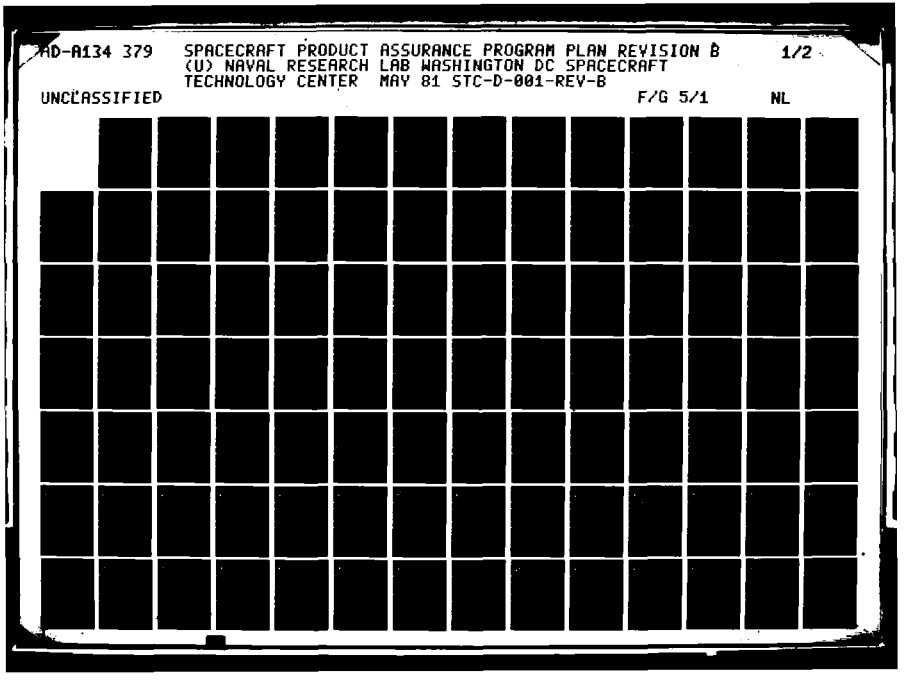
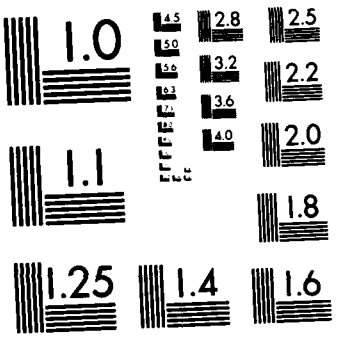

AD-A134 379 SPACECRAFT PRODUCT ASSURANCE PROGRAM PLAN REVISION B
(U) NAVAL RESEARCH LAB WASHINGTON DC SPACECRAFT
TECHNOLOGY CENTER MAY 81 STC-D-001-REV-B
1/2
UNCLASSIFIED
F/G 5/1
NL



(1)

NAVAL RESEARCH LABORATORY

SPACECRAFT
TECHNOLOGY
CENTER

SPACECRAFT
PRODUCT ASSURANCE PROGRAM PLAN

DATE: MAY 1981

NUMBER: STC-D-001-[illegible]
REV B

APPROVAL SIGNATURES:

Albert C. Salvato — May 7, 1981
ALBERT C. SALVATO — DATE
PRODUCT ASSURANCE SECTION HEAD
SPACECRAFT TECHNOLOGY CENTER

Peter G. Wilhelm — 7 May 1981
PETER G. WILHELM — DATE
HEAD, SPACECRAFT TECHNOLOGY CENTER

James G. Winkler — 7 May 1981
JAMES G. WINKLER — DATE
DOCUMENTATION MANAGER
SPACECRAFT TECHNOLOGY CENTER

COPY NO._____ NAME_____

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

1.0 INTRODUCTION

Achievement of the highest possible mission reliability is essential to the success of the space programs undertaken by the Spacecraft Technology Center of the U.S. Naval Research Laboratory (NRL/STC). This maximized mission reliability achievement can only be realized through a comprehensive product assurance program implemented throughout design, development, fabrication and test with the twofold purpose of:

- o Maximizing the inherent design reliability of the spacecraft.
- o Eliminating/precluding any latent defects from the flight hardware.

This plan defines the product assurance program implemented by NRL's Spacecraft Technology Center to achieve this end.

Maximized inherent design reliability is assured by implementation of a thorough reliability analysis program beginning early in the design process and continuing through design finalization. The elements of this reliability analysis program include system and subsystem tradeoff studies, optimized redundancy implementation studies, failure mode and effects analyses (FMEA's), part selection evaluations, electrical stress analyses, design margin analyses and tests, criticality analyses, reliability predictions, and design reviews. This reliability analysis program is described in Section 3.0.

The elimination of latent defects from flight hardware is accomplished by inspections and tests beginning at the part level and continuing throughout hardware fabrication and tests at all levels up to and including the spacecraft level. The defects are eliminated by removal of the defective hardware. The test

and inspection efforts are initiated with the high reliability procurement, screening and destructive physical analysis of the parts (described in Section 4.0), followed by tests and inspections at the module, subsystem and spacecraft levels (described in Sections 6.0 and 7.0).

Precluding the introduction of latent defects in the flight hardware is accomplished by a stringent set of procedures, reports and controlling documentation that assures complete control over spacecraft and subsystem configuration, test and repair, and verifies that all required actions have been taken. These procedures, reports and controlling documentation systems are described in Section 6.0 (NRL/STC Equipment Processing), Section 7.0 (System Test Program), and Section 8.0 (Failure Reporting and Analysis).

To assure comparable reliability achievement by procured units and subsystems, NRL/STC imposes the applicable elements of this product assurance program on participating contractors and monitors their compliance. This aspect of the product assurance program is described in Section 5.0.

2.0 PROGRAM OVERVIEW

This plan describes the comprehensive product assurance program employed by NRL/STC as part of the design, procurement, fabrication, integration and testing of its spacecraft equipment and systems. This program is designed to assure that the highest reliability possible, commensurate with other major program constraints, is achieved by each spacecraft.

To achieve this end the NRL/STC product assurance program incorporates those controls, techniques, and procedures found to be effective on previous spacecraft programs. The key elements of this program are:

- o Reliability Analysis Program (Presented in Section 3.0)
  This analysis program provides for a controlled iterative implementation of the design analysis and review techniques that identify reliability achievement and enhancement potential. The individual elements of the reliability analysis program as they apply during the conceptual design period and at the subsystem and system levels during detailed design and development are:

  1) Preliminary Studies and Evaluation
     These early reliability studies include evaluations of redundancy tradeoffs, with emphasis on equipment interfaces and redundancy implementations, technology selection, part selection evaluations, preliminary reliability math models, with projections of reliability achievement potential, and a preliminary spacecraft Single Point Failure Summary (SPFS).

2) Subsystem Reliability Analyses

As design detail becomes available, the reliability analysis efforts are expanded to include electrical stress analyses, design margin analyses and tests, detailed Failure Mode and Effect Analyses (FMEA's) and reliability predictions.

3) System Reliability Analysis

As the unit and subsystem analyses are updated, they are used to update and refine the spacecraft system level FMEA, SPFS, math model, and reliability prediction to enable assessment of further reliability improvement potential.

4) Design Review

Both formal and informal design reviews are implemented to evaluate the design and verify maximized reliability achievement.

o Parts Program (Reference Section 4.0)

The parts program implemented by NRL/STC utilizes those techniques and methods by which parts reliability will be maximized relative to factors which affect part reliability. It covers the four major part activities which comprise any high reliability parts program. These are:

1) Parts Selection and Qualification

2) Parts Procurement and Screening

3) Destructive Physical Analysis

4) Receiving Inspections and Tests

- Procured Equipment Product Assurance Program
  (Reference Section 5.0)
  The controls and procedures imposed by NRL/STC assure that procured equipment are fabricated with a high reliability and will not degrade spacecraft performance. The basic approach is to require contractors to adhere to the product assurance controls and practices that would be in existence if the item were developed "in house" by NRL/STC, i.e., the program delineated by this plan.

- In-House Equipment Processing (Reference Section 6.0)
  The NRL/STC equipment fabrication, assembly, test and repair is controlled through implementation of NRL/STC Procedure STC-D-007, Flight Hardware Fabrication, Test and Repair, and NRL/STC Procedure STC-D-011, Nonconforming Material, Control of, contained in Appendix A and Appendix D, respectively.

  NRL/STC Procedure STC-D-011 (contained in Appendix D) is used to detail the quality control and configuration activities during fabrication, assembly and repair of the equipment. Nonconfomring Material Reports are generated for all nonconformances with any resulting waivers and/or deviations included, as necessary. Product Assurance is responsible for the maintenance of the nonconformance documentation throughout the fabrication cycle to assure the proper hardware configuration history is known.

- System Test Program (Reference Section 7.0)
  The NRL/STC system test program includes a comprehensive integration and acceptance testing effort supplemented by qualification testing for specific environmental parameters whenever previous qualification information is not available and analysis techniques are not considered sufficient.

  NRL/STC Procedures STC-D-007 and STC-D-[illegible] (contained in Appendix A and Appendix B, respectively) is the governing document for the detailed quality control employed during spacecraft integration and test. The release sheets, subsystem repair action logs and spacecraft log, along with any discrepancy reports, will be maintained by Product Assurance throughout the fabrication and test period to assure that the accepted hardware configurations and repair history are known.

- Failure Reporting and Analysis (Reference Section 8.0)
  The NRL/STC failure reporting system provides a timely and appropriate evaluation of failures, discrepancies, and/or malfunctions that occur during the equipment test. It is a closed-loop system developed by NRL/STC which requires the initiation of a failure report using a Discrepancy Report (DR) and a subsequent failure analysis and corrective action prior to closeout. The NRL/STC procedure, STC-D-008, Failure Reporting Analysis and Corrective Action, governing this activity is contained in Appendix B.

3.0 RELIABILITY ANALYSIS PROGRAM

The purpose of the NRL/STC spacecraft reliability analysis program is to assure that the inherent reliability of the units, subsystems, and spacecraft have been maximized within other major program constraints. The accomplishment of this purpose requires a controlled iterative implementation of the design analysis and review techniques that identify reliability achievement and enhancement potential. This iterative implementation is illustrated in Figure 3-1. The individual elements of this reliability analysis program as they apply during the conceptual design period and at the subsystem and system levels during detailed design and development are described in the following paragraphs.

3.1 Preliminary Studies and Evaluation

The NRL/STC reliability analysis program begins early in the design process to provide reliability inputs to design concept tradeoff studies and identify reliability improvement possibilities when their implementation has no significant cost or schedule impact. These early reliability studies and evaluations include redundancy tradeoff evaluations, with emphasis on equipment interfaces and redundancy implementations, technology selection support studies, part selection evaluations, preliminary system reliability math models, with projections of subsystem/spacecraft reliability achievement potential, and a preliminary spacecraft Single Point Failure Summary (SPFS). During these preliminary studies the analytical techniques described in Paragraph 3.2 for the final subsystem analyses are employed to the extent and level of detail practical.

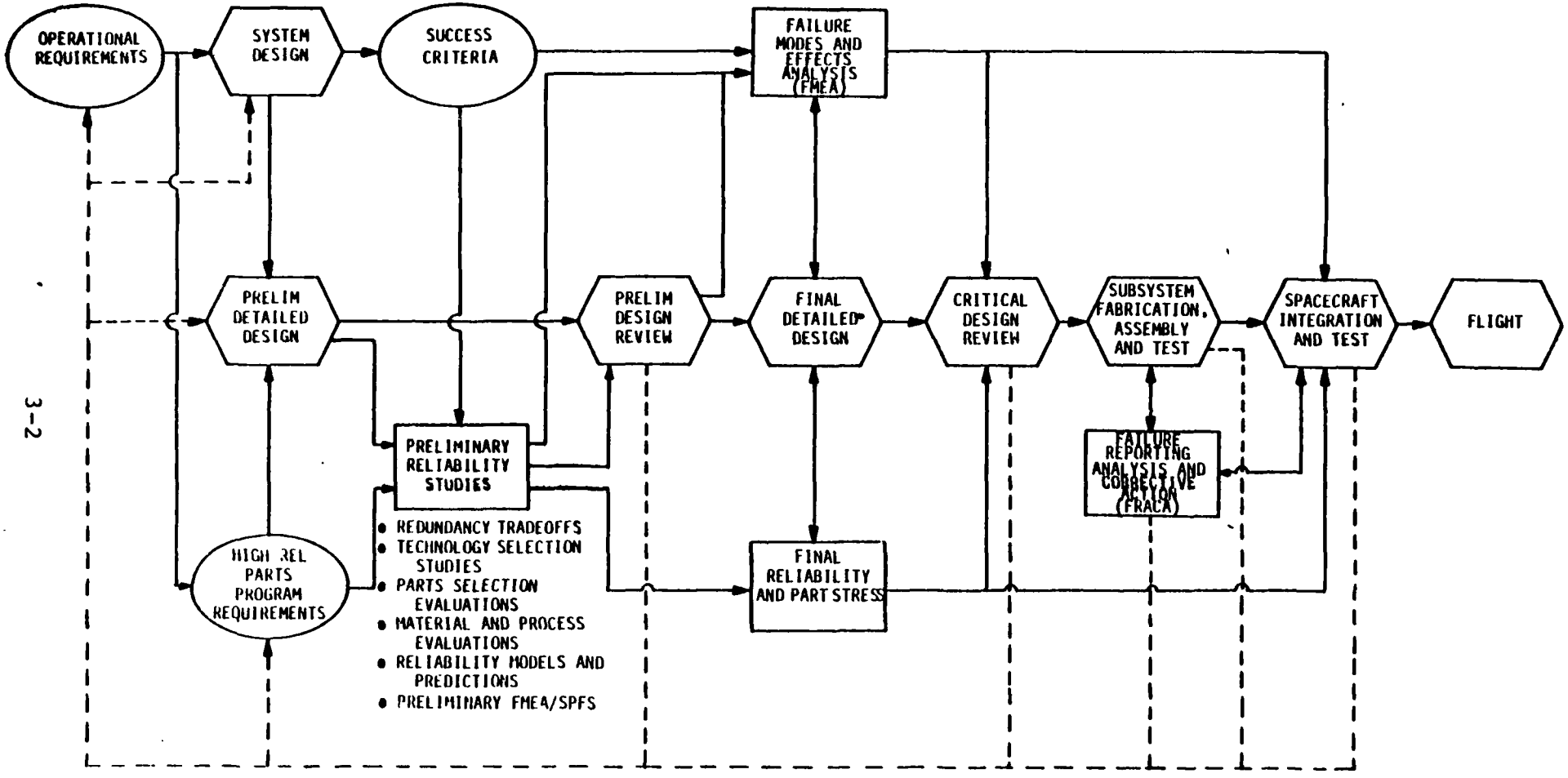


FIGURE 3-1: NRL/STC SPACECRAFT RELIABILITY ANALYSIS FLOW DIAGRAM

3.2 Subsystem Reliability Analyses

As subsystem and unit design detail becomes available, but prior to design finalization, the reliability analysis program scope is increased to include part selection evaluations, electrical stress analyses, design margin analyses and tests, detailed failure mode and effect analyses, and reliability predictions. Those units and subsystems that have not been modified since having been subjected to reliability analyses are reviewed, but do not require the full reliability analysis since the unit/subsystem reliability analyses had been previously performed. The analysis techniques employed on subsystems requiring analysis are described in the following paragraphs.

3.2.1 Failure Mode and Effects Analysis

The NRL/STC subsystem Failure Mode and Effect Analysis (FMEA) is a comprehensive, systematic evaluation of circuit failure modes that can occur and their effect on subsystem and spacecraft operation. Emphasis is placed on the verification of redundancy implementations, the identification of any single point failure modes (failure mode whose occurrence could result in loss of the spacecraft mission) and the identification of any design modifications that would lessen the impact of a failure occurrence on subsystem and spacecraft operation. In addition, failure mode and item criticalities are calculated to provide a quantitative means of failure mode and effect evaluation. The detailed FMEA results are recorded on the FMEA worksheet of Figure 3-2. The content of each column of this worksheet and the applicable ground rules and/or assumptions associated with the data developed in each column are as follows:

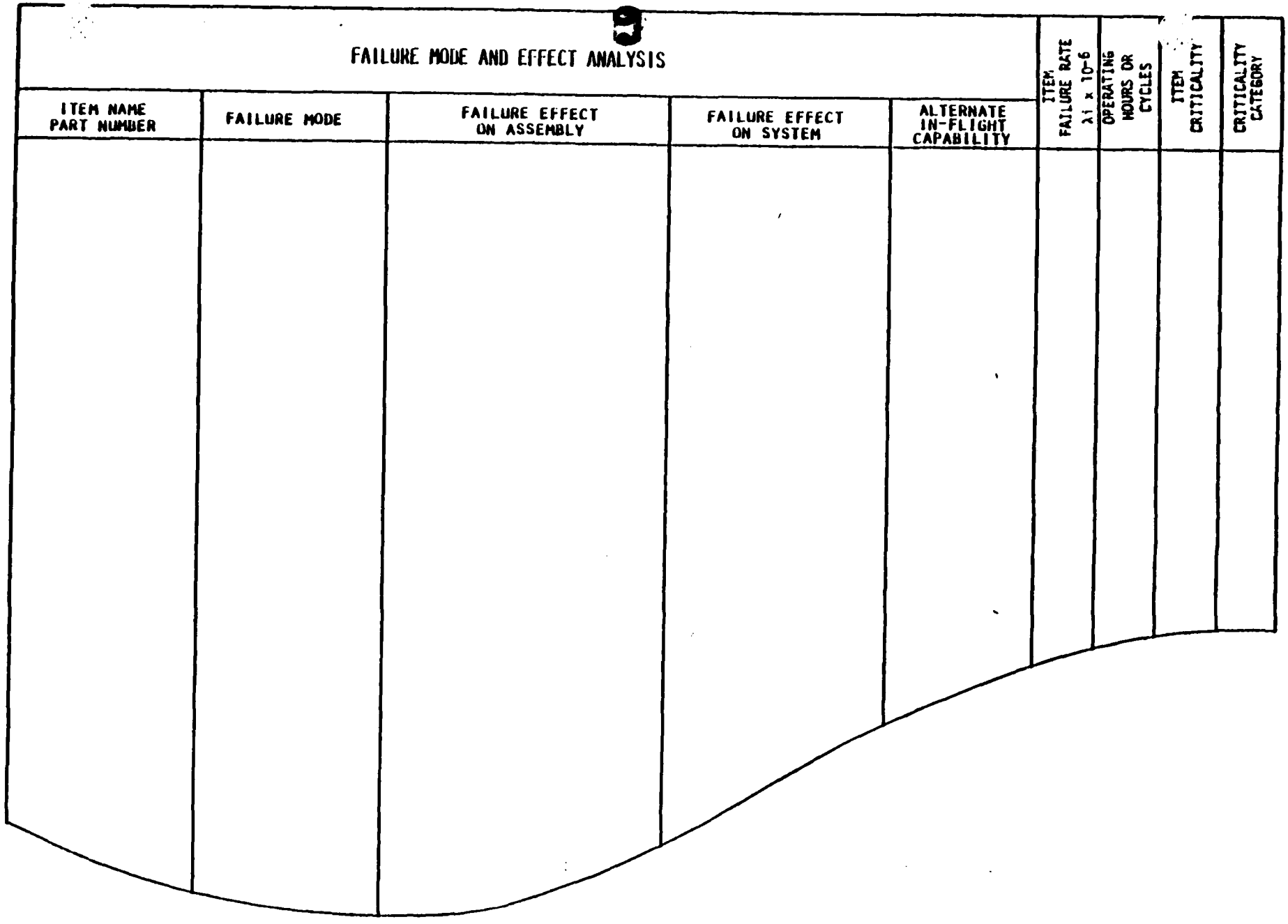


FIGURE 3-2: FAILURE MODE AND EFFECT ANALYSIS WORKSHEET

COLUMN	CONTENT, GROUND RULES AND/OR ASSUMPTIONS
1	ITEM NAME/PART NUMBER: This column is used to identify the subsystem subassembly being analyzed.
2	FAILURE MODE: This column describes the failure mode considered for each subassembly. These failure modes are generally loss of signal, incorrect signal, or short/open of critical parts.
3	FAILURE EFFECT ON ASSEMBLY: This column identifies the effect of singular occurrence of the failure mode of Column 2 on the subsystem.
4	FAILURE EFFECT ON SYSTEM: This column is used to record the effect of the postulated failure mode on the spacecraft.
5	ALTERNATE IN-FLIGHT CAPABILITY: The alternate capability of the subsystem/spacecraft, given occurrence of the postulated failure mode, is recorded in this column. This column clearly indicates the effectiveness of the redundancy incorporated.
6	ITEM FAILURE RATE ($_i$ x 10^{-6}): This column contains the component/circuit subassembly failure rate as determined in the subsystem reliability prediction.
7	OPERATING HOURS OR CYCLES: This column records the mission operating time for the associated subsystem.
8	ITEM CRITICALITY: This column is the product of the data in Columns 6 and 7 and is a measure of item unreliability.
9	CRITICALITY CATEGORY: This column is used to record the relative severity of the failure effect using the following general category definitions:

CATEGORY	DEFINITION
I	Loss of entire subsystem function.
II	Loss of redundancy within the subsystem.
III	Partial loss of redundancy of subsystem function, e.g., loss of a single functional circuit in a redundant logic section.
IV	No effect on subsystem or more than one success path remains.

The overall subsystem FMEA results, including summary classifications of failure effects and their criticalities, identification of any single point failure modes, and any recommended reliability enhancements resulting from the FMEA, are documented in the subsystem reliability analysis report.

3.2.2 Stress Analysis

A detail part stress analysis is performed on all parts where review of the circuit indicates that individual part electrical/thermal stresses may approach the maximum allowable levels of the NRL/STC high reliability derating criteria summarized in Table 3-1. Because of the ultralow power dissipation characteristics of most NRL/STC designs, this selective stress analysis approach has the dual advantage of assuring part application within the derating criteria while minimizing analysis cost. The stress analysis results are recorded in Columns 4, 5 and 6 of the reliability data worksheet of Figure 3-3 and are summarized as part of the subsystem reliability analysis report. Any parts applications where the high reliability derating criteria are exceeded are resolved by design review.

3.2.3 Subsystem Reliability Models and Predictions

Subsystem reliability block diagrams and math models are developed for each subsystem reflecting the findings of the FMEA relative to redundancy implementations and single point failures. These math models employ the exponential reliability distribution with respect to time (i.e., constant failure rate) applicable to electronic and electromechanical hardware for the specific mission time. They are also formulated to reflect the unreliability contribution of any nonoperating standby portion of the subsystem using an operating-to-standby failure rate multiplier of 0.1. A

TABLE 3-1

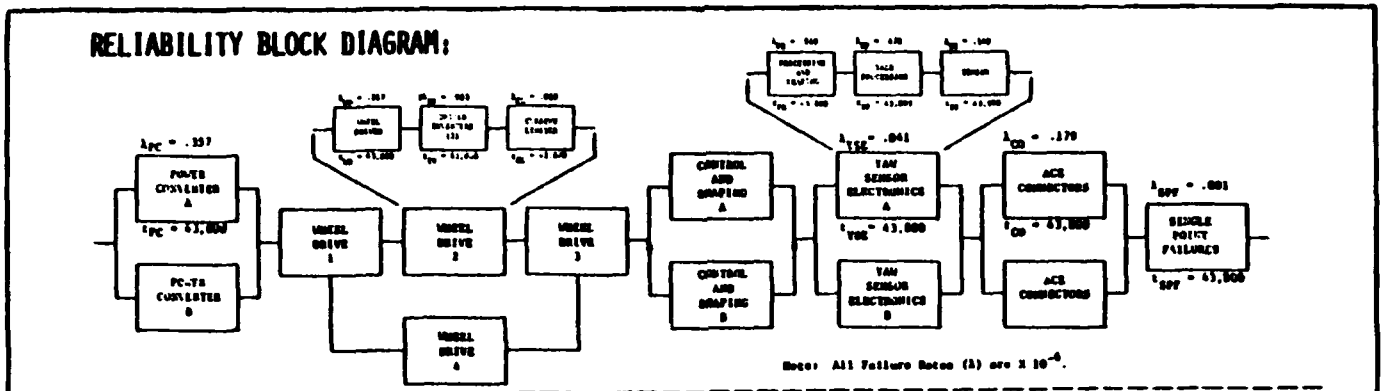
PART STRESS DERATING CRITERIA SUMMARY

PART TYPE	PARAMETER EVALUATED	HI-REL MAXIMUM DERATING CRITERIA[1]
I.C., Digital	Junction Temperature	110°C
I.C., Linear	Power Dissipation	50 %
	VCC	75 %
	Junction Temperature	110°C
Transistor	Power Dissipation	50 %
	V_{CEO}	75 %
	Junction Temperature	110°C
Diode	Power Dissipation	50 %
	Reverse Voltage	75 %
	Junction Temperature	110°C
Capacitor, Tantalum	Voltage	80 %
Capacitor, Ceramic	Voltage	60 %
Resistor, Fixed Comp.	Power	50 %
Resistor, Fixed Film	Power	60 %
Resistor, Fixed WW	Power	40 %
Relay	Contact Current	50 %
Magnetics	Current	50 %

NOTE: [1] Derating criteria are expressed as the maximum allowable stress, expressed in percent of manufacturer's maximum ratings or in degrees centigrade, considered allowable for reliable circuit operation from a part application standpoint.

