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RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

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Current military standards for reliability programs, reliability predictions and qualification testing were written primarily for electronic equipment where component standardization and the valid assumption of an exponential failure rate permit their direct application. These electronic systems, however, often contain nonelectronic assemblies that are critical to operational readiness, mission success or logistics support. Application of current standards to nonelectronic designs depends upon the type equipment being developed, previous

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applications experience, quantity of equipment to be produced and many other factors. To help identify these characteristics and formulate a set of criteria on which to base recommendations, the Rome Air Development Center distributed over 400 questionnaires throughout the Department of Defense and related industries.

Volume I of this report summarizes the results of the survey on reliability programs for nonelectronic designs. Contents include a description of the questionnaire; response to the survey in terms of analysis and testing tasks and program requirements; and the degree of correlation between analysis results, testing data and field performance.

Comments from respondees of the survey reflect considerable experience and knowledge on reliability programs and techniques as applied to nonelectronic designs. Recommended reliability tasks in Volume II of this report were prepared from opinions expressed by respondees combined with results of a literature search and an investigation of ongoing and past reliability programs. Volume II emphasizes the distinguishing characteristics of nonelectronic designs and provides guidelines for tailoring current reliability documents to nonelectronic designs with consideration given to mission criticality, development phase, program dollars, development time and other program constraints.

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RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS
VOLUME I: RESULTS OF SURVEY

SUMMARY

Current military standards for reliability programs, reliability predictions and qualification/acceptance testing were written primarily for electronic equipment where component standardization and the valid assumption of an exponential failure rate permit their direct application. These electronic systems, however, often contain nonelectronic assemblies that are critical to operational readiness, mission success or demand for logistic support and maintenance. Examples of such assemblies include antenna positioning mechanisms, tape and disk drives and printers.

Reliability engineers often include nonelectronic assemblies within the total electronic equipment when planning a reliability program and formulating contractual requirements. Typical tasks imposed require a reliability program in accordance with MIL-STD-785, a reliability prediction in accordance with MIL-STD-756 and MIL-HDBK-217 and reliability testing in accordance with MIL-STD-781. The underlying assumptions and philosophies reflected in these documents may or may not apply to nonelectronic assemblies. Design practices, analytical techniques and testing procedures contained in current documents may be more effective if tailored or modified for application to nonelectronic equipment.

Application of current standards to nonelectronic designs is somewhat of a subjective issue and depends upon the type equipment being developed, previous applications experience, quantity of equipments to be produced and many other factors. To help identify these characteristics and formulate a set of criteria on which to base recommendations, the Rome Air Development Center (RADC) distributed 409 questionnaires in December, 1981 throughout the Department of Defense and related

industries. This survey was designed to identify reliability techniques and practices currently used for nonelectronic assemblies, equipments and systems including nonelectronic portions of electronic systems and totally mechanical systems. A total of 112 completed questionnaires were returned to RADC.

The next phase of the research program involved the collection and analysis of effectiveness data for reliability techniques and practices being used by respondees of the questionnaire. Results of this analysis were used to evaluate the capability of achieving numerical operational goals, cost effectiveness of various reliability tasks, statistical validity of analysis and test results, and the degree of correlation between reliability predictions and test results and between test results and field performance.

During this period of evaluating the responses to the survey, discussions were held with managers of commercial and military reliability programs and a literature search was performed. Results of all tasks performed as part of the research effort were used to develop recommendations for meaningful and cost effective reliability program task requirements to be applied to nonelectronic designs during the development phase.

The survey of reliability programs for nonelectronic designs provided a cross section of procedures and methods for performing such reliability tasks as program planning, analyses, component derating and developmental testing. Survey results permitted a correlation of reliability predictions, test results and field performance. This correlation of information aided in identifying the most effective analysis and test methods for achieving numerical reliability goals. Limited information as to the cost of performing reliability tasks was obtained from the survey and the cost effectiveness of reliability tasks could not be quantified.

This report has been prepared in two volumes. Volume 1 summarizes results of the survey on reliability programs for nonelectronic designs. A description of the questionnaire is provided and response to the survey presented in terms of reliability tasks, program requirements, and the degree of correlation between analysis results, testing data and field performance. Conclusions reached as a result of the survey and recommendations for improving reliability programs for nonelectronic designs are included in Volume 1. Volume 2 of this report is applications oriented and provides recommended guidelines for the procuring activity and contractor to consider in specifying and performing reliability tasks for nonelectronic designs.

TABLE OF CONTENTS

APPENDICES

1. QUESTIONNAIRE

The questionnaire as part of the survey on reliability programs for nonelectronic designs was distributed to various DoD agencies, industry and industrial societies. Table 1 provides a summary of the distribution of and response to the questionnaire.

TABLE 1. RESPONDEES TO THE QUESTIONNAIRE

Recipient	Distribution	Response
Army	40	12
Navy	52	8
Air Force	49	18
Misc DoD Activities	3	2
NASA/Government Agency	15	4
International Government/Agency	7	1
Industry (government contracts)	122	43
Industry (commercial products)	97	16
Industrial Society	13	1
University	11	2
Unidentified	-	5
	409	112

Table 2 provides a summary of the response in terms of equipment representation. The questionnaire as a part of the survey first determined the respondee's specific type of equipment for which the answers to follow would apply. This information provided a relationship between procedural methods currently being used and the generic types of equipment represented in the survey response.

The comprehensive questionnaire included 59 questions directed at reliability engineering tasks constituting a total reliability program. Several questions were asked about operational goals and requirements of reliability programs being developed and whether or not MIL-STD-785 was being used for these programs.

TABLE 2. EQUIPMENT REPRESENTATION IN RESPONSE TO QUESTIONNAIRE

Equipment type	No. of responses
1. Aircraft/Flight Control Systems	16
2. Armored/Wheeled Vehicles	10
3. Missile/Spacecraft Systems	17
4. Transit Systems	2
5. Construction Equipment	3
6. Engines/Power Plants	12
7. Hydraulic/Rocket Engines	6
8. Radar Systems	3
9. Computers/Avionics/Communications	6
10. Air Conditioning Systems	8
11. Transmissions/Power Trains/Gear Boxes	12
12. Motor/Generator Sets	9
13. Ground Support Equipment	4
14. Power Plant Generators/Nuclear Power Plant Systems	5
15. Structures	9
16. Home Appliances/Hand Held Mechanisms	3
17. Hydraulic/Pneumatic Components	35
18. Electrical Components	17
19. Sensors/Gyros/Instruments	16
20. Mechanical Components	24

The next series of questions were designed to document the procedures in use for reliability analysis and testing. Of interest were those methods of analysis for stress margins and derating which may not yet be in procedural format. MIL-STD-781 is one possible standardized testing procedure but its universal application to all types of nonelectronic assemblies is questionable. Response to this series of questions helped to establish the necessity and feasibility of standardizing reliability tasks for nonelectronic equipment.

Other questions in the survey were designed to determine the respondee's degree of correlation between reliability predictions, test results and field performance. Questions on parts selection procedures, application of analysis and test results, and the overall effectiveness of current standards for nonelectronic equipment applications were included. The questionnaire as distributed throughout the reliability engineering community is included in this volume as Appendix A.

2. ANALYSIS OF SURVEY RESULTS

As a first step to determining the adequacy and cost effectiveness of applying current reliability standards to nonelectronic designs, responses to the questionnaire were analyzed by individual question. A numerical summary of questionnaire responses is included in this volume as Appendix B. Next, the information was compiled in chart form to provide an overview of the response on a variety of subjects. This summary is included as Appendix C. Finally, response to those questions which could be answered with a yes or no are summarized in terms of equipment representation in Appendix D.

The second phase of the analysis consisted of a more detailed study of the response in each of the following elements of a reliability program for nonelectronic designs:

- Reliability analysis
- Development testing
- Screening requirements
- Operational environment
- Reliability program tasks/costs
- Parts/Standardization practices

2.1 RELIABILITY ANALYSIS

The Failure Mode, Effects, and Criticality Analysis (FMECA) is believed by many to be the single most effective procedure to ensure reliability of a nonelectronic design. The majority of respondees regularly perform FMECAs and consider this analysis technique to be highly cost effective. A FMECA is considered by many to be most effective in the early development stages for initial screening and feedback to designers. This analytical procedure is very effective when used to interface reliability with design groups for early problem identification and later to help quantify failure modes. Also mentioned in several responses is the ability of a FMECA to pinpoint safety critical items. A majority of respondees cite the FMECA as an important and necessary part of every design effort.

Without a valid failure rate data base to perform an accurate reliability prediction of nonelectronic equipment, many respondees rely on the output of an FMECA to identify critical failure modes from which to perform a detailed reliability prediction. Response to the survey also identified the following uses for a FMECA.

- Initial screen and feedback at component level
- Identification of catastrophic failure mechanisms
- Determination of inspection requirements in an overall Reliability Centered Maintenance (RCM) analysis
- Pinpoint safety critical aspects early in the design stage
- Quantitative evaluation where known problems exist

It was apparent from the survey that FMECAs are performed extensively even when not required by a contract. Existing procedures including ARP 926 and MIL-STD-1629 appear to be satisfactory for nonelectronic designs.

The more detailed stress analysis was identified as expensive but useful for those development programs involving design risk. Overstress was identified on several responses as the major source of existing reliability problems and the stress analysis is apparently very cost effective as a design evaluation tool. Performing a stress analysis of electronic equipment is a fairly routine procedure and results can be used directly for a reliability prediction. MIL-HDBK-217 is a data base of failure rates as a function of stress levels for use in the prediction effort. Stress analysis for nonelectronic equipment is more of an art and can not usually be performed without the services of an experienced stress analyst. Also, results of the stress analysis are not expressed in terms of failure rate and safety factors must somehow be equated into probabilities of failure occurrence.

A review of response to the questionnaire on reliability programs for nonelectronic designs indicates that there are few procedural methods in existence for stress analysis. Response to one of the questions on methods used for stress analyses was as follows.

Procedure	Number of responses expressing utilization
o Assumed stress ratio	14
o Detailed stress analysis	43
o Both procedures	11

Several respondees stated that their internal mechanical engineering group performed a stress analysis as needed. These responses are included in the above summary but it must be assumed that others did not respond because they themselves do not perform a stress analysis. Thus, the preceding table may not reflect all of the stress analyses being performed by engineering groups.

To assure adequate safety margins, a variety of techniques including component derating are used. Although many technical reports have been issued on derating, probabilistic design methods and other design evaluation techniques, and respondees utilize the methods, relatively few companies have written procedures. A summary of response to this subject is as follows:

Procedure	Number of responses expressing utilization
o Stress derating	65
o Probabilistic design	26
o Theoretical stress analysis	35
o Both stress derating & probabilistic design	23

Reliability predictions appear to be the least effective means of evaluating nonelectronic designs. Lack of component standardization for nonelectronic components has prevented the establishment of a usable data bank of failure rate data. Available data does not reflect actual operating field conditions, and the environmental and operational factors upon which predictions depend are not well defined. Section 2.3 will summarize correlations between analysis results and test/field results as experienced by respondees.

In those cases where larger corporations have established data banks for component parts and assemblies of similar types of equipment, failure rates from internal data banks are being used for reliability predictions. Estimates of reliability have been found useful for: allocating spares requirements; evaluating relative merits of design proposals and performing tradeoffs; establishing maintenance/inspection/replacement intervals; and determining if numerical requirements can be met, if and where improvements are necessary and if goals are attainable.

In conclusion, predictions can be effectively applied to nonelectronic programs if corporate field data is available, predictions are based on similar types of equipment and if performed in conjuction with a stress analysis.

MIL-STD-756 was generally thought to be unacceptable for nonelectronic designs. It appears that nonelectronic designs are more sensitive to operation and maintenance error than is the case for electronic equipment. Responses displayed considerable emphasis on the human element as one of the chief prediction problems for nonelectronic designs. MIL-STD-756 does not provide for these concerns.

2.2 DEVELOPMENT TESTING

In some cases respondees reported internal procedures having been developed for mission requirements including equipment performance with environmental profiles and the consideration of operational environment. Many respondees rely on Test, Analyze And Fix (TAAF) growth testing with test results used to initiate corrective actions. It is felt by many that qualification testing, although too late in the development program cycle for reliability inputs, is in fact needed to monitor reliability growth.

Respondees expressed the opinion that test engineers need to have the freedom to tailor test procedures to the particular characteristics of each equipment, but not so much that test results can be altered by inconsistent methods such as the determination of "relevant" and "non-relevant" failures as used in MIL-STD-781. Such practices may enable unsatisfactory equipment to pass test requirements.

MIL-STD-781 for the most part is not appropriate to nonelectronic designs. A summary of response on the subject is as follows:

	Response	Number of responses
o	MIL-STD-781 applicable in its present form	11
o	Applicable but improvements needed for nonelectronic equipment	10
o	Not applicable to nonelectronic equipment and new procedures are required	34

It is generally felt that new procedures should include normal and Weibull distributions and added test levels for nonelectronic equipment where the dominant cause of failure is wear out due to fatigue, abrasion, material corrosion or other time related factors.

Some of the respondees are of the opinion that reliability tests are not useful for estimating time-dependent failure rates because of the extremely long elapsed time necessary to have an acceptable level of statistical significance. Life tests are expensive for nonelectronic equipment because the equipment can not sit on a burn-in rack but must be mechanically exercised. The multi-modal characteristics of nonelectronic equipment and the resulting expense for tests cause many respondees to believe that reliability demonstration test data does not provide sufficient evidence of reliability growth.

Accelerated testing is not used by many respondees because results can not correlate the stress of the test with levels of accelerated life. Also, an accelerated test tends to cause failures that would never occur in normal service. Some respondees indicated that accelerated testing is used only when normal usage and/or testing fails to precipitate failures. No detailed accelerated testing procedures could be detected although the following methods are used to detect age sensitive materials and other potential problems. Testing techniques are not necessarily designed to provide failure rate data for predictions or to use for qualification.

- salt spray
- fatigue life (endurance) determination
- temperature extremes
- overload
- overspeed
- overtorque
- extended limits
- increased cycle rate tests
- step-stress test to failure
- vibration

Accelerated testing is being used successfully by some when physical wear characteristics are a determining factor for component life. Results are occasionally translated by "K" factors and used to predict component life. Accelerated testing appears to be more effective for small sample sizes and at lower levels of assembly. It is most effective for those components subject to wear out. Many respondees are of the opinion that accelerated testing has great potential as a method to achieve the following:

- Detection of dominant failure modes early in the development program for corrective action
- Shorter qualification test time, thereby lowering the cost of reliability testing
- Meaningful and effective tests established for equipments which under nominal conditions have an extremely long life

Several respondees stated that accelerated tests can be highly effective where applicable: those equipments where the effects of accelerated factors such as increased load, stress or temperature are well known and reflect failure conditions and wear out characteristics experienced in service operation.

