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217B PREDICT, SYSTEM RELIABILITY PREDICTION COMPUTER PROGRAM. V--ETC(U)
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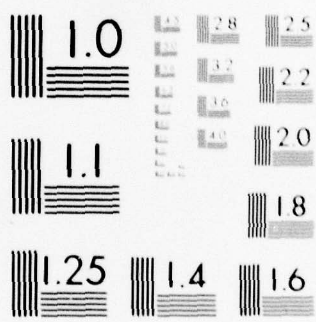

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2 March 1977

LEVEL II

217B PREDICT
SYSTEM RELIABILITY PREDICTION COMPUTER PROGRAM

VOLUME I. USER MANUAL

DEVELOPED BY
SYSTEMS CONSULTANTS INCORPORATED
RIDGECREST, CALIFORNIA 93555

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17. SUMMARY

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The 217B PREDICT computer program provides the capability of performing system reliability predictions in accordance with the complex part failure rate models in MIL-HDBK-217B. The computer program also contains procedures for entering user derived non-MIL-HDBK-217B part failure rates, and for deriving dormant part failure rates in accordance with established failure rate data and techniques. With a minimum of indoctrination the user can perform extensive, fully documented reliability predictions at a minimal cost. The cost savings are achieved by:

(1) Providing complete prediction data for 1 to 13 life cycle events from a single set of input data, thereby minimizing the cost in preparing the data deck and in operating the computer.

(Continuation on Page 2)

18. KEY WORDS FOR INDEXING Operating Failure Rates, Dormant Failure Rates, Automated Prediction, MTBF, Failure Rate Techniques

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17. SUMMARY

(2) Requiring only exceptions to the "standard" part failure rate definitions at the part level, thereby reducing the cost of preparing the data deck.

(3) Using a set of "standard" part failure rates that are recalculated by the computer only if redefined at the part level, thereby minimizing the computer operating cost.

The user manual provides all necessary information required to use the computer program. It does not presuppose any prior computer knowledge on the part of the user. However, it does assume a working knowledge of the failure rate models and techniques in MIL-HDBK-217B, and experience in deriving non-MIL-HDBK-217B failure rates.

The 217B PREDICT computer program is written in standard FORTRAN V language for the UNIVAC 1110 computer and has been used on numerous reliability predictions for the Naval Weapons Center, China Lake, California. The program is adaptable to any large scale digital computer. The computer program contains 5,311 source statements, and uses approximately 37,000 words of storage for coding and storage arrays. For information regarding the computer program contact:

Systems Consultants Incorporated
543 Graaf Street
Ridgecrest, California 93555
(Attention: Mr. R. H. Butler)

ABSTRACT

The 217B PREDICT computer program provides an automated capability of readily performing fully documented system reliability predictions. Using a simplified set of input data, the computer program provides operating and dormant prediction data for multiple life cycle events in a concise, readily understandable output format. In addition, all failure rates and failure rate sources used in the prediction are fully documented in the printout to permit verification of all part failure rates.

This manual provides all necessary information required to use the computer program. It does not presuppose any prior computer knowledge on the part of the user. However, it does assume a working knowledge of the failure rate models and techniques in MIL-HDBK-217B, and experience in deriving non-MIL-HDBK-217B failure rates.

This manual is designed to provide:

(1) A simplified introduction to the computer program data submittal requirements, with examples.

(2) A preliminary set of failure rate derivation guidelines.

(3) An extensive discussion of the computer program submittal requirements and part failure rate models.

(4) An appendix that outlines the Stored Failure Rate Data and data submittal requirements necessary to perform reliability predictions.

NOTE: The intent of the computer program is to provide an active analytical tool that is responsive to the needs of the reliability community. As such, the computer program and this manual are subject to periodic updates in general accordance with the revisions to MIL-HDBK-217. Therefore, for proper implementation, all suggestions or discrepancies noted by the user should be submitted in writing to:

Systems Consultants Incorporated
543 Graaf Street
Ridgecrest, California 93555
(Attention: Mr. R. H. Butler)

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ACKNOWLEDGEMENT

The 217B PREDICT computer program described in this report was designed and developed by R. H. Butler and J. G. Sahm of Systems Consultants Incorporated. Development of this program was funded by the Naval Weapons Center, China Lake, California under Contracts N00123-73-C-0243 and N00123-76-C-0340, and by Systems Consultants Incorporated.

* * * * * * * *

The authors are indebted to numerous persons at Systems Consultants Incorporated and at the Naval Weapons Center for their encouragement and support in the development of 217B PREDICT. In particular, we wish to thank R. L. Seles of Systems Consultants Incorporated for his extensive evaluation of the computer program data base, techniques, and output.

* * * * * * * *

EXECUTIVE SUMMARY

The 217B PREDICT computer program provides the capability of performing system reliability predictions in accordance with the complex part failure rate models in MIL-HDBK-217B. The computer program also contains procedures for entering user-derived non-MIL-HDBK-217B part failure rates, and for deriving dormant part failure rates in accordance with established failure rate data and techniques.

The methodology used in the computer program is based on establishing a set of "standard" part failure rates and part failure rate parameters that are used unless specifically excepted by the user at the part level. The part failure rate parameters define the appropriate environmental factors, operating stress factors, application factors, dormant (operating-to-non-operating) factors, etc., for the respective parts. The failure rate definitions stored within the computer program can be used directly, or can be modified and supplemented to establish the "standard" part failure rate definitions for the user's system. Parts not fitting the "standard" definitions are then specifically excepted at the part level by the user. This technique allows the user to minimize the amount of data that must be entered at the part level by modifying the stored part failure rate definitions to reflect the majority of the part types in his system. The "standard" part failure rate definitions used in performing the prediction are printed out as part of the "summary" data by the computer program. Any deviations from the "standard" part failure rate definitions are printed out at the part level in the prediction data.

The 217B PREDICT computer program is written in the computer-independent FORTRAN IV and V languages and is easily adapted to any large scale digital computer. With a minimum of indoctrination the user can perform extensive, fully documented reliability predictions at a minimal cost. The cost savings are achieved by:

(1) Providing complete prediction data for 1 to 13 life cycle events from a single set of input data, thereby minimizing the cost in preparing the data deck and in operating the computer.

(2) Requiring only exceptions to the "standard" part failure rate definitions at the part level, thereby reducing the cost of preparing the data deck.

(3) Using a set of "standard" part failure rates that are recalculated by the computer only if redefined at the part level, thereby minimizing the computer operating cost.

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SECTION I

GENERAL OVERVIEW

1. INTRODUCTION

The 217B PREDICT computer program provides an automated capability of performing a fully documented system reliability prediction in accordance with the specific methodology in MIL-HDBK-217B (Reference 1), and in general accordance with established techniques for deriving non-electrical and dormant part failure rates. The computer program characteristics, as outlined below, provide an easily used, yet flexible, analysis tool that can be readily used for conceptual, preliminary, or detailed stress analysis predictions.

- o The input data and output data are in direct accordance with the system documentation and with the definitions in MIL-HDBK-217B.
- o With a minimum of input data, the computer program provides failure rate data for all applicable life cycle events.
- o The output data are self-explanatory, and provide part failure rate traceability by documenting all part failure rate parameters and data sources used in performing each prediction.

2. ORGANIZATION OF THE MANUAL

The 217B PREDICT User Manual contains five major sections and two appendices. As outlined below, the sections provide progressively greater insight regarding the use of the computer program in performing reliability predictions, whereas the appendices provide the data necessary to implement the computer program in performing reliability predictions.

- o Section I. General overview of the computer program.
- o Section II. Simplified exercise in compiling the data for the computer program, with examples.
- o Section III. Complex exercise in compiling the data for the computer program, with the corresponding computer printout.
- o Section IV. General prediction guidelines.
- o Section V. Extensive computer program details.
- o Section VI. References.
- o Appendix A. Stored part data and coding form definitions.
- o Appendix B. Outline of part codes and coding forms.

3. COMPUTER PROGRAM TECHNIQUES

Communicating with the computer program is particularly simple for the reliability analyst since all input data are in direct accordance with the assembly/fabrication drawings, e.g., R2 = RCR20G320FM, and in general accordance with the common usage terms reflected in MIL-HDBK-217B, e.g., S2 = π_{S2} = reverse voltage factor for semiconductors. The primary imposition on the user is the need to code the general part type as defined in Sections II and III, e.g., 402 = Carbon Composition Resistor. This coding minimizes the amount of input data from the user and yet provides a very definitive part description for the computer printout.

The input data for the computer program are prepared using fixed format computer coding forms that are keypunched on computer data cards for batch submittal to the UNIVAC 1110 computer as described in Sections II and III. The failure rate data and reliability data are then compiled in general accordance with the following computer program techniques as outlined in Figure 1.1.

Note: Reference is made to the UNIVAC 1110 computer throughout this manual because the program was developed for use on the UNIVAC 1110 computer at the Naval Weapons Center, China Lake, California. However, the computer program is written in the FORTRAN IV and V languages and should be adaptable to any large scale digital computer.

a. Stored Part Data

The computer program contains a set of part failure rate definitions that are used unless othewise modified by the user. The user can supplement and/or modify the Stored Part Data using Supplemental Part Data cards, thereby establishing a unique set of "Standard" part failure rate definitions that reflect his system. Unless otherwise specified, these parameter definitions are used to calculate the dormant, assumed, or applied stress part failure rates in accordance with the complex stress analysis failure rate models in MIL-HDBK-217B as defined herein.

In addition, the user defines the system documentation and environmental stress conditions applicable to the prediction using the System/Subsystem Control Cards.

b. Detailed Failure Rate Subroutine

The Detailed Failure Rate Subroutine is used to reflect explicit part numbering data and part failure rate information. The user enters the part information in direct accordance with the assembly/fabrication drawings, and identifies all exceptions to the "Standard" part failure rate definitions using Assembly/Subassembly Data Cards. This technique significantly reduces the amount of failure rate information required at the part level, while providing explicit part failure rate data for 1 to 3 sets of operating, semioperating, or dormant environmental conditions.

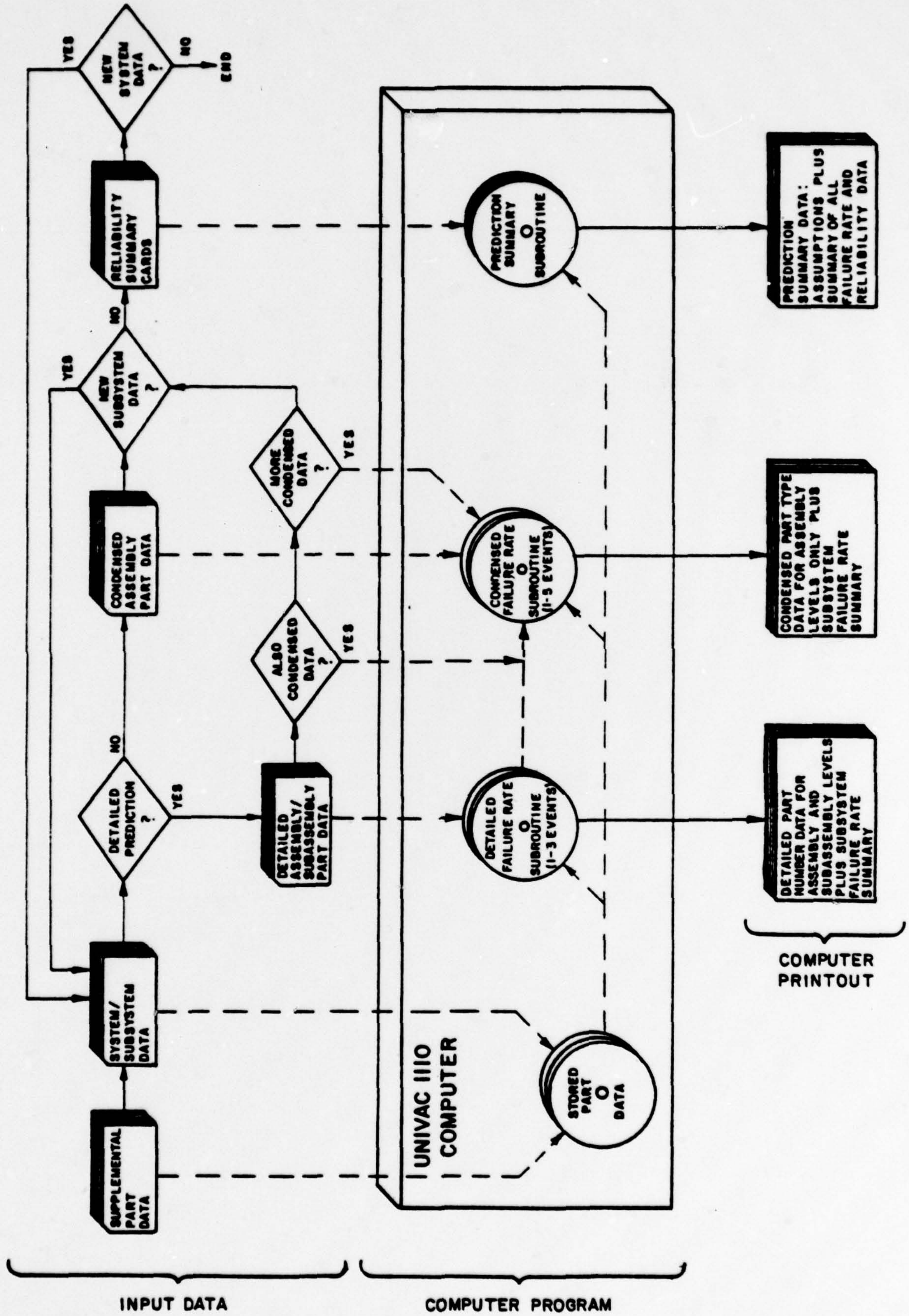

FIGURE 1.1 SYMBOLIC FUNCTIONAL DIAGRAM FOR THE 217 B PREDICT COMPUTER PROGRAM

c. Condensed Failure Rate Subroutine

The Condensed Failure Rate Subroutine is used to provide dormant or assumed stress failure rate data using part count techniques. For example, using the preceding configuration data and the "Standard" part failure rate definitions, the computer program can provide operating or dormant failure rates for an additional 1 to 10 environmental conditions. Therefore the Detailed and Condensed Failure Rate Subroutines can be used to provide total life cycle failure rate information from a single set of input data.

The Condensed Failure Rate Subroutine can also be readily used to perform preliminary predictions for 1 to 5 environmental conditions. The user enters the part information in terms of part type using the Condensed Part Data Cards, and obtains failure rate data that is in direct accordance with the "Standard" part failure rate definitions. These data are in general accordance with the data resulting from a detailed stress analysis prediction, because the same failure rate models and general part failure rate parameters are used for the part failure rate derivation.

d. Prediction Summary Subroutine

The Prediction Summary Subroutine summarizes the failure rate data and assumptions, and compiles the system/subsystem reliability data. The user identifies the life cycle event relationship of the above failure rate data and all associated one-shot devices using Reliability Summary Cards, and obtains reliability data for individual life cycle events or for overall mission events. In addition, all "Standard" part failure rate definitions established by the user are documented in the printout, thereby explicitly defining all failure rate data and sources used in performing the prediction.

SECTION II

COMPILING THE INPUT DATA

1. GENERAL DISCUSSION

The 217B PREDICT computer program does not require any prior computer experience on the part of the user. However, the computer program is based on the assumption that the user has a working knowledge of the failure rate models and techniques in MIL-HDBK-217B, and experience in deriving non-MIL-HDBK-217B part failure rates. In addition, the user should be acquainted with the computer program concept as outlined in Section I, plus its applications and limitations as defined herein. Detailed procedures and assumptions are presented in Section V.

a. Hardware Indenture Levels

The user must organize the assembly/fabrication drawing data in terms of "system," "subsystem," "assembly," and "subassembly" levels as depicted in Figure 2.1. The computer program compiles the part failure rate data at the "assembly" and "subassembly" levels. These data are then summarized at the "subsystem" and "system" levels, with the computed Mean-Time-Between-Failures (MTBF) and reliability (based on the exponential function) for each life cycle event.

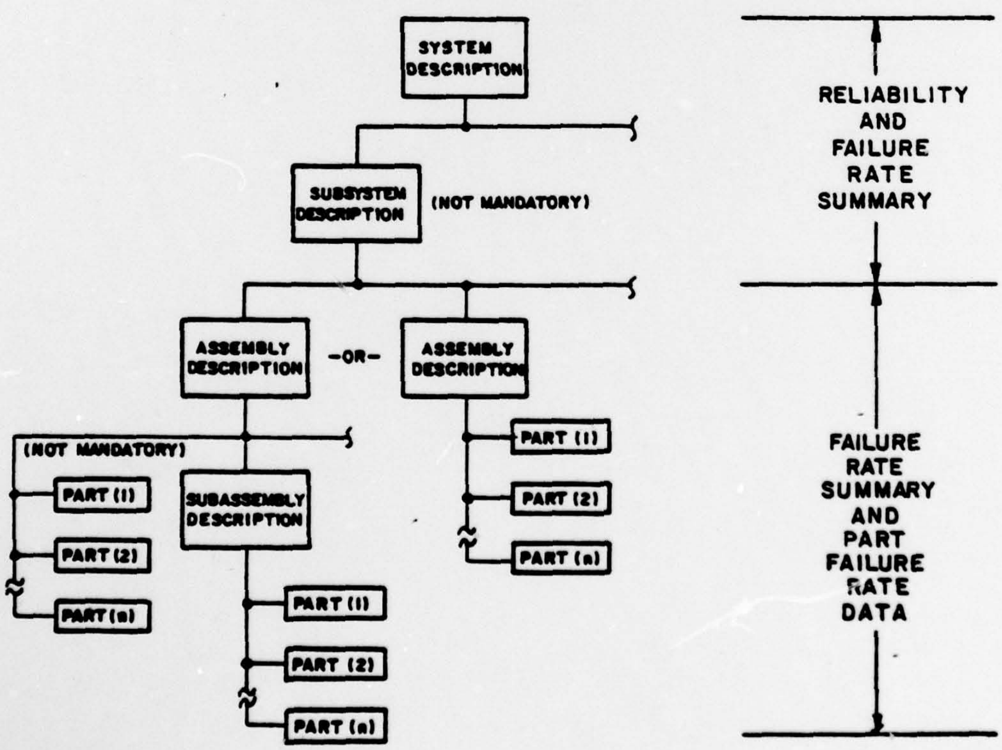

FIGURE 2.1. Generalized Arrangement of Assembly/Fabrication Drawing Data for 217B PREDICT Computer Program.

b. Data Preparation/Submittal

The 217B PREDICT computer program input data are prepared using fixed format computer coding forms and are keypunched on computer data cards for batch submittal to the UNIVAC 1110 computer. The data cards provide explicit computer control in performing the reliability prediction as defined in Appendices A and B, and as outlined below:

(1) Computer Control Cards

@ Card format. UNIVAC 1110 computer control cards, used to identify and execute the 217B PREDICT computer program at the Naval Weapons Center, China Lake, California.

(2) Supplemental Data Cards

Card 1 Format. Used to document additional failure rate data sources used in performing the prediction (not mandatory).

Card 2 Format. Used to submit modifications or additions to the Stored Part Data as defined in Appendix A (not mandatory).

(3) System/Subsystem Control Cards

Card 3 Format. Used to explicitly define the system.

Card 4 Format. Used to explicitly define each subsystem in the system (not mandatory).

Card 5 Format. Used to define the environmental stress conditions to be used for each set of failure rate data (type of failure rate data, equivalent MIL-HDBK-217B environment, and ambient temperature).

(4) Assembly/Subassembly Data Cards

Card 6 Format. Used to explicitly define each assembly in the subsystem.

Card 7 Format. Used to explicitly define each subassembly in the assembly (not mandatory).

Detailed Data Card (Detailed Failure Rate Subroutine only). Used to explicitly define each part in the assembly or subassembly, and to define all exceptions to the "Standard" part failure rate definitions.

Condensed Data Card (Condensed Failure Rate Subroutine only). Used to define each part type and part quantity in the assembly.

(5) Reliability Summary Cards

Card 8 Format. Used to identify the applicable failure rate data and one-shot reliability data for each life cycle event. These data are used in the Prediction Summary Subroutine to compile the overall system reliability data.

c. Type of Failure Rate Data.

The user evaluates and modifies the Stored Part Data as defined in Appendix A to establish the "Standard" part failure rate definitions for the prediction. The Applied Stress Part Data provide minimum operating and dormant failure rate conditions for the Detailed and Condensed Failure Rate Subroutines, and minimize the amount of data to be entered at the part level for the Detailed Failure Rate Subroutine. The Assumed Stress Part Data provide nominal operating failure rate conditions for the Detailed and Condensed Failure Rate Subroutines. These data are defined as:

(1) Applied Stress Part Data (APPLIED) = minimum operating failure rate conditions as modified at the part level to reflect detailed stress analysis data for a mature design that is explicitly defined.

(2) Assumed Stress Part Data (ASSUMED) = nominal operating failure rate conditions that reflect assumed stress data for an early design that is not explicitly defined. The assumed primary stress ratio (S1) is in general accordance with the definitions in Section 3 of MIL-HDBK-217B; the remaining parameters are in accordance with the Applied Stress Part Data.

(3) Dormant Part Data (DORMANT) = minimum operating failure rate conditions times a dormant failure rate π-factor (operating-to-nonoperating failure rate multiplier). This technique provides dormant data that reflects the impact of ambient temperature and part quality.

Inclusion of dormant data in the computer program was considered to be mandatory, yet the resolution of the uncertainties regarding the RADC and Redstone dormant data in References 2, 3, and 4 was beyond the scope of the current development of the computer program. A preliminary evaluation of the dormant data with regard to MIL-HDBK-217B operating data was performed, and generalized dormant π-factors were derived as presented in Appendix A. Use of these factors will provide part failure rate data in general accordance with the RADC and Redstone dormant data, and will also reflect the impact of ambient temperature and part quality. These data and procedures will be used pending further studies of dormant versus operating part failure rates.

d. Part Failure Rate Model.

The following general part failure rate model as used in the computer program is a logical extension of the general part failure rate model in MIL-HDBK-217B.

$$\lambda_p = \lambda_b (\pi_E) \left(\prod_{i=1}^{n} \pi_i \right) \pi_D$$

Where: λ_p = part failure rate for the applicable environment and operating/nonoperating state in failures per million hours

λ_b = basic operating part failure rate as defined in MIL-HDBK-217B

π_E = appropriate environmental π-factor for the applicable part type

Π = mathematical symbol for "the product of"

π_i = value of the i^{th} π-factor for the applicable part type as defined in MIL-HDBK-217B (not applicable to non-MIL-HDBK-217B parts)

π_D = dormant (operating-to-nonoperating) π-factor (π_D reflects nonoperating failure rate data ÷ operating failure rate data for a specific set of environmental conditions = 1.0 for operating part failure rates)

Note: Use of any nonstandard (non-MIL-HDBK-217B) part failure rate requires good engineering judgement, must be fully substantiated in the reliability prediction report, and is subject to procuring agency approval.

The non-MIL-HDBK-217B data presented herein reflects part failure rate data and techniques used over the last several years in performing reliability predictions at the Naval Weapons Center, China Lake, California. These data are included for the convenience of the user. However, it should be noted that the inclusion of these data does not reflect any prior approval on the part of any procuring agency.

e. System/Subsystem Reliability Model

The system and subsystem reliability data compiled using the 217B PREDICT computer program reflects a series reliability model wherein failure of any part constitutes system failure. The "subsystem" and "system" reliability, less the one-shot devices, as calculated by 217B PREDICT assumes statistically independent part failures that exhibit a constant failure rate for the time period being evaluated. These reliabilities are calculated using the exponential function:

$$R(t) = \exp\left(-t \sum_{i=1}^{n} \lambda_i \,(10^{-6})\right)$$

Where: $R(t)$ = "subsystem" or "system" reliability as a function of time

exp = base "e" of the natural logarithm to the power indicated

t = time in hours

λ_i = failure rate of the i^{th} part for the applicable environment and operating/dormant state in failures per million hours.

The one-shot device reliabilities are expressed in terms of probability and are incorporated into the system reliability using the equation:

$$R(s) = R(t) \cdot \sum_{j=1}^{k} P(\text{one-shot})_j$$

Where: $R(s)$ = overall "system or "subsystem" reliability

$R(t)$ = "system" or "subsystem" reliability, less one-shot devices, as calculated using the exponential reliability function

$P(\text{one-shot})_j$ = probability of successful operation of the j^{th} one-shot device

The computer program does not contain any provisions for handling non-series reliability configurations. If non-series reliability calculations are required, it is recommended that the above series model be repressed in the printout. The remaining failure rate data would then be submitted to manual calculation techniques or alternate computer programs, e.g., Reference 5.

2. PARTS COUNT FAILURE RATE DATA

a. Early Design Information

The data depicted in Figures 2.2, 2.3, and 2.4 are representative of the type of basic information necessary to perform a reliability prediction for early design hardware. These data would be compiled by the reliability analyst using engineering judgement and very limited design information.

b. "Standard" Part Failure Rate Definitions.

Comparison of the part data in Figure 2.2 to the Stored Part Data as defined in Appendix A indicates that:

(1) The part quality and application is inadequately defined. However, the resistor and capacitor part definitions indicate the use of established reliability level parts. If the analyst is unable to obtain clarification, the Stored Part Data for a military application could be assumed to be applicable without modification.

(2) The Electromechanical Timer is not reflected in the Stored Part Data. Therefore, the reliability analyst must research the available documentation and define an operating failure rate that reflects the part, part application, and operating environment. If the Stored Part Data does not include the failure rate data source used, the analyst documents same using the Card 1 format as defined in Appendix A. The part failure rate data are added to the Stored Part Data using the Card 2C format as depicted in Table 2.1. If the Card 2C format does not explicitly define the part failure rate derivation, it is the responsibility of the analyst to include the additional information in the basic report.

c. System Configuration Data

The system configuration data are compiled on the Computer Coding Forms in Appendix B, as depicted in Table 2.1. By entering the environmental stress data using the Card 5B format (Condensed Failure Rate Subroutine only), the user can enter the part data on the simplified Condensed Part Data Cards. As depicted in Table 2.1, the environmental stress conditions for each life cycle event are in terms of the type of failure rate data (APPLIED, ASSUMED, or DORMANT), the equivalent MIL-HDBK-217B environmental symbol, and the ambient temperature in degrees Celsius. If the above data are not specifically defined, the analyst defines said conditions in terms of established documentation, e.g., environmental criteria and guidelines in MIL-STD-1670 (Reference 6). The number of part solder connections (#C) is stored by the computer program for the Stored Part Data. The number of part solder connections for data entered on a 2C Card, or other connections, must be entered separately. The part data are entered on the Condensed Part Data Cards in terms of Part Code and Part Quantity only. Although the preliminary parts list does not reflect printed wiring boards or connectors, it is reasonable to assume that they should be included. Detailed procedures and assumptions are presented in Section V.

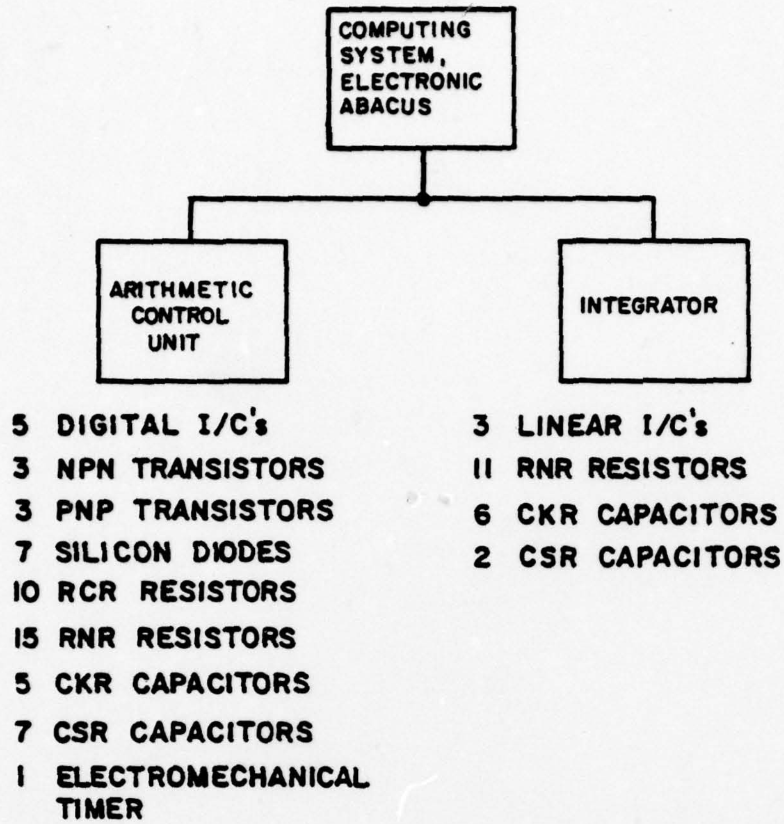

FIGURE 2.2 PRELIMINARY SYSTEM CONFIGURATION DATA (EXAMPLE)

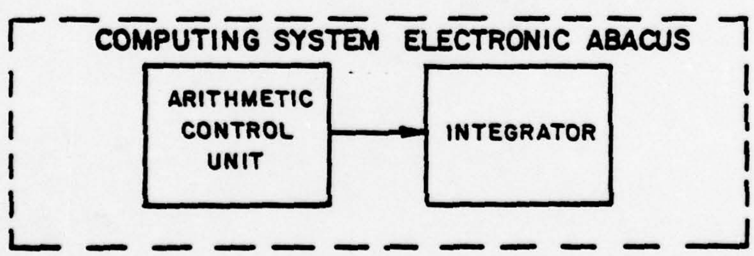

FIGURE 2.3 PRELIMINARY SYSTEM RELIABILITY MODEL (EXAMPLE)

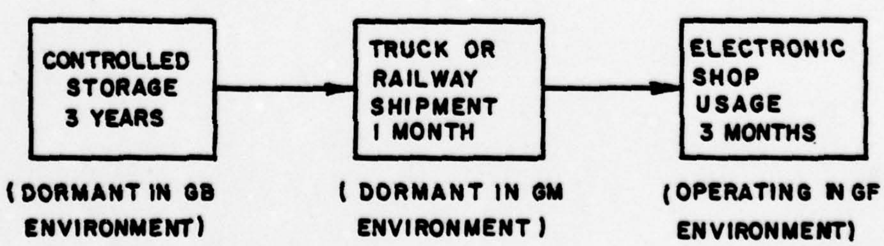

FIGURE 2.4 PRELIMINARY LIFE CYCLE EVENTS (EXAMPLE)

TABLE 2.1. Parts Count Computer Coding Forms (Example)

1. @ CARDS. UNIVAC 1110 computer control cards as defined in Appendix B.