REF. SYMBOL	PART DESCRIPTION	PART NUMBER	RATED STRESS	APPLIED STRESS	STRESS RATIO	FAILURE RATE	F.R. SOURCE

FIGURE 3-3: RELIABILITY DATA WORKSHEET



MATH MODEL

$$R_{ACE} = \left[2R_{PC} - R_{PC}^2\right]\left[R_{MD}^4 + 4R_{MD}^3(1-R_{MD})\right]\left[R_{CSO} + \frac{\lambda_{CSB}}{\lambda_b}(1-R_{CSO})\right]\left[2R_{YSE} - R_{YSE}^2\right]\left[2R_{CO} - R_{CO}^2\right]\left[R_{SPF}\right]$$

Where:

$$R_{PC} = e^{-\lambda_{PC} t_m}$$

$$R_{MD} = e^{-\left(\lambda_{MD} + 2\lambda_{ID} + \lambda_{CL}\right) t_m}$$

$$R_{CSO} = e^{-\lambda_b \left(\lambda_{PS} + \lambda_{ID} + \lambda_{YI}\right) t_m}$$

$$R_{YSE} = e^{-\lambda_{YSE} t_m}$$

$$R_{CO} = e^{-\lambda_{CO} t_m}$$

$$R_{SPF} = e^{-\lambda_{SPF} t_m}$$

Definitions:

- R_{ACE} = The reliability of the redundant ACE over the five year mission.
- R_{PC} = The reliability of the Power Converter over the five year mission.
- R_{MD} = The reliability of 3 out of 4 Wheel Drivers over the five year mission.
- R_{CSO} = The reliability of the operational Control and Shaping module less the Yaw Sensor Electronics over the five year mission.
- R_{CSB} = The reliability of the standby Control and Shaping module less the Yaw Sensor Electronics over the five year mission.
- R_{YSE} = The reliability of the Yaw Sensor Electronics over the five year mission.
- R_{CO} = The reliability of the ACE Bulkhead connectors over the five year mission.
- λ_m = The operating failure rate of the m^{th} circuit in failures per hour.
- t_m = The mission operating time of the m^{th} circuit in hours (43,800 for all circuits).
- t_m = The mission time equals 43,800 hours.
- λ_b = The operating-to-standby failure rate multiplier equals 0.01.
- R_{SPF} = The reliability of the Single Point Failure Modes (see Paragraph 4.3).

PREDICTION:

$$R_{ACE} = .9960$$

ACE RELIABILITY PREDICTION SUMMARY

FIGURE 3-4: SAMPLE RELIABILITY PREDICTION SUMMARY

sample reliability prediction summary (with block diagram and math model) is presented in Figure 3-4.

Subsystem reliability predictions are derived by the application of functional subassembly failure rates and operating/nonoperating mission times in the math models. Subassembly failure rates are derived from part failure rates normally based upon the conservative assumption that failure of any part in the subassembly constitutes subassembly failure. Subassembly operating/nonoperating times are derived from mission operational time lines.

The electronic part failure rates used in the subsystem reliability predictions are derived from MIL-HDBK-217 and reflect the high reliability part procurement and screening provisions of Section 4.0, a Space Flight environmental factor, a 30°C average unit ambient temperature, and calculated/estimated part electrical stresses. The nonelectronic part failure rates are derived from RADC-TR-67-458, GIDEP, and other recognized failure rate sources. Part failure rate information is recorded in Column 7 of Figure 3-3, while the failure rate source is identified in Column 8.

3.2.4 Worst-Case Performance Analysis

A detailed worst-case performance analysis is performed on each critical flight circuit. The purpose of this analysis is to verify that adequate performance margins exist for key circuit performance parameters at nominal and worst-case conditions, and to provide a basis for recommended design improvements where inadequate performance margins exist.

This analysis considers the worst-case combinations of expected variations in part parameters within the circuit due to initial manufacturing tolerances (where not factored out by an acceptable trimming procedure), temperature variations, aging, and radiation (as applicable) and their impact on the circuit performance parameters. Worst-case variations at the input and output interfaces of the circuit are also considered. Typical worst-case performance parameters considered include gain, loop stability, timing, frequency drift, threshold/bias points, regulation, and noise susceptibility. Both manual and computer-aided analysis techniques are employed, as applicable. The worst-case analysis results are formally documented, with any questions of insufficient performance margin resolved via design review.

3.3 System Reliability Analysis

As the unit and subsystem reliability analyses are updated, they are used to update and refine the spacecraft system level FMEA, Single Point Failure Summary, reliability mathematical model, and reliability prediction. This enables the potential for and advisability of further reliability improvement to be assessed based upon overall spacecraft and program considerations.

3.4 Design Review

NRL/STC utilizes the design review as a primary management tool for optimizing a system with respect to constraining requirements. This design review concept encompasses two types of design review activities. The first is a working meeting attended by involved individuals for the express purpose of evaluating specific evidence of potential problems and providing direction for their resolution. Thus, when the reliability analysis efforts result in the definition of a potential problem or reliability

enhancement possibility, it is considered at the working design review level and the resolution/action items documented.

The second type of design review is a comprehensive, formal evaluation of all aspects of the system. These formal design reviews are participated in by key individuals involved in the program and are held at key milestones during system development to assess system development progress. These formal design reviews constitute a reverification of the validity of the individual working review meeting decisions.

Two formal design reviews are normally held. These are the Preliminary Design Review (PDR) and the Critical Design Review (CDR).

The first formal review, the PDR, is held early in the design phase to verify the inherent feasibility and reliability of the design concepts. Reliability information presented at the PDR includes the current reliability analysis results, any potential parts or materials problems foreseen, and any tradeoff study results.

The CDR is held just prior to the detailed design freeze on the major hardware elements being considered and is used to verify the performance, reliability and producibility of the new design elements prior to fabrication and assembly. The reliability information presented includes the final FMEA's, reliability models, and predictions to verify maximized reliability achievement.

Supporting design reviews are held at the subsystem levels where significant new design and/or contractor participation is involved.

4.0 PARTS PROGRAM

The reliability of a part is a function of three major factors. These are:

- o The materials and processes employed in its manufacture;
- o The tests and inspections to which it is subjected; and
- o The electrical and environmental stresses experienced in its application.

This section provides an overview of the NRL/STC parts program and summarizes the techniques and methods by which this parts program maximizes achieved part reliability relative to each of these factors. These part reliability enhancement and assurance techniques and methods cover the four major part activities that comprise any high reliability parts program. These activities are:

- o Parts Selection and Qualification
- o Parts Procurement and Screening
- o Destructive Physical Analysis
- o Receiving Inspections and Tests

4.1 Parts Selection and Qualification

4.1.1 Parts Selection

The parts selection process employed by NRL/STC is illustrated in Figure 4-1. As indicated, parts are selected from the STC Preferred Parts List (STC-D-010) to the maximum extent possible. The PPL includes those parts that are acceptable for use on STC flight hardware. As part of the PPL, there is a list of

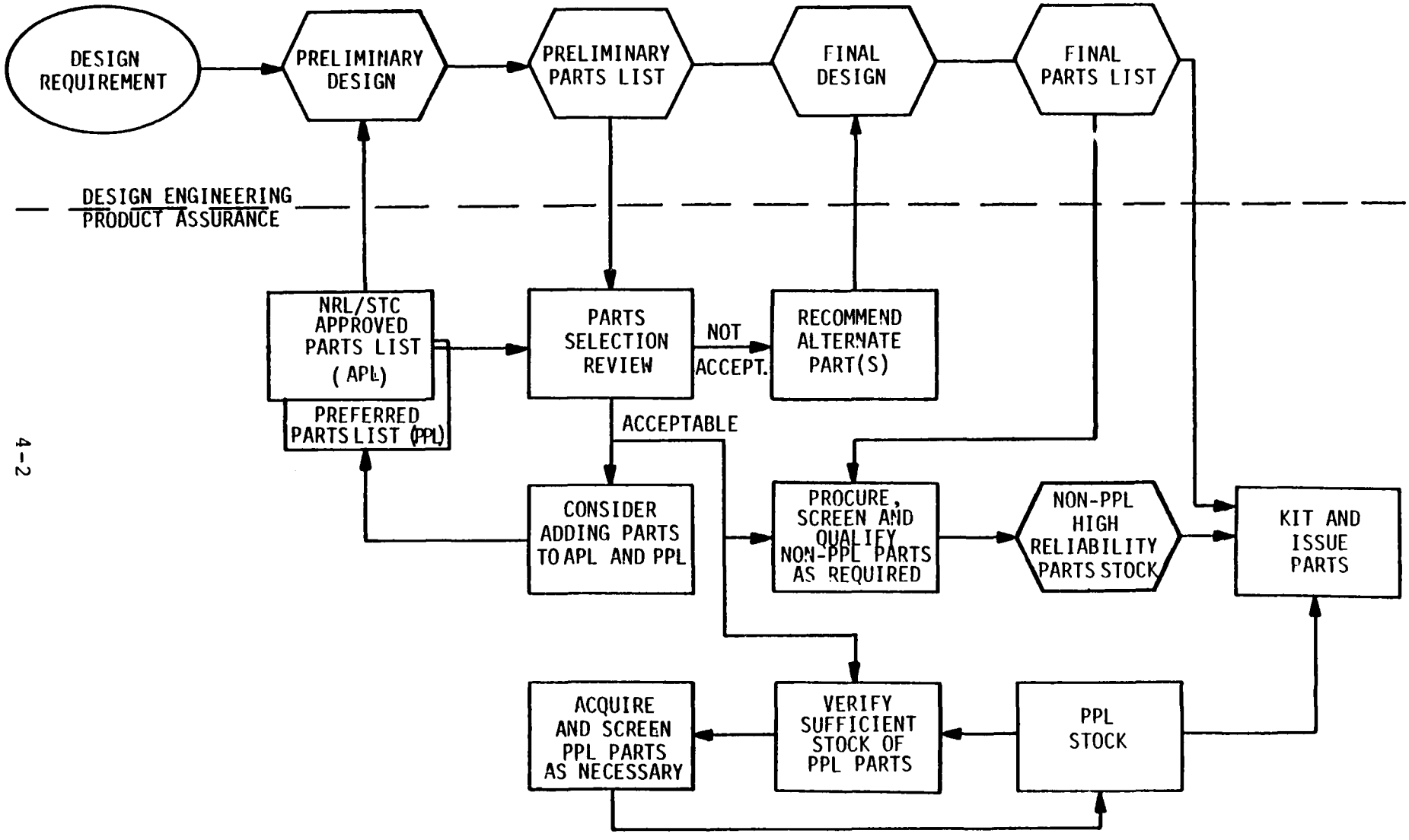


FIGURE 4-1: NRL/STC ELECTRONIC AND ELECTROMECHANICAL PARTS SELECTION APPROACH

parts that have sufficient projected use quantities to justify their being maintained in limited quantities by NRL/STC. Parts selection is accomplished using the following order of precedence:

1) Preferred Parts List, STC-D-010

2) The NRL/STC Approved Parts List (Table 4-1)

3) Nonstandard Parts which NRL/STC has evaluated and approved for selected applications

4) Other parts for which sufficient quality history exists from other sources (e.g., GIDEP, NASA)

For those applications where the design requirement cannot be fulfilled by a part from the PPL, the design engineer, in conjunction with Product Assurance, selects the part that both fulfills the design requirement and meets the NRL/STC high reliability requirements using the NRL/STC Approved Parts List of Table 4-1. If neither a preferred part nor an approved part will suffice, parts that have been previously approved and qualified by NRL/STC as nonstandard parts will be given consideration.

The NRL use history is employed supplemented by the qualified suppliers listings contained in the high reliability and NASA specifications and the GIDEP information library to assure that parts are procured from suppliers that have an adequate quality and process control history. Supplier surveys are also conducted where sufficient information is not otherwise available. Once the nonstandard part has been selected, sufficient parts are procured, qualified where appropriate, screened and subjected to Destructive Physical Analysis (DPA) and receiving inspection as described later in this section.

TABLE 4-1

NRL/STC APPROVED PARTS LIST

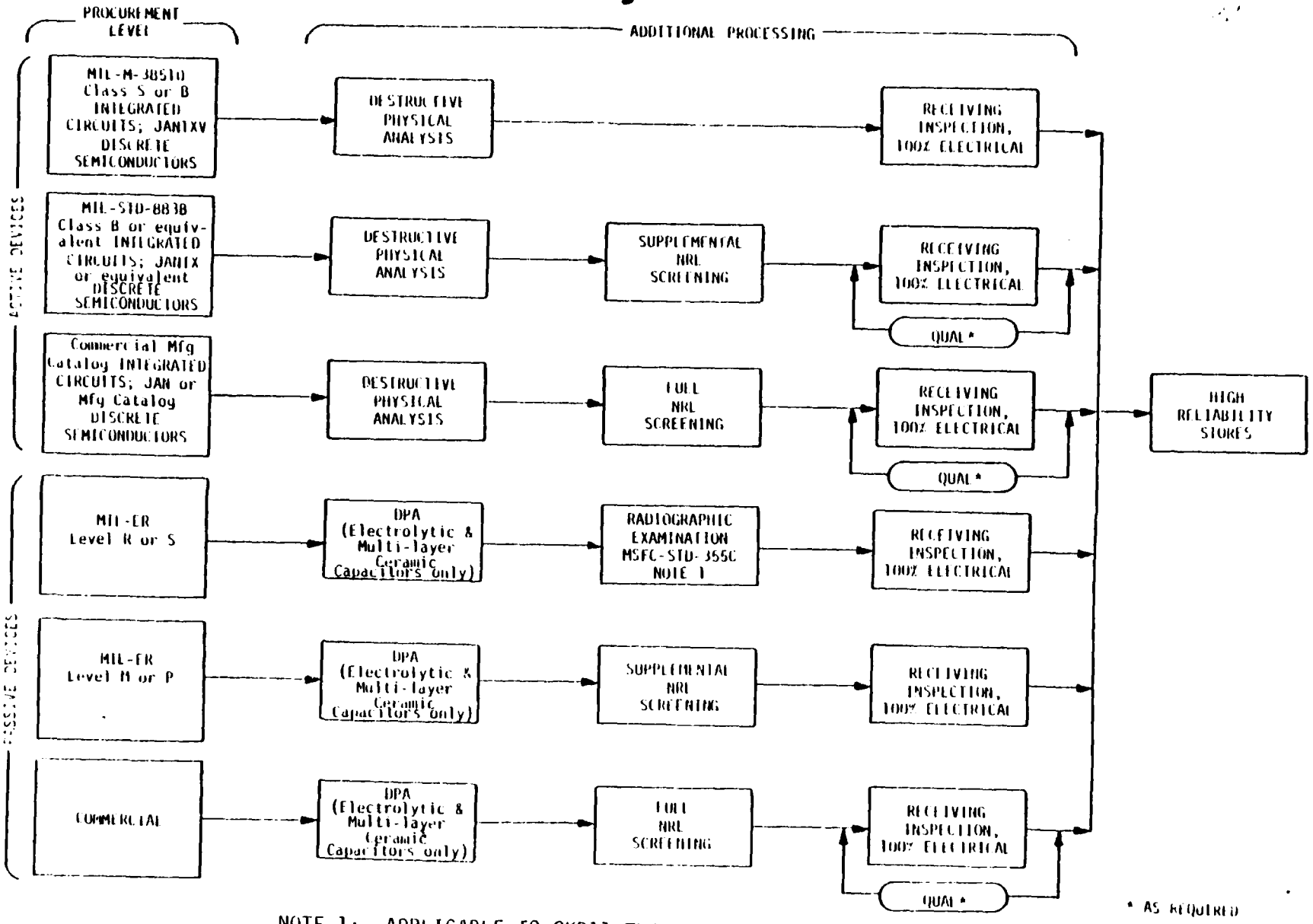
PART CLASS	PROCUREMENT DOCUMENT	
RESISTORS (Level R or S)	• ESTABLISHED RELIABILITY MILITARY SPECIFICATIONS	
	. Fixed Carbon Composition (RCR)	MIL-R-39008
	. Fixed Thick Film (RLR)	MIL-R-39017
	. Fixed Film, High Stability (RNR)	MIL-R-55182
	. Fixed Wirewound, Accurate (RWR)	MIL-R-39007
	. Fixed Wirewound, Power (RER)	MIL-R-39009
CAPACITORS (Level R or S)	• ESTABLISHED RELIABILITY MILITARY SPECIFICATIONS	
	. Fixed Glass (CYR)	MIL-C-23269
	. Solid Electrolytic, Tantalum (CSR)	MIL-C-39003
	. Non-Solid Electrolytic (CLR)	MIL-C-39006
	. Fixed Ceramic (CKR)	MIL-C-39014
TRANSISTORS and DIODES	• JANTXV	MIL-S-19500/xxx
	• JANTX	MIL-S-19500/xxx
INTEGRATED CIRCUITS	• MIL-M-38510, Class S	
	• MIL-M-38510, Class B	
	• MIL-STD-883, Class S	
	• MIL-STD-883, Class B	

4.1.2 Parts Qualification

Parts qualification is relevant to a particular part manufacturer's production line over a period in which the production processes do not change. The high reliability military procurement specifications require the manufacturer to maintain qualification by conducting qualification tests on a sample of parts from the production line periodically (e.g., semi-annually or annually) or whenever the processes are modified. The need for qualification of each specific part type not covered by an ongoing military qualification maintenance program is determined by NRL/STC based upon an assessment of program risk.

4.2 Parts Procurement and Screening

The ever increasing parts reliability required to achieve acceptable space system reliabilities in their long-duration missions has fostered a series of high reliability military standard procurement documents for the more widely used parts types, each more stringent than the previous one. This has created a range of parts procurement possibilities relative to reliability processing controls and screening tests and inspections available from the part manufacturers. However, the specific level of reliability-oriented processing, testing, and inspection available for a specific part type within an acceptable schedule may vary over the entire range of possibilities. To achieve the necessary part reliability, parts are procured with the most reliability-oriented processing, testing, and inspection available from industry within acceptable schedule limits and are upgraded to an acceptable reliability level by performing supplementary screenings and inspections, as necessary. This part procurement and screening approach is illustrated in Figure 4-2, while expanded illustrations of this approach are presented in Figures 4-3 through 4-6. As indicated, this approach takes



