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LIMITED ARTIFICIAL AND NATURAL ICING TESTS PRODUCTION UH-60A HE--ETC(U)
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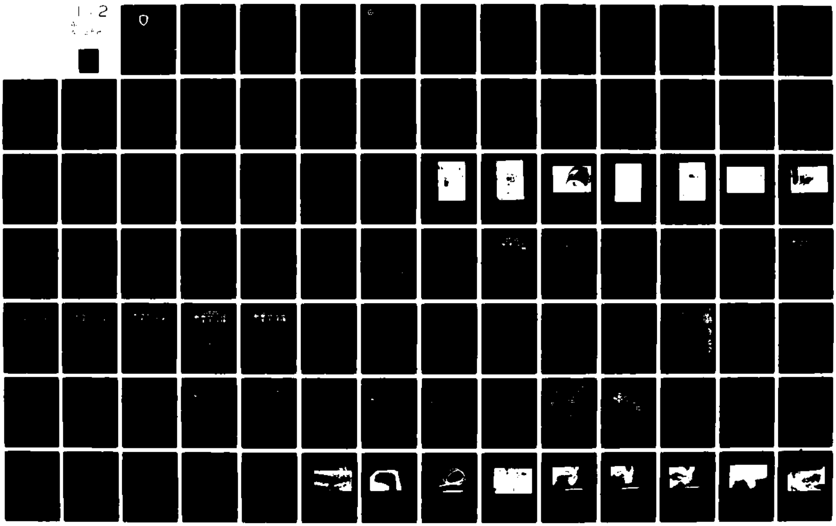

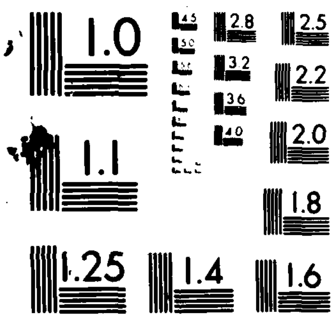

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USAAEFA PROJECT NO. 80-14

LIMITED ARTIFICIAL AND NATURAL ICING TESTS PRODUCTION UH-60A HELICOPTER (RE-EVALUATION)

FINAL REPORT

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AUGUST 1981

Approved for public release; distribution unlimited.

UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER USAAEFA NO. 80-14	2. GOVT ACCESSION NO. AD-A112 582	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LIMITED ARTIFICIAL AND NATURAL ICING TESTS PRODUCTION UH-60A HELICOPTER (RE-EVALUATION)		5. TYPE OF REPORT & PERIOD COVERED FINAL REPORT Dec 22 80 - 24 Feb 81
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) MARVIN L. HANKS JOHN O. BENSON VERNON L. DIEKMANN		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US ARMY AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AFB, CA 93523		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 68-0-BE075-01-68-EC
11. CONTROLLING OFFICE NAME AND ADDRESS US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND 4300 GOODFELLOW BOULEVARD ST. LOUIS, MO 63120		12. REPORT DATE AUGUST 1981
		13. NUMBER OF PAGES 106
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

UH-60A Black Hawk
Artificial and Natural Icing
Anti-ice and Deice Systems

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A limited re-evaluation of the production UH-60A Black Hawk anti-ice and deice systems was conducted to verify correction of deficiencies and shortcomings which were revealed during 1979-1980 icing tests. Artificial and natural icing tests were conducted by the United States Army Aviation Engineering Flight Activity (USAAEFA) at St. Paul, Minnesota, from 22 December 1980 through 24 February 1981. Testing consisted of 22.3 productive flight hours. The previous droop stop deficiency (failure of the droop stops to return to the shutdown position with ice accumulation on the rotor head) was corrected by the installation of a different droop stop with anti-ice protection. The previous anti-flapping restrainer deficiency (failure of the anti-flapping restrainers to return to the shutdown position with ice accumulated on the rotor head) was downgraded to a shortcoming after

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) correction of the droop stop deficiency. The three most important previously identified shortcomings; (1) the large increase in power required with ice accumulation on the rotor system, (2) the large power available losses with activation of the engine and engine inlet anti-ice systems, and (3) the poor location of the deice system circuit breakers, were again documented, although some improvement in power available losses was observed due to installation of the modulating engine inlet anti-ice valves. Five other previously identified, icing related, shortcomings were still present and four were corrected. Three additional icing related shortcomings were identified during these tests: (1) ice impact damage to the upper strobe light assembly, (2) ice impact damage to the nose avionics compartment door, and (3) the poor reliability of the windshield anti-ice control units. The UH-60A Black Hawk helicopter, configured with the anti-ice, deice and heated government competitive test droop stop systems demonstrated safe operation in icing intensities through moderate.

DEPARTMENT OF THE ARMY

HQ, US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND
4300 GOODFELLOW BOULEVARD, ST. LOUIS, MO 63120

DRDAV-D

SUBJECT: Directorate for Development and Qualification Position on the Report of USAAEFA Project No. 80-14, Limited Artifical and Natural Icing Tests, Production UH-60A Helicopter (Re-evaluation)

SEE DISTRIBUTION

1. The purpose of this letter is to establish the Directorate for Development and Qualification position on the subject report. Based on results of these tests and component qualification tests conducted by the contractor, the blade de-ice kit P/N 70070-30003-013 is considered qualified and flight of the UH-60A incorporating this kit will be authorized up to and including moderate icing conditions.

2. This Directorate is in agreement with the report conclusions and recommendations except as indicated below. Additional comments are provided relative to proposed corrective actions and are directed to the report paragraphs as indicated.

a Paragraph 32b: Approved droop stops for use with the blade de-ice kit P/N 70070-30003-013 are identified by P/N's 70105-08151-043 (Interim Production Droop Stop Cam Assembly) and 70105-08151-XXX (Production Droop Stop Cam Assembly). The test conducted here is considered a valid representation of either configuration.

b. Paragraph 34a: The power required increases with ice accumulated on the blade, while an undesirable feature, is inevitable and therefore not considered a shortcoming. The only way to avoid some power required increase is to preclude any ice accumulation. While the specification for the de-icing system did not include a minimum acceptable power rise, the fact that the system is fundamentally de-ice and not anti-ice inherently allowed some increased power required during operation of this subsystem. It is unfortunate that the power required increase during the normal operating cycle of the optimized configuration evaluated in this AEFA report is in fact higher than previous test results. This resulted from variations in the calibration of the ice detector system; however, the current calibration based on testing in the Canadian National Research Council Icing Tunnel is considered the most accurate and most appropriate. No effort is currently planned to reduce the power required increases during the normal operation of the qualified rotor de-ice subsystem. This characteristic is therefore more appropriately considered a "suggested improvement" rather than a shortcoming.

c. Paragraph 34b: The decrease in power available with the engine and engine inlet anti-ice subsystem ON is not considered a shortcoming. The engine inlet anti-ice modulating valve, P/N 70306-10012-107, evaluated during this test program reduced the power decrease by approximately 2-3 percent. The power available decrease with the engine inlet anti-ice subsystem operating results from the relatively large area requiring de-ice which is driven by the integral inlet particle separator. The trade off between the benefits of the integral inlet particle separator and the power available loss during cold temperature operation (less critical from a flight performance viewpoint) is considered a desirable tradeoff. An evaluation of methods of reducing the subject power available decrease should be reviewed during programs for growth versions of the engine; however, this overall phenomenon is more appropriately considered a "suggested improvement" rather than a shortcoming.

d. Paragraph 34c: The deice system circuit breakers will not be relocated because the benefit of a cockpit location does not balance the cost for a normal crew of three.

e. Paragraph 34d: The inadequacy of the drip pan has been previously identified with correcrive action taken. A modified drip pan with increased drain capacity is being incorporated on the first 124 aircraft and a redesigned drip pan with increased dump and drain capacity incorporated on aircraft S/N 79-23319 and subsequent. The improvements to the drip pan could not be evaluated due to interference with installed instrumentation.

f. Paragraph 34e: The inadequate water tightness of the cockpit is a quality control problem which is being corrected.

g. Paragraph 34f: The inadequate cabin heat distribution was originally considered a quality control problem and not necessarily a design problem. Operational use of the aircraft incorporating improved sealing associated with doors and covers has confirmed a more basic problem of an inadequate heater source. The contractor is preparing an Engineering Change Proposal (ECP) for an improved cabin heating system which addresses capacity, sealing and distribution.

h. Paragraph 34g: Ice accumulation on the cockpit steps is not desirable; however, since the exposure time to ice accretion under operational conditions is slight and attention to egress procedures is practical, a redesign of the steps is not considered cost effective. A warning has been incorporated in the Operator's Manual to advise the crew of ice accumulation on the cockpit steps.

i. Paragraph 34h: Ice accretion on the FM homing antenna does not create a serious problem when opening the cockpit door. A note has been incorporated in the Operator's Manual to advise the pilot that a slight pressure on the door will break off the ice.

j. Paragraph 35a: An investigation will be held to determine if design criteria for the strobe light assembly adequately contains criteria for impact damage from ice, rocks, etc. Improved criteria for this type problem will be stressed in future strobe light designs.

k. Paragraph 35b: The impact damage for ice on the nose avionics compartment door is not considered a shortcoming in that it was minor and resulted in no malfunction or other measurable degradation of aircraft operation. Some impact damage is always inherent with a de-icing system.

l. Paragraph 39: Since the OFF position serves the function of system inactive and/or system reset, the current labeling is considered adequate.

3. While the development of a satisfactory anti-ice/de-ice system for helicopters is a long and sometimes painful task, when achieved, it affords the user one of the most single possible improvements in the tactical deployment of a helicopter. Future icing tests should and will concentrate on the definition of safe operating modes following a failure of the de-icing system.

FOR THE COMMANDER:

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

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INTRODUCTION

BACKGROUND

1. The US Army requires the UH-60A helicopter (Black Hawk) to operate safely in an icing environment through the moderate level of intensity. Artificial icing tests were previously conducted in Alaska in 1976 (ref 1, app A) by the United States Army Aviation Engineering Flight Activity (USAAEFA) using a prototype YUH-60A with main and tail rotor deice systems and anti-ice provisions for the pilot and copilot windshields, pitot-static tubes and their support struts, engines and engine inlets. Tests with a production UH-60A with similar deice and anti-ice systems were conducted in Minnesota in 1979 and 1980 (refs 2 and 3). The production UH-60A incorporates a main and tail rotor blade deicing system, anti-icing systems, and an ice detection system. Additional artificial and natural icing tests were required to evaluate corrections to previously identified deficiencies and shortcomings. The United States Army Aviation Research and Development Command directed USAAEFA to conduct artificial and natural icing tests to evaluate these design changes to the production UH-60A helicopter (ref 4) during the winter of 1980-1981. Testing was conducted in accordance with the approved test plan (ref 5).

TEST OBJECTIVES

2. The objectives of this limited re-evaluation were to conduct artificial and natural icing flight tests of the production UH-60A helicopter to verify the correction of deficiencies and shortcomings revealed during 1979-1980 icing tests. The specific items to be evaluated were:

a. Updated icing rate meter calibration

b. Droop stop anti-ice protection

c. Updated engine inlet modulating valve installation

d. Revised deice system off time schedule.

DESCRIPTION

3. The UH-60A is a twin-turbine, single-main-rotor configured helicopter capable of transporting cargo, 11 combat troops, or weapons during day and night, visual and instrument meteorological conditions (IMC). Nonretractable wheel-type landing gear are provided. The main and tail rotors are both four-bladed, with the capability of manual main rotor blade and tail pylon folding. A horizontal stabilator is located on the tail rotor pylon. A more detailed description of the UH-60A is contained in the operator's manual (ref 6, app A). An anti-ice/deice kit system description may also be found in the operator's manual and in appendix B. A description of the helicopter icing spray system (HISS) installed in the CH-47C helicopter, S/N 68-15814, and spray cloud characteristics is presented in references 7 and 8, appendix A, respectively.

TEST SCOPE

4. Inflight artificial and natural icing tests were conducted in the vicinity of St. Paul, Minnesota, from 22 December 1980 through 24 February 1981. A total of 19 flights were conducted totaling 32.4 hours. Of the flights, 14 were in the artificial icing environment, totaling 23.2 hours, and 3 flights were in the natural environment, totaling 5.7 hours. The aircraft was flown in the normal utility configuration with five different droop stop configurations. Tests were conducted at average gross weights from 16,500 to 17,360 pounds with average longitudinal center of gravity (cg) locations from 351.7 to 355.2 inches. Lateral cg was 0.3 inches left. Average density altitude varied from -1500 to 7780 feet. Icing was accomplished at ambient temperatures from -6.0 to -22.0 °C at average liquid water contents (LWC) of 0.25 to 1.0 gram per cubic meter (gm/m^3). Test airspeed ranged from 90 to 141 knots true airspeed (KTAS) and the main rotor speed was 258 rpm (100 percent). Anti-ice and deice systems were operated continuously while in the icing environment. A summary of icing test conditions is presented in table 1, appendix E. Flight limitations contained in the operator's manual and the safety of flight release (ref 9, app A) were observed during the testing.

TEST METHODOLOGY

5. Artificial icing was conducted by flying in a spray cloud generated by the HISS. The test aircraft was immersed in the cloud for the maximum time attainable consistent with HISS fuel and water capacities. Ice accretion was documented by photographic and visual observation both inflight and on the ground following icing condition encounters. A detailed discussion of the test sequence and procedures is contained in reference 5, appendix A.

6. Natural icing tests were conducted by flying in IMC icing conditions under instrument flight rules (IFR). Close coordination with air traffic control and flight service stations was required to find and stay in the icing environment. In addition to the coordination, a combination of radar vectoring, navigational aid holding, and block airspace assignment were used. At the termination of the natural icing encounter, ice accretion was photographically documented. Time in the clouds was limited by the availability of the natural conditions and aircraft IFR fuel requirements.

7. A USAAEFA designed and fabricated visual ice accretion measuring device was used to observe the rate of ice accretion on the airframe. Test data were recorded on magnetic tape in both pulse code modulation (PCM) and frequency modulated (FM) format. A detailed description of special equipment and instrumentation is provided in appendix C.

8. Test techniques, data analysis methods, methods used to determine cloud parameters, and definitions of icing types and severities are presented in appendix D.

RESULTS AND DISCUSSION

GENERAL

9. Artificial and natural icing flight tests of the UH-60A were conducted to verify the correction of deficiencies and shortcomings of the UH-60A helicopter revealed during the 1979-1980 icing tests. This evaluation consisted of a total of 14.3 hours of artificial icing conditions and 5.3 hours of natural icing conditions. A summary of the specific test conditions for each flight is presented in table 1, appendix E. Specific icing conditions in which the UH-60A was tested are summarized in figure 1 for the artificial environment and figure 2 for the natural environment. The previous droop stop deficiency (failure of the droop stops to return to the shutdown position with ice accumulation on the rotor head) was corrected with the installation of a different droop stop with anti-ice protection. The previous anti-flapping restrainer deficiency (failure of the anti-flapping restrainers to return to the shutdown position with ice accumulation on the rotor head) was downgraded to a shortcoming after the correction of the droop stop deficiency. The three previously identified most important shortcomings; the large increase in power required with ice accumulation on the rotor system, the large decrease in power available with engine and engine inlet anti-ice systems ON, and the poor location of the deice system circuit breakers, were again documented, although some reduction in power available losses due to installation of the modulating engine inlet anti-ice valves was observed. Five other previously identified, icing related, shortcomings were still present and four were corrected. Three additional icing related shortcomings were identified during these tests: Ice impact damage to the upper strobe light assembly; ice impact damage to the nose avionics compartment door; and the poor reliability of windshield anti-ice control units. The twelve shortcomings identified during this evaluation and previous testing should be corrected. The UH-60A Black Hawk helicopter, configured with the anti-ice, deice and heated government competitive test (GCT) droop stop systems demonstrated safe operation in icing intensities through moderate.

DEICE SYSTEM OPERATION

General

10. The UH-60A helicopter deice system was evaluated for operational characteristics and effectiveness. Conditions in which the system was tested are presented in table 1, appendix E. During testing in the artificial environment, the operating mode of the system (Trace, Light, Moderate) was manually selected as a function of the LWC (app D) since the ice detector was not immensed in the cloud. During testing in the natural environment the system was operated in the automatic mode. Although the automatic deice cycle schedule was changed to an approximately 30 percent shorter off time from that previously tested, no evidence of rotor blade ice run back was observed. Even with the shorter element off time tested, indicated torque rises (collective fixed) with ice accumulation on the rotor system of 14 percent were recorded (para 21). These indicated torque rises were somewhat higher than the maximum observed torque rises during last years testing and were attributed to more severe natural icing conditions. All other deice system operational characteristics remained unchanged from previous testing.

Ice Detection Subsystem

11. The ice detection subsystem consisted of a Rosemount ice detector mounted on the right engine nacelle and a Rosemount icing rate meter located on the pilot's

instrument panel (app B). The effectiveness of the subsystem was evaluated in natural icing conditions, selected artificial icing conditions (table 1, app E), and limited icing wind tunnel tests at the Rosemount facility in Minneapolis, Minnesota. The natural icing and wind tunnel data are presented in figure 3, appendix E. An airspeed effect is evident from both sets of data with indicated icing rates lower than actual at low airspeeds and higher than actual at high airspeeds. Since icing rate is an input to the deice system controller (dictating OFF time), low airspeeds produce low indications and therefore cause a longer than normal off time resulting in heavier accretions of rotor system ice and larger engine torque increases at a fixed collective setting (para 21). These airspeed related accuracy characteristics were not of sufficient magnitude to affect satisfactory ice shedding characteristics or cause runback. The wind tunnel tests indicated that sufficient accuracy for satisfactory deice system operation was provided at typical IFR cruise airspeeds. Within the scope of these tests, the icing rate system accuracy is satisfactory.

ANTI-ICE SYSTEM OPERATION

General

12. The major difference between anti-ice systems from previous icing tests (ref 3, app A), was the engine inlet anti-ice valves (app B). The test engine inlet anti-ice valves modulated the amount of compressor bleed air to the inlets based on ambient air temperature sensed through a temperature air sense tube (photo 1, app G). All anti-ice systems were activated prior to entering the icing environment and were operational for all icing flights. All observed anti-ice system operational characteristics were identical to previous tests except as noted in the following paragraphs.

Engine Inlet

13. Engine inlet anti-ice system characteristics were evaluated throughout these icing tests as well as during two clear air flights to determine engine characteristics with the installed modulating inlet anti-ice valves. Test conditions are presented in table 1, appendix E. Engine inlet surface temperatures were evaluated at a constant true airspeed (approximately 100 KTAS), various power settings (flight idle to maximum allowable power) and five ambient temperature conditions (-1.5° C to -20.5° C) covering the range of operation of the modulating inlet anti-ice valve. Recorded surface temperature versus referred engine gas generator speed of the right engine inlet are shown in figure 4. The coldest surface temperature recorded (17° C) was at very low power and warm ambient conditions (-1.5° C); *i.e.*, minimum bleed air flow through the modulating valve. No visual evidence of ice formation on any portion of the heated inlet was observed throughout these tests. The engine inlet surface temperature characteristics resulting from modulation of the engine inlet anti-ice bleed air valve are satisfactory.

Windshield

14. Windshield anti-ice system characteristics were evaluated in the artificial and natural icing environments shown in table 1, appendix E. Two windshield anti-ice system control units (NSN 1560-01-H62-1777) failed during 32.4 hours of total test time. These failures resulted in loss of one phase of alternating current supplied to the windshield heating elements which caused two-thirds of the windshield to

be extremely hot and one-third extremely cold. Thermal stresses resulting from these failures caused the cracked windshield (photo 2, app G) during this test. The poor reliability of the windshield anti-ice control units is a shortcoming. The following caution should be placed in the operator's manual as soon as practicable:

CAUTION

> Continued use of a faulty windshield anti-ice system may result in structural damage (delamination and/or cracking) to the windshield.

15. During one artificial icing flight, ice accumulated on the copilot's windshield due to a faulty control unit. After approximately 1 hour of operation in the artificial environment the faulty windshield anti-ice system resumed normal operation, producing a shed of the accumulated ice. The ice departed the aircraft in large pieces passing in the vicinity of the left engine inlet. Although no abnormal engine indications were detected in the cockpit, engine foreign object damage (FOD) was detected after a subsequent flight. This FOD required an engine change. The following caution should be placed in the operator's manual as soon as practicable:

CAUTION

> If ice accumulates on one or more sections of the anti-ice windshields, with the windshield anti-ice system ON, the respective windshield should be turned OFF and the icing conditions exited due to the possibility of engine foreign object damage if the ice should shed from the windshield.

Droop Stops

16. Droop stop anti-ice system operation test conditions are listed in table 1, appendix E. Anti-ice protection was provided by an electrically heated rod (photo 3, app G), inserted through each droop stop pivot bolt (photo 4). Five configurations of droop stops and anti-ice protection were evaluated: production droop stop (P/N 70105-08151-041) with 231 watt heater; production droop stop with 300 watt heater; production droop stop with 300 watt heater and rubber bumper removed; GCT droop stop (P/N 70105-08051-101) with 300 watt heater; and, GCT droop stop with no heater. A production droop stop, production droop stop without rubber bumper and a GCT droop stop are shown in photographs 5, 6, 7, respectively. Artificial icing test results are summarized in figure 1, appendix E. Unsatisfactory droop stop operation was defined as either partial or complete failure of the droop stop to return to the shutdown position (photo 8 and 9). Incomplete seating of the droop stops resulted in damage to the droop stop as shown in photo 10. The only droop stop configuration that demonstrated satisfactory operation at all conditions tested was the GCT droop stop with the 300 watt heater installed. Three natural icing flights were accomplished in this configuration to verify the artificial icing test results. A combination of the greater thermal conductivity along the larger counterweight attachment arms and lower catch efficiency of the larger counterweight was probably responsible for the demonstrated satisfactory performance of this configuration. The government competitive test droop stop with 300 watt heater operated satisfactorily at all conditions tested.

FLIGHT CONTROL SURFACE ICE ACCRETION AND SHEDDING CHARACTERISTICS

General

17. Flight control ice accretion and shedding characteristics were evaluated throughout these tests. Specific test conditions are listed in table 1, appendix E, and shown graphically in figures 1 and 2. The previously identified deficiency relating to failure of the anti-flapping restrainers to return to the shutdown position was downgraded to a shortcoming after correction of the droop stop deficiency. Additionally, two previously unreported shortcomings were identified: ice impact damage to the nose avionics compartment door; and ice impact damage to the upper strobe light assembly.

Main Rotor Blades

18. As previously reported, all inflight data indicated clean shedding of the heated portions of the main rotor blades during the deice cycles. Photographic confirmation of this fact was possible throughout the artificial tests. In natural icing conditions, with the collective fixed, the engine torque rise associated with rotor system ice accretion was completely eliminated at the completion of a deice system cycle (para 21). During icing encounters (natural and artificial) the crew detected fuselage impact with shed ice particles, principally by sound (thump on fuselage) and by visual means under some lighting conditions (artificial conditions only). Most frequently, ice was shed as the advancing rotor blade approached the aircraft three o'clock position. The trajectory of the shed ice particles caused numerous fuselage impacts which could sometimes be heard in the cockpit. Following each icing encounter additional dents (photo 11, app G) were noted on the nose avionics compartment door. The ice impact damage to the nose avionics compartment door is a shortcoming.

19. Additionally, two instances of ice particle impact damage to the upper strobe assembly (photo 12, app G) were documented. One upper strobe assembly sustained sufficient damage to shatter both the red and white lens components which then struck a tail rotor blade producing the damage shown in photo 13. Ice impact damage to the upper strobe assembly is a shortcoming. As a result of rotor blade ice shedding characteristics the following note should be placed in the operator's manual prior to release of the aircraft for flight in an icing environment:

NOTE

> Some ice impact damage to the aircraft can be expected during flight in icing conditions. The aircraft should be closely inspected following icing encounters.

Flap Restrainers

20. Ice accretion characteristics of the main rotor blade anti-flapping restrainers was evaluated throughout these tests. The anti-flapping restrainers are not anti-iced and are susceptable to continuous ice accretion throughout an icing encounter. Previous testing had identified the failure of the anti-flapping restrainers to return

to the shutdown position as a deficiency. During this evaluation all but two shutdowns were accomplished with the anti-flapping restrainers stuck in the fly position (photo 14, app G). Gusty wind conditions up to 18 knots were present during some rotor shutdowns. The main rotor blade tip excursions during coast down under such conditions were mild compared with previous year's experience where similar shutdowns were accomplished with both the droop stops and anti-flap restrainers in the incorrect position. The failure of the anti-flapping restrainers to return to the shutdown position following an icing encounter is a shortcoming. The following CAUTION should be placed in the operator's manual prior to release of the aircraft for flight in icing conditions.

CAUTION

> Strong gusty winds may cause excessive flapping of the main rotor blades during shutdown following an icing encounter due to the probability of failure of the anti-flapping restrainers to operate with ice accumulation.

PERFORMANCE

Level Flight Performance

21. Level flight performance characteristics of the UH-60A helicopter were evaluated at the specific test conditions listed in table 1, appendix E. These performance characteristics were documented before, during, and after ice accretion on the helicopter. Collective position was fixed at pre-immersion trim position, altitude was maintained and airspeed was allowed to vary as necessary during the encounter. Figures 5 through 7 are typical time histories of ice accretions over at least one full deice cycle in various natural icing environments. Indicated torque increases of 4 to 14 percent per engine were observed. Previous testing (ref 3, app A) observed torque increases were only 4 to 12 percent. Somewhat more severe icing conditions during these tests (combination of temperature, LWC, ice type, etc.) were responsible for the higher torque rise observed. The most severe power increase recorded is shown in figure 7, appendix E. The average test conditions were a gross weight of 16,500 pounds, density altitude of 2540 feet, free air temperature (FAT) of -11.0° C and LWC varying from 0.2 to 0.4 gm/m^3. The 14 percent indicated torque required increase shown represents a 30 percent increase in power above that required at the same collective setting with no ice accumulated. Each time the deice system cycled (approximately every 3 minutes for this example) the power decreased to the clean blade value observed at the beginning of the icing encounter. The 30 percent increase in power above the clean blade condition required an increase in fuel flow of approximately 12 percent and approximately 7 percent in turbine gas temperature (TGT) (ref fig 8 thru 12). Over an entire flight the average increase in fuel flow would be approximately 10 percent for these icing conditions. The approximate 10 percent increase in fuel flow will reduce the endurance capabilities of the helicopter by a similar amount and reduce the range capabilities by a slightly larger amount. The large increases in power required with ice accumulation on the rotor systems of the UH-60A helicopter is still a shortcoming. The following NOTE should be placed in the operator's manual prior to release of the aircraft for operations in an icing environment.

NOTE

During flight in icing conditions, large engine torque increases (as much as 14 percent per engine) can be expected. The pilot should closely monitor engine instruments to prevent exceeding engine limits and/or drooping the rotor.

Power Loss With Operation of Anti-Ice Systems

22. Engine power loss characteristics with operation of the anti-ice systems were evaluated throughout these tests. Engine referred characteristics were documented at various ambient air temperatures to fully investigate the effects of the modulating engine inlet anti-ice valve (app B). Modulation is based on a FAT schedule varying from minimum bleed air flow to the engine inlet at temperatures just above freezing to maximum flow at colder FAT's (approx -15° C). This schedule adequately heats the engine inlet to prevent ice formation (para 13) and provides the benefit of reduced engine power losses at warmer FAT's where the inlet requires less bleed air for heating. The engine characteristics of both T-700 engines configured with the modulating engine inlet anti-icing valves are shown in figures 8 through 13, appendix E. In general, the power penalty resulting from use of all engine anti-ice systems at a warmer FAT (near freezing) as apposed to very cold (approx -20° C) was decreased by approximately 25 percent by modulating bleed air to the engine inlet. These decreased losses, although still significant, provide slightly improved (approx 2 percent less) fuel flow characteristics and improved (approx 3 percent less) referred TGT characteristics at a FAT near freezing. The improved TGT characteristics are particularly important in that the TGT limiter can routinely be encountered at normal IFR cruise conditions in icing conditions due to the performance penalties incurred with activation of anti-ice bleed air systems and the increased power required due to ice accumulation on the rotor systems (para 21). The decreased bleed air power losses due to installation of modulating engine inlet bleed air valves, provide slightly improved fuel flow characteristics and improved power available characteristics at ambient temperatures near freezing. However, the losses are still significant and remain a shortcoming. The following NOTE should be placed in the operator's manual prior to release of the aircraft for operation in an icing environment.

