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USAAMRDL TECHNICAL REPORT 71-58

**CH-47A, B AND C SERIES HELICOPTER
ROTOR BLADE FAILURE AND SCRAP RATE
DATA ANALYSIS**

By

R. L. Hunt

November 1971

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FORT EUSTIS, VIRGINIA

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13. ABSTRACT This report provides the results of an analysis of failure data derived from depot inspection, overhaul/rework, and scrappage reports on 5,488 rotor blades of the CH-47 series tandem rotor helicopters. Two types of rotor blades were analyzed for blade mean-time-between-removals, mean-time-to-removals, mean-time-between-unscheduled-removals and mean-time-between-scrappage. Locations on these blades for the major discrepancies were determined. Blade teardown experience was determined. A cost comparison of blade acquisition costs versus the average cost of repair/rework was provided.		

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**DEPARTMENT OF THE ARMY
U. S. ARMY AIR MOBILITY RESEARCH & DEVELOPMENT LABORATORY
EUSTIS DIRECTORATE
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The Eustis Directorate of the U.S. Army Air Mobility Research and Development Laboratory is conducting a series of design studies and hardware evaluations leading to improved reliability and maintainability (R&M) characteristics for future helicopter rotor blades. It is intended that design requirements will be tailored to each aircraft type (utility, attack, transport, etc.) with full consideration of operational environment impacts (combat damage, foreign object damage, etc.) included.

This contract was awarded to analyze the operational R&M history of CH-47A, B, and C model helicopter rotor blades to establish design considerations for transport type aircraft. The findings presented herein are considered to be most accurate and directly usable in establishing expected rotor blade external damage rates for the type of helicopter in question. Results of this analysis will be used for evaluation of advanced rotor blade design concepts currently being investigated under this Directorate's R&M research and development program. This report is published as a parallel to the USAAVLABS Technical Report 71-9, "UH-1 and AH-1 Helicopter Main Rotor Blade Failure and Scrap Rate Data Analysis", which presented data for consideration in the design of utility and attack helicopter rotor blades.

The technical monitor for this contract was Major Vincent G. Ripoll, Reliability and Maintainability Division, Eustis Directorate.

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CH-47A, B AND C SERIES HELICOPTER
ROTOR BLADE FAILURE AND SCRAP RATE
DATA ANALYSIS

Final Report

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Prepared By
The Boeing Company, Vertol Division
Philadelphia, Penna.

for

EUSTIS DIRECTORATE
U.S. ARMY AIR MOBILITY RESEARCH AND DEVELOPMENT LABORATORY
FORT EUSTIS, VIRGINIA

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SUMMARY

This report has the purpose of providing the results of an analysis of failure data derived from depot inspection, overhaul/rework, and scrappage of 5,488 rotor blades of the CH-47 series tandem rotor helicopters. These blades were returned after RVN and CONUS operations over a time period from July 1, 1962 through March 1, 1971, with an accumulation of 2,521,734 actual blade operating hours with an equivalent accumulation of 5,679,399 operating hours for all blades in the helicopter fleet.

Analyses of unscheduled removals, repair, overhaul, and scrap data were conducted on two different types of blades. Compilation of total quantity of blades investigated has been provided, as well as accumulated time on all blades at removal.

Analyses to determine the blade design parameters as mean-time-between-removals (MTBR), mean-time-to-removals (MTTR) and mean-time-between-unscheduled-removals (MTBUR) have been included. Results may be compared for changes in these parameters in preceding from the early to the later model. Changes in these parameters can be attributed to incorporation of engineering changes, evolution of improved manufacturing, shipping, handling and modified maintenance practices.

Analyses to determine reasons for removals, repairs and scrappage as a percentage of total blades removed and of total blades scrapped have been compiled. Reported reasons for removal are consistent with reasons for repair and for scrappage. Blades subjected at the manufacturer's repair facility to close detailed inspection, disassembly, or repair for minor damage sometimes indicated serious defects as extensive water migration, exterior spar corrosion and similarly hidden damages. Additional reasons for scrappage were, therefore, discovered. A very minor quantity of blades may be scrapped due to in-transit depot handling and processing damages. Analysis results for the mean-time-between-scrappage (MTBS) for both CH-47A and B/C blades have been included.

Conclusions of this analysis indicate that the later CH-47B/C blades have been designed to decrease the amount of inherent discrepancies. However, they are more susceptible to externally caused discrepancies than the CH-47A helicopter blades. It is recommended that field repair and blade handling procedures be reviewed for modifications in line with the results of this report.

FOREWORD

This report provides an analysis of rotor blade failure and scrap rate historical data as reported on the tandem rotor helicopters, CH-47A, CH-47B and CH-47C. This analysis was conducted under Contract DAAJ02-71-C-0014 (Task 1F162205A11901) for the Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory (USAAMRDL), Fort Eustis, Virginia.

USAAMRDL technical direction was provided by Major Vincent G. Ripoll.

The principal analyst for The Boeing Company, Vertol Division, was Mr. R. L. Hunt, assisted by Mr. E. C. Daley and Mr. J. J. Chmura, all of M&R Engineering. Program management and technical direction were provided by Mr. H. J. Smith, Sr., Product Support Engineer, Mr. R. E. Spears, Sr., Product Support Engineer, Mr. R. Hazlett, Manager Product Assurance R&D, and Mr. P. W. Fiedler, Unit Chief Reliability and Maintainability.

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INTRODUCTION

Helicopter rotor blade failure and scrap rate information as reported during depot rework is an important source of blade data. This data may be used analytically to determine removal rates and mean removal values, to determine blade scrapage rates and mean scrapage values and enable correlation of these rates and values with the various reasons for blade removal from the helicopter and for subsequent repair or scrapage.

The above data was available, as The Boeing Company, Vertol Division has been repairing and updating CH-47 helicopter rotor blades under a U. S. Army contract since the incorporation of this helicopter into the Army inventory in 1962.

During the time from 1962 through 1970, the Vertol Division has been the sole contractor for depot rework of CH-47 helicopter rotor blades. From all data generated from the rework facility and from field activities, a data system was developed to record utilization, discrepancies, failure modes, configuration control, and reason for blade removal/scrapage. This data has been maintained in a usable format to enable blade analyses to be readily accomplished at any time.

This data has been continually extracted, reviewed and verified by Boeing Company/Vertol Division personnel who possessed specialized backgrounds in the fields of reliability, maintainability, service engineering, design, military/aviation, data analysis and military/civilian overhaul/repair facilities. It is from the above data source that this CH-47A, B and C series helicopter rotor blade failure data and scrap rate data analysis has been compiled.

SCOPE

The objective of this effort was to conduct an analysis of available CH-47A, B and C series helicopter rotor blade failure and scrap rate data to determine unscheduled and scheduled removal rates, to develop mean-time-between-removal values, to determine blade scrapage rates, and to correlate these rates and values with the various reasons for removal and scrapage.

This data was derived entirely from depot level repair and scrapage reports on two types of rotor blades used on three different helicopter models as shown by Table I below.

TABLE I. ANALYZED ROTOR BLADES IDENTIFICATION		
APPLICABLE HELICOPTER	HELICOPTER SERIAL NUMBERS	APPLICABLE ROTOR BLADES PART NUMBERS
CH-47A	59-4982 & Subsequent	P/N 114R1002
CH-47B	66-19098 & Subsequent	P/N 114R1502
CH-47C	67-18494 & Subsequent	P/N 114R1502

The CH-47A type of rotor blade with a steel spar, fiberglass skins, and aluminum ribs is constructed as a symmetrical airfoil. The CH-47B/C type of rotor blade, with a steel spar, fiberglass skins, honeycomb fillers and plastic end ribs is constructed as a nonsymmetrical airfoil. Due to these major design differences, the analytical effort, therefore, treated these two types of blades independently. A detailed discussion of blade differences and how these were treated in the analyses is given under analysis approach, page 3.

ANALYSIS APPROACH

This section describes the preliminary steps taken prior to accomplishment of the analytical efforts concerned with blade removals and blade scrappage.

The two types of blade configurations, i.e., CH-47A symmetrical type and the CH-47B/C nonsymmetrical type, and their different installation locations, i.e., forward and aft rotors, have had a bearing upon the extent of data available for extraction; therefore, these blade configurations and installations are described in detail herein.

The organization of the data into a form suitable for extraction of material useful for the analyses contained in this report required the application of a specific data extraction process which is discussed below.

Certain data limitations exist for the data reporting time period investigated. One limitation concerns the fact that all blade repairs, overhaul, and scrappage have been accomplished at the depot level. Thus data reporting on blade repairs and scrappage occurred at this level for a total of 2,521,734 actual blade hours. During this same interval, if field level (organizational through general support maintenance levels) data had been available, a total of 5,679,399 blade operating hours could have been used as the analysis data base. A second limitation is the possible loss of data due to unusual incidents. A third limitation is the possible dilution of the blade population by excessive categorization. These limitations are discussed herein.

Identification of reasons for removal, repair, and scrappage required a simplified tabulation of the standard military coding to handle the quantity of data. This tabulation is discussed below. Recognition of the inspection criterion against which blades are removed or scrapped is discussed.

Calculation of blade means representative of blade operating experience requires definition of these means and development of appropriate equations. These steps are presented herein.

DESCRIPTION OF CH-47 HELICOPTER ROTOR SYSTEMS

CH-47A Rotor Systems

The CH-47A helicopter rotor system consists of two rotor installations: one at the forward end of the aircraft and one at the aft end, as shown in Figure 1. These installations are similar but not identical. Each installation includes three interchangeable blade assemblies and a rotor head assembly. The helicopter thus has a total of six blades. These blades are not interchangeable between the two locations. Blade rotation direction is counterclockwise for the forward rotor and clockwise for the aft rotor (in a plan view).

CH-47B/C Rotor Systems

The CH-47B/C rotor system is similar to that of the CH-47A. However, the blades used on these two types of aircraft are different and are not interchangeable between aircraft.

DESCRIPTION OF CH-47 HELICOPTER ROTOR BLADES

CH-47A Rotor Blades

The CH-47A rotor blade assembly as shown in Figure 2 is a symmetrical airfoil shape. It consists of a D-spar, an attaching socket, a nose cap assembly, a trailing-edge strip, twelve boxed fairings, tip balance provisions, and a faired tip cover. This blade assembly is symmetrically constructed about its horizontal centerlines without camber.

The blade D-spar is of steel tubing, circular at the root where it is threaded to receive the attaching socket fitting, for mounting to the rotor head assembly.

The blade leading edge is a formed stainless-steel nose cap with a balance weight assembly bonded into it. The leading-edge assembly is bonded to the forward edge of the D-spar.

Twelve boxed fairings, consisting of fiberglass skins bonded to airfoil-shaped aluminum ribs, are bonded to the aft side of the D-spar. The trailing edge is formed by bonding a blade-long laminated stainless-steel strip into a special slot in the aft edge of the boxed fairings. Movable balance

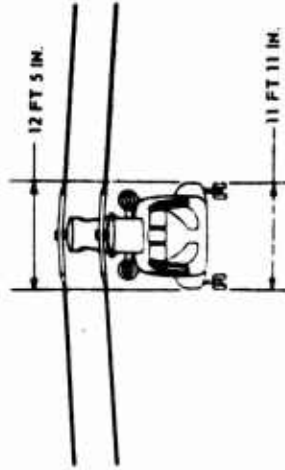
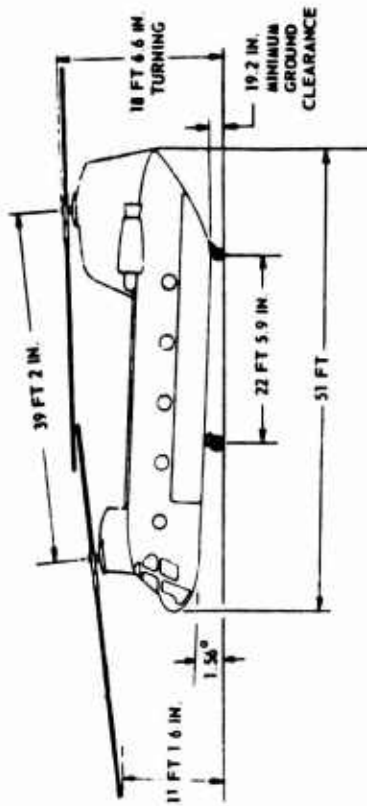
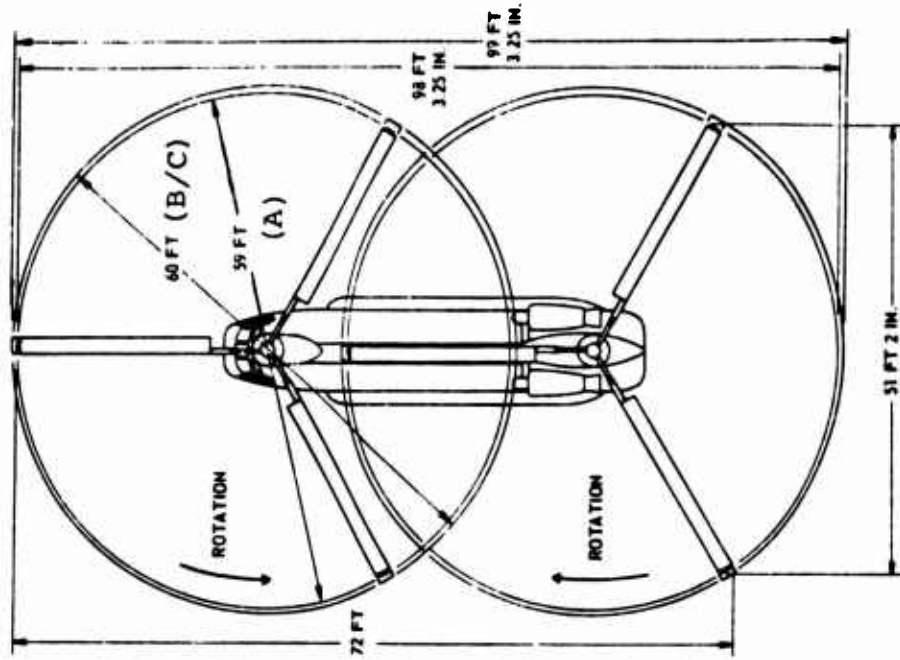


FIGURE 1. CH-47 HELICOPTER ROTOR SYSTEM.

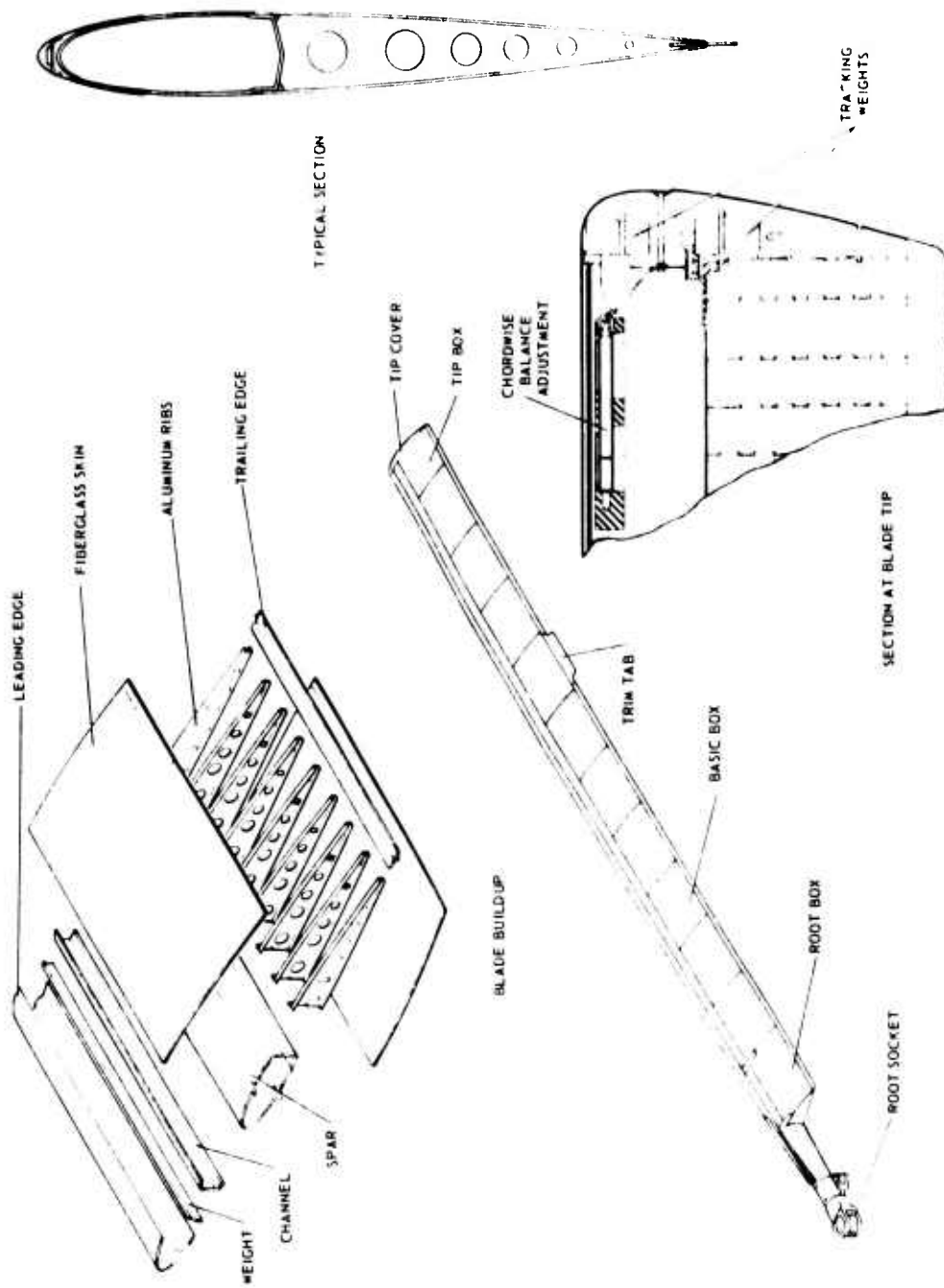


FIGURE 2. CH-47A ROTOR BLADE ASSEMBLY.

and tracking weights are installed on stainless-steel fittings riveted to the tip end of the D-spar. These weights are used to make balance and tracking corrections at the factory. A removable tip cover allows access to these weights. A blade tie-down fitting is located at the blade tip on the bottom surface.

CH-47B/C Rotor Blades

The CH-47B/C rotor blade assembly as shown in Figure 3 is a nonsymmetrical cambered airfoil. The blade assembly consists of a D-spar, an attaching socket, a nose cap assembly, nine boxed fairings, a trailing-edge strip, tip balance provisions and a simplified tip cover. Construction of this blade is similar to the CH-47A blades except for the boxed fairings and nose cap as shown in Figure 3.

DATA EXTRACTION PROCESS

A specific data extraction process was developed and applied to locate, extract, and describe CH-47 rotor blade discrepancies investigated for this report. This was done by the use of an alphanumeric coding system capable of identifying practically all important discrepancies occurring to any part of the entire structure of a CH-47 rotor blade. This alphanumeric system provided different codings for the CH-47A and CH-47B/C blades to allow for blade design differences.

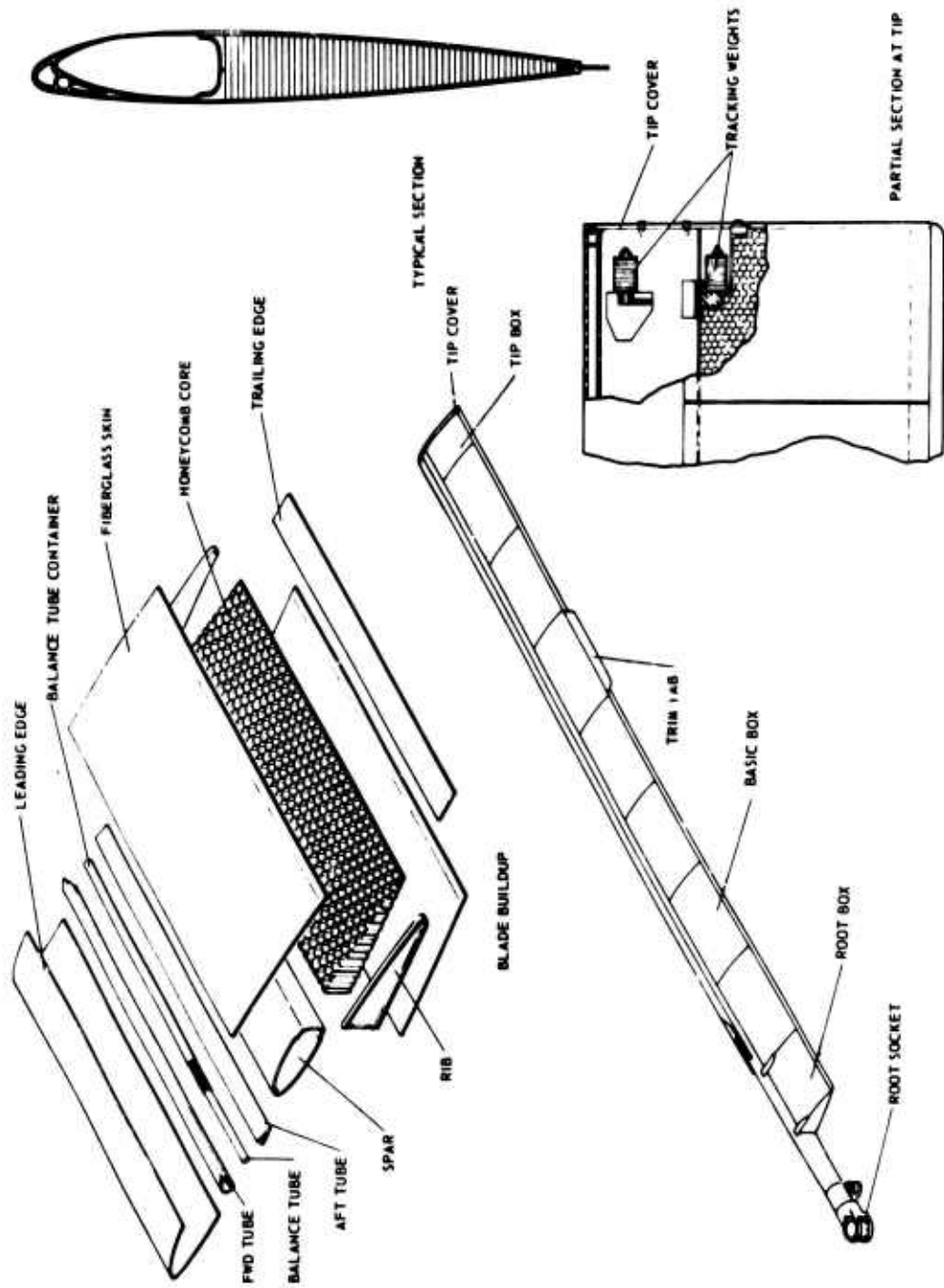


FIGURE 3. CH-47B/C ROTOR BLADE ASSEMBLY.

BLADE REMOVALS ANALYSIS APPROACH

Data Limitations and Use

The data included in this report were compiled from the existing Boeing-Vertol records which have been kept on rotor blades removed elsewhere and shipped to Boeing-Vertol for inspection, repair and scrappage.

The removal dates of interest to this blade removal study are shown in Table II. Note that the time period of interest varies among the CH-47A, B and C model helicopters.

The helicopter flight time accumulated up to the removal dates shown for the CH-47B and CH-47C models have been averaged to provide a consistent basis for the CH-47B/C analysis, as these have not been considered separately.

Loss of Data Due to Unusual Incidents

No data limitations were imposed due to blade damages incurred from unusual field experiences. It could have been decided that blade removal data derived from blade over-stress caused by in-air and massive nearby explosions, severe blade flapping due to extreme windstorms, or close helicopter over-flights should have been excluded. However, it was felt that the exclusion of these unusual experiences would provide a distorted view of the complete in-the-field experience; therefore, this data was included.

Examples of two unusual incidents which occurred in RVN and which subjected a large number of CH-47 helicopter blades to severe damage beyond their design limits were:

1. Typhoon Frieda, in November 1967
2. The Camp Evans ammunition dump explosion, in May 1968

Fifty CH-47 rotor blades were involved in the typhoon incident. Of these fifty blades, nine forward and nine aft blades were X-ray diffraction inspected at the depot and were accepted with return to service. Twelve forward and twelve aft blades were X-ray diffraction inspected at the depot, with subsequent rejection for scrappage. The remaining eight blades were severely damaged and were scrapped without further inspection.

TABLE II. BOEING-VERTOL REPAIR/OVERHAUL/SCRAPPAGE INSPECTION RECORDS - DATES AND HELICOPTER FLIGHT HOURS						
HELICOPTER	ROTOR LOCATION	BLADE PART NUMBER	REMOVAL DATES FOR BLADE INSPECTION	CORRESPONDING HELICOPTER ACCUMULATED FLIGHT HOURS FOR DATES SHOWN	EQUIVALENT BLADE FLIGHT HOURS	
CH-47A	Forward	114R1002	July 1, 1962 thru March 1, 1971	650,206	1,950,618	
	Aft	114R1002	July 1, 1962 thru March 1, 1971	650,206	1,950,618	
CH-47B	Forward	114R1502	June 1967 thru November 1, 1970	159,419	478,257	
	Aft	114R1502	June 1967 thru October 8, 1970	157,914	473,742	
CH-47C	Forward	114R1502	April 1968 thru November 1, 1970	138,694	416,082	
	Aft	114R1502	April 1968 thru October 8, 1970	136,694	410,082	
TOTALS:				1,873,133	5,679,399	

Data does not include aircraft flight time incurred in Germany, Korea and Alaska, but does include CONUS and RVN.

The thirty-three CH-47A and sixty-one CH-47B rotor blades that were involved in the Camp Evans explosion were shipped to Boeing-Vertol for inspection and repair, as required.

Blade Population Sizing

During this study, 5,488 blades were reviewed for removal experience. To keep the analysis results at a reasonable level of confidence, this blade population has not been diluted by a large number of categories. It did provide for the separation of all data into forward and aft rotor blade data.

It was felt that the different operational characteristics between these two locations may produce different effects in the externally-caused or inherent discrepancies of these blades. Since blade construction is the same for blades used at both locations, then blade design is eliminated as a possible factor of any differences that resulted from this study.

