PRELIMINARY AIRWORTHINESS EVALUATION OF THE UH-1H WITH HOT METAL PLUS PLUME INFRARED SUPPRESSOR AND INFRARED JAMMER

FINAL REPORT

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20. ABSTRACT (Continue on reverse if necessary and identify by block number)
The Preliminary Airworthiness Evaluation (PAE) of the UH-1H, with the Central Aeronautical Infrared (IR) Suppressor and an ALO-144 IR Jammer installed, was conducted at Edwards Air Force Base, California, between 13-21 September 1980. A total of 20.7 hours were flown during this test program. This PAE was an evaluation of a redesigned IR suppressor and IR jammer installation for the UH-1H helicopter. The design was for a UH-1H helicopter modified to accommodate the IR suppressor in the tail rotor area and add stabilization in directional stability. The installation was redesigned to reduce the airflow disturbance over the tail rotor and vertical stabilizer. This evaluation was conducted in two phases. Phase I (14 January through 6 February 1981) consisted of flight hours was a comprehensive evaluation of handling qualities of the UH-1H in
both the standard and IR suppressor configurations. Phase II (29 April through 18 May 1985; 11.2 flight hours) was primarily a pressure and temperature survey of the IR suppressor configuration. The handling qualities of the UH-1H helicopter were essentially unchanged by the IR suppressor and IR jammer installation tested. The previously reported degradation in directional stability was not observed during this test. The tail boom surface temperatures were generally higher than those reported by BHT for the initial design and the structural implications of these higher temperatures should be investigated. One deficiency, the metal to metal contact between the engine exhaust ejector and the IR suppressor inner core support struts, was identified. Three shortcomings were also identified.
DEPARTMENT OF THE ARMY
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DRDAV-D

SUBJECT: USAAEFA Report, Preliminary Airworthiness Evaluation of the UH-1H with Hot Metal Plus Plume Infrared Suppressor and Infrared Jammer, USAAEFA Project No. 80-06

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1. The purpose of this letter is to establish the Directorate for Development and Qualification position on subject report. The report documents the test results of the subject evaluation and substantiates that the handling qualities of the JUH-1H with the Hot Metal Plus Plume Suppressor are essentially the same as those of the standard UH-1H helicopter. The tail boom surface temperatures were generally higher than those reported by Bell Helicopter Textron for the initial design.

2. This Directorate agrees with the report's conclusions and recommendations. Additional design development is in progress by BHT under Army contract and further flight testing will be conducted which should accommodate the recommendations and conclusions of this report.

FOR THE COMMANDER:

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

Accession For
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INTRODUCTION

BACKGROUND

1. The United States Army requires a reduced infrared (IR) signature and increased protection from IR seeking weapons for its aircraft. To achieve these goals, the US Army contracted with Bell Helicopter Textron (BHT) to develop an installation to accommodate a Garrett AirResearch Manufacturing Company (Garrett) hot metal plus plume (HMPP) IR suppressor and an AN/ALQ-144 IR jammer on the UH-1H helicopter. BHT was required to prove feasibility of the HMPP IR suppressor design, conduct limited flight testing, and assess IR cooling. Flight testing of the initial design by BHT showed that the suppressor pressures and the suppressor and tail boom temperatures were acceptable; however, the directional stability characteristics of the aircraft were degraded. BHT initiated a redesign of the suppressor and jammer installation to reduce the airflow disturbance, which was believed to be causing the degradation of directional stability. The US Army Aviation Research and Development Command (AVRA/D COM) directed the US Army Aviation Engineering Flight Activity (USAAFF/A) to perform a preliminary airworthiness evaluation (PAE) of the UH-1H with the redesigned IR suppressor and jammer installation (ref 1, app A). A test plan (ref 2) was submitted in January 1981 and an Airworthiness Release (ref 3) was issued in February 1981.

TEST OBJECTIVES

2. The overall objectives of this PAE were to determine if the redesigned suppressor and jammer installation changed the handling qualities of the UH-1H and to conduct a survey of suppressor pressures and suppressor and tail boom temperatures.

3. The specific test objectives were:

   a. To provide quantitative and qualitative flight test data of the aircraft handling qualities.

   b. To determine suppressor pressures and suppressor and tailboom temperatures.

DESCRIPTION

4. The UH-1H is a thirteen-place single engine helicopter using a single two-blade teetering main rotor and pusher tail rotor. The maximum gross weight of the helicopter is 9500 pounds. Power is provided by a Lycoming T53-L-13 free turbine engine rated at 1400 shaft horsepower (SHP). However, the helicopter is limited by the transmission to 1100 SHP. A more complete description may be found in the detail specification (ref 5, app A) and the operator's manual (ref 4). The test helicopter was a UH-1H, S N 69-15532. The significant external differences from the standard UH-1H were removal of the cargo hook and the addition of an anispeed boom, 9.5 feet long, mounted on the centerline of the helicopter at the base of the windshield center post. Internal differences consisted primarily of the instrumentation system. These differences had no significant effect on the flight test results.
5. The IR suppressor and jammer installation consisted of a Garrett HMPP IR suppressor, originally developed for the AH-1S helicopter, an AN/ALQ-144 IR jammer, and a redesigned aft engine cowl to support the suppressor and jammer. A more detailed description of the IR suppressor and jammer installation is provided in appendix B.

TEST SCOPE

6. Flight testing was conducted at Edwards Air Force Base, California (elevation 2302 feet) and Bakersfield, California, (elevation 490 feet) during the period 16 January 1981 through 18 May 1981. A total of 16 flights were conducted during which 20.7 hours were flown. Tests were conducted in two phases. The first phase consisted of an evaluation of handling characteristics with primary emphasis on the lateral-directional stability characteristics of the aircraft with the IR suppressor and jammer installed. Data were also taken with the aircraft in the standard configuration as a basis for comparison. The second phase tests were primarily a survey of IR suppressor pressures and suppressor and tailboom temperatures. Flight restrictions and operating limitations contained in the airworthiness release (ref 3, app A), and the operator's manual (ref 4) were observed. Where possible, flight test data were compared with the applicable specifications (refs 7 and 9) and with data obtained from previous tests of the UH-1H (refs 7, 8, and 9). Flight tests were conducted under the conditions specified in table 1.

TEST METHODOLOGY

7. Established flight test techniques were used throughout this evaluation (ref 10, app A). Test methods used are briefly discussed in the Results and Discussion section of this report. The handling qualities rating scale (HQRS) shown in figure 1, appendix D, was used to supplement pilot comments on handling qualities. All flight test data, during the handling qualities tests, were obtained from calibrated test instrumentation and were recorded on magnetic tape. Data obtained during the pressure/temperature survey were recorded both on magnetic tape (pressures) and by hand from cockpit instrumentation (temperatures). A detailed listing of the test instrumentation is contained in appendix C. The definitions of deficiencies and shortcomings used during this test and data analysis methods used are presented in appendix D.
<table>
<thead>
<tr>
<th>Test</th>
<th>Gross Weight (lbs)</th>
<th>Longitudinal Center of Gravity Location (ft)</th>
<th>Density Altitude (ft)</th>
<th>True Airspeed (KT)</th>
<th>Remarks</th>
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<td>HANDLING CONDITIONS</td>
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NOTES:
1. Figures based on test data from the test data.
2. Instrument Misalignment ± 0.03 M.A.
3. Instrument Misalignment ± 0.03 M.A.
4. Instrument Misalignment ± 0.03 M.A.
RESULTS AND DISCUSSION

GENERAL

8. This PAI was an evaluation of a redesigned IR suppressor and IR jammer installation for the UH-1H helicopter. The initial design was reported by BITT (ref 9, app A) to have caused a degradation in directional stability. The installation was redesigned to reduce the airflow disturbance over the vertical stabilizer. This evaluation was conducted in two phases. Phase I was a comparative evaluation of handling qualities of the UH-1H in both the standard and IR suppressor configurations. Phase II was primarily a pressure and temperature survey of the IR suppressor configuration. The handling qualities of the UH-1H helicopter were essentially unchanged by the IR suppressor and IR jammer installation tested. The previously reported degradation in directional stability was not observed during this test. The tail boom surface temperatures were generally higher than those reported by BITT for the initial design and the structural implications of these higher temperatures should be investigated. One deficiency, the metal to metal contact between the engine exhaust ejector and the IR suppressor innercore support struts, was identified. No new specification non-compliances were identified as a result of the IR suppressor installation on the UH-1H helicopter. Three shortcomings were identified.