NOTE

Significant power available loss can be expected with the actuation of the engine and engine inlet anti-ice systems.

RELIABILITY AND MAINTAINABILITY

Reliability of Deice System

23. During this flight test program, which consisted of 51.2 flight hours (including ferry time) no deice system failures occurred (ref app F, listing of Equipment Performance Reports). This was in sharp contrast to the multiple deice system failures during the previous year's tests (ref 3, app A). The reliability of the UH-60A deice system during these tests was satisfactory.

Jumper Assembly, Bonding

24. During this test program no failures of the jumper assembly, bonding (P/N 70103-08031-043) occurred, as opposed to the multiple failures of a jumper assembly, bonding (P/N 70103-08031-042) experienced during previous testing. The reliability of the jumper assembly, bonding (P/N 70103-08031-043) was satisfactory.

Main Rotor Distributor Wiring Clamps

25. During previous testing and the initial weeks of this year's program, multiple failures of main rotor distributor wiring clamps (photo 15, app G) were observed. After the incorporation of Sikorsky Aircraft Division Engineering Order No. 90790, drawing number 70070-55003 (photo 16, app G), no subsequent failure of these devices were experienced. Within the scope of these tests, the reliability of the improved main rotor distributor wiring clamps was satisfactory.

HUMAN FACTORS

General

26. The human factors associated with operating the UH-60A helicopter in natural and artificial icing conditions were evaluated at the conditions shown in table 1, appendix E. Two system changes were evaluated which resulted in correction of shortcomings discussed in the next two paragraphs. Three previously identified human factors shortcomings were not corrected. The poor location of the deice system circuit breakers; the inadequate watertightness of the cockpit; and, the inadequate cabin heat distribution.

Deice System Operational Check

27. During previous testing, the excessively long (5 minutes) time required to perform the unusually complicated pre-flight test of the deice system was identified as a shortcoming. These system checks could only be performed at 90 percent or greater rotor speed. Rewiring of several logic circuits in the deice system (app B) now allows for all but 1 minute of this check to be completed on the auxiliary power unit generator as long as the backup hydraulic pump is not operating. Although the system check was still complicated, the vast majority of the system functional check was accomplished without starting the main engines. Within the scope of these tests, the deice system operational check is satisfactory.

Icing Rate Meter Location

28. Previous testing had identified the poor location (pilot's panel) and readability (caused by parallax from the copilot's station and recessed face) of the icing rate meter as a shortcoming. For this test the previous icing rate meter installation was canted 10 degrees toward the copilot (photo 17, app G). The readability of the icing rate meter from the copilot's station was improved. The readability of the icing rate meter is satisfactory.

MISCELLANEOUS

29. No corrective action was accomplished for several of the previously identified (ref 3, app A) shortcomings and no specific evaluation was accomplished to investigate them. However, the following discrepancies remain:

a. The poor location of the deice system circuit breakers

b. The insufficient main transmission drip pan capacity

c. The inadequate watertightness of the cockpit

d. The inadequate cabin heat distribution

e. The ice accumulation on the cockpit steps

f. The ice accumulation on the FM homing antennas which interferes with cockpit door opening.

30. The following recommendations still apply since either no corrective action was accomplished prior to this re-evaluation or the corrective action was inadequate to warrant deletion of the previous (ref 3, app A) recommendation.

a. The Windshield Anti-Ice Copilot and Pilot switches should be labeled to indicate the reset feature of the OFF position.

b. The following WARNING should be placed in the operator's manual prior to release of the aircraft for operation in an icing environment:

WARNING

Following an icing encounter, the cockpit crew should be extremely careful when exiting the aircraft due to ice accumulation on the cockpit steps.

c. The following NOTE should be placed in the operator's manual prior to release of the aircraft for operation in an icing environment:

NOTE

Moderate accumulations (approximately 1 inch) of ice on the FM homing antennas can interfere with the normal cockpit door opening. A slight amount of pressure on the door will normally break the ice from the antenna.

CONCLUSIONS

GENERAL

31. The UH-60A Black Hawk helicopter configured with the anti-ice, deice and heated government competitive test droop stop systems demonstrated safe operation in icing intensities through moderate (para 9). A total of twelve shortcomings exist with respect to the UH-60A operation in an icing environment.

SPECIFIC

32. The following specific conclusions were reached upon the completion of the UH-60A artificial and natural icing re-evaluation:

a. The icing rate system accuracy is satisfactory for typical IFR cruise airspeeds (para 11)

b. The government competitive test droop stops with 300 watt heaters operated satisfactorily at all conditions tested (para 16)

c. The modulating engine inlet anti-ice bleed air valves operated satisfactorily in all icing conditions tested and provided some improvement in engine power available losses at relatively warm ambient temperatures (paras 13 and 22)

d. The large power required increase was not noticeably affected by the new deice system OFF time schedule (para 21).

SHORTCOMINGS

33. The previously identified anti-flapping restrainer deficiency (failure of the anti-flapping restrainers to return to the shutdown position with ice accumulation on the rotor head) was downgraded to a shortcoming (para 20).

34. The following previously identified icing related shortcomings remain:

a. The large increased in power required with ice accumulation on the rotor system (para 21)

b. The large decrease in power available with engine and engine inlet anti-ice systems ON (para 22)

c. The poor location of the deice system circuit breakers (para 29)

d. The insufficient main transmission drip pan capacity (para 29)

e. The inadequate watertightness of the cockpit (para 29)

f. The inadequate cabin heat distribution (para 29)

g. The ice accumulation on the cockpit steps (para 29)

h. The ice accumulation on the FM homing antennas which interferes with cockpit door opening (para 29).

35. The following shortcomings, not previously identified, were noted during this re-evaluation:

a. Ice impact damage to the upper strobe light assembly (para 19)

b. Ice impact damage to the nose avionics compartment door (para 18)

c. The poor reliability of the windshield anti-ice control units (para 14).

RECOMMENDATIONS

36. The shortcomings listed in paragraphs 33, 34, and 35 should be corrected.

37. The following WARNING should be placed in the operator's manual prior to release of the aircraft for flight in an icing environment (para 30b):

WARNING

> Following an icing encounter, the cockpit crew should be extremely careful when exiting the aircraft due to ice accumulation on the cockpit steps.

38. The following CAUTION should be placed in the operator's manual prior to release of the aircraft for flight in icing conditions (para 20):

CAUTION

> Strong gusty winds may cause excessive flapping of the main rotor blades during shutdown following an icing encounter due to the probability of failure of the anti-flapping restrainers to operate with ice accumulation.

39. The Windshield Anti-ice Copilot and Pilot switches should be labeled to indicate the Reset feature of the OFF Position (para 30a).

40. The following CAUTION should be placed in the operator's manual immediately (para 14):

CAUTION

> Continued use of a faulty windshield anti-ice system may result in structural damage (delamination and/or cracking) to the windshield.

41. The following CAUTION should be placed in the operator's manual prior to release of the aircraft for operation in an icing environment (para 15).

CAUTION

> If ice accumulates on one or more sections of the anti-iced windshields, with the windshield anti-ice system ON, the respective windshield should be turned OFF and the icing conditions exited due to the possibility of engine foreign object damage if the ice should shed from the windshield.

42. The following NOTE should be placed in the operator's manual prior to release of the aircraft for flight in an icing environment (para 21):

NOTE

During flight in icing conditions large engine torque increases (as much as 14 percent per engine) can be expected. The pilot should closely monitor engine instruments to prevent exceeding engine limits and/or drooping the rotor.

43. The following NOTE should be placed in the operator's manual prior to release of the aircraft for operation in an icing environment (para 22):

NOTE

Significant power available loss can be expected with the actuation of the engine and engine inlet anti-ice systems.

44. The following NOTE should be placed in the operator's manual prior to release of the aircraft for operation in an icing environment (para 30c):

NOTE

Moderate accumulations (approximately 1 inch) of ice on the FM homing antennas can interfere with normal cockpit door opening. A slight amount of pressure on the door will normally break the ice from the antenna.

45. The following NOTE should be placed in the operator's manual prior to release of the aircraft for flight in an icing environment (para 19):

NOTE

Some ice impact damage to the aircraft can be expected during flight in icing conditions. The aircraft should be closely inspected following icing encounters.

APPENDIX A. REFERENCES

1. Final Report, USAAEFA Project No. 76-09-1, *Artificial Icing Test, Utility Tactical Transport Aircraft System (UTTAS), Sikorsky YUH-60A Helicopter*, February 1977.

2. Letter Report, USAAEFA Project No. 78-05, *Artificial and Natural Icing Tests, Production UH-60A Helicopter*, 12 October 1979.

3. Final Report, USAAEFA Project No. 79-19, *Artificial and Natural Icing Tests, Production UH-60A Helicopter*, June 1980.

4. Letter, AVRADCOM, DRDAV-DI, 17 September 1980, subject: Limited Artificial and Natural Icing Tests of the Production UH-60A (Re-evaluation).

5. Test Plan, USAAEFA Project No. 80-14, *Limited Artificial and Natural Icing Tests, Production UH-60A Helicopter*, October 1980.

6. Technical Manual, TM 55-1520-237-10, *Operator's Manual, UH-60A Helicopter*, 21 May 1979, with change 6 dated 7 February 1980.

7. Final Report, USAAEFA Project No. 79-02-2, *Helicopter Icing Spray System (HISS) Nozzle Improvement Evaluation*, to be published.

8. Report, Meteorology Research, Inc., No. MRI 81 dFR-1813, *Natural and HISS Cloud Droplet Data as sampled During the 1980-1981 AEFA/St. Paul Field Program*, unpublished.

9. Letter, AVRADCOM, DRDAV-DI, 10 December 1980, subject: Airworthiness Release for UH-60A Black Hawk Helicopter, S/N 77-22716, To Conduct Artificial and Natural Icing Tests, Project No. 80-14.

APPENDIX B. DESCRIPTION

ANTI-ICE SYSTEMS

General

1. The anti-ice systems installed on the UH-60A helicopter, S/N 77-22716, use a variety of methods to provide ice protection. Engine bleed air is used to anti-ice the engine inlet and the engine. Additional engine anti-ice protection is provided by hot engine oil and the inlet particle separator (IPS) which offers limited protection from foreign materials such as ingested ice. Electrical energy is used to anti-ice the pilot and copilot windshields, the pitot tubes, and the struts that support the pitot tubes. Droop stop anti-ice protection is provided by electrically heating the droop stop pivot bolt.

Engine Anti-Icing

2. Engine anti-icing is accomplished by a combination of hot axial compressor discharge air and heat rejection from the air/oil cooler integral to the main engine frame. A hot air anti-icing valve is electrically controlled by the ENG ANTI-ICE switch on the overhead panel. Anti-icing is off when electrical power is applied to the solenoid of the combination anti-icing and starting bleed valve assembly. Additionally, the valve will automatically open at an N_G less than 86 percent.

3. Axial compressor discharge air (station 2.5) is bled from the compressor casing at the 7 o'clock position, routed through the anti-icing valve, and delivered to the front frame and swirl frame via ducting. Front frame anti-icing air flows through a cored passage in the main frame to the front frame splitter lip, then exits to the main frame scroll and is discharged with IPS air. Within the swirl frame, hot air is ducted around the outer casing to each swirl vane. The hot air is circulated within each vane by a series of baffles, then exits from two areas. Approximately 90 percent of this hot air exits at the vane outer trailing edges. The other 10 percent exits through a series of circumferential slots in the swirl frame hub at the aft edge. This arrangement also acts as a "rain step" to preclude water from adhering to the hub and flowing into the compressor.

4. Anti-icing air is also ducted to the compressor inlet guide vanes (IGV's). A circumferential manifold surrounds the aft flange of the main frame to distribute hot air to the hollow IGV's. Slots in the trailing edge of the IGV's discharge this flow into the compressor inlet. Additionally, hot scavenge oil passing within the scroll vanes in the main frame precludes ice buildup which could result from moisture-laden IPS air.

Engine Inlet Anti-Icing

5. Engine inlet anti-icing is provided by hot axial compressor discharge air which is also electrically controlled by the ENG ANTI-ICE switch on the overhead panel. With the ENG ANTI-ICE switch ON, bleed air passes into inner and outer supply manifolds which are contained within the inner bullet nose and outer lip of the engine inlet. Located in this area is a six inch stainless steel ambient sense line covered with thermal insulating material which replaced the previous 12 inch flexible ambient sense line (fig. 1). Anti-icing is accomplished by a combination of convection and impingement as the bleed air flows between the flexible high-temperature fiberglass wall in the manifolds and the aluminum surface of the inlet. The entire surface of the inlet to the engine swirl frame, to include the bullet nose

forebody and the fixed crotch section, is anti-iced in this manner. Exit provisions for the bleed air are provided through slots at the mouth of the inlet on the inboard side, plus an annular slot in the inlet immediately ahead of the swirl frame. A small portion of the slot immediately ahead of the T_2 sensor is blocked so that hot anti-ice exit air would not give a false T_2 signal to the hydromechanical unit.

6. The engine inlet anti-ice valve (P/N 70306-10012-107) is a modulating valve that controlls the volume of compressed air to the engine inlet as a function of outside air temperature. A decreased temperature results in more bleed into the inlet.

Windshield Anti-Ice

7. The pilot and copilot windshields are electrically anti-iced by transparent conductors imbedded between the laminations of the windshields. AC electrical power heats the windshields, while control of the system is through the use of DC electrical power which incorporates circuit breakers for system protection. Two switches located on the upper console, one for the pilot and one for the copilot, turn the windshield anti-ice system on and off. Power to operate the windshield anti-ice system is provided by the No. 1 and No. 2 AC primary buses through circuit breakers marked PILOT WSHLD ANTI-ICE and COPILOT WSHLD ANTI-ICE, respectively. Two temperature sensors, embedded diagonally across the windshield from each other, provide an input to a controller which maintains the windshield surface temperature at approximately 43°C. Additional system protection is provided by a windshield anti-ice system fault-monitoring circuit that prevents windshield burnout. In the event the monitor circuit turns the windshield anti-ice off, the system may be reactivated by cycling the appropriate windshield anti-ice switch. The windshield anti-ice system is fully operational if the auxiliary power unit (APU) generator is the sole source of AC electrical power, except when the backup hydraulic pump is ON, at which time the windshield anti-ice system is automatically disconnected.

Pitot-Static Anti-Ice

8. Anti-icing of the pilot's and copilot's pitot-static tubes and support struts is accomplished electrically. AC electric power for the pitot heaters is supplied by the No. 1 and No. 2 AC primary buses through the LEFT PITOT HEAT and RIGHT PITOT HEAT circuit breakers to the copilot's and pilot's pitot-static tubes respectively. DC power to the current sensors is provided by the No. 1 DC primary bus through the No. 1 ENG ANTI-ICE circuit breaker. When a low heat or no heat condition is sensed by the current sensor, the RT or LFT PITOT HEAT caution capsules are illuminated on the caution/advisory panel.

Droop Stop Anti-Ice

9. Droop stop anti-icing is accomplished by electrically operated cylindrical heaters installed inside the droop stop pivot bolt. Electrical power for the four heaters is provided by the controller through the slip ring assembly but prior to reaching the distributor (figs. 2 and 3). Both the deice controller and the fault monitor panel sensing circuits are modified to account for the heater power in fault sensing levels.

DEICE SYSTEM

General

10. The UH-60A main and tail rotor blade deice system (fig. 4) uses the cyclic electrothermal deicing concept. A prescribed amount of ice is allowed to accrete on the blade surface. Sufficient heat is applied to the surface to break the ice bond, permitting the ice to be shed by centrifugal force and scavenged away by the airflow. The blade deice system components as shown in figures 2 and 4 were: a Rosemount ice detector (Model 871FF1, P/N 70302-10915-102) mounted on the right engine nacelle; an icing rate meter (P/N 70550-01124-102) blade deice control panel (P/N 70902-01099-041), and a fault monitor panel (P/N X7006-80055-042) mounted on the instrument panel. The system also includes a main and tail rotor slip ring (P/N 70500-02128-041 and P/N 70550-02129-042 respectively) mounted on the main and tail rotor respectively, a blade deice controller (P/N 70550-02126-104), and a main rotor distributor (P/N 70550-02127-102). The main and tail rotor blades contained resistive heating mats.

11. The free air temperature FAT sensor provides a signal to the deice controller to set heater element on times. The ice detector provides a signal to the ICE DETECTED capsule on the caution/advisory panel and a second signal to the icing rate meter. In the AUTO mode, the icing rate meter provides a signal through the blade deice control panel to the deice controller to set heater element off times according to icing intensity. The deice controller provides the blade element electrical heating power through the tail rotor slip rings to the tail rotor blade's heating elements and through the main rotor slip rings and distributor to the main rotor blade's heating elements.

Outside Air Temperature Sensor

12. The FAT sensor is mounted on the nose section between the center windshield and the nose avionics door. A shield is installed in front of the sensor to assist in eliminating kinetic heating effects. The FAT sensor supplies a signal to the blade deice controller to set element on time between 1 and 13 seconds for the eight main rotor deice pulses and between 1 and 32 seconds for the one tail rotor pulse.

Ice Detectors

13. One magnetostrictive, aspirated Rosemount ice detector is mounted on the right engine nacelle. When the BLADE DEICE control panel POWER switch is placed ON, 28 volts direct current (vdc) is supplied from the DEICE CNTRLR circuit breaker to the icing rate meter where it controls the circuit used to heat the aspirated portion of the ice detector. The aspirator is provided to assure ice detection at a hover and consists of engine compressor discharge air passing over an ice detector inlet, causing ambient air to pass over the detector probe. The detector provides two output signals, one to the ICE DETECTED capsule on the caution/advisory panel and one to the icing rate meter.

Icing Rate Meter

14. The icing rate meter is located on the right center of the instrument panel. The meter is canted 10 degrees toward the copilot to allow for better viewing. The icing rate meter provides a signal to the deice controller through the AUTO position

of the MODE SELECT switch on the BLADE DEICE control panel. The signal is used to control element off time. The more severe the rate of icing the shorter the element off time. The icing rate meter is modified to incorporate a new calibration for decreasing element off times. The icing rate meter contains a hold circuit to hold the last icing signal from the ice detector during the time the heating current is supplied to the ice detector. The icing rate meter contains built in test circuitry and fault monitoring circuitry. The test is activated by depressing the test button on the meter. The test conducts a calibration check on the rate meter electronics and checks power application to the ice detector probe heater. Failure to pass this test is indicated by the appearance of the fail flag.

Blade Deice Control Panel

15. The blade deice control panel located on the right center of the instrument panel contains the controls necessary to operate the deice system. The control panel provides power to the controller through the POWER ON-OFF-TEST switch and an icing rate signal to the controller either through the AUTO or MANUAL positions of the MODE SELECT switch. Provisions are included for self-test. The pilot exercises his option to select either automatic or manual off time control of the system. Placing the MODE SELECT switch in AUTO results in an icing rate signal from the rate meter to the controller, regulating off times according to icing intensity. Selection of manual mode of operation by placing the MODE SELECT switch in one of three manual positions replaces the icing rate signal with one of three preset signals corresponding to trace (T), light (L) or moderate (M) icing. The manual mode of operation requires the pilot's assessment of icing intensity, and should only be used if the pilot suspects the icing rate system is malfunctioning. It is important to note that the MODE SELECT switch has no effect on heater on times. The heater element on time (*i.e.*, the period of power application to each rotor blade heating zone) is controlled by the system controller and an outside ambient temperature sensor. The self-test is initiated by placing the POWER switch to TEST. The controller overrides existing element on and off times to execute a test program. The program consists of a 100 second off time followed by approximately 0.5 second element on time applied to the main and tail rotor blade heating elements. The test in progress lamp illuminates during the test and extinguishes when the test is complete. Failure of the test is indicated by illumination of either TR DEICE FAIL or MR DEICE FAIL caution capsules.

Deice Controller

16. The deice controller is located in the cabin overhead. Operating voltage for the controller is supplied through the DEICE CNTRLR circuit breaker located on the mission readiness circuit breaker panel. The main and tail rotor control circuit closes the main rotor contactor and produces a pulse train consisting of eight pulses followed by a waiting period, or off time. The counter always resets to zero; that is, the controller always produces a complete train of eight pulses when operation is initiated or when input power is restored after an interruption. The pulse train is supplied to the control input of the main rotor power distributor through the main rotor slip ring assembly. The same slip ring assembly carries power to the distributor. In response, the distributor supplies power in proper sequence to the rotor blade heating elements. Eight gating pulses are required, since the main rotor blades, each with four independent heating zones, are deiced in pairs. The first gating pulse causes power to be applied to output 1 (zone 1 of blades No. 1 and No. 3);. . . . . . and so on through the sequence of eight pulses. The sequence counter

always resets to output 1 after the off time has elapsed or if there is an interruption of power. The tail rotor control circuit provides an output to the tail rotor contactor coil. Energizing the contactor applies power via the tail rotor slip ring assembly simultaneously to all the heating elements of the tail rotor therefore a distributor is not required. The control circuit responds to the OAT sensor to determine the on time of the tail rotor heating elements. The monitor circuits in the controller continuously check the operation of the system. Three-phase current transformers on the main and tail power leads provide signals corresponding to the actual current delivered to the heaters. By comparing the current delivered with the controller's pulse train, and checking for magnitude balance of the three individual phase currents, the monitor circuits detect such malfunctions as an open circuit heater phase or feeder wire, zero output during a gating pulse, or a short-circuit heater phase. The monitor circuits also detect OAT sensor failure (open- or short-circuit) and an incomplete or improper output pulse train from the controller. Cockpit indicators inform the crew of system fault or failure.

Main and Tail Rotor Blade Heating Elements

17. The main rotor blade heating elements are embedded in the leading edge sheath and cover 21 to 92 percent spanwise and 12 percent upper to 17 percent lower surface chordwise. These elements are divided chordwise into four independent electrical heating zones. Tail rotor blade heating elements are embedded in the leading edge from 25 to 91 percent spanwise and 12 percent upper and lower surface chordwise. These elements are single electrical heating zones.

Fault Monitor Panel

18. The production fault monitor panel is located on the right center of the instrument panel. The panel serves to check the deice system for failures that are otherwise dormant during the normal TEST cycles. The panel accomplishes this by introducing selected failure signals into the system and requiring the deice controller built-in monitor circuitry to function in a specific manner. The fault monitor check is performed as part of the deice system ground check. In the NORM position, the fault monitor allows system test to be performed without the introduction of false failure signals. Thus, the system should complete its self check-out cycle without failure legends being illuminated on the caution panel. In the SYNC 1 and SYNC 2 positions, the fault monitor interrupts the distributor sync line and provides the controller with a false sync input. The controller must interpret these false signals as indications of distributor failure, and produce a MR DEICE FAIL caution light for both cases. The fault monitor provides the controller with a -30 vdc signal when SYNC 1 is selected, and an open circuit signal when SYNC 2 is selected. In the OAT position, the fault monitor "short-circuits" the OAT sensor. Built-in test equipment (BITE) circuitry within the controller must sense the simulated failure and illuminate both the MR DEICE FAIL and TR DEICE FAIL caution lights. In the element on time (EOT) position, the fault monitor biases both BITE circuitry in the controller and the OAT sensor to simulate defective primary EOT timing circuits. The biased BITE circuit is thus deceived into believing that the primary circuits are in error. The controller must illuminate both the MR DEICE FAIL and the TR DEICE FAIL lights when this occurs. The fault monitor also functions automatically during in-flight system use to sense contradictory signals from the deice power circuits. If electric power remains applied to either the main or tail rotor heating elements after the controller signals a FAIL condition or when the

system is off, then the fault monitor illuminates the respective PWR light on its front panel. The light informs the crew that further action is required to isolate the deice loads indicated.

APPENDIX C. INSTRUMENTATION

1. The test instrumentation was installed, calibrated, and maintained by USAAEFA personnel. Data were measured with calibrated instrumentation and displayed or recorded as indicated below. Test instrumentation installation is shown in photo 1.

Pilot/Copilot Panel

Airspeed (ship's system)
Altitude (ship's system)
Altitude (radar)
Rate of climb/descent (ship's system)
Free air temperature (ship's system)
Free air temperature (sensitive)
Rotor speed (sensitive)
Engine torque (both engines)
Engine turbine gas temperature (both engines)
Engine gas generator speed (both engines)
Engine power turbine speed (both engines)
Control position
- Longitudinal
- Lateral
- Directional
- Collective

Icing rate (ship's system)

Engineer Panel (photo 2)

Instrumentation controls
Free air temperature
Time code display
Run number
Fuel flow
Fuel used (totalizer)
Control position
- Longitudinal
- Lateral
- Directional
- Collective

Stabilator position

Digital (PCM) Data Parameters

Airspeed (ship's system)
Altitude (ship's system)
Observed air temperature
Main rotor speed
Engine gas generator speed**
Fuel used**
Engine fuel flow**
Engine output shaft torque**
Engine measured gas temperature**

Control position
- Longitudinal cyclic
- Lateral cyclic
- Directional
- Collective

Stability augmentation position
- Longitudinal
- Lateral
- Directional

Aircraft attitude
- Pitch
- Roll
- Yaw

Aircraft angular velocity
- Pitch
- Roll
- Yaw
- Engine inlet surface temperature** (photo 3)

Customer bleed air pressure**
Engine anti-ice valve position**
Engine inlet duct anti-ice valve position**
Engine inlet modulating valve temperature**
Generator (No. 1, No. 2, and APU)
- Voltage (A phase)
- Current (A phase)

Deice/anti-ice system electrical parameters
- Main rotor voltage (A phase)
- Main rotor current (A phase)

Rosemount icing rate (DC voltage to cockpit meter)
Time of day
Run number
Pilot and engine event pulse

Analog (FM) Data Parameters

Vibration (accelerometers)
- Pilot station vertical
- Pilot station lateral
- Pilot station longitudinal
- Copilot station vertical
- Copilot station longitudinal
- Aircraft cg vertical
- Aircraft cg lateral
- Aircraft cg longitudinal

Airspeed Calibration

2. The airspeed system position error contained in the Airworthiness Release (ref 8, app A) was used to determine calibrated airspeed.

SPECIAL EQUIPMENT

Camera Systems

3. High-speed hand-held 16mm motion picture cameras were located on board the chase aircraft and spray aircraft and were used to document the test aircraft both in the spray cloud and after exit from icing encounters. Additionally, 35mm color slide and black and white still cameras were used for documentation both in the air and on the ground following each icing flight.

Visual Ice Accretion Probe (photo 4)

4. A visual ice accretion indicator probe was fabricated and installed on the test aircraft. It was used to give additional visual cues of ice buildup on the aircraft fuselage. The probe consisted of a small symmetrical airfoil section (OH-6A tail rotor blade sections) with a 3/16-inch diameter steel rod protruding outward from the leading edge at the center span. The protruding rod was painted with 1/4-inch stripes of contrasting colors which provided a comparison basis for visual ice measurements. The probe was mounted on the left cockpit door just below the window. Photo 4 shows the installation of the visual ice accretion probe.

