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ENGINEERING FLIGHT TEST

AH-IG HELICOPTER
HUEYCOBRA

PHASE B
PART 6

FINAL REPORT

RODGER L. FINNESTEAD
PROJECT ENGINEER

WILLIAM J. CONNOR
CWO, AV
US ARMY
PROJECT OFFICER/PILOT

NOVEMBER 1969

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

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

The AH-1G helicopter Phase B, Part 6 test program was conducted at Shafter, California, and Edwards Air Force Base, California, from 12 March through 3 May 1968 by the US Army Aviation Systems Test Activity, Edwards Air Force Base, California. The program was conducted to determine level flight performance, autorotational performance, engine characteristics, armed helicopter mission capability and to evaluate the in-ground-effect (IGE) handling qualities with the canopy doors removed. The helicopter is directionally unstable when hovering IGE with either the doors on or off in winds of 9 to 13 knots for azimuth range from 160 to 260 degrees (clockwise from nose of aircraft). This instability is a major deficiency and detracts from the mission capability of the aircraft. Undue pilot attention is required to avoid overtorquing the main transmission during maneuvers requiring abrupt left-lateral cyclic inputs in forward flight. This overtorque condition will only occur below the critical altitude of the engine. Additional deficiencies and shortcomings have been published in previous reports. Sufficient performance data were not obtained to determine the guarantee compliance.
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INTRODUCTION

BACKGROUND

1. The US Army Aviation Systems Test Activity (USAASATS) was directed by the US Army Test and Evaluation Command (USATECOM) to perform an engineering flight evaluation of the AH-1G helicopter (ref 5, app I). This testing was planned to be accomplished using several test aircraft during different time periods. The results of the Phase B performance tests using aircraft S/N 66-15247 are presented in this report. Handling qualities, vibration characteristics, wing stores jettison capabilities and armament subsystem evaluation test results are presented in parts 1 through 5 of the AH-1G Phase B report.

TEST OBJECTIVES

2. The objectives of this test were as follows:

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

   b. To define the helicopter deficiencies to allow early correction and to provide a basis for evaluation of changes incorporated to correct deficiencies.

   c. To provide limited performance flight test data for incorporation into the operator's manual.

   d. To evaluate directional control margin in ground effect (IGE) with the canopy doors removed.

DESCRIPTION

3. The AH-1G helicopter manufactured by Bell Helicopter Company was designed specifically to meet the US Army requirement for an interim armed helicopter. The helicopter provides for a crew of two, seated tandem. The main rotor system is a two-bladed, door-hinge type with the customary stabilizer bar removed and a conventional antitorque tail rotor located at the top of the vertical stabilizer. The AH-1G is equipped with a three axes stability and control augmentation system to improve helicopter handling qualities. The power plant is a Lycoming T53-L-13
turboshaft engine rated at 1400 shaft horsepower (shp) at sea level (SL) under standard day uninstalled conditions. The engine is de-rated to 1100 shp because of the maximum torque limit of the helicopter's main transmission. The engine is equipped with a particle separator to prevent small foreign objects from entering the engine. The distinctive features of the AH-1G are the narrow fuselage (36 in.), the stub midwing with four external store stations and the integral chin turret. The flight control system is a positive, irreversible, mechanical type with conventional helicopter controls in the pilot's (aft) cockpit. The copilot/gunner's controls in the forward cockpit consist of conventional antitorque pedals, sidearm collective and cyclic controls. An electrical force trim system is connected to the cyclic and directional controls to induce artificial feel and to provide positive control centering. The elevator is synchronized with the cyclic stick. The armament configuration is changed by varying the wing stores and chin turret configuration. The pilot can fire all weapons in the stowed position. The gunner/copilot operates the flexible turret arm, can also fire the wing stores in an emergency using a pilot override switch. The wing stores can be jettisoned by either the pilot or gunner in case of an emergency. The design gross weight (grwt) for the AH-1G is 6600 pounds. Basic aircraft data and operating limits are presented in appendix IV.

SCOPE OF TEST

4. Thirty-five flights totaling 47.6 hours were conducted during the AH-1G Phase B performance and handling qualities testing. Testing was conducted at Edwards Air Force Base (2300-foot elevation), and Shafter (520-foot elevation), California, from 12 March through 3 May 1968. These tests consisted primarily of level flight performance, autorotational performance and engine characteristic and directional control handling quality evaluation IGE. The configurations tested are listed in table 1.
### Table 1. Configurations.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Armament Subsystems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>TAT-102A turret, wing store stations - clean</td>
</tr>
<tr>
<td>Basic</td>
<td>TAT-102A turret, one XM157 outboard each wing</td>
</tr>
<tr>
<td>Inboard alternate</td>
<td>TAT-102A turret, one XM159 inboard each wing</td>
</tr>
<tr>
<td>Outboard alternate</td>
<td>TAT-102A turret, one XM159 outboard each wing</td>
</tr>
<tr>
<td>Light scout</td>
<td>TAT-102A turret, one XM18 inboard each wing, one XM157 outboard each wing</td>
</tr>
<tr>
<td>Heavy scout</td>
<td>TAT-102A turret, one XM18 inboard each wing, one XM159 outboard each wing</td>
</tr>
<tr>
<td>Heavy hog</td>
<td>TAT-102A turret, two XM159 each wing</td>
</tr>
</tbody>
</table>

5. The test program was conducted within the limitations established by the USAAVSCOM AH-1G Safety-of-Flight Release issued by AMSAV-R-F on 1 April 1967.

6. The empty gross weight of the test aircraft in a clean configuration with test instrumentation installed was 5790 pounds with a cg location at 205.97 inches. The test aircraft empty weight without instrumentation installed is not available since some test instrumentation was installed by the contractor prior to aircraft delivery to USASTA. However, aircraft S/N 66-15327 had a dry weight of 5595 pounds and longitudinal cg of 204.18 inches. Both aircraft were equipped with a TAT-102 chin turret.
METHODS OF TEST

7. The methods and data reduction procedures used in these tests are proven engineering flight test techniques and are described briefly in appendix V.

8. All flights were conducted and supported by USAASTA personnel. Tests were conducted in nonturbulent atmospheric conditions.

CHRONOLOGY

9. The chronology of this test report is as follows:

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight test commenced</td>
<td>12 March 1968</td>
</tr>
<tr>
<td>Flight test completed</td>
<td>3 May 1968</td>
</tr>
<tr>
<td>Preliminary data submitted</td>
<td>20 May 1968</td>
</tr>
<tr>
<td>Draft report submitted</td>
<td>17 May 1969</td>
</tr>
</tbody>
</table>
RESULTS & DISCUSSION

GENERAL

10. This report presents the results of engineering flight test Phase B performance and handling qualities of the AH-1G helicopter. Performance tests were conducted to determine the level flight performance, autorotational performance and engine characteristics of the AH-1G helicopter. Directional control tests were conducted to determine if there was any change in handling qualities with the canopy doors removed. Sufficient performance data were not obtained to determine the guarantee compliance stated in reference 3, appendix 1.

AIRCRAFT CONTROL SYSTEM COMPLIANCE CHECK

11. Prior to testing, the rigging of the aircraft and engine control systems was checked for compliance with the appropriate US Army manuals. As new procedures were made available to USASTA, the aircraft and engine rigging changes were accomplished with coordination through the contractor's technical representatives.

LEVEL FLIGHT PERFORMANCE

12. Level flight performance tests were conducted at the test conditions specified. All these tests were performed with the frangible fairings removed ("unfaired" condition). End plates were placed over the front of each rocket pod to simulate a loaded pod (aerodynamically) when inert rockets were not used to achieve the desired aircraft weight.

13. Base-line level flight performance was defined for the heavy hog configuration. The level flight speed-power polars for the heavy hog configuration are presented in figures 4 through 8, appendix II and summarized in nondimensional form in figures 2 and 3. One level flight was conducted at a specified thrust coefficient \( C_p \) of 49.00 \( \times 10^{-4} \) at a forward cg for the other armament configurations presented in table 1 to determine the effect of different wing store combinations on power required. The level flight performance for the different wing armament configurations is presented in figures 9 through 14.