2. CARD 2C. Add part failure rate information to the Stored Part Data.

#	PART CODE	PART DESCRIPTION	OPER FR SOURCE	OPERATING FAIL. RATE	π_E SYM	ENVIR FACTORS	DORM DATA SOURCE	DORMANT FAIL. RATE	π_E SYM	DORM FR FACTOR
2C	201	ELECTROMECH TIMER	RADC1	42.857	GF	ENV-1	ELECT			0.04

3. CARD 3. Define System Description.

#	(SYSTEM DESCRIPTION)	(DWG NO)
3	COMPUTING SYSTEM	X4194304A

4. CARD 5B. Define Environmental Stress Conditions for Condensed FR Subroutine.

#	#	FR TYPE 4	π_E SYM	TEMP 4	FR TYPE 5	π_E SYM	TEMP 5	FR TYPE 6	π_E SYM	TEMP 6	FR TYPE 7	π_E SYM	TEMP 7	FR TYPE 8	π_E SYM	TEMP 8
5B	3	DORMANT	GB	40	DORMANT	GM	50	ASSUMED	GF	50						

5. CARD 6. Define first Assembly Description.

#	(DWG NO)	(ASSEMBLY DESCRIPTION)	QTY 1	2	3	4	5	6	7	8	A
6	X6841199A	ARITHMETIC CONTROL UNIT									

6. CONDENSED PART DATA CARD. Define each of the Assembly Part Types and Quantity.

PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	A
101	5	301	3	302	3	310	7	402	10	406	15	505	5	510	7	
201	1	701	2	901												

TABLE 2.1. Parts Count Computer Coding Forms (Example) (Continued)

7. CARD 6. Define second Assembly Description.

#	(DWG NO)	(ASSEMBLY DESCRIPTION)	QTY	1	2	3	4	5	6	7	8
6	X6341131	INTEGRATOR									

8. CONDENSED PART DATA CARD. Define each of the Assembly Part Types and Quantity.

PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	PART CODE	PART QTY	8
102	3	406	11	505	6	510	2	701	2	901						

9. Card 8. Define the Reliability Summary Cards.

#	#	(LIFE CYCLE EVENT DESC)
8A		CONTROLLED STORAGE IN DEPOT ENVIR

#	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS
8C	SYS	11		3	YRS															

#	#	(LIFE CYCLE EVENT DESC)
8A		UNPACKAGED TRUCK/RAILWAY SHIPMENT

#	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS
8C	SYS	2		1	MON															

#	#	(LIFE CYCLE EVENT DESC)
8A		SHIP USAGE IN AIRFIELD ENVIR

#	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS
8C	SYS	13		3	MON															

TABLE 2.1. Parts Count Computer Coding Forms (Example) (Continued)

10. @ CARDS. UNIVAC 1110 computer control cards as defined in Appendix B.

3. APPLIED STRESS FAILURE RATE DATA

a. Preliminary Design Information

The data depicted in Figures 2.2, 2.3, and 2.4 are representative of the type of basic information necessary to perform a preliminary reliability prediction using stress analysis data as depicted in Table 2.2. The necessary data would be compiled by the reliability analyst using engineering judgement and very limited design information.

b. "Standard" Part Failure Rate Definitions

Comparison of the part data in Table 2.2 to the Stored Part Data as defined in Appendix A indicates that:

(1) The part quality and application is inadequately defined, however, the resistor and capacitor part definitions indicate the use of established reliability level parts. If the analyst is unable to obtain clarification, the Stored Part Data for a military application could be assumed to be applicable with a minimum of modifications. The Stored Part Data are modified using the Card 2B format as depicted in Table 2.3 to reflect the users hardware and to minimize the data entries at the part level.

(2) As noted in Section II.2.b(2), the Electromechanical Timer is not reflected in the Stored Part Data. Therefore, the reliability analyst must research and define an appropriate operating part failure rate that reflects the part, part application, and operating environment. The part failure rate is added to the Stored Part Data using the Card 2C format.

c. System Configuration Data

The system configuration data are compiled on the Computer Coding Forms in Appendix B, as depicted in Table 2.3. By entering the environmental stress data using the Card 5A format (Detailed Failure Rate Subroutine only), the user can enter detailed part data and all exceptions to the "Standard" part failure rate definitions at the part level using the Detailed Part Data Cards. The number of part solder connections (#C) is stored by the computer program for the Stored Part Data. The number of part solder connections for data entered on a 2C Card, or other connections, must be entered separately. As depicted in Table 2.3 the environmental stress conditions for each life cycle event are in terms of the type of failure rate data (APPLIED, ASSUMED, or DORMANT), the equivalent MIL-HDBK-217B environmental symbol, and the ambient temperature in degrees Celsius. If the above data are not specifically defined, the analyst defines said conditions in terms of established documentation, e.g., environmental criteria and guidelines in MIL-STD-1670 (Reference 6). Although the preliminary parts list does not reflect printed wiring boards or connectors, it is reasonable to assume that they should be included. Detailed procedures and assumptions are presented in Section V.

TABLE 2.2. PRELIMINARY STRESS ANALYSIS (EXAMPLE)

STRESS ANALYSIS WORKSHEET

SYSTEM ELECT. ABACUS ASSEMBLY (SEE BELOW) DRAWING ______

PART DESIG.	PART TYPE & QUALITY	VALUE OR NUMBER	REVERSE VOLTAGE			TYPE STRESS	APPLIED STRESS	STRESS AT 25°C		STRESS AT ___°C		COMMENTS
			RATED	APPLIED	RATIO			RATING	RATIO	RATING	RATIO	
			- ARITHMETIC CONTROL UNIT -									
U1,2,5	512 BIT PROM	MCM5303		-ALL CURRENTS AND VOLTAGES WITHIN SPECIFICATIONS-								
U3-4	NAND GATE	5402		-ALL CURRENTS AND VOLTAGES WITHIN SPECIFICATIONS-								
Q1-3	NPN XSTR	2N2222A	CEO=40	<4	<0.1	POWER	<.05	0.5	<0.1			
Q4-6	PNP XSTR	2N2907A	CEO=60	<6	<0.1	POWER	<.06	0.6	<0.1			
CR1-5	DIODE	1N483B	BV=80	<8	<0.1	CURRENT	<.02	0.2	<0.1			
VR1-2	9V ZENER	1N938A				POWER	<.05	0.5	<0.1			
R1	RCR07	3.9K				POWER	.10	0.25	0.40			
R2-5	RCR07	XXX				POWER	<.02	0.25	<0.1			
R6-7	RNR55	XXX				POWER	<.01	0.125	<0.1			
R8	RCR07	5.1K				POWER	.07	0.25	0.28			
R9-13	RNR55	XXX				POWER	<.01	0.125	<0.1			
R14-15	RCR07	XXX				POWER	<.02	0.25	<0.1			
R16-17	RWR74	10Ω				POWER	1.8	5.0	0.36			
R18-19	RCR07	XXX				POWER	<.02	0.25	<0.1			
R20-24	RNR55	XXX				POWER	<.01	0.125	<0.1			
C1-4	CK70	.001				VOLTAGE	<50	500	<0.1			
C5	CSR13	68				VOLTAGE	8	20	0.4			
C6	CSR13	68				VOLTAGE	12	20	0.6			
C7	CMR06	.001				VOLTAGE	<50	500	<0.1			
C8-C9	CSR13	33				VOLTAGE	12	20	0.6			
C10-12	CK70	.001				VOLTAGE	<50	500	<0.1			
			-INTEGRATOR-									
U1-3	OP AMP	µA741		-ALL CURRENTS AND VOLTAGES WITHIN SPECIFICATIONS-								
R1-8	RNR55	XXX				POWER	<.01	0.125	<0.1			
R9-10	RNR55	105Ω				POWER	.025	0.125	0.2			
R11	RNR55	2.05K				POWER	<.01	0.125	<0.1			
C1-4	CK70	.001				VOLTAGE	<50	500	<0.1			
C5-6	CSR13	33				VOLTAGE	8	20	0.4			
C7-8	CK70	.001				VOLTAGE	<50	500	<0.1			

PAGE ____ OF ____

TABLE 2.3. Applied Stress Computer Coding Forms

1. @ CARDS. UNIVAC 1110 computer control cards as defined in Appendix B.

2. CARD 2B. Modify part failure rate parameters in the Stored Part Data.

#	PART CODE	PART DESCRIPTION	PART FR EQUIVALENCY	EQUIV CODE	MODIFIED PART PARAMETER	#	MODIFIED PART PARAMETER	#	MODIFIED PART PARAMETER	#
2B	101				#C = 4					
2B	102				#T = 23					
2B	104				#B = 512					
2B	505		CK STYLE CAPACITOR		A = 10					

3. CARD 2C. Add part failure rate information to the Stored Part Data.

#	PART CODE	PART DESCRIPTION	OPER FR SOURCE	OPERATING FAIL. RATE	%E SYM	ENVIR FACTORS	DORM DATA SOURCE	DORMANT FAIL. RATE	%E SYM	DORM FR FACTOR	#
2C	801	ELECTROMECH TIMER	RADC1	42.857	GF	ENV-1	ELECT			0.04	

4. CARD 3. Define System Description.

#	(SYSTEM DESCRIPTION)	(DWG NO)
3	COMPUTING SYSTEM	X4194304A

5. CARD 5A. Define Environmental Stress Conditions for Detailed FR Subroutine.

#	#	FR TYPE 1	%E SYM	TEMP 1	FR TYPE 2	%E SYM	TEMP 2	FR TYPE 3	%E SYM	TEMP 3
5A	1	DORMANT	GB	40	DORMANT	GM	50	APPLIED	GF	50

6. CARD 6. Define first Assembly Description

#	(DWG NO)	(ASSEMBLY DESCRIPTION)	QTY	1	2	3	4	5	6	7	8	A
6	X6841199A	ARITHMETIC CONTROL UNIT										

TABLE 2.3. Applied Stress Computer Coding Forms (Continued)

7. DETAILED PART DATA CARD. Define parts and exceptions to "standard" definitions.

PART REF DESIG	PART/ASSEMBLY DRAWING NUMBER	PART QTY	PART CODE	MODIFIED PART PARAMETER	MODIFIED PART PARAMETER	MODIFIED PART PARAMETER	MODIFIED PART PARAMETER	A/S
U1,2,5	512 BIT PROM, MCM5303	3	104					
U3,4	NAND GATE, 5402	2	101					
Q1-3	2N2222A, 0.5W	3	301					
Q4-6	2N2907A, 0.6W	3	302					
CR1-5	1N4838, 0.2A	5	310					
VR1-2	1N938A, 0.5W	2	312					
R1	RCR07, 3.9K, 0.25W		402	351 = 0.4				
R2-5	RCR07, XXX, 0.25W	4	402					
R6-7	RNR55, XXX, 0.125W	2	406					
R8	RCR07, 5.1K, 0.25W		402	351 = 0.28				
R9-13	RNR55, XXX, 0.125W	5	406					
R14-15	RCR07, XXX, 0.25W	2	402					
R16-17	RWR74, 10, 5.0W	2	407	351 = 0.36				
R18-19	RCR07, XXX, 0.25W	2	402					
R20-24	RNR55, XXX, 0.125W	5	406					
C1-4	CK70, .001UF, 500V	4	505					
C5	CSR13, 68UF, 20V		510	351 = 0.4				
C6	CSR13, 68UF, 20V		510	351 = 0.6				
C7	CMR06, .001UF, 500V		507					
C8-9	CSR13, 33UF, 20V	2	510	351 = 0.6				
C10-12	CK70, .001UF, 500V	3	505					
			801					
		2	701					
			901					

8. CARD 6. Define second Assembly Description.

#	(DWG NO)	(ASSEMBLY DESCRIPTION)	QTY	1	2	3	4	5	6	7	8
6	X6841181	INTEGRATOR									

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TABLE 2.3. Applied Stress Computer Coding Forms (Continued)

9. DETAILED PART DATA CARD.

PART REF DESIG	PART/ASSEMBLY DRAWING NUMBER	PART QTY	PART CODE	MODIFIED PART PARAMETER	MODIFIED PART PARAMETER	MODIFIED PART PARAMETER	MODIFIED PART PARAMETER	AS
U1-3	OPER AMPL, UA741	3	102					
R1-8	RNR55, XXX, 0.125W	8	406	3SI = 0.2				
R9-10	RNR55, 105, 0.125W	2	406					
R11	RNR55, 2.05K, 0.125W		406					
C1-4	CK70, .001uF, 500V	4	505					
C5-6	CSR13, 33uF, 20V	2	510	3SI = 0.4				
C7-8	CK70, .001uF, 500V	2	505					
		2	701					
			401					

10. CARD 8. Define the Reliability Summary Cards.

#	#	(LIFE CYCLE EVENT DESC)
8A		CONTROLLED STORAGE IN DEPOT ENVIR

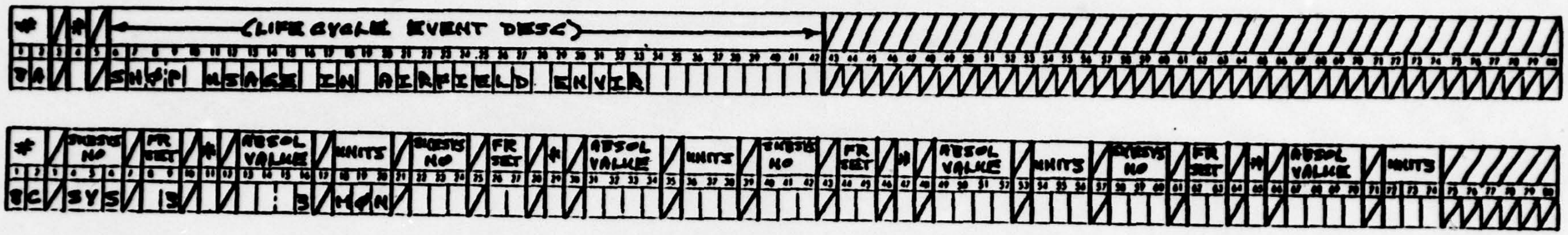
#	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS
8C	SYS	1		3	YRS															

#	#	(LIFE CYCLE EVENT DESC)
8A		UNPACKAGED TRUCK/RAILWAY SHIPMENT

#	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS	SUBSYS NO	FR SET	#	ABSOL VALUE	UNITS
8C	SYS	2		1	MON															

TABLE 2.3. Applied Stress Computer Coding Forms (Continued)

10. CARD 8. Reliability Summary Cards (Continued)



11. A CARDS. UNIVAC 1110 computer control cards as defined in Appendix B.

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SECTION III

SAMPLE PREDICTION

1. CONFIGURATION DATA

In compiling the data to perform a reliability prediction using the computer program, the user must organize his hardware in terms of "system," "subsystem," "assembly," and "subassembly" as depicted in Figure 3.1. The user should note for the summary all one-shot devices that are to be "predicted" using device reliability data instead of time-dependent failure rate data, i.e. part (n+1) in Figure 3.1. The user must also evaluate the applicability of the series system assumption in Section II.1.e. If the user's system contains non-series functions, these data must be isolated as separate data in the computer printout for proper data manipulation in the basic report.

2. LIFE CYCLE EVENT DATA

The user must define all dormant and operating life cycle events that are to be included in the prediction. These definitions should be in direct accordance with specified system requirements for proper data comparison upon completion of the reliability prediction. The life cycle events should be explicitly defined in terms of environmental severity, operating versus dormant state, containerized versus non-containerized storage, event durations, and event temperatures for inclusion in the failure rate data base. The user must also acquire or derive the necessary stress analysis data for formal, explicit prediction results. If these data are not available, the acceptability of the assumed stress part data techniques must be defined by the user.

3. DATA PREPARATION

To prepare the above data for the computer program, the user:

a. Compiles the "system," "subsystem," "assembly," and "subassembly" description on the appropriate cards, and identifies the appropriate environmental conditions for the Detailed and/or Condensed Failure Rate Subroutines using the Card 5A and/or 5B format. These data define the hardware documentation, the failure rate subroutines, and environmental conditions to be used.

   Note: Condensed Failure Rate Data for an assumed hardware configuration (OUTPUT STAGE) can be combined with detailed stress data (ELECTRONIC ABACUS) if submitted prior to implementing the Detailed Failure Rate Subroutine.

b. Evaluates applicability of the Stored Part Data and modifies same, as necessary, using the Card 2B format to establish the "Standard" part failure rate parameters for the prediction.

c. If the Condensed Failure Rate Subroutine only is to be used, the user compiles the part code and part quantity data on the Condensed Part Data Cards. If the user wants additional condensed failure rate data, he must duplicate his Condensed Part data and resubmit same as an additional subsystem (OUTPUT STAGE).

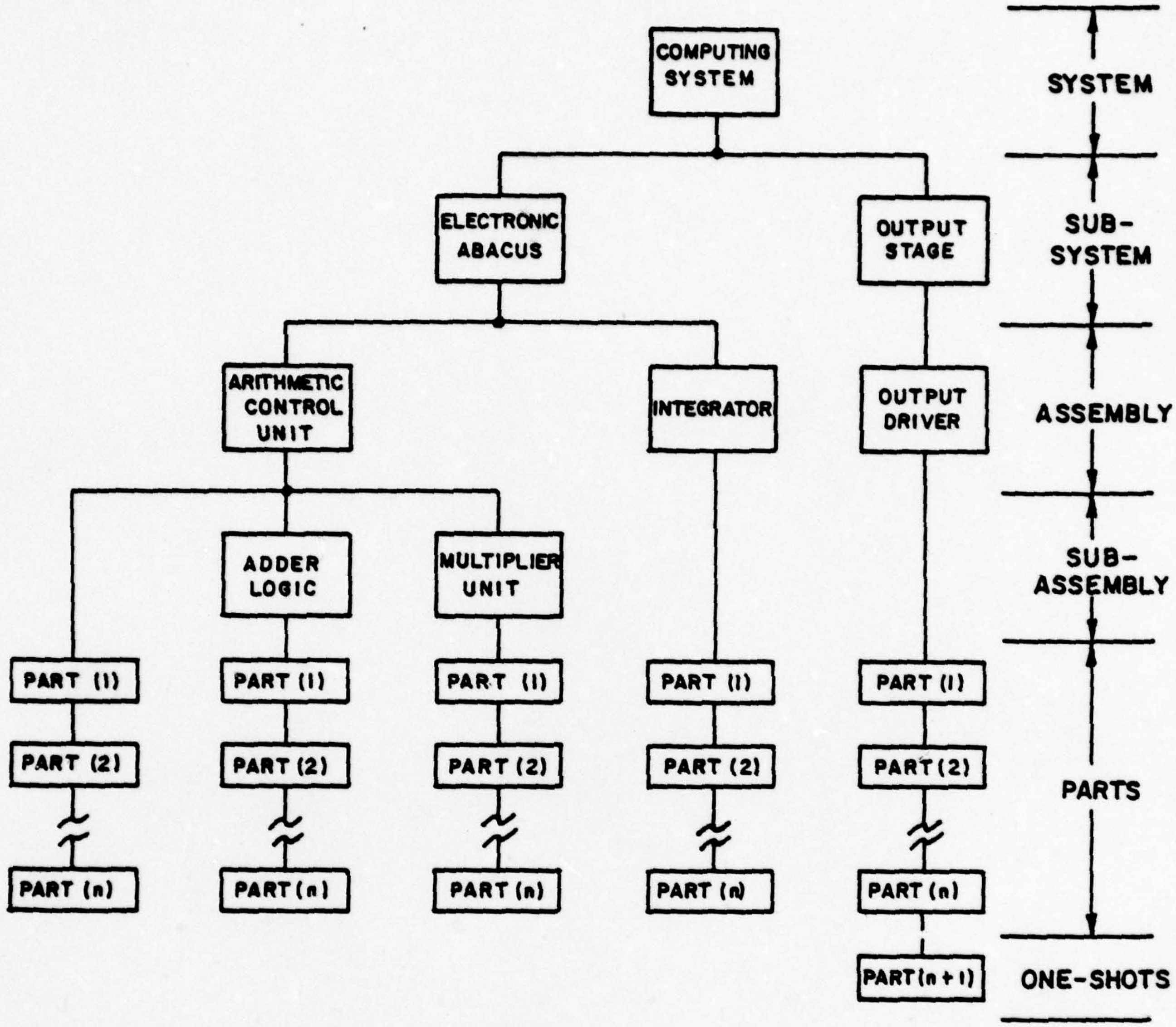

FIGURE 3.1. SYSTEM CONFIGURATION FOR SAMPLE PREDICTION

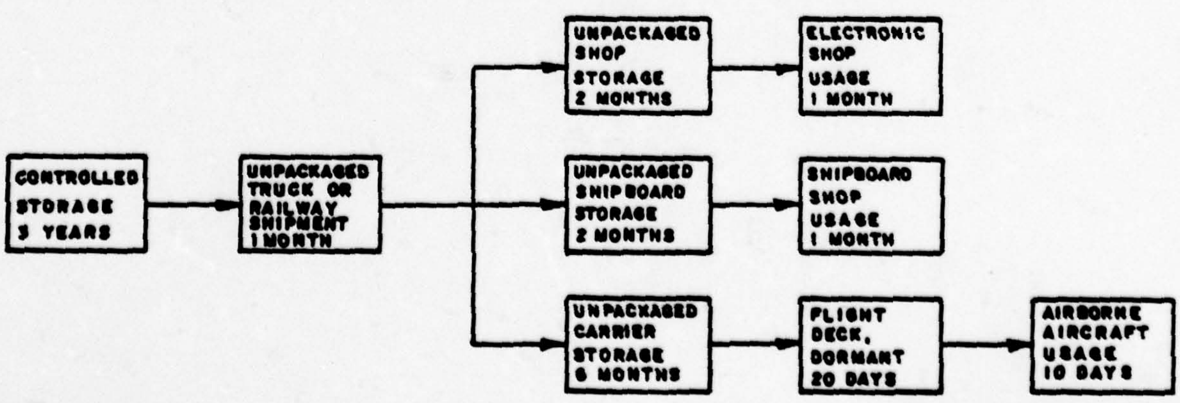

FIGURE 3.2. LIFE CYCLE EVENTS FOR SAMPLE PREDICTION

d. If the Detailed Failure Rate Subroutine, or the Detailed and Condensed Failure Rate Subroutines are to be used, the user compiles, or has compiled, the assembly/fabrication drawing part reference designator and part number data on the Detailed Part Data Cards. The user then evaluates each part data card to enter the part code and all exceptions to the "Standard" part failure rate parameters.

   If the user wants 6 to 10 sets of condensed failure rate data, he inserts a second 5B Card after each set of subsystem part data, i.e., prior to the next 3, 4, or 8 Card in his data deck. The computer program will use the part configuration data stored for the first 5B Card to provide a second set of condensed failure rate data (see Figure 1.1).

e. Defines all additional part data that must be included, i.e., PWB Wave Solder Connections, etc. The number of part solder connections (#C) is stored by the computer program for the Stored Part Data. The number of part connections for data entered on a 2C Card, or other connections, must be entered separately.

f. Defines all additional part failure rate data that must be stored in the computer program using the Card 2A or 2C format, e.g., 801 Electromechanical Timer.

g. Defines the applicable failure rate data and one-shot reliability data for each life cycle event.

h. Organizes data deck in accordance with Figure 2.1, adds appropriate computer control cards to compile the program deck, and submits same to the computer.

4. OUTPUT DATA

Each set of data (Detailed Failure Rate Data, Condensed Failure Rate Data, and Prediction Summary Data) from the computer is uniquely identified, dated, page numbered, and contains its own subsystem or system summary. This allows the user to include the data as separate appendices to his report. The basic report should contain all necessary supplemental failure rate or reliability data.

TABLE 3.1 Sample Prediction Computer Coding Forms

1. Supplemental Part Data.

```
2B 102                                                  PT=  21
2B 105                                                  #B= 512
2B 505                                                  Q =  10
2B 511 NØN-MTLC PLSTC CAP CPV STYLE CAP         5Ø8
2B 701                                                  N =  20
2C 701 ELECTRØMECH TIMER RADC1 42.857 GF EST(1)                      0.04
```

2. System Description.

```
3 CØMPUTING SYSTEM                                       X4194304A
```

3. Condensed Failure Rate Data for 1st Subsystem.

```
4 ØUTPUT STAGE FØR CØMPUTING SYSTEM               (ASSUMED)
5B 1 ASSUMED GF 35 ASSUMED NS 55 ASSUMED AI 45
6 (TØ BE DEF) ØUTPUT DRIVER
 101   6  103  2  105       107  2  301  7  302  5  310  8  402  18
 404   9  407  8  504  11   510  6  701  2  702  2  901
```

4. Condensed Failure Rate Data for 2nd Subsystem.

```
4 ØUTPUT STAGE FØR CØMPUTING SYSTEM               (ASSUMED)
5B 2 DØRMANT GB 25 DØRMANT AF 40 DØRMANT GM 65 DØRMANT NS 55 DØRMANT NU 60
6 (TØ BE DEF) ØUTPUT DRIVER
 101   6  103  2  105       107  2  301  7  302  5  310  8  402  18
 404   9  407  8  504  11   510  6  701  2  702  2  901
```

TABLE 3.1. Sample Prediction Computer Coding Forms (Continued)

5. Control Cards for 3rd Subsystem.

4		ELECTRØNIC ABACUS										X3336088				
5A	1	APPLIED	GF	35	APPLIED	NS	55	APPLIED	AI	45						
5B	2	DØRMANT	GB	25	DØRMANT	GF	40	DØRMANT	GM	65	DØRMANT	NS	60	DØRMANT	NU	55

6. Part Data Cards for 1st Assembly.

6	X6841199A	ARITHMETIC CØNTRØL UNIT				
U1	M38510/20101BJE, MCM5303			105		
U2	M38510/20101BJE, MCM5303			105		
CR1	JANTX1N4838			310		
CR2	JANTX1N4838			310	A = 1.5	
CR3	JANTX1N4838			310	S2 = 0.8	
R1	RCR07G512JM			402		
R2	RCR07G512JM			402	S1 = 0.28	
R3	RCR07G476JM			402	R = 1.6	
R4	RCR07G392JM			402		
C1	M39003/01-2538, CSR13/P			510	S1 = 0.4	SR = 0.6
C2	M39003/01-2538, CSR13/P			510	S1 = 0.6	
C3	CK62BX102M			505		
	X6841085A		2	701	N = 21	
	X6841085A		2	701	N = 18	
	X6841132-			702	N = 24	
	X6841235C			801		
	X6841328-			901	N = 55	
			3	906		

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TABLE 3.1. Sample Prediction Computer Coding Forms (Continued)

7. Part Data Cards for 1st Subassembly in the 1st Assembly

Col. 1	Cols. 2–5	Cols. 7–36	Cols. 37–39	Cols. 42–49	Cols. 51–57
7	X6841197- ADDER LOGIC				
	K1	X68410183-1, 54123	101		
	K2	X68410188-1, 54123	101		
	R1	RCR07G512JM	402		
	R2	RCR07G512JM	402		
	R3	RCR07G391JM	402		
	R4	RNR55C1001FM	406		
	R5	RNR55C1501FM	406	S1 = 0.1	
	R6	RNR55C1501FM	406		
	R7	RNR55C1001FM	406		
	C1	M39003/01-2497, CSR13/P	510		
	C2	M39003/01-2497, CSR13/P	510	S1 = 0.6	SR= 0.6
	C3	M39003/01-2497, CSR13/P	510		
	C4	CK62BX102M	505		
		X6841085A	701	N = 17	
		X6841527-	901	N = 46	

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TABLE 3.1. Sample Prediction Computer Coding Forms (Continued)

8. Part Data Cards for 2nd Subassembly in the 1st Assembly

Col 1	Cols 2–5	Cols 7–35	Cols 37–39	Cols 41–49
7	X6841198A	MULTIPLIER UNIT		
	U1	M38510/20101BJB, MCM5303	105	
	Q1	JANTX2N2222A	301	
	Q2	JANTX2N2222A	301	
	Q3	JANTX2N2222A	301	
	Q4	JANTX2N2907A	302	
	Q5	JANTX2N2907A	302	
	Q6	JANTX2N2907A	302	
	CR1	JANTX1N483B	310	
	CR2	JANTX1N483B	310	
	VR1	JANTX1N938A	312	
	VR2	JANTX1N938A	312	
	R1	RNR55C2981FM	406	S1 = 0.24
	R2	RNR55C2051FM	406	
	R3	RNR55C2002FM	406	
	R4	RNR55C1002FM	406	
	R5	RNR55C1001FM	406	
	R6	RWR74SR100FM	407	
	R7	RLR07C103GM	405	
	R8	RLR07C103GM	405	
	R9	RLR07C103GM	405	
	R10	RLR07C103GM	405	
	R11	RLR07C512GM	405	
	R12	RLR07C513GM	405	
	R13	RLR07C4766M	405	R = 1.6
	R14	RLR07C3926M	405	
	C1	M39003/01-2538, CSR13/P	510	
	C2	CK62BX102M	505	
	C3	CK62BX102M	505	
		X6841085A	701	N = 19
		X6841251-	901	N = 79

TABLE 3.1. Sample Prediction Computer Coding Forms (Continued)

9. Part Data Cards for 2nd Assembly.

6	X6841151C	INTEGRATOR		
	K1	M38510/10103BGC, LM101A	102	
	K2	M38510/10103BGC, LM101A	102	
	K3	M38510/10103BGC, LM101A	102	
	R1	RNR55C2051FM	406	
	R2	RNR55C2052FM	406	
	R3	RNR55C7502FM	406	
	R4	RNR55C7500FM	406	
	R5	RNR55C2611FM	406	
	R6	RNR55C5361FM	406	
	R7	RNR55C1050FM	406	S1 = 0.2
	R8	RNR55C1050FM	406	S1 = 0.2
	R9	RNR55C2052FM	406	
	R10	RNR55C2051FM	406	
	R11	RNR55C2051FM	406	
	C1	CMR05F181FPDM	507	
	C2	CMR05F181FPDM	507	
	C3	M39006/01-3043	506	S1 = 0.5
	C4	CMR05F181FPDM	507	
	C5	M39003/01-2538, CSR13/P	510	SR = 0.2
	C6	M39003/01-2538, CSR13/P	510	
	C7	M39014/01-1405, CKR06/M	505	Q = 1.0
	C8	M39014/01-1405, CKR06/M	505	Q = 1.0
	C9	M39014/01-1405, CKR06/M	505	Q = 1.0
		X6841085A	701	N = 22
		X6841132-	702	N = 22
		X6841329-	901	N = 73

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TABLE 3.1. Sample Prediction Computer Coding Forms (Continued)

10. System/Subsystem Reliability Summary Data.

```
8A    CØNTRØLLED STØRAGE IN DEPØT ENVIR
8C SS2 4      3 YRS SS3 4            SYS
8A    UNPACKAGED TRUCK ØR RAILWAY SHIPMENT
8C SS2 6      1 MØN SS3 6            SYS
8A    UNPACKAGED ELECTRØNICS SHØP STØRAGE
8C SS2 5      2 MØN SS3 5            SYS
8A    ELECTRØNICS SHØP USAGE IN FIELD ENVIR
8B SS1 FUZABLE LINKS                    .9988
8C SS1 4 #    1 MØN SS3 1            SYS
8A    UNPACKAGED SHIPBØARD DEEP STØRAGE
8C SS2 7      2 MØN SS3 7            SYS
8A    SHIPBØARD ELECTRØNICS SHØP USAGE
8B SS1 FUZABLE LINKS                    .9970
8C SS1 5 #    1 MØN SS3 2            SYS
8A    UNPACKAGED DEEP STØRAGE ØN CARRIER
8C SS2 7      6 MØN SS3 7            SYS
8A    UNPACKAGED FLIGHT DECK READY STØRAGE
8C SS2 8     20 DAY SS3 8            SYS
8A    AIRBØRNE FLIGHT TEST MØNITØRING USAGE
8B SS1 FUZABLE LINKS                    .9970
8C SS1 6 #   10 DAY SS3 3            SYS
```