2.3 RELIABILITY PREDICTION, TEST AND FIELD RESULTS

Table 3 represents the degree of success in quantitatively determining field reliability from results of analyses and testing. Appropriate comments from respondees which express actual experiences are included.

Table 3 indicates that the degree of correlation between analysis, test and field results depends upon the data base available, realism of the tests being conducted, maturity of the system in the field, and quality of field service reports. Respondees indicated that modifications are required to environmental test methods to make them more realistic in terms of actual operation. Operational conditions for the equipment need to be better defined and incorporated into reliability programs. In many instances, according to respondees, environmental factors neglected or poorly defined in the design and development stages of programs are a major cause of equipment trouble in field use. Temperature, vibration, contaminants and shock were cited as examples of the shortcomings. Also expressed was the need to expand the use and scope of combined environment reliability test (CERT) procedures to ensure that the combined effects of many environmental stresses acting at once are not overlooked.

TABLE 3. CORRELATION OF PREDICTION AND TEST RESULTS AND FIELD PERFORMANCE

Observation	Number of observations
o Close correlation between analysis and test results - if predictions are updated - sufficiently good to aid in locating design, quality and maintenance problems - for mature systems	8
o Close correlation between analysis results and field performance - actual experience data in commercial airplane business can be used - if reliability is evaluated under correct field conditions - FRAP program predictions have matched fleet performance of sampled equipment	12
o Close correlation between test results and field performance - if stresses and cycles are accurately defined - if all lab failures (relevant and non-relevant) are counted - sufficiently good to aid in locating design, quality and maintenance problems	9
o Projected reliability optimistic in comparison to test results - optimistic by 2:1	5
o Analysis results optimistic in comparison to field performance - optimistic by 2-5:1 - field problems caused by inadequate training of operator and maintenance personnel - human error - predictions don't include workmanship or design deficiencies	15

TABLE 3. (Continued) CORRELATION OF PREDICTION AND TEST RESULTS AND FIELD PERFORMANCE

Observation	Number of observations
o Analysis results conservative with respect to field performance - after 3 years of aggressive reliability growth analytical results are exceeded in service by 20-50% - specified environments are not indicative of actual field usage	6
o Field performance better than projected from test results	1
o Test results optimistic in comparison to field performance - optimistic by 1.5-4:1 - tests provide an optimistic assessment of operational experiences	5
o Poor correlation between analysis and test results	4
o Poor correlation between analysis results and field performance - prediction results usually discarded because methods for reliability analysis are poor - analysis results inaccurate due to lack of meaningful data base - unpredicted failure modes or nonrecognition of dependence - questionable prediction techniques - qualitative aspects of prediction may be more useful - reliability predictions seldom account for in-service exposure to accidental environment severity - poor field data for comparison - due to sparse data in meager or nonexistent data banks, predictions are useless	10
o Poor correlation between test results and field performance - testing is hardware oriented whereas field performance is influenced by personnel training, support equipment, etc. - test environment failed to simulate certain field conditions - lab tests are worst case and field use reflects inadequate training - definitions of failure not consistent	4

2.4 SCREENING REQUIREMENTS

A review of the response to this subject question indicates that methods to screen nonelectronic equipments are as varied as the nonelectronic designs themselves. The following list of screening requirements is based on a priority basis and only one task is allotted per response. For example, if the respondee indicated that MIL-STD-781 testing and a run-in test on each equipment were both performed at his facility, only the run-in test is recorded as the preferable method.

Screening requirement	Number of responses
o Product stress screening	3
o Run-in test	7
o MIL-STD-781 test	2
o Sampling qualification test	13
o First article test	1
o Failure data collection and corrective action	14
o General Q.A. provisions	37
o Production inspection/test	10
o No response	25
	112

2.5 OPERATIONAL ENVIRONMENT/DUTY CYCLE

Comments from the survey of reliability programs for nonelectronic designs indicate that the same profiles are used for analyzing and testing nonelectronic designs as used for electronic designs. Most respondees (28) derive a best estimate of actual operational environment and duty cycle while only a few (7) develop special operational and environmental profiles for the mechanical portions of electronic equipment. Twenty-nine percent of the respondees either do not develop operational profiles (21) or use the profile as specified in the contract (11).

2.6 RELIABILITY PROGRAM TASKS/COSTS

The approach taken to assigning and monitoring reliability tasks for nonelectronic designs appears to be no different than for electronic designs. Most reliability programs are established by contract or upon approval of a reliability program by corporate management. In some cases, tasks are assigned on a program-by-program basis with costs proportional to complexity of the analytical job, test procedure or other anticipated work load. Of the 72 responses to this question, 68% stated this was normal procedure. Detailed cost data is difficult to obtain and respondees provided no actual costs to perform the various reliability tasks.

Another management approach is to include reliability engineering tasks as an integral part of the design effort and engineering budget. Reliability related tasks require about 10% of the total engineering budget for equipment critical to mission success and correspondingly less for nonessential equipment. Nineteen percent of those responding to this particular question stated that their facilities subscribe to this integrated management approach.

The third group of respondees stated that money for reliability is appropriated only when there is pressure from a higher authority or when there are so many problems that money must be spent for reliability engineering tasks. Eight percent of those responding to this question indicated that such a condition exists at their facility.

In summary, no unique methods for assigning program tasks for nonelectronic designs could be detected.

2.7 PARTS/STANDARDIZATION PRACTICES

Information obtained from the survey on this important question was limited. Only twenty-seven facilities indicated that internal standard parts catalogues or other programs for parts control are in existence. Three respondees indicated that MIL-STD-965 was being used.

3. CONCLUSIONS

As a result of the survey on reliability programs for nonelectronic designs, the following conclusions were derived. These conclusions were used toward development of the recommended reliability tasks contained in Volume 2 of this report. They have also been used to formulate recommendations for improving the effectiveness of reliability standards and procedures.

- During the conceptual design phase it is desirable to conduct reliability evaluation tests on critical nonelectronic components as identified by the FMECA. Details of testing time, occurrence of wear, noise, etc. should be recorded.
- Care must be exercised in applying MIL-STD-781 to nonelectronic designs. Qualification tests may be completed prior to detection of time dependent failure mechanisms.
- For development programs of one-of-a-kind systems, the contractor will have to test components whenever possible during the development phase as components become available. The FMECA can dictate critical failure modes requiring test.
- The procuring activity can not always dictate the testing program. The contractor must estimate the total test hours for each component or assembly in his test plan based on past experience, identified critical failure modes, availability of components and parts and data requirements to evaluate reliability.
- Testing procedures for nonelectronic equipment must be designed to evaluate potential failure modes. Wear rate and other time dependent failure mechanisms must be examined in any endurance test regardless of the design phase.
- Fatigue tests should be specified in the contractor's test plan for all parts subject to bending or twisting forces. Fatigue tests are destructive but can be performed at the part level.
- Reliability predictions are not generally applicable to nonelectronic designs unless based on detailed stress analysis or similar equipment operated under a similar environment. The FMECA is the more cost effective approach for nonelectronic designs. Reliability predictions should not be imposed in a contract for nonelectronic designs without an FMECA.

- Procedures contained in MIL-STD-781 are not generally used for nonelectronic equipment. Informal TAAF programs are generally relied upon with emphasis on reliability growth rather than a precise measure of reliability. Qualification testing may not be cost effective for nonelectronic equipment. TAAF combined with results from engineering development tests may provide a better indication of reliability.

- Bayesian techniques are used to determine test times when only small sample sizes are available.

- Operational environment is much more critical in the analysis and testing of nonelectronic equipment than for electronic equipment because of the more direct interface with operator and environment. Equipment definitions in the analytical process must be very precise and test plans for nonelectronic equipment must reflect this sensitivity. Human factors reliability must be included as part of the nonelectronic reliability program.

- Unique designs of nonelectronic equipment prevent typical run-in times. ESS for production must be determined from development tests and FMECA results.

- Very little data has been accumulated on the application of CERT to nonelectronic equipment. Costs of extended test times to detect wear out plus the large size of some equipments requires such tests to be performed at the component or part level.

- Standard derating procedures are not available for nonelectronic designs. The request for proposal should require a discussion of derating criteria in conjunction with requirements for a prediction analysis.

4. RECOMMENDATIONS

The purpose of the survey on reliability programs for nonelectronic designs was to determine the adequacy and cost effectiveness of applying current reliability standards to nonelectronic designs. Although many portions of current reliability tasks and procedures as contained in MIL-STD-785, MIL-STD-1629, MIL-STD-781 and other documents can apparently be used effectively on nonelectronic designs as well as electronic designs, for which they were specifically written, the concensus of the respondees to the questionnaire is that sufficient differences exist to justify the development of new procedures for nonelectronic designs. Design review practices, analytical techniques and testing practices would be more effective if documented to accommodate the unique characteristics of nonelectronic equipment. The procedures could be included as part of existing standards and handbooks or as self contained documents.

Information presently exists which could be made available to a designer or analyst for determining the reliability of a nonelectronic design but the information is widely scattered and there exists a definite lack of standardization in the application of reliability program tasks and procedures for nonelectronic reliability. A Handbook of Prediction Methods for Nonelectronic Designs is required which contains charts, sketches, graphs and application examples for predicting the reliability of impacting devices, sliding-crank mechanisms, actuators, and other nonelectronic components. Descriptions of the components for standardization purposes and common failure modes for the standard nonelectronic components need to be compiled and included in the Handbook. The recommended Handbook would contain sections on applying in-house data and considering new technology for reliability analyses. The Handbook should contain reliability prediction methods for nonelectronic equipment similiar to the methods in MIL-HDBK-217 with predictions based on the rate of occurrence for each component failure mode. Volume 2 of this report describes the relationship between FMECA, stress analysis and prediction procedures and provides guidelines for identifying failure modes and predicting their rate of occurrence. Sufficient information is available in technical reports and data banks to expand these guidelines and develop a prediction methodology for nonelectronic designs.

Procedures for performing a FMECA, reliability prediction and stress analysis should be prepared specifically directed to nonelectronic designs consistent with engineering terms, physics of failure and common failure modes and included in the recommended Handbook of Prediction Methods for Nonelectronic Designs. Easy to apply stress analysis and prediction methods should be prepared as a part of a combined FMECA, prediction and stress analysis procedure which would establish the basic ground rules for nonelectronic reliability analysis tasks. Volume 2 of this report contains guidelines for performing reliability tasks which were derived from results of the survey. These guidelines should now be prepared in MIL-HDBK format with examples of the application of the procedures for specific nonelectronic designs. The completed procedures to be used by designers of nonelectronic equipment and reliability analysts would promote standard terminology for nonelectronic parts and devices, avoid the present duplication of reliability engineering procedures and increase the cost effectiveness of reliability tasks for nonelectronic designs.

Results of the survey on reliability programs for nonelectronic designs indicate that MIL-STD-781 is applicable to electronic systems which contain relatively few nonelectronic components. However, for nonelectronic systems and nonelectronic components new testing procedures are required. New test methods for moving parts need to be developed and incorporated into a Handbook. The Handbook of Testing Procedures for Nonelectronic Equipment should contain sections on utilizing analysis results for designing test procedures and using Bayesian statistical techniques to minimize testing time. Qualification testing is not always possible for nonelectronic equipment from a statistical standpoint and instructions need to be incorporated in the Handbook on using TAAF program results to qualify a nonelectronic design.

Several respondees of the questionnaire indicated an application problem with the differences between the requirements contained in reliability standards and those contained in supporting Data Item Descriptions (DIDs). DIDs have been prepared for so many particular equipments and applications that significant discrepancies now exist in relation to applicable standards. A joint Industry/Government committee should compile recommended changes to standards and DIDs. Many DID's can be deleted or their requirements combined.

APPENDIX A

QUESTIONNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

Check those blocks that indicate the categories of equipment for which you are responsible or in which you have significant experience, relative to design and reliability programs. Nonelectronic equipments to which the responses herein apply include:

☐ A. nonelectronic portions of military electronic systems;
☐ B. totally nonelectronic systems designed to military standards, and/or
☐ C. totally nonelectronic systems designed to industry standards.

1. With what types of nonelectronic systems/equipment are you associated? (Please be as specific as possible).

   Systems:____

   ____

   Components:____

   ____

2. What is your function most closely associated with reliability programs?

   ☐ Engineering Management
   ☐ Product Design
   ☐ Reliability Engineering
   ☐ Maintainability Engineering
   ☐ Analysis
   ☐ Testing
   ☐ Evaluation
   ☐ Field Engineering
   ☐ Marketing
   ☐ Program Management
   ☐ Quality Control/Assurance
   ☐ Test Engineering
   ☐ Standards
   ☐ Other__________________

3. Which of the following categories most accurately describes your field of endeavor?

   ☐ Manufacturing
   ☐ Independent testing laboratory
   ☐ Government (Development Procurement ☐ Production Procurement ☐ Management ☐ Support ☐ User ☐ Research ☐ T&E ☐)
   ☐ Military (Aviation ☐ Land ☐ Sea ☐ SubSea ☐ Space ☐)
   ☐ Corporate Research and Development
   ☐ Design Engineering
   ☐ Software Development
   ☐ Other____

4. Is MIL-STD-785 used in development programs for nonelectronic equipment at your facility when not specifically called out in military contracts? ☐ Yes ☐ No Revision _____ Do you utilize industrial requirements similar to MIL-STD-785 for development programs? ☐ Yes ☐ No (If yes, list by reference number, title, and brief description)

Comments:____

____

5. How are reliability requirements and goals specified for your development programs? (Check all that apply)

☐ System level failure rates
☐ Probability of mission accomplishment
☐ Safety
☐ Other____

6. Which factors are included in the derivation of reliability requirements and goals? (Check all that apply)

☐ Operational environment
☐ Type of performance or acceptance testing to be satisfied
☐ Maintainability requirements
☐ Factors dictated by reliability prediction methods to be used
☐ Development budgets allocated to reliability
☐ Production processes
☐ Cost restraints
☐ Other____

Comments:____

____

7. How are reliability program requirements incorporated in the design phase of your development program? (Check all that apply)

☐ As a separate discipline monitoring the design engineers' efforts
☐ Integrated with manitainability design
☐ As an integral part of the design team effort
☐ By contractual requirement
☐ As a result of design analysis
☐ Integrated with system level goals
☐ Other____

Comments:____

____

8. Reliability values are apportioned to the:

☐ System level (aircraft, radar, etc.)
☐ Equipment level (communications receiver, computer, etc.)
☐ Unit (hydraulic actuator, motor, etc.)
☐ Component (seals, shafts, linkage, etc.)

