All tests conducted at longitudinal center of gravity of FS 160.5, and externally configured with two 150 gallon drop tanks.
[2]Static and dynamic V_{mc} were identical.

Engine Acceleration and Deceleration

24. Engine acceleration and deceleration tests were conducted at the test conditions shown in table 3. Tests were conducted by performing throttle transients and reversals to determine engine acceleration and deceleration characteristics. Target gas generator speeds (N_1) for throttle advance were 90, 85, 80, 75 and 70 percent N_1. A typical time history is presented in figure 45, appendix E. There were no compressor stalls or excessive overshoots of N_1, engine measured gas temperature or torque. Initially, propeller speed had a tendency to momentarily exceed the set governed propeller speed of 1800 rpm. Subsequent throttle transients were performed at a propeller speed of 1600 rpm to prevent possible propeller overspeeds. The YT53-L-704 engine acceleration and deceleration characteristics are satisfactory at the altitude evaluated (14,000 feet pressure altitude) and met the requirements of MIL-F-8785C. The YT53-L-704 engine airstart, acceleration and deceleration characteristics should be evaluated with and without LSSS installed up to 25,000 feet pressure altitude.

Trimmability

25. Trimmability tests were conducted at the test conditions shown in table 3. Tests were conducted by observing trim changes and control margins associated with changes in power and flap positions. The aircraft was trimmed for zero control forces in the power approach configuration, then a rapid power change to 1500, 1600, and 1800 shp was made followed immediately by flap position change. A typical time history of aircraft response is presented in figure 46, appendix E. The required trim changes were minimal at all conditions tested. Trim changes and control margins associated with power and flap position changes of the OV-1D with YT53-L-704 engines are satisfactory and met the requirements of MIL-F-8785C.

Installed Engine Performance

26. Shaft horsepower available and fuel flow rate of both the YT53-L-704 and T53-L-701 specification engine for comparison purposes are presented in figures 47 and 48, appendix E. AVCO Lycoming furnished computer decks were used to calculate the performance of an installed specification engine. Since a YT53-L-704 engine deck does not exist, the T53-L-703 engine deck file number 19.41.32.05 dated February 1986 was used for the prototype engine. Also the T53-L-13B engine deck file number 19.28.25.03 dated July 1982 was used for the T53-L-701 engine. Figures 49 through 53 present the engine characteristics of the

installed YT53-L-704 test engines including both model specification curves for comparison purposes. The test engines, serial number 18068Z and 15610Z, used for this evaluation were calibrated prototype engines, and the power available was considerably greater than the specification engine. Figure 49 shows that at a given N_1 the test engines produced an average of 200 shp more than a specification engine. Although the computer deck is based on a minimum performing engine that has the maximum allowable time before overhaul, the difference is still considered greater than would normally be expected. If the increased power available experienced with the test engines is typical, consideration should be given to modifying the engine model specification.

27. The current fuel flow gages are capable of indicating 1000 pounds per hour (pph) although red lined at 880 pph. During this evaluation, fuel flow rates greater than 1000 pph were obtained. The maximum fuel flow rate of the new engine is 1125 pph. If T53-L-704 engines are installed without flat rating to 1400 shp, the current fuel flow gages should be replaced.

Pitot-Static Calibration

28. The pitot-static position error of the standard ship system was measured in level flight using the pace and ground speed methods. The pace method involved flying the OV-1D in formation with a T-28 aircraft, and using the calibrated T-28 pitot-static system as an airspeed reference. For the ground speed course method, the OV-1D was flown over a measured, straight course marked on the ground. The aircraft was flown at constant indicated airspeeds for two passes over the course on reciprocal headings. The airspeed calibration data is presented in figure 54, appendix E. The maximum position error was +3.6 knots at 259 KIAS and gradually decreased to -3.4 knots error at 87 KIAS. The position error of the ship's airspeed system was not affected by single or dual-engine operation and is satisfactory.

CONCLUSIONS

GENERAL

29. The following conclusions were reached upon the completion of the evaluation of the YT53-L-704 engine and RAS configured OV-1D aircraft.

a. No significant problems were identified with the integration of the YT53-L-704 engines in the OV-1D with the exception of LSSS (para 7).

b. Pedal forces at V_{mc} were not significantly higher (RAS removed) for YT53-L-704 engine power levels up to 1800 shp than for T53-L-701 engine power levels (para 22).

c. RAS installed V_{mc} pedal forces were approximately 50 lb less than RAS removed pedal forces; however, the RAS as installed for Phase IIA was unsatisfactory due to its failure modes and resultant increases in V_{mc} (paras 16 and 22).

d. Handling qualities were essentially unchanged by the additional power available with the YT53-L-704 engines (para 15).

e. Cruise and endurance airspeeds were essentially the same as for T53-L-701 engines, but the maximum range decreased 5.1 percent and the endurance decreased 4.3 percent (para 14).

f. Incorporation of a rudder boost is not required to use the full power capability of the T53-L-704 engines (para 15).

g. The SFIC stall warning system provided adequate warning margin for all conditions except single-engine operation at T53-L-704 power levels (para 21).

h. V_{mc} airspeeds for the takeoff and landing configurations were unchanged from T53-L-701 engine power levels. V_{mc} for flaps-up configuration increased approximately 3/4 knot per 100 shp (para 22).

i. The OV/RV-1D installed fuel flow gages are red lined at 880 pph with the range of fuel flow from 0 to 1000 pph. The maximum rated fuel flow for the T53-L-704 engine is 1125 pph (para 27).

j. The power available with the installed YT53-L-704 engines was considerably greater than the T53-L-703 specification engine (para 26).

k. The high ambient cockpit noise level at high power settings for either the YT53-L-704 or T53-L-701 engine is a deficiency (para 10).

ENHANCING CHARACTERISTIC

30. The increase in hot day power available and single-engine climb performance provided by the YT53-L-704 engines enhances safe mission accomplishment (para 12).

DEFICIENCY

31. The ambient cockpit noise level with both YT53-L-704 and T53-L-701 engines and propeller operating at takeoff and climb power settings preclude normal intelligible communications (para 10).

RECOMMENDATIONS

32. Install T53-L-704 engines on mission operation aircraft (para 12).

33. Improve the OV/RV-1D cockpit communications intelligibility at high power settings (para 10).

34. Flat rate the T53-L-704 engines to 1400 shp, if further testing indicates structural problems or LSSS problems related to operation at power levels greater than 1400 shp (para 12).

35. Evaluate the OV/RV-1D takeoff performance with flaps at zero degrees (para 9).

36. Evaluate the OV/RV-1D takeoff, single-engine climb, and dual-engine level flight performance with T53-L-704 engines and LSSS installed (paras 9, 12, and 14).

37. Evaluate the OV/RV-1D engine airstart, acceleration and deceleration characteristics with T53-L-704 engines and LSSS installed up to 25,000 feet pressure altitude (para 24).

38. Incorporate in chapter 8 of the operator's manual the following warning when the SFIC stall warning system is installed (para 21).

WARNING

> During single-engine operations at near maximum power, the stall warning system does not provide adequate stall warning. Airspeed should not be decreased below the point where full rudder pedal deflection is required to maintain balanced (ball-centered) flight. Simultaneous stall and V_{mc} with resultant loss of control may occur without warning (neither buffet nor artificial warning).

39. Modify the engine model specification if the increased power available with the test YT53-L-704 engine is typical (para 26).

40. Replace the current fuel flow gages if the T53-L-704 engines are installed without flat rating to 1400 shp (para 27).

APPENDIX A. REFERENCES

1. Letter, AVSCOM, AMSAV-ED, 10 October 1985, subject: Evaluation of the OV-1D Aircraft with the YT53-L-704 Engine and Augmentation System Installed. (Test Request)

2. Technical Manual, TM 55-1510-213-10, *Operator's Manual, OV-1D/RV-1D Aircraft,* 4 August 1978.

3. Pilot's Guide, Safe Flight Instrument Corporation, R-2145, *Pre-stall Warning System, Grumman OV-1D/RV-1D (Mohawk),* 20 August 1985.

4. Letter, USAAEFA, SAVTE-TA, 23 June 1986, subject: Letter of Effort, Evaluation of the OV-1D Aircraft with the YT53-L-704 Engine and Rudder Augmentation System, Phase I, USAAEFA Project No. 85-17.

5. Test Plan, USAAEFA Project No. 85-17, *Evaluation of the OV-1D Aircraft with the YT53-L-704 Engine and Rudder Augmentation System (Phase II),* November 1985.

6. Letter, AVSCOM, AMSAV-ED, 8 April 1986, subject: Airworthiness Release, OV-1D(C) 62-5867 with the YT53-L-704 Engine Installed.

7. Letter, AVSCOM, AMSAV-E, 17 March 1986, subject: Airworthiness Release, OV-1D(C), S/N 62-5867, with the YT53-L-704 Engines Installed.

8. Military Specification, MIL-F-8785C, *Flying Qualities of Piloted Airplanes,* 5 November 1980.

9. Flight Test Manual, Naval Air Test Center, FTM No. 104, *Fixed Wing Performance,* July 1977.

10. Flight Test Manual, Naval Air Test Center, FTM No. 103, *Fixed Wing Stability and Control,* 1 January 1975.

APPENDIX B. DESCRIPTION

DESCRIPTION

1. The OV-1D(C) test aircraft S/N 62-5867 is a two-place, twin-engine turboprop aircraft featuring a midwing, triple vertical stabilizer, and a tricycle landing gear. Seven external store stations, including the fuselage are used to carry a variety of surveillance pods and/or fuel tanks. For this program, the aircraft was tested with two 150 gallon drop tanks installed (BASIC configuration); and with two 150 gallon drop tanks, and Side Looking Airborne Radar (SLAR) boom intalled (STORES configuration). The Louvered Scarfed Shroud Suppressor (LSSS) was not installed due to high engine nacelle temperature which surfaced during Phase I ground run evaluations. The major modifications to the test aircraft include:

YT53-L-704 Engines

2. The Lycoming YT53-L-704 engine is the latest version of Lycoming's T-53 family of turboshaft and turboprop power plants. The 1800 shaft horsepower (shp) YT53-L-704 engine was created by combining the gearbox from the existing OV/RV-1D T53-L-701 engine with the compressor and hot section portion of the T53-L-703 engine. The T53-L-703 hot section incorporates the following changes relative to the T53-L-701 which allows operation at the higher power levels:

(a) Impingement cooling in the first stage gas producer turbine blades and nozzle.

(b) Improved materials in the second stage gas producer turbine blades and first and second stage power turbine blades.

(c) Cast first stage power turbine nozzle with temperature measurement harness (replaces exhaust gas temperature measurement).

(d) Miscellaneous seal and bearing changes.

The fuel control for the YT53-L-704 engine was developed by modifying a T53-L-701 unit as follows:

(a) Replaced main metering valve to allow for increased fuel flow required for 1800 shp.

(b) Replaced the 3-D cam to allow for transient operation up to 1800 shp.

(c) Replaced trigger line cam assembly (operates bleed bands during transients).

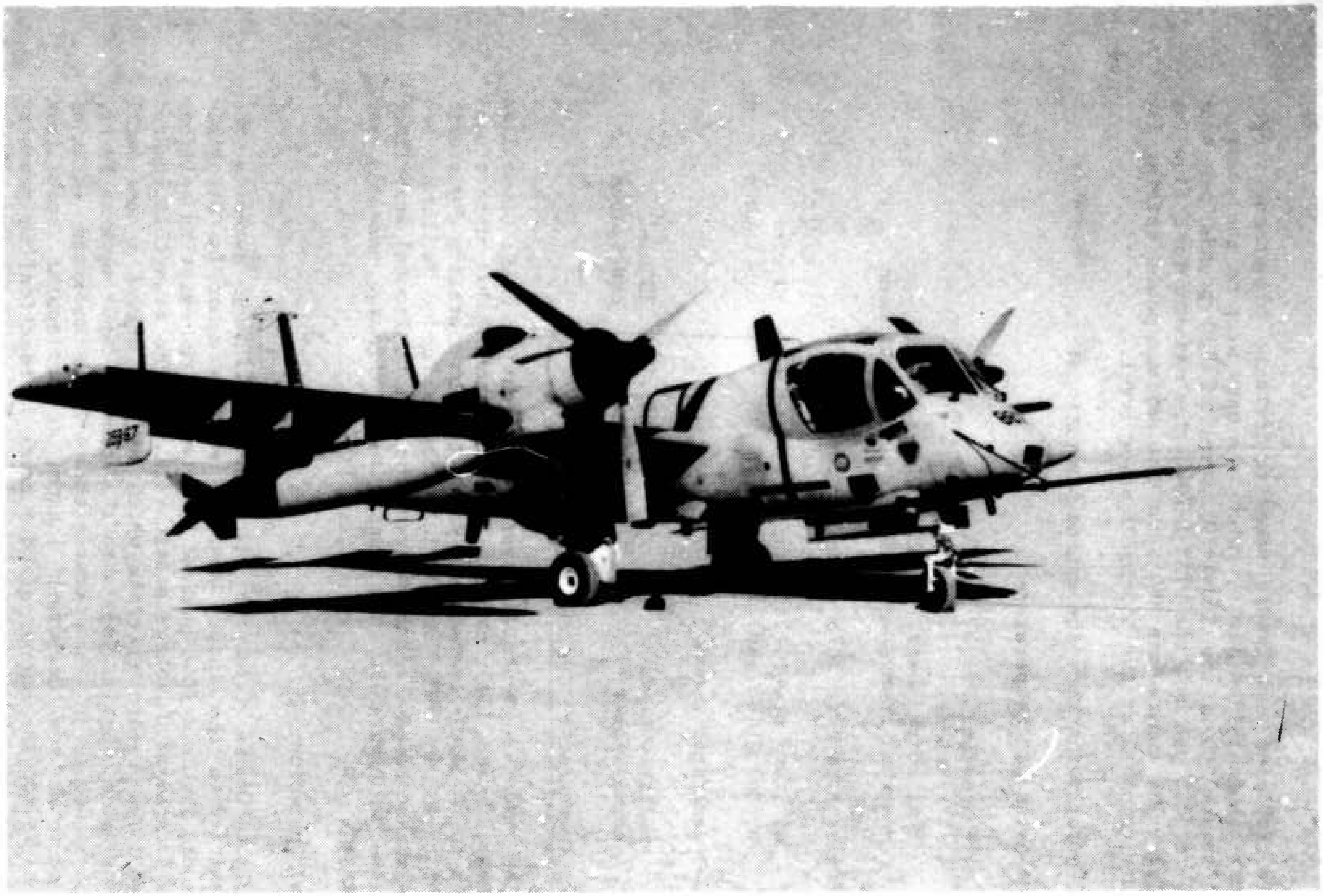


Photo 1. BASIC Configuration with LSSS

(d) Replaced rock shaft screw to increase adjustment range. The maximum fuel flow limit, which is a hard stop on the control, was increased from the T53-L-703 level of 930 pounds per hour (pph) to 1125 pph for the YT53-L-704. The maximum fuel flow for the T53-L-701 engine was 880 pph. The maximum power setting for reverse remained at the T53-L-701 power level.

3. The following were the engine limitations:

Measured gas temperature

- starting	950°C	—
- transients	880-950°C	5 sec
- military power	820-880°C	30 min
- normal power	820°C	continuous

Engine torque (@ 1678 propeller rpm)

military power (1800 shp)	118%	30 min
normal (1400 shp)	102%	continuous

Gas generator speed

military power	105.0%	30 min
normal power	101.2%	continuous

Rudder Augmentation System

4. The rudder augmentation system modification (RAS) (installed for Phase I and IIA) changed the fully reversible directional system to a semi-reversible system by incorporating hydraulic actuators in the left and right outboard rudder bellcrank and linkage assemblies. A schematic of the left horizontal stabilizer is shown in figure 1. The center rudder linkage assembly was unchanged.

Normal Operation:

5. Pilot inputs from the aft fuselage linkage assembly are transmitted to the input valve of each actuator by frangible pushrods. The frangible pushrod is driven by the existing splitter crank located at fuselage station 428.75. The frangible pushrod drives a new reversing crank which in turn drives a new small pushrod which supplies inputs to the actuator input summing lever. Actuator output is then transmitted via a modified existing pushrod to a new bellcrank located at horizontal stabilizer station 76.5. The output of this crank is identical in geometry to the old crank it is replacing. Crank output is transmitted

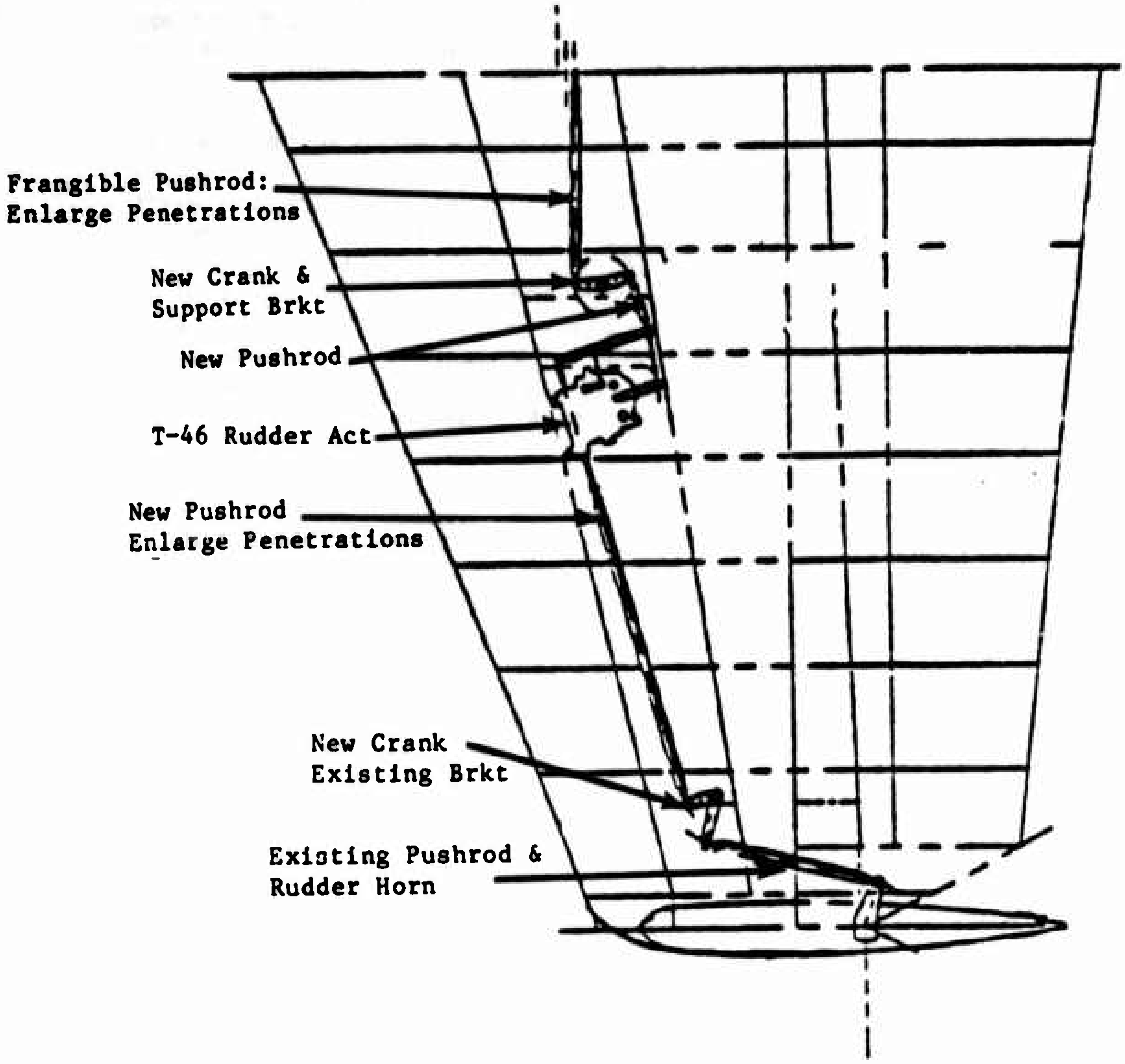


Figure 1. Rudder Augmentation System (Left Horizontal Stabilizer)

via the existing pushrod to the existing horn on the outboard rudder. New structure required for the RAS installation included a new support bracket for the reversing crank located at horizontal stabilizer station 22.664, new support structure for the body mounted (stationary) actuator and a modified rib at horizontal stabilizer station 30.0 to allow for actuator linkage clearance. Larger access covers were required to allow for actuator installation in the stabilizers.

6. The frangible pushrod upstream of the actuator serves two purposes: (1) In the event of a linkage jam at or downstream of the reversing crank (including the actuator) the pilot can exert sufficient pedal force (approximately 300 lb) to intentionally shear two pins in the frangible pushrod. This allows operation of the center rudder and remaining outboard rudder, and prevents exceeding the design strength of the actuator linkage. (2) In the event of an actuator hardover (runaway actuator where the pilot operated valve fails to turn off hydraulic pressure) the frangible pushrod can be intentionally sheared by the pilot.

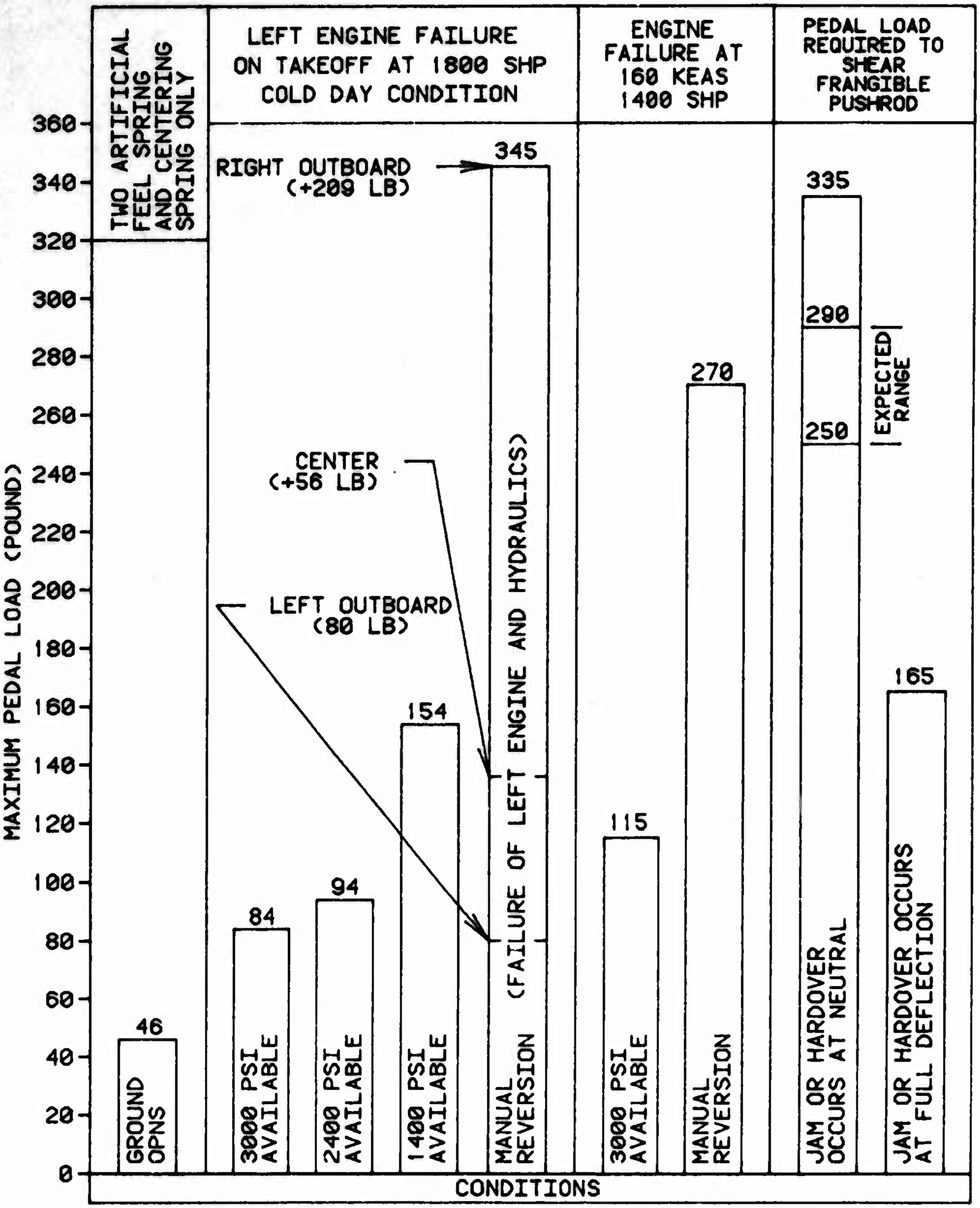
Operational Modes:

7. The actuators could operate in two modes: hydraulically powered and manual reversion. When operating under hydraulic power, input commands are transmitted to the input summing lever of the actuator. The summing lever pivots about the piston rod joint and moves the connecting link. The connecting link, through internal linkage, opens a slide valve inside the actuator and ports hydraulic fluid to move the piston rod and control surface. The piston rod moves the summing lever until the valve is closed (mechanical feedback). The actuator has an integral artificial feel assembly (cam and roller) which is moved in parallel with the pilot input. The artificial feel assembly provided force cues to the pilot during hydraulic operation and during manual reversion and valve centering when in hydraulic operation. During manual reversion operation, the internal valve was locked and the input commands were transmitted to the input summing lever which then acted as a reversing crank. Thereafter, pilot commands moved the piston rod and surface directly. An internal bypass valve allowed hydraulic oil to move from one side of the piston to the other. While operating in the manual reversion mode, airloads were not supported by the hydraulic pressure but were transmitted back to the pilots pedals through the linkage train. During operation in the hydraulic mode, the piston force output due to hydraulic pressure could be supplemented by additional pedal force application. However, the actuator valve input must be against the rate stops before additional pedal force adds to the piston force outputs. The rate stops on the actuator limited

the amount that the valve can be opened. Approximately 0.39 inches of additional input motion is required at the actuator to be against the rate stops. Pedal stops were set to allow for additional pedal motion required to place the valve input against the rate stops and be able to supplement piston output force.

Directional Control System:

8. The RAS installation was designed to provide ±27° of surface motion on the outboard rudders while the center rudder remains at its ±24° limit. The pedal travel are ±2.75 inches no loads, ±4 inches at 300 lb. Figure 2 presents a summary of the pedal loads under various conditions. All pedal loads shown, reflect a mean adjustment position on the pilot pedals. Other adjustment positions would result in lower pedal forces. The first column shows that during ground operations in both manual reversion and hydraulic mode with no airload the maximum pedal load would be 46 lb. The pedal load under this condition was due only to the centering spring below the cockpit floor (a cam and roller assembly) and the two artificial feel springs on each actuator. The next four columns represent maximum pedal loads encountered during an engine failure on takeoff, 1800 shp for various hydraulic pressures. With 3000 pounds per square inch (psi) available to the actuators, the maximum pedal force would be 84 lb. This pedal load resulted from 500 in./lb hinge moment on the center rudder, the centering spring, and two artificial feel springs. At 2400 psi, the actuator was just beyond stall load (external load = pressure x piston area) and an additional 10 lb of pedal force was required to support the hinge moment. 2400 psi is a pressure value which is commonly used to size actuator force output capability. At 1400 psi, the minimum expected available pressure due to line component pressure drops with cold oil and landing gear recycling, approximately 154 lb are required at the pedal to hold the hinge moment. This load was comprised of centering spring, two artificial feel springs, hinge moment on center rudder, and an additional 70 lb applied at the pedals to overcome airloads. In the event of a catastrophic engine failure in which hydraulic pressure is also depleted, the actuator would be in manual reversion mode and it would have to deflect the surface from neutral to 24° with the pedal load gradually increasing to 345 lb. If the pressure dropped to a value which was below the manual reversion threshold (500 psi nominal with decreasing pressure, 800 psi nominal with increasing pressure) during surface deflection, the actuator would stall with the pilot pedal load increasing in proportion to the rate of pressure degradation until the actuator was in manual reversion and the pilot was holding the entire hinge moment. If the surface was fully deflected and then the pressure dropped below the manual reversion threshold,



NOTE: ALL MAXIMUM PEDAL LOADS DO NOT NECESSARILY OCCUR AT THE SAME PEDAL POSITION

Figure 2. Pedal Load Summary

the surface would remain at its present position as long as the commanded input was held. Should the commanded input be reversed while the system pressure is below 500 psi during the engine failure, the actuator would go into manual reversion mode and the pedal loads would increase from 84 to 345 lb. In the event of linkage jam downstream of the reversing crank, the frangible pushrod could be sheared allowing continued use of the center rudder and remaining outboard rudder. Pedal loads required to shear the pushrod varied as a function of surface position. The highest pedal load occurred at neutral where the mechanical advantage of pedal force to pushrod force is at a minimum. Under these circumstances, a load at the pedals of 250 to 290 lb was required to shear the pins, while at full surface deflections a maximum pedal load of 165 lb would be required. The pedal load range at neutral was due to the failure load range of the shear pins and the effects of control system compliance. As the cables and linkage deflected under load, the geometry changed, thereby increasing the mechanical advantage. This change in geometry would allow the frangible pushrod to fail at a lower pedal load than an infinitely rigid system would allow.

System Weight:

9. The system weight was 28.6 lb.

Actuator Features:

10. The T-46 actuator was developed for Fairchild Republic Company by the Bertea Control Systems Division of Parker and was very similar to the A-10 rudder actuator. As mentioned previously, the actuator had manual reversion capability in the event of hydraulic pressure loss. While in manual reversion the hydraulic oil was allowed to bypass from one side of the piston to the other through an orifice. This offce provided a damping force proportional to the square of piston velocity. The actuator and seals were rated for operation on either MIL-H-5606 or MIL-H-83282 hydraulic oil with a maximum flow rate of 0.25 gallons per minute at a no loads rate of 5.28 in./sec. Output force of the single hydraulic system unit was 500 lb with 3000 psi supply. A total stroke of 3.2 inches was available from the actuator; however, only 3.06 inches were used for $\pm 27°$ of surface deflection. During the last 10% of actuator stroke an internal snubber was employed to reduce the impact loads on the cylinder. Since the OV-1D was not utilizing the complete stroke capability, only the last 1-1/2° of surface travel were snubbed. The actuator also employed an integral artifical feel assembly which provided the pilot with force cues which would vary as a function of pedal position. This artificial feel assembly (spring loaded cam and rollers) also provided

surface centering and restraints capability in the event of lost upstream hardware or frangible pushrod failure.

11. Both the pressure and return ports of the actuator incorporated check valves to trap the oil within the actuator in the event of hydraulic line failure. The inlet check valve was also intended to prevent actuator blowback when the applied external load exceeds the pressure within the actuator. This reduced the effective length of the column of oil which supports the load, creating a stiffer load path for flutter considerations. The return port had an integral compensator which was intended to "make-up" lost oil due to internal linkage when operating in manual reversion. Ensuring that lost oil was compensated for guaranteed the pilot will have damping while operating in manual reversion mode for a finite period of time. The T-46 actuator incorporated a yaw damping system which was designed to operate in series with pilot inputs; thereby minimizing minor perturbations of the aircraft flight path. This feature would be active only when a solenoid shutoff valve was energized, providing a total authority of $\pm 4°$ of surface motion. The OV-1D RAS did not use this feature at any time in this installation; however, it would be available for rate damping, if required.

APPENDIX C. INSTRUMENTATION

1. An airborne data acquisition system was installed by the US Army Aviation Engineering Flight Activity (USAAEFA). The system included transducers, potientiometers, wiring, signal conditioning, pulse code modulation encoding, magnetic tape recording of all parameters, cockpit displays of selected parameters, and the capability to telemeter the data to a ground station. The system was installed, operated, and maintained by USAAEFA during all phases.

2. An airspeed boom extending forward from the nose of the aircraft was installed. This boom incorporated angle-of-attack and angle-of-sideslip sensors, and a swiveling pitot-static tube.

3. The parameters measured and recorded for all phases were:

Parameter	Cockpit Indicator
Aircraft attitudes	
Pitch	--
Roll	--
Heading	--
Airspeed	
Boom	Yes
Ship	Yes
Altitude	
Boom	Yes
Ship	Yes
Ambient total air temperature	Yes
Boom angle of attack	Yes
Boom angle of sideslip	Yes
Aircraft angular rates	
Pitch	--
Roll	--
yaw	--
CG normal acceleration	Yes
Control positions	
Longitudinal	--
Lateral	--
Directional	--
Left throttle	--
Right throttle	--
Control force	
Left pedal	--
Right pedal	--
Control surface positions	
Elevator	--
Left outboard aileron	--
Left rudder	--

Right rudder	--
Center rudder	--
Engine	
Fuel flow, left	Yes (ship)
Fuel flow, right	Yes (ship)
Fuel totalizer, left	Yes
Fuel totalizer, right	Yes
Gas generator speed, left	Yes (ship)
Gas generator speed, right	Yes (ship)
Measured gas temperature, left	Yes (ship)
Measured gas temperature, right	Yes (ship)
Propeller speed, left	Yes (ship)
Propeller speed, right	Yes (ship)
Torque, left	Yes (ship)
Torque, right	Yes (ship)
Event markers	
Pilot	--
Recorder ON/OFF	--
Record number	Yes
Safe Flight Stall Warning System	
Pedal shaker event	--
Pendulous accelerometer output	--
Stall warning vane output	--
Strain gages	
Left rudder linkage	--
Right rudder linkage	--
Center rudder linkage	--
Time	Yes
Voice channel	--

APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

GENERAL

1. This appendix contains a description of the test techniques used for evaluating performance and handling qualities of the OV-1D aircraft. Additionally, some of the data reduction and analysis methods used are presented.

TAKEOFF PERFORMANCE

2. Takeoff roll distance was obtained by noting and measuring the start and liftoff points with ground observers. The measured ground roll distance was then compared to the predicted ground roll distance as depicted in the operator's manual.

CLIMB AND LEVEL FLIGHT PERFORMANCE

3. Drag polars were developed for climb and level flight using the equations listed below.

a. Coefficient of lift:

$$C_L = \frac{L}{qS}$$

b. Coefficient of drag:

$$C_D = \frac{D}{qS}$$

Where:

L = gross weight (lb)
$q = 1/2\ \rho\ V_T^2$ (lb/ft^2) dynamic pressure
S = total wing area (ft^2)
D = drag force (lb)
ρ = air density (slug/ft^3)
V_T = aircraft true airspeed on flight path (ft/sec)

c. Shaft horsepower:

$$SHP = \frac{TQ \times NP \times 47.85}{5252}$$

Where:

TQ = engine torque (percent)
NP = propeller speed (rpm)

d. Thrust horsepower:

$$THP = SHP \times \eta_p$$

Where:

η_p = propeller efficiency obtained from Hamilton Standard efficiency chart for a 53C51/7125-6 propeller.

e. Equivalent thrust horsepower:

$$ETHP = THP + SHP_{fn}$$

f. Shaft horsepower due to engine net thrust:

$$SHP_{fn} = \frac{F_n \times V_T}{550}$$

Where:

F_n = Net jet thrust obtained from engine deck

g. Thrust required:

$$T = \text{Thrust (lb)} = \frac{550\ ETHP}{V_T} - F_l - F_{ss} - F_{rj}$$

Where:

F_l = excess thrust due to acceleration and altitude variations (lb)
F_{ss} = sideslip drag effects (lb)
F_{rj} = ram ejector drag (lb)

4. Single-engine climb performance tests were evaluated using the sawtooth climb method. The aircraft was stabilized in a constant airspeed climb with the left engine shutdown and propeller feathered and stopped, and the right engine operating at the target power setting. Each airspeed was flown twice through an altitude band on reciprocal heading. The aircraft was banked up to 5 degrees into the operating engine. The climb performance of the OV-1D was predicted by using the following equation.

$$RC = \frac{(THP_a - THP_{req}) \times 33{,}000}{GW}$$

Where:

RC = rate of climb (ft/min)

THP_a = thrust horsepower available from a specification engine

THP_{req} = thrust horsepower required calculated from the single engine climb drag polar

GW = gross weight (lb)

5. Dual and single-engine level flight performance tests were conducted using the constant pressure altitude method. The aircraft was stabilized and trimmed at incremental airspeeds from minimum airspeed to the maximum level flight airspeed at military rated power while maintaining a constant pressure altitude. Specific range data were derived from the level flight power required data and fuel comsumption of the Lycoming specification engine computer deck. The following equation was used.

$$SR = \frac{V_T \times 0.59248}{WF}$$

Where:

SR = specific range (nautical mile per lb)
WF = fuel flow (lb/hr)

Static Longitudinal Stability

6. The static longitudinal stability tests were accomplished by establishing the trim condition in ball-centered flight and then

varying control positions to obtain airspeed changes about the trim airspeed with throttle control held fixed at the trim value. The airspeed range of interest was approximately + 20 knots from trim. Altitude was allowed to vary as required during the test.

