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TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

TRECOM TECHNICAL REPORT 64-36

**ENGINEERING SURVEY OF AIRCRAFT STRUCTURAL FAILURES
 CAUSED BY CORROSION, FATIGUE, AND ABRASION**

FINAL REPORT

Task 1D121401A14203
 Contract DA 44-177-AMC-98(T)

July 1964

prepared by:

UNIVERSITY OF OKLAHOMA RESEARCH INSTITUTE
 Norman, Oklahoma



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U S ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

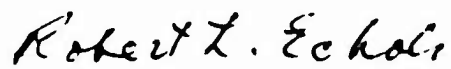
This engineering survey was carried out under Contract DA 44-177-AMC-98(T) by the University of Oklahoma Research Institute under the direction of Dr. Gene M. Nordby. The survey was made of aircraft structural failures caused by corrosion, fatigue, and abrasion.

The report has been reviewed by the U. S. Army Transportation Research Command and is considered to be technically sound.

The conclusions made by the contractor are considered by this command to be valid.



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**Task ID121401A14203
Contract DA 44-177-AMC-98(T)
TRECOM Technical Report 64-36
July 1964**

**ENGINEERING SURVEY OF AIRCRAFT STRUCTURAL FAILURES
CAUSED BY CORROSION, FATIGUE, AND ABRASION**

Final Report

**Prepared by
University of Oklahoma Research Institute
Norman, Oklahoma**

**for
U.S. ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA**

PREFACE

This report covers an engineering survey of aircraft structural failures caused by corrosion, fatigue, and abrasion. The work was accomplished as a research program in the field of structural composites and advanced aircraft materials under U.S. Army Transportation Research Command (USATRECOM) Contract DA 44-177-AMC-98(T). TRECOM Technical Report 64-37 pertains to research conducted under the same contract in the field of fiberglass reinforced sandwich structure for airframe use and is reported separately.

The contract period was from June 10, 1963, to January 31, 1964.

The work was directed by Dr. Gene M. Nordby, Dean of the College of Engineering at the University of Oklahoma. Mr. Bruce V. Ketcham, Professor of Aerospace and Mechanical Engineering, and Mr. W. C. Crisman, Research Engineer, were the principal engineers.

The University of Oklahoma Research Institute expresses appreciation for the assistance by the U.S. Army Aviation Materiel Command, St. Louis, Missouri, in making available their failure report files.

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SUMMARY

A survey of Army aircraft structural failures caused by corrosion, fatigue, and abrasion was made to define critical areas of future structural research. The primary source of data was the Army failure reports, "Equipment Improvement Recommendation". Because of the great number of reports available, a sampling was made consisting of basic airframe failures on four helicopters and two fixed-wing aircraft for the period 1 January 1963 to 31 August 1963. The reports were analyzed individually, and the data were consolidated. Analysis of all data revealed four significant problem areas: (1) corrosion and fatigue of primary airframe structure; (2) separation of metal bonded joints on rotor blades; (3) erosion of rotor blade leading edges; and (4) sustaining rotor blade balance.

CONCLUSIONS

On the basis of the analysis of recent failure reports, it is concluded that:

1. Other promising structural materials should be developed since current research on metallic structural materials in use does not point to correction of the problems of fatigue and corrosion revealed by the analysis. The largest association of failures pertaining to primary aircraft framework (39 per cent of all failures) was found in the area of fatigue and corrosion.
2. Although rotor blade metal bonding separation represents only 9 per cent of the failure sampling, it is an area for concern because it directly involves the integrity of the airframe.
3. Rotor blade damage, especially leading edge erosion, is a problem which should be further investigated.
4. Rotor blades constructed with perforated honeycomb core materials are subject to balance changes due to water collection within the blade.

RECOMMENDATIONS

It is recommended that:

1. Research work in the field of fiberglass-reinforced plastic material for use in primary airframe structures be pursued vigorously.
2. Further study be conducted on the rotor blade bonding separation problem.
3. The solution to the problem of rotor blade damage in operation -- in particular, leading edge erosion -- be sought not only by continued search for protective materials but by the development of new materials of construction.
4. When honeycomb core material is used in rotor blade construction, the nonperforated or sealed type be favored.

DISCUSSION

INTRODUCTION

As a part of an advanced materials research program sponsored by the U.S. Army Transportation Research Command (USATRECOM) under Contract DA 44-177-AMC-98(T), the University of Oklahoma Research Institute conducted a survey of Army aircraft structural failures caused by corrosion, fatigue, and abrasion. The purpose of the survey was to define critical areas of future structural research.

A full-depth survey could not be made because no one document that could be obtained and examined during the desired 6-month contract period contained enough information. A review of Army aircraft failure documents and their availability dictated the use of the "Equipment Improvement Recommendation" (EIR) reports as the best available source of failure data, but even these were not sufficiently complete. Therefore, the limitations described below were imposed on the findings of this survey.