14. All subsequent configurations tested revealed an increase in equivalent flat plate area when compared to the clean configuration.
The increase in equivalent flat plate area for different configurations is presented in figure A for the thrust coefficient of $49.00 \times 10^{-4}$. The increase in equivalent area was greatest for the heavy hog configuration. The increase in equivalent flat plate area for the heavy scout and heavy hog configurations increased nonlinearly at higher airspeeds. This nonlinear increase in equivalent flat plate area was probably caused by the change in aircraft attitude (nose down) as airspeed increased.

![Figure A](image)

**FIGURE A**

**CHANGE IN EQUIVALENT FLAT PLATE AREA DUE TO WING ARMAMENT CONFIGURATION CHANGES**

AH-1G USAF 005247

ROTOR SPEED = 324 RPM

DENSITY ALTITUDE = 5000 FT

GROSS WEIGHT = 6500 LB

$C_T = 4900 \times 10^{-4}$

CT LOCATION = FORWARD

15. The level flight and range performance summary for a thrust coefficient of $49.00 \times 10^{-4}$ is presented in table 2. The value of 0.99 maximum nautical air miles per pound of fuel (NAMPP) decreased about 9.6 percent while the recommended cruise airspeed decreased 8.8 percent when comparing the minimum (clean) and maximum (heavy hog) aerodynamic drag configurations. The maximum airspeed in level flight decreased 8.4 percent in the maximum aerodynamic drag configuration.

16. The level flight performance presented in this report should be incorporated into the appropriate operator's manual.
Table 2. Level Flight and Range Performance Summary.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Cruise Specific Range (NAMPP)</th>
<th>Recommend VCruise for 0.99 Maximum NAMPP (KTAS)</th>
<th>Maximum Airspeed in Level Flight (KTAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>0.2270</td>
<td>138.0</td>
<td>149.0</td>
</tr>
<tr>
<td>Basic</td>
<td>0.2205</td>
<td>135.5</td>
<td>146.5</td>
</tr>
<tr>
<td>Light scout</td>
<td>0.2172</td>
<td>134.0</td>
<td>144.0</td>
</tr>
<tr>
<td>Inboard alternate</td>
<td>0.2162</td>
<td>133.0</td>
<td>143.5</td>
</tr>
<tr>
<td>Outboard alternate</td>
<td>0.2157</td>
<td>132.5</td>
<td>143.0</td>
</tr>
<tr>
<td>Heavy scout</td>
<td>0.2109</td>
<td>129.5</td>
<td>140.5</td>
</tr>
<tr>
<td>Heavy hog</td>
<td>0.2050</td>
<td>127.0</td>
<td>136.5</td>
</tr>
</tbody>
</table>

17. The production AH-1G aircraft equivalent flat plate area was increased approximately 5.0 square feet over that of the Bell Helicopter model 209 aircraft (ref 1, app 1). The engine used during the evaluation of the Bell model 209 was not calibrated below an output torque pressure of 44.5 psi. Therefore, increase in equivalent flat plate area can only be calculated at engine output shaft horsepower above 1020. This increase in equivalent flat plate area was probably caused by these outside external changes:

- a. The addition of two inboard wing stores stations.
- b. The wider fuselage configuration for acceptance of the final chin turret.
- c. The thicker stub wings.
- d. Different configuration of the skid tubes and supporting structure.
- e. The removal of flush-head rivets from the tail boom.
- f. The addition of various access and vent panels.
18. Steady state, autorotational descent performance tests were conducted in the unfaired heavy hog configuration at 5000 feet with an 8500-pound gross and a forward cg. Results of the autorotational tests are presented in figure 15, appendix II.

19. The airspeed for minimum rate of descent (1815 ft/min) at these test conditions was 74.0 knots true airspeed (KTAS) at a rotor speed of 324 rpm. The rate of descent decreased as rotor speed was decreased from 324 rpm while maintaining a constant airspeed of 74.0 KTAS. The minimum rate of descent of 1750 ft/min was observed at the minimum rotor speed limit of 294 rpm. There was a definite increase in aircraft lateral vibration as rotor speed decreased to 310 rpm. The magnitude of these variations was not quantitatively measured. There was no noticeable decrease in aircraft response to a control input with decreasing rotor speed.

20. The autorotational characteristics of the AH-1G helicopter were found to be similar to the UH-1C helicopter. Precise control of rotor speed during autorotation was difficult because small collective control movements resulted in relatively large changes in rotor rpm. In addition, the high-inertia rotor system caused a lag in the response of rotor speed to collective control inputs. These two characteristics resulted in pilot tendency to "chase the rotor speed" (PRS A5). It was not difficult to maintain rotor speed between red lines, but maintaining a selected rotor speed required considerable attention at a time when the pilot's attention should be directed outside the cockpit.

21. The autorotational descent performance presented should be incorporated into the appropriate operator's manual.

POWER AVAILABLE

22. All summary performance values were based upon shaft horsepower available as defined in figure 18, appendix II, since only the tail rotor drive shaft coupling was evaluated on the Phase B program. The power available charts presented were calculated by using the curves and calculation methods presented in model specification number 104.33 for the T53-L-13 engine (ref 4, app I).

23. In order to calculate shaft horsepower available, certain installation power losses had to be assumed or measured. Constant values were assumed for extracted shaft horsepower (zero) and power turbine output speed (6600 rpm). Power available was also calculated using zero, 0.6-percent and 3.6-percent engine bleed.
air to consider the effects of one approved and one proposed aircraft modification. The approved aircraft modification uses engine bleed air to drive the engine oil cooler instead of the tail rotor drive shaft coupling. The proposed aircraft modification calls for the use of engine bleed air to drive a light-weight cockpit air conditioning system. The power available and fuel-flow characteristics are presented in figures 22 through 27, appendix II.

ENGINE INLET CHARACTERISTICS

24. The compressor inlet temperature and pressure recovery characteristics were considerably different for the production AH-1G than for the 209. Most of the change can be attributed to the production aircraft having an engine particle separator installed; the aircraft evaluated in reference 1, appendix I, was not so equipped. This change amounted to a decrease in engine power available of approximately 0.3 percent in a hover and 13.2 percent at 160 knots for a sea level, standard day for the production aircraft.

ENGINE CHARACTERISTICS

Static Stability

25. The engine static "droop" characteristics were good. Very few adjustments were required on the power turbine, speed-select "beep" switch when reducing or increasing engine power output. The engine power turbine speed-select "beep" switch characteristics are presented in figure 19, appendix II. The average time required for rotor speed to change after the "beep" switch was activated was 0.65 seconds. There was no noticeable variation in this delay time between a loaded or unloaded rotor system. The engine "beep" switch trim rate was constant at 7.7 rpm/sec after the time delay. The "beep" control characteristics were satisfactory and much improved over prior UH-1 series aircraft equipped with T53 series engines (PRS A3).

Dynamic Stability

26. Dynamic stability characteristics of the T53-L-13 engine appeared to be satisfactory throughout the flight envelope tested. When rapid power demands were required, no compressor stall was encountered during engine acceleration. Power overshoot and damping were satisfactory.
27. A slight engine oscillation was noted when operating the engine at maximum power available. This oscillation was not considered to be as serious as that reported in reference 10, appendix I. The horsepower fluctuation on the AH-1G was 10 to 15 shp. This fluctuation was not present when power was reduced to slightly below the maximum available.

28. There was only one significant airframe/engine matching shortcoming discovered during this program. A problem was encountered in forward flight when an abrupt maneuver requiring left-lateral cyclic was initiated with the aircraft operating at or near the main-transmission torque limit. The abrupt left-lateral cyclic input caused the rotor speed to decrease while maintaining a constant collective control position. The engine power-turbine governor sensed the rotor speed decrease and increased the fuel flow. This resulted in an increased engine power output and a main transmission overtorque condition. This characteristic is transient in nature and was only encountered in forward flight conditions below the critical altitude of the engine. The largest change in engine torque observed during the program was 13 psi for a left-lateral control input of 3.3 inches at a trim calibrated airspeed of 105 knots. In order to avoid overtorquing of the main transmission, the pilot must continually monitor the torquemeter when performing an abrupt left-lateral cyclic control input. This characteristic is undesirable since the attention of the pilot may be required elsewhere when performing a mission. This condition detracts from the mission capability of the aircraft. Abrupt right cyclic inputs under the same conditions have just the opposite effect: an increase in rotor speed and decrease in engine power output. This problem has been reported previously in reference 2, appendix I.