Static Lateral-Directional Stability

7. These tests were conducted by establishing the trim condition and then varying sideslip angle incrementally up to 15 degrees. During each test, throttle control position, airspeed, and aircraft ground track were held constant and altitude allowed to vary as required.

Dynamic Stability

8. Dynamic longitudinal and lateral-directional stability were evaluated to determine both the short- and long-period characteristics. The short-period response was evaluted by use of longitudinal and pedal doublet inputs and by releases from a steady-heading sideslip. The long-period dynamic response was evaluated longitudinally by slowly returning the flight control to the trim position following an increase or decrease of 10 knots from the trim airspeed.

Unaccelerated Stalls

9. Dual and single-engine unaccelerated stalls were conducted to determine stall warning airspeed, stall speed, and handling qualities associated with the stall. For dual-engine stalls, the operator's manual recommended trim settings were used for the takeoff (TO) configuration. For the climb (CL) and go-around (GA) configurations, trim settings were those required for minimum control force at 1.2 times the power off stall speed (V_{s1}). Trim settings for single-engine stalls were those required for minimum control forces at single-engine best rate of climb airspeed (V_{yse}). The airspeed was decreased at less than one knot per second until the stall occurred.

Single-Engine Minimum Control Airspeed

10. Static and dynamic single-engine minimum control airspeed (V_{mc}) tests were conducted mainly with the critical engine (left engine) inoperative. Some right engine inoperative tests were conducted. Static V_{mc} tests were performed by decreasing the airspeed at less than one knot per second while maintaining zero turn rate and not more than a 5 degree bank angle into the operating engine. Static V_{mc} was defined as the minimum airspeed at which a straight flight path could be maintained using full

directional and/or full lateral control and up to a 5 degree bank angle toward the operating engine. Dynamic V_{mc} evaluations were initiated at 10 knots above static V_{mc} for a particular power setting. The aircraft was stabilized at the desired power setting and then the selected engine power lever was rapidly reduced to idle and the controls held fixed for one second or until a 20 degree bank angle or a heading change of 20 degree was attained whichever occurred first. Tests were repeated reducing the trim airspeed first in 5 knot increments, then in 2 knot increments until dynamic V_{mc} was attained. Dynamic V_{mc} was defined as the minimum airspeed at which aircraft control could be regained in order to maintain a straight flight path with 5 degree of bank or less into the operating engine. Trim settings for the dynamic V_{mc} determination were the operator's manual recommended takeoff trim setting for TO configuration and the trim setting required for zero control forces at 1.2 times V_s, for CL and GA configurations. Dynamic V_{mc} determination in the TO configuration included reducing the propeller to minimum after throttle reduction, simulating operation of the autofeather system.

Engine Acceleration/Deceleration

11. Single and dual-engine acceleration and deceleration tests were conducted by establishing the trim condition and then using a build-up in both rate and magnitude by varying the throttle movement to accelerate or decelerate the engine.

Trimmability

12. Trim change characteristics due to variation in power and flap position were evaluated. The aircraft was trimmed in steady-heading, ball-centered flight at the desired condition and then a configuration change was made while holding one or more initial trim parameters constant.

Airspeed Calibration

13. The test boom and standard ship pitot-static systems were calibrated. The pace and ground speed course methods were used. The pace method involved flying the test aircraft in formation with a T-28 aircraft, and using the calibrated T-28 pitot-static system as an airspeed reference. For the ground speed course method, the test aircraft was flown over a measured, straight course marked on the ground. The aircraft was flown at constant indicated airspeeds for two passes over the course on reciprocal headings. Calibrated airspeed was calculated from the average true airspeed and using the test pressure altitude and temperature

as a reference. The boom system airspeed calibration data is presented in figure A.

Weight and Balance

14. Prior to Phase I and Phase IIB testing, a weight and balance determination was conducted on the aircraft using calibrated scales. The aircraft was weighed in the following configurations:

a. Full oil, trapped fuel, no crew, instrumentation, and RAS.

b. Full oil, trapped fuel, no crew, instrumentation, and no RAS.

c. Full oil, full fuel, no crew, instrumentation, and no RAS.

Rigging Check

15. Mechanical rigging of engine and flight controls was checked for compliance with applicable Grumman Aerospace Corporation documents.

DEFINITIONS

16. Results were categorized as deficiencies or shortcomings in accordance with the following definitions.

Deficiency

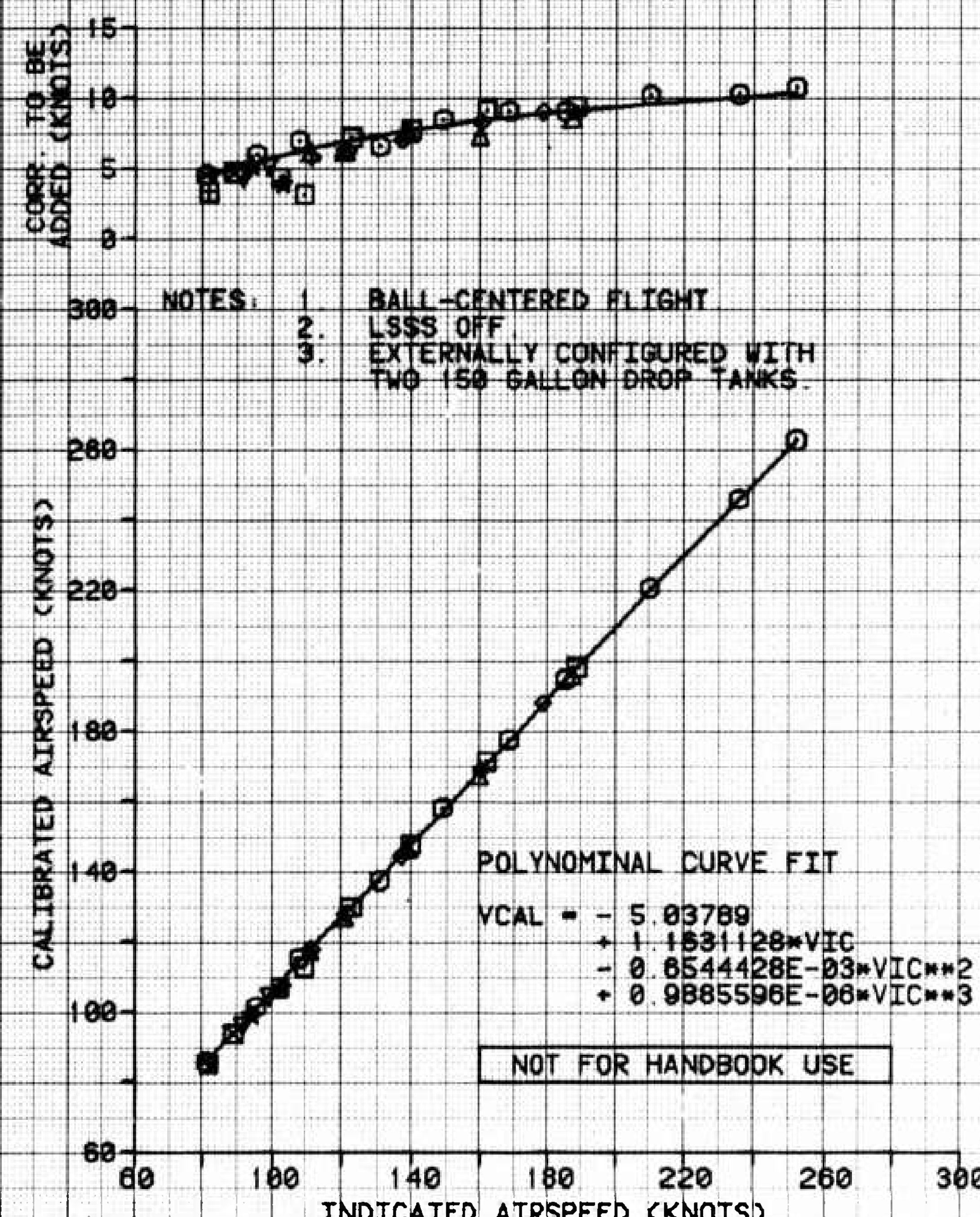
17. A defect or malfunction discovered during the life cycle of an item of equipment that constitutes a safety hazard to personnel, will result in serious damage to the equipment if operation is continued, or indicates improper design or other cause of failure of an item or part, which seriously impairs the equipment's operational capability.

Shortcoming

18. An imperfection or malfunction occurring during the life cycle of equipment which must be reported and which should be corrected to increase efficiency and to render the equipment completely serviceable. It will not cause an immediate breakdown, jeopardize safe operation, or materially reduce the usability of the material or end product.

FIGURE A
BOOM SYSTEM AIRSPEED CALIBRATION
OV-1D(C) USA S/N 62-5867

SYM	GROSS WEIGHT (LB)	LONG CG LOCATION (FS)	PRESSURE ALTITUDE (FT)	OAT (DEG C)	PROP SPEED (RPM)	ENGINE CONFIG	FLAPS POSN (DEG)	TEST METHOD
⊙	15,400	160.8(MID)	2600	23.0	1600	DUAL	0	GRND CRSE
⊗	15,400	160.8(MID)	2600	23.0	1600	DUAL	45	GRND CRSE
⊡	16,200	160.9(MID)	5700	10.0	1600	DUAL	0	PACE
⊠	16,200	160.9(MID)	5700	10.0	1600	DUAL	15	PACE
⊞	16,200	160.9(MID)	5700	10.0	1600	DUAL	45	PACE
◇	16,600	161.1(MID)	5800	14.0	1680	RIGHT	0	PACE
★	16,600	161.1(MID)	5800	14.0	1680	RIGHT	15	PACE
△	16,200	160.9(MID)	5800	13.0	1660	LEFT	0	PACE
▽	16,200	160.9(MID)	5800	13.0	1660	LEFT	15	PACE



APPENDIX E. TEST DATA

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FIGURE 1
CLIMB DRAG POLAR
OV-1D USA S/N 62 - 5867

SINGLE-ENGINE CRUISE CONFIGURATION

SYM	AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALT (FT)	AVG OAT (DEG C)	AVG SHAFT HP (SHP)	AVG PROP SPEED (RPM)	EXTERNAL CONFIGURATION
□	15,580	160.1(MID)	5790	8.5	1560	1653	TWO 150 DROP TNKS
△	15,840	160.9(MID)	5580	10.0	1700	1661	TWO 150 DROP TNKS
★	17,590	159.7(MID)	5920	3.0	1752	1645	TWO 150 DROP TNKS AND SLAR

NOTES: 1. LEFT ENGINE SHUTDOWN.
2. ECU OFF.
3. BALL CENTERED TRIM FLIGHT.

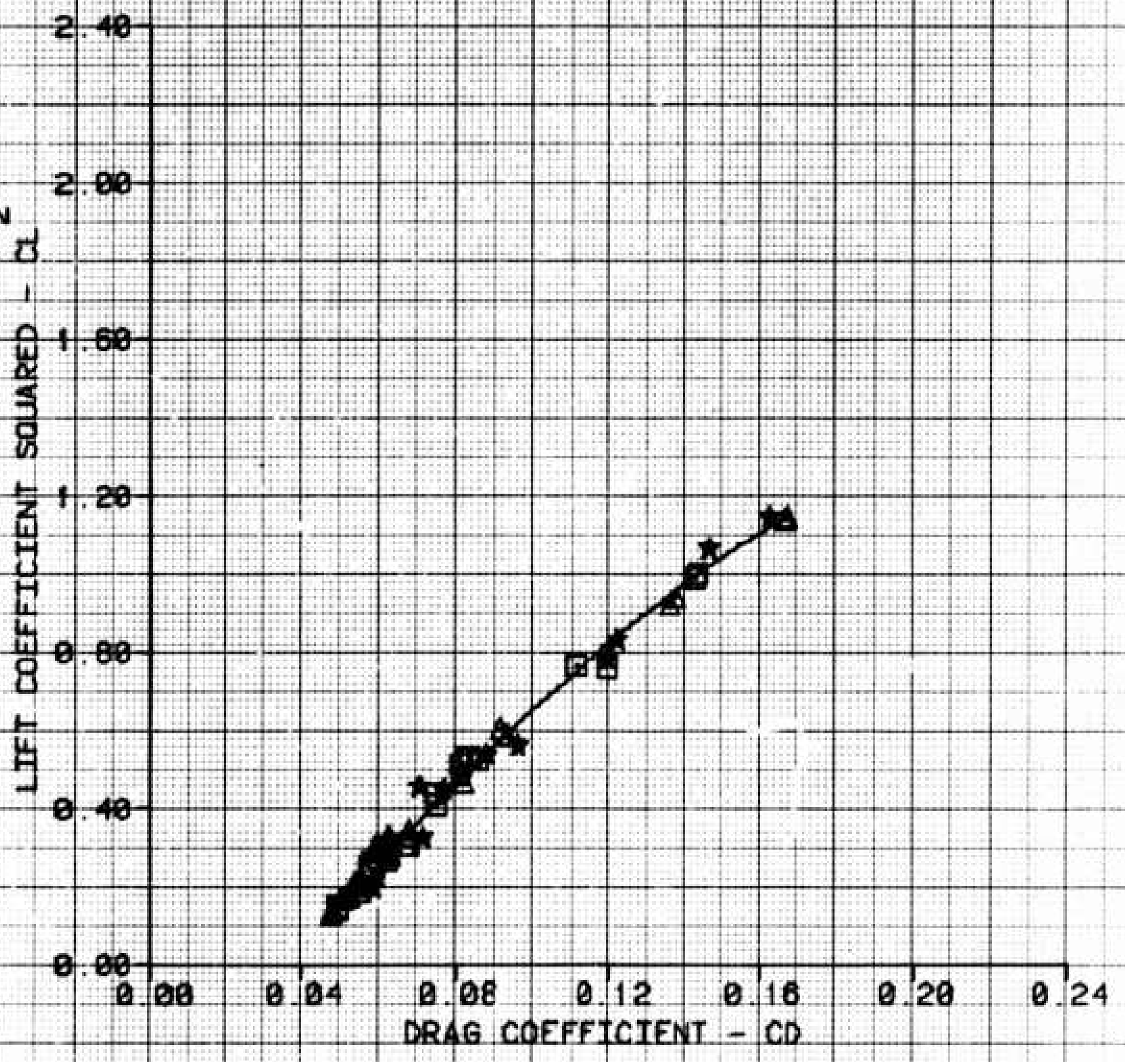


FIGURE 2
SINGLE-ENGINE CLIMB PERFORMANCE AT VYSE
OV-1D USA S/N 62 - 5876

STANDARD DAY ATMOSPHERE

NOTES:
1. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS EITHER WITH OR WITHOUT SIDE LOOKING AIRBORNE RADAR.
2. POWER AVAILABLE FOR YT53-L-704 ENGINE OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAM T53-L-703 FILE NO. 19.41.32.05, FEBRUARY 1986 WITH FOLLOWING ASSUMPTIONS:
   A. MILITARY RATED POWER.
   B. 1678 RPM PROPELLER SPEED.
   C. 15 SHP EXTRACTION.
   D. BLEED AIR OFF.
   E. 0.991 RAM RECOVERY.
3. POWER REQUIRED OBTAINED FROM FIG. 1.

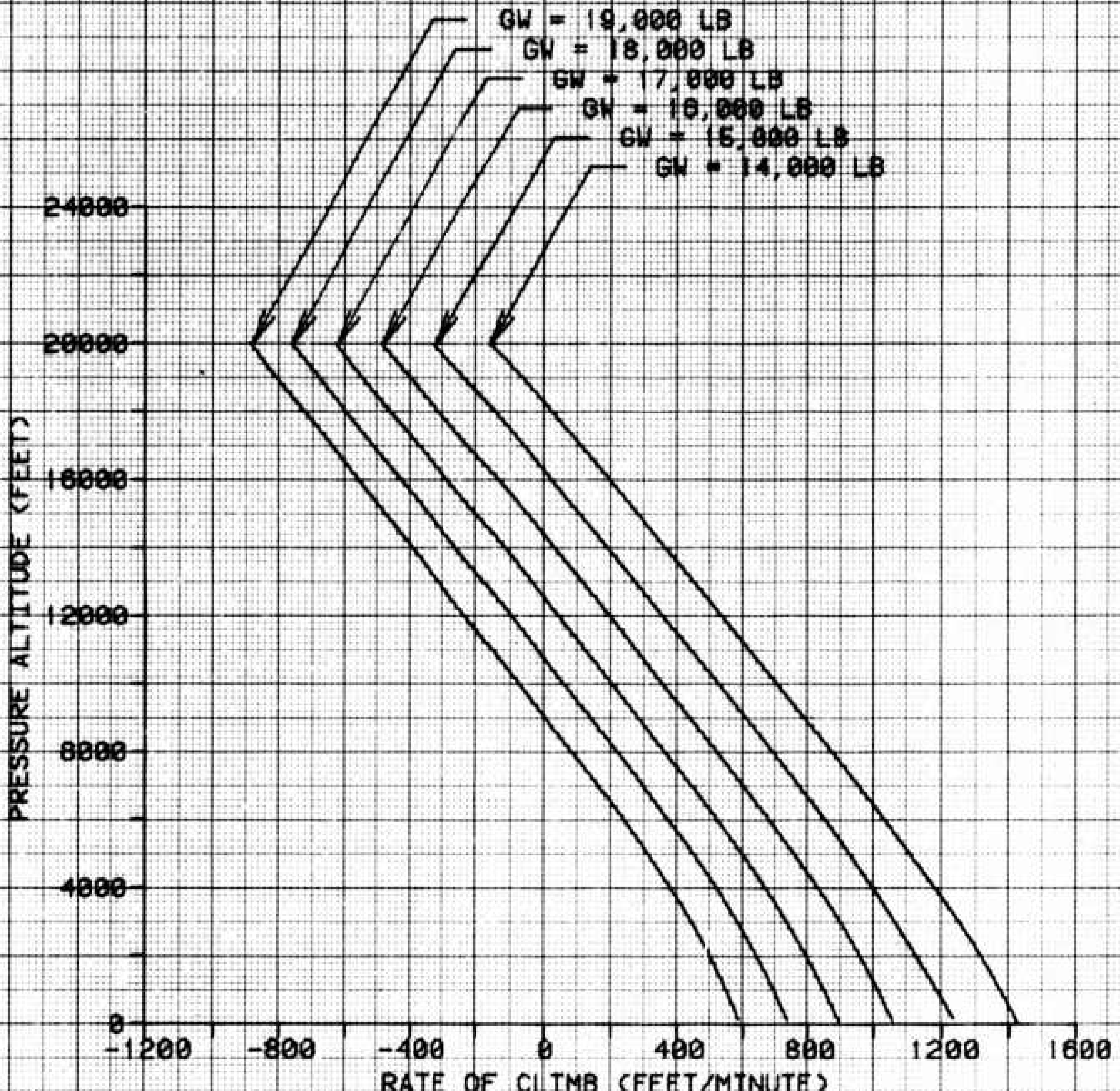


FIGURE 3
SINGLE-ENGINE CLIMB PERFORMANCE AT VYSE
OV-1D USA S/N 62 - 5876

HOT DAY ATMOSPHERE

NOTES:
1. HOT DAY ATMOSPHERE AS DEFINED BY MILITARY SPECIFICATION, MIL-C-005011B (USAF), STANDARD AIRCRAFT CHARACTERISTICS AND PERFORMANCE, PILOTED AIRCRAFT (FIXED WING), 21 JUNE 1977.
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS EITHER WITH OR WITHOUT SIDE LOOKING AIRBORNE RADAR.
3. POWER AVAILABLE FOR YT53-L-704 ENGINE OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAM T53-L-703 FILE NO. 19.41.32.05, FEBRUARY 1986 WITH FOLLOWING ASSUMPTIONS:
   A. MILITARY RATED POWER.
   B. 1678 RPM PROPELLER SPEED.
   C. 15 SHP EXTRACTION.
   D. BLEED AIR OFF.
   E. 0.991 RAM RECOVERY.
4. POWER REQUIRED OBTAINED FROM FIG. 1.

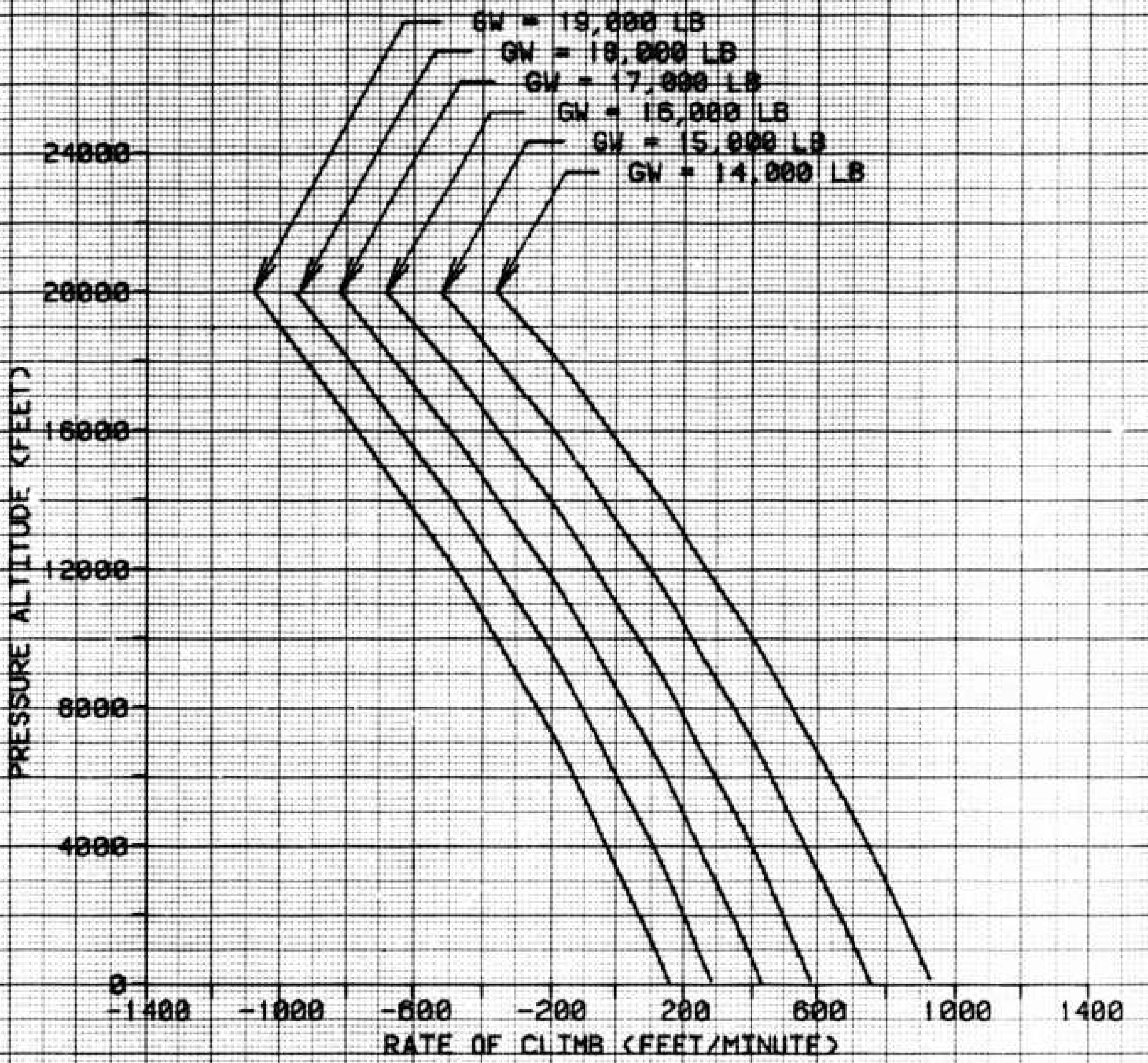


FIGURE 4
SINGLE-ENGINE CLIMB PERFORMANCE COMPARISON
OV-1D USA S/N 62 - 5867

NOTES:
1. 200 FPM CLIMB CAPABILITY AT VYSE.
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS EITHER WITH OR WITHOUT SIDE LOOKING AIRBORNE RADAR.
3. POWER AVAILABLE OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAMS USING T53-L-703 ENGINE FILE NO. 19.41.32.05, FEB 1986 FOR YT53-L-704 ENGINE AND T53-L-15B ENGINE FILE NO. 19.20.25.03, JULY 1982 FOR T53-L-701 ENGINE WITH FOLLOWING ASSUMPTIONS:
   A. MILITARY RATED POWER EXCEPT AS NOTED.
   B. 1970 RPM PROPELLER SPEED.
   C. 15 SHP EXTRACTION.
   D. BLEED AIR OFF.
   E. 0.991 RAM RECOVERY.
4. POWER REQUIRED OBTAINED FROM FIG. 1

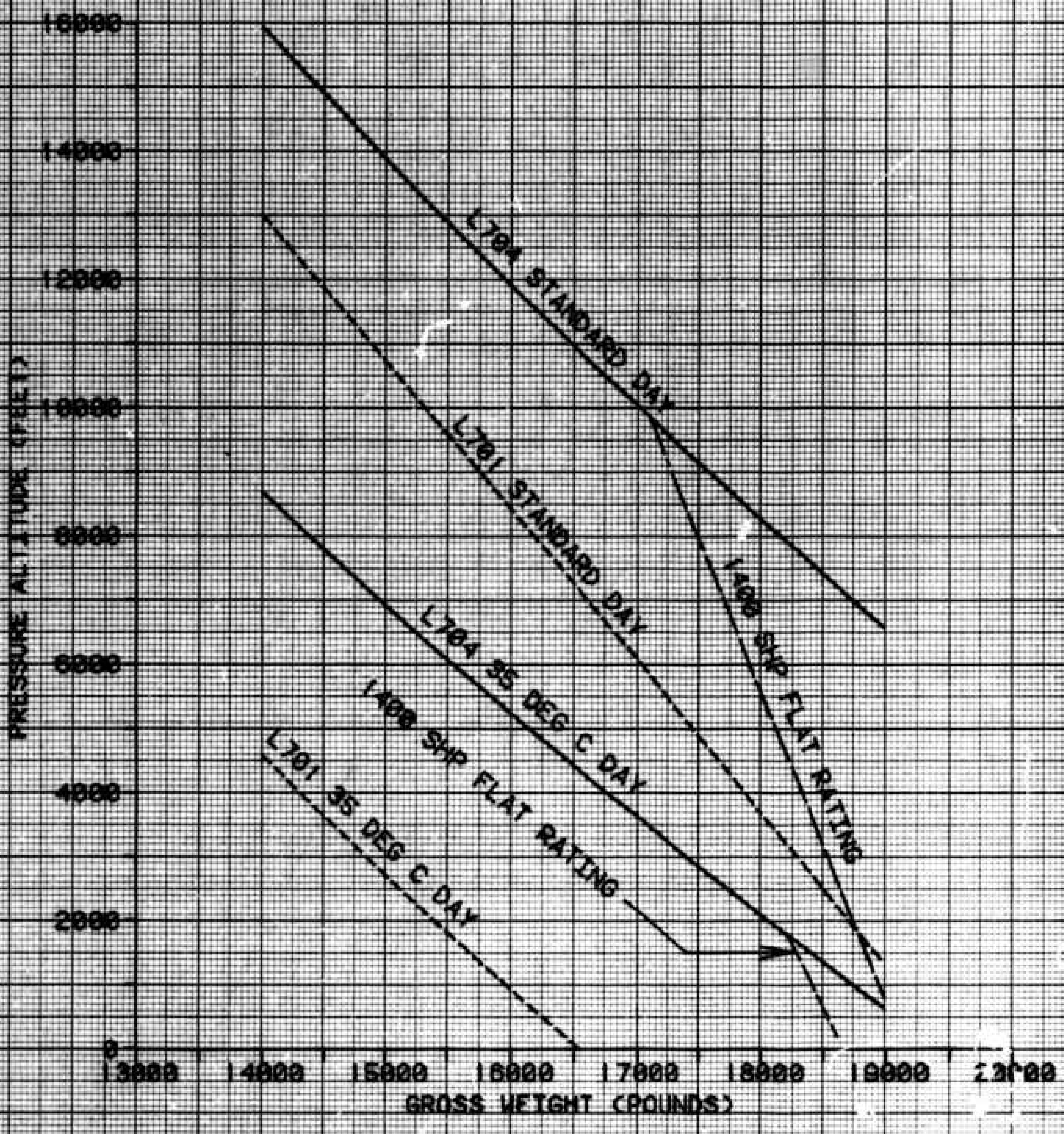
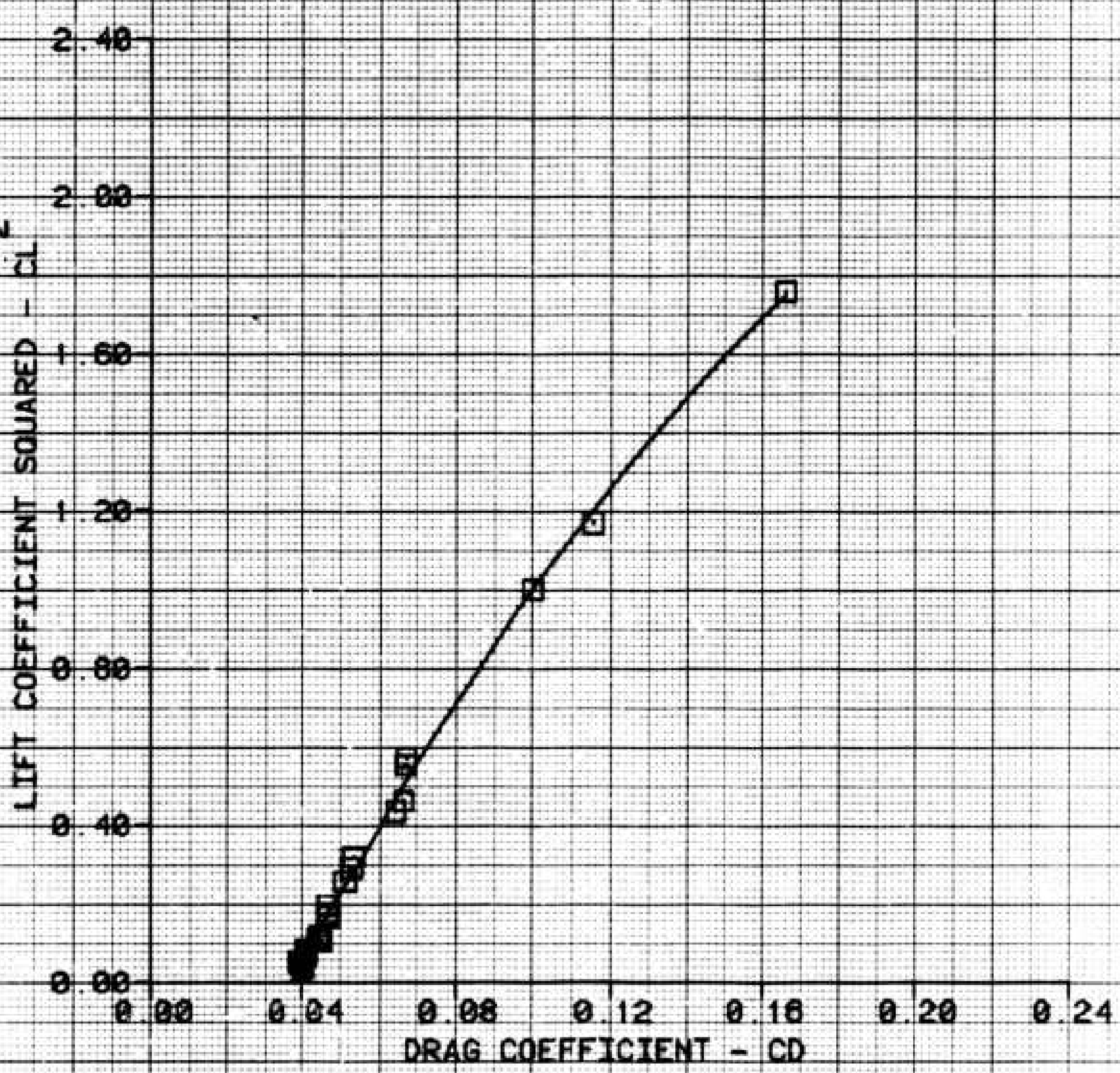


FIGURE 5
LEVEL FLIGHT DRAG POLAR
OV-1D USA S/N 62 - 5867

DUAL-ENGINE CRUISE CONFIGURATION

AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG PROPELLER SPEED (RPM)
15,600	160.8(MID)	4180	18.5	1667

NOTES: 1. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS.
2. ECU OFF.
3. BALL-CENTERED TRIM FLIGHT.