Determination of Reasons for Removal

Reasons for blade removal, where blades are either repaired or scrapped, have been organized into three major groups based strictly on blade discrepancies. One group concerns inherent blade failures and discrepancies, the second concerns external causes of blade damage or failure, and the third concerns scheduled reasons for blade removal.

The first group essentially includes those discrepancies associated with inadequacy of blade design to withstand actual environmental conditions encountered during field operations. The second group concerns blade failure induced by external influences as foreign object damage, combat, and the like. Included in this group are those blade discrepancies caused by errors due to inadequate shop or field repairs, handling, shipping or maintenance. Also included in this group, for the purpose of records only, are those blades removed without adequate or valid removal reasons. The latter group includes those blades received at the depot and inspected with the result that no damages of the kind reported were found.

This study will be concerned with the unscheduled removal reasons as shown in Table III and the scheduled removal reasons as shown in Table IV.

The Boeing-Vertol repair evaluation reports investigated in the study followed the failure code given by TM-38-750, Reference (1).

It should be noted that where blade damage cause was unknown at the time of removal, this removal analysis included a close review of all recorded discrepancies for these blades to determine what discrepancy would have been the major reason for blade removal for repair.

Appendix II shows the detail and depth to which this removal analysis was conducted. In particular, Figures 29, 30 and 31, as well as the accompanying discussion within this appendix, are of interest.

**TABLE III. ROTOR BLADE UNSCHEDULED REASONS FOR
REMOVAL/SCRAPPAGE**

TYPE OF DISCREPANCY	REASON FOR REMOVAL/ SCRAPPAGE	DESCRIPTORS
Inherent Caused Discrepancy	Deterioration	Missing Bare Steel Eroded Rippled Water Migration
	Unbond	Bulged Blistered Bond Void
	Excessive Vibration	Beyond Tolerance Vibration
	Eroded	Eroded & Other Worn
	Corrosion	Corroded & Other Peeling Chipped Stained Seized Water Migration Pitted
	Delamination	Voided Grazed Cracked Split
	Cracked	Creased Grazed Cracked & Other Split
	Fretted	Worn Fretted
	Imbalance	Tip Rod Loose Imbalance
External Caused Discrepancy	Foreign Object Damage (F.O.D.)	Dented Broken Torn Punctured Scored Bent
	Combat Damage	Broken Scored Dented Punctured Torn Spar/Socket Damage

TABLE III - Continued		
TYPE OF DISCREPANCY	REASONS FOR REMOVAL/ SCRAPPAGE	DESCRIPTORS
	Overstress	Overstress & Other Bent Collapse Torn Minor Damage
	Crashes/Strikes	Bent Collapse Torn Minor Damage
Error Caused Discrepancy	Manufacturing/Shipping Maintenance/Repair Shop Error and/Inadequate Field Repair	Human Error
No Valid Removal	No Known or Valid Reason for Removal	No Known Removal Cause
	Unknown/Misc.	Miscellaneous

TABLE IV. ROTOR BLADE SCHEDULED REASONS FOR REMOVAL/SCRAPPAGE		
TYPE OF DISCREPANCY	REASON FOR REMOVAL/ SCRAPPAGE	DESCRIPTORS
Time Change	MWO Compliance	MWO
	No defect - Blade Removed for Scheduled Maintenance	Sched. Maint.
Other	Retired Blade	Retired
	EIR Engineering Evaluation	EIR
	No Defect - Blade Removed to Facilitate Maintenance of Other Component(s)	No Defect
	Unknown/Misc.	Miscellaneous

CH-47A, B and C Blade Inspection Requirements

The CH-47 helicopter blade inspection requirements are discussed below. These requirements are noted herein to establish the criterion against which blades have been removed and scrapped.

Field inspection for serviceable CH-47A blades follows the minimum requirements noted in TM 55-1520-209-20-1, Reference (2), and for serviceable CH-47 B/C blades follows the minimum requirements noted in TM 55-1520-227-20-1, Reference (3). When a blade does not satisfy these conditions, it must be repaired or replaced, as applicable. For those blades sent back for depot rework and repair at the manufacturer's facility, the requirements of TM 55-1520-209-35-2 for the CH-47A blades, Reference (4), and of TM 55-1520-227-35-3 for the CH-47B and CH-47C blades, Reference (5), are followed. Partial or full teardown of 20% to 30% of the blades sent to the depot will occur. These teardowns will assure a complete determination of the extent of blade damage or deterioration.

Blade Identification - Overhaul and Retirement Data

Blade identification by dash number, overhaul time (hours), and blade retirement time (hours) for CH-47A rotor blades are shown in Table V.

Blade identification by dash number, blade overhaul time, and blade retirement time in blade hours for CH-47 B/C rotor blades are shown in Table VI.

Data for Table V has been derived from TM 55-1520-209-20-1, Reference (6), and data for Table II from TM 55-1520-227-20-1, Reference (7).

TABLE V. CH-47A BLADE OVERHAUL AND RETIREMENT HOURS DATA

COMPONENT	PART NUMBER	RETIREMENT INTERVAL (BLADE HRS.)
Forward Rotor Blades	114R1002-27	3600
Aft Rotor Blades	114R1002-28 thru -78	2400
	114R1002-80 thru -92	2400

TABLE VI. CH-47B/C BLADE OVERHAUL AND RETIREMENT HOURS DATA

COMPONENT	PART NUMBER	OVERHAUL INTERVAL (BLADE HRS.)			RETIREMENT INTERVAL (BLADE HRS.)
		CH-47B	CH-47C T55-L-7C	CH-47C T55-L-11	
Forward Rotor Blades	114R1502-9	3600	3600	*	--
	114R1502-13	3600	3600	*	--
	114R1502-15	3600	3600	*	--
	114R1502-17	3600	3600	*	--
	114R1502-23	3600	3600	*	--
	114R1502-25	O/C	O/C	O/C	6000
	114R1502-27	3600	3600	*	--
	114R1502-29	3600	3600	*	--
	114R1502-31	3600	3600	*	--
	114R1502-33	O/C	O/C	O/C	6000
Aft Rotor Blades	114R1502-10	1500	1500	*	--
	114R1502-14	1500	1500	*	--
	114R1502-16	1500	1500	*	--
	114R1502-18	1500	1500	*	--
	114R1502-24	1500	1500	*	--
	114R1502-26	O/C	O/C	O/C	4000
	114R1502-28	1500	1500	*	--
	114R1502-30	1500	1500	*	--
	114R1502-32	1500	1500	*	--
	114R1502-34	O/C	O/C	O/C	4000

* - Not installed in helicopter noted
O/C - On condition removal, see References (2) and (6)

Reasons for Removal Versus Frequency by Blade Removal

It is of primary interest to determine the quantity of blades removed for various reasons. This determination will establish a firm basis for the subsequent calculation of blade means.

This determination took two forms: one, a tabulation of the discrepancies and quantities based upon the reasons for removal, and second, a graphical display of the same information for better understanding of the distributions found.

Calculation of Means

In this study, the calculation of certain means representative of blade operating experience includes the determination of mean-time-between-removals, mean-time-to-removals, and mean-time-between-unscheduled removals. Since nearly all of the same blade removal data is used to derive these various means and their derivations are similar, the derivation of only two of these will be discussed in detail. It should be noted here that blades removed for repair and scrappage are both included.

(1) Calculation of MTBR values.

The mean-time-between-removals (MTBR) for either the forward or aft rotor blades was calculated as three times the sum of all CH-47A or CH-47B/C helicopter operating flight hours accumulated over a selected time period divided by the total quantity of forward or aft blades removed for all causes over that time period of interest. Three times the sum of all helicopter flight hours is required as the CH-47 helicopter uses three-bladed rotors.

Thus, for the forward blades,

$$MTBR_F = \frac{N \sum_{j=1}^3 t_j}{n}$$

where N = Total quantity of helicopters involved

t_j = Flight hours per helicopter

n = Total quantity of forward blades removed

Calculation of the MTBR for the aft blades was accomplished similarly.

(2) Calculation of MTTR values

The mean-time-to-removal (MTTR) was calculated by obtaining each removed blade's operating time (in hours) accumulated up to blade removal and dividing by the quantity of forward or aft blades concerned.

Thus, for the forward blades,

$$MTTR_F = \frac{N \sum_{i=1} t_i}{n}$$

where n = Total quantity of forward rotor blades removed for reason

t_i = Total time in blade flight hours per blade at removal

Calculation of the MTTR for the aft blades was accomplished similarly.

(3) Calculation of MTBUR values

The calculation of mean-time-to-unscheduled removal (MTBUR) was accomplished similarly to the calculation for MTBR discussed above, except that blades removed for scheduled reasons were excluded from the sample of either forward or aft rotor blades.

(4) Calculation of Means Example

To explain the derivation used to obtain the values shown in the subsequent means tabulations in this report, the following example is provided.

Per Table XI, page 34, the mean-time-between-removals of the forward rotor blade ($MTBR_F$) for inherent discrepancies was derived as:

$$MTBR_F = \frac{3 (341 \times 1906 - 650,206.7)}{682} = 2,860 \text{ Hr}$$

where 3 is the quantity of rotor blades on the forward rotor, 341 is the quantity of helicopters involved in the operational area and time period being considered (refer to Table II, page 10), 1,906.7 is the average flight time in hours per helicopter, 650,206 is the resultant helicopter flight time accumulated, and 682 is the quantity of forward blades removed for inherent discrepancies.

Determination of Discrepancy Locations Versus Types of Discrepancies

This calculation was primarily concerned with the frequency of discrepancies or damages accumulated for particular blade samples and for various major areas and components of these blades. Both upper and lower surfaces of these blades were shown in the same chart. Forward and aft rotor blades were considered on separate charts. The discrepancy locations for blades that were scrapped for reasons found after removal have been discussed in the scrappage analysis section.

Results of this analysis were tabulated for the various areas as percentages of the total blade experience.

BLADE SCRAPPAGE ANALYSIS APPROACH

Data Limitation and Use

Data included in this portion of the report was derived from the same sources as that used for the blade removal study.

Primarily, the scrappage analyses differ from the removal analyses in that the reasons for scrappage are used as a basis for calculation.

The time period of interest is shown by Table II, page 10.

Determination of Reasons for Scrappage

Reasons for blade scrappage, in general, have the same scope as those for removal as listed in Tables III, page 13, and IV, page 14.

Calculation of Means

Only one set of estimated scrapped blade means is provided, since the scrapped blades are thoroughly investigated as a part of the removal analysis. This one set of means provided is that of mean-time-between-scrappage.

The calculation of the mean-time-between-scrappage (MTBS) applies only to those blades removed and eventually scrapped, whether the reason for scrappage was known beforehand or was determined after further blade inspection and/or blade tear-down.

The calculation was accomplished similar to that for the MTBR as noted above, except that only scrapped blades were included for forward and aft rotors.

ANALYSES

CH-47 BLADE REMOVALS ANALYSES

The analyses presented herein follow the approaches discussed in the preceding section of the report. These analyses are grouped in chronological order of blade development and deployment:

1. CH-47A Forward and Aft Blades
2. CH-47B/C Forward and Aft Blades

Each group provides the following analyses:

- a. Major percentage of blade removals
- b. Frequency of blade removal vs. removal reasons
- c. Mean-Time-Between-Removal
- d. Mean-Time-To-Removal
- e. Mean-Time-Between-Unscheduled-Removal

Comparisons of the results of these analyses for forward and aft blades and the means are provided.

Table VII provides a review of the number of all blades that have been investigated for removals, repairs and scrappage. The actual accumulated flight time at removal of these blades and the equivalent time on the aircraft is given for comparison.

Note that the number of scrapped blades reviewed are included here for comparison.

TABLE VII. NUMBER OF CH-47A AND CH-47B/C BLADES INVESTIGATED FOR REMOVALS, REPAIRS AND SCRAPPAGE

HELICOPTER	BLADE LOCATION	ALL BLADES		ACCUMULATED TIME ON DEFECTED BLADES		ACCUMULATED TIME ON SCRAPPED BLADES		ACCUMULATED TIME ON AIRCRAFT	
		QTY.	TIME ON BLADES * REMOVAL *	QTY.	TIME ON BLADES * REMOVAL *	QTY.	TIME ON BLADES * REMOVAL *	HELICOPTER FLIGHT TIME	EQUIVALENT BLADE FLIGHT TIME
CH-47A	Forward	2,126	1,028,473	1,932	945,627	194	82,846	650,206	1,950,618
	Aft	2,349	1,105,419	1,855	870,367	494	235,052	650,206	1,950,618
CH-47B/C	Forward	512	202,775	457	186,292	55	22,483	298,113	894,339
	Aft	501	185,967	436	159,758	71	25,309	294,608	883,824
TOTALS	Forward	2,638	1,231,248	2,389	1,125,919	249	105,329	948,319	2,844,957
	Aft	2,850	1,290,486	2,285	1,030,125	565	260,361	944,814	2,831,442
	All blades	5,488	2,521,734	4,674	2,128,418	814	365,690	1,893,133	5,679,399

* Time on blades at removal given in blade hours.

CH-47A Forward and Aft Blades Removal Analysis

The removal status of 4,475 blades was reviewed; 2,126 of these were forward blades and 2,349 were aft blades.

Table VIII summarizes the removal status for the most frequently occurring causes of removal for the forward blades. Table IX summarizes similar information for the aft blades.

Figures 4, 5 and 6 illustrate the quantity of forward blades removed for the reasons under study. Figures 7, 8 and 9 illustrate the quantity of aft blades removed for similar reasons. Note that scrapped blade quantities are identified. In these figures the reason for removal of a blade that is scrapped is used, not the reason for scrappage unless they coincide.

A summary of the percentages of CH-47A forward and aft blade removals versus reasons for removal is presented in Table X, page 32. For a comparison to percentages of CH-47B/C forward and aft blade removals, see Table XX on page 55.

TABLE VIII. PERCENTAGES OF FORWARD BLADE REMOVALS - CH-47A

REPAIRED BLADES		SCRAPPED BLADES			
REMOVAL REASON	QTY.	% OF TOTAL REMOVALS	REMOVAL REASON	QTY.	% OF TOTAL REMOVALS
F.O.D. - Dented	330	15.52	F.O.D. - Dented	54	2.54
Sched. Removal (Sched. Maint.)	276	12.98	Overstressed	44	2.06
Cracked	194	9.13	Combat Damage - Punctured	26	1.23
Corrosion	133	6.26	Combat Damage - Dented	20	0.94
Unbonded (Voids)	121	5.69	Crashes/Strikes (Minor Damage)	10	0.47
F.O.D. - Punctures	119	5.60			
Combat Damage - Punctures	80	3.76			
Sched. Removal (Misc.)	70	3.29			
Overstressed	67	3.15			
Sched. Removal (Facilitate Maint.)	58	2.73			
Eroded	54	2.54			
F.O.D. - Scored	52	2.45			
Delaminated (Voided)	40	1.88			
F.O.D. - Bent	38	1.78			
Remainder	300	14.11	Remainder	40	1.88
TOTALS	1,932*	90.87%		194*	9.12%

* Total forward blade removals equals 1,932 + 194 = 2,126.

TABLE IX. PERCENTAGES OF AFT BLADE REMOVALS - CH-47A

REPAIRED BLADES			SCRAPPED BLADES		
REMOVAL REASON	QTY.	% OF TOTAL REMOVALS	REMOVAL REASON	QTY.	% OF TOTAL REMOVALS
Sched. Removal (Maint.)	361	15.37	Overstressed	215	9.15
Cracked	338	14.39	F.O.D. - Dented	93	3.96
F.O.D. - Dented	250	10.64	Sched. Removal (Maint.)	38	1.62
Unbonded (Voids)	138	5.87	Combat Damage -	31	1.32
Corrosion	92	3.92	Punctures		
F.O.D. - Punctured	85	3.62	Sched. Removal	26	1.11
Combat Damage	67	2.85	(Retired Blades)		
Overstress	64	2.72	F.O.D. - Punctured	15	0.64
Sched. Removal (Misc.)	60	2.55	Combat Damage - Dented	15	0.64
F.O.D. - Scored	46	1.96			
Sched. Removal	30	1.28			
(MWO Compliance)					
F.O.D. - Torn	29	1.24			
No Valid Removal Reason	26	1.11			
F.O.D. - Bent	24	1.02			
Remainder	245	10.43	Remainder	61	2.59
TOTALS	1,855	78.97%		494	21.03%

* Total aft blade removals equals 1,855 + 494 = 2,349.

REMOVAL REASONS		REPAIRED BLADES		SCRAPPED BLADES		% of Total Removals
Reason No.	Discrep.	Blade Qty.	% of Internal Discrep.	% of Internal Discrep.	Rmvl. Qty.	
1	Loose/Missing	14	2.05		14	2.02
2	Bare Steel	1	0.14		1	0.14
3	Eroded	14	2.05		14	2.02
4	Rippled	3	0.43		3	0.43
5	Water Migration	1	0.14		1	0.14
6	Buiged	6	0.87		6	0.87
7	Blistered	1	0.14		1	0.14
8	Bond Void	121	17.74	1	10.00	122
9	Unable to adj	8	1.17		8	1.16
10	Vibration	3	0.43		3	0.43
11	Worn	54	7.91		54	7.80
12	Eroded	18	2.63		18	2.60
13	Corroded	133	19.50	8	80.00	141
14	Peeling					
15	Chipped					
16	Stained					
17	Seized	2	0.29		2	0.28
18	Water Migration					
19	Pitted					
20	Voided	40	5.86		40	5.78
21	Crazed	2	0.29		2	0.28
22	Cracked laminated	5	0.73		5	0.72
23	Split					
24	Creased	1	0.14		1	0.14
25	Crazed	2	0.29		2	0.28
26	Cracked	194	28.44	1	10.00	195
27	Split	2	0.29		2	0.28
28	Worn					
29	Fretted	1	0.14		1	0.14
30	Tip Rod Loose	36	5.27		36	5.20
31	Imbalance	15	2.19		15	2.17
TOTALS		582	100.00%	10	100.00%	592

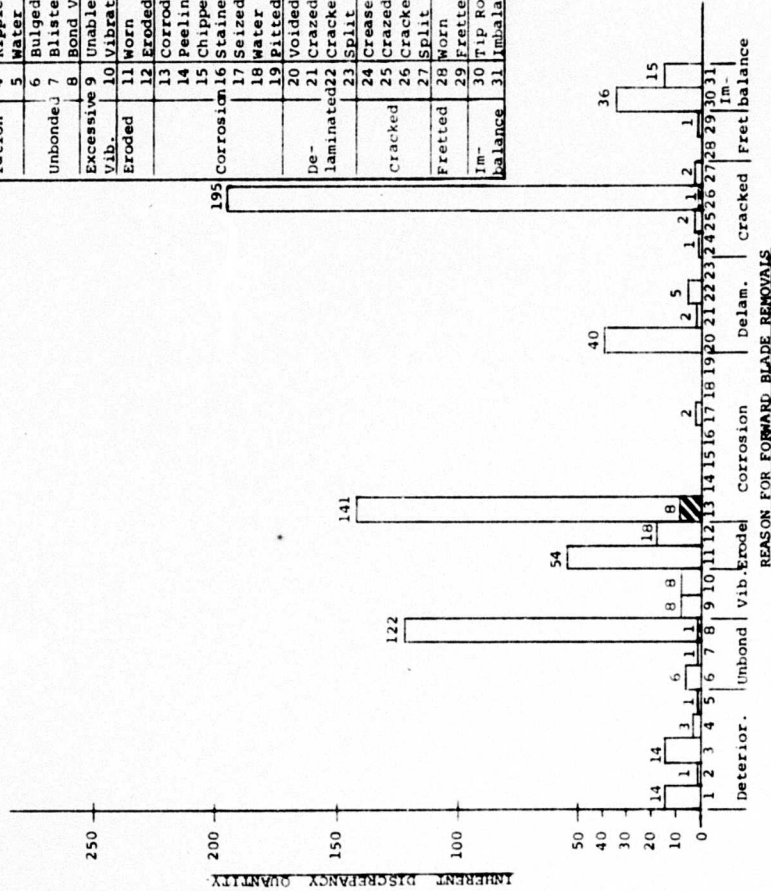


FIGURE 4. INHERENT DISCREPANCY REMOVALS - FORWARD BLADES - CH-47A.

DISTRIBUTION PERCENTAGES

REMOVAL REASON	REPAIRED BLADES		SCRAPPED BLADES		% of External Discrpt.	Rmvl. Qty.	% of Total Removals
	Qty.	% of External Discrpt.	Qty.	% of External Discrpt.			
1 Dented	330	40.64	54	30.16	384	38.75	
2 Broken	14	1.72			14	1.41	
3 Torn	35	4.31			35	3.53	
4 Punctured	119	14.65	4	2.23	123	12.41	
5 Scored	52	6.40	2	1.11	54	5.45	
6 Bent	38	4.67			38	3.83	
7 Broken	4	0.49			4	0.40	
8 Scored	14	1.72	20	11.17	34	3.43	
9 Dented	80	9.85	26	14.52	106	10.70	
10 Punctured							
11 Torn	1	0.12	1	0.55	2	0.20	
12 Spar/Socket	67	8.25	44	24.58	111	11.20	
13 Overstress	1	0.12			1	0.10	
14 Bent	1	0.12			1	0.10	
15 Collapsed	1	0.12			1	0.10	
16 Fractured	1	0.12			1	0.10	
17 Dented							
18 Bent							
19 Collapse							
20 Torn	15	1.84	10	5.58	25	2.52	
21 Minor Damage	26	3.20	7	3.91	33	3.33	
22 Error	15	1.84			15	1.51	
23 No Valid Rmvl.			1	0.55	1	0.10	
24 Misc.							
TOTALS	812	100.00%	179	100.00%	991	100.00%	

Repaired Blades
 Scrapped Blades
 • Manufacturing/Shipping/Handling Error Including Inadequate Field Repair

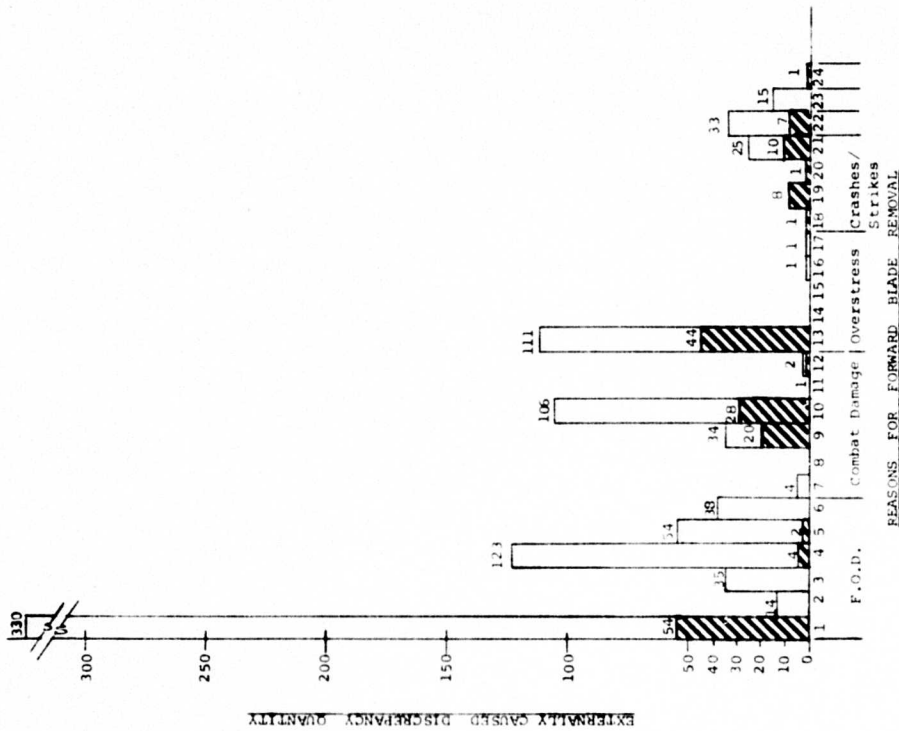


FIGURE 5. EXTERNAL DISCREPANCY REMOVALS - FORWARD BLADES - CH-47A.

DISTRIBUTION PERCENTAGES

Reason No.	REMOVAL REASON	REPAIRED BLADES		SCRAPPED BLADES		Removal Quantities	% of Total Removals
		Blade Qty.	% of Sched. Removals	Blade Qty.	% of Sched. Removals		
1	MMO Compliance	32	7.24	--	--	32	7.22
2	No Defect (Sched. Maint.)	276	62.45	--	--	276	62.31
3	Retired Blades	--	0.90	4	80.00	4	0.90
4	EIR Engr. Evaluation	2	0.45	--	--	2	0.45
5	No Defect (to facilitate maint.)	58	13.12	--	--	58	13.09
6	Miscellaneous	70	15.84	1	20.00	71	16.03
TOTALS		438	100.00	5	100.00%	443	100.00%

Repaired Blades
 Scrapped Blades

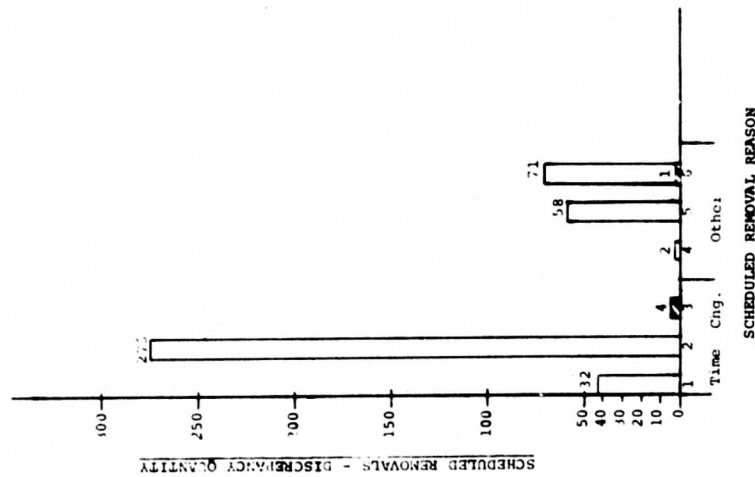


FIGURE 6. SCHEDULED REMOVALS - FORWARD BLADES - CH-47A.