HANDLING QUALITIES

General

9. The handling qualities of the UH-1H were evaluated at the test conditions listed in Table 1. All tests were conducted using standard flight test techniques (ref 10, app A). Tests were conducted with the IR suppressor and IR jammer installed and repeated with the standard UH-1H tailpipe installed. Data obtained from these tests were compared to determine if the handling characteristics of the UH-1H were significantly affected by the installation of the IR suppressor system. Additionally, data were compared with previous tests of a standard UH-1H (refs 7 and 8) and a previous design of the IR suppressor installation (ref 9). Test results show that the handling qualities of the UH-1H are essentially unchanged by the installation of the HMPP IR suppressor and AN-MQ-144 jammer.

Control Positions in Trummed Forward Flight

10. The control positions were evaluated in level flight and in climbs and descents. Test results are presented in figures 1 through 6. appendix I. The control positions in trimmed forward flight are essentially unchanged from the standard UH-1H.

Static Longitudinal Stability

11. Tests were conducted in level flight for both the standard and the IR suppressor configurations. Climb and descent were conducted at approximately 10 pounds per square inch (psi) indicated engine torque in the IR suppressor configuration only. Test results are presented in figures 7 through 10, appendix I. The aircraft exhibited positive longitudinal control force and position stability for all conditions tested. Qualitatively, the stability characteristics observed during climbs and descents were similar to those of the standard UH-1H aircraft. The static longitudinal stability was essentially unchanged by the installation of the IR suppressor assembly.
Static Lateral-Directional Stability

12. The tests were conducted in level flight, climb, and descent. The standard configuration was evaluated in level flight only. Test results are presented in figures 11 through 14, appendix 1. The test aircraft exhibited both positive directional stability and positive dihedral effect. A direct comparison between the IR suppressor configuration (fig. 11) and the standard configuration (fig. 12) shows essentially no change in lateral-directional stability characteristics. Stability characteristics during climbs and descents qualitatively were unchanged from standard UH-1H aircraft. The static lateraldirectional stability of the UH-1H aircraft was essentially unchanged by the installation of the IR suppressor system.

Maneuvering Stability

13. The maneuvering stability characteristics were evaluated using constant airspeed left and right turns with the collective control fixed at the initial trim position. Flight test data for both the IR suppressor installation and the standard UH-1H are presented in figures 15 and 16, appendix 1, respectively. The stick-fixed stability (control position vs load factor) was positive for the load factors tested. Control position gradients were similar for both configurations. Qualitatively there was no change in the stick-fixed stability (control force vs load factor). The maneuvering stability characteristics were essentially the same as those noted for the standard UH-1H.

Dynamic Stability

14. The longitudinal dynamic stability characteristics were evaluated in level flight. Data are presented in figures 17 through 19, appendix 1. Both the short-term and long-term dynamic response was essentially deadbeat and no difference was noted between the IR suppressor and standard tailpipe configurations.

15. The lateral-directional dynamic stability characteristics were evaluated in level flight for both the standard and the IR suppressor configurations. Directional control rudder and pitch were the most effective methods of exciting the lateral-directional oscillation. Data for both configurations are presented in figures 20 through 28, appendix 1. A lightly damped roll-yaw oscillation was observed for both configurations tested. The installation of the IR suppressor system had no significant effect on the lateral-directional characteristics of the standard UH-1H helicopter.

Low-Speed Flight Characteristics

General

16. Testing was accomplished using the ground-pole vehicle method at a constant skid height of 10 feet in winds of 5 knots or less. Data were recorded at 5 knot increments from a hover to 40 knots forward, 30 knots rearward, and 35 knots sideward flight. Control excursions, as presented on the data plots, gave an indication of pilot work load and were supplemented by pilot qualitative comments. The results of these tests were compared to those previously reported for the standard UH-1H helicopter (refs. 7 and 8, app A). The low-speed handling qualities of the UH-1H equipped with the IR suppressor and manner were essentially unchanged from the standard configuration.
Forward and Rearward Flight:

17. The results of the forward and rearward flight tests are presented as figures 29 and 30, appendix E. Figure 30 shows that at rearward airspeeds of 16 to 29 knots true airspeed (KTAS) (forward cg 132.1) less than 1% percent aft longitudinal control margin remained. The aft longitudinal control inputs which were necessary to control the aircraft pitching motion within the 10 to 15 knot range resulted in a higher pilot work load (HOURS 5), as documented in reference 8, appendix A. Depending on pilot seat position, the control equipment attached to his survival vest with the cyclic prior to reaching the full aft longitudinal control position. The lack of adequate longitudinal control margin within the specified limit of the operator's manual was previously reported as a deficiency (ref 7) and was not a result of the IR suppressor and jammer installation.

Sideward Flight:

18. The results of the left and right sideward flight tests are presented as figures 31 and 32, appendix E. The longitudinal trim shift of approximately 2.5 inches during left sideward flight between 8 and 15 KTAS is characteristic of the standard UH-1H (ref 8, app A) and contributed to high pilot work load (HQRS 5). Figure 32, shows that at the left sideward flight limit of 15 KTAS the right directional control pedal stop was contacted. Inadequate directional control margin was previously reported as a deficiency for the standard UH-1H (ref 7) and was not a result of the IR suppressor and jammer installation.

Mission Maneuvering Characteristics

19. Confined area operations, pinnacle operations, map of the earth and contour flight, non-precision and precision instrument approaches were performed in light to moderate turbulence to evaluate aircraft handling characteristics in turbulence. No degradation of handling qualities due to the IR suppressor installation was observed during operation in turbulence. The aircraft response from light to moderate turbulence was essentially unchanged from the standard UH-1H.

Simulated Engine Failures

20. Simulated engine failures were performed in level flight by rapidly rolling the throttle to the flight idle detent. Flight controls were held fixed until activation of the low main rotor speed audio tone. Data are presented in figures 33 through 36, appendix F. Tests showed no degradation of handling qualities due to the IR suppressor installation. The aircraft response to simulated engine failures was essentially unchanged from the standard UH-1H.

Pressure Survey

21. Static and total pressures surrounding the IR suppressor were recorded at the test conditions listed in table 1. The type and location of the pressure sensors are shown in table 1, appendix C. Pressure data is provided in tables 1 and 2, appendix E.
Temperature Survey

22. Temperatures surrounding the IR suppressor and along the tail boom were recorded at the test conditions listed in table 1. The locations of temperature sensitive tapes and thermocouples are shown in table 2, appendix C. All recorded thermocouple and temperature sensitive tape data are presented in tables 3 and 4, appendix E. Generally higher temperatures were observed than those previously reported by BHT (ref 9, app A) for the initial IR suppressor installation. This may be accounted for by the redesign of the IR suppressor installation which resulted in a 5 degree depression of the IR suppressor exhaust centerline. A comparison of maximum tail boom temperatures obtained during this test with those previously reported by BHT is shown in figure 1. An increase of 80°F during hover and 140°F during low speed flight was observed. Further investigation to determine the structural implications of the high tail boom temperatures observed during this test should be conducted prior to release for field operations.

RELIABILITY AND MAINTAINABILITY

General

23. The reliability and maintainability of the IR suppressor and related components of the installation were evaluated during both phases of testing. Phase I testing was performed using an IR suppressor (AirResearch S N 39-D1) which had a total of 235 flight hours when it arrived at USAAI FA. A new IR suppressor (AirResearch S N 129-147) was provided for phase II testing. The new IR suppressor incorporated modifications which were designed to prevent cracking around the inner core support struts. Phase I Testing

24. The IR suppressor was found to be susceptible to cracking around the struts which support the inner core of the suppressor unit. When the unit arrived at USAAI FA, numerous cracks were discovered. It appeared that if flights were conducted without first having the unit repaired, small triangular pieces of metal could be dislodged from the inner core of the unit. The unit was repaired by welding prior to installation. Upon completion of Phase I tests, 19.5 flight hours cracks were again observed in the area where the repair had been made as well as small cracks at each of the remaining struts. The susceptibility of the IR suppressor unit to cracking is a shortcoming which should be corrected prior to follow-on redesign.

25. When attempting to latch the engine cowling open using the latch provided near the tail boom attachment point, the engine cowling contacted the IR suppressor fairing and could not be latched without deforming the engine cowling. If not latched, the engine cowling could cause damage to the fins on the tailpipe of the suppressor. The IR suppressor installation should allow the engine cowling to be latched open in the same manner as the production HH-11. The inability to latch the engine cowling in the open position is a shortcoming, which should be corrected prior to follow-on redesign.

26. A small maintenance-inspection door was provided on the left side of the IR suppressor fairing only. To facilitate maintenance and preflight inspections, a door
should be provided on the right side as well. The lack of a maintenance-inspection
door on the right side of the suppressor fairing is a shortcoming, which should be
corrected prior to follow-on redesign.

