ENGINEERING DESIGN TEST 4
YAH-64 ADVANCED ATTACK HELICOPTER

FINAL REPORT

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MAY 14 1981

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**Abstract:**
Engineer Design Test 4 (EDT-4) was conducted using a prototype YAH-64 aircraft (S/N 77-23258). This test was conducted at Palomar Airport, Carlsbad, California, (elevation 328 feet) between 10 and 29 November 1980. Approximately 33 hours were flown during 27 flights. Major changes affecting performance and handling qualities were made to the YAH-64 since the last evaluation (EDT-2). These included a new, digital stability augmentation system, and a redesigned empennage featuring an automatically programmed stabilator and an increased diameter tail rotor. In previous evaluations the flight envelope and scope of test were limited by structural loads and continuous monitoring of those loads was required for all flights. During this test the flight envelope was much larger and no structural limits were encountered. Hover and level flight performance of the aircraft have been improved since
EDT-2. Handling qualities have been greatly improved. The most significant areas of handling qualities improvements were in low-speed flight characteristics, including directional control margins, short-period dynamic stability characteristics (particularly in high speed flight), and in aircraft pitch attitude during approaches and IRP climbs. Three deficiencies were found during this evaluation. The disengagement of the HARS, DASE, and automatic operation of the stabilator, and erroneous activation of the engine out/low rotor speed audio warning tone with failure of the No. 1 generator, random failure of the master caution light to illuminate with the illumination of some caution or warning panel segment lights; and the restricted pilot's field of view caused by canopy frame structure during NOE and contour flight. Vibration levels have been significantly reduced since EDT-2 but are still objectionable. Forty-four shortcomings were found.
SUBJECT: Directorate for Development and Qualification Position on the Final Report of USAAEFA Project No. 80-03, Engineer Design Test 4, YAH-64 Advanced Attack Helicopter

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1. The purpose of this letter is to establish the Directorate for Development and Qualification position on the subject report. This test was conducted using prototype YAH-64, S/N 77-23258 for the purposes of evaluating improvements in the helicopter. The objectives were to assess the flight handling characteristics with a new empennage configuration, evaluate flight performance, assess changes incorporated to improve vibration characteristics and provide data in establishing the Airworthiness Release for EDT-5.

2. This Directorate agrees with the report findings and conclusions with the following exceptions, and are directed to the report paragraph as indicated.

   a. Paragraph 85e. The revised directional control stop tested is not the final production yaw actuator stop setting. This setting will be established at the conclusion of the altitude testing and be consistent with the specification requirements for directional control margins. A reduced actuator stop setting (equivalent to approximately 27° blade angle) will be used for those aircraft participating in OT-II, however, for structural reasons.

   b. Paragraph 85f. We disagree with the statement that vibration levels were not significantly affected by the removal of the vertical vibration absorber. The absorber was removed midway through EDT-4 for inspection and reinstalled improperly. Consequently, the last half of the flight tests did not generate representative absorber installed data. However, this data was used for comparison with the absorber removed vibration levels. Additionally, a comparison of the low speed flight test results generated prior to removal and reinstallation of the absorber show a significant improvement. This is also supported by the Hughes Helicopters (HH) test results obtained prior to the start of EDT-4. The most important point, however, is the recommendation for further improvement in vibration levels (see paragraph 90c) with which this Directorate strongly supports.
c. Paragraph 86a. As a result of the reported deficiency, HH has modified the electrical system to prevent deactivation of critical relays and incorporated a third bus for OT-II aircraft which will prevent disengagement of the HARS, DASE and automatic operation of the stabilator, and erroneous activation of the engine out/low rotor speed audio tone in the event of a generator failure.

d. Paragraph 86b. The random failure of the master caution light to illuminate with the illumination of some caution or warning panel segment lights has been traced to a faulty master caution panel unit. This unit was replaced and the same failure reoccurred. There appears to be a problem with the caution panel segments not making proper contact to illuminate the master caution light. HH should have this corrected prior to the start of OT-II.

e. Paragraph 86c. The reported restricted pilot's field of view caused by canopy frame structure during NOE and contour flight should not be considered a deficiency only on the basis of an engineering flight evaluation. It is important that qualitative assessments of the aircraft be observed and reported, but the degree of acceptability should remain with the operational evaluators. The recommendation in paragraph 90b suggests emphasis be placed on the characteristics during future operational tests. To increase the probability of successful operational evaluation, the stabilator system has been changed so that pilots can use the stabilator in the manual mode for more efficient attitudes during NOE and contour flying and the maximum down position during manual operation has been increased to 45°.

f. Paragraph 87b. The reported poor design of the pilot's fuel control panel will be corrected for the production aircraft. A magnetic latching switch for the Boost Pump and Tank Select switches will be incorporated so that boost pump ON operation cannot be initiated unless Tank Select is in AFT TK. Likewise, if Tank Select is moved to any position from AFT TK, the boost pump switch will automatically go to OFF. The boost pump ON light will be moved to the caution/advisory panel and a transfer pump function light on the caution/advisory panel will be added. The corrections to the fuel panel will provide an adequate fuel system for the production of AAI.

g. Paragraph 87c. Reported HARS inaccuracies reflected excessive alignment times and heading errors once aligned. The current alignment times exceed specification requirements, but should be corrected for production. The HARS accuracy has been demonstrated to be within specification requirements, and is satisfactory for OT-II testing. The test unit was apparently malfunctioning and should be examined.

h. Paragraph 87d. The absence of SAS pitch rate damping at load factors greater than 1.5 due to saturation of the pitch SAS actuator is not considered a significant enough shortcoming, as indicated in paragraph 87, to warrant modification to the DASE.
1. Paragraph 87f. The reported objectionable 4/rev vertical vibration in rearward flight will be reduced with the use of manual stabilator incidence scheduling. The reported high lateral vibration levels in right sideward flight and high vertical vibration levels during the termination of an approach are characteristic of the helicopter but can be reduced with properly tuned vibration absorbers.

j. Paragraph 87h. Although the poor trimmability at airspeeds between 85 and 110 KCAS is reported as a shortcoming, it is important to note that the IMC evaluation with DASE on yielded a HQRS of 3-4, thereby implying that trimmability appears to be an insignificant problem. Additionally, if the aircraft is enroute at this airspeed range, which is slower than a normal "enroute" speed, and maintaining level flight, then the attitude hold mode engagement would minimize excursions, thereby reducing pilot workload. Therefore, no corrective action is planned at this time.

k. Paragraph 87i. The final determination of the IMC capability should be held until an evaluation of the helicopter with production flight instruments is performed. DASE modifications can possibly be implemented to minimize sideslip excursions from a referenced value equal to "ball centered" (i.e., zero bank angle) flight as opposed to a zero sideslip reference.

l. Paragraph 87l. Although the longitudinal control trim shift from 12 to 18 KTAS is reported as a shortcoming, it is not considered significant enough to warrant modification to the airframe/flight control system.

m. Paragraph 87m. The degree of control trim shifts between 16 and 24 KTAS rearward and between 13 and 18 KTAS forward are not believed to warrant modification to the airframe/flight controls.

n. Paragraph 87n. The improper operation of the stabilator during minimum power descents at 50 and 60 KCAS has been corrected. The random dropout was resolved by increasing the allowable difference between pitot 1 and pitot 2, thereby decreasing the effects of airspeed perturbations. Inaccuracies in the ADS were corrected, thereby improving the stabilator positioning below 60 knots (ADS provides the airspeed signal to the stabilator system below 60 knots).

o. Paragraph 87o. The periodic sampling of hydraulic fluid, as required by Hughes Program Directive 077, is being conducted to check against contamination and to provide baseline data for wear rate to be used in the establishment of preventive maintenance procedures. Production aircraft will not require periodic sampling of flight control hydraulics and therefore cost need not be incurred to provide an easier method for sampling.
p. **Paragraph 88b.** The system tested operated per the specification which provides light segments for each 2% of range and was previously approved at a lighted mock-up inspection by the Army. Any action to display the full green range during normal operation will be held in abeyance until the completion of operational testing.

q. **Paragraph 88f.** The location of the pilot engine control quadrant is not considered a shortcoming. The layout of this quadrant was carefully evaluated at design reviews, mock-up reviews and previous Government flight testing.

r. **Paragraph 88j.** The constant illumination of the lower green segment light on the Marconi vertical scale was designed into the system to provide the pilot an indication that electrical power is being supplied to the instrument and will be retained.

s. **Paragraph 88l.** The anthropometric design of the pilot's cyclic grip is not considered a shortcoming. The design of the grip meets the 5th-95th percentile operator. However, this grip is not considered satisfactory for the total system's operation of the AAH and a new standard grip is available for the production aircraft.

t. **Paragraph 88n.** The cockpit, seats and controls were designed to accommodate the 5th and 95th percentile aviator using US Army anthropometric measurements. As a cost avoidance item, longitudinal seat adjustments were not included in the AAH specification.

u. **Paragraph 88o.** The problem in operating the HARS control switch is due to the smooth knob installed on the test aircraft. The production design will incorporate a knurled knob for easy activation.

v. **Paragraph 88r.** All switches were allocated on a priority basis and reviewed during design, mock-up and cockpit reviews. A better evaluation of the adequacy of these switches will be determined during the icing survey.

3. As relates to recommendations, this Directorate concurs, with the exception of paragraph 90d (relating to shortcoming 87d), 90o and 90q. Rationale for these exceptions are apparent in the appropriate comments of paragraph 2 above.
4. As noted in the report, AEFA conducted those tests necessary to measure power required in level flight and for out-of-ground effect hover. This data (corrected for test instrumentation drag effects) must be used in conjunction with power available to calculate cruise performance and rate of climb. Using calculated power available from the T700-GE-700 model specification and the installation losses measured during contractor flight test, it can be determined that the maximum mission gross weight that the YAH-64 will meet the 450 ft per minute vertical rate of climb requirement using 95% of Intermediate Rated Power when operating under 4000 ft/35°C temperature conditions is approximately 14,325 pounds. At this mission gross weight, the cruise speed at Maximum Continuous Power is approximately 140 KTAS, which is less than the Military Need requirement of 145 knots. Incorporation of the T700-GE-701 engine currently planned by the Army Program Manager will result in cruise speed performance which will meet the Military Need and vertical rates of climb substantially greater than the 450 ft requirement without a major weight reduction effort for the production model.

5. The overall results of this evaluation substantiate the modified empennage design (stabilator) and supports the continued evaluation of the YAH-64 in the attack helicopter role.

FOR THE COMMANDER:

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

BACKGROUND

1. In June 1973, the United States Army Aviation Systems Command (since renamed the United States Army Aviation Research and Development Command), awarded a Phase I Advanced Development Contract to Hughes Helicopters (HH). The contract required HH to design, develop, fabricate, and initiate a development/qualification effort on two Advanced Attack Helicopter (AAH) prototypes and a ground test vehicle as part of a Government Competitive Test. The United States Army Aviation Engineering Flight Activity (USAAEFA) conducted Development Test 1 (DT-1) using two of these aircraft (ref 1, app A). In December 1976, the United States Army Aviation Research and Development Command (AVRADCOM) awarded a Phase 2 Engineering Development Contract to HH for further development and qualification of the YAH-64 to include subsystems and mission equipment. During this program, Engineer Design Tests (EDT) 1 and 2 were conducted to evaluate developmental progress (refs 2 and 3). In August 1980, AVRADCOM requested USAAEFA to conduct this test, EDT-4, which follows major changes to improve flying qualities, structural integrity, flight performance and vibration characteristics (ref 4). A test plan (ref 5) was submitted in September 1980, and an Airworthiness Release (ref 6) was issued in October 1980 and revised in November 1980.

TEST OBJECTIVES

2. The objectives of this test were to assess the flight handling characteristics with the new empennage configuration, evaluate flight performance parameters, evaluate changes made to improve vibration characteristics, and provide data to be used in establishing the air vehicle flight envelope for EDT-5.

DESCRIPTION

3. The YAH-64 is a two-place, tandem-seat, twin-engine helicopter with four-bladed main and antitorque rotors and conventional wheel landing gear. The helicopter is powered by two General Electric YT700-GE-700R turboshaft engines. The YAH-64 has a moveable horizontal stabilator. A 30mm gun is mounted on the underside of the fuselage below the front cockpit. The helicopter has a wing with two store pylons on each side to carry HELLFIRE missiles or 2.75-inch folding fin aerial rockets. The test aircraft was US Army serial number (S/N) 77-23258. Major changes to the helicopter since EDT-2 include:

a. Moveable horizontal stabilator
b. Increased tail rotor diameter
c. Digital Automatic Stabilization Equipment (DASE)
d. Wing flap position fixed
e. Drag reduction fairings
f. Vibration absorbers
g. Stiffened canopy.
An aerodynamic mockup of the Martin-Marietta Target Acquisition Designation System/Pilot Night Vision System (TADS/PNVS) was installed. Further description of the helicopter is contained in the System Specification (ref 7, app A) and in appendix B.

TEST SCOPE

4. Flight testing for EDT-4 was conducted at Palomar Airport, Carlsbad, California (328-foot elevation) from 3 through 19 November 1980. A total of 27 flights were conducted during which 32.7 hours were flown. Two Army pilots performed the evaluation with an HH pilot acting as the aircraft commander. HH installed, calibrated, and maintained the test instrumentation and performed all aircraft maintenance during the test. Flight restrictions and operating limitations contained in the Airworthiness Release issued by AVRADCOM and the Draft Contractor's Flight Manual (ref 8, app A), were observed during the evaluation. Where possible, flight test data were compared to the system specification and results obtained during EDT-2. The scope of the test is shown in table 1.

TEST METHODOLOGY

5. Established flight test techniques and data reduction procedures were used (refs 9 and 10, app A). Test methods are briefly discussed in the Results and Discussion section of this report. A vibration rating scale (VRS) (fig 1, app D) was used to augment crew comments relative to aircraft vibration levels. A handling qualities rating scale (HQRS) (fig 3, app D) was used to supplement pilot comments on the handling qualities. Flight test data were obtained from calibrated test instrumentation and were recorded on magnetic tape. Real time telemetry was used to monitor selected critical parameters throughout the flight test. A detailed listing of the test instrumentation is contained in appendix C. Data analysis methods are described in appendix D.
### Table 1. Test Scope

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<th>Type of Test</th>
<th>Gross Weight (lb)</th>
<th>Longitudinal Center of Gravity Location (ft)</th>
<th>Density Altitude (ft)</th>
<th>Trim Airspeed</th>
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<tr>
<td>Hover</td>
<td>13000 to 17960</td>
<td>205.0 (Aft)</td>
<td>1220</td>
<td>0</td>
<td>100-foot wheel height</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Performance</td>
<td>14660</td>
<td>202.0 (Fwd)</td>
<td>1360</td>
<td>43 to 147</td>
<td>Thrust coefficient, ( C_T = 0.007644 )</td>
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<td></td>
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<td>202.0 (Fwd)</td>
<td>5420</td>
<td>43 to 143</td>
<td>( C_T = 0.00833 )</td>
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<tr>
<td></td>
<td>1540</td>
<td>202.0 (Fwd)</td>
<td>6380</td>
<td>43 to 138</td>
<td>( C_T = 0.00833 )</td>
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<tr>
<td></td>
<td>15640</td>
<td>202.2 (Fwd)</td>
<td>9720</td>
<td>43 to 123</td>
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<td>in trimmed</td>
<td>15500</td>
<td>202.2 (Fwd)</td>
<td>4940</td>
<td>51.167</td>
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<td>Accelerations-decelerations, approaches, up to the earth, contour simulated IMC flight</td>
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NOTES:
1 Configuration 8-HELLFIRE except hover performance which was flown clean wing. Rotor speed 290 RPM (100%) except hover performance which was flown at 281, 290, and 298 RPM, DASE ON.
²IRP = Intermediate Rated Power
³DAS (Digital Automatic Stabilization) Equipment (DASE) ON and OFF
⁴Airspeeds listed are true rather than calibrated.
\( V_{NE} \) = never exceed airspeed
⁵IMC = Instrument Meteorological Conditions
RESULTS AND DISCUSSION

GENERAL

6. Major changes affecting performance and handling qualities were made to the YAH-64 since the last evaluation (EDT-2). These included a new, digital stability augmentation system, and a redesigned empennage featuring an automatically programmed stabilator and an increased diameter tail rotor. In previous evaluations the flight envelope and scope of test were limited by structural loads and continuous monitoring of those loads was required for all flights. During this test the flight envelope was much larger and no structural limits were encountered. Hover and level flight performance of the aircraft have been improved since EDT-2. Handling qualities have been greatly improved. The most significant areas of handling qualities improvements were in low-speed flight characteristics, including directional control margins, short-period dynamic stability characteristics (particularly in high speed flight), and in aircraft pitch attitude during approaches and IRP climbs. Three deficiencies were found during this evaluation: The disengagement of the HARS, DASE, and automatic operation of the stabilator, and erroneous activation of the engine out/low rotor speed audio warning tone with failure of the No. 1 generator; random failure of the master caution light to illuminate with the illumination of some caution or warning panel segment lights; and the restricted pilot's field of view caused by canopy frame structure during nap-of-the-earth (NOE) and contour flight. Vibration levels have been significantly reduced since EDT-2 but are still objectionable. Forty-four shortcomings were found.

PERFORMANCE

General

7. Out-of-ground-effect (OGE) hover performance and level flight performance were measured during this program. Power required for hovering and level flight is less for the EDT-4 aircraft than for the EDT-2 aircraft. Engine power losses due to installation on the airframe were not determined during this test. Therefore, the performance requirements of the system specification could not be checked. Performance tests were flown at the conditions listed in table 1.

Hover Performance

8. Hover performance was measured at a 100-foot wheel height using primarily the tethered technique with a few free-flight data points. Figure 1, appendix E, presents nondimensional hover performance of the YAH-64 as measured during both EDT-4 and EDT-2. Each of the three lines labeled EDT-2 represent a different rotor speed. Tail rotor efficiency changed significantly with rotor speed and caused the separate performance curves. This was manifested as a change in tail rotor power required with a change in rotor speed at constant main rotor thrust coefficient. During EDT-4, nondimensional hover performance was not affected by changing rotor speed. At a gross weight of 14,200 pounds and atmospheric conditions of 4,000 feet, pressure altitude, and 35°C, the EDT-4 aircraft required 2083 shaft horsepower (SHP) to hover OGE at 100 percent rotor speed. This represents a reduction of 119 SHP (5.4 percent) from the EDT-2 configuration at the same conditions.
Level Flight Performance

9. Power required for level flight was measured in the 8-HELLFIRE configuration at a constant rotor speed (290 rpm). Nondimensional data are presented in figures 2 through 4, appendix E. Figure 5 presents a comparison of performance measured during EDT-4 and EDT-2. Dimensional data for each flight are presented in figures 6 through 9. At the conditions shown in figure 5, the power required for level flight at 145 knots, true airspeed (KTAS) has been reduced from 2090 SHP in EDT-2 to 2065 SHP in EDT-4.

HANDLING QUALITIES

General

10. The handling qualities of the YAH-64 were evaluated at the test conditions listed in table 1. All tests were conducted using standard flight test techniques (ref 10). Maneuvers were flown at zero sideslip where possible. All tests with the exception of longitudinal control system characteristics were conducted with the copilot/gunner (CPG) cyclic stick in the retracted position. Test results were compared, where possible with those previously reported (refs 1 through 3, app A). Additionally, the test data were compared with the requirements of the YAH-64 Phase 2 System Specification (ref 7, app A), where possible.

Control System Characteristics

11. The control system mechanical characteristics were evaluated on the ground with external hydraulic and electrical power applied to the aircraft and the rotors stopped. All measurements were taken at pilots station. Tests were performed with the trim feel system ON and OFF. Longitudinal control system characteristics were evaluated with the CPG cyclic stick extended and retracted which affected the mass balance of the control system. Results were qualitatively verified in flight. Data are presented in figures 10 through 17, appendix E. Table 2 is a summary of the control system mechanical characteristics observed during these tests. The control system characteristics have generally been improved over those previously reported during EDT-2 (ref 3, app A).

12. The longitudinal control system characteristics showed a significant improvement in control centering over that previously reported in EDT-2. With trim feel ON control centering was positive with a trim control displacement band of 0.2 inches which is satisfactory. With the trim feel OFF control force gradients were essentially zero and control centering was absent. Control forces could not be trimmed to zero in flight with the CPG cyclic stick extended and slight forward pressure on the cyclic control was required to maintain the desired trim position. The longitudinal breakout force (plus friction) was excessive. The 2.5 pound breakout force contributed to increased pilot workload when attempting to maintain a precise hover (HQRS 4) and may be significant when hovering with reference to PNVS symbology. The excessive longitudinal breakout force (plus friction) is a shortcoming previously reported. The longitudinal control system characteristics failed to meet requirements of the following paragraphs of reference 7, appendix A.
Table 2. Control System Mechanical Characteristics

<table>
<thead>
<tr>
<th>Test Parameter</th>
<th>Longitudinal$^1$</th>
<th>Longitudinal$^2$</th>
<th>Lateral</th>
<th>Directional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakout force (plus friction) (lb)</td>
<td>1.5 Fwd, 2.5 Aft</td>
<td>2.5 Fwd, 1.4 Aft</td>
<td>1.5 Left, 1.4 Right</td>
<td>5.0 Left, 5.0 Right</td>
</tr>
<tr>
<td>Full control travel (in)</td>
<td>10.2</td>
<td>10.2</td>
<td>8.9</td>
<td>5.4$^4$</td>
</tr>
<tr>
<td>Control oscillation</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Free play (in)</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Mechanical coupling</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Force to move stick 0.5 inch from trim (lb)</td>
<td>2.0 Fwd, 2.8 Aft</td>
<td>3.1 Fwd, 1.8 Aft</td>
<td>1.9 Left, 2.0 Right</td>
<td>N/A</td>
</tr>
<tr>
<td>Limit control force (lb)</td>
<td>8.2 Fwd, 9.0 Aft</td>
<td>8.2 Fwd, 9.0 Aft</td>
<td>8.5 Left, 9.7 Right</td>
<td>20.0 Left, 19.6 Right</td>
</tr>
<tr>
<td>Control centering</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive, Absolute</td>
<td>Positive</td>
</tr>
<tr>
<td>Control jump</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Control forces trimmable to zero</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Force gradient (lb-in)</td>
<td>0.9 Fwd, 0.5 Aft</td>
<td>0.6 Fwd, 0.6 Aft</td>
<td>0.8 Left, 0.9 Right</td>
<td>2.5 Left, 2.4 Right</td>
</tr>
</tbody>
</table>

**NOTES:**

$^1$ Rotors static, ground hydraulic and electrical power applied.

$^2$ Copilot-gunner cyclic control stick retracted.

$^3$ Copilot-gunner cyclic control stick extended.

$^4$ Revised directional control stop reduced full control travel to 4.2 inches.
10.3.2.1.1 - the longitudinal breakout force (plus friction) exceeded the 1.5 pound limit by 1.0 pound.

10.3.2.5 - the longitudinal control force could not be trimmed to zero in flight with the CPG cyclic stick extended.

13. Lateral control characteristics also showed an improvement compared to EDT-2 in control centering (trim feel ON) with positive, absolute centering observed. Control force gradients were essentially the same as those for the longitudinal control and though not in compliance with specification requirements were satisfactory in flight. Breakout force (plus friction) was symmetrical about trim and there was no tendency to develop any significant pilot induced oscillation (PIO) laterally. Trim feel OFF operation was essentially the same as that observed for the longitudinal control with no force gradients and no control centering. The lateral control characteristics are satisfactory although the lateral control force gradient failed to meet the requirements of paragraph 10.3.2.2 of reference 7, appendix A in that the maximum of 60 percent of the longitudinal force gradient was exceeded.