DISTRIBUTION PERCENTAGES

REMOVAL NO.	REASON	REPAIRED BLADES		SCRAPPED BLADES		Total Quantity Removed	% of Total Inherent Discrep.
		Quantity	% of Inherent Discrep.	Quantity	% of Inherent Discrep.		
1	Loose/Missing Base Steel	1	0.14			1	0.13
2	Deterioration	18	2.48			18	2.43
3	Ripped	15	2.07			15	2.03
4	Wtr. Migration Intermittent	4	0.55			4	0.54
5							
6							
7	Bulged	2	0.28			2	0.27
8	Unbonded						
9	Blistered Bond Voids	138	19.03	6	37.50	144	19.43
10	Vibr.	1	0.14			1	0.13
11	Unable to adjust	2	0.28			2	0.27
12	Eroded	9	1.24			9	1.22
13	Worn	9	1.24			9	1.22
14	Erosion	92	12.69	7	43.75	99	13.36
15	Corroded						
16	Peeling						
17	Chipped	10	1.37			10	1.35
18	Stained						
19	Corroded	1	0.14			1	0.13
20	Seized						
21	Wtr. Migration	1	0.14			1	0.13
22	Pitted						
23	Voided	11	1.52			11	1.49
24	Delam.	1	0.14			1	0.13
25	Crazed	20	2.76	3	18.75	23	3.10
26	Cracked	19	2.62			19	2.56
27	Split						
28	Creased	14	1.93			14	1.89
29	Cracked	338	46.62			338	45.62
30	Split	10	1.37			10	1.35
31	Fretted	1	0.14			1	0.13
32	Worn						
33	Fretted	4	0.55			4	0.54
34	Tip Rod Loose	4	0.55			4	0.54
35	Imbalanced						
36	Imbalance						
TOTALS		725	100.00%	16	100.00%	741	100.00%

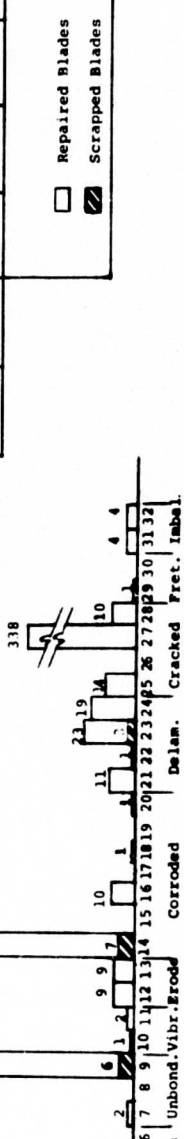


FIGURE 7. INHERENT DISCREPANCY REMOVALS - AFT BLADES - CH-47A.

INHERENT DISCREPANCIES - QUANTITY

DISTRIBUTION PERCENTAGES

No.	REMOVAL REASON		REPAIRED BLADES		SCRAPPED BLADES		Removal Qty.	% of Total Removal
	Reason	Discr.	Blade Qty.	% of Ext. Discr.	Blade Qty.	% of Ext. Discr.		
1	Dented	38.11	93	22.79	343	32.24	32.24	
2	Broken	3.20	4	1.18	25	2.35	2.35	
3	Torn	4.42	4	0.98	33	3.10	3.10	
4	F.O.D.	12.96	15	3.68	100	9.40	9.40	
5	Scored	7.01	2	0.49	48	4.51	4.51	
6	Bent	3.66	3	0.73	27	2.54	2.54	
7	Broken	0.92	2	0.49	8	0.75	0.75	
8	Scored	2.90	15	3.68	34	3.20	3.20	
9	Dented	10.21	31	7.59	98	9.21	9.21	
10	Punctured							
11	Torn							
12	Damage							
13	Overstressed	9.76	215	52.69	279	26.22	26.22	
14	Bent	0.15	1	0.15	1	0.09	0.09	
15	Collapsed							
16	Fractured							
17	Overstressed	0.15	1	0.25	1	0.09	0.09	
18	Bent	0.15	1	0.25	2	0.19	0.19	
19	Collapsed							
20	Torn	0.76	5	1.25	11	1.03	1.03	
21	Minor Damage	0.61	4	0.98	8	0.75	0.75	
22	Mfg/Shipping/Maint. Error							
	Including Inadequate Field Repair		7	1.07	5	1.23	1.13	
23	No Valid Reason For Removal		26	3.96	2	0.49	2.63	
24	Unknown		3	0.73	3	0.28	0.28	
TOTALS			656	100.00%	408	100.00%	1064	100.00%

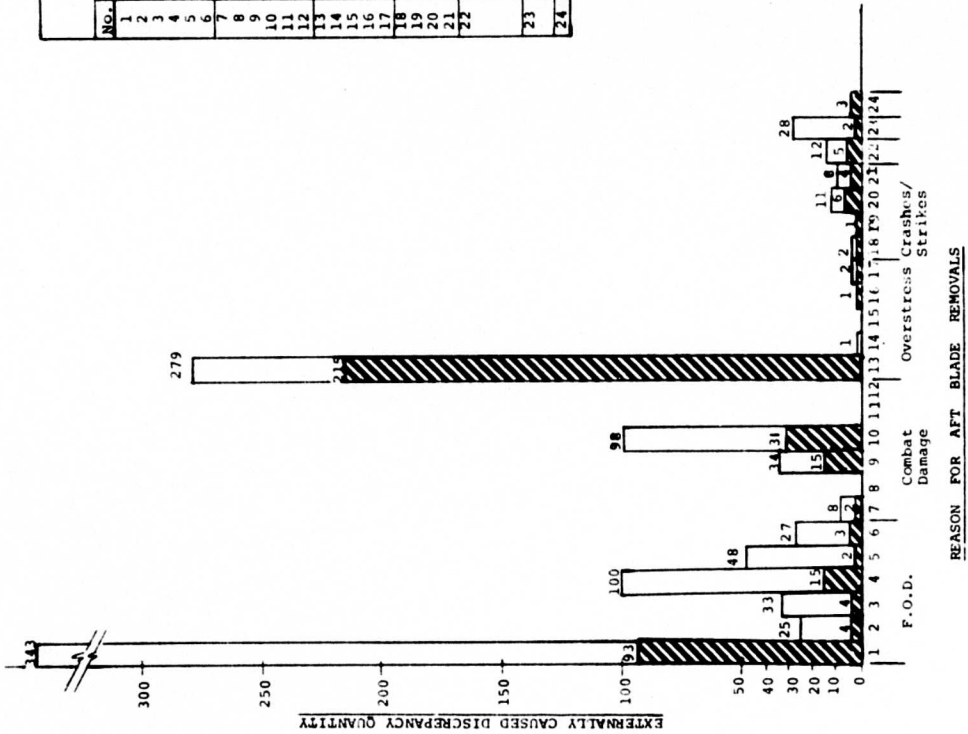


FIGURE 8. EXTERNAL DISCREPANCY REMOVALS - AFT BLADES - CH-47A

DISTRIBUTION PERCENTAGES

REMOVAL REASON		REPAIRED BLADES		SCRAPPED BLADES		Total Qty. Removed	% of Total Removals
		Blade Qty.	% of Scheduled Removals	Blade Qty.	% of Scheduled Removals		
Reason	No. Discrepancy						
1	MWO Compliances	30	6.33	5	7.14	35	6.42
2	No Defect (Scheduled Maintenance)	361	76.16	38	54.29	399	73.35
3	Retired Blades	--	--	26	37.14	26	4.78
4	EIR Engineering	2	0.42	--	--	2	0.38
5	No Defect (to facilitate maint.)	21	4.43	1	1.43	22	4.04
6	Miscellaneous	60	12.66	--	--	60	11.03
TOTALS		474	100.00%	70	100.00%	544	100.00%

Repaired Blades
 Scrapped Blades

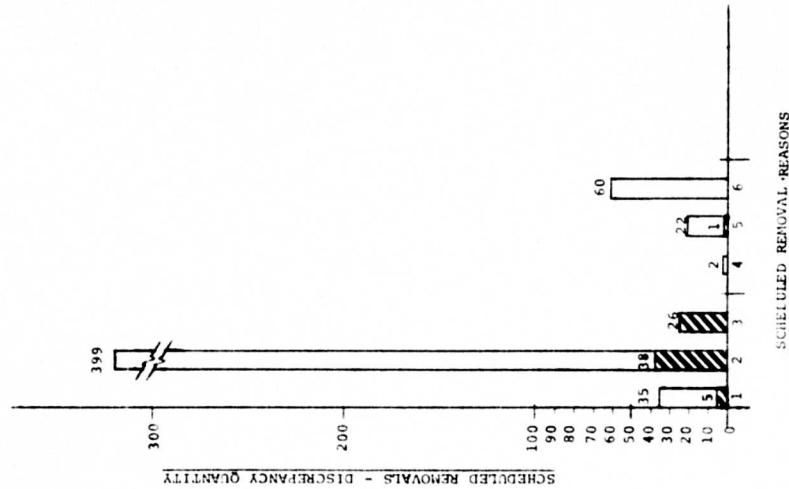


FIGURE 9. SCHEDULED REMOVALS - AFT BLADES - CH-47A

TABLE X. SUMMARY OF PERCENTAGES OF REMOVALS - CH-47A
FORWARD AND AFT ROTOR BLADES

MAJOR DISCREPANCY REMOVAL REASON	FORWARD ROTOR BLADES *						AFT ROTOR BLADES +					
	Total - All Blades		Repaired Blades		Scrapped Blades		Total - All Blades		Repaired Blades		Scrapped Blades	
	Qty.	Pct.	Qty.	Pct.	Qty.	Pct.	Qty.	Pct.	Qty.	Pct.	Qty.	Pct.
Deterioration	33	1.55	33	1.55	--	0	38	1.62	38	1.62	--	0
Unbonded	129	6.07	128	6.02	1	0.05	146	6.22	140	5.60	6	0.26
Vibration	16	0.75	16	0.75	--	0	3	0.13	3	0.13	--	0
Erosion	72	3.39	72	3.39	--	0	18	0.77	18	0.77	--	0
Corrosion	143	6.73	135	6.35	8	0.38	111	4.73	104	4.43	7	0.30
Delaminated	47	2.21	47	2.21	--	0	54	2.30	51	2.17	3	0.13
Cracked	200	9.41	199	9.36	1	0.05	362	15.41	362	15.41	--	0
Fretted	1	0.05	1	0.05	--	0	1	0.04	1	0.04	--	0
Imbalance	51	2.40	51	2.40	--	0	8	0.34	8	0.34	--	0
F.O.D.	648	30.48	588	27.66	60	2.82	576	24.52	455	19.37	121	5.15
Combat Damage	146	6.87	99	4.66	47	2.81	140	5.96	92	3.92	48	2.04
Overstress	113	5.31	69	3.24	44	2.07	283	12.05	66	2.81	217	9.24
Crashes/Strikes	35	1.65	15	0.71	20	0.94	32	0.94	10	0.43	12	0.51
Error	33	1.55	26	1.22	7	0.33	12	0.50	7	0.29	5	0.21
No Valid Reason	15	0.70	15	0.70	--	0	28	1.19	26	1.10	2	0.09
Miscellaneous	1	0.05	--	0	1	0.05	3	0.13	--	0	3	0.13
Time Change	312	14.67	308	14.48	4	0.19	460	19.58	391	16.64	69	2.94
Other	131	6.16	130	6.11	1	0.05	84	3.57	83	3.53	1	0.04
TOTAL	2126	100.00	1932	90.87	194	9.13	2349	100.00	1855	78.97	494	21.04

* Percentages based upon a total of 2,126 forward blades.
+ Percentages based upon a total of 2,349 aft blades.

CH-47A Forward and Aft Blades Means Analyses

A series of evaluations of the CH-47A rotor blades for their average removal characteristics based upon frequency of blade removal was accomplished. These calculations of the various removal means followed the approach outlined on pages 20 and 21. Results are given in blade hours.

Tables XI, XII, and XIII list the means determined for the major discrepant reasons for removal of CH-47A forward rotor blades.

Tables XIV, XV, and XVI list similar determinations accomplished for the CH-47A aft rotor blades.

Table XVII presents a summary of the results of these analyses for both CH-47A forward and aft blades.

TABLE XI. MEAN-TIME-BETWEEN-REMOVALS - FORWARD BLADES - CH-47A

REASONS FOR REMOVAL	RETURNED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	MTBF	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	MTBF	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	MTBF
Inherent Discard	682		2,860	10		195,062	692		2,812
Deterioration	33		59,109				33		59,109
Unbonded	128		15,239	1		1,950,618	129		15,121
Excessive Vibration	16		121,914				16		121,914
Erosion/Wear	72	1,950,618	27,092		1,950,618		72	1,950,618	27,092
Corroded	135		14,449	8		243,827	143		13,641
Delamination	47		41,503				47		41,503
Cracked	199		9,802	1		1,950,618	200		9,733
Fretted	1		1,950,618				1		1,950,618
Imbalance	51		39,247				51		38,247
Externally-Caused Discard	771		2,530	171		11,407	942		2,071
Foreign Object Damage	588		3,317	60		32,510	648		3,015
Combat Damage	99	1,950,618	19,793	47	1,950,618	41,503	146	1,950,618	13,369
Overstressed	69		28,270	44		44,332	113		17,262
Crosses/Strikes	15		130,941	20		97,531	35		55,731
No Valid Removal Reason	15	1,950,618	130,941	1	1,950,618	1,950,618	16	1,950,618	121,914
Error	26	1,950,618	72,024	7	1,950,618	278,660	33	1,950,618	59,109
Scheduled Removal	438		4,453	5		399,124	443		4,403
Time Change	308	1,950,618	6,332	4	1,950,618	487,654	312	1,950,618	6,152
Other	130		15,005	1		1,950,618	131		14,890
All Causes	1,932	1,950,618	1,009	194	1,950,618	10,055	2,126	1,950,618	14,917

* Manufacturing/Shipping/Handling Error Including Inadequate Field Repair

TABLE XII. MEAN-TIME-TO-REMOVAL - FORWARD BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd Blade Flight Hours	MTRPF	Qty. of Blades Removed	Total Fwd Blade Flight Hours	MTRPF	Qty. of Blades Removed	Total Fwd Blade Flight Hours	MTRPF
Inherent Discrepancies	682	320,803	470	10	5,476	548	692	326,279	472
Deterioration	33	15,827	467				33	15,827	467
Unbonded	128	59,167	462	1	24	24	129	59,191	459
Excessive Vibration	16	7,267	454				16	7,267	454
Erosion/Wear	72	35,839	498				72	35,839	498
Corrosion	135	64,209	476	8	5,114	639	143	69,323	485
Delamination	47	24,948	531				47	24,948	531
Cracked	199	91,863	462	1	338	338	200	92,201	461
Fretted	1	99	99				1	99	99
Imbalance	51	21,984	431				51	21,984	431
Externally Caused Discrepancies	771	347,103	450	171	60,518	354	942	407,621	433
Foreign Object Damage	588	270,767	460	60	23,572	283	648	294,339	454
Combat Damage	99	40,775	412	47	14,607	311	146	55,382	379
Overstressed	69	30,250	438	44	17,780	404	113	48,030	425
Crashes/Strikes	15	5,311	354	20	4,559	228	35	9,870	282
No Valid Reason for Removal	15	4,011	287	1	267	267	16	4,278	267
Error Δ	26	7,748	298	7	1,596	228	33	9,344	283
Scheduled Removals	438	265,964	608	5	14,989	2,998	443	280,953	634
MWO Compliance	32	16,894	528				32	16,894	528
Scheduled Maintenance *	276	176,659	640				276	176,659	640
To Facilitate Maintenance *	58	26,524	457				58	26,524	457
EIR	2	1,484	742				2	1,484	742
Retired Blades	70	44,401	634	4	13,420	3,357	74	57,821	3,357
Miscellaneous *				1	1,560	1,560	71	45,961	647
All Causes	1,932	945,627	490	194	82,846	427	2,126	1,028,473	484

* No defect

Δ Manufacturing/Shipping/Handling Error Including Inadequate Field Repair

TABLE XIII. MEAN-TIME-BETWEEN-UNSCHEDULED REMOVAL - FORWARD BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES		SCRAPPED BLADES		TOTAL BLADES		MTBURF	TOTAL Fwd. Bid. Flight Hours	MTBURF	TOTAL Fwd. Bid. Flight Hours
	Qty. of Blades Removed	Total Fwd. Bid. Flight Hours	Qty. of Blades Removed	Total Fwd. Bid. Flight Hours	Qty. of Blades Removed	Total Fwd. Bid. Flight Hours				
Inherent Def. r.p.	682	2,860	10	195,062	692	2,819				
Deteriorated	33	59,109			33	59,109				
Untended	128	15,230	1	1,950,618	129	15,121				
Excessive Vibration	16	121,914			16	121,914				
Erosion/Wear	72	27,092	8	243,827	72	27,092				
Corroded	135	14,449			135	14,449				
Delamination	47	41,503			47	41,503				
Cracked	199	9,802	1	1,950,618	200	9,753				
Fretted	1	1,950,618			1	1,950,618				
Imbalance	51	38,247			51	38,247				
Externally-Caused Discrep.	771	2,530	171	11,407	942	2,071				
Foreign Object Damage	588	3,317	60	32,510	648	3,810				
Combat Damage	99	19,703	47	41,503	146	13,360				
Overstressed	69	28,270	44	44,332	113	17,262				
Cranes/Strikes	15	130,041	20	97,530	35	55,732				
No Valid Removal Reason	15	1,950,618	1	1,950,618	16	1,950,618				
Error *	26	75,024	7	278,660	33	59,109				
All Causes	1,494	1,950,618	189	10,320	1,683	1,159				

* Manufacturing/Shipping/Handling Error Including Inadequate Field Repair.

TABLE XIV. MEAN-TIME-BETWEEN-REMOVAL - AFT BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Aft Blade Flight Hours	MTBR A	Qty. of Blades Removed	Aft Blade Flight Hours	MTBR A	Qty. of Blades Removed	Total Aft Blade Flight Hours	MTBR A
<u>Inherent Discrepancies</u>	725			16		121,914	741		2,632
Deterioration	38		2,690				38		51,332
Unbonded	140		13,933	6		325,103	146		13,360
Excessive Vibration	3		650,206				3		650,206
Erosion/Wear	18	1,950,618	180,367		1,950,618		18	1,950,618	108,367
Corrosion	104		18,755	7		278,659	111		17,573
Delamination	51		38,247				51		38,247
Cracked	362		5,388	3		650,206	365		5,344
Fretted	1		1,950,618				1		1,950,618
Imbalance	8		243,827				8		243,827
<u>Externally Caused Discrepancies</u>	623			198		4,900	1,021		1,910
Foreign Object Damage	455		2,131	121		16,121	176		3,388
Combat Damage	92	1,950,618	4,287	48	1,950,618	40,638	140	1,950,618	13,933
Overstressed	66		21,202	217		8,989	283		6,893
Crashes/Strikes	10		29,555	12		162,552	22		88,664
No Valid Reason for Removal	26	1,950,618	195,062	5	1,950,618	390,124	31	1,950,618	62,923
Error	7	1,950,618	75,024	5	1,950,618	390,124	12	1,950,618	167,552
<u>Scheduled Removals</u>	474		278,680	78		27,866	552		3,586
MRO Compliance	30		4,115	5		390,124	35		5,737
Scheduled Maintenance	361		65,000	5		51,332	399		4,889
Facilitate Maintenance	21	1,950,618	5,403	1	1,950,618	1,950,618	22	1,950,618	88,664
EIR	2		92,886				2		975,309
Retired			975,309						75,024
Miscellaneous	60		32,510				60		32,510
All Causes	1,855	1,950,618	1,052	494	1,950,618	3,950	2,349	1,950,618	838

• Manufacturing/Shipping/Handling Error Including Inadequate Field Repair.

TABLE XV. MEAN-TIME-TO-REMOVAL - AFT BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Aft Bld. Flight Hours	MTTR ^A	Qty. of Blades Removed	Total Aft Bld. Flight Hours	MTTR ^A	Qty. of Blades Removed	Total Aft Bld. Flight Hours	MTTR ^A
Inherent discrep.	725	442,206	610	16	5,550	347	741	447,756	604
Deterioration	38	23,168	610				38	23,168	610
Unbonded	140	80,038	572	6	1,703	284	146	81,741	560
Excessive Vibration	3	1,851	617				3	1,851	617
Erosion/Wear	18	10,436	580				18	10,436	580
Corrosion	104	69,682	670	7	2,382	340	111	72,064	649
Delamination	51	33,958	666				51	33,958	666
Cracked	362	218,001	602	3	1,465	488	365	219,466	601
Fretted	1	202	202				1	202	202
Imbalance	8	4,870	609				8	4,870	610
Externally-Caused Discrepancies	623	211,296	339	398	144,816	364	1,021	356,112	339
Foreign Object Damage	455	157,344	346	121	44,321	366	576	201,665	350
Combat Damage	92	30,886	336	48	17,041	355	140	47,927	342
Overstressed	66	20,187	306	217	79,069	364	283	99,256	351
Crashes/Strikes	10	2,879	288	12	4,385	365	22	7,264	330
No Valid Removal Reason	26	9,860	379	5	2,557	511	31	12,417	401
Error	7	2,748	393	5	2,057	411	12	4,805	400
Scheduled Removals	474	404,257	431	70	80,072	1,144	544	284,329	323
MWO Compliance	30	8,411	430	5	1,492	298	35	9,903	283
Scheduled Maintenance	361	160,818	445	38	18,885	497	399	179,703	450
Facilitate Maintenance	21	6,859	327	1	294	294	22	7,153	325
EIR		543	272				2	543	272
Miscellaneous	60	27,626	460				60	27,626	460
Retired Blades				26	59,401	2,285	26	59,401	2,284
TOTAL All Causes	1,855	870,367	469	494	235,052	476	2,349	1,105,419	471

* Manufacturing/Shipping/Handling Error Including Inadequate Field Repair.

TABLE XVI. MEAN-TIME-BETWEEN-UNSCHEDULED-REMOVAL - AFT BLADES - CH-47A

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Aft Blade Flight Hours	MTBUR A	Qty. of Blades Removed	Aft Blade Flight Hours	MTBUR A	Qty. of Blades Removed	Aft Blade Flight Hours	MTBUR A
Inherent Discrepancies	725		2,690	16		121,914	741		2,632
Deterioration	38		51,332				38		51,332
Unbonded	140		13,933	6		325,103	146		13,360
Excessive Vibration	3		650,206				3		650,206
Erosion/Wear	18		180,367				18		108,367
Corroded	104	1,950,618	38,725	7	1,950,618	278,659	111	1,950,618	17,573
Delamination	51		38,247				51		38,247
Cracked	362		5,388	3		650,206	365		5,344
Fretted	1		1,950,618				1		1,950,618
Imbalance	8		243,827				8		243,827
Externally-Caused Discrepancies	623		3,131	398		4,900	1,021		1,910
Foreign Object Damage	455		4,287	121		6,121	576		3,386
Combat Damage	92	1,950,618	21,202	48	1,950,618	40,638	140	1,950,618	13,933
Overstressed	66		29,555	217		8,989	283		6,803
Crashes/Strikes	10		195,062	12		162,552	22		88,664
NO VALID Removal Reason	26	1,950,618	75,024	5	1,950,618	390,123	31	1,950,618	62,923
Error #	7	1,950,618	278,659	5	1,950,618	390,123	12	1,950,618	162,552
All Causes	1,381	1,950,618	1,412	424	1,950,618	4,600	1,805	1,950,618	1,080

* Manufacturing/shipping/handling error including inadequate field repair

TABLE XVII. SUMMARY OF CH-47A FORWARD AND AFT BLADE MEANS

BLADE	COMBINED VALUES		INHERENT DISCREPANCY	EXTERNALLY CAUSED DISCREPANCY	ERROR CAUSED DISCREPANCY	SCHEDULED REMOVALS	NO VALID REMOVAL REASON
	MTBF _F	MTTR _F					
FORWARD BLADES	Repaired	1,009	2,860	2,530	75,024	4,453	130,041
	Scrapped	10,055	195,062	11,407	278,660	390,124	1,950,618
	Total	917	2,071	2,071	59,109	4,403	121,914
AFT BLADES	Repaired	490	470	450	258	608	267
	Scrapped	427	548	354	228	2,997	267
	Total	484	472	433	283	634	267
FORWARD BLADES	Repaired	1,307	2,860	2,530	75,024	N.A.	130,041
	Scrapped	10,320	195,062	11,407	278,660	N.A.	1,950,618
	Total	1,159	2,071	2,071	59,109	N.A.	121,914
AFT BLADES	Repaired	1,052	2,690	3,131	278,659	4,115	75,024
	Scrapped	3,950	121,914	4,900	390,135	27,866	390,124
	Total	830	2,632	1,910	162,552	3,586	62,923
FORWARD BLADES	Repaired	469	610	339	393	431	379
	Scrapped	476	347	364	411	1,144	511
	Total	471	604	349	400	523	401
AFT BLADES	Repaired	1,412	2,690	3,131	278,659	N.A.	75,024
	Scrapped	4,600	121,914	4,900	390,124	N.A.	390,124
	Total	1,080	2,632	1,910	162,552	N.A.	62,923

N.A. - Not Applicable
 MTBF - Mean-Time-Between Removals
 MTTR - Mean-Time-To-Removal
 MTBUR - Mean-Time-Between Unscheduled Removals

Discrepancy Locations Versus Types of Discrepancies

Data included herein has been based upon 'Reasons for Removal' only.

This investigation simplified the amount of data handled by confining the results to discrepancy locations versus types of inherent discrepancies and to externally-caused discrepancies only.

Figures 10 and 11 illustrate the results obtained for the CH-47A forward blades. Figures 12 and 13 illustrate similar results obtained for the CH-47A aft blades.