Phase II Testing

27. During removal of the new IR suppressor, warpage of the aft outer ring portion
of the exhaust ejector (Bell part no. 205-068-217-101) and metal-to-metal contact
between the exhaust ejector and suppressor were discovered. Score marks on the
leading edge of the IR suppressor struts plus warpage and torn metal at the aft edge
at the 1 o'clock position on the exhaust ejector indicates ejector movement of
±1/2 inch against the struts (photos 1 and 2). The IR suppressor struts and exhaust
ejector areas were carefully inspected on each daily aircraft inspection. Damage to
the above was discovered after 3.1 hours of low speed flight testing and 1.5 hours
of ferry flight time to the test site at Bakersfield, California and back. Continued
metal-to-metal contact between the engine exhaust ejector and the IR suppressor
support struts will cause structural damage to both components and a significant
reduction in service life. Should such structural damage go undetected, portions of
either component could break loose and cause damage to the airframe. An
Equipment Performance Report (EPR) (80-06-1) shown in appendix F was
submitted during this test. The metal-to-metal contact between the engine exhaust
ejector and the IR suppressor innercone support struts due to the positioning of the
IR suppressor is a deficiency, which should be corrected prior to further operation
with the IR suppressor installed.

28. The IR suppressor (S/N 129-147) exhibited four burned areas on its outer
surface immediately aft of the fiberglass fairing (near the trailing edge of the IR
suppressor struts). The largest burned area was approximately 6 by 2 inches at the
end of Phase II testing (11.2 flight hours). An EPR (80-06-2) was submitted and is
shown in appendix F. Further investigation of conditions creating burned areas
(hot spots) on the IR suppressor is warranted.
CONCLUSIONS

GENERAL

29. The handling qualities of the UH-1H helicopter were essentially unchanged by the installation of the IR suppressor and jammer (paras 9 and 19).

30. Tailboom surface temperatures were generally higher than those previously reported by BHT for the initial design of the IR suppressor installation (para 22).

31. One deficiency has been identified as a result of the IR suppressor and IR jammer installation on the UH-1H helicopter (para 27).

DEFICIENCY

32. The metal to metal contact between the engine exhaust ejector and the IR suppressor innercore support struts due to the positioning of the IR suppressor unit (para 27).

SHORTCOMINGS

33. The following shortcomings were identified during this test and are listed in the order of importance:

   a. The susceptibility of the IR suppressor unit to cracking (para 24)
   
   b. The inability to latch the engine cowling in the open position (para 25)
   
   c. The lack of a maintenance-inspection door on the right side of the suppressor fairing (para 26).

SPECIFICATION COMPLIANCE

34. No new specification non-compliances were identified for the UH-1H as a result of the IR suppressor and jammer installation.
RECOMMENDATIONS

35. The following recommendations are made:

   a. Correct the deficiency listed in paragraph 32 prior to further operation with IR suppressor installed (para 27)

   b. Correct the shortcomings listed in paragraph 33 in follow-on redesign

   c. Investigate the structural implications of the high (maximum of 340° F observed) tailboom temperatures observed during this test in follow-on redesign (para 22)

   d. Investigate the effects of the burned areas (hot spots) on the effectiveness and serviceability of the IR suppressor unit (para 28).
APPENDIX A. REFERENCES


APPENDIX B. DESCRIPTION

GENERAL

1. The test helicopter, US Army S/N 69-15532, was a production UH-1H modified to accommodate test instrumentation and the IR suppressor and IR jammer installation. The principal structural modification was the redesign of the aft engine cowling to provide support for the HMPP IR suppressor and the AN/ALQ-144 IR jammer. Photos 1 through 4 show the test aircraft with the IR suppressor, IR jammer and test instrumentation installed.

IR SUPPRESSOR SYSTEM

2. The IR suppressor installation consisted of four major components: the engine exhaust ejector (photo 5), the IR suppressor unit (photo 6), and an AN/ALQ-144 jammer (photo 7) which was mounted on top of the cowling assembly (photo 8). The IR suppressor is a plug-type suppressor manufactured by the Garrett AiResearch Manufacturing Company. The suppressor uses the size and shape of the plug to hide the hot engine parts. The suppressor also had circumferentially oriented vents to act as an ejector to entrain compartment and ambient air to mix with the engine exhaust, thereby reducing exhaust gas temperature. Airflow through the engine was extended aft and upward by the exhaust ejector and the IR suppressor. An insulation blanket was installed on the engine exhaust ejector.

3. The weight of the complete installation was approximately 127 pounds. The weight of the original aircraft components replaced by the suppressor/jammer installation was approximately 26 pounds for a net weight increase of 101 pounds. The aircraft basic weight and longitudinal center of gravity location (with test instrumentation and IR suppressor and jammer installed) was 5930 pounds at FS 142.0.

4. The IR suppressor and IR jammer installation evaluated during this program was a redesign of a previous installation which was reported to have caused a significant degradation in directional stability (ref 9, app A). The redesigned installation allowed both the IR suppressor and the IR jammer to be lowered in order to reduce the airflow disturbance over the vertical stabilizer.

FLIGHT ENVELOPE

5. The UH-1H with the IR suppressor and IR jammer installed was cleared for flight within the flight envelope specified in the operator's manual (ref 6, app A).
APPENDIX C. INSTRUMENTATION

The airborne data acquisition system was installed, calibrated and maintained by USAAEFA. The system used pulse code modulation (PCM) encoding for standard handling qualities data and pressure data. Magnetic tape was used to record parameters on board the aircraft. A test instrumentation boom was mounted at the base of the aircraft windshield and extended forward for 9.5 feet. A swiveling pitot static tube and angle of attack and sideslip vanes were mounted on the boom. Temperature data were recorded by hand from a manually selectable digital display. A total of 24 thermocouples supplemented by temperature sensitive tapes were used. Pressure data were obtained using an electro/mechanical scanivalve which sequentially sampled the differential pressure. The dwell time at each sampling port was 0.5 second. Instrumentation and related special equipment installed in the aircraft and used for this test are:

Pilot Station

Event switch

Copilot Station

Instrumentation controls and displays
Event switch
Control fixture (jig)

Displayed on Instrument Panel

Airspeed (boom and ship's system)
Altitude (boom and ship's system)
Angle of sideslip
Free air temperature
Control position
   Longitudinal
   Lateral
   Directional
   Collective
Rotor speed
Engine torque
Fuel used
Tape correlation counter

Hand Recorded

Temperatures (shown in table 2)
Oil cooler inlet air temperature

Recorded on Tape

Airspeed (boom system)
Altitude (boom system)
Angle of sideslip
Angle of Attack
Free air temperature
Control positions
   Longitudinal
La~ce.1

Directional
Collective
Rotor speed
Engine torque
Fuel used
Tape correlation counter
Pitch attitude
Pitch rate
Roll attitude
Roll rate
Aircraft heading
Yaw rate
Throttle position
Pilot's event
Copilot's event
Center of gravity normal acceleration
Longitudinal
Lateral
Time
Pressures (shown in table 1)

Best Available Copy
<table>
<thead>
<tr>
<th>Pressure Port No.</th>
<th>Type of Measurement</th>
<th>Pressure Port Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Static pressure</td>
<td>3 o'clock - 2 inches standoff at mouth of suppressor (FS 213.3)</td>
</tr>
<tr>
<td>2</td>
<td>Static pressure</td>
<td>6 o'clock - 2 inches standoff at mouth of suppressor perpendicular to center-line through (FS 213.2)</td>
</tr>
<tr>
<td>3</td>
<td>Static pressure</td>
<td>9 o'clock - 2 inches standoff at mouth of suppressor (FS 213.2)</td>
</tr>
<tr>
<td>4</td>
<td>Static pressure</td>
<td>12 o'clock - 2 inches standoff at mouth of suppressor perpendicular to center-line through FS 213.2</td>
</tr>
<tr>
<td>5</td>
<td>Static pressure</td>
<td>3 o'clock - 1 inch standoff from suppressor at FS 223.7</td>
</tr>
<tr>
<td>6</td>
<td>Static pressure</td>
<td>6 o'clock - 1 inch standoff from suppressor perpendicular to center-line through FS 223.7</td>
</tr>
<tr>
<td>7</td>
<td>Static pressure</td>
<td>9 o'clock - 1 inch standoff from suppressor at FS 223.7</td>
</tr>
<tr>
<td>8</td>
<td>Static pressure</td>
<td>12 o'clock - 1 inch standoff from suppressor perpendicular to center-line through FS 223.7</td>
</tr>
<tr>
<td>9</td>
<td>Total pressure</td>
<td>3 o'clock - surface of suppressor at first inlet</td>
</tr>
<tr>
<td>10</td>
<td>Total pressure</td>
<td>6 o'clock - surface of suppressor at first inlet</td>
</tr>
<tr>
<td>11</td>
<td>Total pressure</td>
<td>9 o'clock - surface of suppressor at first inlet</td>
</tr>
<tr>
<td>12</td>
<td>Total pressure</td>
<td>12 o'clock - surface of suppressor at first inlet</td>
</tr>
<tr>
<td>13</td>
<td>Total pressure</td>
<td>3 o'clock - surface of suppressor at second inlet</td>
</tr>
<tr>
<td>14</td>
<td>Total pressure</td>
<td>6 o'clock - surface of suppressor at second inlet</td>
</tr>
<tr>
<td>15</td>
<td>Total pressure</td>
<td>9 o'clock - surface of suppressor at second inlet</td>
</tr>
</tbody>
</table>
16 Total pressure 12 o'clock - surface of suppressor at second inlet
17 Total pressure 3 o'clock - surface of suppressor at third inlet
18 Total pressure 6 o'clock - surface of suppressor at third inlet
19 Total pressure 9 o'clock - surface of suppressor at third inlet
20 Total pressure 12 o'clock - surface of suppressor at third inlet
21 Static pressure Aircraft static (boom system)