Comments: ______________________________

9. What method is used at your facility to ensure that requirements are met? (Check all that apply)

☐ Must meet specific numerical requirements or is not accepted
☐ Penalty for reduced reliability (Lower price or loss of fee)
☐ RIW (Manufacturer must fix it if it fails under warranty)
☐ Incentives (Added fee or other compensation for exceeding stated reliability requirements)
☐ Qualification Tests
☐ Reliability Growth monitoring

Comments: ______________________________

10. Does your reliability program distinguish between reliability as it affects the mission and as it affects logistics support? ☐ Yes ☐ No What analytical methods/techniques or models are used?

Comments: ______________________________

11. In your opinion, is MIL-STD-785 applicable to development programs involving nonelectronic equipment? ☐ Yes ☐ No. Can its application be cost effective in establishing a reliability program for nonelectronic equipment? ☐ Yes ☐ No. (Check all that apply)

Comments: ______________________________

12. What is your opinion as to the cost effectiveness of applying the following methods for nonelectronic design analysis? Please comment in terms of system and component levels, specific types of equipment, etc.

FMEA____

Reliability Prediction____

Stress Analysis ____

Qualification Testing Analysis____

Accelerated Testing Analysis____

Reliability Growth____

Other____

13. Please list the industrial, governmental or internal procedures or methods which your facility actually uses for reliability analysis of nonelectronic designs.

- ☐ MIL-STD-756
- ☐ MIL-STD-1629
- ☐ ARP 926
- ☐ Nonelectronic Reliability Notebook
- ☐ Assumed stress ratios
- ☐ Detailed stress analysis
- ☐ Other ______________________________

Comments: ______________________________

____

14. Who in your facility normally performs reliability analyses of nonelectronic equipment?

Department	Analyst's functional title
☐ Mechanical Design Engineering	______________
☐ Electrical Design Engineering	______________
☐ Reliability Design Engineering	______________
☐ Quality Assurance	______________
☐ Other ______________	______________

15. What is the lowest equipment level at which you perform a reliability analysis? Use A=system, B=component, C=part

Reliability prediction ______________

FMEA ______________

Apportionment ______________

Stress analysis ______________

Other ______________

Comments: ______________________________

____

16. Are the results of reliability analyses actually used for any of the following functions or activities at your facility? Please remember that this is not a theoretical text book question and your response should be based upon your personal experience.

☐ design reviews
☐ spare parts listings
☐ maintenance plans
☐ design program decisions
☐ cost trade-off decisions
☐ test planning
☐ reliability growth
☐ other____

17. Please comment on any experience you may have regarding the degree of correlation between analysis results and actual field performance.

18. Do you perform Failure Mode and Effects Analyses (FMEA) on nonelectronic equipment? ☐ Yes ☐ No If yes, are they performed: (Check all that apply)

☐ as part of every design/development effort
☐ in event of unexpected catastrophic failures
☐ only when reliability is determined to be below contract requirements
☐ only if required under the contract
☐ in accordance with MIL-STD-1629
☐ in accordance with ARP 926
☐ in accordance with other requirements

Comments:____

19. Which of the following approaches to conducting an FMEA apply to your analyses? (Check all that apply)

☐ bottom up
☐ top down
☐ hardware
☐ functional
☐ mission oriented
☐ safety oriented
☐ maintenance oriented
☐ quantitative criticality
☐ qualitative criticality

Comments:____

____

20. Do you use reliability/maintainability predictions as an input to determine any of the following? Check one or more:

☐ Life Cycle Costs
☐ Acquisition Costs
☐ Logistic Support Costs
☐ Development Costs
☐ Spares Requirements

21. What sources of data do you use to predict reliability?

☐ MIL-HDBK-217
☐ RADC Nonelectronic Reliability Notebook
☐ 3-M Data
☐ AF-66 Data
☐ GIDEP
☐ MIL-HDBK-5
☐ Other____________

Comments on application, validity or usefulness of these sources:

____

____

____

22. Do you use reliability predictions as a means of determining whether design objectives for nonelectronic systems have been achieved? ☐ Yes ☐ No If yes, what method/procedure is used?

23. Please comment on any experience you may have regarding the degree of correlation between reliability predictions and test results.

24. Do you include effects of overhaul or maintenance actions in your reliability predictions? ☐ Yes ☐ No

Comments:

25. Is MIL-STD-756 a satisfactory tool for performing reliability predictions for nonelectronic equipment? ☐ Yes ☐ No

Comments:

26. What analytical techniques do you use to perform a stress analysis? At what equipment level?

27. Do you use MIL-HDBK-5 to assess reliability? ☐ Yes ☐ No Is MIL-HDBK-5 a satisfactory tool for determining properties and characteristics of materials for reliability evaluation purposes? ☐ Yes ☐ No What other data sources do you use?

28. Describe briefly the procedures you use to assure adequate safety margins.

☐ theoretical stress analysis
☐ piece part testing data
☐ system qualification testing
☐ probabilistic design methods
☐ stress derating
☐ other ______________________________

Description______________________________

____

29. Is planned reliability growth included in your reliability programs? ☐ Yes ☐ No How are growth requirements specified and measured?

____

____

30. How are test results incorporated into your revised growth projection?

____

____

31. What methods do you use to ensure that inherent design reliability is preserved during production?

____

____

32. Do you have any internal parts selection procedures for nonelectronic components? ☐ Yes ☐ No

Describe:______________________________

____

33. Do you develop individual operational and/or environmental profiles prior to testing nonelectronic equipments? ☐ Yes ☐ No If yes, describe procedures used.

34. Do you use MIL-STD-781 for testing nonelectronic equipment?
☐ Yes ☐ No

☐ Revision B
☐ Revision C

35. Do you use commercial procedures which are similar to MIL-STD-781 for testing nonelectronic designs? ☐ Yes ☐ No If yes, describe by number, title and contents:

36. With that type of wear out characteristics are you concerned during reliability testing?

37. What method do you use to adjust the reliability established from laboratory test results in estimating operational reliability?

38. How are accept/reject criteria established for reliability tests?

39. Do your testing procedures assume a constant failure rate distribution?
☐ Yes ☐ No If no, what distribution do you apply to testing procedures?

40. Do you believe MIL-STD-781 is appropriate for testing nonelectronic equipment? ☐ Yes ☐ No If yes, provide one or two equipment examples for each category to which you feel MIL-STD-781 applies. Answer based on ☐ Rev B, ☐ Rev C, ☐ Both

☐ system level ______________________________

____

☐ component level ______________________________

____

41. Could MIL-STD-781 be improved to make it more applicable to nonelectronic equipment testing or should new procedures be developed?

☐ Improvement Required
☐ New Procedures Required
☐ No Improvement or New Procedures Required

Suggestions for improvements/new procedures: ______________________________

____

42. What method(s) do you use to determine sample size and test time or number of test cycles when only small sample sizes are available?

____

____

43. What method do you use to establish risk factors resulting from truncated tests?

____

____

44. Please comment on any experience you may have regarding the degree of correlation between reliability testing and field performance results.

____

____

45. Indicate the tests most effective at your facility for verifying nonelectronic equipments. (Check all that apply)

	Level of Application		
Type	System	Component	Materials
☐ Vibration	☐	☐	☐
☐ Temperature	☐	☐	☐
☐ Humidity	☐	☐	☐
☐ Shock	☐	☐	☐
☐ Salt Spray	☐	☐	☐
☐ Step Stress	☐	☐	☐
☐ Constant Stress	☐	☐	☐
☐ Progressive Stress	☐	☐	☐
☐ Environmental	☐	☐	☐
☐ Screening Tests	☐	☐	☐
☐ Corrosion	☐	☐	☐
☐ Production Processes	☐	☐	☐

46. Please describe how reliability tests for nonelectronic equipment are normally performed at your facility.

- ☐ For a specified period of time
- ☐ Until a predetermined number of events/cycles are completed
- ☐ Until a predetermined number of failures have occurred
- ☐ Until catastrophic failure occurs
- ☐ Recurring until all major failure modes are identified

Comments: ______________________________

____

47. Do you use accelerated testing methods to determine performance/reliability? ☐ Yes ☐ No

Procedures used: ______________________________

____

48. How do you evaluate test results in establishing quantitative reliability?

____

____

49. How do you analyze the validity of your assumed failure rate distribution and its effects on test results?

____

50. Please rate the following Standards, Specifications and Handbooks on the basis of effectiveness in achieving and demonstrating reliability for nonelectronic equipment. Check the appropriate column to show whether the listing is applicable to the system or component levels or to both and then its degree of effectiveness.

DOCUMENT ID	TITLE/SUBJECT	APPLICATION	EFFECTIVENESS
		Sys./Comp/Both	Exc./Good/Poor
FED-STD-151B	Metals: Test Methods	☐ ☐ ☐	☐ ☐ ☐
MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes	☐ ☐ ☐	☐ ☐ ☐
MIL-STD-210D	Climatic Extremes for Military Equipment	☐ ☐ ☐	☐ ☐ ☐
MIL-STD-454G	Standard General Requirements for Electronic Equipment	☐ ☐ ☐	☐ ☐ ☐
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipments)	☐ ☐ ☐	☐ ☐ ☐
MIL-STD-471A	Maintainability/Verification Demonstration/Evaluation	☐ ☐ ☐	☐ ☐ ☐
MIL-STD-721B	Definition of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety	☐ ☐ ☐	☐ ☐ ☐
MIL-STD-756A	Reliability Prediction	☐ ☐ ☐	☐ ☐ ☐
MIL-STD-757	Reliability Evaluation from Demonstration Data	☐ ☐ ☐	☐ ☐ ☐

DOCUMENT ID	TITLE/SUBJECT	APPLICATION			EFFECTIVENESS		
		Sys.	Comp	Both	Exc.	Good	Poor
MIL-STD-781B	Reliability Tests Exponential Distribution	☐	☐	☐	☐	☐	☐
MIL-STD-781C	Reliability Tests Exponential Distribution	☐	☐	☐	☐	☐	☐
MIL-STD-785B	Reliability Program for Systems and Equipment Development and Production	☐	☐	☐	☐	☐	☐
MIL-STD-882A	System Safety Program for Systems and Equipment; Requirements for;	☐	☐	☐	☐	☐	☐
MIL-STD-810C	Environmental Test Methods	☐	☐	☐	☐	☐	☐
MIL-STD-965	Parts Control Program	☐	☐	☐	☐	☐	☐
MIL-STD-1304A(AS)	Reliability Reports	☐	☐	☐	☐	☐	☐
MIL-STD-1312	Fasteners, Test Methods	☐	☐	☐	☐	☐	☐
MIL-STD-1378B	Requirements for Employing Standard Hardware Program Modules	☐	☐	☐	☐	☐	☐
MIL-STD-1388	Logistic Support Analysis	☐	☐	☐	☐	☐	☐
MIL-STD-1472B	Human Engineering Design Criteria for Military Systems, Equipment and Facilities	☐	☐	☐	☐	☐	☐

DOCUMENT ID	TITLE/SUBJECT	APPLICATION			EFFECTIVENESS		
		Sys.	Comp	Both	Exc.	Good	Poor
MIL-STD-1535A	Supplier Quality Assurance Program Requirements	☐	☐	☐	☐	☐	☐
MIL-STD-1543	Reliability Program Requirements for Space and Missile Systems	☐	☐	☐	☐	☐	☐
MIL-STD-2068(AS)	Reliability Development Tests	☐	☐	☐	☐	☐	☐
MIL-STD-2070(AS)	Procedures for Performing a Failure Mode, Effects and Criticality Analysis for Aeronautical Equipment	☐	☐	☐	☐	☐	☐
MIL-STD-2074(AS)	Failure Classification for Reliability Testing	☐	☐	☐	☐	☐	☐
MIL-HDBK-5C	Metallic Materials and Elements for Aerospace Vehicles	☐	☐	☐	☐	☐	☐
H-50	Evaluation of Contractors Quality Program	☐	☐	☐	☐	☐	☐
H-51	Evaluation of Contractors Inspection System	☐	☐	☐	☐	☐	☐
H-53	Guide for Sampling Inspection	☐	☐	☐	☐	☐	☐
H-106	Multi-Level Continuous Sampling Procedures and Tasks for Inspection by Attributes	☐	☐	☐	☐	☐	☐

DOCUMENT ID	TITLE/SUBJECT	APPLICATION			EFFECTIVENESS		
		Sys.	Comp	Both	Exc.	Good	Poor
H-107	Single-Level Continuous Sampling Procedures and Tables for Inspection by Attributes	☐	☐	☐	☐	☐	☐
H-108	Sampling Procedures and Tables for Life and Reliability Testing (Based on Exponential Distribution)	☐	☐	☐	☐	☐	☐
H-109	Statistical Procedures for Determining Validity of Suppliers' Attributes Inspection	☐	☐	☐	☐	☐	☐
MIL-HDBK-217C	Reliability Prediction of Electronic Equipment	☐	☐	☐	☐	☐	☐
MIL-HDBK-251	Reliability/Design, Thermal Applications	☐	☐	☐	☐	☐	☐
MIL-HDBK-472	Maintainability Prediction	☐	☐	☐	☐	☐	☐
MIL-Q-9858A	Quality Program Requirements	☐	☐	☐	☐	☐	☐
NAT-STD-3518	Environmental Test Methods for Aircraft Equipment and Associated Ground Equipment	☐	☐	☐	☐	☐	☐
MIL-E-5272C	Environmental Testing, Aeronautical and Associated Equipment, General Specification for	☐	☐	☐	☐	☐	☐
MIL-H-46855B	Human Engineering Requirements for Military Systems, Equipment and Facilities	☐	☐	☐	☐	☐	☐

DOCUMENT ID	TITLE/SUBJECT	APPLICATION Sys./Comp/Both	EFFECTIVENESS Exc./Good/Poor
NAT-STD-4108	NATO Inspection and Quality Control Requirements for Industry; AQAP-1, AQAP-4, AQAP-9	☐ ☐ ☐	☐ ☐ ☐
MIL-P-11268K	Parts, Materials and Processes Used in Electronic Equipment	☐ ☐ ☐	☐ ☐ ☐
MIL-R-22732C	Reliability Requirements for Shipboard Electronic Equipment	☐ ☐ ☐	☐ ☐ ☐
MIL-T-5422F	Testing, Environmental, Aircraft Electronic Equipment	☐ ☐ ☐	☐ ☐ ☐
ATSM-E6	Definitions of Terms Relating to Methods of Mechanical Testing	☐ ☐ ☐	☐ ☐ ☐
ARP 926A	Fault/Failure Analysis	☐ ☐ ☐	☐ ☐ ☐
NAVAIR-01-1A-32	Reliability Engineering Handbook	☐ ☐ ☐	☐ ☐ ☐
NAVAIR-01-1A-33	Maintainability Engineering Handbook	☐ ☐ ☐	☐ ☐ ☐
RDH-376	Reliability Design Handbook published by the Reliability Analysis Center (IIT Research Institute)	☐ ☐ ☐	☐ ☐ ☐
AD/A-005-657	Nonelectronic Reliability Notebook (US Dept. of Commerce for Rome Air Development Center)	☐ ☐ ☐	☐ ☐ ☐

51. How are costs for reliability programs allocated, budgeted and monitored at your facility?

____

____

52. Have any of your government contracts specified a requirement for inclusion of a reliability centered maintenance (RCM) program? ☐ Yes ☐ No

Example contract:____

____

53. Do government directives (Data Item Descriptions, instructions, etc.) add to the effectiveness of contractual reliability and maintainability requirements? Yes ☐ No ☐

Comments:____

____

54. Is there a significant lack of standardization in the nonelectronic product world in application of terms, specifications or qualified product lists? ☐ Yes ☐ No

If yes, what efforts are currently underway or should be initiated to solve this problem?