02/28/77 OUTPUT STAGE FOR COMPUTING SYSTEM DWG NO (ASSUMED) PAGE 1

*** CONDENSED PART FAILURE RATE DATA FOR ***
(TO BE DEF) OUTPUT DRIVER

PART DESCRIPTION	PART QTY	ASSUMED GF FAIL. RATE AT 35 C	ASSUMED NS FAIL. RATE AT 55 C	ASSUMED AI FAIL. RATE AT 45 C
MONO S/MSI DIG I/C	6	.02820	.10438	.09976
MONO LSI DIG I/C	2	.07218	.23221	.20819
MONO RAM INTEG CKT	1	.15510	.45887	.39023
MOS S/MSI DIG I/C	2	.03004	.12561	.10739
SI NPN TRANSISTOR	7	.00301	.01882	.01680
SI PNP TRANSISTOR	5	.00449	.02776	.02500
STD SILICON DIODE	8	.00449	.03185	.02679
CARBON COMP RES	18	.00052	.00265	.00148
W/W CMS POWER RES	9	.01755	.04968	.03866
W/W POWER RESISTOR	8	.01039	.02840	.02247
MTLC PPR/PLSTC CAP	11	.00014	.00029	.00028
SOLID TANTALUM CAP	6	.00023	.00056	.00051
PWB CONNECTOR	2	.09380	.14588	.11712
RACK & PANEL CONN	2	.09380	.14588	.11712
TWO-SIDED PW BOARD	1*	.00120	.00240	.00360
PART CONNECTIONS	78*	.00044	.00044	.00044
(TO BE DEF) OUTPUT DRIVER	87	1.27232	3.67493	3.14388

NOTE: * = PART QTY NOT INCL IN TOTAL

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ANTN. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.3. Condensed Failure Rate Data for Assumed Output Driver Configuration

02/28/77 OUTPUT STAGE FOR COMPUTING SYSTEM DWG NO (ASSUMED) PAGE 2

CONDENSED FR SUMMARY

DWG NUMBER	ASSEMBLY OR SUBASSEMBLY DESCRIPTION	PART QTY	ASSUMED GF FAIL. RATE AT 35 C	ASSUMED NS FAIL. RATE AT 55 C	ASSUMED AI FAIL. RATE AT 45 C
(TO BE DEF)	OUTPUT DRIVER	87	1.27232	3.67493	3.14388

OUTPUT STAGE FOR COMPUTING SYSTEM

TOTAL PART QTY AND ENVIRONMENTAL STRESS FAILURE RATE	87	1.27232	3.67493	3.14388
ENVIRONMENTAL STRESS MEAN-TIME-BETWEEN FAILURES (HOURS)		785964.80	272113.77	318078.06

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ARITH. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.3. Condensed Failure Rate Data for Assumed Output Driver Configuration (Cont'd)

CONDENSED FR RANKING

GENERAL PART DESCRIPTION	PART QTY	(RANKING COLUMN) ASSUMED GF @ 35 C -FR SUM-	-%-	ASSUMED NS @ 55 C -FR SUM-	-%-	ASSUMED AI @ 45 C -FR SUM-	-%-
PWB CONNECTOR	2	.18760	14.745	.29175	7.939	.23424	7.451
RACK & PANEL CONN	2	.18760	14.745	.29175	7.939	.23424	7.451
MONO S/MSI DIG I/C	6	.16919	13.298	.62630	17.042	.59858	19.040
W/W CHS POWER RES	9	.15799	12.418	.44709	12.166	.34798	11.069
MONO RAM INTEG CKT	1	.15510	12.191	.45887	12.487	.39023	12.412
MONO LSI DIG I/C	2	.14436	11.346	.46442	12.637	.41639	13.244
W/W POWER RESISTOR	8	.08315	6.535	.22720	6.182	.17976	5.718
MOS S/MSI DIG I/C	2	.06009	4.723	.25122	6.836	.21477	6.831
STD SILICON DIODE	8	.03594	2.825	.25477	6.933	.21434	6.818
PART CONNECTIONS	78*	.03432	2.697	.03432	.934	.03432	1.092
SI PNP TRANSISTOR	5	.02243	1.763	.13880	3.777	.12499	3.976
SI NPN TRANSISTOR	7	.02107	1.656	.13177	3.586	.11758	3.740
CARBON COMP RES	18	.00935	.735	.04765	1.297	.02670	.849
MTLC PPR/PLSTC CAP	11	.00153	.121	.00323	.088	.00313	.100
SOLID TANTALUM CAP	6	.00139	.109	.00339	.092	.00303	.096
TWO-SIDED PW BOARD	1*	.00120	.094	.00240	.065	.00360	.115

* = PART QTY NOT INCLUDED IN TOTAL OF PARTS

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ARITH. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.3. Condensed Failure Rate Data for Assumed Output Driver Configuration (Cont'd)

02/28/77	OUTPUT STAGE FOR COMPUTING SYSTEM	DWG NO (ASSUMED)	PAGE 1

*** CONDENSED PART FAILURE RATE DATA FOR ***
(TO BE DEF) OUTPUT DRIVER

PART DESCRIPTION	PART QTY	DORMANT GB FAIL. RATE AT 25 C	DORMANT GF FAIL. RATE AT 40 C	DORMANT GM FAIL. RATE AT 65 C	DORMANT NS FAIL. RATE AT 55 C	DORMANT NU FAIL. RATE AT 60 C
MONO S/MSI DIG I/C	6	.00065	.00270	.01044	.00998	.01247
MONO LSI DIG I/C	2	.00139	.00526	.01990	.01848	.02309
MONO RAM INTEG CKT	1	.00296	.00992	.03638	.03235	.04040
MOS S/MSI DIG I/C	2	.00065	.00300	.01405	.01149	.01484
SI NPN TRANSISTOR	7	.00025	.00145	.00954	.00856	.00904
SI PNP TRANSISTOR	5	.00035	.00212	.01422	.01271	.01345
STD SILICON DIODE	8	.00010	.00068	.00548	.00457	.00501
CARBON COMP RES	18	.00001	.00002	.00015	.00007	.00013
W/W CHS POWER RES	9	.00006	.00022	.00094	.00060	.00098
W/W POWER RESISTOR	8	.00004	.00013	.00053	.00034	.00056
MTLC PPR/PLSTC CAP	11	.00006	.00011	.00025	.00024	.00055
SOLID TANTALUM CAP	6	.00008	.00017	.00046	.00040	.00097
PWB CONNECTOR	2	.00108	.00419	.01406	.00584	.01409
RACK & PANEL CONN	2	.00108	.00419	.01406	.00584	.01409
TWO-SIDED PW BOARD	1*	.00002	.00005	.00010	.00010	.00024
PART CONNECTIONS	78*	.00000	.00002	.00004	.00002	.00004
(TO BE DEF) OUTPUT DRIVER	87	.02197	.09278	.42861	.35143	.44887

NOTE: * = PART QTY NOT INCL IN TOTAL

FIGURE 3.3 OUTPUT DRIVER FR DATA	FIGURE 3.4 ARITH. CONTROL FR DATA	FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.3. Condensed Failure Rate Data for Assumed Output Driver Configuration (Cont'd)

02/28/77 OUTPUT STAGE FOR COMPUTING SYSTEM DWG NO (ASSUMED) PAGE 2

CONDENSED FR SUMMARY

DWG NUMBER	ASSEMBLY OR SUBASSEMBLY DESCRIPTION	PART QTY	DORMANT GB FAIL. RATE AT 25 C	DORMANT GF FAIL. RATE AT 40 C	DORMANT GM FAIL. RATE AT 65 C	DORMANT NS FAIL. RATE AT 55 C	DORMANT NU FAIL. RATE AT 60 C
(TO BE DEF)	OUTPUT DRIVER	87	.02197	.09278	.42861	.35143	.44887

OUTPUT STAGE FOR COMPUTING SYSTEM

TOTAL PART QTY AND ENVIRONMENTAL STRESS FAILURE RATE	87	.02197	.09278	.42861	.35143	.44887
ENVIRONMENTAL STRESS MEAN-TIME-BETWEEN FAILURES (HOURS)		45514750.67	10778309.12	2333112.89	2845515.26	2227830.28

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ARITH. CONTROL FR DATA | FIGURE 3.6 RELIABILITY SUMMARY

FIGURE 3.3. Condensed Failure Rate Data for Assumed Output Driver Configuration (Cont'd)

CONDENSED FR RANKING

GENERAL PART DESCRIPTION	PART QTY	DORMANT GB @ 25 C -FR SUM-	DORMANT GB @ 25 C -%-	DORMANT GF @ 40 C (RANKING COLUMN) -FR SUM-	DORMANT GF @ 40 C (RANKING COLUMN) -%-	DORMANT GM @ 65 C -FR SUM-	DORMANT GM @ 65 C -%-	DORMANT NS @ 55 C -FR SUM-	DORMANT NS @ 55 C -%-	DORMANT NU @ 60 C -FR SUM-	DORMANT NU @ 60 C -%-
MONO S/MSI DIG I/C	6	.00391	17.811	.01623	17.490	.06263	14.612	.05986	17.033	.07480	16.664
SI PNP TRANSISTOR	5	.00175	7.951	.01062	11.443	.07111	16.592	.06353	18.078	.06726	14.984
MONO LSI DIG I/C	2	.00279	12.679	.01053	11.347	.03979	9.284	.03697	10.520	.04619	10.290
SI NPN TRANSISTOR	7	.00172	7.833	.01018	10.976	.06678	15.580	.05993	17.053	.06326	14.092
MONO RAM INTEG CKT	1	.00296	13.459	.00992	10.697	.03638	8.489	.03235	9.205	.04040	9.001
PWB CONNECTOR	2	.00216	9.841	.00839	9.040	.02811	6.560	.01167	3.321	.02817	6.276
RACK & PANEL CONN	2	.00216	9.841	.00839	9.040	.02811	6.560	.01167	3.321	.02817	6.276
MOS S/MSI DIG I/C	2	.00130	5.937	.00601	6.476	.02811	6.558	.02299	6.541	.02968	6.613
STD SILICON DIODE	8	.00080	3.634	.00547	5.894	.04385	10.230	.03653	10.396	.04006	8.925
W/W CNS POWER RES	9	.00057	2.612	.00199	2.144	.00844	1.969	.00537	1.527	.00885	1.971
PART CONNECTIONS	78*	.00034	1.562	.00137	1.480	.00275	.641	.00137	.391	.00309	.688
MTLC PPR/PLSTC CAP	11	.00061	2.794	.00125	1.349	.00276	.645	.00262	.744	.00603	1.343
W/W POWER RESISTOR	8	.00031	1.404	.00104	1.118	.00423	.987	.00273	.776	.00446	.994
SOLID TANTALUM CAP	6	.00047	2.117	.00103	1.115	.00279	.650	.00242	.689	.00582	1.296
CARBON COMP RES	18	.00009	.417	.00031	.337	.00267	.622	.00133	.380	.00239	.533
TWO-SIDED PW BOARD	1*	.00002	.109	.00005	.052	.00010	.022	.00010	.027	.00024	.053

* = PART QTY NOT INCLUDED IN TOTAL OF PARTS

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ARITH. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.3. Condensed Failure Rate Data for Assumed Output Driver Configuration (Cont'd)

02/28/77 ELECTRONIC ABACUS DWG NO X83886088 PAGE 1

*** DETAILED PART FAILURE RATE FOR ***
X6841199A ARITHMETIC CONTROL UNIT

DESIG	PART/DRAWING NUMBER	PART DESCRIPTION	PART QTY	APPLIED GF FAIL. RATE AT 35 C	APPLIED NS FAIL. RATE AT 55 C	APPLIED AI FAIL. RATE AT 45 C	EXCEPTIONS TO APPLIED STRESS PART FR PARAMETERS IN PREDICTION SUMMARY
U1	M36510/201C1BJB,MCM53C3	MONO RAM INTEG CKT	1	.15510	.45887	.39023	
U2	M36510/20101BJB,MCM5303	MONO RAM INTEG CKT	1	.15510	.45887	.39023	
CR1	JANTX1N483B	STD SILICON DIODE	1	.00253	.01872	.01547	
CR2	JANTX1N483B	STD SILICON DIODE	1	.00632	.04679	.03866	A = 1.5
CR3	JANTX1N483B	STD SILICON DIODE	1	.00289	.02139	.01767	S2= 0.8
R1	RCR07G512JM	CARBON COMP RES	1	.00052	.00265	.00148	
R2	RCR07G512JM	CARBON COMP RES	1	.00073	.00380	.00210	S1=0.28
R3	RCR07G476JM	CARBON COMP RES	1	.00083	.00424	.00237	R = 1.6
R4	RCR07G392JM	CARBON COMP RES	1	.00052	.00265	.00148	
C1	M39003/01-2538,CSR13/P	SOLID TANTALUM CAP	1	.00280	.00681	.00610	S1= 0.4 SR= 0.6
C2	M39003/01-2538,CSR13/P	SOLID TANTALUM CAP	1	.00071	.00174	.00156	S1= 0.6
C3	CK62BX102M	CERAMIC CAPACITOR	1	.04002	.08417	.08208	
	X6841085A	PWB CONNECTOR	2	.09746	.15149	.12165	N = 21
	X6841085A	PWB CONNECTOR	2	.08659	.13483	.10819	N = 18
	X6841132-	RACK & PANEL CONN	1	.10866	.16369	.13554	N = 24
	X6841235C	ELECTROMECH TIMER	1	42.85700	107.14250	107.14250	
	X6841328-	TWO-SIDED PW BOARD	1*	.00120	.00240	.00360	N = 55
		PART CONNECTIONS	3*	.00044	.00044	.00044	
		PART CONNECTIONS	52*	.00044	.00044	.00044	
	ASSEMBLY SUBTOTAL		18	43.72723	109.02110	108.71497	NOTE: * = PART QTY NOT INCL IN TOTAL

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ELECT. ABACUS FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus

02/28/77 ELECTRONIC ABACUS DWG NO X83886080 PAGE 2

*** DETAILED PART FAILURE RATE FOR ***
X6841197- ADDER LOGIC

NEXT ASSY:
ARITHMETIC CONTROL UNIT

DESIG	PART/DRAWING NUMBER	PART DESCRIPTION	PART QTY	APPLIED GF FAIL. RATE AT 35 C	APPLIED NS FAIL. RATE AT 55 C	APPLIED AI FAIL. RATE AT 45 C	EXCEPTIONS TO APPLIED STRESS PART FR PARAMETERS IN PREDICTION SUMMARY
U1	X68410188-1,54123	MONO S/MSI DIG I/C	1	.02820	.10438	.09976	
U2	X68410188-1,54123	MONO S/MSI DIG I/C	1	.02820	.10438	.09976	
R1	RCR07G512JM	CARBON COMP RES	1	.00052	.00265	.00148	
R2	RCR07G512JM	CARBON COMP RES	1	.00052	.00265	.00145	
R3	RCR07G391JM	CARBON COMP RES	1	.00052	.00265	.00149	
R4	RNR55C1001FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R5	RNR55C1501FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	S1= 0.1
R6	RNR55C1501FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R7	RNR55C1001FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
C1	M39003/01-2497,CSR13/P	SOLID TANTALUM CAP	1	.00017	.00040	.00036	
C2	M39003/01-2497,CSR13/P	SOLID TANTALUM CAP	1	.00612	.01489	.01333	S1= 0.6 SR= 0.6
C3	M39003/01-2497,CSR13/P	SOLID TANTALUM CAP	1	.00017	.00040	.00035	
C4	CK62BX102M	CERAMIC CAPACITOR	1	.04002	.08417	.08208	
	X6841085A	PWB CONNECTOR	1	.08303	.12938	.10379	N = 17
	X6841529-	TWO-SIDED PW BOARD	1*	.00120	.00240	.00360	N = 46
		PART CONNECTIONS	50*	.00044	.00044	.00044	
X6841197-	ADDER LOGIC		14	.22746	.53089	.46633	NOTE: * = PART QTY NOT INCL IN TOTAL

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ELECT. ABACUS FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus (Cont'd)

02/28/77 ELECTRONIC ABACUS DWG NO X8388608B PAGE 3

*** DETAILED PART FAILURE RATE FOR ***
X6841198A MULTIPLIER UNIT

NEXT ASSY:
ARITHMETIC CONTROL UNIT

DESIG	PART/DRAWING NUMBER	PART DESCRIPTION	PART QTY	APPLIED GF FAIL. RATE AT 35 C	APPLIED NS FAIL. RATE AT 55 C	APPLIED AI FAIL. RATE AT 45 C	EXCEPTIONS TO APPLIED STRESS PART FR PARAMETERS IN PREDICTION SUMMARY
U1	M38510/20101BJB,MCM5303	MONO RAM INTEG CKT	1	.15510	.45887	.39023	
Q1	JANTX2N2222A	SI NPN TRANSISTOR	1	.00217	.01350	.01212	
Q2	JANTX2N2222A	SI NPN TRANSISTOR	1	.00217	.01350	.01212	
Q3	JANTX2N2222A	SI NPN TRANSISTOR	1	.00217	.01350	.01212	
Q4	JANTX2N2907A	SI PNP TRANSISTOR	1	.00314	.02004	.01781	
Q5	JANTX2N2907A	SI PNP TRANSISTOR	1	.00314	.02004	.01781	
Q6	JANTX2N2907A	SI PNP TRANSISTOR	1	.00314	.02004	.01781	
CR1	JANTX1N483B	STD SILICON DIODE	1	.00253	.01872	.01547	
CR2	JANTX1N483B	STD SILICON DIODE	1	.00253	.01872	.01547	
VR1	JANTX1N938A	ZENER DIODE	1	.01698	.09940	.09193	
VR2	JANTX1N938A	ZENER DIODE	1	.01698	.09940	.09193	
R1	RNR55C2981FM	HIGH STAB FILM RES	1	.00492	.01791	.01084	S1=0.24
R2	RNR55C2051FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R3	RNR55C2002FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R4	RNR55C1002FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R5	RNR55C1001FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R6	RWR74SR100FM	W/W POWER RESISTOR	1	.01039	.02840	.02247	
R7	RLR07C103GM	INSUL FILM RES	1	.00750	.01406	.01053	
R8	RLR07C103GM	INSUL FILM RES	1	.00750	.01406	.01053	
R9	RLR07C103GM	INSUL FILM RES	1	.00750	.01406	.01053	
R10	RLR07C103GM	INSUL FILM RES	1	.00750	.01406	.01053	
R11	RLR07C512GM	INSUL FILM RES	1	.00750	.01406	.01053	
R12	RLR07C513GM	INSUL FILM RES	1	.00750	.01406	.01053	
R13	RLR07C476GM	INSUL FILM RES	1	.01201	.02249	.01685	R = 1.6
R14	RLR07C392GM	INSUL FILM RES	1	.00750	.01406	.01053	
C1	M39003/01-2538,CSR13/P	SOLID TANTALUM CAP	1	.00017	.00040	.00036	
C2	CK62BX102M	CERAMIC CAPACITOR	1	.04002	.08417	.08208	
C3	CK62BX102M	CERAMIC CAPACITOR	1	.04002	.08417	.08208	
	X6841085A	PWB CONNECTOR	1	.09018	.14032	.11264	N = 19
	X6841251-	TWO-SIDED PW BOARD	1*	.00120	.00240	.00360	N = 79
		PART CONNECTIONS	76*	.00044	.00044	.00044	
X6841198A	MULTIPLIER UNIT		29	.51174	1.36840	1.16970	NOTE: * = PART QTY NOT INCL IN TOTAL
X6841199A	ARITHMETIC CONTROL UNIT		61	44.46643	110.92039	110.35100	

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ELECT. ABACUS FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus (Cont'd)

02/28/77 ELECTRONIC ABACUS DWG NO X83886080 PAGE 4

*** DETAILED PART FAILURE RATE FOR ***
X6841181C INTEGRATOR

DESIG	PART/DRAWING NUMBER	PART DESCRIPTION	PART QTY	APPLIED GF FAIL. RATE AT 35 C	APPLIED NS FAIL. RATE AT 55 C	APPLIED AI FAIL. RATE AT 45 C	EXCEPTIONS TO APPLIED STRESS PART FR PARAMETERS IN PREDICTION SUMMARY
U1	M38510/10103BGC,LM101A	MONO S/MSI LIN I/C	1	.03384	.13873	.12380	
U2	M38510/10103BGC,LM101A	MONO S/MSI LIN I/C	1	.03384	.13873	.12380	
U3	M38510/10103BGC,LM101A	MONO S/MSI LIN I/C	1	.03384	.13873	.12380	
R1	RNR55C2051FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R2	RNR55C2052FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R3	RNR55C7502FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R4	RNR55C7500FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R5	RNR55C2611FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R6	RNR55C5361FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R7	RNR55C1050FM	HIGH STAB FILM RES	1	.00470	.01707	.01034	S1= 0.2
R8	RNR55C1050FM	HIGH STAB FILM RES	1	.00470	.01707	.01034	S1= 0.2
R9	RNR55C2052FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R10	RNR55C2051FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
R11	RNR55C2051FM	HIGH STAB FILM RES	1	.00420	.01513	.00921	
C1	CMR05F181FPDM	MICA CAPACITOR	1	.00067	.00224	.00150	
C2	CMR05F181FPDM	MICA CAPACITOR	1	.00067	.00224	.00150	
C3	M39006/01-3043	NONSOLID TANTA CAP	1	.02906	.10612	.09500	S1= 0.5
C4	CMR05F181FPDM	MICA CAPACITOR	1	.00067	.00224	.00150	
C5	M39003/01-2539,CSR13/P	SOLID TANTALUM CAP	1	.00047	.00115	.00103	SR= 0.2
C6	M39003/01-2538,CSR13/P	SOLID TANTALUM CAP	1	.00017	.00040	.00036	
C7	M39014/01-1405,CKR06/M	CERAMIC CAPACITOR	1	.00400	.00842	.00821	Q = 1.0
C8	M39014/01-1405,CKR06/M	CERAMIC CAPACITOR	1	.00400	.00842	.00821	Q = 1.0
C9	M39014/01-1405,CKR06/M	CERAMIC CAPACITOR	1	.00400	.00842	.00821	Q = 1.0
	X6841085A	PWB CONNECTOR	1	2.72326	4.36065	3.45658	N = 22
	X6841132-	RACK & PANEL CONN	1	2.72326	4.36065	3.45658	N = 22
	X6841329-	TWO-SIDED PW BOARD	1*	.00120	.00240	.00360	N = 73
		PART CONNECTIONS	70*	.00044	.00044	.00044	
			----	---------	---------	---------	
X6841181C	INTEGRATOR		25	5.67095	9.48068	7.54803	NOTE: * = PART QTY NOT INCL IN TOTAL

FIGURE 3.3 OUTPUT DRIVER FR DATA	FIGURE 3.4 ELECT. ABACUS FR DATA	FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus (Cont'd)

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DETAILED FR SUMMARY

DWG NUMBER	ASSEMBLY OR SUBASSEMBLY DESCRIPTION	PART QTY	APPLIED GF FAIL. RATE AT 35 C	APPLIED NS FAIL. RATE AT 55 C	APPLIED AI FAIL. RATE AT 45 C
	ASSEMBLY SUBTOTAL	18	43.72723	109.02110	108.71497
X6841197-	ADDER LOGIC	14	.22746	.53089	.46633
X6841198A	MULTIPLIER UNIT	29	.51174	1.36840	1.16970
X6841199A	ARITHMETIC CONTROL UNIT	61	44.46643	110.92039	110.35100
X6841181C	INTEGRATOR	25	5.67095	9.48068	7.54803

ELECTRONIC ABACUS

TOTAL PART QTY AND ENVIRONMENTAL STRESS FAILURE RATE	86	50.13738	120.40107	117.89902
ENVIRONMENTAL STRESS MEAN-TIME-BETWEEN FAILURES (HOURS)		19945.20	8305.57	8481.83

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ELECT. ABACUS FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus (Cont'd)

DETAILED FR RANKING

GENERAL PART DESCRIPTION	PART QTY	(RANKING COLUMN) APPLIED GF @ 35 C -FR SUM-	-%-	APPLIED NS @ 55 C -FR SUM-	-%-	APPLIED AI @ 45 C -FR SUM-	-%-
ELECTROMECH TIMER	1	42.85700	85.479	107.14250	88.988	107.14250	90.876
PWB CONNECTOR	7	3.26456	6.511	5.20298	4.321	4.13270	3.505
RACK & PANEL CONN	2	2.83192	5.648	4.52935	3.762	3.59213	3.047
MONO RAM INTEG CKT	3	.46531	.928	1.37662	1.143	1.17068	.993
CERAMIC CAPACITOR	7	.17210	.343	.36193	.301	.35295	.299
PART CONNECTIONS	251*	.11044	.220	.11044	.092	.11044	.094
MONO S/MSI LIN I/C	3	.10152	.202	.41620	.346	.37141	.315
HIGH STAB FILM RES	20	.08572	.171	.30930	.257	.18802	.159
INSUL FILM RES	8	.06454	.129	.12091	.100	.09057	.077
MONO S/MSI DIG I/C	2	.05640	.112	.20877	.173	.19953	.169
ZENER DIODE	2	.03395	.068	.19880	.165	.18387	.156
NONSOLID TANTA CAP	1	.02906	.058	.10612	.088	.09500	.081
STD SILICON DIODE	5	.01681	.034	.12433	.103	.10273	.087
SOLID TANTALUM CAP	8	.01076	.021	.02621	.022	.02346	.020
W/W POWER RESISTOR	1	.01039	.021	.02840	.024	.02247	.019
SI PNP TRANSISTOR	3	.00943	.019	.06013	.050	.05342	.045
SI NPN TRANSISTOR	3	.00651	.013	.04051	.034	.03635	.031
TWO-SIDED PW BOARD	4*	.00480	.010	.00960	.008	.01440	.012
CARBON COMP RES	7	.00416	.008	.02127	.018	.01189	.010
MICA CAPACITOR	3	.00201	.004	.00672	.006	.00450	.004

* = PART QTY NOT INCLUDED IN TOTAL OF PARTS

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ELECT. ABACUS FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus (Cont'd)

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*** CONDENSED PART FAILURE RATE DATA FOR ***
X6841199A ARITHMETIC CONTROL UNIT

PART DESCRIPTION	PART QTY	DORMANT GB FAIL. RATE AT 25 C	DORMANT GF FAIL. RATE AT 40 C	DORMANT GM FAIL. RATE AT 65 C	DORMANT NS FAIL. RATE AT 60 C	DORMANT NU FAIL. RATE AT 55 C
MONO S/MSI DIG I/C	2	.00065	.00270	.01044	.01019	.01226
MONO RAM INTEG CKT	3	.00296	.00992	.03638	.03418	.03857
SI NPN TRANSISTOR	3	.00025	.00145	.00954	.00904	.00856
SI PNP TRANSISTOR	3	.00035	.00212	.01422	.01345	.01271
STD SILICON DIODE	5	.00010	.00068	.00548	.00501	.00457
ZENER DIODE	2	.00055	.00311	.01891	.01819	.01749
CARBON COMP RES	7	.00001	.00002	.00015	.00009	.00011
INSUL FILM RES	8	.00001	.00003	.00009	.00006	.00010
HIGH STAB FILM RES	9	.00001	.00002	.00009	.00006	.00009
W/W POWER RESISTOR	1	.00004	.00013	.00053	.00036	.00054
CERAMIC CAPACITOR	4	.00310	.00644	.01372	.01355	.02677
SOLID TANTALUM CAP	6	.00008	.00017	.00046	.00043	.00091
PWB CONNECTOR	6	.00108	.00419	.01406	.00651	.01258
RACK & PANEL CONN	1	.00108	.00419	.01406	.00651	.01258
ELECTROMECH TIMER	1	.28571	1.71428	2.85713	4.28570	5.71427
TWO-SIDED PW BOARD	3*	.00002	.00005	.00010	.00010	.00024
PART CONNECTIONS	181*	.00000	.00002	.00004	.00002	.00004
X6841199A ARITHMETIC CONTROL UNIT	61	.32076	1.82999	3.28951	4.64531	6.18745

NOTE: * = PART QTY NOT INCL IN TOTAL

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ELECT. ABACUS FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus (Cont'd)

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*** CONDENSED PART FAILURE RATE DATA FOR ***
X6841181C INTEGRATOR

	PART DESCRIPTION	PART QTY	DORMANT GB FAIL. RATE AT 25 C	DORMANT GF FAIL. RATE AT 40 C	DORMANT GM FAIL. RATE AT 65 C	DORMANT NS FAIL. RATE AT 60 C	DORMANT NU FAIL. RATE AT 55 C
	MONO S/MSI LIN I/C	3	.00066	.00317	.01387	.01300	.01513
	HIGH STAB FILM RES	11	.00001	.00002	.00009	.00006	.00009
	CERAMIC CAPACITOR	3	.00310	.00644	.01372	.01355	.02677
	NONSOLID TANTA CAP	1	.00468	.01040	.04203	.03900	.08515
	MICA CAPACITOR	3	.00011	.00082	.00335	.00274	.00523
	SOLID TANTALUM CAP	2	.00008	.00017	.00046	.00043	.00091
	PWB CONNECTOR	1	.00108	.00419	.01406	.00651	.01258
	RACK & PANEL CONN	1	.00108	.00419	.01406	.00651	.01258
	TWO-SIDED PW BOARD	1*	.00002	.00005	.00010	.00010	.00024
	PART CONNECTIONS	70*	.00000	.00002	.00004	.00002	.00004
		----	---------	---------	---------	---------	---------
X6841181C INTEGRATOR		25	.01903	.05191	.16744	.14278	.25748

NOTE: * = PART QTY NOT INCL IN TOTAL

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ELECT. ABACUS FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus (Cont'd)

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CONDENSED FR SUMMARY

DWG NUMBER	ASSEMBLY OR SUBASSEMBLY DESCRIPTION	PART QTY	DORMANT GB FAIL. RATE AT 25 C	DORMANT GF FAIL. RATE AT 40 C	DORMANT GM FAIL. RATE AT 65 C	DORMANT NS FAIL. RATE AT 60 C	DORMANT NU FAIL. RATE AT 55 C
X6841199A	ARITHMETIC CONTROL UNIT	61	.32076	1.82999	3.28951	4.64531	6.18745
X6841181C	INTEGRATOR	25	.01903	.05191	.16744	.14278	.25748

ELECTRONIC ABACUS

TOTAL PART QTY AND ENVIRONMENTAL STRESS FAILURE RATE	86	.33979	1.88190	3.45696	4.78809	6.44493
ENVIRONMENTAL STRESS MEAN-TIME-BETWEEN FAILURES (HOURS)		2943007.49	531378.13	289271.86	208851.55	155160.65

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ELECT. ABACUS FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus (Cont'd)

02/28/77 ELECTRONIC ABACUS DWG NO X8388608B PAGE 4

CONDENSED FR RANKING

GENERAL PART DESCRIPTION	PART QTY	DORMANT GB @ 25 C -FR SUM-	DORMANT GB @ 25 C -%-	(RANKING COLUMN) DORMANT GF @ 40 C -FR SUM-	DORMANT GF @ 40 C -%-	DORMANT GM @ 65 C -FR SUM-	DORMANT GM @ 65 C -%-	DORMANT NS @ 60 C -FR SUM-	DORMANT NS @ 60 C -%-	DORMANT NU @ 55 C -FR SUM-	DORMANT NU @ 55 C -%-
ELECTROMECH TIMER	1	.28571	84.086	1.71428	91.093	2.85713	82.649	4.28570	89.508	5.71427	88.663
CERAMIC CAPACITOR	7	.02172	6.392	.04511	2.397	.09606	2.779	.09487	1.981	.18736	2.907
MONO RAM INTEG CKT	3	.00887	2.611	.02977	1.582	.10915	3.157	.10254	2.141	.11571	1.795
PWB CONNECTOR	7	.00757	2.227	.02936	1.560	.09840	2.846	.04554	.951	.08803	1.366
NONSOLID TANTA CAP	1	.00468	1.376	.01040	.553	.04203	1.216	.03900	.814	.08515	1.321
MONO S/MSI LIN I/C	3	.00199	.586	.00951	.506	.04162	1.204	.03901	.815	.04539	.704
RACK & PANEL CONN	2	.00216	.636	.00839	.446	.02811	.813	.01301	.272	.02515	.390
SI PNP TRANSISTOR	3	.00105	.308	.00637	.338	.04267	1.234	.04035	.843	.03812	.591
ZENER DIODE	2	.00110	.324	.00622	.331	.03782	1.094	.03638	.760	.03499	.543
MONO S/MSI DIG I/C	2	.00130	.384	.00541	.287	.02088	.604	.02037	.425	.02451	.380
PART CONNECTIONS	251*	.00110	.325	.00442	.235	.00884	.256	.00442	.092	.00994	.154
SI NPN TRANSISTOR	3	.00074	.217	.00436	.232	.02862	.828	.02711	.566	.02568	.399
STD SILICON DIODE	5	.00050	.147	.00342	.182	.02740	.793	.02504	.523	.02283	.354
MICA CAPACITOR	3	.00034	.099	.00245	.130	.01005	.291	.00822	.172	.01568	.243
SOLID TANTALUM CAP	8	.00062	.183	.00138	.073	.00372	.107	.00345	.072	.00726	.113
HIGH STAB FILM RES	20	.00012	.036	.00035	.019	.00177	.051	.00127	.026	.00178	.028
INSUL FILM RES	8	.00004	.013	.00025	.013	.00074	.021	.00047	.010	.00079	.012
TWO-SIDED PW BOARD	4*	.00010	.028	.00019	.010	.00038	.011	.00038	.008	.00096	.015
W/W POWER RESISTOR	1	.00004	.011	.00013	.007	.00053	.015	.00036	.007	.00054	.008
CARBON COMP RES	7	.00004	.010	.00012	.006	.00104	.030	.00062	.013	.00078	.012

* = PART QTY NOT INCLUDED IN TOTAL OF PARTS

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ELECT. ABACUS FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.4. Detailed and Condensed Failure Rate Data for Electronic Abacus (Cont'd)

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*** GENERAL INFORMATION ***

INTRODUCTION: THE ENCLOSED RELIABILITY PREDICTION DATA WERE COMPILED USING THE '217B PREDICT' COMPUTER PROGRAM. THE PROGRAM CALCULATES INDIVIDUAL PART FAILURE RATES USING THE STANDARD PART FAILURE RATE PARAMETERS DEFINED HEREIN UNLESS OTHERWISE DEFINED AT THE PART LEVEL. DETAILED PROCEDURES AND ASSUMPTIONS USED ARE OUTLINED BELOW AND ARE DISCUSSED IN THE BASIC REPORT.