14. The directional control characteristics were improved in that breakout force (plus friction) had been reduced from a maximum of 9.5 pounds reported in EDT-2 to a maximum of 5.0 pounds. Undesirable control jump when retrimming (a previously reported shortcoming) was not observed during this test. Directional control centering was less positive than previously reported but posed no particular problem in flight. The directional control system characteristics are satisfactory.

Control Positions in Trimmed Forward Flight

15. The control positions in trimmed level flight and dives were evaluated from 51 to 167 knots, calibrated airspeed (KCAS). Data are presented in figure 18, appendix E. The aircraft exhibited an undesirable variation in the trimmed longitudinal control position between 85 and 110 KCAS. Within this airspeed range less than 1/4 inch of cyclic control position change was required. This resulted in poor trimmability and will contribute significantly to pilot workload during instrument meteorological conditions (IMC) flight. The poor trimmability at airspeeds between 85 and 110 KCAS is a shortcoming previously reported.

16. Control positions during intermediate rated power (IRP) climbs and minimum power descents (less than 10 percent torque per engine) were evaluated at airspeeds between 49 and 124 KCAS. Data are presented in figure 19, appendix E. The pitch attitude variation with power application has been greatly improved. The field of view during IRP climbs, a previously reported shortcoming, is now satisfactory. The longitudinal control trim shift with power changes has also been significantly improved. A trim shift observed during this test was 1 inch and is satisfactory.

17. Failure of automatic stabilator operation was observed during minimum power descents at 50 and 60 KCAS. The stabilator ran away to positions considerably off the design schedule and then shut down the automatic mode. Re-engagement required only pushing the reset button. The control positions are shown in figure 19, appendix E. The maximum stabilator deflection attained was 23 degrees trailing edge down. This required a longitudinal control position of 6.9 inches from full forward. The remaining control position margin of 3.3 inches was adequate and aircraft control was maintained throughout the test. The failure appeared to have been caused by erroneous airspeed information supplied to the stabilator control
unit. The improper operation of the automatic stabilator during minimum power
descents at 50 and 60 KCAS is a shortcoming.

18. Yaw oscillations of ±3 degrees were observed at airspeeds between 40 and
70 KCAS. The oscillations were annoying to the pilot and appeared to be caused by
the digital automatic stabilization equipment (DASE) attempting to maintain flight
at zero sideslip. The pilot was unable to damp the oscillations with directional
inputs. The oscillations did not appear to be a problem during NOE flight. Sideslip
information was provided to the DASE computer from a transducer installed on a
test instrumentation boom rather than from the Air Data Sensor (ADS) as proposed
for the production configuration. The response of the transducer may have
contributed to the yaw oscillation observed. The yaw oscillations at airspeeds
between 40 and 70 KCAS should be re-evaluated with the ADS providing sideslip
information to the DASE.

19. The attitude hold mode incorporated in the DASE was evaluated during
trimmed level flight. With attitude hold engaged, pilot effort required to maintain
airspeed was reduced. When retrimming (depressing the trim release button on the
cyclic grip) with the attitude hold engaged uncommanded aircraft response was
noted in all three axes. The response was greatest in yaw (±10 degrees) and was
more pronounced when retrimming after flying with the attitude hold on for one
minute or more. The aircraft response was annoying and contributed to increased
pilot workload when attempting to establish a precise trim condition. The
uncommanded aircraft response when retrimming with the attitude hold engaged is a
shortcoming. Consideration should be given to incorporating an altitude hold feature
in the attitude hold mode of the DASE.

Static Longitudinal Stability

20. The static longitudinal stability characteristics were evaluated at trim airspeeds
of 56 and 147 KCAS. The data from these tests are provided in figures 20 and 21,
appendix E. The longitudinal cyclic control position gradient indicates
approximately neutral stability at both airspeeds tested. The lack of positive static
longitudinal stability, although satisfactory and desirable for the low speed attack
mission, will contribute to increased pilot workload during IMC flight at higher
airspeeds where more precise airspeed control is required (para 47).

Static Lateral-Directional Stability

21. The static lateral-directional stability characteristics were evaluated at the
condition's shown in table 1. The aircraft was trimmed in level flight at zero sideslip.
The collective control position was approximately constant and sideslip angles were
varied in 5-degree increments (left and right) while maintaining constant airspeed.
Data are presented in figures 22 and 23, appendix E. At 56 KCAS the helicopter
exhibited positive directional stability (increased left directional control for increase
in right sideslip), and positive dihedral effect (increased right lateral control with
increased right sideslip). Sideforce cues were weak about trim at this airspeed as
evidenced by the small change in roll attitude. At 144 KCAS directional stability and
dihedral effect were again positive however, sideforce cues were significantly
increased. At zero sideslip the left roll attitude was approximately 7 degrees. This
attitude was uncomfortable to the pilot and may be a significant problem during
IMC flight because the DASE attempts to maintain zero sideslip at airspeeds greater
than 50 knots (para 47). Except for the roll attitude at zero sideslip, the static
lateral-directional stability characteristics are satisfactory.
Maneuvering Stability

22. The maneuvering stability characteristics were evaluated using constant airspeed left and right turns and symmetrical pullups and pushovers at the flight conditions listed in table I. The stick-fixed stability (control position vs load factor) was positive up to load factors of 1.6 (fig 24, app E). Above 1.6g the stability became neutral and pitch rate damping was lost due to saturation of the pitch stability augmentation system (SAS) actuator. A time history of pitch SAS actuator position is shown in figure 25, appendix E. Random, uncommanded pitch excursions were observed during steady turns at bank angles of greater than 40 degrees. The loss of pitch rate damping was also observed during contour flight when making turns at 1.6g and greater. This was annoying to the pilot as the aircraft exhibited a pitch up or "dig in" tendency which significantly increased pilot work load (HQRS 5). The absence of SAS pitch rate damping at load factors greater than 1.6 due to the saturation of pitch SAS actuator is a shortcoming which should be corrected prior to operational testing.

Dynamic Stability

23. The short-term dynamic stability characteristics of the YAH-64 were evaluated at the conditions listed in table I. Aircraft motions were induced by one inch lateral, longitudinal, and directional doublets, with the DASE both ON and OFF and attitude hold OFF. Following the input all controls were held fixed until the motion subsided or until recovery became necessary. A typical time history of the short-term aircraft response, DASE OFF, is presented in figure 26.

24. The response of the YAH-64 to control doublets with the DASE ON was essentially deadbeat and is satisfactory. The response of the YAH-64 to DASE OFF control doublets was a short-term three-axis oscillation. This coupled three-axis oscillation (with 4-second period) was excited by control inputs in any of the three axes and was similar in character for all of the inputs. The damping of the oscillation decreased with increasing airspeed until the short-term stability became neutral at 115 KCAS. At airspeeds greater than 115 KCAS, the stability remained neutral. The trend found during EDT-2 of a large decrease in stability with an increase in airspeed was not present in EDT-4. The oscillations were controllable by the pilot flying in visual meteorological conditions (VMC) with some increase in pilot work load. However, the pilot flying in IMC may encounter a significant increase in pilot work load when flying in turbulent conditions DASE OFF (para 47).

25. The longitudinal long-term dynamic stability characteristics of the YAH-64 were evaluated at the conditions in table I. Aircraft motions were introduced by displacing the cyclic control aft of trim, allowing the airspeed to decrease by 10 KCAS and returning the control to trim. All controls were then held fixed until the aircraft motions subsided or until a limit condition was reached. These tests were performed DASE ON and OFF and attitude hold ON and OFF. A typical time history of the aircraft response to a ten knot slow excitation at 80 KCAS with the DASE ON and attitude hold OFF is presented in figure 27.

26. The aircraft longitudinal long-term response with the attitude hold ON was essentially deadbeat and is satisfactory. The aircraft response with the attitude hold OFF and with the DASE ON or OFF at 80 KCAS was divergent. The period of the oscillation was approximately 70 seconds. The pilot could control the oscillation; however, the ability of the pilot to maintain precise pitch control and airspeed control while flying IMC will be degraded.
Ground Handling Characteristics

27. The ground handling characteristics of the YAH-64 with DASE ON and OFF were evaluated throughout this test program on both concrete and macadam taxiways. Wind conditions were generally less than 25 knots. During this evaluation, the yaw DASE authority was 10 percent and the Command Augmentation System (CAS) was automatically disengaged by a touchdown squat switch located on the left main landing gear. Directional control while taxiing was easily accomplished with the DASE ON. With the DASE OFF (no yaw rate damping), the pilot tended initially to overcontrol directionally; however, within a short time the pilot could easily compensate for the lack of yaw rate damping.

28. The YAH-64 requires a high brake pedal pressure during ground taxi operations and when setting and releasing the parking brake. In addition to the high pedal pressure, the design of the pedals requires the pilot to raise his heels off the floor to apply brake pedal pressure. Additionally, a portion of the cockpit structure above the pedals occasionally restricted the pilot from removing his feet from the brake pedals after a brake application. The above factors combined to cause inadvertent directional control inputs during brake application, which is a shortcoming previously reported.

29. The tail wheel lock/unlock light is located on the upper left of the pilot's instrument panel behind the canopy jettison handle and below the glare shield. Landings and takeoffs are performed with the tailwheel locked and ground taxiing is performed with the tailwheel unlocked. After landing or before takeoff, the pilot must activate the tailwheel lock/unlock switch and then watch for the illumination of the tailwheel unlock light. This process requires that the pilot divert his attention from outside the cockpit to the tailwheel unlock light. The poor location of the tailwheel unlock light is a shortcoming previously reported.

30. The parking brake handle position is the only cockpit indication of whether the brakes are set or released. During ground operations, the brakes were found to be set with the parking brake handle not in the full out set position. The lack of a reliable indication of parking brake status is a shortcoming previously reported.

Takeoff and Landing Characteristics

31. Takeoffs and landings were evaluated during each flight. Normal, maximum performance, minimum power, running, and level acceleration takeoffs were accomplished. Normal, steep approach, running and simulated autorotative landings were accomplished. Figure 28 is a time history of a normal takeoff. The longitudinal control displacement from a hover to 70 KCAS was approximately 1 inch. On previous evaluations (EDT-2) the control displacement was 2 inches. The longitudinal control displacement required during takeoff is now considered satisfactory.

32. Figures 29 and 30 are typical time histories of a simulated autorotation and a steep approach, respectively. The pitch attitudes required during these maneuvers are improved from EDT-2, however, the point of intended landing was blocked from the pilot's view at a height above the ground of 150 to 200 feet. The primary restrictions to the field of view during approach were the PNVS turret (located on the nose of the aircraft) and the CPG helmet which obstructed approximately 40 percent of the forward windscreen. The restricted pilot's forward field of view during a steep approach and a simulated autorotation (previously reported as a
deficiency) is now considered a shortcoming which should be identified as an area of special interest during operational testing.

**Low-Speed Flight Characteristics**

33. The low-speed flight characteristics of the YAH-64 were evaluated using calibrated ground pace vehicle as a speed reference. Surface wind conditions were less than 5 knots. The test aircraft wheel height was approximately 20 feet in-ground-effect (IGE). Flights were conducted with the DASE ON and OFF. Data are presented in Figures 31 through 38.

**Forward and Rearward Flight:**

34. Figure 31 shows the control positions in low-speed forward and rearward flight. The longitudinal control position variation with airspeed is nonlinear but satisfactory. Large, abrupt lateral control trim shifts occur between 16 and 24 KTAS rearward and between 13 and 18 KTAS forward airspeeds. When executing hovering flight and hovering turns in gusty wind conditions, the pilot will not be able to maintain a precise ground track. The large, abrupt control trim shifts between 16 and 24 KTAS rearward and between 13 and 18 KTAS forward flight is a shortcoming.

**Sideward Flight:**

35. In general, the trends of lateral cyclic and directional controls with airspeed were proper. Minor reversals were noted but were not objectionable. During the conduct of this evaluation and following the low speed flight tests, the left tail rotor stop was changed from a nominal 33 degrees to 27 degrees. With the 33 degrees rigging there was approximately 1.8 inches of left directional control margin at 45 KTAS right sideward flight. However, with the 27 degrees rigging only 0.6 inch would have remained. Both riggings reflected an improved directional control margin since EDT-2 for test day conditions. At higher gross weights and density altitudes, the directional control margin with 27 degrees rigging may be inadequate. Figure 32 also shows the variation of longitudinal control with lateral velocity. There is an approximate 1 inch longitudinal trim shift between 10 KTAS and 25 KTAS left sideward flight. This longitudinal trim shift makes precise pitch control and maintenance of a precise ground track difficult during acceleration from 12 to 18 KTAS left sideward flight. The abrupt longitudinal control trim shift from 12 to 18 KTAS left sideward flight is a shortcoming. A reevaluation of the revised tail rotor rigging from 33 degrees to 27 degrees should be conducted.

36. Trim control positions and pilot work load bands are presented in Figure 33 for DASE OFF sideward flight. The highest work load was at speeds greater than 15 KTAS left sideward flight. The pilot was able to control heading within ±3 degrees to 45 KTAS left and right sideward flight with an increase in longitudinal and directional control work load. The ease of control in DASE OFF sideward flight is a significant improvement from EDT-2.

**Critical Azimuth Flight:**

37. A flight was performed to determine the critical azimuth. The critical azimuth was found to be approximately 240 degrees relative to the nose of the aircraft in a clockwise direction (fig 34). Critical azimuth was defined by high pilot work load
since all control margins were adequate. Figures 34 and 36 show the control positions and work load bands for flight at the critical azimuth DASE ON and OFF, respectively. The pilot was able to control aircraft heading within ±4 degrees at the critical azimuth, DASE ON and OFF to 45 KTAS. This represents a significant improvement from EDT-2 and is satisfactory (aircraft directional control was lost during EDT-2).

Low-Speed Maneuvering:

38. Directional control step inputs were made while in left and right sideward flight at 35 KTAS with the DASE ON to check specification compliance. Data for a left directional control input is presented in figure 37. In both left and right sideward flight, yaw rates of greater than 15 deg/sec were generated within 1.5 seconds which meets the systems specification requirement. These tests were performed with the 33 degrees left pedal stop tail rotor rigging. It is projected that specification requirements would also have been met, for test day conditions, with the revised tail rotor rigging of 27 degrees.

39. Lateral accelerations from a hover to 35 KTAS left and right sideward flight were performed. The pilot was able to perform the maneuver rapidly, stabilize at 35 KTAS sideward flight, and maintain directional control throughout the maneuver. With the 33 degrees tail rotor rigging, greater than 10 percent control margins were available throughout the maneuver. This represents improved directional control from EDT-2. During EDT-2, lateral accelerations could not be conducted because of inadequate directional control.

40. Lateral reversal maneuvers were evaluated by stabilizing the aircraft in sideward flight at 35 KTAS and reversing direction to establish approximately 35 KTAS sideward flight in the opposite direction. The maneuver was performed at both a moderate rate and aggressively from left and right sideward flight. Figure 38 is a time history of moderate rate lateral reversal from 35 KTAS right sideward flight. The aircraft was controllable during the moderate rate reversal, altitude was maintained, and heading change throughout the maneuver was ±15 degrees. Altitude could not be maintained during an aggressive lateral reversal and considerable pilot effort was required to maintain aircraft control (HQRS 8). When performing an aggressive lateral reversal in an NOE environment the pilot may be unable to maintain sufficient aircraft control to prevent settling into obstacles. Additionally, all lateral reversals were performed with the original tail rotor rigging of 33 degrees. The revised tail rotor rigging of 27 degrees would have provided only 0.1-inch left directional control margin during a moderate rate reversal and insufficient left directional control during an aggressive lateral reversal. The left directional control margin with a revised tail rotor rigging of 27 degrees will be insufficient for the performance of lateral reversal maneuvers. A reevaluation of the revised tail rotor rigging from 33 degrees to 27 degrees should be conducted. The operational requirement for lateral reversal maneuvers should be thoroughly investigated and clearly defined due to the hazardous nature of the maneuver.

Power Management

41. Power management characteristics of the YAH-64 were evaluated throughout EDT-4. The torque matching and turbine gas temperature (TGT) limiting features of the YT 700-GE-700R engines continued to be excellent.
42. The YAH-64 incorporated a pilot adjustable engine power control lever friction. During this evaluation the aircraft was operated with the adjustable friction full OFF. With the friction full OFF a force of approximately 7 pounds was required to operate both power levers. Precise engine power lever movement, such as during engine control unit (ECU) lockout operation, was difficult. The excessive control force required to operate the engine power control levers failed to meet the requirements of paragraph 10.3.3.2.3 of reference 7, appendix A by 2.0 pounds. The high inherent friction of the engine power control levers is a shortcoming previously reported.

43. The pilot engine control quadrant was located on the left console. Operation of the power levers, such as during ECU lockout operation, was made difficult because the pilot's arm contacted the armor protection on the pilot's seat when grasping the power levers in a normal fashion. The poor location of the pilot engine control quadrant is a shortcoming.

Mission Maneuvering Characteristics

44. The mission maneuvers evaluated during this test were selected primarily to evaluate the aircraft handling qualities during the terrain flight mode of operation. Pilot duties were limited to maneuvering of the aircraft only, and no mission scenario was simulated. The following standards for NOE and contour flight, as defined by reference 11, appendix A, were used during this evaluation.

- **NOE Flight:** "Fly as close to the earth's surface as vegetation or obstacles permit."
- **Contour flight:** "Maintain 20-foot obstacle clearance ± 10 feet, generally conforming to the contours of the earth."

45. Significant obstructions to the pilot's field of view were observed during NOE and contour flight. Obstructions included the CPG helmet which obstructed approximately 40 percent of the forward windscreen (with CPG seated at the design eye position), canopy reflections which were most evident when flying in haze or smoke, and the overhead circuit breaker panel which obstructed the pilot's field of view during a left banked turn. Distortion was also present in the canopy windows for approximately one inch on either side of each canopy frame structural member and further restricted the pilot's field of view. The restricted pilot's field of view caused by the above items was a shortcoming. The major obstruction to the pilot's field of view was the canopy frame structure shown by the shaded areas of figure 1 (previously reported in reference 1, appendix A as the top priority shortcoming). The structure blocked the pilot's field of view at the eleven and one-o'clock positions. During NOF flight, when attempting to fly between trees or other obstacles, the pilot was unable to accurately determine the height of the obstacles since they were obstructed from view at the time a height decision was required. As a result, the pilot flew 10 to 20 feet higher than the terrain would normally have allowed, thereby preventing NOF flight in accordance with reference 11. Similar restrictions to the pilot's field of view were observed during contour flight and the pilot could not maintain the aircraft within the specified 20 feet ± 10 feet obstacle clearance when making turns due to the poor field of view caused primarily by the canopy frame structure. The restricted pilot's field of view caused by canopy frame structure during NOE and contour flight (as defined by current aircrew training
Figure 1. Canopy Frame Structure
manual) is a deficiency. The pilot’s field of view during NOE and contour flight should be identified as a special area of interest for operational testing.

46. Masking and unmasking maneuvers were performed with and without the hover augmentation system (HAS) engaged. Pilot workload was significantly reduced during hover, masking and unmasking with the HAS engaged. A slight left lateral drift occasionally occurred after engagement of the HAS. Engagement of the HAS required the pilot to remove his hand from the collective control and reach forward on the left console to activate a toggle switch. The requirement for the pilot to remove his hand from the flight controls to engage the HAS is undesirable particularly when in the NOE environment. Additionally, an altitude-hold feature incorporated in the HAS would allow the pilot to briefly remove his hands from the controls to perform mission essential tasks (e.g., change radio frequencies, adjust the PNVS, refer to maps, etc.), while in a masked position. The handling qualities of the YAH-64 during masking and unmasking maneuvers are satisfactory for the attack helicopter mission. An altitude-hold feature should be considered for incorporation into the HAS. Provisions should also be incorporated to allow the pilot to engage the HAS without removing his hands from the flight controls.

Instrument Flight Capability

47. A limited IMC evaluation, which consisted of level flight, climbs, climbing and descending turns, and simulated radar vectoring, was conducted. Tests were performed under simulated IMC conditions (pilot wearing hood) with both DASE ON and OFF at airspeeds of 87 and 115 KCAS. The pilot was concerned only with aircraft control and did not attempt to navigate, perform approaches, change radio frequencies or make radio calls as would be required during actual IMC flight. The electronic attitude direction indicator (EADI) was inoperative and aircraft attitude information was obtained from the standby attitude indicator. The rate of turn indicator was also inoperative. The highest pilot workload occurred while trying to control airspeed with DASE OFF. Small, frequent longitudinal control inputs were required to maintain airspeed within ±10 KIAS (DASE OFF) particularly during climbing turns (HQRS 5-6). Power changes caused excitation of the three-axis oscillation and was most pronounced at 115 KCAS (see para 24). The pilot workload required in the longitudinal axis was considerably reduced with DASE ON (HQRS 3-4) with the major workload being for airspeed control. Factors contributing to the increased pilot workload in the longitudinal axis were previously discussed and are as follows: Excessive longitudinal control breakout force (plus friction) (para 12), poor trimability (para 15), neutral static longitudinal stability (para 20) and the divergent longitudinal long-period oscillation (para 26). A left roll attitude of 5 degrees was observed at 115 KCAS with zero sideslip as maintained by the DASE. This was uncomfortable to the pilot and may induce vertigo under actual IMC conditions. The uncomfortable and potentially vertigo-inducing left roll attitude at cruise airspeed during simulated IMC flight is a shortcoming. A thorough evaluation of the instrument flight capability of the YAH-64 should be conducted with production flight instruments installed.

Aircraft Systems Failures

Simulated Single Engine Failures:

48. Single engine failures were simulated by having the CPG retard one of the power levers to the idle position during various flight conditions as shown in table 1.
Collective pitch reduction was made after 2.0 seconds or at the activation of the low main rotor rpm warning. Representative time histories of simulated single engine failures during an IRP climb and at $V_H$ is shown in figures 39 and 40, respectively. Aircraft response to the engine failure was mild and only small, instinctive control inputs were required to maintain aircraft attitude (HQRS 2). Available collective control delay time was only 1.2 seconds (0.8 seconds less than specification requirements); however, when the collective was reduced the main rotor speed was re-established at 100 percent in less than 3 seconds. The minimum main rotor speed attained was 90 percent. This was 3 percent below the minimum power on transient limit of 93 percent. Although aircraft response to the single engine failure was satisfactory to the pilot, single engine operation below 93 percent main rotor speed should be investigated to insure that structural limits will not be exceeded. The available collective control delay time failed to meet the 2.0 second requirement of paragraph 10.3.8.1.1 of reference 7, appendix A by 0.8 second at IRP.

49. The activation threshold of the low main rotor rpm warning, a previously reported deficiency, was evaluated during flight. The warning activated consistently at 95 percent main rotor speed ($N_G$) (as opposed to 91 percent previously reported in ref 3, app A) and is satisfactory for the attack helicopter mission.

50. The engine out warning system was evaluated by simulating the failure condition on the ground. The gas producer ($N_G$) warning activated at 63 percent and would provide an engine out warning in the event of a complete engine failure. The power turbine ($N_p$) warning activated consistently at 93 percent and provided a satisfactory engine out warning of a partial power engine malfunction. A previously reported deficiency (ref 3, app A) stated that adequate cues were not available to warn the pilot of a partial power engine malfunction which resulted in $N_G$ stabilizing at idle speed (67-68 percent). The $N_p$ warning activated at 71 percent $N_G$ and will provide an engine out warning above idle $N_G$. The engine out warning system is satisfactory.