Cloud Sampling Equipment

5. An instrumentation package (photo 5) was installed during selected flights to sample the natural and artificial icing cloud environments. The equipment was provided, maintained and the data were analyzed by Meteorological Research Incorporated (MRI). An axial scattering probe (ASP) was installed on the right side of the aircraft (photo 6) and a cloud particle spectrometer was installed on the left side (photo 7). A detailed description of this equipment is contained in MRI technical report, "Droplet Size and Liquid Water Characteristics of the USAAEFA (CH-47) Helicopter Spray System and Natural Clouds as Sampled by a JUH-1H Helicopter", MRI 80 FR-1748 dated August 1980.

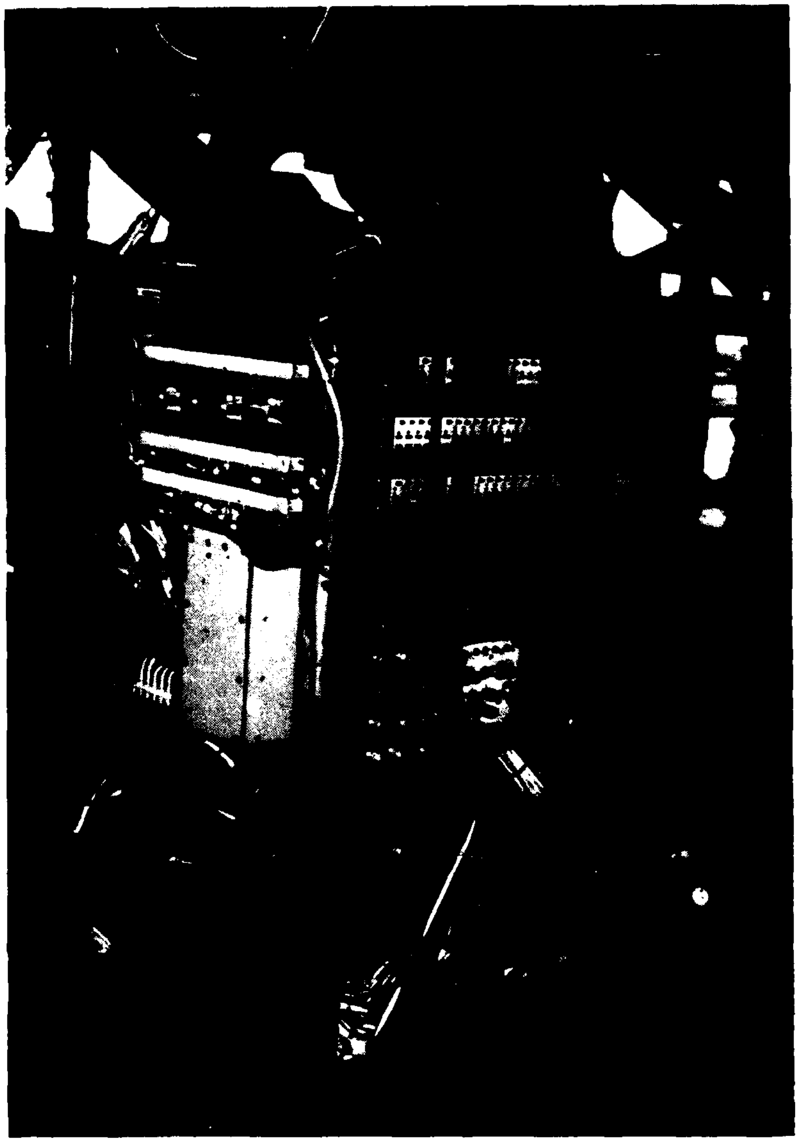


Photo 1. Instrumentation Package Installed in Cargo Compartment

Photo 2. Engineer Control Panel

Photo 3. Engine Inlet Surface Temperature Thermocouple Installation

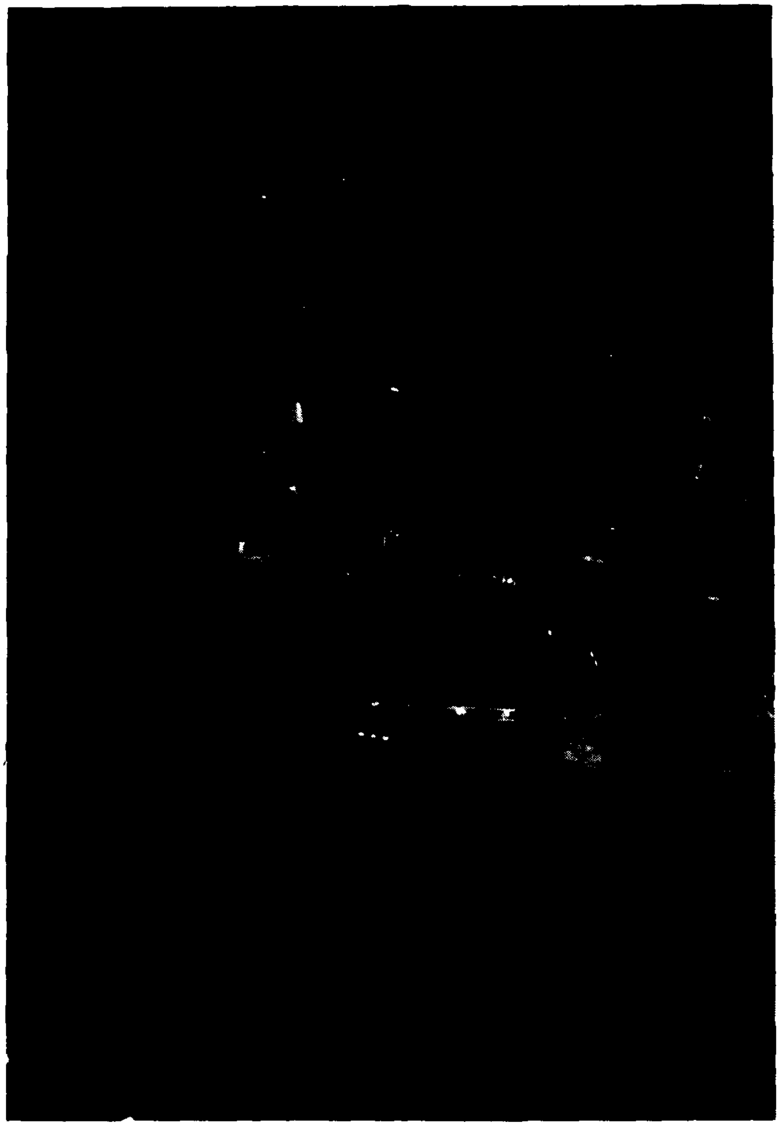


Photo 4. Visual Ice Accretion Probe Installed on Pilot's Door

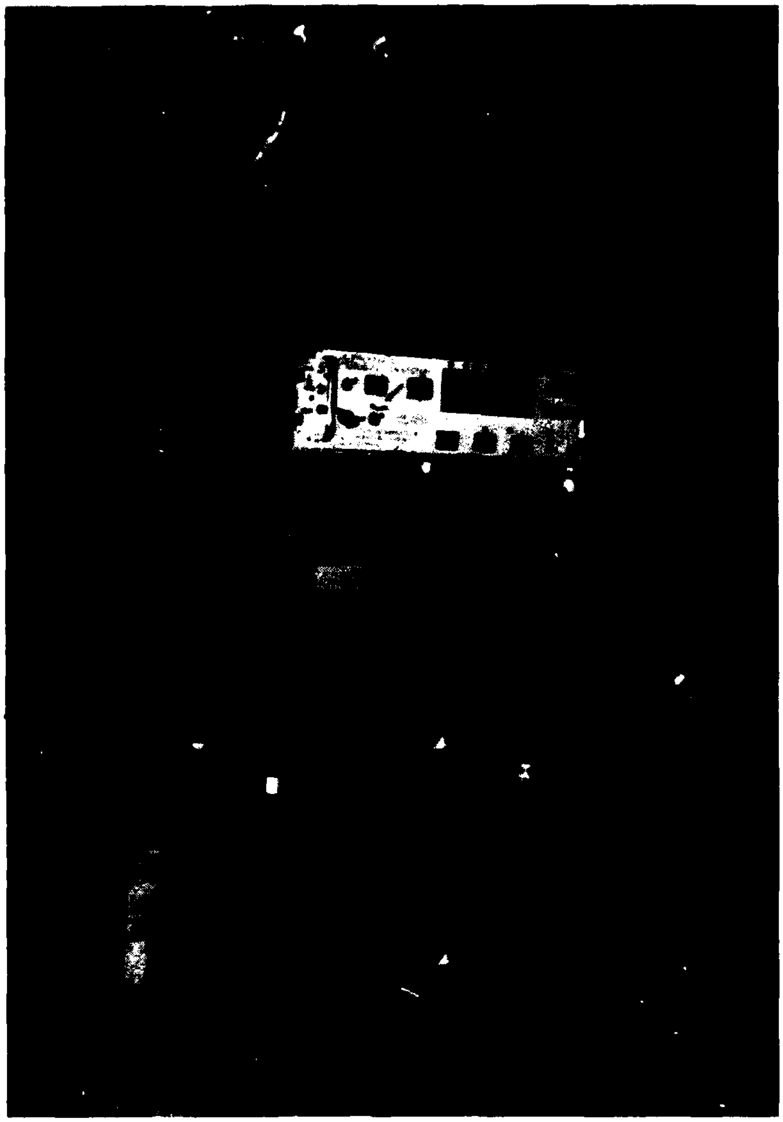


Photo 5. Meteorological Research Incorporated instrumentation Package

Photo 6. Axial Scattering Probe Installation

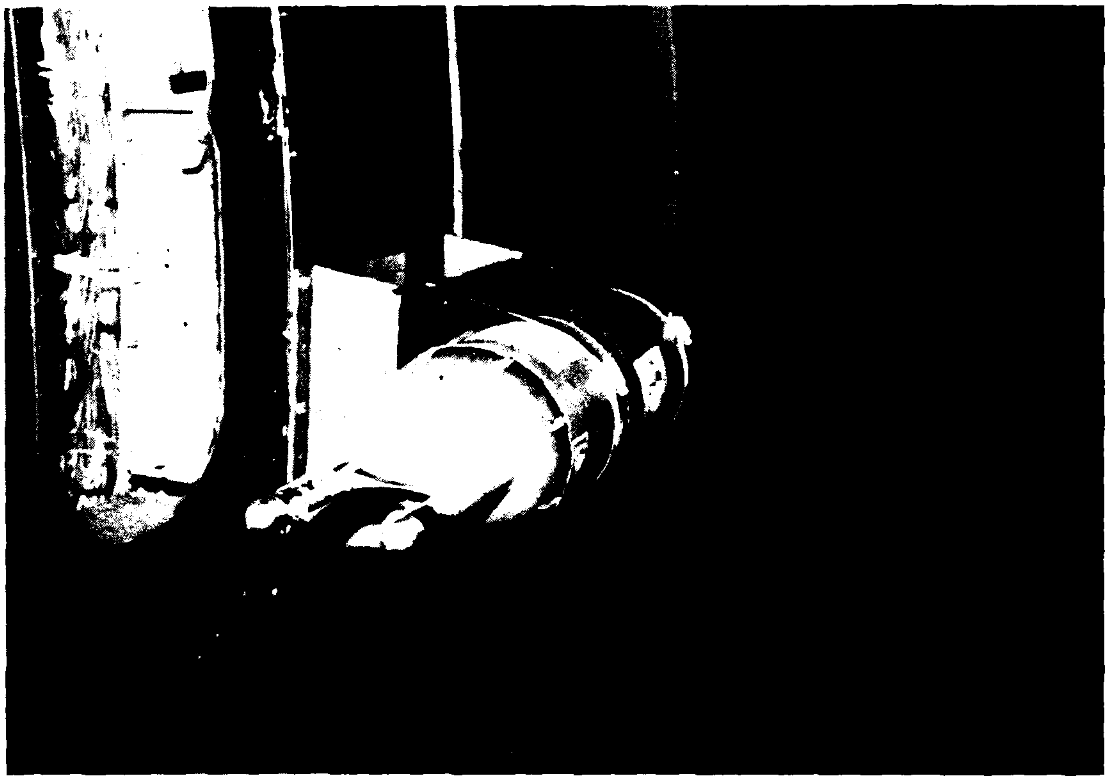


Photo 7. Cloud Particle Spectrometer Installation

APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

GENERAL

1. The deice system tested on the UH-60A was a production system. A buildup program was used to gain experience with flight in icing conditions. The procedure remained the same for each flight up to entry into the cloud. All anti-ice systems (*i.e.*, pitot heat, windshield anti-ice, engine, and engine air induction system anti-ice) were activated while enroute to the test area. The test aircraft then entered the artificial spray cloud from a position below and approximately 150 feet behind the spray aircraft. Test and spray aircraft separation distance was maintained during the icing flight by observing yellow (greater than 160 feet) and red (closer than 140 feet) lights mounted on a panel below the aft pylon above the spray aircraft cargo ramp. The visual indications were supplemented as required by information relayed from the spray aircraft. The magnetic tape recording system was activated periodically during natural and artificial cloud encounters. During artificial tests, airspeed and free air temperature (FAT), were established with the calibrated instrumentation system of the spray aircraft. All artificial flights were flown with a predetermined liquid water content (LWC) and FAT. Flight continued in the cloud condition until a test aircraft limitation was reached or until the spray aircraft fuel or water limit was reached. Vibration and performance parameters were monitored continuously during each flight.

ICE ACCRETION AND SHEDDING

2. Ice accretion was determined in flight using the visual ice accretion probe indicator. The visual probe was monitored by the copilot during flight in the cloud. The Rosemount icing rate meter was used to monitor LWC.

3. Ice accretion was documented using hand-held, high-speed motion picture cameras photographing from both the chase aircraft and spray aircraft. Postflight photographs were made to document the ice remaining on the individual components of the airframe and rotors. A description of the camera systems is presented in appendix C.

4. The icing severity was a function of time in the spray cloud, temperature, and LWC. The programmed icing severity was compared with the Rosemount detector. Ice accretion was measured in flight using the visual probe and high-speed photography. When practical, postflight ice accretions were measured immediately upon landing.

5. Ice shedding characteristics were qualitatively assessed by crew members in the test, spray, and chase aircraft.

ENGINE PERFORMANCE

6. Engine and engine inlet anti-ice system performance data were obtained in conjunction with the icing flights. The test aircraft was stabilized in trimmed level flight at the various test altitudes and temperatures. Testing was conducted with all anti-ice systems OFF for baseline data, then with all anti-ice systems ON. The cabin heater was turned on and the temperature controller was set to maximum on some test conditions.

7. The engine power required to operate the anti-ice/deice systems was also determined by measuring engine performance at various test conditions. Shaft horsepower was calculated using equation (1).

$$SHP = N_R \times Q \times K \times \frac{2\pi}{33{,}000} \qquad (1)$$

Where:

SHP = Calculated shaft horsepower (shp)

N_R = Main rotor rotational speed (rev/min)

Q = Engine output shaft torque (ft-lb)

K = Gearing constant between engine and main rotor (76.05)

8. Data on SHP, turbine gas temperature (TGT), fuel flow (W_f), and gas generator speed (N_G) were referred as follows:

a. Referred SHP (RSHP):

$$RSHP = SHP/\delta_1\sqrt{\theta_1} \qquad (2)$$

b. Referred gas temperature (RGAST):

$$RGAST = \frac{TGT + 273.15}{(\theta_1)^{0.96}} - 273.15\ (^\circ C) \qquad (3)$$

c. Referred fuel flow (RW_f):

$$RW_f = \frac{W_f}{(\delta_1)(\theta_1)^{0.50}} \text{(lb/hr)} \qquad (4)$$

d. Referred gas generator speed (RN_G):

$$RN_G = \frac{N_G}{(\delta_1)^{0.50}} (\%) \qquad (5)$$

Where:

$\delta = [1 - (6.875586 \times 10^{-6})(H_p)]^{5.25585}$ = pressure ratio

H_p = Test pressure altitude (ft)

$$\theta_1 = \frac{OAT_{static} + 27315}{288.15} = \text{temperature ratio}$$

OAT_{static} = Test static air temperature (°C)

TGT = Turbine gas temperature (°C)

W_f = Engine fuel flow (lb/hr)

N_G = Gas producer speed referenced to 44,700 rpm (percent)

WEIGHT AND BALANCE

9. Prior to testing, the aircraft gross weight, longitudinal and lateral cg were determined by using calibrated scales. The longitudinal cg was calculated by a summation of moments about a reference datum line (FS 0.0). The aircraft was weighed empty, which included instrumentation minus fuel.

DEFINITIONS

10. Icing characteristics were described using the following definitions of icing types and severity.

a. Icing type definitions:

(1) Rime ice: An opaque granular deposit of ice formed by the rapid freezing of small supercooled water droplets.

(2) Clear ice: A semitransparent smooth deposit of ice formed by the slower freezing of larger supercooled water droplets.

(3) Glime ice: A mixture of clear ice and rime ice.

b. Icing severity definitions:

(1) Trace icing: Ice becomes perceptible. Rate of accumulation slightly greater than rate of sublimation. It is not hazardous even though deicing equipment is not used, unless encountered for an extended period of time (over 1 hour).

(2) Light icing: The rate of accumulation may create a problem if flight is prolonged in this environment (over 1 hour). Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if the deicing/anti-icing equipment is used.

(3) Moderate icing: The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or diversion is necessary.

(4) Severe icing: The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate diversion is necessary.

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

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 an item or part, which seriously impairs the equipment's operational capability. A deficiency normally disables or immobilizes the equipment; and if occurring during test phases, will serve as a bar to type classification action.

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. If occurring during test phases, the shortcoming should be corrected if it can be done without unduly complicating the item or inducing another undesirable characteristic such as increase cost, weight, etc.

APPENDIX E. TEST DATA

INDEX

Table 1. Specific Test Conditions

Flight No.	Environment	Ave Gross Weight (lb)	Ave Long. CG (FS)	Ave Density Altitude (ft)	Ave FAT (°C)	Ave[1] Rosemount Indicated LWC (gm/m^3)	Maximum[1] Rosemount Indicated LWC (gm/m^3)	Ave TAS (KTAS)	Total Time In Cloud (min)	Ice Accreted On Visual Probe (in.)
1	Artificial	16,700	352.7	2740	-7.0	1.00	1.00	118	50	N/A[2]
2	Artificial	16,760	353.0	3540	-7.5	1.00	1.00	120	50	N/A
5	Artificial	16,500	352.0	4140	-15.0	0.60	0.60	122	78	N/A
6	Artificial	16,600	352.3	1400	-15.0	0.60	0.60	117	84	N/A
8	Artificial	17,040	354.1	7780	-6.0	1.00[3]	1.00[3]	122	50	N/A
9	Natural	16,940	353.6	2640	-6.0	0.34	0.78	141	114	2.5
10	Artificial	16,500	351.7	-1500	-20.0	0.25[3]	0.25[3]	116	66	N/A
11	Artificial	16,500	351.8	3920	-13.0	0.75[3]	0.75[3]	114	72	N/A
12	Natural	16,800	353.0	2400	-9.0	0.44	0.54	128	96	4.0
13	Natural	16,760	352.8	2480	-9.5	0.29	0.33	106	108	3.5
15	Artificial	17,200	354.6	-100	-22.0	0.25[3]	0.25[3]	120	72	N/A
16	Artificial	17,100	354.1	-560	-21.5	0.75[3]	0.75[3]	111	72	N/A
17	Artificial	16,740	352.9	1560	-10.0	1.00	1.00	116	60	N/A
18	Artificial	16,660	352.6	2460	-13.0	1.00	1.00	118	48	N/A
19	Artificial	17,360	355.2	-460	-19.0	1.00	1.00	115	24	N/A
21	Artificial	17,100	354.2	4360	-7.0	1.00[3]	1.00[3]	118	48	N/A
22	Artificial	17,140	354.3	6880	-7.0	–[4]	–[4]	90 119	20 20	N/A

NOTES:

[1] Programmed LWC indicated for artificial icing flights.
[2] Location of the visual probe precluded it from exposure to the spray cloud during artificial icing.
[3] Additionally, sweeps of the HISS *cloud* at 0.25, 0.50, 0.75, and 1.00 gm/m^3 LWC were accomplished on these flights.
[4] Sweeps of the HISS cloud at 0.25, 0.50, 0.75, and 1.00 gm/m^3 LWC were accomplished on these flights.

FIGURE 1

ARTIFICIAL ICING TEST CONDITIONS

FREE AIR TEMPERATURE (DEG C)	LIQUID WATER CONTENT (GRAMS/CUBIC METER)			
	0.25	0.5	0.75	1.0
- 5				1X,4
-10			2X	3X,4 5X
-15		4		
-20	3,4,5			

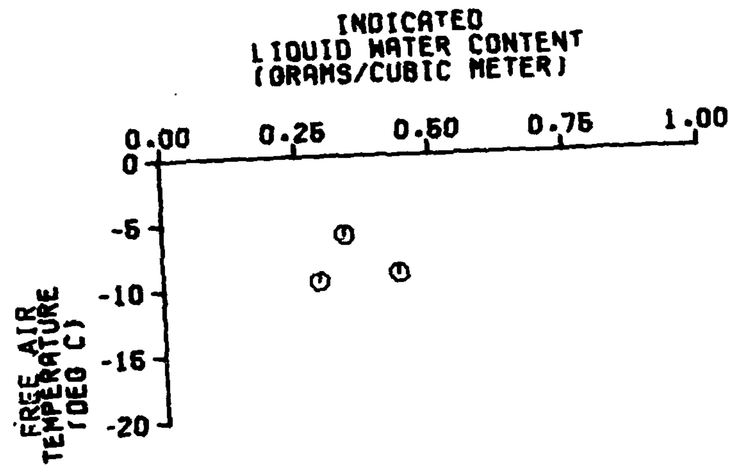
NOTE: AVERAGE AIRSPEED 120 KTAS,GROSS WEIGHT 16900 LB, ROTOR SPEED 258 RPM,LONG CG FS 353.4 (MID),AND ALL ANTI-ICE AND DE-ICE SYSTEMS "ON"

DROOP STOP CONFIGURATIONS

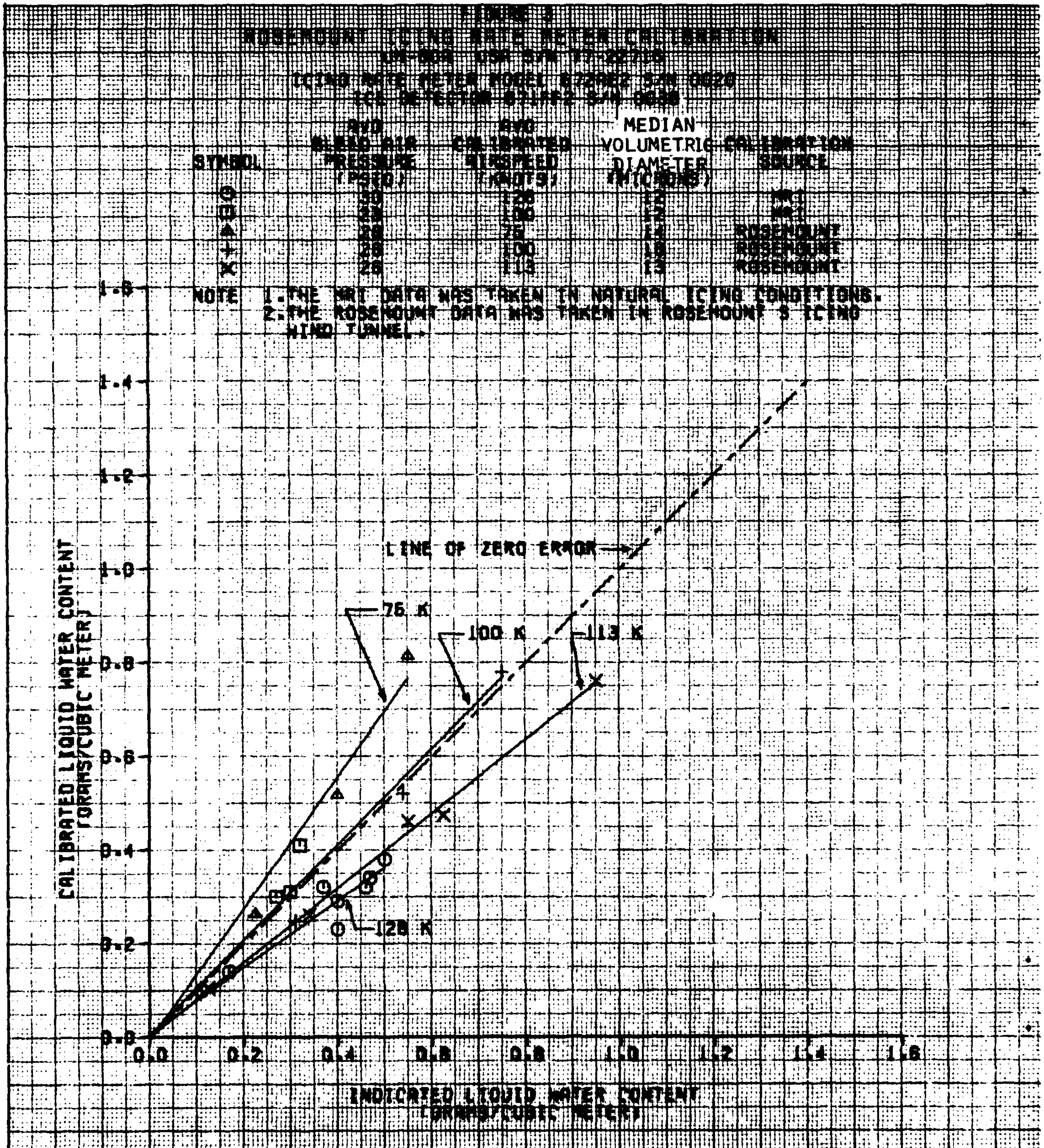
1) PRODUCTION WITH 231 WATT HEATERS
2) PRODUCTION WITH 300 WATT HEATERS
3) PRODUCTION WITH 300 WATT HEATERS AND NO RUBBER BUMPER
4) GCT WITH 300 WATT HEATERS
5) GCT NO HEATERS
\) UNSATISFACTORY DROOP STOP OPERATION

FIGURE 2

NATURAL ICING TEST CONDITIONS



NOTE ROTOR SPEED = 258 RPM
AVG GROSS WEIGHT = 16840 LBS
AIR SPEED 106 TO 141 KTAS
AVG CG FS 353.1 IN
EACH CONDITION AT LEAST 1.5 HRS
GCT DROOP STOPS WITH 300 WATT HEATERS



ROSEMOUNT ICING RATE METER CALIBRATION
MEDIAN VOLUMETRIC DIAMETER (MICRONS)
SYMBOL
AVG BLEED AIR PRESSURE (PSIG)
AVG CALIBRATED AIRSPEED (KNOTS)
CALIBRATION SOURCE
ROSEMOUNT
NOTE 1. THE NRT DATA WAS TAKEN IN NATURAL ICING CONDITIONS.
2. THE ROSEMOUNT DATA WAS TAKEN IN ROSEMOUNT'S ICING WIND TUNNEL.
LINE OF ZERO ERROR
75 K
100 K
113 K
128 K
CALIBRATED LIQUID WATER CONTENT (GRAMS/CUBIC METER)
INDICATED LIQUID WATER CONTENT (GRAMS/CUBIC METER)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6

FIGURE 4

INLET SURFACE TEMPERATURE CHARACTERISTICS

UH-60A USA S/N 77-22716

T700-GE-700 S/N 207811 (RIGHT)

SYMBOL	AVG DENSITY ALTITUDE (FEET)	AVG AMBIENT TEMPERATURE (DEG C)	AVG TRUE AIRSPEED (KNOTS)
⊙	6880	-1.5	102
⊡	9560	-6.5	104
▲	12760	-12.0	105
+	3000	-17.5	102
X	7800	-20.5	104