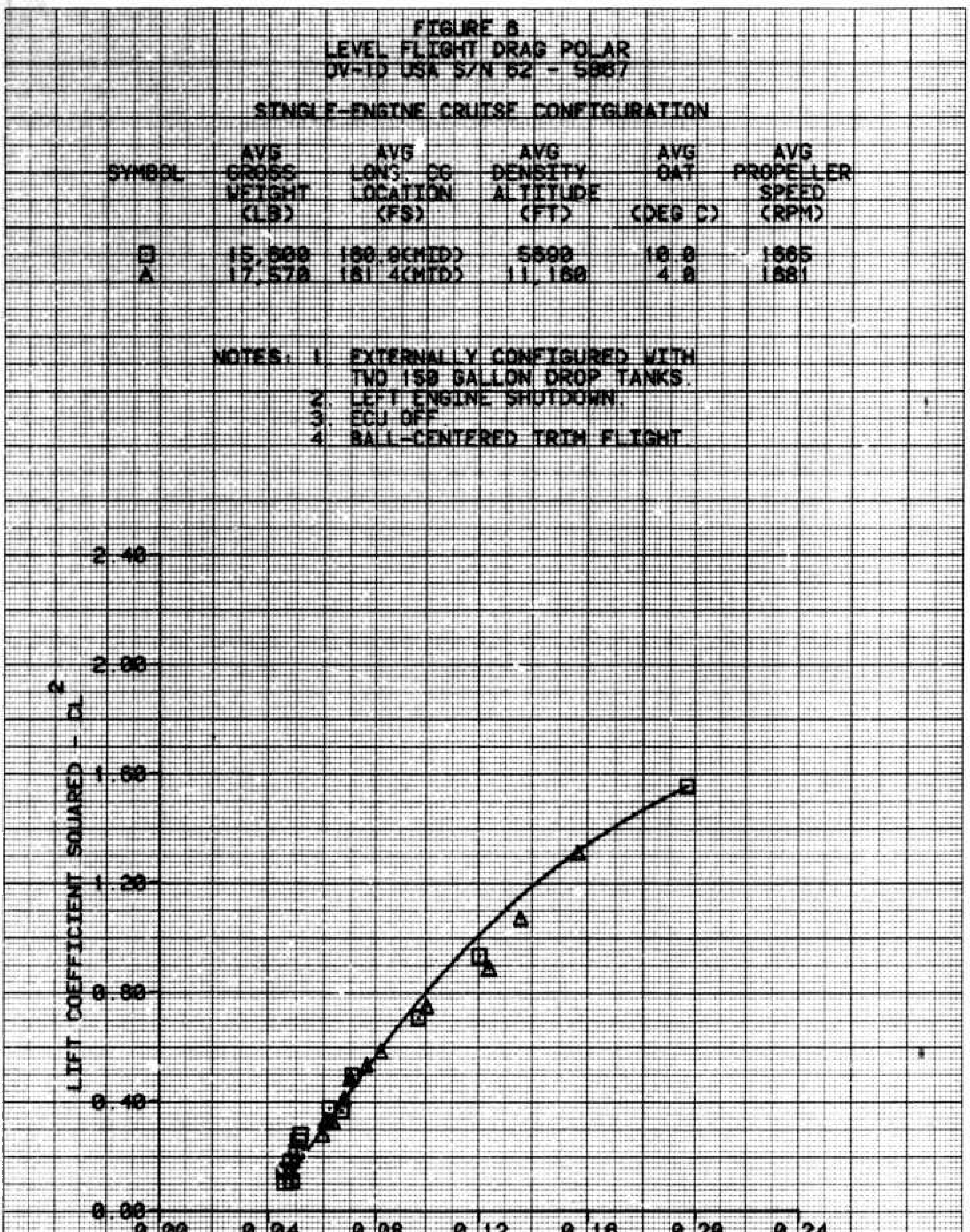


FIGURE 8
LEVEL FLIGHT DRAG POLAR
OV-1D USA S/N 62 - 5887
SINGLE-ENGINE CRUISE CONFIGURATION
SYMBOL
AVG GROSS WEIGHT (LB)
AVG LONG. CG LOCATION (FS)
AVG DENSITY ALTITUDE (FT)
AVG OAT (DEG C)
AVG PROPELLER SPEED (RPM)
15,500 | 160.9(MID) | 5600 | 10.0 | 1665
17,570 | 161.4(MID) | 11,160 | 4.0 | 1681
NOTES: 1. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS.
2. LEFT ENGINE SHUTDOWN.
3. ECU OFF
4. BALL-CENTERED TRIM FLIGHT
LIFT COEFFICIENT SQUARED - CL2
DRAG COEFFICIENT - CD
0.00
0.40
0.80
1.20
1.60
2.00
2.40
0.00
0.04
0.08
0.12
0.16
0.20
0.24

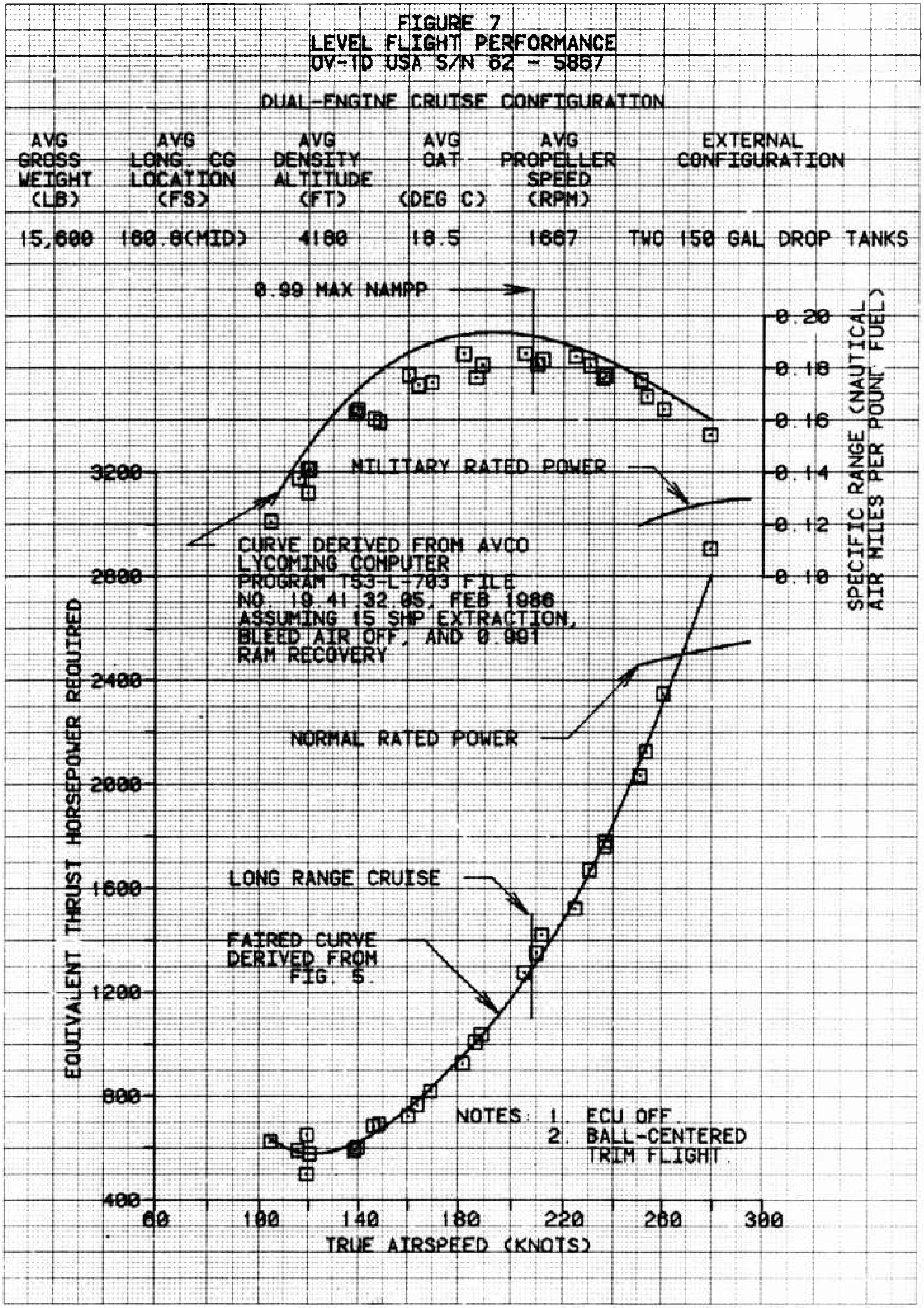


FIGURE 7
LEVEL FLIGHT PERFORMANCE
OV-1D USA S/N 62 - 5867
DUAL-ENGINE CRUISE CONFIGURATION
AVG GROSS WEIGHT (LB)
AVG LONG. CG LOCATION (FS)
AVG DENSITY ALTITUDE (FT)
AVG OAT (DEG C)
AVG PROPELLER SPEED (RPM)
EXTERNAL CONFIGURATION
15,600
160.8(MID)
4180
18.5
1667
TWO 150 GAL DROP TANKS
0.99 MAX NAMPP
MILITARY RATED POWER
CURVE DERIVED FROM AVCO LYCOMING COMPUTER PROGRAM T53-L-703 FILE NO. 19.41.32.05, FEB 1986 ASSUMING 15 SHP EXTRACTION, BLEED AIR OFF, AND 0.981 RAM RECOVERY
NORMAL RATED POWER
LONG RANGE CRUISE
FAIRED CURVE DERIVED FROM FIG. 5
NOTES: 1. ECU OFF.
2. BALL-CENTERED TRIM FLIGHT.
EQUIVALENT THRUST HORSEPOWER REQUIRED
400
800
1200
1600
2000
2400
2800
3200
SPECIFIC RANGE (NAUTICAL AIR MILES PER POUND FUEL)
0.10
0.12
0.14
0.16
0.18
0.20
60
100
140
180
220
260
300
TRUE AIRSPEED (KNOTS)

FIGURE 8
LEVEL FLIGHT PERFORMANCE
OV-1D USA S/N 62 - 5857

SINGLE-ENGINE CRUISE CONFIGURATION

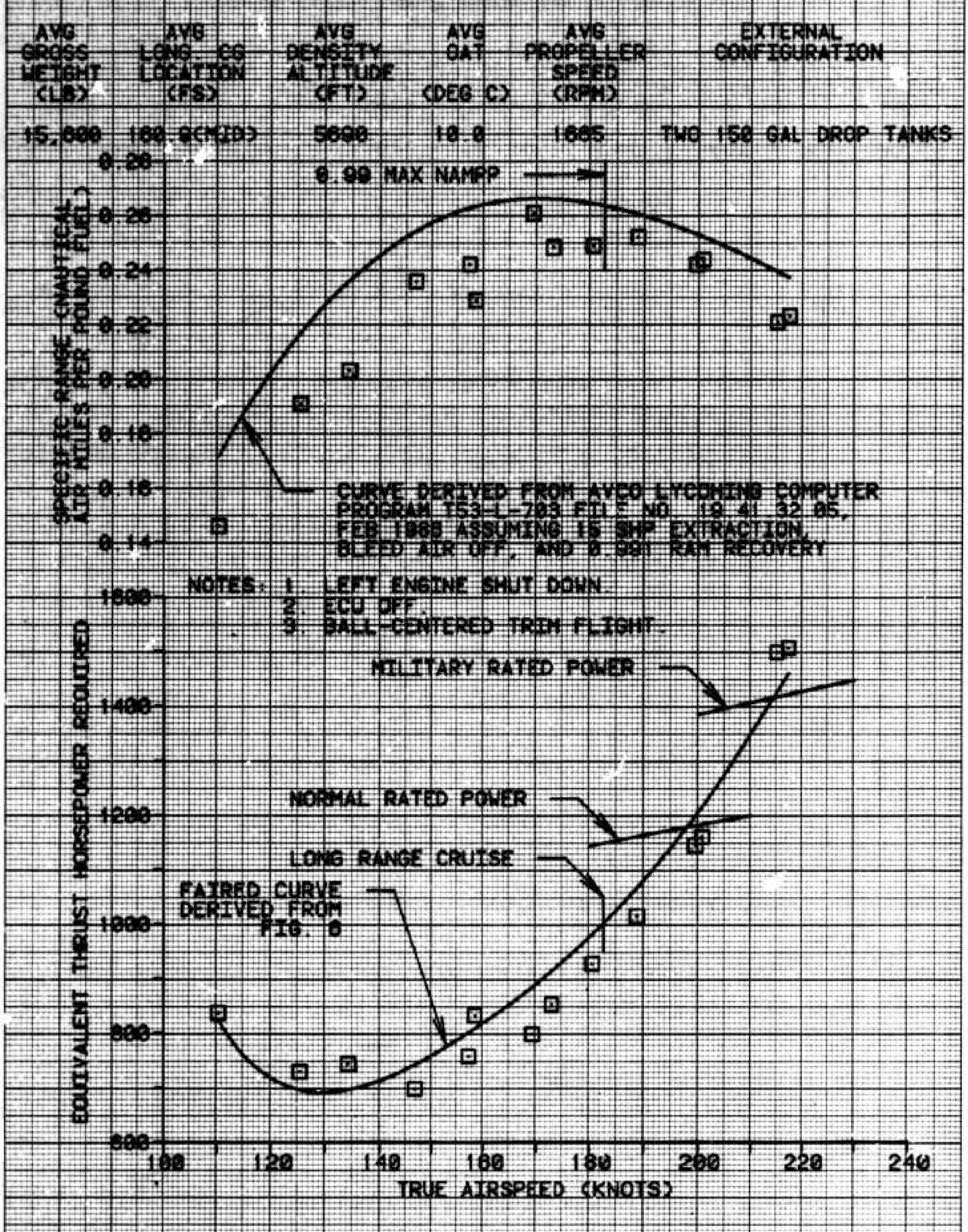


FIGURE 9
LEVEL FLIGHT PERFORMANCE
OV-1D USA S/N 62 - 5867

SINGLE-ENGINE CRUISE CONFIGURATION

AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (DEG C)	AVG PROPELLER SPEED (RPM)	EXTERNAL CONFIGURATION
17,570	181.4(MID)	11,180	4.0	1681	TWO 150 GAL DROP TANKS

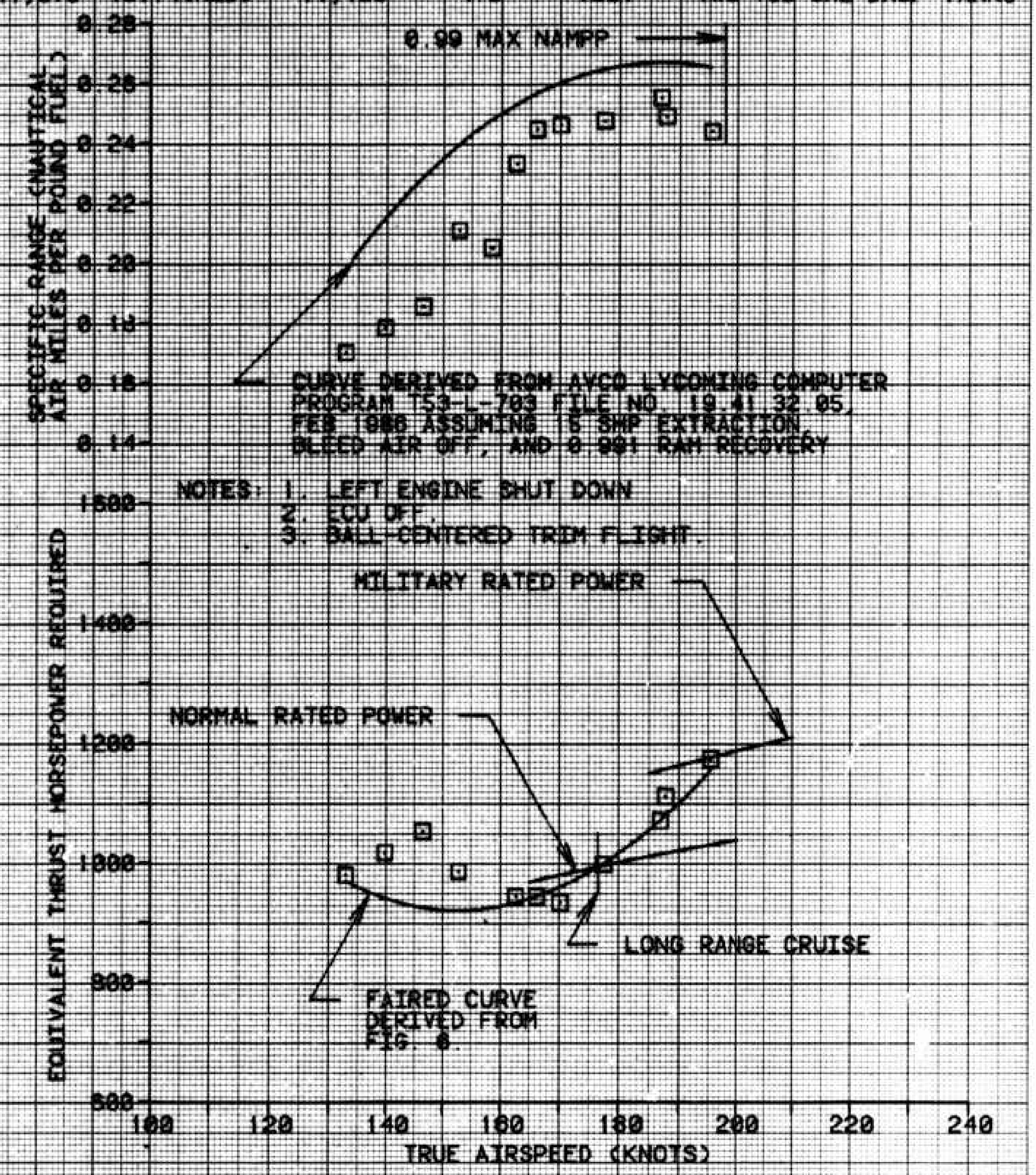


FIGURE 10
DUAL-ENGINE LEVEL FLIGHT RANGE SUMMARY
OV-1D USA S/N 62-5867

STANDARD DAY ATMOSPHERE

NOTES: 1. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS.
2. SPECIFIC FUEL COMSUMPTION FOR YT53-L-704 ENGINE OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAM T53-L-703 FILE NO. 19.41.32.05, FEBRUARY 1988 WITH FOLLOWING ASSUMPTIONS:
A. 1450 RPM PROPELLER SPEED.
B. 15 SHP EXTRACTION.
C. 0.01 BLEED AIR.
D. 0.991 RAM RECOVERY.
3. POWER REQUIRED OBTAINED FROM FIG. 5

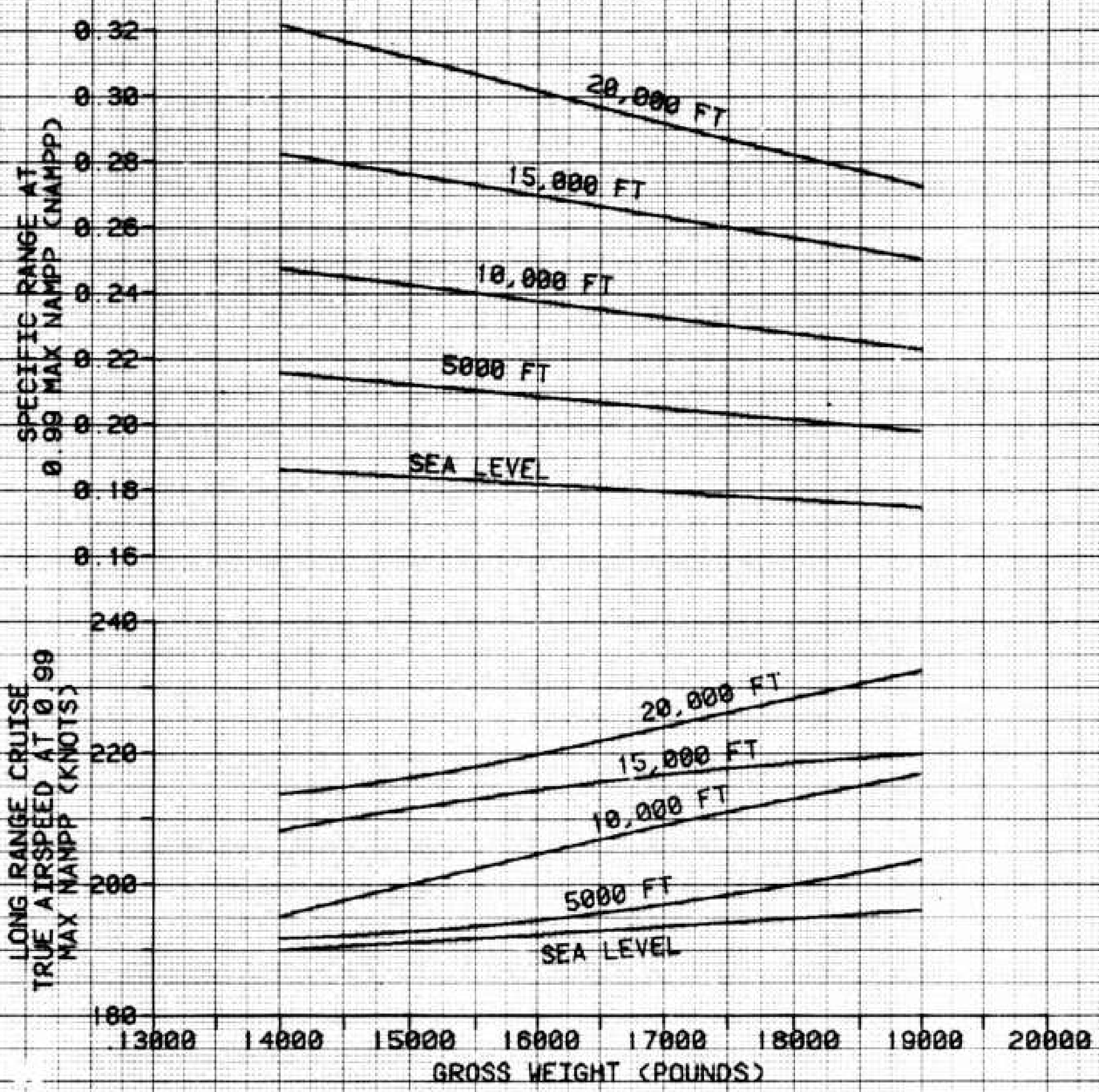


FIGURE 1.

DUAL-ENGINE LEVEL FLIGHT RANGE SUMMARY

OV-1D USA S/N 62-5867

HOT DAY ATMOSPHERE

NOTES: 1. HOT DAY ATMOSPHERE AS DEFINED BY MIL SPEC, MIL-C-005011B (USAF), STANDARD AIRCRAFT CHARACTERISTICS AND PERFORMANCE, PILOTED AIRCRAFT (FIXED WING), 21 JUNE 1977.

2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS.

3. SPECIFIC FUEL CONSUMPTION FOR YT53-L-704 ENGINE OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAM T53-L-703 FILE NO. 19.41.32.05, FEBRUARY 1986 WITH FOLLOWING ASSUMPTIONS:

A. 1450 RPM PROPELLER SPEED.

B. 15 SHP EXTRACTION.

C. 0.01 BLEED AIR.

D. 0.991 RAM RECOVERY.

4. POWER REQUIRED OBTAINED FROM FIG. 5

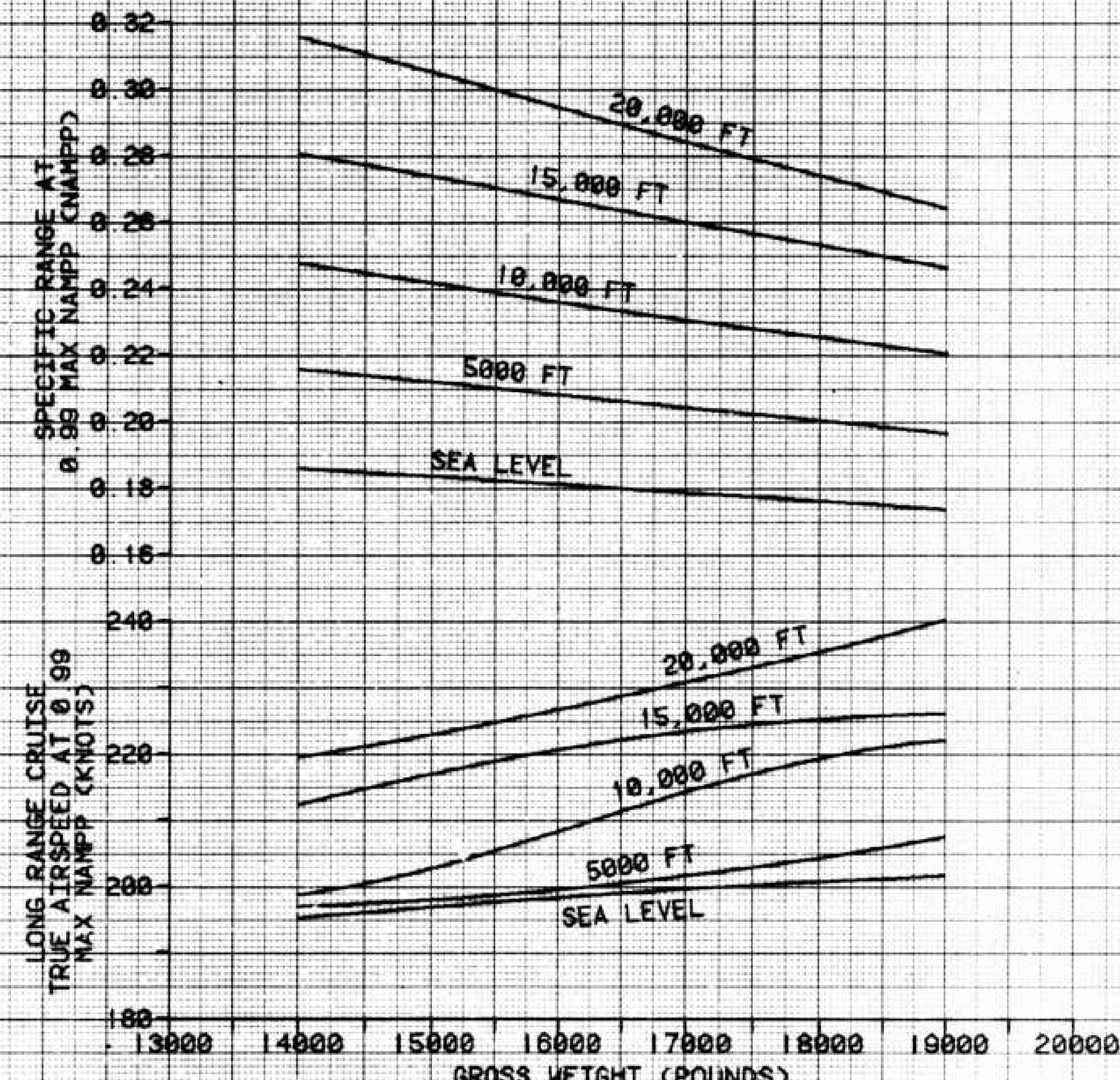


FIGURE 12
DUAL-ENGINE LEVEL FLIGHT ENDURANCE SUMMARY
OV-1D USA S/N 62-5867

STANDARD DAY ATMOSPHERE

NOTES: 1. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS.
2. SPECIFIC FUEL CONSUMPTION FOR YT53-L-704 ENGINE OBTAIND FROM AVCO LYCOMING COMPUTER PROGRAM T53-L-703 FILE NO. 19.41.32.06, FEBRUARY 1986 WITH FOLLOWING ASSUMPTIONS:
A. 1450 RPM PROPELLER SPEED.
B. 15 SHP EXTRACTION.
C. 0.01 BLEED AIR.
D. 0.991 RAM RECOVERY.
3. POWER REQUIRED OBTAINED FROM FIG. 5

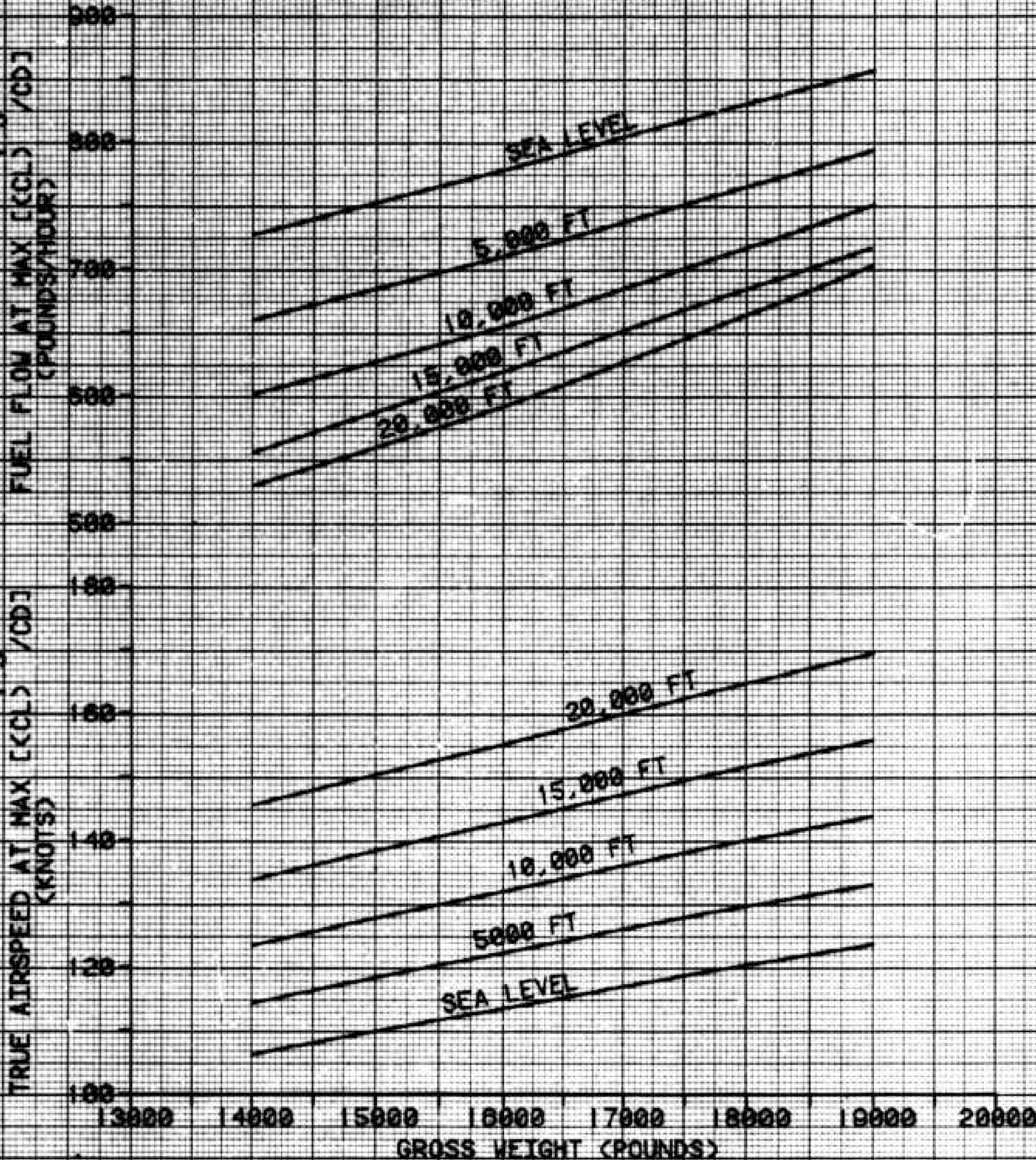


FIGURE 13
DUAL-ENGINE LEVEL FLIGHT ENDURANCE SUMMARY
OV-1D USA S/N 62-5867

HOT DAY ATMOSPHERE

NOTES: 1. HOT DAY ATMOSPHERE AS DEFINED BY MIL SPEC MIL-C-005011B (USAF), STANDARD AIRCRAFT CHARACTERISTICS AND PERFORMANCE, PILOTED AIRCRAFT (FIXED WING), 21 JUNE 1977.
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS.
3. SPECIFIC FUEL CONSUMPTION FOR YT53-L-704 ENGINE OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAM T53-L-703 FILE NO. 19.41.32.05, FEBRUARY 1986 WITH FOLLOWING ASSUMPTIONS:
A. 1450 RPM PROPELLER SPEED.
B. 15 SHP EXTRACTION.
C. 0.01 BLEED AIR.
D. 0.991 RAM RECOVERY.
4. POWER REQUIRED OBTAINED FROM FIG. 5

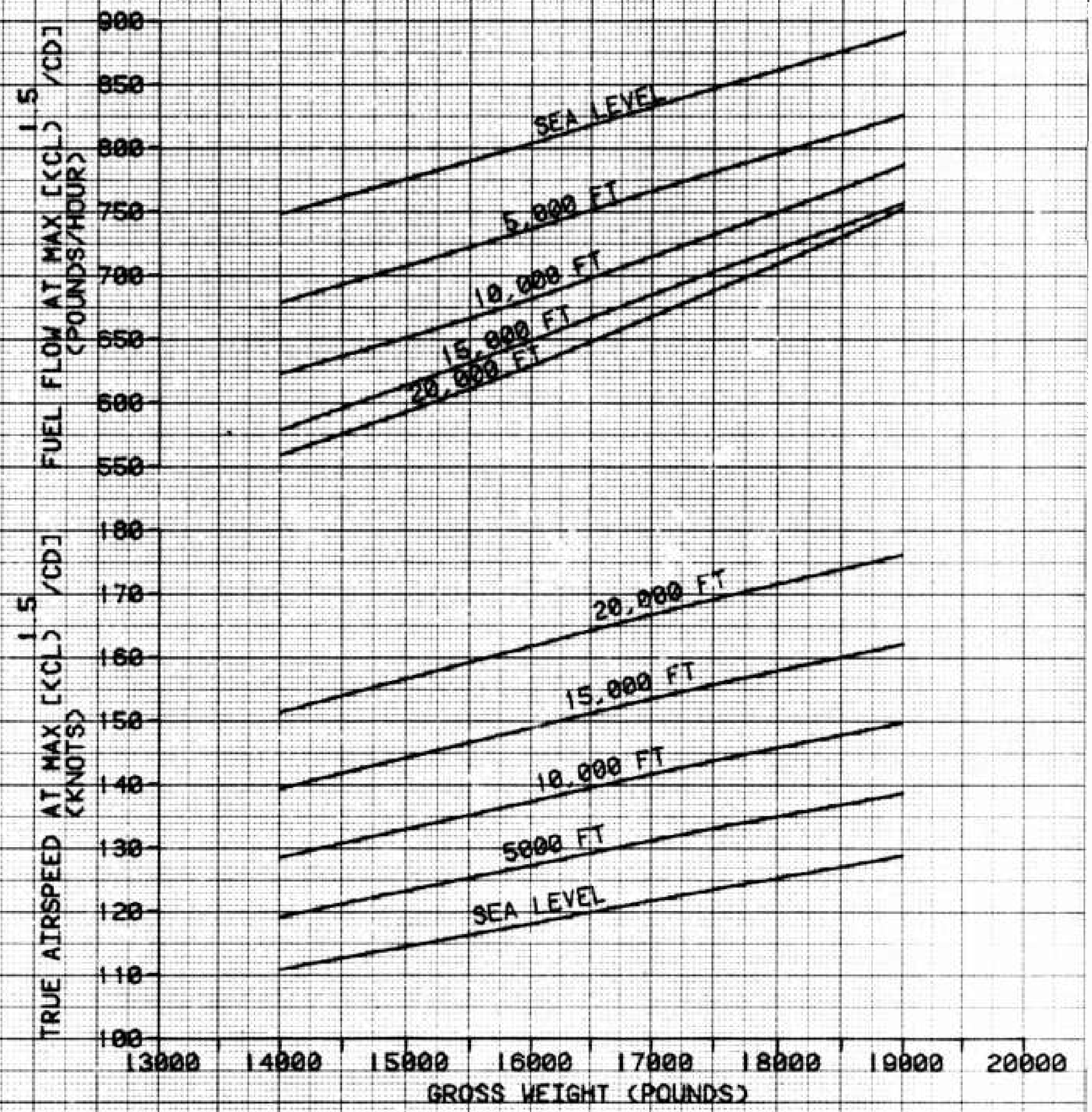


FIGURE 14
DUAL-ENGINE LEVEL FLIGHT RANGE SUMMARY COMPARISON
OV-1D USA S/N 62-5867

PRESSURE ALTITUDE = 14,000 FEET

NOTES: 1. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS.
2. HOT DAY ATMOSPHERE AS DEFINED BY MIL SPEC, MIL-C-005011B (USAF), STANDARD AIRCRAFT CHARACTERISTICS AND PERFORMANCE, PILOTED AIRCRAFT (FIXED WING), 21 JUNE 1977.
3. SPECIFIC FUEL CONSUMPTIONS OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAMS USING T53-L-703 ENGINE FILE NO. 19.41.32.05, FEB 1986 FOR YT53-L-704 ENGINE AND T53-L-13B ENGINE FILE NO. 19.28.25.03, JULY 1982 FOR T53-L-701 ENGINE WITH FOLLOWING ASSUMPTIONS:
A. 1450 RPM PROPELLER SPEED.
B. 15 SHP EXTRACTION.
C. 0.01 BLEED AIR.
D. 0.991 RAM RECOVERY.
4. POWER REQUIRED OBTAINED FROM FIG. 5