NOTE 1: APPLICABLE TO CKR11 THROUGH CKR14 ONLY

FIGURE 4-2: NRL/STC ELECTRONIC AND ELECTROMECHANICAL PART PROCUREMENT AND SCREENING APPROACH

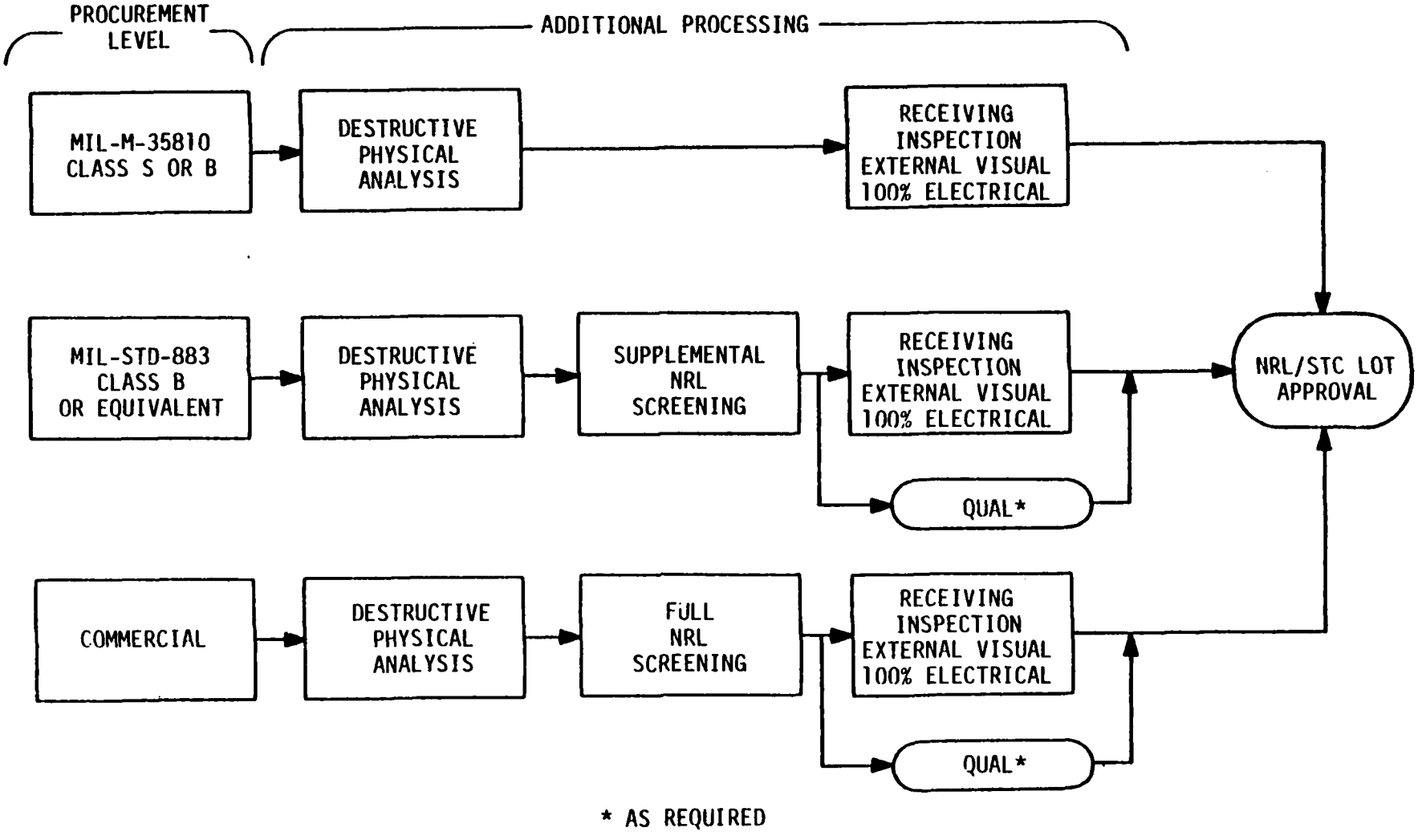


FIGURE 4-3: NRL/STC HIGH RELIABILITY PROGRAM INTEGRATED CIRCUITS

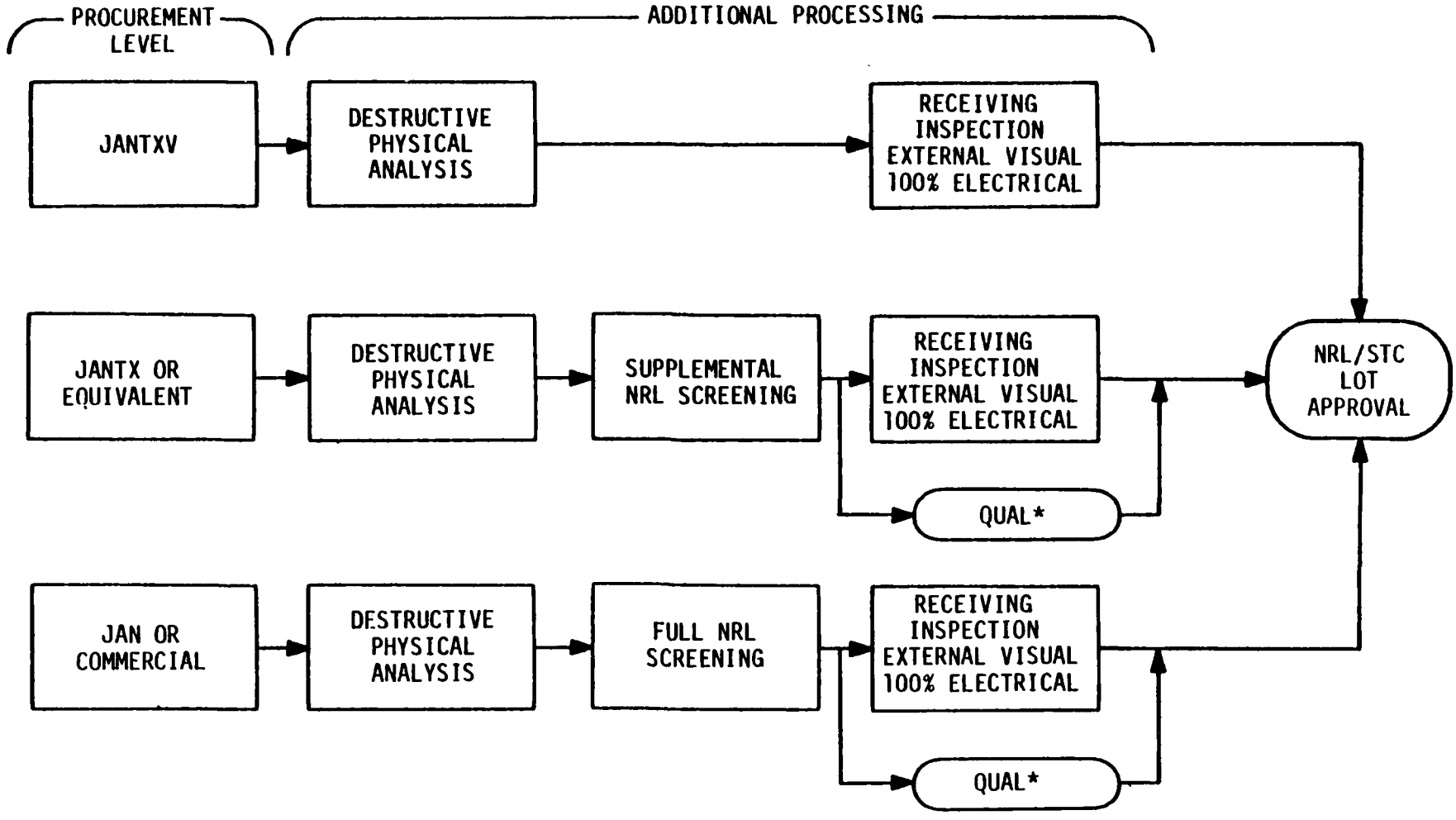
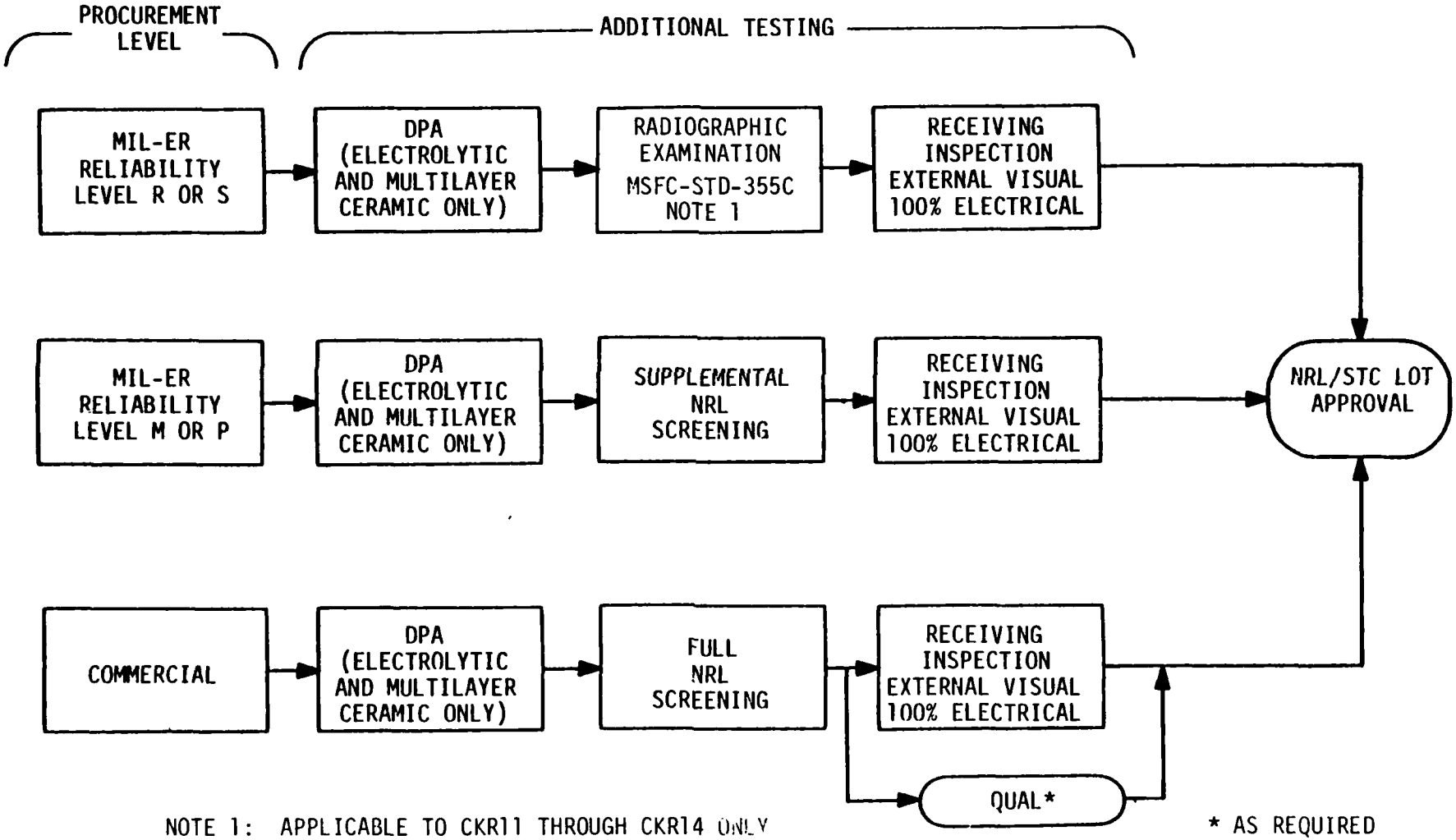


FIGURE 4-4: NRL/STC HIGH RELIABILITY PROGRAM FOR DISCRETE SEMICONDUCTORS



NOTE 1: APPLICABLE TO CKR11 THROUGH CKR14 ONLY

* AS REQUIRED

FIGURE 4-5: NRL/STC HIGH RELIABILITY PROGRAM FOR CAPACITORS

(RESISTORS, RELAYS, CRYSTALS, FUSES, FILTERS, COILS, INDUCTORS,
TRANSFORMERS, CONNECTORS, SWITCHES AND SPECIAL DEVICES)

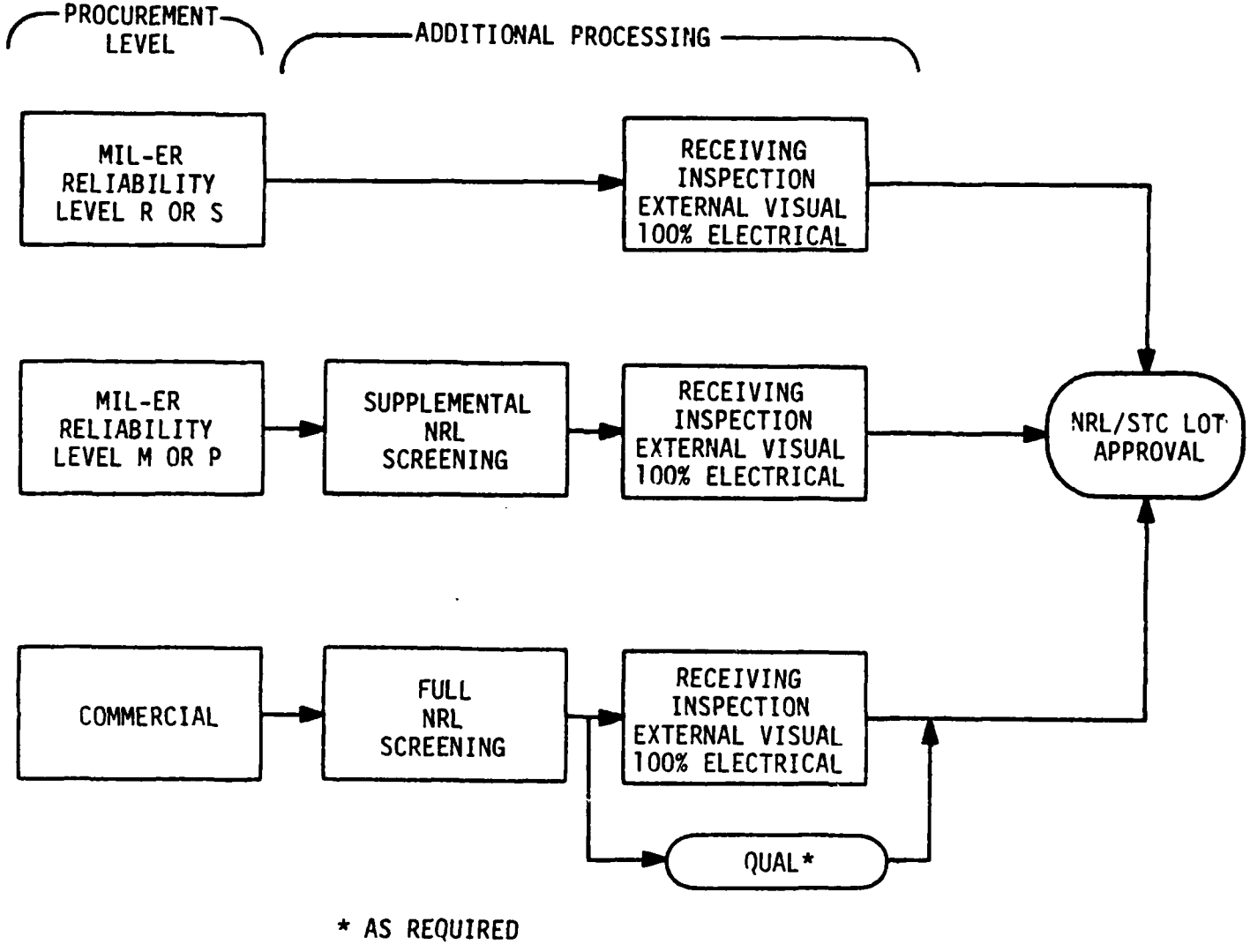


FIGURE 4-6: NRL/STC HIGH RELIABILITY PROGRAM FOR OTHER PASSIVE PARTS

maximum advantage of the high reliability parts programs available from the parts industry and upgrades the procured parts where necessary. This parts procurement and screening approach is discussed in detail in the following paragraphs.

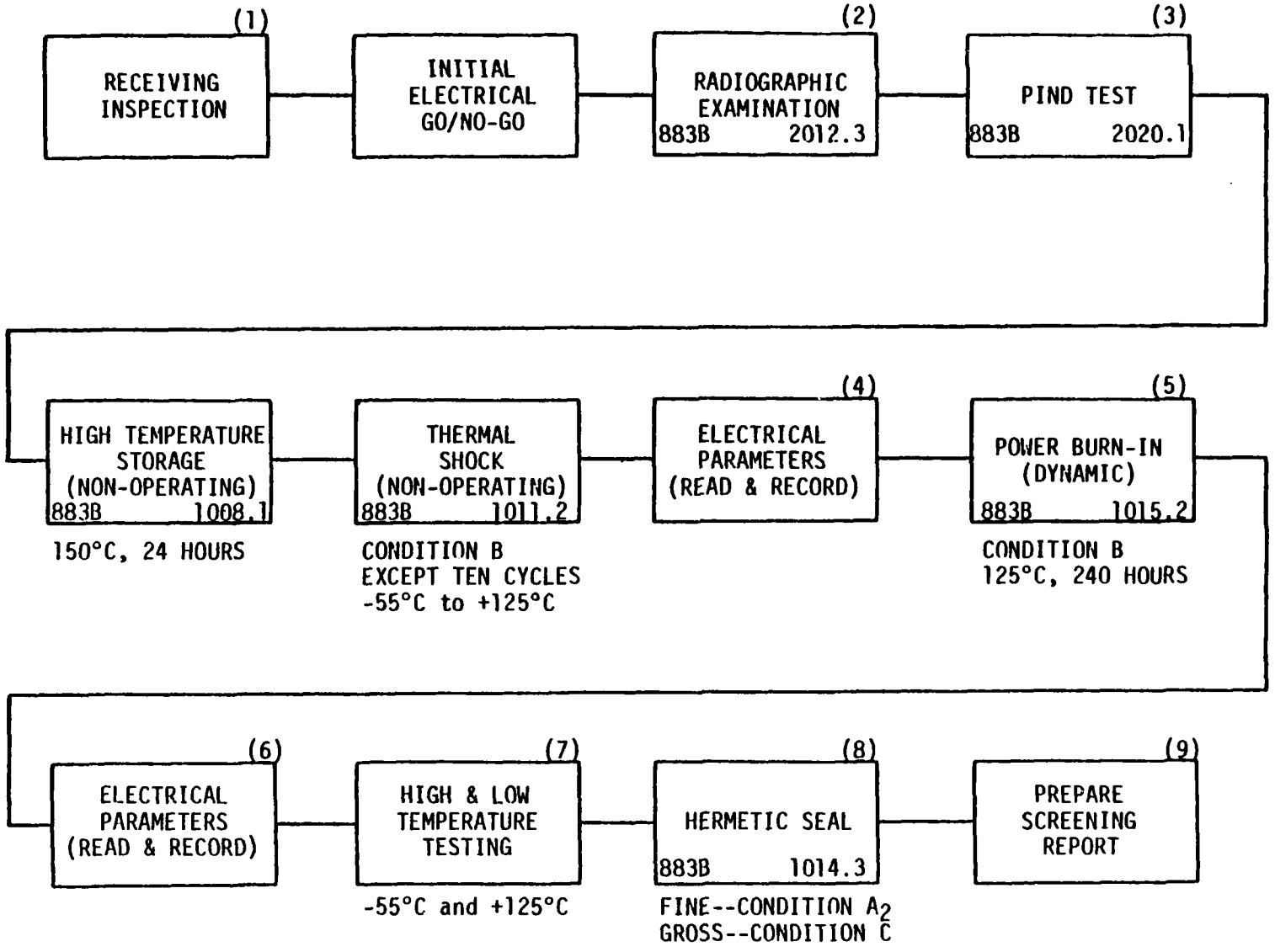
4.2.1 Parts Procurement Control

Parts for use on NRL/STC programs are procured to the high reliability military specifications whenever possible. When the parts required are not available to these high reliability specifications, parts are procured with the best reliability processing, testing, and inspections available and supplementary screens and inspections are performed as necessary. The procurement and processing of those parts that require supplementary screens and inspections are controlled by this plan.

4.2.2 Parts Screening

The purpose of the parts screening required by NRL/STC is to gain confidence by 100% nondestructive testing that each lot of parts to be used in flight spacecraft applications is free from incipient failures and to precipitate failure of any marginal devices. The parts screening tests and inspections are, therefore, those known to uncover the potential failure mechanisms of the parts. The full screening test and inspection methods, as defined by the applicable test documents and military standards, are presented in the screening flow diagrams of Figures 4-7 through 4-18. Full screening tests and inspections are required on industrial grade parts, while a supplemental screen is performed on parts that have been subjected to some level of reliability-oriented processing and testing not considered sufficient for the NRL/STC flight applications. The applicability of this supplemental screening is presented in Figures 4-3 through

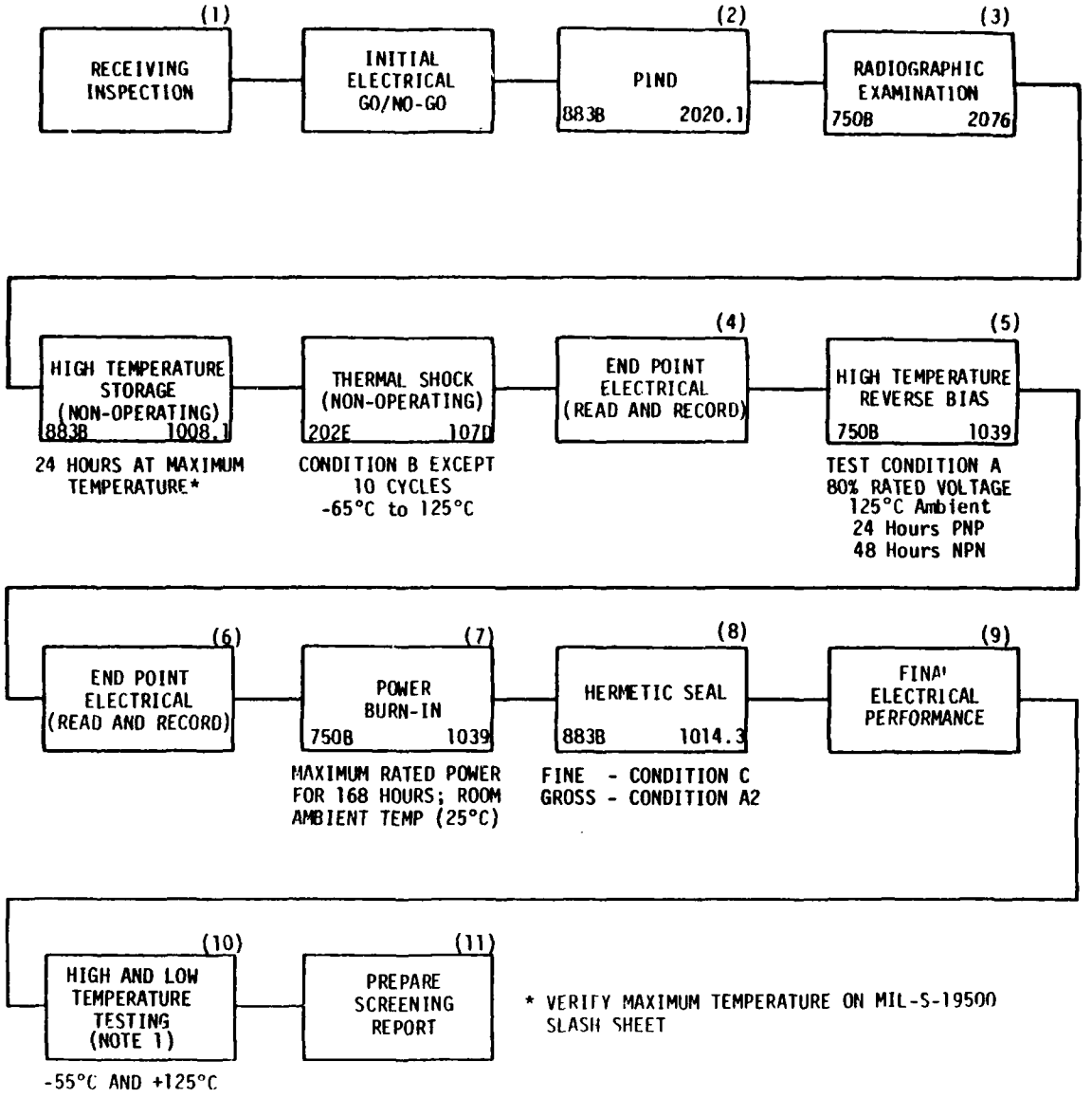
COMMERCIAL GRADE FULL SCREEN



MIL-STD-883B, CLASS B OR EQUIVALENT PARTS SUPPLEMENTAL SCREEN:
Steps (1) through (9) above, except that duration of Step (5) is 96 hours.

FIGURE 4-7: INTEGRATED CIRCUIT SCREENING FLOW DIAGRAM

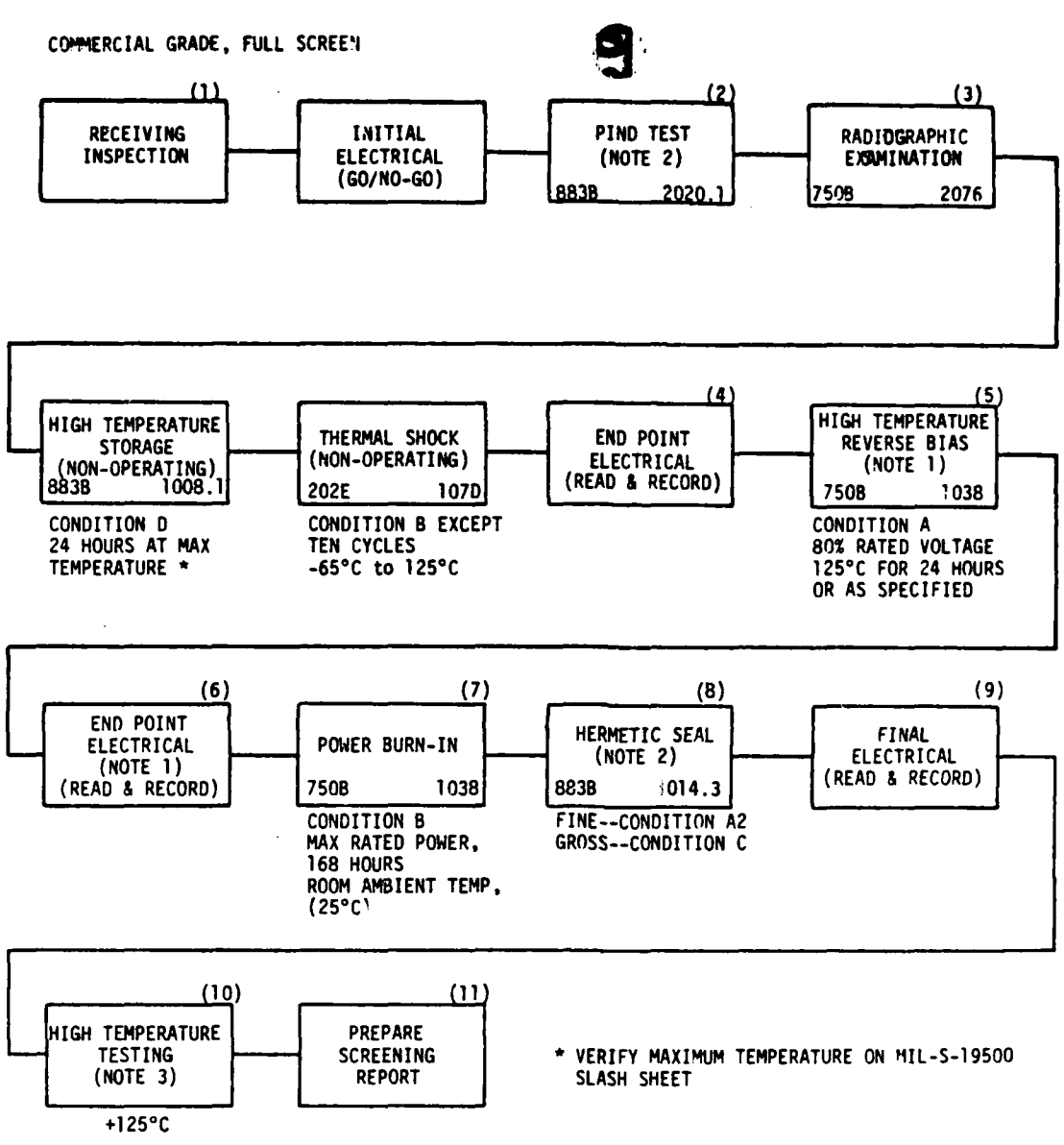
COMMERCIAL GRADE, FULL SCREEN



NOTE 1: USE SAMPLE WITH AN AQL OF 2.5%

JANTX OR EQUIVALENT PARTS, SUPPLEMENTAL SCREEN: Steps (1) through (11) above, except that duration of Step (7) is 96 hours.