In most cases the EIR reports gave no background data on the failures, nor could the contractor obtain drawings or operating manual details on the failed element in time to provide adequate assistance. In addition, the possibility for the overlooking and nonreporting of many failures vital to this type of survey exists simply because field personnel may not be fully aware of the importance of certain failures that do not appear to endanger the integrity of the aircraft immediately.

Owing to the limited time of the contract period and the vast number of EIR reports, only a cross section of the reports could be appropriately evaluated. Consequently, the information found in this report represents only a beginning. The cross section chosen was a group of reports (dated between January 1, 1963, and August 31, 1963) on four helicopters (UH-1, OH-13, UH-19, and CH-34) and two fixed-wing aircraft (U-6 and O-1). Pertinent information concerning the basic airframe and rotor blades was included.

DESCRIPTION OF WORK

Initially the work program involved locating the best source of failure reports (EIR's) and establishment of contacts, clearances, and procedures

for report collection. Trips were made to SMC Logistic Data Center, Lexington Army Depot, Lexington, Kentucky, and the U.S. Army Aviation and Materiel Command, St. Louis, Missouri. The most logical source of failure reports and the only one that could be effectively utilized during the contract period was found to be at the latter location.

After screening the repository at the U.S. Army Aviation Materiel Command, some 2,300 reports relevant to structural failures were selected and subsequently read in detail at the University of Oklahoma Research Institute facilities.

The reading yielded 463 valuable failure reports all of which were studied and analyzed in detail. The aspects of the failure important to revealing the underlying cause and to providing guidance for correction were recorded by means of a code (the report analysis system is given in the appendix). The coded data were then summed both singly and associatively in an effort to determine problem areas common to all the aircraft -- patterns of failure, aircraft features with high failure rates, materials with high failure rates, etc. Though the sorting of these data was done by hand, the system was designed so that it could handle a much larger volume via a punch card system.

Finally, the 1963 Defense Documentation Center (DDC) indexes were scanned to get a picture of current work that might have application to the problem areas.

SURVEY RESULTS

Tables 1 through 4 contain the summation from all reports of each item in the breakdown of reported information (each item in the analysis code). These tables served as a guide for obtaining (by further sorting) the significant results listed below. It is emphasized that these results are from an overall point of view and not necessarily from the details of any one aircraft or part -- the failure report information was searched for aspects that could affect or have application to all future aircraft structures.

1. There were several types of failures that could be involved in the fatigue mechanism: Fuselage skin wrinkling accounted for 7 per cent of all failures; metallic cracks accounted for 47 per cent (56 per cent of these were in the primary framework, i.e., skin, stringer, frame, etc.); loose rivets accounted for 1 per cent; and catastrophic fractures on landing gears accounted for

TABLE 1
SUMMATION OF FAILURE OCCURRENCE
BY AIRCRAFT IDENTIFICATION CODE

| Coded Item* | Elements of the Code* | | | | | | | | | | | | | | | |
|-------------|-----------------------|-----|-----|-----|----|----|----|----|-----|----|----|----|----|----|----|----|
| | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| d. | 48 | 415 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - | - | - |
| e. | 360 | 65 | 33 | 0 | 2 | 3 | - | - | - | - | - | - | - | - | - | - |
| | 205 | 0 | 0 | 0 | 42 | 26 | 0 | 0 | 142 | 0 | 0 | 0 | 0 | 28 | 0 | 20 |
| | 32 | 147 | 110 | 104 | 17 | 0 | 0 | 0 | 27 | 0 | 7 | 19 | - | - | - | - |
| f. | 463 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - |

*Refer to code in appendix.

TABLE 2
SUMMATION OF FAILURE OCCURRENCE
BY AIRCRAFT HISTORY CODE

| Coded Item* | Elements of the Code* | | | | | | | | | | | |
|-------------|-----------------------|-----|-----|----|----|-----|----|-----|----|----|----|----|
| | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
| a. | 463 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - |
| b. | 20 | 14 | 15 | 4 | 1 | 406 | 2 | 1 | - | - | - | - |
| c. | 58 | 326 | 39 | 6 | 1 | 2 | 0 | 1 | 30 | - | - | - |
| d. | 348 | 92 | 0 | 0 | 1 | 2 | 0 | 19 | 0 | 1 | 0 | - |
| e. | 335 | 103 | 0 | 5 | 1 | 1 | 0 | 18 | 0 | 0 | 0 | - |
| f. | 367 | 1 | 40 | 0 | 0 | 5 | 0 | 33 | 17 | - | - | - |
| g. | 369 | 1 | 41 | 0 | 0 | 5 | 0 | 32 | 4 | 11 | - | - |
| h. | 203 | 2 | 0 | 7 | 0 | 2 | 66 | 102 | 21 | 57 | 2 | 1 |
| i. | 192 | 2 | 0 | 7 | 0 | 2 | 71 | 106 | 21 | 58 | 2 | 2 |
| j. | 312 | 0 | 0 | 0 | 0 | 151 | 0 | - | - | - | - | - |
| k. | 1 | 451 | 0 | 1 | 0 | 0 | - | - | - | - | - | - |
| l. | 166 | 91 | 117 | 63 | 18 | 7 | 1 | - | - | - | - | - |
| | 223 | 238 | 2 | 0 | 0 | 0 | 0 | - | - | - | - | - |
| | 142 | 9 | 202 | 86 | 17 | 6 | 1 | - | - | - | - | - |
| m. | 147 | 243 | 2 | 36 | 1 | 30 | 1 | 3 | 0 | 0 | - | - |