DIRECTIONAL CONTROL EVALUATION

29. An ICE directional control evaluation was conducted with the canopy doors on and off to determine if there was any significant change in handling qualities of the aircraft. The test was conducted with the SCAS yaw channel OFF and in the outboard alternate configuration. The ground paced method of test was used with conditions limited to an airspeed range from zero to 17.5 KTAS at critical wind azimuths of 160, 200 and 240 degrees (clockwise from nose of aircraft). The results of these tests are graphically presented in figures 16 through 18, appendix II.

30. The test revealed little if any change in the aircraft directional handling qualities with the canopy doors on or off. However, an area of directional instability existed between 9 and 13
knots at each wind azimuth flown. In this area, rapid and sometimes large directional control movements were required to maintain the desired heading. This instability is a major deficiency and detracts from the mission suitability of the aircraft (PRS A6).

31. The directional control evaluation reported in reference 8, appendix I, was found to agree with the data presented in this report. Some scatter in the data was noted where directional instability occurred but was not considered to be significant.

AIRSPEED CALIBRATION

32. The helicopter was equipped with a test airspeed indicator system (boom) in addition to the standard helicopter airspeed indicator system. Airspeed calibration flights were conducted to determine the position error of the test system. A trailing bomb was used as an airspeed reference up to 101 knots. From 80 to 180 knots indicated airspeed (KIAS), a T-28 airplane with a calibrated airspeed system was used as an airspeed reference. The test aircraft system was also calibrated (between 39 and 159 KTAS) using the ground speed course. Calibration of the test system was conducted in the clean configuration in level flight, dive, climb and autorotation at a rotor speed of 324 rpm. The test results are presented in figure 28, appendix II.
CONCLUSIONS

33. The following conclusions were reached after completion of the AH-1G Phase B, Part 6 performance tests:

a. The equivalent flat plate area can increase as much as 7.7 square feet depending on wing armament configuration. This increase in equivalent flat plate area decreased the specific range of the aircraft 9.6 percent (para 15).

b. Changes in the production fuselage increased the equivalent flat plate area by 5.0 square feet over the aircraft reported in reference 1, appendix 1 (para 17).

c. The minimum steady state autorotational descent in the heavy hog configuration is 1815 ft/min for a rotor speed of 324 rpm at a true airspeed of 74.0 knots (para 19).

d. The steady state autorotational rate of descent decreased to 1750 ft/min for a rotor speed of 294 rpm at a true airspeed of 74.0 knots (para 19).

e. Precise control of rotor speed during autorotation was difficult because small collective control movements resulted in relatively large changes in rotor speed (para 20).

f. The changes in the production inlet configuration increased the engine power available loss as much as 13.2 percent depending on airspeed (para 24).

g. The removal of the canopy door did not significantly affect the low-speed directional control margin or IGE flying qualities (para 30).

34. Correction of the following deficiency is mandatory for acceptance of the aircraft: Directional instability existed between 9 and 13 knots for the wind azimuths between 160 and 240 degrees (para 30).

35. Correction of the following shortcoming is desirable for acceptance of the aircraft weapons system: Undue pilot attention required to avoid overtorquing the main transmission during maneuvers requiring abrupt left-lateral cyclic inputs (para 28).
RECOMMENDATIONS

36. The performance data presented in this report should be incorporated into the operator's manual (paras 16 and 21).

37. The shortcomings should be corrected on a high-priority basis (para 30).
APPENDIX I. REFERENCES


APPENDIX II. TEST DATA
Figure No. 1
Change in Equivalent Flat Plate Area
Due to Wing Armament Configuration Changes
AH-1G USA YK15247
Rotor Speed = 324 RPM
Density Altitude = 5000 FT
Gross Weight = 8500 LB
C_t = 4.900 x 10^-4
C.G. Location = Forward

Note: All Rocket Pods Unfaired
Figure No. 2

Non-Dimensional Level Flight Performance

AH-1G USAF 515247
TS3-L-13 WLE 14001
Heavy HOG Configuration
(Unfaired)
Center of Gravity--Forward

Note: Points obtained from Figure 4 through B Appendix II

\[ C_{T} \times 10^4 = \frac{W}{\text{AA(SLR)}} \times 10^4 \]
FIGURE NO. 3
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE
AM-IG USA NAVY PAT
T53-L-15 WALE MOD
HEAVY HELICOPTER CONFIGURATION
(J.FA, RED)
CENTER OF GRAVITY FORWARD

NOTE: POINTS OBTAINED FROM FIGURE NO. 3 THROUGH APPENDIX E.
Figure No. 5
Level Flight Performance
AH-1G USA 5/6/5247
T53-L-13 WLE 14001
Rotor RPM = 324
Density Altitude = 3920 ft.
C_T = 49.22 x 10^-6
Gross Weight = 8880 lb
C.G. Location: 19.9 in (FBD)
Heavy Hog Configuration (Unfaired)

Engine Output Shaft Horsepower vs True Airspeed (Knots)

- Maximum NAMPP
- Transmission Input Torque Limit
- Recommended Cruise Airspeed

Fairied Curves Derived from Figures 2, 3 and 19, APP. II.
FIGURE No. 6
LEVEL FLIGHT PERFORMANCE
AH-1G USA 943615247
T53-L-13 943614001
ROTOR RPM = 324.5
DENSITY ALTITUDE = 4190 FT.
Ct = 5.63 x 10^-3
GROSS WEIGHT = 9210 LB.
C.G. LOCATION = 193.0 IN. (FWD)
HEAVY HOG CONFIGURATION (UNFAIRED)

ENGINE OUTPUT SHAFT HORSEPOWER

TRUE AIRSPEED ~ KNOTS

RECOMMENDED CRUISE AIRSPEED

FAIRED CURVES DERIVED FROM FIGURES 2-3
C.19 APP. II
Figure No. 7

Level Flight Performance
AH-1G USA S/N 5247
TS3-1-13 3/4 LE 4001
Rotor RPM: 324.5
Density Altitude: 9470 ft.
Ct: 53.22 X10^-6
Gross Weight: 8075 lb
C.G. Location: 192.6 in. (Fwd)
Heavy HOG Configuration (Unfaired)

Maximum Power Available

Engine Output Shaft Horsepower vs. True Airspeed (Knots)

Recommended Cruise Airspeed

Faired Curves Derived From Figures 2, 3, 18 
& 19, APP. II

Nautical Miles Per Pound of Fuel

Maximum NAMP
FIGURE NO. 8
LEVEL FLIGHT PERFORMANCE
AH-1G USA 8/NG15247
TS3-L-13 .9/LE14001
ROTOR RPM - 324.5
DENSITY ALTITUDE - 9390FT
CT = 36.79 x 10^-6
GROSS WEIGHT = 8640 LB
C.G. LOCATION = 191.5 IN.(FWD)
HEAVY HOG CONFIGURATION (UNFAIRED)

FAIRED CURVES DERIVED FROM FIGURES 2, 3
18-19 APP.II

MAXIMUM POWER AVAILABLE

ENGINE OUTPUT SHAFT HORSEPOWER

TRUE AIRSPEED - KNOTS

RECOMMENDED CRUISE AIRSPEED

NAUT. MILES PER POUND OF FUEL

99 MAXIMUM NAMPP
Figure No. 9

Level Flight Performance

AH-1G USA, SN 615247
TS3-L13 ¾ LEI 4001

ROTOR RPM = 824
DENSITY ALTITUDE = 4250 FT.
Ct = 48.11 x 10^-3
GROSS WEIGHT = 8545 LB.
C.G. LOCATION = 192.4 IN. (FWD.)
CLEAN CONFIGURATION