DATA SOURCES: THE PART FAILURE RATE DATA WERE DERIVED IN ACCORDANCE WITH THE PROCEDURES AND DATA IN THE FOLLOWING REFERENCES.

217B = MIL-HDBK-217B AND NOTICE 1, 'RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT,' SEPT 1976
REDSTN = US ARMY REDSTONE ARSENAL STORAGE REPORT LC-76-1, 'MISSILE MATERIAL RELIABILITY PREDICTION HANDBOOK,' MAY 1976
RADC1 = ROME AIR DEVELOPMENT CENTER REPORT RADC-TR-75-22, 'NONELECTRONIC RELIABILITY NOTEBOOK,' JAN 1975
RADC2 = ROME AIR DEV CENTER REPORT RADC-TR-73-248, 'DORMANCY & POWER ON-OFF CYCLING EFFECTS ON RELIABILITY,' AUG 1973
FARADA = FAILURE RATE DATA HANDBOOK, NAVAL FLEET MISSILE SYSTEM ANALYSIS AND EVALUATION GROUP, MAR 1968 AND UPDATES
MANUAL = 217B PREDICT SYSTEM RELIABILITY PREDICTION COMPUTER PROGRAM USER MANUAL DEFINITION FOR NON-MIL-HDBK-217B DATA
REPORT = SEE THE BASIC RELIABILITY PREDICTIONS REPORT FOR MORE DEFINITIVE DEFINITIONS OF THE DATA AS NOTED HEREIN

*** SUMMARY OF RELIABILITY DATA ***

RELIABILITY DATA: THE FOLLOWING RELIABILITY DATA ARE BASED ON THE ASSUMPTION THAT THE SYSTEM CONTAINS NO MAJOR REDUNDANT SECTIONS AND THEREFORE CAN BE TREATED AS A SERIES SYSTEM WHEREIN ANY FAILURE CONSTITUTES SYSTEM FAILURE. THE EVENT RELIABILITY, LESS THE ONE-SHOT DEVICES, ARE CALCULATED USING THE EXPONENTIAL FUNCTION BASED ON THE ASSUMPTION THAT THE PART FAILURES ARE STATISTICALLY INDEPENDENT OF ONE ANOTHER AND EXHIBIT A CONSTANT FAILURE RATE FOR THE LIFE CYCLE BEING EVALUATED.

SYSTEM AND LIFE CYCLE EVENT DESCRIPTION	STRESS DATA	AMBIENT TEMP	MIL-HDBK-217B ENVIRONMENT	EVENT FAIL. RATE	EVENT DURATION	EVENT RELIABILITY
1. CONTROLLED STORAGE IN DEPOT ENVIR						
OUTPUT STAGE FOR COMPUTING SYSTEM	DORMANT @	25 C	GROUND, BENIGN	.02197	3. YRS	.99942277
ELECTRONIC ABACUS	DORMANT @	25 C	GROUND, BENIGN	.33979	3. YRS	.99111011
SYSTEM LEVEL FAILURE RATE SUBTOTAL:				.36176	3. YRS	.99053801
COMPUTING SYSTEM						.99053801
2. UNPACKAGED TRUCK OR RAILWAY SHIPMENT						
OUTPUT STAGE FOR COMPUTING SYSTEM	DORMANT @	65 C	GROUND, MOBILE	.42861	1. MON	.99968716
ELECTRONIC ABACUS	DORMANT @	65 C	GROUND, MOBILE	3.45696	1. MON	.99747960

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ARITH. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.5. Reliability Summary For Computing System

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*** SUMMARY OF RELIABILITY DATA ***

SYSTEM AND LIFE CYCLE EVENTDESCRIPTION	STRESS DATA	AMBIENT TEMP	MIL-HDBK-217B ENVIRONMENT	EVENT FAIL. RATE	EVENT DURATION	EVENT RELIABILITY
2. UNPACKAGED TRUCK OR RAILWAY SHIPMENT						
SYSTEM LEVEL FAILURE RATE SUBTOTAL:				3.88557	1. MON	.99716755
COMPUTING SYSTEM						.99716755
3. UNPACKAGED ELECTRONICS SHOP STORAGE						
OUTPUT STAGE FOR COMPUTING SYSTEM	DORMANT B	40 C	GROUND, FIXED	.09278	2. MON	.99986455
ELECTRONIC ABACUS	DORMANT B	40 C	GROUND, FIXED	1.88190	2. MON	.99725620
SYSTEM LEVEL FAILURE RATE SUBTOTAL:				1.97468	2. MON	.99712112
COMPUTING SYSTEM						.99712112
4. ELECTRONICS SHOP USAGE IN FIELD ENVIR						
OUTPUT STAGE FOR COMPUTING SYSTEM	ASSUMED B	35 C	GROUND, FIXED	1.27232	1. MON	.99907164
ONE-SHOT: FUZABLE LINKS						.998800
ELECTRONIC ABACUS	APPLIED B	35 C	GROUND, FIXED	50.13738	1. MON	.96406140
SYSTEM LEVEL FAILURE RATE SUBTOTAL:				51.40971	1. MON	.96201061
COMPUTING SYSTEM						.96201061
5. UNPACKAGED SHIPBOARD DEEP STORAGE						
OUTPUT STAGE FOR COMPUTING SYSTEP	DORMANT B	55 C	NAVAL, SHELTERED	.35143	2. MON	.99948704
ELECTRONIC ABACUS	DORMANT B	60 C	NAVAL, SHELTERED	4.78809	2. MON	.99303377

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ARITH. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.5. Reliability Summary For Computing System (Cont'd)

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*** SUMMARY OF RELIABILITY DATA ***

SYSTEM AND LIFE CYCLE EVENTDESCRIPTION	STRESS DATA	AMBIENT TEMP	MIL-HDBK-217B ENVIRONMENT	EVENT FAIL. RATE	EVENT DURATION	EVENT RELIABILITY
5. UNPACKAGED SHIPBOARD DEEP STORAGE						
SYSTEM LEVEL FAILURE RATE SUBTOTAL:				5.13952	2. MON	.99252438
COMPUTING SYSTEM						.99252438
6. SHIPBOARD ELECTRONICS SHOP USAGE						
OUTPUT STAGE FOR COMPUTING SYSTEM	ASSUMED @	55 C	NAVAL, SHELTERED	3.67493	1. MON	.99732089
ONE-SHOT: FUZABLE LINKS						.997000
ELECTRONIC ABACUS	APPLIED @	55 C	NAVAL, SHELTERED	120.40107	1. MON	.91385907
SYSTEM LEVEL FAILURE RATE SUBTOTAL:				124.07600	1. MON	.91066517
COMPUTING SYSTEM						.91066517
7. UNPACKAGED DEEP STORAGE ON CARRIER						
OUTPUT STAGE FOR COMPUTING SYSTEM	DORMANT @	55 C	NAVAL, SHELTERED	.35143	6. MON	.99846192
ELECTRONIC ABACUS	DORMANT @	60 C	NAVAL, SHELTERED	4.78809	6. MON	.97924655
SYSTEM LEVEL FAILURE RATE SUBTOTAL:				5.13952	6. MON	.97774039
COMPUTING SYSTEM						.97774039
8. UNPACKAGED FLIGHT DECK READY STORAGE						
OUTPUT STAGE FOR COMPUTING SYSTEM	DORMANT @	60 C	NAVAL, UNSHELTERED	.44887	20. DAY	.99978457
ELECTRONIC ABACUS	DORMANT @	55 C	NAVAL, UNSHELTERED	6.44493	20. DAY	.99691121

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ARITH. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.5. Reliability Summary For Computing System (Cont'd)

*** SUMMARY OF RELIABILITY DATA ***

SYSTEM AND LIFE CYCLE EVENTDESCRIPTION	STRESS DATA	AMBIENT TEMP	MIL-HDBK-217B ENVIRONMENT	EVENT FAIL. RATE	EVENT DURATION	EVENT RELIABILITY
8. UNPACKAGED FLIGHT DECK READY STORAGE						
SYSTEM LEVEL FAILURE RATE SUBTOTAL:				6.89380	20. DAY	.99669644
COMPUTING SYSTEM						.99669644
9. AIRBORNE FLIGHT TEST MONITORING USAGE						
OUTPUT STAGE FOR COMPUTING SYSTEM	ASSUMED @	45 C	AIRBORNE, INHABITED	3.14388	10. DAY	.99924575
ONE-SHOT: FUZABLE LINKS						.997000
ELECTRONIC ABACUS	APPLIED @	45 C	AIRBORNE, INHABITED	117.89902	10. DAY	.97210081
SYSTEM LEVEL FAILURE RATE SUBTOTAL:				121.04291	10. DAY	.96845350
COMPUTING SYSTEM						.96845350

*** SUMMARY OF FAILURE RATE DATA ***

FAILURE DATA: THE FOLLOWING FAILURE RATE DATA WERE DERIVED IN ACCORDANCE WITH THE NOTED STRESS AND ENVIRONMENTAL CONDITIONS. FOR EXPLICIT PART FAILURE RATE DEFINITIONS SEE PART FAILURE RATE PRINTOUT (NOTE: FAILURE RATES ARE IN FAILURES PER MILLION HOURS)

1. OUTPUT STAGE FOR COMPUTING SYSTEM , DWG NO (ASSUMED) , PART COUNT 87

STRESS DATA USED =	ASSUMED	ASSUMED	ASSUMED
MIL-HDBK-217B ENVIR =	GF ENVIR	NS ENVIR	AI ENVIR
AMBIENT TEMPERATURE =	AT 35 C	AT 55 C	AT 45 C
FAILURE RATE TOTAL =	1.27232	3.67493	3.14388
MTBF TOTAL (HOURS) =	785964.80	272113.77	318078.C6

2. OUTPUT STAGE FOR COMPUTING SYSTEM , DWG NO (ASSUMED) , PART COUNT 87

STRESS DATA USED =	DORMANT	DORMANT	DORMANT	DORMANT	DORMANT
MIL-HDBK-217B ENVIR =	GB ENVIR	GF ENVIR	CM ENVIR	NS ENVIR	NU ENVIR
AMBIENT TEMPERATURE =	AT 25 C	AT 40 C	AT 65 C	AT 55 C	AT 60 C
FAILURE RATE TOTAL =	.02197	.09278	.42861	.35143	.44887
MTBF TOTAL (HOURS) =	45514750.67	10778309.12	2333112.89	2845515.26	2227830.28

FIGURE 3/3 OUTPUT DRIVER FR DATA | FIGURE 3/4 ARITH. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.5. Reliability Summary For Computing System (Cont'd)

*** SUMMARY OF FAILURE RATE DATA ***

FAILURE DATA: THE FOLLOWING FAILURE RATE DATA WERE DERIVED IN ACCORDANCE WITH THE NOTED STRESS AND ENVIRONMENTAL CONDITIONS. FOR EXPLICIT PART FAILURE RATE DEFINITIONS SEE PART FAILURE RATE PRINTOUT (NOTE: FAILURE RATES ARE IN FAILURES PER MILLION HOURS)

3. ELECTRONIC ABACUS , DWG NO X8388608B , PART COUNT 86

STRESS DATA USED =	APPLIED	APPLIED	APPLIED	DORMANT	DORMANT	DORMANT	DORMANT	DORMANT
MIL-HDBK-217B ENVIR =	GF ENVIR	NS ENVIR	AI ENVIR	GB ENVIR	GF ENVIR	GM ENVIR	NS ENVIR	NU ENVIR
AMBIENT TEMPERATURE =	AT 35 C	AT 55 C	AT 45 C	AT 25 C	AT 40 C	AT 65 C	AT 60 C	AT 55 C
FAILURE RATE TOTAL =	50.13736	120.40107	117.89902	.33979	1.88190	3.45696	4.78809	6.44493
MTBF TOTAL (HOURS) =	19945.20	8305.57	8481.83	2943007.49	531378.13	289271.86	208851.55	155160.65

*** FAILURE RATE PARAMETER DEFINITIONS ***

CODING FORMAT: THE FOLLOWING CODING FORMAT IS USED HEREIN TO DEFINE THE PART FAILURE RATE PARAMETERS IN RECOGNIZABLE TERMINOLOGY, I.E. IN GENERAL ACCORDANCE WITH MIL-HDBK-217B DEFINITIONS. THIS FORMAT IS USED TO DEFINE THE STANDARD PART FAILURE RATE PARAMETERS, AND TO IDENTIFY THE EXCEPTIONS TO THE STANDARD PART FAILURE RATE PARAMETERS AT THE PART LEVEL IN THE ENCLOSED PRINTOUT

XYY=ZZZZ, WHERE: X = FAILURE RATE COLUMN LIMITATION AT THE PART LEVEL ONLY. LIMITS THE APPLICABILITY OF THE SPECIFIED PART FAILURE RATE PARAMETER TO A SINGLE LIFE CYCLE EVENT AT THE PART LEVEL IN THE ENCLOSED PART FAILURE RATE PRINTOUT. IF BLANK, THE FAILURE RATE PARAMETER APPLIES TO EACH OF THE LIFE CYCLE EVENTS NOTED.

YY = PART FAILURE RATE PARAMETER SYMBOL IN GENERAL ACCORDANCE WITH MIL-HDBK-217B AS DEFINED BELOW.

ZZZZ = PART FAILURE RATE PARAMETER VALUE USED TO CALCULATE THE PART FAILURE RATE, OR TO DEFINE THE USE OF 'OPER' OR 'DORM' PART FAILURE RATES AT THE PART LEVEL IF DIFFERENT THAN THE REST OF THE ASSEMBLY.

PARAMETER SYMBOLS: THE FOLLOWING PART FAILURE RATE PARAMETER SYMBOLS AS USED HEREIN ARE IN GENERAL ACCORDANCE WITH MIL-HDBK-217B.

SYM	DEFINITION	SYM	DEFINITION	SYM	DEFINITION
A	= SEMICONDUCTOR APPLICATION FACTOR	* LM	= LASER LAMBDA MEDIA FAILURE RATE	* R	= RES VALUE FACTOR/SEMCON PWR RATING
B	= LASER BALLAST FACTOR	* LP	= LASER LAMBDA PUMP HOURS FAIL RATE	* RL	= TYPE RELAY LOAD(RES, IND, OR LMP)
BV	= U-W XSTR REVERSE C-E VOLTAGE RATING	* M	= U-W XSTR NETWORK MATCHING FACTOR	* RT	= CAPACITOR RATED TEMPERATURE (C)
C	= COMPLEXITY OR CONSTRUCTION FACTOR	* N	= # ACTIVE CONN PINS OR PWB HOLES	* S	= SYNCHRO OR RESOLVER SIZE FACTOR
C	= LASER COUPLING CLEANLINESS FACTOR	* #B	= SYNCHRO/RESOLVER # BRUSHES FACTOR	* SR	= CSR CAPACITOR SERIES RESISTANCE
CF	= RELAY OR SWITCH CONTACT FORM FACTOR	* #B	= # BITS IN ROM OR RAM INTEG CKT	* S1	= PRIMARY OPERATING STRESS RATIO
CV	= CYR CAPACITOR VALUE FACTOR	* #C	= # ACTIVE PART CONNECTIONS	* S2	= SEMICONDUCTOR REVERSE VOLT FACTOR
CY	= NUMBER OF CYCLES OR MATINGS	* #G	= #GATES IN DIGITAL INTEG CIRCUIT	* T	= U-W XSTR PEAK JUNCTION TEMP(C)
DI	= LASER DISCHARGE CURRENT (MA)	* #T	= # XSTRS IN LINEAR INTEG CIRCUIT	* T	= HYBRID & ETM TEMPERATURE FACTOR
F	= CKT FUNCTION OR FAMILY/QUALITY FACTOR	* O	= LASER GAS OVERFILL FACTOR	* TJ	= INTEG CKT JUNCTION TEMPERATURE(C)
F	= U-W XSTR FREQUENCY/POWER FACTOR	* OP	= ROTARY DEVICE OPERATING TIME(HRS)	* TM	= SEMICOND MAX OPER JUNCTION TEMP (C)
FR	= PART FAILURE RATE (FAIL/MILLION HRS)	* OS	= LASER OPTICAL SURFACES FACTOR	* TP	= POTENTIOMETER TAP CONNECTION FACTOR
IN	= INSERT/INSUL MATERIAL TEMP RATING	* P	= INTEG CIRCUIT PACKAGE FACTOR	* TR	= INDUCT/ROTARY/CONN TEMP RISE (C)
L	= INTEGRATED CIRCUIT LEARNING FACTOR	* P	= LASER BEAM AVER POWER OUTPUT(KW)	* TS	= SEMICOND START OF TEMP DERATING (C)
LB	= LAMBDA BASIC-PART FR LESS FACTORS	* %M	= ROTARY DEVICE % MECH FAILURES	* V	= POTENTIOMETER VOLTAGE FACTOR
LC	= LASER LAMBDA COUPLING FAILURE RATE	* Q	= PART QUALITY LEVEL	* VC	= U-W XSTR OPERATING C-E VOLTAGE

FIGURE 3.3 OUTPUT DRIVER FR DATA / FIGURE 3.4 ARITH. CONTROL FR DATA / FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.5. Reliability Summary For Computing System (Cont'd)

DORMANT FACTORS: THE FOLLOWING DORMANT FR FACTORS WERE USED AS NOTED HEREIN IN THE ABSENCE OF ESTABLISHED DORMANT FAILURE RATE DATA

ELECT = ESTIMATED DORMANT ELECTRICAL PART FAILURE RATE = 0.10 TIMES THE APPLIED STRESS PART FAILURE RATE
MECH = ESTIMATED DORMANT MECHANICAL PART FAILURE RATE = 0.04 TIMES THE OPERATING PART FAILURE RATE

ENVIRONMENTAL FACTORS: THE FOLLOWING ENVIRONMENTAL FACTORS WERE USED AS NOTED HEREIN. THE EST-1 ENVIRONMENTAL FACTORS REFLECT A TYPICAL MIX OF ELECTRICAL PARTS IN AN AIRBORNE MISSILE AND WERE ONLY USED IN THE ABSENCE OF ESTABLISHED ENVIRONMENTAL DATA.

BEAD = ENVIR FACTORS, THERMISTOR: GB= 1, SF= 1, GF= 5, GM= 25, NS= 14, NU= 19, AI= 12, AU= 16, ML= 57 (SYM PER 217B ENVIR)
DISK = ENVIR FACTORS, THERMISTOR: GB= 1, SF= 1, GF= 5, GM= 25, NS= 14, NU= 19, PI= 12, AU= 15, ML= 55 (SYM PER 217B ENVIR)
EST(1) = ENVIR FACTORS, GEN ELECT ; GB= 1, SF= 1, GF= 6, GM= 10, NS= 15, NU= 20, AI= 15, AU= 30, ML= 40 (SYM PER 217B ENVIR)

*** STANDARD PART FAILURE RATE DATA USED ***

PART FR DATA: THE FOLLOWING FAILURE RATE DATA AND SOURCES WERE USED TO CALCULATE THE INDIVIDUAL PART FAILURE RATES FOR THIS PREDICTION UNLESS OTHERWISE NOTED AT THE PART LEVEL IN THE ENCLOSED PART FAILURE RATE PRINTOUT

NOTE: 1. ASTERISK (*) IDENTIFIES THOSE ENTRIES THAT REQUIRE ADDITIONAL DEFINITIVE DISCUSSION IN THE BASIC REPORT.

2. THE PART CODE IS A SEMI-ARBITRARY PART IDENTIFIER USED FOR COMPUTER PROGRAM CONTROL IN PERFORMING THIS PREDICTION.

3. OPER FR SOURCE, ENVIR FACTORS, AND DORM FR SOURCE IDENTIFIES THE DATA SOURCE USED, I.E. THE FAILURE RATE SOURCE OR PART PARAMETER SOURCE PREVIOUSLY NOTED IN THIS SUMMARY, OR DATA EQUIVALENCY TO AN ALTERNATE PART CODE (PC-XXX).

4. DORMANT PART FAILURE RATE IS ESTIMATED BY MULTIPLYING THE APPLIED STRESS OPERATING FAILURE RATE AS DEFINED BELOW TIMES THE DORMANT FR FACTOR. UNLESS OTHERWISE NOTED, THE DORMANT FAILURE RATE FACTOR IS THE FAILURE RATE FROM THE DORMANT SOURCE FOR A SPECIFIED ENVIRONMENT DIVIDED BY THE APPLIED STRESS PART FAILURE RATE AT THE SAME ENVIRONMENT, WITH THE CONSERVATIVE CONSTRAINT THAT THE DORMANT FR FACTOR SHALL NOT BE GREATER THAN 1.0 NOR LESS THAN 0.001

* PART CODE	PART DESCRIPTION	PART FR EQUIV OR PART DEFINITION	OPER FR SOURCE	ENVIR FACTORS	DORMANT FR FACTOR-SOURCE		APPLIED STRESS PART FR PARAMETERS OR OPERATING PART FR AND ENVIRONMENT	ASSUMED STRESS
101	MONO S/MSI DIG I/C		217B	217B	.100	REDSTN	#G= 20, L = 1.0, Q = 2.0, P = 1.0, #C= 14	
102	MONO S/MSI LIN I/C		217B	217B	.100	PC-101	#T= 21, L = 1.0, Q = 2.0, #C= 10	
103	MONO LSI DIG I/C		217B	217B	.100	PC-101	#G= 100, L = 1.0, Q = 2.0, P = 1.0, #C= 16	
105	MONO RAM INTEG CKT		217B	217B	.100	PC-101	#B= 512, L = 1.0, Q = 2.0, P = 1.0, #C= 16	
107	MOS S/MSI DIG I/C		217B	217B	.100	PC-101	#G= 20, L = 1.0, Q = 2.0, P = 1.0, #C= 14	
301	SI NPN TRANSISTOR		217B	217B	.634	REDSTN	S1= 0.1, S2= 0.3, C = 1.0, A = 0.7, Q = 0.4 R = 1.0, TS= 25, TM= 175, #C= 3	S1= 0.3
302	SI PNP TRANSISTOR		217B	217B	.634	PC-301	S1= 0.1, S2= 0.3, C = 1.0, A = 0.7, Q = 0.4 R = 1.0, TS= 25, TM= 125, #C= 3	S1= 0.3
310	STD SILICON DIODE		217B	217B	.244	REDSTN	S1= 0.1, S2= 0.7, C = 1.0, A = 0.6, Q = 1.0 R = 1.0, TS= 25, TM= 175, #C= 2	S1= 0.3
312	ZENER DIODE		217B	217B	.176	REDSTN	S1= 0.1, A = 1.0, Q = 1.0, TS= 25, TM= 175 #C= 2	S1= 0.3
402	CARBON COMP RES	RCR STYLE RESISTOR	217B	217B	.028	REDSTN	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
404	W/W CHS POWER RES	RER STYLE RESISTOR	217B	217B	.012	PC-401	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ARITH. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.5. Reliability Summary For Computing System (Cont'd)

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*** STANDARD PART FAILURE RATE DATA USED ***

PART CODE	PART DESCRIPTION	PART FR EQUIV OR PART DEFINITION	OPER FR SOURCE	ENVIR FACTORS	DORMANT FR FACTOR	DORMANT FR SOURCE	APPLIED STRESS PART FR PARAMETERS OR OPERATING PART FR AND ENVIRONMENT	ASSUMED STRESS
405	INSUL FILM RES	RLR STYLE RESISTOR	217B	217B	.004	REDSTN	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
406	HIGH STAB FILM RES	RNR STYLE RESISTOR	217B	217B	.004	PC-405	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
407	W/W POWER RESISTOR	RWR STYLE RESISTOR	217B	217B	.012	PC-401	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
504	MTLC PPR/PLSTC CAP	CHR STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, RT= 125, Q = 1.0, TR= 0.0, #C= 2	S1= 0.3
505	CERAMIC CAPACITOR	CKR STYLE CAP	217B	217B	.159	REDSTN	S1= 0.1, RT= 125, Q = 10, #C= 2	S1= 0.3
506	NONSOLID TANTA CAP	CLR STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, Q = 1.0, #C= 2	S1= 0.3
507	MICA CAPACITOR	CMR STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, Q = 1.0, #C= 2	S1= 0.3
510	SOLID TANTALUM CAP	CSR STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, Q = 0.3, SR=0.07, #C= 2	S1= 0.3
701	PWB CONNECTOR	1/2 MATED PAIR	217B	217B	.040	MANUAL	IN= B, Q = MS, N = 20, TR= 0.0, CY= 0.0 #C= N/A	
702	RACK & PANEL CONN	1/2 MATED PAIR	217B	217B	.040	MANUAL	IN= B, Q = MS, N = 20, TR= 0.0, CY= 0.0 #C= N/A	
801	ELECTROMECH TIMER		RADC1	EST(1)	.040	ELECT	OPER FR, GF ENV = 42.85700	
901	TWO-SIDED PW BOARD		217B	217B	.040	MANUAL	N = 100	
906	PART CONNECTIONS	PWB WAVE SOLDER	PC-903	PC-903	.040	PC-903	OPER FR, GF ENV = .00044	

FIGURE 3.3 OUTPUT DRIVER FR DATA | FIGURE 3.4 ARITH. CONTROL FR DATA | FIGURE 3.5 RELIABILITY SUMMARY

FIGURE 3.5. Reliability Summary For Computing System (Cont'd)

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SECTION IV

GENERAL PREDICTION GUIDELINES

1. RELIABILITY PREDICTION TASKS

The tasks to be performed and the techniques to be used in performing a reliability prediction, either manually or with a computer program, are very similar. The primary benefit offered by a computer program is the automation and the accuracy of the part failure rate calculations, and of the assembly and system failure rate summaries. However, the use of a computer program does not alleviate the responsibility of the reliability analyst to explicitly define the following data for each reliability prediction that he performs.

- System Definition. Define the system and its component parts in terms of established hardware documentation.
- Life Cycle Events. Define each life cycle event to be accounted for in terms of specified or implied system requirements.
- Environments. Define the equivalent environment for each life cycle event in general accordance with MIL-HDBK-217B definitions.
- Ambient Temperature. Define the ambient temperature for the system and its component parts for each life cycle event in terms of specified or implied requirements.
- Reliability Model(s). Derive the appropriate system reliability mathematical model(s) for each life cycle event in terms of the system operational requirements.
- One-Shot Devices. Research, define, and justify the appropriate reliability data for all one-shot devices in the system.
- Non-MIL-HDBK-217B Failure Rates. Research, define, and justify the appropriate part failure rates for all system parts not addressed in MIL-HDBK-217B.
- MIL-HDBK-217B Failure Rates. Research and define all of the part failure rate parameters in MIL-HDBK-217B for each of the appropriate parts in the system.

2. PART FAILURE RATE DERIVATION GUIDELINES

Reliability predictions for governmental agencies are usually required to be prepared in accordance with the general requirements of MIL-STD-756, in conjunction with the specific methodology of MIL-HDBK-217. However, these documents require the use of supplemental data and procedures for mechanical, electromechanical, and nonstandard electronic parts in all environments, and for standard electronic parts in nonoperating environments. The objective of the following guidelines is to standardize the data sources and procedures used in performing reliability predictions. It should be noted that the inclusion of these guidelines does not reflect any prior approval on the part of any procuring agency.