*Refer to code in appendix.

**TABLE 3
SUMMATION OF FAILURE OCCURRENCE
BY LOCATION OF FAILED PART CODE**

| Coded Item* | Elements of the Code* | | | | | | | | | | | | | | | | | |
|----------------|-----------------------|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|-----|----|----|
| | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| a. | 161 | 15 | 1 | 0 | 7 | 42 | 161 | 2 | 36 | 16 | 3 | 0 | 19 | 0 | 0 | - | - | - |
| b. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| c. | 374 | 16 | 73 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| d. | 78 | 4 | 16 | 1 | 0 | 40 | 0 | 0 | 8 | 3 | 0 | 53 | 1 | 0 | 2 | 104 | 2 | 11 |
| e. | 10 | 14 | 46 | 60 | 17 | 33 | 124 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 1 | 63 | 52 |
| | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| a. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| b. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| c. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| d. | 1 | 26 | 2 | 18 | 8 | 4 | 25 | 0 | 13 | 2 | 15 | 0 | 1 | 2 | 10 | 6 | 4 | 3 |
| e. | 25 | 7 | 2 | 2 | 0 | 0 | - | - | - | - | - | - | - | - | - | - | - | - |

*Refer to code in appendix.

TABLE 4
SUMMATION OF FAILURE OCCURRENCE BY
MATERIAL AND FAILURE DESCRIPTION CODE

| Coded Item* | Elements of the Code* | | | | | | | | | | | | | |
|-------------|-----------------------|-----|-----|----|-----|-----|----|----|----|----|----|----|----|----|
| | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 |
| a. | 110 | 211 | 109 | 0 | 0 | 2 | 10 | 0 | 3 | 8 | 10 | - | - | - |
| b. | 0 | 445 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 8 | - | - | - | - |
| c. | 0 | 445 | 0 | 0 | 10 | 0 | 0 | 8 | - | - | - | - | - | - |
| d. | 170 | 5 | 220 | 0 | 30 | 38 | - | - | - | - | - | - | - | - |
| e. | 315 | 4 | 0 | 1 | 6 | 3 | 1 | 4 | 0 | 23 | 1 | 0 | 11 | 1 |
| f. | 234 | 217 | 12 | - | - | - | - | - | - | - | - | - | - | - |
| g. | - | 463 | - | - | - | - | - | - | - | - | - | - | - | - |
| h. | - | 463 | - | - | - | - | - | - | - | - | - | - | - | - |
| i. | - | 463 | - | - | - | - | - | - | - | - | - | - | - | - |
| j. | - | 463 | - | - | - | - | - | - | - | - | - | - | - | - |
| k. | 3 | 1 | 0 | 0 | 0 | 138 | 0 | 32 | 7 | 0 | 0 | 0 | 86 | 1 |
| l. | 9 | 33 | 11 | 0 | 343 | 0 | 32 | 2 | 3 | 0 | 16 | 2 | 1 | 0 |
| | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | |
| a. | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| b. | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| c. | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| d. | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| e. | 0 | 84 | 9 | - | - | - | - | - | - | - | - | - | - | - |
| f. | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| g. | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| h. | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| i. | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| j. | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| k. | 71 | 23 | 51 | 3 | 10 | 3 | 1 | 7 | 4 | 1 | 5 | 14 | 2 | |
| l. | 9 | 2 | - | - | - | - | - | - | - | - | - | - | - | |

*Refer to code in appendix.

2 per cent for a total of 57 per cent of all failures. As indicated by the underlined items, 34 per cent of all failures were involved in fatigue of primary structure.

2. Separation of metal to metal bonded joints accounted for 11 per cent of the total failures; 80 per cent of these occurred on rotor blades.
3. Corrosion accounted for 7 per cent of all the failures -- 62 per cent of these being magnesium stringers and skin, and 22 per cent being steel tubular trusses. All of these occurred on fuselage structures.
4. In addition to corrosion, 11 per cent of the total failures involved surface damage. Of this 11 per cent, dents in rotor blades accounted for 26 per cent; rotor blade erosion accounted for 20 per cent; and landing skid shoe abrasion during pilot training accounted for 50 per cent.
5. Rotors developing vibrations during service accounted for 8 per cent of the total failures. Sixty-two per cent of these failures involved blades that became unbalanced during service, while 37 per cent became untrackable during service. Of the blades that became unbalanced, 61 per cent were reported to contain water. These blades containing water utilized perforated honeycomb core in their construction.