FIGURE 4-8: TRANSISTOR SCREENING FLOW DIAGRAM

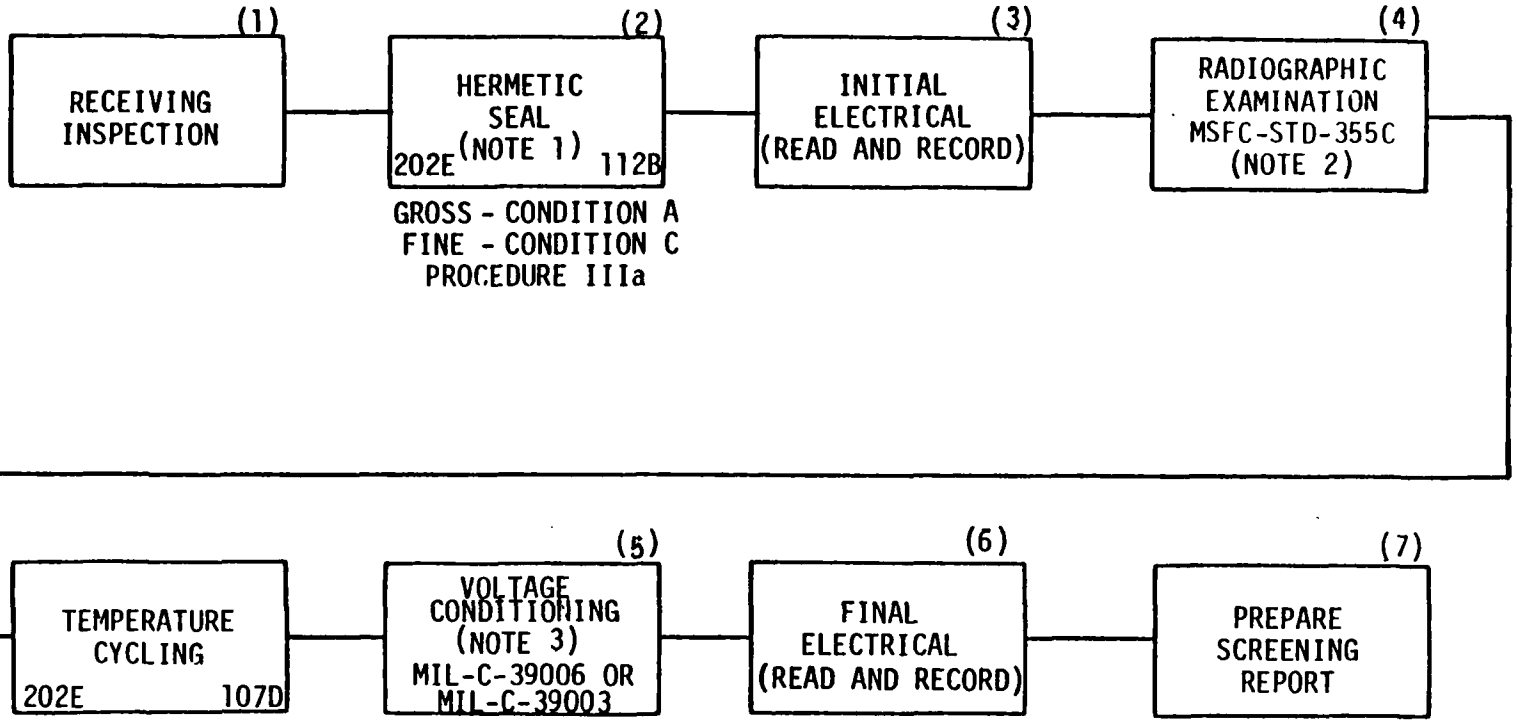


NOTE 1: NOT APPLICABLE TO ZENER AND REFERENCE DIODES
NOTE 2: NOT APPLICABLE TO DIODES WITHOUT CAVITIES
NOTE 3: USE SAMPLE WITH AN AQL OF 2.5%

JANTX OR EQUIVALENT PARTS, SUPPLEMENTAL SCREEN: Steps (1) through (11) above, except that duration of Step (7) is 96 hours.

FIGURE 4-9: DIODE SCREENING FLOW DIAGRAM

COMMERCIAL GRADE, FULL SCREEN

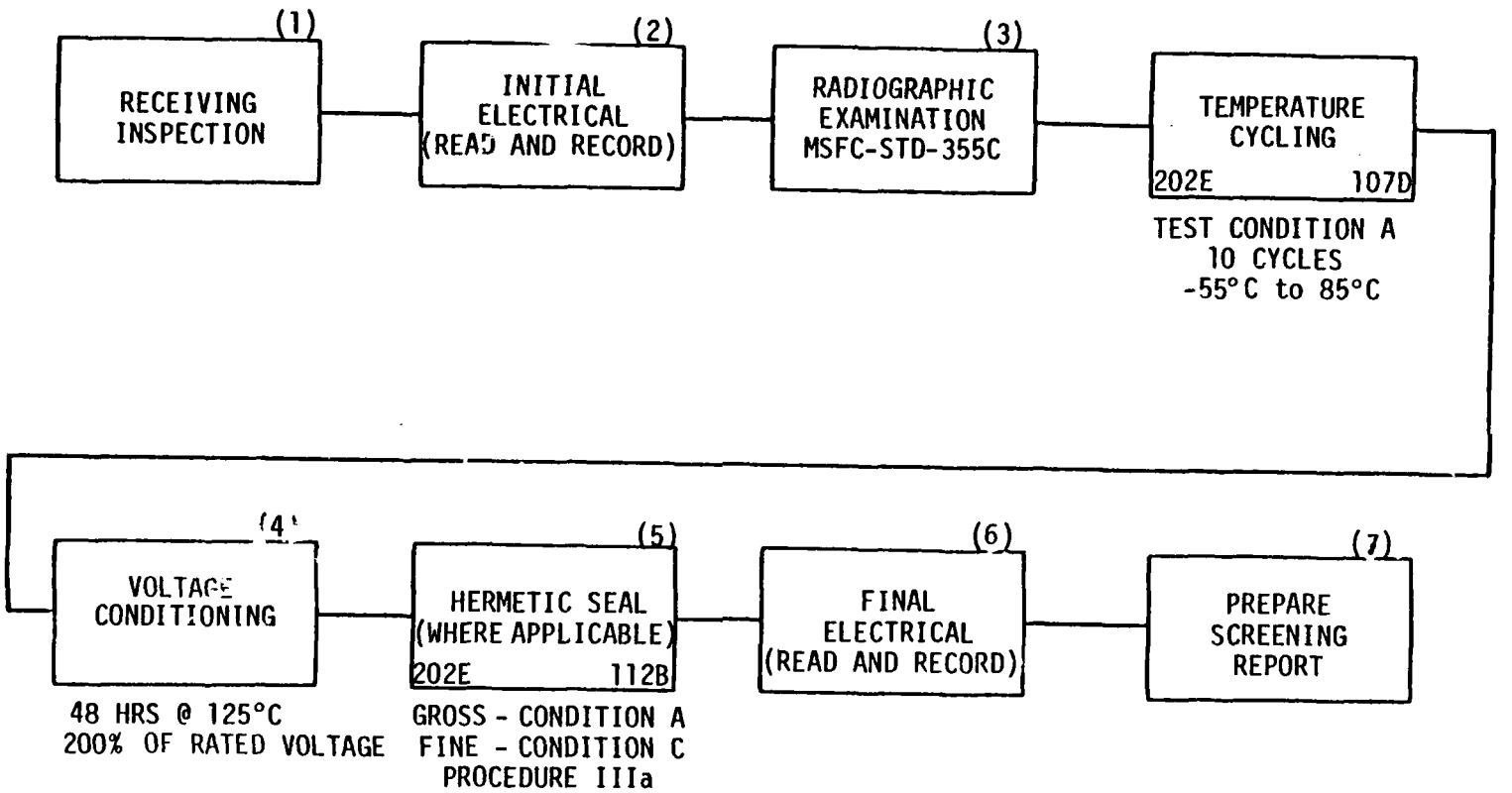


NOTE 1: Applicable to Hermetically Sealed Devices and Devices Without Sleeving Around Body
NOTE 2: Not Applicable to Wet Slug or Film Type Tantalum Capacitors
NOTE 3: Voltage Conditioning at 100% Rated Voltage and 85°C

M or P Level, Supplemental Screen: Steps (1) through (7) above, except that Step (3) is a Go/No-Go Test.

FIGURE 4-10: TANTALUM CAPACITOR SCREENING FLOW DIAGRAM

COMMERCIAL GRADE, FULL SCREEN

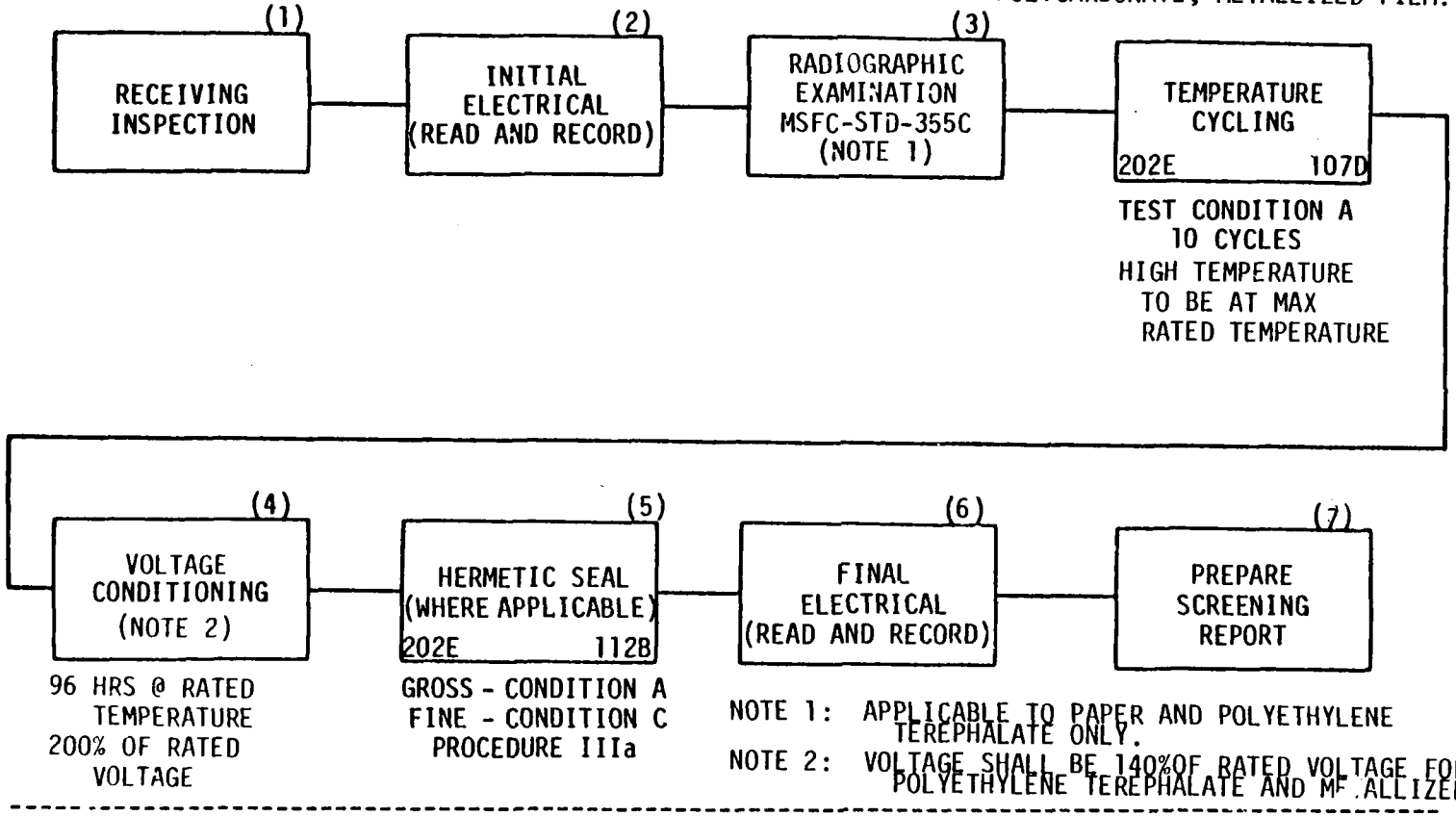


M or P Level, Supplemental Screen: Steps (1) through (7) above, except that Step (2) is a Go/No-Go Test and Step (3) is applicable to CKR11 through CKR14 only.

FIGURE 4-11: CERAMIC CAPACITOR SCREENING FLOW DIAGRAM

COMMERCIAL GRADE, FULL SCREEN

CAPACITOR TYPES INCLUDE: GLASS; PORCELAIN; MICA; PAPER; POLYETHYLENE TEREPHALATE; AND POLYCARBONATE, METALLIZED FILM.



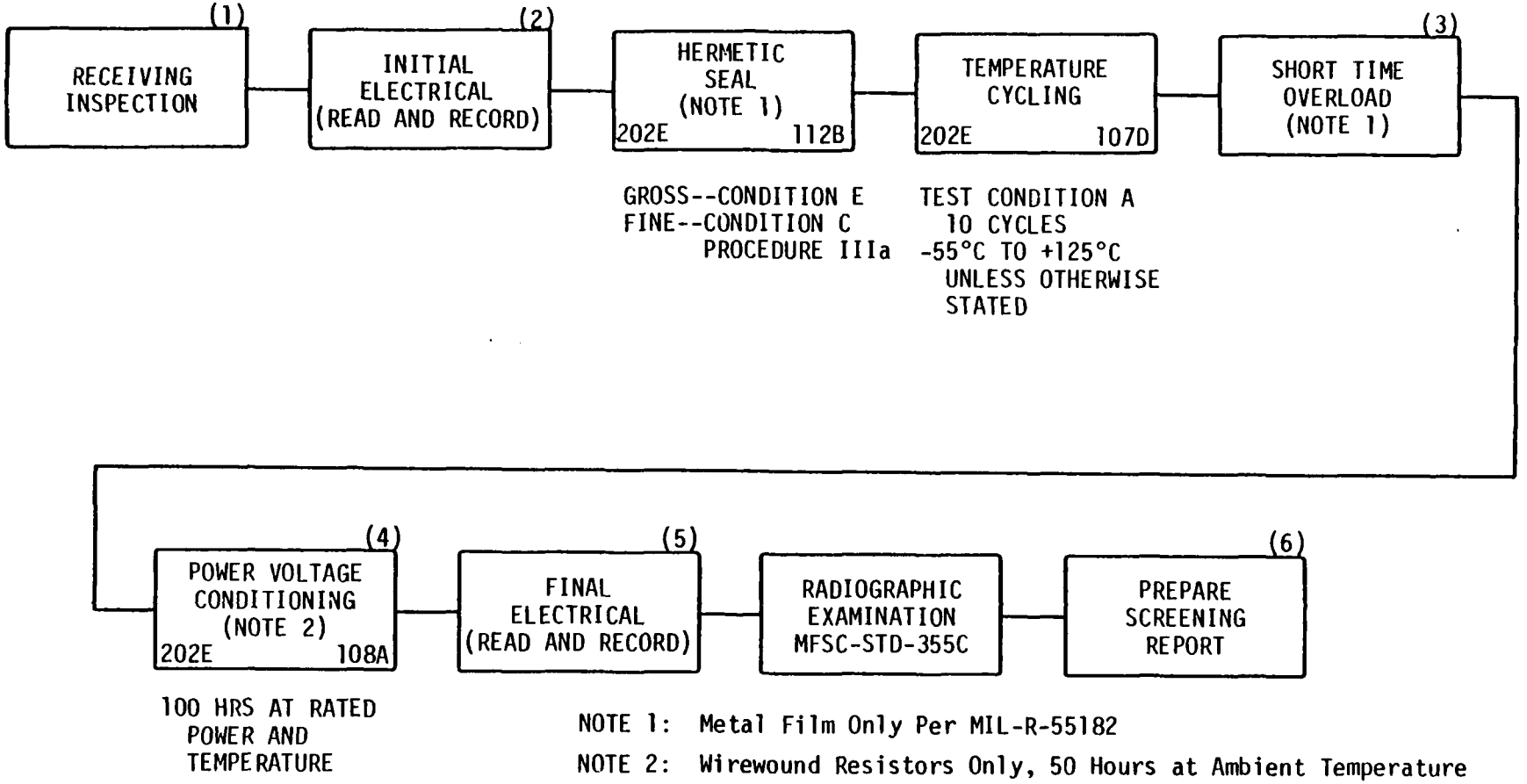
NOTE 1: APPLICABLE TO PAPER AND POLYETHYLENE TEREPHALATE ONLY.

NOTE 2: VOLTAGE SHALL BE 140%OF RATED VOLTAGE FOR PAPER, POLYETHYLENE TEREPHALATE AND METALLIZED POLYCARBONATE

M or P Level, Supplemental Screen: Steps (1) through (7) above, except that Step (2) is a Go/No-Go Test.

FIGURE 4-12: MISCELLANEOUS CAPACITOR SCREENING FLOW DIAGRAM

COMMERCIAL GRADE, FULL SCREEN



M or P Level, Supplemental Screen: Steps (1) through (6) above, except that Step (2) is a Go/No-Go Test.

FIGURE 4-13: RESISTOR SCREENING FLOW DIAGRAM

COMMERCIAL GRADE, FULL SCREEN

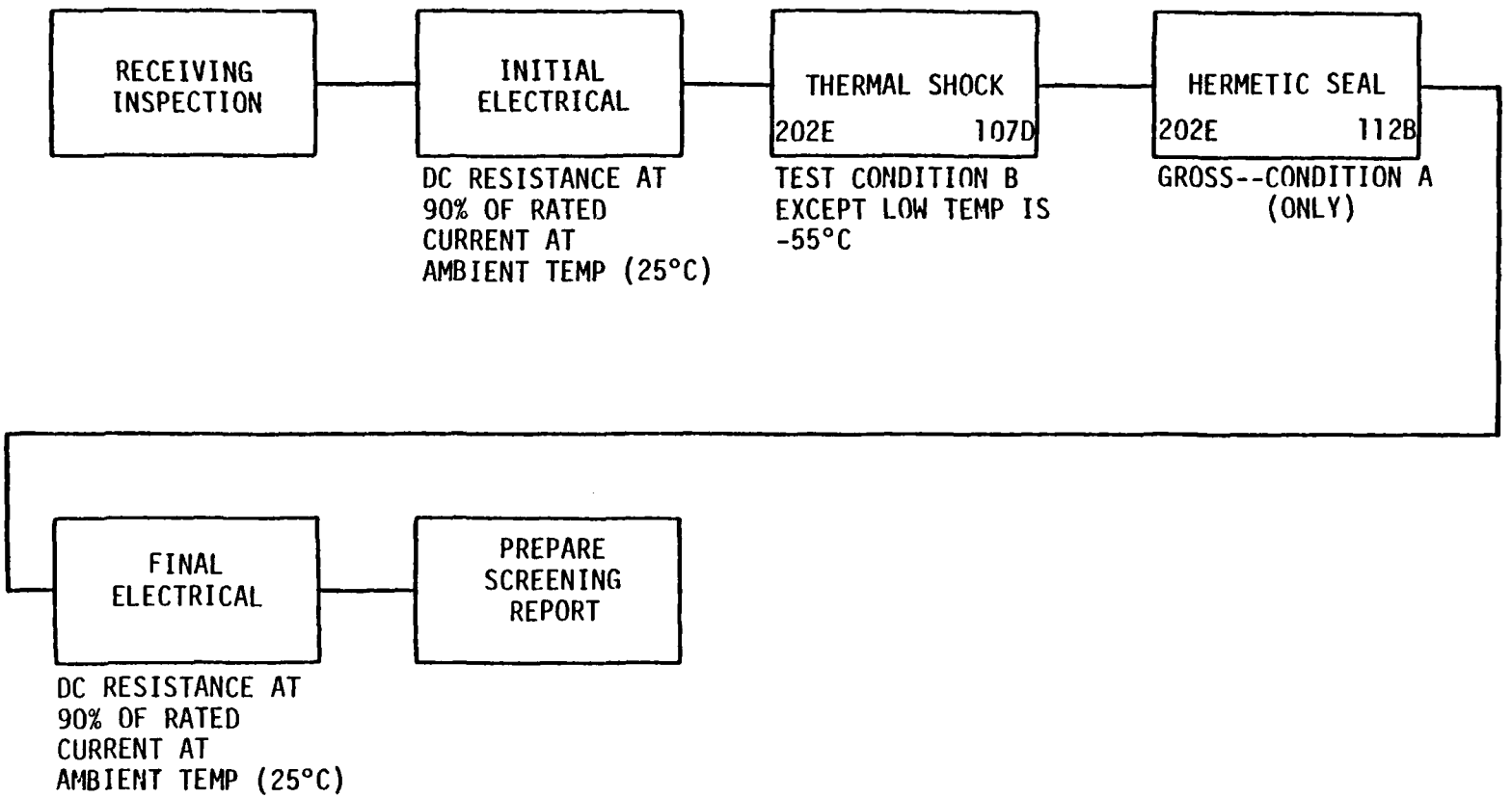
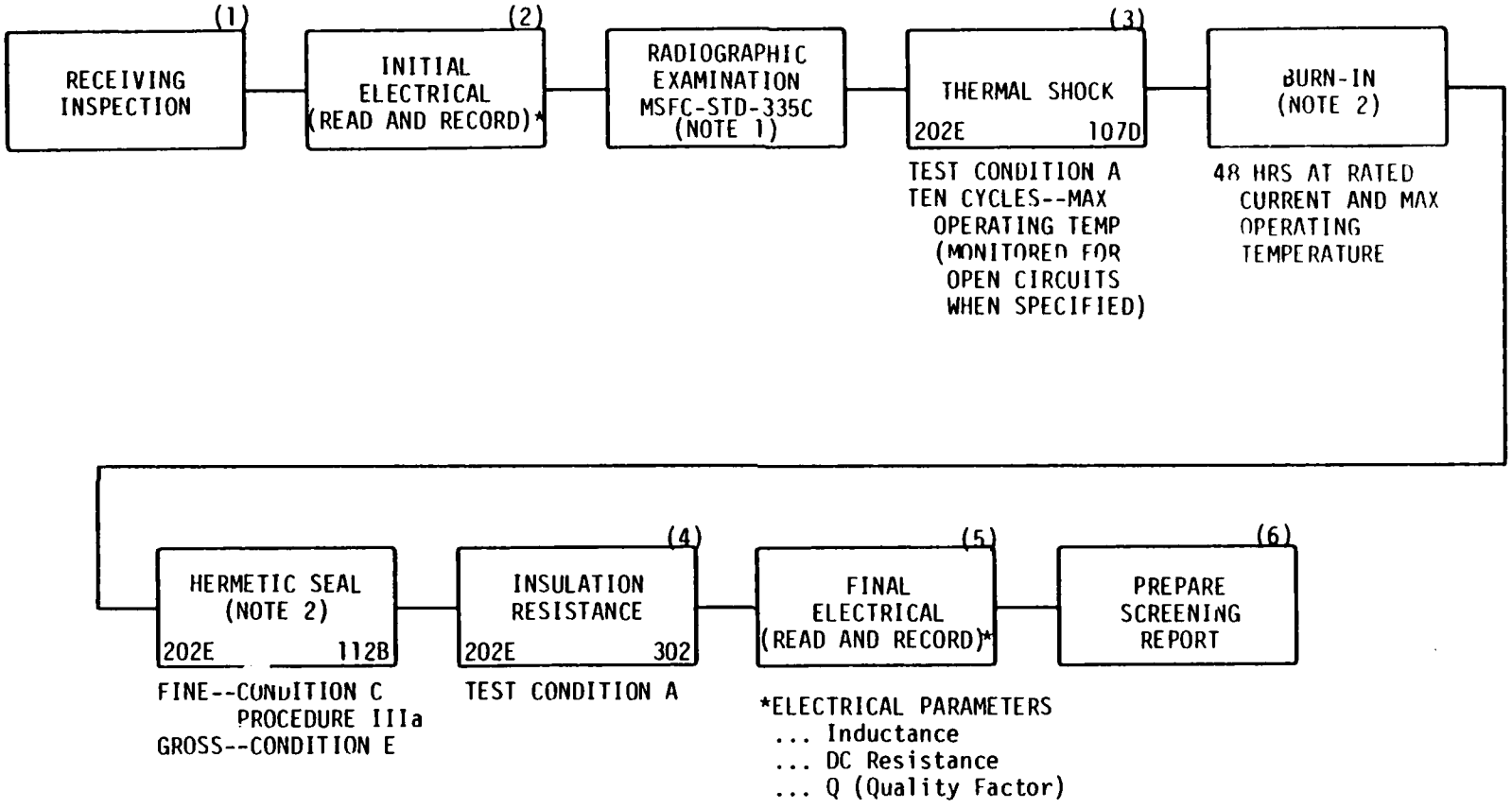


FIGURE 4-14: FUSE SCREENING FLOW DIAGRAM

COMMERCIAL GRADE, FULL SCREEN



NOTE 1: Applicable when specified by the device drawing.

