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RELIABILITY PROGRAM PLAN. EXTERNALLY MOUNTED, AUTOMATICALLY EXP--ETC(U).
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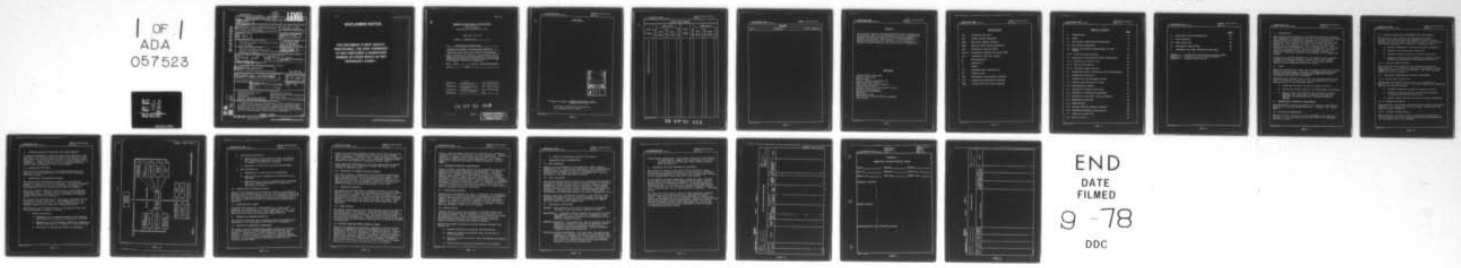

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Automated Life Raft (ALR)
Mission Reliability
Malfunctions
MTBR (Mean Time Between Removal)
Mission - Affecting Malfunctions
Mission Success Criteria
PDLM (Periodic Depot Level Maintenance)
Reliability Tasks
FMEA (Failure Mode and Effect Analysis)

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

This document defines the Boeing-Vertol Division Reliability Program Plan (RPP) for the externally mounted, automatically expelled/inflated multiplace life raft for helicopters (Automated Life Raft) (ALR) Program. The RPP defines the approach/tasks/methods for identifying and controlling potential system/component failures and their consequences.

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A DIVISION OF THE BOEING COMPANY
P.O. BOX 16858
PHILADELPHIA, PENNSYLVANIA 19142

CODE IDENT. NO. 77272

NUMBER D210-11132-1

TITLE RELIABILITY PROGRAM PLAN
EXTERNALLY MOUNTED, AUTOMATICALLY EXPELLED/
INFLATED MULTI PLACE LIFE RAFT FOR HELICOPTERS

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MODEL H-46 CONTRACT N62269-76-C-0341

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FORM 46280 (5/73)

SHEET 1

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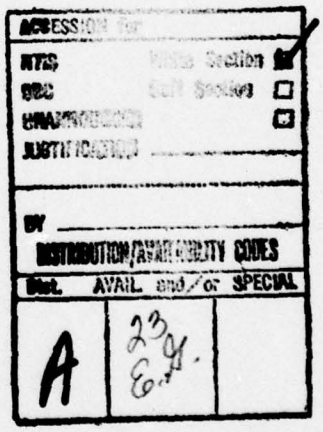

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ABSTRACT

This document defines the Boeing-Vertol Division Reliability Program Plan (RPP) for the Externally Mounted, Automatically Expelled/Inflated, Multiplace Life Raft For Helicopters (Automated Life Raft) (ALR) Program. The RPP defines the approach/tasks/methods for identifying and controlling potential system/component failures and their consequences.

KEY WORDS

Automated Life Raft (ALR)
Mission Reliability
Malfunctions
Mission Affecting Malfunctions
Mission Success Criteria
MTBR (Mean Time Between Removal)
Reliability Analyses
Periodic Depot Level Maintenance (PDLM)
Reliability Objectives
Reliability Requirements
Redundancy
Reliability Tasks
FMEA (Failure Mode and Effect Analysis)
Allocations

ABBREVIATIONS

ALR	AUTOMATED LIFE RAFT
GSE	GROUND SUPPORT EQUIPMENT
MTBR	MEAN TIME BETWEEN REMOVALS
PDLM	PERIODIC DEPOT LEVEL MAINTENANCE
PDR	PRELIMINARY DESIGN REVIEW
MMH/FH	MAINTENANCE MANHOUR PER FLIGHT HOUR
ILS	INTEGRATED LOGISTICS SUPPORT
M	MAINTAINABILITY
R	RELIABILITY
S	SAFETY
S/V	SURVIVABILITY/VULNERABILITY
HF	HUMAN FACTORS
MRA	MAINTENANCE REQUIREMENTS ANALYSES
MEA	MAINTENANCE ENGINEERING ANALYSIS
FMEA	FAILURE MODE AND EFFECT ANALYSIS

TABLE OF CONTENTS

1. INTRODUCTION

This document establishes the Contractors Reliability Program Plan, prepared in accordance with NACD Contract N62269-76-C-0341. The purpose of the Reliability Program is to identify and control potential system and component failures and their consequences. This includes the design and initial testing of flight quality components to obtain realistic weight, cost and relative risk assessments; and to demonstrate the cost and technical characteristics, including reliability, are sufficiently predictable to provide for subsequent conduct of efficient, effective engineering development of an operational system.