Digital Automatic Stabilization Equipment Failures:

51. Simulated single axis and total DASE failures were evaluated by turning off the respective axes or by total disengagements of the DASE. All controls were free for three seconds following the failure. Aircraft response to a single axis DASE failure was moderate. For a pitch axis failure, the aircraft response was a mild nose-down pitch. For a roll axis failure the aircraft response was a mild left roll. There was a negligible response to a yaw axis failure. The aircraft response to a total DASE failure was the three-axis short-term oscillation discussed in paragraph 24. The pilot required one-half inch lateral and longitudinal control inputs to maintain trim attitude with a total DASE failure. The requirement to use control inputs in excess of 0.25 inch to maintain the desired aircraft attitude failed to meet the requirements of paragraph 10.3.2.7.1 of the detailed specification. However, the aircraft response was controllable and is satisfactory.

Stabilator Failures:

52. Stabilator failures were evaluated at the conditions in table 1 in level flight by introducing a single stabilator actuator hardover. All controls were free for three seconds following the failure. Figure 41 is a typical time history of a stabilator failure. After the trailing edge of the stabilator had moved down approximately 10 degrees, the actuator position miscompare circuit automatically actuated and
stopped the stabilator travel. The aircraft response was a nose-down pitch of less than 10 degrees and the aircraft attitude was easily controlled after the three seconds. The minimum longitudinal control margin during recovery at 120 KCAS was in excess of 10 percent. Aircraft response following stabilator hardovers in level flight is satisfactory.

53. Takeoffs with the stabilator failed were performed. The stabilator was failed in the full trailing-edge-down position and both normal and level acceleration takeoffs were made. Figure 42 is a typical time history of a takeoff with a failed stabilator. The pilot was aware of the failure upon accelerating through 50 KCAS because of the abnormal nose-down pitch attitude of the aircraft. At 100 KCAS the pitch attitude was approximately 10 degrees nose down and approximately 40 percent of longitudinal control remained. The aircraft was easily controllable. The aircraft response to a takeoff and acceleration to 100 knots indicated airspeed (KIAS) with the stabilator failed in the full trailing-edge-down position (25 degrees) is satisfactory.

54. Landings were made with the stabilator failed in a high speed flight position (4 degrees trailing edge up). Figure 43 is a typical time history of a landing with the stabilator failed. The aircraft was easily controllable during both normal approaches and simulated autorotations with the stabilator failed. The pitch attitude during the approach was slightly more nose up than with the stabilator operating normally; however, it was considered satisfactory for a failure mode. The aircraft response to a landing with the stabilator failed in a high-speed position is satisfactory.

Generator Failures:

55. Generator failures were simulated in flight by turning off either the No. 1 or No. 2 generator switch. A No. 2 generator failure produced disengagement of the DASE. Disengagement of the DASE with failure of the No. 2 generator is a shortcoming. A No. 1 generator failure caused disengagement of the heading and attitude reference system (HARS), disengagement of the DASE, failure of the automatic mode of stabilator operation and activation of the low rpm/engine out audio tone. During NOE or instrument flight or when operating the PNVS such failures and erroneous warnings would adversely affect flight safety. The failure of these systems and erroneous activation of the engine out/low rpm audio tone with the failure of the No. 1 generator is a deficiency which should be corrected prior to operational testing. In addition, the planned electromagnetic interference (EMI) evaluation should be conducted prior to operational testing. The YAH-64 failed to meet the requirements of paragraph 10.3.2.7.8 of reference 7, appendix A in that failure of a single generator caused failure of the DASE.

VIBRATION CHARACTERISTICS

56. The vibration characteristics and canopy drumming of the YAH-64 were evaluated throughout the test program. Qualitative evaluations were made at both crew stations with vibration absorber removed and installed. Vibration characteristics are shown in figures 44 through 77, appendix E, and test conditions are shown in table 3.

57. The 4/rev (19.2 Hz) vertical vibration of 0.3 to 0.4g in rearward flight at airspeeds greater than 25 KTAS was objectionable to the pilot (VRS 6) (fig 44). However, at the same conditions the vibration at the copilot seat (fig 45) was not
### Table 3. Vibration Test Conditions

<table>
<thead>
<tr>
<th>Gross Weight (lb)</th>
<th>Longitudinal CG Location (fs)</th>
<th>Density Altitude (ft)</th>
<th>Flight Regime</th>
<th>Location¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>14820</td>
<td>201.3 (Fwd)</td>
<td>440</td>
<td>Left and right sideward</td>
<td>Pilot seat and floor</td>
</tr>
<tr>
<td>14720</td>
<td>201.4 (Fwd)</td>
<td>280</td>
<td>Forward and rearward</td>
<td>Copilot seat and floor Aircraft cg</td>
</tr>
<tr>
<td>15640</td>
<td>202.2 (Fwd)</td>
<td>9720</td>
<td>Level</td>
<td>Aircraft cg</td>
</tr>
<tr>
<td>14400</td>
<td>205.7 (Aft)</td>
<td>5840</td>
<td>Level²</td>
<td>Pilot and copilot seat Aircraft cg</td>
</tr>
<tr>
<td>15600</td>
<td>202.3 (Fwd)</td>
<td>5700</td>
<td>Climb</td>
<td>Pilot and copilot seat Aircraft cg</td>
</tr>
<tr>
<td>15580</td>
<td>202.3 (Fwd)</td>
<td>4480</td>
<td>Descent</td>
<td>Pilot and copilot seat</td>
</tr>
<tr>
<td>14600</td>
<td>202.0 (Fwd)</td>
<td>1360</td>
<td>Level</td>
<td></td>
</tr>
<tr>
<td>14860</td>
<td>202.0 (Fwd)</td>
<td>5420</td>
<td>Level</td>
<td></td>
</tr>
<tr>
<td>15740</td>
<td>205.2 (Aft)</td>
<td>5020</td>
<td>Level</td>
<td></td>
</tr>
<tr>
<td>15740</td>
<td>202.0 (Fwd)</td>
<td>6380</td>
<td>Level</td>
<td></td>
</tr>
</tbody>
</table>

¹ Three-axis vibration at each location
² Vibration absorber out
objectionable. In right sideward flight at airspeeds greater than 15 KTAS the lateral vibration of 0.2 to 0.3g (fig 49) was objectionable (VRS 4). Similarly, the vibration at the copilot’s station under the same flight conditions was not objectionable (fig 50).

58. The vibration in climb and descent were evaluated at both the pilot and CPG stations (figs 54 through 59) and was found to be satisfactory.

59. The vibration characteristics were evaluated in level flight at the pilot station (figs 60 through 72). As in low-speed flight the vibration levels at the CPG station were generally lower than at the pilot station. The 4/rev lateral vibration of greater than 0.2g at the pilot’s seat in level flight at airspeeds less than 53 KCAS (figs 64 and 66) were objectionable (VRS 4). Also the 4/rev vertical vibration of 0.25g at the pilot’s seat in level flight at airspeeds greater than 117 KCAS was objectionable (VRS 5).

60. The vibration characteristics during the termination of the approach were qualitatively evaluated. These vibrations were similar to those encountered during rearward flight at airspeeds greater than 25 KTAS and were objectionable to the pilot (VRS 6).

61. The vibration characteristics were evaluated with the vertical vibration absorber removed. Figures 73 through 77 depict the vibration levels during level flight with the absorber removed. Although the 4/rev vertical vibration levels are slightly greater at high speed for similar gross weight and density altitude, there were no qualitative differences noticed at the pilot or CPG station. During climbing, descending, and low-speed flight there were no significant differences noticed with the vibration absorber removed.

62. The vibration characteristics and canopy drumming of the YAH-64 are generally improved from EDT-2. While canopy drumming was not objectionable during this test, the vibration characteristics remain objectionable during several flight conditions. The objectionable 4/rev vertical vibration in rearward flight at airspeeds greater than 25 KTAS, lateral vibration in right sideward flight at airspeeds less than 15 KTAS, lateral vibration in level flight at airspeeds less than 50 KCAS and greater than 117 KCAS, and the vertical vibration during the termination of the approach remain a shortcoming. Efforts to reduce the objectionable 4/rev vibration should continue.

HUMAN FACTORS

Cockpit Evaluation

63. The pilot cockpit of the YAH-64 was evaluated throughout the test program. This included an evaluation of cockpit design with primary emphasis on instrument displays, switch function and design, and ease of operation of system controls. Pilot comfort was also considered. Two previously reported shortcomings, the need for additional cockpit storage area and provisions for passing mission essential items between cockpits, should be further evaluated during operational testing.

64. The engine torque indicator vertical scale was limited to 120 percent. The airworthiness release for EDT-4 allowed a transient torque limit of 125 percent. The
engine torque indicator should have an adequate range to span the allowable aircraft limits. The lack of adequate display capability of the engine torque indicator vertical scale is a shortcoming.

65. The collective pitch control friction was difficult to adjust to the desired level. A small adjustment of the friction twist grip frequently produced too much friction. The friction level was not constant throughout the range of collective control travel. The design incorporates a friction-bar slider assembly which is attached to the cockpit floor and to the collective lever. The friction bar slider assembly was susceptible to damage during routine maintenance and often was found to be slightly bent which produced a ratcheting effect when applying collective pitch. Maintenance action had been taken several times during the test, however, the problem was not corrected. The poor design of the collective pitch control friction mechanism is a shortcoming.

66. During normal operation, the Marconi instruments displayed only three segment lights at any one time and did not show all green segments to indicate the limits of the normal range of operation. This is different from Marconi instruments in other Army aircraft and detracted from the pilot's ability to rapidly cross check instrument indications. The failure of the Marconi instruments to display the full green range during normal operation is a shortcoming.

67. The rocket panel displays, the Marconi instrument indications, and the caution, warning and advisory panel segment lights were unreadable in direct sunlight. In order to determine the indications being displayed the pilot had to remove his hand from the flight controls and shade the appropriate instrument or panel. This was annoying to the pilot and undesirable particularly in a high work load environment. The washout of the rocket panel displays, Marconi instrument indication, and caution, warning and advisory panel segment lights in direct sunlight is a shortcoming previously reported.

68. The environmental control unit (ENCU) was evaluated during flight and was found to be much more effective at the CPG station. When the pilot adjusted the control for a comfortable temperature, the CPG station was either too hot or too cold. When attempting to heat the cockpit, the CPG station was too warm; when cooling the cockpit, the CPG station was too cool. Tests were not conducted at extreme temperatures. Operation of the ENCU should be a special area of interest during climatic testing. The inability to maintain both crew stations at the same temperature, using the ENCU, is a shortcoming.

69. The lower green segment light of each Marconi instrument vertical scale remained illuminated during operation. This green light indicated that electrical power was being supplied to the instrument. In addition to the pilot initiated test feature, the illumination of any light on the vertical scale would show that power was being supplied. The illumination of the lower segment light was confusing to the pilot and detracted from his cross check of instrument indications. The constant illumination of the lower green segment light on the Marconi vertical scale is a shortcoming previously reported.

70. During auxiliary power unit (APU) start the APU ON advisory light illuminates prior to reaching 100 percent N_G. This is a false indication of APU status and could lead to automatic shutdown of APU if systems (e.g., generator) are activated.
prematurely. The illumination of the APU ON advisory light prior to the APU stabilizing at 100 percent rpm is a shortcoming previously reported.

71. The pilot's cyclic grip incorporated eight different functions activated by thumb switches. In addition, some additional functions are required to be activated simultaneously such as the weapons action switch and the trigger switch. An extreme reach was also required for operation of the trim release switch. A pilot with a smaller than normal hand will have difficulty in operating the switches on the cyclic and will frequently be required to reposition his hand on the cyclic grip in order to perform the necessary functions. The poor anthropometric design of the pilot's cyclic grip is a shortcoming previously reported.

72. Various annoying tones were present in the intercom system throughout the test. Flying with the PRI LTS circuit breaker out helped to alleviate some of the tones; however, they still were not reduced to a satisfactory level. The tone was continuous and appeared to be of an EMI nature. The annoying tone present in the intercom system is a shortcoming. The planned EMI evaluation should be conducted prior to operational testing.

73. The pilot seat currently installed in the YAH-64 is adjustable only in the vertical axis. The directional pedals are also adjustable, however, the cyclic and collective controls are not. During this test a 70 percentile height aviator was unable to obtain a comfortable seating position with reference to the cyclic and collective controls. It will be extremely difficult for a person near the extreme range of US Army anthropometric measurements to achieve a comfortable seating position. The difficulty in attaining a comfortable seating position with reference to the cyclic and collective controls is a shortcoming. Consideration should be given to installing a longitudinal adjustment for the pilot seat.

74. The operation of the HARS control switch was difficult. When positioning the switch to or from the OPER position it was necessary to pull out on the switch and simultaneously turn it to the desired position. Occasionally the pilot fingers would slip off the switch and he was required to remove his glove to operate the switch properly. The difficulty in operating the HARS control switch is a shortcoming.

75. Frequent, intermittent illumination of the master caution and engine fuel pressure warning lights was observed during engine start. Though no related problems were encountered during engine start the indications were distracting to the pilot. During each engine start the pilot was required to reset the master caution light 6 to 8 times due to the intermittent illumination of the engine fuel pressure warning lights. The intermittent illumination of the master caution and engine fuel pressure warning lights during engine start is a shortcoming.

76. Illumination of a green advisory light on the caution, warning and advisory panel caused the master caution light to illuminate. The illumination of the amber master caution light is actually an erroneous indication, in this instance, since it alerts the pilot to a malfunction when actually none has occurred. The illumination of the master caution light with green advisory segment lights is a shortcoming.

77. The anti-ice panel was located on the aft portion of the pilot's left console. Several of the switches were obstructed from view by the aircraft structure and the armor plating on the left of the pilot's seat. The switches were difficult to reach and some of the switch labeling was hidden from view. When operating the anti-ice
panel switches the pilot will be required to rely on feel only (for several switches) and, due to the awkward location of the panel, may inadvertently activate other switches located on or near the anti-ice panel. The poor location of the anti-ice panel switches is a shortcoming.

78. During engine start the Marconi torque indicator displayed a full scale deflection (120 percent). This is an undesirable and erroneous indication and is distracting to the pilot. The full scale illumination of the Marconi engine torque indicator during engine start is a shortcoming previously reported.

79. The lack of adequate cockpit storage area and the lack of provisions to allow the passing of mission essential equipment between cockpits were two previously reported shortcomings. Though not thoroughly evaluated during EDT-4 it appeared that the cockpit storage area would not be readily accessible in flight and that the small slot on the lower left portion of the blast shield would be inadequate for passing items between cockpits. The requirement for additional cockpit storage area and provisions for passing mission essential items between cockpits should be further evaluated during operational testing.

Fuel Management

80. The fuel management system was evaluated primarily to determine if the previously reported deficiency (ref 3, app A) had been corrected. Due to the inoperative fuel transfer pump, the design changes incorporated to correct the previous deficiency, could not be evaluated. Low fuel transfer rate, a previously reported shortcoming, also could not be evaluated. A fuel transfer capability sufficient to supply adequate fuel to both engines operating at IRP should be demonstrated with the fuel transfer pump installed in the aircraft. A complete description of the YAH-64 fuel system is included in appendix B.

81. The design of the pilot's fuel control panel (fig 2) was evaluated throughout the test program. The switch labeling and function (although redesigned since EDT-2) remain confusing and the engine fuel switches were difficult to see with the engine power control levers in the full aft position. Normal operation of the fuel system required frequent pilot attention to the fuel control panel in order to maintain comparable fuel levels in each tank. When attempting to transfer fuel or use fuel from one tank only, no immediate indication was available to show the direction of transfer or the failure of the transfer pump. The TK SEL switch does not always indicate the correct operation of the system. With the boost pump ON (required for operation above 10,000 feet, pressure altitude) the TK SEL switch is disabled and may be positioned to the FROM FWD position when in fact, fuel will be supplied to both engines from the aft tank. Additionally, the TK SEL switch can be inadvertently activated by the pilots sleeve or glove. Ideally, operation of the fuel management system should be such that the pilot would not be required to activate various switches on the fuel control panel during flight unless a malfunction or emergency condition existed. The poor design of the pilot's fuel control panel is a previously reported shortcoming.

RELIABILITY AND MAINTAINABILITY

82. The reliability and maintainability features of the YAH-64 aircraft were evaluated throughout the test. Nineteen Equipment Performance Reports (EPRs)
Figure 2. Pilot's Fuel Control Panel
were prepared and submitted during this test and are listed in appendix G. This section is only intended to document those undesirable reliability and maintainability features encountered.

a. The master caution light randomly failed to illuminate with the illumination of a caution or warning segment light. The random failure occurred a minimum of eight times during six flights and occurred in conjunction with the illumination of the following caution panel segment lights: SAS, F FEEL, STAB FAIL, GEN 1, GEN 2. The problem appeared initially at the pilot station but occurred once at the CPG station also. Maintenance action was taken, to include replacement of the pilot's warning panel, but subsequent flights showed that the problem had not been corrected. Failure of the master caution light to illuminate, primarily when the pilot's attention is directed outside the aircraft (as during NOE flight) will be hazardous since the pilot may not be alerted to a potentially critical malfunction. Random failure of the master caution light to illuminate with the illumination of some caution or warning panel segment light is a deficiency.

b. The fuel transfer pump failed to operate during the test program. Frequent maintenance action, including replacement of the fuel transfer pump, was performed. All attempts to correct the problem were unsuccessful. All tests were flown without a fuel transfer capability and fuel management was accomplished by using the tank select function. The inoperative fuel transfer pump is a shortcoming which should be corrected prior to operational testing.

c. The heading and attitude reference system (HARS) failed to align accurately during the test. Alignments, both normal and fast, were inconsistent and indicated heading varied as much as ±20 degrees from actual runway heading. The inconsistent and inaccurate alignment of the HARS is a shortcoming which should be corrected prior to operational testing.

d. The Marconi scale for the No. 2 engine power turbine speed ($N_p$) showed 102 percent (caution range) throughout the test. The main rotor speed and No. 1 engine $N_p$ both read 100 percent. The illumination of the caution range is distracting to the pilot since it indicates an overspeed condition. The indication of the No. 2 engine $N_p$ at 102 percent with the main rotor speed at 100 percent is a shortcoming.

e. The rotor brake failed to hold with both engines at idle. During the start of the second engine, the rotor brake began to slip as 60 percent $N_p$ was reached. To initially set the rotor brake, the switch had to be moved to the BRAKE position then rapidly through OFF to the LOCK position. The requirement to move the switch through the OFF position may contribute to some loss of brake pressure. The failure of the rotor brake to hold with both engines at idle is a shortcoming previously reported. The performance of the rotor brake failed to meet the requirements of paragraph 3.7.1.1.7 of reference 7, appendix A, in that the rotor brake failed to hold with both engines at idle.

f. An excessive accumulation of oil was noted on the main transmission deck and in the upper fairing maintenance access area. This accumulation was due primarily to the moderate leakage of the engine nose gearboxes (EPR 80-03-7, app G). A leak in the main transmission left input seal, at the rate of 60 drops per minute, was noted prior to engine start with the auxiliary power unit in
The excessive accumulation of oil on the main transmission deck and in the upper fairing maintenance access area is a shortcoming.

g. The correct fluid service level of the primary and utility hydraulic reservoirs was difficult to determine. It was impossible to see any decals or markings on the primary reservoir. The utility reservoir was marked with a decal indicating normal range but no minimum or maximum service level was indicated. Additionally, the decal marking was subject to deterioration and appeared to be peeling off. The difficulty in determining the correct service level of the primary and utility hydraulic reservoirs is a shortcoming previously reported.

h. Hydraulic fluid samples were being taken from the return side of the primary and utility ground service panel. The fluid taken from this point is not representative since it does not circulate throughout the system. No means were available to take an accurate sample of primary or utility hydraulic fluid. The lack of an acceptable method for sampling the primary and utility hydraulic fluid is a shortcoming.

i. The primary and utility hydraulic reservoirs were frequently found to be overserviced during the preflight inspection. It appeared that the ground hydraulic service equipment overserviced the reservoirs when operating the aircraft with ground hydraulic power only. There was no method for bleeding the reservoir down to the proper service level prior to flight. During APU start some of the hydraulic fluid would be automatically dumped overboard through a drain line; however, it was not sufficient to return the reservoir to the proper service level. The lack of a method for bleeding an overserviced primary or utility hydraulic reservoir is a shortcoming.

j. A temporary loss of electrical power was observed when transitioning from aircraft power to external power. Various system failure indications were noted, to include automatic stabilator and engine out warnings, due to the power transient. Electrical power was restored to the aircraft by activating the EXT PWR RESET switch. The temporary loss of electrical power when transitioning from aircraft power to external power is a shortcoming previously reported.

k. During preflight it was extremely difficult to determine the engine oil levels without first opening the engine cowlings. A small piece of polished metal had been installed on the inside of the cowling which allowed the pilot to look up through the fire access door to see the sight gauge. Due to oil accumulation, scratches on the polished metal mirror, wiring harnesses, and insufficient lighting, it was extremely difficult to accurately determine the engine oil level using this method. The difficulty in accurately determining the engine oil levels without opening the engine cowlings is a shortcoming previously reported.

l. The fire bottle discharge lights, located on the fire test panel, failed to illuminate with activation of the PRESS TO TEST switch. The lights are designed to illuminate to advise the pilot when a fire bottle has been discharged. The PRESS TO TEST function is a preflight check to check the operation of the lights only. The failure of the fire bottle discharge lights to illuminate with the activation of the PRESS TO TEST switch is a shortcoming.

m. Activation of the rotor brake switch during engine shutdown caused activation of the automatic stabilator failure audio tone. This occurrence was
observed on the last three flights during EDT-4 and is an indication of EMI. The initiation of the automatic stabilator audio tone with the activation of the rotor brake switch during shutdown is a shortcoming. The planned EMI evaluation should be conducted prior to operational testing.

AIRCRAFT PITOT-STATIC SYSTEM

83. Calibration of the ship's airspeed system was accomplished during level, climbing, and descending flights. Two calibrated pace aircraft were used as speed references. Data from these calibrations are presented in figures 78 through 80, appendix E.

84. The YAH-64 has two ship's airspeed systems. One utilizes the left-hand pitot tube and the other uses the right-hand one. Both systems use the same two static ports located on either side of the fuselage. The airspeed systems functioned satisfactorily.
CONCLUSIONS

GENERAL

85. Based on the EDT-4 flight test of the YAH-64 helicopter, the following conclusions were reached:

   a. Major improvements in aircraft handling qualities as well as some improvement in performance and vibration characteristics have been made since EDT-2.

   b. The new empennage and tail rotor configuration has made a significant improvement in the pitch attitude of the aircraft during approach and IRP climbs, (para 16).

   c. Low-speed flight characteristics including directional control margins have been greatly improved (para 35, 36, 37).

   d. Short-period dynamic stability characteristics have been significantly improved, particularly in high speed flight (para 24).

   e. Directional control margins with the revised directional control stop may be inadequate at high gross weight and high density altitudes and during lateral reversal maneuvers (para 35 and 40).

   f. The removal of the vertical vibration absorber did not significantly affect the vibration levels (para 61).

   g. Nineteen Equipment Performance Reports have been submitted during this test (para 83).

   h. Three deficiencies have been identified.

   i. Forty-four shortcomings have been identified.

DEFICIENCIES

86. The deficiencies reported herein are not necessarily intended to bar type classification per AR 310-25 (see app D for definition of deficiency used in this report). The following deficiencies (in order of importance) were identified:

   a. The disengagement of the HARS, DASE, and automatic operation of the stabilator, and erroneous activation of the engine out/low rotor speed audio tone with failure of the No. 1 generator (para 55).

   b. Random failure of the master caution light to illuminate with the illumination of some caution or warning panel segment lights (para 82a).

   *c. The restricted pilot's field of view caused by canopy frame structure during NOE and contour flight (para 45).