FAIRED CURVES DERIVED FROM FIGURES 1, 2, 3, AND 14 APP. II

TRANSMISSION INPUT TORQUE LIMIT

RECOMMENDED CRUISE AIRSPEED

ENGINE OUTPUT SHAFT HORSEPOWER

NAUT. AIR MILES PER POUND OF FUEL

TRUE AIRSPEED ~ KNOTS

24
Figure No. 10

Level Flight Performance

AH-1G USA S/N 15-247
TS-1-13-5-LE14001

Rotor RPM = 323.5
Density Altitude = 4200 ft.
C_T = 48.8*10^-6
Gross Weight = 8650 lbs.
C.G. Location = 19.5 in. (FWD)
Basic Configuration (Unfaired)

Engine Output Shaft Horsepower vs. True Airspeed (Knots)

Transmission Input Torque Limit

Recommended Cruise Airspeed

Gross Weight = 8650 lbs.
C.G. Location = 19.5 in. (FWD)
Basic Configuration (Unfaired)

Fairied Curves Derived from Figures 1, 2, 3, and 4.
**Figure No. II**

**Level Flight Performance**

AH-1G USA S/N GJ5247

T53-L-13 111 LEMOOL

**Rotor RPM**: 325.5

**Density Altitude**: 4300 ft.

Cₚ = 48.30 x 10⁻⁶

**Gross Weight**: 8645 lb

C.G. Location: 192.2 in (fwd)

Light Scout Configuration (Unfaired)

---

**Graph Details**

- **Engine Output Shaft Horsepower** vs **True Airspeed (Knots)**
- **Transmission Input Torque Limit**
- **Recommended Cruise Airspeed**
- **25 Maximum N.A.**
- **10 Naut. Airmiles per Pound of Fuel**

**Legend**

- FAIRED CURVES DERIVED FROM FIGURES 1, 2, 3, 19 APP II
FIGURE No 12
LEVEL FLIGHT PERFORMANCE
AH-1G USA 5/N5Z47
T55-L-13 WLEV4001
ROTOR RPM = 323.5
DENSITY ALTITUDE = 4120 FT.
C_T = 49.32 x 10^-4
GROSS WEIGHT = 8765 LB.
C.G. LOCATION = 192.8 IN. (FWD)
INBOARD ALTERNATE CONFIGURATION (UNFAIRED)

ENGINE OUTPUT - SHAFT HORSEPOWER

TRUE AIRSPEED ~ KNOTS

RECOMMENDED CRUISE AIRSPEED

TRANSMISSION INPUT TORQUE LIMIT

FAIRED CURVES DERIVED FROM FIGURES 1, 2, 3,
AND 19 APP. II
Figure No. 13
Level Flight Performance
AH-1G USA S/N 615247
TS3-L-1394#LEI4001
ROTOR RPM • 323.5
DENSITY ALTITUDE • 5960 FT
CT • 48.81 X 10^{-4}
GROSS WEIGHT • 8715 LBS
C.G. LOCATION • 193.0 IN. (FND)
OUTBOARD ALTERNATE CONFIGURATION (UNFAIRED)

Transmission input torque limit

Fairied curve derived from Figures 1, 2, 3 and 19 App. II

Recommended cruise airspeed

Engine output shaft horsepower

True airspeed—knots
**Figure No. 15**

**Autorotational Descents**

AH-1G USAF HIGHS

T53-L-7B IN LE 14000

**Hvy. Hg Configuration**

<table>
<thead>
<tr>
<th>Rate of Descent</th>
<th>Cal. Airspeed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>40</td>
</tr>
<tr>
<td>2400</td>
<td>50</td>
</tr>
<tr>
<td>3000</td>
<td>60</td>
</tr>
<tr>
<td>3400</td>
<td>70</td>
</tr>
</tbody>
</table>

**Specifications:**
- AVE. GROSS WT. = 8500 LBS.
- DENSITY ALTITUDE = 5000 FT.
- AVE. C.G. STATION = 141.6 IN.
- AVE. AIRSPEED = 140 KTAS

**Graphs:**
- **Rate of Descent vs. Rotor RPM:**
  - Maximum power off - Rotor speed limit
  - Minimum power on - Rotor speed limit

- **Calibrated Airspeed vs. RPM:**
  - Maximum airspeed for power off

---

*Note: The graphs depict autorotational descent rates and calibrated airspeeds across different rotor RPM values.*
Figure No. 16

ENGINE CHARACTERISTICS
AH-1G USA 5/14/52-7
TS-3-L-13 5/14/54-7
ENGINE PARTICLE SEPARATOR INSTALLED

NOTE: SHAFT HORSEPOWER AVAILABLE BASED ON SOLID CURVE
Figure No. 17

Engine Characteristics

AH-1G USA 3/4G15547
T55-L-13 S/N LE 14001

Engine Particle separator installed

Note: Shaft horsepower available based on solid curve
NOTES:
1. CURVE BASED ON LYCOMING T53-L-13 ENGINE.
2. ENGINE TURBOCHARGED TO 1.3:1.
3. GENERATOR ELECTRICAL LOAD = ZERO.
4. PERCENT AIR BLEED (MW/ML) = ZERO.
5. ENGINE OIL COOLER DRIVEN BY TAIL ROTOR DRIVE SHAFT COUPLING.
6. FUEL CONSUMPTION 3% CONSERVATIVE.
7. ICAO STANDARD DAY.
8. ROTOR SPEED 324 RPM.
Figure No. 20

Specification: Shaft Horsepower Available

AH-1G USA 44G15247
TS3-L-13 94LE1400
Engine particle separator installed

Notes:
1. Curve based on Lycoming TS3-L-13
2. Engine model specification no. 10483
3. Engine inlet characteristics based on Figure No. 16.11
4. Generator electrical load: Zero
5. Percent airflow (N1 / N2) = 0.47
6. Engine oil cooler driven by engine bleed air.
7. Cadal standard day
8. Rotor speed 324 RPM
FIGURE NO. 22
SPECIFICATION SHAFT HORSEPOWER AVAILABLE
AH-1G USA EG18-24 T
T5B-L-13 9/14-4001
ENGINE PARTICLE SEPARATOR INSTALLED

NOTES:
1. CURVE BASED ON LVC0MING T5B-L-13
2. ENGINE INLET CHARACTERISTICS BASED ON FIGURE NO. 16-417
3. GENERATOR ELECTRICAL LOAD = ZERO
4. PERCENT AIR BLEED (AH/W) = 3.6%
5. ENGINE OIL COOLER DRIVEN BY ENGINE BLEED AIR
6. COCKPIT AIR CONDITIONING DRIVEN BY ENGINE BLEED AIR
7. 5000 FT STANDAR DAY
8. ROTOR SPEED 524 RPM

SHAFT HORSEPOWER AVAILABLE

5000 FT
10000 FT
15000 FT
20000 FT

SEAL LEVEL

TRANSMISSION INPUT TORQUE LIMIT
Figure No. 24

Engine Characteristics

AH-1G USA KLG 5247
T53-L-13 (T400)
Engine Particle Separator Installed

Notes:
1. Curve based on Lycoming T53-L-13 engine model specification No. 104-33
2. Curve based on engine inlet characteristics presented in Figure Nos. 16 & 17 for zero airspeed
3. Generator electrical load = zero
4. Percent air bleed ($W_b/W_a$) = zero
5. Rotor speed = 324 RPM
6. Engine oil cooler driven by tail rotor drive shaft coupling
7. Solid symbols derived from engine manufacturer's calibration conducted on 22 August 1967
NOTES:
1. CURVE BASED ON LYCOMING TS3-L-13 ENGINE MODEL SPECIFICATION NO.104.33.
2. CURVE BASED ON ENGINE INLET CHARACTERISTICS PRESENTED IN FIGURE NO. 16.411 FOR ZERO AIRSPEED.
3. GENERATOR ELECTRICAL LOAD = ZERO
4. PERCENT AIR BLEED(MY/ML) = ZERO
5. ROTOR SPEED = 324 RPM
6. ENGINE OIL COOLER DRIVEN BY TAIL ROTOR DRIVE SHAFT COUPLING.
7. SOLID SYMBOLS DERIVED FROM ENGINE MANUFACTURE'S CALIBRATION CONDUCTED ON 22 AUGUST 1967.
Figure No. 26
ENGINE CHARACTERISTICS
AH-1G USAF 815247
TS5-6-118 FL 4001
ENGINE PARTICLE SEPARATOR INSTALLED