LITERATURE SEARCH (DDC) RESULTS

A search of the recent literature listed by the Defense Documentation Center (DDC) yielded the information in each problem area as discussed below:

1. Despite the many current research programs on metal fatigue, no one program or combination of programs points to a direct solution. Although it would be desirable to have an accurate theory to explain the exact nature of the fatigue mechanism, structural failures could be reduced significantly through the development of structural materials with improved damping characteristics. Since sandwich materials offer great potential from this standpoint, work in this area should be continued.

2. The information in the failure reports was insufficient to isolate the exact cause of the majority of the metal bonding separations found on rotor blades -- more background information is needed since many factors, such as usage, design, fabrication, adhesive, etc., may be involved. Bonding separation is considered a vital problem and further study is recommended.
3. The most urgent and important case of material surface damage noted in the survey was rotor blade dents and leading edge erosion. Recent work in this area has been done by the Boeing Company (TCREC Technical Report 62-111, Helicopter Rotor Blade Erosion Protective Materials, Phase I), and should be continued.
4. No research programs were found which would lead to a clear-cut solution of the corrosion problem. The approach that offers the greatest promise is probably the development of construction materials which are not susceptible to corrosion, such as fiberglass reinforced plastics.
5. A significant failure in the realm of rotor blade construction was discovered during the course of the survey. Blades that became unbalanced while in service were reported to contain water. Liaison with the manufacturer revealed that perforated honeycomb core was used in the construction of these blades. These facts indicate that either water which had leaked into the blade or internal condensation had passed through the perforations and collected to produce the unbalanced condition. Thus, it is recommended that when honeycomb core material is employed in rotor blade construction, the sealed or nonperforated type be favored.

APPENDIX

REPORT ANALYSIS SYSTEM AIRCRAFT STRUCTURAL FAILURES

INTRODUCTION

Usually, the degree to which a coding system is subject to the interpretation of the operator is inversely proportional to the complexity of the code. To hold the developmental time and cost to a minimum, and to facilitate rapid use of the code to aircraft structural failures caused by fatigue, corrosion, and abrasion, a relatively simple one was devised. Hence, there are, of necessity, areas open for interpretation. These instructions were written to ensure uniform use of the code.

In the use of the code, care must be exercised to focus attention on the failure itself and not its results or some side effect. The terms "none" and "unknown" found throughout the code should be used with care: "none" when the report so states or implies, and "unknown" when an answer is suspected to exist under the item in question. When an item is not deemed to be significant to the failure, it should be coded "not applicable". This applies to all items.

To account for all failures, University of Oklahoma Research Institute (OURI) numbers should be assigned to account for the additional failures of like items totaled under item 7 (quantity defective) in block 32 of the basic EIR. These data sheets should be fastened to the prime data sheet with a note to the key puncher to punch them so that they are identical to the prime sheet except where indicated. (Example: OURI number, aircraft serial number, aircraft hours, etc.).

Notes should be made on the data sheet in that some information does not lend itself to tabular recording. A word picture of the failure will permit the statistical results to be qualified by pointing out the limitations which affect them, and thus will add insight to and increase confidence in the survey.

The following special notes that pertain to the specified parts of the code will further serve to aid in its use:

2. Aircraft History

b. How discovered

The item most significant to the failure should be used.

c. Symptom of failure

This item pertains to the operational aspect of the machine rather than to the maintenance or to any other aspect.

d. Significant occurrence prior to failure, and

e. Occurrence at time of failure

These items are intended to bring out any (operational or maintenance) occurrence that could have brought about or had significant influence on the failure. This is directed toward a one-time occurrence.

f. Mission prior to failure, and

g. Mission at failure

These items are to define the setting of the failure. They serve to isolate the type of operation (both flight and maintenance) under which failure occurs.

h. Mission environment prior to failure, and

i. Mission environment at failure

These items are included to describe the atmosphere, when significant, in which the aircraft was operating when the failure occurred.

j. Aircraft weight

This item serves to define further the type of operation under which failure occurs.

k. Alteration status in vicinity of failure

This item is included to point out any modification in the vicinity of the failure that could have influenced the failure. Routine maintenance, unless significant, should not be included.

1. Hours of operation

Hours since new or overhaul, whichever is significant.