NOTE: Suppressor pressure sensor locations are illustrated in figure 1.
Table 2. Thermocouple and Temperature Tape Locations

<table>
<thead>
<tr>
<th>Thermocouple Number</th>
<th>Type of Measurement</th>
<th>Thermocouple Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Surface temperature</td>
<td>9 o'clock - engine exhaust duct (FS 213.3)</td>
</tr>
<tr>
<td>2</td>
<td>Surface temperature</td>
<td>3 o'clock - engine exhaust duct (FS 213.3)</td>
</tr>
<tr>
<td>3</td>
<td>Air temperature</td>
<td>9 o'clock - between mouth of suppressor and engine exhaust duct (FS 215.3)</td>
</tr>
<tr>
<td>4</td>
<td>Air temperature</td>
<td>3 o'clock - between mouth of suppressor and engine duct (FS 215.3)</td>
</tr>
<tr>
<td>5</td>
<td>Air temperature</td>
<td>9 o'clock - 1 inch from suppressor surface at FS 223.7</td>
</tr>
<tr>
<td>6</td>
<td>Air temperature</td>
<td>12 o'clock - 1 inch from suppressor surface perpendicular to centerline of suppressor through FS 223.7</td>
</tr>
<tr>
<td>7</td>
<td>Air temperature</td>
<td>3 o'clock - 1 inch from suppressor surface at FS 223.7</td>
</tr>
<tr>
<td>8</td>
<td>Air temperature</td>
<td>6 o'clock - 1 inch from suppressor perpendicular to centerline of suppressor through FS 223.7</td>
</tr>
<tr>
<td>9</td>
<td>Air temperature</td>
<td>6 o'clock - between mouth of suppressor and engine centerline of suppressor through FS 236.2</td>
</tr>
<tr>
<td>10</td>
<td>Air temperature</td>
<td>Inlet to the oil cooler blower</td>
</tr>
<tr>
<td>11 - 24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Temperature Tape Number**

<table>
<thead>
<tr>
<th>Tape Number</th>
<th>Type of Measurement</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 - 45</td>
<td>Surface temperature</td>
<td>As illustrated in figure 2</td>
</tr>
</tbody>
</table>

NOTE: Suppressor thermocouple locations illustrated in figure 1.
Total Pressure
3, 6, 9, & 12 o'clock

Static Pressure
3, 6, 9, & 12 o'clock

Temperature thermocouples
9 o'clock/3 o'clock

Surface temp on insulation
3 & 9 o'clock

Air temp
3 & 9 o'clock
1" standoff

Air temp
6 o'clock pos. only
1" standoff

10 inlet to oil cooler blower

Figure 1
Pressure and temperature sensor locations
\textbf{FIGURE 2}

\textit{THERMOCOUPLE AND TEMPERATURE TAPE LOCATIONS}
APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

HANDLING QUALITIES

1. Stability and control data were collected and evaluated using standard test methods as described in reference 10, appendix A.

2. The Handling Qualities Rating Scale (HQRS) presented in figure 1 was used to augment pilot comments relative to pilot workload.

PRESSURE/TEMPERATURE SURVEY

3. Pressures were recorded during stabilized flight conditions using PCM instrumentation. IR suppressor pressures were referenced to aircraft boom static pressure by means of a differential pressure transducer and scanivalve. A total of 20 pressure ports on the scanivalve were used to sample the differential pressure. Pressures were measured in pounds per square inch differential (psid) and values determined by averaging the pressures recorded for each port using data plots similar to the one shown in figure 2. The location of each pressure sensor is shown in table 1, appendix C.

4. Temperatures were hand recorded from a selectable digital display. A total of 24 thermocouples were used. Temperature sensitive tapes were used to supplement thermocouple readings. The locations of the thermocouples and temperature sensitive tapes are shown in table 2, appendix C.

AIRSPEED CALIBRATION

5. Calibrated airspeed was obtained by correcting indicated airspeed using instrument and position error corrections. The airspeed from the boom system was used for all data reduction. The calibration for the boom airspeed system used during this test is shown in figure 3.

DEFINITIONS

6. Definitions of deficiencies and shortcomings used during this test are shown below.

   a. Deficiency - 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.

   b. 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 usability of the material or end product.
Figure 1. Handling Qualities Rating Scale
APPENDIX E. TEST DATA

INDEX

<table>
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<tr>
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<th>Figure Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control positions in trimmed flight</td>
<td>1 through 6</td>
</tr>
<tr>
<td>Collective fixed static longitudinal stability</td>
<td>7 through 10</td>
</tr>
<tr>
<td>Static lateral-directional stability</td>
<td>11 through 14</td>
</tr>
<tr>
<td>Maneuvering stability</td>
<td>15 and 16</td>
</tr>
<tr>
<td>Dynamic stability</td>
<td>17</td>
</tr>
<tr>
<td>Longitudinal long period</td>
<td>18 and 19</td>
</tr>
<tr>
<td>Longitudinal short period</td>
<td>20 through 28</td>
</tr>
<tr>
<td>Lateral-directional oscillation</td>
<td>29 through 32</td>
</tr>
<tr>
<td>Low Speed Flight</td>
<td>33 through 36</td>
</tr>
<tr>
<td>Simulated engine failure</td>
<td>Table 1 and 2</td>
</tr>
<tr>
<td>Pressure survey</td>
<td>Table 3 and 4</td>
</tr>
<tr>
<td>Temperature survey</td>
<td></td>
</tr>
</tbody>
</table>

35
FIGURE 1
CONTROL POSITIONS IN TRIMMED FLIGHT
DTL-71 D7A 67-9 9F-918532

<table>
<thead>
<tr>
<th>AVG</th>
<th>AVG CG</th>
<th>AVG</th>
<th>AVG</th>
<th>AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRSS HEIGHT</td>
<td>LOCATION</td>
<td>DENSITY</td>
<td>DAT</td>
<td>ROTOR</td>
</tr>
<tr>
<td>LBT</td>
<td>(FB)</td>
<td>(BL)</td>
<td>(FEET)</td>
<td>(C)</td>
</tr>
<tr>
<td>8400</td>
<td>141.2 (AFT)</td>
<td>0.1 (LF)</td>
<td>6020</td>
<td>8.0</td>
</tr>
</tbody>
</table>

NOTE: 1. INFRARED SUPPRESSOR AND INFRARED JAMMER INSTALLED.
2. ZERO SIDESLIP.

TOTAL COLLECTIVE CONTROL TRAVEL = 10.8 IN.

TOTAL DIRECTIONAL CONTROL TRAVEL = 6.8 IN.

TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.

TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.