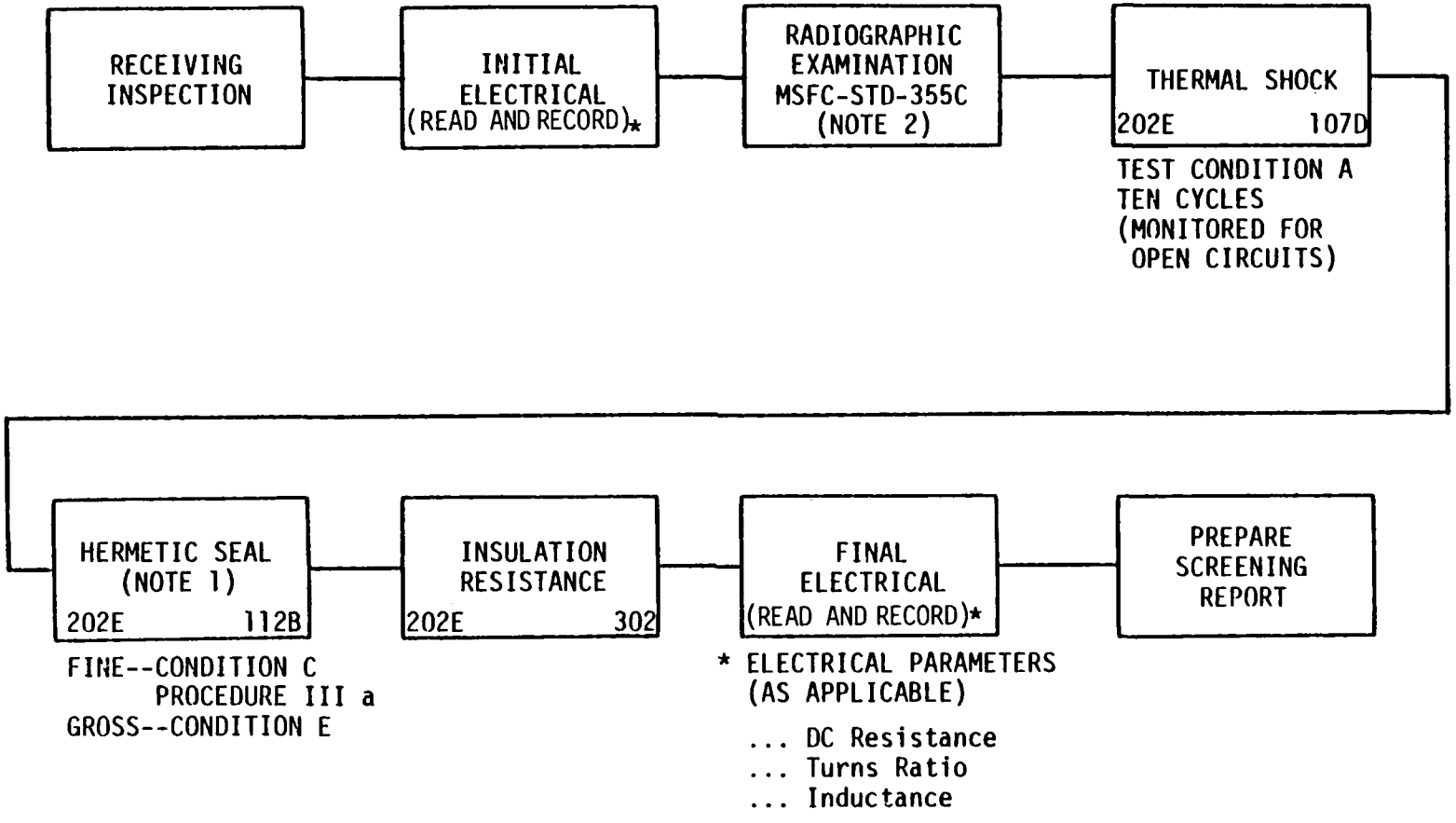
NOTE 2: Applicable to Molded, RF devices per MIL-C-39010.

NOTE 3: Applicable only to hermetic devices.

MS device types, Supplemental Screen: Steps (1) through (6) above, except that step (2) is a Go/No-Go Test

FIGURE 4-15: INDUCTOR SCREENING FLOW DIAGRAM

COMMERCIAL GRADE, FULL SCREEN



NOTE 1: Applicable only to hermetic devices.

NOTE 2: Applicable when specified by the device drawing.

FIGURE 4-16: TRANSFORMER SCREENING FLOW DIAGRAM

COMMERCIAL GRADE, FULL SCREEN

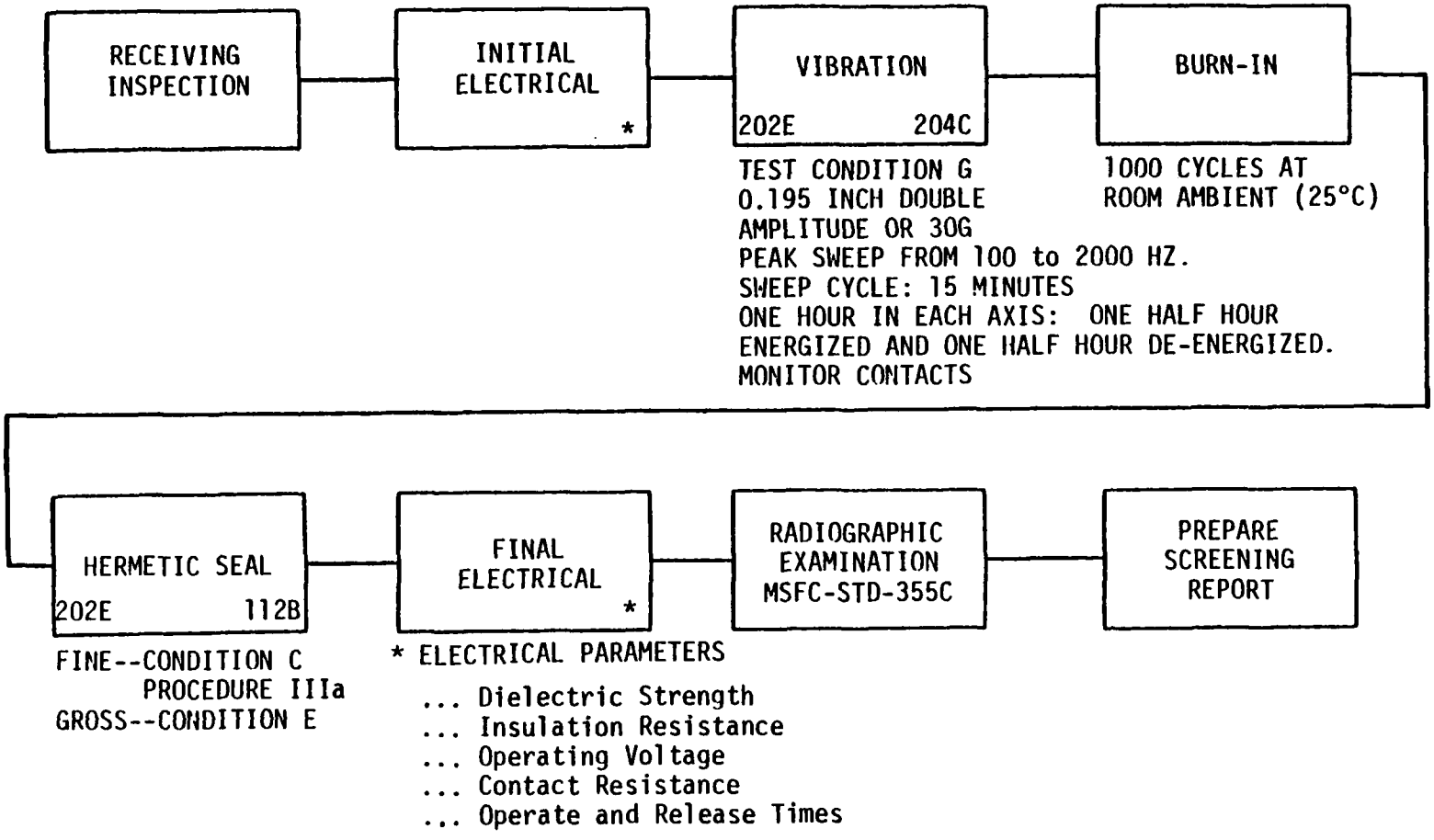
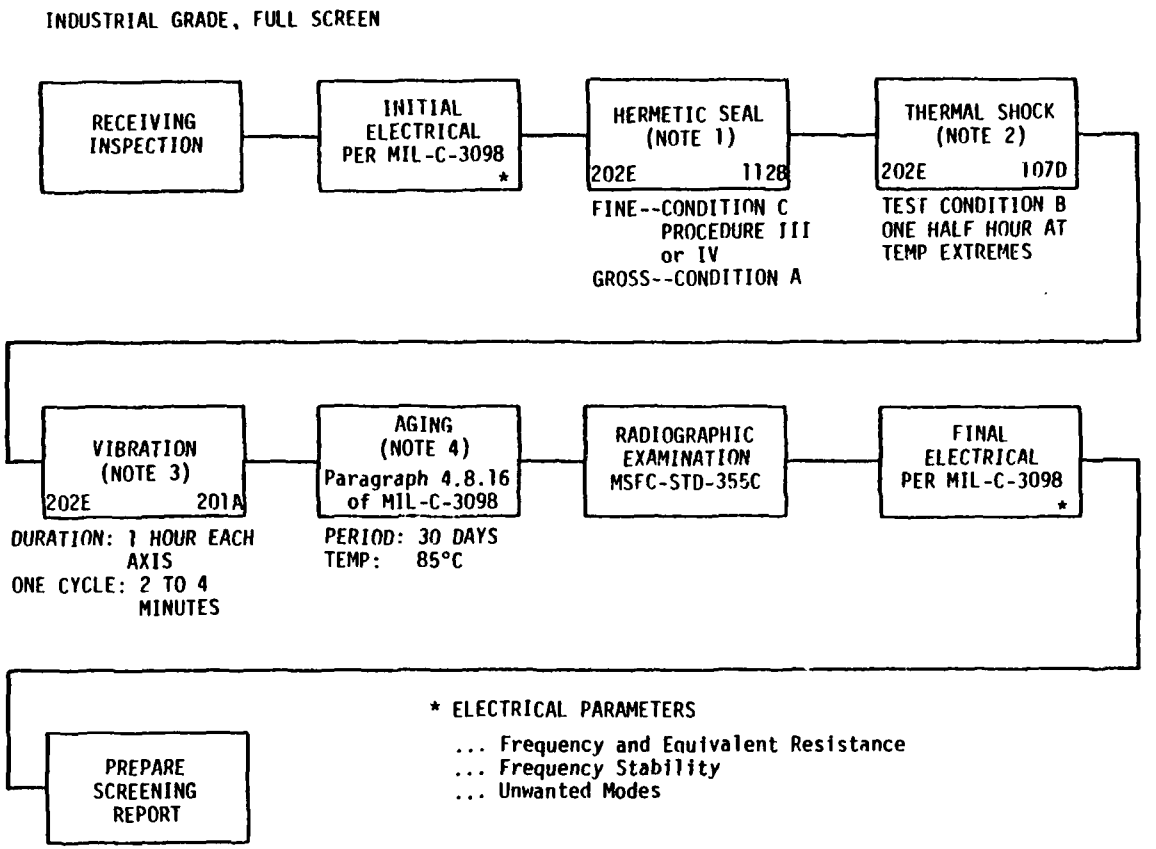


FIGURE 4-17: RELAY SCREENING FLOW DIAGRAM



NOTE 1: APPLICABLE TO CRYSTAL UNITS IN METAL HOLDERS. FOR UNITS IN GLASS HOLDERS, REFERENCE PARAGRAPH 4.8.13.2 OF MIL-C-3098.
NOTE 2: APPLICABLE TO CRYSTAL UNITS IN METAL HOLDERS. FOR UNITS IN GLASS HOLDERS, IMMERSE IN BOILING WATER FOR 15 SECONDS ±1 SECOND, AND THEN IN ICE WATER FOR 5 SECONDS ±1 SECOND.
NOTE 3: OPTIONAL VIBRATION TEST PER MIL-STD-202E, METHOD 204, TEST CONDITION A, DURATION OF 1 HOUR EACH AXIS.
NOTE 4: OPTIONAL ACCELERATED AGING: UNITS ABOVE 800 KHZ MAY BE AGED AT A TEMPERATURE OF 105°C, ±3°C, FOR 168 HOURS.

FIGURE 4-18: CRYSTAL SCREENING FLOW DIAGRAM

TABLE 4-2

ELECTRICAL PARAMETERS TO BE MEASURED AT
INTERIM AND FINAL TEST

PART TYPE	PARAMETERS TO BE MEASURED 100% @ 25°C at all electrical tests*
CAPACITORS	Capacitance, D_F, I_R
DIODES (All)	V_F, I_R, B_{VR}
TRANSISTORS (General)	h_{FE}, I_{CBO}, $V_{CE_{SAT}}$, BV_{CBO} (At Final Test, add BV_{CEO}, BV_{EBO}, and I_{EBO})
TRANSISTORS (FET)	BV_{DSS}, BV_{GSS}, I_{DSS}
INTEGRATED CIRCUITS (Linear)	DC Parameters, Gain
INTEGRATED CIRCUITS (Digital)	DC Parameters, Functional Performance (Propagation Delay Time also Tested for Critical Applications).
RESISTORS	Resistance

* Sample tests for industrial grade parts (AQL of 2.5%) at high/low temperature at final electrical test when specified.

NOTE: See individual screening charts for device types not covered by this table.

4-6. Electrical parameters tested during screening are identified in Table 4-2.

4.3 Destructive Physical Analysis

The Destructive Physical Analysis (DPA) is a thorough destructive analysis of the construction and workmanship of a sample of devices from a manufacturer's lot (a population of devices manufactured over a controlled period of time using the same processes). The purpose of the DPA is to evaluate the construction and workmanship evident in the sample devices, determine the adequacy and control of the processes employed, and utilize this information to assess the inherent reliability of the lot. The NRL/STC Destructive Physical Analysis procedure, STC-D-009, is contained in Appendix C. This analysis procedure is extremely effective in identifying parts with marginal construction/workmanship. The following part types are to be subjected to DPA:

- Integrated Circuits (Monolithic and Hybrid)
- Dual Transistors
- Transistors
- Diodes (Glass and Metal)
- Capacitors (Tantalum and Multi-layer Ceramic)
- Crystals
- Relays

4.3.1 DPA Sample Size

The DPA sample is selected randomly from each lot prior to screening. The DPA sample is determined from the lot size using a modification to MIL-STD-105, Sampling Plan S-3. This sample size-to-lot relationship is presented in Table 4-3.

TABLE 4-3

DESTRUCTIVE PHYSICAL ANALYSIS SAMPLE SIZE

PROCURED LOT SIZE	DPA SAMPLE
1 - 50	2*
51 - 100	3
101 - 150	4
151 - 200	5
201 - 500	8
501 - 3200	13

*Stud mounted transistors and active devices containing gold-aluminum metallization interfaces require a minimum sample of 3.

4.3.2 Analysis Procedure

The specific DPA steps accomplished on each of the aforementioned part types are presented in the analysis flow diagrams of Appendix C. These DPA flow diagrams identify the minimum quantity of devices from each sample to be subjected to the analysis/test activity. Where no quantity is specified, the entire sample is used. All parts are functionally tested prior to DPA.

4.3.3 DPA Accept/Reject Criteria

The pre-cap visual inspection criteria of the applicable military standards and the Scanning Electron Microscope (SEM) inspection criteria of MIL-STD-883B, Method 2018, are used as major inputs in the decision to determine acceptance or rejection. However, assessment of the specific anomalies encountered and their relationship to the long-term reliability of the associated lot of parts are performed and may override these criteria. This relationship can only be determined by thorough engineering knowledge and insight into the device fabrication processes and practical experience with the manifestations of both random and lot-oriented process anomalies and their reliability impact. The existence of cosmetic or clearly random anomalies is documented but is not used as a sole basis for recommending rejection. However, reliability degrading defects which indicate that a process, workmanship or assembly problem exists that is likely to be found throughout a lot or manufacturing time period is used as a basis for lot rejection, resampling for DPA, or special screening, as appropriate.

4.3.4 DPA Results Documentation

The DPA results, including all test and inspection results, supported by visual and Scanning Electron Microscope (SEM) microphotographs, are documented in a formal DPA report which is maintained in the NRL/STC part lot history file.

4.4 Receiving Inspections and Tests

Receiving inspections and tests are performed on all flight spacecraft parts to provide final assurance that the parts have been procured and processed in accordance with the NRL/STC

high reliability requirements. These receiving inspections and tests include:

- o 100% External Visual Examination of the parts.
- o Review of the data package accompanying the parts to verify that:
  - .... all required tests and inspections were performed and the parts passed;
  - .... there were no anomalous trends in the parts data or excessive fallouts; and
  - .... the sample Destructive Physical Analysis (DPA) was performed and was passed (when required).
- o 100% functional testing of the parts at ambient temperature.

When full screening is performed on a lot of parts, the receiving inspection is accomplished in conjunction with the final electrical tests performed as part of the screening program. If any failure trends are noted, the screening fallout devices are subjected to failure analysis as part of the receiving inspection lot acceptance/rejection decision. Authorization for the performance of a failure analysis will be the responsibility of the Product Assurance Section Head.

5.0 PROCURED EQUIPMENT PRODUCT ASSURANCE PROGRAM

5.1 General

Sections 4.0 and 6.0 describe the controls and procedures that are implemented on the NRL/STC fabricated modules and subsystems to meet the high reliability requirements for spacecraft. This section describes the controls which are implemented for procurement of equipments from contractors to assure that these equipments are also fabricated with a high inherent reliability and will not degrade the spacecraft performance.

The basic approach to procuring reliable equipments is to require contractors to adhere to the reliability plans and practices that are in existence for an equipment which is developed "in house" by NRL/STC. With these restrictions applied, the contractor-fabricated equipment incorporates the same quality and reliability as the NRL/STC equipments and maximized spacecraft reliability is achieved.

5.2 Procurement Controls

NRL imposes definitive specifications, acceptance criteria, and contractual requirements on its contractors for the reliability of their product and maintains adequate channels of communications. All contracts contain necessary provisions for surveillance of the contractor to assure satisfactory performance, assist in problem solution, and provide feedback for corrective action as necessary.

The following restrictions and requirements are, therefore, placed upon contractors:

1) Contractors are required to implement a parts procurement, screening, and qualification program in accordance

with Section 4.0. Screening, DPA, and qualification as appropriate, are performed by an NRL-approved source.

2) Contractors are required to fabricate hardware with NASA-approved soldering techniques and materials (reference NHB 5400.3(a)-1).

3) Contractors are required to perform module/subsystem reliability analyses on equipment in accordance with Section 3.0. NRL/STC may elect to have these analyses performed by an NRL-approved independent source.

4) Contractors are required to perform acceptance tests on each unit. Prior to testing, a detailed test plan is submitted to NRL for approval. In addition, a detailed test report, documenting the test results, is required.

5) Contractors are required to institute a failure reporting, analysis, and corrective action (FRACA) program compatible with the NRL/STC Discrepancy Reporting System. Copies of all applicable failure reports are required with each accepted module/subsystem.

6) Design reviews are held with NRL at specified intervals. At these reviews, the status of Quality and Reliability programs are reviewed. A documentation system which provides traceability from part to unit, similar to STC-D-007, is required.

7) NRL performs periodic inspections and audits of the contractor's program to assure compliance.

8) Contractors are required to have an inspection program compliant with MIL-I-45208, documented by an NRL/STC-approved Quality Assurance Plan.

6.0 NRL/STC EQUIPMENT PROCESSING

6.1 General

The fabrication, assembly, test, and repair of in-house equipment is controlled through implementation of Procedure STC-D-007, Flight Hardware Fabrication, Test and Repair (Appendix A).

6.2 Periodic Design Reviews

The design review policy for product assurance is described in Section 3.0.

6.3 Parts Program

The standard high reliability parts program is required with parts procurement, screening, and destructive physical analysis performed in accordance with Section 4.0. Parts selection is accomplished in accordance with Paragraph 4.1.1.

6.4 Breadboards

All new designs are breadboarded to verify functional performance, part stress levels, and assembly instructions and processes. Parts used in breadboarding of new designs need not be screened to the high reliability levels of flight hardware but must be completely interchangeable in form, fit, and function.

Parts and materials used for breadboard fabrication are not commingled with the high reliability bonded stores.

6.5 Inspections

In-process inspections of fabricated units is performed in accordance with MIL-I-45208 under the direction of the STC Product Assurance Section Head. As a minimum, two inspections are performed for each module as follows:

- o Release Package

  Inspect to assure all drawings, schematics, unique assembly process directions, parts, and required forms are included and properly completed.

- o Assembly Completion

  Inspect for quality workmanship, conformance to drawings, test results, and completeness of documentation.

Additional inspections are conducted when considered necessary by the Product Assurance Section Head.

6.5.1 Nonconforming Material

Material that does not conform to the workmanship standards, specification or drawing requirements, work or process instructions, configuration requirements, purchase orders and their requirements, or any contract requirements shall be reported using the Nonconforming Material Report form as specified in NRL/STC Procedure, STC-D-011 (Nonconforming Material, Control of) contained in Appendix D herein.

6.6 Failure Accountability and Analysis

All failures are reported on a Discrepancy Report as described in Section 8.0. Test and repair is accomplished in accordance with STC-D-007.

6.7 Qualification Test Program (New Designs)

Qualification testing of new design subsystems and units is performed to verify the ability of the subsystem to operate reliably in the expected use environment. A qualification test plan/procedure is prepared for each subsystem developed which

describes the tests to be performed, the test sequence, and the test measurements to be made. The qualification test plan/procedure defines the performance, EMI, thermal cycling, thermal vacuum, random vibration, and shock tests to be performed. The qualification test plan/procedure is subject to approval by the subsystem manager and the Product Assurance Section Head prior to start of the test program.

6.8 Acceptance Test Program

An acceptance test plan/procedure is prepared for each subsystem and unit. This plan and/or procedure is approved by the subsystem manager and the Product Assurance Section Head prior to the start of fabrication. The acceptance test plan/procedure specifies the EMI, vibration and thermal vacuum (thermal cycling) testing, and the high temperature, room ambient and low temperature performance testing required of each flight subsystem and/or unit. The number of thermal cycles from -10°C to +60°C is typically determined by the number of parts in the unit to be tested. If the unit has less than 1,000 parts, it typically undergoes six (6) thermal cycles. If the unit has more than 1,000 parts, it typically undergoes ten (10) thermal cycles.

7.0 SYSTEM TEST PROGRAM

7.1 General

NRL/STC system test programs are predicated on prior performance of lower level tests at the piece part and component levels to demonstrate performance and environmental acceptability prior to integration. Part tests are described in Section 4.0 under the parts program, while equipment tests are described under Sections 5.0 and 6.0 for equipment procurement and NRl processing, respectively.

The NRL/STC system test program includes a comprehensive integration and acceptance testing effort supplemented by Qualification testing for specific environmental parameters whenever previous qualification information is not available and analysis techniques are not considered sufficient.

7.1.1 Acceptance Tests

Acceptance tests consist of verification by analysis and verification by test of the ability of the spacecraft to withstand specified environments. Typical tests to be performed and the method of verification are shown in Table 7-1.

Prior to spacecraft integration all subsystems must successfully pass the subsystem qualification and acceptance tests described in Paragraphs 6.7 and 6.8.

7.1.2 Responsibility For Tests

Acceptance tests are conducted by the Spacecraft Technology Center under the direction of the Spacecraft Manager. Responsibility for test monitoring and reporting is assigned to the STC Product Assurance Section Head.

TABLE 7-1

ACCEPTANCE TEST PARAMETERS AND VERIFICATION METHOD

PARAMETER	VERIFICATION METHOD	
	ANALYSIS	TEST
SPIN BALANCE	X	X
CENTER OF GRAVITY	X	
MASS PROPERTIES	X	
ACCOUSTIC VIBRATION	X	X
RANDOM VIBRATION	X	X
SOLAR ARRAY DEPLOYMENT	X	X
FUNCTIONAL PERFORMANCE	X	X
EMI TEST	X	X
THERMAL VACUUM	X	X

7.2 Quality Control Procedures

Spacecraft Technology Center Procedure STC-D-007 (Appendix A) is the governing document for establishment of more detailed quality control procedures employed during spacecraft integration and test. Release sheets, subsystem repair action logs, and spacecraft log, along with any discrepancy reports, are maintained by Quality Control throughout the fabrication and test period to assure that the accepted hardware configuration and repair history are known.