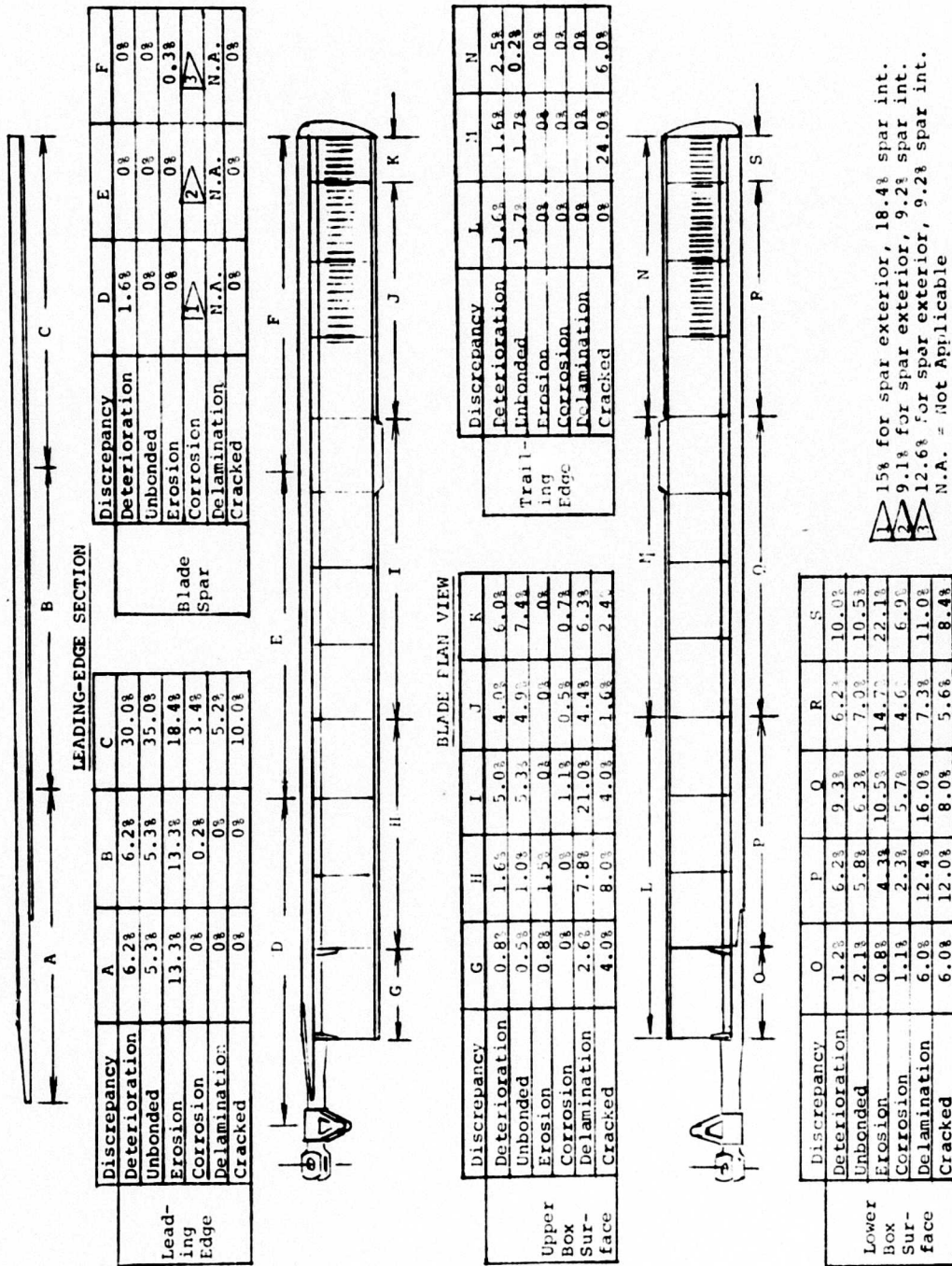


FIGURE 10. INHERENT DISCREPANCY LOCATIONS - FORWARD BLADES - CH-47A.

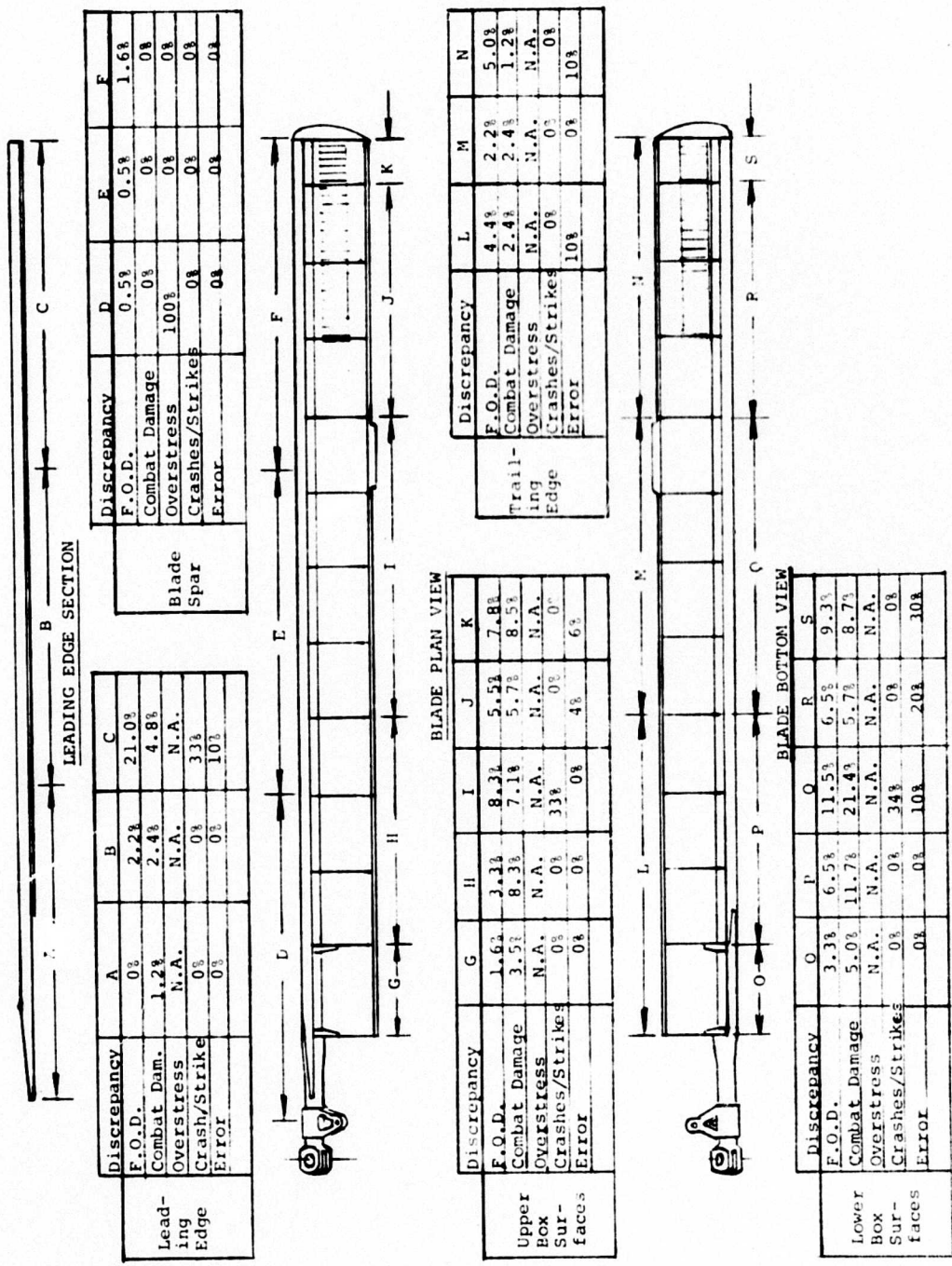


FIGURE 11. EXTERNAL DISCREPANCY LOCATIONS - FORWARD BLADES - CH-47A.

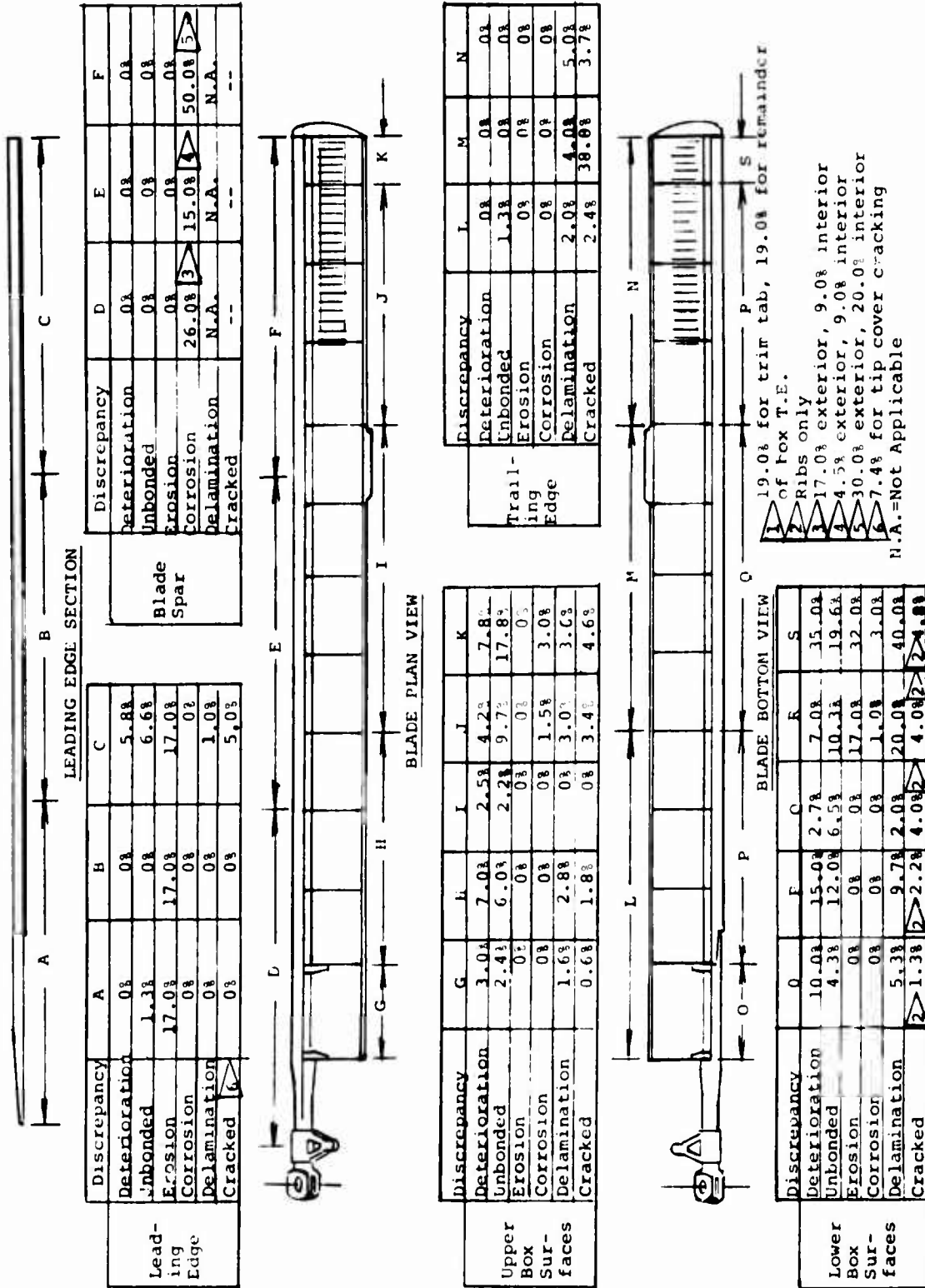
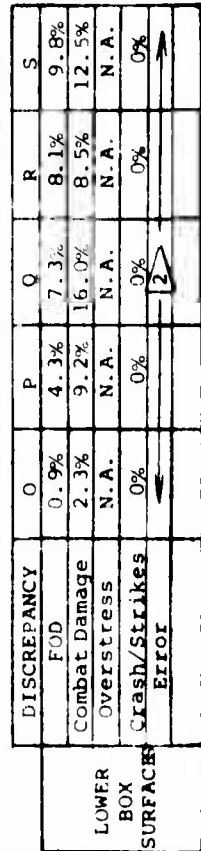
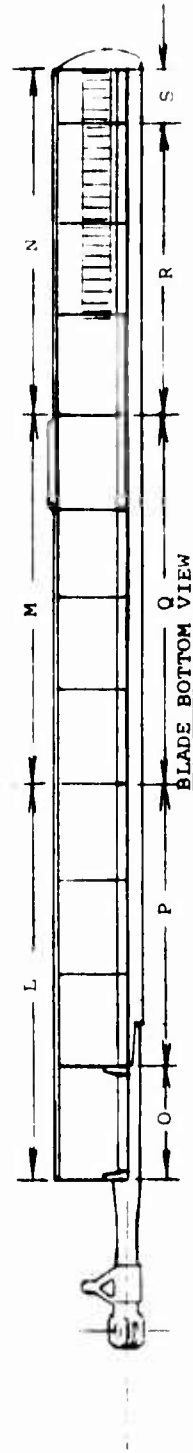
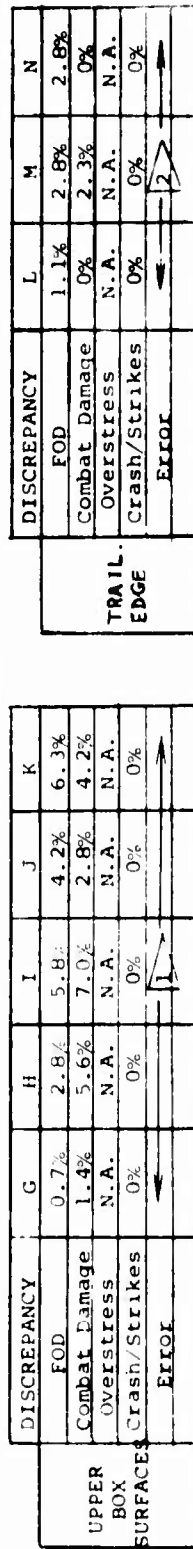
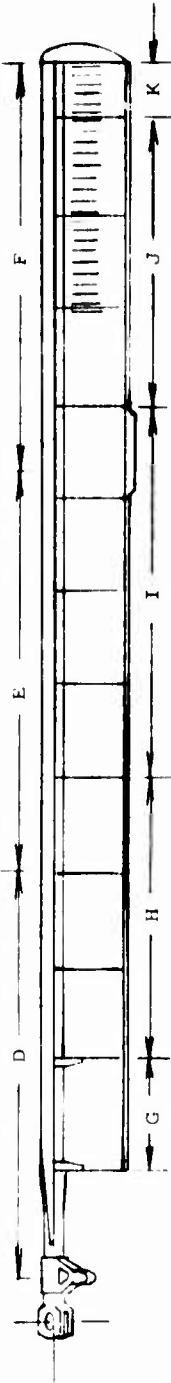
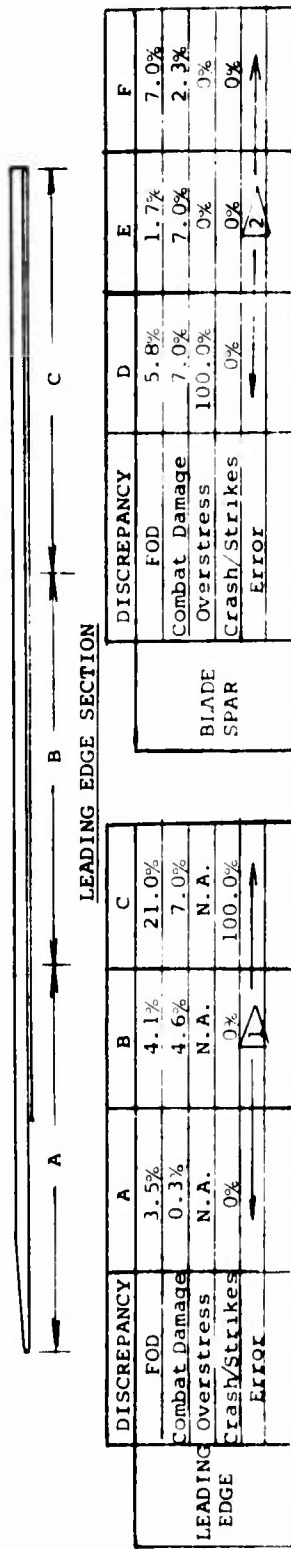


FIGURE 12. INHERENT DISCREPANCY LOCATIONS - AFT BLADES - CH-47A.



1.7% for Trim Tab, 1.1% for remainder of T. E
 Insufficient data to determine distribution
 N.A. = Not Applicable

FIGURE 13. EXTERNAL DISCREPANCY LOCATIONS - AFT BLADES - CH-47A.

CH-47B/C Forward and Aft Blades Removal Analysis

The removal status of 1,013 rotor blades was reviewed, 512 of which were forward blades and 501 were aft blades.

Table XVIII summarizes the removal status for the most frequently occurring causes of removal of the forward blades. Table XIX summarizes similar information for the aft blades.

Figures 14, 15 and 16 illustrate the quantity of forward blades removed for the reasons under study. Figures 17, 18, and 19 illustrate the quantity of aft blades removed for similar reasons. Note that scrapped blade quantities are identified. In these figures the reason for removal of a blade that is scrapped is used, not the reason for scrappage unless they coincide.

A summary of the percentages of CH-47B/C forward and aft blade removals versus reasons for removal is presented in Table XX, on page 55; for a comparison to the percentages of CH-47A forward and aft blade removals, see Table X, page 32.

TABLE XVIII. PERCENTAGES OF FORWARD BLADE REMOVALS - CH-47B/C					
REPAIRED BLADES			SCRAPPED BLADES		
REMOVAL REASON	QTY.	% OF TOTAL REMOVALS *	REMOVAL REASON	QTY.	% OF TOTAL REMOVALS *
F.O.D. Denting	106	20.70	Combat Damage Punctures	17	3.32
F.O.D. Punctures	30	5.86	F.O.D. Denting	12	2.34
Combat Damage Punct.	30	5.86	Combat Damage - Dent	10	1.95
Unbond.(Bulged) Boxes	30	5.86	F.O.D. - Punctured	4	0.78
Corrosion	30	5.86	Overstress	3	0.59
Overstress	29	5.66	Manuf/Ship/Maint Error	3	0.59
No Defect-Sched.Maint.	23	4.49			
Box - Bond Voids	18	3.52			
Unbonded - Blistered	16	3.13			
No Valid Rem. Reason	16	3.13			
Combat Damage - Dent	14	2.73			
F.O.D. Torn	13	2.54			
No Defect - To Facilitate Maint.	10	1.95			
Remainder	92	17.97	Remainder	6	1.17
TOTALS	457	89.26%		55	10.74%

* Total forward blade removals equals 457 + 55 = 512

TABLE XIX. PERCENTAGES OF AFT BLADE REMOVALS - CH-47B/C

REPAIRED BLADES		SCRAPPED BLADES			
REMOVAL REASON	QTY.	% OF TOTAL REMOVALS *	REMOVAL REASON	QTY.	% OF TOTAL REMOVALS *
F.O.D. Denting Unbonded Boxes	91	18.16	F.O.D. Dented Crashes/Strikes - Minor Damage	23	4.59
F.O.D. Punctures	39	7.78	Combat Damage - Dents	13	2.60
Combat Damage - Punct.	35	6.99	Combat Damage - Punct.	5	1.80
Overstress	34	6.79	Internal Discrep. Corr.	8	1.59
Unbonded (Bulged) Boxes	27	5.39	F.O.D. - Punctures	3	0.60
No Valid Removal Reason	26	5.19		3	0.60
No Defect (Sched.Maint.)	23	4.59			
Corrosion	22	4.39			
Unbonded (Voids) Boxes	17	3.39			
MWO Compliance	14	2.79			
Combat Damage - Dents	13	2.60			
Delaminated (Voids)	13	2.60			
Remainder	9	1.80			
	67	13.37	Remainder	12	2.40
TOTALS	430	85.83%		71	14.17%

* Total aft blade removals equals 430 + 71 = 501 blades

DISTRIBUTION PERCENTAGES

REMOVAL REASON	RETURNED BLADES		SCRAPPED BLADES		% of Total Rmvl Qty. RMA.
	Blade Qty.	% of Inherent Discrep.	Blade Qty.	% of Inherent Discrep.	
1 Loose/Missing	1	0.66			1 0.64
2 Bare Steel					
3 Eroded					
4 Rippled	1	0.66			1 0.64
5 Water Migrate					
6 Bulged	30	19.87			30 19.44
7 Blistered	16	10.50			16 10.26
8 Bond Void	18	11.92	1	20.00	19 12.18
9 Unable to ad)					
10 Vibration	5	3.31			5 3.20
11 Worn	5	3.31			5 3.20
12 Etoded	6	3.97	1	20.00	7 4.49
13 Corrodec	30	19.87	1	20.00	31 19.87
14 Feeling					
15 Chipped					
16 Stained					
17 Seized					
18 Water Migrate	3	1.99			3 1.92
19 Fitted	4	2.65			4 2.56
20 Voided	3	1.99			3 1.92
21 Crazed	6	3.97			6 3.85
22 Cracked	3	1.99			3 1.92
23 Split	4	2.65	1	20.00	5 3.20
24 Crased	3	1.99			3 1.92
25 Crased					
26 Cracked	9	5.96	1	20.00	10 6.41
27 Split					
28 Worn					
29 Fretted	1	0.66			1 0.64
30 Tip Rod Loose					
31 Imbalance	3	1.99			3 1.92
TOTALS	151	100.00%	5	100.00%	156 100.00%

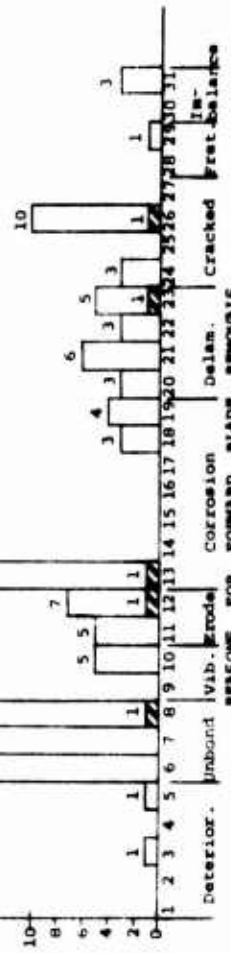


FIGURE 14. INHERENT DISCREPANCY-CAUSED REMOVALS - FORWARD BLADES - CH-47 B/C.

DISTRIBUTION PERCENTAGE

REMOVAL REASON	REPAIRED BLADES		SCRAPPED BLADES		% of Total Removals
	Blade Qty.	% of Extern. Discrep.	Blade Qty.	% of Extern. Discrep.	
Reason	106	39.70	12	24.00	118
1 Dented	1	0.38	1		0.32
2 Broken	13	4.87	13		4.10
3 Torn	30	11.23	34	8.00	10.73
4 Punctured	4	1.50	4		1.26
5 Scored	8	2.99	8		2.52
6 Bent	1	0.36	1		0.32
7 Broken	3	1.12	3		0.94
8 Scored	14	5.24	10	20.00	24
9 Dented	30	11.23	17	34.00	47
10 Punctured	2	0.75	2		0.64
11 Torn	1	0.38	1	2.00	2
12 Spar/Socket	29	10.86	3	6.00	32
13 Overstress	1	0.38	1		0.32
14 Bent	3	1.12	3		0.94
15 Collapse	1	0.38	1		0.32
16 Fractured	1	0.38	1		0.32
17 Dented	1	0.38	1		0.32
18 Bent	1	0.38	1		0.32
19 Collapse	1	0.38	1		0.32
20 Torn	1	0.38	1		0.32
21 Minor Damage	3	1.12	3	6.00	6
22 Error*	16	5.99	16	100.00%	16
23 No Valid Rmvl	267	100.00%	50	100.00%	317
TOTALS					100.00%

Repaired Blades
 Scrapped Blades
 * Manufacturing/Shipping/
 Handling Error Including
 Inadequate Field Maintenance

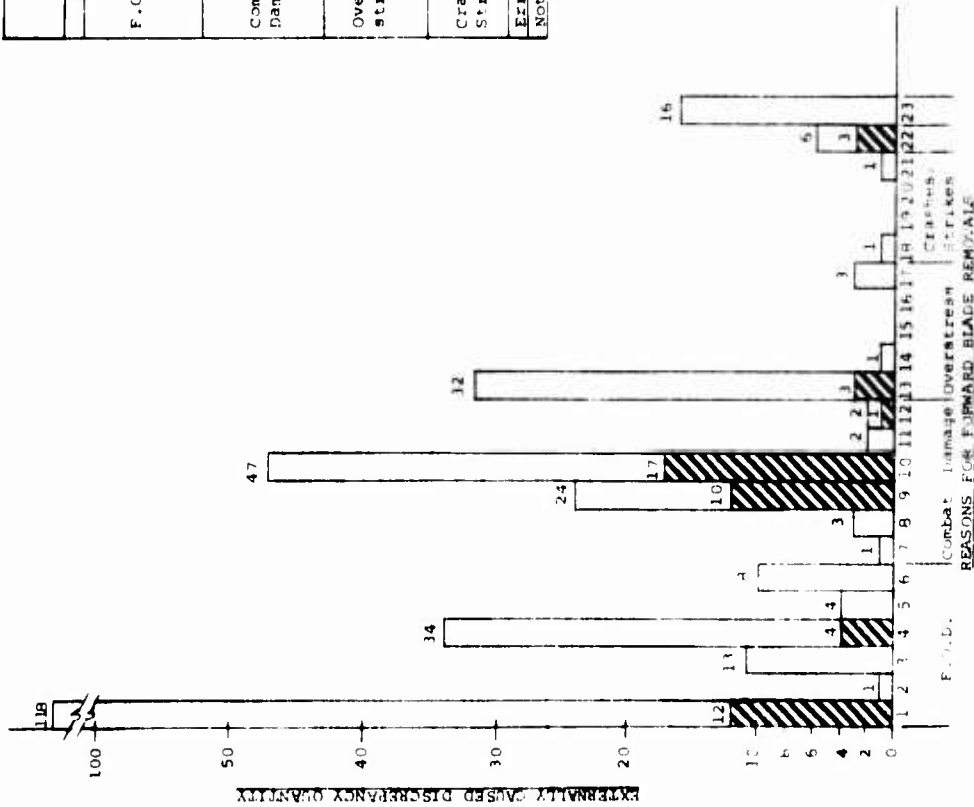


FIGURE 15. EXTERNALLY-CAUSED DISCREPANCY REMOVALS - FORWARD BLADES - CH-47 B/C.