(UNGRADED AIRFIELD (KTB))
<table>
<thead>
<tr>
<th>AVE.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS</td>
</tr>
<tr>
<td>HEIGHT</td>
</tr>
<tr>
<td>(LBS)</td>
</tr>
<tr>
<td>8800</td>
</tr>
<tr>
<td>142.1 (RFT)</td>
</tr>
<tr>
<td>0.1 (LFT)</td>
</tr>
<tr>
<td>5020</td>
</tr>
<tr>
<td>8.0</td>
</tr>
<tr>
<td>325</td>
</tr>
</tbody>
</table>

**FLIGHT CONDITION**

**NOTE:**
1. STANDARD UH-1H TAILPIPE INSTALLED
2. ZERO SIDESLIP

**TOTAL COLLECTIVE CONTROL TRAVEL = 10.8 IN.**

**TOTAL DIRECTIONAL CONTROL TRAVEL = 6.8 IN.**

**TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.**

**TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.**
<table>
<thead>
<tr>
<th>Longitudinal Control Position (Inches From Full Forward)</th>
<th>Lateral Control Position (Inches From Full Left)</th>
<th>Directional Control Position (Inches From Full Left)</th>
<th>Collective Control Position (Inches From Full Down)</th>
<th>Angle of Attack (Deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MU</td>
<td>LT</td>
<td>RT</td>
<td>UN</td>
<td>UP</td>
</tr>
<tr>
<td>0</td>
<td>*</td>
<td>o</td>
<td>*</td>
<td>o</td>
</tr>
<tr>
<td>6</td>
<td>*</td>
<td>o</td>
<td>*</td>
<td>o</td>
</tr>
<tr>
<td>12</td>
<td>*</td>
<td>o</td>
<td>*</td>
<td>o</td>
</tr>
<tr>
<td>18</td>
<td>*</td>
<td>o</td>
<td>*</td>
<td>o</td>
</tr>
<tr>
<td>24</td>
<td>*</td>
<td>o</td>
<td>*</td>
<td>o</td>
</tr>
<tr>
<td>30</td>
<td>*</td>
<td>o</td>
<td>*</td>
<td>o</td>
</tr>
</tbody>
</table>

**Figure 2:** Control Positions in Trimmed Flight Condition

- Block 1: Infrared Support Unit
- Block 2: Zero Block

**Note:**
- Block 1: Infrared Support Unit
- Block 2: Zero Block
**Figure 4**

Control Positions in Trimmed Flight

<table>
<thead>
<tr>
<th>Engine Torque (PSI)</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Travel (IN)</td>
<td></td>
<td>12.2</td>
<td>12.3</td>
<td>6.8</td>
<td>10.8</td>
<td>10.8</td>
</tr>
</tbody>
</table>

### Control Positions

<table>
<thead>
<tr>
<th>Gross Weight (LB)</th>
<th>Long Location (FT)</th>
<th>Lat Location (FT)</th>
<th>Density (C)</th>
<th>Day Rotor Calibrated (RPM)</th>
<th>Airspeed (KTS)</th>
<th>Trim</th>
</tr>
</thead>
<tbody>
<tr>
<td>8580</td>
<td>141.0</td>
<td>0.1</td>
<td>5100</td>
<td>8.0</td>
<td>82</td>
<td>66</td>
</tr>
<tr>
<td>8500</td>
<td>140.0</td>
<td>0.1</td>
<td>5080</td>
<td>8.0</td>
<td>82</td>
<td>67</td>
</tr>
</tbody>
</table>

**Notes:**
1. Infrared suppressor and infrared jammer installed
2. Zero sideslip
FIGURE 4
CONTROL POSITIONS IN TRIMMED FLIGHT
UH-1H USAF SYM 69-16532

<table>
<thead>
<tr>
<th>GROSS</th>
<th>AVG CG</th>
<th>AVG LOCATION</th>
<th>DENSITY</th>
<th>AVG DAY</th>
<th>AVG ROTOR</th>
<th>CALIBRATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEIGHT (ft)</td>
<td>(ft)</td>
<td>(ft)</td>
<td>(psi)</td>
<td>(rpm)</td>
<td>(rpm)</td>
<td>(kt)</td>
</tr>
<tr>
<td>8660</td>
<td>142.1</td>
<td>0.1</td>
<td>6100</td>
<td>8.0</td>
<td>824</td>
<td>88</td>
</tr>
<tr>
<td>10200</td>
<td>111.9</td>
<td>0.1</td>
<td>6000</td>
<td>8.0</td>
<td>324</td>
<td>87</td>
</tr>
</tbody>
</table>

NOTE: 1. STANDARD UH-1H TAILPIPE INSTALLED
2. ZERO SIDESLIP

TOTAL COLLECTIVE CONTROL TRAVEL = 10.4 IN.
TOTAL DIRECTIONAL CONTROL TRAVEL = 6.9 IN.
TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.
TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.

ENGINE TORQUE (PSI)
### Control Positions in Trimmed Flight

**Note:**
1. Infrared suppressor and infrared jammer installed.
2. Zero sideslip.

<table>
<thead>
<tr>
<th>Weight</th>
<th>Avg. Long.</th>
<th>Avg. Lat.</th>
<th>Density</th>
<th>Altitude</th>
<th>Rotor Speed</th>
<th>Calibrated</th>
<th>TRIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>8640</td>
<td>131.5 (FWD)</td>
<td>0.0 (MID)</td>
<td>5200</td>
<td>240</td>
<td>324</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>8600</td>
<td>131.5 (FWD)</td>
<td>0.0 (MID)</td>
<td>5220</td>
<td>240</td>
<td>324</td>
<td>97</td>
<td></td>
</tr>
</tbody>
</table>

**Figure:**
- Total Collective Control Travel = 10.6 in.
- Total Directional Control Travel = 6.8 in.
- Total Lateral Control Travel = 12.3 in.
- Total Longitudinal Control Travel = 12.2 in.

**Graphs:**
- Angle of attack vs. collective, directional, and total control.
- Engine torque (PSI) vs. control positions.
**Figure 7**

**Collective Fixed Static Longitudinal Stability**

<table>
<thead>
<tr>
<th>Avg Gross Weight (lb)</th>
<th>Avg Long Location (FB)</th>
<th>Avg Lat Location (BL)</th>
<th>Avg Density (ft³/ft³)</th>
<th>Avg Altitude (ft)</th>
<th>Avg Rotor Speed (RPM)</th>
<th>Avg Flight Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>8800</td>
<td>142.2 (AFT)</td>
<td>0.1 (LT)</td>
<td>5360</td>
<td>6.5</td>
<td>32%</td>
<td>Level</td>
</tr>
<tr>
<td>8860</td>
<td>142.2 (AFT)</td>
<td>0.1 (LT)</td>
<td>5340</td>
<td>6.5</td>
<td>32%</td>
<td>Level</td>
</tr>
</tbody>
</table>

**Notes:**
1. Infrared suppressor and infrared jammer installed.
3. Shaded symbols denote trim.

**Total Directional Control Travel = 6.8 in.**

**Total Lateral Control Travel = 12.5 in.**

**Total Longitudinal Control Travel = 12.2 in.**

**Calibrated Airspeed (KTS)***
**FIGURE 1**

**COLLECTIVE FIXED STATIC LATERAL STABILITY**

UM-1H USAF S/N 69-15532

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION (PS)</th>
<th>AVG DENSITY (PEET)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG ROTOR SPEED (KPH)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>8460</td>
<td>142.0 (AFT) 0.1 (LT)</td>
<td>6260</td>
<td>9.0</td>
<td>324</td>
<td>LEVEL.</td>
</tr>
<tr>
<td>8460</td>
<td>142.0 (AFT) 0.1 (LT)</td>
<td>6260</td>
<td>9.0</td>
<td>324</td>
<td>LEVEL.</td>
</tr>
</tbody>
</table>

**NOTE:**
1. STANDARD UM-1H TAILPIPE INSTALLED
2. ZERO SIDESLIP
3. SHADED SYMBOLS DENOTE TRIM

**TOTAL DIRECTIONAL CONTROL TRAVEL = 6.8 IN.**

**TOTAL LATERAL CONTROL TRAVEL = 12.9 IN.**

**TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.**

**CALIBRATED AIRSPEED (KTS)**
Figure 9: Collective Fixed Static Longitudinal Stability

<table>
<thead>
<tr>
<th>AVG TEMP</th>
<th>AVG C G</th>
<th>AVG W</th>
<th>AVG H</th>
<th>AVG D</th>
<th>AVG D</th>
<th>AVG R</th>
<th>AVG C</th>
<th>AVG R</th>
</tr>
</thead>
<tbody>
<tr>
<td>840</td>
<td>41.8 (AFT)</td>
<td>0.1 (LIT)</td>
<td>4600</td>
<td>5.5</td>
<td>52%</td>
<td>CLIMB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8320</td>
<td>41.8 (AFT)</td>
<td>0.1 (LIT)</td>
<td>6280</td>
<td>5.5</td>
<td>52%</td>
<td>DESCENT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 1. Infrared suppressor and infrared Jammer installed
2. Zero sideslip
3. Shaded symbols denote trim

Total directional control travel = 6.8 in.