3. Location of Failed Part

b. Position of failed part

This item will serve to identify the position of the failure on the major component or to complete the identification of the major component and then to locate the position of the failure on this component, whichever is pertinent.

c. Function of failed part

This item was included to differentiate between the failures occurring in the airframe (the framework carrying the major loads), to include rotor blades; the elements of the airframe such as fairings that carry no major loads; and the parts and components on the airframe that are essential to the integrity of the airframe, such as the helicopter transmissions or the main thrust bearing in the transmission.

d. Name of failed part

The names listed under this item are as inclusive as possible, to permit categorizing of failures without being hamstrung with individual details.

e. Condition significant in immediate vicinity

This item was included to give insight to the mechanism of the failure. Any condition that could have brought about, contributed to, or been significant to the failure should be noted.

4. Material and Failure Description

a. Composition of failed part

This item was included to aid in establishing what structural material has experienced the most failures. The possibility

exists of the significance of this item's being weakened by the term "unknown". Every effort should be made to obtain the necessary technical data on each aircraft. Should a component be composed of several materials fastened together, only the composition of the failed section should be used.

- b. If composite, core composition; and
- c. If composite, skin composition

When these items are employed following the use of laminate in a., they will be understood to describe the composition of the layers in the laminate, the term "skin" being used for outside or exposed layer. They were originally included to describe honeycomb core sandwich materials.

- e. Method of loading

Many times the method of loading can be determined by the layout of the failed structure or part.

- f. Metallic fracture

This item is included to assist in fatigue cases, but it also covers static breaks.

- g. Metallic fracture surface, peripheral;
- h. Metallic fracture surface, core;
- i. Metallic fracture appearance, peripheral; and
- j. Metallic fracture appearance, core

These items are to describe the physical features of a catastrophic rupture, a complete separation. Their greatest benefit would be to substantiate a fatigue failure. For a skin crack these would most logically be coded "not applicable" while for a crack in a thicker element "unknown" would be an acceptable code.

k. Mode of failure

In this item, mode of failure means method of failure, and hence, is one of the most valuable of all the facets to the description of the failure. Not only does this item permit description of a catastrophic type failure, but also of a failure where degeneration of performance is involved.

l. Condition of the failed part

This item is included to help pinpoint the significant local environment or conditions that existed at the time of the failure.

CODE

This code was developed for use on punched cards as illustrated on the Failure Report Analysis Sheet which is included as the last item in this appendix. The code is quite extensive and can be used for failure analyses far beyond the scope of the failure incidence covered in this report.

1. Aircraft Identification

- a. OURI log number: (5 columns)
- b. Date of failure--month, day, year: (6 columns)
- c. Aircraft serial number: (6 columns)
- d. Aircraft category: (2 columns)

- 01 Fixed wing
- 02 Helicopter
- 03 Tilt wing VTOL
- 04 Fan in wing VTOL
- 05 Vectored jet VTOL
- 06 Tilt rotor VTOL
- 07 Unload rotor convertiplane

- e. Aircraft designation:

Special configuration: (2 columns)

- 01 None
- 02 Unknown
- 03 Attack
- 04 Special electronic installation
- 05 Trainer
- 06 Not significant

Aircraft: (2 columns)

- | | |
|---------|----------|
| 01 UH-1 | 04 OH-6 |
| 02 OH-4 | 05 OH-13 |
| 03 OH-5 | 06 UH-19 |

| | | | |
|----|-------|----|------|
| 07 | CH-21 | 17 | U-8 |
| 08 | OH-23 | 18 | U-9 |
| 09 | CH-34 | 19 | OV-1 |
| 10 | CH-37 | 20 | CV-2 |
| 11 | NH-41 | 21 | XV-3 |
| 12 | CH-46 | 22 | XV-4 |
| 13 | CH-47 | 23 | XV-5 |
| 14 | O-1 | 24 | XV-6 |
| 15 | U-1 | 25 | CV-7 |
| 16 | U-6 | | |

Aircraft Model: (2 columns)

| | | | |
|----|-----------|----|---|
| 01 | No letter | 07 | L |
| 02 | A | 08 | S |
| 03 | B | 09 | D |
| 04 | C | 10 | F |
| 05 | E | 11 | G |
| 06 | K | 12 | H |

f. Aircraft Operator: (2 columns)

| | |
|----|-----------------------|
| 01 | Active Army |
| 02 | Army (N.G. & Reserve) |
| 03 | Navy |
| 04 | Naval Reserve |
| 05 | Air Force |
| 06 | Air National Guard |
| 07 | Coast Guard |

2. Aircraft History

a. Source of this data: (2 columns)

| | |
|----|----------------------------------|
| 01 | Failure report (EIR, etc.) |
| 02 | Accident report |
| 03 | Forced landing message |
| 04 | Engineering changes |
| 05 | Analysis report |
| 06 | Commercial operator |
| 07 | Failure report + analysis report |

b. How discovered: (2 columns)

- 01 Unknown
- 02 Ground operational check
- 03 Operational deficiency in flight
- 04 During accident investigation
- 05 Caused accident
- 06 During maintenance
- 07 In-flight observation
- 08 Operational deficiency in flight plus caused accident

c. Symptom of failure: (2 columns)