7.3 Component History Record

The log and record sheets described in STC-D-007 constitute the entire component history package for the spacecraft and are maintained throughout the fabrication and test periods. These log and record sheets and their functions are as follows:

1) Form STQC-006, Module Release Sheet

This form defines the exact parts complement for each module by serial number. It also describes the rework accomplished and the location of each component in the module.

2) Form STQC-008, Subsystem Release Sheet

This form defines the module complement of each subsystem by slot and serial number. It also records the replacements made by slot, module serial number, and date of installation.

3) Spacecraft Log

This log records the date and serial number of each subsystem installation/removal action throughout the life of the spacecraft.

4) Discrepancy Report

This form is used to record all discrepancies which occur throughout the complete test cycle from the part level through spacecraft testing. A separate report is initiated for each discrepancy noted. It defines when the item failed, the environmental conditions, and the symptoms which were noted.

The Discrepancy Report also provides space for recording results of an analysis of the failed hardware and corrective action taken to prevent recurrence.

5) Subsystem Repair Action Log

This log provides a summary of each repair action by subsystem and serial number. All repair actions are referenced to the applicable Discrepancy Report.

Items 1) through 3) provide complete traceability of the spacecraft configuration by subsystem, module and component. Items 4) and 5) provide a complete failure and repair history for each level of spacecraft hardware.

7.4 Failure Analysis

A failure analysis is performed on all failures occurring during spacecraft integration and test. The analysis must be documented and summarized on the applicable discrepancy report and corrective action initiated before the discrepancy report can be closed out. The procedure for documenting failure analyses is described in Appendix B.

The extent and type of failure analysis performed is that required to determine failure cause and, therefore, varies from a simple witnessing or deduction of the failure cause (such as in the case of a test operator error that is recognized when it occurs) to a comprehensive analysis of the failed hardware, including tests and physical or chemical analysis as necessary.

Corrective action to be taken is that deemed necessary to preclude recurrence of the failure. Upon completion of the corrective action and closeout of the discrepancy report, copies are filed as specified by Procedure STC-D-007.

7.5 Data Reviews

Periodic data reviews are conducted by the Product Assurance Section Head to assure completeness and accuracy of data. These reviews are instituted at any time during the fabrication and test phase. However, specific review points specified by STC-D-007 are as follows:

- Module Release

  Review release package and module release sheet for completeness and accuracy.

- Subsystem Release

  Review release package and subsystem release sheet for completeness and accuracy. Assure that the applicable module release packages and applicable test sheets are incorporated in the subsystem package.

- Spacecraft Integration

  Review complete integration package. Assure that all module and subsystem documentation are incorporated in the spacecraft package. Assure that all test and repair procedures are available.

- Discrepancy Report Origination

  Review each Discrepancy Report initiated to assure completeness of documentation. Review package to assure that the applicable module/subsystem documentation package has been replaced whenever a module/subsystem is replaced. Assure completeness of all failure data.

- Completion of Acceptance Tests

  Review the acceptance test logs and data package for accuracy, completeness and achievement of requirements.

7.6 Test Reports

Test reports are issued upon completion of acceptance testing. The reports contain all test data sheets, a summary of tests performed, test results, problems encountered, and actions initiated to resolve those problems.

8.0 FAILURE REPORTING AND ANALYSIS

8.1 General

The failure reporting system employed by NRL/STC provides timely and appropriate evaluation of failures, discrepancies, and/or malfunctions that are directly related to the design and test program. A timely, complete, closed-loop discrepancy reporting system documents all failures which occur during acceptance testing to assure that all failures observed during the system testing are reported, evaluated from the reliability and operational viewpoints, analyzed, and then acted upon as necessary. This effort requires evaluation of design changes which may prevent recurrence of the failure mode and therefore improve the reliability of the equipment.

The Failure Reporting Analysis and Corrective Action (FRACA) Procedure, STC-D-008, is included as Appendix B. It requires the initiation of a failure report using a Discrepancy Report (DR) and a subsequent failure analysis and corrective action prior to DR closeout. The extent and type of failure analysis required to determine failure cause varies from a simple witnessing or deduction of the failure cause (such as in the case of a test operator error that is recognized when it occurs) to a comprehensive analysis of the failed hardware including tests and physical or chemical analysis as necessary.

8.2 Failure Reporting Format

The reporting of failures and/or troubles during system testing is accomplished through the use of the Discrepancy Report (DR) form shown in Figure 8-1. Discrepancy Reports are initiated on all failures which affect the operation of the system. DR's are not initiated on defects such as missing screws or paint chips, etc., which do not affect system operation.

	SPACECRAFT TECHNOLOGY CENTER DISCREPANCY REPORT	REPORT No. № 3015 DATE

	NAME	PART NUMBER	S/N
SYSTEM OR SUBSYSTEM			
LOWER HARDWARE LEVELS			

MALFUNCTION OCCURRED DURING	( ) Qualification Test ( ) Acceptance Test ( ) Integration Test ( ) Bench Test
ENVIRONMENT WHEN FAILED	( ) Acceleration ( ) Thermal-Vacuum ( ) Humidity ( ) Ambient ( ) Other ( ) Shock ( ) Temperature ( ) Vibration ( ) RFI/EMI
HARDWARE LEVEL WHEN FAILED	( ) Part ( ) Sub-Assembly ( ) Unit ( ) System ( ) Spacecraft

DESCRIPTION OF DISCREPANCY, INCLUDING SYMPTOMS AND TEST/ENVIRONMENTAL CONDITIONS

REPORTED BY:

HARDWARE REMOVED	NAME	PART NUMBER	S/N

REMOVED HARDWARE RESULTS AND HARDWARE DISPOSITION

PERFORMED BY:

CORRECTIVE ACTION

EFFECTIVITY	APPROVED	DATE

FIGURE 8-1: DISCREPANCY REPORT

8.3 Follow-Up Cycle

8.3.1 DR Distribution

The DR is initiated immediately upon failure occurrence by the engineer during all applicable test activities. The DR form consists of an original and one copy. The DR is written to document the occurrence of an anomaly and the level at which the anomaly occurred (system, subsystem, etc.). The original DR form remains with the hardware to document the complete failure analysis and corrective actions performed. The copy is sent to the Product Assurance Section and placed in a suspense file until DR closeout. The original DR is used as a shop traveller for the analysis and repair actions that are accomplished at the equipment level at which the anomaly occurs. If disassembly to a lower level and hardware removal are required for analysis and repair, these are noted on the original DR, and lower tier hardware DR's are prepared and used as shop travellers for the failed lower level equipments to document the failure analysis and corrective actions performed. The distribution procedure is described in greater detail in NRL/STC Failure Reporting, Analysis and Corrective Action Procedure, STC-D-008, contained in Appendix B.

8.3.2 Failure Analysis

Failure analysis is performed on all failures for which a DR is prepared, as described in Paragraph 7.4 and Appendix B.

8.3.3 Corrective Action, Closeout

The FRACA system is closed loop, requiring that any required corrective action on each hardware failure be in process prior to closeout. Closeout of each DR is accomplished when the project engineer and Product Assurance representative sign off the original DR.

Failures experienced are reviewed to detect any failure trends requiring corrective action not evident in the individual analyses. The trend analysis consists of reviews of the failures that may have resulted from the same or related causes which were not evident from the individual failure analyses. Analysis of the failure trends provides insights into underlying failure causes not always discernible at the individual failure level, such that further investigations can be made and corrective actions taken as required.

APPENDIX A

NRL/STC FLIGHT HARDWARE
FABRICATION TEST AND REPAIR PROCEDURE

STC-D-007

NOTE

THIS PROCEDURE IS INCLUDED FOR REFERENCE ONLY AND MAY NOT REFLECT THE LATEST REVISION.

FOR LATEST REVISION, CONTACT PRODUCT ASSURANCE SECTION HEAD.

	SUBJECT: FLIGHT HARDWARE FABRICATION, TEST AND REPAIR	NUMBER STC-D-007
		REVISION A
		PAGE 1 OF 8
POLICIES AND PROCEDURES	EFFECTIVE DATE: 5 JANUARY 1981	APPROVAL SIGNATURE: A.C. SALVATO

1.0 SCOPE

This document describes the procedure employed by the Spacecraft Technology Center of the Naval Research Laboratory to control the fabrication, assembly, test and repair of spacecraft hardware.

2.0 MODULE/SUBSYSTEM ASSEMBLY

An assembly operation is initiated by the responsible subsystem manager, who completes the Module Release Sheet of Figure 1 (Form STQC-006) or the Subsystem Release Sheet of Figure 2 (Form STQC-008). The completed module release sheet identifies the module by name and part number, and identifies the next higher assembly and system for which the module is to be produced. It also identifies the components and/or modules required to complete the assembly operations. The release sheet is transmitted to the Electronic Assembly Coordinator (EAC), who then acquires the necessary assembly drawings, schematics and any unique assembly process directions and unique parts and forms the initial release package. The EAC then forwards the release package to the Product Assurance Section Head for review. As part of this review, the Subsystem Repair Action (SRA) Log of Figure 3 is initiated by completion of the header information. The SRAL is placed in the release package for ultimate integration into the Spacecraft repair action file once the subsystem is installed in the Spacecraft.

The Release Package is then forwarded to high reliability stores, where the Parts Specialist assigns the module/subsystem serial number, acquires the required parts, components and/or modules from the STC bonded stock and records the part/module identity by lot and/or serial number on the release sheet. The parts are added to the Release Package and returned to the EAC for input to assembly. The package may be released to assembly with shortages if necessary. A shortages list is maintained on any release by the Parts Specialist and monitored to facilitate timely acquisition of the missing parts.

MODULE RELEASE SHEET (STQC - 006)
NDW-NRL-3900/7908 (3-75)

MODULE NAME	MODULE NUMBER
SYSTEM NAME	MOTHER BOARD
ORIGINATOR	PAYLOAD NUMBER

COMP.	VALUE	SN									

Parts Checked By

Parts Installed By

Location Check

Q. C. Check

Rework

Rework By

[illegible]

FIGURE 1: FORM STQC-006, MODULE RELEASE SHEET

SUBSYSTEM RELEASE SHEET (STQC - 008)
NDW-NRL-3900/7909 (3-72)

SUBSYSTEM NAME	SUBSYSTEM MGR.	
MOTHERBOARD NUMBER	PAYLOAD NUMBER	DATE

	NAME	DATE
M.B. INSPECTED		
TERMINALS INSTALLED		
TERMINALS INSPECTED		
MODULE INSTALLATION		
MECHANICAL ASSEMBLY		
CONNECTOR(S) SOLDERED TO M.B.		
CONNECTOR RING-OUT & WIRE CHECK		
MODULE LOCATION CHECK		
SUBSYSTEM Q.C.		

SLOT NUMBER	MODULE	S/N	REPLACEMENT					
			S/N	INSTALL.	DATE	S/N	INSTALL.	DATE

FIGURE 2: FORM STQC-008, SUBSYSTEM RELEASE SHEET

SPACECRAFT TECHNOLOGY CENTER

SUBSYSTEM REPAIR ACTION LOG

SUBSYSTEM _____ SPACECRAFT _____

SN _____ MB _____ MGR _____

DATE REMOVED	DISCREPANCY REPORT/REMARKS	INITIALS	REINSTALLED	INIT.

FIGURE 3: SUBSYSTEM REPAIR ACTION LOG

Upon completion of assembly, the completed item is returned to the EAC or Product Assurance Section Head for inspection. The inspection results and any rework requirements are recorded on an inspection road map which, as illustrated in Figure 4, is a reproduction of the assembly drawing. Once an assembled module/subsystem has been accepted, the release sheet is signed by the inspector. The accepted hardware and release package are then returned to the EAC, who removes and files the second copy of the release sheet with the inspection results. The assembled hardware is then transmitted to the subsystem Manager for test. The release package accompanies the released hardware through test. Upon successful test completion, it is transmitted to high reliability stores awaiting release to the next higher assembly. The module release packages are integrated into the appropriate subsystem release package.

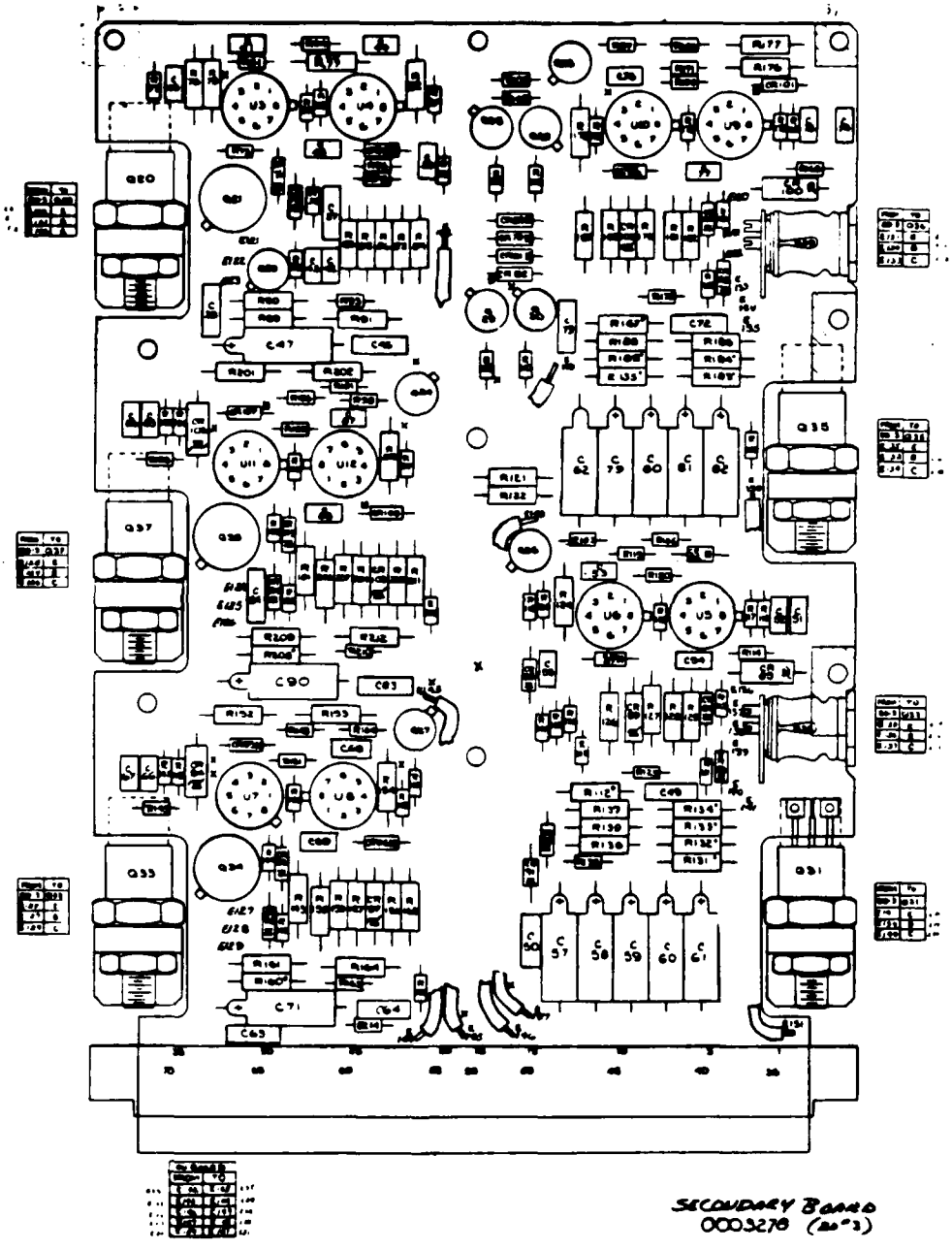


FIGURE 4: SAMPLE INSPECTION ROAD MAP

3.0 TEST AND REPAIR OF RELEASED HARDWARE

Any discrepancies noted on released flight or prototype hardware are recorded on the Discrepancy Report (DR) form of Figure 5 and processed in accordance with STC-D-008, NRL/STC Failure Reporting and Corrective Action Procedure. Any released hardware requiring repair is transmitted, accompanied by a DR and its release package to the EAC, who reviews the required repair action, makes a copy of the DR for his suspense file, acquires any replacement parts from the Parts Specialist (bonded stores), and transmits the hardware to assembly for repair. The repair is entered on the applicable Subsystem Repair Action Log Card (Figure 3) at this time.

Once the repair has been completed and the hardware is retested, the DR is completed, a copy filed in the STC assembly area, and the original placed in the module/subsystem release package. The hardware is then returned to the subsystem manager for retest and re-installed in the higher level of assembly or maintained in high reliability stores for use on another flight system. The repair Action Log is updated at this time.

4.0 SPACECRAFT CONFIGURATION RECORDS

Spacecraft logs are maintained on all flight spacecraft using the form of Figure 6. This form records the date and serial number of each module subsystem installation/removal action throughout the life of the spacecraft.

SPACECRAFT TECHNOLOGY CENTER
DISCREPANCY REPORT

REPORT No. № 3015

DATE

	NAME	PART NUMBER	S/N
SYSTEM OR SUBSYSTEM			
LOWER HARDWARE LEVELS			

MALFUNCTION OCCURRED DURING: ( ) Qualification Test ( ) Acceptance Test ( ) Integration Test ( ) Bench Test

ENVIRONMENT WHEN FAILED: ( ) Acceleration ( ) Thermal-Vacuum ( ) Humidity ( ) Ambient ( ) Other ( ) Shock ( ) Temperature ( ) Vibration ( ) RFI/EMI

HARDWARE LEVEL WHEN FAILED: ( ) Part ( ) Sub-Assembly ( ) Unit ( ) System ( ) Spacecraft

DESCRIPTION OF DISCREPANCY, INCLUDING SYMPTOMS AND TEST/ENVIRONMENTAL CONDITIONS

REPORTED BY:

HARDWARE REMOVED	NAME	PART NUMBER	S/N

REMOVED HARDWARE RESULTS AND HARDWARE DISPOSITION

PERFORMED BY:

CORRECTIVE ACTION

EFFECTIVITY	APPROVED	DATE

FIGURE 5: DISCREPANCY REPORT

IDENTIFICATION	ITEM	S/N	DATE INSTALLED	DATE REPLACED	S/N	DATE INSTALLED	DATE REPLACED	S/N	DATE INSTALLED

FIGURE 6: SPACECRAFT LOG

APPENDIX B

NRL/STC FAILURE REPORTING ANALYSIS AND
CORRECTIVE ACTION PROCEDURE
STC-D-008

NOTE

THIS PROCEDURE IS INCLUDED FOR REFERENCE ONLY
AND MAY NOT REFLECT THE LATEST REVISION

FOR LATEST REVISION, CONTACT PRODUCT ASSURANCE SECTION HEAD

	SUBJECT: FAILURE REPORTING ANALYSIS AND CORRECTIVE ACTION	NUMBER STC-D-008
		REVISION A
		PAGE 1 OF 12
POLICIES AND PROCEDURES	EFFECTIVE DATE: 5 JANUARY 1981	APPROVAL SIGNATURE: A.C. SALVATO

1.0 SCOPE

This document establishes a uniform procedure to be employed by the U.S. Naval Research Laboratory, Spacecraft Technology Center (NRL/STC) to control the Failure Reporting Analysis and Correction Action (FRACA) efforts on spacecraft hardware.

2.0 DOCUMENTS

The NRL/STC Discrepancy Report (DR) form (See Figure 1) shall be used for recording data/information required for all failures occuring during the design and test program which affect the operation of the system. Where more space is required the Discrepancy Report Continuation Sheet form of Figure 2 shall be used.

3.0 RESPONSIBILITIES

The NRL/STC Product Assurance Section Head shall be responsible for implementing and directing this FRACA program on hardware developed by NRL/STC. It shall be his responsibility to ensure that the failures and follow-up actions are adequately documented to enable resolution of all failures. He is also responsible for interpreting the requirements of this procedure and for approving and incorporating any changes.

4.0 PROCEDURES

4.1 Discrepancy Reporting

The DR shall be initiated immediately upon failure occurrence by the engineer during all test activities. The engineer shall assure that all relevant information is included and that the DR is complete and accurate.

SPACECRAFT TECHNOLOGY CENTER
DISCREPANCY REPORT

REPORT No. Nº 3015

DATE

	NAME	PART NUMBER	S/N
SYSTEM OR SUBSYSTEM			
LOWER HARDWARE LEVELS			

MALFUNCTION OCCURRED DURING: ( ) Qualification Test ( ) Acceptance Test ( ) Integration Test ( ) Bench Test

ENVIRONMENT WHEN FAILED: ( ) Acceleration ( ) Thermal-Vacuum ( ) Humidity ( ) Ambient ( ) Other ( ) Shock ( ) Temperature ( ) Vibration ( ) RFI/EMI

HARDWARE LEVEL WHEN FAILED: ( ) Part ( ) Sub-Assembly ( ) Unit ( ) System ( ) Spacecraft

DESCRIPTION OF DISCREPANCY, INCLUDING SYMPTOMS AND TEST/ENVIRONMENTAL CONDITIONS

REPORTED BY:

HARDWARE REMOVED	NAME	PART NUMBER	S/N

REMOVED HARDWARE RESULTS AND HARDWARE DISPOSITION

PERFORMED BY

CORRECTIVE ACTION

EFFECTIVITY	APPROVED	DATE

FIGURE 1: DISCREPANCY REPORT FORM

SPACECRAFT TECHNOLOGY CENTER
DISCREPANCY REPORT CONTINUATION SHEET

REPORT No.

DATE

ADDITIONAL DESCRIPTION AND SIGNIFICANT PARAMETERS (WAVEFORMS, VOLTAGES, GRAPHS, ETC.)

PERFORMED BY:

FIGURE 2: DISCREPANCY REPORT CONTINUATION SHEET

4.1.1 Distribution. The NRL/STC form is provided with an original and one yellow copy. Distribution of the original, the yellow copy and any additional reproduced copies shall be as described below. The DR report number shall be referenced in all logs as appropriate to enable location of the DR copy in the Product Assurance Section Files.

1. Original (White). The original copy shall remain with the failed system, unit, assembly, module or part and perform the function of a shop traveller until the failure analysis is completed. Upon completion and close-out of the DR, the original shall be made a part of the equipment release documentation package.

2. Copy (Yellow). The yellow copy shall be sent to the Product Assurance Section. This copy shall remain in a suspense file until the failure analysis and corrective action is completed and a copy of the completed and approved original copy is received by the Product Assurance Section for close-out of the DR.

3. Reproduced Copies. A reproduced copy of the original shall be provided to the responsible Project Engineer. Copies of the finalized original shall also be provided to the Project Engineer and the Product Assurance Section for formal DR closeout.

4.1.2 Additional DR's. Additional DR's shall be used to document the sequence of events on any hardware item removed from the original failed item. (The first DR remains with the original failed item.) The number of additional DR's shall be those necessary to completely document the sequence of events from higher level assemblies to the failed part.

In each case where a new DR is initiated, the previous DR shall be referenced so that a particular failure can be traced from initial failure occurrence to the final analyzed cause and corrective action. The previous DR will also

reference the new DR. The following example illustrates the manner in which the DR's are prepared and copies are distributed.

EXAMPLE:

A failure occurs during a system level test and the fault is isolated to a module. The top half of the DR form is prepared for the system. When the system is disassembled and the module is removed from one of the system unit assemblies, the module identification data is entered in the "Hardware Removed," "Name," "Part Number," and "S/N" blocks on the system level DR. A module level DR is then prepared and the report number of the system level DR is entered in the space provided for "Description of Discrepancy, Including Symptoms and Test/Environmental Conditions." In like manner, the module level DR report number is referenced on the system level DR in the space provided for "Removed Hardware Results and Hardware Disposition."

Distribution of the DR's is as follows:

The yellow copy of both the system DR and the module DR are sent to the Product Assurance Section. The original of the system DR remains with the system documentation package and the orignal of the module DR remains with the failed module to function as a shop traveller during the failure analysis and repair of the module. A copy of each of the system and module DR originals is reproduced and provided to the project engineer.

If further failure analysis is required of the failed parts removed from the module, a third level DR is prepared for the parts in the same manner as described previously for the module. The parts level DR original will accompany the failed parts through failure analysis. When the analysis is completed, the "Corrective Action" block of the parts DR is filled in and the analysis and repair/inspection data is entered on the module DR in the "Removed Hardware Results Disposition" and "Corrective Action" blocks. The data from the module

and part level DR's is summarized on the system DR original and the Project Engineer and a representative of the Product Assurance Section will complete the "Effectivity," "Approved" and "Date" blocks on the original. The parts DR original is retained by Product Assurance. The module DR original is filed with the module documentation package. The system level DR original is filed with the system release documentation package, and two copies of the parts, module and system DR originals are distributed as follows:

One copy is provided to the Project Engineer;
One copy is retained by Product Assurance to close out the FRACA suspense file.