DISTRIBUTION PERCENTAGES

REMOVAL REASON		REPAIRED BLADES		SCRAPPED BLADES		% of Total Removals
Reason No.	Discrep.	Blade Qty.	% of Scheduled Removals	Scheduled Blade Qty.	% of Scheduled Removals	
1	NO	2	5.13			5.13
2	Compliance	23	58.97			58.97
3	No Defect (Scheduled Maintenance)					
4	Retired Blades	2	5.13			5.13
5	EIR Engr. Evaluation	10	25.64			25.64
6	No Defect (To facilitate maint.)	2	5.13			5.13
TOTALS		39	100.00%			100.00%

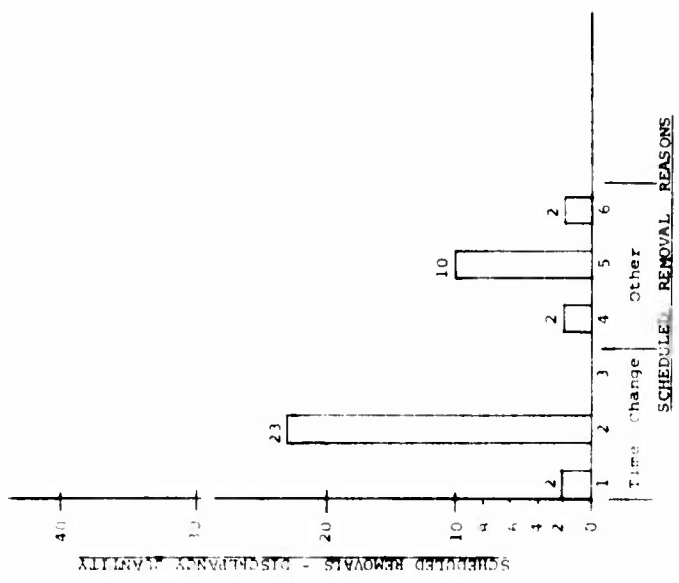


FIGURE 16. SCHEDULED REMOVALS - FORWARD BLADES - CH-47 B/C.

REMOVAL REASON		REPAIR BLADES		SCRAP BLADES		Quantity of Removals	% of Total Removals
Reason No.	Discrep.	Blade Qty	% of Inher. Discr.	Blade Qty	% of Inher. Discr.		
1	Loose/missing						
2	Base Steel						
3	Eroded	2	1.61			2	1.56
4	Rippled						
2	Water Migrate	2	1.61			2	1.56
6	Builed	26	20.97			26	20.31
7	Blistered	39	31.45			39	30.47
8	Round Void	14	11.29			14	10.94
9	Unable to ad)	3	2.42			3	2.34
10	Vibration	1	0.81			1	0.78
11	Worn						
12	Eroded	2	1.61	1	25.00	3	2.34
13	Corroded	17	13.71	3	75.00	20	15.63
14	Peeling						
15	Chipped						
16	Stained						
17	Seized						
18	Water Migrate	1	0.81			1	0.78
19	Pitted	1	0.81			1	0.78
20	Voided	9	7.26			9	7.03
21	Crased						
22	Cracked	1	0.81			1	0.78
23	Split						
24	Creased						
25	Crased						
26	Cracked	5	4.03			5	3.91
27	SBlat						
28	Worn						
29	Fretted						
30	Tip Rod Loose	1	0.81			1	0.78
31	Imbalance						
TOTALS		124	100.00%	4	100.00%	128	100.00%

Repaired Blades
 Scrapped Blades

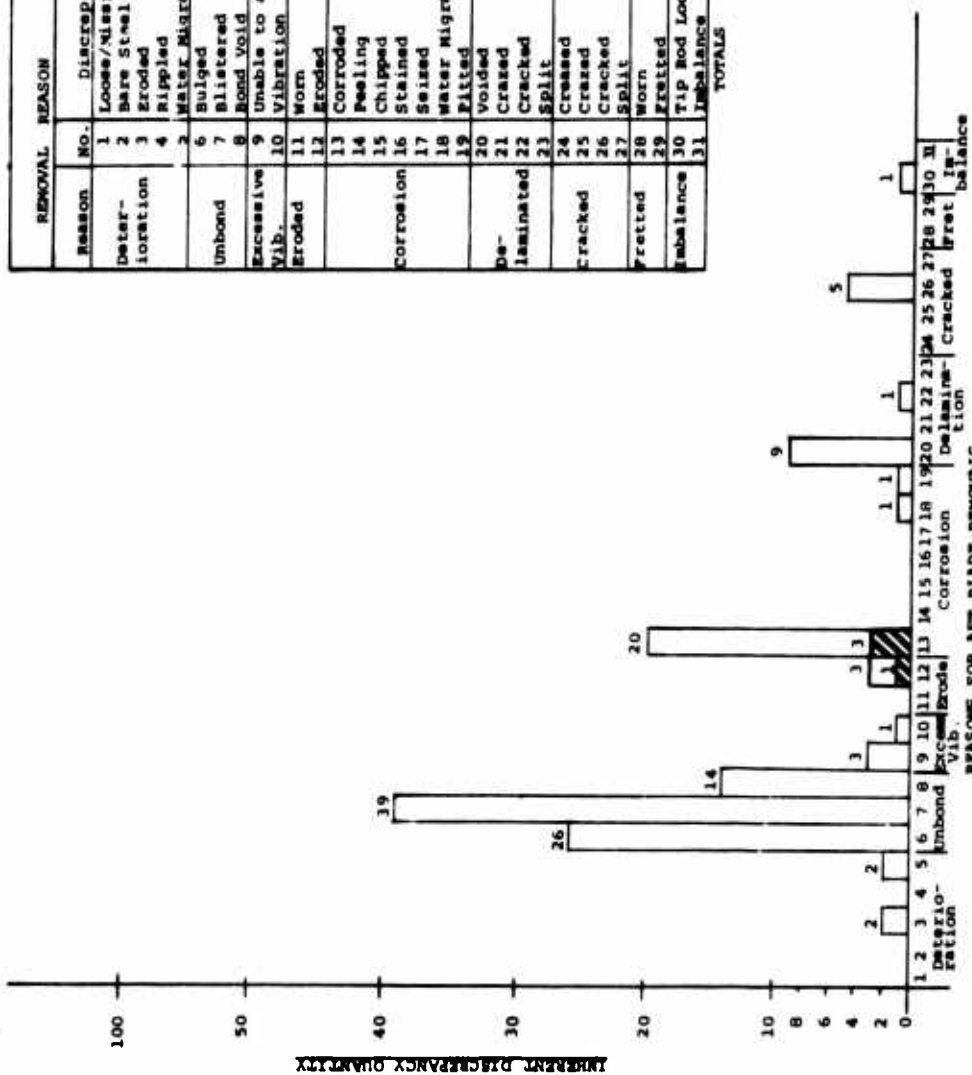


FIGURE 17. INHERENT DISCREPANCY-CAUSED REMOVALS - AFT BLADES - CH-47 B/C.

DISTRIBUTION PERCENTAGES

REMOVAL REASON		REPAIRED BLADES		SCRAPPED BLADES		Removals	% of Total
No. Reason	Discr.	Blade Qty.	% of External Discr.	Blade Qty.	% of External Discr.		
1	Dented	91	34.34	23	35.38	114	34.55
2	Broken			1	1.54	1	0.30
3	F.O.D.	17	6.42			17	5.15
4	Torn	35	13.21	3	4.62	38	11.51
5	Punctured	7	2.64	2	3.08	9	2.73
6	Scored						
7	Bent	6	2.25			6	1.82
8	Broken						
9	Scored			1	1.54	1	0.30
10	Combat Damage	13	4.91	9	13.84	22	6.67
11	Punctured	34	12.83	8	12.30	42	12.73
12	Torn	3	1.13	1	1.54	4	1.21
13	SPK/Socket						
14	Overstress	27	10.19			27	8.16
15	Bent						
16	Collaps						
17	Fractured	4	1.51	1	1.54	5	1.52
18	Dented						
19	Bent						
20	Crashes/Collapse	2	0.75	1	1.54	3	0.91
21	Strikes Torn			13	20.00	13	3.94
22	Minor Damage	3	1.13	2	3.08	5	1.52
23	Manuf/Ship/Maint Error						
24	No. Valid Removal Reason	23	8.68			23	6.97
TOTALS		265	100.00%	65	100.00%	330	100.00%

Repaired blades
 Scrapped blades

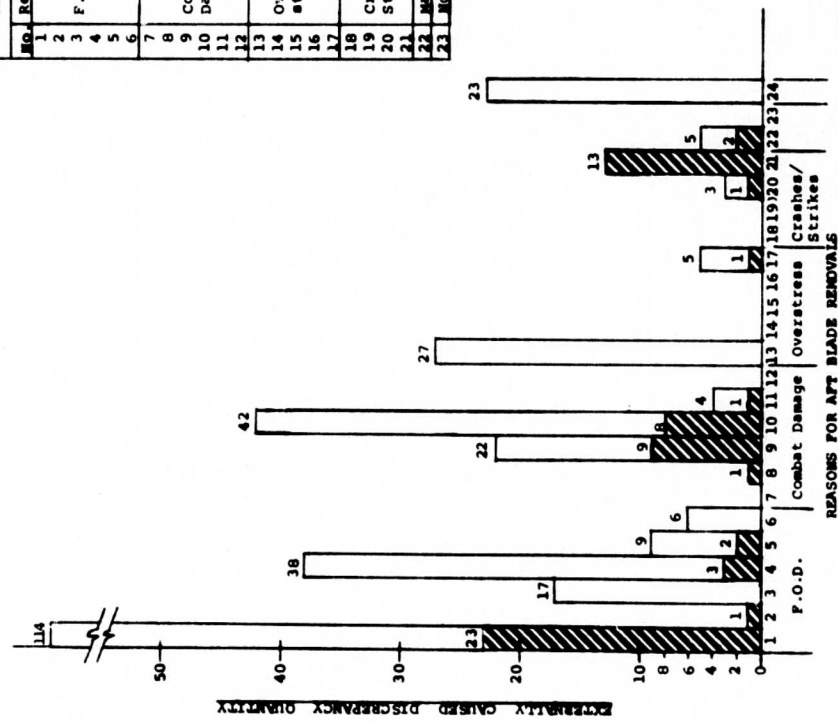


FIGURE 18. EXTERNALLY-CAUSED DISCREPANCY REMOVALS - APT BLADES - CH-47 B/C.

DISTRIBUTION PERCENTAGES

REMOVAL REASON	REPAIRED BLADES		SCRAPPED BLADES		Removal Qty	% of Total Removals
	Blade Qty	% of Scheduled Removals	Blade Qty	% of Scheduled Removals		
Reason No. 1: M/O Compliance	13	31.71	2	100.00	13	30.23
Reason No. 2: No Defect (Scheduled Maintenance) Retired Blades	22	53.6	0	0	24	55.81
Reason No. 4: EIR Engr. Eval. No Defect (to facilitate maint)	6	14.63	0	0	6	13.95
Reason No. 6: Other	41	100.00	2	100.00	43	100.00
TOTALS						

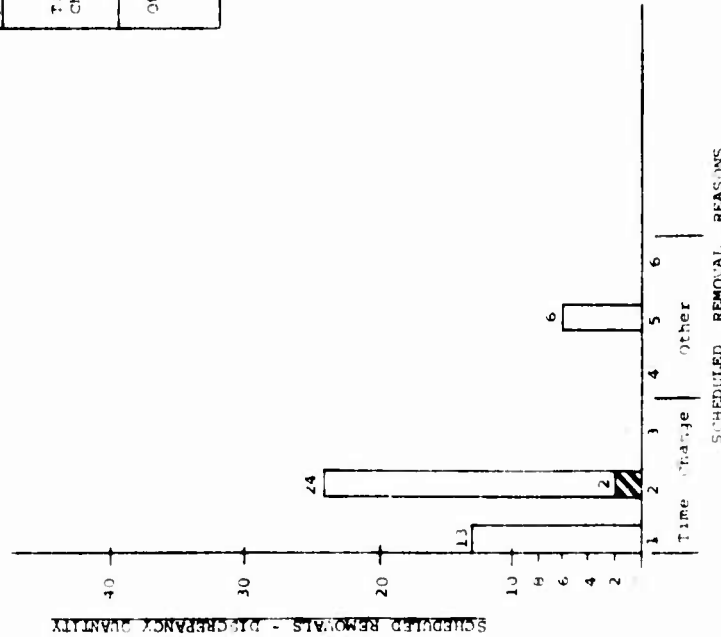


FIGURE 19. SCHEDULED REMOVALS - AFT BLADES - CH-47 B/C.

TABLE XX. SUMMARY OF PERCENTAGES OF REMOVALS -
CH-47B/C FORWARD AND AFT ROTOR BLADES

MAJOR DISCREPANCY REMOVAL REASON	FORWARD ROTOR BLADES *						AFT ROTOR BLADES +					
	Total - All Blades		Repaired Blades		Scrapped Blades		Total - All Blades		Repaired Blades		Scrapped Blades	
	Qty.	%	Qty.	%	Qty.	%	Qty.	%	Qty.	%	Qty.	%
Deterioration	2	0.39	2	0.39	0	0	4	0.80	4	0.80	0	0
Unbonded	65	12.69	64	12.50	1	0.19	79	15.77	79	15.77	0	0
Vibration	5	0.98	5	0.98	0	0	4	0.80	4	0.80	0	0
Erosion	12	2.34	11	2.15	1	0.19	3	0.60	2	0.40	1	0.20
Corrosion	38	7.42	37	7.23	1	0.19	22	4.39	19	3.79	3	0.60
Delaminated	17	3.32	16	3.13	1	0.19	10	2.00	10	2.00	0	0
Cracked	13	2.54	12	2.35	1	0.19	5	1.00	5	1.00	0	0
Fretted	1	0.19	1	0.19	0	0	0	0	0	0	0	0
Imbalance	3	0.59	3	0.59	0	0	1	0.20	1	0.20	0	0
F.O.D.	178	34.76	162	31.64	16	3.12	185	36.92	156	31.14	29	5.78
Combat Damage	79	15.43	51	9.96	28	5.47	69	13.77	50	9.98	19	3.79
Overstress	36	7.03	33	6.44	3	0.59	32	6.39	31	6.19	1	0.20
Crashes/Strikes	2	0.39	2	0.39	0	0	16	3.19	2	0.40	14	2.79
Error	6	1.18	3	0.59	3	0.59	5	1.00	3	0.60	2	0.40
No Valid Reason	16	3.12	16	3.12	0	0	23	4.59	23	4.59	0	0
Miscellaneous	0	0	0	0	0	0	0	0	0	0	0	0
Time Change	25	4.88	25	4.88	0	0	37	7.38	35	6.99	2	0.40
Other	14	2.74	14	2.74	0	0	6	1.20	6	1.19	0	0
TOTALS	512	100.00%	457	89.27	55	10.72	501	100.00%	430	85.84	71	14.16

* Percentages Based Upon A Total Of 512 Forward Blades

+ Percentages Based Upon A Total of 501 Aft Blades

CH-47B/C Forward and Aft Blades Means Analysis

A series of evaluations of the CH-47B/C rotor blades for their average removal characteristics as based upon frequency of blade removal was accomplished. These calculations of the various removal means followed the approach outlined on pages 20 and 21. Results are given in blade hours.

Tables XXI, XXII and XXIII list the means determined for the major discrepant reasons for removal of the CH-47B/C forward rotor blades. Tables XXIV, XXV and XXVI list similar determinations accomplished for the CH-47B/C aft rotor blades.

Table XXVII presents a summary of the results of these analyses for both CH-47B/C forward and aft blades. This summary may be compared to the CH-47A blade summary shown by Table XVII, on page 40.

TABLE XXI. MEAN-TIME-BETWEEN-REMOVALS - FORWARD BLADES - CH-47 B/C

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	MTBR _F	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	MTBR _F	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	MTBR _F
Inherent Discrep.	151		5,922	5		178,867	156		5,733
Deterioration	2		447,169	--		--	2		447,169
Unbonded	64		13,974	1		894,339	65		13,759
Excessive Vibration	5		178,867	--		--	5		178,867
Erosion/Wear	11	894,339	81,304	1	894,339	894,339	12	894,339	74,528
Corroded	37		24,171	1		894,339	38		23,535
Delamination	16		55,896	1		894,339	17		52,603
Cracked	12		74,528	1		894,339	13		68,795
Fretted	1		894,339	--		--	1		894,339
Imbalance	3		298,113	--		--	3		298,113
Externally-Caused Discrep.	248		3,606	47		19,028	295		3,032
Foreign Object Damage	162		5,520	16		55,896	178		5,024
Combat damage	51	894,339	17,536	28	894,339	31,941	79	894,339	11,321
Overstressed	33		27,101	3		298,113	36		24,843
Crashes/Strikes	2		447,169	--		--	2		447,169
No valid Removal Reason	16	894,339	55,896	--	--	--	16	894,339	55,896
Error *	3	894,339	298,113	3	894,339	298,113	6	894,339	149,056
Scheduled Removals	39		22,932	--	--	--	39		22,932
Time Change	25	894,339	35,774	--	--	--	25	894,339	35,774
Other	14		63,881	--	--	--	14		63,881
All Causes	457	894,339	1,957	55	894,339	16,260	512	894,339	1,747

* Manufacturing/shipping/handling error including inadequate field repair

TABLE XXII. MEAN-TIME-TO-REMOVAL - FORWARD BLADES - CH-47 B/C

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	MTRF	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	MTRF	Qty. of Blades Removed	Total Fwd. Bld. Flight Hours	MTRF
Inherent Discr.	151	63,336	419	5	2,186	437	65,522	420	
Deterioration	2	999	499	--	--	--	999	499	
Unbonded	54	23,923	374	1	445	445	24,368	375	
Excessive Vibration	5	1,852	370	--	--	--	1,852	370	
Erosion/Wear	11	6,038	549	1	221	221	6,259	522	
Corroded	37	18,431	498	1	835	835	19,266	507	
Delamination	16	5,941	371	1	349	349	6,290	370	
Cracked	12	4,739	395	1	336	336	5,075	390	
Fretted	1	500	500	--	--	--	500	500	
Imbalance	3	913	304	--	--	--	913	304	
Externally-Caused Discr.	248	93,926	379	47	18,423	392	112,349	381	
Foreign Object Damage	162	63,688	394	16	8,692	543	72,580	408	
Combat Damage	51	19,497	382	28	9,220	329	28,717	364	
Overstressed	33	9,346	283	3	511	170	9,857	274	
Crashes/Strikes	2	1,195	597	--	--	--	1,195	597	
No. Valid Removal Reason	16	4,916	307	--	--	--	4,916	307	
Error*	3	262	87	3	1,874	624	2,136	356	
Scheduled Removals	39	17,852	458	--	--	--	17,852	458	
Time Change	25	13,396	536	--	--	--	13,396	536	
Other	14	4,456	318	--	--	--	4,456	318	
All Causes	457	180,292	395	55	22,483	409	202,775	396	

* Manufacturing/shipping/handling error including inadequate field repair.

TABLE XXIII. MEAN-TIME-BETWEEN-UNSCHEDULED-REMOVALS - FORWARD BLADES - CH-47 B/C

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Fwd. Bid. Flight Hours	MTBUR _F	Qty. of Blades Removed	Total Fwd. Bid. Flight Hours	MTBUR _F	Qty. of Blades Removed	Total Fwd. Bid. Flight Hours	MTBUR _F
Inherent Discrep.	151		5,922	5		178,867	156		5,733
Deterioration	2		447,169	--		--	2		447,169
Unbonded	64		13,974	1		894,339	65		13,759
Excessive Vibration	5		178,867	--		--	5		178,867
Erosion/Wear	11	894,339	81,304	1	894,339	894,339	12	894,339	74,528
Corroded	37		24,171	1		894,339	38		23,535
Delamination	16		55,896	1		894,339	17		52,608
Cracked	12		74,528	1		894,339	13		68,795
Fretted	1		894,339	--		--	1		894,339
Imbalance	3		298,113	--		--	3		298,113
Externally-Caused Discrep.	248		3,606	47		19,028	295		3,032
Foreign Object Damage	162	894,339	5,520	16	894,339	55,896	178	894,339	5,024
Combat Damage	51		17,536	28		31,941	79		11,321
Overstressed	33		27,101	3		298,113	36		24,843
Crashes/Strikes	2		447,169	--		--	2		447,169
No Valid Removal Reason	16	894,339	55,896	--	--	--	16	894,339	55,896
Error *	3	894,339	298,113	3	894,339	298,113	6	894,339	149,056
All Causes	418	894,339	2,140	55	894,339	16,260	473	894,339	1,891

* Manufacturing/shipping/maintenance/handling error including inadequate field repair.

Discrepancy Locations Versus Types of Discrepancies

Data included herein has been based upon 'Reasons for Removal' only.

This investigation simplified the amount of data handled by confining the results to major discrepancy locations versus types of inherent discrepancies and to externally-caused discrepancies only.

Figures 20 and 21 demonstrate the results of analyses for inherent and externally-caused discrepancies of the forward blades.

Figures 22 and 23 demonstrate the results of analyses for inherent and externally-caused discrepancies of the aft blades.

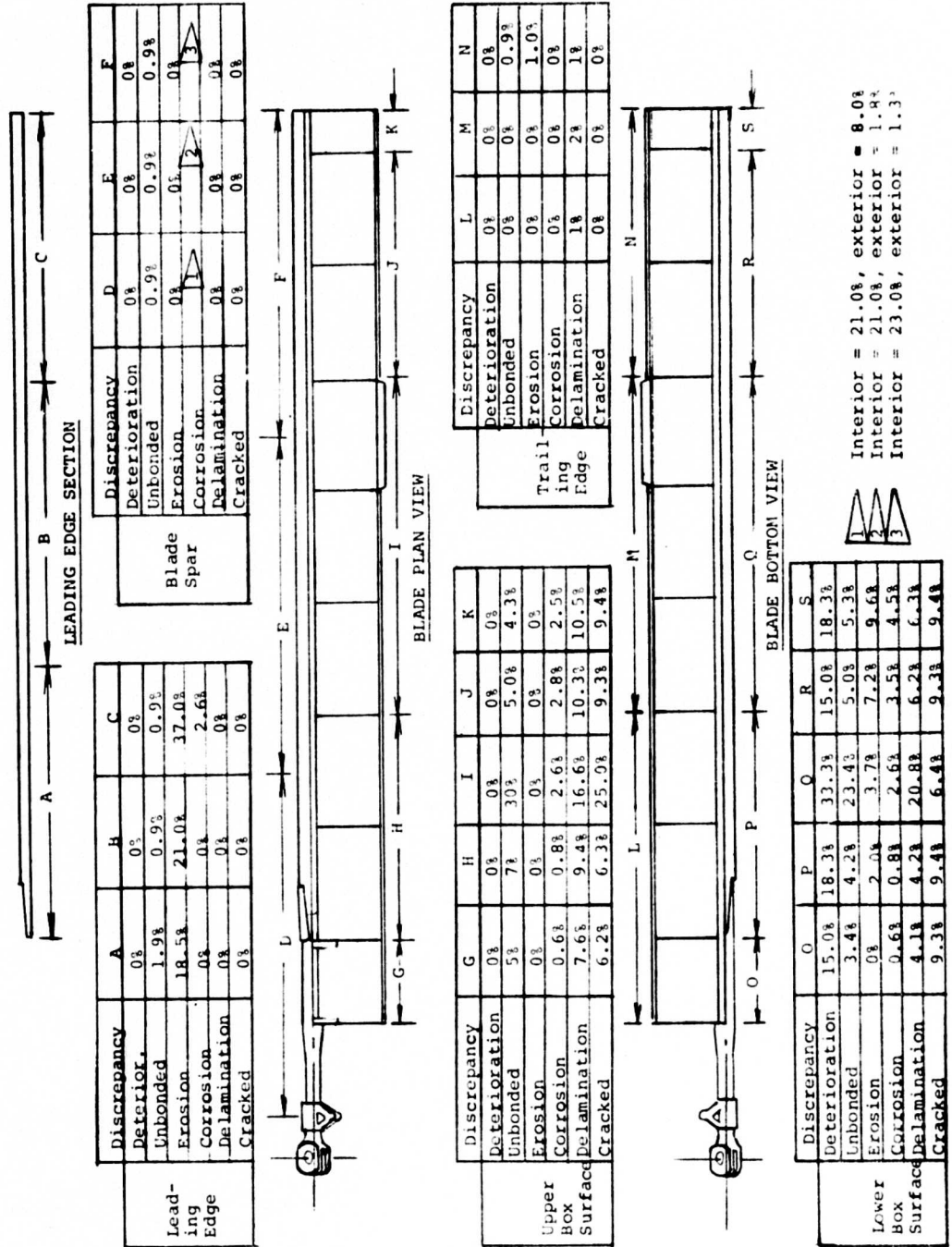


FIGURE 20. INHERENT DISCREPANCY LOCATIONS - FORWARD BLADES - CH-47B/C.

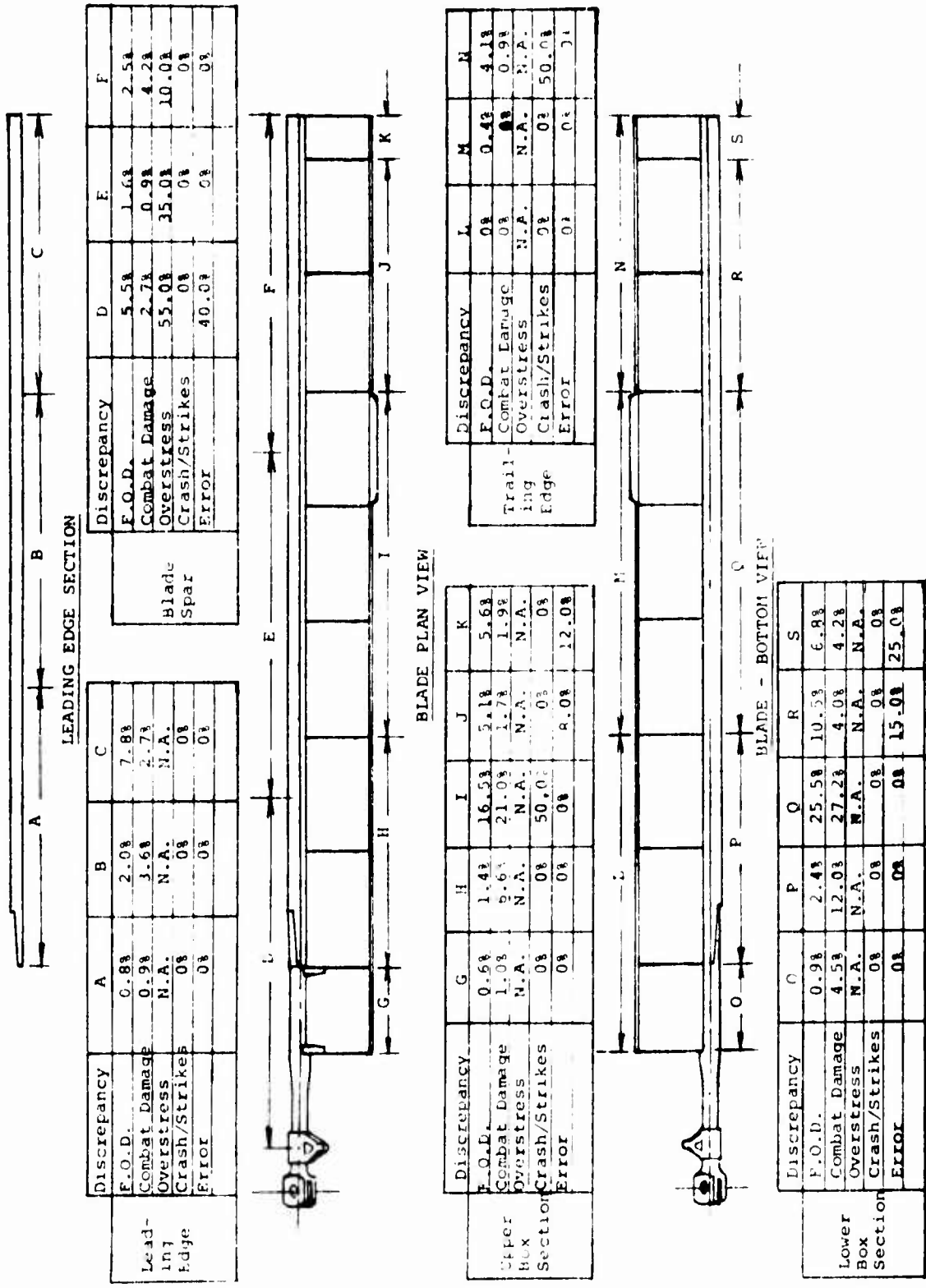


FIGURE 21. EXTERNALLY-CAUSED DISCREPANCY LOCATIONS - FORWARD BLADES - CH-47 E/C.