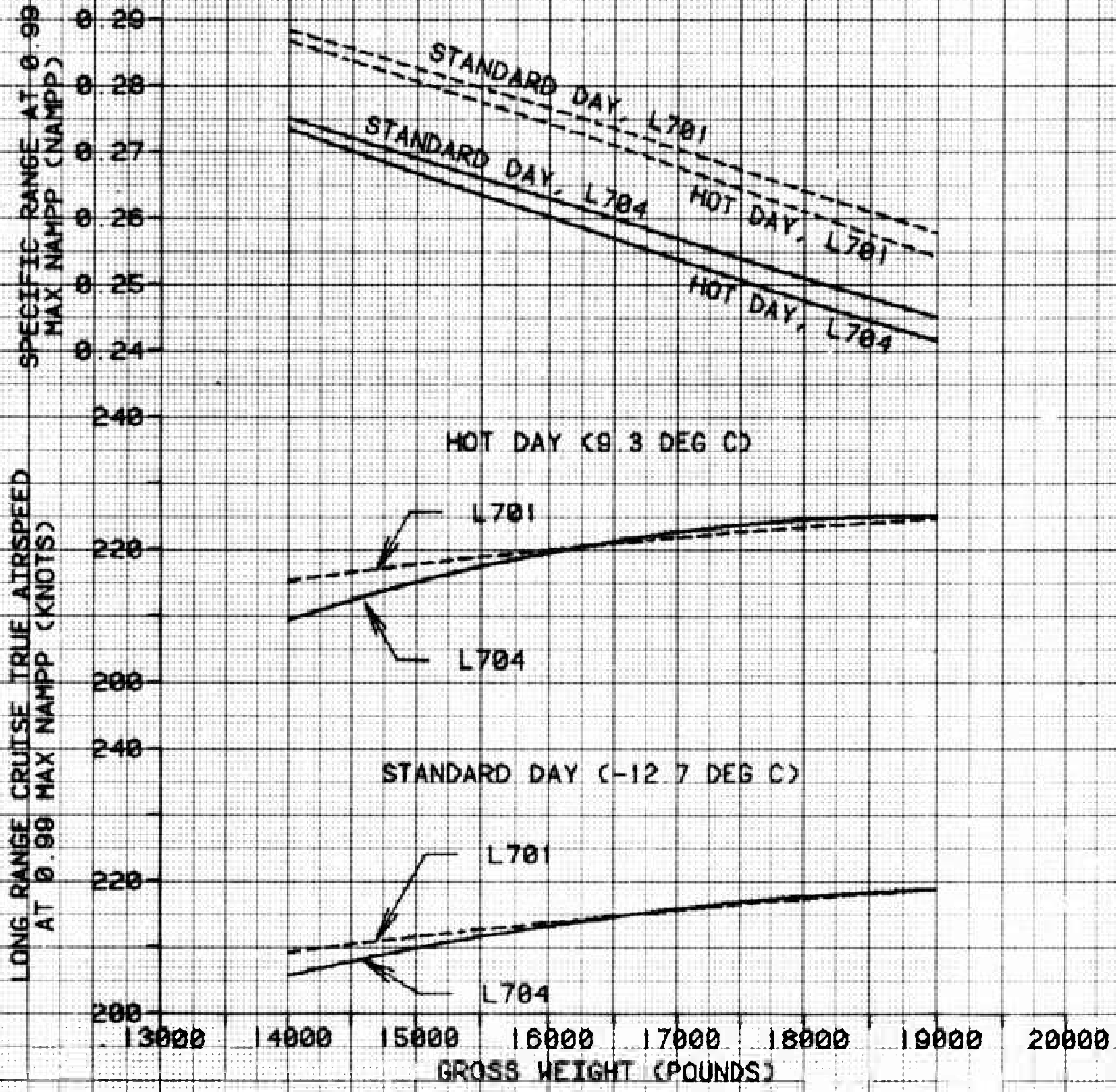
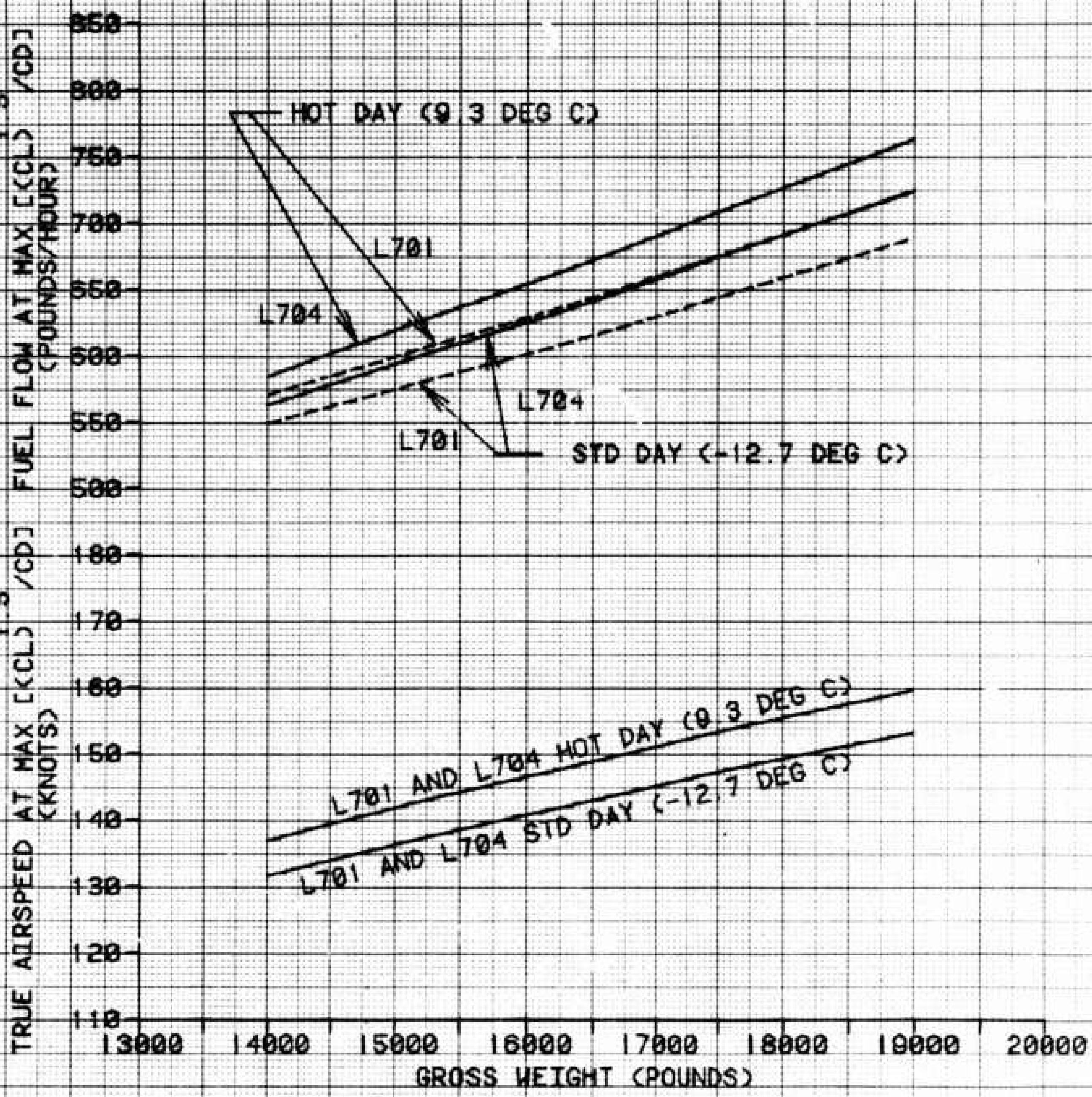


FIGURE 15
DUAL-ENGINE ENDURANCE SUMMARY COMPARISON
OV-1D USA S/N 62-5867

PRESSURE ALTITUDE = 14,000 FEET

NOTES:
1. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS.
2. HOT DAY ATMOSPHERE AS DEFINED BY MIL SPEC, MIL-C-005011B (USAF), STANDARD AIRCRAFT CHARACTERISTICS AND PERFORMANCE, PILOTED AIRCRAFT (FIXED WING), 21 JUNE 1977.
3. SPECIFIC FUEL CONSUMPTIONS OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAMS USING T53-L-703 ENGINE FILE NO. 19.41.32.05, FEB 1985 FOR YT53-L-704 ENGINE AND T53-L-13B ENGINE FILE NO. 19.28.26.03, JULY 1982 FOR T53-L-701 ENGINE WITH FOLLOWING ASSUMPTIONS.
A. 1450 RPM PROPELLER SPEED.
B. 15 SHP EXTRACTION.
C. 0.01 BLEED AIR.
D. 0.991 RAM RECOVERY.
4. POWER REQUIRED OBTAINED FROM FIG. 5



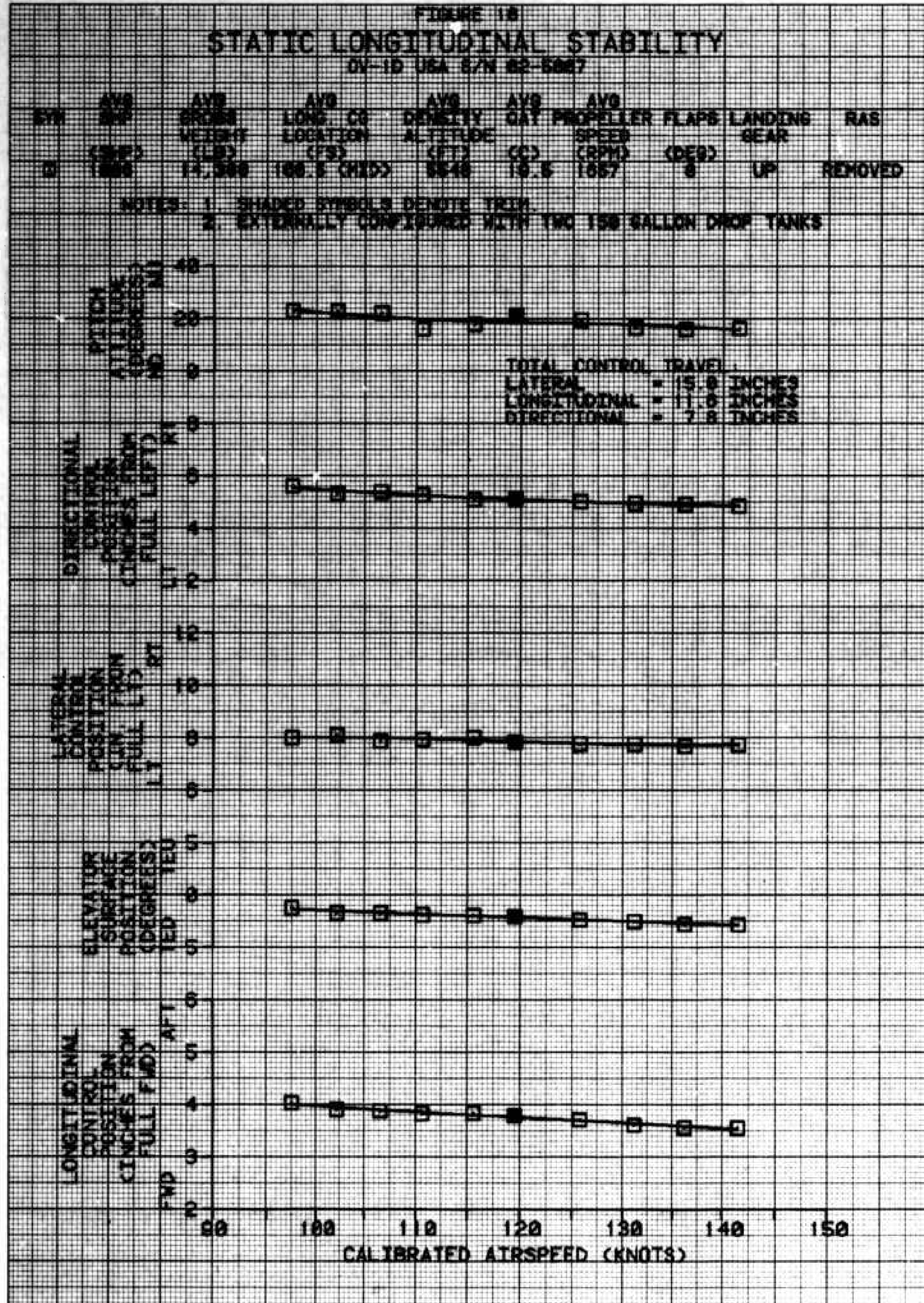


FIGURE 18
STATIC LONGITUDINAL STABILITY
SYM
AVG SHP (SHP)
AVG GROSS WEIGHT (LB)
AVG LONG. CG LOCATION (FS)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG PROPELLER SPEED (RPM)
FLAPS (DEG)
LANDING GEAR
RAS
(MID)
1657
UP
REMOVED
NOTES: 1. SHADED SYMBOLS DENOTE TRIM.
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS
TOTAL CONTROL TRAVEL:
LATERAL = 15.8 INCHES
LONGITUDINAL = 11.8 INCHES
DIRECTIONAL = 7.8 INCHES
PITCH ATTITUDE (DEGREES)
ND
NU
DIRECTIONAL CONTROL POSITION (INCHES FROM FULL LEFT)
LT
RT
LATERAL CONTROL POSITION (IN. FROM FULL LT)
ELEVATOR SURFACE POSITION (DEGREES)
TED
TEU
LONGITUDINAL CONTROL POSITION (INCHES FROM FULL FWD)
FWD
AFT
90
100
110
120
130
140
150
CALIBRATED AIRSPEED (KNOTS)

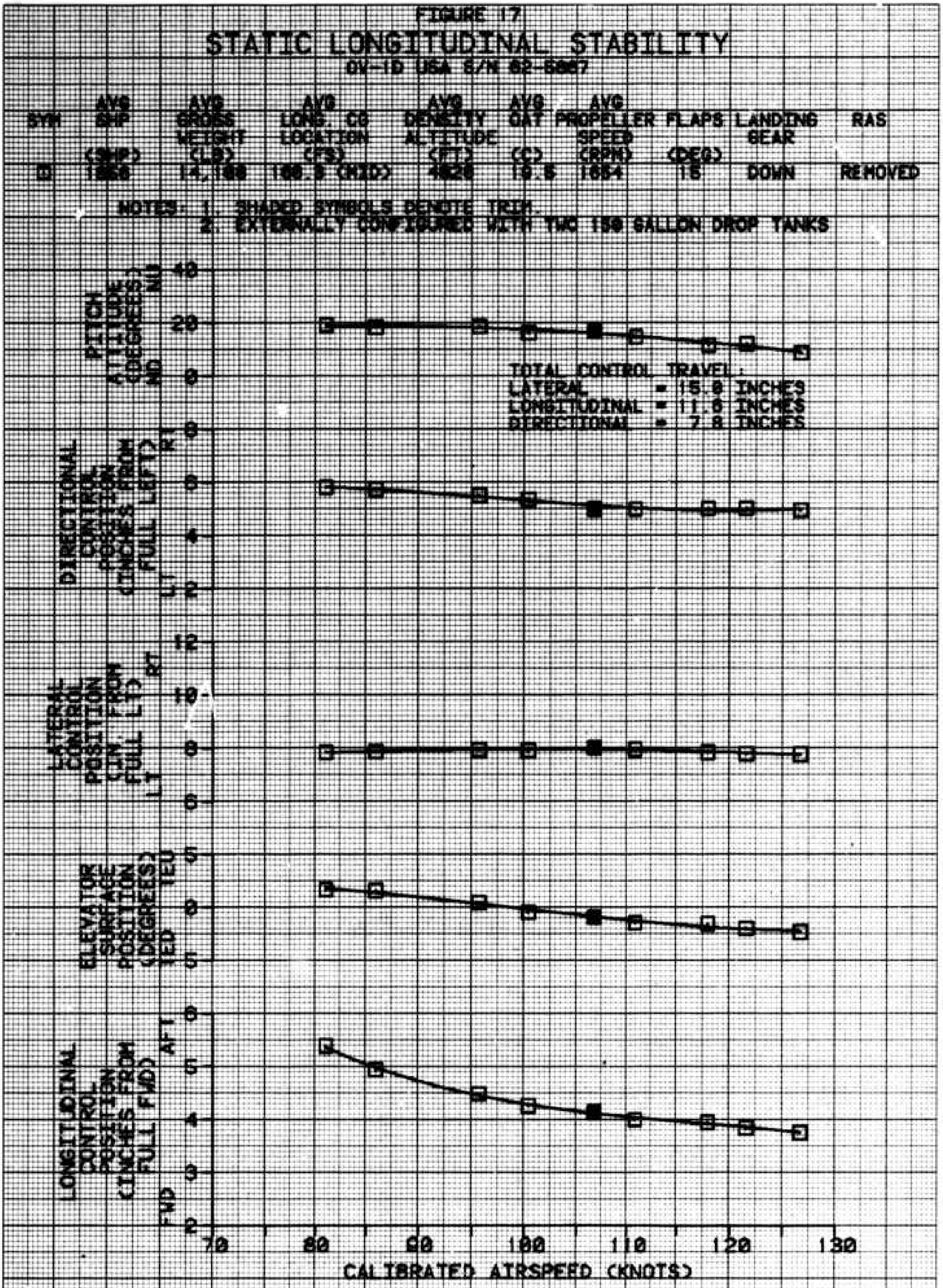


FIGURE 17
STATIC LONGITUDINAL STABILITY
OV-1D USA S/N 62-5867
SYM
AVG SHP (SHP)
AVG GROSS WEIGHT (LB)
AVG LONG. CG LOCATION (FS)
AVG DENSITY ALTITUDE (FT)
AVG OAT (C)
AVG PROPELLER SPEED (RPM)
FLAPS (DEG)
LANDING GEAR
RAS
15
DOWN
REMOVED
NOTES: 1. SHADED SYMBOLS DENOTE TRIM.
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS
TOTAL CONTROL TRAVEL:
LATERAL = 15.0 INCHES
LONGITUDINAL = 11.6 INCHES
DIRECTIONAL = 7.8 INCHES
PITCH ATTITUDE (DEGREES)
ND
NU
DIRECTIONAL CONTROL POSITION (INCHES FROM FULL LEFT)
LT
RT
LATERAL CONTROL POSITION (IN. FROM FULL LT)
ELEVATOR SURFACE POSITION (DEGREES)
TED
TEU
LONGITUDINAL CONTROL POSITION (INCHES FROM FULL FWD)
FWD
AFT
70
80
90
100
110
120
130
CALIBRATED AIRSPEED (KNOTS)

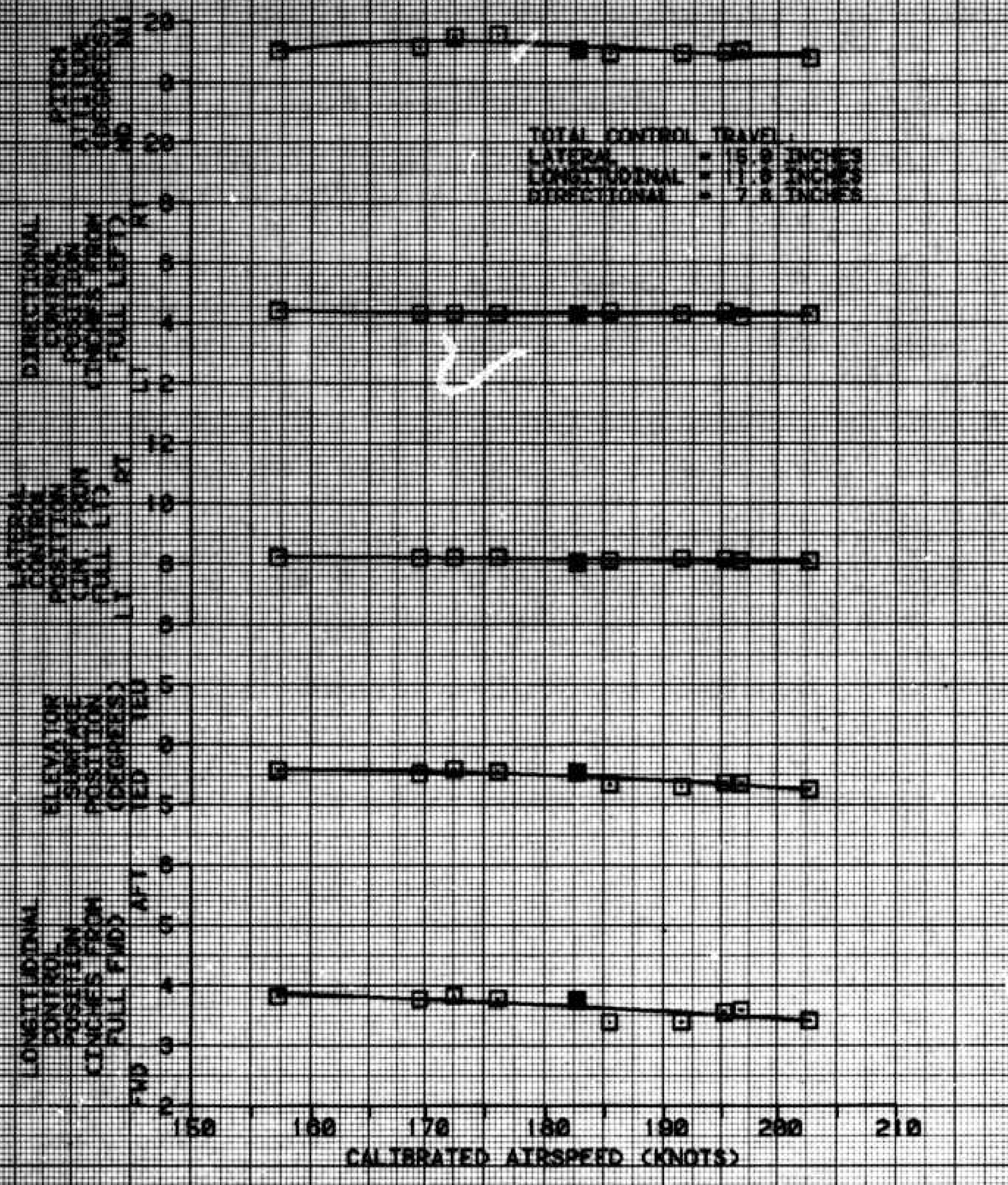
FIGURE 18

STATIC LONGITUDINAL STABILITY

OV-1D USA S/N 62-5867

SYM	AVG SHP (SHP)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	LANDING GEAR	RAS
⊡	1721	16,800	161.2 (MID)	5000	19.5	1667	0	UP	REMOVED

NOTES: 1. SHADED SYMBOLS DENOTE TRIM.
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS AND SLAR.



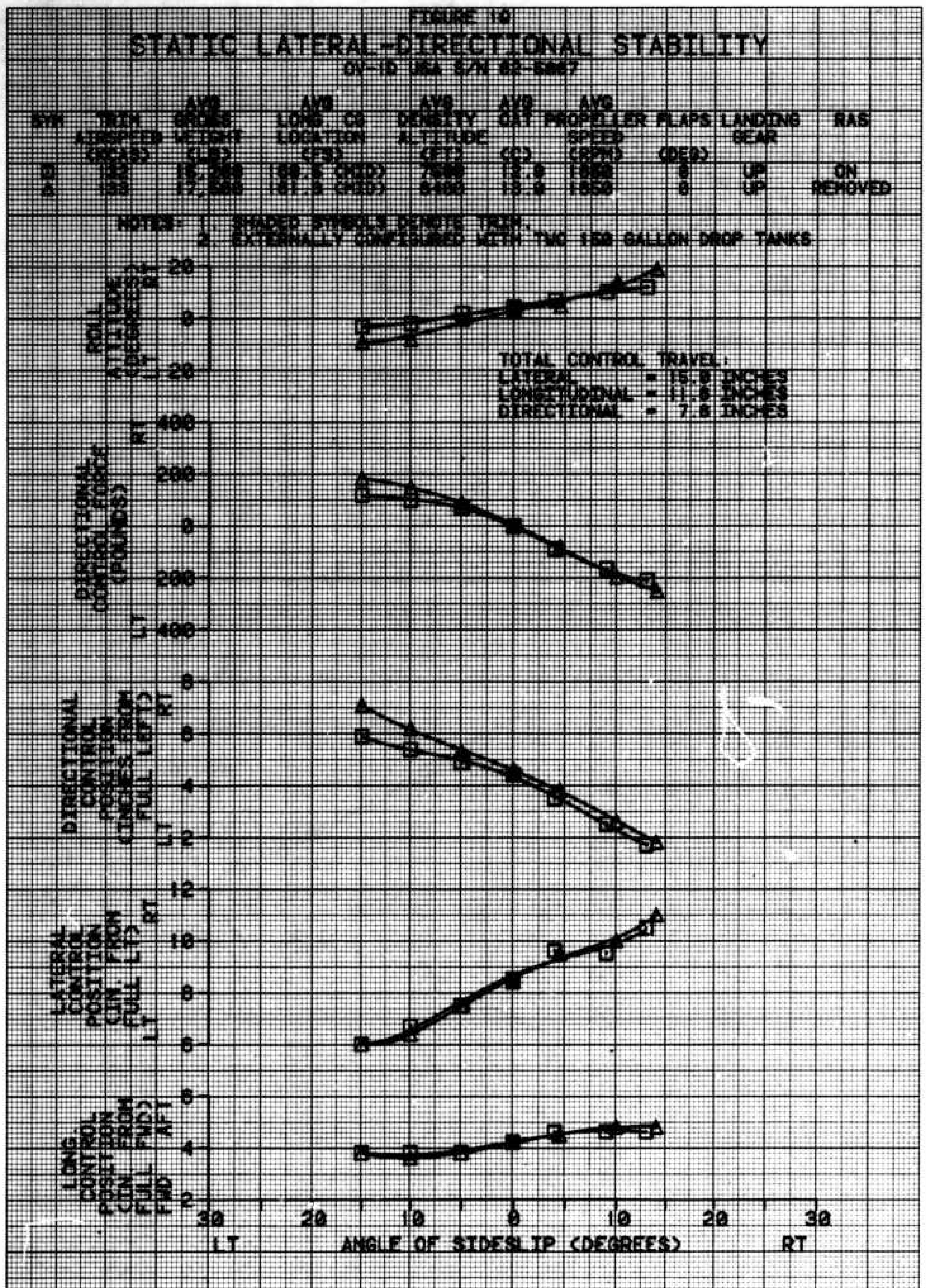


FIGURE 10
STATIC LATERAL-DIRECTIONAL STABILITY
OV-1D USA S/N 62-5867
SYM | TRIM AIRSPEED (KCAS) | AVG GROSS WEIGHT (LB) | AVG LONG. CG LOCATION (FS) | AVG DENSITY ALTITUDE (FT) | AVG OAT (C) | AVG PROPELLER SPEED (RPM) | FLAPS (DEG) | LANDING GEAR | RAS
□ 182 | 16,200 | 180.5 (MID) | 7600 | 12.9 | 1850 | 0 | UP | ON
△ 155 | 17,000 | 181.3 (MID) | 6400 | 13.8 | 1850 | 0 | UP | REMOVED
NOTES: 1. SHADED SYMBOLS DENOTE TRIM.
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS
ROLL ATTITUDE (DEGREES)
RT
LT
20
0
20
TOTAL CONTROL TRAVEL:
LATERAL = 15.0 INCHES
LONGITUDINAL = 11.6 INCHES
DIRECTIONAL = 7.6 INCHES
DIRECTIONAL CONTROL FORCE (POUNDS)
RT
LT
400
200
0
200
400
DIRECTIONAL CONTROL POSITION (INCHES FROM FULL LEFT)
RT
LT
8
6
4
2
LATERAL CONTROL POSITION (IN. FROM FULL LT)
RT
LT
12
10
8
6
LONG. CONTROL POSITION (IN. FROM FULL FWD)
AFT
FWD
6
4
2
30
20
10
0
10
20
30
LT
ANGLE OF SIDESLIP (DEGREES)
RT

FIGURE 20

STATIC LATERAL-DIRECTIONAL STABILITY

OV-1D USA S/N 62-5947

SYM	TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	LANDING GEAR	RAS
□	160	15,200	160.5 (MID)	7500	12.0	1960	0	UP	ON
△	160	17,000	161.5 (MID)	8400	13.0	1950	0	UP	REMOVED

NOTES: 1. SHADED SYMBOLS DENOTE TRIM
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

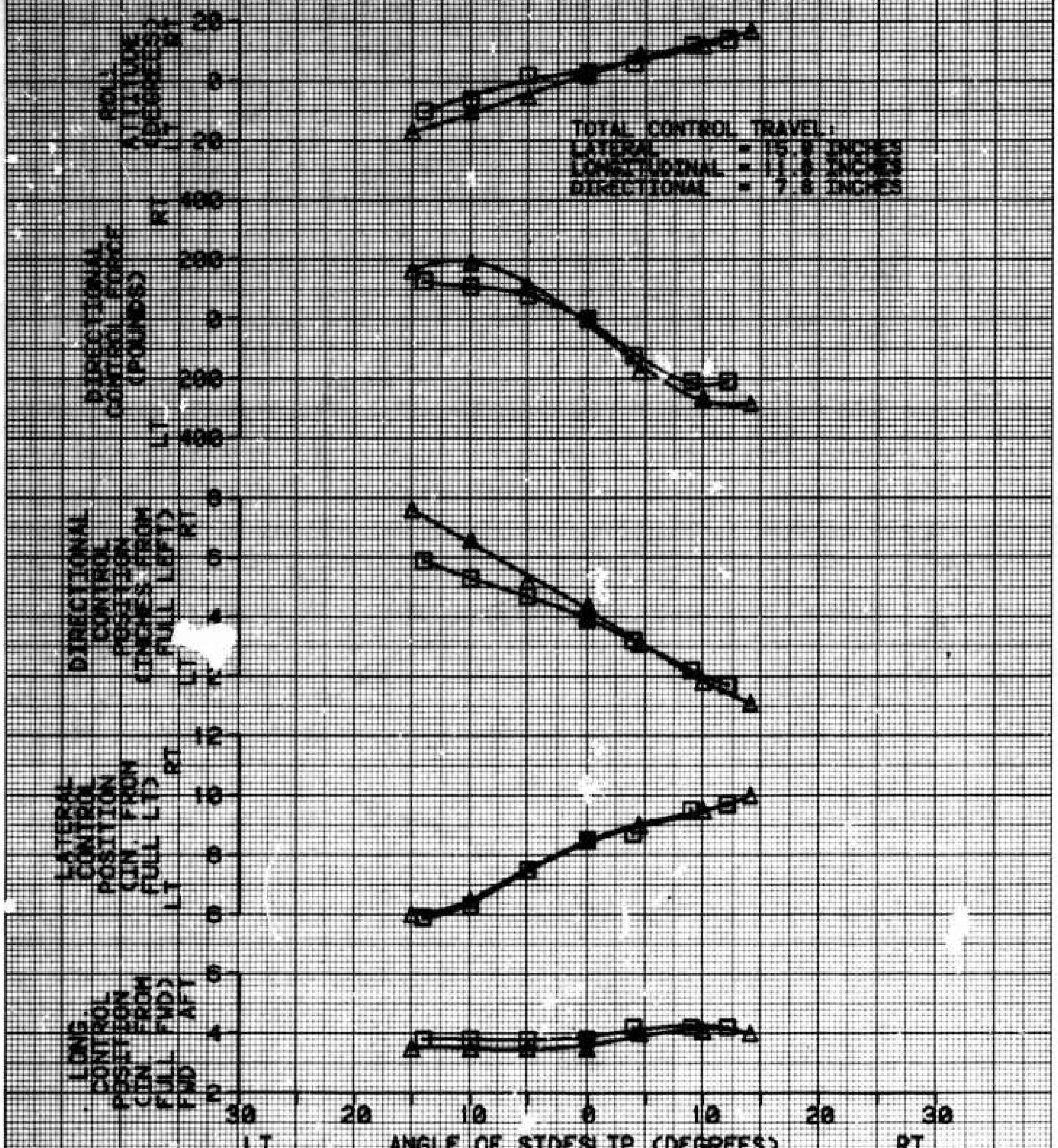


FIGURE 21

STATIC LATERAL-DIRECTIONAL STABILITY

OV-1D USA S/N 62-5867

SYM	TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	LANDING GEAR	RAS
□	120	14,500	160.5 (MID)	5000	20.0	1650	15	DOWN	ON
Δ	118	16,000	161.3 (MID)	6400	17.0	1650	15	DOWN	REMOVED

NOTES: 1. SHADED SYMBOLS DENOTE TRIM
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