Total lateral control travel = 12.8 in.

Total longitudinal control travel = 12.2 in.

Calibrated airspeed (Kts)
<table>
<thead>
<tr>
<th>Weight (Lb)</th>
<th>AVG CG Location (Ft)</th>
<th>AVG Density (G)</th>
<th>AVG Altitude (Feet)</th>
<th>AVG Rotor Speed (RPM)</th>
<th>AVG Flight Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>8840</td>
<td>141.6 (AFT) 0.1 (LT)</td>
<td>4900</td>
<td>5.5</td>
<td>224</td>
<td>CLIMB</td>
</tr>
<tr>
<td>8820</td>
<td>141.6 (AFT) 0.1 (LT)</td>
<td>5200</td>
<td>5.5</td>
<td>324</td>
<td>DESCENT</td>
</tr>
</tbody>
</table>

**NOTE:**
1. INFRARED SUPPRESSOR AND INFRARED JAMMER INSTALLED
2. ZERO SIDESLIP
3. SHAPED SYMBOLS DENOTE TRIM

**Figure 10:**
- **Total Longitudinal Control Travel:** 12.2 in.
- **Total Lateral Control Travel:** 12.5 in.
- **Total Directional Control Travel:** 6.8 in.

**Calibrated Airspeed (KTS):**

<table>
<thead>
<tr>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>120</th>
<th>140</th>
</tr>
</thead>
</table>
**FIGURE II**

**STATIC LATERAL-DIRECTIONAL STABILITY**

<table>
<thead>
<tr>
<th>AVG.</th>
<th>AVG.</th>
<th>AVG.</th>
<th>AVG.</th>
<th>AVG.</th>
<th>AVG.</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEIGHT (LB)</td>
<td>LOCATION (FT)</td>
<td>DENSITY (STP)</td>
<td>Rotor</td>
<td>CALIBRATED</td>
<td>RISPEED</td>
</tr>
<tr>
<td>0.0</td>
<td>142.0 (RFT)</td>
<td>0.1 (LT)</td>
<td>6200</td>
<td>6.5</td>
<td>324</td>
</tr>
<tr>
<td>0.0</td>
<td>142.0 (RFT)</td>
<td>0.1 (LT)</td>
<td>6200</td>
<td>6.5</td>
<td>324</td>
</tr>
</tbody>
</table>

**NOTE:**
1. INFRARED SUPPRESSOR AND INFRARED JAMMER INSTALLED
2. LEVEL FLIGHT

---

**TOTAL LATERAL CONTROL TRAVEL = 12.2 IN.**

**TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.**

**TOTAL LATERAL CONTROL TRAVEL = 8.8 IN.**
<table>
<thead>
<tr>
<th>Gross Weight (LB)</th>
<th>AVG Long Location (FT)</th>
<th>AVG Lat Location (FT)</th>
<th>AVG Density (PSF)</th>
<th>AVG DAT Rotor Speed (RPM)</th>
<th>AVG CALIBRATED AIRSPEED (KTS)</th>
<th>Trim</th>
</tr>
</thead>
<tbody>
<tr>
<td>8060</td>
<td>141.7 (AFT)</td>
<td>0.1 (FT)</td>
<td>6140</td>
<td>0.0</td>
<td>320</td>
<td>-3.5</td>
</tr>
<tr>
<td>8240</td>
<td>141.7 (AFT)</td>
<td>0.1 (FT)</td>
<td>6140</td>
<td>0.0</td>
<td>324</td>
<td>-6.5</td>
</tr>
</tbody>
</table>

**Table Note:**
1. Standard UM-1H tailpipe installed
2. Shaded symbols denote trim
3. Level flight

**Diagram Note:**
- Total Longitudinal Control Travel = 12.2 in.
- Total Lateral Control Travel = 12.8 in.
- Total Directional Control Travel = 6.8 in.
FIGURE 13
STATIC LATERAL-DIRECTIONAL STABILITY
OH-1H OBC 67N 68-15592

<table>
<thead>
<tr>
<th>AVG G A H E T (FT)</th>
<th>AVG C G (FT)</th>
<th>AVG D E N S I T Y (PC)</th>
<th>AVG O D I A E (K)</th>
<th>AVG R O T O R (RPM)</th>
<th>AVG F L I G H T (KTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8800</td>
<td>141.6 (AFT)</td>
<td>0:1 (LFT)</td>
<td>5350</td>
<td>7.0</td>
<td>82%</td>
</tr>
<tr>
<td>8780</td>
<td>141.6 (AFT)</td>
<td>0:1 (LFT)</td>
<td>4860</td>
<td>7.0</td>
<td>82%</td>
</tr>
</tbody>
</table>

NOTE:
1. INFRARED SUPPRESSOR AND INFRARED JAMMER INSTALLED
2. SHAD ED SYMBOLS DENOTE TRIM
3. TRIM CALIBRATED AIRSPEED 86 KTS

TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.
TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.
TOTAL DIRECTIONAL CONTROL TRAVEL = 6.8 IN.
FIGURE 14
STATIC LATERAL-DIRECTIONAL STABILITY
OH-TR USA SFN 69-15632

<table>
<thead>
<tr>
<th>AVG. GROSS</th>
<th>AVG. LOCATION</th>
<th>AVG. DENSITY</th>
<th>AVG. FLIGHT</th>
<th>AVG. ROTOR</th>
<th>AVG. SPEED</th>
<th>AVG. CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>8600 LB</td>
<td>141.6 (RT)</td>
<td>0.1 (LT)</td>
<td>6360 (C)</td>
<td>82 (RPM)</td>
<td>7.0 (KTS)</td>
<td>CLIMB</td>
</tr>
<tr>
<td>8780 LB</td>
<td>141.6 (RT)</td>
<td>0.1 (LT)</td>
<td>6560 (C)</td>
<td>82 (RPM)</td>
<td>7.0 (KTS)</td>
<td>DESCENT</td>
</tr>
</tbody>
</table>

NOTE:
1. INFRARED SUPPRESSOR A, INFRARED JAMMER INSTALLED
2. SHADED SYMBOLS DENOTE TRIM
3. TRIM CALIBRATED AIRSPEED 37 KTS

TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.

TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.

TOTAL DIRECTIONAL CONTROL TRAVEL = 6.8 IN.

ANGLE OF SIDESLIP (DEG)
FIGURE 15
MANEUVERING STABILITY
UH-1H USA S/N 69-15532

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LOCATION (FS)</th>
<th>AVG DENSITY (BL)</th>
<th>AVG OAT (FT)</th>
<th>AVG SPEED (°C)</th>
<th>AVG ROTOR</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>8960</td>
<td>142.1 (AFT)</td>
<td>0.1 (LT)</td>
<td>5960</td>
<td>7.5</td>
<td>324</td>
<td>67 KCAS LT TURN</td>
</tr>
<tr>
<td>8960</td>
<td>142.1 (AFT)</td>
<td>0.1 (LT)</td>
<td>5940</td>
<td>7.5</td>
<td>324</td>
<td>67 KCAS RT TURN</td>
</tr>
<tr>
<td>8940</td>
<td>142.0 (AFT)</td>
<td>0.1 (LT)</td>
<td>5920</td>
<td>7.5</td>
<td>324</td>
<td>97 KCAS LT TURN</td>
</tr>
<tr>
<td>8940</td>
<td>142.0 (AFT)</td>
<td>0.1 (LT)</td>
<td>5940</td>
<td>7.5</td>
<td>324</td>
<td>97 KCAS RT TURN</td>
</tr>
</tbody>
</table>

NOTE: INFRARED SUPPRESSOR AND INFRARED JAMMER INSTALLED

TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.

TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.

C.G. NORMAL ACCELERATION (G)
### FIGURE 10
MANEUVERING STABILITY
UM-1H USA 5/N 69-15532

<table>
<thead>
<tr>
<th>GROSS WEIGHT (LB)</th>
<th>AVG CB LOCATION (FS)</th>
<th>AVG CB LOCATION (BL)</th>
<th>AVG DENSITY (PSI)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG OAT (°F)</th>
<th>AVG ROTOR SPEED (RPM)</th>
<th>FLIGHT CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>8680</td>
<td>141.1 (AFT) 0.1 (LT)</td>
<td>6260</td>
<td>6.0</td>
<td>324</td>
<td>86 KCAS LEFT TURN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8680</td>
<td>141.1 (AFT) 0.1 (LT)</td>
<td>6380</td>
<td>6.0</td>
<td>324</td>
<td>86 KCAS RIGHT TURN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** STANDARD UM-1H TAILPIPE INSTALLED.

**TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.**

**TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.**

C.G. NORMAL ACCELERATION (G)
Figure 29
Low Speed Forward and Rearward Flight
UH-1H USA 569-1532

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Weight</td>
<td>8660 lb</td>
</tr>
<tr>
<td>CG Location</td>
<td>132.1 ft (FWD)</td>
</tr>
<tr>
<td>CG Lat</td>
<td>0.0 ft (MID)</td>
</tr>
<tr>
<td>CG Altitude</td>
<td>1020 ft</td>
</tr>
<tr>
<td>Density</td>
<td>19.0 g/L</td>
</tr>
<tr>
<td>OAT</td>
<td>324 °C</td>
</tr>
<tr>
<td>Rotor Speed</td>
<td>8660 RPM</td>
</tr>
</tbody>
</table>

Notes:
1. Infrared suppressor and infrared jammer installed.
2. I denotes maximum control excursions.
3. Skid height 10 ft.

TOTAL COLLECTIVE CONTROL TRAVEL = 10.8 IN.
TOTAL DIRECTIONAL CONTROL TRAVEL = 6.8 IN.
TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.
TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.
### Table 3a
LOW SPEED FORWARD AND REARWARD FLIGHT  
UH-1H USA S/N 69-15532

<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 ROTOR SPEED (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8860</td>
<td>141.9 (AFT)</td>
<td>1.0 (LT)</td>
<td>2540</td>
<td>16.0</td>
<td>324</td>
</tr>
</tbody>
</table>

**Notes:**
1. INFRARED SUPPRESSOR AND INFRARED JAMMER INSTALLED.
2. INDICATES MAXIMUM CONTROL EXCURSIONS.
3. SKID HEIGHT 10 FT

**Graphs:**
- **Pitch Attitude (deg):**
  - Total Collective Control Travel = 10.8 in.
- **Collective Control Position:**
  - Total Directional Control Travel = 6.8 in.
- **Directional Control Position:**
  - Total Lateral Control Travel = 12.3 in.
- **Lateral Control Position:**
  - Total Longitudinal Control Travel = 12.2 in.

**Graphs:**
- Pitch Attitude (deg)
- Collective Control Position
- Directional Control Position
- Lateral Control Position
- Longitudinal Control Position

**Graph Axes:**
- X: REARWARD TRUE AIRSPEED (KT)
- Y: FORWARD RANGE
FIGURE 31
SIDeward FLIGHT
UH-1H USA S/N 69-15532

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG CG LONG LOCATION (FS)</th>
<th>AVG LAT LOCATION (BL)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG OAT (°C)</th>
<th>AVG ROTOR SPEED (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8860</td>
<td>132.8 (FWD)</td>
<td>0.0 (MID)</td>
<td>940</td>
<td>18.0</td>
<td>324</td>
</tr>
</tbody>
</table>

NOTES:
1. INFRARED SUPPRESSOR AND INFRARED JAMMER INSTALLED.
2. I DENOTES MAXIMUM CONTROL EXCURSIONS.
3. SKID HEIGHT 10 FT.

TOTAL COLLECTIVE CONTROL TRAVEL = 10.8 IN.

TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.

TOTAL DIRECTIONAL CONTROL TRAVEL = 6.8 IN.
FIGURE 32
SIDeward FLIGHT
UN-IH USA S/N 69-16532

<table>
<thead>
<tr>
<th>AVG GROSS WEIGHT (LB)</th>
<th>AVG DENSITY (FS) (BL)</th>
<th>AVG ALTITUDE (FT)</th>
<th>AVG DAT (K)</th>
<th>AVG Rotor Speed (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8840</td>
<td>141.0</td>
<td>2520</td>
<td>16.0</td>
<td>324</td>
</tr>
</tbody>
</table>

NOTES:
1. INFRARED SUPPRESSOR AND INFRARED JAMMER INSTALLED.
2. IDMENOTES MAXIMUM CONTROL EXCURSIONS.
3. SKID HEIGHT 10 FT.

ROLL ATTITUDE (DEG)

TOTAL COLLECTIVE CONTROL TRAVEL = 10.8 IN.

TOTAL LONGITUDINAL CONTROL TRAVEL = 12.2 IN.

TOTAL LATERAL CONTROL TRAVEL = 12.3 IN.

TOTAL DIRECTIONAL CONTROL TRAVEL = 6.8 IN.
<table>
<thead>
<tr>
<th>Sensor Number</th>
<th>Description</th>
<th>Climb 70 KIAS</th>
<th>Level 70 KIAS</th>
<th>Level 60 KIAS</th>
<th>Level 80 KIAS</th>
<th>Level 100 KIAS</th>
<th>Sideslip 90 KIAS</th>
<th>Autorotation 70 KIAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Static ^3</td>
<td>-0.95</td>
<td>-0.10</td>
<td>-0.03</td>
<td>-0.17</td>
<td>-0.18</td>
<td>-0.17</td>
<td>-0.048</td>
</tr>
<tr>
<td>2</td>
<td>Pressure</td>
<td>-1.30</td>
<td>-0.55</td>
<td>-0.30</td>
<td>-0.28</td>
<td>-0.53</td>
<td>-0.78</td>
<td>-0.103</td>
</tr>
<tr>
<td>3</td>
<td>Pressure</td>
<td>-1.50</td>
<td>-0.75</td>
<td>-0.57</td>
<td>-0.23</td>
<td>-0.38</td>
<td>-0.22</td>
<td>-0.043</td>
</tr>
<tr>
<td>4</td>
<td>Pressure</td>
<td>-0.55</td>
<td>-0.05</td>
<td>-0.37</td>
<td>-0.37</td>
<td>0.007</td>
<td>0.13</td>
<td>0.022</td>
</tr>
<tr>
<td>5</td>
<td>Static</td>
<td>0.05</td>
<td>0.06</td>
<td>0.077</td>
<td>0.097</td>
<td>0.032</td>
<td>0.048</td>
<td>0.022</td>
</tr>
<tr>
<td>6</td>
<td>Pressure</td>
<td>-0.015</td>
<td>0.30</td>
<td>0.062</td>
<td>0.082</td>
<td>0.051</td>
<td>0.093</td>
<td>0.072</td>
</tr>
<tr>
<td>7</td>
<td>Static</td>
<td>0.025</td>
<td>0.037</td>
<td>0.052</td>
<td>0.072</td>
<td>0.017</td>
<td>0.108</td>
<td>0.107</td>
</tr>
<tr>
<td>8</td>
<td>Pressure</td>
<td>0.035</td>
<td>0.022</td>
<td>0.032</td>
<td>0.047</td>
<td>0.052</td>
<td>0.093</td>
<td>0.037</td>
</tr>
<tr>
<td>9</td>
<td>Total</td>
<td>-0.050</td>
<td>0.032</td>
<td>0.057</td>
<td>0.092</td>
<td>0.39</td>
<td>0.063</td>
<td>0.022</td>
</tr>
<tr>
<td>10</td>
<td>Pressure</td>
<td>-0.010</td>
<td>0.042</td>
<td>0.057</td>
<td>0.084</td>
<td>0.067</td>
<td>0.098</td>
<td>0.047</td>
</tr>
<tr>
<td>11</td>
<td>Pressure</td>
<td>-0.025</td>
<td>0.035</td>
<td>0.052</td>
<td>0.080</td>
<td>0.103</td>
<td>0.093</td>
<td>0.123</td>
</tr>
<tr>
<td>12</td>
<td>Pressure</td>
<td>0.009</td>
<td>0.018</td>
<td>0.015</td>
<td>0.019</td>
<td>0.048</td>
<td>0.088</td>
<td>0.022</td>
</tr>
<tr>
<td>13</td>
<td>Total</td>
<td>-0.020</td>
<td>0.032</td>
<td>0.052</td>
<td>0.077</td>
<td>0.027</td>
<td>0.008</td>
<td>0.008</td>
</tr>
<tr>
<td>14</td>
<td>Pressure</td>
<td>-0.005</td>
<td>0.003</td>
<td>0.003</td>
<td>0.037</td>
<td>0.057</td>
<td>0.078</td>
<td>0.067</td>
</tr>
<tr>
<td>15</td>
<td>Pressure</td>
<td>-0.010</td>
<td>0.032</td>
<td>0.052</td>
<td>0.082</td>
<td>0.022</td>
<td>0.027</td>
<td>0.063</td>
</tr>
<tr>
<td>16</td>
<td>Pressure</td>
<td>0.005</td>
<td>0.022</td>
<td>0.007</td>
<td>0.017</td>
<td>-0.33</td>
<td>0.127</td>
<td>-0.178</td>
</tr>
<tr>
<td>17</td>
<td>Total</td>
<td>0.010</td>
<td>0.037</td>
<td>0.077</td>
<td>0.114</td>
<td>0.032</td>
<td>0.008</td>
<td>0.008</td>
</tr>
<tr>
<td>18</td>
<td>Pressure</td>
<td>-0.035</td>
<td>0.042</td>
<td>0.062</td>
<td>0.102</td>
<td>0.027</td>
<td>0.075</td>
<td>0.023</td>
</tr>
<tr>
<td>19</td>
<td>Pressure</td>
<td>0.015</td>
<td>0.027</td>
<td>0.052</td>
<td>0.082</td>
<td>0.028</td>
<td>0.049</td>
<td>0.028</td>
</tr>
<tr>
<td>20</td>
<td>Pressure</td>
<td>0.006</td>
<td>0.020</td>
<td>0.007</td>
<td>0.035</td>
<td>0.023</td>
<td>1.177</td>
<td>-0.193</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Sensor numbers correspond to location shown in appendix C.
2. Indicated engine torque 40 psi.
3. Pressure measured in psi differential referred to boom indicated static pressure.
Table 2. IR Suppressor Pressure Survey