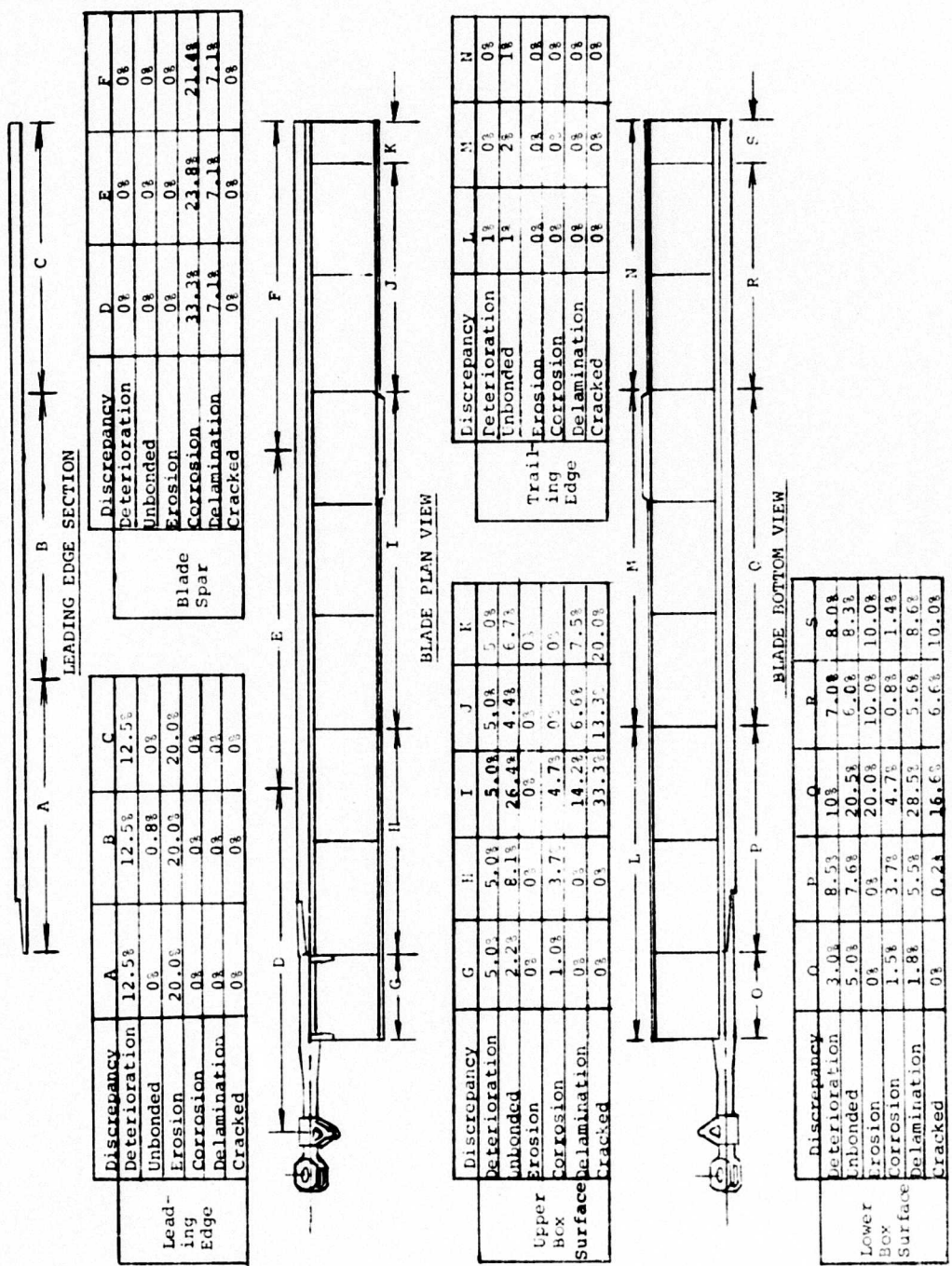


FIGURE 22. INHERENT DISCREPANCY LOCATIONS - AFT BLADES - CH-47 B/C.

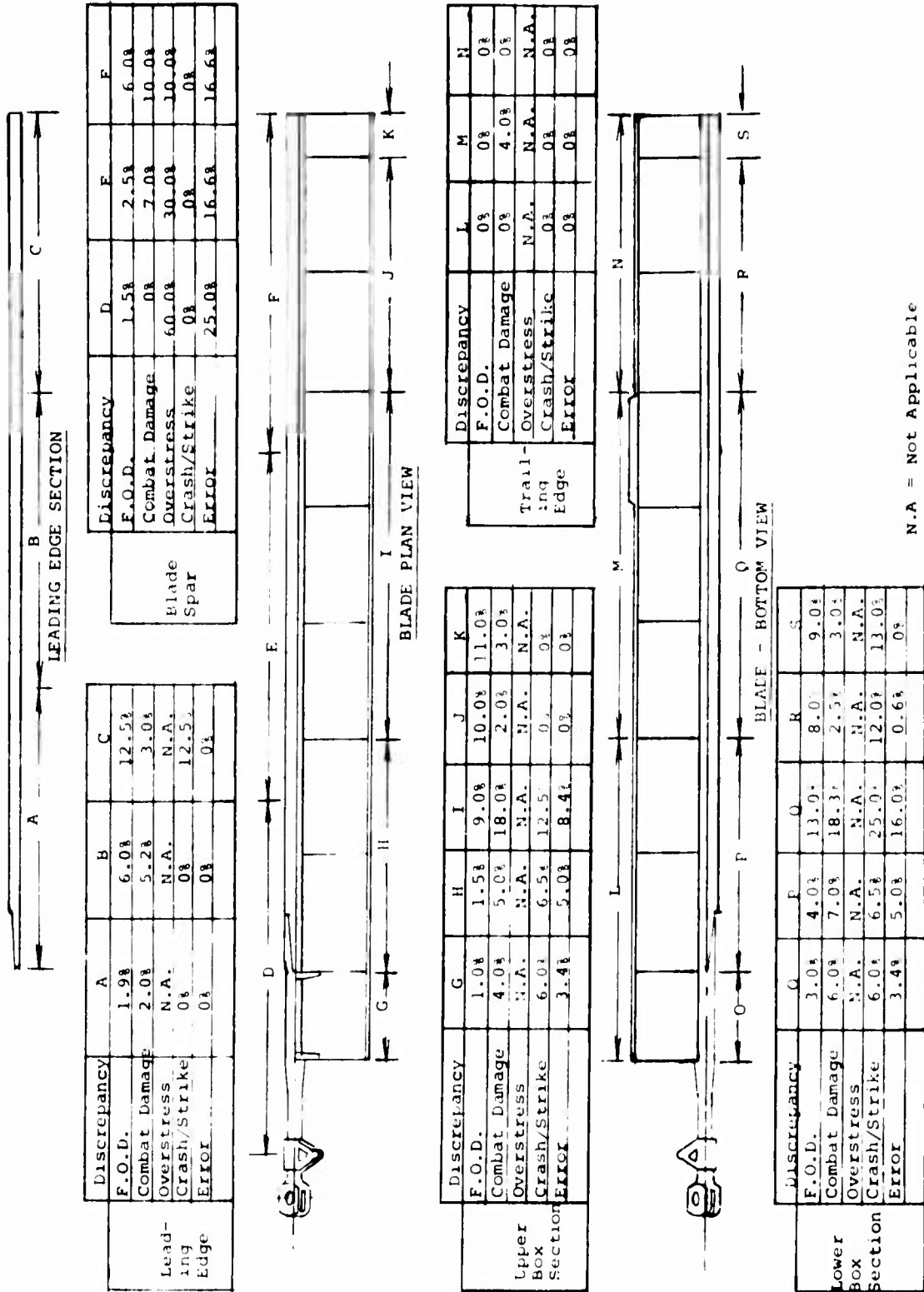


Figure 23. EXTERNALLY-CAUSED DISCREPANCY LOCATIONS - AFT BLADES - CH-47B/C.

TABLE XXIV. MEAN-TIME-BETWEEN-REMOVALS - AFT BLADES - CH-47 B/C

REASONS FOR REMOVALS	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Aft Bld. Flight Hours	MTBRA	Qty. of Blades Removed	Aft Bld. Flight Hours	MTBRA	Qty. of Blades Removed	Aft Bld. Flight Hours	MTBRA
Inherent Discrep.	124		7,128	4		220,956	128		6,905
Deterioration	4		220,956	--		--	4		220,956
Unbonded	79		11,188	--		--	79		11,188
Excessive Vibration	4		220,956	--		--	4		220,956
Erosion/Wear	2	883,824	441,912	1	883,824	883,824	3	883,824	294,608
Corroded	19		46,517	3		--	22		40,174
Delamination	10		88,382	--		--	10		88,382
Cracked	5		176,765	--		--	5		176,765
Fretted	--		--	--		--	--		--
Imbalance	1		883,824	--		--	1		883,824
Externally-Caused Discrep.	239		3,698	63		14,029	302		2,927
Foreign Object Damage	156		5,666	29		30,477	185		4,773
Combat Damage	50	883,824	17,676	19	883,824	883,824	69	883,824	12,808
Overstressed	31		28,510	1		883,824	32		27,619
Crashes/Strikes	2		441,912	14		63,130	16		22,231
No Valid Removal Reason	23	883,824	38,427	--		--	23	883,824	38,427
Error *	3	883,824	294,608	2	883,824	441,912	5	883,824	176,765
Scheduled Removals	41		21,557	2		441,912	43		20,552
Time Change	35	883,824	25,252	2	883,824	441,912	37	883,824	23,881
Other	6		147,304	--		--	6		147,304
All Causes	430	883,824	2,055	71	883,824	12,448	501	883,824	1,764

* Manufacturing/shipping/handling error including inadequate field repair

TABLE XXV. MEAN-TIME-TO-REMOVAL - AFT BLADES - CH-47 B/C

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Aft Bld. Flight Hours	MTTRA	Qty. of Blades Removed	Total Aft Bld. Flight Hours	MTTRA	Qty. of Blades Removed	Total Aft Bld. Flight Hours	MTTRA
Inherent Discrep.	124	50,713	409	4	2,401	600	128	53,114	415
Deterioration	4	1,421	355	--	--	--	4	1,421	355
Unbonded	79	30,954	392	--	--	--	79	30,954	392
Excessive Vibration	4	1,863	466	--	--	--	4	1,863	466
Erosion/Wear	2	366	183	1	391	391	3	757	252
Corroded	19	11,428	601	3	2,010	670	22	13,438	611
Delamination	10	2,230	223	--	--	--	10	2,230	223
Cracked	5	1,909	381	--	--	--	5	1,909	381
Fretted	--	--	--	--	--	--	--	--	--
Imbalance	1	542	542	--	--	--	1	542	542
Externally-Caused Discrep.	239	82,526	345	63	20,876	331	302	103,402	342
Foreign Object Damage	156	59,420	301	29	11,513	397	185	70,433	383
Combat Damage	50	16,092	322	19	8,223	433	69	24,315	352
Overstressed	31	6,609	213	1	316	316	32	6,425	316
Crashes/Strikes	2	405	202	14	824	59	16	1,229	77
No Valid Removal Reason	23	7,474	325	--	--	--	23	7,474	325
Error *	3	244	81	2	554	277	5	798	160
Scheduled Removals	41	18,801	459	2	1,478	739	43	20,279	472
Time Change	35	15,964	456	2	1,478	739	37	17,442	471
Other	6	2,837	473	--	--	--	6	2,837	473
All Causes	430	159,758	372	71	25,309	356	501	185,067	369

* Manufacturing/shipping/handling error including inadequate field repair

REASONS FOR REMOVAL	REPAIRED BLADES			SCRAPPED BLADES			TOTAL BLADES		
	Qty. of Blades Removed	Total Aft Bld. Flight Hours	MTBUR _A	Qty. of Blades Removed	Total Aft Bld. Flight Hours	MTBUR _A	Qty. of Blades Removed	Total Aft Bld. Flight Hours	MTBUR _A
Inherent Discorp. deterioration	124	7,128	7,128	4		220,956	128		6,905
Unbonded	4	220,956	220,956	--		--	4		220,956
Excessive Vibration	79	11,188	11,188	--		--	79		11,188
Erosion/Wear	4	220,956	220,956	--		--	4		220,956
Corroded	2	883,824	441,912	1	883,824	883,824	3	883,824	294,608
Delamination	19	46,517	46,517	3		294,608	22		40,174
Cracked	10	88,382	88,382	--		--	10		88,382
Fretted	5	176,765	176,765	--		--	5		176,765
Imbalance	--	--	--	--		--	--		--
Externally-caused Discorp.	1	883,824	883,824	--		--	1		883,824
Foreign Object Damage	239	3,598	3,598	63		14,029	102		2,927
Combat Damage	156	5,666	5,666	29	883,824	30,477	185	883,824	4,777
Overstressed	50	17,676	17,676	19		46,517	69		12,809
Crashes/Strikes	31	28,510	28,510	1		883,824	32		27,619
No Valid Removal Reason	2	441,912	441,912	14		63,130	16		55,239
Error *	23	883,824	38,427	--	883,824	--	23	883,824	38,427
All Causes	3	883,824	294,608	2	883,824	441,912	5	883,824	176,765
	389	883,824	2,272	69	883,824	12,809	458	883,824	1,910

* Manufacturing/shipping/handling error including inadequate field repair

TABLE XXVII. SUMMARY OF CH-47B/C FORWARD AND AFT BLADE MEANS

BLADE		COMBINED VALUES	INHEPENT DISCREPANCY	EXTERNALLY CAUSED DISCREPANCY	ERROR CAUSED DISCREPANCY	SCHEDULED REMOVALS	NO VALID REMOVAL REASON
FORWARD BLADES	MTBF _F	1,957	5,922	3,606	298,113	22,932	55,896
	Scrapped	16,070	178,867	19,028	298,113	--	--
	Total	1,747	5,733	3,032	149,056	22,932	55,896
FORWARD BLADES	MTTF _F	390	419	379	87	458	307
	Scrapped	409	437	392	624	--	--
	Total	396	420	381	356	458	307
FORWARD BLADES	MTBUR _F	2,140	5,922	3,606	298,113	N.A.	55,896
	Scrapped	16,070	178,867	19,028	298,113	N.A.	--
	Total	1,891	5,733	3,032	149,056	N.A.	55,896
AFT BLADES	MTBF _A	2,055	7,128	3,698	294,608	21,557	38,427
	Scrapped	12,448	220,956	14,029	441,912	441,912	--
	Total	1,764	6,905	2,927	176,765	20,554	38,427
AFT BLADES	MTTF _A	372	409	345	81	459	325
	Scrapped	356	600	331	277	739	--
	Total	369	415	342	160	472	325
AFT BLADES	MTBUR _A	2,272	7,128	3,698	294,608	N.A.	38,427
	Scrapped	12,809	220,956	14,029	441,912	N.A.	--
	Total	1,930	6,905	2,927	176,765	N.A.	38,427

N.A. - Not Applicable
 MTBR - Mean-Time-Between Removals
 MTR - Mean-Time-To-Removal
 MTBUR - Mean-Time-Between-Unscheduled-Removals

CH-47 BLADE SCRAPPAGE ANALYSES

This section of the report includes analyses of the scrappage of the forward and aft rotor blades for both CH-47A and CH-47B/C helicopters.

Analyses concern the following:

- a. Major percentages of blades scrapped
- b. Quantity of blades scrapped vs. actual reasons for scrappage
- c. Blade teardown experience
- d. Mean-Time-to-Scrappage

The following helicopter blade scrappage analyses have been based upon the known reasons for blade scrappage, not upon reasons for blade removal. Certain blades were removed for reasons other than any known spar damage in the field and returned for inspection and overhaul. Subsequent repair action uncovered spar damage. However, other blades were scrapped, either in the field or immediately upon return inspection without any rework action attempted. In these cases where the reason for scrappage was not given in Boeing-Vertol records, the reason for blade removal was used as the scrappage reason. It may be assumed that reasons for removal may be a good indicator of the reasons for scrappage of blades in the field. Field scrappage reasons and data are not accessible to Boeing-Vertol except through Field Service Representative reports.

Tables XXVIII and XXIX summarize the scrapped blade status for the most frequently occurring causes for scrappage. Table XXVIII concerns the forward blades and Table XXIX concerns the aft blades.

Table XXX, page 77, summarizes the percentages of blade scrappage for CH-47A and CH-47B/C forward and aft blades in terms of reasons for blade scrappage.

TABLE XXVIII. PERCENTAGES OF FORWARD BLADE SCRAPPAGE - CH-47A AND CH-47B/C					
CH-47A FWD BLADES			CH-47B/C FWD BLADES		
SCRAP DISCREPANCY/REMOVAL CAUSE	QTY. BLADES	PERCENT OF TOTAL*	SCRAP DISCREPANCY/REMOVAL CAUSE	QTY. BLADES	PERCENT OF TOTAL +
Dented - F.O.D.	54	7.86	Dented - F.O.D.	15	11.91
Overstressed	44	6.40	Dented - Combat Damage	14	11.12
Punctured - Combat Damage	26	3.78	Punctured - Combat Damage	10	7.94
Dented-Combat Damage	20	2.91	Scored - F.O.D.	3	2.38
Minor Damage-Crashes	10	1.46	Dented - Crash Damage	3	2.38
Collapsed-Crashes	8	1.16	Overstressed	3	2.38
Corroded	8	1.16	Punctured - F.O.D.	2	1.59
Punctured - F.O.D.	4	.58	Torn - Combat Damage	1	.79
Retired	4	.58	Torn - Crash Damage	1	.79
Mishandled - Error	3	.44	Shop Error	1	.79
Shop Error	2	.29	Arc Burn - Error	1	.79
Arc Burn - Error	2	.29	Corroded	1	.79
Scheduled Maint.	2	.29	TOTALS:	55	43.65%
Scored - F.O.D.	2	.29			
Spar/Socket-Combat Damage	1	.15			
Bent-Crash Damage	1	.15			
Torn-Crash Damage	1	.15			
Cracked	1	.15			
Unbonded	1	.15			
TOTALS:	194	28.24%			

* Based upon 687 CH-47A forward and aft scrapped blades. See Table XXIX.

+ Based upon 126 CH-47B/C forward and aft scrapped blades. See Table XXIX.

TABLE XXIX. PERCENTAGES OF AFT BLADE SCRAPPAGE - CH-47A AND CH-47B/C					
CH-47A AFT BLADES			CH-47B/C AFT BLADES		
SCRAP DISCREPANCY/REMOVAL CAUSE	QTY. BLADES	PERCENT OF TOTAL*	SCRAP DISCREPANCY/REMOVAL CAUSE	QTY. BLADES	PERCENT OF TOTAL+
Overstressed	217	31.59	Dented - F.O.D.	23	18.26
Dented - F.O.D.	93	13.54	Dented - Crash Damage	13	10.32
Scheduled Maint.	44	6.40	Dented - Combat Damage	9	7.14
Punctured - Combat Damage	31	4.51	Punctured-Combat Damage	8	6.35
Retired	30	4.36	Overstressed	4	3.18
Punctured - F.O.D.	15	2.18	Punctured-F.O.D.	3	2.38
Dented-Combat Damage	15	2.18	Corroded	3	2.38
Corroded	7	1.02	Scored - F.O.D.	2	1.59
Torn-Crash Damage	6	.87	Mishandled-Error	2	1.59
Unbonded	6	.87	Broken - F.O.D.	1	.79
Broken - F.O.D.	4	.58	Scored - Combat Damage	1	.79
Torn - F.O.D.	4	.58	Torn-Combat Damage	1	.79
Minor Crash Damage	4	.58	Torn-Crash Damage	1	.79
Bent - F.O.D.	3	.44	TOTALS:	71	56.35%
Arc Burn - Error	3	.44			
Cracked	3	.44			
Scored - F.O.D.	2	.29			
Broken-Combat Damage	2	.29			
Bent-Crash Damage	1	.15			
Collapsed-Crash Damage	1	.15			
Mishandled-Error	1	.15			
Shop Error	1	.15			
TOTALS:	493	71.76%			

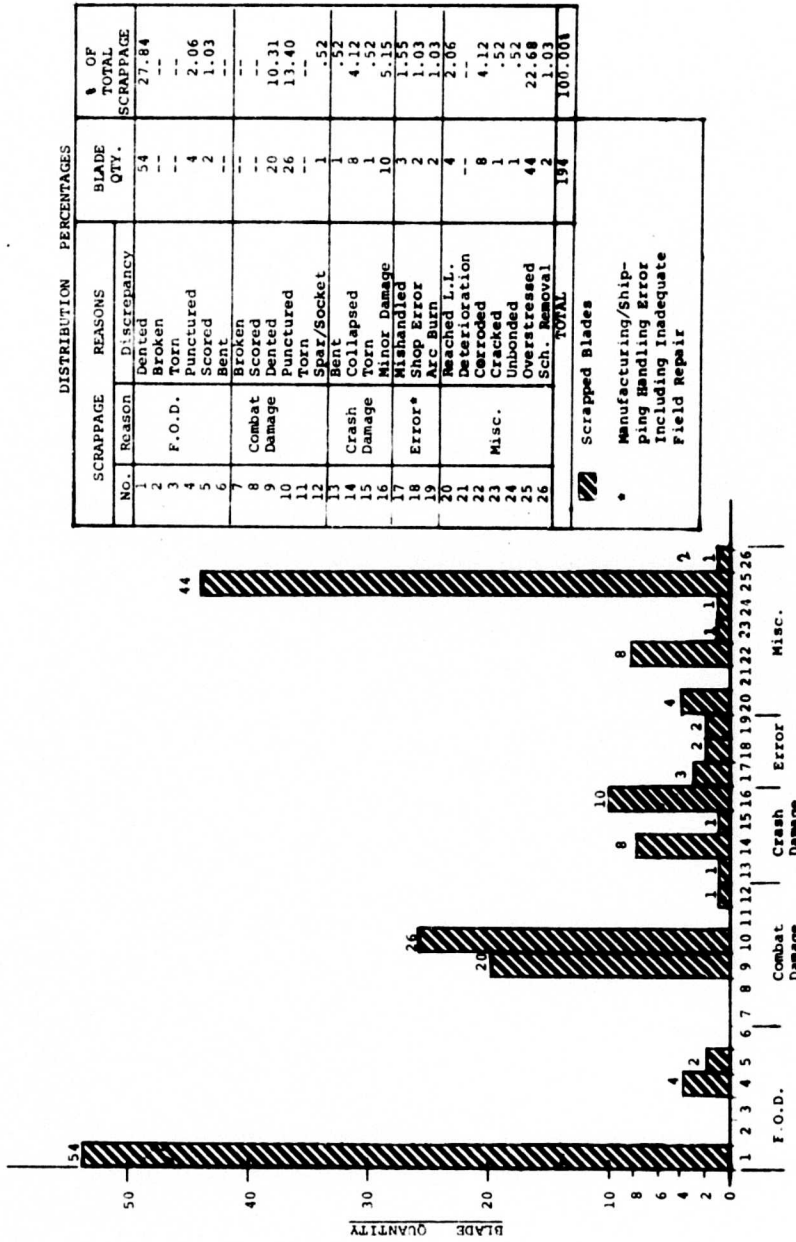
* Based upon 687 CH-47A forward and aft scrapped blades. See Table XXVIII.

+ Based upon 126 CH-47 B/C forward and aft scrapped blades. See Table XXVIII

The distribution of the percentage of CH-47B/C forward and aft rotor blades that have been scrapped for known causes, either internal or external, is shown in Figures 24, 25, 26 and 27.

Prior to a decision as to the extent of blade damage (including spar damage), the blades may require either a partial or a complete teardown during their repair in Boeing-Vertol shops. A partial teardown consists of the replacement of all blade boxes, the trailing edge and the trim tab. The complete teardown consists of the replacement of all the blade boxes, the trailing edge, the trim tab, and the nose cap, plus any miscellaneous parts, as required. Figure 28 has been provided to indicate the quantity of blades that required either partial or complete teardown versus those blades found unsatisfactory as a result of teardown and therefore scrapped.

Calculation results of mean-time-between-scrappage of forward and aft blades for the CH-47A blades are shown in Table XXXI and for the CH-47B/C in Table XXXII. Table XXXIII summarizes all scrapped blade means.



DISTRIBUTION PERCENTAGES

NO.	SCRAPAGE REASONS		BLADE QTY.	% OF TOTAL SCRAPAGE
	Reason	Discrepancy		
1	Dented		54	27.84
2	Broken		--	--
3	F.O.D.		--	--
4	Punctured		4	2.06
5	Scored		2	1.03
6	Bent		--	--
7	Broken		--	--
8	Scored		--	--
9	Dented		20	10.31
10	Punctured		26	13.40
11	Torn		--	--
12	Spear/Socket		1	.52
13	Bent		1	.52
14	Crash		8	4.12
15	Collapsed		1	.52
16	Damage		10	5.15
17	Minor Damage		3	1.55
18	Mishandled		2	1.03
19	Shop Error		2	1.03
20	Arc Burn		2	1.03
21	Reached L.L.		4	2.06
22	Deterioration		--	--
23	Corroded		8	4.12
24	Cracked		1	.52
25	Unbonded		1	.52
26	Overstressed		44	22.68
27	Sch. Removal		2	1.03
28	TOTAL		194	100.00%

▨ Scrapped Blades
 * Manufacturing/Shipping Error Including Inadequate Field Repair

REASONS FOR FWD BLADE SCRAPAGE

FIGURE 24. SCRAPAGE - FORWARD BLADES - CH-47A.