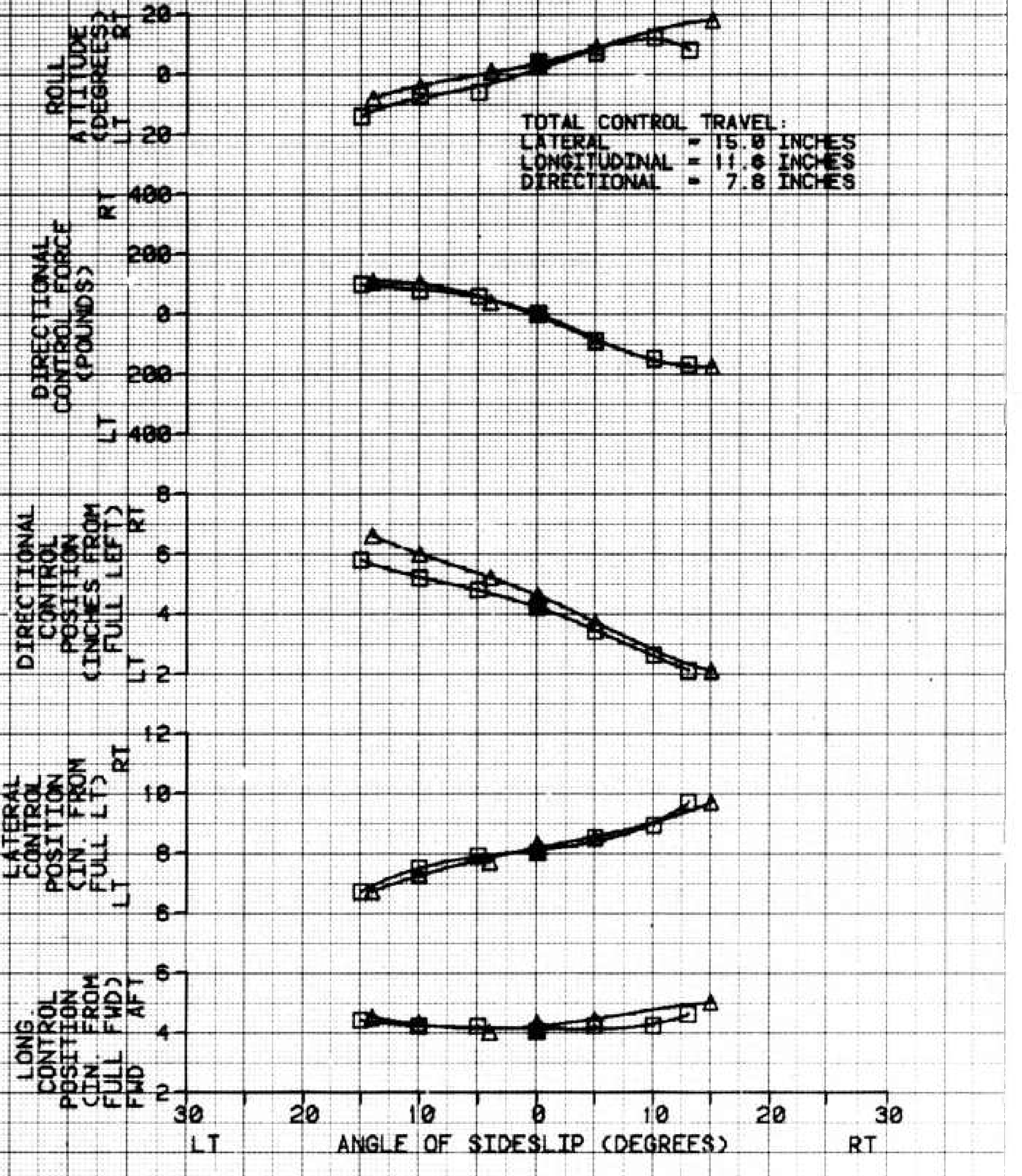
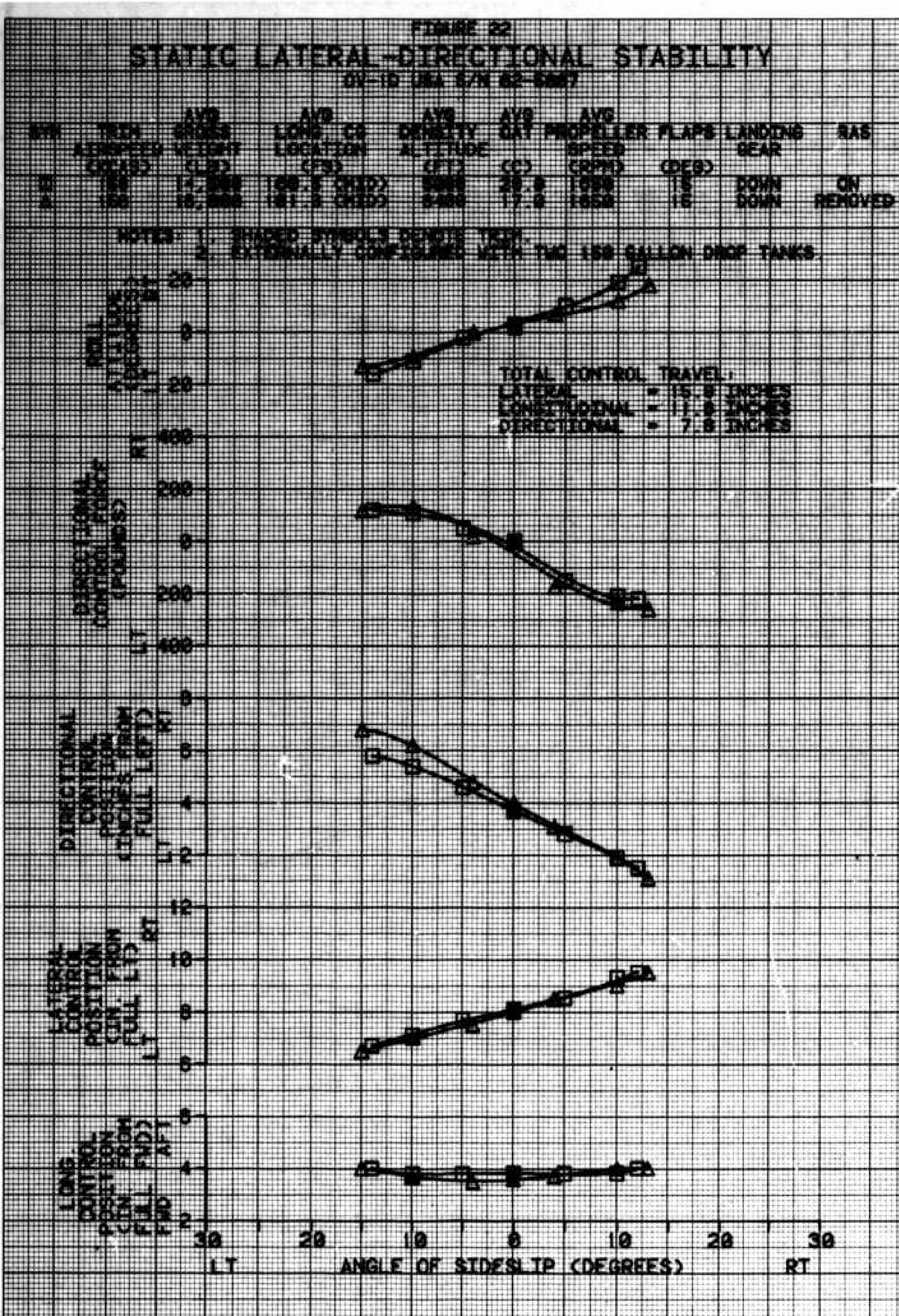


FIGURE 22

STATIC LATERAL-DIRECTIONAL STABILITY



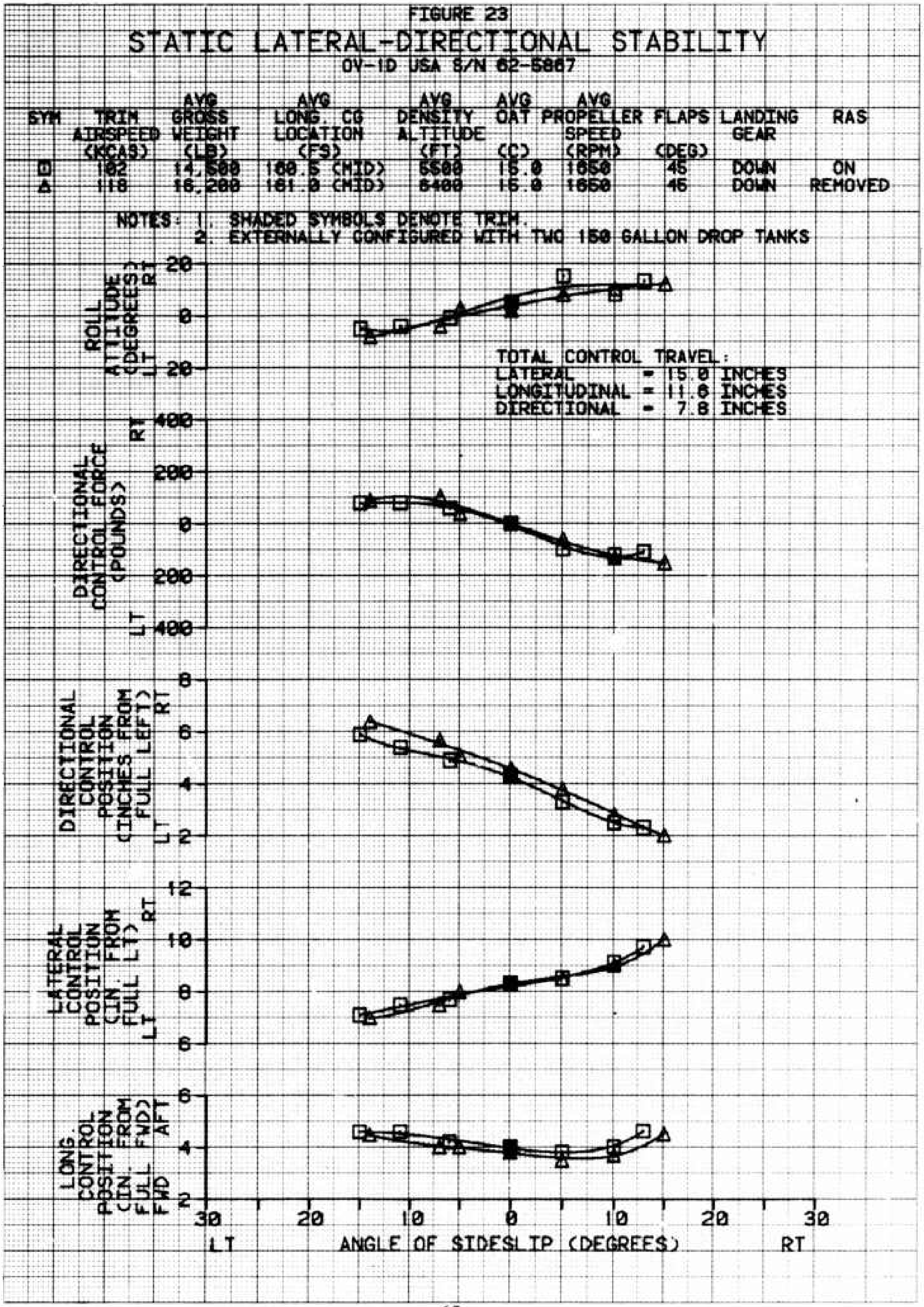


FIGURE 23
STATIC LATERAL-DIRECTIONAL STABILITY
OV-1D USA S/N 62-5867
SYM | TRIM AIRSPEED (KCAS) | AVG GROSS WEIGHT (LB) | AVG LONG. CG LOCATION (FS) | AVG DENSITY ALTITUDE (FT) | AVG OAT (C) | AVG PROPELLER SPEED (RPM) | FLAPS (DEG) | LANDING GEAR | RAS
□ 102 14,500 160.5 (MID) 5500 15.0 1650 45 DOWN ON
△ 118 16,200 161.0 (MID) 6400 16.0 1650 45 DOWN REMOVED
NOTES: 1. SHADED SYMBOLS DENOTE TRIM.
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS
TOTAL CONTROL TRAVEL:
LATERAL = 15.0 INCHES
LONGITUDINAL = 11.6 INCHES
DIRECTIONAL = 7.8 INCHES
ROLL ATTITUDE (DEGREES) LT RT
DIRECTIONAL CONTROL FORCE (POUNDS) LT RT
DIRECTIONAL CONTROL POSITION (INCHES FROM FULL LEFT) LT RT
LATERAL CONTROL POSITION (IN. FROM FULL LT) LT RT
LONG. CONTROL POSITION (IN. FROM FULL FWD) FWD AFT
ANGLE OF SIDESLIP (DEGREES)
LT RT

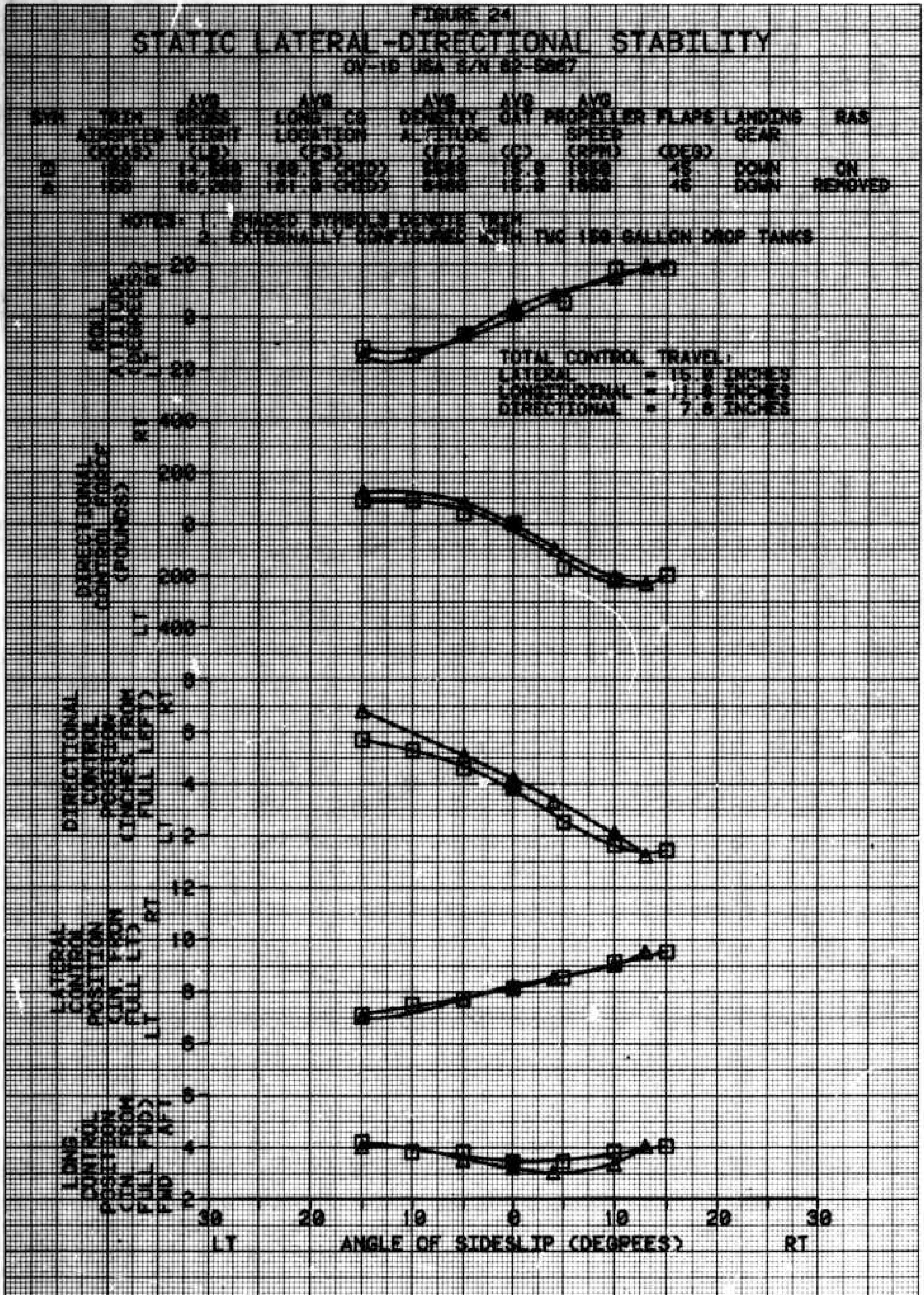


FIGURE 24
STATIC LATERAL-DIRECTIONAL STABILITY
OV-10 USA S/N 62-5967

SYM	TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	LANDING GEAR	RAS
□	150	14,500	180.5 (MID)	5500	15.0	1650	45	DOWN	ON
△	150	16,200	181.0 (MID)	5400	15.0	1650	45	DOWN	REMOVED

NOTES: 1. SHADED SYMBOLS DENOTE TRIM
2. EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

TOTAL CONTROL TRAVEL:
LATERAL = 15.0 INCHES
LONGITUDINAL = 11.0 INCHES
DIRECTIONAL = 7.8 INCHES

ROLL ATTITUDE (DEGREES)
RT
LT
DIRECTIONAL CONTROL FORCE (POUNDS)
RT
LT
DIRECTIONAL CONTROL POSITION (INCHES FROM FULL LEFT)
RT
LT
LATERAL CONTROL POSITION (IN. FROM FULL LT)
RT
LT
LONG. CONTROL POSITION (IN. FROM FULL FWD)
AFT
FWD
30 20 10 0 10 20 30
LT
ANGLE OF SIDESLIP (DEGREES)
RT

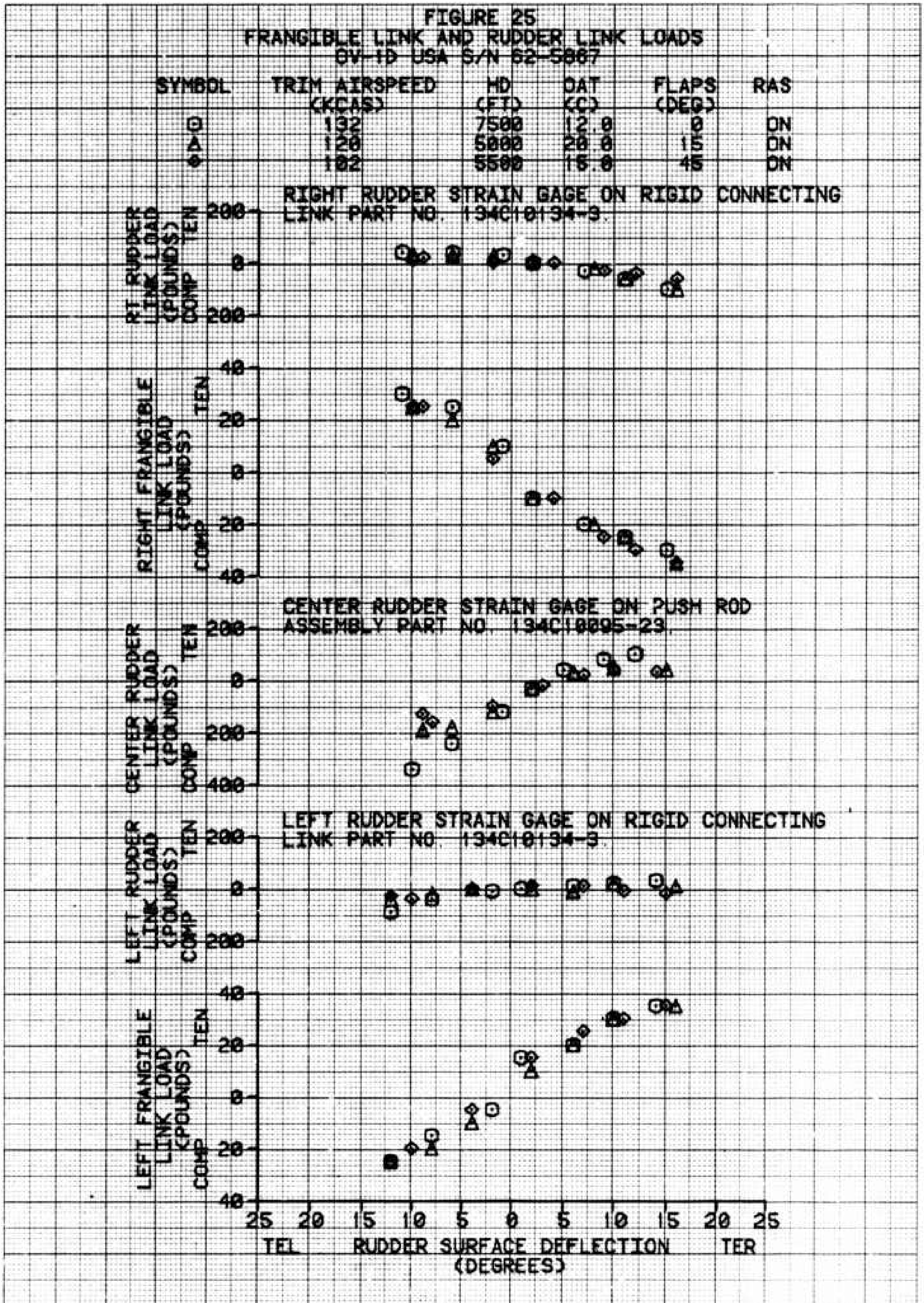


FIGURE 25
FRANGIBLE LINK AND RUDDER LINK LOADS
OV-1D USA S/N 62-5867
SYMBOL
TRIM AIRSPEED (KCAS)
HD (FT)
OAT (C)
FLAPS (DEG)
RAS
132 7500 12.0 0 ON
120 5000 20.0 15 ON
102 5500 15.0 45 ON
RIGHT RUDDER STRAIN GAGE ON RIGID CONNECTING LINK PART NO. 134C10134-3.
RT RUDDER LINK LOAD (POUNDS) COMP TEN
RIGHT FRANGIBLE LINK LOAD (POUNDS) COMP TEN
CENTER RUDDER STRAIN GAGE ON PUSH ROD ASSEMBLY PART NO. 134C10095-23.
CENTER RUDDER LINK LOAD (POUNDS) COMP TEN
LEFT RUDDER STRAIN GAGE ON RIGID CONNECTING LINK PART NO. 134C10134-3.
LEFT RUDDER LINK LOAD (POUNDS) COMP TEN
LEFT FRANGIBLE LINK LOAD (POUNDS) COMP TEN
200
0
200
40
20
0
20
40
200
0
200
400
200
0
200
40
20
0
20
40
25 20 15 10 5 0 5 10 15 20 25
TEL
RUDDER SURFACE DEFLECTION (DEGREES)
TER

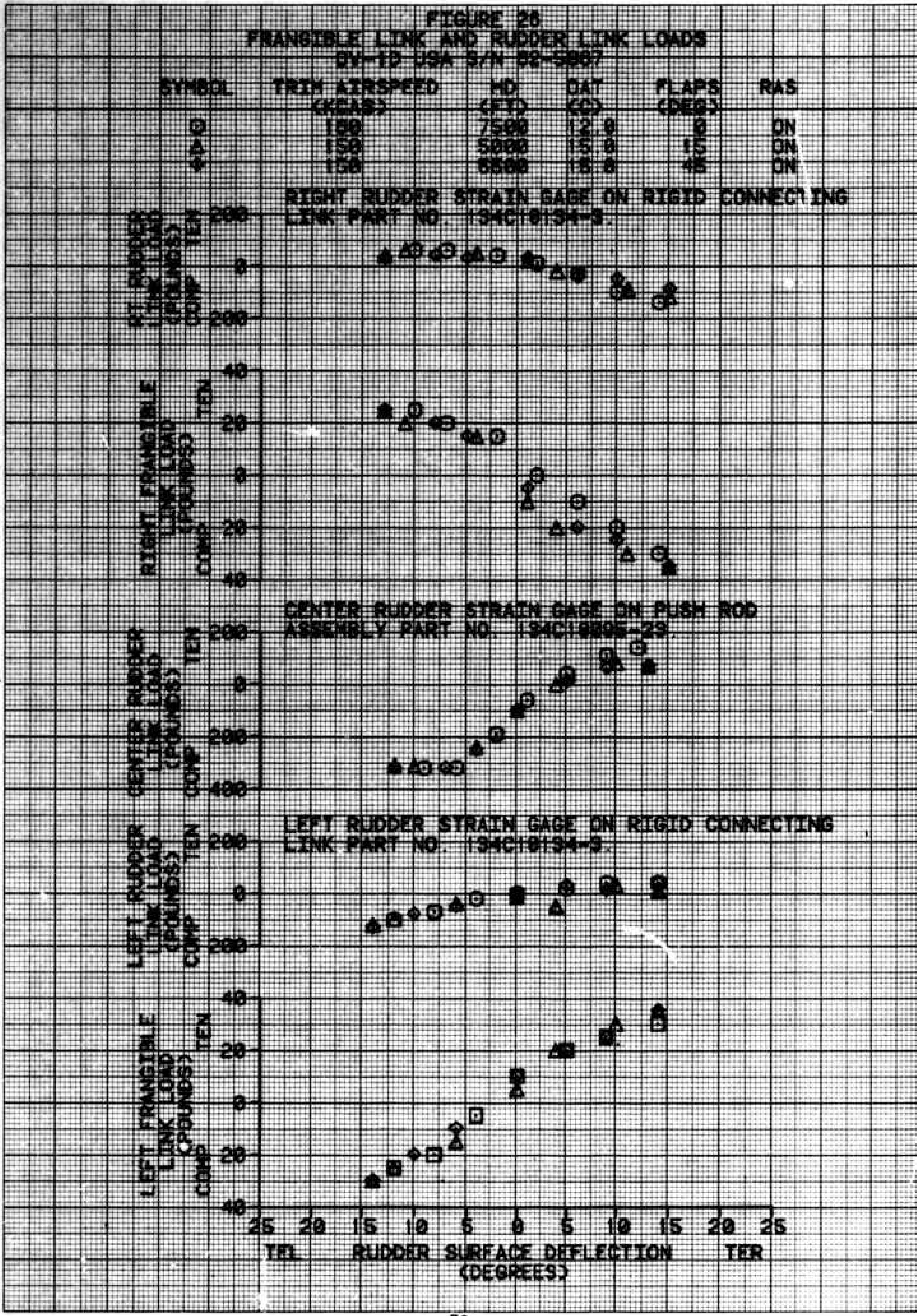


FIGURE 26
FRANGIBLE LINK AND RUDDER LINK LOADS
OV-1D USA S/N 62-5867
SYMBOL TRIM AIRSPEED (KCAS) HD (FT) OAT (C) FLAPS (DEG) RAS
○ 180 7500 12.0 0 ON
△ 150 5000 15.0 15 ON
◇ 150 6500 15.0 45 ON
RIGHT RUDDER STRAIN GAGE ON RIGID CONNECTING LINK PART NO. 134C10134-3.
RT. RUDDER LINK LOAD (POUNDS)
COMP TEN
200
0
200
RIGHT FRANGIBLE LINK LOAD (POUNDS)
COMP TEN
40
20
0
20
40
CENTER RUDDER STRAIN GAGE ON PUSH ROD ASSEMBLY PART NO. 134C10095-29.
CENTER RUDDER LINK LOAD (POUNDS)
COMP TEN
200
0
200
400
LEFT RUDDER STRAIN GAGE ON RIGID CONNECTING LINK PART NO. 134C10134-3.
LEFT RUDDER LINK LOAD (POUNDS)
COMP TEN
200
0
200
LEFT FRANGIBLE LINK LOAD (POUNDS)
COMP TEN
40
20
0
20
40
25 20 15 10 5 0 5 10 15 20 25
TEL RUDDER SURFACE DEFLECTION TER
(DEGREES)

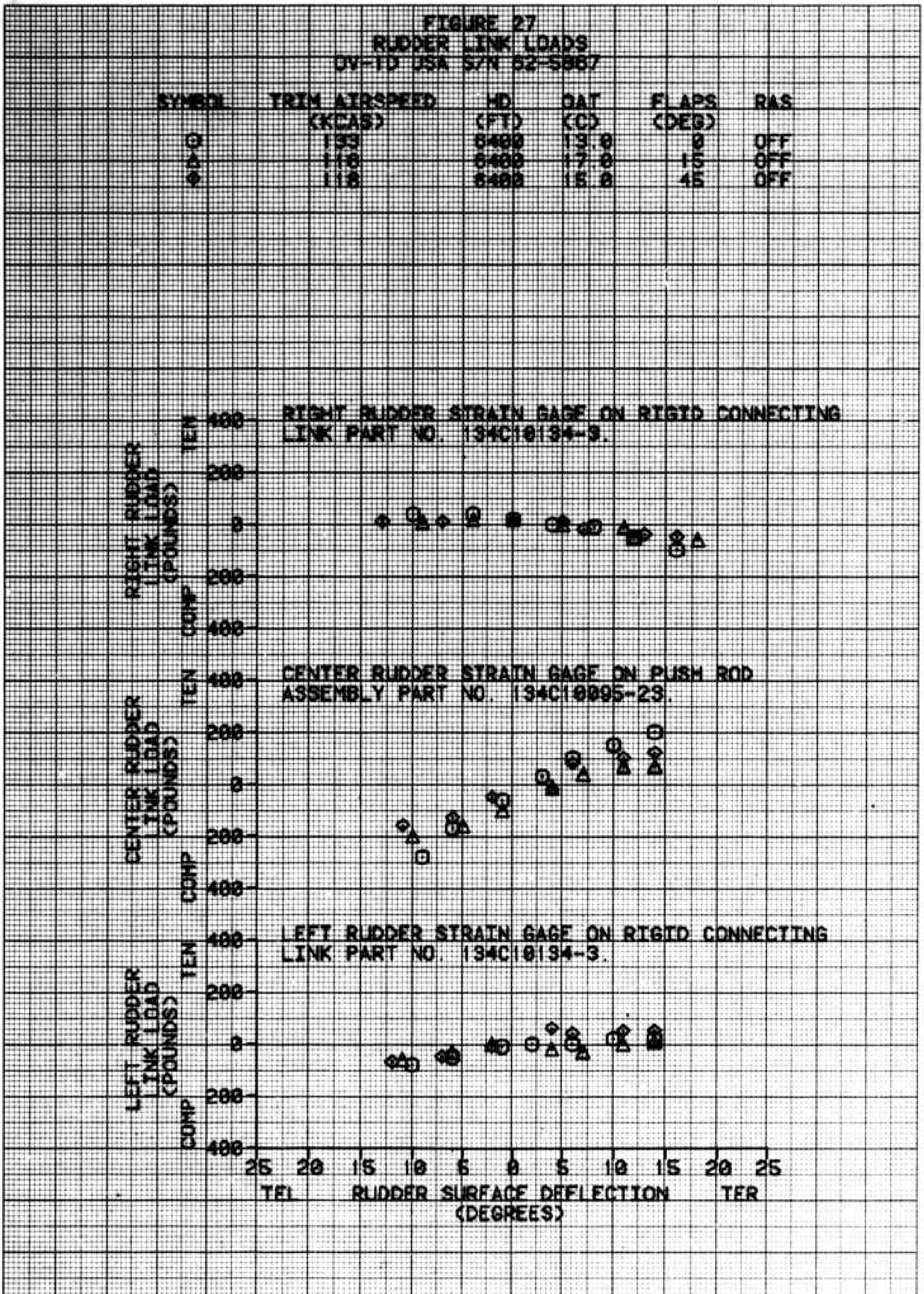


FIGURE 27
RUDDER LINK LOADS
OV-1D USA S/N 62-5867
SYMBOL
TRIM AIRSPEED (KCAS)
HD (FT)
OAT (C)
FLAPS (DEG)
RAS
○ 133 6400 13.0 0 OFF
△ 118 6400 17.0 15 OFF
◇ 118 6400 15.0 45 OFF
RIGHT RUDDER STRAIN GAGE ON RIGID CONNECTING LINK PART NO. 134C10134-3.
RIGHT RUDDER LINK LOAD (POUNDS)
CENTER RUDDER STRAIN GAGE ON PUSH ROD ASSEMBLY PART NO. 134C10095-23.
CENTER RUDDER LINK LOAD (POUNDS)
LEFT RUDDER STRAIN GAGE ON RIGID CONNECTING LINK PART NO. 134C10134-3.
LEFT RUDDER LINK LOAD (POUNDS)
TEN
COMP
400
200
0
200
400
25 20 15 10 5 0 5 10 15 20 25
TEL
RUDDER SURFACE DEFLECTION (DEGREES)
TER

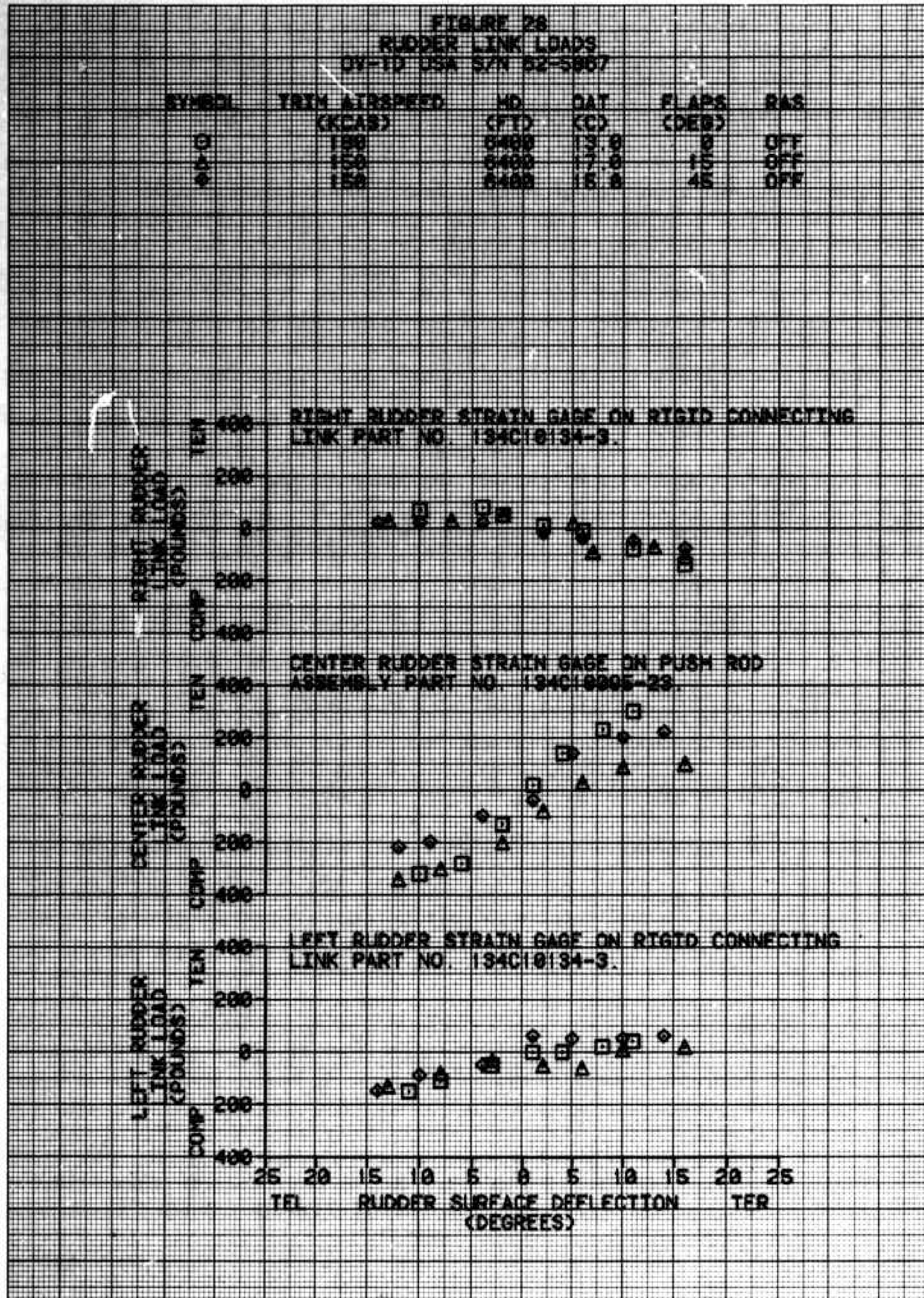


FIGURE 28
RUDDER LINK LOADS
OV-1D USA S/N 62-5867
SYMBOL TRIM AIRSPEED (KCAS) HD (FT) OAT (C) FLAPS (DEG) SAS
□ 100 6400 13.0 0 OFF
△ 150 6400 17.0 15 OFF
◇ 150 6400 16.8 45 OFF
RIGHT RUDDER STRAIN GAGE ON RIGID CONNECTING LINK PART NO. 134C10134-3.
RIGHT RUDDER LINK LOAD (POUNDS)
CENTER RUDDER STRAIN GAGE ON PUSH ROD ASSEMBLY PART NO. 134C10005-23.
CENTER RUDDER LINK LOAD (POUNDS)
LEFT RUDDER STRAIN GAGE ON RIGID CONNECTING LINK PART NO. 134C10134-3.
LEFT RUDDER LINK LOAD (POUNDS)
TEN
COMP
400
200
0
200
400
25 20 15 10 5 0 5 10 15 20 25
TEL
RUDDER SURFACE DEFLECTION (DEGREES)
TER

FIGURE 29
DYNAMIC LONGITUDINAL STABILITY (PHUGOID)
OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)
128	14,300	160.4(MID)	5500	20.0	1650	0