<table>
<thead>
<tr>
<th>Sensor Number</th>
<th>Description</th>
<th>Forward</th>
<th></th>
<th>Left Sideward</th>
<th></th>
<th>Right Sideward</th>
<th></th>
<th>Rearward</th>
<th></th>
<th>Hover</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10 KTAS</td>
<td>20 KTAS</td>
<td>30 KTAS</td>
<td>40 KTAS</td>
<td>10 KTAS</td>
<td>20 KTAS</td>
<td>30 KTAS</td>
<td>5 KTAS</td>
<td>10 KTAS</td>
<td>20 KTAS</td>
</tr>
<tr>
<td>1</td>
<td>Static Pressure</td>
<td>0.015</td>
<td>0.010</td>
<td>0.005</td>
<td>0.005</td>
<td>0.010</td>
<td>0.010</td>
<td>0.005</td>
<td>0.005</td>
<td>0.015</td>
<td>0.010</td>
</tr>
<tr>
<td>2</td>
<td>Static Pressure</td>
<td>0.015</td>
<td>0.010</td>
<td>0.005</td>
<td>0.005</td>
<td>0.010</td>
<td>0.010</td>
<td>0.005</td>
<td>0.005</td>
<td>0.015</td>
<td>0.010</td>
</tr>
<tr>
<td>3</td>
<td>Total Pressure</td>
<td>0.015</td>
<td>0.010</td>
<td>0.005</td>
<td>0.005</td>
<td>0.010</td>
<td>0.010</td>
<td>0.005</td>
<td>0.005</td>
<td>0.015</td>
<td>0.010</td>
</tr>
<tr>
<td>4</td>
<td>Total Pressure</td>
<td>0.015</td>
<td>0.010</td>
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NOTES:

1 Sensor numbers correspond to location shown in appendix C.
2 Pressure measured in psi differential referred to boom indicated static pressure.
### TABLE 3
**IR SUPPRESSOR AND TAILBOOM TEMPERATURE SURVEY**

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<th>Source</th>
<th>Tail</th>
<th>Left</th>
<th>Right</th>
<th>Sideslip</th>
<th>Ice Hover</th>
<th>Temp (F)</th>
<th>Level Flight</th>
<th>Sidesteps</th>
<th>Tail and Foot</th>
<th>Hangar Weight</th>
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**NOTES:**
1. Temperatures in degrees Celsius.
2. Thermocouple and temperature tape numbers correspond to locations shown in Appendix C.
3. Indicated Engine Torque 40psi.
4. Winds 8 to 10 KTS, Azimuth relative to nose of aircraft.
5. Temperature sensitive tapes were graduated in 10°F increments.
6. Temperatures presented are the highest indicated by the tape, converted to degrees Celsius.
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**NOTES**

1. Temperatures in degrees Celsius.
2. Thermocouple and temperature tape numbers correspond to locations shown in Appendix C.
3. Temperature sensitive tapes were graduated in 10°F increments.
4. Temperatures presented are the highest indicated by the tape, converted to degrees Celsius.
APPENDIX F. EQUIPMENT PERFORMANCE REPORTS
EQUIPMENT PERFORMANCE REPORT

TO: Commander
U.S. Army Aviation R&D
4300 Goodfellow Blvd.
St. Louis, MO 63120

FROM: Commander
U.S. Army Aviation Engineering Flight Activity
ATTN: DARCOM (Stu 217)

DATE: 8 June 1981

1. EPR NO.: 80-06-1
2. TECH/AVSCOM PROJ NO.: USAF 80-061

I. MAJOR ITEM DATA

1. MODEL: UH-1H
2. SERIAL NO.: 69-15532
3. QUANTITY: one
4. MFR.:
5. USA NO.:

II. PART DATA

1. Nomenclature/Description: Exhaust Duct
2. MFR PART NO.: Bell p/n 205-068-217-1
3. MFR:
4. Bell Helicopter Textron
5. PART TEST LIFE:

III. INCIDENT DATA

1. DATE OF OCCURRENCE:
2. TYPE OF REPORT:
3. ACTION TAKEN:
4. MAINT SPT, ELM, CODE:
5. OBSERVED DURING:
6. TEST ENVIRONMENT:
7. INFORMATION:
8. INCIDENT:
9. CAUSE:
10. DAMAGE:
11. DETECTED:
12. OCCURRED DURING:
13. SIDEW: or REARWARD:
14. LATERAL:
15. DISCONNECTED:
16. REMOVED:
17. MAINTENANCE:
18. OUTER:
19. INSPECTION:
20. FUNCTION:
21. INCIDENT:
22. DESCRIPTION:

During removal of the IR suppressor (191430-4), it was noted that there was damage to the exhaust duct (19134-1-1) where the exhaust duct fits internally into the IR suppressor bellmouth. The exhaust duct is warped out of shape and has been contacting the leading edge of the IR suppressor struts inside the bellmouth. Score marks on the struts indicate that there has been lateral flexing or movement against the strut. Looking at the exhaust duct from the rear of the aircraft at the 1 to 2 o'clock position, approximately ¼ inch of duct metal has been pushed forward and torn where the suppressor strut contacted the duct.

I suspect two possible causes: (1) The exhaust duct warped out of shape against the struts causing the score marks on the struts, (2) The IR suppressor may be positioned too close to the exhaust duct as a result of the new fairing and bulkhead rework. In particular it appears that the new gusset support (Bell p/n 205-038-210-121 and -122) may move the suppressor further forward against the duct.

Recommend that the suppressor be repositioned aft of its present location and that the outer ring of the exhaust duct be reinforced similar to the standard UH-1 exhaust duct to prevent warpage.

IV. INCIDENT CLASSIFICATION

The INCIDENT CLASSIFICATION is SUBJECT TO RECLASSIFICATION.

Best Available Copy
The new UH-1H canopy assembly (serial no. 129-417) provided for Phase II of this program was observed to have developed four burned areas (hot spots) as indicated by discoloration of the UH-1H, and the positions around the suppressor surface of the burned points. These hot spots appeared as shown in the accompanying illustration. A qualitative investigation of the conditions creating the burned areas is warranted.
**DISTRIBUTION LIST**

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Deputy Chief of Staff for Operations (DAMO-RQ) 1
Deputy Chief of Staff for Personnel (DAPE-HRS) 1
Deputy Chief of Staff for Research Development and Acquisition (DAMA-PPM-T, DAMA-RA, DAMA-WSA) 3
Comptroller of the Army (DACA-EA) 1
US Army Materiel Development and Readiness Command (DRCDE-DH, DRCQA-E, DRCRE-I, DRCDE-RT) 4
US Army Training and Doctrine Command (ATTG-U, ATCD-T, ATCD-ET, ATCD-B) 4
US Army Aviation Research and Development Command (DRDAV-DI, DRDAV-EE, DRDAV-EG) 10
US Army Test and Evaluation Command (DRSTS-CT, DRSTS-AD) 2
US Army Troop Support and Aviation Materiel Readiness Command (DRSTS-O) 1
US Army Logistics Evaluation Agency (DALO-LEI) 1
US Army Materiel Systems Analysis Agency (DRXSY-R, DRXSY-MP) 2
US Army Operational Test and Evaluation Agency (CSTE-POD) 1
US Army Armor Center (ATZK-CD-TE) 1
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Defense Technical Information Center (DDR) 12
US Military Academy (MADN-F) 1
MTMC-TEA (MTT-TRC/Steve Hola) 1