*Previously reported as a shortcoming.
SHORTCOMINGS

87. The most significant shortcomings found during this test are listed in order of relative importance (see app D for definition of shortcoming).

a. The inoperative fuel transfer pump (para 82b).

*b. The poor design of the pilot's fuel control panel (para 81).

c. The inconsistent and inaccurate alignment of the HARS (para 82c).

d. The absence of SAS pitch rate damping at load factors greater than 1.6 due to saturation of the pitch SAS actuator (para 22).

**e. The restriction to the pilot's field of view caused by window edge distortion, the overhead circuit breaker panel, canopy reflections, CPG helmet, and the PNVS turret (para 32 and 45).

**f. The objectionable 4/rev vertical vibration in rearward flight at airspeeds greater than 25 KTAS, lateral vibration in right sideward flight at airspeeds greater than 15 KTAS, lateral vibration in level flight at airspeeds less than 50 KCAS and greater than 117 KCAS and the vertical vibration during termination of the approach (para 62).

*g. Disengagement of the DASE with failure of the No. 2 generator (specification noncompliance) (para 55).

*h. The poor trimability at airspeeds between 85 and 110 KCAS (para 15).

i. The uncommanded aircraft response when retimming with the attitude hold engaged (para 19).

j. The uncomfortable and potentially vertigo-inducing left roll attitude at cruise airspeed during simulated IMC flight (para 47).

*k. The excessive longitudinal breakout force (specification noncompliance) (para 12).

*l. The abrupt longitudinal control trim shift from 12 to 18 KTAS (para 35).

* m. The large, abrupt lateral control trim shifts between 16 and 24 KTAS rearward and between 13 and 18 KTAS forward flight (para 34).

*n. The inadvertent directional control inputs during brake application (para 28).

o. The lack of adequate display capability of the engine torque indicator vertical scale (para 64).

*Previously reported as a shortcoming.
**Previously reported as a deficiency.
p. The poor design of the collective pitch control friction mechanism (para 65).

q. The inability to maintain both crew stations at the same temperature using the ENCU (para 68).

*r. The lack of a reliable indication of parking brake status (para 30).

s. The indication of the No. 2 engine $N_p$ at 102 percent with the main rotor speed at 100 percent (para 82d).

t. The improper operation of the automatic stabilator during minimum power descents at 50 and 60 KCAS (para 17).

u. The lack of an acceptable method for sampling the primary and utility hydraulic fluid (para 82h).

*v. The high inherent friction of the engine power control levers (specification noncompliance) (para 42).

w. The annoying tone present in the intercom system (para 72).

*Previously reported as a shortcoming.

88. Additional shortcomings found are listed below:

*a. The failure of the rotor brake to hold with both engines at idle (specification noncompliance) (para 82e).

b. The failure of the Marconi instruments to display the full green range during normal operation (para 66).

c. The excessive accumulation of oil on the main transmission deck and in the upper fairing maintenance access area (para 82f).

*d. The difficulty in determining the correct service level of the primary and utility hydraulic reservoirs (para 82g).

e. The lack of a method for bleeding an overserviced primary or utility hydraulic reservoir (para 82i).

*f. The poor location of the pilot engine control quadrant (para 43).

*g. The temporary loss of electrical power when transitioning from aircraft power to external power (para 82j).

*h. The washout of the rocket panel displays, Marconi instrument indications and caution, warning and advisory panel segment lights in direct sunlight (para 67).

*i. The poor location of the tail wheel unlock light (para 29).

*j. The constant illumination of the lower green segment light on the Marconi vertical scale (para 69).

*Previously reported as a shortcoming.
*k. The illumination of the APU ON advisory light prior to the APU stabilizing at 100 percent rpm (para 70).

*l. The poor anthropometric design of the pilot’s cyclic grip (para 71).

*m. The difficulty in accurately determining the engine oil levels without opening the engine cowlings (para 82k).

*n. The difficulty in attaining a comfortable seating position with reference to the cyclic and collective controls (para 73).

o. The difficulty in operating the HARS control switch (para 74).

p. The intermittent illumination of the master caution and engine fuel pressure warning lights during engine start (para 75).

q. The illumination of the master caution light with green advisory segment lights (para 76).

r. The poor location of the anti-ice panel switches (para 77).

*s. The full scale illumination of the Marconi engine torque indicator during engine start (para 78).

*t. The initiation of the automatic stabilator audio tone with the activation of the rotor brake switch during shutdown (para 82m).

u. The failure of the fire bottle discharge lights to illuminate with the activation of the PRESS TO TEST switch (para 82l).

SPECIFICATION COMPLIANCE
89. The YAH-64 was found not to be in compliance with the following paragraphs of the Phase 2 Advanced Attack Helicopter System Specification AMC-SS-AAH-H10000A. Additional specification noncompliance, beyond the scope of this evaluation, may exist.

a. 3.7.1.1.7 Failure of the rotor brake to hold with both engines at idle (para 82e).

b. 10.3.2.1.1 Excessive longitudinal control breakout force (plus friction) (para 12).

***c. 10.3.2.2 Excessive lateral control force gradient (para 13).

***d. 10.3.2.5 Longitudinal control force could not be trimmed to zero with the CPG cyclic control stick extended (para 12).

*Previously reported as a shortcoming.
***Considered acceptable.
e. 10.3.2.7.1 Control inputs in excess of 0.25 inch were required to maintain the desired aircraft attitude with disengagement of the DASE (para 51).

f. 10.3.2.7.8 Failure of a single generator caused disengagement of the DASE (para 55).

g. 10.3.3.2.3 Excessive control force required to operate the engine power control levers (para 42).

h. 10.3.8.1.1 Insufficient available collective delay time following single engine when operating at IRP (para 48).

Considered acceptable.
RECOMMENDATIONS

90. The following recommendations are made:

a. Correct the deficiencies listed in paragraphs 86a and 86b prior to conducting operational testing.

b. Identify field of view as a special area of interest for operational testing (para 32 and 45).

c. Continue efforts to reduce the objectionable 4/rev vibrations (para 62).

d. Correct the shortcomings listed in paragraphs 87a, 87c, and 87d prior to operational testing.

e. Demonstrate a fuel transfer capability, sufficient to supply adequate fuel to both engines operating at IRP, with the fuel transfer pump installed in the aircraft (para 80).

f. Conduct the planned electromagnetic interference evaluation prior to operational testing (para 55, 72, and 82m).

g. Evaluate the need for additional cockpit storage area and provisions for passing mission essential items between cockpits during operational testing (para 79).

h. Investigate the structural implications of single engine operation below 93 percent main rotor speed (para 48).

i. Correct the remaining shortcomings listed in paragraphs 87 and 88 prior to production.

j. Reevaluate the decision to revise tail rotor rigging from 33 degrees to 27 degrees left directional control (para 35 and 40).

k. Conduct further evaluation of the instrument flight capability of the YAH-64 configured with production flight instruments (para 47).

l. Investigate and clearly define the operational requirement for lateral reversal maneuvers (para 40).

m. Reevaluate the yaw oscillations at airspeeds between 40 and 70 KCAS with the ADS providing sideslip information to the DASE (para 18).

n. Identify ENCU operation as a special area of interest during climatic testing (para 68).

o. Consider incorporating an altitude-hold feature in the hover augmentation system and the attitude hold mode of the DASE (para 19 and 46).

p. Incorporate provisions to allow the pilot to engage the hover augmentation system without removing his hands from the flight controls (para 46).

q. Consider installing a longitudinal seat adjustment for the pilot seat (para 73).
APPENDIX A. REFERENCES


2. Final Report, USAEEFA Project No. 77-36, Engineer Design Test 1, Hughes YAH-64 Advanced Attack Helicopter, September 1978.


5. Test Plan, USAEEFA Project No. 80-03, Engineer Design Test 4, YAH-64 Advanced Attack Helicopter, September 1980.


APPENDIX B. DESCRIPTION

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   Vertical Stabilizer
   Wing
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   Collective Control System
   Directional Control System
   Trim Feel System
   Horizontal Stabilator
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   Digital Automatic Stabilization Equipment
Hydraulic System
   General
   Primary Hydraulic System
   Utility Hydraulic System
   Servoactuators
Power Plant
Infrared (IR) Suppression System
Fuel System
Figure 2. Powertrain
GENERAL

1. The YAH-64 Advanced Attack Helicopter (fig 1) is a tandem, two-place twin turbine engine, single main rotor aircraft manufactured by Hughes Helicopters, a division of Summa Corporation. The main rotor is a four-bladed fully articulated system. It is supported by a stationary mast which transmits flight loads directly to the fuselage. The tail rotor is a four-bladed semi-rigid, delta-hinged system incorporating elastomeric teetering bearings. The rotors are driven by two General Electric YT 700-GE-700R engines through the power train shown in figure 2. An auxiliary power unit (APU) is installed primarily for starting the engines and to provide electrical and hydraulic power when the aircraft is on the ground and rotors are not turning. The aircraft is designed to carry various combinations of ordnance stores internally in the ammunition bay and externally on the four wing store positions. The YAH-64 is designed to operate during day, night and marginal weather combat conditions using the Martin Marietta Target Acquisition Designation System (TADS)/Pilot’s Night Vision System (PNVS). The test aircraft, S/N 77-23258, (photos 1 through 16) was configured with an aerodynamic mockup of the TADS/PNVS, a 30mm CHAIN GUN and a HELLFIRE missile launcher loaded with four dummy missiles on each of the two inboard wing pylons. The major aircraft modifications since Engineer Design Test 2 (EDT-2) consist of an increase in tail rotor diameter, the installation of a moveable horizontal stabilator, the incorporation of Digital Automatic Stabilization Equipment (DASE), installation of a vertical vibration absorber, stiffening of the canopy window panels and fixing the position of the moveable wing flaps. Various modifications were incorporated to reduce drag and are listed in table 1. Neither the Back Up Control System (BUCS) nor the Electronic Attitude Direction Indicator (EADI) were operational during this test.

DIMENSIONS AND GENERAL DATA

<table>
<thead>
<tr>
<th></th>
<th>EDT-2</th>
<th>Mod 2B</th>
<th>EDT-4</th>
</tr>
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<tbody>
<tr>
<td><strong>Main Rotor</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter (ft)</td>
<td>48</td>
<td>48</td>
<td>48</td>
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<td>Blade chord (in.)</td>
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<td>21.0*</td>
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<td>Main rotor blade area (ft²)</td>
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<td>166.5</td>
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<td>Main rotor disc area (ft²)</td>
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<td>1809.56</td>
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<td>0.092</td>
<td>0.092</td>
</tr>
<tr>
<td>Airfoil</td>
<td>H11-02**</td>
<td></td>
<td>H11-02**</td>
</tr>
<tr>
<td>Twist</td>
<td>-9 deg</td>
<td>-9 deg</td>
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<tr>
<td>Number of blades</td>
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<td>4</td>
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<tr>
<td>Rotor speed at 100 percent N₁ (rpm)</td>
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<td>289.3</td>
<td>289.3</td>
</tr>
<tr>
<td>Tip speed at 100 percent N₁ (ft/sec)</td>
<td>727.09</td>
<td>727.09</td>
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*Includes tips.
**Outer 20 inches swept back 20 degrees and transitioned to an NACA 006 airfoil.
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<thead>
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<th>EDT-2 Mod 2</th>
<th>EDT-4</th>
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<td><strong>Tail Rotor</strong></td>
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<td>Tail rotor solidity</td>
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<td>8.8 washout</td>
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<td>Teetering angle (deg)</td>
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<td><strong>Horizontal Stabilizer/Stabilator</strong></td>
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<td>Weight (lb)</td>
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<tr>
<td>Area (ft²)</td>
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<td>Span (ft)</td>
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<td>Variable</td>
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<td>Sweepback of trailing edge (deg)</td>
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<tr>
<td>Dihedral (deg)</td>
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<td>0</td>
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<tr>
<td><strong>Vertical Stabilizer</strong></td>
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<tr>
<td>Area (from boom Cₖ) (ft²)</td>
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<td>32.2</td>
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<tr>
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<td>113.0</td>
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<tr>
<td>Root chord (at boom Cₖ) (in.)</td>
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<tr>
<td>Geometric aspect ratio</td>
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<td>Airfoil</td>
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<td>NACA 4415</td>
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<td>modified at root (Cₖ) boom tapering to NACA 4415</td>
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</tr>
<tr>
<td>at 66 in. from boom Cₖ</td>
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</tbody>
</table>

***Reference is 3.2 inches from centerline (Cₖ).***
**FLIGHT CONTROL DESCRIPTION**

**General**

2. The YAH-64 helicopter employs a single hydromechanical irreversible flight control system. The hydromechanical system is mechanically activated with conventional cyclic, collective and directional pedal controls, through a series of push-pull tubes attached to four airframe-mounted hydraulic servoactuators. The four hydraulic servoactuators control longitudinal cyclic, lateral cyclic, main rotor collective and tail rotor collective pitch. Hydraulic power is supplied by two independent 3000-psi hydraulic systems which are powered by hydraulic pumps mounted on the accessory gearbox to allow full operation under a dual-engine failure condition. A Digital Automatic Stabilization Equipment (DASE) system is installed to provide rate damping. The DASE control authority is limited to 10 percent of pilot control authority in pitch, roll, and yaw. The DASE also provides attitude hold and a Hover Augmentation System (HAS). An electrically-actuated horizontal stabilator is attached to the lower aft side of the vertical stabilator. Movement of the stabilator can be controlled either manually or automatically. A Trim Feel System (TFS) is incorporated in the cyclic and pedal controls to provide a control force gradient with control displacement from a selected trim position. A trim release switch, located on the cyclic grip, provides either a momentary or continuous interruption of the TFS in all axes simultaneously to allow the cyclic or pedal controls to be placed in a new trim position. Full control travel is 10.2 inches in the longitudinal control, 8.9 inches in the lateral control.
Table 1. Drag Reduction Modifications

<table>
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<th>ECRR* Number</th>
<th>Date</th>
<th>Description</th>
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<tr>
<td>39319</td>
<td>7 Aug 80</td>
<td>Addition of main landing gear opening covers on top and bottom of forward avionics bays (FABS)</td>
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<tr>
<td>39320</td>
<td>7 Aug 80</td>
<td>Trailing edge of vertical stabilizer adjusted to 16 degrees</td>
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<tr>
<td>40380</td>
<td>7 Aug 80</td>
<td>Addition of upper main rotor mast fairing</td>
</tr>
<tr>
<td>40493</td>
<td>7 Aug 80</td>
<td>Addition of FABS rear extension fairings</td>
</tr>
<tr>
<td>40091</td>
<td>7 Aug 80</td>
<td>Doppler radar antenna fairing extension</td>
</tr>
<tr>
<td>40992</td>
<td>7 Aug 80</td>
<td>Addition of wing root fairings</td>
</tr>
<tr>
<td>40988</td>
<td>7 Aug 80</td>
<td>Closure on rear end of tail cone</td>
</tr>
<tr>
<td>53296</td>
<td>19 Sep 80</td>
<td>Improved tail rotor gear box fairing</td>
</tr>
<tr>
<td>53277</td>
<td>19 Sep 80</td>
<td>Improved fairing between engine nacelles</td>
</tr>
<tr>
<td>53501</td>
<td>7 Aug 80</td>
<td>Addition of fences on fairing between engine nacelles</td>
</tr>
<tr>
<td>53298</td>
<td>3 Nov 80</td>
<td>Wing store flight stow position adjusted up 3 degrees</td>
</tr>
<tr>
<td>39322</td>
<td>7 Aug 80</td>
<td>Addition of wing tip light fairing</td>
</tr>
</tbody>
</table>

*Engineering change request and record
12.0 inches in the collective control and 5.4 inches in the directional pedals (during the test program, the left pedal stop was moved 1.2 inches, restricting total travel to 4.2 inches).

### Cyclic Control System

3. The cyclic control system (fig 3) consists of dual-tandem cyclic controls attached to individual support assemblies in each cockpit. The support assembly houses the primary longitudinal and lateral control stops, and two linear variable displacement transducers (LVDT) designed to measure electrically the longitudinal and lateral motions of the cyclic for DASE computer inputs. A series of push-pull tubes and bellcranks transmits the motion of the cyclic control to the servoactuators and the mixer assembly. Motion of the mixer assembly positions the nonrotating swashplate, which transmits the control inputs to the rotating swashplate to control the main rotor blades in cyclic pitch (fig 4). The cyclic stick grips are shown in figure 5. A stick fold linkage is provided to allow the copilot/gunner (CPG) to lower the cyclic stick to prevent interference when operating the weapon systems.

### Collective Control System

4. The collective pitch control system (fig 6) consists of dual-tandem controls which transmit collective control inputs to the main rotor through a series of push-pull tubes and bellcranks attached to the collective servoactuator. Motion of the servoactuator is transmitted through the mixer assembly to the swashplate to control the main rotor blades in collective pitch. Collective inputs are also transmitted to the load demand spindle of each engine hydromechanical unit (HMU). The HMU meters the fuel as appropriate to provide collective pitch compensation. Located at each collective control base assembly are the primary control stop, an LVDT, and a 1g balance spring. The LVDT supplies electrical inputs to the stabilator control units.

5. The collective control stick (fig 7) incorporates a switch box assembly, an engine chop collar, a stabilator control panel and an adjustable friction control. The engine chop collar allows rapid deceleration of the engine to flight idle, primarily to allow immediate action in the event of a tail rotor failure.

### Directional Control System

6. The directional control system (fig 8) consists of a series of push-pull tubes and bellcranks which transmits directional pedal inputs to the tail rotor hydraulic servoactuator located in the vertical stabilizer. Attached to each directional pedal assembly are the primary tail rotor control stops and one LVDT. Two sets of wheel brake cylinders are attached to the directional pedals and a 360 degrees swiveling tail wheel is incorporated. The tail wheel may be locked in the trailing position by means of a switch located on the pilot’s instrument panel.

### Trim Feel System

7. A TFS is incorporated in the longitudinal, lateral, and directional control systems. The TFS uses individual magnetic brake clutch assemblies in each of the control linkages. Trim feel springs are incorporated to provide a control force gradient and positive control centering. The electromagnetic brake clutch is powered by 28 VDC and is protected by the trim circuit breaker. A complete DC electrical
12.0 inches in the collective control and 5.4 inches in the directional pedals (during the test program, the left pedal stop was moved 1.2 inches, restricting total travel to 4.2 inches).

Cyclic Control System

3. The cyclic control system (fig 3) consists of dual-tandem cyclic controls attached to individual support assemblies in each cockpit. The support assembly houses the primary longitudinal and lateral control stops, and two linear variable displacement transducers (LVDT) designed to measure electrically the longitudinal and lateral motions of the cyclic for DASE computer inputs. A series of push-pull tubes and bellcranks transmits the motion of the cyclic control to the servoactuators and the mixer assembly. Motion of the mixer assembly positions the nonrotating swashplate, which transmits the control inputs to the rotating swashplate to control the main rotor blades in cyclic pitch (fig 4). The cyclic stick grips are shown in figure 5. A stick fold linkage is provided to allow the copilot/gunner (CPG) to lower the cyclic stick to prevent interference when operating the weapon systems.

Collective Control System

4. The collective pitch control system (fig 6) consists of dual-tandem controls which transmit collective control inputs to the main rotor through a series of push-pull tubes and bellcranks attached to the collective servoactuator. Motion of the servoactuator is transmitted through the mixer assembly to the swashplate to control the main rotor blades in collective pitch. Collective inputs are also transmitted to the load demand spindle of each engine hydromechanical unit (HMU). The HMU meters the fuel as appropriate to provide collective pitch compensation. Located at each collective control base assembly are the primary control stop, an LVDT, and a 1g balance spring. The LVDT supplies electrical inputs to the stabilator control units.

5. The collective control stick (fig 7) incorporates a switch box assembly, an engine chop collar, a stabilator control panel and an adjustable friction control. The engine chop collar allows rapid deceleration of the engine to flight idle, primarily to allow immediate action in the event of a tail rotor failure.

Directional Control System

6. The directional control system (fig 8) consists of a series of push-pull tubes and bellcranks which transmits directional pedal inputs to the tail rotor hydraulic servoactuator located in the vertical stabilizer. Attached to each directional pedal assembly are the primary tail rotor control stops and one LVDT. Two sets of wheel brake cylinders are attached to the directional pedals and a 360 degrees swiveling tail wheel is incorporated. The tail wheel may be locked in the trailing position by means of a switch located on the pilot's instrument panel.

Trim Feel System

7. A TFS is incorporated in the longitudinal, lateral, and directional control systems. The TFS uses individual magnetic brake clutch assemblies in each of the control linkages. Trim feel springs are incorporated to provide a control force gradient and positive control centering. The electromagnetic brake clutch is powered by 28 VDC and is protected by the trim circuit breaker. A complete DC electrical
Figure 4. Main Rotor Swashplate Assembly
Figure 5. Cyclic Stick Grips

1. TRIM RELEASE SWITCH
2. CPG GRIP-MOMENTARY
3. PILOT GRIP-DISCRETE/MOMENTARY
4. WEAPONS ACTION SWITCH
5. TO BE DETERMINED
6. DASE RELEASE SWITCH
7. GUARDED TRIGGER SWITCH
8. REMOTE TRANSMITTER SELECTOR SWITCH
9. (PILOT GRIP ONLY)
10. RADIO, ICS ROCKER SWITCH
Figure 6. Collective Control Subsystem
Figure 7. Collective Stick and Switch Box

- Stick Grip
- CPG
- Switch Box
- Engine Chop Collar
- Stabilator Control Switch
- Friction Adjust
- Audio Tone Reset Button
- Pilot
Figure 8. Directional Controls
failure will disable the TFS and allow the cyclic and directional pedals to move freely without resistance from the trim feel springs. The trim release switch on the pilot’s cyclic grip allows either momentary or discreet release of the TFS. The CPG has a momentary release capability only.

**Horizontal Stabilator**

8. The horizontal stabilator is attached to the aft lower portion of the vertical stabilizer. The stabilator airfoil has a span of 10.7 feet, the tip cord is 2.7 feet and the root cord is 3.6 feet (total 33.4 square feet). A dual, series 28 VDC electromechanical actuator allows incidence changes of +45 degrees (trailing edge down) to -10 degrees of travel. Software limits in the stabilator control unit (SCU) limits the incidence change to +25 degrees and -5 degrees in the automatic mode of operation. Automatic positioning of the stabilator during flight is primarily a function of airspeed and collective position as shown in figure 9. The stabilator also responds with low gain (0.25 deg/deg/sec) and limited authority (±2.5 deg) to pitch rate inputs to the SCU. Safety features include an automatic shutdown capability which allows operation in the manual mode by means of a stabilator control panel located on each collective stick. An audio step tone is associated with the failure of the automatic mode of operation. A stabilator kill switch, located on the pilot’s collective stick, disables both the automatic and manual operation to protect against a hardover failure.

9. The stabilator is controlled in the automatic mode by two SCUs. Each SCU controls one side of the dual actuator. Both SCUs receive collective control position information from an LVDT. Two independent pitch rate gyros provide pitch rate information to the SCUs (one gyro for each SCU). The Air Data System (ADS) provides airspeed to both SCUs. The left-hand pitot-static system supplies airspeed to one SCU and the right-hand system provides airspeed to the other SCU. Both SCUs receive position information from both sides of the dual actuator. The maximum rate of stabilator travel is 8 degrees per second.