In this plan special emphasis will be placed on the relative tradeoffs between maintenance, mission, and flight safety reliability in order to optimize the relationship between mission effectiveness and life cycle costs.

2. SCOPE

This plan specifically covers the reliability engineering effort required for the design, fabrication, demonstration and test of the Externally Mounted, Automatically Expelled/Inflated Multiplace Life Raft For Helicopters.

The Reliability Program shall follow the guidelines of MIL-STD 785A, as described in this plan, and be directed toward the accomplishment of the following tasks:

a. Establish detailed reliability design criteria.

b. Review and evaluate designs for achievement of criteria.

c. Monitor tests and evaluate data obtained to update criteria and objectives and ensure that adequate controls are established for discovered modes of failure.

3. RELIABILITY CONTRACTUAL REQUIREMENTS

This paragraph contains the specific reliability requirements contained in Contract N62269-76-C-0341. (Section 1-1, Page 2, Task I)

3.1 ALR SYSTEM REQUIREMENT

The reliability objective for the ALR System is to have as a minimum, a 0.90 reliability at the 90% level when installed in the helicopter.

3.2 GENERAL RELIABILITY REQUIREMENTS FOR ALR PROGRAM

The contractor shall design the Automated Life Raft to meet, as a minimum, the requirements for PDLM to PDLM service life before removal for overhaul and a 5 year service life before retirement or extension. The design shall:

a. Include redundancy to provide failsafe components

b. Consider fail-operational capability

c. Include incipient failure or hazard indicators

d. Minimize the deleterious effects on component life resulting from adverse environmental conditions.

3.2.1 Military Specifications

The contractor will comply with the appropriate military specifications in the design, fabrication and testing of the components includes in the ALR Program. (See NADC Contract N62269-76-C-0341, Section I)

3.3 RELIABILITY REQUIREMENTS-SYSTEMS ENGINEERING

3.3.1 Reliability Program Plan

The Reliability Program Plan follows the guidelines of MIL-STD 847 and 1304 (AS) and is directed towards the accomplishment of the following tasks:

a. Establish detailed reliability design criteria.

b. Monitor the ALR Tests and evaluate data obtained to update criteria and objectives.

c. Monitor design process to assure criteria compliance.

3.3.2 Reliability Reports

The contractor will report the results of the above reliability efforts on a quarterly basis during design, fabrication and testing of ALR components.

3.3.3 Informal Program Review

The contractor will hold informal reliability engineering reviews between contractor and customer reliability personnel on a quarterly basis as a minimum.

4. SYSTEM RELIABILITY OBJECTIVES AND APPORTIONMENTS

To ensure achievement of the total ALR System objective, the contractor will develop discrete values for malfunction rates and mission and flight safety reliability for the ALR System components. These values will serve as internal design goals. Paragraph 9, contains definitions for the reliability and flight safety expressions used in the Program.

4.1 RELIABILITY RATIONALE

ALR reliability objectives will be established using as a baseline the most comprehensive malfunction data available from H-46 Aircraft.

5. ORGANIZATION AND RESPONSIBILITIES

The organization established to achieve the reliability objective is shown on the following page. The H-46/107 Program Manager is responsible for the integration of designs that are compatable with the objectives of the H-46 Program.

Within the Product Assurance Organization is the Reliability Engineering Unit. These Reliability Engineers are assigned to the ALR Program, maintaining unit continuity and drawing support from the unit as required.

The Reliability Engineering Unit has direct cognizance of the Reliability Program Plan (RPP). They prepare the RPP, and on approval of the RPP, have the direct responsibility for working, supporting and monitoring reliability tasks.