- 01 Unknown
- 02 None
- 03 Vibration
- 04 Loss of operational efficiency
- 05 Loss of control
- 06 Vibration and loss of control
- 07 Noise during operation
- 08 Noise during run-down or securing
- 09 Not applicable

d. Significant occurrence prior to failure: (2 columns)

- 01 Unknown
- 02 None
- 03 High G maneuver
- 04 Hard landing or landing on unsuitable surface
- 05 Mishandling while on ground
- 06 Flight in turbulence
- 07 Overspeed of rotating component
- 08 Exposure to high humidity or rain
- 09 Failure to remove drilling or machining chips
- 10 Overtorqued
- 11 Excessive component vibration developed

e. Occurrence at time of failure: (2 columns)

- 01 Unknown
- 02 None
- 03 High G maneuver

- 04 Hard landing or landing on unsuitable surface
- 05 Mishandling while on ground
- 06 Flight in turbulence
- 07 Overspeed of rotating component
- 08 Exposure to high humidity or rain
- 09 Installing or removing part
- 10 Overtorqued
- 11 Excessive component vibration developed

f. Mission prior to failure: (2 columns)

- 01 Unknown
- 02 Acrobatic flight
- 03 Normal utility or cargo flight including landing or take-off
- 04 Nap-of-the-earth flight
- 05 Short strip or small area landing or take-off
- 06 Training, not covered by other missions listed
- 07 Instrument flight
- 08 Not applicable
- 09 Combat operations

g. Mission at failure: (2 columns)

- 01 Unknown
- 02 Acrobatic flight
- 03 Normal utility or cargo flight including landing or take-off
- 04 Nap-of-the-earth flight
- 05 Short strip or small area landing or take-off
- 06 Training, not covered by other missions listed
- 07 Instrument flight
- 08 Not applicable
- 09 Compliance with maintenance order
- 10 Combat operations

h. Mission environment prior to failure: (2 columns)

- 01 Unknown
- 02 Arctic
- 03 Arid
- 04 Sandy/dusty
- 05 Tropic

- 06 Coastal (rain and high humidity with salt atmosphere)
- 07 Moderate-average, summer
- 08 Not applicable
- 09 Rain and high humidity
- 10 Moderate-average, winter
- 11 Icing
- 12 Gusty winds

i. Mission environment at failure: (2 columns)

- 01 Unknown
- 02 Arctic
- 03 Arid
- 04 Sandy/dusty
- 05 Tropic
- 06 Coastal (rain and high humidity with salt atmosphere)
- 07 Moderate-average, summer
- 08 Not applicable
- 09 Rain and high humidity
- 10 Moderate-average, winter
- 11 Icing
- 12 Gusty winds

j. Aircraft weight: (1 column)

- 1 Unknown
- 2 Near normal gross weight
- 3 Near empty
- 4 Above normal gross weight
- 5 Intermediate weight
- 6 Not applicable

k. Alteration status in vicinity of failure: (2 columns)

- 01 Unknown
- 02 None
- 03 Non-compliance with safety directive
- 04 Local repair in vicinity recently
- 05 Local repair of failed part recently
- 06 Indication of need for repair or balance

l. Hours of operation:

Hours on airframe: (4 columns)
Hours on power plant: (4 columns)
Hours on failed part: (4 columns)

Note: Use the following key in the first column of each of the above.

- 1 Unknown
- 2 Not applicable
- 3 0 - 1,000 hours
- 4 1,000 - 2,000 hours
- 5 2,000 - 3,000 hours
- 6 3,000 - 4,000 hours
- 7 5,000 - 6,000 hours

m. Last overhaul station of failed part: (2 columns)

- 01 Unknown
- 02 Has not been overhauled - new
- 03 U.S. Army Transportation Aeronautical Depot Maintenance Center (ARADMAC)
- 04 Bell Helicopter Company
- 05 Not applicable
- 06 Parsons
- 07 Sikorsky
- 08 Avialando
- 09 Societe Anonyme Belge Construction (SABCA)
- 10 Sud-Aviation

3. Location of Failed Part

a. Major component: (2 columns)

- | | |
|----------------------------|-------------------------------|
| 01 Fuselage | 09 Transmission |
| 02 Wing | 10 Power plant |
| 03 Control system | 11 Tail rotor pylon |
| 04 Vertical tail surface | 12 Wing nacelle |
| 05 Horizontal tail surface | 13 Tail boom (on helicopters) |
| 06 Undercarriage | 14 Crew restraint system |
| 07 Rotor blade or blades | 15 Passenger restraint system |
| 08 Rotor head | |

b. Position of failed part: (2 columns)

- | | |
|-------------------------|----------------------|
| 01 Not applicable | 07 Control system |
| 02 Front or root | 08 Louver |
| 03 Intermediate or main | 09 Seat structure |
| 04 Aft or tip or tail | 10 Occupant tie-down |
| 05 Control surface | 11 Main at tip |
| 06 Flap | 12 Counter weight |

c. Function of failed part: (1 column)