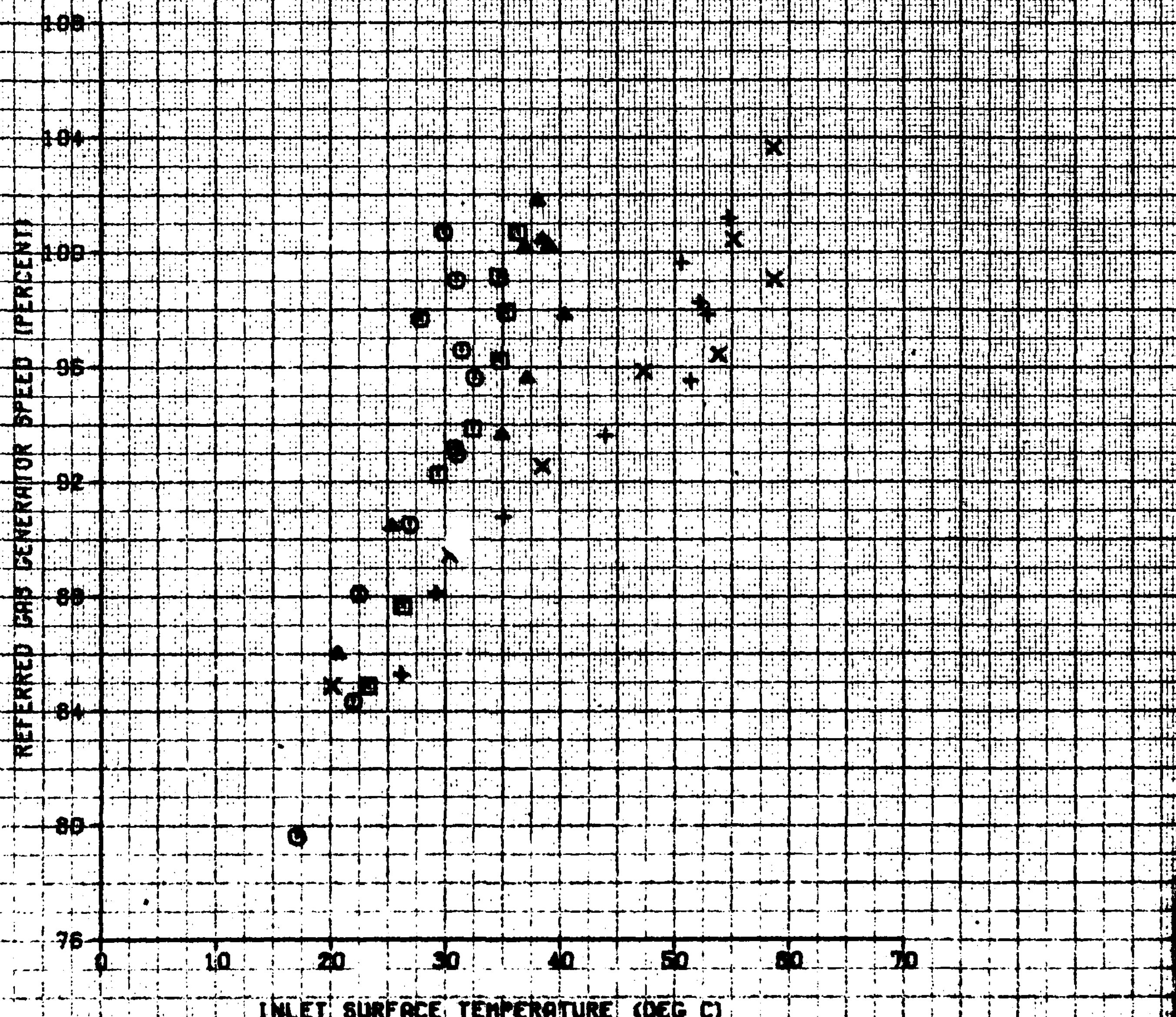


FIGURE 6
BLADE DE-ICE CYCLE
UH-60A USA S/N 77-22716

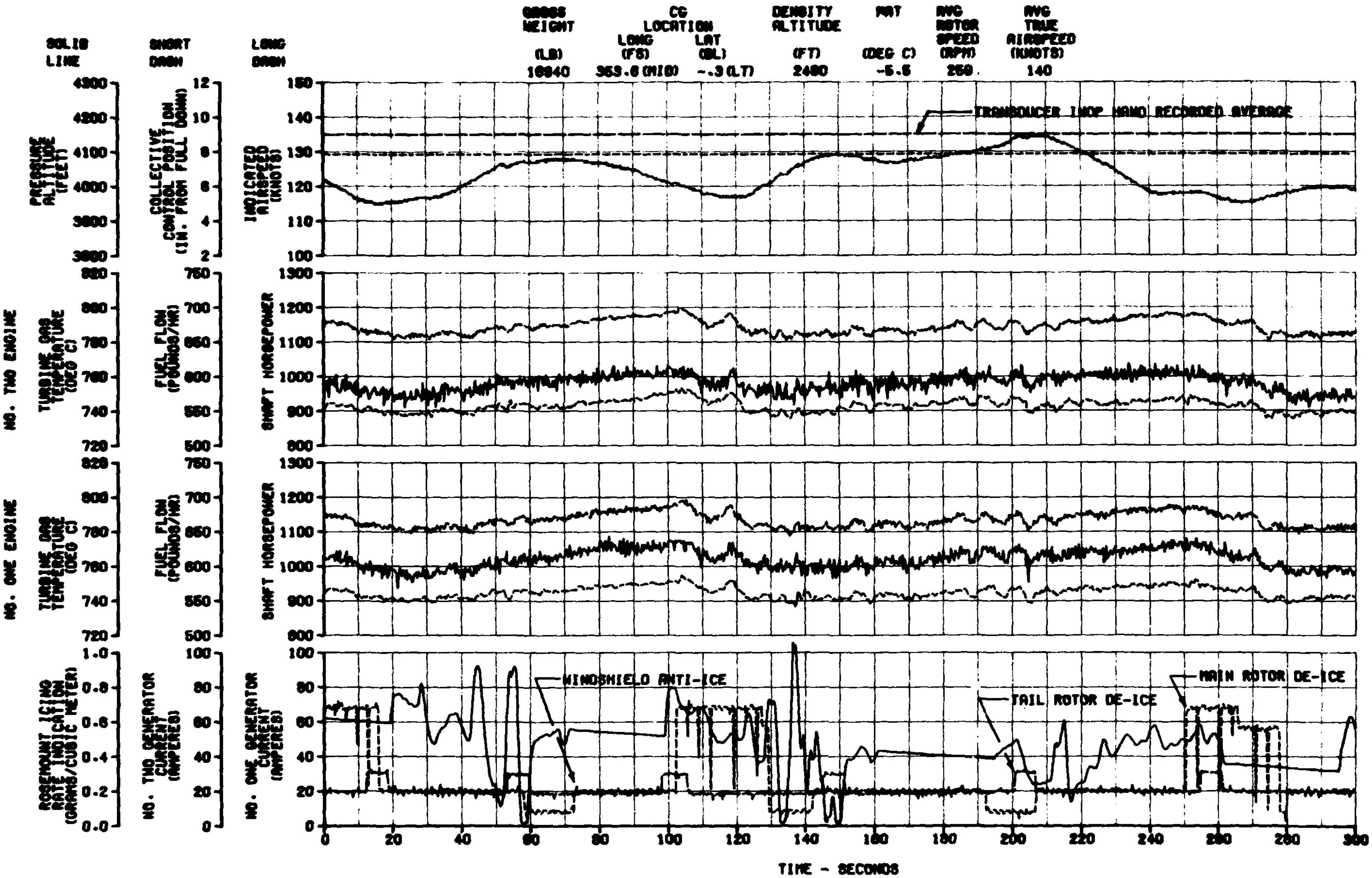


FIGURE 6
BLADE DE-ICE CYCLE
UH-60A USA S/N 77-22716

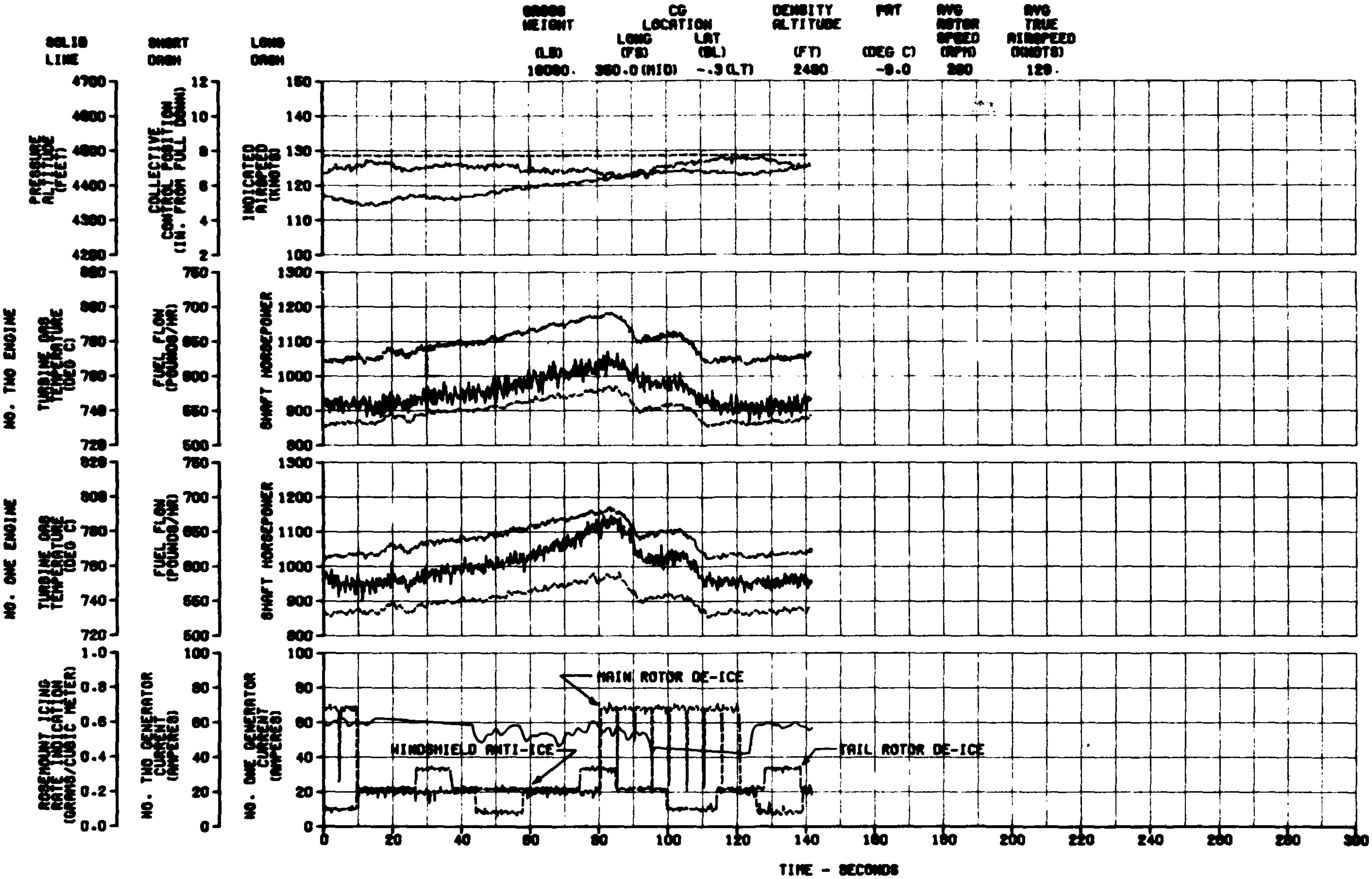
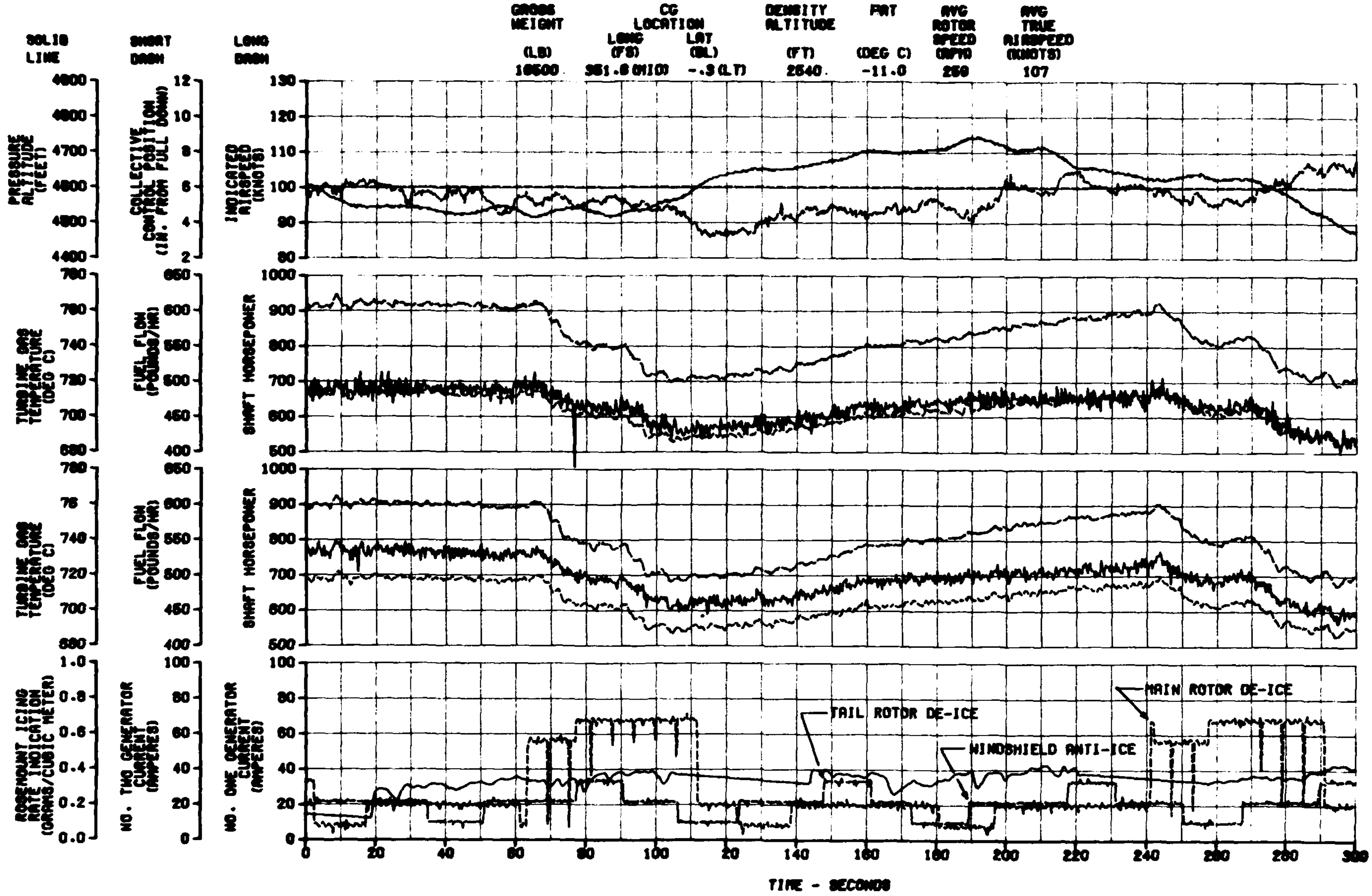
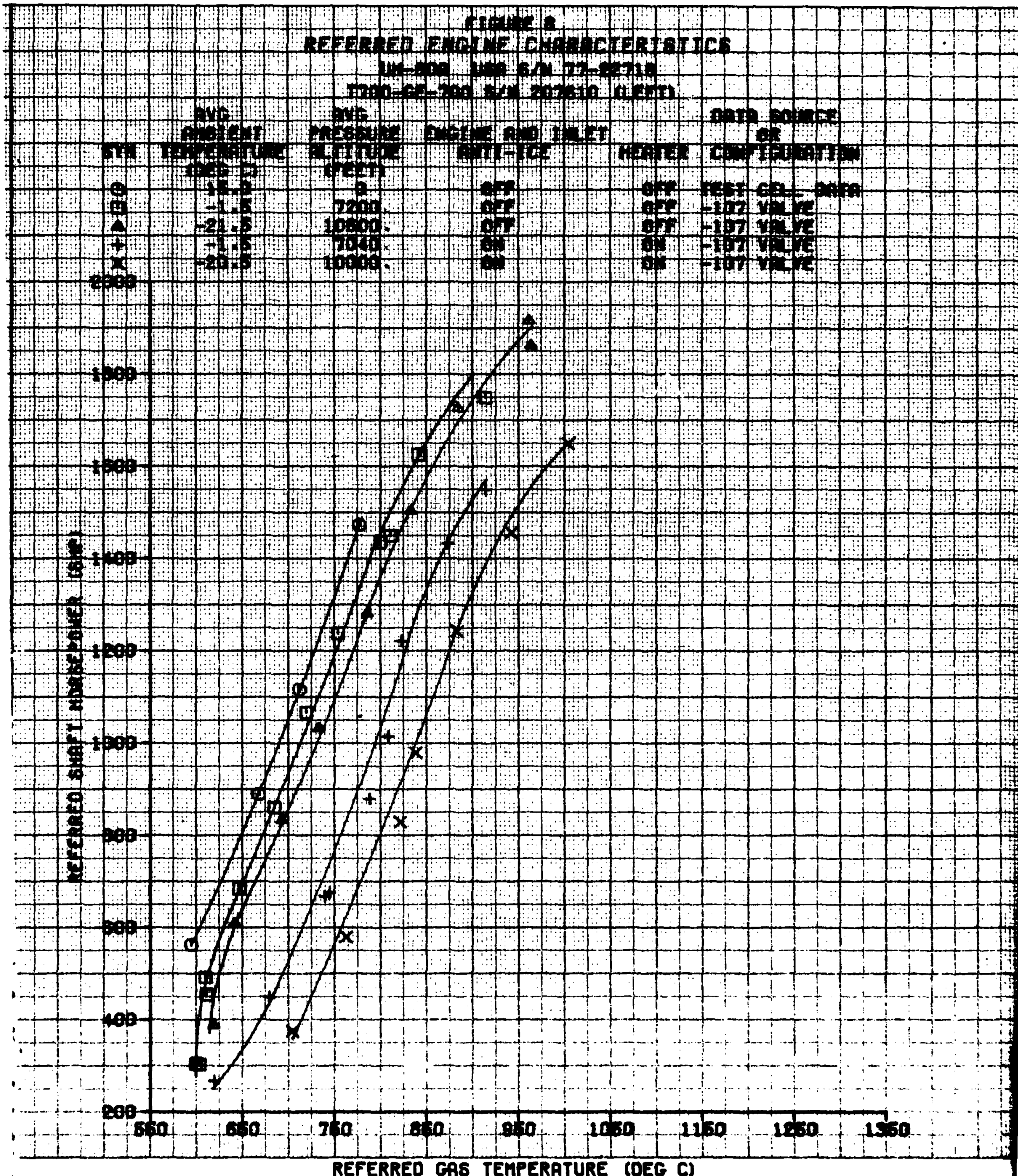


FIGURE 7
BLADE DE-ICE CYCLE
UH-60A USA S/N 77-22716




REFERRED ENGINE CHARACTERISTICS
-1.5
7200.
-21.5
10800.
-1.5
7040.
OFF
ON
-107 VALVE
200
REFERRED GAS TEMPERATURE (DEG C)

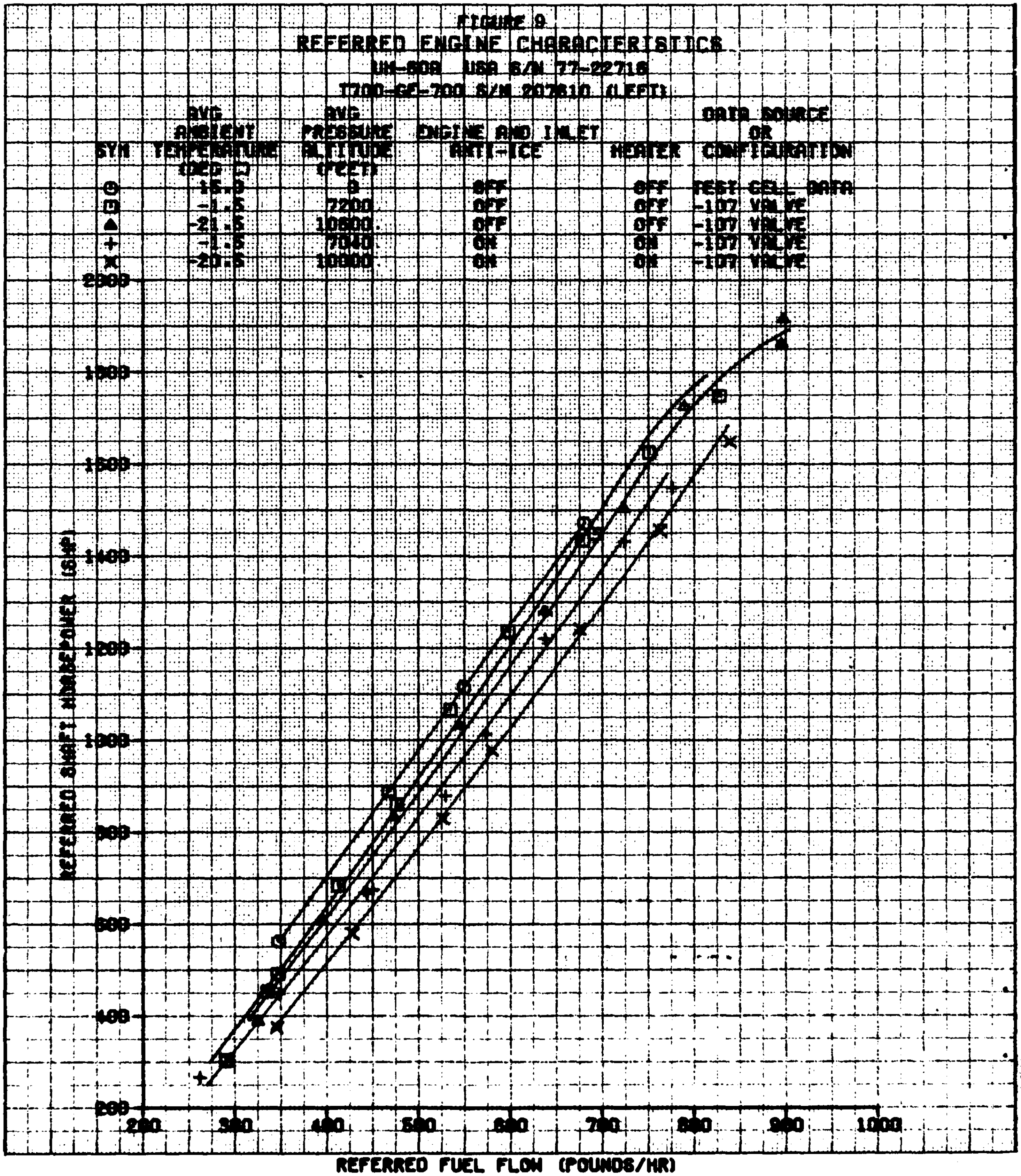


FIGURE 9
REFERRED ENGINE CHARACTERISTICS
UH-60A USA S/N 77-22716
T700-GE-700 S/N 207610 (LEFT)
SYM
AVG AMBIENT TEMPERATURE (DEG C)
AVG PRESSURE ALTITUDE (FEET)
ENGINE AND INLET ANTI-ICE
HEATER
DATA SOURCE OR CONFIGURATION
15.0 0 OFF OFF TEST CELL DATA
-1.5 7200 OFF OFF -107 VALVE
-21.5 10600 OFF OFF -107 VALVE
-1.5 7040 ON ON -107 VALVE
-20.5 10000 ON ON -107 VALVE
2000
1800
1600
1400
1200
1000
800
600
400
200
200
300
400
500
600
700
800
900
1000
REFERRED SHAFT HORSEPOWER (SHP)
REFERRED FUEL FLOW (POUNDS/HR)

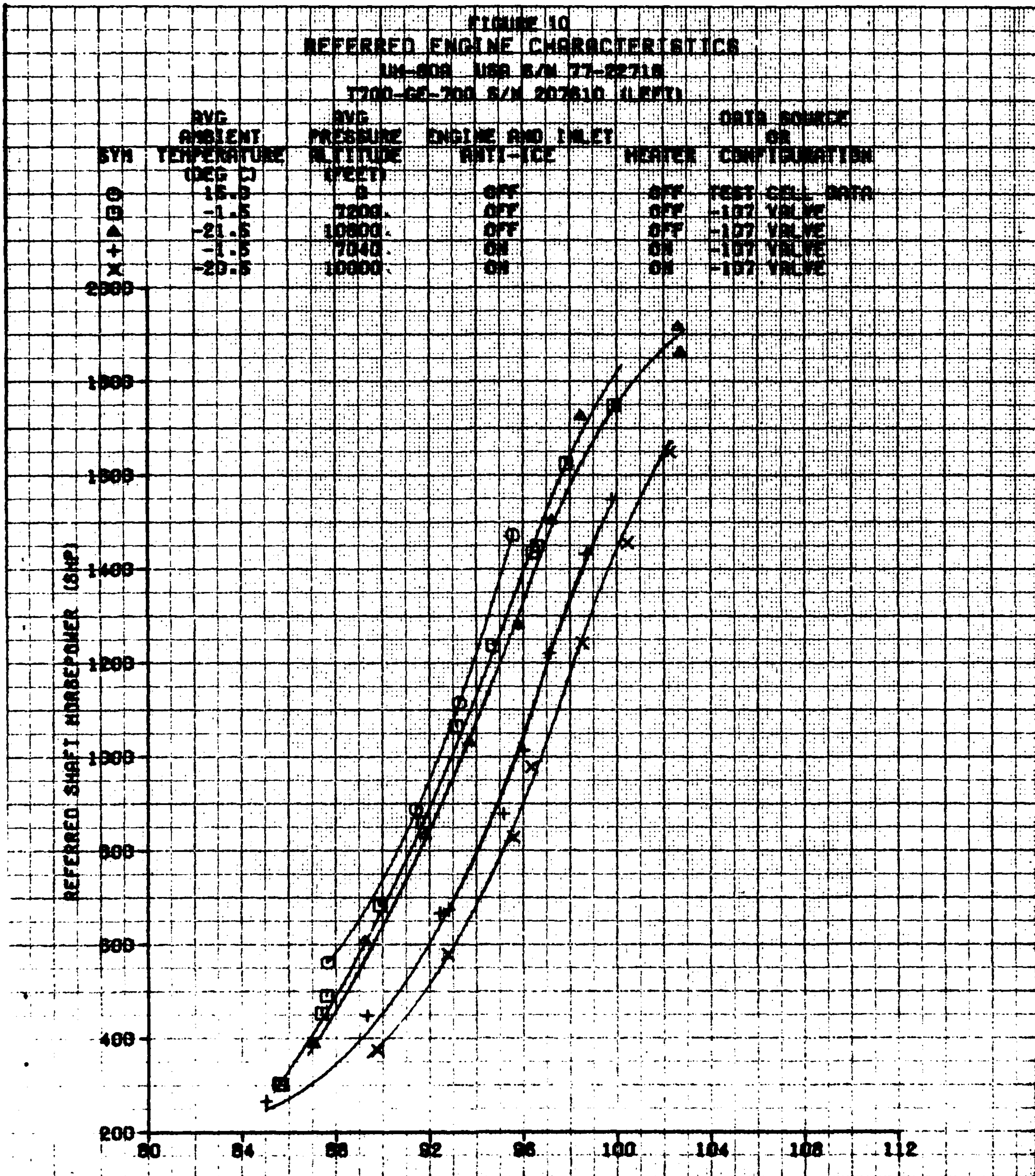
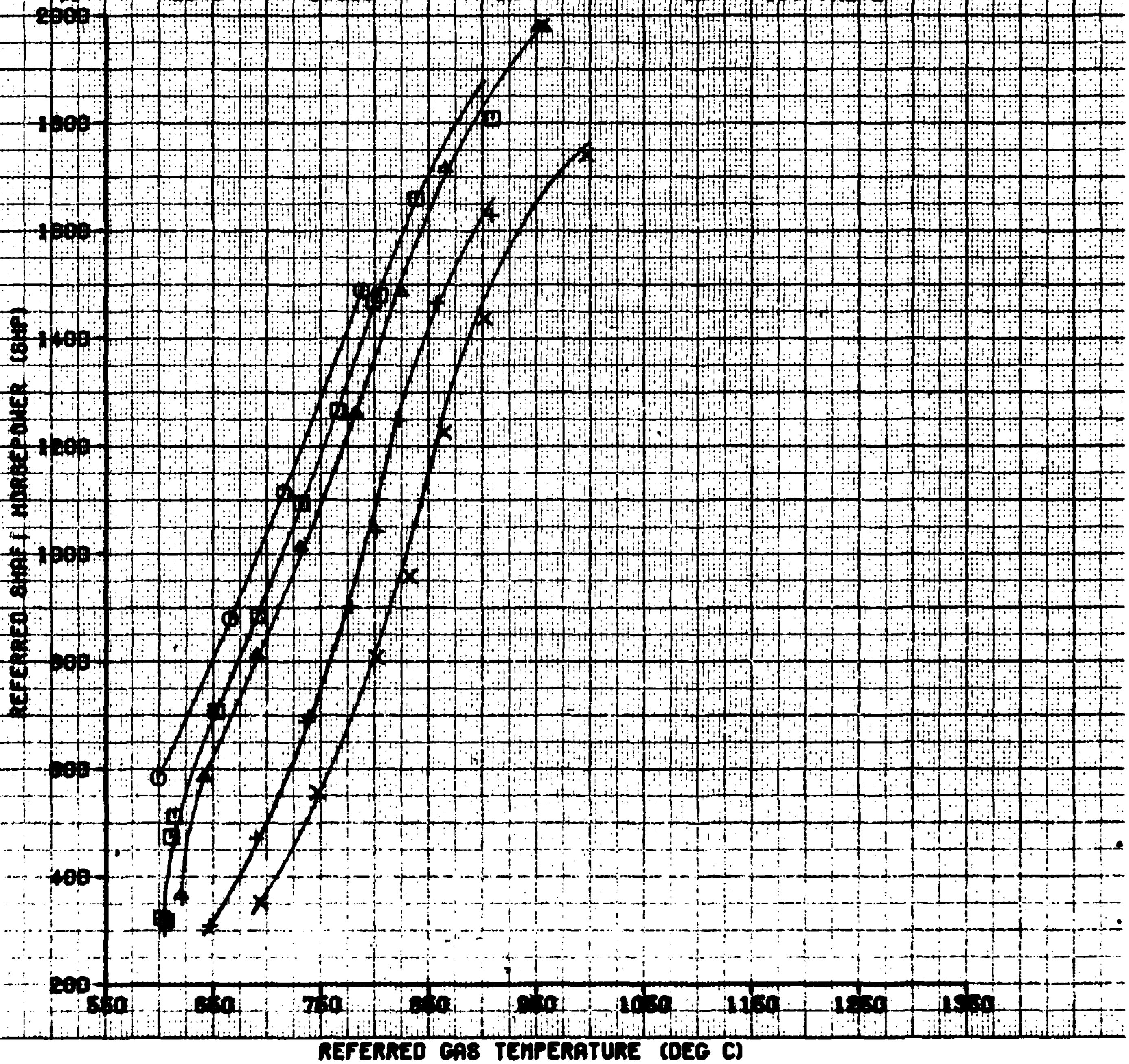