____

____

55. Should there be separate reliability specifications/standards for large equipments (flight control systems, howitzers, computers) as compared to smaller, more easily tested equipments (motors, printers, actuators)? ☐ Yes ☐ No

Comments:____

____

56. To your knowledge, are any of the engineering professional societies currently engaged in a productive effort to develop or upgrade standards or specifications that will have an effect on reliability/maintainability of nonelectronic equipment? ☐ Yes ☐ No

If yes, identify the society/organization and the particulars of their projects.

57. Does the added requirement of ruggedization for certain military equipment affect reliability? ☐ Yes ☐ No If yes, explain, including the effect of ruggedization on size and weight.

58. Is sufficient information available to perform reliability analysis for nonelectronic design? If not, do you think a Handbook is possible which could provide procedures, guidance and material information?

59. Additional comments which will help us to determine the adequacy and cost effectiveness of applying current reliability specifications to nonelectronic equipment.

NAME: ____________________

COMPANY/AGENCY: ____________________

MAILING ADDRESS: ____________________

____

____

TELEPHONE NUMBER: ____________________

APPENDIX B

NUMERICAL SUMMARY OF QUESTIONNAIRE RESPONSES

Introduction:

Nonelectronic equipments to which the responses herein apply include:

69 (62%) indicated nonelectronic portions of military electronic systems

51 (46%) indicated totally nonelectronic systems designed to military standards

32 (29%) indicated totally nonelectronic systems designed to industry standards

10 (9%) did not respond

Questions:

1. With what types of nonelectronic equipment are you associated? 112 responded to the question (100%).

2. What is your function most closely associated with reliability programs?

Engineering Management	26	(23%)
Product Design	6	(5%)
Reliability Engineering	78	(70%)
Maintainability Engineering	36	(32%)
Analysis	20	(18%)
Testing	21	(19%)
Evaluation	24	(21%)
Field Engineering	2	(2%)
Marketing	2	(2%)
Program Management	6	(5%)
Quality Control/Assurance	15	(13%)
Test Engineering	5	(4%)
Standards	6	(5%)
Other	7	(6%)

3. Which of the following categories most accurately describes your field of endeavor?

Manufacturing	17	(15%)
Independent Testing Laboratory	1	(1%)
Government	50	(45%)
Military	31	(28%)
Corporate Research and Development	10	(9%)
Design Engineering	34	(30%)
Software Development	4	(4%)
Other	11	(10%)

4a. Is MIL-STD-785 used in development programs for nonelectronic equipment at your facility when not specifically called out in military contracts?

Yes	40	(36%)
No	49	(44%)
No response	23	(21%)

4b. Do you utilize industrial requirements similar to MIL-STD-785 for development programs?

Yes	17	(15%)
No	45	(40%)
No response	50	(45%)

5. How are reliability requirements and goals specified for your development programs? (Check all that apply)

System level failure rates	90	(80%)
Probability of mission accomplisiment	73	(65%)
Safety	45	(40%)
Other	35	(31%)

6. Which factors are included in the derivation of reliability requirements and goals? (Check all that apply)

Operational environment	101	(90%)
Type of performance or acceptance testing to be satisfied	66	(59%)
Maintainability requirements	71	(63%)
Factors dictated by reliability methods to be used	40	(36%)
Development budgets allocated to reliability	32	(29%)
Production processes	17	(15%)
Cost restraints	35	(31%)
Other	21	(19%)
No response	3	(3%)

7. How are reliability program requirements incorporated in the design phase of your development program? (Check all that apply)

As a separate discipline monitoring the design engineer's efforts	59	(53%)
Integrated with maintainability design	45	(40%)
As an integral part of the design team effort	64	(57%)
By contractual requirement	69	(62%)
As a result of design analysis	40	(36%)
Integrated with system level goals	55	(49%)
Other	10	(9%)
No response	7	(6%)

8. Reliability values are apportioned to the:

System level	53	(47%)
Equipment level	67	(60%)
Unit	57	(51%)
Component	23	(21%)
No response	9	(8%)

9. What method is used at your facility to ensure that requirements are met? (Check all that apply)

Must meet specific numerical requirements or is not accepted	55	(49%)
Penalty for reduced reliability (lower price or loss of fee)	10	(9%)
RIW (Manufacturer must fix it if it fails under warranty)	28	(25%)
Incentives (Added fee or other compensation for exceeding stated reliability requirements)	28	(25%)
Qualification tests	78	(70%)
Reliability growth monitoring	61	(54%)
No response	7	(6%)

10. Does your reliability program distinguish between reliability as it affects the mission and as it affects logistics support?

Yes	70	(63%)
No	33	(29%)
No response	9	(8%)

11a. In your opinion, is MIL-STD-785 applicable to development programs involving nonelectronic equipment?

Yes	73	(65%)
No	13	(12%)
No response	26	(23%)

11b. Can its application be cost effective in establishing a reliability program for nonelectronic equipment?

Yes	70	(63%)
No	12	(11%)
No response	30	(27%)

12. What is your opinion as to the cost effectiveness of applying the following methods for nonelectronic design analysis?

FMEA - Cost effective	87	(78%)
Reliability Prediction - Cost effective	64	(57%)
Stress Analysis - Cost effective	76	(68%)
Qualification Testing Analysis - Cost effective	74	(66%)
Accelerated Testing Analysis - Cost effective	52	(46%)
Reliability Growth - Cost effective	49	(44%)
No response	8	(7%)

13. Please list the industrial, governmental or internal procedures or methods which your facility actually uses for reliability analysis of nonelectronic designs.

MIL-STD-756	35	(31%)
MIL-STD-1629	29	(26%)
ARP 926	8	(7%)
Nonelectronic Reliability Notebook	48	(43%)
Assumed stress ratios	17	(15%)
Detailed stress analysis	51	(46%)
Other	35	(31%)
No response	12	(11%)

14. Who in your facility normally performs reliability analyses of nonelectronic equipment?

Mechanical Design Engineering	28	(25%)
Electrical Design Engineering	5	(4%)
Reliability Design Engineering	67	(60%)
Quality Assurance	14	(13%)
Other	18	(16%)
No response	15	(13%)

15. What is the lowest equipment level at which you perform a reliability analysis? Use A = system, B = component, C = part

Reliability prediction	A	7	(6%)
	B	34	(30%)
	C	53	(47%)
	No response	5	(4%)
FMEA	A	8	(7%)
	B	36	(32%)
	C	41	(37%)
	No response	14	(13%)
Apportionment	A	7	(6%)
	B	52	(46%)
	C	18	(16%)
	No response	22	(20%)
Stress analysis	A	1	(1%)
	B	10	(9%)
	C	68	(61%)
	No response	20	(18%)
No response		13	(12%)

16. Are the results of reliability analyses actually used for any of the following functions or activities at your facility? Please remember that this is not a theoretical text book question and your response should be based upon your personal experience.

Design review	89	(79%)
Spare parts listings	51	(46%)
Maintenance plans	58	(52%)
Design program decisions	68	(61%)
Cost trade-off decisions	61	(54%)
Test planning	59	(53%)
Reliability growth	53	(47%)
Other	20	(18%)
No response	7	(6%)

17. Please comment on any experience you may have regarding the degree of correlation between analysis results and actual field performance.

Good	31	(28%)
Poor	20	(18%)
Conservative	7	(6%)

Optimistic	9	(8%)
No response/not applicable	45	(40%)

18a. Do you perform Failure Mode and Effects Analyses (FMEA) on nonelectronic equipment?

Yes	82	(73%)
No	23	(21%)
No response	7	(6%)

18b. If yes, are they performed: (Check all that apply)

as part of every design/development effort	45	(40%)
in event of unexpected catastrophic failures	24	(21%)
only when reliability is determined to be below contract requirements	3	(3%)
in accordance with MIL-STD-1629	29	(26%)
in accordance with ARP 926	10	(9%)
in accordance with other requirements	24	(21%)
no response	30	(27%)

19. Which of the following approaches to conducting an FMEA apply to your analyses? (Check all that apply)

bottom up	52	(46%)
top down	58	(52%)
hardware	57	(51%)
functional	70	(63%)
mission oriented	65	(58%)
safety oriented	51	(46%)
maintenance oriented	26	(23%)
quantitative critically	37	(33%)
qualitative critically	49	(44%)
no response	21	(19%)

20. Do you use reliability/maintainability predictions as an input to determine any of the following? Check one or more:

Life Cycle Costs	61	(54%)
Acquisition Costs	17	(15%)
Logistic Support Costs	65	(58%)
Development Costs	17	(15%)
Spares Requirements	76	(68%)
No response	23	(21%)

21. What sources of data do you use to predict reliability?

MIL-HDBK-217	77	(69%)
RADC Nonelectronic Reliability Notebook	66	(59%)
3-M Data	23	(21%)
AF-66 Data	17	(15%)
GIDEP	49	(44%)
MIL-HDBK-5	11	(10%)
Other	64	(57%)
No response	6	(5%)

22. Do you use reliability predictions as a means of determining whether design objectives for nonelectronic systems have been achieved?

Yes	54	(48%)
No	44	(39%)
No response	14	(13%)

23. Please comment on any experience you may have regarding the degree of correlation between reliability predictions and test results.

Good	8	(7%)
Poor	3	(3%)
Conservative	24	(21%)
Optimistic	24	(21%)
No response	53	(47%)

24. Do you include effects of overhaul or maintenance actions in your reliability predictions?

Yes	50	(45%)
No	46	(41%)
No response	16	(14%)

25. Is MIL-STD-756 a satisfactory tool for performing reliability predictions for nonelectronic equipment?

Yes	31	(28%)
No	40	(36%)
No response	41	(37%)

26. What analytical techniques do you use to perform a stress analysis?

MIL-STD-217 procedures	4	(4%)
Probabilistic Stress/Strength	7	(6%)
Conventional Engineering/Mechanical Stress/Strength	18	(16%)
Computer Aided	5	(4%)
NASTRAN/Finite Element	10	(9%)
No response/not applicable	68	(61%)

27a. Do you use MIL-HDBK-5 to assess reliability?

Yes	11	(10%)
No	25	(22%)
No response	76	(68%)

27b. Is MIL-HDBK-5 a satisfactory tool for determining properties and characteristics of materials for reliability evaluation purposes?

Yes	13	(12%)
No	14	(13%)
No response	85	(76%)

28. Describe briefly the procedures you use to assure adequate safety margins.

theoretical stress analysis	56	(50%)
piece part testing data	43	(38%)
system qualification testing	55	(49%)
probabilistic design methods	32	(29%)
stress derating	69	(62%)
other	15	(13%)
no response	20	(18%)

29. Is planned reliability growth included in your reliability programs?

Yes	58	(52%)
No	38	(34%)
No response	16	(14%)

30. How are test results incorporated into your revised growth projection?

Update old growth projection	17	(15%)
Corrective action/TAAF	5	(4%)
Graphically tailored in each case	5	(4%)
Duane plot	6	(5%)
Not performed	7	(6%)
No response	72	(64%)

31. What methods do you use to ensure that inherent design reliability is preserved during production?

None	3	(3%)
Basic quality control methods	50	(45%)
Sample testing	37	(33%)
Process inspection	19	(17%)
No response/not applicable	24	(21%)

32. Do you have any internal parts selection procedures for nonelectronic components?

Yes	56	(50%)
No	30	(27%)
No response	26	(23%)

33. Do you develop individual operational and/or environmental profiles prior to testing nonelectronic equipments?

Yes	70	(63%)
No	26	(23%)
No response	16	(14%)

34. Do you use MIL-STD-781 for testing nonelectronic equipment?

Yes	43	(38%)
No	48	(43%)
No response	21	(19%)

35. Do you use commercial procedures which are similar to MIL-STD-781 for testing nonelectronic designs?

Yes	11	(10%)
No	62	(55%)
No response	39	(35%)

36. With what type of wear out characteristics are you concerned during reliability testing?

Fatigue	31	(28%)
Corrosion	12	(11%)
Lubrication breakdown, contamination and leakage	14	(13%)
Out of specified limits	5	(4%)
Abrasion/Wear	7	(6%)
Storage	4	(4%)
None	8	(7%)
No response	51	(46%)

37. What method do you use to adjust the reliability established from laboratory test results in estimating operational reliability?

Derating factors	23	(21%)
Judgement/past experience	11	(10%)
Not performed	20	(18%)
No response	61	(54%)

38. How are accept/reject criteria established for reliability tests?

Contractually specified	16	(14%)
Past experience	10	(9%)
MIL-STD-781 procedures	23	(21%)
Tailored for each program	21	(19%)
No response/not applicable	42	(38%)

39. Do your testing procedures assume a constant failure rate distribution?

Yes	67	(60%)
No	23	(21%)
No response	22	(19%)

40. Do you believe MIL-STD-781 is appropriate for testing nonelectronic equipment?

Yes	21	(19%)
No	44	(39%)
No response	47	(42%)

41. Could MIL-STD-781 be improved to make it more applicable to nonelectronic equipment testing or should new procedures be developed?