- 1 Structural, vital (airframe carrying major loads)
- 2 Nonstructural, vital (airframe components and fixtures)
- 3 Structural, not vital (airframe and appendages not carrying major loads)

d. Name of failed part: (2 columns)

- | | |
|----------------------------|-------------------------------------|
| 01 Skin | 19 Beam or spar |
| 02 Fitting | 20 Shoe |
| 03 Strut | 21 Blade grip |
| 04 Brace | 22 Leading edge |
| 05 Bearing | 23 Mounting cap |
| 06 Beam flange or stringer | 24 Bulkhead mount or gusset |
| 07 Beam web | 25 Ring or frame gusset |
| 08 Link | 26 Rib |
| 09 Fastener, hardware | 27 Stiffener or doubler |
| 10 Cowling or cover | 28 Bulkhead |
| 11 Shaft | 29 Ring or frame |
| 12 Mount structure | 30 Ring or frame with bulkhead |
| 13 Tubing | 31 Door or window |
| 14 Belt | 32 Pedestal |
| 15 Yoke | 33 Accessory mount structure |
| 16 Same as major component | 34 Instrument panel mount structure |
| 17 Horn | 35 Strut cap |
| 18 Trim tab | 36 Spring strut (leafed) |

e. Condition significant in immediate vicinity: (2 columns)

- 01 Near notch or cut out
- 02 In curvature or bend

- 03 Near joint, welded
- 04 Near joint, riveted or bolted
- 05 Near notch or cut out and in curvature
- 06 Clear
- 07 Exposure to slipstream
- 08 Exposure to localized heat source
- 09 Exposure to high noise level
- 10 Near manufacturing flaw such as a scratch
- 11 Misfitted or misaligned with mating parts during installation
- 12 Near an unintentional injury to part
- 13 Insufficient lubrication
- 14 Near abrupt change in section--threads, flange, etc.
- 15 Insufficient bonding material
- 16 Insufficient bonding material and exposed to slipstream
- 17 None
- 18 Unknown
- 19 Exposure to landing surface
- 20 Near power plant
- 21 Sealing material deteriorated or separated
- 22 New part installed in system
- 23 Near stored part
- 24 Near joint, riveted or bolted, in curvature

4. Material and Failure Description

a. Composition of failed part: (2 columns)

- | | |
|-------------------------------|------------------------------|
| 01 Metal, steel | 07 Composite--honeycomb core |
| 02 Metal, aluminum | 08 Laminate |
| 03 Metal, magnesium | 09 Not applicable |
| 04 Metal | 10 Metal and rubber |
| 05 Metal, unknown composition | 11 Wood |
| 06 Plastic, solid | |

b. If composite, core composition: (2 columns)

- | | |
|-------------------|---------------------|
| 01 Unknown | 06 Metal, aluminum |
| 02 Not applicable | 07 Metal, magnesium |
| 03 Paper | 08 Metal |
| 04 Fiberglass | 09 Metal |
| 05 Metal, steel | 10 Rubber |

c. If composite, skin composition: (2 columns)

- | | |
|-------------------|-------------------------------|
| 01 Unknown | 05 Metal, aluminum |
| 02 Not applicable | 06 Metal, magnesium |
| 03 Fiberglass | 07 Metal |
| 04 Metal, steel | 08 Metal, unknown composition |

d. Type of load: (2 columns)

- 01 Unknown
- 02 Static
- 03 Repeated or cyclic, resonance unknown
- 04 Resonant vibration
- 05 Surface impact and abrasion
- 06 Not applicable

e. Method of loading: (2 columns)

- | | |
|------------------------|------------------------------|
| 01 Unknown | 10 Bending-torsion-tension |
| 02 Pure shear | 11 Tension-bending |
| 03 Tension | 12 Thrust and radial |
| 04 Compression | 13 Bending and shear |
| 05 Torsion | 14 Tension and shear |
| 06 Tension-compression | 15 Tension-compression-shear |
| 07 Bending | 16 Not applicable |
| 08 Bending and torsion | 17 Compression and shear |
| 09 Tension and torsion | |

f. Metal fracture: (2 columns)

- 01 Not applicable
- 02 Cracked
- 03 Completely separated

g. Metallic fracture surface, peripheral: (2 columns)

- 01 Unknown
- 02 Not applicable
- 03 Stop marked
- 04 Peaked and/or with 45-degree surfaces

- 05 Beach marked
- 06 Granular, coarse
- 07 Granular, fine

h. Metallic fracture surface, core: (2 columns)

- 01 Unknown
- 02 Not applicable
- 03 Peaked and/or with 45-degree surfaces
- 04 Beach marked
- 05 Granular, coarse
- 06 Granular, fine

i. Metallic fracture appearance, peripheral: (2 columns)