The data sources and failure rate guidelines presented herein are intended to supplement the failure rate data for operating electronic parts and prediction procedures in MIL-HDBK-217B. Adherence to these data sources and guidelines will result in more consistent, meaningful failure rates for standard and nonstandard parts in dormant and operating environments. It should be noted that these sources and guidelines are not intended to cover all contingencies, and are not a substitute for good engineering judgement.

a. Operating Part Failure Rate Guidelines

(1) Standard Part Failure Rate Data. Failure rate data for all standard electrical/electromechanical parts shall be derived from MIL-HDBK-217B in accordance with Section 2.0 (Part Stress Analysis Prediction). All part parameter data and data source(s) shall be recorded for the Part Stress Analysis Prediction.

(2) Nonstandard Part Failure Rate Data. Failure rate data for operating parts not contained in MIL-HDBK-217B shall be derived in accordance with one of the following procedures which are listed in order of preference. (Note: Use of any nonstandard part failure rate requires good engineering judgement, must be fully substantiated in the prediction report, and is subject to procuring agency approval.)

- o Part failure rate based on extensive data from a current, established source. Record failure rate, data source, and source environment. (Note: Reference 4 has been released as a current data source, but is still subject to evaluation and general acceptance.)
- o Part failure rate based on equivalency of part characteristics to an established standard or nonstandard part. Record characteristics which make the part equivalent, the failure rate, data source, and source environment.
- o Part failure rate based on limited industrial/government test data such as FARADA (Reference 7). Record failure rate, data source, source environment, plus all additional data and assumptions used in deriving the part failure rate.

(3) Nonstandard Part Environmental π-factors. In the absence of established environmental modifiers (π-factors) for the nonstandard parts, the generalized environmental π-factors of Table 4.1 can be used to convert the source failure rate to the operating environment(s) of interest as defined in Table 4.2. For example, a failure rate for an operating uninhabited aircraft environment (A_U) from the RADC Nonelectronic Reliability Notebook (Reference 4) would be multiplied by 10÷30 = 0.333 to derive an equivalent mobile ground environment (G_M) failure rate. These generalized environmental factors reflect a typical mix of MIL-HDBK-217B electrical parts in a typical airborne missile system. Again, it should be noted that the inclusion of the above data does not reflect any prior approval on the part of any procuring agency.

b. Dormant Part Failure Rates Guidelines

The Redstone and RADC data in References 2, 3, and 4 represent the most current sources for dormant failure rate data. However, these data are very limited and have not been fully evaluated for applicability in performing reliability predictions. Therefore, caution should be exercised in their use. In the absence of more definitive data, it is recommended herein that the dormant failure rates be estimated by multiplying the minimum stress operating part failure rates times an operating-to-dormant π-factor.

Inclusion of dormant data in the computer program was considered to be mandatory, yet the resolution of the uncertainties regarding the RADC and Redstone dormant data in References 2, 3, and 4 was beyond the scope of the current development of the computer program. A preliminary evaluation of the dormant data with regard to MIL-HDBK-217B operating data was performed, and generalized dormant π-factors were derived as presented in Appendix A. These factors will provide part failure rate data in general accordance with the RADC and Redstone dormant data, and will also reflect the impact of ambient temperature and part quality. These data and procedures will be used pending further studies of dormant versus operating part failure rates.

In the absence of established dormant part failure rate data, the generalized dormant π-factor of 0.1 is used for electrical/electromechanical parts as depicted in Reference 8. Based on a preliminary evaluation of the FARADA and RADC nonelectronic data (References 4 and 7), a 25:1 ratio between operating and nonoperating failure rates for mechanical parts is probably more realistic than the 10:1 ratio that has been accepted for electronic parts. This ratio of 0.04 will be used pending further studies of dormant versus operating part failure rates for nonelectronic parts.

TABLE 4.1 Generalized Electrical Environmental Factors

	MIL-HDBK-217B ENVIRONMENTAL SYMBOL VERSUS ENVIRONMENTAL FACTOR							
See Table 4.2	G_B	G_F	G_M	N_S	N_U	A_I	A_U	M_L
Nonstandard Part	1	6	10	15	20	15	30	40

TABLE 4.2. Environmental Descriptions

Environment (Environmental Symbol for π_E Factors)	Nominal Military Operating or Dormant Conditions, with Typical Examples
Ground, Benign (G_B)	Optimum operating or dormant conditions. 1. Research/development laboratory 2. Containerized or noncontainerized depot storage in a controlled environment 3. Containerized field or shipboard storage in controlled environment
Ground, Fixed (G_F)	Fixed ground, sheltered or unsheltered conditions. 1. Heated or unheated building 2. Exposed ground installation 3. Noncontainerized field/ready storage
Ground, Mobile or Portable (G_M)	Mobile/portable ground installation. 1. Truck/tank/mobile-launcher installation 2. Nonairborne aircraft installation in an airfield environment 3. Noncontainerized field mobile storage
Naval, Sheltered (N_S)	Fixed interior shipboard or submarine installation in semicontrolled environment. 1. Interior ship installation 2. Noncontainerized shipboard storage in semicontrolled environment
Naval, Unsheltered (N_U)	Fixed exposed shipboard installation or mobile/portable shipboard or submarine installation. 1. Hangar deck or flight deck shipboard installation 2. Nonairborne aircraft installation in shipboard environment 3. Noncontainerized shipboard ready storage in hangar deck or flight deck environment
Airborne, Inhabited (A_I)	Aircraft cockpit or cabin installation.
Airborne, Uninhabited (A_U)	Aircraft non-cockpit/non-cabin installation.
Missile, Launch (M_L)	Launch and sustained airborne missile flight.

3. DISCUSSION OF INHERENT RELIABILITY

Reliability may be expressed as the probability that a device will perform its task under a given set of conditions, where the device could be an individual piece part or a complex system of parts. It may also be expressed in terms of Mean-Time-Between-Failure (MTBF) i.e., the mean or statistical average time which may be expected between random failures of a large population of the devices under a given set of conditions.

Inherent reliability is defined as the potential reliability of a design. With a completely mature design, suitable for manufacture and use, and with no degradation caused by workmanship, assembly, defective parts, improper test procedures, or previous environmental degradation, the inherent reliability is the reliability potential of the physical device under a specified set of conditions. Consequently, inherent reliability predictions consider only the random failure rates for the individual piece parts, solder joints, printed circuit boards, etc., and assumes a proven mature design with quality control and assurance programs adequate to remove all manufacturing defects prior to equipment delivery.

An inherent prediction considers each of the events in the system life cycle as an independent event i.e., the reliability for each life cycle event is considered as if no degradation from previous events has occurred. This is equivalent to an assumption of perfect reliability ($R = 1.0$) at the beginning of each life cycle event.

The inherent reliability prediction provides the capability of comparing the reliability of similar equipments and evaluating the effects of changes to equipment, and provides the baseline from which estimates of field reliability, logistic requirements, maintainability requirements, and overall life cycle reliability can be derived given the necessary supplemental data.

Predictions of inherent reliability in accordance with MIL-HDBK-217B take into consideration both electrical stress and the severity of the environment in which the device is operating. For example, the shock, vibration, and temperature levels associated with missile Launch and Sustained Free Flight are normally more severe than those during missile Captive Flight. As a result, more incipient failures are likely to be induced, and the predicted MTBF will typically be lower for Launch and Sustained Free Flight than for Captive Flight.

Mean-Time-Between-Failure (MTBF) is merely a convenient means of expressing the failure rate of a device. Mathematically, it is equal to the reciprocal of the device failure rate during the constant failure rate period. MTBF bears no direct relationship with the useful (or prewearout) life of the device. It is quite possible for the predicted inherent MTBF to exceed the useful life of a device under certain conditions. This only reflects the fact that the failure rate is low during the constant failure rate period and does not "anticipate" the wearout of the device.

A hypothetical failure rate characteristic for virtually all electrical/electromechanical parts is shown in Figure 4.1. The failure rate curve is characterized by two periods of relatively high failure rate, an initial high failure rate period which is caused by so called "infant mortality," and a final high failure rate period which is caused by wearout at the end of the parts useful life. The failure rate during the constant failure rate period for these parts is readily derived using the specific methodology in MIL-HDBK-217B.

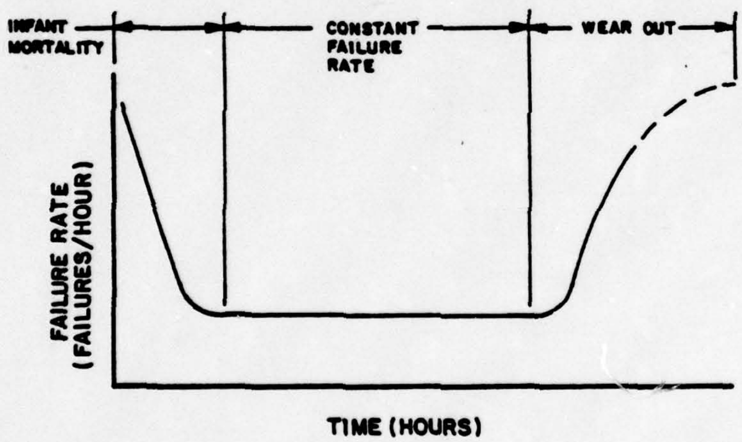

FIGURE 4.1. Hypothetical Failure Rate Curve for Electronic Parts

Mechanical parts do not follow the typical characteristic shown in Figure 4.1. Instead, they exhibit an increasing failure rate as a function of time as the hypothetical failure rate characteristic of Figure 4.2 indicates i.e., wearout failures begin to occur (albeit at a low rate) as soon as the mechanical parts are operated. Estimates of the relatively constant failure rate period associated with these parts are derived from evaluation of raw or semi-statistical data as reflected in FARADA or the RADC nonelectronic data (References 4 and 7). Use of these data requires good engineering judgement and is normally subject to procuring agency approval.

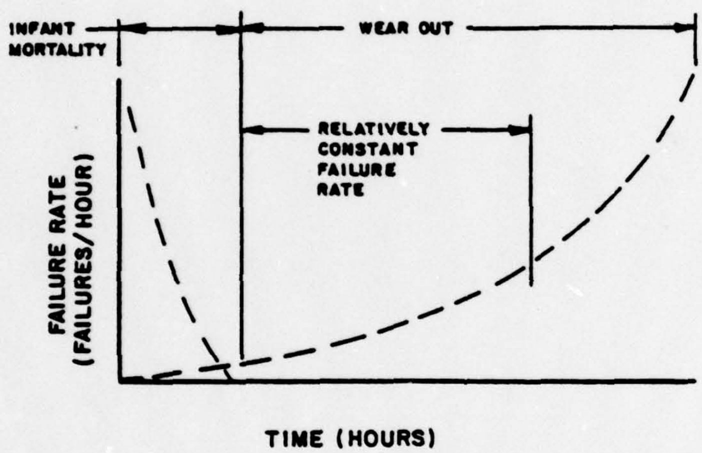

FIGURE 4.2. Hypothetical Failure Rate Curve for Mechanical Parts

The purpose of quality control, system burn-in, and parts screening during the manufacturing process is to remove infant mortality failures prior to field delivery, so that the higher reliability level associated with the middle of the curve applies to the hardware in the field. Scheduled preventive maintenance is required to prevent the wearout of individual piece parts from degrading the reliability level achieved by the hardware in the field.

SECTION V

COMPUTER PROGRAM DETAILS

1. DATA DECK SETUP

The 217B PREDICT computer program input data are arranged in general accordance with Figure 5.1 for batch submittal to the UNIVAC 1110 computer. These data are prepared and keypunched using computer coding forms and data processing cards as defined in Appendix A and as discussed below:

a. UNIVAC 1110 Control Cards

The required control card data for the 217B PREDICT computer program data submittal to the UNIVAC 1110 computer are depicted in Figure 5.1 and are defined explicitly in Appendix B. The UNIVAC 1110 control cards use a Free Format, wherein fields on the cards are separated by commas. Spaces are also inserted between some data items for clarity. It should be noted that the computer control card data is subject to current revision updates of the Programmer Reference Manual UP-4144 (Reference 9) and is presented herein for reference only.

b. 217B PREDICT Data Deck

The general arrangement of the 217B PREDICT computer program input data is depicted in Figure 5.1. These data are in Fixed Format that is right hand justified for all numerical entries and is left hand justified for all alphanumerical entries as defined in Appendix A. Coding forms for these data are outlined in Appendix B for the user's convenience.

2. DATA PREPARATION

The prediction data are compiled for the computer program in accordance with the major engineering tasks normally required to manually perform a reliability prediction as outlined below:

a. Configuration Data

Arrange the assembly/fabrication drawing data in terms of "system," "subsystem" (not mandatory), "assembly," and "subassembly" (not mandatory) levels as depicted in Figure 2.1. Evaluate the applicability of the series reliability model to the hardware configuration being evaluated. If the series model is not directly applicable, modify the above configuration data, as required, to provide the appropriate data for the manual calculations that will be required of the resultant computer data.

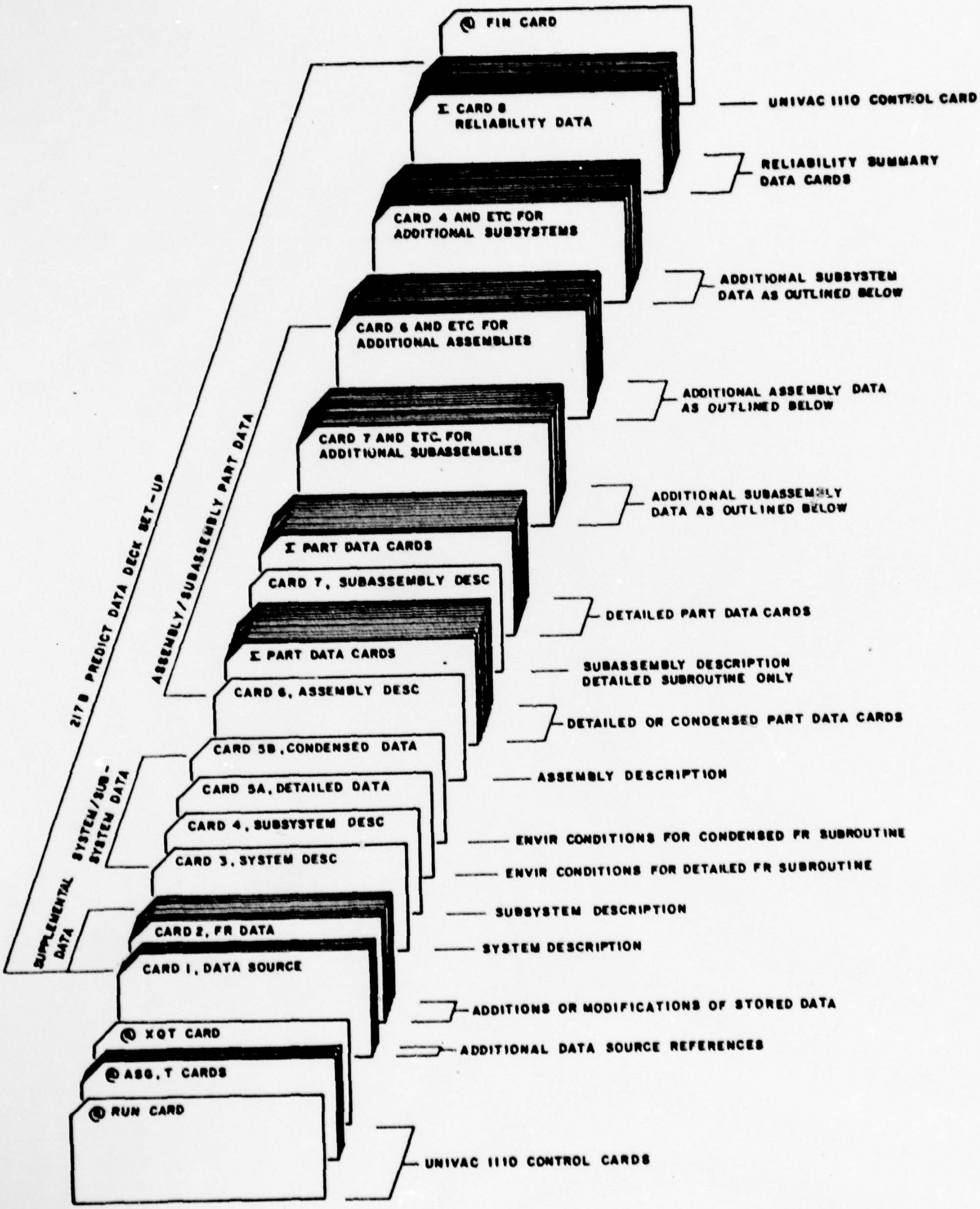

FIGURE 5.1. GENERALIZED 217B PREDICT PROGRAM DECK SET-UP

b. Card 1, Data Source Reference (not mandatory)

Use the Card 1 format to document the failure rate data sources used in performing the prediction, less those already noted in the Stored Part Data (see Appendix A). The data sources, as documented in the prediction summary, provide the capability of explicitly defining the part failure rate data source for traceability.

c. Card 2A, Environmental π-Factors (not mandatory)

Use the Card 2A format to enter environmental π-factors that are not defined in MIL-HDBK-217B or in the Stored Part Data (see Appendix A). The environmental π-factors provide the ability to include and document new environmental data as they become available.

d. Card 2B, Modify Stored Part Data (not mandatory)

Use the Card 2B format to modify the Stored Part Data (see Appendix A) and/or to use the data for an alternate part code as a failure rate equivalency for the part. Modification of the Stored Part Data provides the ability to define and document the failure rate parameters for the majority of the parts in the user's system, thereby minimizing the data that must be entered at the part level (Detailed Failure Rate Subroutine only).

Note: In selecting a part code for a nonstored part type it is preferable to select a non-assigned part code within the applicable part category depicted in Appendices A or B. However, if a non-assigned part code is not available, the user can use a preassigned part code if it is not used elsewhere in the user's system. Although the user is constrained to the 180 part codes in the Appendices, these data are considered to be adequate for all applications when used to reflect generic part types, e.g., Carbon Composition Resistor, not RCR07 Resistor. For example, in a recent prediction for an airborne missile system with 5,310 piece parts, only 66 part types were used.

Multiple 2B Cards can be submitted for a specific part code if extensive part failure rate parameter modifications are required, or Card 2B can be followed by a Card 2C if part failure rate modifications and data source modifications are required.

It should be noted that the equivalent code references the Stored Part Data definitions as modified by previously submitted 2B Card definitions, e.g., if the part quality for part code 101 was changed from Q = 2 to Q = 5, and then part code 101 was defined as the failure rate equivalency for part code 803, the part quality for part code 803 would also be Q = 5.

If additional explanatory information is required to explicitly define the origin and derivation of the failure rate data used, it is the responsibility of the reliability analyst to include same in the basic report.

e. Card 2C, Supplement Stored Part Data (not mandatory)

Use the Card 2C format to modify and/or supplement the Stored Part Data (see Appendix A). Supplementing the Stored Part Data provides the ability to include and document non-MIL-HDBK-217B operating failure rate data and/or dormant failure rate data.

Again, if additional explanatory information is required to explicitly define the origin and derivation of the part failure rate data used, it is the responsibility of the reliability analyst to include same in the basic report.

f. Card 3, System Description

Use the Card 3 format to explicitly define and document the system being evaluated.

g. Card 4, Subsystem Description (not mandatory)

Use the Card 4 format to explicitly define and document each subsystem, if applicable, in the users system.

h. Card 5A, Detailed Environmental Stress Conditions

Use the Card 5A format to define and document the environmental stress conditions to be used for 1 to 3 detailed failure rate data sets (Detailed Failure Rate Subroutine only). The environmental stress conditions are defined in terms of:

- o The ambient temperature in degrees Celsius for the system or subsystem being evaluated.
- o The appropriate environment in accordance with MIL-HDBK-217B environmental symbols.
- o The type of failure rate data (APPLIED, ASSUMED, or DORMANT) as defined below.

Note: The Type of Failure Rate Data can be redefined at the assembly level for the Detailed and Condensed Failure Rate Subroutine, and at the subassembly and part level for the Detailed Failure Rate Subroutine, e.g., the system/subsystem failure rate data may be based on Applied Stress Part Data, yet one assembly is not powered. The Type of Failure Rate Data for that assembly can be changed on the assembly card (Card 6).

The user can also select which set of failure rate data shall be used for the part ranking in the failure rate summary. This summary defines the summation of the part failure rates for each part type, i.e., part code, and the percentage of the total system/subsystem failure rate for each part type.

i. Type of Failure Rate Data

The user evaluates and modifies the Stored Part Data as defined in Appendix A to establish the "Standard" part failure rate definitions for the prediction. The Applied Stress Part Data provide minimum operating and dormant failure rate conditions for the Detailed and Condensed Failure Rate Subroutines, and minimize the amount of data to be entered at the part level for the Detailed Failure Rate Subroutine. The Assumed Stress Part Data provide nominal operating failure rate conditions for the Detailed and Condensed Failure Rate Subroutines. These data are defined as:

(1) Applied Stress Part Data (APPLIED) = minimum operating failure rate conditions as modified at the part level to reflect detailed stress analysis data for a mature design that is explicitly defined.

(2) Assumed Stress Part Data (ASSUMED) = nominal operating failure rate conditions that reflect assumed stress data for an early design that is not explicitly defined. The assumed primary stress ratio (S1) is in general accordance with the definitions in Section 3 of MIL-HDBK-217B; the remaining parameters are in accordance with the Applied Stress Part Data.

(3) Dormant Part Data (DORMANT) = minimum operating failure rate conditions times a dormant failure rate π-factor (operating-to-nonoperating failure rate multiplier). This technique provides dormant data that reflects the impact of ambient temperature and part quality.

Inclusion of dormant data in the computer program was considered to be mandatory, yet the resolution of the uncertainties regarding the RADC and Redstone dormant data in References 2, 3, and 4 was beyond the scope of the current development of the computer program. A preliminary evaluation of the dormant data with regard to MIL-HDBK-217B operating data was performed, and generalized dormant π-factors were derived as presented in Appendix A. Use of these factors will provide part failure rate data in general accordance with the RADC and Redstone dormant data, and will also reflect the impact of ambient temperature and part quality. These data and procedures will be used pending further studies of dormant versus operating part failure rates.

j. Card 5B, Condensed Environmental Stress Conditions

Use the Card 5B format to define and document the environmental stress conditions to be used for 1 to 5 sets of condensed failure rate data using the Condensed Failure Rate Subroutine. The environmental stress conditions are in terms of ambient temperature, environment, and type of failure rate data (APPLIED, ASSUMED, or DORMANT) as previously defined.

Submitting a 5A and 5B Card prior to the part data tells the computer program that the part type and quantity data versus assembly shall be stored for all following data. Therefore condensed failure rate data for an assumed hardware configuration can be combined with detailed stress data only if submitted as system or subsystem data prior to implementing the Detailed Failure Rate Subroutine (see Sample Prediction, Section III).

k. Card 6, Assembly Description

Use the Card 6 format to explicitly define and document each assembly in the users subsystem or system (Detailed and Condensed Failure Rate Subroutines). This card can also be used to redefine the Type of Failure Rate Data to be used for the assembly, or to zero the failure rates if the assembly is not applicable to a specific life cycle event.

l. Card 7, Subassembly Description (not mandatory)

Use the Card 7 format to explicitly define and document each subassembly in the user's assembly (Detailed Failure Rate Subroutine only). This card can also be used to redefine the Type of Failure Rate Data to be used for the subassembly, or to zero the failure rates if the subassembly is not applicable to a specific life cycle event.

m. Detailed Part Data Card

The Detailed Part Data Card (Detailed Failure Rate Subroutine only) includes the part reference designator, part number, part type, part quantity, and all exceptions to the "Standard" part failure rate definitions. The Type of Failure Rate Data for the part can be redefined.

n. Condensed Part Data Card

The Condensed Part Data Card (Condensed Failure Rate Subroutine only) is limited to the part type and part quantity. These data are compiled in the process of using the Detailed Failure Rate Subroutine or are defined by the user in the absence of Card 5A and Detailed Part Data Cards.

o. Card 8A, Life Cycle Event Description (not mandatory)

Use the Card 8A format to explicitly define each life cycle event(s) to be predicted. If the series reliability model is not appropriate, the user can inhibit the computer printout of the reliability data by not submitting any Card 8 data, thereby obtaining the failure rate summary only for use in alternate calculation techniques.

p. Card 8B, One-Shot Reliability (not mandatory)

Use the Card 8B format to define the one-shot device description, data source, reliability, and applicable subsystem or system. Identify the subsystems using "SS(n)," where (n) reflects the order that the subsystem Card 4's are submitted to the computer, i.e., the first subsystem Card 4 in the system data deck would be "SS1."

Multiple 8B Cards may be submitted to define all of the one-shot devices in the user's system. However, if additional explanatory information is required to explicitly define the origin and derivation of the one-shot reliability data used, it is the responsibility of the reliability analyst to include same in the basic report.

q. Card 8C, Life Cycle Event Subsystem Failure Rate Data (not mandatory)

Use the Card 8C format to define the subsystem failure rate data sets and one-shot reliabilities that are to be included in the printout for each life cycle event. Identify the subsystems using the "SS(n)" format as defined above, and the end of the applicable subsystem failure rate data sets by entering "SYS." Identify the applicable subsystem failure rate data sets in terms of the Cards 5A and 5B failure rate data set numbers, e.g., 6 = the Card 5B failure rate data set consisting of FR TYPE6, π_E SYM6, and TEMP6. Card 5A contains failure rate data sets 1 through 3 and the initial Card 5B submitted for the subsystem contains failure rate data sets 4 through 8. If a second Card 5B is submitted for the subsystem, the failure rate data sets are defined as data sets 9 through 13.

The Card 8C format can be used to combine subsystem failure rate data and one-shot reliability data to reflect the system reliability for a single life cycle event, e.g., for Missile Launch and Sustained Free Flight. This format can also be used to reflect multiple life cycle events, e.g., Airborne Captive Flight, plus Missile Launch and Sustained Free Flight.

3. SYSTEM/SUBSYSTEM RELIABILITY MODEL

The system and subsystem reliability data compiled using the 217B PREDICT computer program reflects a series reliability model wherein failure of any part constitutes system failure. The "subsystem" and "system" reliability, less the one-shot devices as calculated by 217B PREDICT assumes statistically independent part failures that exhibit a constant failure rate for the time period being evaluated. These reliabilities are calculated using the exponential function:

$$R(t) = \exp\left(-t \sum_{i=1}^{n} \lambda_i \,(10^{-6})\right)$$

Where:

- $R(t)$ = "subsystem" or "system" reliability as a function of time
- exp = base "e" of the natural logarithm to the power indicated
- t = time in hours
- λ_i = failure rate of the i^{th} part for the applicable environment and operating/dormant state in failures per million hours.

The one-shot device reliabilities are expressed in terms of probability and are incorporated into the system reliability using the equation:

$$R(s) = R(t) \div \prod_{j=1}^{k} P(\text{one-shot})_j$$

Where:

- $R(s)$ = overall "system or "subsystem" reliability
- $R(t)$ = "system" or "subsystem" reliability, less one-shot devices, as calculated using the exponential reliability function
- $P(\text{one-shot})_j$ = probability of successful operation of the j^{th} one-shot device

The computer program does not contain any provisions for handling non-series reliability configurations. If non-series reliability calculations are required, it is recommended that the above series model be repressed in the printout. The remaining failure rate data would then be submitted to manual calculation techniques or alternate computer programs, e.g., Reference 5.

4. PART FAILURE RATE MODEL

The following general part failure rate model as used in the computer program is a logical extension of the general part failure rate model in MIL-HDBK-217B.

$$\lambda_p = \lambda_b (\pi_E) \left(\prod_{i=1}^{n} \pi_i \right) \pi_D$$

Where: λ_p = part failure rate for the applicable environment and operating/nonoperating state in failures per million hours

λ_b = basic operating part failure rate as defined in MIL-HDBK-217B

π_E = appropriate environmental π-factor for the applicable part type

Π = mathematical symbol for "the product of"

π_i = value of the i^{th} π-factor for the applicable part type as defined in MIL-HDBK-217B (not applicable to non-MIL-HDBK-217B parts)

π_D = dormant (operating-to-nonoperating) π-factor (π_D relfects nonoperating failure rate data $\div$ operating failure rate data for a specific set of environmental conditions = 1.0 for operating part failure rates)

Note: Use of any nonstandard (non-MIL-HDBK-217B) part failure rate requires good engineering judgement, must be fully substantiated in the reliability prediction report, and is subject to the procuring agency approval.

The non-MIL-HDBK-217B data presented herein reflects part failure rate data and techniques used over the last several years in performing reliability predictions at the Naval Weapons Center, China Lake, California. These data are included for the convenience of the user. However, it should be noted that the inclusion of these data does not reflect any prior approval on the part of any procuring agency.

5. COMPUTER PROGRAM CALCULATIONS OF PART FAILURE RATES

The operating part failure rates are calculated using the Applied or Assumed Part Failure Rate Definitions (Stored Part Data) in Appendix A as modified by the user. As noted in Section I, the Applied Stress Part Data can be modified at the part level (Detailed Failure Rate Subroutine only) thereby providing definitive stress data on a part-by-part basis. Whereas the Assumed Stress Part Data provides the capability of performing a reliability prediction using assumed configuration and/or application data. The dormant part failure rates are calculated using the Dormant Failure Rate Factor and the Applied Part Failure Rate Definitions as modified by the user. The MIL-HDBK-217B part failure rate equations as implemented by the computer program are outlined below.

a. Monolithic Bipolar and MOS Integrated Circuits

$$\lambda_p = \pi_L \cdot \pi_Q \cdot [C_1 \cdot \pi_T + C_2 \cdot \pi_E] \cdot \pi_p \text{ per MIL-HDBK-217B}$$

$$= L \cdot Q \cdot [f(\#) \cdot f(TJ) + f(\#) \cdot (E)] \cdot P \cdot D \text{ per 217B PREDICT}$$

Where:

L = Stored production learning factor = 1.0

Q = Stored Class B quality factor = 2.0

f(#) = C1 and C2 is a function of the number of gates (#G), transistors (#T), or BITS (#B), as defined in Appendix A

f(TJ) = π_{T1} is a function of the junction temperature (TJ) entered by the user at the part level, or as a function of the ambient temperature as defined in MIL-HDBK-217B

E = Stored MIL-HDBK-217B environmental factors

P = Stored package lead factor = 1.0

D = Stored dormant failure factor = 0.1 based on Redstone Class B Bipolar Digital I/C (1-20 gates) dormant failure rate divided by MONO S/MSI DIG I/C Applied Stress Part Failure Rates in Ground Fixed environment with TJ = +25°C. This value is assumed to be applicable to all Class B integrated circuits. Note: D = 1.0 when calculating the operating part failure rate.

The dormant part failure rates are calculated using the Dormant Failure Rate Factor and the Applied Stress Part Failure Rate with the junction temperature set equal to the ambient temperature.

b. Hybrid Circuits

Each hybrid microcircuit is a fairly unique device. Since none of the devices have been standardized, their complexity cannot be determined from their name or function. Similar hybrids can have a wide range of complexity that limits the categorization of these devices. If hybrids are included in a design, it is the responsibility of the reliability analyst to thoroughly investigate their use and construction on an individual basis, and to document same in the basic report. Therefore, it is considered herein to be cost effective to limit the users entry to the base failure rate and associated π-factors for his devices.