Improvement Required	24	(21%)
New Procedures Required	43	(38%)
No Improvement or New Procedures Required	5	(4%)
No response	49	(44%)

42. What method(s) do you use to determine sample size and test time or number of test cycles when only small sample sizes are available?

Economic considerations	28	(25%)
Contract requirements	10	(9%)
MIL-STD-781 procedures	5	(4%)
Statistical (B_{10}, Chi-square, Poisson, etc.)	18	(16%)
Bayesian techniques	3	(3%)
No response/not applicable	49	(44%)

43. What method do you use to establish risk factors resulting from truncated tests?

General statistical techniques	17	(15%)
MIL-STD-781 procedures	7	(6%)
Engineering judgement	6	(5%)
Not performed	5	(4%)
No response/not applicable	77	(69%)

44. Please comment on any experience you may have regarding the degree of correlation between reliability testing and field performance results.

Good	22	(20%)
Poor	14	(13%)
Conservative	5	(4%)
Optimistic	4	(4%)
No response/not applicable	67	(60%)

45. Indicate the tests most effective at your facility for verifying nonelectronic equipments. (Check all that apply)

Vibration	81	(72%)
Temperature	80	(71%)
Humidity	62	(55%)
Shock	68	(61%)
Salt Spray	43	(38%)
Step Stress	21	(19%)
Constant Stress	25	(22%)

Progressive Stress	20	(18%)
Environmental	58	(52%)
Screening Tests	35	(31%)
Corrosion	42	(38%)
Production Processes	36	(32%)
No response/not applicable	21	(19%)

46. Please describe how reliability tests for nonelectronic equipment are normally performed at your facility.

For a specified period of time	57	(51%)
Until a predetermined number of events/cycles are completed	55	(49%)
Until a predetermined number of failures have occurred	10	(9%)
Until catastrophic failure occurs	16	(14%)
Recurring until all major failure modes are identified	7	(6%)
No response/not applicable	32	(28%)

47. Do you use accelerated testing methods to determine performance/reliability?

Yes	52	(46%)
No	40	(36%)
No response	20	(18%)

48. How do you evaluate test results in establishing quantitative reliability?

MTBF	5	(4%)
Basic statistical methods	29	(26%)
Not performed	7	(6%)
Expected level of improvement	5	(4%)
No response/not applicable	66	(59%)

49. How do you analyze the validity of your assumed failure rate distribution and its effects on test results?

Statistics/curve fitting	14	(13%)
Weibull plot	3	(3%)
Not performed	14	(13%)
Past experience	4	(4%)
No response/not applicable	77	(69%)

51. How are costs for reliability programs allocated, budgeted and monitored at your facility?

Percent of project budget	12	(11%)
Cost estimate of expected tasks	17	(15%)
Contract/project office	43	(38%)
No response/not applicable	40	(36%)

52. Have any of your government contracts specified a requirement for inclusion of a reliability centered maintenance (RCM) program?

Yes	26	(23%)
No	55	(49%)
No response	31	(28%)

53. Do government directives (Data Item Descriptions, instructions, etc.) add to the effectiveness of contractual reliability and maintainability requirements?

Yes	60	(54%)
No	22	(20%)
No response	30	(27%)

54. Is there a significant lack of standardization in the nonelectronic product world in application of terms, specifications or qualified products lists?

Yes	58	(52%)
No	14	(13%)
No response	40	(36%)

55. Should there be separate reliability specifications/standards for large equipments (flight control systems, howitzers, computers) as compared to smaller, more easily tested equipments (motors, printers, actuators)?

Yes	48	(43%)
No	29	(26%)
No response	35	(31%)

56. To your knowledge, are any of the engineering professional societies currently engaged in a productive effort to develop or upgrade standards or specifications that will have an effect on reliability/maintainability of nonelectronic equipment?

Yes	27	(24%)
No	51	(46%)
No response	34	(30%)

57. Does the added requirement of ruggedization for certain military equipment affect reliability?

Yes	45	(40%)
No	7	(6%)
No response	60	(54%)

58a. Is sufficient information available to perform reliability analysis for nonelectronic designs?

Yes	20	(18%)
No	36	(32%)
No response	56	(50%)

58b. If not, do you think a Handbook is possible which could provide procedures, guidance and material information.

Yes	60	(54%)
No	9	(8%)
No response	43	(38%)

APPENDIX C

SUMMARY OF RESPONSE
TO QUESTIONNAIRE
ON RELIABILITY PROGRAMS
FOR NONELECTRONIC DESIGNS

SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RELIABILIT

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TEST PROGRAM
1.	Fuel cart recuperator		o 785 applicable and cost effective for nonelectronic equipment but only with a mating test method o Requirements established at system level in terms of mission success o Reliability control through TAAF using CERT	o 756 not used; reliability prediction methods are ineffective	o Effective at component level for initial screen and feedback	o For production verification at system level o Computer design, CADR used	o Use 781C since it includes methods for test and reliability analysis o Budget restricts sample size/test tim
2.	Coal conversion plants, naval machinery and propulsion plants, nuclear plants, aircraft and automotive engines	Pumps, gears, seals, fans, compressors, motors, etc.	o 785 used in conjunction with IEEE Reliability Analysis Guide-785 applicable for nonelectronic equipment o Numerical requirements established at system level o Reliability control through reliability growth monitoring	o 756 not satisfactory for nonelectronic equipment because of lack of component standardization o Predictions effective for matured equipment; used for life cycle costs and spares requirements	o Effective for first-of-a-kind equipment at component and system level o Used in every program for catastrophic failures	o Effective utilization at component level o Theoretical stress analysis used to ensure adequate safety margins	o No testing performed o 781 is applicable but improvement is required - test environment often fails to simulate field conditions resulting in limited use of test data
3.	Electro-optical visual detection systems	Bioculars, periscopes, reticles, lightweight hand-operated mechanisms	o 785 used and effective o Requirements based on system level failure rates and cost restraints o Reliability control through qualification tests and RIW	o 756 used with Nonelectronic Reliability Notebook for spares requirements o 756 needs more detail and examples	o Used in event of reliability problems and/or catastrophic failures		o 781 effectively used, but needs add test levels for nonelectronic equipment o Use 810C either directly or as a guide for environmen tal profiles
4.	Commercial aircraft systems	Pumps, valves, actuators, etc.	o 785 not used, but applicable, cost effective o Reliability requirements established in terms of system level failure rate, component MTBF o Reliability control by continuous contractor/supplier interface	o 756 not used o 217, RADC, Published Airline Data very useful for reliability predictions o Overhaul/maintenance considerations must be included in reliability prediction	o ARP-926A used to detect catastrophic failures on all programs o A must for safety critical components	o Very cost effective	o 781 not used - no comment on its appli cation
5.	Hydraulic equipment, engines		o No comment on 785 or internal reliability program	o 756 not used, not satisfactory	o Not performed	o Expensive; useful only in areas of high risk	o 781 used but not appropriate for non electronic equipment o 781 requires new procedures with add distributions
6.	Military aircraft	Hydraulic, electrical and mechanical components	o 785 used and cost effective o Mission models developed to establish MFHBF requirements and system level failure rates o Reliability control through qualification tests, RIW and reliability growth monitoring	o 756 used but not satisfactory o Reliability predictions useful for mission related functional equipment o 3-M and AF-66 data used but needs much sanitizing and many assumptions to use as information base	o Performed for logistics support analysis in accordance with 1629	o Relation of stress factors to failure rates not usually available	o 781 not used and new procedures required-favors TA approach in testing program o Bayesian techniq used to determine test times when un small sample sizes available

AIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

LYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
ction n at l design,	o Use 781C since it includes methods for test and reliability analysis o Budget restricts sample size/test time	o No procedures used-not very effective	n TAAF using CERT used to ensure reliability requirements being met	o No internal part selection procedures	o Constant failure rate assumed for MTGF calculation	o Correlation between analyses and field results very poor and prediction results usually dicarded because methods for reliability analysis poor o Correlation between reliability prediction and test results poor	o For hybrid system use 781 - for completely nonelectronic a new test method is required
utiliza- ponent al stress d to ate ins	o No testing performed o 781 is applicable but improvement is required - test environment often fails to simulate field conditions resulting in limited use of test data	o Effective for first article testing, at system and component level	o Monitors to ensure requirements are met for matured equipment		o Depends on equipment under test	o Analysis results inaccurate due to lack of meaningful data base o Correlation between prediction and test poor due to different environments o Test environment failed to simulate certain field conditions	
	o 781 effectively used, but needs added test levels for nonelectronic equipment o Use 810C either directly or as a guide for environmental profiles	o Not used	o No reliability growth program	o No internal parts selection procedures	o Constant failure rate assumed	o Analyses results are conservative with respect to field performance 3:1 o Field problems caused by inadequate training of operator and maintenance personnel	o 788 provides uniform criteria - if more nonelectronic failure data were available it would have wider usage o Standardization of nonelectronic components would be very helpful
effec-	o 781 not used - no comment on its application	o No procedures used-not very effective	o Initial & mature MTBF specified and monitored o Very important to monitor in early development phase	o Internal standard parts catalogue used	o Tailored to application, usually Weibull	o Close correlation of prediction to field results in commercial airplane business because actual experience data can be used	
; useful as of	o 781 used but not appropriate for nonelectronic equipments o 781 requires new procedures with added distributions	o No procedures used but may be cost effective at system level	o Can be very effective but must be separately funded to work o TAAF used o Requirements specified based on two years from initial fielding		o Constant failure rate assumed indiscriminately; need more distribution analysis	o Prediction analysis optimistic with respect to field performance due to human error	
of stress failure ually	o 781 not used and new procedures required-favors TAAF approach in testing program o Bayesian techniques used to determine test times when only small sample sizes available	o No procedures used; has only limited experience	o Useful during development programs to predict progress towards requirements and feasibility of requirements				o Qualification tests important for uncovering failure modes with high probability of occurrence o Specs must be detailed and quantified in terms a designer can understand and measure

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SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RELIA

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS
7.	Aircraft structures, construction equipment structures, surgical implants	Primarily materials selection of structural alloys both ferrous and non-ferrous	o 785 used and applicable - cost effectiveness is system dependent o Performance ruquirements used to established system level failure rates; reliability control by qualification tests, RIW and growth monitoring	o 756 used, but not satisfactory	o 1629 used o FMEA's cost effective for system only	o Useful for components o NASTRAN finite element computer program used
8.	Aircraft systems, airfield equipments and control gear	Hydraulic, electrical, fuel, and gaseous components of aircraft equipment	o 785 not used o Use UK Ministry of Defense Standard 00-40 "Achievement of Reliability and Maintainability" o Requirements based on mission success probability o incentives used in verifying reliability	o 756 not used o Difficult to quantify cost effectiveness of prediction effort but essential o UK data bases normally used	o Well worth effort at all indenture levels if done at correct time	o Essential where meaningful, i.e. pressure vessels, undercarriages, etc.
9.	Heavy machinery, vehicles, home appliances, computer hardware, etc.	Turbines, pumps, high speed printer, etc.	o 785 applicable, used as guide - internal procedures used	o Internal procedures used o In-house failure rate data bank used	o Applicable to subsystem, system o Best for new products and in event of catastrophic failures	o Used on critical structural components
10.	Fighter aircraft systems	Engines, munitions, and support equipment	o No comment on 785 or internal reliability program	o No comment on 756 o Predictions are required for determining inspection intervals and maintenance plans o Difficult for non-electronic parts because many are specifically designed and non-standardized	o Vital to RCM method of determining system/unit inspection requirements	o Very important to load bearing components particularly where redundancy is not possible
11.	Flight Control servo mechanisms	Servos	o 785 not used - reliability requirements established in terms of MTBF for accentance test o Test results used to determine corrective action	o 756 satisfactory o Predictions give approximate MTBF for use as yardstick to measure proposals	o ARP-926 used o Very effective-pinpoints safety critical aspects early in design stage	o 217 used o Very effective to detect piece - parts not properly derated in design
12.	Nuclear power plant systems	Valves, pumps, piping	o 785 effective, but used as a reference only; in-house standards utilized o Numerical reliability requirements established at system level; reliability control by qualification tests	o 756 not satisfactory and new procedures need to be developed o Predictions cost effective but methods need improvement o In-house data used for predictions	o Use in-house FMECA which is suitable for analyzing nonelectronic systems	

NAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

STRESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
o Useful for components o NASTRAN finite element computer program used	o Mechanical operational environment established for each test program	o System dependent; effective for many missile systems o Salt spray and overstress tests to determine fatigue characteristics			o Gaussian, Weibull, log normal used for evaluating test results		
Essential where eaningful, i.e. ressure vessels ndercarriages, etc.	o 781 used, new procedures to include related software required o A factor of 2-3 applied to test results in estimating field reliability	o Could be cost effective if proven methods existed	o Very cost effective for components o Duane model assumed		o Constant and normal failure rate assumed	o Prediction analysis to field results are optimistic by 1.5-5:1 o Reliability analysis to test results are optimistic by 2:1 o Reliability testing to field results are optimistic by 2:1	o Past experience and improved technology determine reliability requirements
Used on critical tructural compon- nts	o 781 not used - in-house testing standard used o Start in early stages for greatest effectiveness o Qualification tests by sampling used to ensure reliability requirements are met	o Performed according to product by in-house standards	o Target established for each year after development; measured by field service	o Used for ball bearings, springs, etc.	o Do not assume constant failure rate; considering Weibull o For small sample size use marginal analysis for approximate distribution of life	o Difficult to make common conclusions	o 781 should consider impact of assembly and positional adjustment, i.e. adjusting screw o Correlation/reference of field data needed in 756 o Reliability programs must be individually tailored
Very important to oad bearing com- onents particularly here redundancy is ot possible	o DT&E, OT&E, SEOS used to ensure reliability requirements are met o Tests structured for performance; reliability usually piggyback	o Important for components subject to wear out	o Effective at total system level only			o Reliability testing is hardware oriented whereas field performance is influenced by personnel training, support equipment, etc., which changes outcome	o Reliability approach is the same for nonelectronics and electronics at system level o Reliability programs need more emphasis on logistics support
217 used Very effective to tect piece - parts t properly derated design	o 781 used for accept-reject criteria but not applicable - new procedures required o Qualification testing performed to determine recurring failures for corrective action	o Performed to search for failure modes only	o Effective for pinpointing improperly derated pice-parts o MTBF growth curves part of contractual requirements	o Company standards book	o Constant failure rate assumed	o Field MTBF 60% of predicted	o 781 used when possible, otherwise tests search for failure modes o Handbook possible on specific system basis only
	o 781 not used - new procedures required	o Use in-house standards	o Field performance failure data used to maintain reliability growth			o Not enough field service time for comparison	

SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RELI

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TE
13.	Armored vehicles, anti-tank guided missiles, artillery		o 785 not used but applicable - analysis only; no reliability programs developed o Distinguishes between reliability as it effects mission and logistics in system simulation model	o Reliability values are furnished by contractor for use in operational research type analysis			
14.	MX Second Stage, Polaris, Minuteman	Nozzle, flex seal, thrust vector actuator, etc.	o 785 often used but needs tailoring to delete "electronics" requirements o System level failure rates established for contractual requirements o Flight reliability verified based on experiencing zero critical failures	o 756 not used as contract requirement o Stress/strength calculations, design margin requirements and engineering estimates used for predictions	o Used to interface reliability with design for early problem identification, later used to quantify failure modes		o In-ho used in
15.	Trailers for Ground Launched Cruise Missile	Trailer-lift actuator	o 785 not used but applicable o Requirements based on mission success probability by operational environment and maintainability requirements	o 756 not satisfactory - implies exponential distribution			o 781 n ment o Accep teria e per 781C o Test reduced of 1.5- operati bility
16.		Mounting trays, avionics racks, housing and nonelectronic components of avionics units	o Normally has reliability guarantees which impose free consignment spares, "no cost" redesign and retrofit until guarantee is met o MIL-STD-785 not used	o Prior product data in same operational environment is <u>by far</u> the best source	o Used on safety critical components per ARP-926		
17.	Solid fuel propulsion system, graphite composite structures	Rocket motor parts, insulators, nozzles, igniters, etc.	o Numerical requirements based on mission success probability by operational environment and production processes; reliability control by qualification test and reliability growth monitoring with incentives o MIL-STD-785 not used	o 756 not used o Prediction is excellent quantitative audit of engineering design o Detailed probabilistic analyses performed to evaluate predicted reliability	o Internal procedures used	o Used for predictions o Finite element analysis performed at part level	o Tests verify charact reliabi perform
18.	Missile control systems	Actuators, gyros	o 785 not used but applicable and cost effective o Requirements based on mission success probability; reliability control by qualification test and reliability growth monitoring	o 756 satisfactory but predictions have minimal effectiveness	o Not cost effective at any level but used in every design effort per 1629		o 781 n appropr

ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

SIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
						o Analysis results are usually optimistic in comparison to test and field results	
	o In-house standards used in lieu of 781	o Temperature extremes used to identify age-sensitive materials	o Used to monitor reliability progress and identify problem components	o Use standards manual per AFR 73-1 and SAMSO		o Insufficient data in stand-by operational mode of missiles	o Handbook should provide easy way to tailor requirements and documents o Matrix should be developed to identify requirements versus program phase
	o 781 needs improvement o Accept/reject criteria established per 781C o Test results reduced by a factor of 1.5-2 to predict operational reliability						
			o Monitored by in-service operational reliability reports from users (Airlines)	o Reliability components engineering and mechanical engineering maintain a non-electronics approved vendors parts listing		o After approximately 3 years of agressive reliability growth analytical results are exceeded in service by 20-50%	
edic- ent ormed	o Tests performed to verify no wearout characteristics - no reliability tests performed	o Used where tests are very costly as with rocket motors per internal procedures		o Internal standardized parts program	o Binomial used for testing "one-shot" devices	o Number of tests too small for comparison	o Government directives just generate "paper work" for reporting purposes o Sufficient information from in-house data for reliability analysis - no handbook needed
	o 781 not used, not appropriate	o None performed					o Sufficient information does not exist for reliability analysis for non-electronic designs

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SUMMARY OF RESPONSE TO QUESTIONNAIRE ON

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS
19.	Ground jammer radar system, modular threat emitter radar system	Servomotors, air conditioners, blowers, gear trains	o 785 used and effective depending on application o Numerical requirements specified in terms of system level failure rate and mission success probability; reliability control by qualification test	o 756 used o Useful at component to system level on a parts count basis and application environment	o Not performed o Cost effective from line replaceable unit to system level o Piece part FMEA useful for critical areas	o Performed per 217 o May not be cost effective for non-electronic designs
20.	Battle tanks, generator sets, fuel systems	Pumps and other components constituting referenced systems	o 785 applicable and cost effective o Numerical requirements specified in terms of system level failure rate and mission success probability; control by qualification tests and RIW with incentives	o 756 not satisfactory o Predictions used for life cycle and logistics support costs and spares requirements		
21.	Earthmoving and construction equipment		o 785 not used, no comment on application o Reliability requirements specified in terms of system level failure rate; reliability control by growth monitoring			
22.	Radar systems, displays, communication systems	Antennas, pedestals, motors, gyros, brushes, etc.	o 785 not used - not applicable for non-electronic equipment - electronics oriented o Numerical requirements specified in terms of system level failure rate and mission success probability; reliability control by qualification test	o 756 not useful o Corporate field data used for prediction	o Not performed	
23.	Structures, pneumatics, hydraulics, mechanisms	Metallic and composite structures, valves, drive systems, regulators, etc.	o 785 applicable and cost effective but not used o Numerical requirements specified in terms of system level failure rate o Analyses and tests used to demonstrate reliability for small quantity programs	o Good for qualitative decision when evaluating concepts or performing trade-offs	o Excellent to component level o Performed on every major design effort to support system safety in accordance with ARP-926	
24.	Ground launched cruise missile	Launch control center	o 785 used sparingly, needs considerable modification o Requirements based mainly on availability and dormancy o Money spent on reliability programs depends upon HQ pressure or when things fall apart	o 756 unsatisfactory	o Should be integrated with system safety program and LSA	

STIONNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

STRESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
o Performed per 217 o May not be cost effective for nonelectronic designs	o 781C used and appropriate - needs improvement o Individual operational and environment profiles developed based on unique operation scenario	o Not performed o May not be cost effective	o Not performed o May not be cost effective		o Constant failure rate assumed	o Analysis to field data optimistic by 2:1	o High risk/short time test plans per 781 used for small sample sizes
	o 781 used o For small sample sizes - ask for all samples possible within budget restraints			o MIL-STD-965 used			
		o Full scale testing performed to determine fatigue life	o Used to ensure requirements are met o Needed to determine if first production machine has reasonable reliability			o Good if field stresses and cycles are accurately defined	o Final reliability improvement occurs after field data collected and corrective action taken
	o 781 used but not appropriate for nonelectronic equipment - new mechanically oriented procedures required o Test results used to monitor reliability growth	o Accelerated temperature tests performed		o In-house standardized mechanical parts listing	o Constant failure rate assumed	o Reasonable field correlation dependent on sophistication and training of operating personnel	o Has not seen any nonelectronic programs requiring reliability engineering activities o DID's and specifications differ-good review for Government/Industry panel
	o 781 appropriate but not used						o Reliability programs budgeted by percent of project cost o DID's of excellent value
	o 781C not appropriate-need new document with normal and Weibull distributions o Specified environment and estimate of service use profile developed		o Used for system and major subsystems and selected components	o Internal procedures used o Significant lack of standardization		o Insufficient field usage data available to correlate results	o Reliability programs not as well integrated into overall picture as they should be

SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RELIAB

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TEST
25.	Tanks, aircraft, trucks	Guns, missiles, etc.	o 785 not used o Numerical requirements specified in terms of system level failure rate and mission success probability				o Fixed l plans use sample st o Hardwar always t approved mode o Basic AR 702-3
26.	Sonobuoys	Pneumatically activated flotation equipment	o Various elements of 785 tailored to specific need o Test results used for reliability improvement purposes - main thrust of reliability program is contribution to design effort	o 756 too old and provides no data o Predictions are a good reliability monitor of design evolution o Non-electronic aspects of electronic system are usually a small contribution to total failure rate	o Performed per 1629 o Practical only for systems	o Reliance on engineering analysis of yield strength margins and safety	o 781 use phasis pl product rather th ics o All sam terminate design u pensate f statistic tainty of tests
27.	Personal computers	Keyboards, floppy disk drives, winchester disk drives	o 785 applicable but not used - similar internal procedures used o Reliability requirements driven by competitive products and customer service needs; reliability control by qualification test and growth monitoring	o 756 not used o In-house data provides greatest utility o Field failure rate predicted to be 2:1 over laboratory tests	o Not performed		o 781 use modified rules-int cedures u o Tests b pected cu usage of o 781 nee appropri plans
28.		Radar structures, aircraft structural modifications for electronic equipment	o 785 used but only partially applicable o Numerical requirement specified in terms of system level failure rate and mission success probability; reliability control by qualification test	o 756 used, but not satisfactory for nonelectronic equipment			o 781 use appropri nonelect ment
29.	Aircraft towbars	Structural portions of fire control pads	o 785 not used but applicable o Reliability program requirements depen.. on the program and what type of incentives dictated by reliability engineer	o 756 used, applicable o Field failure rate predicted to be 4-7:1 over laboratory tests	o Performed on most programs		o Produc cation t ensure liabilit XVIII C o For n 781 need failure bution o For s sizes C confide
30.	Aircraft control systems		o 785 not used - no comment on its application o Numerical requirements specified in terms of system level failure rate and safety factors	o Prediction based mainly on service reports	o Performed in event of unexpected catastrophic failure and when required by contract		o 781 n o Operat ronment establi

TIONNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

	STRESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
		o Fixed length test plans used for small sample sizes o Hardware items always tested to an approved operational mode o Basic guidance per AR 702-3				o Constant failure rate assumed		o Test results include usage of replacement parts, special tools, manuals and maint. time for cost of ownership predictions o Operator/maintainer error needs more investigation-often escalates cost of ownership
29 or	o Reliance on engineering analysis of yield strength margins and safety	o 781 used but emphasis placed on product improvement rather than statistics o All sample tests terminated - over - design used to compensate for the statistical uncertainty of sampling tests	o Performed only when normal usage/testing fails to precipitate failures				o Too many human variables in the recording of failures (relevancy, accountability and other extenuating circumstances) to achieve worthwhile data or any kind of correlation	o Qualification testing good for important "first alert" of trouble and should be recognized as such o Mission/logistics reliability often contractually required with little guidance
		o 781 used with modified procedures/rules-internal procedures used o Tests based on expected customer usage of equipment o 781 needs more appropriate test plans	o Used for printer products at component level		o Implemented by components engineering group	o Constant failure rate assumed only because nonelectronic equipment tested is part of primarily electronic system	o Field reports are too contradictory to to draw conclusions	o Reliability allocated by % of total budget to satisfy the need to be competitive
		o 781 used but not appropriate for nonelectronic equipment	o Not performed		o MIL-STD-965 used	o Assumed distribution depends on type of test and equipment design	o Analysis to field results optimistic by 2-5:1 o Test results to field results optimistic by 2-4:1	
t		o Production verification testing to ensure inherent reliability per 781C XVIII C performed o For nonelectronics, 781 needs revised failure rate distribution o For small sample sizes Chi-square 50% confidence used						
nt - nd		o 781 not used o Operational/environmental profiles established	o Perform fatigue and endurance tests	o Fatigue test results, i.e. crack initiation and growth rates, reflected in inspection program	o Procedures used for highly stressed and critical parts	o Testing procedures assume Weibull, log normal, normal	o Analysis to field results correlation poor due to unpredicted failure modes or nonrecognition of dependence	

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SUMMARY OF RESPONSE TO QUESTIONNAIRE ON

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS/ANALYSIS
31.	Guns, tanks, earth moving equipment	Engines, transmissions, gun tubes, pumps	o 785 used but needs extensive modification - different qualification tests geared towards non-electronic equipment o Numerical requirements in terms of system level failure rates and mission success probability	o 756 unsatisfactory o Government data banks useful to agree upon contractual requirements but need improvement	o Performed where known problems exist or if required under contract	o Effective - overstress one major source of problems
32.		Airframe bearings	o Not involved with reliability program requirements	o 3-M and flight test data used		
33.	Propulsion systems, kinetic energy systems	Accelerometers, motors, gears, springs, bearings, flywheels	o Numerical requirements specified in terms of system level failure rates and safety o 785 not used but applicable	o 756 used, satisfactory	o Performed in accordance with 1629	o Effective for critical parts only o NASTRAN analysis used
34.	Electromechanical production line equipment	Miscellaneous electromechanical components and arming/fuzing devices	o 785 used, applicable o Requirements established in terms of mission success probability; reliability control by growth monitoring	o 756 unsatisfactory	o Performed only if contractually required	o Probabilistic stress/strength techniques used
35.		Actuators, gear boxes, transmissions, hoists, winches	o 785 not used but applicable o Numerical requirements specified in terms of system level failure rates and safety; reliability control by growth monitoring	o 756 used for qualitative prediction o Predictions may be cost effective depending on accuracy/detail of prediction	o Performed if required by contract according to 1629 or other specified document	o NASTRAN analysis used
36.	Helicopters, weapon subsystems, rotor subsystems		o 785 not used - use tailored specifications to satisfy mission needs of major components o Requirements/goals based mainly on system MTBR and safety o 785 not applicable to development programs		o Absolutely needed and should be used throughout development and into fielding	

TIONNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

STRESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
o Effective - overstress one major source of problems	o 781 used o Qualification testing needed - otherwisw reliability is a guess	o Not effective	o Started out as simple management tool-has become too mathematically complex-should return to Adam and Eve stage	o Left up to designers	o Constant failure rate assumed usually	o Wide dispersion between analyses, lab tests and field performance - lab tests are "worst case" and field use reflects inadequate training	o Reliability requirements usually are a compromise between customer wants and state of the art
	o Test plans tailored to include environment; based on past experience o Laboratory tests used to guide selection of parts for best performance				o Weibull or normal		o Prefer sample sizes of at least 6 to obtain B10 life
o Effective for critical parts only o NASTRAN analysis used	o 781 not appropriate - new procedures need TAAF growth test		o Will be getting more use and become cost effective as experience is gained		o Constant failure rate assumed		
o Probabilistic stress/strength techniques used	o 781 not used o Accept/reject criteria established from FMECA		o Reliability growth monitored by testing		o Constant failure rate assumed	o Prediction optimistic over test and field results - tests provide a pessimistic assessment of operational experiences	
o NASTRAN analysis used	o 781 used, applicable, but needs improvement - eliminate burn-in, temperature cycling and other electronic testing techniques	o May precipitate failures that would never occur in normal service o Overspeed/overtorque tests performed	o Reliability growth monitored by Duane plots		o Constant failure rate assumed o Use Chi-square distribution to establish quantitative reliability	o Field MTBF exceeded prediction and test results	
	o 781 used but considered unsatisfactory for nonelectronic equipment o 781 should define the techniques and methods to relate predictions to each other	o Procedures designed by contractors not well enough defined but considered absolutely necessary	o Not peformed o Difficult to measure because of numerous design changes after first production run		o Constant failure rate assumed	o Field results much worse than predicted	o Trying to integrate reliability program as part of design team effort o Better DoD control of field reliability data is required o Need a detailed study of weight reduction effects on system reliability