FIGURE 10
REFERRED ENGINE CHARACTERISTICS
UH-60A USA S/N 77-22716
T700-GE-700 S/N 207810 (LEFT)
SYM
AVG AMBIENT TEMPERATURE (DEG C)
AVG PRESSURE ALTITUDE (FEET)
ENGINE AND INLET ANTI-ICE
HEATER
DATA SOURCE OR CONFIGURATION
15.0
0
OFF
OFF
TEST CELL DATA
-1.5
7200
OFF
OFF
-107 VALVE
-21.5
10800
OFF
OFF
-107 VALVE
-1.5
7040
ON
ON
-107 VALVE
-20.5
10000
ON
ON
-107 VALVE
REFERRED SHAFT HORSEPOWER (SHP)
REFERRED GAS GENERATOR SPEED (PERCENT)

FIGURE 11
REFERRED ENGINE CHARACTERISTICS
UH-60A USA S/N 77-22716
T700-GE-700 S/N 207611 (RIGHT)

SYM	AVG AMBIENT TEMPERATURE (DEG C)	AVG PRESSURE ALTITUDE (FEET)	ENGINE AND INLET ANTI-ICE	HEATER	DATA SOURCE OR CONFIGURATION
⊙	15.0	0	OFF	OFF	TEST CELL DATA
⊡	-1.5	7200	OFF	OFF	-107 VALVE
▲	-21.5	10600	OFF	OFF	-107 VALVE
+	-1.5	7040	ON	ON	-107 VALVE
X	-20.5	10000	ON	ON	-107 VALVE



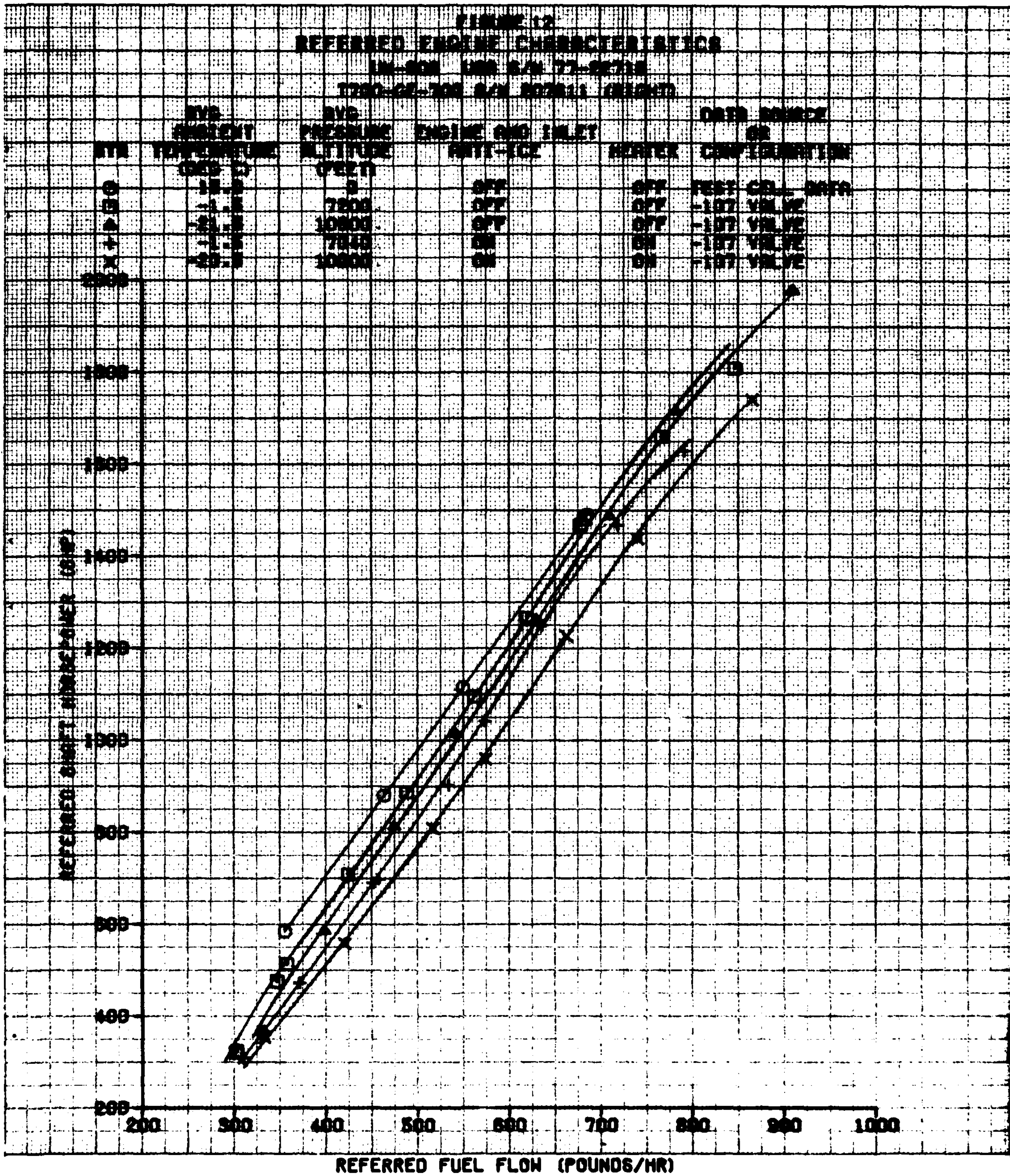


FIGURE 12
REFERRED ENGINE CHARACTERISTICS
DATA SOURCE
ENGINE AND INLET
ANTI-ICE
HEATER
CONFIGURATION
0 OFF OFF TEST CELL DATA
7200 OFF OFF -107 VALVE
10000 OFF OFF -107 VALVE
7040 ON ON -107 VALVE
10000 ON ON -107 VALVE
200
400
600
800
1000
1200
1400
1600
1800
300
500
700
900
1000
REFERRED FUEL FLOW (POUNDS/HR)

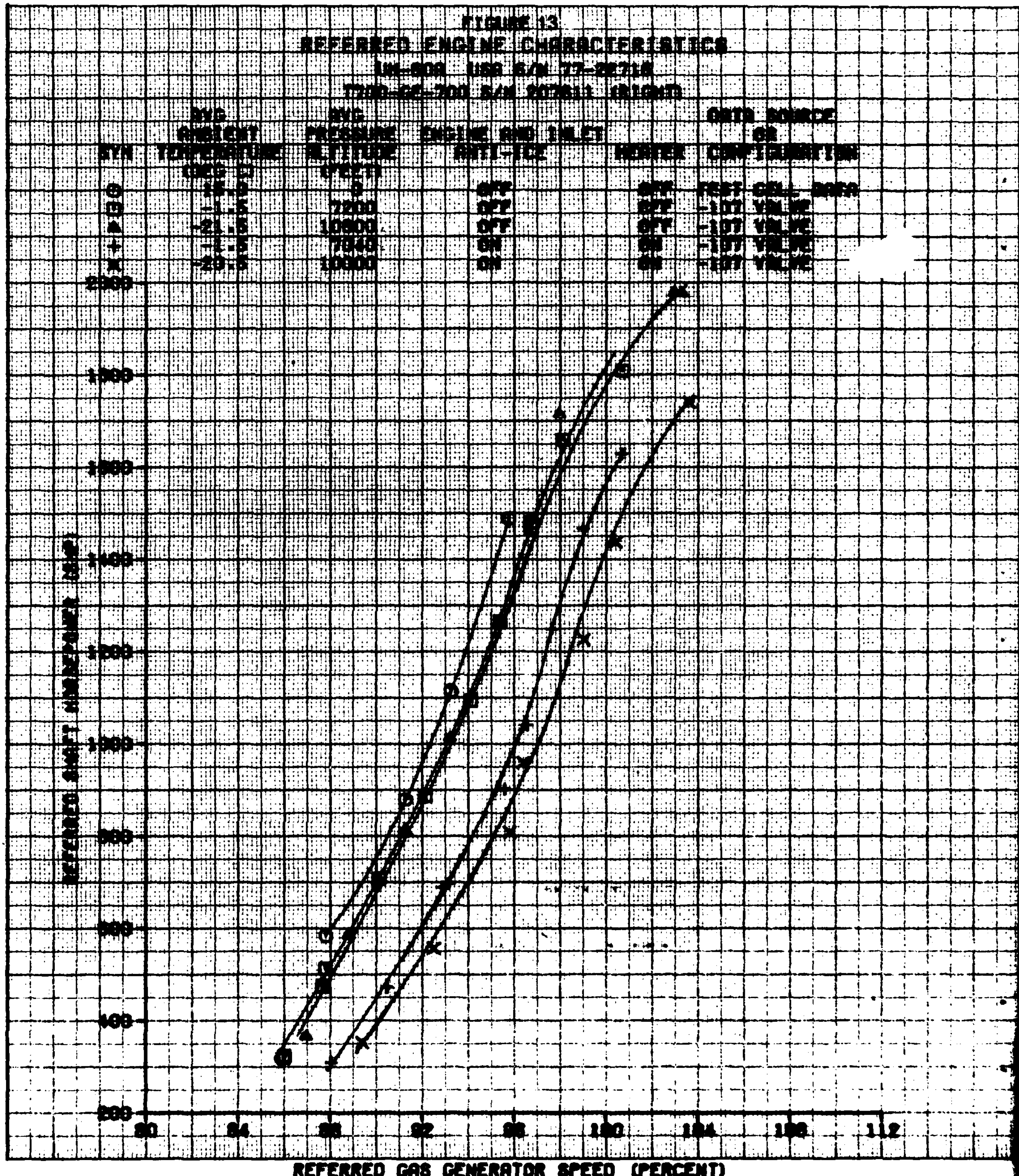


FIGURE 13
REFERRED ENGINE CHARACTERISTICS
80
84
88
92
96
100
104
108
112
REFERRED GAS GENERATOR SPEED (PERCENT)

APPENDIX F. EQUIPMENT PERFORMANCE REPORTS

The following Equipment Performance Reports (EPR) SAV Form 1002, 1 May 1976, were submitted during the conduct of this evaluation.

EPR Number	Subject
80-14-01	Windshield anti-ice controller failure
80-14-02	Main rotor deice/ADF noise
80-14-03	Torn main rotor deice helical wiring
80-14-04	Broken support clamps - main rotor deice wiring
80-14-05	Chaffed droop stop heater distributor wire
80-14-06	Droop stop icing (Production w/rubber, 231 watt heater)
80-14-07	Anti-flapping restrainer icing
80-14-08	BIM indicator
80-14-09	Windshield anti-ice controller failure
80-14-10	Ice shed damage to upper Anti-collision Light
80-14-11	Gouge in tail rotor blade
80-14-12	BIM indicator
80-14-13	Ice shed damage to upper Anti-collision Light
80-14-14	Droop stop icing (Production w/rubber, 300 watt heater)
80-14-15	Dents in nose door assembly
80-14-16	Cracks in stabilator
80-14-17	Cracked anti-flap assembly
80-14-18	BIM indicator
80-14-19	Droop stop icing (GCT without heater)
80-14-20	Droop stop icing (Production w/o rubber, 300 watt heaters)
80-14-21	BIM indicator
80-14-22	Cracked copilot's windshield

EQUIPMENT PERFORMANCE REPORT

DATE	5 January 1981
	DAVTE-TB

TO	FROM
COMMANDER US ARMY AVIATION SYSTEMS COMMAND ATTN: DRSAV-ED PO BOX 209 ST LOUIS, MISSOURI 63166	Commander US Army Aviation Engineering Flight Actv ATTN: DAVTE-TB Stop 217 Edwards AFB, CA 93523

EPR NUMBER	PROJECT NUMBER	TEST TITLE
80-14-1	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

ITEM	UH-60A	SERIAL NO	77-22716
QUANTITY	1	MANUFACTURER	Sikorsky

SECTION B - PART DATA

NOMENCLATURE DESCRIPTION: Windshield Anti-Ice Controller	NSN: 1560-01-H62-1777
MFR PART NO: 70550-02024-103	MANUFACTURER: Sikorsky
QUANTITY: One	NEXT ASSEMBLY: --

SECTION C - INCIDENT DATA

TEST ENVIRONMENT	INCIDENT CLASS	ACTION TAKEN
Ferry Flight Cruise, 140KIAS, 20°C	a. DEFICIENCY X b. SHORTCOMING c. SUGGESTED IMPROVEMENT d. OTHER	X REPLACED REPAIRED ADJUSTED DISCONNECTED REMOVED NONE

TIME AND DATE OF INCIDENT: 1230, 19 Dec 80

SECTION D - INCIDENT DESCRIPTION

(Deficiencies and Shortcomings are subject to reclassification)

Pilot's windshield anti-ice controller did not heat the two inboard panels of pilot's windshield. The outboard panel was lightly heated. When switched to copilot's side, controller again failed to function properly. Lack of windshield anti-ice capability would impair the pilot/copilot's field of view after an icing encounter. Replaced controller.

TYPED NAME AND TITLE OF PREPARER	SIGNATURE
MARVIN L. HANKS, MAJ Project Officer, USAAEFA Proj. No. 80-14	Marvin L. Hanks

SAV Form 1002, 1 Nov 76 — Edition of 1 Aug 74, may be used.

5 January 1981

EQUIPMENT PERFORMANCE REPORT

DAVTE-TB

TO: COMMANDER, US ARMY AVIATION SYSTEMS COMMAND, ATTN: DRDAV-EQ, PO BOX 209, ST. LOUIS, MISSOURI 63166

FROM: Commander, US Army Aviation Engineering Flight Activity, ATTN: DAVTE-TB Stop 217, Edwards AFB, CA 93523

EPR Number	Project Number	Test Title
80-14-2	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

Unit: UH-60A	Serial No.: 77-22716
Quantity: 1	Manufacturer: Sikorsky

SECTION B - PART DATA

Nomenclature/Description: Direction finder set (AN/ARN-89 (LF/ADF)	NSN: 5826-00-790-6426
R-1496 (ARN-89)	Manufacturer: Sikorsky
Quantity: One	Next Assembly: ----

SECTION C - INCIDENT DATA

Test Environment	Incident Class	Action Taken
Ferry flight Cruise - 140 KIAS 8.4 hours total Clear, - 20°C	X b. Shortcoming	X None

Time and date of incident: 1500, 19 December 1980

SECTION D - INCIDENT DESCRIPTION

A continuous electrical interference in the form of static was noted in the Direction Finder Set AN/ARN-89 (LF/ADF) when the main rotor de-ice system was turned on. The static was discernible when tuned to a weak station and only on certain frequencies. No interference was noted in the reliability of the HSI No. 2 needle.

MARVIN L. HANKS, MAJ
Project Officer, USAAEFA Proj. No. 80-14

Signature: Marvin L. Hanks

DAV Form 1002

Edition of 1 Aug 74, may be used.

5 January 1981

DAVTE-TB

EQUIPMENT PERFORMANCE REPORT

TO
COMMANDER
US ARMY AVIATION SYSTEMS COMMAND
ATTN: DRDAV-EQ
PO BOX 209
ST LOUIS, MISSOURI 63166

FROM
Commander
US Army Aviation Engineering Flight Activity
ATTN: DAVTE-TB Stop 217
Edwards AFB, CA 93523

EPR NUMBER	PROJECT NUMBER	TEST TITLE
80-14-3	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

UH-60A	SERIAL NO 77-22716
	MANUFACTURER Sikorsky

SECTION B - PART DATA

NOMENCLATURE DESCRIPTION: Helical Wiring Main Rotor De-Ice Distributor

NSN: --

MFR PART NO: 70550-02127-102

MANUFACTURER: Sikorsky

QUANTITY: One

NEXT ASSEMBLY: 70550-02127-102 Distributor Box, Blade De-Ice System

SECTION C - INCIDENT DATA

X b.	Ferry flight Cruise - 140 KIAS 8.4 hours total Clear -20°C	a. DEFICIENCY X b. SHORTCOMING c. SUGGESTED IMPROVEMENT d. OTHER	REPLACED X REPAIRED ADJUSTED DISCONNECTED REMOVED NONE

2100, 19 December 1980

SECTION D - INCIDENT DESCRIPTION

(Deficiencies and Shortcomings are subject to reclassification)

Black covering on helical wiring harness from main rotor distributor to yellow blade was torn approximately two inches lengthwise near the midpoint where clamp attached to top of rotor hub above blade attaching point. The tear could expose the wiring harness to weather conditions which would cause deterioration and a possible main rotor de-ice system failure.

MARVIN L. HANKS, MAJ
Proj Officer, USAAEFA Proj. No. 80-14

SIGNATURE: Marvin L. Hanks

AV Form 1002

Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT

5 January 1981

DAVTE-TB

TO	FROM
Commander US Army Aviation Systems Command ATTN: DRSAV-EQ PO Box 209 St Louis, Missouri 63166	Commander US Army Aviation Engineering Flight Activity ATTN: DAVTE-TB Stop 217 Edwards AFB, CA 93523

EPR NUMBER	PROJECT NUMBER	TEST TITLE
80-14-4	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

MODEL: UH-60A	SERIAL NO: 77-22716
QUANTITY: 1	MANUFACTURER: Sikorsky

SECTION B - PART DATA

NOMENCLATURE/DESCRIPTION: Clamps	NSN: --
MFR PART NO: TA02313PN12T	MANUFACTURER: Sikorsky
QUANTITY: Two	NEXT ASSEMBLY: 70550-02127-102 Distributor Box, Blade De-ice System Assembly

SECTION C - INCIDENT DATA

TIME OF OCCURRENCE	TEST ENVIRONMENT	INCIDENT CLASS	ACTION TAKEN
X a. DURING OPERATION	Ferry flight	a. DEFICIENCY	X REPLACED
X b. ...	Cruise - 140 KIAS	X b. SHORTCOMING	REPAIRED
c.	8.6 hours total	c. SUGGESTED IMPROVEMENT	ADJUSTED
	Clear -20°C	d. OTHER	DISCONNECTED
			REMOVED
			NONE

DATE AND TIME OF INCIDENT: 2100, 19 December 1980

SECTION D - INCIDENT DESCRIPTION

(Deficiencies and shortcomings are subject to reclassification)

Clamps which hold the wiring harness from the main rotor distributor to the blades were found broken following an 8.4 hour ferry flight from Connecticut to St. Paul, Minnesota. The broken clamps were mounted on top of the main rotor hub above the blade attaching point on the red and yellow rotor blades. They were broken at the first bend in the clamp closest to the screw attaching point. Replaced with a special built-up clamp (Part No. TA 0230027).

TYPED NAME AND TITLE	SIGNATURE
MARVIN L. HANKS, MAJ Project Officer, USAAEFA Proj. No. 80-14	Marvin L. Hanks

SAV Form 1002, Mar 76. Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT

5 January 19[illegible]

DAVTE-TB

TO	FROM
COMMANDER US ARMY AVIATION SYSTEMS COMMAND ATTN DRSAV-EQ PO BOX 209 ST LOUIS, MISSOURI 63166	Commander US Army Aviation Engineering Flight Activity ATTN: DAVTE-TB Stop 217 Edwards AFB, CA 93523

EPR NUMBER	PROJECT NUMBER	TEST TITLE
80-14-5	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

UH-60A	77-22716
1	Sikorsky

SECTION B - PART DATA

Droop Stop Heater Distributor Wire	MIL-W-16878/5FE 20AWG
--	Sikorsky
Four	70550-02127-102 Distributor Box, Blade De-Ice System

SECTION C - INCIDENT DATA

	TEST ENVIRONMENT	INCIDENT CLASS	ACTION TAKEN
	Ferry flight	X a. DEFICIENCY	REPLACED
X	Cruise - 140 KIAS	b. SHORTCOMING	X REPAIRED
	Clear, -20°C	c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			NONE

2100, 19 December 1980

SECTION D - INCIDENT DESCRIPTION

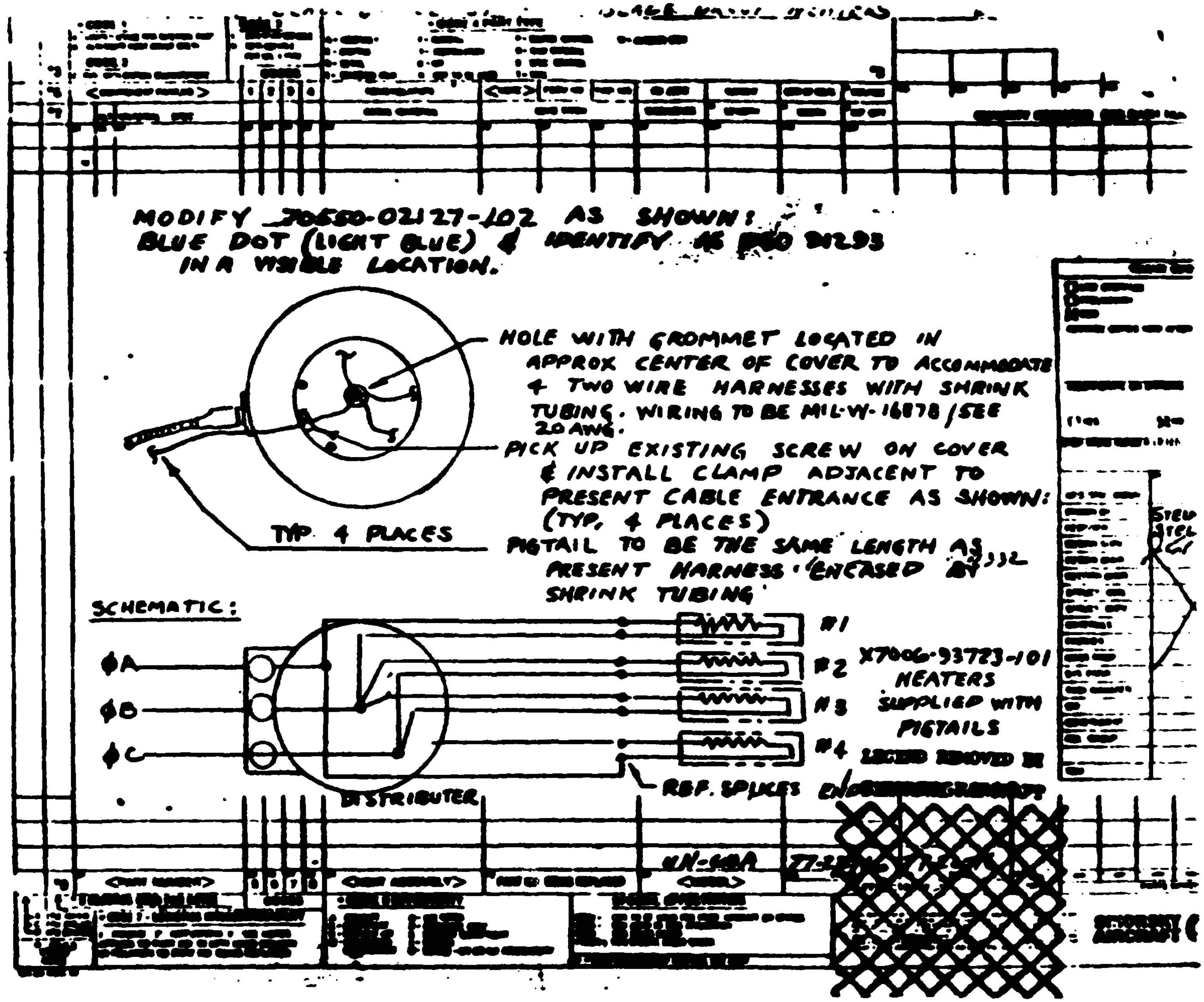
The wiring which carries electrical current from the main rotor distributor to the droop stop heater on one rotor blade was chafed bare and one strand broken at the clamp on the main rotor hub above the blade attaching point. The droop stop was not being heated. Plastic covering (shrink) around the wires was cracked in several other locations. The type of plastic covering and exposed location of this wiring in its present configuration does not provide adequate protection for the wire and can result in the droop stop heaters not functioning.

MARVIN L. HANKS, MAJ
Project Officer, USAAEFA Proj. No. 80-14

Marvin L. Hanks

AV Form 1002
May 74

Edition of 1 Aug 74, may be used.