NOTES: 1. CURVE BASED ON LYCOMING TS5-L13 ENGINE
MODEL SPECIFICATION NO. 104.33
2. CURVE BASED ON ENGINE INLET CHARACTERISTICS
PRESENTED IN FIGURE NO. 16 FOR ZERO AIRSPEED
3. GENERATOR ELECTRICAL LOAD = ZERO
4. PERCENT AIR BLEED (M_W / M_a) = ZERO
5. ROTOR SPEED = 324 R.P.M.
6. ENGINE OIL COOLER DRIVEN BY TAIL
ROTOR DRIVE SHAFT COUPLING
7. SOLID SYMBOLS DERIVED FROM ENGINE
MANUFACTURES CALIBRATION CONDUCTED
ON 22 AUGUST 1967

Exhaust Gas Temperature / °F

Referred Shaft Horsepower - SHP / Tₚ / Tₑₖ
Figure No 27
ENGINE CHARACTERISTICS
AH-1G USA 5G15247
T55-L-13 54LE14001
ENGINE PARTICLE SEPARATOR INSTALLED

NOTES: 1. CURVE BASED ON LYCOMING T55-L-13 ENGINE
MODEL SPECIFICATION NO. 104.33
2. CURVE BASED ON ENGINE INLET CHARACTERISTICS
PRESENTED IN FIGURE NO. 16, FOR ZERO AIRSPEED
3. GENERATOR ELECTRICAL LOAD = ZERO
4. PERCENT AIRBLEED ($W_{B}/W_{a}$) = ZERO
5. ROTOR SPEED = 324 RPM
6. ENGINE OIL COOLER DRIVEN BY TAIL ROTOR
DRIVE SHAFT COUPLING
7. SOLID SYMBOLS DERIVED FROM ENGINE
MANUFACTURER'S CALIBRATION CONDUCTED
ON 22 AUGUST 1967
Figure No. 28

ENGINE CHARACTERISTICS

AH-1G, USA 96-15247
T55-L-13, WLE14001
ENGINE PARTICLE SEPARATOR INSTALLED

NOTES:
1. CURVE BASED ON LYCOMING T55-L-13 ENGINE
   MODEL SPECIFICATION NO. 104.33
2. CURVE BASED ON ENGINE INLET CHARACTERISTICS
   PRESENTED IN FIGURE NOS. 16 & 17 FOR ZERO AIRSPEED
3. GENERATOR ELECTRICAL LOAD = ZERO
4. PERCENT AIRBLEED (Hm6/Hm) = ZERO
5. ROTOR SPEED = 324 RPM
6. ENGINE OIL COOLER DRIVEN BY TAIL ROTOR
   DRIVE SHAFT COUPLING
7. SOLID SYMBOLS DERIVED FROM ENGINE
   MANUFACTURER'S CALIBRATION CONDUCTED
   ON 22 AUGUST 1967
**Figure No. 29**

**Engine "Beep" Control Characteristics**

**AH-1G USA** 3/NG15247

**T53-L-13** 8/4LHE14001

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>AIRSPEED (KIAS)</th>
<th>DENSITY ALT. (FT.)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>105</td>
<td>5000</td>
<td>LEVEL FLIGHT</td>
</tr>
<tr>
<td>□</td>
<td>ZERO</td>
<td>1500</td>
<td>GROUND RUN (COLLECTIVE FULL DOWNG)</td>
</tr>
</tbody>
</table>

**Graph:**
- **Time Required for Rotor Speed to Change After Beep Control is Actuated (~Seconds)**
  - Rotor Speed ~ RPM range: 250 to 350

- **Engine Beep Control Upper Limit**
- **Trim Point**
- **Delay Time**
- **Engine Beep Control Lower Limit**

**Time Beep Control Switch Was Actuated (~Seconds)**
Figure No. 30
Tail Rotor Pitch Required with Wind Azimuth 180°
AH-1G USAF 4626ST
Outboard Alternate Configuration (Faired)

Notes:
1. Standard tail rotor
2. Full left pedal = 15° tail rotor pitch with SCAS null
3. Ground speed determined with calibrated pace car
4. True airspeed determined by vector addition of ground speed and wind
5. Solid symbol denotes data derived from USAVNTA report NOGG-DG
6. Total directional control displacement = 7.07 in. from full left

Doors on:
Density Altitude = 1040 ft.
Gross Weight = 9750 lbs.
Center of Gravity = 14.5 GLL (MID)
Rotor speed = 324 RPM

Doors off:
Data not available for this configuration.
Figure No. 31

Tail Rotor Pitch Required with Wind Azimuth 200°

AH-1G USAV N/G 152647
Outboard Alternate Configuration (Fairied)

Notes:
1. Standard Tail Rotor
2. Full left pedal: 19° tail rotor pitch, with SCAS NULL
3. Ground speed determined with calibrated pace car
4. True airspeed determined by vector addition of ground speed & wind
5. Solid symbol denotes data derived from USAVNTA Report No. 65-06
6. Total directional control displacement = 7.07 in. from full left

Doors On
Density Altitude = 1020 ft
Gross Height = 6155 lbs.
Center of Gravity = 195.7 in. (MID)
Rotor Speed = 324 RPM

Doors Off
Density Altitude = 1100 ft
Gross Height = 7955 lbs.
Center of Gravity = 195.5 (MID)
Rotor Speed = 324 RPM

Tail Rotor Pitch ~ Percent from Full Left

True Airspeed ~ Knots
Figure No. 32
TAIL ROTOR PITCH REQUIRED WITH WIND AZIMUTH 240°
AH-1G USAVX6G15247
OUTBOARD ALTERNATE CONFIGURATION (FAIRED)

NOTES:
1. STANDALONE TAPE ROTOR
2. FULL LEFT PEDAL - 19° TAIL ROTOR WITH SCAG NULL
3. GROUND SPEED DETERMINED WITH CALIBRATED PACE CAR
4. TRUE AIRSPEED DETERMINED BY VECTOR ADDITION OF GROUND SPEED & WIND
5. SOLID SYMBOL DENOTES DATA DERIVED FROM USAVNTA REPORT RQ.06-06 (REF. 8, APP.T)
6. TOTAL DIRECTIONAL CONTROL DISPLACEMENT = 7.0 FT FROM FULL LEFT

DOORS ON
DENSITY ALTITUDE = 900 FT.
GROSS WEIGHT = 8260 LBS.
CENTER OF GRAVITY = 19.8 IN. (MID)
ROTOR SPEED = 324 RPM

DOORS OFF
DENSITY ALTITUDE = 1220 FT.
GROSS WEIGHT = 8260 LBS.
CENTER OF GRAVITY = 19.4 IN. (MID)
ROTOR SPEED = 324 RPM
<table>
<thead>
<tr>
<th>SYM.</th>
<th>GROSS WEIGHT</th>
<th>C.G. STATION</th>
<th>DENSITY ALTITUDE</th>
<th>ROTOR SPEED CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>~LBS.</td>
<td>~IN.</td>
<td>~FT.</td>
<td>~RPM</td>
</tr>
<tr>
<td>O</td>
<td>7265</td>
<td>193.5</td>
<td>1020FT</td>
<td>324 CLEAN</td>
</tr>
<tr>
<td>△</td>
<td>7200</td>
<td>193.3</td>
<td>5000FT</td>
<td>324 CLEAN</td>
</tr>
</tbody>
</table>

**NOTES:**
1. DATA COLLECTED USING THE GROUND SPEED METHOD.
2. DATA COLLECTED USING THE PACER AIRCRAFT METHOD.
3. DATA COLLECTED USING THE TRAILING BOMB METHOD.
4. SHAD ED SYMBOLS DENOTE CLIMB AT LIMIT POWER.
5. FLAGGED SYMBOLS DENOTE AUTOROTATION.
APPENDIX III. TEST INSTRUMENTATION

Flight test instrumentation was installed in the test helicopter prior to the start of this evaluation. This instrumentation provided data from four sources; pilot's panel, copilot/gunner's panel, photopanel and a 24-channel oscillograph. All instrumentation was calibrated. The flight test instrumentation was installed and maintained by the Instrumentation Branch, Logistics Division, USAASTA.