DISTRIBUTION PERCENTAGE

NO.	REASON	REASONS		BLADE QTY.	% OF TOTAL SCRAPPAGE
		SCRAPPAGE	DISCREPANCY		
1	Dented			93	18.86
2	Broken			4	0.81
3	F.O.D.			4	0.81
4	Torn			15	3.04
5	Punctured			2	0.41
6	Scored			3	0.61
7	Bent			2	0.41
8	Broken			0	0
9	Scored			15	3.04
10	Combat Damage			31	6.28
11	Punctured			0	0
12	Torn			0	0
13	Spall/Socket			0	0
14	Bent			1	0.22
15	Crash/Strikes			1	0.22
16	Collapsed			6	1.22
17	Torn			4	0.81
18	Minor Damage			1	0.22
19	Mishandled			1	0.22
20	Shop Error			3	0.61
21	Arc Burn			30	6.09
22	Reached LL			0	0
23	Deterioration			7	1.42
24	Corroded			3	0.61
25	Cracked			6	1.22
26	Unbonded			217	44.02
	Overstressed			44	8.92
	Sen. Removal			493	100.00%
	TOTAL				

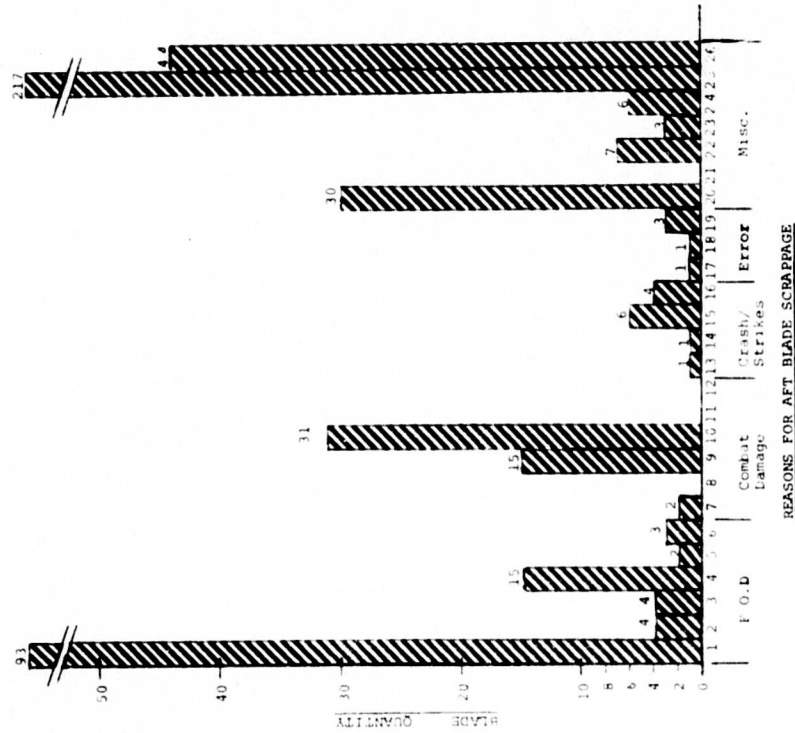



FIGURE 25. SCRAPPAGE - AFT BLADES - CH-47A.

DISTRIBUTION PERCENTAGES

No.	SCRAPAGE REASON		Blade Qty.	% of Total Scrapage
	Reason	Discrep.		
1	Dented	15	27.3	
2	F.O.L.	2	3.6	
3	Scored	3	5.5	
4	Combat Damage	14	25.4	
5	Punctured	10	18.2	
6	Crash	1	1.8	
7	Damage	1	1.8	
8	Dented	3	5.5	
9	Shop Error	1	1.8	
10	Arc Burn	1	1.8	
11	Corroded	1	1.8	
12	Overstressed	3	5.5	
TOTALS			55	100.0%

 Scrapped Blades
 • Manufacturing/Shipping/
 Handling Error Including
 Inadequate Field Repair

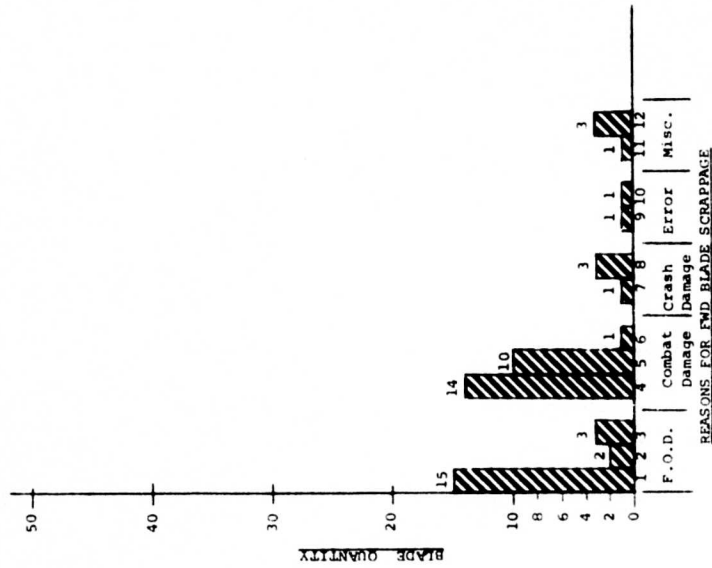


FIGURE 26. SCRAPAGE - FORWARD BLADES - CH-47B/C.

DISTRIBUTION PERCENTAGES

SCRAPPAGE REASON		Blade Qty.	% of Total Scrappage
1	Dented	23	32.4
2	Broken	1	1.4
3	F.O.D.	3	4.2
4	Punctured	2	2.8
5	Scored	1	1.4
6	Combat Damage	9	12.7
7	Dented	8	11.3
8	Punctured	1	1.4
9	Torn	13	18.3
10	Crash Damage	1	1.4
11	Error	2	2.8
12	Misc.	3	4.2
13	Overstressed	4	5.6
TOTALS		71	100.0%

- ▨ Scrapped Blades
- * Manufacturing/Shipping/Handling Error Including Inadequate Field Repair

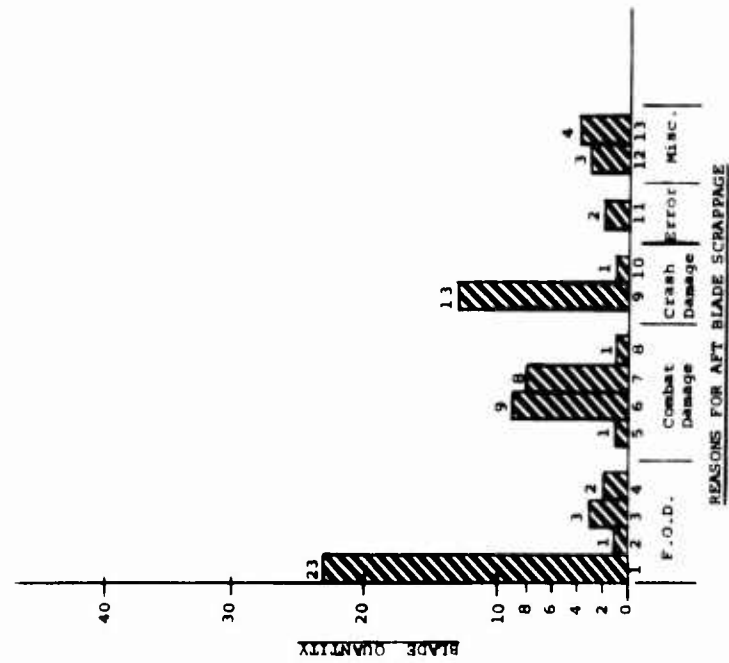


FIGURE 27. SCRAPPAGE - APT BLADES - CH-47B/C.

TABLE XXX. SUMMARY OF PERCENTAGES OF BLADE SCRAPPAGE -
CH-47A AND CH-47B/C FORWARD AND AFT BLADES

REASONS FOR SCRAP	FORWARD SCRAPPED BLADES		AFT SCRAPPED BLADES	
	Quantity	Percentage	Quantity	Percentage
<u>Foreign Object Damage</u>	<u>60</u>	<u>30.9</u>	<u>121</u>	<u>24.5</u>
Dented	54	27.8	93	18.9
Broken			4	0.8
Torn	4	2.1	4	0.8
Punctured			15	3.0
Scored	2	1.0	2	0.4
Bent			3	0.6
<u>Combat Damage</u>	<u>47</u>	<u>24.2</u>	<u>48</u>	<u>9.7</u>
Broken			2	0.4
Scored				
Dented	20	10.3	15	3.0
Punctured	26	13.4	31	6.4
Torn				
Spar/Socket	1	0.5		
<u>Crash/Strikes</u>	<u>20</u>	<u>10.3</u>	<u>12</u>	<u>2.4</u>
Bent	1	0.5	1	0.2
Collapsed	8	4.1	1	0.2
Torn	1	0.5	6	1.2
Minor Damage	10	5.2	4	0.8
Error			5	1.0
Mishandled	3	1.6	1	0.2
Shop Error	2	1.0	1	0.2
Arc Burn	2	1.0	3	0.6
<u>Miscellaneous</u>	<u>60</u>	<u>30.9</u>	<u>307</u>	<u>62.3</u>
Reached Life Limit	4	2.1	30	6.1
Deterioration				
Corroded	8	4.1	7	1.4
Cracked	1	0.5	3	0.6
Unbonded	1	0.5	6	1.2
Overstressed	44	22.7	217	44.0
Scheduled Removal	2	1.0	44	8.9
<u>TOTALS</u>	<u>194</u>	<u>100.0%</u>	<u>493</u>	<u>100.0%</u>

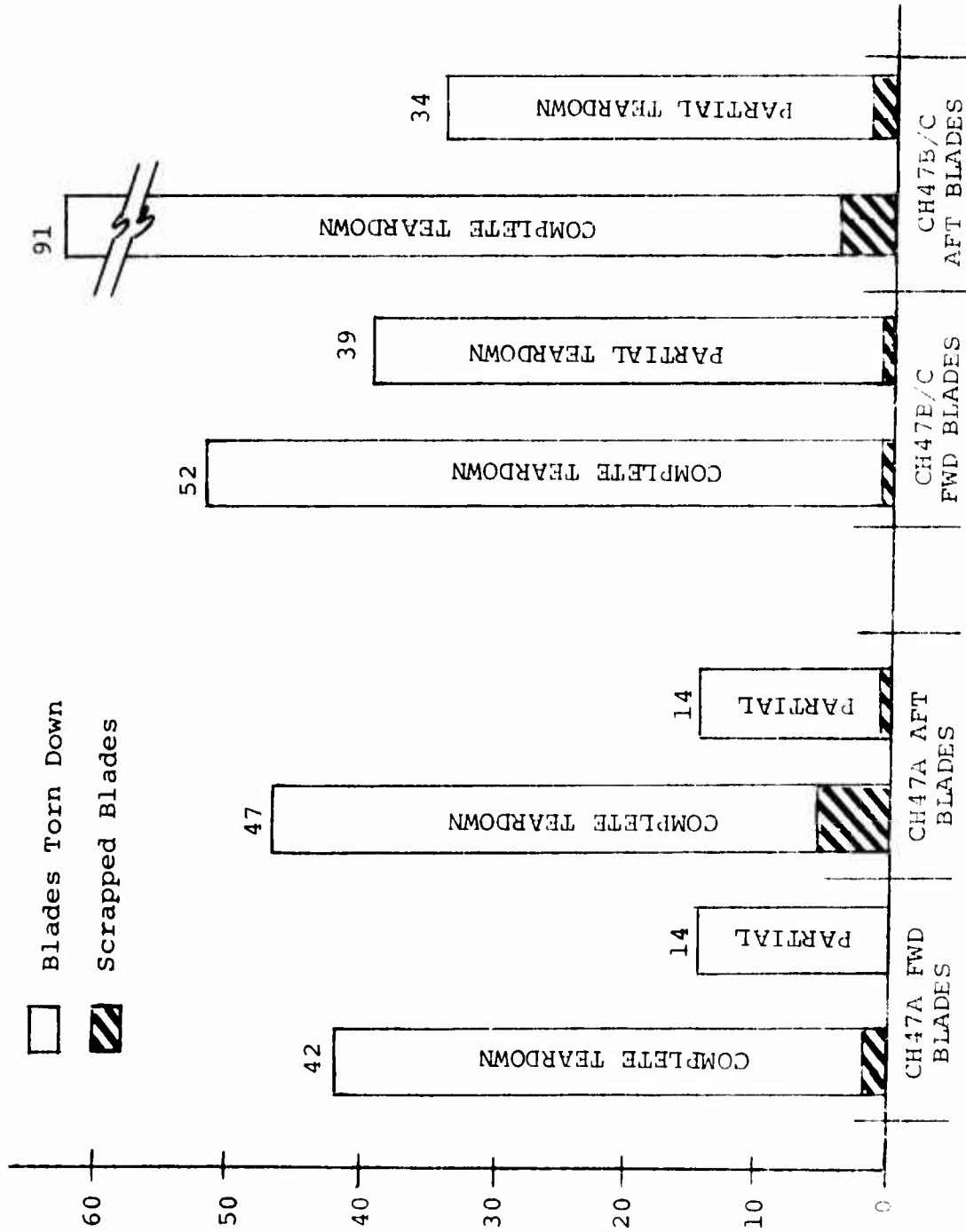


FIGURE 28. BLADE TEARDOWN EXPERIENCE.

TABLE XXXI. MEAN-TIME-BETWEEN-SCRAPPAGE - FORWARD AND AFT SCRAPPED BLADES - CH-47A

REASONS FOR SCRAP	FWD. SCRAPPED BLADES				AFT SCRAPPED BLADES			
	Qty. of Blades Scrapped	Fwd. Blade Flt. Hours	MTBS _F	Qty. of Blades Scrapped	Aft Blade Flt. Hours	MTBS _F	Qty. of Blades Scrapped	MTBS _F
<u>Foreign Object Damage</u>								
Dented	60		32,510	121		16,121		
Broken	54		36,122	93		20,974		
Torn		1,950,618		4	1,950,618	487,655		
Punctured	4		487,655	4		130,041		
Scored	2		975,309	15		975,309		
Bent				2		650,206		
				5				
<u>Combat Damage</u>	47		41,503	48		40,638		
Broken				2		975,309		
Scored								
Dented	20	1,950,618	97,531	15	1,950,618	130,041		
Punctured	26		75,023	31		62,923		
Torn	1		1,950,618					
Spar/Socket								
<u>Crash/Strikes</u>	20		97,531	12		162,552		
bent	1		1,950,618	1		1,950,618		
Collapsed	8	1,950,618	243,828	1	1,950,618	1,950,618		
Torn	1		1,950,618	6		325,103		
Minor Damage	10		195,062	4		487,655		
<u>Error</u>	7		278,655	5		390,124		
Mishandled	3	1,950,618	650,206	1	1,950,618	1,950,618		
Shop Error	2		975,309	1		1,950,618		
Arc Burn	2		975,309	3		650,206		
<u>Miscellaneous</u>	60		32,510	307		6,354		
Reached Life Limit	4		487,655	30		65,021		
Deterioration		1,950,618			1,950,618			
Corroded	8		243,828	7		278,660		
Cracked	1		1,950,618	3		650,206		
Unbonded	1		1,950,618	6		325,103		
Overstressed	44		44,332	217		8,989		
Scheduled Removal	2		975,309	44		44,332		
All Causes	194	1,950,618	10,055	493	1,950,618	3,957		

* Error occurred During Manufacturing/Shipping/Maintenance or Field Repair

TABLE XXXII. MEAN-TIME-BETWEEN-SCRAPPAGE - FORWARD AND AFT SCRAPPED BLADES - CH-47B/C

REASONS FOR SCRAP	FWD. SCRAPPED BLADES			AFT SCRAPPED BLADES		
	Qty. of blades scrapped	Fwd. Blade Flt. hours	MTBS _F	Qty. of blades scrapped	Aft Blade Flt. hours	MTBS _A
<u>Foreign Object Damage</u>						
Dented	20		44,716	29		30,476
Broken	15	894,339	59,623	23	883,824	38,427
Punctured	2		447,169	1		883,824
Scored	3		298,113	2		294,608
<u>Combat Damage</u>						
Scored	25		35,774	19		46,517
Dented	14	894,339	63,881	1	883,824	883,824
Punctured	10		89,434	8		98,203
Torn	1		894,339	1		110,478
<u>Crash/Strikes</u>						
Torn	4	894,339	223,585	14	883,824	883,824
Dented	1		894,339	1		63,130
<u>Error *</u>						
Mishandled	2		447,169	13		67,986
Shop Error	1	894,339	894,339	2	883,824	441,912
Arc Burn	1		894,339			
<u>Miscellaneous</u>						
Corroded	4	894,339	223,585	7		126,260
Overstressed	1		894,339	3	883,824	294,608
<u>All Causes</u>						
	55	894,339	16,261	71	883,824	12,448

* Error Occurred During Manufacturing/Shipping/Maintenance Or Field Repair

TABLE XXXIII. SUMMARY OF CH-47A, B AND C SCRAPPED BLADE MEANS								
BLADES		ALL CAUSES	FOREIGN OBJECT DAMAGE	COMBAT DAMAGE	CRASHES/STRIKES	ERROR	MISC.	
CH-47A	FORWARD	10,055	32,510	41,503	97,531	278,659	32,150	
	AFT	3,957	16,121	40,638	162,552	390,124	6,354	
CH-47B	FORWARD	16,261	44,716	35,774	223,585	447,169	223,585	
	AFT	12,448	30,476	46,517	63,130	441,912	126,260	

COST ANALYSIS

A comparison of the CH-47 rotor blade acquisition cost and the average cost of repaired/reworked rotor blades was made. Included in the total average cost of the repaired/reworked blades is a \$40.00 transportation cost to and from New Cumberland Army Depot (NCAD).

Table XXXVI of Appendix I identifies the various CH-47A (114R1002) and CH-47B/C (114R1502) blades by part number and location. The table shows a selected quantity of blades, transportation costs to and from NCAD, the average repair/rework costs per blade, and the acquisition costs per blade.

The cost comparison of the repair/rework average costs per blade versus the acquisition cost of a new blade is given by this table in percentages.

TABLE XXXIII. SUMMARY OF CH-47A, B AND C SCRAPPED BLADE MEANS

BLADES		ALL CAUSES	FOREIGN OBJECT DAMAGE	COMBAT DAMAGE	CRASHES/ STRIKES	ERROR	MISC.
CH-47A	FORWARD	10,055	32,510	41,503	97,531	278,659	32,150
	AFT	3,957	16,121	40,638	162,552	390,124	6,354
CH-47B	FORWARD	16,261	44,716	35,774	223,585	447,169	223,585
	AFT	12,448	30,476	46,517	63,130	441,912	126,260

CONCLUSIONS AND RECOMMENDATIONS

Removal summaries for all CH-47A blades are given by Table XXXIV and for all CH-47 B/C blades by Table XXXV. As a result of review of these tables and the entire study, the following conclusions and recommendations are made:

1. Existing field repair techniques, criteria and/or practices for bonded rotor blades may be inadequate. The detailed data used for this study can be utilized to determine where the inadequacies occur. Recommendations for cost-effective improvements to repair techniques, equipment, procedures and personnel training can be made on the basis of these determinations.
2. Trend curves showing the rate of improvement of mean-time parameters for early CH-47A blades through the latest CH-47B/C blades can be derived from the data bank used for this study. Design recommendations based on information extracted and analyzed from the present data bank could lead to improved blade configurations.
3. This analysis indicates that returned blades intended for repair/overhaul are being retired or scrapped at periods somewhat less than published life limits. This requires a consideration of acquisition costs in comparison to repair costs and the life remaining in the blade. However, at present, a definitive cost/break-even scale is not available to guide this early retirement practice. Data extracted for this study can be utilized to develop an optimum life limit/repair costs scale for aiding the decision to retire late-life blades.
4. The quantity of blades needed to provide a representative sample for meaningful analyses is presently unknown. The CH-47A blade data should be analyzed in smaller groups by manufacturing date and compared to the total results to determine the number required for a representative sample. The CH-47B/C blade analysis should be continued until a representative sample is completed.
5. To provide a calendar year analysis of blade discrepancies, the present data should be related to blade manufacturing and repair dates and a yearly updating of the overhaul/repair data should be performed.

TABLE XXXIV. REMOVAL SUMMARY DISTRIBUTION - ALL DISCREPANCIES - CH-47A REPAIRED AND SCRAPPED BLADES

REMOVAL	REASON	Fwd Motor Blades		Aft Motor Blades		All Blades		
		Total Blades	% of Total	Total Blades	% of Total	Total Blades	% of Total	
Deterior.	Loose/Missing	14	0.66	1	0.04	15	0.34	
	Bare Steel	1	0.05	18	0.77	19	0.43	
	Eroded	14	0.66	15	0.64	29	0.65	
	Rippled	3	0.14	4	0.17	7	0.16	
	Water Migrate	1	0.05			1	0.02	
Unbond	Bulged	6	0.28	2	0.09	8	0.18	
	Blistered	1	0.05			1	0.02	
	Bond Void	122	5.74	144	6.13	266	5.94	
Vibration	Beyond Tolerance	8	0.38	1	0.04	9	0.20	
	Vibration	8	0.38	2	0.09	10	0.22	
Eroded	Worn	54	2.54	9	0.38	63	1.40	
	Eroded	18	0.85	9	0.38	27	0.60	
Corrosion	Corroded	141	6.63	99	4.22	240	5.36	
	Peeling							
	Chipped			10	0.42	10	0.22	
	Stained							
	Seized	2	0.09	1	0.04	3	0.07	
	Water Migrate							
Delam.	Pitted			1	0.04	1	0.02	
	Voided	40	1.88	11	0.47	51	1.14	
	Crazed	2	0.09	1	0.04	3	0.07	
	Cracked	5	0.24	23	0.98	25	0.63	
	Split			9	0.81	19	0.43	
Cracked	Creased	1	0.05	14	0.60	15	0.34	
	Crazed	2	0.09			2	0.04	
	Cracked	195	9.17	338	14.39	533	11.91	
	Split	2	0.09	10	0.42	12	0.27	
Fretted	Worn			1	0.04	1	0.02	
	Fretted	1	0.05			1	0.02	
Balance	Tip Rod Loose	36	1.69	4	0.17	40	0.89	
	Imbalance	15	0.70	4	0.17	19	0.43	
SUBTOTALS		692	32.55	741	31.54	1433	32.02	
EXTERNAL DISCREPANCIES	F.O.D.	Dented	384	18.06	343	14.60	727	16.25
		Broken	14	0.66	25	1.06	39	0.87
		Torn	35	1.65	33	1.40	68	1.52
		Punctured	123	5.78	100	4.26	223	4.98
		Scored	54	2.54	48	2.04	102	2.28
	Bent	38	1.79	27	1.15	65	1.45	
	Combat Damage	Broken	4	0.19	8	0.34	12	0.27
		Scored						
		Dented	34	1.60	34	1.45	68	1.52
		Punctured	106	4.98	98	4.30	204	4.56
	Over-stress	Torn						
		Spar/Socket	2	0.09			2	0.04
		Overstress	111	5.22	279	11.88	390	8.72
		Bent			1	0.04	1	0.02
	Crashes/Strikes	Collapsed	1	0.05			2	0.04
		Fractured	1	0.05	2	0.09	3	0.07
		Dented						
Bent		1	0.05	1	0.04	2	0.07	
Manuf/Ship/Handling Error	Collapse	8	0.38	1	0.04	9	0.20	
	Torn	1	0.05	11	0.47	12	0.27	
	Minor Damage	25	1.17	8	0.34	33	0.74	
No Valid Removal	15	0.70	28	1.19	43	0.96		
Miscellaneous	1	0.05	3	0.13	4	0.09		
SUBTOTALS		991	46.61	1064	45.29	2055	45.92	
SCHED. DISCR.	MWO Compliance	32	1.50	35	1.49	67	1.50	
	No Defect (Sch. Maint.)	276	12.98	399	16.99	675	15.08	
	Retired Blades	4	0.19	26	1.11	30	0.67	
	EIR Engineering	2	0.09	2	0.09	4	0.09	
	No Defect (Fac. Maint.)	58	2.73	22	0.94	80	1.79	
Miscellaneous	71	3.34	60	2.55	131	2.93		
SUBTOTALS		443	20.83	544	23.17	987	22.06	
TOTALS		2126	100.00%	2349	100.00%	4475	100.00%	