10. The SCUs have a fault detection feature which will switch the stabilator mode of operation from automatic to manual if any of the following conditions are sensed:

   a. A mismatch between the positions of the two halves of the actuator equivalent to 10 degrees of stabilator travel. If there is a runaway failure of one side of the actuator, this feature will disable the automatic mode after 10 degrees of stabilator travel.

   b. A mismatch in the rates of actuator travel of more than 10 degrees per second. This could only occur if one side of the actuator were extending while the other was retracting.

   c. The stabilator at a position of 20 degrees or greater with an airspeed greater than 110 knots.

   d. A stabilator angle of 30 degrees or greater with air-speed less than 60 knots.

   e. Improper AC voltage or an actuator short circuit.
NOTES:
1. Voltages input to stabilator control unit to simulate inputs from air data system for airspeeds to 50 kts.
2. Left and right pitot system pressurized to obtain airspeeds above 50 knots.
Flight Control Rigging

11. A flight controls rigging check was performed in accordance with procedures outlined in HH Experimental Test Procedure (ETP) 7-211500000, dated 1 August 1979, (main and tail rotor controls) and ETP 7-211123600, dated 21 April 1980 (horizontal stabilator). Prior to the 18th flight of EDT-4, the tail rotor rigging was revised to conform with a HH Internal Communication document (File No. 80-1331-067), dated 20 November 1980. Horizontal stabilator rigging is shown in figure 9. Tables 2 and 3 present the collective and cyclic rigging.

12. Tail rotor rigging is shown below:

- Full right pedal = 13.1 degrees (thrust to left)
- Full left pedal (initial) = 33.1 degrees (thrust to right)
- Full left pedal (revised) = 27.3 degrees (thrust to right)

Digital Automatic Stabilization Equipment

13. The DASE provides rate damping in three axes, control augmentation for cyclic and directional controls, pitch and roll attitude-hold in forward flight, and hover augmentation. Additionally, in forward flight the DASE attempts to maintain zero sideslip. A block diagram of the DASE is shown in figure 10. The DASE is controlled by the digital automation stabilization equipment computer (DASEC). The DASEC receives information which describes the aircraft state from the heading and attitude reference system (HARS). This information includes aircraft angular velocities (3-axes), aircraft attitudes (pitch and roll), and inertial horizontal velocity (measured by the Doppler radar). The LVDT provides longitudinal, lateral, and directional control position information to the DASEC. The DASE design calls for sideslip and airspeed information to be supplied to the DASEC by the ADS mounted on top of the main rotor mast. On the test aircraft, however, sideslip information was supplied by a transducer mounted on the test airspeed boom. The DASEC processes the information and sends control inputs through the stability and control augmentation system (SCAS) solenoid valves on the longitudinal, lateral and directional servoactuators. The DASE authority is limited to ±10 percent of the pilot's control authority in each axis. Transducers on the servoactuators provide position feedback information to the DASEC.

14. The directional, lateral, and longitudinal rate damping and control augmentation functions of the DASE are activated using the three switches on the DASE control panel (fig 11) labeled YAW, ROLL, and PITCH respectively. Schematic diagrams showing gains and transfer functions are shown in figures 12 through 14. Additionally, when the YAW switch is engaged and the aircraft is at an airspeed greater than 50 knots, the DASE will attempt to maintain zero sideslip.

15. Attitude-hold mode or hover augmentation system (HAS) mode may be engaged using the DASE panel switch labeled ATTD/HOVER HOLD (fig 11). At airspeeds above 50 knots, activation of this switch will engage pitch and roll attitude hold. Figures 15 and 16 are schematic diagrams describing this mode. At airspeeds below 50 knots, the HAS mode is engaged. In this mode, the DASE will attempt to maintain a position over the ground as well as maintaining pitch and roll attitudes.
### Table 2. Angle Measurements
#### Pilots Collective and Cyclic Controls

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<th>Blade Azimuth Position (deg)</th>
<th>Item</th>
<th>Collective</th>
<th>Rig Pins</th>
<th>Stick Position</th>
<th>Measured Clinometer Angle (deg · min)</th>
<th>Leading Edge Up or Down</th>
</tr>
</thead>
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<td></td>
<td></td>
<td></td>
<td>Longitudinal Cyclic</td>
<td>Lateral Cyclic</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Collective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Longitudinal</td>
<td>Lateral</td>
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<td></td>
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<td>$\psi = 90$</td>
<td>1</td>
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<td>In</td>
<td>Rig</td>
<td>Rig</td>
<td>$0^\circ - 15^\circ$</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>In</td>
<td>Out</td>
<td>Rig</td>
<td>Fwd</td>
<td>$21^\circ - 5^\circ$</td>
</tr>
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<td>In</td>
<td>Out</td>
<td>Rig</td>
<td>Att</td>
<td>$11^\circ - 0^\circ$</td>
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<tr>
<td></td>
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<td>In</td>
<td>Rig</td>
<td>Rig</td>
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<tr>
<td></td>
<td>6</td>
<td>Out</td>
<td>In</td>
<td>Down</td>
<td>Rig</td>
<td>$8^\circ - 55^\circ$</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>In</td>
<td>In</td>
<td>Rig</td>
<td>Rig</td>
<td>$0^\circ - 0^\circ$</td>
</tr>
<tr>
<td>$\psi = 270$</td>
<td>8</td>
<td>In</td>
<td>In</td>
<td>Rig</td>
<td>Rig</td>
<td>$1^\circ - 0^\circ$</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>In</td>
<td>Out</td>
<td>Rig</td>
<td>Fwd</td>
<td>$20^\circ - 25^\circ$</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>In</td>
<td>Out</td>
<td>Rig</td>
<td>Att</td>
<td>$11^\circ - 40^\circ$</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>In</td>
<td>In</td>
<td>Rig</td>
<td>Rig</td>
<td>$1^\circ - 0^\circ$</td>
</tr>
<tr>
<td>$\psi = 0$</td>
<td>12</td>
<td>In</td>
<td>In</td>
<td>Rig</td>
<td>Rig</td>
<td>$1^\circ - 15^\circ$</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>In</td>
<td>Out</td>
<td>Rig</td>
<td>Left</td>
<td>$10^\circ - 30^\circ$</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>In</td>
<td>Out</td>
<td>Rig</td>
<td>Right</td>
<td>$8^\circ - 15^\circ$</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>In</td>
<td>In</td>
<td>Rig</td>
<td>Rig</td>
<td>$1^\circ - 10^\circ$</td>
</tr>
<tr>
<td>$\psi = 180$</td>
<td>16</td>
<td>In</td>
<td>In</td>
<td>Rig</td>
<td>Rig</td>
<td>$0^\circ - 10^\circ$</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>In</td>
<td>Out</td>
<td>Rig</td>
<td>Left</td>
<td>$11^\circ - 50^\circ$</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>In</td>
<td>Out</td>
<td>Rig</td>
<td>Right</td>
<td>$7^\circ - 50^\circ$</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>In</td>
<td>In</td>
<td>Rig</td>
<td>Rig</td>
<td>$0^\circ - 10^\circ$</td>
</tr>
</tbody>
</table>
Table 3. Computation of Blade Angle Travel
Pilots Collective and Cyclic Controls

<table>
<thead>
<tr>
<th>Computation</th>
<th>Travel (deg·min)</th>
<th>Tolerance (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LONGITUDINAL CYCLIC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Forward 1:2 (Item 9 - 2) = (If Item 2 is leading edge down, add Item 2)</td>
<td>20° - 45'</td>
<td>20° (minimum)</td>
</tr>
<tr>
<td>2. Aft 1:2 (Item 3 - Item 10) = (If Item 10 is leading edge down, add Item 10)</td>
<td>11° - 20'</td>
<td>10° (minimum)</td>
</tr>
<tr>
<td><strong>LATERAL CYCLIC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Left 1:2 (Item 13 - Item 17) = (If Item 17 is leading edge down, add Item 17)</td>
<td>11° - 10'</td>
<td>10.5° (minimum)</td>
</tr>
<tr>
<td>4. Right 1:2 (Item 18 - Item 14) = (If Item 14 is leading edge down, add Item 14)</td>
<td>8° - 2'</td>
<td>7.0° (minimum)</td>
</tr>
<tr>
<td><strong>COLLECTIVE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Full pitch travel (Item 5 - Item 6) = (If Item 6 is leading edge down, add Item 6)</td>
<td>19° - 5'</td>
<td>18.0° (minimum)</td>
</tr>
<tr>
<td>6. Collective pitch full down Measured (a 3.4 radius (Theo. chord line)</td>
<td></td>
<td>-1° to +2°</td>
</tr>
<tr>
<td>Measured (a pitch housing (Bolt pad machined surface 2.4 inches inboard of lead-lag hinge)</td>
<td>8° - 55'</td>
<td>-10° to -7°</td>
</tr>
</tbody>
</table>
Figure 11. DASE Control Panel
Figure 12. Pitch Rate Damping and Control Augmentation Functions
Figure 13. Roll Rate Damping and Control Augmentation Functions
Figure 14. Yaw Rate Damping and Control Augmentation Functions
Figure 15. Pitch Attitude Hold
HYDRAULIC SYSTEM

General

16. The hydraulic system consists of four hydraulic servoactuators powered simultaneously by two independent 3000-psi hydraulic systems. Each servoactuator simultaneously receives pressure from the primary and utility systems to drive the dual-tandem actuators. This design allows the remaining system to automatically continue powering the servos in the event of a single hydraulic system failure. The two systems (primary and utility) are driven by the accessory gearbox utilizing variable displacement pumps, independent reservoirs and accumulators. The Auxiliary Power Unit (APU) drives all accessories, including the hydraulic pumps, when the aircraft is on the ground and the rotor is not turning. The accessory gearbox is driven by the main transmission during flight and provides for normal operation of both hydraulic systems during autorotation. An emergency hydraulic system is provided to allow emergency operation of the flight controls in the event of a dual system failure.

Primary Hydraulic System

17. The primary hydraulic system (fig 17) consists of a one-pint capacity reservoir, which is pressurized to .30 psi using air from the shaft-driven compressor; an accumulator, which has a nitrogen precharge of 1600 psi, designed to reduce surges in the hydraulic system; and a primary manifold that directs the fluid to the lower side of the four servoactuators. The primary system also provides the hydraulic pressure for operation of the DASE and BUCS functions.

Utility Hydraulic System

18. The utility hydraulic system (fig 18) consists of an air pressurized 1.3 gallon reservoir and a 3000-psi accumulator which drives the APU starting motor. The utility manifold directs fluid to the upper side of the servoactuators, the stores pylon system, tail wheel lock mechanism, area weapon turret drive, and rotor brake. Other manifold functions include an auxiliary isolation check valve which isolates the area weapon turret drive and external stores actuators when either a low pressure or low fluid condition exists; a low pressure sensor isolates the accumulator as an emergency hydraulic source for the servoactuators in the event of a dual hydraulic system failure. The accumulator assembly stores enough fluid for emergency operation of the flight controls through four full strokes of the collective stick and one 180 degrees heading change. The emergency system may be activated by either the pilot’s or CPG’s emergency switch. An electrically activated emergency shutoff valve is designed to isolate the utility side of the directional servoactuator and the tail wheel lock mechanism when a low fluid condition exists. However, the electrical connections were not installed during EDT-4.

Servoactuators

19. Individual hydraulic servoactuators are provided for longitudinal, lateral, collective, and directional controls. Each servoactuator (fig 19) consists of a ballistically tolerant housing, a single actuator rod with dual frangible pistons, a LAP assembly, BUCS plunger, and various parts for routing of both primary and utility hydraulic fluid. The system is designed to accommodate all flight loads with a failure of either system. However, DASE and BUCS functions would be lost with
Figure 17. Primary Hydraulic System
Figure 18. Utility Hydraulic System
failure of the primary system. The BUCS plunger assemblies were installed during EDT-4, however, electrical connections were omitted.

POWER PLANT

20. The power plant for the YAH-64 helicopter is the General Electric YT700-GE-700R front drive turboshaft engine, rated at 1563 shp (sea level, standard day, uninstalled). The engines are mounted in nacelles on either side of the main transmission. The basic engine consists of four modules: A cold section, a hot section, a power turbine, and an accessory section. Design features of each engine include an axial-centrifugal flow compressor, a through-flow combustor, a two-stage air-cooled high-pressure gas generator turbine, a two-stage uncooled power turbine, and self-contained lubrication and electrical systems. In order to reduce sand and dust erosion, and foreign object damage, an integral particle separator operates when the engine is running. The YT700-GE-700R engine also incorporates a history recorder which records total engine events. Engines S/N 207-263R and S/N 207-277R were installed in the left and right positions, respectively. Pertinent engine data are shown below:

<table>
<thead>
<tr>
<th>Model</th>
<th>YT700-GE-700R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Turboshaft</td>
</tr>
<tr>
<td>Rated power (intermediate)</td>
<td>1563 shp sea level, standard day, uninstalled</td>
</tr>
<tr>
<td>Output speed (at 100 percent $N_R$)</td>
<td>20,952 rpm</td>
</tr>
<tr>
<td>Compressor</td>
<td>5 axial stages, 1 centrifugal stage</td>
</tr>
<tr>
<td>Variable geometry</td>
<td>Inlet guide vanes, stages 1 and 2 Stator vanes</td>
</tr>
<tr>
<td>Combustion chamber</td>
<td>Single annular chamber with axial flow</td>
</tr>
<tr>
<td>Gas generator turbine stages</td>
<td>2</td>
</tr>
<tr>
<td>Power turbine stages</td>
<td>2</td>
</tr>
<tr>
<td>Direction of rotation (aft looking forward)</td>
<td>Clockwise</td>
</tr>
<tr>
<td>Weight (dry)</td>
<td>415 lb</td>
</tr>
<tr>
<td>Length</td>
<td>46.5 in.</td>
</tr>
<tr>
<td>Maximum diameter</td>
<td>25 in.</td>
</tr>
<tr>
<td>Fuel</td>
<td>MIL-T-5624 (JP-4 or JP-5)</td>
</tr>
<tr>
<td>Lubricating oil</td>
<td>MIL-L-7808 or MIL-L-23699</td>
</tr>
</tbody>
</table>

85
Electrical power requirements
for history recorder and \( N_p \)
overspeed protection

Electrical power requirements
for anti-ice valve, filter bypass
indication, oil filter bypass
indication, and magnetic
chip detector

**INFRARED (IR) SUPPRESSION SYSTEM**

21. The IR suppression system was designed to replace the engine cooling fan used in the Phase 1 aircraft. The IR suppression consists of finned exhaust pipes attached to the engine outlet and bent outboard to mask hot engine parts. The finned pipes radiate heat which is cooled by rotor downwash in hover and turbulent air flow in forward flight. The engine exhaust plume is cooled by mixing it with engine cooling air and bay cooling air (fig 20). The exhaust acts as an eductor, creating air flow over the combustion section of the engine providing engine cooling. Fixed louvers on the top and bottom of the aft cowl and a door on the bottom forward cowling provide convective cooling to the engine during shutdown. The movable bottom door is closed by engine bleed air during engine operation.

**FUEL SYSTEM**

22. The YAH-64 fuel system has two fuel cells located fore and aft of the ammunition bay. The system includes a fuel boost pump in the aft cell for starting and for high-altitude operation, a fuel transfer pump for transferring fuel between cells, a fuel crossfeed/shutoff valve, and provisions for pressure and gravity fueling and defueling. Additionally, provisions exist for external, wing-mounted fuel tanks. Figure 21 is a schematic of the fuel system. Figure 22 shows the locations and capacities of the two internal fuel cells.

23. By using the tank select switch on his fuel control panel (fig 23), the pilot can select either or both tanks from which the engines will draw fuel. With the tank select switch in the NRML position, the left (No. 1) engine will draw fuel from the forward fuel cell and the right (No. 2) engine will draw from the aft cell (fig 24). When FROM FWD is selected on the tank select switch, the two fuel crossfeed/shutoff valves are positioned so that both engines draw fuel from the forward tank (fig 25). The FROM AFT position allows the engines to draw fuel from the aft tank only (fig 26). The tank select switch is disabled whenever the boost pump is on. When the boost pump is on, the fuel crossfeed/shutoff valves are positioned to allow only fuel from the aft cell to feed both engines (fig 27). The air-driven boost pump operates automatically during engine start and may be activated by the switch on the pilot or CPG fuel control panel (fig 23).

24. The pilot and CPG also have the capability to transfer fuel between tanks using the transfer switch on the fuel control panels (fig 23). Moving the fuel transfer switch out of the OFF position closes the refuel valve and starts the air-driven pump transferring fuel in the selected direction (fig 28).
Figure 21. Fuel Cell Locations

FWD FUEL CELL
151 GAL
989.1 LB

AFT FUEL CELL
218 GAL
1427.9 LB
Figure 23. Fuel System Controls
Figure 24. Fuel Crossfeed Operation Normal
Figure 26. Fuel Crossfeed Operation from Aft
Figure 27. Fuel System Boost Operation
APPENDIX C. INSTRUMENTATION

The airborne data acquisition system was installed, calibrated, and maintained by Hughes Helicopters. The system used pulse code modulation (PCM) encoding, and magnetic tape was used to record parameters on board the aircraft. A boom was mounted on the left side of the aircraft, extending forward of the nose. A pitot-static tube, an angle-of-attack sensor, and an angle-of-sideslip sensor were mounted on the boom. Instrumentation and related special equipment installed in the aircraft and used for this test are shown in the following lists:

Pilot Station (Aft Cockpit)

- Pressure altitude (boom)
- Pressure altitude (ship)
- Airspeed (boom)
- Cable tension
- Airspeed (right-hand ship system)
- Main rotor speed
- Engine torque (both engines)*
- Engine measured gas temperature (both engines)*
- Engine power turbine speed (both engines)*
- Engine gas producer speed (both engines)*
- Angle of sideslip
- Event switch
- Tether cable angles (longitudinal and lateral)
- Longitudinal control position
- Lateral control position
- Directional control position
- Collective control position
- Stabilator angle*

Copilot/Engineer Station

- Airspeed (boom)
- Altitude (boom)
- Main rotor speed
- Engine torque (both engines)*
- Engine measured gas temperature (both engines)*
- Engine gas producer speed (both engines)*
- Total air temperature
- Time code display
- Event switch
- Data system controls

*Standard aircraft instruments

PCM Parameters

- Time code
- Event
- Main rotor speed
- Fuel temperature (both engines)
- Fuel used (both engines)
- Engine fuel flow rate (both engines)
- Engine gas producer speed (both engines)
Engine power turbine speed (both engines)
Airspeed (boom)
Airspeed (ship, right and left)
Altitude (boom)
Altitude (ship)
Total air temperature
Angle of attack
Angle of sideslip
Tether cable tension
Tether cable angle (longitudinal and lateral)
Engine torque (both engines)
Engine measured gas temperature (both engines)
Control positions:
  Longitudinal cyclic
  Lateral cyclic
  Pedal
  Collective
  Stabilator
Aircraft attitudes:
  Pitch
  Roll
  Yaw
Aircraft angular velocities:
  Pitch
  Roll
  Yaw
Vibration accelerometers:
  Pilot station (3 axes) (pilot seat)
  Pilot floor (3 axes)
  Copilot station (3 axes) (copilot station)
  Center of gravity (3 axes)
Stability augmentation system actuator positions:
  Longitudinal
  Lateral
  Directional
Engine power available spindle (both engines)
Air data system:
  ADS Vx
  ADS Vy
  ADS Vz
  ADS Hp
  ADS OAT
APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

DATA ANALYSIS METHODS

1. The helicopter performance test data were generalized by use of nondimensional coefficients and were such that the effects of compressibility and blade stall were not separated and defined. The following nondimensional coefficients were used to generalize the hover and level flight test results obtained during this flight test program.

a. Coefficient of power ($C_p$):

$$C_p = \frac{\text{SHP}(550)}{\rho A(\Omega R)^3}$$  (1)

b. Coefficient of thrust ($C_T$):

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

c. Advance ratio ($\mu$):

$$\mu = \frac{1.6878 V_T}{\Omega R}$$  (3)

d. Advancing tip Mach number ($M_{\text{tip}}$):

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

Where:

- $\text{SHP}$ = Engine output shaft horsepower (both engines)
- 550 = Conversion factor (ft-lb/sec)/shp
- $\rho$ = Air density (slug/ft$^3$)
- $A$ = Main rotor disc area (ft$^2$)
- $\Omega$ = Main rotor angular velocity (radian/sec)
- $R$ = Main rotor radius (ft)
- Thrust = Gross weight (lb) during free flight in which there is no acceleration or velocity component in the vertical direction. Tether load must be added in the case of tethered hover.
- 1.6878 = Conversion factor (ft/sec)/kt
- $V_T$ = True airspeed (kt)
- $a$ = Speed of sound (ft/sec) = $1116.45 \sqrt{\mathbf{g}}$

SHAFT HORSEPOWER REQUIRED

2. Engine output shaft torque was determined by the use of the engine torquemeter. The torquemeter was calibrated in a test cell by the engine manufacturer. The outputs from the engine torquemeters were recorded on the onboard data recording system. The output shp was determined from the engine
output shaft torque and rotational speed by the following equation:

\[
\text{SHP} = \frac{2\pi \times N_p \times Q}{33,000}
\]  

(5)

Where:

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

**LEVEL FLIGHT PERFORMANCE**

3. Level flight performance data were reduced to nondimensional form using equations 1, 2, and 3. Each speed-power was flown at a predetermined \( C_T \) with rotor speed held constant. To maintain the ratio of gross weight to air density ratio \((W/o)\) constant, altitude was increased as fuel was consumed.

4. Test-day (measured) level flight power was corrected to standard-day conditions (average for the flight) by assuming that the test-day dimensionless parameters \( C_p, C_T, \) and \( \mu \) are identical to \( C_p, C_T, \) and \( \mu \), respectively.

From equation 1, the following relationship can be derived:

\[
\text{SHP}_t = \frac{\text{SHP}_s}{\left(\frac{\rho_s}{\rho_t}\right)^2}
\]  

(6)

Where:

- \( t \) = test day
- \( s \) = standard day

5. Test specific range was calculated using level flight performance curves and the measured fuel flow.

\[
\text{SR} = \frac{V_T}{W_f}
\]  

(7)

Where:

- \( \text{SR} \) = Specific range (Nautical air miles per pound of fuel)
- \( V_T \) = True airspeed (kt)
- \( W_f \) = Fuel flow (lb/hr)

**HANDLING QUALITIES**

6. Stability and control data were collected and evaluated using standard test methods as described in reference 10, appendix A. Definitions of deficiencies and
shortcomings used during this test are shown below.

Definition - 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 - 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 useability of the material or end product.

VIBRATIONS
7. The PCM vibration data were reduced by means of a fast Fourier transform from the analog flight tape. Vibration levels, representing peak amplitudes, were extracted from this analysis at selected harmonics of the main rotor frequency. The Vibration Rating Scale, presented in figure 1, was used to augment crew comments on aircraft vibration levels.

AIRSPEED CALIBRATION
8. The boom pitot-static system and both ships' systems were calibrated by using the pace aircraft method to determine the airspeed position error. Calibrated airspeed \( V_{c} \) was obtained by correcting indicated airspeed \( V_i \) using instrument \( \Delta V_{ic} \) and position \( \Delta V_{p} \) error corrections.

\[
V_{c} = V_i + \Delta V_{ic} + \Delta V_{p}
\]  

9. True airspeed \( V_d \) was calculated from the calibrated airspeed and density ratio.

\[
V_d = \frac{V_c}{\sqrt{\sigma}}
\]  

Where:

\[
\sigma = \text{Density ratio } \left( \frac{\rho_i}{\rho_o} \right) \text{ where } \rho_o \text{ is the density at sea level on a standard day.}
\]

10. The airspeed from the boom system was used for all data reduction. The calibration of this system is presented as figure 2.