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SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RE

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	
37.	Pneumatic systems	Cylinders, valves	o 785 not applicable to fluid power; use ANSI and NFPA methods o Total system reliability, safety and repairability specified for development program; reliability control by qualification test and RIW	o 756 unsatisfactory-internal procedures used	o Not performed		o 78 to m equi at m
38.	Radar system pedestals, reflectors, water coolers, air conditioners	Motors, valves, gear trains, bearings, gyros, gauges	o 785 not used, not applicable o Numerical requirements specified in terms of system level failure rate and mission success probability; reliability control by qualification test and growth monitoring	o 756 unsatisfactory o Inadequate data available for effective prediction	o Performed per 1629 in event of unexpected catastrophic failure o Effective on any type equipment	o Designers perform a computerized stress analysis o Very effective as a design and reliability tool but reliability know how is not always available	o 781 appli
39.	Solid rocket motors		o 785 not used but applicable o Reliability requirements established in terms of safety and mission success probability; control by qualification test and growth monitoring with incentives	o Observed and demonstrated reliability compared with requirements	o Performed on every design effort	o Strength and stress distributions compared at lowest level which has data available	o Succ data e maximu comput
40.	Air Defense Missile System	Launchers, power generators, air conditioners, vehicles, handling equipment	o Reliability usually specified in terms of system effectiveness; reliability control by qualification test and growth monitoring with incentives o 785 not used but applicable	o Predictions usually not valid - data does not fit actual operating field conditions	o 1629 contractually required		o 781 o Test identi predict tions o Relia ing use design predict ic prod perform
41.	Automatic and manual lubrication systems	Thermistors, pumps, gauges, meter units, hydraulic components	o 100% parts inspection used o Reliability specified in terms of system level failure rate; reliability control by RIW	o Predictions are guesses only while testing results are specific o 1/2 laboratory life results used to estimate field operational reliability	o Not performed	o Metallurgical stress tests performed on all metal parts	o Field is the to test their form o Accep teria confirm establi
42.	o Power generation, transmission and distribution equipment and systems	Generators, turbines, boilers, pumps, motors, etc.	o Developed own reliability standards based on 785 o Reliability specified in terms of system level failure rate; reliability control by RIW and penalties for reduced reliability	o 756 not used but satisfactory o Predictions are very cost effective at component level o IEEE Project 500 is most applicable for reliability predictions o Fault trees are good predictors of field performance	o Performed under contract per 1629 o Very cost effective since anaysis results can be used in many ways		o 781 n - new p require

NAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

ESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
	o 781 not applicable to nonelectronic equipment especially at system level	o Increased cycle rate tests performed	o Product Problem Reports program used				o Military standards are often written on items they should not and in an unnecessarily restrictive manner
signers perform mputerized ss analysis ry effective as sign and relia- ty tool but re- bility know how t always avail- e	o 781 used but not applicable	o Not performed - validity of techniques uncertain and not fully proven	o Duane model used to incorporate test results into revised growth projection o When tied in with a test-analyze-fix program it could be effective	o PPSL "DISC" controlled parts	o Constant failure rate assumed for electronic equipment	o Insufficient field service data for nonelectronic items	
rength and ss distributions pared at lowest l which has data ilable	o Success/failure data evaluated by maximum likelihood computer program	o Good on lower indenture levels - may be misleading on upper levels o Tests performed at elevated temperatures	o Requirements specified by customer		o Assumption of constant failure rate tested statistically in aging and accelerated aging tests	o Analysis/test/field use results all show gond correlation	o Probabilistic stress/strength analysis is the most effective method to estimate reliability -should receive more emphasis
	o 781 not applicable o Tests usually identify errors in prediction assumptions o Reliability testing used to influence design not field predictions - periodic production tests performed	o Perform overstress, step-stress and test-to-failure for critical hardware	o Growth is tracked but not usually valid for prediction o Threshold values at specified program review points established		o Constant failure rate assumed	o Correlations have not been good - can be very misleading	
tallurgical s tests per- d on all metal s	o Field performance is the only method to test products and their ability to perform o Accept/reject criteria based on 95% confirmation to established standards	o Increased cycle times test performed only to prove durability	o Growth requirements specified and measured by comparison to previous models under exact conditions		o Constant failure rate assumed		o Only the government generates its own terms and specifications which tend to be excessive and costly o Manufacturers should be required to specify equipment reliability and then be responsible through warranty program
	o 781 not applicable - new procedures required	o No accelerated tests performed - can't always associate stress of test with level of accelerated life				o Prediction results are optimistic with respect to test results	

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SUMMARY OF RESPONSE TO QUESTIONNAIRE

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS
43.	Aircraft systems and equipment, power plants, structures		o 785 used as specified by LSA requirements o Involvement in RCM analysis - no reliability programs developed	o When 3-M data is unavailable, contractor predictions are used	o Performed as part of every design effort	
44.	Solenoid and air operated directional air control valves	Instrumentation included in referenced systems	o Developed own standards o 100% check on all finished products o Roving inspectors monitor machine assembly operations o Reliability control by qualification test and RIW	o Use own lab test results		o Performed on all components on an o going basis in accordance with in ternal procedures
45.	Automobiles, trucks, engines, pumps, gearboxes	Shafts, gears, bearings, housings etc.	o Reliability requirements established in terms of system level failure rate and mission success probability; reliability control by qualification test and growth monitoring o 785 not used, but applicable		o Performed as part of some design efforts or in event of unexpected catastrophic failure	
46.	Tactical generator sets	Gas turbine engines, control systems	o 785 used; cost effective with careful application and judgment o Reliability requirements established in terms of system level failure rate and mission success probability; reliability control by qualification test	o Use contractor and commercially available methods for bearings, gears, etc.		o Uses finite element, thermal and mechanical analysis at component level
47.		Generators and other components which support communications systems	o 785 not used but applicable o Operational availability requirements established per AR702-3 in terms of equipment MTBF; reliability control by qualification test	o 756 satisfactory o Predictions based on similar types of equipment		o 217 used at black box level
48.	Transit equipment and systems		o 785 not applicable or used directly but some basic tenants can/should be considered and used for all equipment programs o Reliability requirements established in terms of system level failure rate, mission success probability and safety	o Predictions are very dependent on environment and operational factors, usually not well defined o Predictions often derived and based on similar types of equipment	o Limited value - often performed too early or with inadequate operational and environmental knowledge	

IONNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

STRESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
							o ILS programs need to be used to minimise duplication
Performed on all mponents on an on- ing basis in cordance with in- rnal procedures	o Uses NFPA and ANSI standards o Qualification tests based on number of cycles performed	o Performed on all assemblies - sometimes in conjunction with life tests to establish life guarantee and to detect potential failure modes				o Good correlation betweem test results and field use	
	o The most effentive method to ensure adequate safety margins involves testing the now design and comparing results with previous designs	o For small sample sizes accelerated tests are essential and very effective			o Normally assume Weibull distribution for testing		
Uses finite ele- nt, thermal and chanical analysis t component level	o 781 applicable - no changes required o Must meet specific numerical requirements in qualification tests		o Not currently used in programs - probably should be				
217 used at black x level	o Accept/reject criteria based on MTBF during 60 day field test or in accordance with 781C o 781 needs tests other than exponential				o Constant failure rate assumed	o Correlation between reliability predictions and test results is good as long as initial prediction is updated	
		o Difficult to see exact relationship to increased level of "stress" on non-electronic equipment o Performs accelerated accumulation of duty cycles, often not at an accelerated level of stress		o "Previous Transit Qualified" (i.e., a type of QPL) being established for many large components		o Correlations very poor - too many variables and questionable prediction techniques	

SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RELIAB

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TEST
49.	Tandem rotor helicopters	All components constituting system	o 785 not used but applicable o Requirements/goals derived from expected level of improvement in removal rates over older systems o Reliability control by growth monitoring	o Block diagrams, allocations and predictions used for reliability analysis o Maintenance operational adjustment factors used for reliability prediction			o 781 not o Goals se sis force an agressi program in meet goals
50.	Optics, RCS systems	Fasteners, RCS components	o 785 cost effectiveness depends on cost of program and criticality of reliability goals o Reliability requirements established in terms of MTBF and mission success probability; reliability control by qualification test and growth monitoring	o 756 not used - data sources provide inadequate failure mode ratios	o Performed in every design effort at all levels per 1629		o 781 not to nonelec equipment - test plans o Test resu to evaluate bility and based on te and failure
51.	Tactical aircraft, missiles/launch vehicles	Hydraulics, turbofan engines, gas generators	o 785 used, applicable o Reliability requirements established in terms of system, subsystem and component MTBF; reliability control by system level testing and growth monitoring	o Low effectiveness-prediction factors not well understood	o Performed only if called out in contract - moderate effectiveness	o Used effectively to form a basis - then modify and adjust from test experience	o 781B used o Wear-out in enduranc
52.	Missile control systems, rocket engines, fuzes, launchers, etc.	Valves, pumps, structures, motors, bearings, actuators, etc.	o 785 used but considered not applicable - does not solve unreliable nonelectronic equipment problems o Uses Engineering Practices Manual - Reliability 1980	o 756 unsatisfactory-recommend RADC Notebook and MIL-STD-XXX Reliability Stress Analysis (Draft) o Useful to determine if requirements can be met and if and where improvements are necessary	o Uses bottom up "hardware approach" per task 101 paragraph 3.1 of 1629A o Should be done early to identify major problem areas-otherwise not effective	o Most cost effective method for improving nonelectronic reliability-must be approached on a strength vs. stress basis	o 781 nnt u appropriate o Qualificat are mandato uncover pro missed by an methods o Perform p reliability tion tests
53.	Aircraft, munitions, missiles	Landing gear, airframe, engines, rocket motors	o 786 not used but applicable o Reliability requirements not established at this facility; reliability growth models and mission success models used for evaluation of requirements	o 217 predictions unsatisfactory as they only look at piece parts vs. total system and do not consider the real world environment o RADC Notebook used	o Required in the development process to identify early corrective actions and reduce overall failure rates		o 781 not u o Growth mo dated with results vs. tion
54.	Liquid rocket propulsion (engines), marine propulsion (fans and pumps)	Valves, nozzles, gas generators, injectors, etc.	o 785 used and applicable when tailored to eliminate those specific requirements that aru unique to electronic equipment o Reliability specified in terms of life/durability requirements; reliability control by growth monitoring with incentives/penalties	o Can be an effective tool for supporting conceptual and detailed design efforts if the predictions are based upon "hard" data from similar products	o Very effective tool at all levels if it is performed in conjunction with the conceptual and detailed design effort	o Necessary design requirement but not normally applied effectively - most designs are to specified margins with no correlation to numerical reliability requirements	o Very few require test demonstrate termined rel due to cost ations

AIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

SS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
	o 781 not appropriate o Goals set by analysis force pursuit of an agressive TAAF program in field to meet goals	o Overtorque and overtemperature tests used on specific components - K factors used to predict reliability			o Constant failure rate assumed		o Poisson table used for accept/reject criterion and risk factors
	o 781 not appropriate to nonelectronic equipment - Weibull test plans needed o Test results used to evaluate reliability and confidence based on test time and failures				o For small sample sizes - binomial for specimen reliability requirements-Weibull for specimen test time requirements		o Safety margins established through probabilistic stress/strength methods o Failure mode information is notoriously inadequate
effectively m a basis - odify and from test ence	o 781B used o Wear-out examined in endurance testing			o A central driving force for parts standardization is needed	o Constant failure rate assumed	o Poor numerical correlations - qualitative aspects of prediction may be more useful	o Error from constant failure rate assumptions significantly less than errors caused by data translation, small sample sizes, etc.
cost effec- ethod for im- g nonelectron- iability-must proached on a th vs. stress	o 781 not used, not appropriate o Qualification tests are mandatory to uncover problem areas missed by analytical methods o Perform production reliability verification tests	o Best method for measuring system life early in development phase o Method for accelerated to real time conversion is needed o Arrhenius relationship used - minimum N=5; N=30 desired	o Good management tool for tracking development program o AMSAA or similar model used	o Use published designers handbook (approved parts list) o Large design variance between mechanical equipment - standardization must be based on commonality	o Plot results on Weibull paper to check for increasing wear-out type failure when assuming constant failure rate	o Math model reliability predictions ± 2% of field test results after maturity	o Nonelectronic equipment failures in field can often be traced to improper stress/strength analysis in design
	o 781 not used o Growth model updated with test results vs. prediction	o Needs to be performed on munition systems that spend the majority of their life in the dormant state	o Used to determine the expected impact of reliability on the total system maturity		o Constant failure rate assumed	o Good correlations if reliability is evaluated under correct field conditions	
sary design ment but not ly applied ively - most are to ied margins o correlation rical relia- requirements	o Very few items require testing to demonstrate a predetermined reliability due to cost considerations	o Seldom used since results cannot be correlated to equipment reliability level at nominal conditions	o Cumulative failures vs. cumulative test experience is a very powerful tool for nonelectronic equipments o Monitoring of reliability growth rates is an "absolute must do" to support program decisions		o Constant failure rate assumed	o Very good analysis/field system level correlation	o Probabilistic design methods should be encouraged when weight is a problem o Reliability specifications for large vs. small rockets should be handled differently due to high cost of testing higher thrust devices

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SUMMARY OF RESPONSE TO QUESTIONNAIRE ON