MODIFY 70550-02127-102 AS SHOWN:
BLUE DOT (LIGHT BLUE) & IDENTIFY AS 31293
IN A VISIBLE LOCATION.
HOLE WITH GROMMET LOCATED IN APPROX CENTER OF COVER TO ACCOMMODATE 4 TWO WIRE HARNESSES WITH SHRINK TUBING. WIRING TO BE MIL-W-16878/SEE 20 AWG.
PICK UP EXISTING SCREW ON COVER & INSTALL CLAMP ADJACENT TO PRESENT CABLE ENTRANCE AS SHOWN: (TYP, 4 PLACES)
TYP 4 PLACES
PIGTAIL TO BE THE SAME LENGTH AS PRESENT HARNESS ENCASED BY SHRINK TUBING
SCHEMATIC:
ϕA
ϕB
ϕC
DISTRIBUTER
#1
#2
#3
#4
X7006-93723-101 HEATERS SUPPLIED WITH PIGTAILS
REF. SPLICES
LEGEND REMOVED BY
UH-60A

EQUIPMENT PERFORMANCE REPORT

TO: COMMANDER, US ARMY AVIATION SYSTEMS COMMAND, ATTN: [illegible], PO BOX [illegible], ST. LOUIS, MISSOURI [illegible]	**DATE:** 22 December 1980
	DAVTE-TB
FROM: US Army Aviation Engineering Flight Activity, ATTN: DAVTE-TB, Stop 217, Edwards AFB, CA 93523	

1. EPR NUMBER	2. PROJECT NUMBER	3. TEST TITLE
80-14-6	USAAEFA Project No. 80-14	(Re-evaluation)

SECTION A - MAJOR ITEM DATA

MODEL: UH-60A	SERIAL NO: 77-22716
QUANTITY: 1	MANUFACTURER: Sikorsky

SECTION B - PART DATA

NOMENCLATURE/DESCRIPTION: Droop Stop Heater (231 Watt)	NSN: ----
10. MFR PART NO: X7006-93723-101	11. MANUFACTURER: Sikorsky
12. QUANTITY: Four	13. NEXT ASSEMBLY: 70550-02127-102 Distributor Box, Blade De-Ice System

SECTION C - INCIDENT DATA

14. OBSERVED DURING	15. TEST ENVIRONMENT	16. INCIDENT CLASS	17. ACTION TAKEN
X a. OPERATION	Artificial Icing	X a. DEFICIENCY	REPLACED
b. MAINTENANCE	120 KIAS	b. SHORTCOMING	REPAIRED
c.	$-5°C$, 1.0 gm/m^3	c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			X NONE

18. DATE AND HOUR OF INCIDENT: 0800, 22 December 1980

SECTION D - INCIDENT DESCRIPTION

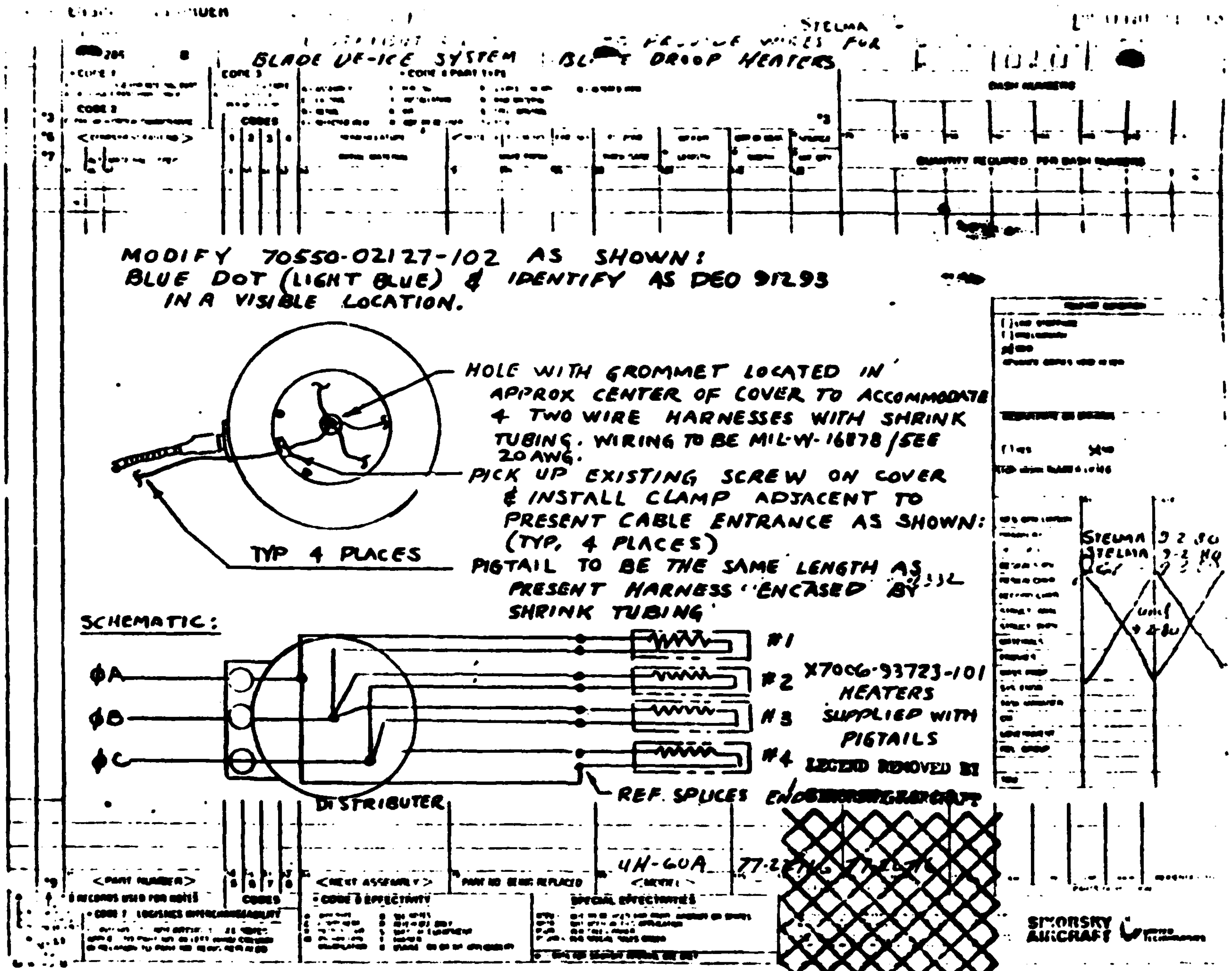
19. DESCRIBE INCIDENT FULLY (Deficiencies and Shortcomings are subject to reclassification)

One droop stop failed to return to static position during shutdown and the remaining droop stops did not seat completely. The 231 watt droop stop heater functioned to keep ice clear of the pivot bolt, but ice accumulation on the droop stop weight prevented droop stops from returning to static position properly. Main rotor blade tip droops within five feet of ground with droop stop not in the static position (aircraft twelve o'clock position - level ground).

20. DEFECTIVE MATERIAL SENT TO

NAME, TITLE, TEL EXT OF PREPARER	SIGNATURE
MARVIN L. HANKS, MAJ Project Officer, USAAEFA Proj. No. 80-14	SIGNED

AV Form 1002, 1 May 76 — Edition of 1 Aug 74, may be used.


BLADE DE-ICE SYSTEM
DROOP HEATERS
STELMA
MODIFY 70550-02127-102 AS SHOWN:
BLUE DOT (LIGHT BLUE) & IDENTIFY AS DEO 91293
IN A VISIBLE LOCATION.
HOLE WITH GROMMET LOCATED IN APPROX CENTER OF COVER TO ACCOMMODATE 4 TWO WIRE HARNESSES WITH SHRINK TUBING. WIRING TO BE MIL-W-16878/SEE 20 AWG.
PICK UP EXISTING SCREW ON COVER & INSTALL CLAMP ADJACENT TO PRESENT CABLE ENTRANCE AS SHOWN: (TYP, 4 PLACES)
PIGTAIL TO BE THE SAME LENGTH AS PRESENT HARNESS ENCASED BY SHRINK TUBING
TYP 4 PLACES
SCHEMATIC:
ϕA
ϕB
ϕC
DISTRIBUTER
#1
#2
#3
#4
X7006-93723-101 HEATERS SUPPLIED WITH PIGTAILS
REF. SPLICES
LEGEND REMOVED BY
UH-60A
SIKORSKY AIRCRAFT

EQUIPMENT PERFORMANCE REPORT

22 December 1980

DAVTE-TB

FROM: Commander
US Army Aviation Engineering Flight Activity
ATTN: DAVTE-TB Stop 217
Edwards AFB, CA 93523

TO: Commander
US Army Aviation Systems Command
ATTN: DRSAV-ED
PO Box 209
St. Louis, Missouri 63166

EPR Number	Project Number	Test Title
80-14-7	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

Model: UH-60A	Serial No: 77-22716
Quantity: 1	Manufacturer: Sikorsky

SECTION B - PART DATA

Nomenclature/Description: Anti-Flap Assembly	NSN: 1560-01-H62-0294
Mfr. Part No.: 70105-08100-041	Manufacturer: Sikorsky
Quantity: Four	Next Assembly: Hub Assembly, Main Rotor 70103-08100-041

SECTION C - INCIDENT DATA

X a.	Artificial Icing 120 KIAS -5°C, 1.0 gm/ m^3	X a. Deficiency b. Shortcoming c. Suggested Improvement d. Other	Replaced Repaired Adjusted Disconnected Removed X None

0800, 22 December 1980

SECTION D - INCIDENT DESCRIPTION

Anti-Flapping cam failed to return to shutdown position due to ice accumulation on the assembly. Shutdown in high winds could result in excessive flapping due to improper position of anti-flap cam after an icing encounter.

MARVIN L. HANKS, MAJ
Project Officer, USAAEFA Proj. No. 80-14

Marvin L. Hanks

AV Form 1002

Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT

22 December 1980

DAVTE-TB

FROM: Commander
US Army Aviation Engineering Flight Activity
ATTN: DAVTE-TB Stop 217
Edwards AFB, CA 93523

80-14-8	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

UH-60A	77-22716
	Sikorsky

SECTION B - PART DATA

Main Rotor Blade BIM Indicator	1560-01-H62-0195
SH115-20520-001	Sikorsky
None	Main Rotor Blade

SECTION C - INCIDENT DATA

X	Artificial Icing -5°C, 1.0 gm/ m^3 Two flights, 1.3, 1.4 50 min in cloud each flt	X	X

1800, 22 December 1980

SECTION D - INCIDENT DESCRIPTION

BIM on green main rotor blade showed red after aircraft had been flown on two artificial icing flights. Aircraft had been in hangar approximately three hours when red BIM was noted on daily. Blade temperature was stabilized overnight, pressure checked and found in tolerance but low (8.5 psi). Pressure was increased to nominal range (~10psi) and leak check ok. Extensive down time required for temperature stabilization so pressure check would be accurate.

MARVIN L. HANKS, MAJ
Project Officer, USAAEFA Proj. No. 80-14

AV Form 1002

EQUIPMENT PERFORMANCE REPORT

January 1981

DAVTE-TB

FROM

Commander
US Army Aviation Engineering Flight Activity
ATTN: DAVTE-TB Stop 217
Edwards AFB, CA 93523

80-14-9	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

UH-60A

77-22716

Sikorsky

SECTION B - PART DATA

Windshield Anti-Ice Controller

1560-01-H62-1777

70550-02024-103

Sikorsky

One

SECTION C - INCIDENT DATA

X

Artificial Icing
-12°C, 0.6 gm/ m^3
Eng Inlet Icing

X

ACTION TAKEN

X REPLACED

REPAIRED

1305 8 January 1981

SECTION D - INCIDENT DESCRIPTION

Copilot's windshield anti-ice controller did not heat the two inboard panels of the copilot's windshiled until 1.3 hours into flight. Copilot's windshield inboard panels iced over while in artificial cloud. Attempts to cycle system didnot result in panels being heated. When panels did function, ice melted and slid off of windshield in a sheet - possible engine ice ingestion. New controllers ordered from Sikorsky.

MARVIN L. HANKS, MAJ
Project Officer, USAAEFA Proj. No. 80-14

12 January 1981

EQUIPMENT PERFORMANCE REPORT

DAVTE-TB

TO	FROM
Commander US Army Aviation Systems Command ATTN: DRSAV-ED PO Box 209 St Louis Missouri 63166	Commander US Army Aviation Engineering Flight Activity ATTN: DAVTE-TB Stop 217 Edwards AFB, CA 93523

EPR NUMBER	PROJECT NUMBER	TEST TITLE
80-14-10	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

UH-60A	SERIAL NO: 77-22716
	MANUFACTURER: Sikorsky

SECTION B - PART DATA

NOMENCLATURE DESCRIPTION: Anti-collision Light (upper)	NSN: 1560-01-062-1796
MFR PART NO: 70553-05002-105	MANUFACTURER: Sikorsky
QUANTITY: One	NEXT ASSEMBLY

SECTION C - INCIDENT DATA

OCCURRED DURING	TEST ENVIRONMENT	INCIDENT CLASS	ACTION TAKEN
X a. OPERATION b. MAINTENANCE c.	Artificial Icing $-5°C$, 1.0 gm/ m^3	a. DEFICIENCY X b. SHORTCOMING c. SUGGESTED IMPROVEMENT d. OTHER	X REPLACED REPAIRED ADJUSTED DISCONNECTED X REMOVED NONE

DATE AND TIME OF INCIDENT: 0910, 12 January 1981, Flight #8

SECTION D - INCIDENT DESCRIPTION

DESCRIBE INCIDENT FULLY (Deficiencies and Shortcomings are subject to reclassification)

Upper anti-collision light was damaged during artificial icing. The top red lens was missing and the lower white lens was shattered with pieces missing. Light continued to function during flight. Tail rotor blade damage was incurred apparently due to the glass lens hitting the tail rotor (see FPR No. 80-14-11)

MARVIN L. HANKS, MAJ
Project Officer, USAAEFA Proj. No. 80-14

SIGNATURE: [signature]

SAV Form 1002

Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT

DATE: 12 January 1981

DAVTE-TB

TO: COMMANDER, US ARMY AVIATION SYSTEMS COMMAND, ATTN: DRSAV-EQ, PO BOX 209, ST. LOUIS, MISSOURI 63166

FROM: Commander
US Army Aviation Engineering Flight Activity
ATTN: DAVTE-TB Stop 217
Edwards AFB, CA 93523

EPR NUMBER	PROJECT NUMBER	
80-14-11	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

MODEL: UH-60A	SERIAL NO: 77-22716
	MANUFACTURER: Sikorsky

SECTION B - PART DATA

NOMENCLATURE DESCRIPTION: Tail Rotor Blade	NSN: 1560-01-H62-4417
MFR PART NO: 70101-11200-044	MANUFACTURER: Sikorsky
QUANTITY: One	NEXT ASSEMBLY: Tail Rotor

SECTION C - INCIDENT DATA

X a. OPERATION	Artificial Icing -5°C, 1.0 gm/ m³	X a. DEFICIENCY	REPLACED
b. MAINTENANCE		b. SHORTCOMING	X REPAIRED
c.		c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			NONE

DATE AND HOUR OF INCIDENT: 0930, 12 January 1981, Flt #8

SECTION D - INCIDENT DESCRIPTION

DESCRIBE INCIDENT FULLY (Deficiencies and Shortcomings are subject to reclassification)

The green tail rotor blade was damaged as listed below-apparently by glass from lens on upper anti-collision light (see EPR No. 80-14-10). Phonecon with Sikorsky (Mr. Lombardi) and AVRADCOM (Mr. Tim Hughes): Paint over damage to prevent moisture getting inside and fly: Patch with resin when it becomes available.

Gouge - 14-3/4" from cuff 3/16" X 3/16" x 0.056" deep
Scratches on Area A 15-5/6 1/16 x 1/16 x 0.021
(see maintenance manual) 17-15/16 1/8 x 3/4 x 0.025
17-15/16 1/8 x 3/4 x 0.024

NAME, TITLE OF PREPARER: MARVIN L. HANKS, MAJ
Project Officer, USAAEFA Proj. No. 80-14

SIGNATURE: Marvin L. Hanks

DAV Form 1002, 1 Nov 76 — Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT

15 January 1981

DAVTE-TB

TO	FROM
COMMANDER US ARMY AVIATION SYSTEMS COMMAND ATTN: DRSAV-EQ PO BOX 209 ST LOUIS, MISSOURI 63166	Commander US Army Aviation Engineering Flight Activity ATTN: DAVTE-TB Stop 217 Edwards AFB, CA 93523

EPR NUMBER	PROJECT NUMBER	TEST TITLE
80-14-12	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

MODEL: UH-60A	SERIAL NO: 77-22716
QUANTITY: 1	MANUFACTURER: Sikorsky

SECTION B - PART DATA

NOMENCLATURE/DESCRIPTION: Main Rotor Blade BIM Indicator	NSN: 1560-01-H62-0195
MFR PART NO: 56115-20520-001	MANUFACTURER: Sikorsky
QUANTITY: One	NEXT ASSEMBLY: Main Rotor Blade

SECTION C - INCIDENT DATA

INCIDENT DURING	TEST ENVIRONMENT	INCIDENT CLASS	ACTION TAKEN
a. OPERATION	Artificial icing	X a. DEFICIENCY	X REPLACED
X b. MAINTENANCE	19°C, 0.25 gm/m³	b. SHORTCOMING	REPAIRED
c.		c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			NONE

DATE AND TIME OF INCIDENT: 1200, 15 January 1981

SECTION D - INCIDENT DESCRIPTION

DESCRIPTION (Deficiencies and Shortcomings are subject to reclassification)

BIM on yellow main rotor blade showed red after one artificial icing flight and being hangared for approximately one hour. Blade temperature stabilized and pressure check showed low (8.5 psi) but in tolerance. BIM changed 16 Jan 81, pressurized and checked ok. Extensive downtime required for temperature stabilization so pressure check would be accurate.

MARVIN L. HANKS, MAJ
Project Officer, USAAEFA Proj. No. 80-14

SIGNATURE: [signature]

AV Form 1002, 1 Nov 76 — Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT

16 January 1981

DAVTE-TB

TO

COMMANDER
US ARMY AVIATION SYSTEMS COMMAND
ATTN: DRSAV-EQ
PO BOX 209
ST LOUIS, MISSOURI 63166

FROM

Commander
US Army Aviation Engineering Flight Activity
ATTN: DAVTE-TB Stop 217
Edwards AFB, CA 93523

EPR NUMBER	PROJECT NUMBER	TEST TITLE
80-14-13	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

UH-60A	SERIAL NO. 77-22716
[illegible]	MANUFACTURER Sikorsky

SECTION B - PART DATA

NAME/FEATURE DESCRIPTION: Anti-Collision Light (upper)	NSN: 1560-01-H62-1796
MFR PART NO: 70553-05002-105	MANUFACTURER: Sikorsky
QUANTITY: One	NEXT ASSEMBLY: --

SECTION C - INCIDENT DATA

[illegible]	TEST ENVIRONMENT	INCIDENT CLASS	ACTION TAKEN
X a. [illegible]	Artificial icing	a. DEFICIENCY	REPLACED
b. MAINTENANCE	-11°C, 0.75 gm/m^3	X b. SHORTCOMING	REPAIRED
c.		c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			X REMOVED
			NONE

DATE AND HOUR OF INCIDENT: 1300, 16 Jan 81

SECTION D - INCIDENT DESCRIPTION

(Deficiencies and Shortcomings are subject to reclassification)

Upper anti-collision light was damaged during artificial icing..Both red and white lenses were broken - light still functioned. Lenses apparently broken by ice shedding from main rotor.

MARVIN L. HANKS, PROJECT OFFICER
USAAEFA Project No. 80-14

SIGNATURE: Marvin L. Hanks

AV Form 1002

Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT

16 January 1981

DAVTE-TB

TO

COMMANDER
US ARMY AVIATION SYSTEMS COMMAND
ATTN: DRDAV-EQ
PO BOX 209
ST LOUIS, MISSOURI 63166

FROM

Commander
US Army Aviation Engineering Flight Act
ATTN: DAVTE-TB
Edwards AFB, CA 93523

80-14-14	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

UH-60A	77-22716
1	MANUFACTURER: Sikorsky

SECTION B - PART DATA

[illegible] Assembly-Droop Stop (production)	NSN: 1560-01-H62-4393
70105-08151-041	MANUFACTURER: Sikorsky
Four	NEXT ASSEMBLY: Main Rotor

SECTION C - INCIDENT DATA

	TEST ENVIRONMENT	INCIDENT CLASS	ACTION TAKEN
X	Artificial icing	X a. DEFICIENCY	REPLACED
	$-11°C$, 0.75 gm/ m^3	b. SHORTCOMING	REPAIRED
		c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			X NONE

1300, 16 Jan 81

SECTION D - INCIDENT DESCRIPTION

(Deficiencies and Shortcomings are subject to reclassification)

Production main rotor droop stops with rubber strip and 300 watt heaters failed to return to static position during normal shutdown. Droop stops were approximately halfway out with ice buildup on rubber strip preventing return to full static position. An icing encounter with more ice accretion could result in the droop stop not returning to static position and allowing one or more of the main rotor blades to droop to within five feet of ground.

MARVIN L. HANKS, MAJ, PROJECT OFFICER
USAAEFA Project No. 80-14

SIGNATURE: Marvin L. Hanks

AV Form 1002

Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT

16 January 1981

DAVTE-TB

TO	FROM
COMMANDER, US ARMY AVIATION SYSTEMS COMMAND, ATTN: DRSAV-EQ, PO BOX 209, ST LOUIS MISSOURI 63166	Commander, US Army Aviation Engineering Flight Act, ATTN: DAVTE-TB Stop 217, Edwards AFB, CA 93523

EPR NUMBER	PROJECT NUMBER	TEST TITLE
80-14-15	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

UH-60A	77-22716
1	Sikorsky

SECTION B - PART DATA

Door Assembly, Nose	
70217-01010-044	Sikorsky
One	

SECTION C - INCIDENT DATA

X a.	Artificial Icing -11°C, 0.75 gm/ m^3	b. SHORTCOMING X	NONE X

1300, 16 January 1981

SECTION D - INCIDENT DESCRIPTION

Numerous dents noted in nose avionics compartment door. Apparently caused by ice shedding from main rotor impacting on door. Damage to fiberglass door causes voids which reduce structural strength.

MARVIN L. HANKS, MAJOR, PROJECT OFFICER
USAAEFA Project No. 80-14

AV Form 1002 — Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT
(AVSCOM Reg 702-8)

DATE: 27 January 1981

OFFICE SYMBOL: DAVTE-TB

TO:
COMMANDER
US ARMY AVIATION SYSTEMS COMMAND
ATTN: [illegible]
PO BOX [illegible]
ST. LOUIS, MISSOURI [illegible]

FROM:
US Army Aviation Engineering Flight Activity
ATTN: DAVTE-TB, Stop 217
Edwards AFB, CA 93523

1. EPR NUMBER	2. PROJECT NUMBER	3. TEST TITLE
80-14-16	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

4. MODEL: UH-60A	5. SERIAL NO: 77-22716
6. QUANTITY: 1	7. MANUFACTURER: Sikorsky

SECTION B - PART DATA

8. NOMENCLATURE/DESCRIPTION: Stabilator	9. NSN: 1560-01-H62-4195
10. MFR PART NO: 70200-07060-043	11. MANUFACTURER: Sikorsky
12. QUANTITY: One	13. NEXT ASSEMBLY: ----

SECTION C - INCIDENT DATA

14. OBSERVED DURING	15. TEST ENVIRONMENT	16. INCIDENT CLASS	17. ACTION TAKEN
a. OPERATION	Natural Icing - 2 Flts	X a. DEFICIENCY	X REPLACED
X b. MAINTENANCE	-130 KIAS, -7°C, Mod Rime, 0.5 LWC	b. SHORTCOMING	REPAIRED
c.	-90 KIAS, -7°C, Mod Rime, 0.3 LWC	c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	[illegible]
			[illegible]
			NONE

18. DATE AND HOUR OF INCIDENT: 1000, 27 January 1981

SECTION D - INCIDENT DESCRIPTION

19. DESCRIBE INCIDENT FULLY (Deficiencies and Shortcomings are subject to reclassification)

The stabilator was found cracked in numerous locations during a 30 hour time-phased inspection. No evidence of cracks had been noted on previous inspections. The cracks were located as follows: (See attached picture)

1. A three inch crack in the 90° bend of the angle on the inboard side of the left inboard rib (BL9) forward of the forward spar where rib joins spar.

2. One 0.5 inch crack in the left inboard rib (BL9) forward of the forward spar, outboard of rib at bottom corner where rib joins spar.

3. One 0.5 inch crack in the right inboard rib (BL9) forward of the forward spar, outboard of rib at top corner where rib joins spar.

4. Two approximately one inch cracks in the nose of left inborad rib (BL9).

20. DEFECTIVE MATERIAL SENT TO

NAME, TITLE, TEL EXT OF PREPARER	SIGNATURE
MARVIN L. HANKS, MAJ, Project Officer USAAEFA Project No. 80-14	SIGNED

SAV Form 1 May 70 1082 — Edition of 1 Aug 74, may be used.