PILOT'S PANEL

Standard system airspeed  
Boom system airspeed  
Boom system altitude  
Rate of climb  
Gas producer speed  
Torque pressure (standard system)  
Exhaust gas temperature  
Longitudinal control position  
Lateral control position  
Pedal control position  
Collective control position  
Center of gravity normal acceleration  
Angle of sideslip

ENGINEER'S PANEL

Boom system airspeed  
Boom system altitude  
Outside air temperature  
Rotor speed  
Gas producer speed  
Fuel used total  
Torque pressure (high)  
Torque pressure (low)  
Exhaust gas temperature  
Oscillograph correlation counter  
Photopanel correlation counter  
Fuel temperature
PHOTOPANEL

Boom system airspeed
Standard system airspeed
Boom system airspeed
Rotor speed
Gas producer speed
Fuel used total
Torque pressure (high)
Torque pressure (low)
Exhaust gas temperature
Compressor inlet temperature
Compressor inlet total pressure
Inlet guide vane position
Bleed band position (light)
Fuel pressure at nozzle
Time (10-second stopwatch)
Oscillograph correlation counter
Photopanel correlation counter
Engineer's event
Pilot's event

OSCILLOGRAPH

Longitudinal control position
Lateral control position
Directional control position
Collective control position
Pitch attitude
Roll attitude
Yaw attitude
Pitch rate
Roll rate
Yaw rate
CG normal acceleration
Angle of sideslip
Angle of attack
Engineer's event
Pilot's event
Photopanel correlation blip
APPENDIX IV. BASIC AIRCRAFT DATA & OPERATING LIMITS

AIRCRAFT DATA

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall length (rotor turning)</td>
<td>637.2 inches</td>
</tr>
<tr>
<td>Overall width (rotor trailing)</td>
<td>124.0 inches</td>
</tr>
<tr>
<td>Center line of main rotor to center line of tail rotor</td>
<td>320.7 inches</td>
</tr>
<tr>
<td>Elevator area (total)</td>
<td>198.6 inches</td>
</tr>
<tr>
<td>Elevator area (both panels)</td>
<td>10.9 square feet</td>
</tr>
<tr>
<td>Elevator airfoil section</td>
<td>Inverted Clark Y</td>
</tr>
<tr>
<td>Vertical stabilizer area</td>
<td>18.5 square feet</td>
</tr>
<tr>
<td>Vertical stabilizer airfoil section</td>
<td>Special chamber</td>
</tr>
<tr>
<td>Fuselage Station (FS)</td>
<td>499.0</td>
</tr>
</tbody>
</table>

Wing area:
- Total: 27.8 square feet
- Outboard of B.L. 18.0 (both sides): 18.5 square feet
- Tip: 10.33 feet
- Wing airfoil section:
  - Root: NACA 0030
  - Tip: NACA 0024
  - Angle of incidence: 14 degrees

MAIN ROTOR DATA

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of blades</td>
<td>2</td>
</tr>
<tr>
<td>Diameter</td>
<td>44 feet</td>
</tr>
<tr>
<td>Disc area</td>
<td>1520.4 square feet</td>
</tr>
<tr>
<td>Blade chord</td>
<td>27 inches</td>
</tr>
<tr>
<td>Rotor solidity</td>
<td>0.065</td>
</tr>
<tr>
<td>Blade area (both blades)</td>
<td>99 square feet</td>
</tr>
<tr>
<td>Blade airfoil</td>
<td>9.33 percent symm.</td>
</tr>
<tr>
<td>Blade twist</td>
<td>Section special</td>
</tr>
<tr>
<td>Hub precone angle</td>
<td>-0.455 deg/ft</td>
</tr>
<tr>
<td></td>
<td>2.75 degrees</td>
</tr>
</tbody>
</table>
ANTITORQUE ROTOR DATA

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of blades</td>
<td>2</td>
</tr>
<tr>
<td>Diameter</td>
<td>8.5 feet</td>
</tr>
<tr>
<td>Disc area</td>
<td>56.74 square feet</td>
</tr>
<tr>
<td>Blade chord</td>
<td>8.41 inches</td>
</tr>
<tr>
<td>Rotor solidity</td>
<td>0.105</td>
</tr>
<tr>
<td>Blade airfoil</td>
<td>NACA 0010 modified</td>
</tr>
<tr>
<td>Blade twist</td>
<td>Zero degrees</td>
</tr>
</tbody>
</table>

TRANSMISSION DRIVE SYSTEM RATIOS

<table>
<thead>
<tr>
<th>Ratio Description</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine to main rotor</td>
<td>20.383:1.0</td>
</tr>
<tr>
<td>Engine to antitorque rotor</td>
<td>3.990:1.0</td>
</tr>
<tr>
<td>Engine to antitorque drive system</td>
<td>1.535:1.0</td>
</tr>
</tbody>
</table>

LIMIT AIRSPEED ($V_L$)

Any configuration with XM159 rocket pods: 180 KCAS below a 3000-foot density altitude; decrease 8 KCAS per 1000 feet above 3000 feet.

All other configurations: 190 KCAS below a 4000-foot density altitude; decrease 8 KCAS per 1000 feet above 4000 feet.

GROSS WEIGHT/CENTER OF GRAVITY ENVELOPE

Forward center of gravity limit: Below 7000 pounds, FS 190.0; linear increase to FS 192.1 at 9500 pounds.

Aft center of gravity limit: Below 7880 pounds FS 201.4; linear decrease to FS 200 at 9500 pounds.

SIDESLIP LIMITS

Five degrees at $V_L$ with linear increase at 20 degrees at 60 KCAS.

ROTOR AND ENGINE SPEED LIMITS (Steady State)

Power on:

| Engine rpm | 6600 to 6400 |
| Rotor rpm  | 324 to 314    |
Power off:
   Rotor rpm transient lower limit 304 to 339
   Rotor rpm 250

Power on during dives and maneuvers:
   Rotor rpm 319 to 324

TEMPERATURE AND PRESSURE LIMITS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine oil temperature</td>
<td>95°C</td>
</tr>
<tr>
<td>Transmission oil temperature</td>
<td>110°C</td>
</tr>
<tr>
<td>Engine oil pressure</td>
<td>25 to 100 psi</td>
</tr>
<tr>
<td>Transmission oil pressure</td>
<td>30 to 70 psi</td>
</tr>
<tr>
<td>Fuel pressure</td>
<td>5 to 20 psi</td>
</tr>
</tbody>
</table>

T53-L-13 ENGINE LIMITS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal rated (maximum continuous)</td>
<td>625°C</td>
</tr>
<tr>
<td>Military rated (30-minute limit)</td>
<td>645°C</td>
</tr>
<tr>
<td>Starting and acceleration (5-second limit)</td>
<td>675°C</td>
</tr>
<tr>
<td>Maximum for starting and acceleration</td>
<td>760°C</td>
</tr>
<tr>
<td>Torque pressure limit</td>
<td>50 psi</td>
</tr>
</tbody>
</table>
APPENDIX V. TEST TECHNIQUES & DATA REDUCTION PROCEDURES

INTRODUCTION

Nondimensional Method

1. Level-flight helicopter performance results may be generalized through use of nondimensional coefficients. Test results obtained at specific test conditions may be used to define accurately, performance at conditions not specifically tested. The following nondimensional coefficients were used to generalize the level-flight test results obtained during this flight test program.

\[ \text{Power Coefficient } = \frac{C_p}{\rho A (QR)^3} = \frac{550 \text{ SHP}}{\rho A (QR)^3} \]

\[ \text{Thrust Coefficient } = C_T = \frac{WT}{\rho A (QR)^2} \]

\[ \text{Tip-Speed Ratio } = \mu = \frac{1.689 V_T}{QR} \]

Instrumentation

2. All instrumentation was calibrated prior to being installed in the aircraft. A detailed tabulation of the instrumentation used is given in appendix III. All quantitative data obtained during this flight test program were derived from special sensitive instrumentation. Data were obtained from four sources:

   a. Oscillograph.
   b. Photopanel.
   c. Pilot's panel (hand recorded).
   d. Engineer's panel (hand recorded).