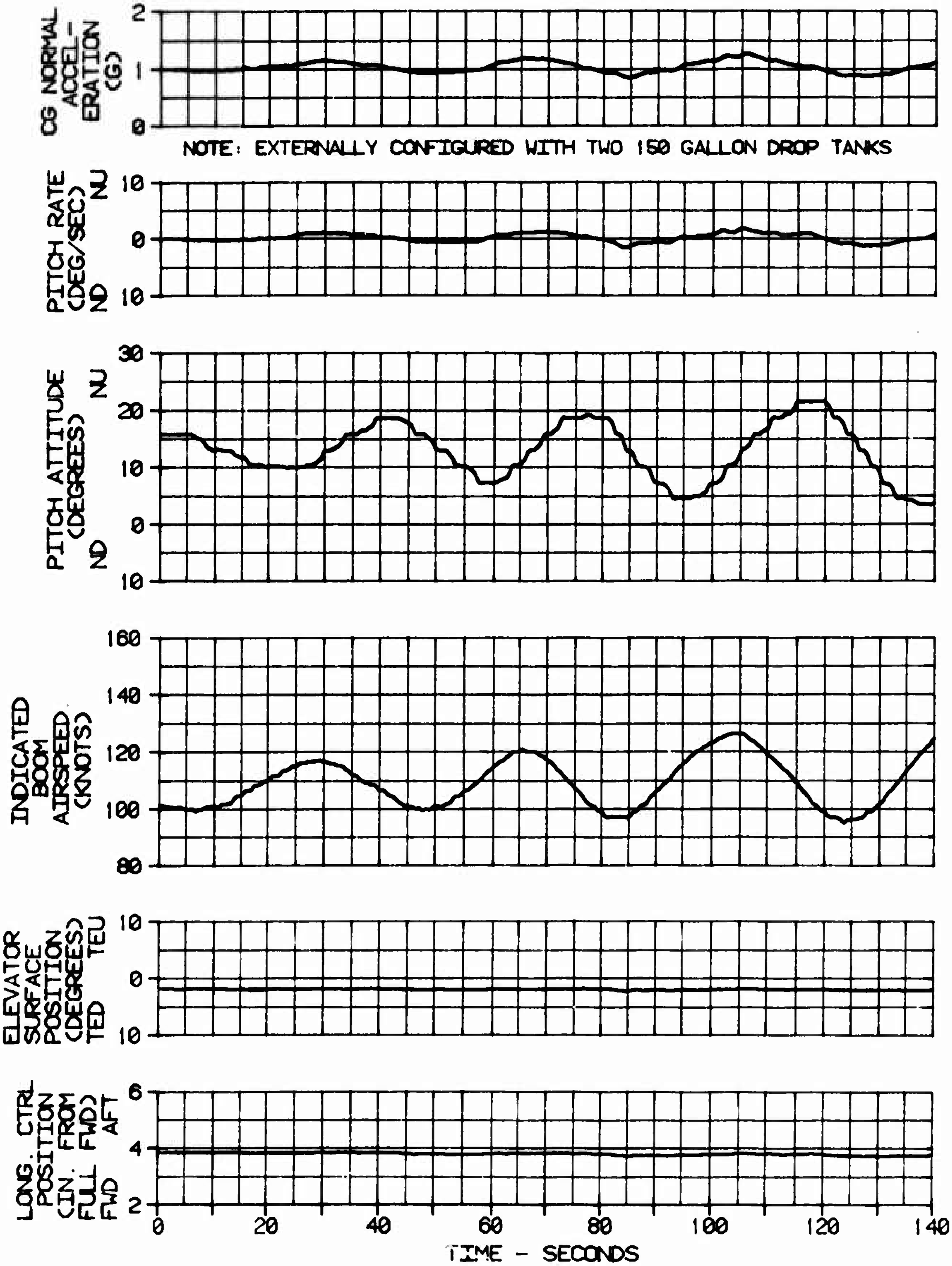


FIGURE 30
DYNAMIC LONGITUDINAL STABILITY (PHUGOID)
OV-1D USA S/N 62-5887

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)
128	16,900	159.4(MID)	5800	7.0	1650	15

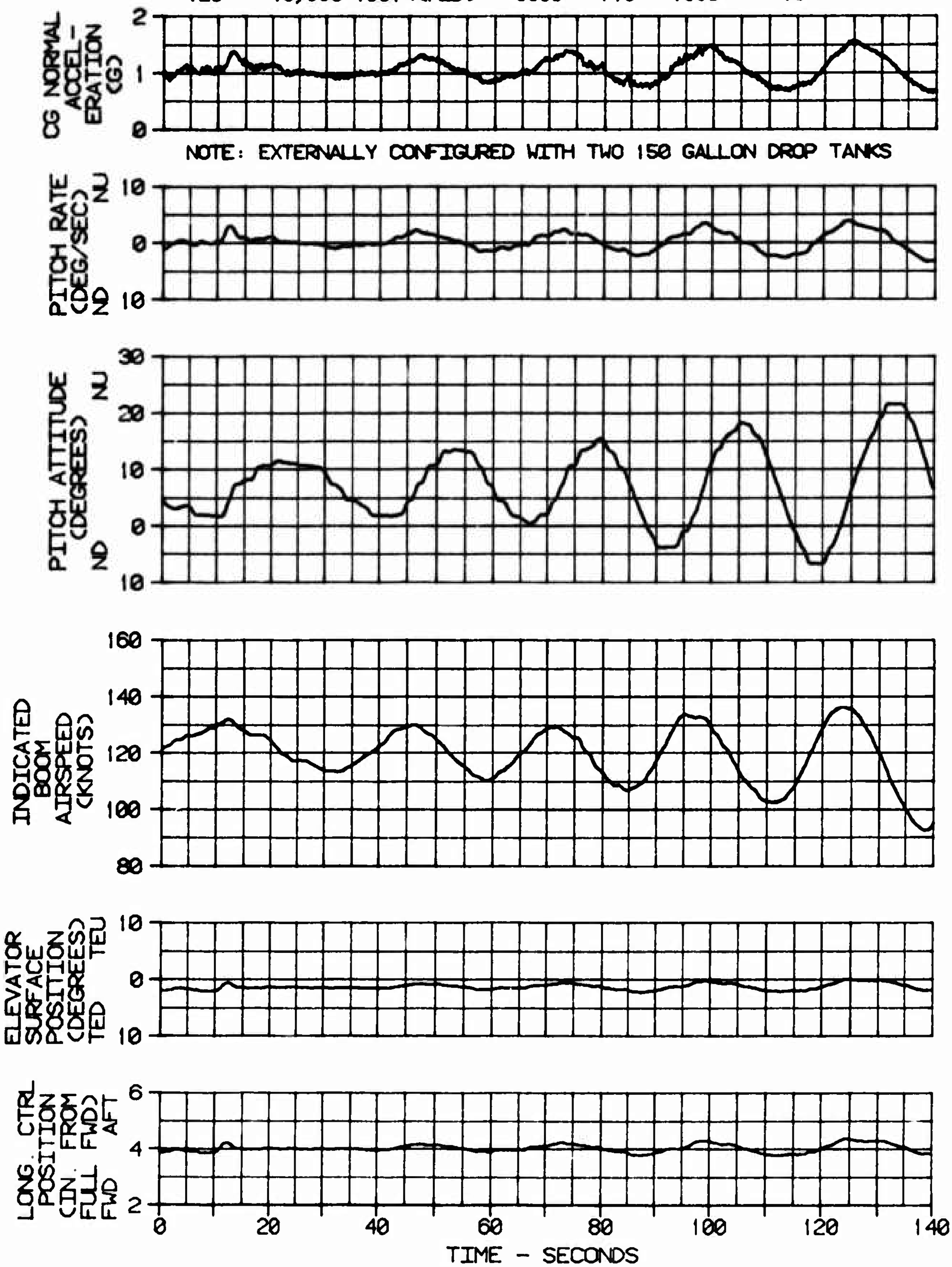


FIGURE 31

DYNAMIC LONGITUDINAL STABILITY (SHORT PERIOD)

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)
128	14,300	160.4(MID)	5500	20.0	1650	0

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

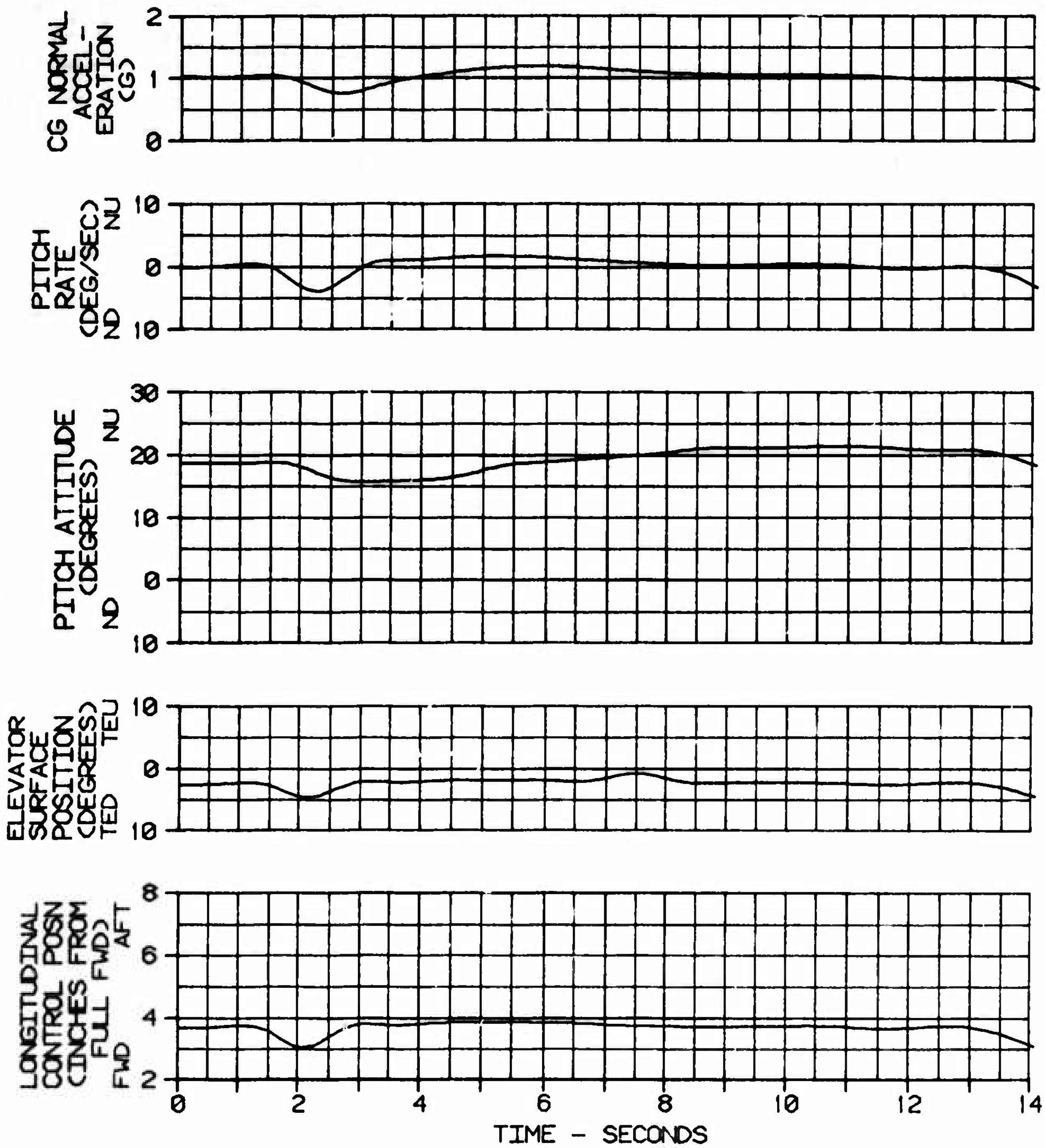


FIGURE 32

DYNAMIC LONGITUDINAL STABILITY (SHORT PERIOD)

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)
128	16,900	159.4(MID)	5600	7.0	1650	15

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

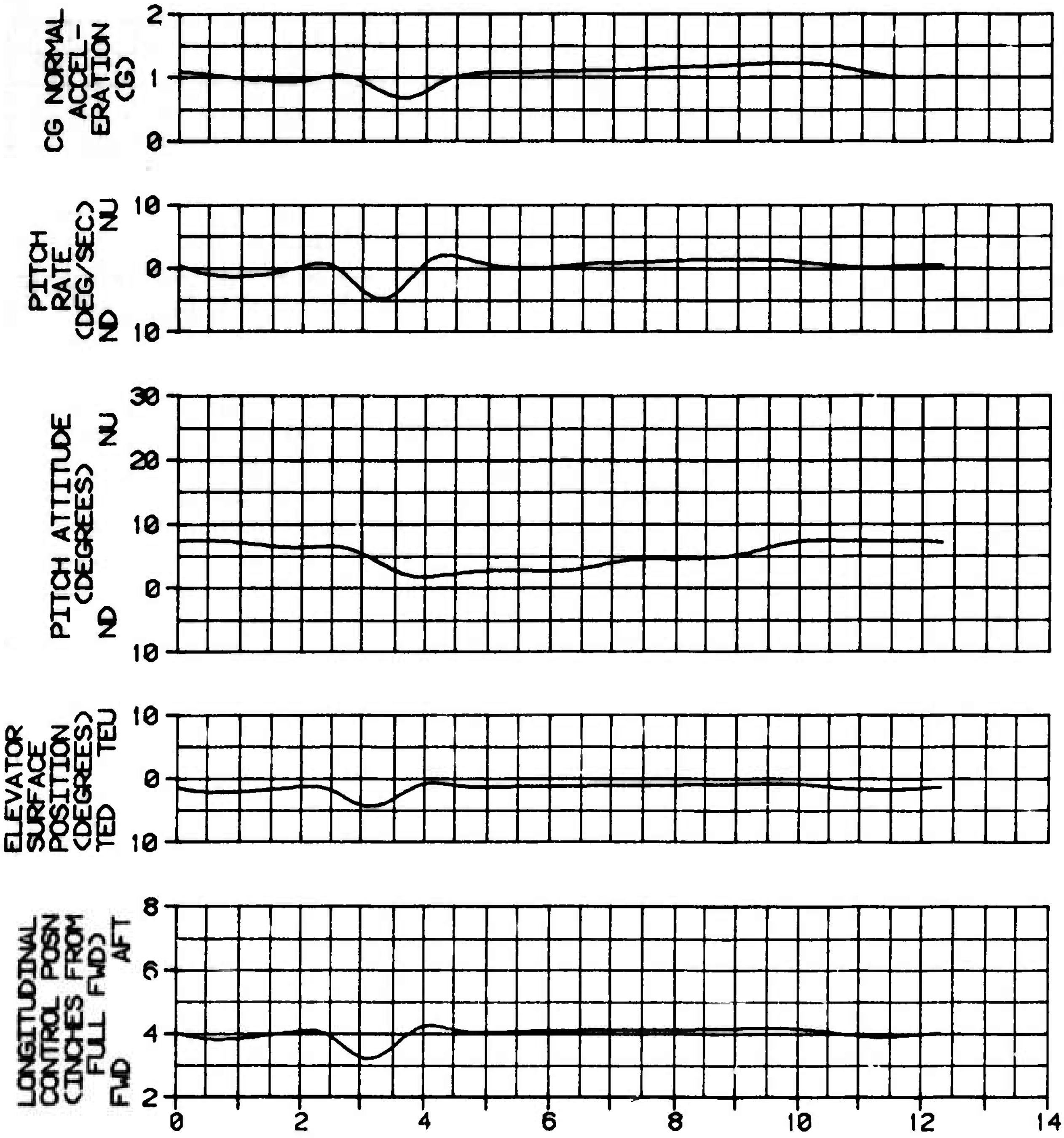


FIGURE 33

AIRCRAFT RESPONSE FOLLOWING RELEASE FROM SIDESLIP

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
180	14,700	160.8(MID)	6300	13.0	1650	0	ON

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

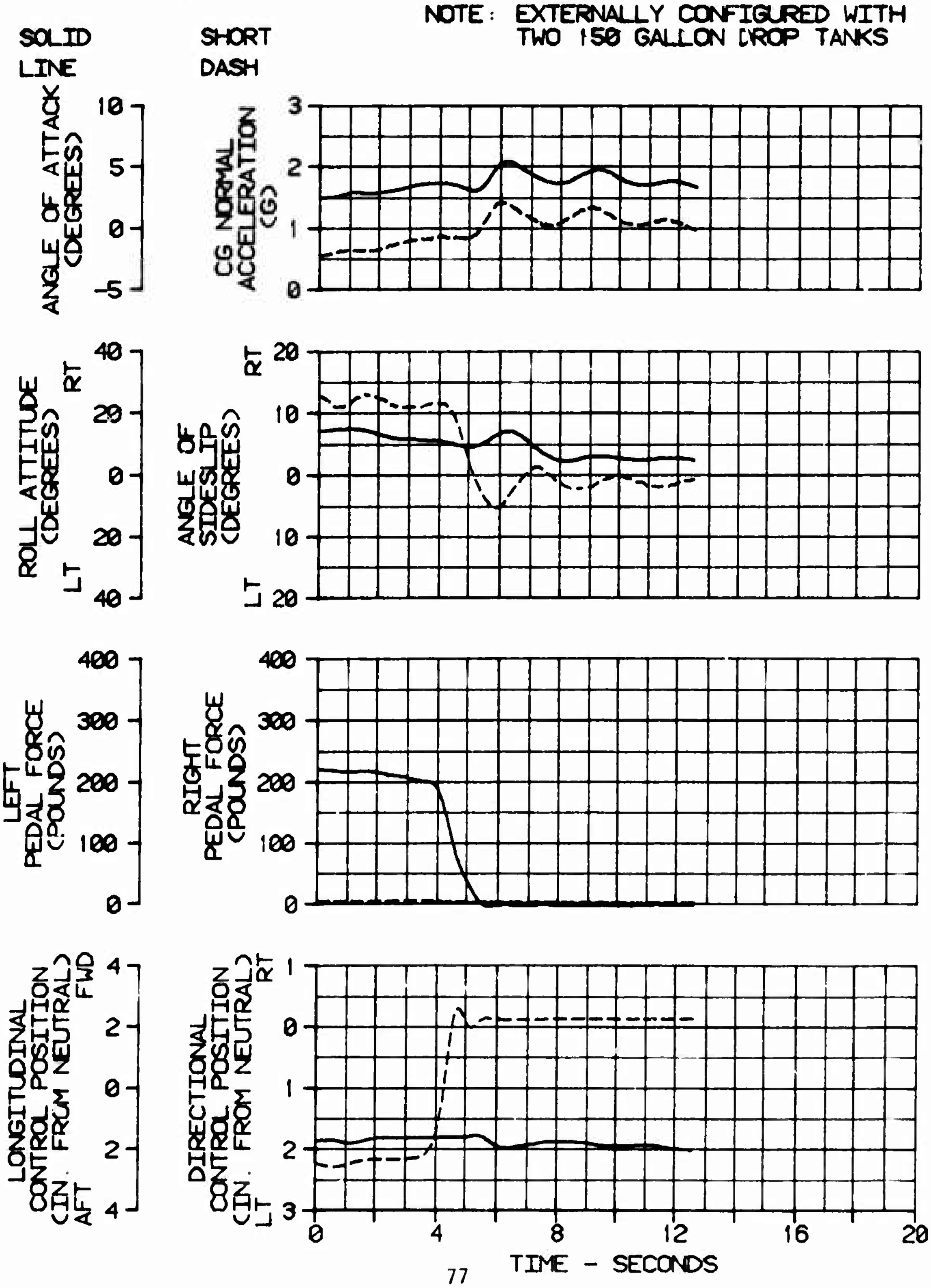


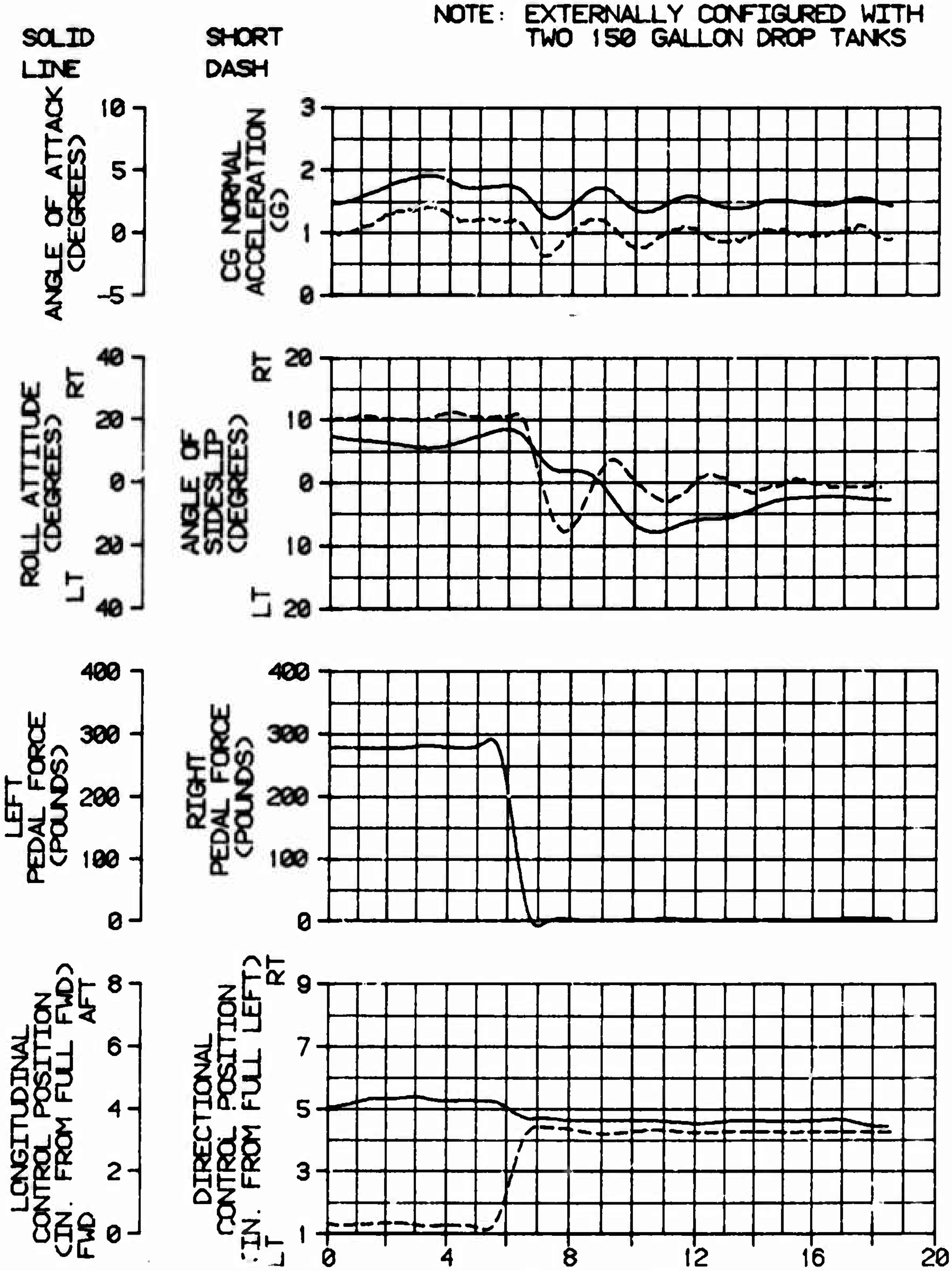
FIGURE 34

AIRCRAFT RESPONSE FOLLOWING RELEASE FROM SIDESLIP

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
180	17,200	161.3(MID)	6300	16.0	1650	0	REMOVED

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS



78 TIME - SECONDS

FIGURE 35

AIRCRAFT RESPONSE FOLLOWING RELEASE FROM SIDESLIP

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
150	14,700	160.8(MID)	6300	13.0	1650	15	ON

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

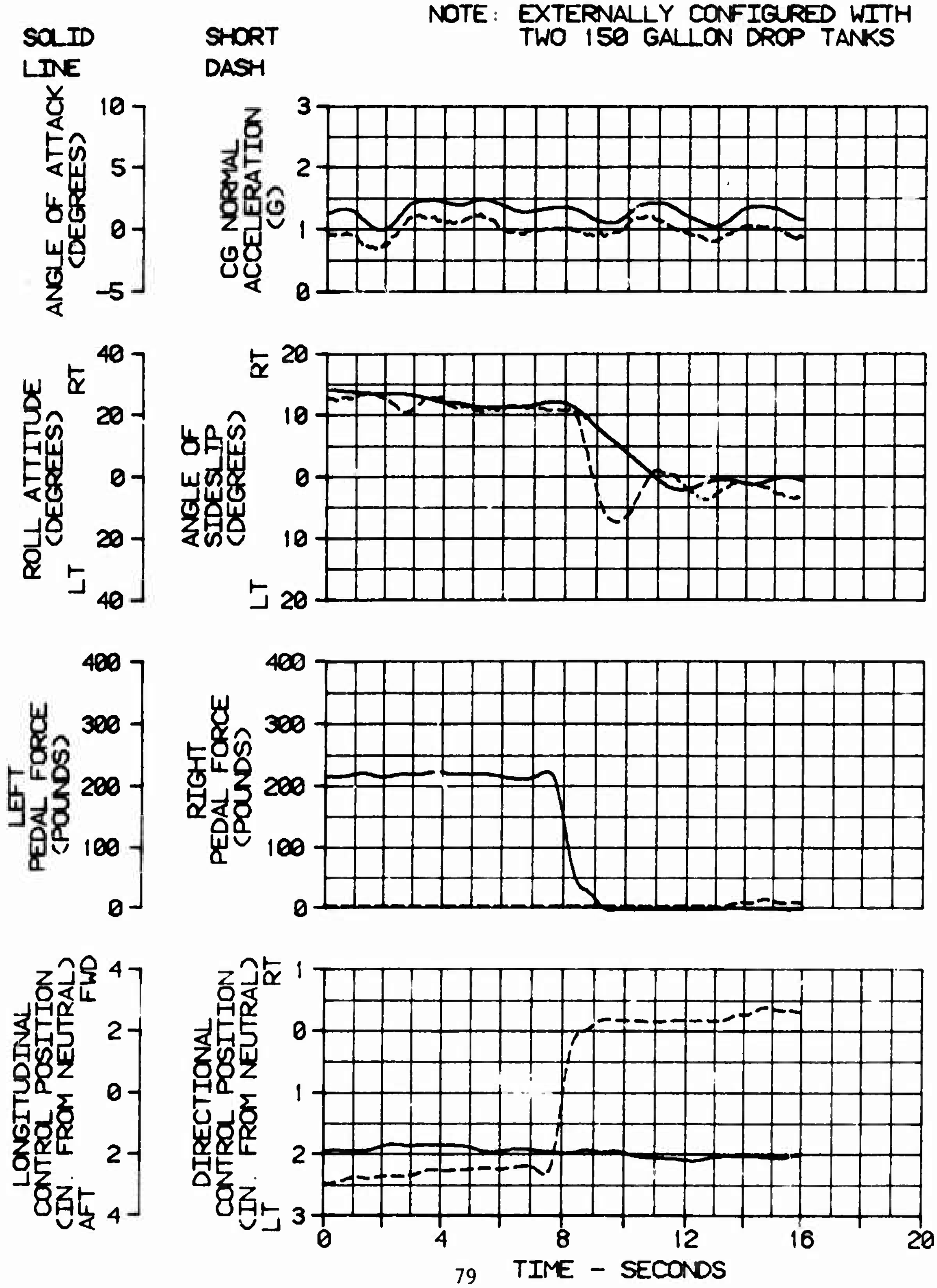


FIGURE 36

AIRCRAFT RESPONSE FOLLOWING RELEASE FROM SIDESLIP

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
150	16,700	161.3(MID)	6300	16.0	1650	15	REMOVED

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

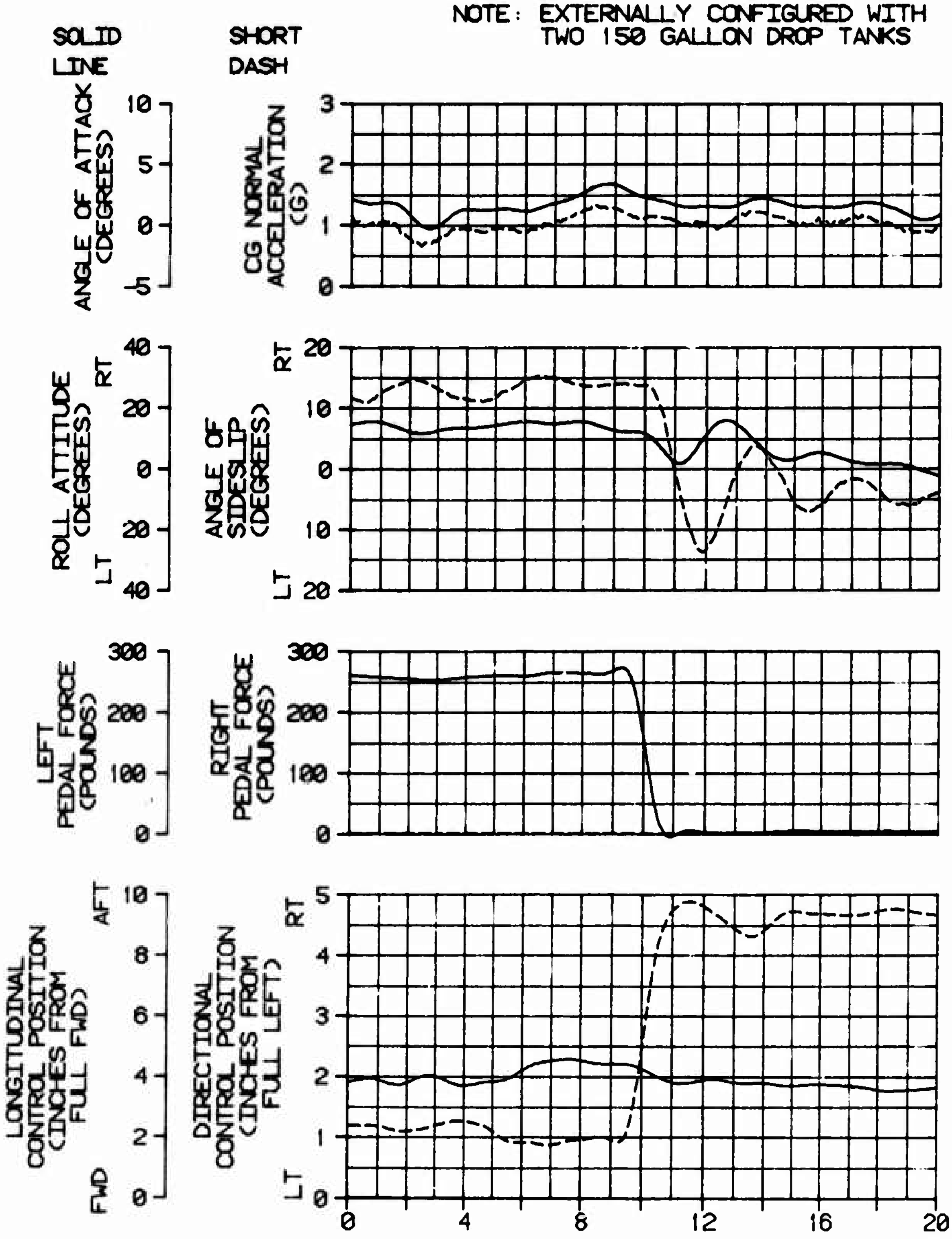


FIGURE 37

AIRCRAFT RESPONSE FOLLOWING RELEASE FROM SIDESLIP

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
150	14,700	160.8(MID)	6300	13.0	1650	45	ON

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

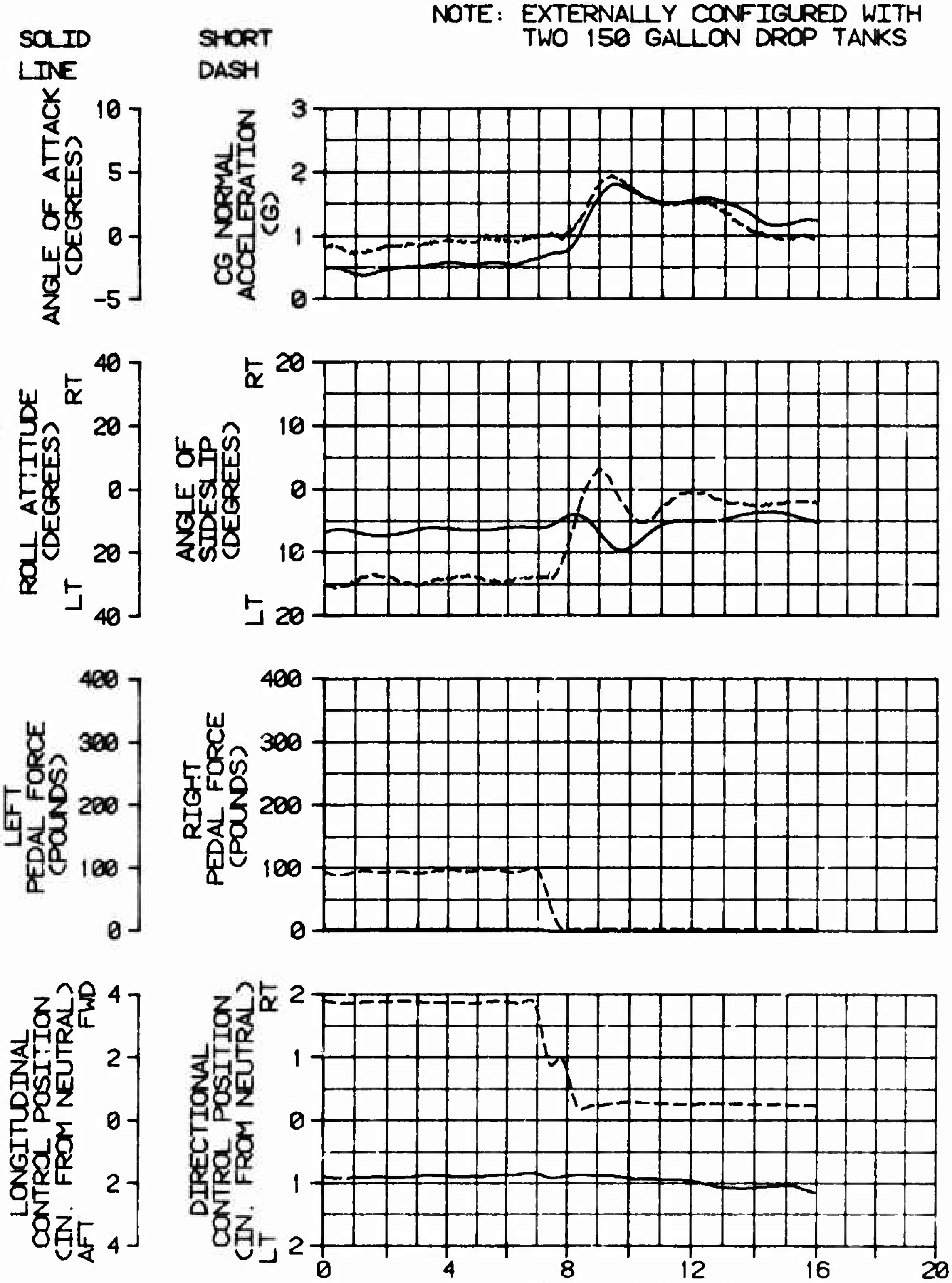


FIGURE 38

AIRCRAFT RESPONSE FOLLOWING RELEASE FROM SIDESLIP

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
150	16,200	161.1(MID)	6300	18.0	1650	45	REMOVED