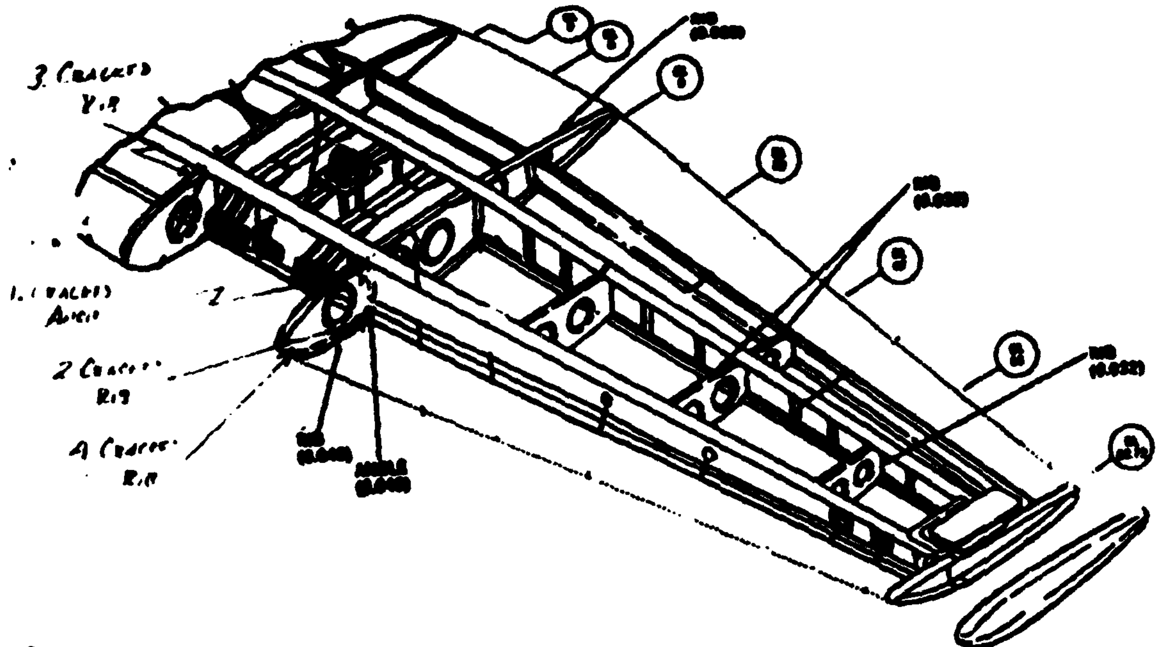


Figure 26-1 (Sheet 1 of 6)

EQUIPMENT PERFORMANCE REPORT
(AVSCOM Reg 702-3)

DATE: 30 January 1981

OFFICE SYMBOL: DAVTE-TB

TO:
COMMANDER
US ARMY AVIATION SYSTEMS COMMAND
ATTN: DRSAV-ED
PO BOX 209
ST. LOUIS, MISSOURI 63166

FROM:
COMMANDER
US Army Aviation Engineering Flight Activity
ATTN: DAVTE-TB, Stop 217
Edwards AFB, CA 93523

1. EPR NUMBER	2. PROJECT NUMBER	3. TEST TITLE
80-14-17	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

4. MODEL UH-60A	5. SERIAL NO 77-22716
6. QUANTITY 1	7. MANUFACTURER Sikorsky

SECTION B - PART DATA

8. NOMENCLATURE/DESCRIPTION Anti-Flap Assembly	9. NSN 1560-01-H62-0294
10. MFR PART NO 70105-08100-041	11. MANUFACTURER Sikorsky
12. QUANTITY One	13. NEXT ASSEMBLY Hub Assembly, Main Rotor 70103-08100-041

SECTION C - INCIDENT DATA

14. OBSERVED DURING	15. TEST ENVIRONMENT	16. INCIDENT CLASS	17. ACTION TAKEN
X a. OPERATION	Climb, level, descent	X a. DEFICIENCY	X REPLACED
b. MAINTENANCE	0 - 105 KIAS	b. SHORTCOMING	REPAIRED
c.	700 - 3500' MSL	c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			NONE

18. DATE AND HOUR OF INCIDENT: 1430, 30 January 1981

SECTION D - INCIDENT DESCRIPTION

19. DESCRIBE INCIDENT FULLY (Deficiencies and Shortcomings are subject to reclassification)

Anti-flapping cam failed to pivot to fly position during run-up. Resulted in mod 1:1 vertical vibration at takeoff, climb level, descent. After shutdown damage was:

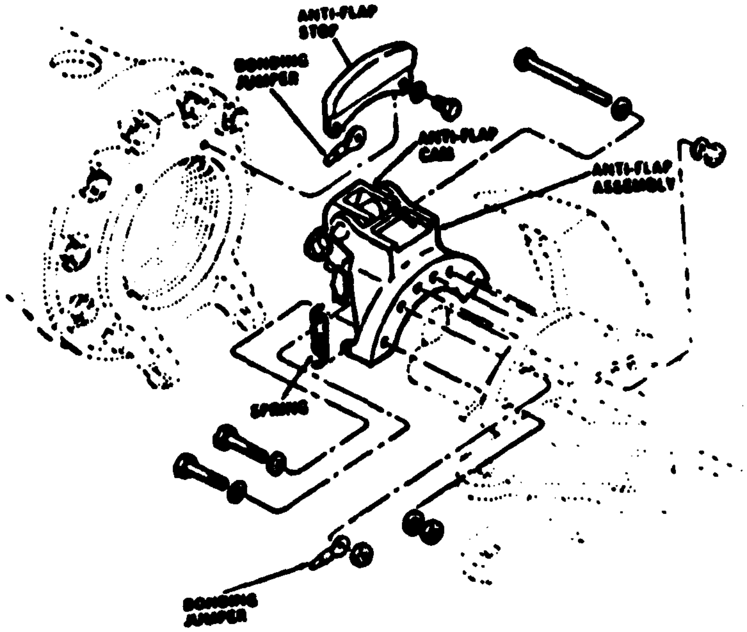
1. Scored anti-flap stop and cam
2. Cracked anti-flap assembly - top of assembly, near leading edge, deep crack

20. DEFECTIVE MATERIAL SENT TO

NAME, TITLE, TEL EXT OF PREPARER	SIGNATURE
MARVIN L. HANKS, MAJ, Project Officer USAAEFA Project No. 80-14	SIGNED

AV Form 1002, 1 May 76 — Edition of 1 Aug 74, may be used.

ANTI-FLAP ASSEMBLY



EQUIPMENT PERFORMANCE REPORT
(AVSCOM Reg 702-1)

DATE: 4 February 1981

OFFICE SYMBOL: DAVTE-TB

TO:
COMMANDER
US ARMY AVIATION SYSTEMS COMMAND
ATTN DRSAV-ED
PO BOX 209
ST. LOUIS, MISSOURI 63166

FROM:
COMMANDER
US Army Aviation Engineering Flight Activity
ATTN: DAVTE-TB, Stop 217
Edwards AFB, CA 93523

1. EPR NUMBER	2. PROJECT NUMBER	3. TEST TITLE
80-14-18	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

4. MODEL: UH-60A	5. SERIAL NO: 77-22716
6. QUANTITY: 1	7. MANUFACTURER: Sikorsky

SECTION B - PART DATA

8. NOMENCLATURE/DESCRIPTION: Main Rotor Blade BIM Indicator	9. NSN: 1560-01-H62-0195
10. MFR PART NO: 56115-20520-001	11. MANUFACTURER: Sikorsky
12. QUANTITY: One	13. NEXT ASSEMBLY: Main Rotor Blade

SECTION C - INCIDENT DATA

14. OBSERVED DURING	15. TEST ENVIRONMENT	16. INCIDENT CLASS	17. ACTION TAKEN
a. OPERATION	Artificial Icing -20°C, 0.25 gm/m^3	X a. DEFICIENCY	X REPLACED
X b. MAINTENANCE		b. SHORTCOMING	REPAIRED
c.		c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			NONE

18. DATE AND HOUR OF INCIDENT: 1000, 4 February 1981

SECTION D - INCIDENT DESCRIPTION

19. DESCRIBE INCIDENT FULLY (Deficiencies and Shortcomings are subject to reclassification)

BIM on yellow main rotor blade showed red after one artificial icing flight and being hangared for approximately one hour. Blade temperature was stabilized and pressure check was low but in tolerance (8.5 PSI). BIM changed 4 February 1981, pressurized and checked OK.

20. DEFECTIVE MATERIAL SENT TO

NAME, TITLE, TEL EXT OF PREPARER:
MARVIN L. HANKS, MAJ, Project Officer
USAAEFA Project No. 80-14

SIGNATURE: **SIGNED**

SAV Form 1002, 1 May 76 — Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT (AVSCOM Reg 70-13)	DATE: 5 February 1981
	OFFICE SYMBOL: DAVTE-TB

TO	FROM
COMMANDER US ARMY AVIATION SYSTEMS COMMAND ATTN: DRSAV-EQ PO BOX 209 ST. LOUIS, MISSOURI 63166	COMMANDER US Army Aviation Engineering Flight Activity ATTN: DAVTE-TB, Stop 217 Edwards AFB, CA 93523

1. EPR NUMBER	2. PROJECT NUMBER	3. TEST TITLE
80-14-19	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

4. MODEL: UH-60A	5. SERIAL NO: 77-22716
6. QUANTITY: 1	7. MANUFACTURER: Sikorsky

SECTION B - PART DATA

8. NOMENCLATURE/DESCRIPTION: Cam Assembly, Droop Stop (GCT)	9. NSN: 1560-01-H62-4393
10. MFR PART NO: 70105-08051-101	11. MANUFACTURER: Sikorsky
12. QUANTITY: Four	13. NEXT ASSEMBLY: Main Rotor

SECTION C - INCIDENT DATA

14. OBSERVED DURING	15. TEST ENVIRONMENT	16. INCIDENT CLASS	17. ACTION TAKEN
X a. OPERATION	Artificial Icing $-9°C$, $1.0\ gm/m^3$	X a. DEFICIENCY	X REPLACED
b. MAINTENANCE		b. SHORTCOMING	REPAIRED
c.		c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			NONE

18. DATE AND HOUR OF INCIDENT: 1030, 5 February 1981

SECTION D - INCIDENT DESCRIPTION

19. DESCRIBE INCIDENT FULLY *(Deficiencies and Shortcomings are subject to reclassification)*

Main rotor droop stops used during Government Competitive Test (GCT) failed to return to static position during normal shutdown. Droop stops did not have heaters installed. One droop stop had an ice weld on the pivot bolt that kept the droop stop in the flying position during shutdown. Ice accretion on the weights of the other three droop stops prevented them from seating more than halfway.

20. DEFECTIVE MATERIAL SENT TO

NAME, TITLE, TEL EXT OF PREPARER	SIGNATURE
MARVIN L. HANKS, MAJ, Project Officer USAAEFA Project No. 80-14	SIGNED

SAV Form 1002, 1 May 76 — Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT

DATE	6 February 1981
OFFICE SYMBOL	DAVTE-TB

TO	FROM
COMMANDER US ARMY AVIATION SYSTEMS COMMAND ATTN: DRSAV-ED PO BOX 209 ST. LOUIS, MISSOURI 63166	COMMANDER US Army Aviation Engineering Flight Activity ATTN: DAVTE-TB, Stop 217 Edwards AFB, CA 93523

1. EPR NUMBER	2. PROJECT NUMBER	3. TEST TITLE
80-14-20	USAAEFA Project No. 80-14	UH-60A Icing (Re-evaluation)

SECTION A - MAJOR ITEM DATA

4. MODEL UH-60A	5. SERIAL NO 77-22716
6. QUANTITY 1	7. MANUFACTURER Sikorsky

SECTION B - PART DATA

8. NOMENCLATURE/DESCRIPTION Cam Assembly Droop Stop	9. NSN 1560-01-H62-4393
10. MFR PART NO 70105-08151-041	11. MANUFACTURER Sikorsky
12. QUANTITY	13. NEXT ASSEMBLY

SECTION C - INCIDENT DATA

14. OBSERVED DURING	15. TEST ENVIRONMENT	16. INCIDENT CLASS	17. ACTION TAKEN
X a. OPERATION	Artificial Icing -10°C, 1.0 gm/m³	X a. DEFICIENCY	REPLACED
b. MAINTENANCE		b. SHORTCOMING	REPAIRED
c.		c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			X NONE

18. DATE AND HOUR OF INCIDENT 1250, 6 February 1981

SECTION D - INCIDENT DESCRIPTION

19. DESCRIBE INCIDENT FULLY (Deficiencies and Shortcomings are subject to reclassification)

Production main rotor droop stops without rubber strip and 300 watt heaters failed to return to static position during normal shutdown. Droop stops were approximately halfway out with ice buildup on droop stop weight preventing return to full static position. An icing encounter with more ice accretion could result in the droop stop not returning to static position and allowing one or more of the main rotor blades to droop to within five feet of ground.

20. DEFECTIVE MATERIAL SENT TO

NAME, TITLE, TEL EXT OF PREPARER	SIGNATURE
MARVIN L. HANKS, MAJ, Project Officer Project No. 80-14	SIGNED

AAV Form 1002, 1 Mar 76 — Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT (AVSCOM Reg 70-41)	DATE: 12 February 1981 OFFICE SYMBOL: DAVTE-TB
TO: COMMANDER US ARMY AVIATION SYSTEMS COMMAND ATTN DRSAV-EQ PO BOX 209 ST. LOUIS, MISSOURI 63166	FROM: Commander US Army Aviation Engr Flight Activity ATTN: DAVTE-TB (Stop 217) Edwards AFB, California 93523

1. EPR NUMBER	2. PROJECT NUMBER	3. TEST TITLE
80-14-21	80-14	UH-60A Icing (Reevaluation)

SECTION A - MAJOR ITEM DATA

4. MODEL: UH-60A	5. SERIAL NO: 77-22716
6. QUANTITY: 1	7. MANUFACTURER: Sikorsky

SECTION B - PART DATA

8. NOMENCLATURE/DESCRIPTION: Main Rotor Blade BIM Indicator	9. NSN: 1560-01-1162-0195
10. MFR PART NO: 56115-20520-001	11. MANUFACTURER: Sikorsky
12. QUANTITY: One	13. NEXT ASSEMBLY: Main Rotor Blade

SECTION C - INCIDENT DATA

14. OBSERVED DURING	15. TEST ENVIRONMENT	16. INCIDENT CLASS	17. ACTION TAKEN
[ ] a. OPERATION	-20° C, IMC	[X] a. DEFICIENCY	[X] REPLACED
[X] b. MAINTENANCE		[ ] b. SHORTCOMING	[ ] REPAIRED
[ ] c.		[ ] c. SUGGESTED IMPROVEMENT	[ ] ADJUSTED
		[ ] d. OTHER	[ ] DISCONNECTED
			[ ] REMOVED
			[ ] NONE

18. DATE AND HOUR OF INCIDENT: 1430, 10 February 1981

SECTION D - INCIDENT DESCRIPTION

19. DESCRIBE INCIDENT FULLY (Deficiencies and Shortcomings are subject to reclassification)

BIM on yellow main rotor blade turned red after one flight at -20° C, and being hangared for one hour. Blade temperature was stabilized and pressure check was low but in tolerance (8.5 psi). BIM changed 10 February 1981, pressurized and checked OK.

20. DEFECTIVE MATERIAL SENT TO

NAME, TITLE, TEL EXT OF PREPARER	SIGNATURE
MARVIN L. HANKS, MAJ, Project Officer USAAEFA Project No. 80-14	Marvin L. Hanks

EAV Form 1002, 1 May 76 — Edition of 1 Aug 74, may be used.

EQUIPMENT PERFORMANCE REPORT
(AVSCOM Reg 70-13)

DATE: 12 February 1981

OFFICE SYMBOL: DAVTE-TB

TO:
COMMANDER
US ARMY AVIATION SYSTEMS COMMAND
ATTN: [illegible]
PO BOX [illegible]
ST. LOUIS, MISSOURI [illegible]

FROM:
COMMANDER
US Army Aviation Engr Flt Activity
ATTN: DAVTE-TB (Stop 217)
Edwards AFB, California 93523

1. EPR NUMBER	2. PROJECT NUMBER	3. TEST TITLE
80-14-22	80-14	UH-60A Icing (Reevaluation)

SECTION A - MAJOR ITEM DATA

4. MODEL: UH-60A	5. SERIAL NO: 77-22716
6. QUANTITY: 1	7. MANUFACTURER: Sikorsky

SECTION B - PART DATA

8. NOMENCLATURE/DESCRIPTION: Windshield Nose Section, Outboard LH	9. NSN: 1560-01-H62-0333
10. MFR PART NO: 70206-01003-101	11. MANUFACTURER: Sikorsky
12. QUANTITY: One	13. NEXT ASSEMBLY:

SECTION C - INCIDENT DATA

14. OBSERVED DURING	15. TEST ENVIRONMENT	16. INCIDENT CLASS	17. ACTION TAKEN
X a. OPERATION	Artificial Icing	X a. DEFICIENCY	X REPLACED
b. MAINTENANCE	$-17°$ C, 1.0 gm/m^3	b. SHORTCOMING	REPAIRED
c.	120 KIAS	c. SUGGESTED IMPROVEMENT	ADJUSTED
		d. OTHER	DISCONNECTED
			REMOVED
			NONE

18. DATE AND HOUR OF INCIDENT: 1300, 12 February 1981

SECTION D - INCIDENT DESCRIPTION

19. DESCRIBE INCIDENT FULLY (Deficiencies and Shortcomings are subject to reclassification)

During artificial icing flight, copilot's windshield cracked from midway up center post side, across top of windshield, to midway down door post side. Flames and smoke were visible on windshield for 2-3 seconds. Burning odor was smelled by crew. Crew turned off CP anti-ice system, exited cloud, returned to base.

20. DEFECTIVE MATERIAL SENT TO:

NAME, TITLE, TEL EXT OF PREPARER	SIGNATURE
MARVIN L. HANKS, MAJ, Project Officer USAAEFA Project No. 80-14	Marvin L. Hanks

AV Form 1 May 76 1002 — Edition of 1 Aug 74, may be used.

APPENDIX G. PHOTOGRAPHS

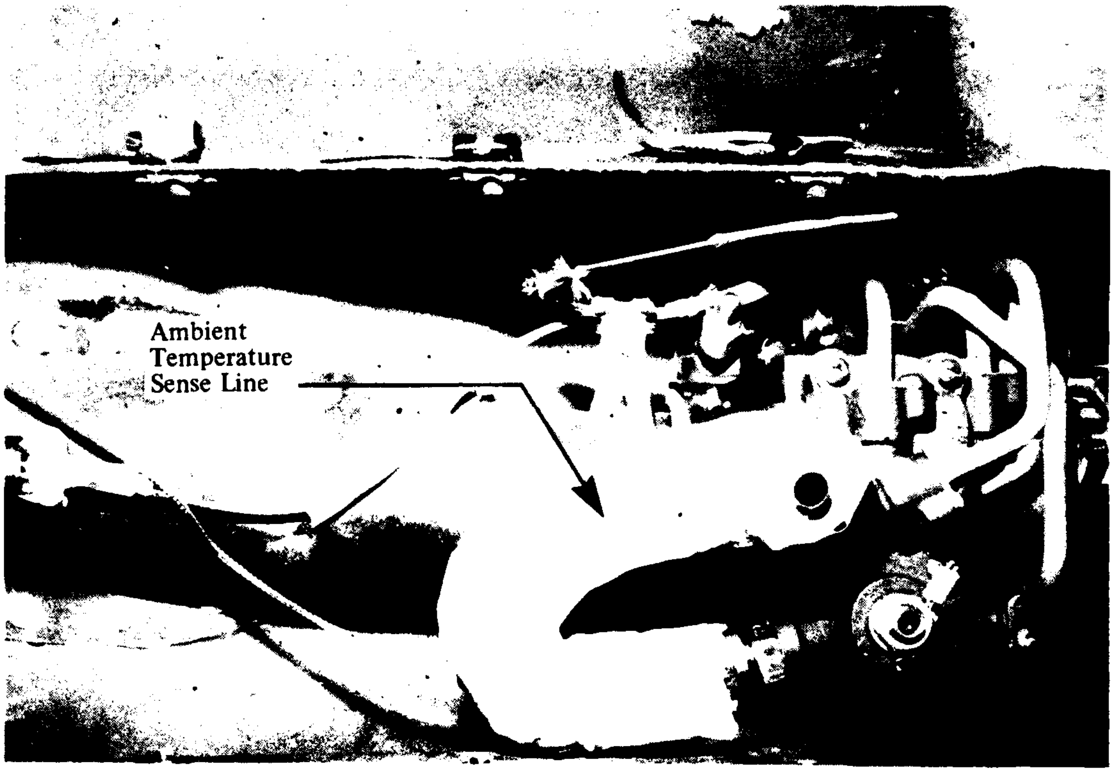


Photo 1. Engine Inlet Anti-Ice Valve with Insulated Ambient Temperature Sense Line