Weight and Balance

3. A high degree of control was maintained on weight and balance of the test helicopter. Variations in empty gross weight and cg...
because of changes in instrumentation of helicopter components were defined by periodically weighing the helicopter. Fuel load was defined by measuring the fuel specific gravity and temperature after each fueling, and by using an external sight gage on the calibrated fuel cell to determine fuel volume. Fuel used in flight was recorded by a calibrated fuel-used system, and the results were cross-checked with the sight gage reading following each flight. Helicopter loading and cg were controlled by using ballast.

PERFORMANCE TEST

Level Flight

4. Level flight performance was defined by measuring the shaft horsepower required to maintain level flight throughout the airspeed range of the helicopter. A constant $C_T$ was maintained by increasing altitude as fuel was consumed. A broad range of thrust coefficients was flown in the hog configuration. One speed power was flown in each of the other wing armament configurations. The results of the hog configuration level-flight tests were converted to nondimensional form and carpet-plotted as $C_p$ versus $C_T$ with lines of constant tip-speed ratio ($\mu$). This carpet plot defined level flight performance for all gross weights, density altitudes and airspeeds throughout the range of $C_T$ tested. The level-flight performance data for the other wing armament configurations were compared to the clean configuration for increase in equivalent flat plate area ($f$):

$$\Delta f = \frac{2 \Delta C_p A (\Omega R)^3}{(V_T \times 1.689)^3}$$

$$\Delta f = \frac{2 \Delta C_p A}{(\mu)^3}$$

5. Specific range performance was calculated from the true airspeed at a power setting and the engine fuel flow at that power setting.

$$\text{Specific Range} = \frac{\text{true airspeed} \cdot \text{nautical air miles}}{\text{fuel flow} \cdot \text{per pound of fuel}}$$
Autorotation

6. Autorotational descent performance data were acquired during sawtooth autorotations. Variation in rate of descent with airspeed was defined by stabilizing at a constant airspeed with a rotor speed of 324 r.p.m. and measuring rate of descent. To determine the effect of rotor speed upon rate of descent, airspeed was stabilized and rotor speed was varied. The observed rate of descent was corrected to tape-line rate of descent by the expression:

\[
\frac{R}{D_{tapeline}} = \frac{(dhp/dt)(T_a/T_{std})}{(dhp/dt)(T_a/T_{std})}
\]

Power Determination

7. The engine torquemeter is essentially a piston (restrained by oil) the pressure of which is proportional to the power output of the engine. The equation for determining the test shp as obtained from engine manufacturer test cell calibration curves is developed as outlined in paragraphs 8 through 12.

8. The horsepower transmitted by a rotating shaft may be expressed in the following manner:

\[
SHP = \frac{2\pi}{12 \times 33,000} \times N_E \times TRQ
\]

9. Calibration of the engine torquemeter system indicated that the engine shaft output torque was slightly nonlinear as a function of indicated torque pressure. This nonlinear relationship is graphically presented in figure I. This plot was used to obtain engine output torque (TRQ) by the graph with engine output torque pressure (P).

10. The rotor speed can be determined from engine output shaft speed as follows:

\[
N_R = \frac{N_E}{20.383}
\]

11. Substituting the last equations, a convenient equation for determining output shaft horsepower can be developed:

\[
SHP = \frac{2\pi \times 20.383 \times TRQ \times N_R}{12 \times 33,000} = 3.234 \times 10^{-4} \times TRQ \times N_R
\]

12. This equation was used during the program to determine the shaft horsepower for each test condition.

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Figure No. 1

ENGINE CHARACTERISTICS
T53-L-13 945E14001

NOTES: 1. POINTS OBTAINED FROM ENGINE MANUFACTURES
        CALIBRATION TEST CONDUCTED ON 22 AUGUST 1967

2. DASHED LINE OBTAINED FROM LYCOMING T-53-L-13
        ENGINE MODEL SPECIFICATION NO. 104-33

ENGINE OUTPUT TORQUE - TRQ - IN. LB.

ENGINE OUTPUT TORQUE PRESSURE ~ PSI, AT. OF H2O
STABILITY AND CONTROL

Directional Control Evaluation

13. Directional control tests were conducted by stabilizing the helicopter at various azimuths and airspeeds and by recording the required control positions to maintain the desired heading. A ground vehicle with a calibrated speedometer was used as an aid in stabilizing the helicopter. Ambient wind velocity and direction were measured by vane and anemometer at a location free from the effect of rotor downwash. Tests were conducted when wind velocities were less than 4 knots.

MISCELLANEOUS

Engine "Beep" Control Characteristics

14. The engine "beep" control characteristics were defined both with a loaded and unloaded main rotor system. The engine "beep" control characteristics were defined by stabilizing at a rotor speed of 324 rpm while in level flight and on the ground. The engine "beep" control was then actuated for a specified amount of time. A continuous record was made of engine and rotor speed response during the maneuver. This process was repeated until the entire speed-range authority of the "beep" control was determined.

Airspeed Calibration

15. The test airspeed indicator system (boom) was calibrated by comparing its readings to a known reference. A calibrated trailing bomb was suspended from the helicopter with a cable approximately 50 feet in length to avoid proximity effect. The aircraft was then stabilized at various airspeeds in level flight, climb and autorotation. By comparing the airspeed corrected for instrument errors of the boom system to the bomb system, the error was defined.

16. The test airspeed indicator system (boom) was calibrated at higher airspeeds, in level flight and dive using a T-28 pacer aircraft. The test and pacer aircraft were stabilized at the same airspeed, and data were recorded in each aircraft simultaneously. Since the position error of the pacer is known, the calibrated airspeed of the aircraft can be readily computed.
## APPENDIX VI. SYMBOLS & ABBREVIATIONS

Listed and defined in the following table are symbols and abbreviations used in this report.