- 01 Unknown
- 02 Not applicable
- 03 Shiny
- 04 Dull and velvety

j. Metallic fracture appearance, core: (2 columns)

- 01 Unknown
- 02 Not applicable
- 03 Shiny
- 04 Dull
- 05 Velvety

k. Mode of failure: (2 columns)

- 01 Shear
- 02 Tension
- 03 Compression
- 04 Fatigue followed by shear
- 05 Fatigue followed by tension or compression
- 06 Evidence of fatigue but indeterminate
- 07 Bending
- 08 Column or panel buckling
- 09 Material cracked and separated from internal stresses
- 10 Core crushing

- 11 Dimpling of face
- 12 Shear crimping
- 13 Skin or surface crack
- 14 Large deflection occurred
- 15 Surface of material damaged
- 16 Became unbalanced
- 17 Bonding separation
- 18 Sealing incomplete
- 19 Fastener came loose
- 20 Insufficient clearance between elements
- 21 Support collapsed
- 22 Shape of surface altered
- 23 Type of material failure unknown
- 24 Excessive clearance between elements
- 25 Holes in materials
- 26 Blade would not remain in track in forward flight
- 27 Fastener hole enlarged

1. Condition of failed part: (2 columns)

- 01 Unknown
- 02 Corroded
- 03 Eroded
- 04 Like new
- 05 Normal wear state
- 06 Discolored as from heat
- 07 Excessive wear--abrasion
- 08 Bent
- 09 Imperfect details of design
- 10 Galled and chipped
- 11 Absorbed water
- 12 Scratched or gouged
- 13 Imperfect details in manufacture
- 14 Threads stripped
- 15 Absorbed water and frozen
- 16 Cracked and deteriorated (for nonmetals)

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AIRCRAFT IDENTIFICATION

Recorded _____
 Punched _____
 Verified _____

| OURI LOG NUMBER | | | | | | | DATE OF FAILURE | | | | | | | AIRCRAFT SERIAL NUMBER | | | | | | | AIRCRAFT CATEGORY | | | AIRCRAFT DESIGNATION | | | AIRCRAFT OPERATOR | | | | | | | | | | | | | | | |
|-----------------|---|---|---|---|---|---|-----------------|---|----|----|----|----|----|------------------------|----|----|----|----|----|----|-------------------|----|----|----------------------|----|----|-------------------|----|----|----|----|----|----|----|----|----|--|--|---|--|--|--|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | | | | | | |
| / | | | / | | | | / | | | | / | | | | / | | | / | | | | / | | | / | | | | / | | | / | | | | / | | | / | | | |

AIRCRAFT HISTORY

| SOURCE | | DISCOVERED | | SYMPTOM | | BEFORE FAILURE | | AT FAILURE | | MISSION BEFORE | | MISSION AT | | EVIDENCE PRIOR | | EVIDENCE AT | | WEIGHT | | ALTERATION | | LAST OVERHAUL | | | | | | | | | | | | | |
|--------|----|------------|----|---------|----|----------------|----|------------|----|----------------|----|------------|----|----------------|----|-------------|----|--------|----|------------|----|---------------|----|----|----|----|----|----|----|----|----|----|----|----|--|
| 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | |
| / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | |

| OURI LOG NUMBER | | | | | | | HOURS ON AIRFRAME | | | | | HOURS POWER PLANT | | | | HOURS ON FAILED PART | | | | | | | | | | | | | | | | | | |
|-----------------|---|---|---|---|---|---|-------------------|---|----|----|----|-------------------|----|----|----|----------------------|----|----|----|----|----|----|--|--|--|--|--|--|--|--|--|--|--|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | | | | | | | | | | | | |
| | | | / | | | | / | | | | | / | | | | | / | | | | | / | | | | | | | | | | | | / |

LOCATION OF FAILED PART

| COMPONENT | | POSITION | | FUNCTION | | NAME | | VICINITY | | | | |
|-----------|----|----------|----|----------|----|------|----|----------|----|----|----|----|
| 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| | | / | | | / | | / | | | / | | |

1. Shaded blocks to be left blank.
2. Entries between shaded areas must be right justified.
3. Unfilled blocks to be zeroed.

MATERIAL AND FAILURE DESCRIPTION

| COMPOSITION | | COMPOSITE, CORE | | COMPOSITE, SKIN | | TYPE LOAD | | LOADING | | TYPE FRACTURE | | SURFACE, PERIPHERY | | SURFACE, CORE | | APPEARANCE, SURFACE | | APPEARANCE, CORE | | FAILURE MODE | | CONDITION | | | | | | | | | | | | | |
|-------------|----|-----------------|----|-----------------|----|-----------|----|---------|----|---------------|----|--------------------|----|---------------|----|---------------------|----|------------------|----|--------------|----|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 |
| / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | | / | | |

FAILURE REPORT ANALYSIS SHEET

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