WEIGHT AND BALANCE
11. Prior to testing, the aircraft gross weight and cg were determined by using calibrated scales. The aircraft was weighed with no fuel in the 8-HELLFIRE

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DEGREE OF VIBRATION | DESCRIPTION¹ | PILOT RATING
---|---|---
No vibration | Not apparent to experienced aircrew full occupied by their tasks, but noticeable if their attention is directed to it or if not otherwise occupied. | 0
Slight | Experienced aircrew are aware of the vibration but it does not affect their work, at least over a short period. | 2
Moderate | Vibration is immediately apparent to experienced aircrew even when fully occupied. Performance of primary task is affected or tasks can only be done with difficulty. | 8
Severe | Sole preoccupation of aircrew is to reduce vibration level. | 10

¹Based upon the Subjective Vibration Assessment Scale developed by the Aeroplane and Armament Experimental Establishment, Boscombe Down, England.

Figure 1. Vibration Rating Scale
**NOTES:**
1. **8 HELLFIRE CONFIGURATION (INBOARD).**
2. **PACE METHOD UTILIZED (AH-1S).**
3. **FLAGGED SYMBOLS DENOTE T-28 PACE.**
4. **BLOCKER PLATE INSTALLED FORWARD OF BOOM STATIC SOURCE.**
5. **DATA NOT FOR HANDBOOK USE.**

**FIGURE 2**

**BOOM AIRSPEED CALIBRATION**

VH-64 USA S/N 77-23268

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG GC LOCATION LS</th>
<th>AVG DENSITY LAT (FT)</th>
<th>AVG OAT ALTITUDE (C)</th>
<th>AVG SPEED (RPM)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15740</td>
<td>205.2 (AFT)</td>
<td>0.0</td>
<td>5020</td>
<td>6.5</td>
<td>290</td>
</tr>
</tbody>
</table>

**CALIBRATED AIRSPEED (KNOTS) VS. INSTRUMENT CORRECTED AIRSPEED (KNOTS)**

**LINE OF ZERO ERROR.**
Figure 3. Handling Qualities Rating Scale

1Based Upon Cooper-Harper Handling Qualities Rating Scale (Ref NASA TND-5153) And Definitions In Accordance With AR 310-25.

*Definition of REQUIRED OPERATION involves designation of flight phase and/or subphases with accompanying conditions.
configuration, with instrumentation on board. The aircraft weight was 13,176 pounds with a longitudinal cg location at FS 208.3.

HANDLING QUALITIES RATING SCALE

12. The Handling Qualities Rating Scale (HQRS) presented in figure 3 was used to augment pilot comments relative to handling qualities and work load.
## APPENDIX E. TEST DATA

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>FIGURE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nondimensional hover performance</td>
<td>1</td>
</tr>
<tr>
<td>Level flight performance</td>
<td>2 - 9</td>
</tr>
<tr>
<td>Control system mechanical characteristics</td>
<td>10 - 17</td>
</tr>
<tr>
<td>Control positions in trimmed forward flight</td>
<td>18 - 19</td>
</tr>
<tr>
<td>Collective-fixed static longitudinal stability</td>
<td>20 - 21</td>
</tr>
<tr>
<td>Static lateral-directional stability</td>
<td>22 - 23</td>
</tr>
<tr>
<td>Maneuvering stability</td>
<td>24 - 25</td>
</tr>
<tr>
<td>Dynamic stability</td>
<td>26 - 27</td>
</tr>
<tr>
<td>Takeoff characteristics</td>
<td>28</td>
</tr>
<tr>
<td>Landing characteristics</td>
<td>29 - 30</td>
</tr>
<tr>
<td>Low-speed flight characteristics</td>
<td>31 - 36</td>
</tr>
<tr>
<td>Directional control input</td>
<td>37</td>
</tr>
<tr>
<td>Lateral reversal</td>
<td>38</td>
</tr>
<tr>
<td>Simulated engine failures</td>
<td>39 - 40</td>
</tr>
<tr>
<td>Stabilator failure</td>
<td>41</td>
</tr>
<tr>
<td>Stabilator failed takeoff</td>
<td>42</td>
</tr>
<tr>
<td>Stabilator failed landing</td>
<td>43</td>
</tr>
<tr>
<td>Vibrations</td>
<td>44 - 77</td>
</tr>
<tr>
<td>Airspeed calibrations</td>
<td>78 - 80</td>
</tr>
</tbody>
</table>
NOTES: 1. AVERAGE DENSITY ALTITUDE = 1220 FEET
2. AVERAGE OAT = 21 DEGREES C
3. WINDS LESS THAN 5 KNOTS
4. TETHERED HOVER TECHNIQUE
5. SHAPED SYMBOLS DENOTE FREE FLIGHT TECHNIQUE
6. CLEAN CONFIGURATION
FIGURE 2
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 77-23258

NOTES: 1. AVG LONGITUDINAL CG LOCATION FS 202.0 (FWD)
2. ROTOR SPEED = 390 RPM
3. 8-HELLFIRE CONFIGURATION
4. CURVES DERIVED FROM FIGS 6 THROUGH 9
5. ZERO SIDESLIP

THRUSTR COEFFICIENT, $C_T X 10^6 = \frac{6M}{\rho A(AR)^2} X 10^6$

POWER COEFFICIENT, $C_P X 10^5 = \frac{5500 \text{ SHP}}{\rho A(AR)^3} X 10^5$

$\mu = 0.10 - 0.14$
FIGURE 1
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 77-23258

NOTES: 1. AVG LONGITUDINAL CG LOCATION PS 202.0 (FWD)
2. ROTOR SPEED = 290 RPM
3. S-HELLEFIRE CONFIGURATION
4. CURVES DERIVED FROM FIGS. 6 THROUGH 9
5. ZEROSIDESLIP

POWER COEFFICIENT, \( \frac{F_p}{\rho V^2} \times 10^4 \)

THrust COEFFICIENT, \( \frac{C_T}{\rho V^2} \times 10^4 \)

\( \nu = 0.20 \)
\( \nu = 0.22 \)
\( \nu = 0.24 \)
\( \nu = 0.26 \)
FIGURE 4
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-54 USA S/N 77-23258

NOTES:
1. AVE. LONITUDINAL CG LOCATION FS 202:0 (FWD)
2. ROTOR SPEED = 290 RPM
3. 8-HELLFIRE CONFIGURATION
4. CURVES DERIVED FROM FIGS 6 THROUGH 9
5. ZERO SIDESLIP
### FIGURE 5
LEVEL FLIGHT PERFORMANCE
YAN-64 USA S/N 77-23258

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG LONG CG (FT)</th>
<th>AVG PRESSURE (IN)</th>
<th>AVG OAT (°C)</th>
<th>AVG MOTOR SPEED (RPM)</th>
<th>AVG CT</th>
<th>CONFIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>14200</td>
<td>202 (FWD)</td>
<td>4000</td>
<td>35</td>
<td>289</td>
<td>0.0075</td>
<td>8-HELLFIRE</td>
</tr>
</tbody>
</table>

![Graph showing engine shaft horsepower required vs. true airspeed (knots).]
FIGURE 6
LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 77-23258

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG LONG LOCATION (FS)</th>
<th>AVG LAT LOCATION (BL)</th>
<th>AVG DENSITY (FT)</th>
<th>AVG OAT (C)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG $C_T$</th>
<th>CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14600</td>
<td>202.0 (FWD)</td>
<td>0.0</td>
<td>1360</td>
<td>17.5</td>
<td>290</td>
<td>66.51</td>
<td>B-HELLFIRE</td>
</tr>
</tbody>
</table>

SPECIFIC RANGE (Nautical Miles/LB Fuel)

ENGINE SHOFT HORSEPOWER REQUIRED

ADVANCING TIP MACH NUMBER

TRUE AIRSPEED (KNOTS)
### Figure 7

**Level Flight Performance**

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG FLIGHT LOCATION (FS)</th>
<th>AVG DENSITY (SL) (BL) (FT)</th>
<th>AVG OAT (ºC)</th>
<th>AVG ROTOR SPEED (RPM) x10</th>
<th>AVG CT4 CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14860</td>
<td>202.0 (FWD)</td>
<td>0.0</td>
<td>5420</td>
<td>10.0</td>
<td>290</td>
</tr>
</tbody>
</table>

**Graphs**

- **Specific Range (Miles/LB fuel)** vs True Airspeed (Knots)
- **Engine Shaft Horsepower Required** vs True Airspeed (Knots)
- **Advancing Tip Mach Number** vs True Airspeed (Knots)
LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 77-23258

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION (FS)</th>
<th>AVG DENSITY (FT)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG SPEED (RPM)</th>
<th>AVG ROTOR RPM X10</th>
<th>AVG CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15740</td>
<td>202.0 (FWD)</td>
<td>0.0</td>
<td>6380</td>
<td>8.0</td>
<td>290</td>
<td>83.37</td>
<td>8-HELLFIRE</td>
</tr>
</tbody>
</table>

**Figure 8**

Specific Range (Mach, Air Miles/LB Fuel)

Engine Shaft Horsepower Required

True Airspeed (Knots)
FIGURE 9
LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 77-23258

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION (FS)</th>
<th>AVG LATITUDE (BL)</th>
<th>AVG DENSITY (FT)</th>
<th>AVG DAT SPEED (°C)</th>
<th>AVG Rotor Speed (RPM)</th>
<th>AVG CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15640</td>
<td>202.2 (FWD)</td>
<td>0.0</td>
<td>9720</td>
<td>0.5</td>
<td>290</td>
<td>91.87</td>
</tr>
</tbody>
</table>
FIGURE 10
LIMITS OF CYCLIC CONTROL TRAVEL
YAH-64 USA S/N 77-23258

NOTES:
1. ROTORS STATIC.
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
3. CONTROL POSITION MEASURED AT CENTER OF GRIP.
4. COLLECTIVE CONTROL FULL DOWN.
5. NO CYCLIC CONTROL PATTERN CHANGE WITH CHANGE OF COLLECTIVE CONTROL POSITION.
FIGURE 11.
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 77-23258

NOTES:
1. ROTORS STATIC.
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND
   POWER UNITS.
4. COPILOT/GUNNER CYCLIC CONTROL RETRACTED.
5. TRIM FEEL ON.

LONGITUDINAL CONTROL POSITION
(INCHES FROM FULL FORWARD)
FIGURE 12
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 77-23258

NOTES: 1. ROTORS STATIC.
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
4. COPILOT/GUNNER CYCLIC CONTROL EXTENDED.
5. TRIM FEEL ON.

LONGITUDINAL CONTROL FORCE (POUNDS)

PULL 8

6

4

2

0

LONGITUDINAL CONTROL POSITION (INCHES FROM FULL FORWARD)

PUSH 10

12

FWD 2 4 6 8 10 12 AFT
FIGURE 13
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USAF SPN 77-023660

NOTES:
1. ROTORS STATIC
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND
4. COPILOT/GUNNER CYCLIC CONTROL RETRACTED
5. TRIM FEEL OFF

LONGITUDINAL CONTROL FORCE
(POUNDS)

PULL

LONGITUDINAL CONTROL FORCE POSITION
(INCHES FROM FULL FORWARD)

0 2 4 6 8 10 12
FWD

120
FIGURE 14
LATERAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 77-23268

NOTES:
1. ROTORS STATIC.
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
4. TRIM FEEL ON.
NOTES:
1. ROTORS STATIC.
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
4. TRIM FEEL OFF.
FIGURE 16
DIRECTIONAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 77-23258

NOTES:
1. ROTORS STATIC.
2. FORCES MEASURED AT THE DIRECTIONAL CONTROL.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
4. TRIM FEEL ON.
FIGURE 17
DIRECTIONAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 77-23258

NOTES:
1. ROTORS STATIC.
2. FORCES MEASURED AT THE DIRECTIONAL CONTROL.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY
GROUND POWER UNITS.
4. TRIM FEEL OFF.
5. REVISED DIRECTIONAL CONTROL STOP INSTALLED
AT 1.2 INCHES FROM FULL LEFT.
NOTE:
1. B-Hellfire Configuration.
2. Erroneous airspeed input to stabilator control unit caused stabilator failure during descent points at 50 and 59 KIAS. (Shaded symbols)
3. Climb at 100.
4. Descent at less than 10K torque per engine.
### Table: Collective-Fixed Static Longitudinal Stability

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION (FS)</th>
<th>AVG DENSITY (SL)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG FLIGHT CONDITION</th>
<th>TREND</th>
</tr>
</thead>
<tbody>
<tr>
<td>14260</td>
<td>205.8 (AFT)</td>
<td>5200</td>
<td>12</td>
<td>289</td>
<td>LEVEL FLIGHT ON</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. 8 HELLFIRE CONFIGURATION
2. SHADED SYMBOLS DENOTE TRIM

### Diagrams

- **Stabilator Position (Deg):**
  - Total Travel = 5.4 Inches

- **Pitch Attitude (Deg):**
  - Total Travel = 9.9 Inches

- **Directional Control Position:**
  - Total Travel = 10.2 Inches

- **Lateral Control Position:**
  - Total Travel = 8.9 Inches

- **Longitudinal Control Position:**
  - Total Travel = 10.2 Inches

### Graphs

- Graphs showing the relationships between calibrated airspeed (knots) and various control positions and travel measurements.
**Figure 21: Collective-Fixed Static Longitudinal Stability**

YAH-64 USA S/N 77-2325B

<table>
<thead>
<tr>
<th>Avg Gross Weight (LB)</th>
<th>Avg CG Location</th>
<th>Avg Density (FT)</th>
<th>Avg Altitude (FT)</th>
<th>Avg Rotor Speed (RPM)</th>
<th>Avg Flight Condition</th>
<th>Ave Base Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>14500</td>
<td>205.9 (AFT)</td>
<td>5200</td>
<td>7.5</td>
<td>289</td>
<td>LVL FLT</td>
<td>ON</td>
</tr>
</tbody>
</table>

**Notes:**
1. 8-HELFIRE Configuration.
2. Shaded symbols denote trim.

**Graphs:**
- Stabilator Position (deg): Total Directional Control Travel = 5.4 Inches.
- Pitch Attitude (deg): Total Lateral Control Travel = 8.9 Inches.
- Directional Control Position (in. from full LIT): Total Longitudinal Control Travel = 10.2 Inches.
FIGURE 22
STATIC LATERAL-DIRECTIONAL STABILITY
YAH-84 USAF 57-2225B

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION (Ft)</th>
<th>AVG DENSITY (GAL)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG Q (°)</th>
<th>AVG Rotor Speed (RPM)</th>
<th>AVG Airspeed (KCAS)</th>
<th>TRIM</th>
<th>OCS</th>
<th>CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14,500</td>
<td>205.7(AFT)</td>
<td>0.0</td>
<td>4900</td>
<td>11.5</td>
<td>289</td>
<td>56</td>
<td>0</td>
<td></td>
<td>ON</td>
</tr>
</tbody>
</table>

NOTES:
1. 8-HELLFIRE CONFIGURATION
2. SHARED SYMBOLS DENOTE TRIM

- TOTAL COLLECTIVE CONTROL TRAVEL = 12.0 INCHES
- TOTAL LONGITUDINAL CONTROL TRAVEL = 10.2 INCHES
- TOTAL LATERAL CONTROL TRAVEL = 8.9 INCHES
- TOTAL DIRECTIONAL CONTROL TRAVEL = 5.4 INCHES
### FIGURE 23
STATIC LATERAL - DIRECTIONAL STABILITY
YAH-64 USA S/N 77-22258

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WT</td>
<td>C.G. LOCATION</td>
<td>DENSITY</td>
<td>OAT</td>
<td>Rotor CALIBRATED</td>
<td>SPEED</td>
</tr>
<tr>
<td></td>
<td>(LB)</td>
<td>(FS)</td>
<td>(BL)</td>
<td>(°)</td>
<td>(°)</td>
<td>(RPM)</td>
</tr>
<tr>
<td>14740</td>
<td>205.8(AFT)</td>
<td>0.0</td>
<td>5440</td>
<td>6.0</td>
<td>289</td>
<td>144.0</td>
</tr>
</tbody>
</table>

**NOTES:**
1. HELLFIRE CONFIGURATION
2. SHADED SYMBOLS DENOTE TRIM

- **ROLLIDE**
  - LT 10
  - RT 10

- **TOTAL COLLECTIVE CONTROL TRAVEL = 12.0 INCHES**
  - 0
  - TOTAL LONGITUDINAL CONTROL TRAVEL = 10.2 inches.

- **TOTAL LATERAL CONTROL TRAVEL = 6.9 inches.**
  - LT 7
  - RT 7

- **TOTAL DIRECTIONAL CONTROL TRAVEL = 5.4 INCHES**
  - LT 5
  - RT 5
## Figure 24
### Maneuvering Stability

<table>
<thead>
<tr>
<th>Sym</th>
<th>Avg Gross Weight (LB)</th>
<th>Avg CG Location (F5)(BL)</th>
<th>Avg Long Lat Altitude (FT)</th>
<th>Avg Density (o C)</th>
<th>Avg Rotor Speed (RPM)</th>
<th>Flight Condition</th>
<th>Dase Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14720</td>
<td>206.0 0.0</td>
<td>5320</td>
<td>6.5</td>
<td>289</td>
<td>RT TURN</td>
<td>ON</td>
</tr>
<tr>
<td></td>
<td>14920</td>
<td>205.8 0.0</td>
<td>5580</td>
<td>6.5</td>
<td>289</td>
<td>LT TURN</td>
<td>ON</td>
</tr>
</tbody>
</table>

**Notes:**
1. 8 Hellfire Configuration.
2. 145 KCAS.

- **Stabilator Position (Deg)**: The stabilator position remains constant throughout the graph.
- **Roll Control (Deg)**: The roll control shows a gradual increase from 0 to 60 degrees.
- **Lateral Control Position (In from Full Left)**: The lateral control position remains relatively constant, with a slight increase towards the right.
- **Longitudinal Control Position (In from Full Right)**: The longitudinal control position shows a gradual increase from 0 to 6.

**Total Lateral Control Travel = 8.9 Inches**

**Total Longitudinal Control Travel = 10.2 Inches**

C.G. Normal Acceleration (g)
FIGURE 29
MANEUVERING STABILITY
YAH-64 USA S/N 77-23258

<table>
<thead>
<tr>
<th>AVG</th>
<th>AVG CG</th>
<th>AVG</th>
<th>AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS</td>
<td>LOCATION</td>
<td>DENSITY</td>
<td>CALIBRATED</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>LONG</td>
<td>LAT</td>
<td>ALTITUDE</td>
</tr>
<tr>
<td>(LB)</td>
<td>(FS)</td>
<td>(BL)</td>
<td>(FT)</td>
</tr>
<tr>
<td>14000</td>
<td>206.1 (AFT)</td>
<td>0.0</td>
<td>9620</td>
</tr>
</tbody>
</table>

NOTE: DATA OBTAINED DURING STEADY TURN

- PITCH RATE
- PITCH SAS ACTUATOR
- LONGITUDINAL CONTROL POSITION
- NORMAL ACCELERATION

ELAPSED TIME (SECONDS)

INCR

INCR

INCR

INCR

LONG CONTROL POSITION (IN FROM FULL TILT)

PITCH SAS ELEVATION POSITION (DEG/SEC)

PITCH SAS REACTION FORCE (LBS)

CG VERTICAL ACCELERATION (G-FACTS)

CG VELOCITY Acceleration (G-FACTS)
Figure 06
3-AXIS SHORT-TERM OSCILLATION
YAH-64 USA S/N 77-23258

<table>
<thead>
<tr>
<th>AVG</th>
<th>AVG CG</th>
<th>AVG</th>
<th>TRIM</th>
<th>TRIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS WEIGHT</td>
<td>LOCATION</td>
<td>DENSITY</td>
<td>RATER</td>
<td>CALIBRATED</td>
</tr>
<tr>
<td>(LB)</td>
<td>(FS)</td>
<td>(BL)</td>
<td>(C) (RPM)</td>
<td>(KT)</td>
</tr>
<tr>
<td>15040</td>
<td>206.5 (AFT)</td>
<td>0.0</td>
<td>5620</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>290</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- SIDESLIP ANGLE
- NORMAL ACCELERATION
- DIRECTIONAL CONTROL
- ROLL ATTITUDE
- LATERAL CONTROL
- PITCH ATTITUDE
- LONGITUDINAL CONTROL
FIGURE 31
LOW-SPEED FORWARD AND REARWARD FLIGHT
YAH-64 USA 5/N 77-22558

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG GS LOCATION (FS)</th>
<th>AVG LAT DENSITY (BL)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG OAT °C</th>
<th>AVG R.P.M. (RPM)</th>
<th>AVG WHEEL HEIGHT (FT)</th>
<th>BASE CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14720</td>
<td>201.4 (FWD)</td>
<td>0.0</td>
<td>280</td>
<td>16.0</td>
<td>289</td>
<td>20</td>
<td>OR</td>
</tr>
</tbody>
</table>

NOTES:
1. B-HELLFIRE CONFIGURATION
2. I DENOTES EXTREME TRAVEL FROM TRIM DURING ATTEMPTED STABILIZED POINT

TOTAL COLLECTIVE CONTROL TRAVEL = 12.0 INCHES

TOTAL DIRECTIONAL CONTROL TRAVEL = 5.4 INCHES

TOTAL LATERAL CONTROL TRAVEL = 8.9 INCHES

TOTAL LONGITUDINAL CONTROL TRAVEL = 10.2 INCHES
NOTES:
1. HELIFIRE CONFIGURATION
2. I DENOTES EXTREME TRAVEL FROM TRIM DURING ATTEMPTED STABILIZED POINT

TOTAL COLLECTIVE CONTROL TRAVEL = 12.0 INCHES

TOTAL LONGITUDINAL CONTROL TRAVEL = 10.2 INCHES

TOTAL LATERAL CONTROL TRAVEL = 0.9 INCHES

TOTAL BIENIERTICAL CONTROL TRAVEL = 5.4 INCHES

REVISED DIRECTIONAL STOP
Table:

<table>
<thead>
<tr>
<th>Gross Weight (LB)</th>
<th>Avg Long Lat Location (FS) (BL)</th>
<th>Avg Density Altitude (FT)</th>
<th>Avg OAT (°C)</th>
<th>Avg Wheel Height (FT)</th>
<th>True Airspeed (KTS)</th>
<th>Trim Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>14420</td>
<td>201.3(FWD)0.0</td>
<td>400</td>
<td>15.0</td>
<td>20</td>
<td>30.0</td>
<td>ON</td>
</tr>
<tr>
<td>14080</td>
<td>201.0(FWD)0.0</td>
<td>-160</td>
<td>11.5</td>
<td>20</td>
<td>30.0</td>
<td>ON</td>
</tr>
</tbody>
</table>

Notes:
1. HELLPFIRE CONFIGURATION
2. T0 DENOTES EXTREME TRAVEL FROM TRIM DURING ATTEMPTED STABILIZED POINT

Diagram:
- Total Collective Control Travel = 12.0 inches
- Total Longitudinal Control Travel = 10.2 inches
- Total Lateral Control Travel = 8.9 inches
- Total Directional Control Travel = 5.4 inches

Figure 34
CRITICAL AZIMUTH
YAH-64 USA S/N 77-23250
FIGURE 35
CRITICAL AZIMUTH
YAH-66 USA 5/A 7/1-2256

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>BASE HEIGHT</th>
<th>BASE LOCATION</th>
<th>BASE DENSITY</th>
<th>BASE OAT</th>
<th>BASE Rotor Speed</th>
<th>BASE WHEEL DENSITY</th>
<th>BASE WHEEL LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HELLFIRE CONFIGURATION</td>
<td>14300</td>
<td>200</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>220</td>
<td>220</td>
</tr>
</tbody>
</table>

NOTES
1. HELLFIRE CONFIGURATION
2. RELATIVE WIND AZIMUTH 240 DEG.
3. "I" DENOTES EXTREME TRAVEL FROM TRIM DURING ATTEMPTED STABILIZED POINT

TOTAL COLLECTIVE CONTROL TRAVEL = 18.0 INCHES

TOTAL LONGITUDINAL CONTROL TRAVEL = 10.2 INCHES

TOTAL LATERAL CONTROL TRAVEL = 8.9 INCHES

TOTAL DIRECTIONAL CONTROL TRAVEL = 5.4 INCHES

REvised DIRECTIONAL STOP
### CRITICAL AZIMUTH

**YAH-6A USA 5/N 77-23258**

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG C.G. LOCATION (FT)</th>
<th>AVG DENSITY (FS)</th>
<th>AVG OAT (°C)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG WHEEL HEIGHT (FT)</th>
<th>AVG BASE CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14500</td>
<td>201.9 (FWD)</td>
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<td>-180</td>
<td>11.5</td>
<td>290</td>
<td>20.0</td>
</tr>
</tbody>
</table>

**NOTES:**
1. **HILLFIRE CONFIGURATION**
2. **RELATIVE WIND AZIMUTH 240 DEG.**
3. **0 DENOTES EXTREME TRAVEL FROM TRIM DURING ATTEMPTED STABILIZED POINT.**

---

![Graphs showing various control positions and travel ranges](image)

- **TOTAL COLLECTIVE CONTROL TRAVEL = 12.0 INCHES**
- **TOTAL LONGITUDINAL CONTROL TRAVEL = 10.2 INCHES**
- **TOTAL LATERAL CONTROL TRAVEL = 8.9 INCHES**
- **TOTAL DIRECTIONAL CONTROL TRAVEL = 5.4 INCHES**

---

**TRUE AIRSPEED (KNOTS):**
### FIGURE 37
DIRECTIONAL CONTROL INPUT
YAH-64 USA S/N 77-23258

<table>
<thead>
<tr>
<th>AVG GROSS</th>
<th>AVG CG LOCATION</th>
<th>AVG DENSITY</th>
<th>AVG OAT</th>
<th>AVG ROTOR SPEED</th>
<th>WHEEL HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>14400</td>
<td>201.9 (FWD)</td>
<td>0.0</td>
<td>-194</td>
<td>11.0</td>
<td>290</td>
</tr>
</tbody>
</table>

**NOTES:**
1. 8-HELLFIRE CONFIGURATION
2. INPUT MADE AT 35 KTAS RIGHT SIDEWARD FLIGHT
3. BASE ON

---

![Diagram of directional control position](image)

**1.5 SEC**

![Diagram of yaw rate vs time](image)

144
### Lateral Reversal

**YAH-64 USA S/N 77-23258**

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION</th>
<th>AVG DENSITY</th>
<th>AVG CG</th>
<th>AVG TRIM</th>
<th>BASE CONDITION</th>
<th>CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14,700</td>
<td>201.9 (AFT)</td>
<td>20</td>
<td>12.5</td>
<td>290</td>
<td>ON</td>
<td>8-HELLFIRE</td>
</tr>
</tbody>
</table>

**FIGURE 38**

<table>
<thead>
<tr>
<th>Rotor Configuration</th>
<th>Configuration: 8-HELLFIRE</th>
</tr>
</thead>
</table>

**Radar Altitude**

- **Radar Altitude (Feet):**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

**Directional Control**

- **Directional Cont Posn (Inches from Full Lt):**
  - INCR 50.
  - 20.
  - 10.
  - 0.