TABLE XXXV. REMOVAL SUMMARY DISTRIBUTION - ALL DISCREPANCIES - CH-47/R/C REPAIRED AND SCRAPPED BLADES

REMOVAL REASON		Forward Rotor Blades		Aft Rotor Blades		All Blades		
		Total Blades	% of Total	Total Blades	% of Total	Total Blades	% of Total	
Inherent Discrepancies	Deterior.	Loose/Missing Bare Steel						
		Eroded Rippled	1	0.19	2	0.40	3	0.30
	Unbonded	Water Migr.	1	0.19	2	0.40	3	0.30
		Bulged	30	5.86	26	5.19	56	5.53
		Blistered	16	3.13	39	7.78	55	5.43
	Vibration	Bond Void	19	3.71	14	2.79	33	3.26
		Beyond Tolerance			3	0.60	3	0.30
	Eroded	Vibration	5	0.97	1	0.20	6	0.59
		Worn	5	0.97			5	0.49
	Corrosion	Eroded	7	1.37	3	0.60	10	0.99
		Corroded	31	6.05	20	4.00	51	5.03
		Peeling						
		Chipped						
		Stained						
	Delam.	Seized						
		Water Migr.	3	0.58	1	0.20	4	0.39
		Pitted	4	0.78	1	0.20	5	0.49
	Cracked	Voided	3	0.58	9	1.79	12	1.18
Crazed		6	1.17			6	0.59	
Cracked		3	0.58	1	0.20	4	0.39	
Split		5	0.97			5	0.49	
Fretted	Crazed	3	0.58			3	0.30	
	Cracked	10	1.95	5	1.00	15	1.48	
Imbalance	Split							
	Worn	1	0.19			1	0.10	
SUBTOTALS	Fretted	1	0.19	1	0.20	2	0.20	
	Tip Rod Loose			1	0.20	1	0.10	
	Imbalance	3	0.58			3	0.30	
SUBTOTALS		156	30.40	128	25.55	284	28.04	
External Discrepancies	F.O.D.	Dented	118	23.04	114	22.75	232	22.90
		Broken	1	0.19	1	0.20	2	0.20
		Torn	13	2.54	17	3.39	30	2.96
		Punctured	34	6.64	38	7.58	72	7.11
		Scored	4	0.78	9	1.79	13	1.28
	Combat Damage	Bent	8	1.56	6	1.20	14	1.38
		Broken	1	0.19			1	0.10
		Scored	3	0.58	1	0.20	4	0.39
		Dented	24	4.69	22	4.34	46	4.54
		Punctured	47	9.18	42	8.38	89	8.78
	Over-stress	Torn	2	0.39	4	0.80	6	0.59
		Spar/Socket	2	0.39			2	0.20
		Overstress	32	6.26	27	5.39	59	5.82
	Crashes/ Strikes	Bent	1	0.19			1	0.10
		Collapsed						
Fractured		3	0.58	5	1.00	8	0.79	
Manuf/Ship/Hand. Error	Dented	1	0.19			1	0.10	
	Collapsed			3	0.60	3	0.30	
	Torn			13	2.59	13	1.28	
Miscellaneous	Minor Damage	1	0.19			1	0.10	
	Manuf/Ship/Hand. Error	6	1.17	5	1.00	11	1.09	
	No Valid Removal Reason	16	3.13	23	4.59	39	3.85	
SUBTOTALS		317	61.86	330	65.87	647	63.86	
Sch. Disacr.	MWO Compliance	2	0.39	13	2.59	15	1.48	
	No Defect (Sch.Maint.)	23	4.49	24	4.79	47	4.64	
	Retired Blades							
	EIR Engineering	2	0.39			2	0.20	
	No Defect (Comp. Rmv)	10	1.95	6	1.20	16	1.58	
SUBTOTALS		39	7.61	43	8.58	82	8.10	
TOTALS		512	100.00	501	100.00	1013	100.00	

LITERATURE CITED

- (1) ARMY EQUIPMENT RECORD PROCEDURES, Department of The Army, Technical Manual 38-750; Headquarters, Department of The Army, May 1967; Appendix 1, Codes p. A1-1 through A1-8.
- (2) ORGANIZATIONAL MAINTENANCE MANUAL, ARMY MODEL CH-47A HELICOPTER, Department of The Army Technical Manual-55-1520-209-20-1; Headquarters, Department of The Army, May 1968; Chapter 8, Section II, p. 8-3 through 8-12J.
- (3) ORGANIZATIONAL MAINTENANCE MANUAL, ARMY MODEL CH-47B AND CH-47C HELICOPTER, Department of The Army Technical Manual-55-1520-227-20-1; Headquarters, Department of The Army, August 6, 1970; Chapter 8, Section II, p. 8-3 through 8-11.
- (4) DS, GS AND DEPOT MAINTENANCE MANUAL, ARMY MODEL CH-47A HELICOPTER, Department of The Army, Technical Manual 55-1520-209-35-2; Headquarters, Department of The Army, May 1968, Chapter 18, Section II, p. 18-49 through 18-96C.
- (5) DS, GS, AND DEPOT MAINTENANCE MANUAL, ARMY MODEL CH-47B AND CH-47C HELICOPTER, Department of The Army, Technical Manual 55-1520-227-35-3; Headquarters, Department of The Army, August 6, 1970; Chapter 18, Section II, p. 18-41 through 18-72.
- (6) ORGANIZATIONAL MAINTENANCE MANUAL, ARMY MODEL CH-47A HELICOPTER, Department of The Army Technical Manual 55-1520-209-20-1; Headquarters, Department of The Army, May 1968; Chapter 3, Section IV, p. 3-65 through 3-66.
- (7) ORGANIZATIONAL MAINTENANCE MANUAL, ARMY MODEL CH-47B AND CH-47C HELICOPTER, Department of The Army Technical Manual 55-1520-227-20-1; Headquarters, Department of The Army, August 6, 1970; Chapter 3, Section V, p. 3-82.
- (8) ARMY EQUIPMENT RECORD PROCEDURES, Department of The Army Technical Manual 38-750; Headquarters, Department of The Army, May 1967; Chapter 3, Paragraph 3-8, p. 3-73 through 3-100.

APPENDIX I
COST ANALYSIS

The objective of this cost analysis was to analyze the aircraft support costs for rotor blades to determine the average comparative costs of new versus repair/rework blades.

Table XXXVI is provided to indicate results of this analysis.

TABLE XXXVI. COST COMPARISON - CH-47 NEW VS. REPAIR/REWORK BLADES

Component	Qty. Sample Blades	Transportation To & From NCAD	Total Aver. Costs Per Blade	Acquisition Cost Per Blade	Repair/Rework vs. New
Fwd. Rotor Blade (114R1002)	939	\$40.00/Blade	\$2,808	\$13,200	21.3%
Aft Rotor Blade (114R1002)	919	\$40.00/Blade	\$2,416	\$13,200	18.3%
Fwd. and Aft Blade Avg. (114R1002)	1,858	\$40.00/Blade	\$2,614	\$13,200	19.8%
Fwd. Rotor Blade (114R1502)	106	\$40.00/Blade	\$2,175	\$13,800	15.8%
Aft Rotor Blade (114R1502)	60	\$40.00/Blade	\$2,413	\$13,800	17.5%
Fwd. and Aft Blade Avg. (114R1502)	166	\$40.00/Blade	\$2,261	\$13,800	16.4%

These costs do not include replacement parts which are GFE. Costs were derived from completed government delivery orders from July 1967 through March 1971.

APPENDIX II
DATA EXTRACTION PROCESS

A data extraction procedure was developed and applied to locate, extract and describe CH-47 rotor blade discrepancies investigated for the purposes of this report. This was done by using an alphanumeric coding system, expanded to accommodate identification of discrepancies within the entire structure of the CH-47 rotor blade. This alphanumeric system provides different codings for the CH-47A and CH-47B/C blades.

Each rotor blade returned to Vertol for repair is treated as if it were appearing in the overhaul system for the first time. A thorough inspection of the blade is made by the Quality Assurance Department. The results of this inspection, including follow-up inspection, are recorded on a Boeing-Vertol Inspection Report throughout the repair/overhaul process. Each rotor blade assembly upon receipt at Boeing-Vertol is usually accompanied by a Form DA-2410 originated and completed per Army Equipment Record Procedures, TM 38-750, Reference (8), by the using activity. This form will contain blade historical data. An internally originated SAV-HQ Form 391 (Component Disassembly Evaluation Summary) is also completed for contract purposes. Accuracy of subsequent data analysis is dependent upon the accuracy of these documents, as well as the experience of the reviewer of these forms.

The data extraction record devised for this study is comprised of three sheets containing historical data and primary and secondary discrepancy areas of interest under investigation. The sample forms shown are typical of analysis of CH-47A blades. Figure 29 contains historical and chronological data obtained and/or derived from SAV-HQ Form 391 and Form DA-2410. Figures 30 and 31 identify major and minor discrepancy areas in respect to the blade structure. Boeing-Vertol part numbers are included for identification purposes. Thus, a considerable amount of practical information concerning the effect of design, manufacture and operational experience of each rotor blade in the field is extracted in a readily available form. Figures 33 through 40 demonstrate the alphanumeric coding system for the CH-47A blades. A similar system was developed and employed for the CH-47B/C blades.

A concise description of the construction of the data recording sheets, Figures 29, 30 and 31, is given below to illustrate the depth of the data extraction process. Starting with Sheet 1 of the 3-sheet Data Extraction Record (Figure 29), the headings are largely self-explanatory, but the following is provided to indicate consistency of data interpretation:

1. Item No. - Necessary only for arithmetical continuity and identification of the blade being analyzed.
2. Serial No. - Serial number of blade being analyzed.
A-1 indicates blades located on forward rotor head.
A-2 indicates blades located on aft rotor head.
3. Dash No. - Indicates changes to basic configuration of blade at arrival (I) and when shipped out of Boeing-Vertol repair/overhaul activity (O).
4. TT - Total flight time on blade upon arrival at Boeing-Vertol. Time is obtained from DA-2410 and/or SAV-HQ Form 391 or Boeing Inspection Report. The DA-2410 form from the User Activity is the primary source of this information.
5. TSLR - Time since last repair which is determined from blade historical records and/or noted on DA-2410. Since each blade is considered new when shipped to Customer after repair/overhaul, this can be considered flight time since last repair.
6. Previous Repairs - Number of times blade has been repaired/overhauled at Boeing-Vertol before.
7. Life Limit - Total number of hours blade may be used under normal operating conditions without spar overstress condition. Appears in overhaul and retirement schedule of TM 55-1520-227-20-1 (Reference 6) for CH-47B/C blades. The life limit is fixed at 2400 for the aft CH-47A blades and 3600 for the forward CH-47A blades.
8. Date Received - Julian date blade is received at repair/overhaul facility.
9. Failure Code - Major discrepancy noted on DA-2410. Should the failure cause noted on DA-2410 be inconsistent with results of inspection as noted in Inspection Report, the obvious cause of failure should be noted under remarks.

PART NUMBER: 114R1002 NOMENCLATURE: FWD ROTOR BLADES

SER. NO.	DASH NO.	TY	TSUR	PREVIOUS	LIFE LIMIT	DATE RECEIVED	DATE REMOVED	FAILURE CODE	MODEL A/C	REMARKS
279	-208 19 33	210	—	0	3600	5112	5033	Unk A	A	Blade delivered less socket DA #2410 incomplete
280	-208 33 57	1126	916	1	3600	0287	Unk	Unk A	A	Complete Teardown - T/E damage * B/S intermittent skin to rib voids Box #2, #3, #4, #5, #7, #8, #9
281	-209 33 -	368	—	0	NA	NA	6133	540 A	A	Scrap - Scrapped in field
282	-210 33 33	316	—	0	3600	6252	6198	200 A	A	Insp. did not reveal reason for removal.
283	-210 33 61	724	408	1	3600	9139	—	804 A	A	Complete teardown for spar insp. Dented noscap obvious reason for removal.

FIGURE 29. DATA EXTRACTION RECORD - SHT. 1 - CH-47A.

Item	Serial No.	114R1210	114R1077	114R1077	Trans. Cap	114R1372	114R1042	114R1043	Socket	NAS46P8L97	Incidence	114R1350	Incidence	114R1350 (2)	Clamp Land	114R1065	Anchor	114R1066	114R1066	114R1066	Anchor	114R1087	Stacking Wt.	114R1374	Channel	22R1102	Bal. Wt.	114R1214	Root Box	114R1214	D. C. Doublets	AB-4307	Hycol Sealer	EC2216	Sealer	EC1675	Sealer	114R1001						
279 -208																																												
280 -208																																												
281 -209																																												
282 -210																																												
283 -210																																												

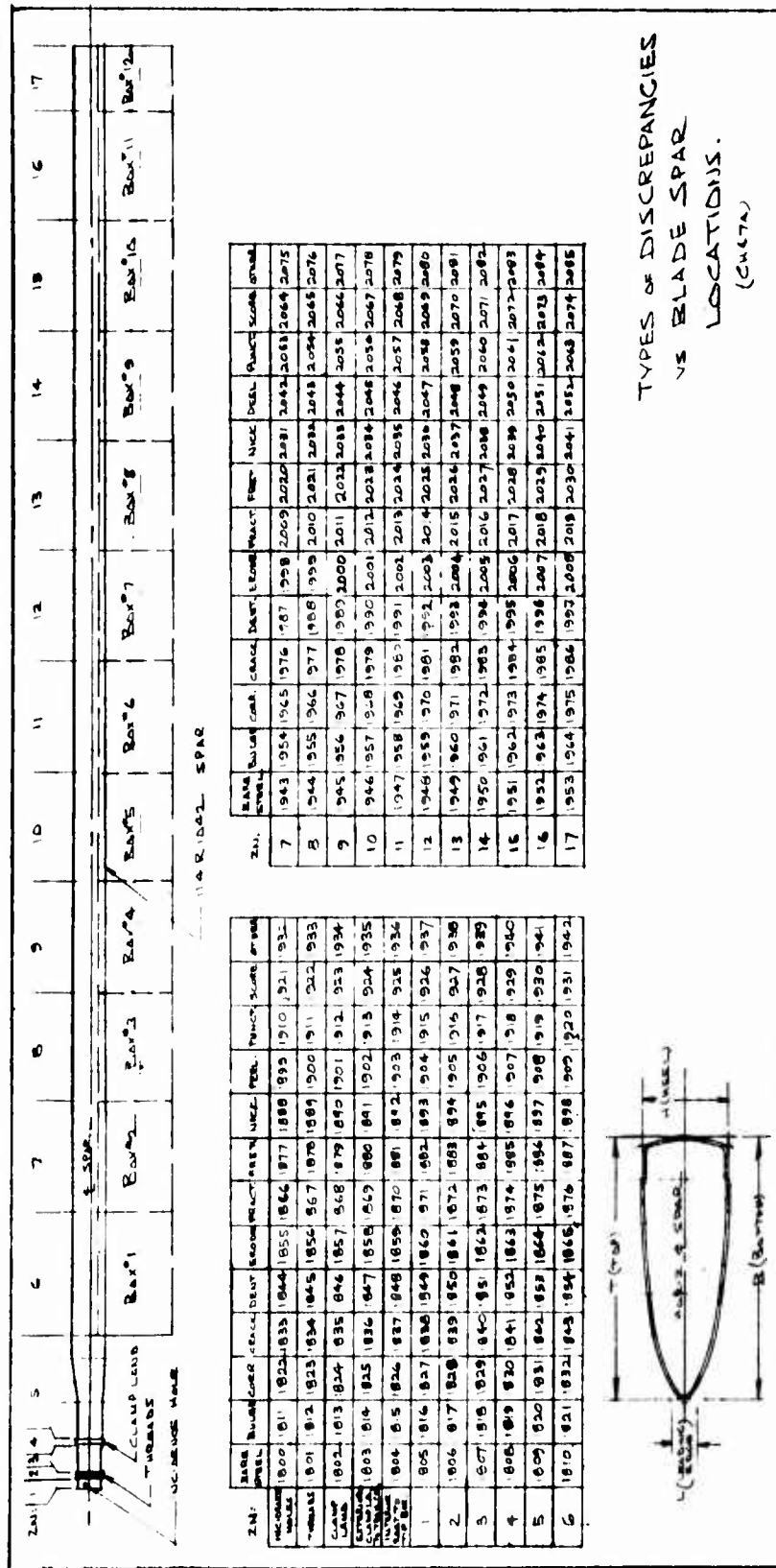
FIGURE 30. DATA EXTRACTION RECORD - SHT. 2 - CH-47A.

10. Model A/C - A, B or C aircraft, as applicable.
11. Remarks - Major discrepancies, dispositions, or actions taken during repair or overhaul should be noted. Notations such as scrap, complete teardown, partial teardown, TBO Sample, EIR Sample including number, are included. If the blade has been shipped to the Customer, an 'S' is placed in the remarks column. If a Boroscope inspection has been completed, a 'B' is placed in the remarks column.

Sheet 2 of the Data Extraction Record (Figure 30) and Sheet 3 (Figure 31) provided column headings in terms of the various blade major assemblies and/or subassemblies. Physical and/or environmental damage to the blade surfaces and structure as described in the Inspection Report was analyzed in respect to the primary discrepancy which resulted in blade rework and/or scrappage. Codings which were used are described below:

1. A major discrepancy which resulted in scrappage of a part or parts and which was also the cause of blade removal from the aircraft was denoted by placing a '1' in the upper left-hand corner of the appropriate line for that blade. Several examples are shown in Figure 30. Subsequent discrepancies also affecting that part are noted in the same column beneath the first entry.
2. A major discrepancy which was considered the primary reason for blade scrappage, but not the blade removal reason, was denoted by placing a '1' similar to point 1 above. Subsequent discrepancies are noted below this entry.
3. A major discrepancy which required rework or overhaul of a part or parts and which was determined as the blade removal cause was denoted by placing a '2' in the upper left-hand corner of the appropriate line for that blade. Subsequent discrepancies are noted below this entry.

4. Major blade discrepancies were plotted generally in grid form against blade locations as shown by Figures 32 through 40. Different numbers are employed for each different blade location and particular discrepancy. In those cases where the locating grid was inadequate to describe location, an alphabetical prefix was added to the location number. Alpha prefixes used were 'T' for top of blade, 'B' for bottom of blade, 'L' for leading edge, 'I' for spar interior, etc.
5. Discrepancies of secondary importance were described by use of a simple alphanumeric code which is part of the Boeing/Vertol CH-47 Overhaul Data Fact Sheet.



TYPES OF DISCREPANCIES
 VS BLADE SPAR
 LOCATIONS.
 (CH-47A)

FIGURE 32. ALPHANUMERIC CODE - SHT. 1 - CH-47A.

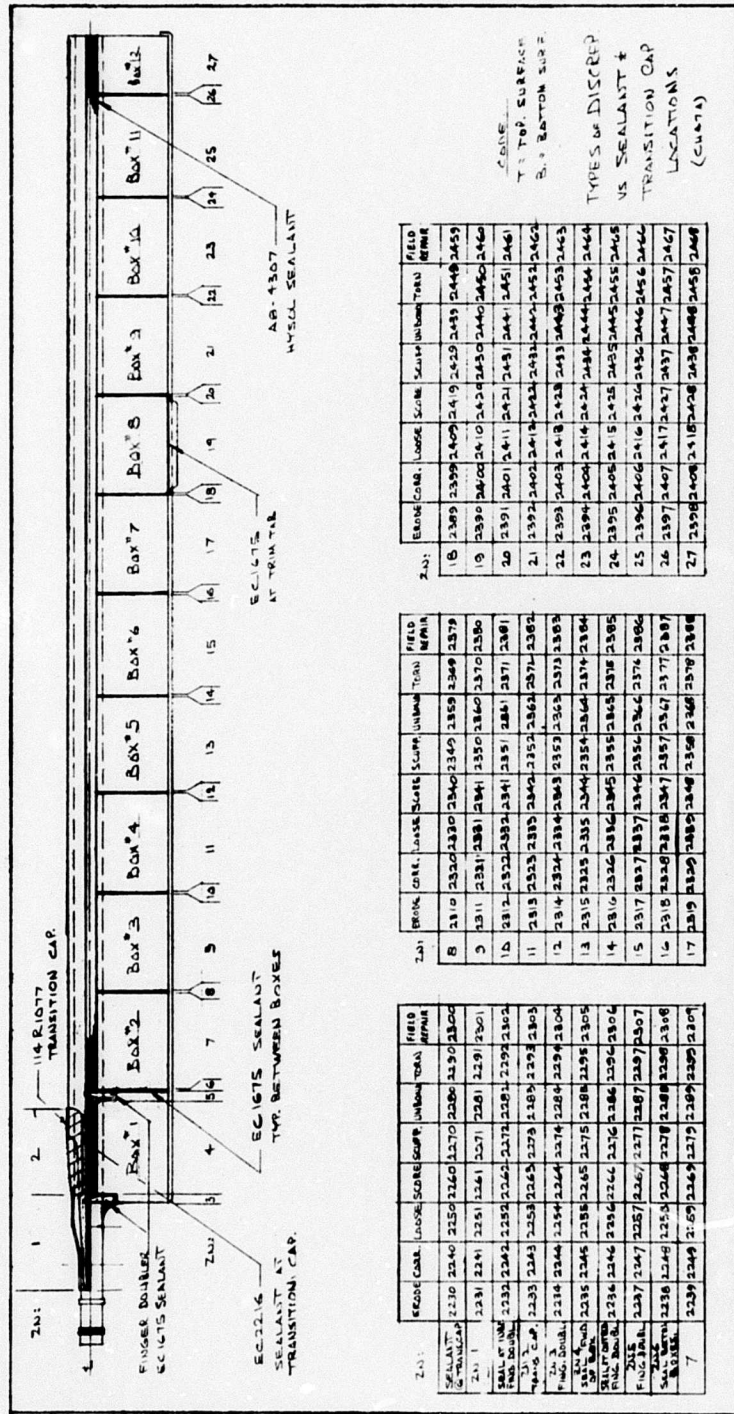
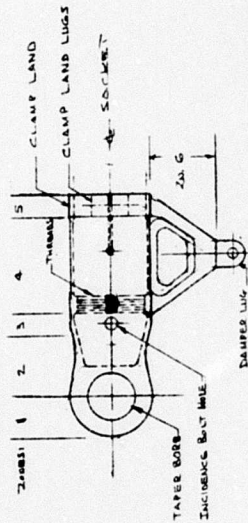


FIGURE 33. ALPHANUMERIC CODE - SHT. 2 - CH-47A.



SOCKET EXTERIOR

	CORR	FRST	NICK	SCORE	BASE	BEANT
TAPER	2084	2099	2112	2126	2138	2151
FRST	2087	2100	2113	2126	2139	2152
NICK	2088	2101	2114	2127	2140	2153
SCORE	2089	2102	2115	2128	2141	2154
BASE	2090	2103	2116	2129	2142	2155
BEANT	2091	2104	2117	2130	2143	2156
CLAMP	2092	2105	2118	2131	2144	2157
LUG	2093	2106	2119	2132	2145	2158
CLAMP	2094	2107	2120	2133	2146	2159
LUG	2095	2108	2121	2134	2147	2160
CLAMP	2096	2109	2122	2135	2148	2161
LUG	2097	2110	2123	2136	2149	2162
CLAMP	2098	2111	2124	2137	2150	2163

SOCKET INTERIOR

	CORR	FRST	NICK	SCORE	BASE	OTHER
THRESH	2164	2170	2176	2182	2189	2194
FRST	2165	2171	2177	2183	2189	2195
NICK	2166	2172	2178	2184	2190	2196
SCORE	2167	2173	2179	2185	2191	2197
BASE	2168	2174	2180	2186	2192	2198
OTHER	2169	2175	2181	2187	2193	2199

REMOVALS FOR REWORK/INSPECTION.

	REMOVALS FOR REWORK/INSPECTION	REMOVALS FOR REWORK/INSPECTION	REMOVALS FOR REWORK/INSPECTION	REMOVALS FOR REWORK/INSPECTION	
	REMOVALS FOR REWORK/INSPECTION	REMOVALS FOR REWORK/INSPECTION	REMOVALS FOR REWORK/INSPECTION	REMOVALS FOR REWORK/INSPECTION	
L.E. NOSE CAP	2200	2206	2212	2218	2224
ROOT BOX	2201	2207	2213	2219	2225
BASIC BOX	2202	2208	2214	2220	2226
TIP BOX	2203	2209	2215	2221	2227
TRAIL EDGE	2204	2210	2216	2222	2228
TRIM TR	2205	2211	2217	2223	2229

TYPES OF DISCREPANCIES
VS SOCKET &
REMOVALS FOR REWORK/INSPECT.
(CH47A)

SOCKET 114 R 1043

FIGURE 34. ALPHANUMERIC CODE - SHT. 3 - CH-47A.

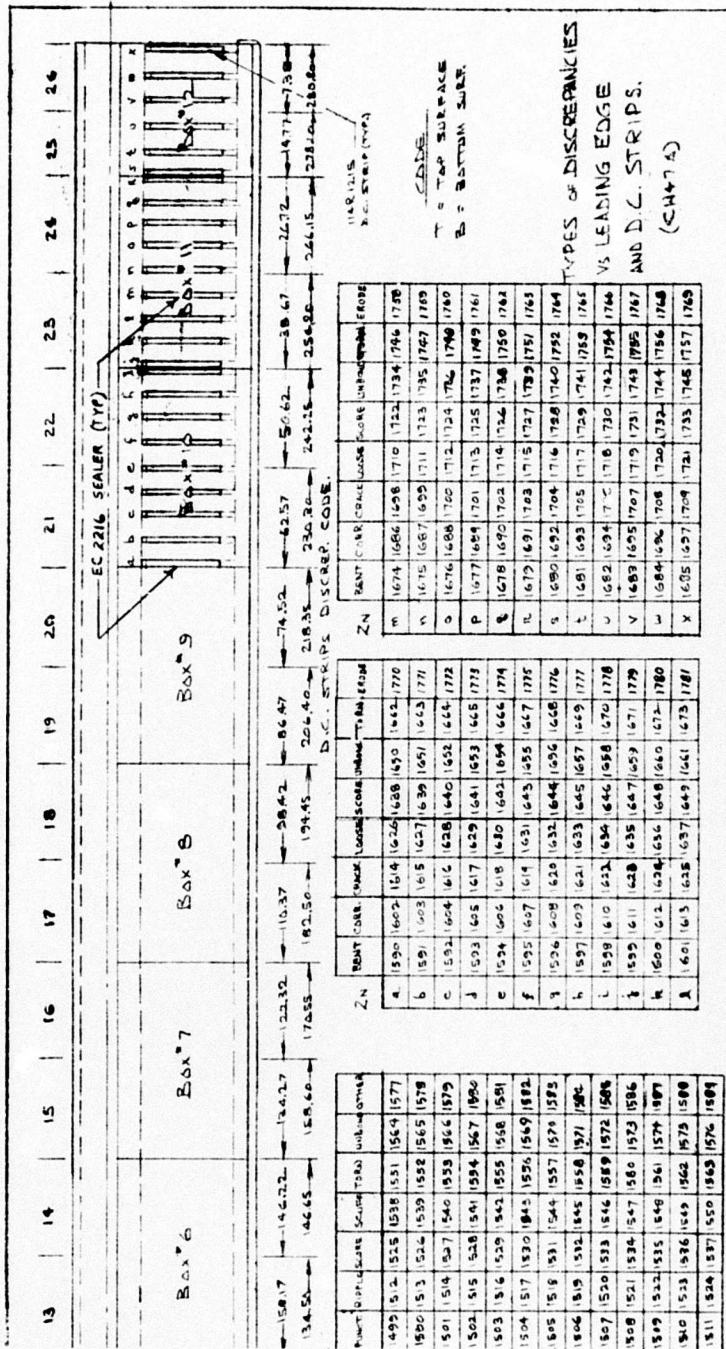


FIGURE 39. ALPHANUMERIC CODE - SHT. 8 - CH-47A.