Organizations that provide support to reliability tasks, and their prime areas of support, include:

a. Design Engineering

1. Preparation of subsystem/assembly block diagrams and functions in support of reliability analyses.

2. Preparation of data packages (drawings, schematics, design requirements) in support of design reviews.

3. Solutions to identified reliability problems.

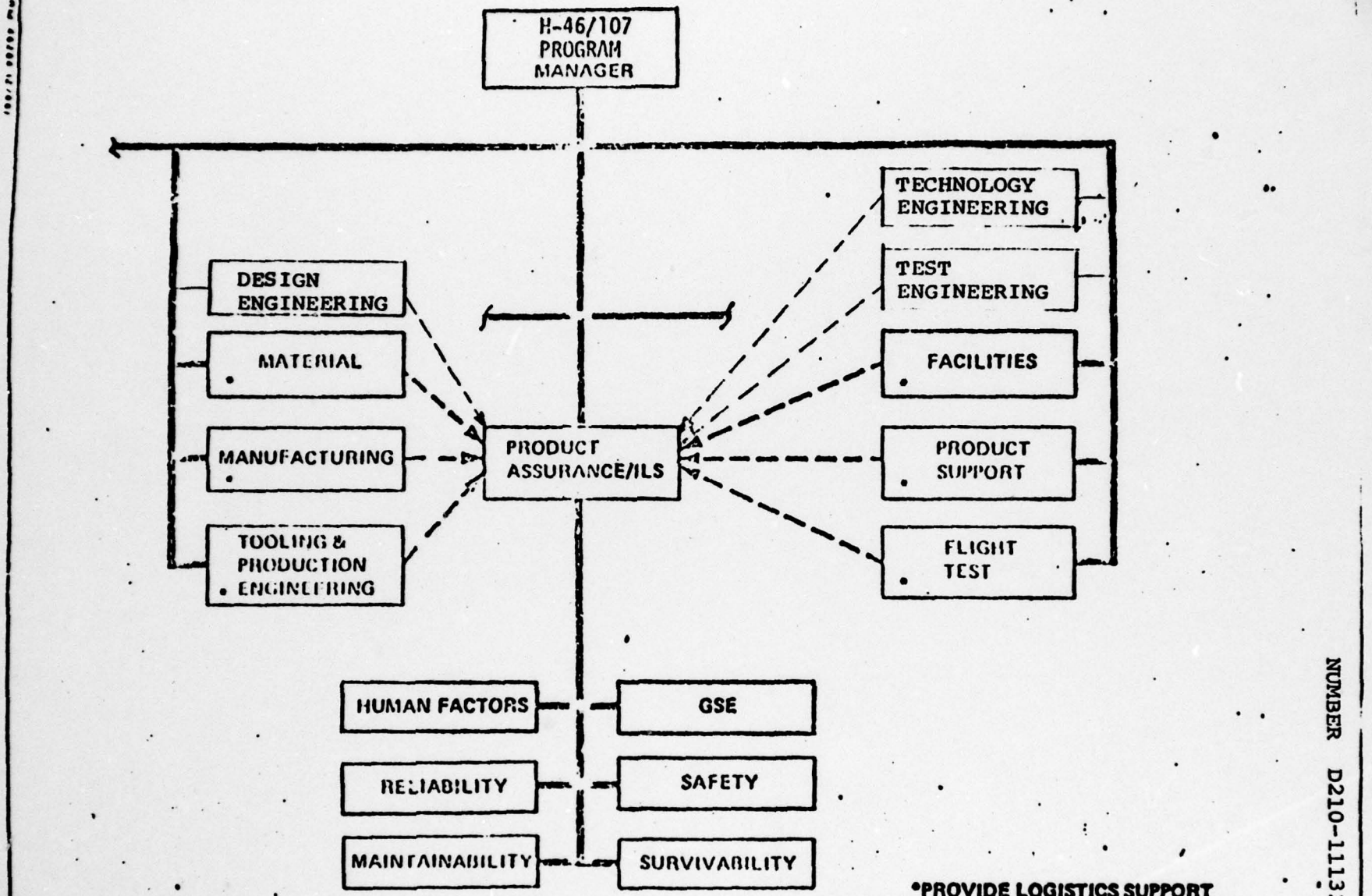
H-46/107
PROGRAM
MANAGER
DESIGN
ENGINEERING
MATERIAL
MANUFACTURING
TOOLING &
PRODUCTION
ENGINEERING
PRODUCT
ASSURANCE/ILS
TECHNOLOGY
ENGINEERING
TEST
ENGINEERING
FACILITIES
PRODUCT
SUPPORT
FLIGHT
TEST
HUMAN FACTORS
RELIABILITY
MAINTAINABILITY
GSE
SAFETY
SURVIVABILITY
*PROVIDE LOGISTICS SUPPORT

Figure 1

b. Technology Engineering

1. Determination of the effect of loss of function of a subsystem/component on aircraft operation in support of reliability analyses.