**Yaw Attitude**

- **Yaw Attitude (Deg):**
  - 160.
  - 150.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

**Roll Attitude**

- **Roll Attitude (Deg):**
  - 30.
  - 30.
  - 20.
  - 10.
  - 10.

**Longitudinal Control**

- **Long Control Posn (In from Full Fwd):**
  - 18.
  - 20.
  - 10.
  - 0.

- **Roll Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

**Pitch Attitude**

- **Pitch Attitude (Deg):**
  - 18.
  - 20.
  - 10.
  - 0.

- **Roll Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Yaw Rate:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Yaw Rate:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control Posn (Inches from Full Fwd):**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Lateral Control:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Pitch Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control Posn (Inches from Full Fwd):**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Pitch Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Pitch Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control Posn (Inches from Full Fwd):**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Pitch Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Pitch Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control Posn (Inches from Full Fwd):**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Pitch Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Pitch Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control Posn (Inches from Full Fwd):**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Pitch Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Longitudinal Control:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.

- **Pitch Attitude:**
  - RT 180.0
  - INCR 60.
  - 140.
  - 10.
  - 40.
  - 20.
  - 0.
FIGURE 39
SINGLE ENGINE FAILURE
YAH-64 USA S/N 77-23258

AVG GROSS WEIGHT
AVG CG LOCATION
AVG DENSITY
AVG TRIM TRIM
AVG ROTOR CALIBRATED BASE
AVG AIRSPEED FLIGHT CONDITION
(LB) (PSI) (BL) (FT) (F) (RPM) (KTS)
14480 205.7(AFT) 0.0 3740 11.0 289 76 OFF IRP CLimb

NOTE: G-HELFIRE CONFIGURATION

NORMAL ACCELERATION
COLLECTIVE CONTROL

RIGHT ENGINE TORQUE
LEFT ENGINE TORQUE
MAIN ROTOR SPEED
YAW RATE
FIGURE 44
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 77-23258
PILOT SEAT

<table>
<thead>
<tr>
<th>AVG</th>
<th>AVG CG LOCATION</th>
<th>DENSITY</th>
<th>OAT</th>
<th>ROTOR</th>
<th>FLIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS WEIGHT (LB)</td>
<td>LONG (FS)</td>
<td>LAT (BL)</td>
<td>ALTITUDE (FT)</td>
<td>SPEED (°C)</td>
<td>CONDITION (RPM)</td>
</tr>
<tr>
<td>14720</td>
<td>201.4 (FWD)</td>
<td>0.0</td>
<td>230</td>
<td>14.6</td>
<td>289</td>
</tr>
</tbody>
</table>

Note 1: 8 HELLFIRE CONFIGURATION
2 WHEEL HEIGHT 20 FEET

- VERTICAL
- LATERAL
- LONGITUDINAL

- 8/REV = 38.5 Hz
- 4/REV = 19.3 Hz
- 2/REV = 9.8 Hz
- 1/REV = 4.8 Hz

TRUE AIRSPEED (KNOTS)
### Figure 45
Vibration Characteristics

YAP-64 USA S/N 77-23488
Co Pilot Seat

<table>
<thead>
<tr>
<th>Avg Gross Weight (lb)</th>
<th>Avg CG Location (fs)</th>
<th>Avg Density (AFT)</th>
<th>Avg Altitude (ft)</th>
<th>Avg GAT</th>
<th>Avg Rotor Speed (rpm)</th>
<th>Avg Flight Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>14720</td>
<td>201.4</td>
<td>120</td>
<td>280</td>
<td>14.0</td>
<td>289</td>
<td>LON SPEED</td>
</tr>
</tbody>
</table>

**Note:**
- 8: Hellfire Configuration
- 2: Wheel Height 20 Feet

---

**8/REV = 38.5 Hz**

**4/REV = 19.8 Hz**

**2/REV = 9.6 Hz**

**1/REV = 4.8 Hz**

---

**Time Afspeed (Knots)**

**Single Amplitude Vibratory Acceleration (g)**
### VIBRATION CHARACTERISTICS

**YAH-64 USA 5/W 79-22958**

**PILOT FLOOR**

<table>
<thead>
<tr>
<th>AVG GROSS</th>
<th>AVG CG LOCATION</th>
<th>AVG DENSITY</th>
<th>OAT (°F)</th>
<th>AVG SPEED (KNOTS)</th>
<th>AVG CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14720</td>
<td>201.4 (FWD) 0.0</td>
<td>280</td>
<td>14.0</td>
<td>289</td>
<td>ENSPEED</td>
</tr>
</tbody>
</table>

**NOTE 1:**

- 8 HELLFIRE CONFIGURATION:
  - 2 WHEEL HEIGHT 20 FEET

- **VERTRICAL**
- **LATERAL**
- **LONGITUDINAL**

**8/REV = 38.5 Hz**

**4/REV = 19.3 Hz**

**2/REV = 9.6 Hz**

**1/REV = 4.8 Hz**

**TRUE AIRSPEED (KNOTS)**

**BEAMWARD**

153
<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION (FSL)</th>
<th>AVG DENSITY</th>
<th>AVG OAT (°C)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14720</td>
<td>201.4 (FWD) 0.0</td>
<td>280</td>
<td>14.0</td>
<td>289</td>
<td>LOWSPEED</td>
</tr>
</tbody>
</table>

**NOTE**
- 8 HELIFIRE CONFIGURATION
- WHEEL HEIGHT 20 FEET

**Diagram Details**
- **B/REV = 38.5 Hz**
- **A/REV = 19.3 Hz**
- **2/REV = 9.6 Hz**
- **1/REV = 4.8 Hz**

**Legend**
- ◊ VERTICAL
- □ LATERAL
- △ LONGITUDINAL

**Axes**
- *X-axis*: TRUE AIRSPEED (KNOTS)
- *Y-axis*: SINGLE AMPLITUDE VIBRATION ACCELERATION (G)
### Figure 49
Vibration Characteristics
YAH-64 USA S/N 77-23258
Pilot Seat

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG LOCATION (FS) (BL)</th>
<th>AVG DENSITY (OAT)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG SPEED (KNOTS)</th>
<th>AVG ROTOR RPM</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14820</td>
<td>201.3 (FWD) 0.0</td>
<td>440</td>
<td>15</td>
<td>290</td>
<td>Low Speed</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
1. Hellfire Configuration
2. Wheel Height 20 Feet

- ○: Vertical
- □: Lateral
- △: Longitudinal

- 1/REV = 4.8 Hz
- 2/REV = 9.6 Hz
- 4/REV = 19.3 Hz
- 8/REV = 38.5 Hz

True Airspeed (Knots)
FIGURE 50
VIBRATION CHARACTERISTICS
YAH-64 USA S/N FT-23358
CO PILOT SEAT

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION (FS)</th>
<th>AVG DENSITY (G/M3)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG FLIGHT ALTITUDE (FT)</th>
<th>AVG SPEED (MPH)</th>
<th>AVG CONDITION (°C)</th>
<th>AVG ROTOR RPM</th>
<th>FLIGHT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14820</td>
<td>201.3 (FWD) 0.0</td>
<td>440</td>
<td>15</td>
<td>290</td>
<td>Lowspeed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE 1 8 HELIFIRE CONFIGURATION
2 WHEEL HEIGHT 20 FEET
○ VERTICAL
□ LATERAL
△ LONGITUDINAL

- 8/REV = 38.5 Hz
- 4/REV = 19.3 Hz
- 2/REV = 9.6 Hz
- 1/REV = 4.8 Hz

TRUE AIRSPEED (KNOTS)

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Figure 31
Vibration Characteristics
YAH-64 USA 571F FM-580/60
Pilot Floor

<table>
<thead>
<tr>
<th>AVE</th>
<th>AVE CG</th>
<th>AVG</th>
<th>AVG</th>
<th>AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>CROSS</td>
<td>LOCATION</td>
<td>DENSITY</td>
<td>QAT</td>
<td>ROTOR FLIGHT</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>LONG</td>
<td>LAT</td>
<td>ALTITUDE</td>
<td>SPEED</td>
</tr>
<tr>
<td>Lb</td>
<td>FT</td>
<td>FT</td>
<td>°F</td>
<td>RPM</td>
</tr>
<tr>
<td>2013.5</td>
<td>30</td>
<td>10</td>
<td>440</td>
<td>160</td>
</tr>
</tbody>
</table>

Note 1: 8 HELIFIRE CONFIGURATION
2. Wheel height 20 feet
○ Vertical
□ Lateral
△ Longitudinal

8/REV = 38.5 Hz

6/REV = 19.3 Hz

2/REV = 9.6 Hz

1/REV = 42 Hz

True Airspeed (Knots)
FIGURE 52
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 77-23258
CO PILOT FLOOR

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG. CG LOCATION (FS)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG RPM</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14820</td>
<td>201.3 (FWD)</td>
<td>440</td>
<td>15</td>
<td>290</td>
<td>LONG SPEED</td>
</tr>
</tbody>
</table>

NOTE 1 8 HELLFIRE CONFIGURATION
2. WHEEL HEIGHT 20 FEET

- VERTICAL
- LATERAL
- LONGITUDINAL

8/REV = 38.5 Hz

4/REV = 19.3 Hz

2/REV = 9.6 Hz

1/REV = 4.8 Hz

TRUE AIRSPEED (KNOTS)
**Figure 63**

**Vibration Characteristics**

YAH-64 USA S/N 77-28000

**Aircraft CG**

<table>
<thead>
<tr>
<th>Gross Weight (LB)</th>
<th>Avg. Location (FS)</th>
<th>Long Altitude (FT)</th>
<th>Cat Rotor Speed (RPM)</th>
<th>Flight Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>14820</td>
<td>201.3 (FWD)0.0</td>
<td>440</td>
<td>15</td>
<td>290</td>
</tr>
</tbody>
</table>

**Note:**
1. Helicopter Configuration
2. Wheel Height 20 Feet

- ○ Vertical
- □ Lateral
- △ Longitudinal

**Single Amplitude Vibration Acceleration (g):**

- 6/REV = 36.5 Hz
- 4/REV = 19.2 Hz
- 2/REV = 8.6 Hz
- 1/REV = 4.3 Hz

**True Airspeed (Knots):**

<table>
<thead>
<tr>
<th>Feet</th>
<th>60</th>
<th>40</th>
<th>20</th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Figure 54: Vibration Characteristics**

**YAH-64 USA S/N 77-23888**

**Pilots Seat**

<table>
<thead>
<tr>
<th>Weight (LB)</th>
<th>Avg CG Location</th>
<th>Altitude (FT)</th>
<th>Avg OAT (°C)</th>
<th>Rotor Speed (RPM)</th>
<th>Flight Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>15600</td>
<td>202.3 (FWD) 0.0</td>
<td>5700</td>
<td>8.0</td>
<td>289</td>
<td>CLIMB</td>
</tr>
</tbody>
</table>

**Note:** 8 Hellfire Configuration

- **Vertical**
- **Lateral**
- **Longitudinal**

**Graphs:**

- **0/Rev = 38.5 Hz**
- **4/Rev = 19.3 Hz**
- **2/Rev = 9.6 Hz**
- **1/Rev = 4.8 Hz**

**Calibrated Airspeed (Knots):**
## Figure 55
VIBRATION CHARACTERISTICS
YAH-94 USA S/N 77-23258
GO PILOT SEAT

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG CB LOCATION (FS)</th>
<th>AVG DENSITY (BL)</th>
<th>AVG OAT (FT)</th>
<th>AVG ROTOR SPEED (C)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15600</td>
<td>202.3 (FWD) 0.0</td>
<td>5700</td>
<td>8.0</td>
<td>289</td>
<td>CLIMB</td>
</tr>
</tbody>
</table>

NOTE 8 HELLFIRE CONFIGURATION
- **VERTICAL**
- **LATERAL**
- **LONGITUDINAL**

![Graph]

- 6/REV= 36.5 Hz
- 4/REV= 19.3 Hz
- 2/REV= 9.6 Hz
- 1/REV= 4.8 Hz

CALIBRATED AIRSPEED (KNOTS)

162
FIGURE 66
VIBRATION CHARACTERISTICS
AH-64 USA S/N 77-02256
AIRCRAFT CG

<table>
<thead>
<tr>
<th>AVG GROSS</th>
<th>AVG CG LOCATION</th>
<th>AVG DENSITY</th>
<th>AVG OAT</th>
<th>AVG ROTOR</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEIGHT (LB)</td>
<td>LONG LAT (FS) [BL]</td>
<td>ALTITUDE (FT)</td>
<td>SPEED (°C)</td>
<td>RPN</td>
<td></td>
</tr>
<tr>
<td>15600</td>
<td>202.5 [FWD]</td>
<td>0.0</td>
<td>5700</td>
<td>8.0</td>
<td>289</td>
</tr>
</tbody>
</table>

NOTE: 8-HELLFIRE CONFIGURATION

- ○ VERTICAL
- □ LATERAL
- △ LONGITUDINAL

1/REV = 38.5 Hz
4/REV = 19.3 Hz
2/REV = 9.6 Hz
1/REV = 4.8 Hz

CALIBRATED AIRSPEED (KNOTS)
### Figure 57

**Vibration Characteristics**

**VH-64 USA S/N 77-23528**

**Pilots Seat**

<table>
<thead>
<tr>
<th>AVG</th>
<th>AVG CG Location</th>
<th>DENSITY</th>
<th>OAT</th>
<th>ROTOR</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS WEIGHT (LB)</td>
<td>LONG: LAT (FS) (BL)</td>
<td>ALTITUDE (FT)</td>
<td>SPEED (°C)</td>
<td>RPM</td>
<td>CONDITION</td>
</tr>
<tr>
<td>15580</td>
<td>202.3 (FWD)</td>
<td>0.0</td>
<td>4480</td>
<td>9.0</td>
<td>290</td>
</tr>
</tbody>
</table>

**Note**

- **HELLFIRE CONFIGURATION**
  - ○ VERTICAL
  - □ LATERAL
  - △ LONGITUDINAL

**Graphs**

- 8/REV = 38.5 Hz
- 4/REV = 19.3 Hz
- 2/REV = 9.6 Hz
- 1/REV = 4.8 Hz

**Calibrated Airspeed (Knots)**
<table>
<thead>
<tr>
<th></th>
<th>AVG</th>
<th>AVG CG</th>
<th>AVG</th>
<th>AVG</th>
<th>AVG</th>
<th>FLIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS</td>
<td></td>
<td>LOCATION</td>
<td>DENSITY</td>
<td>OAT</td>
<td>ROTOR</td>
<td></td>
</tr>
<tr>
<td>WEIGHT</td>
<td></td>
<td>(LB)</td>
<td>(FS)</td>
<td>(BL)</td>
<td>ALTITUDE</td>
<td>SPEED</td>
</tr>
<tr>
<td>15580</td>
<td>4480</td>
<td>202.3(FWD)</td>
<td>0.0</td>
<td>9.0</td>
<td>290</td>
<td>DESCENT</td>
</tr>
</tbody>
</table>

Note: HELLFIRE CONFIGURATION
- VERTICAL
- LATERAL
- LONGITUDINAL

8/REV = 38.5 Hz

4/REV = 19.3 Hz

2/REV = 9.6 Hz

1/REV = 4.8 Hz

Calibrated Airspeed (Knots)
FIGURE 59
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 77-23258
AIRCRAFT CG

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG LOCATION LONG (FS) LAT (BL)</th>
<th>DENSITY (FT)</th>
<th>OAT (°C)</th>
<th>Rotor Speed (RPM)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15580</td>
<td>202.3 (FWD)</td>
<td>0.0</td>
<td>4480</td>
<td>9.0</td>
<td>290 Descend</td>
</tr>
</tbody>
</table>

NOTE: 8-HELLFIRE CONFIGURATION
- ○ VERTICAL
- □ LATERAL
- △ LONGITUDINAL

Graph shows vibration acceleration (g) vs. calibrated airspeed (knots) with
- 8/REV=38.5 Hz
- 4/REV=19.3 Hz
- 2/REV=9.6 Hz
- 1/REV=4.8 Hz
TABLE 1

<table>
<thead>
<tr>
<th>AVG WEIGHT (LB)</th>
<th>AVG LOCATION</th>
<th>AVG DENSITY</th>
<th>AVG OAT (°C)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14600</td>
<td>202.0</td>
<td>0.0</td>
<td>1360</td>
<td>17.5</td>
<td>290</td>
</tr>
</tbody>
</table>

NOTE: 8-HELLFIRE CONFIGURATION

- ○ VERTICAL
- □ LATERAL
- △ LONGITUDINAL

---

**Figure 60**

VIBRATION CHARACTERISTICS

YAH-64 USA S/N 77-2325B

PILOT SEAT

<table>
<thead>
<tr>
<th>SINGLE AMPLITUDE VIBRATORY ACCELERATION (G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/REV = 4.8 Hz</td>
</tr>
<tr>
<td>2/REV = 9.6 Hz</td>
</tr>
<tr>
<td>4/REV = 19.3 Hz</td>
</tr>
<tr>
<td>8/REV = 38.6 Hz</td>
</tr>
</tbody>
</table>

CALIBRATED AIRSPEED (KNOTS)

167
FIGURE 61
VIBRATION CHARACTERISTICS
YAH-64: USA S/N 77-2325B
COPILOT SEAT

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG Location (FS)</th>
<th>AVG Long Altitude (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG Rotor Speed (RPM)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14500</td>
<td>292</td>
<td>0 (FWD) 10.0</td>
<td>1360</td>
<td>17.5</td>
<td>289 LEVEL</td>
</tr>
</tbody>
</table>

NOTE: 8-HELLFIRE CONFIGURATION

○ VERTICAL
□ LATERAL
△ LONGITUDINAL

8/REV = 38.5 Hz

4/REV = 19.3 Hz

2/REV = 9.6 Hz

1/REV = 4.8 Hz

CALIBRATED AIRSPEED (KNOTS)
FIGURE 62
VIBRATION CHARACTERISTICS
YAH-64 USA 5/N FF-23258
PILOT SEAT

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION (FS) (BL)</th>
<th>AVG DENSITY</th>
<th>AVG QAT (FT)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14880</td>
<td>202.0 (FWD) 0.0</td>
<td>5420</td>
<td>10.0</td>
<td>290</td>
<td>LEVEL</td>
</tr>
</tbody>
</table>

NOTE: 8 HELIFERE CONFIGURATION

- ○ VERTICAL
- □ LATERAL
- △ LONGITUDINAL

\[ 8/\text{REV} = 38.5 \text{ Hz} \]

\[ 4/\text{REV} = 19.3 \text{ Hz} \]

\[ 2/\text{REV} = 9.6 \text{ Hz} \]

\[ 1/\text{REV} = 6.8 \text{ Hz} \]

CALIBRATED AIRSPEED (KNOTS)
FIGURE 63
VIBRATION CHARACTERISTICS
VH-54 USA S/N 77-23258
CP PILOT SEAT

<table>
<thead>
<tr>
<th>AVE.</th>
<th>AVE. CO.</th>
<th>AVG. DENSITY</th>
<th>QAT. ROTOR</th>
<th>FLIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS</td>
<td>LOCATION</td>
<td>ALTITUDE</td>
<td>SPEED</td>
<td>CONDITION</td>
</tr>
<tr>
<td>[LB]</td>
<td>[FS]</td>
<td>[BL]</td>
<td>[FT]</td>
<td>[°C]</td>
</tr>
<tr>
<td>14860</td>
<td>202.0 [FWD]</td>
<td>0.0</td>
<td>5420</td>
<td>10.0</td>
</tr>
</tbody>
</table>

NOTE: 8 HELLFIRE CONFIGURATION

- ☬ VERICAL
- ☐ LATERAL
- ▲ LONITUDINAL

- 8/REV = 38.5 Hz
- 4/REV = 19.3 Hz
- 2/REV = 9.6 Hz
- 1/REV = 4.8 Hz

CALIBRATED AIRSPEED (KNOTS)
### Figure 64

**Vibration Characteristics**

VAH-64 USA 5/N 77-23258
PILOT SEAT

<table>
<thead>
<tr>
<th>AVG CG LOCATION</th>
<th>AVG DENSITY</th>
<th>AVG OAT</th>
<th>AVG ROTOR</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS WEIGHT</td>
<td>LONG LATITUDE</td>
<td>ALTITUDE</td>
<td>SPEED</td>
<td>CONDITION</td>
</tr>
<tr>
<td>(LB) (FS) (BL)</td>
<td>(FT) (°C) (RPM)</td>
<td>(FWD)</td>
<td>(BL)</td>
<td>6380 8.0 290 LEVEL</td>
</tr>
</tbody>
</table>