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

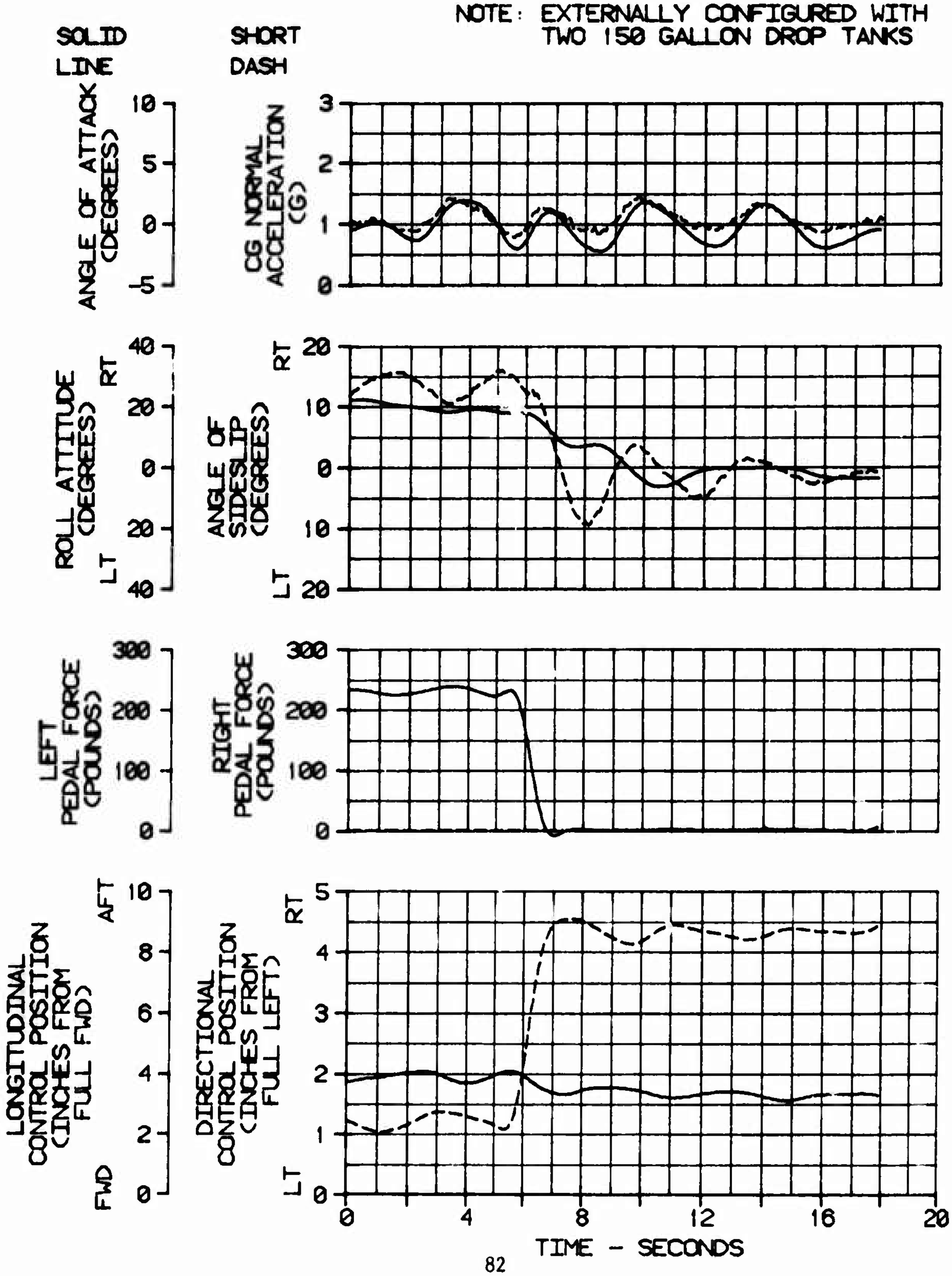


FIGURE 39

DIRECTIONAL DOUBLET

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
160	14,700	160.8(MID)	6300	13.0	1650	0	ON

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

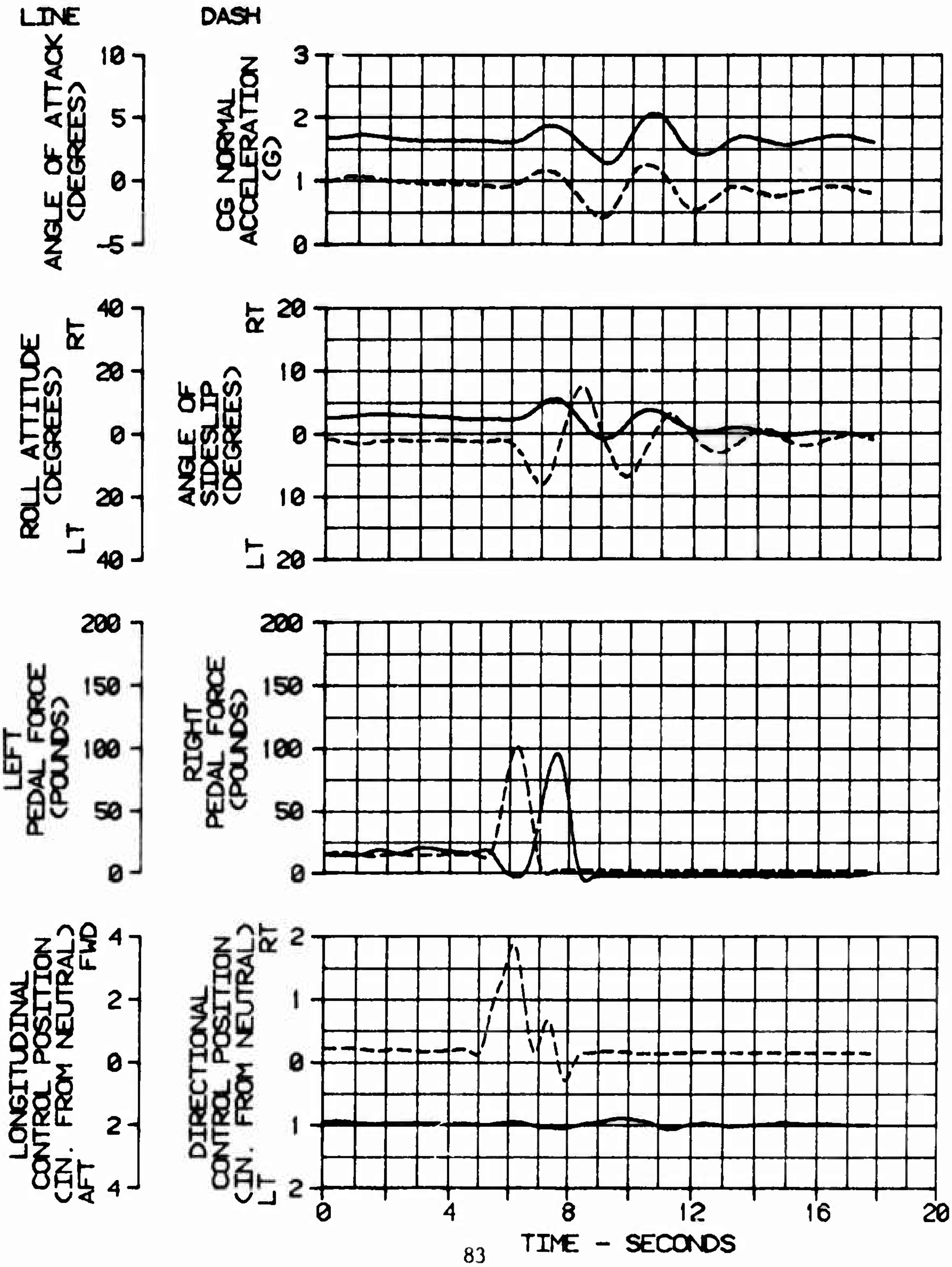


FIGURE 40

DIRECTIONAL DOUBLET

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
150	14,700	160.8(MID)	6300	13.0	1650	45	ON

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

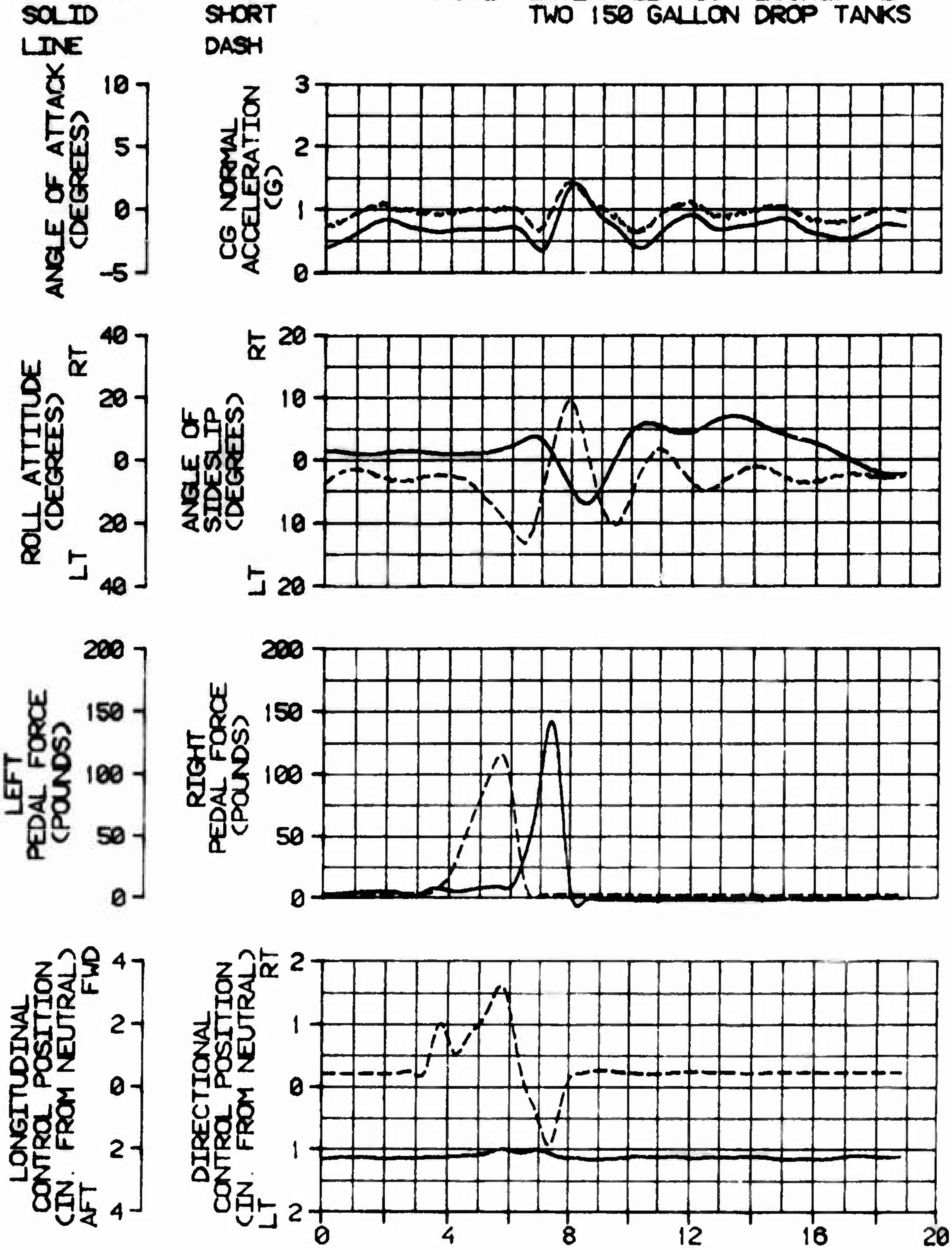


FIGURE 41

DYNAMIC SINGLE ENGINE MINIMUM CONTROL AIRSPEED (Vmc)

OV-1D USA S/N 62-5867

AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
17,000	159.4(MID)	5000	7.0	1650	0	REMOVED

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS AND SLAR

SOLID LINE SHORT DASH

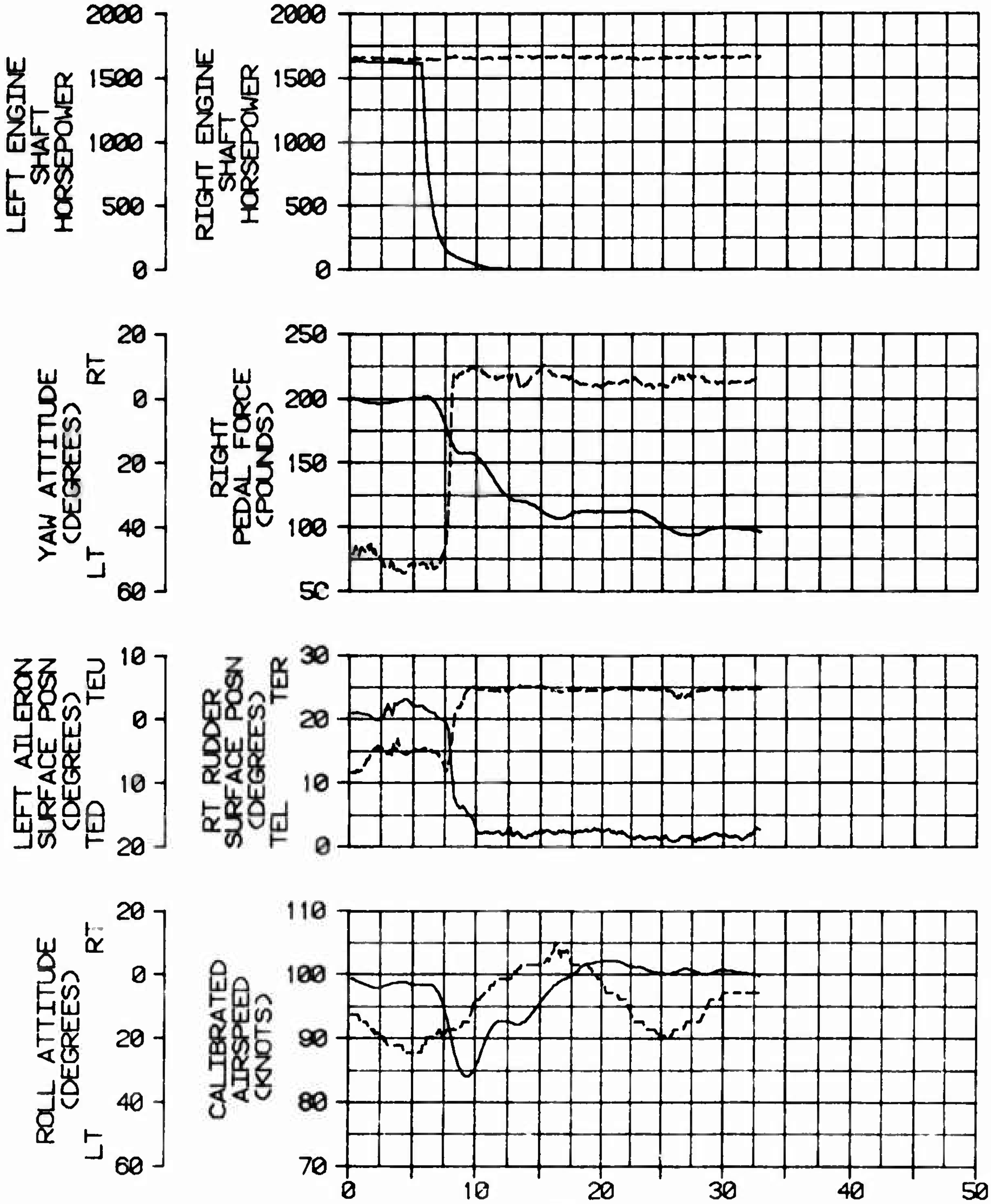


FIGURE 42

DYNAMIC SINGLE ENGINE MINIMUM CONTROL AIRSPEED (Vmc)

OV-1D USA S/N 62-5867

AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
16,900	159.4(MID)	5600	7.0	1650	15	REMOVED

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS AND SLAR

SOLID LINE

SHORT DASH

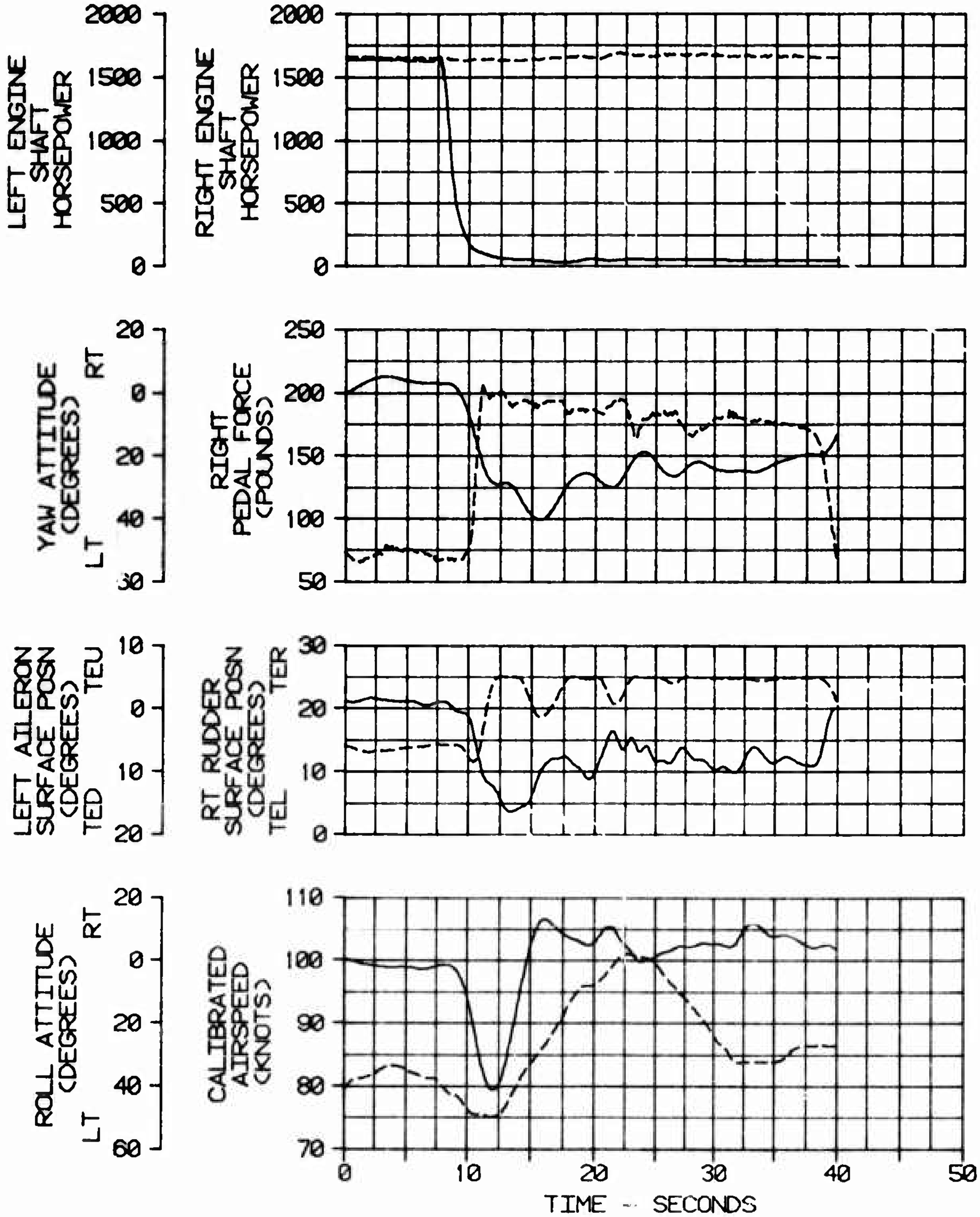


FIGURE 43
PEDAL FORCE VS. ENGINE SHAFT HORSEPOWER
AT SINGLE-ENGINE MINIMUM CONTROL AIRSPEED

OV-1D USA S/N 62-5887

AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)
18,200	161.0 (MID)	5800	8.0	1650

NOTES: 1. LEFT ENGINE SHUTDOWN AND PROPELLER FEATHERED.
2. SHADED SYMBOLS DENOTE RUDDER AUGMENTATION SYSTEM (RAS) INSTALLED AND OPERATING.
3. OPEN SYMBOLS DENOTE RAS REMOVED.

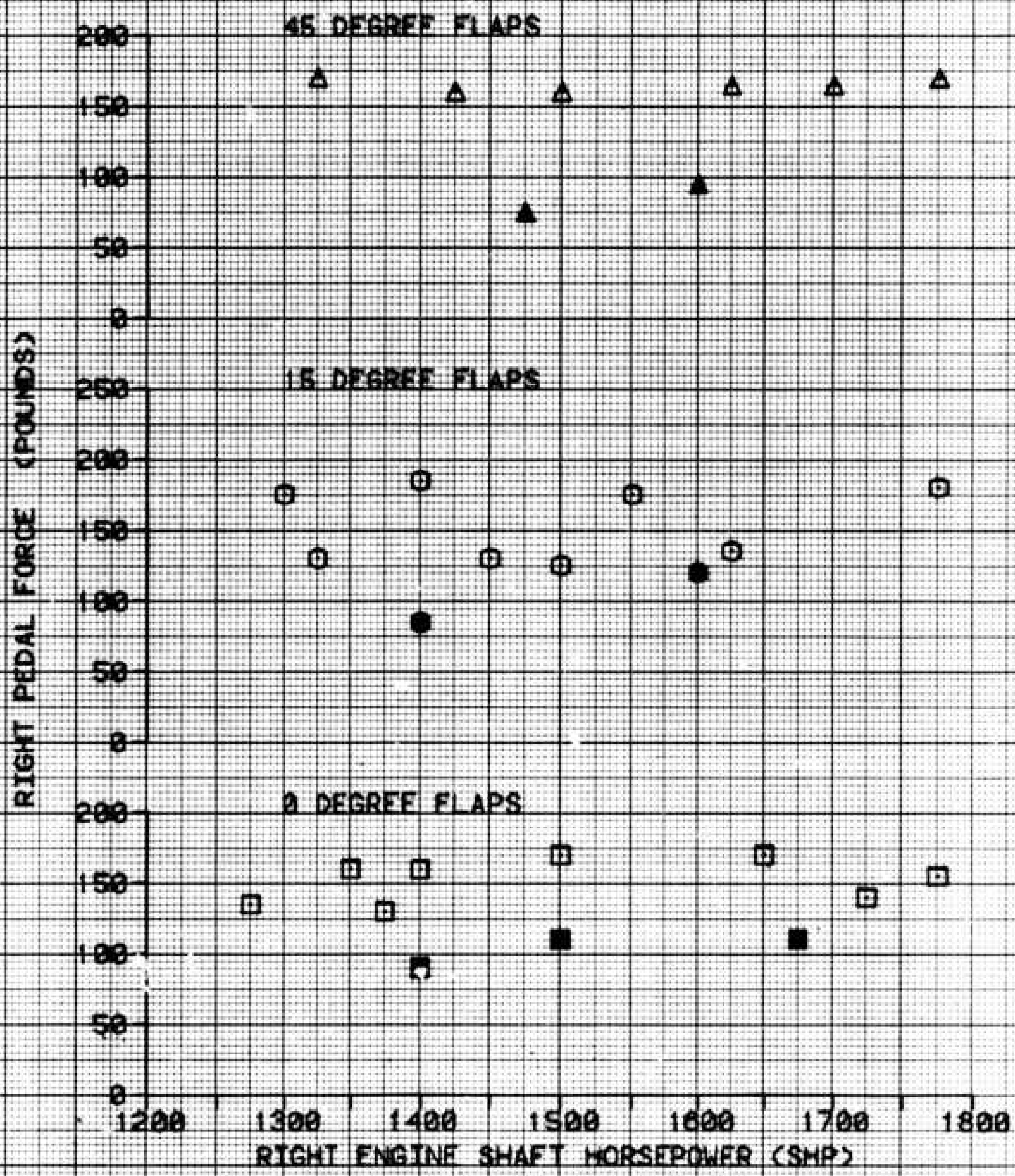


FIGURE 44

HIGH SPEED ENGINE FAILURE

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMEN-TATION
290	15,300	160.7(MID)	6000	22.0	1650	0	REMOVED

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

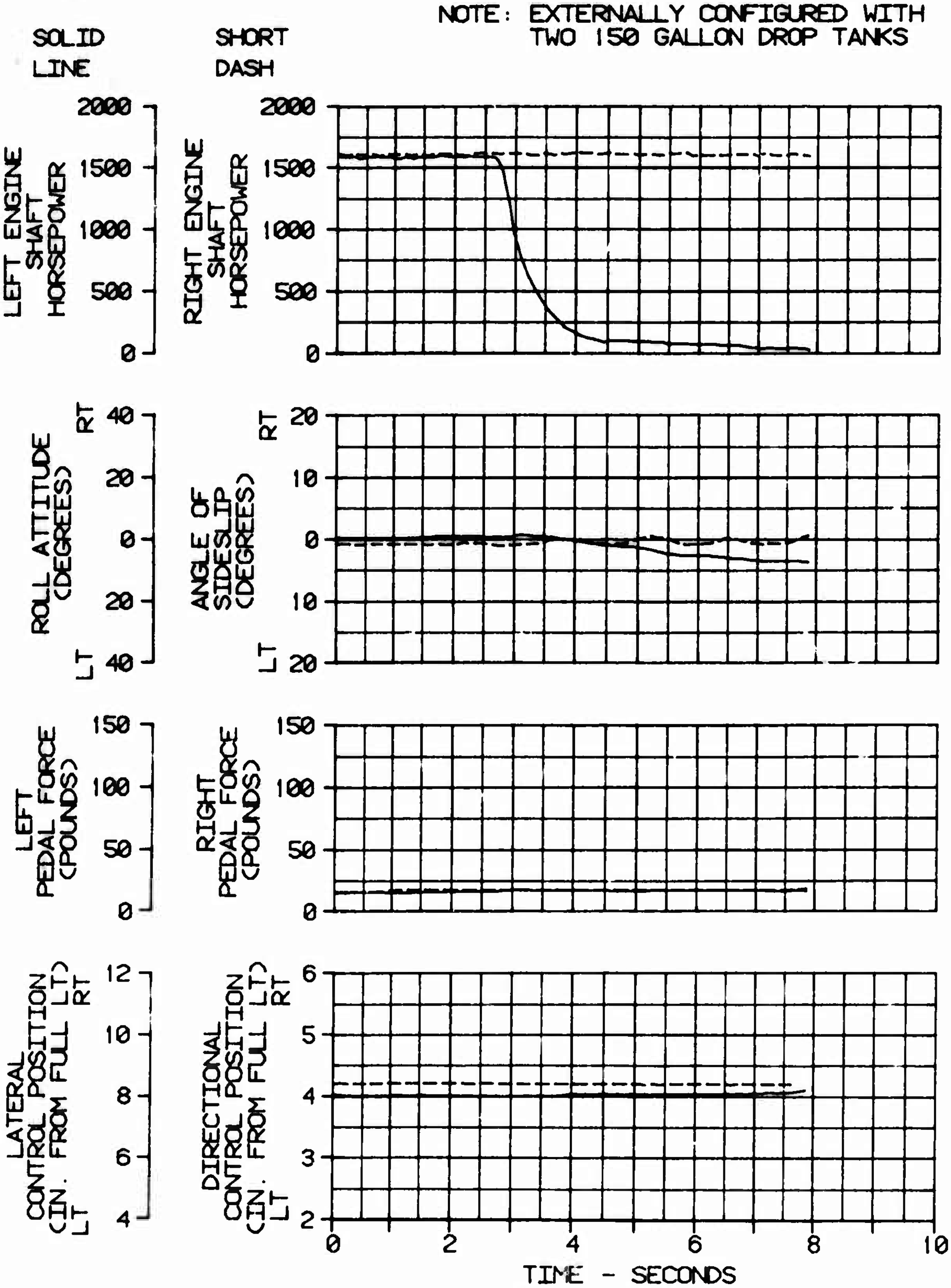


FIGURE 45

ENGINE RESPONSE TO THROTTLE TRANSIENT

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	FLAPS (DEG)	RUDDER AUGMENTATION
133	17,600	161.4(MID)	14,000	-1.0	1650	45	REMOVED

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

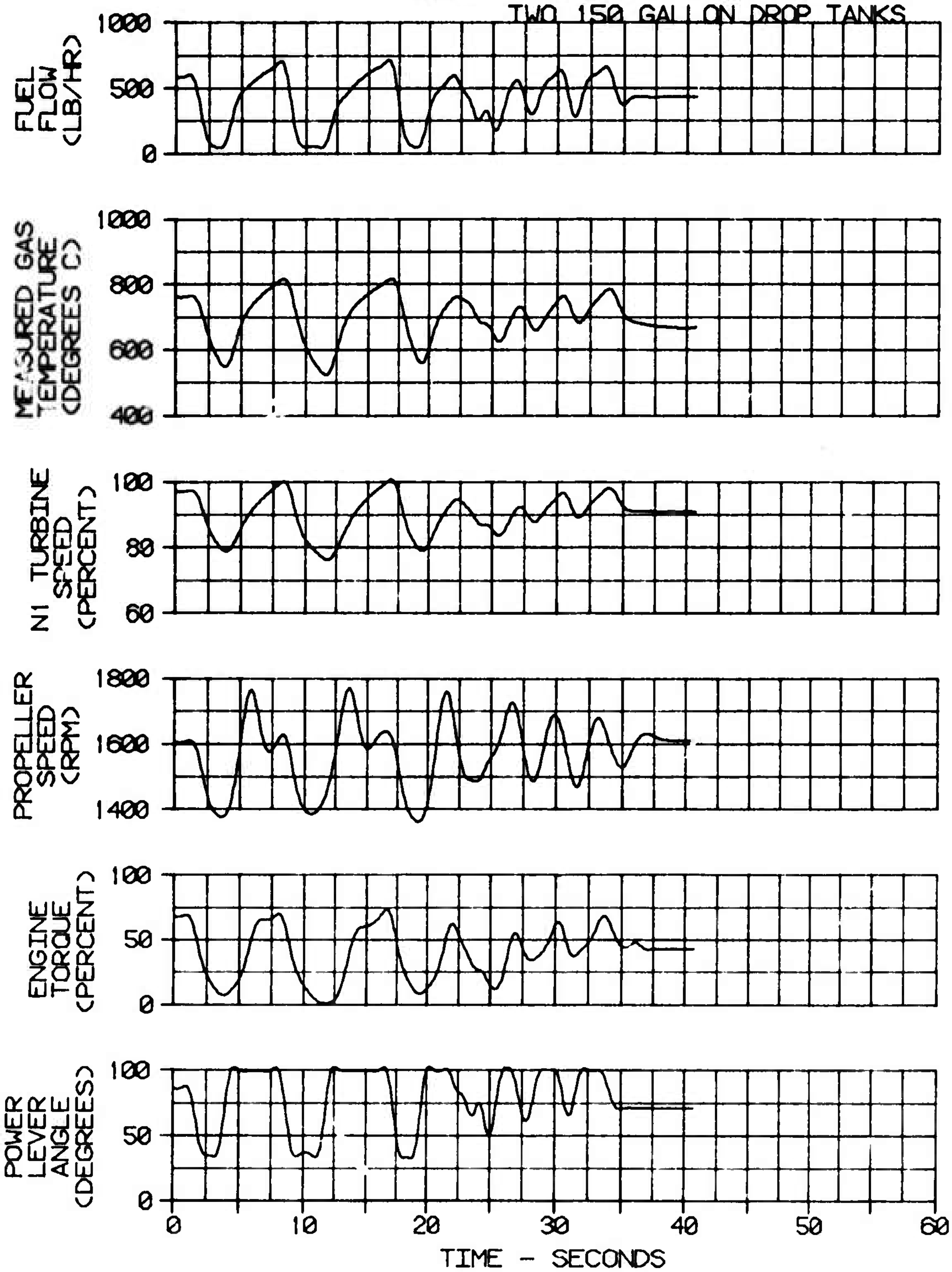


FIGURE 46

GO-AROUND MANEUVER

OV-1D USA S/N 62-5867

TRIM AIRSPEED (KCAS)	AVG GROSS WEIGHT (LB)	AVG LONG. CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (C)	AVG PROPELLER SPEED (RPM)	RUDDER AUGMENTATION
104	16,900	159.5(MID)	3000	9.0	1650	REMOVED

NOTE: EXTERNALLY CONFIGURED WITH TWO 150 GALLON DROP TANKS

SOLID LINE SHORT DASH

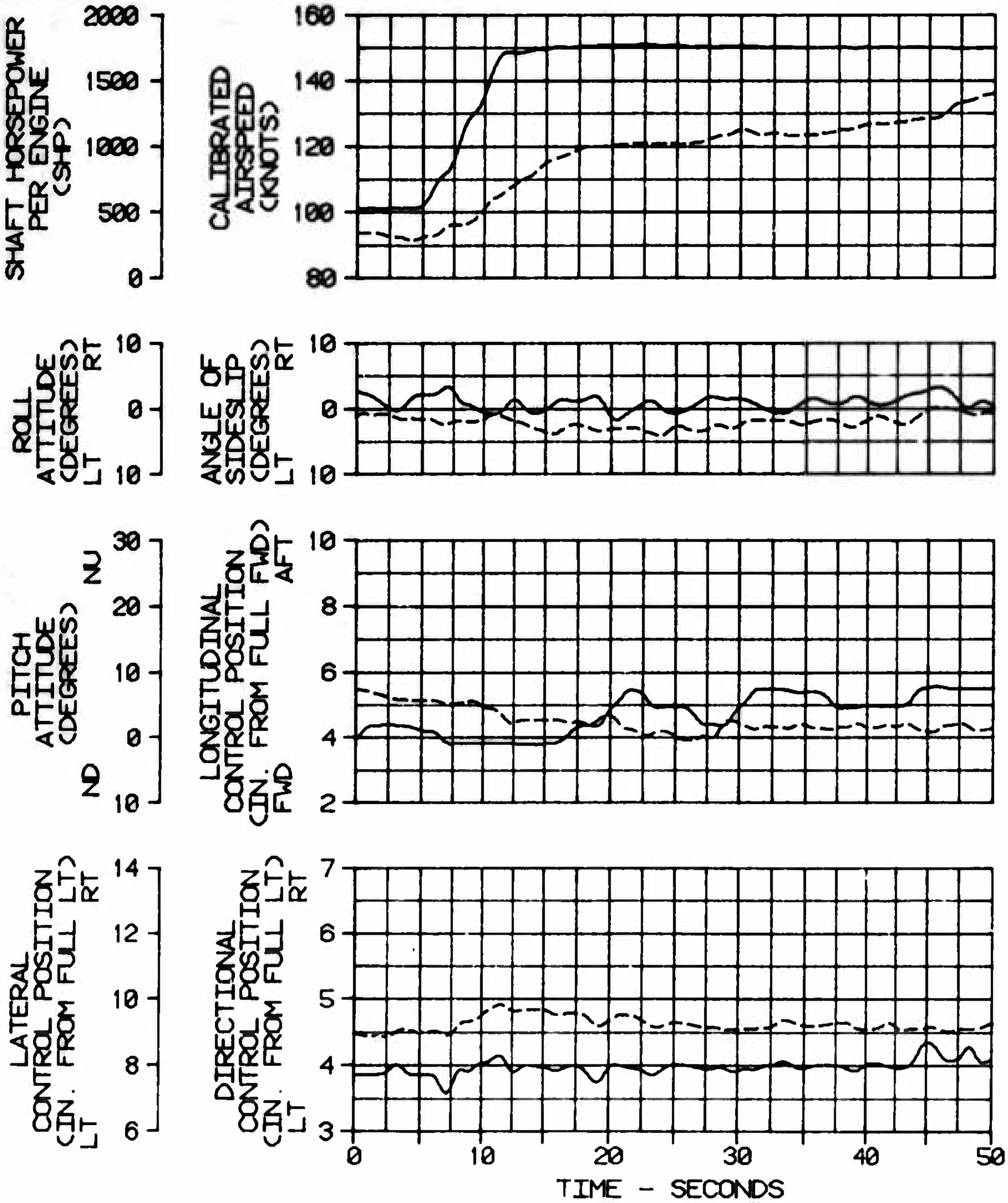


FIGURE 47
SHAFT HORSEPOWER AVAILABLE
OV-1D
MILITARY RATED POWER
ENGINE SPEED 6482 RPM (1678 PROPELLER RPM)

NOTES: 1. POWER AVAILIBLE OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAMS T53-L-703 ENGINE FILE NO. 19.41.32.05, FEB 1986 FOR YT53-L-704 ENGINE AND T53-L-13B ENGINE FILE NO. 19.28.25.03, JULY 1982 FOR T53-L-701 ENGINE WITH FOLLOWING ASSUMPTIONS:

A. ZERO AIRSPEED.
B. ZERO INLET PRESSURE LOSS.
C. ZERO INLET TEMPERATURE RISE.
D. ZERO EXIT DUCT PRESSURE LOSE.
E. 15 HP EXTRACTION.
F. ZERO BLEED AIR.
G. 0.991 RAM RECOVERY FACTOR.