4.2 Failure Analysis

Failure Analysis shall be performed on all failures for which a DR is prepared to determine cause so that the necessary corrective action can be taken to maintain system reliability. The investigations shall be performed to the level of detail necessary to resolve the problem.

The Product Assurance Section shall also determine what failed parts require detailed failure analysis based on information such as:

a) Data provided by the formal discrepancy reporting system.
b) Narrative engineering reports and lots.
c) Personal contact with engineering and test personnel.

4.2.1 Accountability For Parts. Disposition of parts after failure analysis shall be as directed by the Product Assurance Section.

4.2.2 Reporting Procedures. A formal failure analysis report shall be prepared by any laboratory performing an investigation and forwarded promptly to the Product Assurance Section.

4.3 Corrective Action

The Product Assurance Section shall review the status of each DR on a regular basis to assess the progress of the failure reporting and corrective action system.

Required corrective action shall be in-process prior to close-out of the DR. Close-out of each DR will be implemented by the project engineer after corrective action has been undertaken. Close-out is accomplished by both the project engineer and the product assurance representative signing the original DR and forwarding a copy to the Product Assurance Section.

5.0 INSTRUCTIONS FOR COMPLETING DOCUMENTS

5.1 DR Form

5.1.1 DR Form Organization. The original Discrepancy Report Form serves as a master upon which all update information will be entered. The DR is divided into four major sections:

Hardware Description and Environmental Data

The top section of the DR is completed by the originator. It identifies the hardware levels and conditions under which the failure occurred.

Description of Discrepancy

This section is completed by the originator. It is used to define the nature of the report, describe the problem(s) encountered, to identify parts or modules replaced and other pertinent data. The continuation sheet shall be used if more space is required.

Removed Hardware Results

This section is used to record the results of investigations and analyses performed and conclusions covering the reasons for the failures or problem. Reference to failure analysis reports or other documents is made in this section. The continuation sheet shall be used if more space is required.

Corrective Action

This section is used to describe the recommended corrective action. Corrective action document numbers as well as narrative indicating completion of corrective actions should be included. A continuation sheet shall be used if more space is required. Close-out of the DR is accomplished by authorized signatures from:

a) Project Engineer
b) Product Assurance

5.1.2 Detailed Instructions. Figure 3 shows a copy of the DR form with instructions for each block item. The applicable information required shall be incorporated as available. In those instances where the specified data is not available, the block shall be marked "NA".

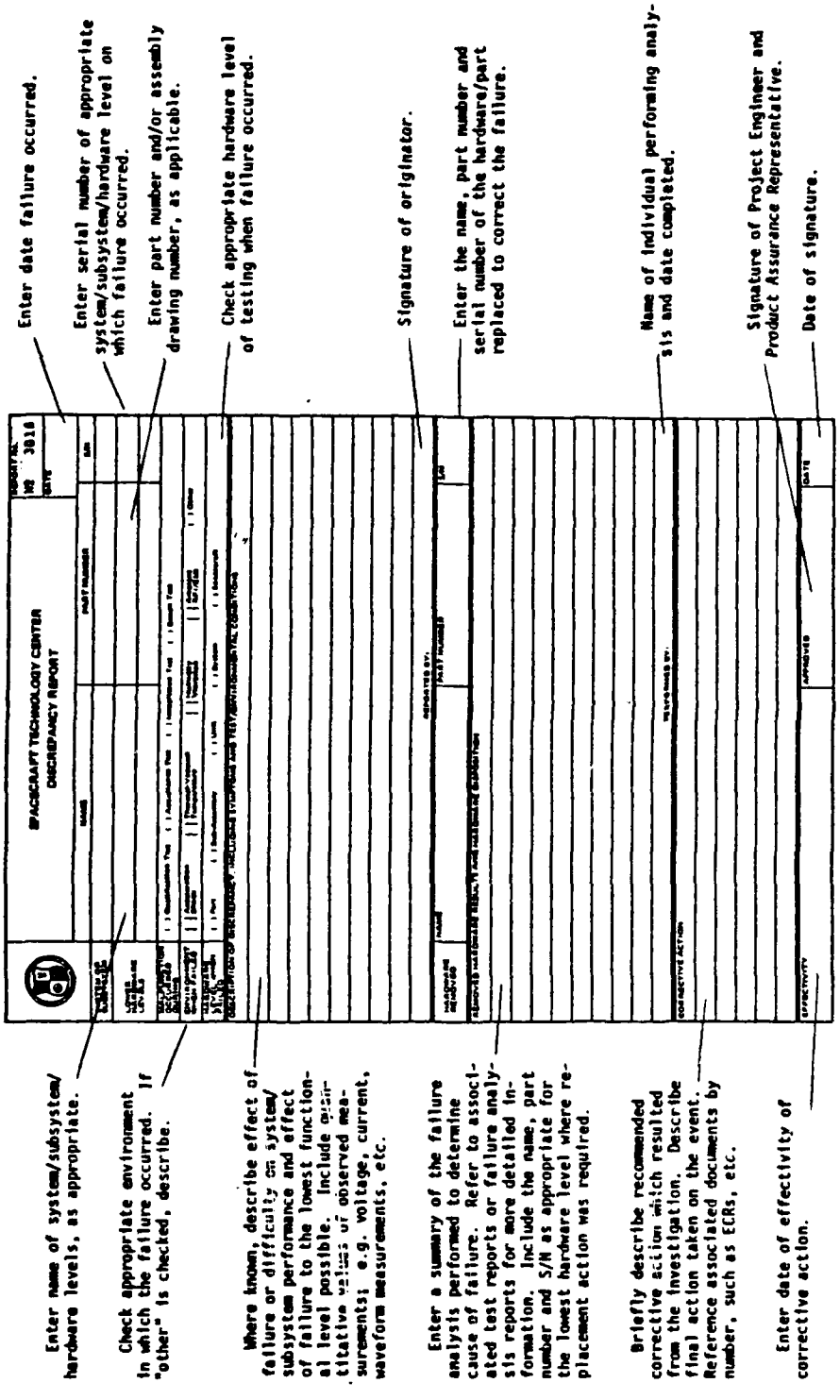


FIGURE 3: INSTRUCTIONAL DR FORM

5.2 Failure Analysis Report

A Failure Analysis Report shall be completed by the activity performing the failure analysis. Format is optional provided the following minimum information is included:

a) Engineer - The name of the engineer responsible for performing the analysis.

b) Activity Performing Analysis - The name of the contractor, subcontractor or other agency performing the analysis.

c) Date Failed Parts Submitted for Analysis - The date that the failed parts were made available to the analyst.

d) Date Analysis Completed - The analyst shall specify the date that the analysis investigation was completed.

e) DR Number - The serial number of the DR shall be included.

f) Classification of Failure (Modes) - A statement of the primary defect or damage as determined by the analyst shall be included; e.g., Capacitor Shorted.

g) Narrative Discussion - The cause of failure shall be discussed in the report. For example, the analyst shall describe the procedures used in locating and defining the defect or damage and a statement of the results obtained. Methods used by the analyst, such as electrical or mechanical measurements, X-rays, dissection, or manufacturer or user tests shall also be included in the discussion.

h) Responsibility for Failures - A statement identifying the area or functional organization which in the analyst's opinion was principally responsible for the defects or damage shall be included. For example, the responsibility could be assigned to the equipment designer, the manufacturer, or the user.

i) Recommendations - The analyst's recommendation for improving the situation shall be included. As applicable, recommendations shall include revision of manufacturing or handling processes, revision of a specification, revision to the design or a component, or a change to another component known to be of better quality and higher reliability.

6.0 DEFINITIONS

The following definitions shall apply:

Failure - Any trouble in a part or assembly evidenced by one or more relevant characteristics not conforming to specified limits.

Failure Analysis - Investigations required to determine mode and cause of significant failure or malfunctions in order that necessary corrective action can be taken to improve reliability.

Failure Analysis Laboratory - Facilities with which detailed investigation will be performed on failed parts, components, assemblies, etc.

Failure Cause - The reason for (external to the device) that the condition that resulted in failure exists.

Examples:
a) Improper cleaning
b) Excessive temperature
c) Contaminated welder atmosphere
d) Excessive power in field application

Failure Mechanism - The physical or chemical condition (within the device) from which the failure directly resulted.

Examples:
a) Cracked wire
b) Surface contamination
c) "Open" weld
d) Melted or burned internal parts

Failure Mode - Most frequent types (mechanisms) of electrical or mechanical failure in electrical components, such as fused open emitter or cracked wafer.

Hardware - Any item identifiable as a part of the overall system.

Discrepancy - Any event requiring unusual adjustment or replacement of parts or equipment.

Part - A device or component contained in a subassembly or an assembly which is of such construction that it is not practical to further disassemble for maintenance purposes, such as a resistor, electron tube, capacitor, etc.

Subassembly - Partial assembly of parts, such as a terminal board or PC card.

APPENDIX C

NRL/STC DESTRUCTIVE PHYSICAL ANALYSIS
PROCEDURE
STC-D-009

NOTE

THIS PROCEDURE IS INCLUDED FOR REFERENCE ONLY
AND MAY NOT REFLECT THE LATEST REVISION

FOR LATEST REVISION, CONTACT PRODUCT ASSURANCE SECTION HEAD

	SUBJECT: DESTRUCTIVE PHYSICAL ANALYSIS	NUMBER STC-D-009
		REVISION A
		PAGE 1 OF 13
POLICIES AND PROCEDURES	EFFECTIVE DATE: 5 JANUARY 1981	APPROVAL SIGNATURE: A.C. SALVATO

1.0 SCOPE

This procedure establishes the Destructive Physical Analysis (DPA) procedures to be employed by the Spacecraft Technology Center of the U.S. Naval Research Laboratory on electronic parts for spacecraft hardware.

2.0 REFERENCE DOCUMENTS

The following documents of the exact issue shown form a part of this procedure to the extent specified herein:

MIL-STD-105D	Sampling Procedures and Tables for Inspection By Attributes
MIL-STD-202E	Test Methods For Electronic and Electrical Component Parts
MIL-STD-750B	Test Methods For Semiconductor Devices
MIL-STD-883B	Test Methods And Procedures For Microelectronics

3.0 TEST AND INSPECTION EQUIPMENT

The test equipment, instruments and tools required to conduct DPAs shall be capable of measuring the applicable mechanical or electrical parameter specified in Paragraph 5.0.

4.0 DPA REQUIREMENT

Destructive Physical Analysis is required on all part types defined in Paragraph 4.2.

4.1 DPA Approach

The Destructive Physical Analysis (DPA) is a thorough destructive analysis of the construction and workmanship of a sample of devices from a manufacturer's lot (i.e., a population of devices manufactured over a controlled period of time using the same processes). The purpose of the DPA is to evaluate the construction and workmanship evident in the sample devices, determine the adequacy and control of processes employed, and utilize this information to assess the inherent reliability of the lot.

This analysis procedure is extremely effective in identifying parts with marginal construction/workmanship.

4.2 Part Types to be Analyzed

The following part types will be subjected to DPA:

- Integrated Circuits (Monolithic and Hybrid)
- Dual Transistors
- Transistors
- Diodes (Glass and Metal)
- Capacitors (Tantalum and Multi-layer Ceramic)
- Crystals
- Relays

Parts that have been rejected electrically during screening shall be considered for use as DPA samples. The DPA sample shall be selected from each lot after receiving electrical and/or screening.

4.3 DPA Sample Size

The DPA sample size shall be determined from the lot size using a modification to MIL-STD-105, Sampling Plan S-3. This sample size to lot size relationship is presented in Table 4-1.

TABLE 4-1

DESTRUCTIVE PHYSICAL ANALYSIS SAMPLE SIZE

PROCURED LOT SIZE	DPA SAMPLE
1 - 50	2*
51 - 100	3
101 - 150	4
151 - 200	5
201 - 500	8
501 - 3200	13

* Stud mounted transistors and active devices containing gold-aluminum metallization interfaces shall require a minimum sample of three (3).

5.0 DPA PROCEDURES

The devices shall be subjected to the specific DPA steps depicted in the appropriate flow diagrams of Figures 5-1 through 5-11. These DPA flow diagrams identify the minimum quantity of devices from each sample to be subjected to the analysis/test activity. Where no quantity is specified, the entire sample shall be used. The following paragraphs provide the detailed procedures applicable to each of these activities.

5.1 DPA Sample Selection

The DPA sample shall be taken at random from the lots at the completion of screening or receiving inspection. Parts which have been rejected electrically during screening or receiving inspection shall be considered for use as DPA samples. Only limit failures shall be used. Any catastrophic failures which might cloud the analysis shall not be used.

5.2 Visual Inspection

All samples shall be inspected to ensure they are free of visual defects which would prove detrimental to use. Each component shall be legibly marked or coded for type, manufacturer and value as required by the applicable procurement document. All devices shall be checked to ensure they conform to the dimensional requirements.

5.3 Electrical Tests

All samples shall be tested to ensure they meet the manufacturer's specifications and that no damage has occurred in subsequent testing, screening or handling which could cloud any internal inspection.

5.4 Hermetic Seal

All samples which require Hermetic Seal shall be tested according to the applicable procedures of MIL-STD-750B and MIL-STD-883B for Fine and Gross Leak.

5.5 Delidding

Delidding shall be performed according to the following procedures:

Microcircuits

Flat-Packs-Metal

Flat-packs, solder-sealed metal, shall be opened using a dry grinding technique. The devices shall be inverted on a dry Buehler grinding wheel

using 180 grit paper. The device shall be held against the wheel and the lid ground slowly until it becomes thin enough for a cavity indentation to be visible. The device shall then be secured in a face up position, any foreign material blown off, and the lid punctured with a sharp knife blade. The lid shall be peeled back to expose the cavity being careful not to disturb the internal structure. Metal flat-packs with welded lids shall be opened by securing the package in a face up position and filing the weld with a small file. Filings shall be blown from the outside of the package prior to puncturing the thin area with a knife blade and peeling the lid off.

Dual-In-Line, Solder Seal

These packages shall be delidded using the same techniques as solder-sealed metal flat-packs.

Flat-Packs, Ceramic

The preferred method requires the use of a special holding fixture and a torch. An oxygen-butane flame shall be passed over the lid of the part while it is under light pressure from the blades of a flat-pack delidding vise. Each pass shall last two to three seconds. The vise shall be tightened slightly after each application of heat. In general, two passes are required and seldom more than four. Care must be taken that the blades of the delidding vise are positioned above the leads, not on the ends, since pressure on the ends may allow some leads to come off with the lid breaking the wire bonds.

The following technique may be used if the equipment is not available to open a device using the Preferred Method. However, this method is less desirable due to the greater possibility of damage to internal structure.

The ceramic package shall be held securely by the lower body which may require bending of the terminal leads. Care shall be taken to apply minimal force when bending of the leads is required. The point of a sharp knife blade shall be placed on the seal line above the lead frame and struck lightly with a small hammer. This action shall be repeated around the package, striking the seal line at intervals until the seal is fractured and the lid may be carefully lifted off.

Dual-In-Line, Ceramic

These packages shall be delidded using the same techniques as the ceramic flat-pack, except that the blades of the delidding vise shall be applied in the seal area. Since the seal is separate from the lead frame on DIPS, pressure may be applied at the ends or along the sides without damaging the part.

Metal Can Devices

A commercially available can-opener or header remover shall be used to cut the can at a point above the weld flange but below the level of the header. After the can is cut, the device shall be blown off to remove any foreign material. The device shall be held with the leads up and the header carefully lifted from the cap. Care shall be taken to prevent damage to the internal structure and trap any loose foreign material in the cap.

Transistors

Transistors, except for power transistors, shall be opened using the technique described for metal can microcircuits.

Power Transistors, Flange Mounted

The cap shall be filed or ground until it can be punctured with a sharp knife and peeled off. Care must be taken that the internal construction is not damaged by the knife blade. After performing the visual inspections, it may be necessary to peel the remainder of the cap from the flange to facilitate photography and die shear test. (Alternate techniques, e.g. lathes or saw, may be used.)

Power Transistors Stud Mounted

Examine the crimp areas of all device(s) and select equal samples from the device(s) which have the least deformation and those that appear to be overcrimped. Pot and section the terminals of the device(s) into the crimp area. A minimum of one device shall be potted.

Diodes, Glass

A line shall be scribed across the diode near the plane of the die with a file or diamond scribe. Fracture the body at the scribe line.

The diode shall be examined for any anomalies noticed prior to opening. The surface of the die shall be examined for cracks and peeling, or corroded metallization.

Crystals and Relays

During the process of opening the enclosure, care shall be exercised to assure that external liquid, gaseous, particulate, or other type contamination do not enter the interior areas.

Enclosures similar to the TO-5 type and other round type holders (such as MIL-H-10056/21, /24, and /29) shall be opened using a special can opener device designed specifically for that purpose.

A flat grinding wheel (disc surface) shall be used to grind off the flange of hermetically sealed cold weld holders where the cover is joined by cold

weld to the base. Precautions shall be taken to prevent the grinding operation from penetrating the case during each grinding application. The grinding operation should only remove sufficient wall material thickness (approximately 80 to 90 percent) so that the remaining wall thickness can be readily cut through with a sharp cutting instrument such as an Exacto knife blade. The enclosure and inner assembly shall be firmly held by hand during each step of the opening procedure to avoid damage to the device. Tools such as vices, clamps, pliers, or similar instruments shall not be used. Prior to penetration or opening of the enclosure after completion of the grinding operation, all external surfaces shall be cleaned to remove any particulate or other contaminants from the external case. Hands and instruments used in the final opening step shall also be thoroughly cleaned and free of any contaminants prior to case penetration. The final opening step shall be done over a clean white contaminant-free bench or paper surface.

5.6 Internal Visual Examination

Each device shall be examined internally for defects or anomalies which present reliability risks to the end item equipment. Devices shall be inspected in the most meaningful way, whether it be delidded, cross-sectioned, or by a special method due to an abnormal package. Typical photographs shall be taken along with any anomalies seen. Photographs will be included in the report or retained in the traveller. MIL-STD-883B and MIL-STD-750B procedures shall be followed as applicable.

5.7 Bond Pull

Subsequent to the completion of the visual inspection, wire bonds shall be pulled in accordance with MIL-STD-883B, Method 2011.2, Test Condition D. Sample size shall be all wires or 38 wires equally spaced around the die, whichever is less. The pull strength criteria are listed below:

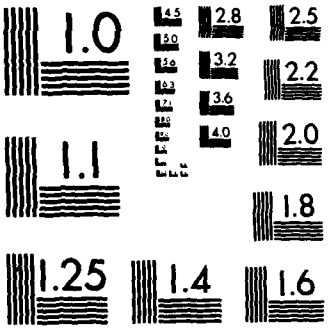
WIRE	MINIMUM STRENGTH
0.7 mil gold	0.7 grams
1 mil gold	1.5 grams
1 mil aluminum	1.0 gram
2 mils aluminum	4.0 grams
8 mils aluminum	50.0 grams

Results of bond strength measurements shall be tabulated by device and included in the DPA report.

If other wire sizes are encountered, comparable minimum strengths shall be established. Wires shall be pulled for lot samples of two devices scheduled for SEM analysis prior to submission of those devices to such analysis unless the analyst determined that information may be lost or disturbed by the bond strength measurement. Wires shall not be pulled on the SEM sample when the total lot sample is greater than two.

AD-A134 379 SPACECRAFT PRODUCT ASSURANCE PROGRAM PLAN REVISION B (U) NAVAL RESEARCH LAB WASHINGTON DC SPACECRAFT TECHNOLOGY CENTER MAY 81 STC-D-001-REV-B 2/2

UNCLASSIFIED F/G 5/1 NL



5.8 Die Shear Strength

A device sample shall be subjected to a die shear test. The device shall be held in a fixture such that a flat-ended wedge-shaped tool placed parallel to the header is allowed to push on the edge of the die. The force on the die shall be slowly increased until the die bond or the die fails. The percentage of silicon remaining attached to the header in the die area and the force applied to shear shall be recorded. Shear force shall be greater than 50 grams for a die of 150 sq. mils with the minimum force linearly increasing to 450 grams for 2500 sq. mils and larger die. For power transistors with 250 x 250 mils die, the die bond shall be evaluated using a center punch technique of shattering the die. A center punch shall be placed near the center of the die and struck with a small hammer. When the die shatters, metal will be left where die bond voids existed. The percentage of die attach shall be recorded.

5.9 Scanning Electron Microscope (SEM)

A SEM examination shall be performed on devices as required according to MIL-STD-883B, Method 2018. Photographs shall be taken showing typical views and shall be included in the report. Any anomalies shall be photographed and included in the report with text describing the anomalies.

6.0 REPORTS

A formal report shall be prepared for each lot. This report shall include all data and photographs taken during the DPA and will state lot acceptability or rejection. When a lot is rejected, the report shall state the reasons for rejection and present the data which results in this conclusion.

7.0 RECORDS

All records shall be retained in the files of the laboratory performing the analysis unless otherwise directed by the NRL/STC Product Assurance Section Head.