$\lambda_p = \lambda_b \cdot \pi_T \cdot \pi_E \cdot \pi_Q \cdot \pi_F$ per MIL-HDBK-217B

=LB•f(T)•E•Q•F•D per 217B PREDICT

Where: LB = Lambda basic, stored base failure rate. Although a value for lambda basic is stored it is not intended to reflect the users device. The user must derive and enter the applicable value for his particular device(s) using the Card 2B format. If extensive hybrids are used in the design, the user should enter a composite value for lambda basic in the Stored Part Data for the dormant failure rate calculations, and then modify this value as required at the part level.

f(T) = $\pi_T(T)$ is a function of the package mounting base temperature, which is assumed to be equivalent to the ambient temperature, unless otherwise defined by the user at the part level.

E = Stored MIL-HDBK-217B environmental factors

Q = Stored Class B quality factor = 1.0

F = Stored circuit function factor as defined in Appendix A

D = Stored dormant failure rate factor = 0.1. In the absence of specific data, the Monolithic Bipolar Circuit derivation is assumed to be applicable.

c. Tubes, Electronic Vacuum

$$\lambda_p = \lambda_b \cdot \pi_E \text{ per MIL-HDBK-217B}$$

$$= LB \cdot E \cdot D \text{ per 217B PREDICT}$$

Where: LB = Lambda basic, stored base failure rate

E = Stored MIL-HDBK-217B environmental factors

D = Stored dormant failure rate factor as depicted in Appendix A. Based on equivalent Redstone dormant failure rate divided by the appropriate tube failure rate in MIL-HDBK-217B in Ground Fixed environments, or by equating to the above data for a similar device.

d. Laser Devices

Helium/Neon and Argon Ion

$$\lambda_p = \pi_E \cdot [\lambda_{MEDIA} + \lambda_{COUPLING}] \text{ per MIL-HDBK-217B}$$

$$= E \cdot (LM + LC) \cdot D \text{ per 217B PREDICT}$$

CO_2 Sealed

$$\lambda_p = \pi_E \cdot [\pi_O \cdot \pi_B \cdot \lambda_{MEDIA} + \pi_{OS} \cdot \lambda_{COUPLING}] \text{ per MIL-HDBK-217B}$$

$$= E \cdot [O \cdot B \cdot f(DI) + OS \cdot LC] \cdot D \text{ per 217B PREDICT}$$

CO_2 Flowing

$$\lambda_p = \pi_E \cdot [\lambda_{MEDIA} + \pi_{OS} \cdot \lambda_{COUPLING}] \text{ per MIL-HDBK-217B}$$

$$= E \cdot [0.0 + OS \cdot f(P)] \cdot D \text{ per 217B PREDICT}$$

YAG and Ruby Rod

$$\lambda_p = \pi_E \cdot [\lambda_{MEDIA} + \lambda_{PUMP} + \pi_C \cdot \pi_{OS} \cdot \lambda_{COUPLING}] \text{ per MIL-HDBK-217B}$$

$$= E \cdot [LM + LP + C \cdot OS \cdot LC] \cdot D \text{ per 217B PREDICT}$$

Where: E = Stored MIL-HDBK-217B environmental factors

LM = Lambda media, stored base failure rate

LC = Lambda coupling, stored base failure rate

O = Stored gas overfill factor = 1.0

B = Stored ballast factor = 1.0

f(P) = $\lambda_{COUPLING}$ is a function of the average output laser beam power (P) in kilowatts

OS = Stored number of optical surfaces = 2.0

LP = Lambda pump, stored base failure rate

f(DI) = λ_{MEDIA} is a function of the discharge current (DI) in milliamperes

C = Stored coupling cleanliness factor = 30

D = Stored dormant failure rate factor = 0.04. In the absence of definitive data, the estimated mechanical factor is assumed to be applicable.

e. Microwave Power Transistors

$\lambda_p = \lambda_b \cdot \pi_Q \cdot \pi_A \cdot \pi_F \cdot \pi_T \cdot \pi_M \cdot \pi_E$ per MIL-HDBK-217B

= LB•Q•A•F•f(V)•M•E•D per 217B PREDICT

Where: LB = Lambda basic, stored base failure rate

Q = Stored JANTX quality factor = 2.0

A = Stored application factor = 1.0

F = Stored operating power and frequency factor = 1.0

f(V) = π_T is a function of the operating voltage (VC), the rated BV_{CES}(BV), and the peak junction temperature (T) as defined in Appendix A.

M = Stored matching network factor = 1.0

E = Stored MIL-HDBK-217B environmental factors

D = Stored dormant failure rate factor = 0.32. Based on Redstone JANTX Microwave Transistor (Gold Refractory Metalization) dormant failure rate divided by MICROWAVE XSTR, AU Applied Stress Part failure rate in Ground Fixed environment.

f. Semiconductors

$\lambda_p = \lambda_b \cdot \pi_E \cdot \pi_A \cdot \pi_Q \cdot \pi_{S2} \cdot \pi_C \cdot \pi_R$ per MIL-HDBK-217B

= f(λ)•E•A•Q•S2•C•R•D per 217B PREDICT

Where: f(λ) = λ_b = base failure rate as a function of the primary applied stress ratio (S1), the temperature that derating is started (TS), the maximum junction temperature (TJ), and the ambient temperature

E = Stored MIL-HDBK-217B environmental factors

A = Stored application factor as defined in Appendix A

Q = Stored quality factor as defined in Appendix A

S2 = Stored reverse voltage factor as defined in Appendix A

C = Stored complexity factor as defined in Appendix A

R = Stored power or current rating factor = 1.0

D = Stored dormant failure rate factor as defined in Appendix A. Based on equivalent Redstone dormant failure rate divided by the appropriate semiconductor Applied Stress part failure rate in Ground Fixed environment at +25°C, or by equating to the above data for a similar part.

g. Resistors

$\lambda_p = \lambda_b \cdot \pi_E \cdot \pi_R \cdot \pi_Q$ per MIL-HDBK-217B

$= f(\lambda) \cdot E \cdot R \cdot Q \cdot D$ per 217B PREDICT

Where: $f(\lambda)$ = λ_b = base failure rate as a function of the primary applied (power) stress ratio (S1) and the ambient temperature

E = Stored MIL-HDBK-217B environmental factors

R = Stored resistance factor = 1.0

Q = Stored quality factor as defined in Appendix A

D = Stored dormant failure rate factor as defined in Appendix A. Based on equivalent Redstone dormant failure rate divided by the appropriate resistor Applied Stress part failure rate in Ground Fixed environment at +25°C, or by equating to the above data for a similar part.

h. Potentiometers

$\lambda_p = \lambda_b \cdot \pi_{TAPS} \cdot \pi_R \cdot \pi_V \cdot \pi_C \cdot \pi_E \cdot \pi_Q$ per MIL-HDBK-217B

$= f(\lambda) \cdot TP \cdot R \cdot V \cdot C \cdot E \cdot Q \cdot D$ per 217B PREDICT

Where: $f(\lambda)$ = λ_b = base failure rate as a function of the primary applied (power) stress ratio (S1) and the ambient temperature. The applied stress ratio is a function of the applied power, the power rating, the ganged factor, and the loading effect on the potentiometer as defined in MIL-HDBK-217B

TP = Stored potentiometer taps factor = 1.0

R = Stored resistance factor = 1.0

V = Stored voltage ratio factor = 1.0

C = Stored construction factor = 1.0

E = Stored MIL-HDBK-217B environmental factors

Q = Stored quality factor as defined in Appendix A

D = Stored dormant failure rate factor as defined in Appendix A. Based on equivalent Redstone dormant failure rate divided by the appropriate potentiometer Applied Stress part failure rate in Ground Fixed environment at +25°C, or by equating to the above data for a similar part.

i. Capacitors

$$\lambda_p = \lambda_b \cdot \pi_E \cdot \pi_{CV} \cdot \pi_{SR} \cdot \pi_Q \text{ per MIL-HDBK-217B}$$

$$= f(\lambda) \cdot E \cdot CV \cdot SR \cdot Q \cdot TR \cdot D \text{ per 217B PREDICT}$$

Where: $f(\lambda)$ = λ_b = base failure rate as a function of the primary applied (voltage) stress ratio (S1), the ambient temperature, the voltage limit temperature rise (TR), and the rated temperature (RT) for the device

E = Stored MIL-HDBK-217B environmental factors

CV = Stored capacitance value factor = 1.0

SR = Stored series resistance factor = 1.0

Q = Stored quality factor as defined in Appendix A

TR = Stored voltage limit temperature rise in degrees Celsius = 0.0

D = Stored dormant failure rate factor as defined in Appendix A. Based on equivalent Redstone or RADC dormant failure rate divided by the appropriate capacitor Applied Stress part failure rate in Ground Fixed environment at +25°C, or by equating to the above data for a similar part.

j. Transformers and Inductors

$$\lambda_p = \lambda_b \cdot \pi_E \cdot \pi_f \text{ per MIL-HDBK-217B}$$

$$= f(\lambda) \cdot D \cdot F \cdot D \text{ per 217B PREDICT}$$

Where: $f(\lambda)$ = λ_b = base failure rate as a function of the style of transformer or inductor as defined in Appendix A, the insulation temperature rating (IN) in degrees Celsius, and the temperature rise (TR)

E = Stored MIL-HDBK-217B environmental factors

F = Stored family and quality factors as defined in Appendix A

D = Stored dormant failure rate factor = 0.5. The RADC and Redstone dormant failure rate data are considered herein to be inadequate for defining explicit factors. The above estimate is based on a cursory comparison of these data to the Applied Stress part failure rates for the transformers and inductors in a Ground Fixed environment at +25°C.

Dormant part failure rates are calculated with zero temperature rise (TR).

k. Motors

$$\lambda_p = [\lambda_b \cdot \pi_F + (P_{POP} \cdot 10^4)/t_{op}] \cdot \pi_E \text{ per MIL-HDBK-217B}$$

$$= [f(\lambda) \cdot (F) + (\%M \cdot 10^4)/OP] \cdot E \cdot D \text{ per 217B PREDICT}$$

Where: $f(\lambda)$ = λ_b = base failure rate as a function of insulation temperature rating (IN) in degrees Celsius, plus the frame and hot spot temperature rise (TR) in degrees Celsius

F = Stored family and quality factor as defined in Appendix A

%M = Stored percentage of mechanical motor failures during operating time (OP) = 0.5

OP = Stored operating time (OP) in hours = 2,000

E = Stored MIL-HDBK-217B environmental factors. In the absence of definitive data, the π_E factor for G_B and S_F are assumed herein to equal 1.0, and the π_E factor for M_L is assumed herein to equal 93 (10 times AU factor) based on the relay and switch data.

D = Stored dormant failure rate factor = 1.0. The RADC dormant failure rate data are considered herein to be inadequate for defining explicit factors. The above estimate is based on a cursory comparison of these data to the Applied Stress part failure rates for motors in a Ground Fixed environment at +25°C.

l. Blowers and Fans

Each motor and fan as defined in MIL-HDBK-217B will be a fairly unique device. Given that the specified data is available, the reliability analyst will be required to thoroughly investigate their use and construction on an individual basis, and to document same in the basic report. Therefore, it is considered herein to be cost effective to limit the users entry to just the resulting operating part failure rate for his device(s).

Although the fixed service life operating part failure rate from MIL-HDBK-217B is stored, it is not intended to reflect the users device. The user must derive and enter the applicable value for his particular device(s) using the Card 2C format.

The dormant part failure rate is estimated by multiplying the operating part failure rate times the dormant failure rate factor of 1.0. The RADC dormant failure rate data are considered herein to be inadequate for defining explicit factors. The above estimate is based on a cursory evaluation of these data and various operating part failure rate data from MIL-HDBK-217B, RADC Nonelectronic Notebook, and FARADA.

m. Synchros and Resolvers (Low Speed, Low Load)

$\lambda_p = \lambda_b \cdot \pi_S \cdot \pi_N \cdot \pi_E$ per MIL-HDBK-217B

$= f(\lambda) \cdot S \cdot \#B \cdot E \cdot D$ per 217B PREDICT

Where: $f(\lambda)$ = λ_b = base failure rate as a function of the ambient temperature and the frame temperature rise (TR)

S = Stored size factor as defined in Appendix A

#B = Stored number of brushes and quality factor = 4.0

E = Stored MIL-HDBK-217B environments factors as a function of part quality (Q). In the absence of definitive data, the π_E factor for S_F are assumed to equal G_B, and for M_L are assumed to equal 10 times the A_U factor based on relay and switch data.

D = Stored dormant failure rate factor = 0.5. The RADC dormant failure rate data are considered herein to be inadequate for defining explicit factors. The above estimate is based on a cursory comparison of these data to the Applied Stress part failure rate data in a Ground Fixed environment at +25°C. Dormant part failure rates are calculated with zero temperature rise.

n.

n. Elapsed Time Meters

$\lambda_p = \lambda_b \cdot \pi_T \cdot \pi_E$ per MIL-HDBK-217B

$= LB \cdot T \cdot E \cdot D$ per 217B PREDICT

Where: LB = Lambda basic, stored base failure rate

T = Stored temperature factor = 0.5

E = Stored MIL-HDBK-217B environmental factors as a function of part quality (Q). In the absence of definitive data, the π_E factor for N_S and N_U is assumed herein to be equal to the factors for the resolvers and synchros.

D = Stored dormant failure rate factor = 0.5. In the absence of definitive data, the dormant failure rate factor is assumed herein to be equivalent to the resolvers and synchros.

o. Connectors (1/2 Mated Pair)

$$\lambda_p = [\lambda_b \cdot \pi_E \cdot \pi_P + N \cdot \lambda_{CYC}]/2 \text{ per MIL-HDBK-217B}$$

$$= [(f(\lambda)/2) \cdot E \cdot f(P) + N \cdot f(CY)/2] \cdot D \text{ per 217B PREDICT}$$

Where: $f(\lambda)$ = λ_b = base failure rate as a function of the insert material class (IN), the ambient temperature, and the temperature rise (TR)

E = Stored MIL-HDBK-217B environmental factors as a function of part quality (Q)

f(P) = π_p = active contacts factor as a function of the number of active contacts (N)

N = Number of active contacts

f(CY) = λ_{CYC} = base cycling failure rate as a function of the cycling rate (CY) = zero for CY = 0.0

D = Stored dormant failure rate factor = 0.04. The RADC and Redstone dormant failure rate data are considered herein to be inadequate for defining explicit factors. The above estimate is based on a cursory comparison of these data to the Applied Streee part failure rate data in a Ground Fixed environment at +25°C.

p. Relays

$$\lambda_p = \lambda_T \cdot \pi_L \cdot \pi_E \cdot \pi_C \cdot \pi_{CYC} \cdot \pi_F \text{ per MIL-HDBK-217B}$$

$$= f(\lambda) \cdot f(L) \cdot E \cdot CF \cdot CY \cdot F \cdot D \text{ per 217B PREDICT}$$

Where: $f(\lambda)$ = λ_T = base failure rate as a function of the part temperature rating and the ambient temperature

f(L) = Stored loading factor as a function of the primary stress (current) ratio (S1) and the type of relay load (RL = RES, IND, or LMP)

E = Stored MIL-HDBK-217B environmental factors as a function of the part quality (Q)

CF = Stored contact form factor = 3.0

CY = Stored cycling rate in cycles per hour = 1.0

F = Stored application and construction factor = 5.0

D = Stored dormant failure factor = 0.04. The RADC and Redstone dormant failure rate data are considered herein to be inadequate for defining explicit factors. The above estimate is based on a cursory comparison of these data to the Applied Stress part failure rate data in a Ground Fixed environment at +25°C.

q. Switches

$\lambda_p = \lambda_b \cdot \pi_E \cdot \pi_C \cdot \pi_{CYC}$ per MIL-HDBK-217B

= LB·E·CF·CY·D per 217B PREDICT

Where: LB = λ_b = Stored base failure rate

E = Stored MIL-HDBK-217B environmental factors

CF = Stored contact form factor = 1.0

CY = Stored cycling rate in cycles per hour = 1.0

D = Stored dormant failure rate factor = 1.0. The RADC and Redstone dormant failure rate data are considered herein to be inadequate for defining explicit factors. The above estimate is based on a cursory comparison of these data to the Applied Stress part failure rate data in a Ground Fixed environment at +25°C.

r. Printed Wiring Boards

$\lambda_p = \lambda_b \cdot N \cdot \pi_E$ per MIL-HDBK-217B

= f(λ)·N·E·D per 217B PREDICT

Where: f(λ) = λ_b = base failure rate as a function of the type of printed wiring board

N = Stored number of plated through holes = 100

E = Stored MIL-HDBK-217B environmental factors

D = Stored dormant failure rate factor = 0.04. The RADC dormant failure rate data, as depicted in the Redstone report, indicates a dormant factor of 0.008. However, in the absence of definitive background information, the judgement is made herein to use the above factor to provide a conservative estimate of the dormant part failure rate.

s. Solder Connections

$\lambda_p = \lambda_b \cdot E \cdot D$ per 217B PREDICT

Where: λ_b = Base failure rate as a function of the type of solder connection. These data were extracted from the Miscellaneous Part Section in MIL-HDBK-217B, and are assumed herein to be equivalent to a Ground Fixed environment.

E = Stored environmental factors for connectors are assumed herein to be applicable for deriving failure rates at environments of greater or lesser severity

D = Stored dormant failure rate factor = 0.04. The factor is considered herein to represent a reasonable compromise between the data presented in the RADC and Redstone reports.

t. Non-MIL-HDBK-217B Parts

$\lambda_p = \lambda_b \cdot E \cdot D$ per 217B PREDICT

Where: λ_b = Base failure rate at a specified environment as defined by the user

E = The appropriate environmental factors as defined by the user

D = The appropriate dormant failure rate factor as defined by the user

SECTION VI

REFERENCES

1. MIL-HDBK-217B and Notice 1, "Military Standardization Handbook, Reliability Prediction of Electronic Equipment," 7 September 1976.

2. Rome Air Development Center Technical Report No. RADC-75-248, "Dormancy and Power On-Off Cycling Effects on Electronic Equipment and Part Reliability," August 1973.

3. U. S. Army Redstone Arsenal Storage Report LC-76-1, "Missile Material Prediction Handbook, Parts Count Prediction," May 1976.

4. RADC-TR-75-22, "RADC Nonelectronic Reliability Notebook," January 1975.

5. National Aeronautics and Space Administration Technical Report 32-1543, "Reliability Computation from Reliability Block Diagrams," 1 December 1971.

6. MIL-STD-1670A, "Military Standard, Environmental Criteria and Guidelines for Air-Launched Weapons," 30 July 1976.

7. Failure Rate Data (FARADA) Handbook, Naval Fleet Missile Systems Analysis and Evaluation Group, March 1968 and updates.

8. TRW Systems Group Report No. D00289 (GIDEP Report Number 347.20.00.00-G4-04). "An Investigation of the Ratio Between Standby and Operating Part Failure Rates," February 1971.

9. Naval Weapons Center Utility Program Number UP-4144, "Sperry UNIVAC 1110 Series Executive System Programmer Reference Manual," 1975.

APPENDIX A

STORED PART DATA

AND

CODING FORM DEFINITIONS

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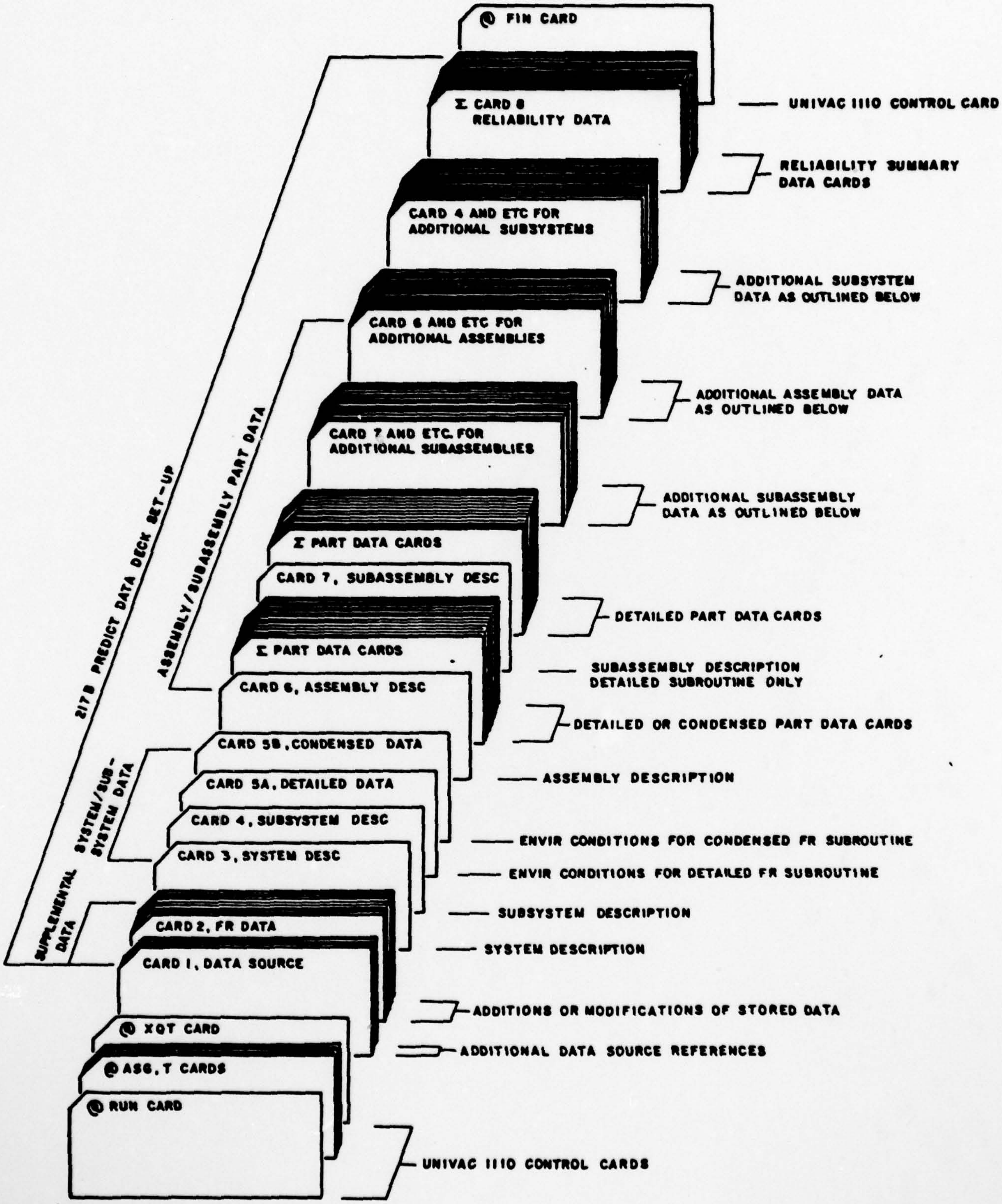

FIGURE A.1. GENERALIZED 217B PREDICT PROGRAM DECK SET-UP

TABLE A.1. Stored Part Data for 217B PREDICT Computer Program

*** GENERAL INFORMATION ***

INTRODUCTION: THE ENCLOSED RELIABILITY PREDICTION DATA WERE COMPILED USING THE '217B PREDICT' COMPUTER PROGRAM. THE PROGRAM CALCULATES INDIVIDUAL PART FAILURE RATES USING THE STANDARD PART FAILURE RATE PARAMETERS DEFINED HEREIN UNLESS OTHERWISE DEFINED AT THE PART LEVEL. DETAILED PROCEDURES AND ASSUMPTIONS USED ARE OUTLINED BELOW AND ARE DISCUSSED IN THE BASIC REPORT.

DATA SOURCES: THE PART FAILURE RATE DATA WERE DERIVED IN ACCORDANCE WITH THE PROCEDURES AND DATA IN THE FOLLOWING REFERENCES.

217B = MIL-HDBK-217B AND NOTICE 1, 'RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT,' SEPT 1976
REDSTN = US ARMY REDSTONE ARSENAL STORAGE REPORT LC-76-1, 'MISSILE MATERIAL RELIABILITY PREDICTION HANDBOOK,' MAY 1976
RADC1 = ROME AIR DEVELOPMENT CENTER REPORT RADC-TR-75-22, 'NONELECTRONIC RELIABILITY NOTEBOOK,' JAN 1975
RADC2 = ROME AIR DEV CENTER REPORT RADC-TR-73-248, 'DORMANCY & POWER ON-OFF CYCLING EFFECTS ON RELIABILITY,' AUG 1973
FARADA = FAILURE RATE DATA HANDBOOK, NAVAL FLEET MISSILE SYSTEM ANALYSIS AND EVALUATION GROUP, MAR 1968 AND UPDATES
MANUAL = 217B PREDICT SYSTEM RELIABILITY PREDICTION COMPUTER PROGRAM USER MANUAL DEFINITION FOR NON-MIL-HDBK-217B DATA
REPORT = SEE THE BASIC RELIABILITY PREDICTIONS REPORT FOR MORE DEFINITIVE DEFINITIONS OF THE DATA AS NOTED HEREIN

*** FAILURE RATE PARAMETER DEFINITIONS ***

CODING FORMAT: THE FOLLOWING CODING FORMAT IS USED HEREIN TO DEFINE THE PART FAILURE RATE PARAMETERS IN RECOGNIZABLE TERMINOLOGY, I.E. IN GENERAL ACCORDANCE WITH MIL-HDBK-217B DEFINITIONS. THIS FORMAT IS USED TO DEFINE THE STANDARD PART FAILURE RATE PARAMETERS, AND TO IDENTIFY THE EXCEPTIONS TO THE STANDARD PART FAILURE RATE PARAMETERS AT THE PART LEVEL IN THE ENCLOSED PRINTOUT

XYY=ZZZZ, WHERE: X = FAILURE RATE COLUMN LIMITATION AT THE PART LEVEL ONLY. LIMITS THE APPLICABILITY OF THE SPECIFIED PART FAILURE RATE PARAMETER TO A SINGLE LIFE CYCLE EVENT AT THE PART LEVEL IN THE ENCLOSED PART FAILURE RATE PRINTOUT. IF BLANK, THE FAILURE RATE PARAMETER APPLIES TO EACH OF THE LIFE CYCLE EVENTS NOTED.

YY = PART FAILURE RATE PARAMETER SYMBOL IN GENERAL ACCORDANCE WITH MIL-HDBK-217B AS DEFINED BELOW.

ZZZZ = PART FAILURE RATE PARAMETER VALUE USED TO CALCULATE THE PART FAILURE RATE, OR TO DEFINE THE USE OF 'OPER' OR 'DORM' PART FAILURE RATES AT THE PART LEVEL IF DIFFERENT THAN THE REST OF THE ASSEMBLY.

PARAMETER SYMBOLS: THE FOLLOWING PART FAILURE RATE PARAMETER SYMBOLS AS USED HEREIN ARE IN GENERAL ACCORDANCE WITH MIL-HDBK-217B.

SYM	DEFINITION	SYM	DEFINITION	SYM	DEFINITION
A	= SEMICONDUCTOR APPLICATION FACTOR	* LM	= LASER LAMBDA MEDIA FAILURE RATE	* R	= RES VALUE FACTOR/SEMCON PWR RATING
B	= LASER BALLAST FACTOR	* LP	= LASER LAMBDA PUMP HOURS FAIL RATE	* RL	= TYPE RELAY LOAD(RES, IND, OR LMP)
BV	= U-W XSTR REVERSE C-E VOLTAGE RATING	* M	= U-W XSTR NETWORK MATCHING FACTOR	* RT	= CAPACITOR RATED TEMPERATURE (C)
C	= COMPLEXITY OR CONSTRUCTION FACTOR	* N	= # ACTIVE CONN PINS OR PWB HOLES	* S	= SYNCHRO OR RESOLVER SIZE FACTOR
C	= LASER COUPLING CLEANLINESS FACTOR	* #B	= SYNCHRO/RESOLVER # BRUSHES FACTOR	* SR	= CSR CAPACITOR SERIES RESISTANCE
CF	= RELAY OR SWITCH CONTACT FORM FACTOR	* #B	= # BITS IN ROM OR RAM INTEG CKT	* S1	= PRIMARY OPERATING STRESS RATIO
CV	= CYR CAPACITOR VALUE FACTOR	* #C	= # ACTIVE PART CONNECTIONS	* S2	= SEMICONDUCTOR REVERSE VOLT FACTOR
CY	= NUMBER OF CYCLES OR MATINGS	* #G	= #GATES IN DIGITAL INTEG CIRCUIT	* T	= U-W XSTR PEAK JUNCTION TEMP(C)
DI	= LASER DISCHARGE CURRENT (MA)	* #T	= # XSTRS IN LINEAR INTEG CIRCUIT	* T	= HYBRID & ETM TEMPERATURE FACTOR
F	= CKT FUNCTION OR FAMILY/QUALITY FACTOR	* O	= LASER GAS OVERFILL FACTOR	* TJ	= INTEG CKT JUNCTION TEMPERATURE(C)
F	= U-W XSTR FREQUENCY/POWER FACTOR	* OP	= ROTARY DEVICE OPERATING TIME(HRS)	* TM	= SEMICOND MAX OPER JUNCTION TEMP (C)
FR	= PART FAILURE RATE (FAIL/MILLION HRS)	* OS	= LASER OPTICAL SURFACES FACTOR	* TP	= POTENTIOMETER TAP CONNECTION FACTOR
IN	= INSERT/INSUL MATERIAL TEMP RATING	* P	= INTEG CIRCUIT PACKAGE FACTOR	* TR	= INDUCT/ROTARY/CONN TEMP RISE (C)
L	= INTEGRATED CIRCUIT LEARNING FACTOR	* P	= LASER BEAM AVER POWER OUTPUT(KW)	* TS	= SEMICOND START OF TEMP DERATING (C)
LB	= LAMBDA BASIC-PART FR LESS FACTORS	* %M	= ROTARY DEVICE % MECH FAILURES	* V	= POTENTIOMETER VOLTAGE FACTOR
LC	= LASER LAMBDA COUPLING FAILURE RATE	* Q	= PART QUALITY LEVEL	* VC	= U-W XSTR OPERATING C-E VOLTAGE

TABLE A.1. Stored Part Data for 217B PREDICT Computer Program (Cont'd)

DORMANT FACTORS: THE FOLLOWING DORMANT FR FACTORS WERE USED AS NOTED HEREIN IN THE ABSENCE OF ESTABLISHED DORMANT FAILURE RATE DATA

ELECT = ESTIMATED DORMANT ELECTRICAL PART FAILURE RATE = 0.10 TIMES THE APPLIED STRESS PART FAILURE RATE
MECH = ESTIMATED DORMANT MECHANICAL PART FAILURE RATE = 0.04 TIMES THE OPERATING PART FAILURE RATE

ENVIRONMENTAL FACTORS: THE FOLLOWING ENVIRONMENTAL FACTORS WERE USED AS NOTED HEREIN. THE EST-1 ENVIRONMENTAL FACTORS REFLECT A TYPICAL MIX OF ELECTRICAL PARTS IN AN AIRBORNE MISSILE AND WERE ONLY USED IN THE ABSENCE OF ESTABLISHED ENVIRONMENTAL DATA.