<table>
<thead>
<tr>
<th>Symbols and Abbreviations</th>
<th>Definition</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rotor disc area</td>
<td>ft²</td>
</tr>
<tr>
<td>CG, cg</td>
<td>Center of gravity</td>
<td>---</td>
</tr>
<tr>
<td>Cₚ</td>
<td>Power coefficient</td>
<td>---</td>
</tr>
<tr>
<td>Cₜ</td>
<td>Thrust coefficient</td>
<td>---</td>
</tr>
<tr>
<td>DEG, deg</td>
<td>Degrees</td>
<td>degrees</td>
</tr>
<tr>
<td>dhp/dt</td>
<td>Rate of descent</td>
<td>ft/min</td>
</tr>
<tr>
<td>ECT</td>
<td>Engine exhaust gas temperature</td>
<td>°C</td>
</tr>
<tr>
<td>f</td>
<td>Equivalent flat plate area</td>
<td>ft²</td>
</tr>
<tr>
<td>fig., figs.</td>
<td>Figure, figures</td>
<td>---</td>
</tr>
<tr>
<td>ft</td>
<td>Feet</td>
<td>feet</td>
</tr>
<tr>
<td>FS</td>
<td>Fuselage Station</td>
<td>inches</td>
</tr>
<tr>
<td>fwd</td>
<td>Forward</td>
<td>---</td>
</tr>
<tr>
<td>GRWT, grwt</td>
<td>Gross weight</td>
<td>pounds</td>
</tr>
<tr>
<td>H₀</td>
<td>Density altitude</td>
<td>feet</td>
</tr>
<tr>
<td>IGE</td>
<td>In ground effect</td>
<td>---</td>
</tr>
<tr>
<td>in.</td>
<td>Inch, inches</td>
<td>inches</td>
</tr>
<tr>
<td>KCAS</td>
<td>Knots calibrated airspeed</td>
<td>knots</td>
</tr>
<tr>
<td>KIAS</td>
<td>Knots indicated airspeed</td>
<td>knots</td>
</tr>
<tr>
<td>KTAS</td>
<td>Knots true airspeed</td>
<td>knots</td>
</tr>
<tr>
<td>Symbols and Abbreviations</td>
<td>Definition</td>
<td>Units</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>LB, lb</td>
<td>Weight</td>
<td>pounds</td>
</tr>
<tr>
<td>MAX, max</td>
<td>Maximum</td>
<td>---</td>
</tr>
<tr>
<td>MIN, min</td>
<td>Minimum</td>
<td>---</td>
</tr>
<tr>
<td>NAMPP</td>
<td>Nautical air miles per pound of fuel</td>
<td>---</td>
</tr>
<tr>
<td>N\textsubscript{E}</td>
<td>Engine speed</td>
<td>rpm</td>
</tr>
<tr>
<td>N\textsubscript{R}</td>
<td>Main rotor speed</td>
<td>rpm</td>
</tr>
<tr>
<td>N\textsubscript{1}</td>
<td>Engine compressor speed</td>
<td>percent</td>
</tr>
<tr>
<td>P</td>
<td>Engine output torque pressure</td>
<td>in. of Hg</td>
</tr>
<tr>
<td>psi</td>
<td>Pounds per square inch</td>
<td>lb/in\textsuperscript{2}</td>
</tr>
<tr>
<td>R</td>
<td>Rotor radius</td>
<td>feet</td>
</tr>
<tr>
<td>R/D</td>
<td>Rate of descent</td>
<td>ft/min</td>
</tr>
<tr>
<td>ref</td>
<td>Reference or referred</td>
<td>---</td>
</tr>
<tr>
<td>RPM, rpm</td>
<td>Revolutions per minute</td>
<td>rpm</td>
</tr>
<tr>
<td>SCAS</td>
<td>Stability control augmentation system</td>
<td>---</td>
</tr>
<tr>
<td>SEC</td>
<td>Second</td>
<td>---</td>
</tr>
<tr>
<td>SHP, shp</td>
<td>Shaft horsepower</td>
<td>---</td>
</tr>
<tr>
<td>S/N</td>
<td>Serial number</td>
<td>---</td>
</tr>
<tr>
<td>STD, std</td>
<td>Standard</td>
<td>---</td>
</tr>
<tr>
<td>TEMP, temp</td>
<td>Temperature</td>
<td>°F or °C</td>
</tr>
<tr>
<td>TRQ</td>
<td>Engine output torque</td>
<td>in-lb</td>
</tr>
<tr>
<td>WT</td>
<td>Weight</td>
<td>pounds</td>
</tr>
<tr>
<td>V\textsubscript{cal}</td>
<td>Calibrated airspeed</td>
<td>knots</td>
</tr>
<tr>
<td>Symbols and Abbreviations</td>
<td>Definition</td>
<td>Units</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>$V_{\text{cruise}}$</td>
<td>Cruise airspeed</td>
<td>knots</td>
</tr>
<tr>
<td>$V_{H}$</td>
<td>Maximum airspeed for level flight</td>
<td>knots</td>
</tr>
<tr>
<td>$V_{L}$</td>
<td>Limit airspeed</td>
<td>knots</td>
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<tr>
<td>$V_{T}$</td>
<td>True airspeed</td>
<td>knots</td>
</tr>
<tr>
<td>$W_a$</td>
<td>Engine air flow</td>
<td>lb/hour</td>
</tr>
<tr>
<td>$W_{bl}$</td>
<td>Engine bleed air flow</td>
<td>lb/hour</td>
</tr>
<tr>
<td>$^\circ C$</td>
<td>Degrees centigrade</td>
<td>degrees</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>Difference</td>
<td>---</td>
</tr>
<tr>
<td>$\Omega$</td>
<td>Main rotor angular velocity</td>
<td>radians/sec</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Tip-speed ratio</td>
<td>---</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Air mass density</td>
<td>slugs/ft$^3$</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Temperature ratio</td>
<td>---</td>
</tr>
<tr>
<td>$%$</td>
<td>Percent</td>
<td>---</td>
</tr>
</tbody>
</table>

Listed below are the subscripts used in this report.

- $a$: Ambient
- $\text{std}$: Standard
- $t$: Test
<table>
<thead>
<tr>
<th>CONTROLLABLE</th>
<th>SATISFACTORY</th>
<th>EXCELLENT, HIGHLY DESIRABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPABLE OF BEING CONTROLLED OR MANAGED IN CONTEXT OF MISSION, WITH AVAILABLE PILOT ATTENTION</td>
<td>MEETS ALL REQUIREMENTS AND EXPECTATIONS, GOOD ENOUGH WITHOUT IMPROVEMENT CLEARLY ADEQUATE FOR MISSION.</td>
<td>GOOD, PLEASANT, WELL BEHAVED</td>
</tr>
<tr>
<td>PILOT COMPENSATION, IF REQUIRED TO ACHIEVE ACCEPTABLE PERFORMANCE, IS FEASIBLE.</td>
<td>UNSATISFACTORY RELUCTANTLY ACCEPTABLE, DEFICIENCIES WHICH WARRANT IMPROVEMENT, PERFORMANCE ADEQUATE FOR MISSION WITH FEASIBLE PILOT COMPENSATION.</td>
<td>SOME MINOR BUT ANNOYING DEFICIENCIES. IMPROVEMENT IS REQUESTED. EFFECT ON PERFORMANCE IS EASILY COMPENSATED FOR BY PILOT.</td>
</tr>
<tr>
<td>UNACCEPTABLE DEFICIENCIES WHICH REQUIRE MANDATORY IMPROVEMENT, INADEQUATE PERFORMANCE FOR MISSION EVEN WITH MAXIMUM FEASIBLE PILOT COMPENSATION.</td>
<td>MAJOR DEFICIENCIES WHICH REQUIRE MANDATORY IMPROVEMENT FOR ACCEPTANCE, CONTROLABLE. PERFORMANCE INADEQUATE FOR MISSION, OR PILOT COMPENSATION REQUIRED FOR MINIMUM ACCEPTABLE PERFORMANCE IN MISSION IS TOO HIGH.</td>
<td>CONTROLLABLE WITH DIFFICULTY. REQUIRES SUBSTANTIAL PILOT SKILL AND ATTENTION TO RETAIN CONTROL AND CONTINUE MISSION.</td>
</tr>
<tr>
<td>UNCONTROLLABLE CONTROL WILL BE LOST DURING SOME PORTION OF MISSION.</td>
<td>CONTROLLABLE IN MISSION.</td>
<td>MARGINALLY CONTROLABLE IN MISSION. REQUIRES MAXIMUM AVAILABLE PILOT SKILL AND ATTENTION TO RETAIN CONTROL.</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>A8</th>
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<th>A10</th>
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APPENDIX VII. PILOT RATING SCALE
The AH-1G helicopter Phase B, Part 6 test program was conducted at Shafter, California, and Edwards Air Force Base, California, from 12 March through 3 May 1968 by the US Army Aviation Systems Test Activity, Edwards Air Force Base, California. The program was conducted to determine level flight performance, autorotational performance, engine characteristics, armed helicopter mission capability and to evaluate the in-ground-effect (IGE) handling qualities with the canopy doors removed. The helicopter is directionally unstable when hovering IGE with either the doors on or off in winds of 9 to 13 knots for azimuth range from 160 to 260 degrees (clockwise from nose of aircraft). This instability is a major deficiency and detracts from the mission capability of the aircraft. Undue pilot attention is required to avoid overtorquing the main transmission during maneuvers requiring abrupt left-lateral cyclic inputs in forward flight. This overtorque condition will only occur below the critical altitude of the engine. Additional deficiencies and shortcomings have been published in previous reports. Sufficient performance data were not obtained to determine the guarantee compliance.
<table>
<thead>
<tr>
<th>KEY WORDS</th>
<th>LINK A</th>
<th>LINK B</th>
<th>LINK C</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH-1G helicopter</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Phase B, Part 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conducted to determine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level flight performance</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Autorotational performance</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Engine characteristics</td>
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<td></td>
<td></td>
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<tr>
<td>Armed helicopter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mission capability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handling qualities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canopy doors removed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directionally unstable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hovering IGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overtorquing main transmission</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>