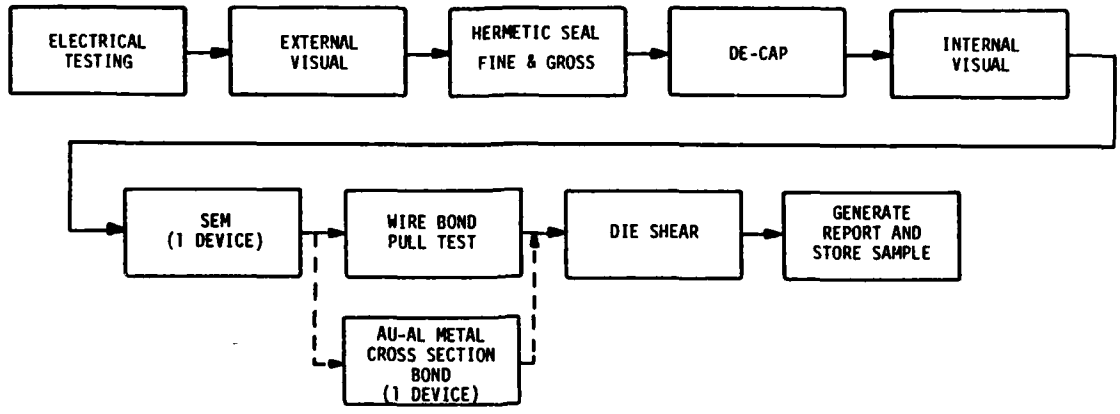


FIGURE 5-1: DPA FLOW DIAGRAM - INTEGRATED CIRCUITS

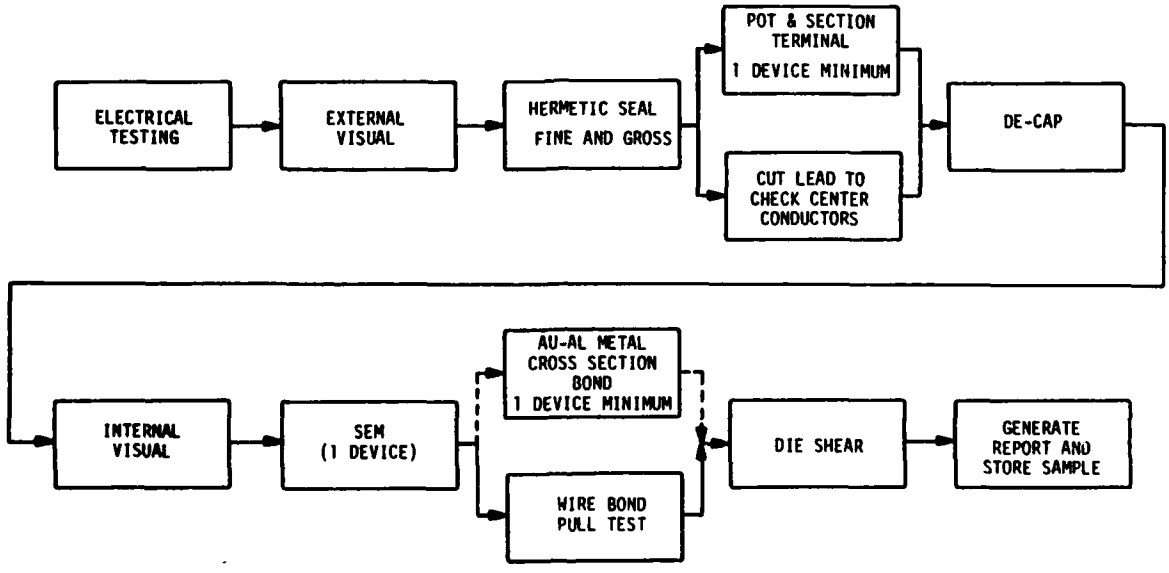


FIGURE 5-2: DPA FLOW DIAGRAM - POWER TRANSISTORS, STUD MOUNTED

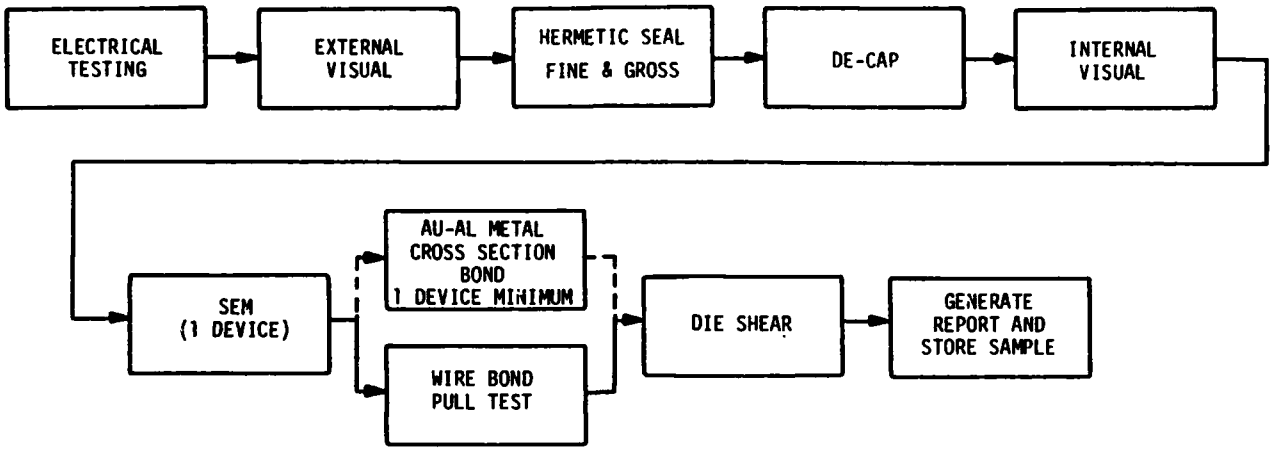


FIGURE 5-3: DPA FLOW DIAGRAM - TRANSISTORS (OTHER THAN STUD MOUNTED) AND DUAL TRANSISTORS

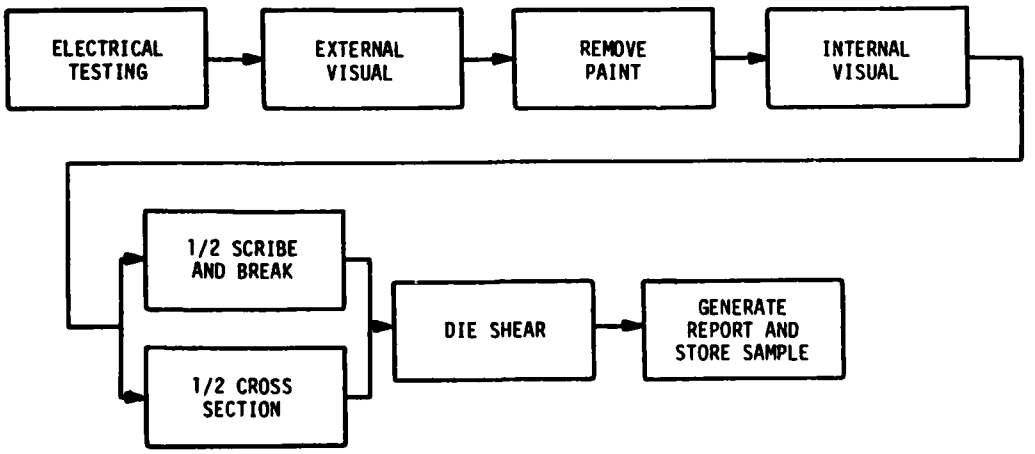


FIGURE 5-4: DPA FLOW DIAGRAM - GLASS DIODES

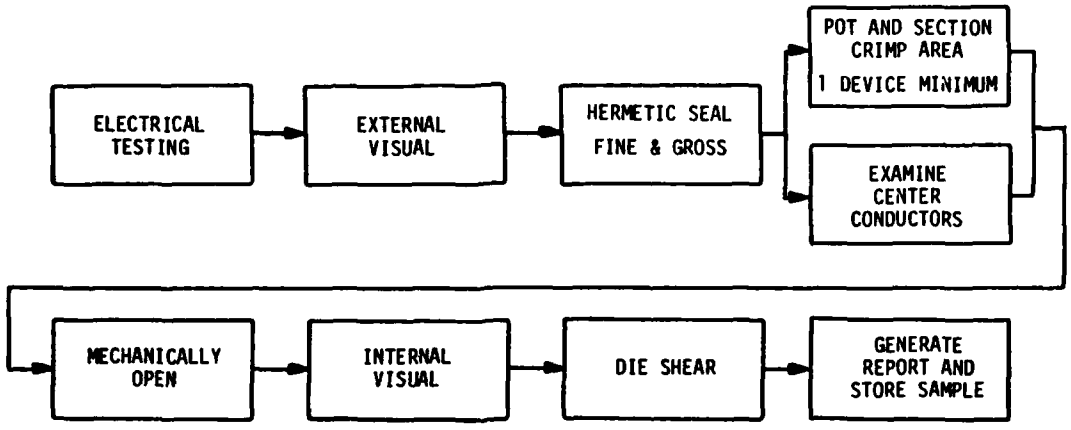


FIGURE 5-5: DPA FLOW DIAGRAM - DIODES (METAL CAN)

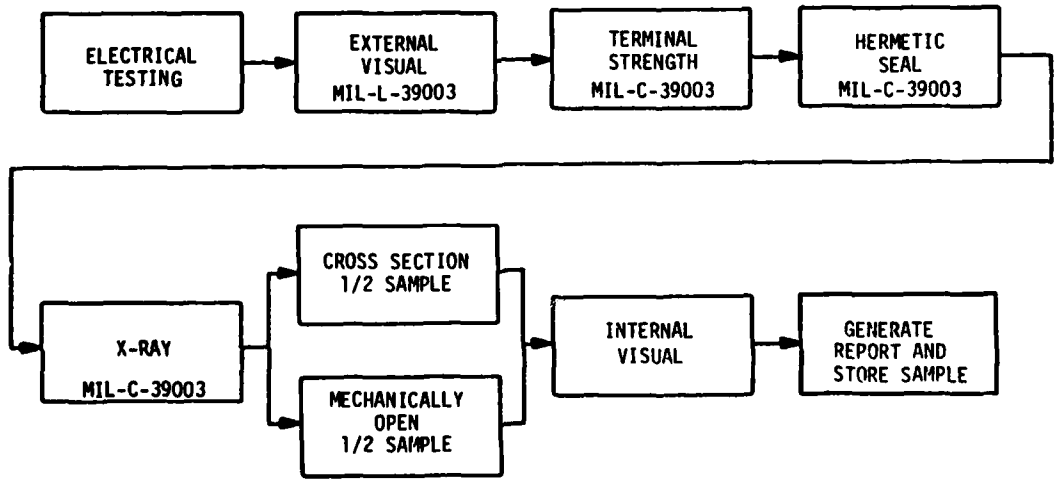


FIGURE 5-6: DPA FLOW DIAGRAM - CAPACITOR (TANTALUM, SOLID)

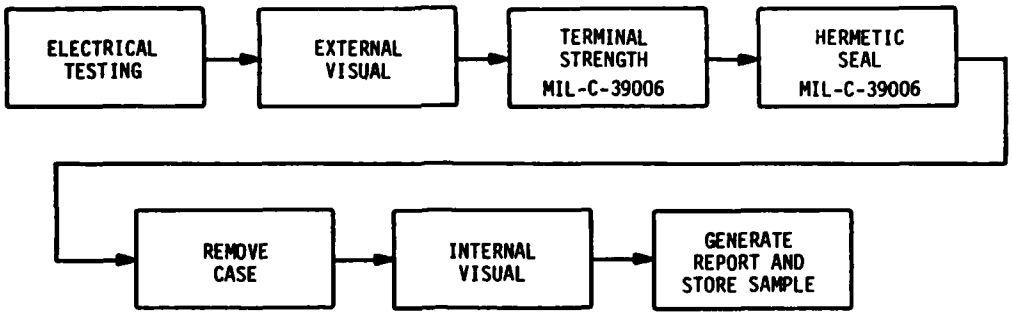


FIGURE 5-7: DPA FLOW DIAGRAM - CAPACITOR (TANTALUM FOIL)

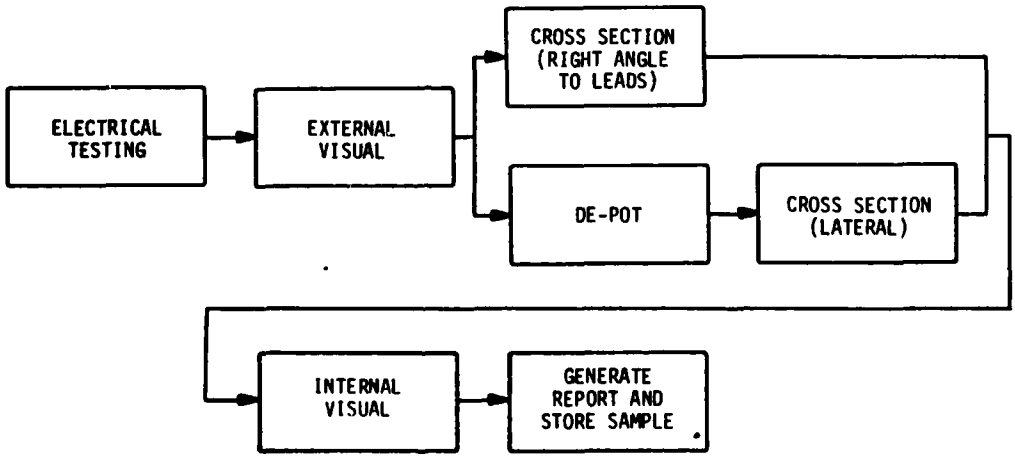


FIGURE 5-8: DPA FLOW DIAGRAM - CAPACITOR (MULTI-LAYER CERAMIC)

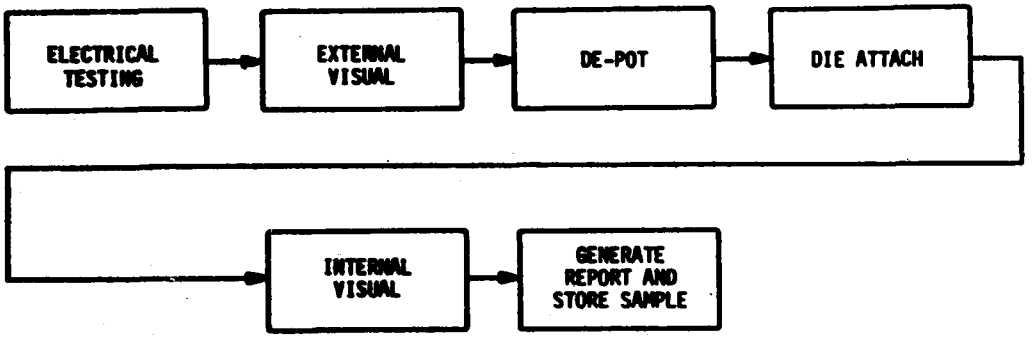


FIGURE 5-9: DPA FLOW DIAGRAM - MICRODIODES

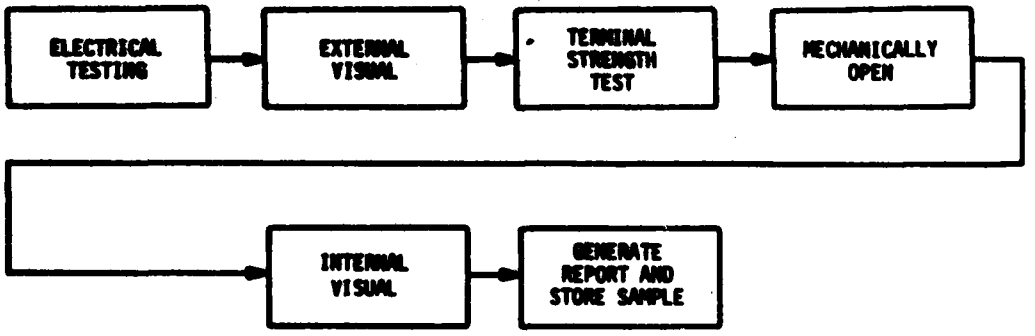


FIGURE 5-10: DPA FLOW DIAGRAM - CRYSTALS

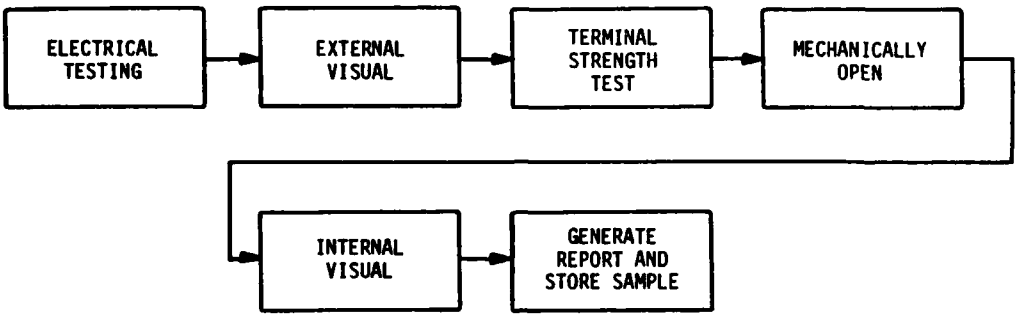


FIGURE 5-11: DPA FLOW DIAGRAM - RELAYS

APPENDIX D

NRL/STC NONCONFORMING MATERIAL CONTROL
PROCEDURE
STC-D-011

NOTE

THIS PROCEDURE IS INCLUDED FOR REFERENCE ONLY
AND MAY NOT REFLECT THE LATEST REVISION

FOR LATEST REVISION, CONTACT PRODUCT ASSURANCE SECTION HEAD

	SUBJECT: NON-CONFORMING MATERIAL, CONTROL of	NUMBER STC-D-011 REVISION A PAGE 1 OF 10
POLICIES AND PROCEDURES	EFFECTIVE DATE: 23 JULY 1982	APPROVAL SIGNATURE: A. C. Schmitt

1.0 PURPOSE

This document establishes a uniform procedure to be employed by the U.S. Naval Research Laboratory, Spacecraft Technology Center (NRL/STC) to control the reporting and dispositioning of non-conforming material on all programs.

2.0 APPLICABILITY

All articles that have been found to deviate from configuration control, specifications, instructions, Purchase Orders, or contract requirements shall be considered as non-conforming and shall be processed in accordance with this procedure. This procedure applies to all flight parts, assemblies, and end items processed by NRL/STC. All contractors supplying parts, assemblies or end items for NRL/STC flight hardware shall have an acceptable procedure for controlling non-conforming material.

3.0 DEFINITIONS

3.1 Material Review Board (MRB)

A formal review board established for the purpose of reviewing, evaluating and dispositioning specific non-conforming materials and for assuring the initiation and accomplishment of corrective action to preclude recurrence. The MRB shall consist of the Quality Assurance Manager, the responsible Design Engineer and the sponsor or his designated representative. Each program shall prepare a list of personnel who are responsible for filling these MRB positions and their alternates.

NOTE 1: The configuration manager shall be notified of all MRB action effecting end item configuration.

3.2 Non-Conforming Material

Non-conforming material shall be defined as any raw material, part, or assembly in which one or more characteristics do not conform to the technical requirements of the specification, Purchase Order, Contract, drawing, or other applicable product description.

3.3 Standard Repair Procedure

A standard repair procedure approved by the MRB that will accomplish repairs resulting in the usability of the non-conforming material. This procedure, after initial approval, may be used for repair of non-conforming material as necessary without additional approval for subsequent occurrences.

3.4 Deviation

Written authorization, granted prior to the manufacture of an item, to depart from a particular performance or design requirement of a contract, specification, or referenced document, for a specific number of units or specific period of time.

3.5 Waiver

A written authorization to accept a configuration item or other designated items, which during production or after having been submitted for inspection or test, are found to depart from specified requirements, but nevertheless are considered suitable for use "as is" or after rework by an approved method.

3.6 Non-Conforming Material Report (NMR)

Written authorization to process a configuration item, or other designated items, in accordance with the disposition of 4.5. An NMR is initiated when an item is identified as not conforming to drawings, processes, procedures or standards in effect at the time of manufacture, test or inspection.

4.0 PROCEDURE

The following steps shall be used for handling of non-conforming material:

4.1 Material identified as non-conforming will be removed from the process flow at the point the discrepant characteristic is noted.

4.2 A Non-Conforming Material Report (NMR) (Figure 1) will be initiated by y individual who discovers the non-conformance using the instructions per Table 1.

4.3 The Quality Assurance Manager will perform a preliminary review of the non-conforming material to determine if MRB action is required as follows:

4.3.1 If the material can be reworked to the print, the Quality Assurance Manager will so indicate on the Non-Conforming Material Report and return the material for the rework and/or completion of operations. After rework, the material will be routed through inspection for acceptance and return to the process flow.

4.3.2 If the material cannot be reworked or returned for completion of operations, or is obviously unfit, the Quality Assurance Manager will submit the material for Material Review Board action.

4.4 The non-conforming material, together with the Non-Conforming Material Report and other necessary drawings and support documentation, will be identified and placed under control of the Quality Assurance Manager. The Production Manager will be notified of such action.

4.5 The Material Review Board will review and evaluate the specific non-conformance and make one of the following dispositions (the MRB may include other personnel in an advisory capacity):

NOTE 2: The "USE AS IS" and "REPAIR" dispositions require an approved NMR. A copy of the approved NMR will accompany the hardware (see 4.8). Non-conforming material will be held in a designated area until the NMR has been dispositioned.

4.5.1 USE AS IS - This disposition is limited to non-conformances that do not adversely affect reliability, maintainabliity, safety, performance, or interchangeablilty, or do not depart from the basic objective of the drawing or specification.

4.5.2 SCRAP - This disposition is used for non-conformances that are not usable and are not economically repairable. However, usable parts/assemblies may be removed as "Salvage Material".

4.5.3 RETURN TO VENDOR - This disposition is used for nonconformances of vendor supplied parts and materials and will indicate whether rework or replacement is required.

4.5.4 REPAIR - This disposition is used for non-conformances that can be repaired using "standard repair procedures" or other suitable methods to meet specifications or get the material to a usable state. The Standard Repair Procedures will be delineated on the Non-Conforming Material Report (Reference 3.3).

4.6 On completion of the disposition, the MRB will determine the cause of the nonconformance and will complete the Corrective Action section of the Non-Conforming Material Report. The Quality Assurance Manager is responsible for assuring that prompt Corrective Action is implemented by the responsible individual by performing a follow-up audit. Completion of corrective action closes out the Non-Conforming Material Report.

4.7 The MRB members will sign the Non-Conforming Material Report in the space provided. The material will be processed according to the disposition decision as follows:

4.7.1 USE AS IS - Material will be returned to the process flow at the point it was initially removed. A copy of the Non-Conforming Material Report will be retained in the shop traveller folder accompanying the material.

4.7.2 SCRAP - Material will be discarded or destroyed and the Non-Conforming Material Report will be used to indicate how and by whom this action was taken. The NMR will be sent to the Quality Assurance Manager to be filed.

4.7.3 RETURN TO VENDOR - Material will be sent to Purchasing for return action. A copy of the Non-Conforming Material Report will be used to indicate the Debit Memo number by which the material was returned to the vendor. This copy will be sent to the Quality Assurance Manager to be filed along with the original Non-Conforming Material Report.

4.7.4 REWORK/REPAIR - Material will be sent to the appropriate manufacturing area along with a copy of the Non-Conforming Material Report and the associated documentation. On completion of the repair action, the material will be inspected and verified to be acceptable to the repair instructions. The copy of the Non-Conforming Material Report will be signed or stamped by the inspector to indicate acceptance and the copy retained in the shop traveller folder accompanying the material.

4.8 The Quality Assurance Manager will maintain a log of all Non-Conforming Material Reports that will include the Non-Conforming Material Report Number, date, Part Number, Part Name, Lot Quantity, Reject Quantity, description of the non-conformance, Disposition, Corrective Action and Corrective Action Responsibility. The original of the Non-Conformance Report is to be returned to the Quality Assurance Manager for filing by NMR number. A copy (second page) shall remain with the hardware, and on completion of the disposition, shall be included in the final documentation package.

NAVAL RESEARCH LABORATORY
SPACECRAFT TECHNOLOGY CENTER

STQC-021 (5/81)

NMR No. (1)

Sheet (2) of –

NONCONFORMING MATERIAL REPORT

PART NO/DRAWING NO. (3)	REV. (4)	PART NAME (5)	SER. NO. (6)	DATE (7)

VENDOR/CUSTOMER (8)	CONTRACT NO. (9)	P.O. NO. (10)	JOB NO. (11)	QTY REC. (12)	QTY ACC. (13)	QTY REJ. (14)

NONCONFORMANCE		DISPOSITION
ITEM (15)	DESCRIPTION (16)	(17)

INSPECTOR (18)	DATE (19)

MATERIAL REVIEW BOARD ACTIVITY

FINAL DISPOSITION (20)		MRB APPROVAL	DATE
USE AS IS	REWORK/REPAIR	QUALITY ASSURANCE (21)	
SCRAP	RETURN TO VENDOR	DESIGN ENGINEER (22)	
		SPONSOR (23)	

CORRECTIVE ACTION

ACTION REQUIRED: (24)

ACTION RESPONSIBILITY: (25)

ACTION COMPLETION: (26)

FIGURE 1. NON-CONFORMING MATERIAL REPORT

TABLE 1

Instructions for Completion of Non-Conforming Material Report Form (NMR)

1. The Quality Assurance Manager or his designated representative will assign a unique non-repeating number of at least six (6) digits to be entered in block 1.

2. Enter the sheet number and the total number of sheets covered by the Non-Conforming Material Report (NMR).

3. Enter the unique part number or drawing number that completely identifies the item(s) covered by the NMR. NOTE: Only one (1) part type can be used for each NMR.

4. Enter the revision level, if applicable, for the part or drawing number.

5. Enter the correct part name that identifies the item(s) covered by the NMR.

6. When applicable, enter the serial number of the item(s) covered by the NMR. If space is insufficient use Section 16.

7. Enter the month, day and year the NMR is initiated.

8. Enter the name of the vendor for purchased materials and the name of the customer if other than NRL/STC.

9. Enter the appropriate contract number for the item(s) covered by the NMR.

10. When applicable, enter the Purchase Order number for those item(s) purchased. If not a purchased item, enter "N/A".

11. Enter the appropriate designation or charge number associated with the program for which the item(s) are being used.

TABLE 1 - Continued

Instructions for Completion of Non-Conforming Material Report Form (NMR)

12. Enter the quantity of items covered by the NMR.

13. Enter the quantity of items accepted by the NMR.

14. Enter the quantity of items rejected by the NMR.

15. Enter a sequential number starting with one (1) to identify each non-conformance.

16. Enter a concise and accurate description of the non-conformance using applicable serial numbers to identify those items to the non-conformance.

17. Enter a narrative description of the disposition of each non-conformance using the item numbers of block 15 to cross reference each non-conformance with its description.

18. The individual responsible for issuing the non-conforming report will sign their full name in this block.

19. Enter the month, day and year the issuer signs the non-conforming report.

TABLE 1 - Continued

Instructions for Completion of Non-Conforming Material Report Form (NMR)

NOTE 3: Sections 20 through 28 will be part of the Material Review Board (MRB) Activity.

20. The appropriate disposition will be circled by the QA member of the MRB.

21. The Quality Assurance representative of the MRB will sign and date this block.

22. When applicable, the Design Engineer on the MRB will sign and date this block.

23. When applicable, the sponsor assigned to the MRB will sign and date this block.

24. When designated by the MRB, a short narrative shall be entered to describe the action necessary to prevent recurrence of the identified non-conformance.

25. When designated by the MRB, the name of the person responsible for taking the appropriate corrective action is entered in this block.

26. When applicable, the person responsible for completion of the appropriate corrective action will sign and date this block.