BEAD = ENVIR FACTORS, THERMISTOR: GB= 1, SF= 1, GF= 5, GM= 25, NS= 14, NU= 19, AI= 12, AU= 16, ML= 57 (SYM PER 217B ENVIR)
DISK = ENVIR FACTORS, THERMISTOR: GB= 1, SF= 1, GF= 5, GM= 25, NS= 14, NU= 19, PI= 12, AU= 15, ML= 55 (SYM PER 217B ENVIR)
EST(1) = ENVIR FACTORS, GEN ELECT : GB= 1, SF= 1, GF= 6, GM= 10, NS= 15, NU= 20, AI= 15, AU= 30, ML= 40 (SYM PER 217B ENVIR)

*** STANDARD PART FAILURE RATE DATA USED ***

PART FR DATA: THE FOLLOWING FAILURE RATE DATA AND SOURCES WERE USED TO CALCULATE THE INDIVIDUAL PART FAILURE RATES FOR THIS PREDICTION UNLESS OTHERWISE NOTED AT THE PART LEVEL IN THE ENCLOSED PART FAILURE RATE PRINTOUT

NOTE: 1. ASTERISK (*) IDENTIFIES THOSE ENTRIES THAT REQUIRE ADDITIONAL DEFINITIVE DISCUSSION IN THE BASIC REPORT.

2. THE PART CODE IS A SEMI-ARBITRARY PART IDENTIFIER USED FOR COMPUTER PROGRAM CONTROL IN PERFORMING THIS PREDICTION.

3. OPER FR SOURCE, ENVIR FACTORS, AND DORM FR SOURCE IDENTIFIES THE DATA SOURCE USED, I.E. THE FAILURE RATE SOURCE OR PART PARAMETER SOURCE PREVIOUSLY NOTED IN THIS SUMMARY, OR DATA EQUIVALENCY TO AN ALTERNATE PART CODE (PC-XXX).

4. DORMANT PART FAILURE RATE IS ESTIMATED BY MULTIPLYING THE APPLIED STRESS OPERATING FAILURE RATE AS DEFINED BELOW TIMES THE DORMANT FR FACTOR. *UNLESS OTHERWISE NOTED, THE DORMANT FAILURE RATE FACTOR IS THE FAILURE RATE FROM THE DORMANT SOURCE FOR A SPECIFIED ENVIRONMENT DIVIDED BY THE APPLIED STRESS PART FAILURE RATE AT THE SAME ENVIR-ONMENT,* WITH THE CONSERVATIVE CONSTRAINT THAT THE DORMANT FR FACTOR SHALL NOT BE GREATER THAN 1.0 NOR LESS THAN 0.001

PART * CODE	PART DESCRIPTION	PART FR EQUIV OR PART DEFINITION	OPER FR SOURCE	ENVIR FACTORS	DORMANT FR FACTOR-SOURCE	APPLIED STRESS PART FR PARAMETERS OR OPERATING PART FR AND ENVIRONMENT	ASSUMED STRESS
101	MONO S/MSI DIG I/C		217B	217B	.100 REDSTN	#G= 20, L = 1.0, Q = 2.0, P = 1.0, #C= 14	
102	MONO S/MSI LIN I/C		217B	217B	.100 PC-101	#T= 32, L = 1.0, Q = 2.0, #C= 10	
103	MONO LSI DIG I/C		217B	217B	.100 PC-101	#G= 100, L = 1.0, Q = 2.0, P = 1.0, #C= 16	
104	MONO ROM INTEG CKT		217B	217B	.100 PC-101	#B=1032, L = 1.0, Q = 2.0, P = 1.0, #C= 16	
105	MONO RAM INTEG CKT		217B	217B	.100 PC-101	#B=1032, L = 1.0, Q = 2.0, P = 1.0, #C= 16	
107	MOS S/MSI DIG I/C		217B	217B	.100 PC-101	#G= 20, L = 1.0, Q = 2.0, P = 1.0, #C= 14	
108	MOS S/MSI LIN I/C		217B	217B	.100 PC-101	#T= 32, L = 1.0, Q = 2.0, #C= 10	
109	MOS LSI DIG I/C		217B	217B	.100 PC-101	#G= 100, L = 1.0, Q = 2.0, P = 1.0, #C= 16	
110	MOS ROM INTEG CKT		217B	217B	.100 PC-101	#B=1032, L = 1.0, Q = 2.0, P = 1.0, #C= 16	
111	MOS RAM INTEG CKT		217B	217B	.100 PC-101	#B=1032, L = 1.0, Q = 2.0, P = 1.0, #C= 16	
113	THK FILM DIG HYB		217B	217B	.100 PC-101	LB= 1.0, Q = 1.0, F = 0.8, #C= 24	
114	THK FILM LIN HYB		217B	217B	.100 PC-101	LB= 1.0, Q = 1.0, F = 1.0, #C= 24	
115	THK FILM HYB, MIX	DIG & LIN CKTS	217B	217B	.100 PC-101	LB= 1.0, Q = 1.0, F = 1.1, #C= 24	
117	THIN FILM DIG HYB		217B	217B	.100 PC-101	LB= 1.0, Q = 1.0, F = 0.8, #C= 24	
118	THIN FILM LIN HYB		217B	217B	.100 PC-101	LB= 1.0, Q = 1.0, F = 1.0, #C= 24	
119	THIN FILM HYB, MIX	DIG & LIN CKTS	217B	217B	.100 PC-101	LB= 1.0, Q = 1.0, F = 1.1, #C= 24	
201	RECEIVER TUBE	TRIODE, TETRODE	217B	217B	.002 REDSTN	LB= 5.0, #C= 8	

TABLE A.1. Stored Part Data for 217B PREDICT Computer Program (Cont'd)

*** STANDARD PART FAILURE RATE DATA USED ***

* PART CODE	PART DESCRIPTION	PART FR EQUIV OR PART DEFINITION	OPER FR SOURCE	ENVIR FACTORS	DORMANT FR FACTOR-SOURCE		APPLIED STRESS PART FR PARAMETERS OR OPERATING PART FR AND ENVIRONMENT	ASSUMED STRESS
202	PWR RECT TUBE		217B	217B	.002	PC-201	LB= 10, #C= 8	
203	LOW PWR KLYSTRON	LOCAL OSCILLATOR	217B	217B	.003	REDSTN	LB= 30, #C= 8	
204	HIGH PWR KLYSTRON	<10 MEGAWATTS	217B	217B	.032	PC-205	LB= 200, #C= 8	
205	MAGNETRON	<10 KILOWATTS	217B	217B	.032	REDSTN	LB= 200, #C= 8	
206	TWT	<100 WATTS	217B	217B	.028	REDSTN	LB= 30, #C= 8	
207	TRIODE XMIT TUBE		217B	217B	.002	PC-201	LB= 75, #C= 8	
208	TETRODE XMIT TUBE	TETRODE & PENTODE	217B	217B	.002	PC-201	LB= 100, #C= 8	
209	CRT		217B	217B	.002	PC-201	LB= 15, #C= 8	
212	LASER, HELIUM/NEON		217B	217B	.040	MECH	LM= 84, LC= 0.1, #C= 6	
213	LASER, ARGON ION		217B	217B	.040	MECH	LM= 457, LC= 6.0, #C= 6	
214	LASER, CO2 SEALED		217B	217B	.040	MECH	DI= 20, LC= 10, O = 1.0, B = 1.0, OS= 2.0 #C= 6	
215	LASER, CO2 FLOWING		217B	217B	.040	MECH	P = 0.1, OS= 2.0, #C= 6	
216	LASER, SS, YAG ROD		217B	217B	.040	MECH	LM= 0.1, LC=16.3, LP=1.6K, C = 30, OS= 2.0 #C= 6	
217	LASER, SS, RUBY RD		217B	217B	.040	MECH	LM=1.0K, LC=16.3, LP=1.6K, C = 30, OS= 2.0 #C= 6	
219	MICROWAVE XSTR, AL	ALUM METALIZATION	217B	217B	.320	PC-220	LB= 0.1, Q = 2.0, A = 1.0, F = 1.0, VC= 6.0 BV= 15, T = 110, M = 1.0, #C= 3	
220	MICROWAVE XSTR, AU	GOLD METALIZATION	217B	217B	.320	REDSTN	LB= 0.1, Q = 2.0, A = 1.0, F = 1.0, VC= 6.0 BV= 15, T = 110, M = 1.0, #C= 3	
301	SI NPN TRANSISTOR		217B	217B	.634	REDSTN	S1= 0.1, S2= 0.3, C = 1.0, A = 0.7, Q = 0.4 R = 1.0, TS= 25, TM= 175, #C= 3	S1= 0.3
302	SI PNP TRANSISTOR		217B	217B	.634	PC-301	S1= 0.1, S2= 0.3, C = 1.0, A = 0.7, Q = 0.4 R = 1.0, TS= 25, TM= 125, #C= 3	S1= 0.3
303	GE NPN TRANSISTOR		217B	217B	.634	PC-301	S1= 0.1, S2= 0.3, C = 1.0, A = 0.7, Q = 0.4 R = 1.0, TS= 25, TM= 100, #C= 3	S1= 0.3
304	GE PNP TRANSISTOR		217B	217B	.634	PC-301	S1= 0.1, S2= 0.3, C = 1.0, A = 0.7, Q = 0.4 R = 1.0, TS= 25, TM= 100, #C= 3	S1= 0.3
305	FIELD EFFECT XSTR		217B	217B	.043	REDSTN	S1= 0.1, C = 1.0, A = 0.7, Q = 0.4, TS= 25 TM= 175, #C= 3	S1= 0.3
306	UNIJUNCTION XSTR		217B	217B	1.000	REDSTN	S1= 0.1, Q = 1.6, TS= 25, TM= 175, #C= 3	S1= 0.3
310	STD SILICON DIODE		217B	217B	.244	REDSTN	S1= 0.1, S2= 0.7, C = 1.0, A = 0.6, Q = 1.0 R = 1.0, TS= 25, TM= 175, #C= 2	S1= 0.3
311	GERMAINIUM DIODE		217B	217B	.244	PC-310	S1= 0.1, S2= 0.7, C = 1.0, A = 0.6, Q = 1.0 R = 1.0, TS= 25, TM= 100, #C= 2	S1= 0.3
312	ZENER DIODE		217B	217B	.176	REDSTN	S1= 0.1, A = 1.0, Q = 1.0, TS= 25, TM= 175 #C= 2	S1= 0.3
313	THYRISTOR/SCR		217B	217B	.634	PC-301	S1= 0.1, Q = 1.0, R = 1.0, TS= 25, TM=125 #C= 2	S1= 0.3
314	VARIACTOR DIODE		217B	217B	.244	PC-310	S1= 0.1, Q = 5.0, TS= 25, TM= 175, #C= 2	S1 0.3
315	STEP RCVY DIODE		217B	217B	.244	PC-310	S1= 0.1, Q = 5.0, TS= 25, TM= 175, #C= 2	S1= 0.3
316	TUNNEL DIODE		217B	217B	.244	PC-310	S1= 0.1, Q = 5.0, TS= 25, TM= 175, #C= 2	S1= 0.3
317	SI RF DETECT DIODE		217B	217B	.320	PC-220	S1= 0.1, Q = 3.5, TS= 25, TM= 150, #C= 2	S1= 0.3

TABLE A.1. Stored Part Data for 217B PREDICT Computer Program (Cont'd)

*** STANDARD PART FAILURE RATE DATA USED ***

PART CODE	PART DESCRIPTION	PART FR EQUIV OR PART DEFINITION	OPER FR SOURCE	ENVIR FACTORS	DORMANT FR FACTOR	SOURCE	APPLIED STRESS PART FR PARAMETERS OR OPERATING PART FR AND ENVIRONMENT	ASSUMED STRESS
318	SI RF MIXER DIODE		217B	217B	.320	PC-220	S1= 0.1, Q = 3.5, TS= 25, TM= 150, #C= 2	S1= 0.3
319	GE RF DETECT DIODE		217B	217B	.320	PC-220	S1= 0.1, Q = 3.5, TS= 25, TM= 70, #C= 2	S1= 0.3
320	GE RF MIXER DIODE		217B	217B	.320	PC-207	S1= 0.1, Q = 3.5, TS= 25, TM= 70, #C= 2	S1= 0.3
401	ACCURATE W/W RES	RBR STYLE RESISTOR	217B	217B	.012	REDSTN	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
402	CARBON COMP RES	RCR STYLE RESISTOR	217B	217B	.028	REDSTN	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
403	PWR FILM RESISTOR	RD STYLE RESISTOR	217B	217B	1.600	REDSTN	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
404	W/W CHS POWER RES	RER STYLE RESISTOR	217B	217B	.012	PC-401	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
405	INSUL FILM RES	RLR STYLE RESISTOR	217B	217B	.004	REDSTN	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
406	HIGH STAB FILM RES	RNR STYLE RESISTOR	217B	217B	.004	PC-405	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
407	W/W POWER RESISTOR	RWR STYLE RESISTOR	217B	217B	.012	PC-401	S1= 0.1, R = 1.0, Q = 1.0, #C= 2	S1= 0.1
409	LOW TEMP W/W POT	RA STYLE POT	217B	217B	.052	REDSTN	S1= 0.1, R = 1.0, Q = 2.0, V = 1.0, TP= 1.0 #C= 3	S1= 0.1
410	SEMI-PRCN W/W POT	RK STYLE POT	217B	217B	.052	REDSTN	S1= 0.1, R = 1.0, Q = 2.0, V = 1.0, TP= 1.0 #C= 3	S1= 0.1
411	NON-W/W POT	RJR STYLE POT	217B	217B	.032	REDSTN	S1= 0.1, R = 1.0, Q = 1.0, V = 1.0, TP= 1.0 #C= 3	S1= 0.1
412	POWER W/W POT	RP STYLE POT	217B	217B	.016	PC-413	S1= 0.1, R = 1.0, Q = 2.0, V = 1.0, TP= 1.0 C = 1.0, #C= 3	S1= 0.1
413	PRECISION W/W POT	RR STYLE POT	217B	217B	.016	REDSTN	S1= 0.1, R = 1.0, Q = 2.5, V = 1.0, TP= 1.0 C = 1.0, #C= 1.0	S1= 0.1
414	W/W TRIMMER POT	RTR STYLE POT	217B	217B	.008	REDSTN	S1= 0.1, R = 1.0, Q = 1.0, V = 1.0, #C= 3	S1= 0.1
415	COMPOSITION POT	RV STYLE POT	217B	217B	.514	REDSTN	S1= 0.1, R = 1.0, Q = 2.5, V = 1.0, TP= 1.0 #C= 3	S1= 0.1
417	BEAD THERMISTOR	RTH24 STYLE	217B	BEAD	.086	PC-418	LB=.021 #C= 2	
418	DISK THERMISTOR	RTH6 STYLE	217B	DISK	.086	REDSTN	LB=.065 #C= 2	
501	BUTTON MICA CAP	CB STYLE CAPACITOR	217B	217B	.283	REDSTN	S1= 0.1, Q = 5.0, #C= 2	S1= 0.3
502	TEMP COMP CERM CAP	CC STYLE CAPACITOR	217B	217B	.071	RADC2	S1= 0.1, Q = 5.0, #C= 2	S1= 0.3
503	ALUM ELECTRO CAP	CE STYLE CAPACITOR	217B	217B	.988	RADC2	S1= 0.1, Q = 3.0, #C= 2	S1= 0.3
504	MTLC PPR/PLSTC CAP	CHR STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, RT= 125, Q = 1.0, TR= 0.0, #C= 2	S1= 0.3
505	CERAMIC CAPACITOR	CKR STYLE CAP	217B	217B	.159	REDSTN	S1= 0.1, RT= 125, Q = 1.0, #C= 2	S1= 0.3
506	NONSOLID TANTA CAP	CLR STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, Q = 1.0, #C= 2	S1= 0.3
507	MICA CAPACITOR	CMR STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, Q = 1.0, #C= 2	S1= 0.3
508	PAPER/PLASTIC CAP	CPV STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, RT= 125, Q = 1.0, TR= 0.0, #C= 2	S1= 0.3
509	PLASTIC CAPACITOR	CQR STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, RT= 125, Q = 1.0, TR= 0.0, #C= 2	S1= 0.3
510	SOLID TANTALUM CAP	CSR STYLE CAP	217B	217B	1.000	REDSTN	S1= 0.1, Q = 0.3, SR=0.07, #C= 2	S1= 0.3
512	ALUM-OXIDE CAP	CU STYLE CAPACITOR	217B	217B	.103	REDSTN	S1= 0.1, Q = 3.0, #C= 2	S1= 0.3
513	VARI-CERAMIC CAP	CV STYLE CAPACITOR	217B	217B	.297	REDSTN	S1= 0.1, Q = 4.0, #C= 2	S1= 0.3
514	GLASS CAPACITOR	CYR STYLE CAP	217B	217B	.400	REDSTN	S1= 0.1, Q = 1.0, CV= 1.0, #C= 2	S1= 0.3
516	VARI-PISTON CAP	PC STYLE CAPACITOR	217B	217B	.297	PC-513	S1= 0.1, Q = 3.0, #C= 2	S1= 0.3
601	LOW PWR PULSE XFMR	MIL-T-21038 STYLE	217B	217B	.500	MANUAL	F = 1.5, IN= 130, TR= 5.0, #C= 5	
602	PULSE TRANSFORMER	MIL-T-27 STYLE	217B	217B	.500	MANUAL	F = 1.5, IN= 130, TR= 30, #C= 5	
603	AUDIO TRANSFORMER	MIL-T-27 STYLE	217B	217B	.500	MANUAL	F = 3.0, IN= 130, TR= 30, #C= 5	

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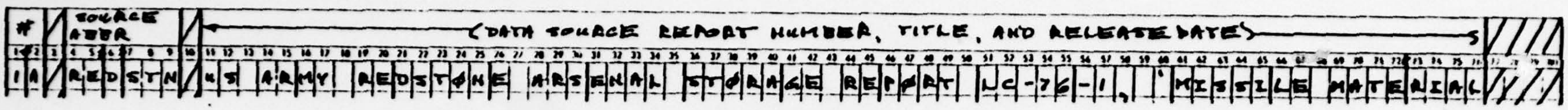
TABLE A.1. Stored Part Data for 217B PREDICT Computer Program (Cont'd)

*** STANDARD PART FAILURE RATE DATA USED ***

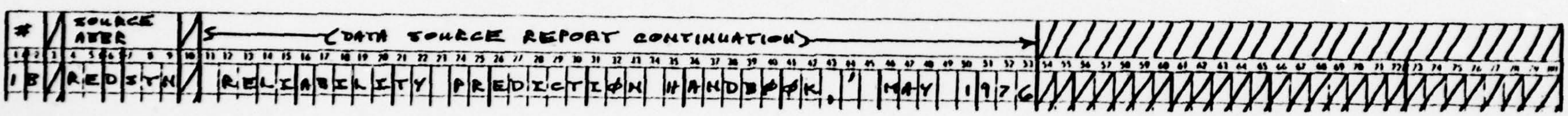
* PART CODE	PART DESCRIPTION	PART FR EQUIV OR PART DEFINITION	OPER FR SOURCE	ENVIR FACTORS	DORMANT FR FACTOR-SOURCE	APPLIED STRESS PART FR PARAMETERS OR OPERATING PART FR AND ENVIRONMENT	ASSUMED STRESS
604	POWER TRANSFORMER	MIL-T-27 STYLE	217B	217B	.500 MANUAL	F = 8.0, IN= 130, TR= 30, #C= 10	
605	RF TRANSFORMER	MIL-C-15305 STYLE	217B	217B	.500 MANUAL	F = 12, IN= 130, TR= 30, #C= 5	
607	PULSE INDUCTOR	MIL-T-27 STYLE	217B	217B	.500 MANUAL	F = 1.5, IN= 130, TR= 5.0, #C= 2	
608	AUDIO INDUCTOR	MIL-T-27 STYLE	217B	217B	.500 MANUAL	F = 3.0, IN= 130, TR= 5.0, #C= 2	
609	POWER INDUCTOR	MIL-T-27 STYLE	217B	217B	.500 MANUAL	F = 8.0, IN= 130, TR= 5.0, #C= 2	
610	RF INDUCTOR	MIL-C-15305 STYLE	217B	217B	.500 MANUAL	F = 12, IN= 130, TR= 5.0, #C= 2	
612	AC BRUSHLESS MOTOR		217B	217B	1.000 MANUAL	F = 5.0, IN= 130, TR= 50, XM= 0.5, OP= 2K #C= 5	
613	COMMUTATOR MOTOR		217B	217B	1.000 MANUAL	F = 24, IN= 130, TR= 50, XM= 0.5, OP= 2K #C= 5	
615	FAN/BLOWER	217B FIXED LIFE	217B	217B	1.000 MANUAL	OPER FR, GF ENV = 2.04600	
616	SYNCHRO		217B	217B	.500 MANUAL	S = 2.0, #B= 4.0, TR= 40, Q = LQ, #C= 5	
617	RESOLVER		217B	217B	.500 MANUAL	S = 3.0, #B= 4.0, TR= 40, Q = LQ, #C= 5	
619	ELAPSED TIME METER	AC TYPE	217B	217B	.500 MANUAL	LB= 20, T = 0.5, Q = LQ, #C= 2	
701	PWB CONNECTOR	1/2 MATED PAIR	217B	217B	.040 MANUAL	IN= B, Q = MS, N = 10, TR= 0.0, CY= 0.0 #C= N/A	
702	RACK & PANEL CONN	1/2 MATED PAIR	217B	217B	.040 MANUAL	IN= B, Q = MS, N = 20, TR= 0.0, CY= 0.0 #C= N/A	
703	CABLE CONNECTOR	1/2 MATED PAIR	217B	217B	.040 MANUAL	IN= B, Q = MS, N = 30, TR= 0.0, CY= 0.0 #C= N/A	
704	COAXIAL CONNECTOR	1/2 MATED PAIR	217B	217B	.040 MANUAL	IN= C, Q = MS, N = 2.0, TR= 0.0, CY= 0.0 #C= N/A	
707	RELAY, 85C RATING		217B	217B	.040 MANUAL	S1= 0.1, CF= 3.0, CY= 1.0, F = 5.0, RL=RES Q = MS, #C= 8	
708	RELAY, 125C RATING		217B	217B	.040 MANUAL	S1= 0.1, CF= 3.0, CY= 1.0, F = 5.0, RL=RES Q = MS, #C= 8	
711	TOGGLE SWITCH	SNAP-ACTION	217B	217B	1.000 MANUAL	LB= .01, CF= 1.0, CY= 1.0, #C= 8	
712	PUSHBUTTON SWITCH	SNAP-ACTION	217B	217B	1.000 MANUAL	LB=0.01, CF= 1.0, CY= 1.0, #C= 8	
713	SENSITIVE SWITCH	2 ACTIVE POLES	217B	217B	1.000 MANUAL	LB=.407, CY= 1.0, #C= 8	
714	ROTARY SWITCH	2 CERAMIC WAFERS	217B	217B	1.000 MANUAL	LB=.404, CY= 1.0, #C= 8	
901	TWO-SIDED PW BOARD		217B	217B	.040 MANUAL	N = 100	
902	MULTILAYER PW BD		217B	217B	.040 MANUAL	N = 100	
903	PWB WAVE SOLDER		217B	PC-701	.040 MANUAL	OPER FR, GF ENV = .00044	
904	HAND SOLDER		217B	PC-701	.040 MANUAL	OPER FR, GF ENV = .00390	
905	REFLOW LAP SOLDER		217B	PC-701	.040 MANUAL	OPER FR, GF ENV = .00012	
906	PART CONNECTIONS	PWB WAVE SOLDER	PC-903	PC-903	.040 PC-903	OPER FR, GF ENV = .00044	
920	PART TO BE DEFINED				.000		

TABLE A.2. Supplemental Data Card Definitions

a. CARD 1A. Add Data Source Reference to Summary Printout (Not Mandatory).



COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1-2	Enter "1A." Card 1A documents additional references used in performing the reliability prediction (limit of 0 to 9 Card 1A entries).
4-9	Arbitrary Data Source Abbreviation used to reference the data source used for the Card 2A and 2C part parameter inputs.
11-76	Data Source Report Number, Title, and Release Date.

b. CARD 1B. Data Source Continuation Card (Not Mandatory).

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1-2	Enter "1B." Card 1B provides continuation of Card 1A data (limit of 0 to 1 Card 1B entries for each Card 1A entry).
4-9	Card 1A Data Source Abbreviation
11-53	Continuation of Card 1A documentation.

AD-A073 833 SYSTEMS CONSULTANTS INC RIDGECREST CALIF F/G 9/2
217B PREDICT, SYSTEM RELIABILITY PREDICTION COMPUTER PROGRAM. V--ETC(U)
MAR 77 N00123-73-C-0243
UNCLASSIFIED GIDEP-E071-0295 NL

2 OF 2
AD A073833

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

TABLE A.2. Supplemental Data Card Definitions (Continued)

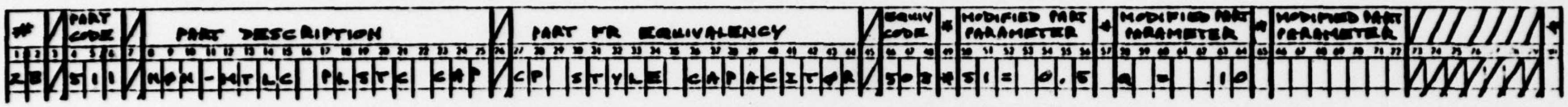
c. CARD 2A. Add Environmental Factors to Stored Part Data (not mandatory).

#	SOURCE ABBR	BRIEF DESCRIPTION	GB ENVIR FACTOR	SF ENVIR FACTOR	GF ENVIR FACTOR	GM ENVIR FACTOR	NS ENVIR FACTOR	NU ENVIR FACTOR	AI ENVIR FACTOR	AU ENVIR FACTOR	ML ENVIR FACTOR
2A	MANUAL	GEN ELECT	GB= 1	SF= 1	GF= 6	GM= 10	NS= 15	NU= 20	AI= 15	AU= 30	ML= 40

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1-2	Enter "2A." Card 2A defines additional environmental factors to be used for operating and dormant failure rate data as defined by the user on Card 2C (limit of 0 to 9 Card 2A entries).
4-9	Data Source Abbreviation as defined on Card 1A and as modified herein to specifically define the environmental factors for computer program control.
11-20	The user may include a brief description. This description will be added to the "ENVIR FACTORS" printout from the computer, e.g., ENVIR FACTORS, GEN ELECT.
22-24	Enter the MIL-HDBK-217B environmental symbol and equal sign for the summary printout, i.e., GF =.
25-26 (typical)	Enter the environmental factor to be used, e.g., 1 or 1.0 (right hand justified). Data defaults to zero for the program and to blank for the printout in the absence of an entry.

TABLE A.2. Supplemental Data Card Definitions (Continued)

d. CARD 2B. Modify or Equate to Stored Part Data (not mandatory).



COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1-2	Enter "2B." Used to modify stored part failure rate parameters or to use the stored data as a failure rate equivalency to a new part. This card can be used in conjunction with Card 2C, but must always precede same (number of Card 2B entries is not limited).
4-6	Enter 3 digit part code in accordance with Table B.1 for computer control.
8-25	Enter part type description for part level printout and summary printout.
27-44	Enter failure rate equivalency or additional part information (not mandatory).
46-48	Enter preassigned part code failure rate equivalency (not mandatory).
49 (typical)	Enter "*" if the following part parameter data is to modify the assumed value for S1.
50-51 (typical)	Enter the data symbol for the part parameter to be modified as defined in Table B.
52 (typical)	Enter "=" for summary printout.
53-56 (typical)	Enter new part parameter data to be used for the prediction.
80	Enter "*" if additional discussion of part is provided in the basic report.

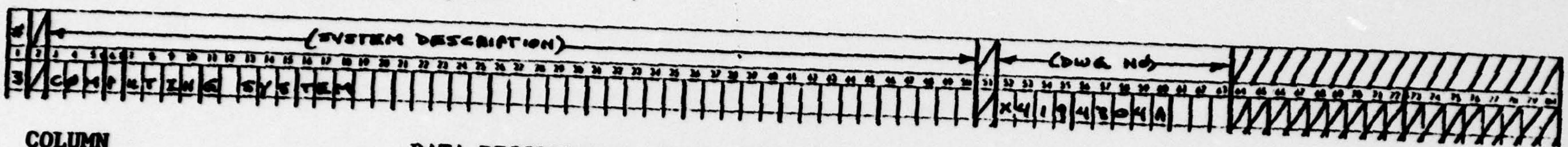
TABLE A.2. Supplemental Data Card Definitions (Continued)

e. CARD 2C. Supplement or Equate to Stored Part Data (not mandatory).

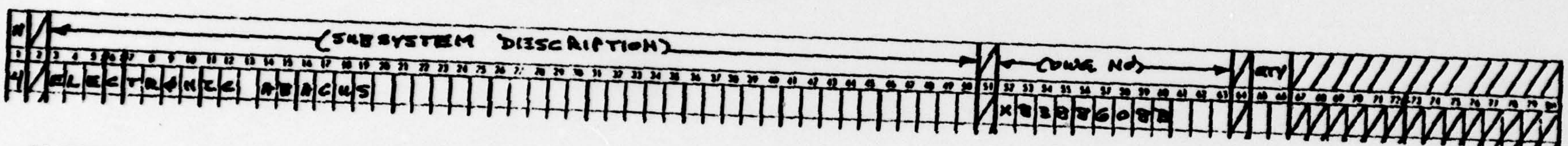
#	PART CODE	PART DESCRIPTION	OPER FR SOURCE	OPERATING FAIL. RATE	π_E SYM	ENVIR FACTORS	DORM DATA SOURCE	DORMANT FAIL. RATE	π_E SYM	DORM FR FACTOR		*
1 2	4 5 6	8–25	27–32	34–39	41 42	44–49	51–56	58–63	65 66	68–72	73–79	80
2C	801	ELECTROMECH TIMER	RADC1	42.887	GF	ENV-1	ELECT			0.04		

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1-2	Enter "2C." Used to supplement or equate to the Stored Part Data. This card can be used in conjunction with Card 2B, but must always follow same (number of Card 2C entries is not limited).
4-6	Enter 3 digit part code in accordance with Table A.1 for computer control.
8-25	Enter part type description for part level printout and summary printout.
27-32	Enter operating failure rate Data Source Abbreviation as defined in Table A.1 or as defined on Card A1 for summary printout.
34-39	Enter operating failure rate as defined in data source (in $f/10^6$ hours).
41-42	Enter equivalent MIL-HDBK-217B environmental symbol for above failure rate.
44-49	Define environmental factors to be used in terms of the Data Source Abbreviation as defined in Table A.1 or on Card 2A. Enter PC-XXX if stored factors for equivalent part are to be used, where XXX equals the 3 digit part code for the equivalent part.
51-56	Must enter Data Source Abbreviation for the dormant failure rate or failure rate factor as defined in Table A.1 or on Card 1A. Enter PC-XXX if stored factor for equivalent part is to be used, where XXX equals the 3 digit part code for the equivalent part.
58-63	Enter dormant failure rate as defined in data source (in $f/10^6$ hours) if the computer program is to calculate the failure rate factor.
65-66	Enter equivalent MIL-HDBK-217B environmental symbol for above failure rate.
68-72	If the dormant failure rate factor is predefined enter same. If the derivation of the factor requires additional explanation, it is the responsibility of the user to provide same in the report.
80	Enter "*" if additional discusssion of part is provided in the basic report.