2. Solutions to identified reliability problems.

c. Test Engineering

1. Preparation of test plans and procedures.

2. Data acquisition (reporting of malfunctions and failures).

3. Identification of test instrumentation interfaces with test subsystem/components in support of reliability analyses.

5.1 CONTROL OVER RELIABILITY EFFORT

Control of the Reliability Engineering effort is exercised by managing task accomplishment, schedule, and manpower expenditure. Existing policies and procedures within the management structure, are used to facilitate problem resolution and dissemination of any special controls required for satisfactory program implementation.

5.2 SUBCONTRACTOR CONTROL

Allocated ALR reliability requirements are levied on B/V suppliers as appropriate to fulfill program objectives. The principal means for executing these requirements is through Boeing source control or performance specifications.

6. RELIABILITY PROGRAM ACTIVITIES

This section describes the reliability tasks and methods for accomplishing the contractual requirements of Paragraph 3.

6.1 ANALYSIS OF HISTORICAL EXPERIENCE

The initial task of establishing design reliability criteria is accomplished by utilizing experience gained from other programs. Documentation of past successes, failures and effective corrective actions is utilized to identify design criteria that will result in prevention of component/subsystem failures, maintenance problems and aborts/delays due to critical failure modes.

Corrective techniques employed include use of high reliability parts, derating, environmental protection and the selected use of redundancy. Specific criteria are developed to establish the effects of storage, shelf life, packaging, transportation, handling and maintenance on equipment failure rates.

These experience-generated criteria are applied during design to ensure their full influence on design decisions, trade studies and design reviews.

6.2 DEFINITION OF SUCCESS/FAILURE CRITERIA

The design project, supported by the Reliability Engineering Unit, has established preliminary definitions of abort, delay and subsystem failure. Since performance requirements are used as the definition of successful operation, deviation from required limits is not construed to constitute a failure in those cases where functional performance is not lost.

6.3 RELIABILITY ANALYSIS

The analytical methods used to determine allocations are per MIL-STD 1304(AS). Functional diagrams and failure mode, effect, and criticality analyses are used to provide the basis for allocation and analysis. The failure mode and effects analysis is performed jointly by the design engineer and the reliability engineer. Allocations for aborts and delays are made. Rates for malfunctions requiring unscheduled maintenance are also allocated.

6.4 TRADE STUDIES

The design reliability criteria described previously are applied as primary design constraints. Trade studies and evaluations of configurations are conducted by design engineering, supported by reliability engineers to assess the degree of conformity with reliability objectives. Analyses of the effects of failures on operational and maintenance costs are one of the prime factors of evaluation.

6.5 FAILURE MODE AND EFFECT ANALYSIS (FMEA)

Analysis of appropriate subsystem, component, and part failure modes is performed to identify foreseeable failure or hazard occurrances and direct attention to corrective actions. Design Engineering identifies foreseeable types and modes of system malfunction, resulting effects, and hazards resulting therefrom. Inter-system failure modes and effects are then evaluated by the Reliability Unit. Probability of occurrance is predicted and failure modes classified to establish the effect on system performance and safety in accordance with MIL-STD-882.

Failure mode and effect analyses are performed per SAE-ARP-926, Paragraph 2. prior to construction of test components. Appendix A contains the format of a failure mode and effect analysis. Procurement specifications, where appropriate, shall require suppliers to perform and submit for Boeing approval, similar FMEAs.

6.6 COMPONENT/SUBSYSTEM COMPATABILITY

Highly reliable individual parts can be incompatible when integrated as functioning components and subsystems. To ensure compatibility, Design Engineering groups analyze interface effects and interactions of performance variables, tolerances between major parts, components, and subsystems, and assess the effect of environments induced on one subsystem by another. Protective devices are provided, tolerances changed, or equipment relocated to correct incompatibilities. A compatibility analysis is conducted prior to the preliminary design review and this analysis is expended as the design progresses to include evaluation of tolerance and drift conditions.

6.7 INSTALLATION ANALYSIS

Installation requirements for parts, components, and subsystems are analyzed by Design and Reliability Engineering to establish internal operating environments and verify design operating capability. External interaction between adjacent equipment is analyzed and designs changed as necessary to provide compatibility. Equipment location and mounting is analyzed to verify that environmental limits are not exceeded.

6.8 DESIGN REVIEWS

Informal design reviews are conducted on the ALR Program and its specific subsystems and equipment at strategic points in the design process. Design compliance with reliability criteria is monitored at each review and recommendations provided. Selected supplier designs are subject to design review by Boeing Engineering and Quality Control personnel.