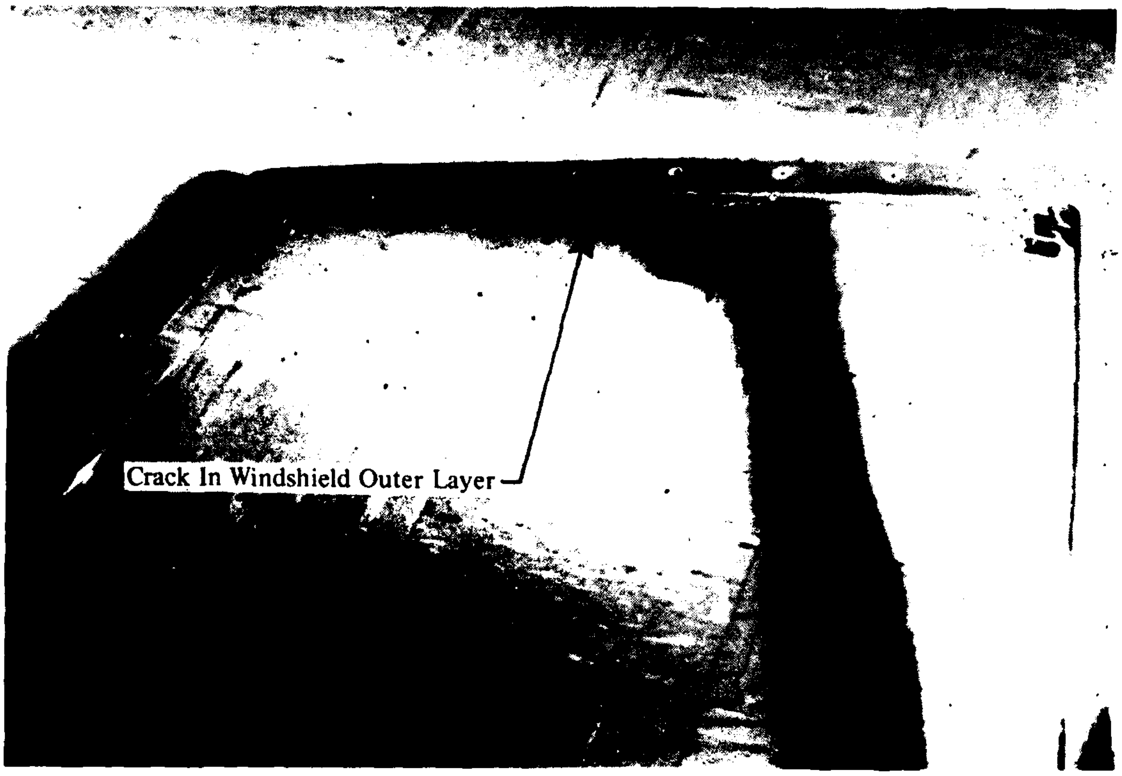


Photo 2. Cracked Copilot's Windshield

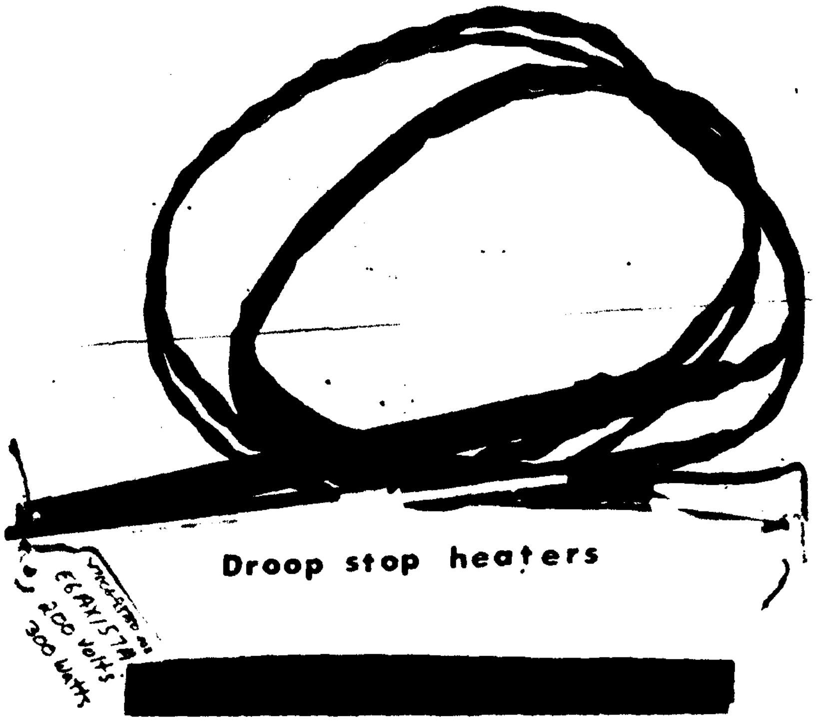


Photo 3. Droop Stop Heater, Uninstalled

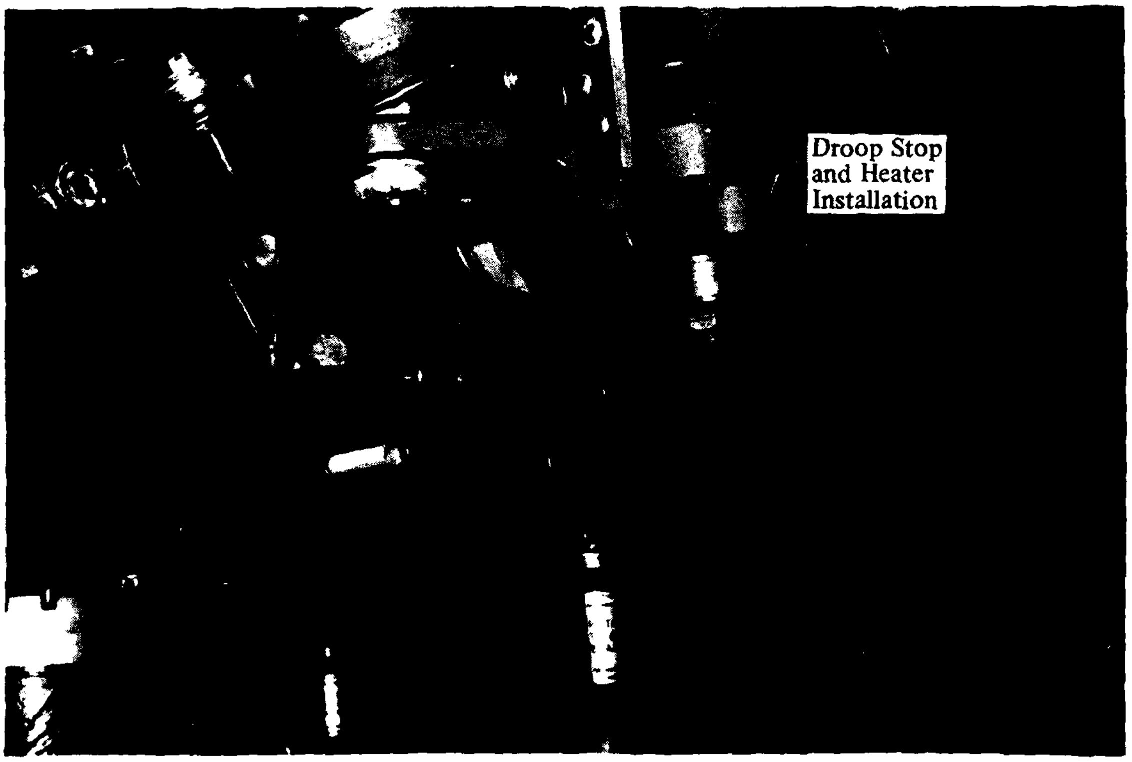


Photo 4. Installed Droop Stop Heater

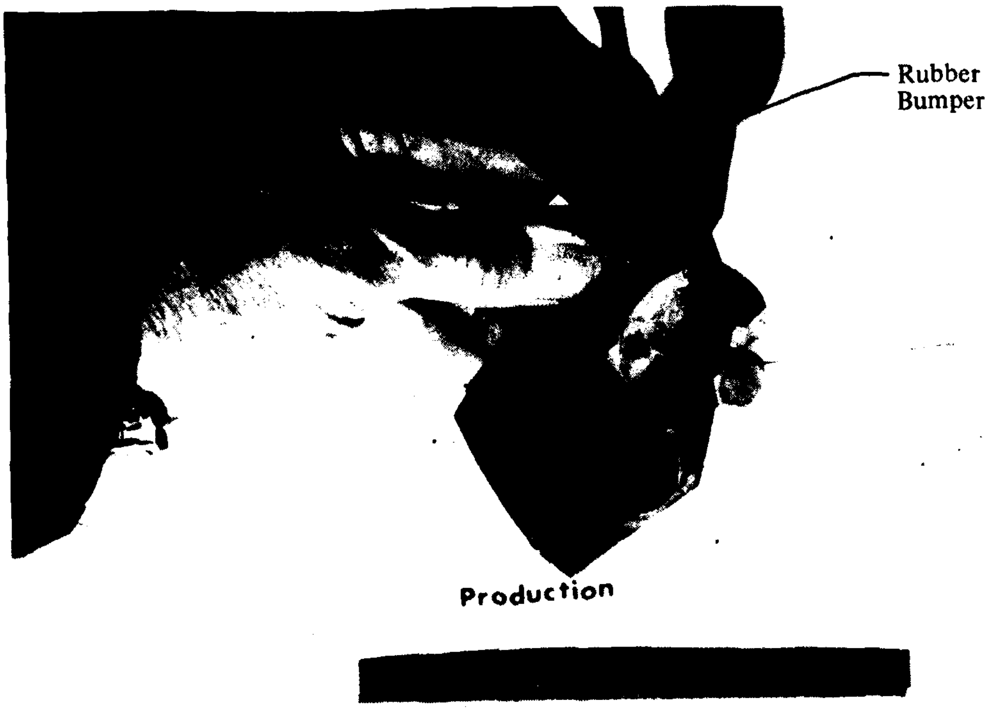


Photo 5. Production Droop Stop

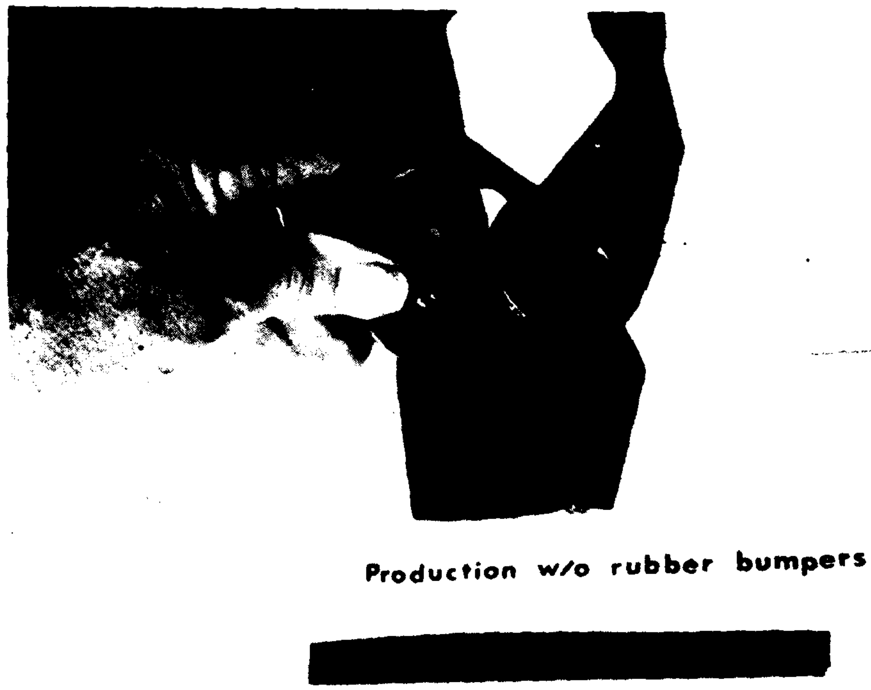


Photo 6. Production Droop Stop Without Rubber Bumper

Photo 7. Government Competitive Test Droop Stop

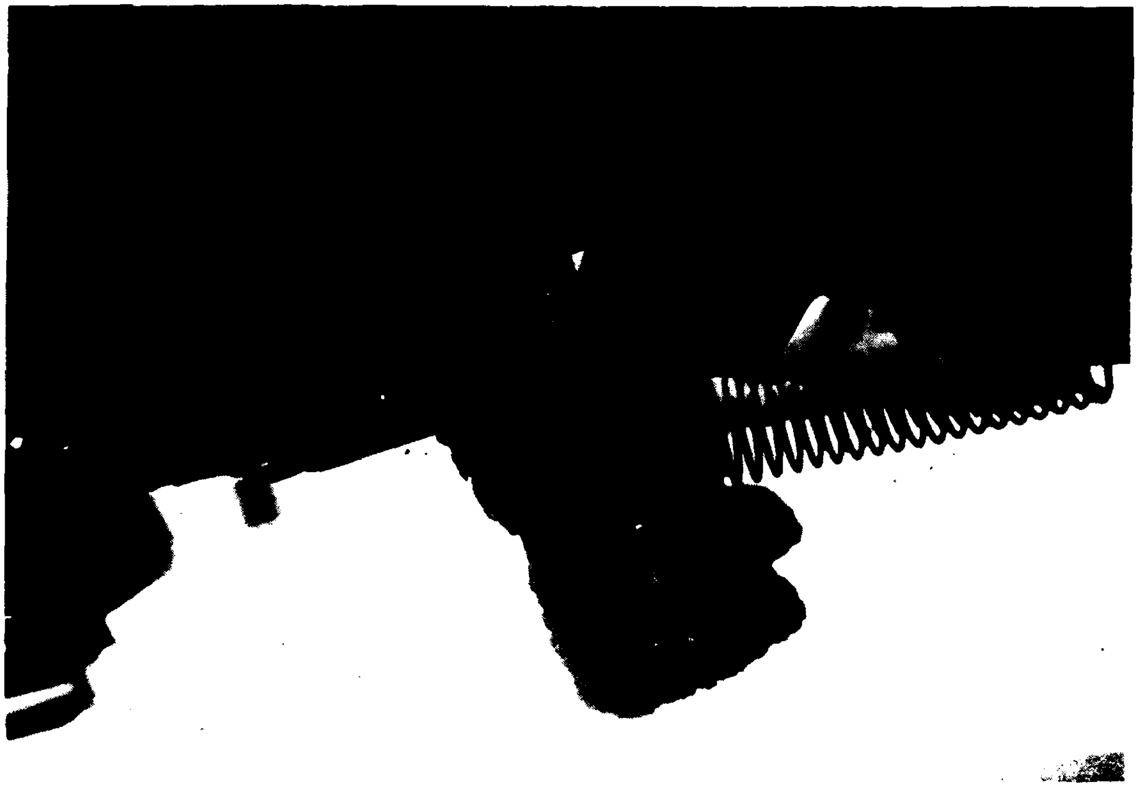


Photo 8. Production Droop Stop with 230 Watt Heater After Shutdown in Incorrect Position

Conditions:

Environment - Artificial	Avg FAT - -7.0°C
Configuration - Production Droop Stop with 230 Watt Heater	Avg LWC - 1.0 gm/m^3
Flight 1	Time in Cloud - 50 Minutes

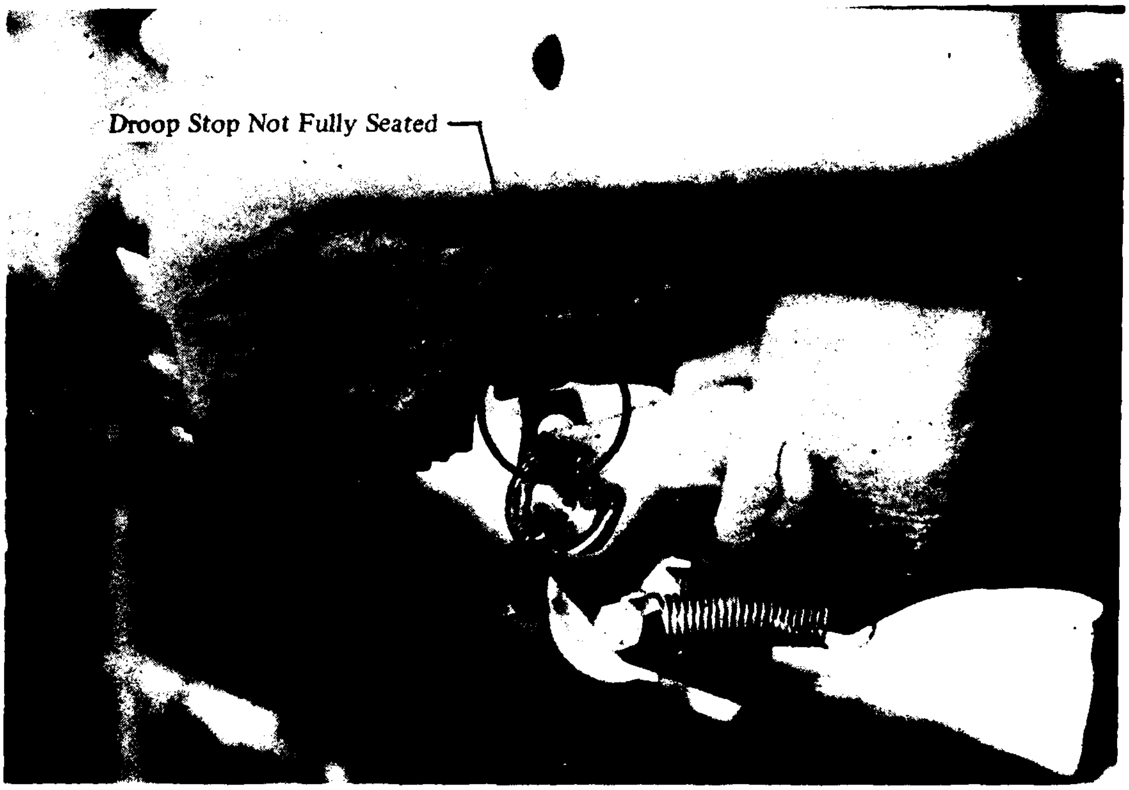


Photo 9. Production Droop Stop with 300 Watt Heater, Not Fully Seated

Conditions:

Environment - Artificial
Configuration - Production Droop Stop with 300 Watt Heater
Flight - 11

Avg FAT - -13.0°C
Avg LWC - 0.75 gm/m^3
Time in Cloud - 72 Minutes

AD-A112 582 ARMY AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AFB CA F/G 1/3
LIMITED ARTIFICIAL AND NATURAL ICING TESTS PRODUCTION UH-60A HE--ETC(U)
AUG 81 M L HANKS, V L DIEKMANN, J O BENSON
UNCLASSIFIED USAAEFA-80-14 NL

2 2

END
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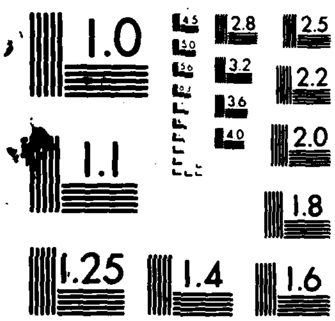

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

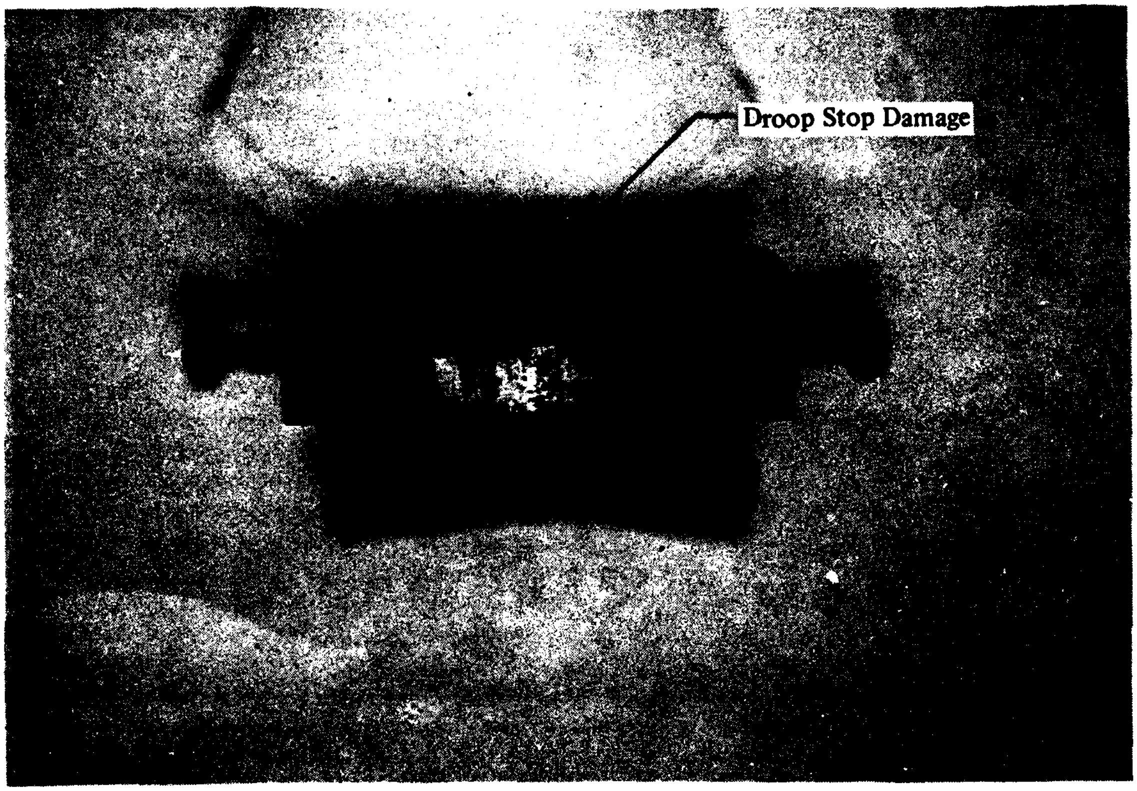

Photo 10. Droop Stop Damage Due to Shutdown with Droop Stop Being Not Fully Seated

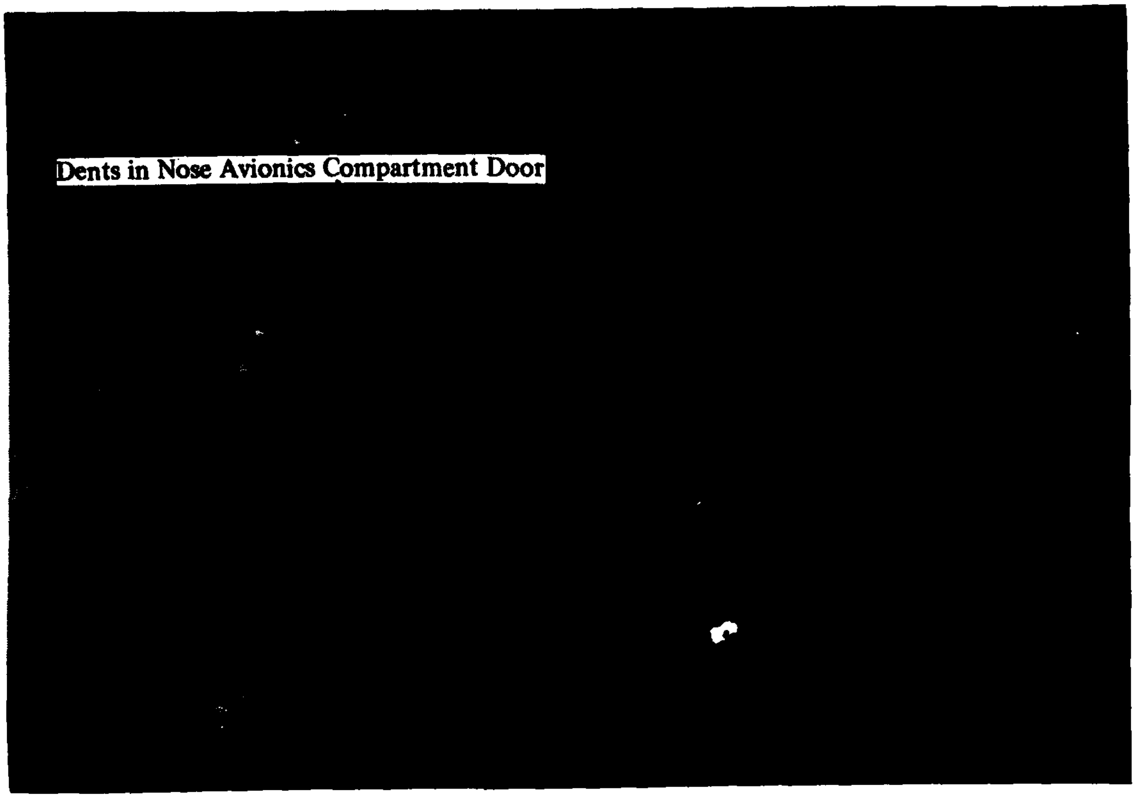

Photo 11. Ice Impact Damage to Nose Avionics Compartment Door

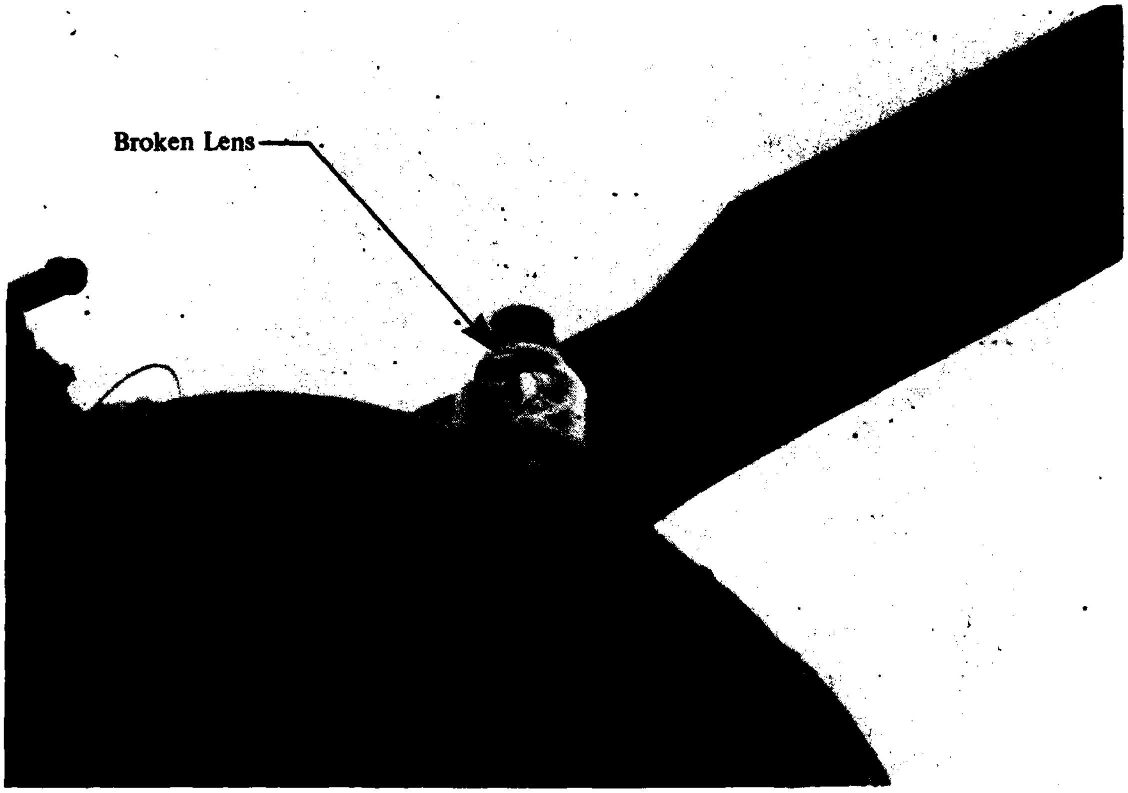

Photo 12. Broken Upper Strobe Light Assembly

Conditions:

Environment - Artificial
Configuration-GCT Droop Stop
with 300 Watt Heater
Flight - 8

Avg FAT- -6.0°C
Avg LWC- 1.0 gm/m^3
Time in Cloud- 50 Minutes

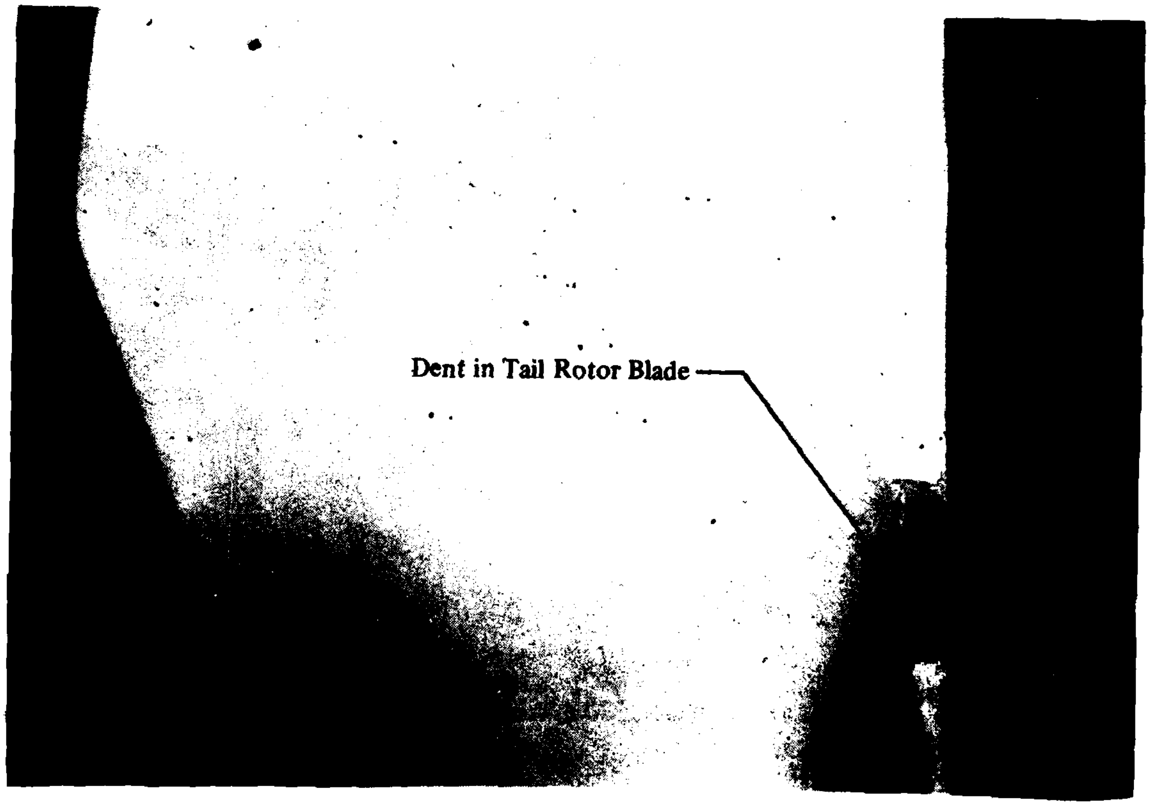

Photo 13. Dents in Tail Rotor Blade Due to Contact with Broken Upper Strobe Assembly Lens Pieces

Photo 14. Anti-Flapping Restrainer Iced in the Fly Position

Conditions:

Environment - Natural
Configuration - Unprotected

Flight-12

Avg FAT- - 9.0°C
Avg LWC- 0.44 gm/m^3
Time in Cloud - 96 Minutes

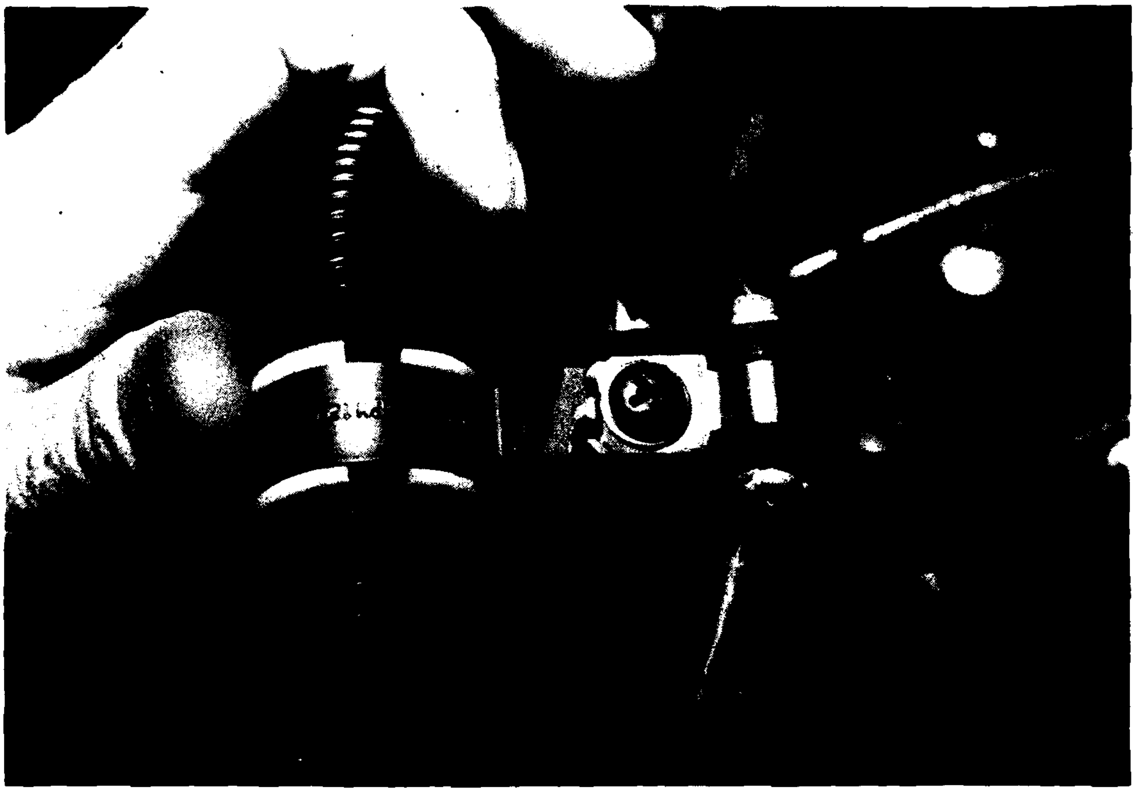

Photo 15. Broken Main Rotor Distributor Wire Attachment Clamp

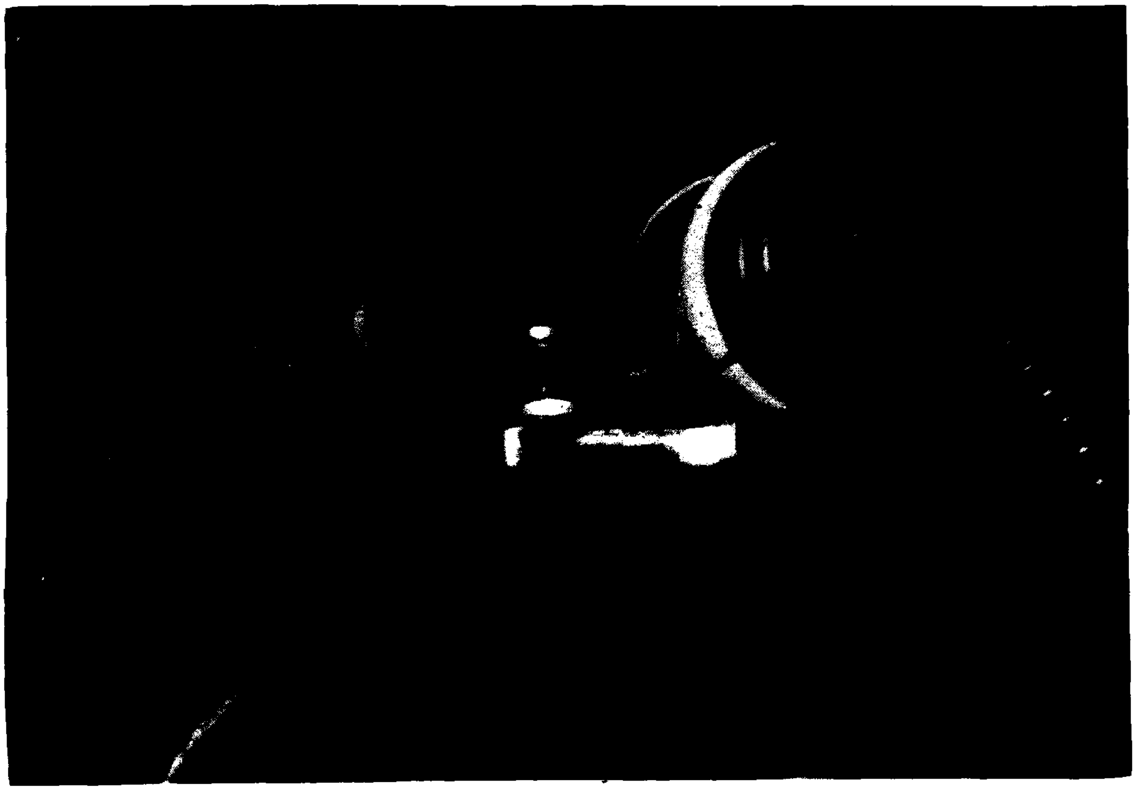

Photo 16. New Installation for Main Rotor Distributor Wire Clamps

Photo 17. Canted Icing Rate Meter

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Project Manager, BLACK HAWK (DRCPM-BH-T)	5

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