TABLE A.3. System Control Card Definitions

a. CARD 3. System Description

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1	Enter "3." Card 3 identifies and documents the user's "system" (number of Card 3 entries is not limited).
3-50	Enter a definitive description of the "system."
52-63	Enter the assembly/fabrication drawing number and revision.

b. CARD 4. Subsystem Description (not mandatory).



COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1.	Enter "4." Card 4 identifies and documents each "subsystem" in the "system." The subsystem description data will default to the system description data in the absence of Card 4 (number of Card 4 entries is not limited).
3-50	Enter a definitive description of the subsystem.
52-63	Enter the assembly/fabrication drawing number and revision.
65-66	Enter the number of duplicate subsystems, defaults to 1.0 in the absence of an entry (right hand justified).

TABLE A.3. System Control Card Definitions (Continued)

c. CARD 5A. Environmental Stress Conditions for Detailed FR Subroutine

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1-2	Enter "5A.". Can submit one 5A Card per subsystem data deck.
4	Define the subsystem failure rate data set to be used for the part ranking in the Detailed Failure Rate Summary, e.g., 2 = FR TYPE2, π_E SYM2, and TEMP2.
6-12 (typical)	Define the Type of Failure Rate Data (APPLIED, ASSUMED, or DORMANT).
14-15 (typical)	Define the equivalent MIL-HDBK-217B environmental symbol.
17-19 (typical)	Define the ambient temperature for the subsystem in degrees Celsius (right hand justified).

TABLE A.3. System Control Card Definitions (Continued)

d. CARD 5B. Environmental Stress Conditions for Condensed FR Subroutine

#	#	FR TYPE 4	π_E SYM	TEMP 4	FR TYPE 5	π_E SYM	TEMP 5	FR TYPE 6	π_E SYM	TEMP 6	FR TYPE 7	π_E SYM	TEMP 7	FR TYPE 8	π_E SYM	TEMP 8
1–2	4	6–12	14–15	17–19	21–27	29–30	32–34	36–42	44–45	47–49	51–57	59–60	62–64	66–72	74–75	77–79
5B	3	DORMANT	GB	40	DORMANT	GM	50	ASSUMED	GF	50						

COLUMN | DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1–2	Enter "5B." Can submit one 5B Card per subsystem data deck. Given a 5A and 5B Card are submitted, a second 5B Card can be entered at the end of the subsystem part data to define an additional five failure rate data sets, i.e., prior to the next 3, 4, or 8 Card in the data deck.
4	Define the subsystem failure rate data set to be used for the part ranking in the Condensed Failure Rate Summary, e.g., 5 = FR TYPE5, π_E SYM5, and TEMP5.
6–12 (typical)	Define the Type of Failure Rate Data (APPLIED, ASSUMED, or DORMANT).
14–15 (typical)	Define the equivalent MIL-HDBK-217B environmental symbol.
17–19 (typical)	Define the ambient temperature for the subsystem in degrees Celsius (right hand justified).

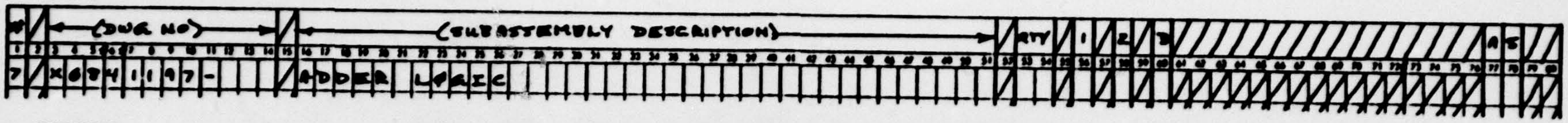
TABLE A.4. Assembly/Subassembly Data Card Definitions

a. CARD 6. Assembly Description

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1	Enter "6." Defines each "assembly" in the users "subsystem/subsystem" (number of Card 6 entries is not limited).
3-14	Enter the assembly/fabrication drawing number and revision.
16-51	Enter a definitive description of the assembly.
53-54	Enter number of duplicate assemblies, defaults to 1.0 if blank (right hand justified).
56 (typical)	Define the Type of Failure Rate Data for the assemby if different than definition on Cards 5A or 5B. Enter P = APPLIED, S = ASSUMED, Ø = DORMANT. (Note: Computer program will not accept zero as an input), or N = Not Applicable (sets all assembly failure rates to zero). This provides the capability to change the type of Failure Rate Data for the detailed failure rate data set 1 to 3 or for the condensed failure rate data set 4 to 8. However, it should be noted that changing data set 4 to 8 will affect the first and second 5B Card (if submitted).
77	Alphabetical or numerical code for manual assembly sorting (not mandatory).

TABLE A.4. Assembly/Subassembly Data Card Definitions (Continued)

b. CARD 7. Subassembly Description (not mandatory)



COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1	Enter "7." Defines each "subassembly" in the users "assembly" (number of Card 7 entries is not limited).
3-14	Enter the assembly/fabrication drawing number and revision.
16-51	Enter a definitive description of the subassembly.
53-54	Enter number of duplicate subassemblies, defaults to 1.0 if blank (right hand justified).
56 (typical)	Define the Type of Failure Rate Data for the subassembly if different than the definition on Card 5A. Enter P = APPLIED, S = ASSUMED, Ø = DORMANT. (Note: Computer program will not accept zero as an input), or N = Not Applicable (sets all subassembly failure rates to zero).
77	Alphabetical or numerical code for manual assembly sorting (not mandatory).
78	Alphabetical or numerical code for manual subassembly sorting (not mandatory).

TABLE A.4. Assembly/Subassembly Data Card Definitions (Continued)

c. Detailed Part Data Card (Detailed FR Subroutine Only)

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
2-7	Enter assembly/fabrication drawing part reference designator (number of Detailed Part Data Card entries is not limited).
9-31	Enter assembly/fabrication drawing part number, plus any additional descriptive data as appropriate for interpreting the part number.
33-35	Enter part quantity, defaults to 1.0 if blank (right hand justified).
37-39	Enter 3 digit part code as modified by user for computer control.
41 (typical)	Limits modified part parameter to 1 of the 3 failure rate data sets on Card 5A, e.g., 2 = change applicable to failure rate data set 2 only. Data applies to all three failure rate data sets if blank. If entries with same parameter symbol are used, enter blank first.
42-43 (typical)	Enter the data symbol for the part parameter to be modified as defined in Table A.1. Enter "FR" if the Type of Failure Rate Data for the part is affected.
44 (typical)	Enter "=" for part level printout.
45-48 (typical)	Enter new part parameter value to be used (right hand justified). If Type of Failure Rate Data for part differs from the assembly definitions, then enter OPER = applied data, DORM = dormant data, or N/A = not applicable (sets part failure rate to zero).
77	Alphabetical or numerical code for manual assembly sorting (not mandatory).
78	Alphabetical or numerical code for manual subassembly sorting (not mandatory).
80	Enter "*" if next card is Detailed Part Data Continuation Card.

TABLE A.4. Assembly/Subassembly Data Card Definitions (Continued)

d. Detailed Part Data Continuation Card (not mandatory)

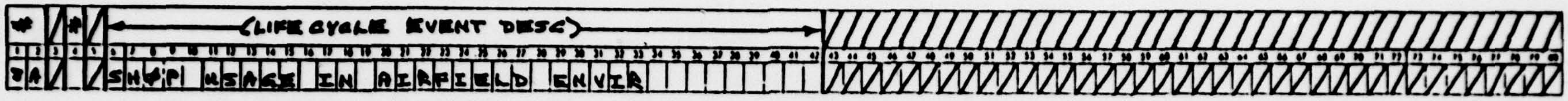
COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
2-7	Enter assembly/fabrication drawing part reference designator (limit of 0 to 1 Continuation Cards for each Detailed Part Data Card).
9 (typical)	Limits modified part parameter to 1 of 3 sets of environmental stress conditions, i.e, 1 = FR TYPE1, 2 = FR TYPE2, or 3 = FR TYPE3.
10-11 (typical)	Enter the data symbol for the part parameter to be modified as defined in Table A.1. Enter "FR" if the Type of Failure Rate Data for the part is affected.
12 (typical)	Enter "=" for part level printout.
13-16 (typical)	Enter new part parameter value to be used (right hand justified). Can enter OPER, DORM, or N/A if Type of Failure Rate Data is affected.
77	Alphabetical or numerical code for manual assembly sorting (not mandatory).
78	Alphabetical or numerical code for manual subassembly sorting (not mandatory).

e. Condensed Part Data Card (Condensed FR Subroutine Only)

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
2-4 (typical)	Enter 3 digit part code as modified by user for computer control (number of Condensed Part Data Card entries is not limited).
6-8 (typical)	Enter part quantity, defaults to 1.0 if blank (right hand justified).
77	Alphabetical or numerical code for manual assembly sorting (not mandatory).

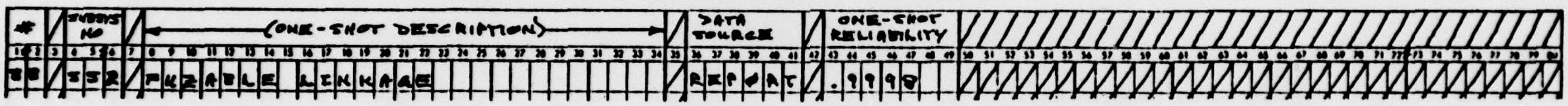
TABLE A.5. Reliability Summary Card Definitions

a. CARD 8A. Life Cycle Event Description (not mandatory, Absence of 8A Card will inhibit the reliability summary in the printout).



COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1-2	Enter "8A." Defines the life cycle event(s) for the printout (number of Card 8A entries is not limited).
4	The system summary of the subsystem data is inhibited if a "*" is entered.
6-42	Enter a definitive description of the life cycle events(s).

b. CARD 8B. One-shot Description and Reliability (not mandatory)



COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1-2	Enter "8B." Provide individual one-shot data (number of Card 8B entries is not limited).
4-6	Define the applicable subsystem using "SSn" format, where "n" reflects the order that the subsystem 4 Cards are submitted in the data deck, e.g., the first subsystem Card 4 would be "SS1." If the one-shot is applicable to the system Card 3 enter "SYS."
8-34	Enter a definitive description for the one-shot.
36-41	Define the Data Source wherein the one-shot reliability is derived. If the derivation is submitted in the basic report enter REPORT.
43-49	Enter the one-shot reliability.

TABLE A.5. Reliability Summary Card Definitions (Continued)

c. CARD 8C. Failure Rate Data for the Life Cycle Event

COLUMN	DATA DESCRIPTION (DATA LEFT HAND JUSTIFIED UNLESS OTHERWISE NOTED)
1-2	Enter "8C." Define the failure rate data for the life cycle event (limit of 1 to 2 Card 8C data sets for each Card 8A entry).
4-6 (typical)	Define the applicable subsystem using the "SSn" format, where "n" reflects the order that the subsystem 4 Cards are submitted in the data deck, e.g., the first subsystem Card 4 would be "SS1." The end of the applicable subsystem failure rate data must be noted by entering "SYS."
8-9 (typical)	Define the subsystem failure rate data set to be used as defined on the 5A and 5B Cards, e.g., 5 = FR TYPE5, π_E SYM5, and TEMP5 (right hand justified). If a second 5B Card is submitted, define the second set of 5B failure rate data sets as 9 through 13.
11 (typical)	Enter "*" if one-shot reliability data as defined on Card 8B is to be included in the printout for the subsystem.
13-16 (typical)	Enter the absolute value for the duration, e.g., 1 or 1.0 (right hand justified). Duration data defaults to last Card 8C entry for the life cycle event if blank.
18-20 (typical)	Enter the units for the duration as SEC, MIN, HRS, DAY, WKS, MON, or YRS.

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APPENDIX B

OUTLINE OF PART CODES
AND
CODING FORMS

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TABLE B.1. OUTLINE OF 217B PREDICT PART CODES

PART CODE	GENERAL PART TYPE	PART CODE	GENERAL PART TYPE	PART CODE	GENERAL PART TYPE
101	MONO S/MSI DIG I/C	401	RBR STYLE RESISTOR	701	PWB CONNECTOR
102	MONO S/MSI LIN I/C	402	RCR STYLE RESISTOR	702	RACK AND PANEL CONN
103	MONO LSI DIG I/C	403	RD STYLE RESISTOR	703	CABLE CONNECTOR
104	MONO ROM INTEG CKT	404	RER STYLE RESISTOR	704	COAXIAL CONNECTOR
105	MONO RAM INTEG CKT	405	RLR STYLE RESISTOR	705	
106		406	RNR STYLE RESISTOR	706	
107	MOS S/MSI DIG I/C	407	RWR STYLE RESISTOR	707	RELAY, 85C RATING
108	MOS S/MSI LIN I/C	408		708	RELAY, 125C RATING
109	MOS LSI DIG I/C	409	RA STYLE POT	709	
110	MOS ROM INTEG CKT	410	RK STYLE POT	710	
111	MOS RAM INTEG CKT	411	RJR STYLE POT	711	TOGGLE SWITCH
112		412	RP STYLE POT	712	PUSHBUTTON SWITCH
113	THK FILM DIG HYBRID	413	RR STYLE POT	713	SENSITIVE SWITCH
114	THK FILM LIN HYBRID	414	RTR STYLE POT	714	ROTARY SWITCH
115	THK FILM HYBRID, MIX	415	RV STYLE POT	715	
116		416		716	
117	THIN FILM DIG HYBIRD	417	BEAD THERMISTOR	717	
118	THIN FILM LIN HYBRID	418	DISK THERMISTOR	718	
119	THIN FILM HYBRID, MIX	419		719	
120		420		720	
201	RECEIVER TUBE	501	CB STYLE CAPACITOR	801	
202	PWR RECT TUBE	502	CC STYLE CAPACITOR	802	
203	LOW PWR KLYSTRON	503	CE STYLE CAPACITOR	803	
204	HIGH PWR KLYSTRON	504	CHR STYLE CAPACITOR	804	
205	MAGNETRON	505	CKR STYLE CAPACITOR	805	
206	TWT	506	CLR STYLE CAPACITOR	806	
207	TRIODE XMIT TUBE	507	CMR STYLE CAPACITOR	807	
208	TETRODE XMIT TUBE	508	CPV STYLE CAPACITOR	808	
209	CRT	509	CQR STYLE CAPACITOR	809	
210		510	CSR STYLE CAPACITOR	810	
211		511		811	
212	LASER, HELIUM/NEON	512	CU STYLE CAPACITOR	812	
213	LASER, ARGON ION	513	CV STYLE CAPACITOR	813	
214	LASER, CO2 SEALED	514	CYR STYLE CAPACITOR	814	
215	LASER, CO2 FLOWING	515		815	
216	LASER, SS, YAG ROD	516	PC STYLE CAPACITOR	816	
217	LASER, SS, RUBY ROD	517		817	
218		518		818	
219	ALUM BOND RF POWER XSTR	519		819	
220	GOLD BOND RF POWER XSTR	520		820	
301	SI NPN TRANSISTOR	601	LOW PWR PULSE XFMR	901	TWO-SIDED PW BOARD
302	SI PNP TRANSISTOR	602	PULSE TRANSFORMER	902	MULTILAYER PW BOARD
303	GE NPN TRANSISTOR	603	AUDIO TRANSFORMER	903	PWB WAVE SOLDER
304	GE PNP TRANSISTOR	604	POWER TRANSFORMER	904	HAND SOLDER
305	FIELD EFFECT XSTR	605	RF TRANSFORMER	905	REFLOW LAP SOLDER
306	UNIJUNCTION XSTR	606		906	PART CONN PER PROG
307		607	PULSE INDUCTOR	907	
308		608	AUDIO INDUCTOR	908	
309		609	POWER INDUCTOR	909	
310	STD SILICON DIODE	610	RF INDUCTOR	910	
311	GERMAINIUM DIODE	611		911	
312	ZENER DIODE	612	AC BRUSHLESS MOTOR	912	
313	THYRISTOR/SCR	613	COMMUTATOR MOTOR	913	
314	VARIACTOR DIODE	614		914	
315	STEP RCVY DIODE	615	FAN/BLOWER	915	
316	TUNNEL DIODE	616	SYNCHRO	916	
317	SI RF DETECT DIODE	617	RESOLVER	917	
318	SI RF MIXER DIODE	618		918	
319	GE RF DETECT DIODE	619	ELAPSED TIME METER	919	
320	GE RF MIXER DIODE	620		920	PART TO BE DEFINED

NOTE: * THE 900 SERIES PART TYPES ARE NOT INCLUDED IN THE SYSTEM PARTS COUNT

TABLE B.2. OUTLINE OF UNIVAC 1110 CONTROL CARDS *

RUN CARD WITH USER IDENTIFICATION DATA AND ASSIGN 217B PREDICT PROGRAM CARD

```
@RUN/(PROG NO).(10 DIGIT JO. NO.) 90.NWC CODE (PROG DESC) ,  ,   (NO. OUTPUT PGS = 200 IF BLANK)
                                                            (RUN TIME = 2 MINUTES IF BLANK)
@ASG,AX 3600297*217B
```

ASSIGN ADDITIONAL STORAGE TAPES

```
@ASG,T  8.
@ASG,T  1.
@ASG,T  3.
@ASG,T  2.,F2///1000
@ASG,T 13.,F2///500
```

ASSURES ADEQUATE COMPUTER STORAGE FOR:
1. SUMMARY OF SUBSYSTEM DATA
2. RELIABILITY SUMMARY
3. ASSEMBLY/SUBASSEMBLY DATA
4. PART CODE VERSUS QUANTITY
5. ERROR STATEMENTS

EXECUTE PROGRAM CARD (WITH 217B PREDICT DATA DECK)

```
@XQT 3600297*217B.PREDICT
         (ADD 217B PREDICT DATA DECK)
```

END OF PROGRAM CARDS (ROLL OUT PROGRAM TO MINIMIZE STORAGE COST)

```
@NWC UTILITY RØLØUT 3600297*217B.
@FIN
```

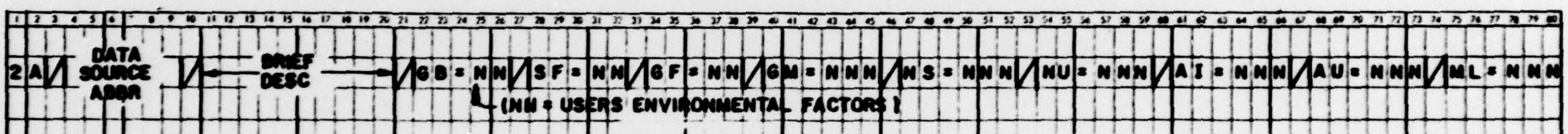
* THIS PAGE ILLUSTRATES THE CONTROL CARDS REQUIRED TO EXECUTE THE 217B PREDICT PROGRAM ON THE UNIVAC 1110 COMPUTER AT THE NAVAL WEAPONS CENTER, CHINA LAKE, CALIFORNIA. THE REQUIRED CONTROL CARDS WILL VARY WITH THE TYPE OF COMPUTER AND THE INSTALLATION PECULIARITIES.

TABLE B.3. OUTLINE OF SUPPLEMENTAL DATA CARDS

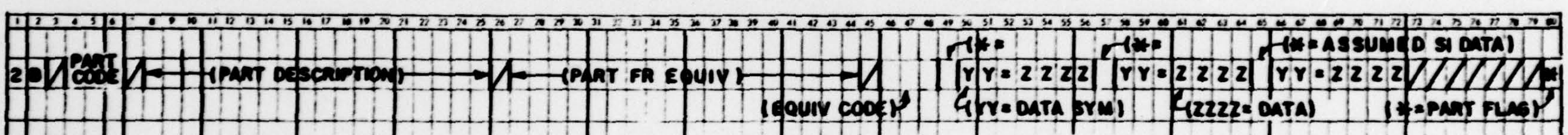
CARD 1A: ADD DATA SOURCE REFERENCE FOR RELIABILITY SUMMARY PRINTOUT (NOT MANDATORY)

CARD 1B: DATA SOURCE CONTINUATION CARD (NOT MANDATORY)

CARD 2A: ADD ENVIRONMENTAL FACTORS TO STORED PART DATA (NOT MANDATORY)



CARD 2B: MODIFY OR EQUATE TO STORED PART DATA (NOT MANDATORY)



CARD 2C: SUPPLEMENT OR EQUATE TO STORED PART DATA (NOT MANDATORY)

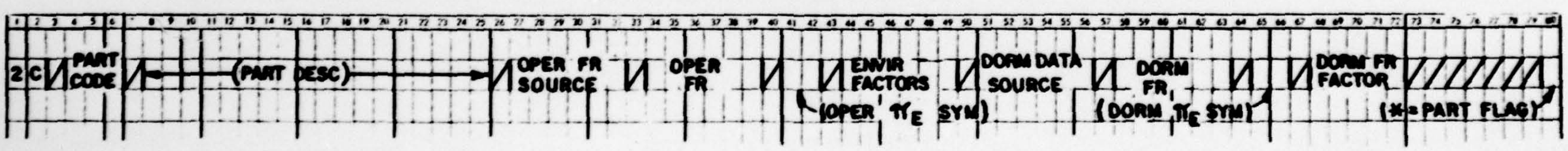


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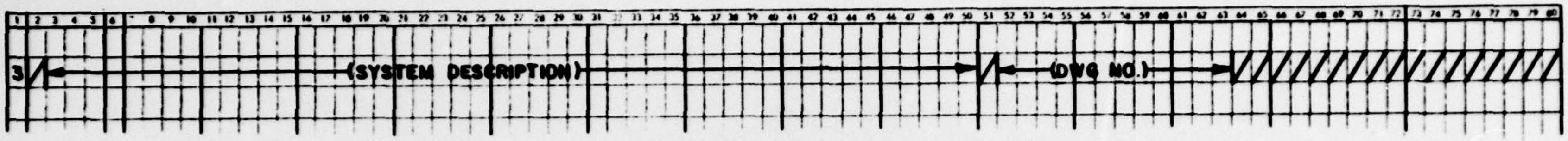
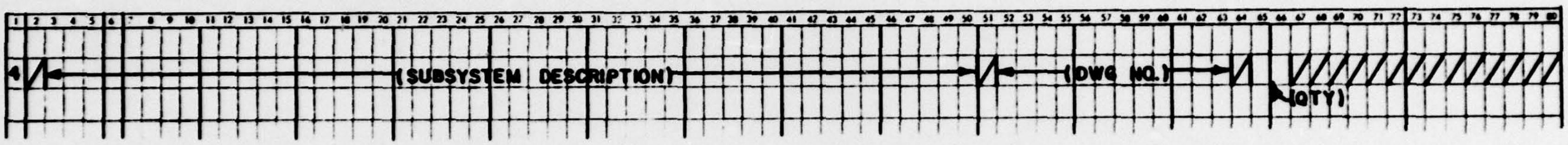
TABLE B.4. OUTLINE OF SYSTEM CONTROL CARDS

CARD 3: SYSTEM DESCRIPTION



CARD 4: SUBSYSTEM DESCRIPTION (NOT MANDATORY)



CARD 5A: ENVIRONMENTAL STRESS CONDITIONS FOR DETAILED FR SUBROUTINE (1 PER SUBSYSTEM)

CARD 5B: ENVIRONMENTAL STRESS CONDITIONS FOR CONDENSED FR SUBROUTINE (1-2 PER SUBSYSTEM)

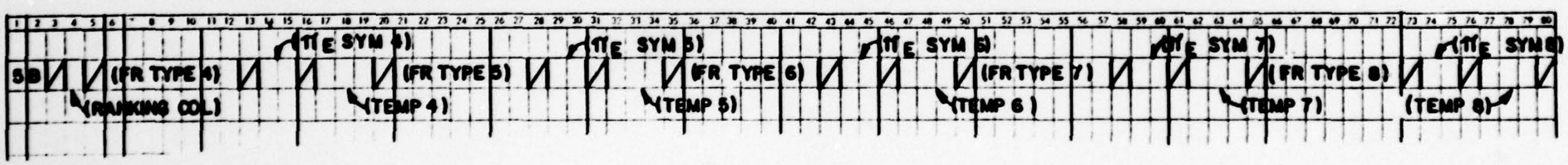
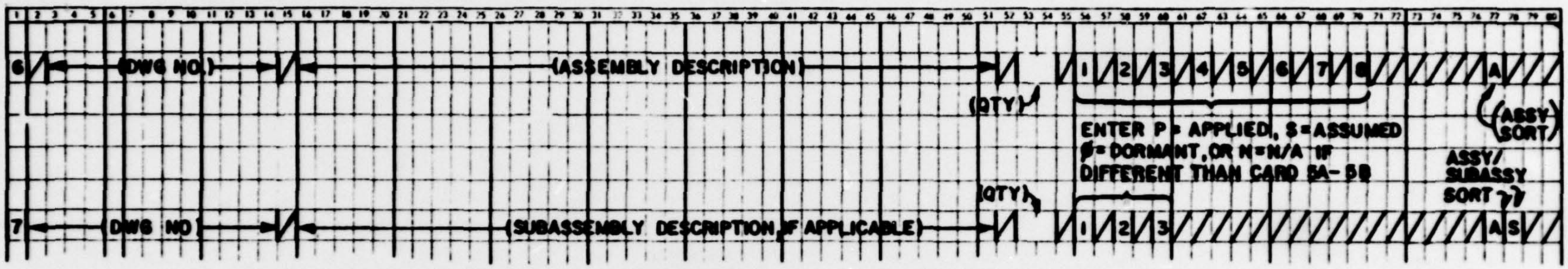
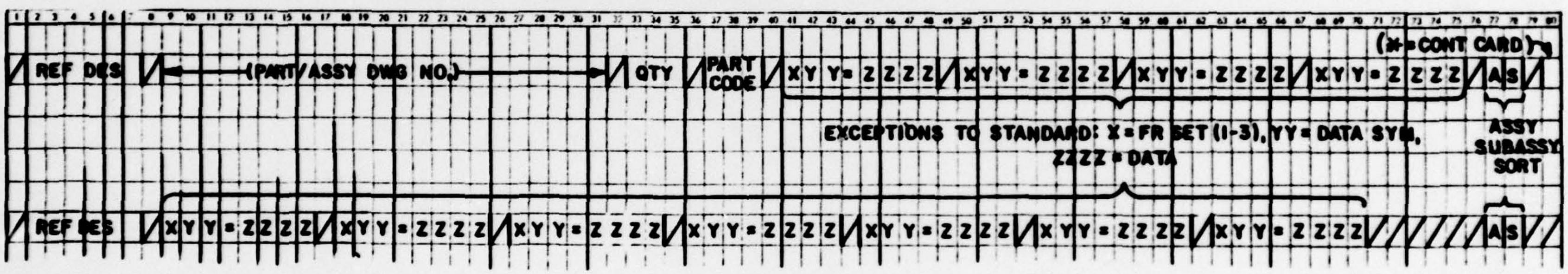


TABLE B.5. OUTLINE OF ASSEMBLY/SUBASSEMBLY DATA CARDS

CARD 6: ASSEMBLY DESCRIPTION AND CARD 7: SUBASSEMBLY DESCRIPTION (NOT MANDATORY)



DETAILED PART DATA CARD, AND CONTINUATION CARD (DETAILED FR SUBROUTINE ONLY)



CONDENSED PART DATA CARD (CONDENSED FR SUBROUTINE ONLY)

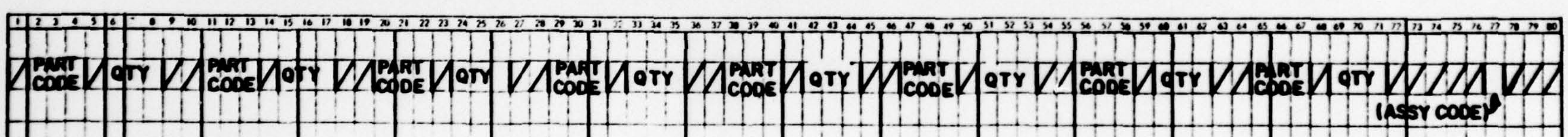


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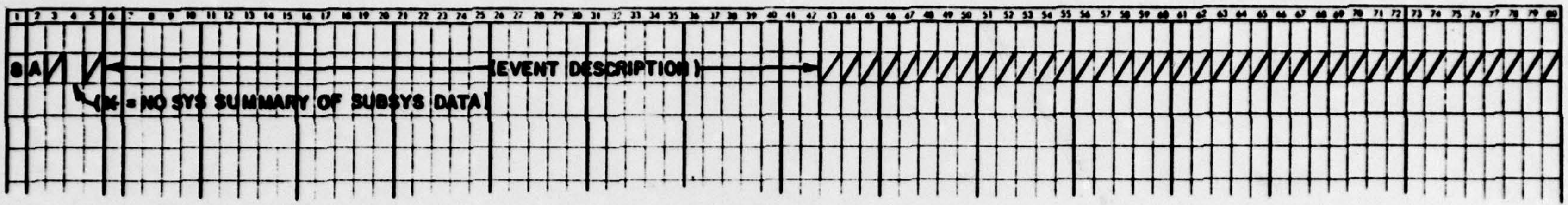
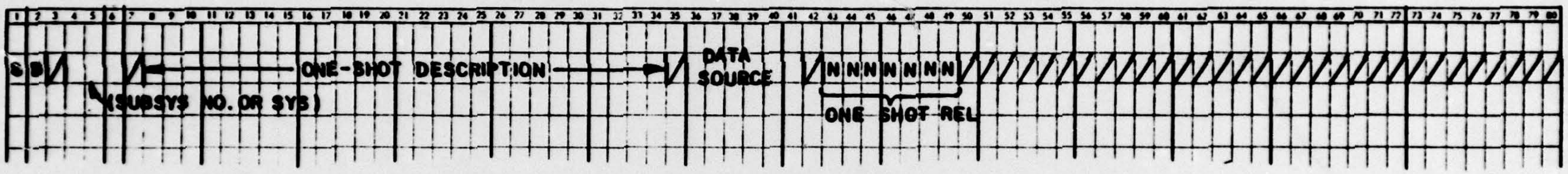
TABLE B.6. OUTLINE OF RELIABILITY SUMMARY CARDS

CARD 8A: EVENT DESCRIPTION AND FR DATA FOR ALL SUBSYSTEMS (IF APPLICABLE)



CARD 8B: ONE-SHOT DESCRIPTION AND RELIABILITY (NOT MANDATORY)



CARD 8C: INDIVIDUAL FR DATA FOR 1-8 SUBSYSTEMS AND SYSTEM (IF APPLICABLE)