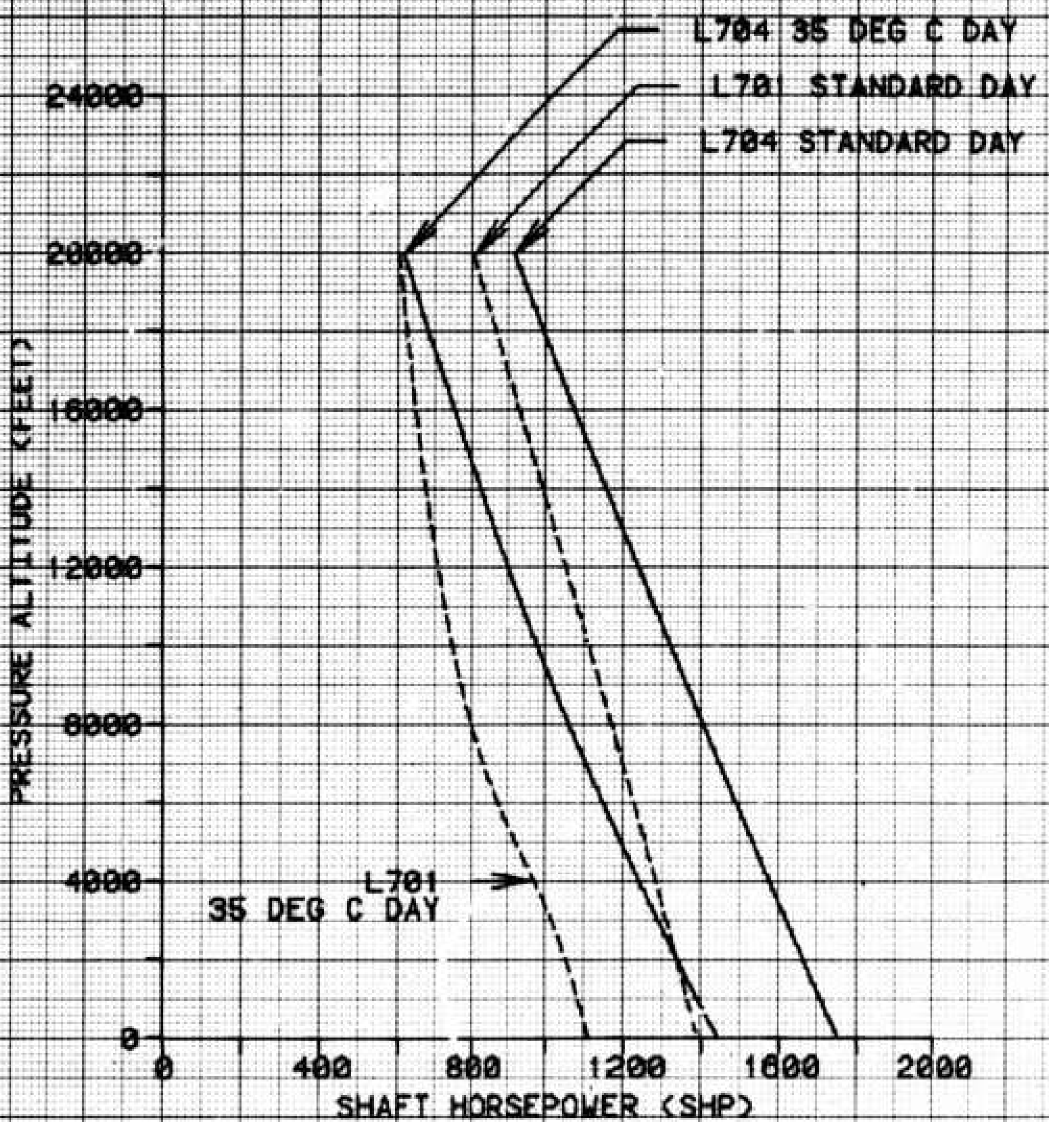
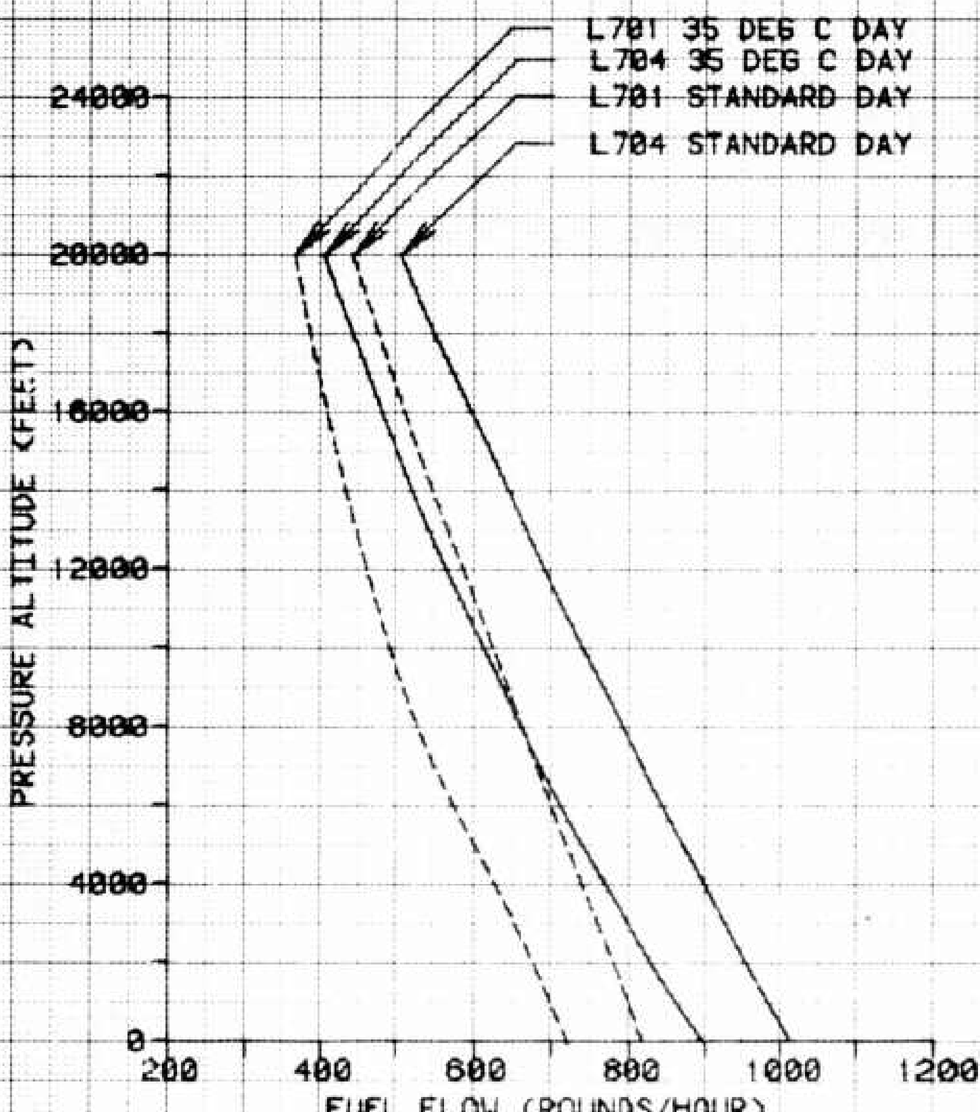


FIGURE 48
FUEL FLOW
OV-1D
MILITARY RATED POWER
ENGINE SPEED 6482 RPM (1878 PROPELLER RPM)

NOTES: 1. FUEL FLOW OBTAINED FROM AVCO LYCOMING COMPUTER PROGRAMS T53-L-703 ENGINE FILE NO. 19.41.32.05, FEB 1986 FOR YT53-L-704 ENGINE AND T53-L-13B ENGINE FILE NO. 19.28.25.03, JULY 1982 FOR T53-L-701 ENGINE WITH FOLLOWING ASSUMPTIONS:

A. ZERO AIRSPEED.
B. ZERO INLET PRESSURE LOSS.
C. ZERO INLET TEMPERATURE RISE.
D. ZERO EXIT DUCT PRESSURE LOSE.
E. 15 HP EXTRACTION.
F. ZERO BLEED AIR.
G. 0.991 RAM RECOVERY FACTOR.



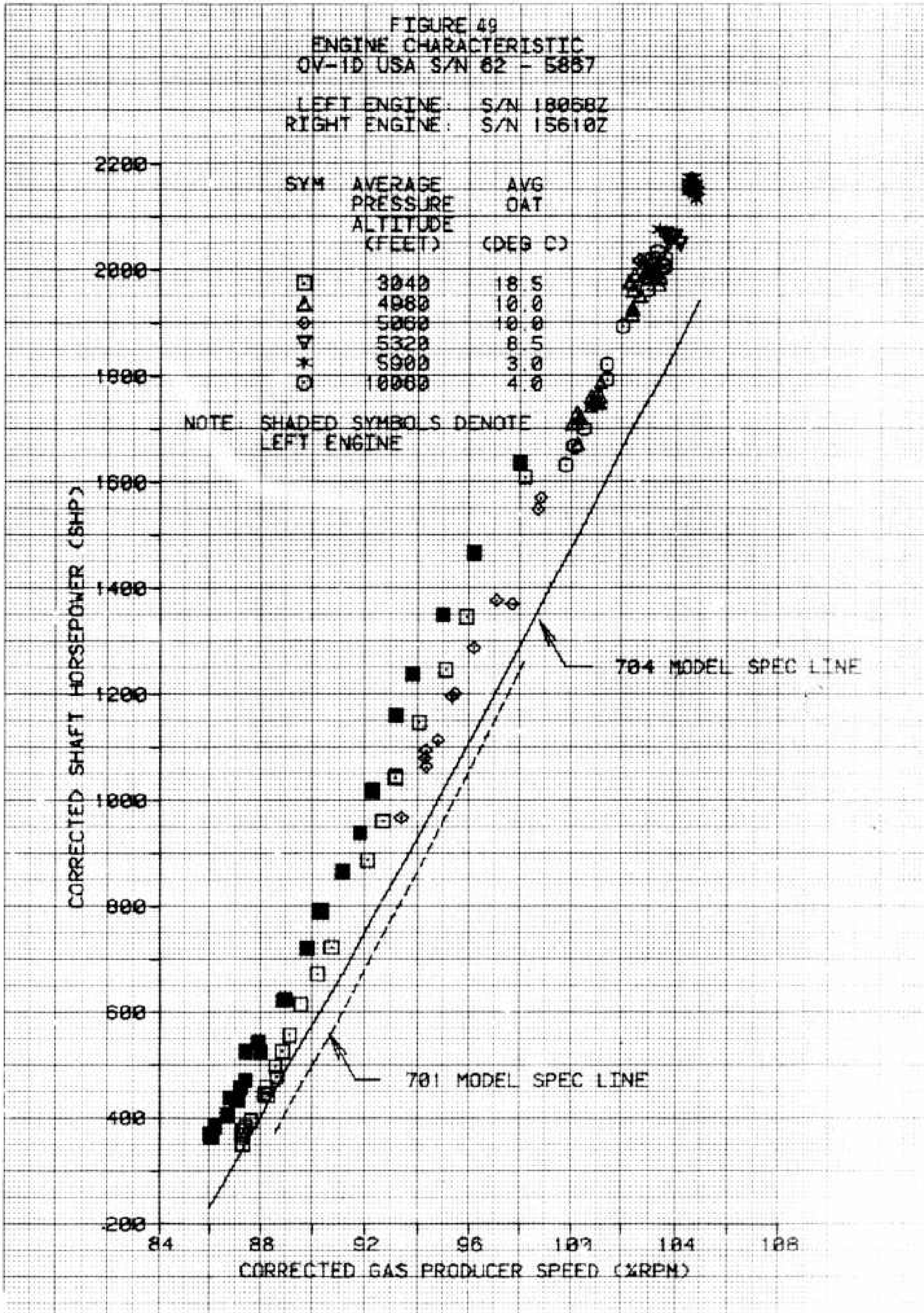


FIGURE 49
ENGINE CHARACTERISTIC
OV-1D USA S/N 62 - 5857
LEFT ENGINE: S/N 18058Z
RIGHT ENGINE: S/N 15610Z
SYM AVERAGE PRESSURE ALTITUDE (FEET) AVG OAT (DEG C)
3040 18.5
4980 10.0
5060 10.0
5320 8.5
5900 3.0
10060 4.0
NOTE: SHADED SYMBOLS DENOTE LEFT ENGINE
704 MODEL SPEC LINE
701 MODEL SPEC LINE
CORRECTED SHAFT HORSEPOWER (SHP)
CORRECTED GAS PRODUCER SPEED (%RPM)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
84
88
92
96
100
104
108

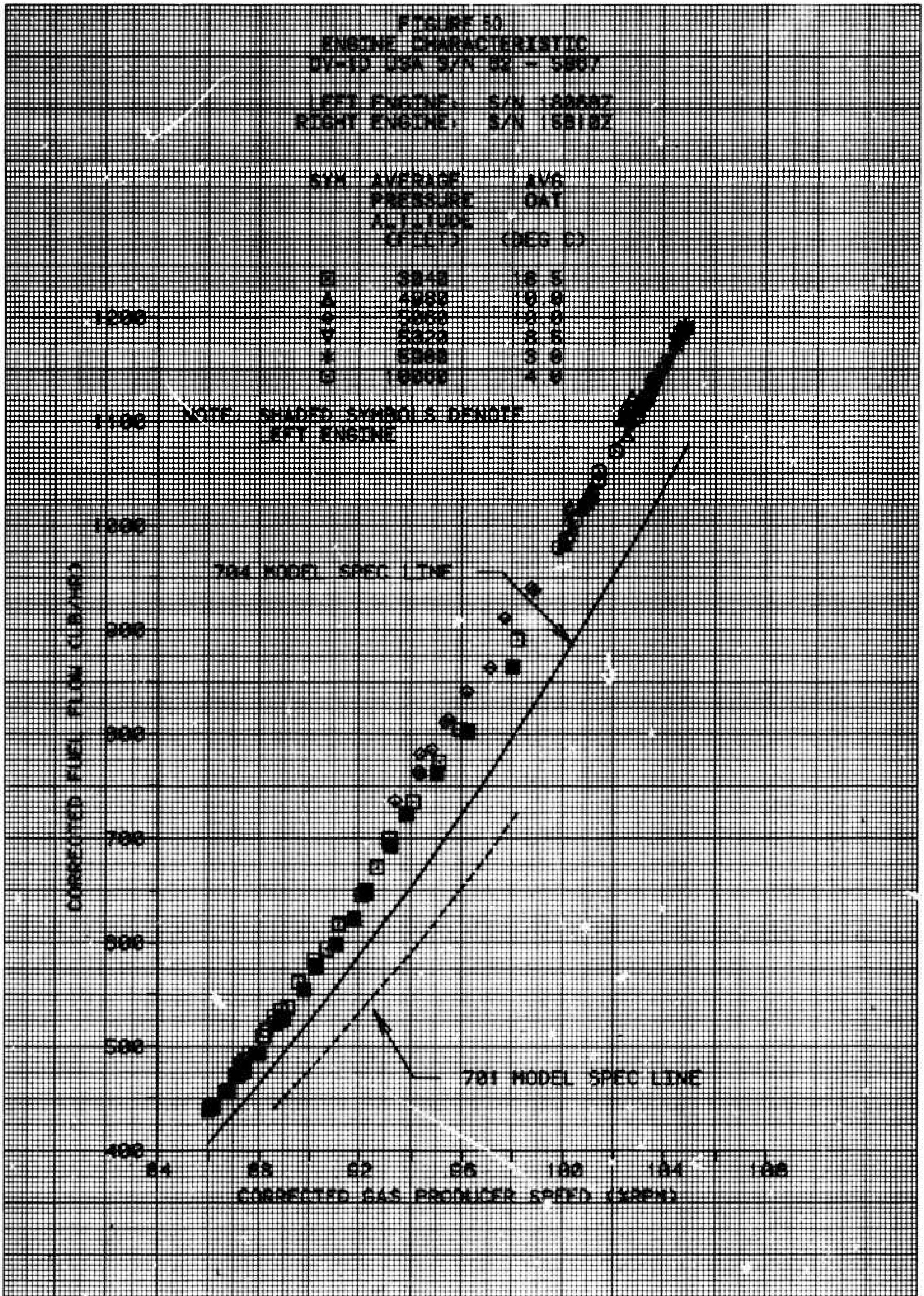
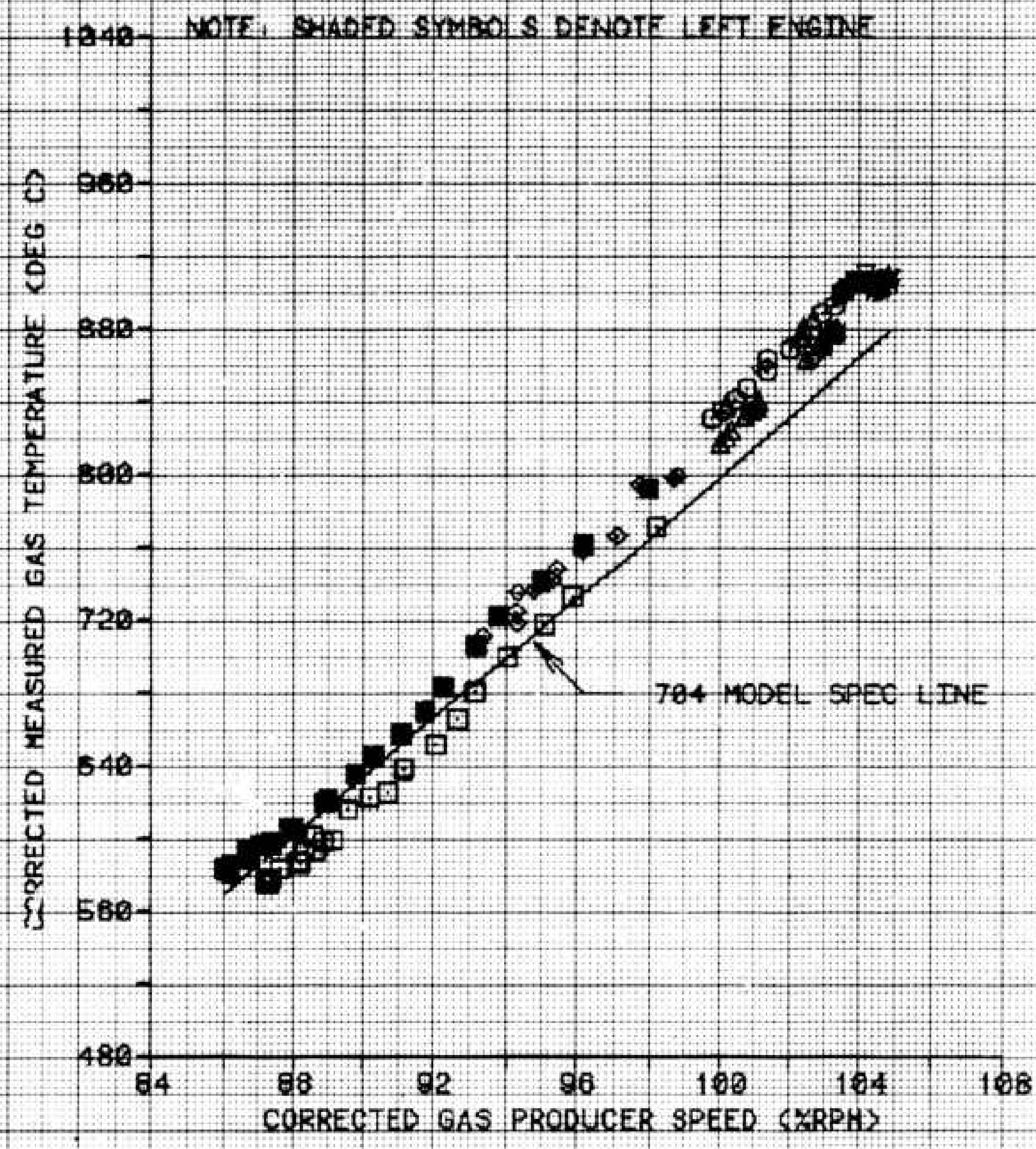


FIGURE 50
ENGINE CHARACTERISTIC
LEFT ENGINE
RIGHT ENGINE
SYM
AVERAGE PRESSURE ALTITUDE (FEET)
AVG OAT (DEG C)
NOTE: SHADED SYMBOLS DENOTE LEFT ENGINE
704 MODEL SPEC LINE
701 MODEL SPEC LINE
CORRECTED FUEL FLOW (LB/HR)
1200
1100
1000
900
800
700
600
500
400
84
88
92
96
100
104
108
CORRECTED GAS PRODUCER SPEED (%RPM)

FIGURE 51
ENGINE CHARACTERISTIC
OV-1D USA S/N 62 - 5867

LEFT ENGINE: S/N 180687
RIGHT ENGINE: S/N 15610Z

SYM	AVERAGE PRESSURE ALTITUDE (FEET)	AVG OAT (DEG C)
☐	3040	18.5
△	4980	10.0
◇	5060	10.0
▽	5320	8.5
*	5900	3.0
⬡	10060	4.0



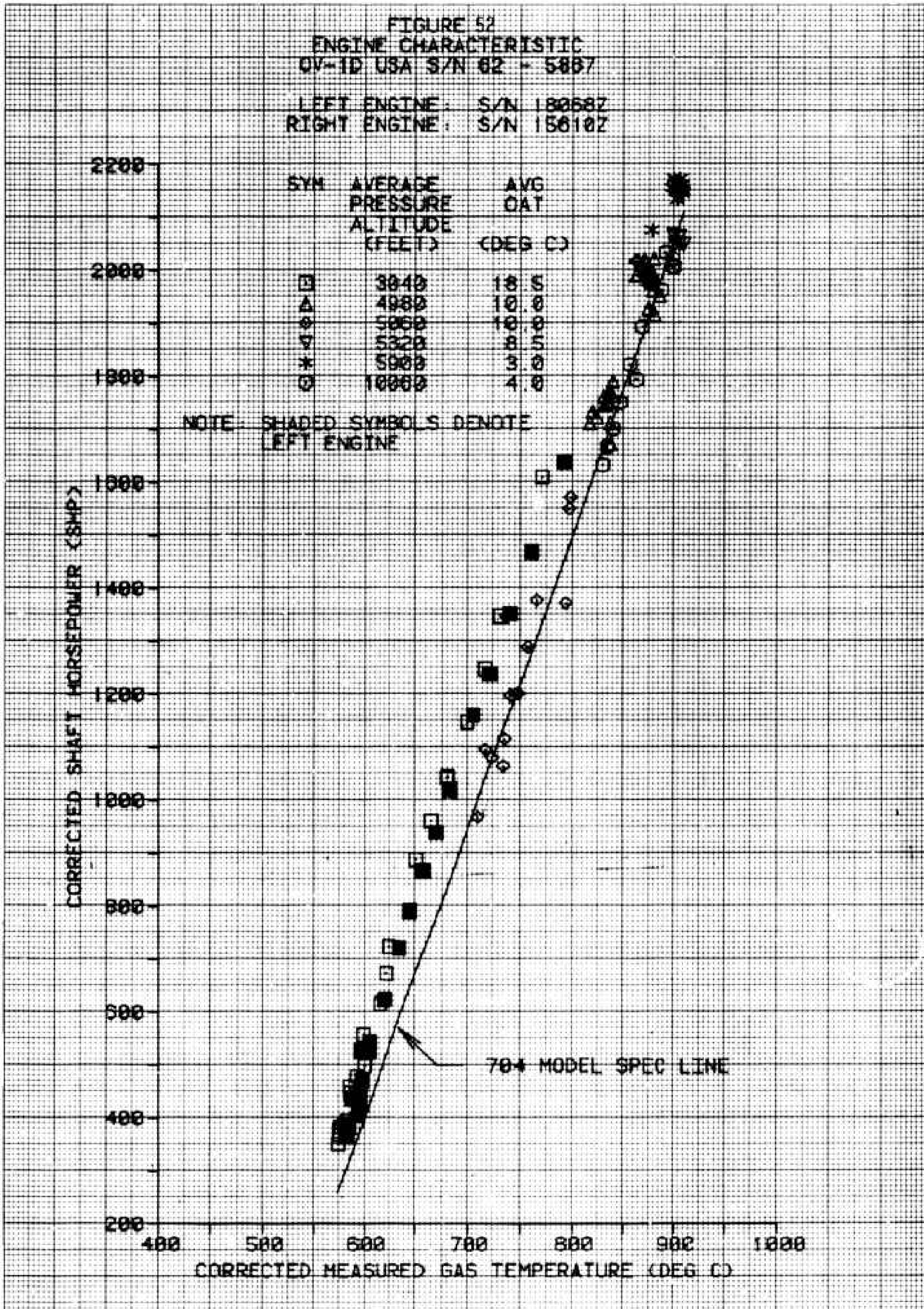


FIGURE 52
ENGINE CHARACTERISTIC
OV-1D USA S/N 62 - 5887
LEFT ENGINE: S/N 180687
RIGHT ENGINE: S/N 156107
SYM AVERAGE PRESSURE ALTITUDE (FEET) AVG OAT (DEG C)
3040 18.5
4980 10.0
5060 10.0
5320 8.5
5900 3.0
10060 4.0
NOTE: SHADED SYMBOLS DENOTE LEFT ENGINE
704 MODEL SPEC LINE
CORRECTED SHAFT HORSEPOWER (SHP)
CORRECTED MEASURED GAS TEMPERATURE (DEG C)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
400
500
600
700
800
900
1000

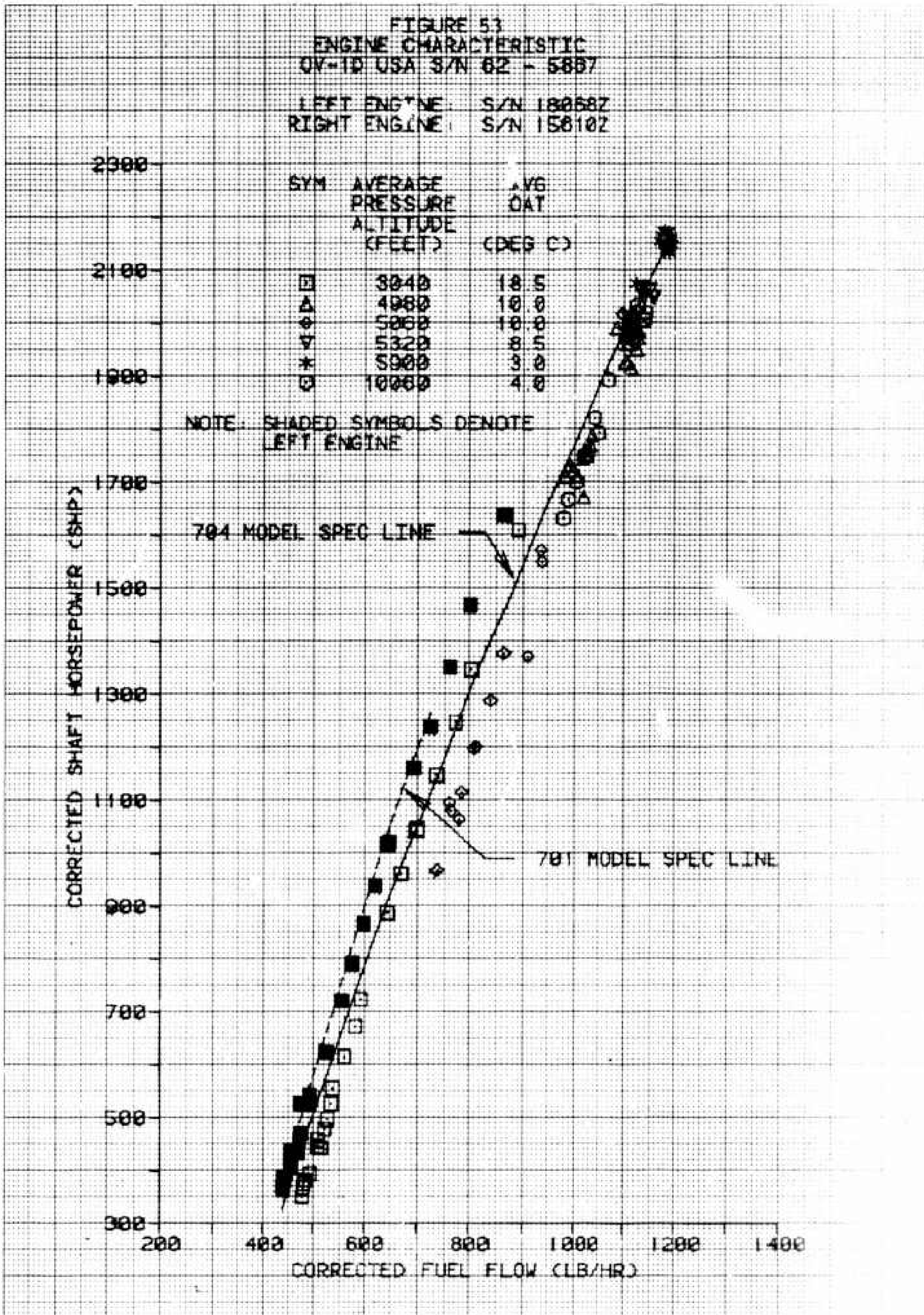
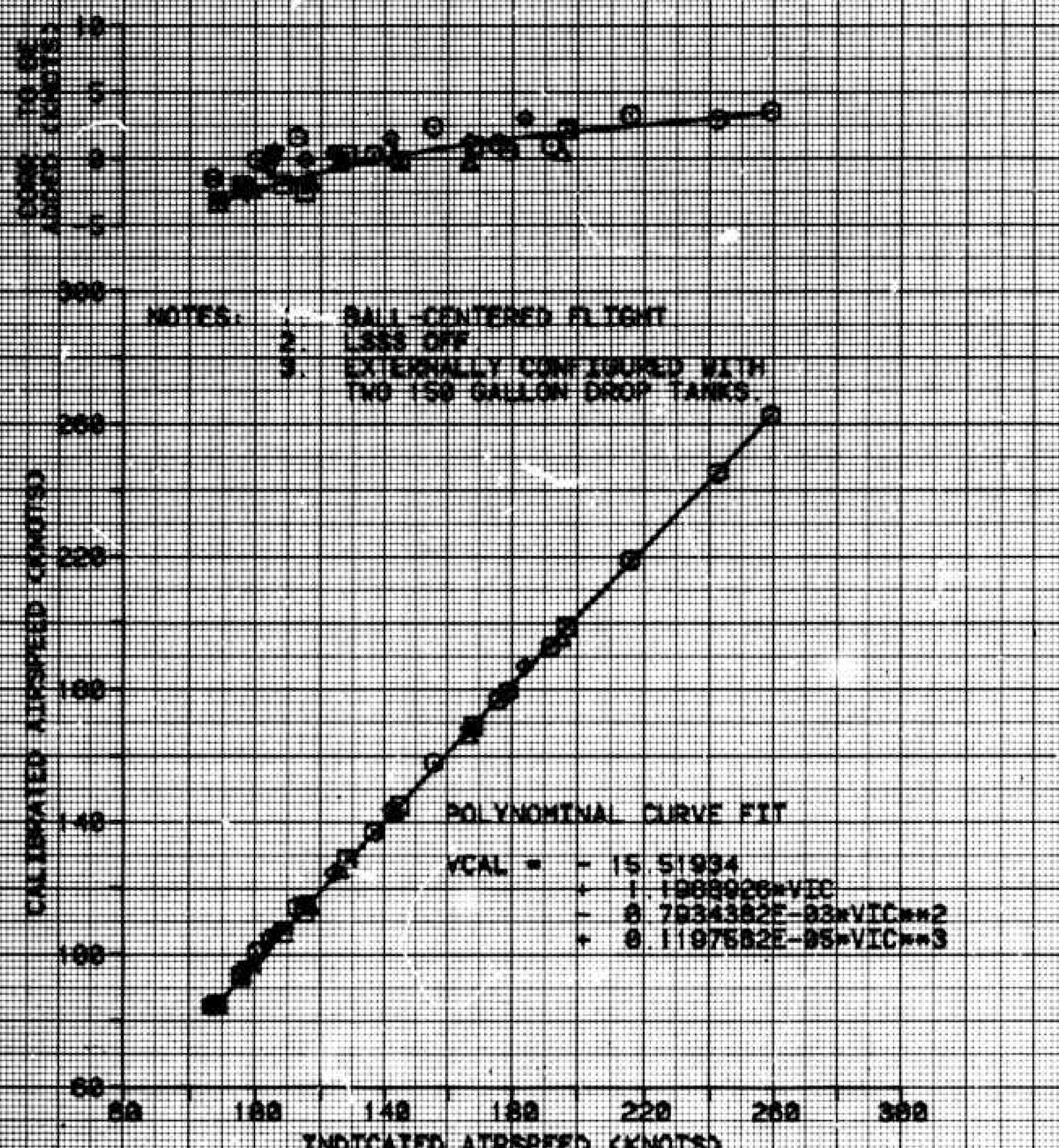


FIGURE 53
ENGINE CHARACTERISTIC
OV-1D USA S/N 62 - 5887
LEFT ENGINE S/N 180687
RIGHT ENGINE S/N 158107
SYM AVERAGE PRESSURE ALTITUDE (FEET) AVG OAT (DEG C)
3040 18.5
4980 10.0
5060 10.0
5320 8.5
5900 3.0
10060 4.0
NOTE: SHADED SYMBOLS DENOTE LEFT ENGINE
704 MODEL SPEC LINE
701 MODEL SPEC LINE
CORRECTED SHAFT HORSEPOWER (SHP)
CORRECTED FUEL FLOW (LB/HR)
2300
2100
1900
1700
1500
1300
1100
900
700
500
300
200
400
600
800
1000
1200
1400

FIGURE 54
SHIP SYSTEM AIRSPEED CALIBRATION
OV-1D(C) USA S/N 62-5887

SYM	GROSS WEIGHT (LB)	LONG CG LOCATION (FS)	PRESSURE ALTITUDE (FT)	OAT (DEG C)	PROP SPEED (RPM)	ENGINE CONFIG	FLAPS POSN (DEG)	TEST METHOD
○	15,400	160.7(MID)	2000	23.0	1900	DUAL	0	GRND CRSE
●	15,400	160.9(MID)	2000	23.0	1900	DUAL	45	GRND CRSE
	15,200	160.9(MID)	5700	10.0	1900	DUAL	0	PACE
	15,200	160.9(MID)	5700	10.0	1900	DUAL	15	PACE
	15,200	160.9(MID)	5700	10.0	1900	DUAL	45	PACE
	15,000	161.1(MID)	5000	14.0	1900	RIGHT	0	PACE
	15,000	161.1(MID)	5000	14.0	1900	RIGHT	15	PACE
	15,200	160.9(MID)	5000	13.0	1900	LEFT	0	PACE
	15,200	160.9(MID)	5000	13.0	1900	LEFT	15	PACE



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