**Note:** 8-HELLFIRE CONFIGURATION

- ○ VERTICAL
- □ LATERAL
- △ LONGITUDINAL

**Single Amplitude Vibratory Acceleration (g)**

- 8/REV = 38.5 Hz
- 4/REV = 19.3 Hz
- 2/REV = 9.6 Hz
- 1/REV = 4.8 Hz

**Calibrated Airspeed (Knots)**

171
### Figure 65

**Vibration Characteristics**

**YAH-64 USA S/N 77-23238**

**Copilot Seat**

<table>
<thead>
<tr>
<th>AVG Gross Weight (Lb)</th>
<th>AVG Location</th>
<th>AVG Density</th>
<th>AVG QAT</th>
<th>AVG Rotor</th>
<th>AVG Flight Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>15740</td>
<td>202.0 (FWD)</td>
<td>0.0</td>
<td>6380</td>
<td>8.0</td>
<td>290 LEVEL</td>
</tr>
</tbody>
</table>

**Note:** 8-HELLFIRE Configuration

- **O** Vertical
- **□** Lateral
- **△** Longitudinal

#### Frequency Response:
- **8/Rev** = 38.5 Hz
- **4/Rev** = 19.3 Hz
- **2/Rev** = 9.6 Hz
- **1/Rev** = 4.8 Hz

**Calibrated Airspeed (Knots)**

---

172
FIGURE 67
VIBRATION CHARACTERISTICS
VAH-64 USA 5/N '77-29258
COPILOT SEAT

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG LOCATION (FS)</th>
<th>AVG DENSITY (FWO)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>AVG FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15640</td>
<td>202.2</td>
<td>0.0</td>
<td>9720</td>
<td>0.5</td>
<td>290</td>
<td>LEVEL</td>
</tr>
</tbody>
</table>

NOTE: 8-HELFFIRE CONFIGURATION

○ VERTICAL
□ LATERAL
△ LONGITUDINAL

CALIBRATED AIRSPEED (KNOTS)
**Figure 68**

**Vibration Characteristics**

**YAH-64 USA 5/4 FLY 2.522**

**PILOT FLOOR**

<table>
<thead>
<tr>
<th>AVG GROSS</th>
<th>AVG CG LOCATION</th>
<th>AVG DENSITY</th>
<th>AVG OAT</th>
<th>AVG ROTOR</th>
<th>AVG FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15640</td>
<td>202.2 (FWD) 0.0</td>
<td>9720</td>
<td>0.5</td>
<td>290</td>
<td>LEVEL</td>
</tr>
</tbody>
</table>

**NOTE:** 8-HELLFIRE CONFIGURATION

- ○ VERTICAL
- □ LATERAL
- △ LONGITUDINAL

**Single Amplitude Vibratory Acceleration (g)**

- 1/REV = 4.8 Hz
- 2/REV = 9.6 Hz
- 4/REV = 19.3 Hz
- 8/REV = 38.5 Hz

**Calibrated Airspeed (KNOIS)**

175
FIGURE 59
VIBRATION CHARACTERISTICS
YAH-64 USA S/N F7-29258
COPILOT FLOOR

<table>
<thead>
<tr>
<th>AVG WEIGHT (LB)</th>
<th>AVG CG LOCATION</th>
<th>AVG DENSITY</th>
<th>AVG OAT °C</th>
<th>AVG Rotor RPM</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15640</td>
<td>202.2 (FWD)</td>
<td>0.0</td>
<td>9720</td>
<td>0.5</td>
<td>290</td>
</tr>
</tbody>
</table>

NOTE: 8-MEHLFIRE CONFIGURATION
- ○ VERTICAL
- □ LATERAL
- △ LONGITUDINAL

- 8/REV=38.5 Hz
- 4/REV=19.3 Hz
- 2/REV=9.6 Hz
- 1/REV=4.6 Hz

CALIBRATED AIRSPEED (KNOTS)
<table>
<thead>
<tr>
<th>PILOT SEAT</th>
<th>PILOT SEAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEIGHT (LB)</td>
<td>15740</td>
</tr>
<tr>
<td>LOCATION (FS) (BL)</td>
<td>205.2 (AFT) 0.0</td>
</tr>
<tr>
<td>ALTITUDE (FT)</td>
<td>5020</td>
</tr>
<tr>
<td>DENSITY</td>
<td>4.5</td>
</tr>
<tr>
<td>Rotor Speed (RPM)</td>
<td>290</td>
</tr>
<tr>
<td>Flight Condition</td>
<td>LEVEL FLIGHT</td>
</tr>
</tbody>
</table>

**NOTE:** HELLFIRE CONFIGURATION
- VERTICAL
- LATERAL
- LONGITUDINAL

**DATA: 8/REV = 38.5 Hz**

**DATA: 4/REV = 19.3 Hz**

**DATA: 2/REV = 9.6 Hz**

**DATA: 1/REV = 4.8 Hz**

**CALIBRATED AIRSPEED (KNOTS)**
FIGURE 72
VIBRATION CHARACTERISTICS
YAH-64 USA S/N FF-23285
CO PILOT SEAT

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG LOCATION (FS)</th>
<th>AVG DENSITY</th>
<th>AVG OAT (°C)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15740</td>
<td>205.2 (AFT) 0.0</td>
<td>5020</td>
<td>6.5</td>
<td>290</td>
<td>LEVEL FLIGHT</td>
</tr>
</tbody>
</table>

NOTE: HELLFIRE CONFIGURATION
○ VERTICAL
□ LATERAL
△ LONGITUDINAL

8/REV = 38.5 Hz

4/REV = 19.3 Hz

2/REV = 9.6 Hz

1/REV = 4.8 Hz

CALIBRATED AIRSPEED (KNOTS)
FIGURE 14
VIBRATION CHARACTERISTICS
YAH-64 USA F/N BF-HOLP-000
PILOT SEAT

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG LOCATION LONG (FS) LAT (BL)</th>
<th>AVG DENSITY (FT)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG Rotor Speed (°C)</th>
<th>AVG FLIGHT CONDITION (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14400</td>
<td>205.7</td>
<td>0.0</td>
<td>5840</td>
<td>8.5</td>
<td>290</td>
</tr>
</tbody>
</table>

NOTES:
1. 8-HELLFIRE CONFIGURATION
2. VERTICAL VIBRATION ABSORBER REMOVED

- VERTICAL
- LATERAL
- LONGITUDINAL

- 8/REV=38.5 Hz
- 4/REV=19.3 Hz
- 2/REV=9.6 Hz
- 1/REV=4.8 Hz

CALIBRATED AIRSPEED (KNOTS)
### FIGURE 76
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 77-22558
COPILOT FLOOR

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG LOCATION (FS)</th>
<th>AVG DENSITY (FT)</th>
<th>OAT (°C)</th>
<th>AVG SPEED (RPM)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14400</td>
<td>205.7 (AFT)</td>
<td>0.0</td>
<td></td>
<td>5840</td>
<td>8.5</td>
</tr>
</tbody>
</table>

**NOTES:**
1. 8 HELLFIRE CONFIGURATION
2. VERTICAL VIBRATION ABSORBER REMOVED

---

**Graphical Data**

- **Vertical Acceleration (g)**
  - 8/REV = 38.5 Hz
  - 4/REV = 19.3 Hz
  - 2/REV = 9.6 Hz
  - 1/REV = 4.8 Hz

- **Calibrated Airspeed (Knots)**
  - Values range from 20 to 160 knots.
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 78-20508
AIRCRAFT CG

<table>
<thead>
<tr>
<th>WEIGHT (LB)</th>
<th>LONG (FS)</th>
<th>LAT (BL)</th>
<th>ALTITUDE (FT)</th>
<th>OAT (°C)</th>
<th>ROTOR RPM</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14400</td>
<td>205.7 (AFT)</td>
<td>0.0</td>
<td>5040</td>
<td>8.5</td>
<td>290</td>
<td>LEVEL FLIGHT</td>
</tr>
</tbody>
</table>

NOTES:
1. 8 HELLFIRE CONFIGURATION
2. VERTICAL VIBRATION ABSORBER REMOVED

- 8/REV = 38.5 Hz
- 4/REV = 19.3 Hz
- 2/REV = 9.6 Hz
- 1/REV = 4.18 Hz

CALIBRATED AIRSPEED (KNOTS)
FIGURE 74  
VIBRATION CHARACTERISTICS  
YAH-64 USA S/N 77-23858  
COPILOT SEAT

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG LOCATION LONG (FS)</th>
<th>AVG LOCATION LAT (BL)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG Rotor Speed (RPM)</th>
<th>AVG FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>14400</td>
<td>205.7 (AFT)</td>
<td>0.0</td>
<td>5840</td>
<td>8.5</td>
<td>290</td>
<td>LEVEL</td>
</tr>
</tbody>
</table>

NOTES: 1. 8-HELLFIRE CONFIGURATION  
2. VERTICAL VIBRATION ABSORBER REMOVED

○ VERTICAL  
■ LATERAL  
△ LONGITUDINAL

8/REV = 38.5 Hz
4/REV = 19.3 Hz
2/REV = 9.6 Hz
1/REV = 4.8 Hz

CALIBRATED AIRSPEED (KNOTS)
<table>
<thead>
<tr>
<th>Avg Gross Weight (LB)</th>
<th>Average Location (FS)</th>
<th>Average Latitude (BL)</th>
<th>Average Altitude (FT)</th>
<th>Average OAT (°C)</th>
<th>Average RPM</th>
<th>Flight Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>14400</td>
<td>205.7 (AFT)</td>
<td>0.0</td>
<td>5840</td>
<td>8.5</td>
<td>290</td>
<td>Level Flight</td>
</tr>
</tbody>
</table>

**Notes:**
1. B Hellfire Configuration
2. Vertical vibration absorber removed

![Graph and Chart]

- Vertical
- Lateral
- Longitudinal

**Calibrated Airspeed (Knots)**
FIGURE 79
SHIP'S AIRSPEED CALIBRATION RIGHT WING

<table>
<thead>
<tr>
<th>AVG Gross Weight (LB)</th>
<th>AVG Long Location (FS)</th>
<th>AVG LAT (BL)</th>
<th>AVG Altitude (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG Rotor Speed (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14840</td>
<td>206.3 (AFT)</td>
<td>0.0</td>
<td>4060</td>
<td>7.5</td>
<td>290</td>
</tr>
</tbody>
</table>

NOTES: 1. HELLFIRE CONFIGURATION (INBOARD)
2. PAGE METHOD UTILIZED (AH-1S)

- ○ 500 FPM CLimb
- ○ 1000 FPM CLimb
- △ 1500 FPM CLimb
- ○ 500 FPM DESCENT
- ○ 1000 FPM DESCENT
- ○ 1500 FPM DESCENT

LINE OF ZERO ERROR

INSTRUMER-CORRECTED AIRSPEED (KNOTS)
Figure 60
SKEP’S AIRSPEED CALIBRATION LEFT WING
VAH-64 USA 15/11 Y7-23258

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (Lb)</th>
<th>AVG CG LOCATION (FS)</th>
<th>AVG GEAR EXTENSION (IN)</th>
<th>AVG DENSITY (AT)</th>
<th>AVG OAT (°F)</th>
<th>AVG ROTON SPEED (RPM)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>18770</td>
<td>305.2(AFT)</td>
<td>0.0</td>
<td>5020</td>
<td>5.5</td>
<td>290</td>
</tr>
<tr>
<td>10</td>
<td>18770</td>
<td>305.2(AFT)</td>
<td>0.0</td>
<td>5020</td>
<td>5.5</td>
<td>290</td>
</tr>
</tbody>
</table>

Notes: 1. BELLFIRE CONFIGURATION (INBOARD)
2. PACE METHOD UTILIZED (AF-15)
3. FLAED SYMBOLS DENOTE T-28 PACE.

Line of Zero Error
### APPENDIX F. GLOSSARY

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Speed of sound</td>
</tr>
<tr>
<td>A</td>
<td>Main rotor disc area (ft²)</td>
</tr>
<tr>
<td>AAH</td>
<td>Advance Attack Helicopter</td>
</tr>
<tr>
<td>ADS</td>
<td>Air Data System</td>
</tr>
<tr>
<td>app</td>
<td>Appendix</td>
</tr>
<tr>
<td>APU</td>
<td>Auxiliary Power Unit</td>
</tr>
<tr>
<td>AVRADCOM</td>
<td>US Army Aviation Research and Development Command</td>
</tr>
<tr>
<td>BL</td>
<td>Butt Line</td>
</tr>
<tr>
<td>BUCS</td>
<td>Back-up Control System</td>
</tr>
<tr>
<td>C</td>
<td>Celsius</td>
</tr>
<tr>
<td>CAS</td>
<td>Control Augmentation System</td>
</tr>
<tr>
<td>cg</td>
<td>Center of Gravity</td>
</tr>
<tr>
<td>Cl</td>
<td>Centerline</td>
</tr>
<tr>
<td>Cₚ</td>
<td>Coefficient of Power</td>
</tr>
<tr>
<td>CFG</td>
<td>Copilot/gunner</td>
</tr>
<tr>
<td>Cₜ</td>
<td>Coefficient of Thrust</td>
</tr>
<tr>
<td>DASE</td>
<td>Digital Automatic Stabilization Equipment</td>
</tr>
<tr>
<td>DASEC</td>
<td>Digital Automatic Stabilization Equipment Computer</td>
</tr>
<tr>
<td>deg</td>
<td>Degree</td>
</tr>
<tr>
<td>DT-1</td>
<td>Development Test 1</td>
</tr>
<tr>
<td>EADI</td>
<td>Electronic Attitude Direction Indicator</td>
</tr>
<tr>
<td>ECRR</td>
<td>Engineering Change Request and Record</td>
</tr>
<tr>
<td>ECU</td>
<td>Electrical Control Unit</td>
</tr>
<tr>
<td>EDT-1</td>
<td>Engineer Design Test 1</td>
</tr>
<tr>
<td>EDT-2</td>
<td>Engineer Design Test 2</td>
</tr>
<tr>
<td>EMI</td>
<td>Electromagnetic Interference</td>
</tr>
<tr>
<td>ENCU</td>
<td>Environmental Control Unit</td>
</tr>
<tr>
<td>EPR</td>
<td>Equipment Performance Report</td>
</tr>
<tr>
<td>ETP</td>
<td>Experimental Test Procedure</td>
</tr>
<tr>
<td>FABS</td>
<td>Forward Avionics Bays</td>
</tr>
<tr>
<td>fig</td>
<td>Figure</td>
</tr>
<tr>
<td>FOD</td>
<td>Foreign Object Damage</td>
</tr>
<tr>
<td>fs, FS</td>
<td>Fuselage Station</td>
</tr>
<tr>
<td>ft</td>
<td>Feet</td>
</tr>
<tr>
<td>HARS</td>
<td>Heading and Attitude Reference System</td>
</tr>
<tr>
<td>HAS</td>
<td>Hover Augmentation System</td>
</tr>
<tr>
<td>GCT</td>
<td>Government Competitive Test</td>
</tr>
<tr>
<td>GPM</td>
<td>Gallons Per Minute</td>
</tr>
<tr>
<td>GW</td>
<td>Gross Weight</td>
</tr>
<tr>
<td>HH</td>
<td>Hughes Helicopters</td>
</tr>
<tr>
<td>HMU</td>
<td>Hydromechanical Unit</td>
</tr>
<tr>
<td>Hₚ</td>
<td>Pressure altitude</td>
</tr>
<tr>
<td>HQRS</td>
<td>Handling Qualities Rating Scale</td>
</tr>
<tr>
<td>Hz</td>
<td>Hertz</td>
</tr>
<tr>
<td>IGE</td>
<td>In Ground Effect</td>
</tr>
<tr>
<td>IMC</td>
<td>Instrument Meteorological Conditions</td>
</tr>
<tr>
<td>in</td>
<td>Inches</td>
</tr>
<tr>
<td>IR</td>
<td>Infrared</td>
</tr>
<tr>
<td>IRP</td>
<td>Intermediate Rated Power</td>
</tr>
<tr>
<td>KCAS</td>
<td>Knots Calibrated Airspeed</td>
</tr>
<tr>
<td>KIAS</td>
<td>Knots Indicated Airspeed</td>
</tr>
<tr>
<td>KTAS.</td>
<td>Knots True Airspeed</td>
</tr>
<tr>
<td>lb</td>
<td>Pound</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>LVDT</td>
<td>Linear Variable Displacement Transducer</td>
</tr>
<tr>
<td>$M_a$</td>
<td>Advancing tip mach number</td>
</tr>
<tr>
<td>NAMPP</td>
<td>Nautical air miles per pound of fuel</td>
</tr>
<tr>
<td>$N_E$</td>
<td>Gas producer speed</td>
</tr>
<tr>
<td>NOE</td>
<td>Nap of the Earth</td>
</tr>
<tr>
<td>$N_P$</td>
<td>Power turbine speed</td>
</tr>
<tr>
<td>$N_R$</td>
<td>Main rotor speed</td>
</tr>
<tr>
<td>OAT</td>
<td>Outside air temperature</td>
</tr>
<tr>
<td>OGE</td>
<td>Out of Ground Effect</td>
</tr>
<tr>
<td>OT-II</td>
<td>Operational Test II</td>
</tr>
<tr>
<td>PCM</td>
<td>Pulse Code Modulation</td>
</tr>
<tr>
<td>PIO</td>
<td>Pilot Induced Oscillation</td>
</tr>
<tr>
<td>PNVS</td>
<td>Pilot Night Vision System</td>
</tr>
<tr>
<td>psi</td>
<td>Pounds per square inch</td>
</tr>
<tr>
<td>psig</td>
<td>Pounds per square inch gauge</td>
</tr>
<tr>
<td>Q</td>
<td>Engine output shaft torque</td>
</tr>
<tr>
<td>ref</td>
<td>Reference</td>
</tr>
<tr>
<td>rpm</td>
<td>Revolutions per minute</td>
</tr>
<tr>
<td>SAS</td>
<td>Stability Augmentation System</td>
</tr>
<tr>
<td>SCAS</td>
<td>Stability and Control Augmentation System</td>
</tr>
<tr>
<td>SCU</td>
<td>Stabilator Control Unit</td>
</tr>
<tr>
<td>sec</td>
<td>Seconds</td>
</tr>
<tr>
<td>SHP, shp</td>
<td>Shaft Horsepower</td>
</tr>
<tr>
<td>S/N</td>
<td>Serial Number</td>
</tr>
<tr>
<td>TADS</td>
<td>Target Acquisition and Designation System</td>
</tr>
<tr>
<td>TFS</td>
<td>Trim Feel System</td>
</tr>
<tr>
<td>TGT</td>
<td>Turbine gas temperature</td>
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<tr>
<td>$T_h$</td>
<td>Turbine gas temperature</td>
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<tr>
<td>USAFA</td>
<td>US Army Aviation Engineering Flight Activity</td>
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<tr>
<td>V</td>
<td>Velocity</td>
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<tr>
<td>VDC</td>
<td>Volts Direct Current</td>
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<tr>
<td>$V_h$</td>
<td>Maximum Horizontal Velocity</td>
</tr>
<tr>
<td>VMC</td>
<td>Visual Meteorological Conditions</td>
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<tr>
<td>VNE</td>
<td>Never exceed airspeed</td>
</tr>
<tr>
<td>$V_T$</td>
<td>True airspeed</td>
</tr>
<tr>
<td>VRS</td>
<td>Vibration Rating Scale</td>
</tr>
<tr>
<td>WL</td>
<td>Water line</td>
</tr>
<tr>
<td>wf</td>
<td>Fuel flow rate</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>Incremental change</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Advance ratio</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Air density ($\text{slugs/ft}^3$)</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Air density ratio</td>
</tr>
<tr>
<td>$\Omega$</td>
<td>Main rotor angular velocity (radians/sec)</td>
</tr>
<tr>
<td>~</td>
<td>Approximately</td>
</tr>
<tr>
<td>$4/\text{rev}$</td>
<td>4th harmonic of the main rotor</td>
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APPENDIX G. EQUIPMENT PERFORMANCE REPORTS

The following EPRs were submitted:

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>SUBJECT</th>
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<tbody>
<tr>
<td>80-03-1</td>
<td>Fuel transfer pump</td>
</tr>
<tr>
<td>80-03-2</td>
<td>TADS/PNVS mounting bracket</td>
</tr>
<tr>
<td>80-03-3</td>
<td>Rotor brake system</td>
</tr>
<tr>
<td>80-03-4</td>
<td>Collective friction assembly</td>
</tr>
<tr>
<td>80-03-5</td>
<td>External power monitor</td>
</tr>
<tr>
<td>80-03-6</td>
<td>Stabilator control panel</td>
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<tr>
<td>80-03-7</td>
<td>Engine nose gearbox leak</td>
</tr>
<tr>
<td>80-03-8</td>
<td>Master caution light</td>
</tr>
<tr>
<td>80-03-9</td>
<td>Engine/rotor speed indicator</td>
</tr>
<tr>
<td>80-03-10</td>
<td>Heading attitude reference system</td>
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<tr>
<td>80-03-11</td>
<td>Stabilator control unit</td>
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<td>80-03-12</td>
<td>Hydraulic fluid sample procedure</td>
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<tr>
<td>80-03-13</td>
<td>Main rotor lead/lag bearings</td>
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<tr>
<td>80-03-14</td>
<td>Utility hydraulic manifold bleed/overservice</td>
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<tr>
<td>80-03-15</td>
<td>Main transmission leak</td>
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<tr>
<td>80-03-16</td>
<td>Impending bypass button, nose gearbox</td>
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<tr>
<td>80-03-17</td>
<td>Main transmission input clutch assembly seal leak</td>
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<tr>
<td>80-03-18</td>
<td>Stabilator bearings (bushings)</td>
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<tr>
<td>80-03-19</td>
<td>Main transmission impending bypass buttons (2 each)</td>
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<tr>
<td>DISTRIBUTION</td>
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<td>Deputy Chief of Staff for Logistics (DALO-SMM)</td>
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<tr>
<td>Deputy Chief of Staff for Operations (DAMO-RQ)</td>
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<tr>
<td>Deputy Chief of Staff for Personnel (DAPE-HRS)</td>
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<tr>
<td>Deputy Chief of Staff for Research Development and Acquisition (DAMA-PPM-T, DAMA-RA, DAMA-WSA)</td>
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<tr>
<td>Comptroller of the Army (DACA-EA)</td>
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<td>US Army Materiel Development and Readiness Command (DRCDE-DH, DRCQA-E, DRCRE-I, DRCDE-RT)</td>
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<tr>
<td>US Army Training and Doctrine Command (ATTG-U, ATCD-T, ATCD-ET, ATCD-B)</td>
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<td>US Army Aviation Research and Development Command (DRDAV-DI, DRDAV-EE, DRDAV-EG)</td>
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<td>US Army Infantry Center (ATSH-TSM-BH)</td>
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<tr>
<td>US Army Safety Center (IGAR-TA, IGAR-Library)</td>
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</table>
US Army Research and Technology Laboratories/
    Applied Technology Laboratory (DAVDL-ATL-D, DAVDL-Library)  2
US Army Research and Technology Laboratories/
    Aeromechanics Laboratory (DAVDL-AL-D)  1
US Army Research and Technology Laboratories/
    Propulsion Laboratory (DAVDL-PL-D)  1
Defense Technical Information Center (DDR)  12
Advanced Attack Helicopter (DRCPM-AAH-TM, DRCPM-AAH-APM-TE)  6
General Electric - AEG (Mr. Koon)  1
Hughes Helicopters (Mr. Gerry Ryan)  3
US Army Missile Command (DRCPM-HDT-T)  1