Reliability support provided at Design Reviews includes such factors as:

a. Current reliability estimates and predictions.

b. Potential identified problem areas and corrective action planning.

c. Identification of critical items and appropriate special controls.

d. Specification compliance demonstration by analysis.

e. Review of reliability action item status.

7. RELIABILITY DATA DOCUMENTATION

7.1 DATA SUBMITTAL

Reports will be prepared in accordance with NADC Contract N62269-76-C-0341. Significant milestones, task accomplishments, problem areas, prediction, and test reporting data will be included for the tasks outlined in the program plan that are pertinent to the reporting period covered.

7.2 DATA COLLECTION

During development testing, Boeing will establish and maintain a Reliability Reporting and Corrective Action Program to collect, process and analyze failure data; to analyze selected failed assemblies; and to prevent failure recurrence. This program will be conducted utilizing current established procedures and techniques. Equipment Reliability logs and summary sheets for maintaining individual records are shown in Appendix B and C.

Special reporting, performance monitoring, and failure classification instructions will be issued to support the test and evaluation program. Subcontractor failure analysis support will be required whenever appropriate.

8. RELIABILITY DEFINITIONS

FAILURE - The inability of an item to perform its required functions within previously specified limits.

MALFUNCTION - A component condition requiring corrective action, the occurrence of which does not necessarily imply complete functional failure of the component or its related subsystem system.

MISSION RELIABILITY - The probability that an aircraft declared ready shall perform its mission of specified length and profile, under environmental conditions not exceeding design specifications, without incurring a mission affecting malfunction.

MISSION AFFECTING MALFUNCTION - Any functional failure or combination of functional failures which so degrade the performance or capability of the aircraft that a take-off is delayed (more than 15 minutes) or cancelled, or a flight is aborted because established mission success criteria have not been met.

FLIGHT SAFETY RELIABILITY - Any material failure or malfunctions, or combinations thereof, that could result in a major accident because established flight safety criteria have not been met.

9. AUTOMATED LIFE RAFT RELIABILITY RATIONALE

This system is unique in that all of the reliability goals, objectives and requirements are met if the system is installed on the H-46 Helicopter, is functional, and is never used throughout the operational flight cycle of the helicopter.

If the system is always operational, causes no mission aborts and is never used then it has performed as designed. The ALR reliability may be measured in MMH/FH. It may be measured in calendar months. In this RPP it is intended that PDLM periods (time accumulated by the helicopter between obligatory returns to O & R facilities) will be the reliability yardstick. (Calendar months)

The system is also unique in that the most hazardous instances may occur should the system function inadvertently during flight. This situation could be more hazardous to flight than having no automated life rafts installed. Reliability Engineering activities are particularly emphasized throughout the design and test (progress) stages of ALR development to control such a situation and provide reliable safeguards should any system or subsystem malfunction occur.

THE BOEING COMPANY

PREPARED BY:
CHECKED BY:
DATE:

MODEL NO.

APPENDIX A

SYSTEM _____
SUBSYSTEM _____
COMPONENT _____
MODULE/ITEM _____

FAILURE MODE AND EFFECTS ANALYSIS FORMAT

PAGE ____ OF ____
DATE _____
PREPARED BY _____
APPROVED BY _____

ITEM IDENTIFICATION		FUNCTION	FAILURE MODE	FAILURE RATE PER 1000 FH	FAILURE EFFECT ON			FAILURE DETECTION METHOD	R CAT.	DESIGN PROVISIONS TO REDUCE FAILURE MODES	REMARKS
NAME	DRAWING REF.				COMPONENT FUNCTIONAL ASSEMBLY	NEXT HIGHER SUBSYSTEM	TOTAL SYSTEM				

Form 10010 D/500

APPENDIX B

INDIVIDUAL FAILURE ANALYSIS REPORT

System _____ Assembly _____ Subassy _____

Part No. _____ Component _____ Serial No. _____

Report No. _____ Test Type _____ Compon. Hrs. _____

Component Analysis

Design Analysis

Recommendations For Corrective Action

The BOEING COMPANY

PREPARED BY:
CHECKED BY:
DATE:

MODEL NO.

APPENDIX · C

Nomenclature _____

Part Number _____

FAILURE SUMMARY RECORD

Page _____ of _____

Date _____

Failure Report		Unit Serial No.	Component Operating Hours	Description Of Failure	Test Status - All Units			Remarks
Date	Number				Cumulative Failures	Cumulative Test Hours	MTBF	

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