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS
55.	Air compressors, pumps, clutches, engines, controllable pitch propellers	Valves, bearings and other components for referenced systems	o 785 applicable o Computer modeling used to determine top level reliability requirements o Reliability growth monitoring used to ensure requirements are met	o 756 unsatisfactory o TIGER computer program identifies critical equipments where reliability improvement would be most cost effective	o Performed only if required under contract per 1629 o Effective in identifying equipments with high probability of failure	
56.	Aircraft subsystems	Nonelectronic aircraft equipment	o 785 applicable o Reliability programs contain similar task elements to 785 and are tailored to specific program o Reliability requirements established in terms of system level failure rates with extensive use of math models	o Provides assurance of meeting specified reliability requirements and tracking achievement as the program develops	o Used for early determination of failure modes and evaluation of their criticality to facilitate timely revisions o Internal procedures correlate closely to 1629	
57.	Generators, air conditioning units, printers, etc.	Switches, relays, gears, motors, etc.	o 785 not used but considered applicable o Reliability requirements established in terms of system level failure rates and mission success probability; reliability control by qualification test and growth monitoring	o 756 not adequate for mostly mechanical systems o Cost effective if accurate part level failure rates are available o Specifying numerical reliability to nonelectronic equipments should be discontinued	o Performed if required by contract per 1629 o Cost effective for mission critical failures o Top down (fault tree) on critical items only	o Very cost effective at part level
58.	Fuel systems, power trains, suspensions	Sensors, hydraulics, automotive controls	o 785 used and applicable o Reliability requirements established in terms of system level failure rates and mission success probability; reliability control by growth monitoring	o 756 not satisfactory o Internally controlled test data base used for nonelectronic components	o Not effective - use only if required by contract per 1629 and ARP-926	
59.	Navy and Air Force aircraft, hydrofoil, gun-boats, windmills, solar hot water heaters		o 785 used and applicable o Reliability requirements established in terms of system level failure rates and mission success probability o Many requirements have reliability demonstration requirements and limited RIW			
60.		Flight instruments, sensors, gyros	o Tasks tailored for each program similar to 785 o Requirements established in terms of MTBF	o 756 not satisfactory o K-Factors from past experience used to adjust lab tests to field reliability predictions o GIDEP and internal experience used for failure rates	o Performed only on safety related equipments o Necessary but difficult to assign failure modes and distributions to piece parts	

TIONNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

STRESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
	o 781 used but not appropriate o Test results used to update computer program o Maintainability demonstration tests give MTTR data		o Used to ensure the top level requirements of the ship are met during development and construction phase		o Constant failure rate assumed	o FRAP program predictions have matched fleet performance of sampled equipment	o A handbook is needed which approaches reliability analysis from a mechanical design viewpoint where stress analysis is included
	o New 781 procedures needed with test conditions for nonelectronic components such as hydraulic actuators and control valves o Factors are applied to lab tests to account for the proposed use environment		o Assessment of achieved reliability against good growth curves can warn of the possibility of not meeting requirements	o A Program Parts Selection List is developed by internal standards function	o During flight tests MTBF's are calculated and assumed to follow constant failure rate		o Component operational and logistics reliability predictions are used in models to determine system mission and logistics reliability then compared to reliability requirements/goals
o Very cost effective at part level	o 781 not appropriate o Test results are used to recalculate cumulative and instantaneous MTBF	o Use elevated temperature, temperature cycling and vibration with uncertain effectiveness	o Customer applies the Duane model requesting a growth rate (alpha)	o Use a series of standard parts manuals	o Constant failure rate assumed	o Good prediction, test, field use correlations for mature systems	o In development of ground radar systems nonelectronic parts represented 10% of predicted failure rate but 80% of actual failure rate due to lack of reliability attention to nonelectronic items
	o Not feasible to adjust lab test results to estimate field reliability		o Growth requirements specified and measured by Duane model		o Constant failure rate assumed	o Good correlation between test, prediction and field use results	
	o 781 applicable and used for testing o Previous experience and operational ratios determined from lab testing used to adjust lab to field reliability	o Used on a limited basis only			o Constant failure rate assumed, however, have tracking growth models	o "Rule of thumb" - testing 3X better than field performance	o For small sample sizes, cost effectiveness based on failure impact determines number of test samples o Achievement of reliability for nonelectronic devices requires a standardization program
	o 781 used and appropriate o Reliability demonstration/evaluation tests used to ensure requirements are met	o Useful and cost effective for parts where fatigue is of concern o Temperature cycling used	o Monitored using field data	o Use company preferred standard parts list	o Constant failure rate assumed	o Good correlations when based on past field performance data	o Uses series model for logistics support, mission reliability block diagram for mission requirements

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SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RELIA

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TEST
61.	Commercial transport airplane systems - electronic and non-electronic	Components of referenced systems	o Requirements/goals based on component MTBF warranties o Probability studies of dispatching an airplane on time performed o Qualification tests, reliability growth monitoring and RIW used to ensure requirements are met	o Extensively used - both safety and cost effectiveness are dominant factors o Mostly use internal data bank of commercial airplanes	o Used as a prelude to system probability analyses at component level to obtain a safety perspective o Especially needed for new technology or critical (safety or operational) systems		o Develop profiles hours, t vibration) necessari these prof
62.		Vanes, flow sensors, phase change materials	o 785 applicable with some tailoring o Nonelectronic reliability is only a small part of total reliability effort o Requirements/goals based on similarity to known designs	o 756 is obsolete for everything o 217 should devote more research to low population/high failure rate parts	o Very effective because mechanical parts are subject to wear		o Qualific have some are extre
63.	Aircraft/missile flight controls and mechanical systems, rail transit vehicle systems		o Reliability requirements established in terms of system level failure rates, mission success probability and safety; reliability control by growth monitoring and RIW with incentives and penalties	o Questionable technical value except for evaluation of relative merits of two design proposals	o Most valuable analysis available o Safety oriented analysis performed	o Useful for electronics and basic structures if applied environments are accurately known o Not very effective at detailed component level due to poor environmental data	o Qualific ing of litt since under late in dev cycle o Sample s development based on bu engineering
64.	Wide range of electronic/electro-mechanical systems	Components constituting referenced system	o 785 not applicable o Reliability requirements established in terms of system level failure rates o Parts specified by derating and quality part level	o 756 unsatisfactory	o Useful for qualitative safety analyses	o Effective for unit and component structural and moving parts	o Test resu to establi tive actio
65.	Military transport aircraft		o 785 used, applicable o Temperature, pressure, vibration, humidity usage profiles established for aircraft-mission success probabilities and failure rate requirements established	o Needed for trade/cost benefit studies o Based on historical, AFR 66-1, Navy 3-M and commercial airline data	o Single most important reliability analysis tool - performed on most design efforts o Uses SAE ARP-926	o Important for component/equipment design assurance	o Qualifica routinely to monitor ty growth
66.	Hydraulic and electrical turret and antenna controls	Gyros, torquers, hydraulic actuators	o Tailoring aspects of 785 make it applicable to any program and all types of equipment o Reliability requirements established in terms of failure rate and mission success probability	o Of very limited value - sum of failure rates and reliability models are used	o Safety is the prime concern of any FMEA o Could be useful at all levels depending on the ability to influence design - timing becomes critical factor	o Worst case stress determined for critical items at part level - fatigue models used	o 781 "afte testing" i priate - u required u tract-new required o Test resu periodicall to verify original e still hold

NNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

RESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
	o Develop operational profiles (cycles, hours, temperature, vibration) but do not necessarily test to these profiles		o Usually in terms of airplane dispatch reliability growth				o Reliability problem stems from the lack of failure data, not methodology
	o Qualification tests have some merit but are extremely costly	o Not used-dubious-question is always raised whether failure was accelerated or damaged before its time by the test					o Recommends government use "all equipment reliability test concept" - costs more but provides better results
eful for elec- nics and basic uctures if lied environments accurately known ot very effective detailed compo- t level due to r environmental a	o Qualification testing of little value since undertaken too late in development cycle o Sample sizes for development tests based on budget and engineering judgement	o Valuable if it can be performed on a representative article and environments are accurately known		o Heart of problem is the wide variety of mechanical devices with unique applications - not sure if they can be standardized in generic groups/families			
ffective for unit component struc- al and moving ts	o Test results used to establish corrective actions	o Effective for component and system moving parts					
portant for com- ent/equipment ign assurance	o Qualification tests routinely required to monitor reliability growth	o Not routinely used because of uncertainty of acceleration factors	o Growth curves specified by customer and proposed to by the contractor	o A standard parts manual is maintained with approved fasteners, switches, relays, lights, etc.	o Exponential distribution considered satisfactory		o Too many variables exist to expect to cover them in one handbook
rst case stress rmined for crit- items at part l - fatigue is used	o 781 "after the fact testing" is inappropriate - used only if required under contract-new procedures required o Test results are periodically reviewed to verify if the original assumptions still hold	o Performed only on the most cricital items at lowest level of assembly practical	o Should not be needed if other analyses are done properly		o 756 satisfactory - exponential assumption generally has little error o Baysian statistics used for small sample sizes	o Field MTBF much lower than predicted	o Recommends Baysian statistical techniques to reduce test time o Moving part problems usually design or lot workmanship created

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SUMMARY OF RESPONSE TO QUESTIONNAIRE ON

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS
67.	Environmental control, flight control, landing gear, structures, etc.	Miscellaneous components constituting referenced systems	o Individual system/LRU reliability requirements based on operational impact requirements for modifications based on economic payback	o Uses MSG-2/MSG-3 analysis logic for reliability analysis	o Used in qualitative way to support MSG and develop initial maintenance plan	o For structures use residual strength crack propagation rate
68.	Tanks, tracked vehicles, wheeled vehicles	Tracks, tires, engines, transmissions, axles, etc.	o Judicious application of 785 is cost effective o Reliability requirements based on durability life for major subsystems and MTBMA	o 756 useless o Mostly ineffective due to lack of good techniques and data	o Very effective at all levels if performed by designers with reliability/maintainability personnel monitoring effort o 1629 used	o Effective if performed probabilistically but not enough people know how and do it
69.	Attitude reference systems, office copiers, sonobuoy receiver systems	Gyros, copier components such as paper feeders, document handlers, photoreceptors, sorters, etc.	o 785 not used but applicable o Reliability requirements established in terms of system level failure rate; reliability control by qualification test, growth monitoring and RIW	o Duane growth model and Weibull analysis used o Predictions should be superseded by the "fix effectiveness" methodology once hard data becomes available through TAAF efforts	o Effective in prioritizing areas with high effect/occurrence impact at system level	o Imposed stresses on piece parts compared with calculated safety margins
70.	Wind tunnels, steam plants, compressor stations	Valves, pumps, filters, fittings, etc.	o NASA NHB 5300.4 used for reliability programs; requirements developed in terms of safety and margin type testing o Analyses are qualitative and used to evaluate risk or do tradeoff comparisons	o No opinion - not popular for one-of-a-kind, extreme environment items	o Excellent at all levels for all types of equipment	o Mandatory in almost all cases
71.	Wide range of telecommunications equipment		o Most 785 tasks are applicable to both electronic and nonelectronic systems o Reliability requirements established in terms of mission success probability and failure rate; qualification tests and growth monitoring used to ensure requirements	o Predictions only as good as available data - 217 used	o Effective but high in cost	
72.	Hydraulic actuators, fluidic amplifiers, logic devices	Flow meters, temperature sensors	o 785 used but considered not cost effective for nonelectronic units	o Design/material improvement is easy to see without wasting time and money on doubtful numbers		

STIONNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

STRESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
o For structures use residual strength crack propagation rate		o Used for structures, fatigue, and ultimate yield strength	o Rate of unscheduled removal versus hours are used and projected for next calendar year		o Assume constant failure rate distribution for complex units 2/3 of time	o Reliability predictions seldom account for in-service exposuré to accidental environment severity	
o Effective if performed probabilistically but not enough people know how and do it	o Testing procedures based on durability life requirements and confidence desired; truncated tests not generally used o 781 seldom used and not applicable to nonelectronic equipment	o Not used due to insufficient correlation of test results to nominal operational performance	o Test results used for Duane plot of data against growth projection		o Exponential distribution assumed for reliability, generally binomial for durability failure rate o Kolmegov-Smirnov tests check validity of assumed failure rates	o Correlations vary widely due to test/field conditions and human factors	o Major breakthrough or fresh approach needed to improve mechanical reliability o Due to variety in application factors a successful data base and/or reliability prediction method does not exist
o Imposed stresses on piece parts compared with calculated safety margins	o MIL-STD-781 used and applicable if tailored to mechanical systems o Sample sizes based on cost considerations o Run-in tests performed during manufacturing	o Very good if applied early in subsystem test/analyze phase to probe for weaknesses o Safety margins for critical environments are determined by overstress testing	o TAAF combined with reliability prediction is the most effective means to control and improve nonelectronic equipment	o Critical parts are subject to lot sampling control to specified LTPD, AOQL numerics		o Field results demonstrate higher reliability than in-house test and analysis results	o A handbook is possible to provide methodology and data but methods should be empirical and easy to apply
o Mandatory in almost all cases	o Qualification tests used to ensure reliability requirements are met o Emphasis in reliability program is placed on testing to assure reliability in extreme environments	o Use only when other methods/information not available					o Reliability program centered on FMEA's on critical subsystems and risk assessment
	o 781 not appropriate - new procedures required				o Constant failure rate assumed	o Poor field data for comparison	o Mechanical components of systems are treated as electronic in application of 785 and 781
	o 781 used o Items tested until a life-time of flying hours are accumulated in a simulated flight profile distribution	o Useful, but can be misleading			o Constant failure rate assumed	o Experience shows failure rates are 2-10 times higher than predicted	o Contractors judge interpretation of rules (relevant vs nonrelevant failures) to pass a demonstration test o Sample size is dollar limited

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SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RELIA

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TEST P
73.	Hydraulics equipment, ejection seats, flight control systems	Pumps, actuators. turbines, valves	o Mission reliability evaluated by company developed computerized model or probabilistic techniques similar to 756B o Maintenance/logistics reliability utilizes MTBF and MTBMA	o Used for preliminary design objectives o Relatively low impact on product reliability	o Performed if under contract per 1629 at system level	o Effectiveness limited to safety sensitive components	
74.	B-1 structure, propulsion and control systems, space shuttle structure thermal protection and control systems; satellite antennas	Radar rotary joints and pedestals, piping, thermal dissipators	o Reliability requirements established in terms of service life, failure rates and mission success probability-emphasis in reliability control is on testing to requirements	o Insufficient data-field service data is not returned to design or reliability engineers o AF 66-1 and Navy 3-M do not provide detailed data on nonelectronic items	o Current FMEA procedures do not address fracture mechanics or continuum mechanical failure modes	o Because most elements are standardized they are not stress analyzed after being used with success	o 781 used in system c o 781 needs distribution testsing co adequate st thermal/fat analysis
75.	Code matrix reader, power distribution box, air conditioning	Motors, meters, fans, cables, film tracks, cameras, switches, relays		o RADC Notebook and 217 used			o Accept/rej teria per 78
76.	Miscellaneous weapon systems	Controls, dispensers	o Emphasis at this facility is on the manufacturing aspects of industrial contracts - 785 not used	o 756 used as one of several tools for prediction	o Only performed if required under contract		o Accept/rej determined b of failures number of hou
77.	Nuclear weapons, tank ammunition, tank guns, artillery shells	Mechanical timers, barometric sensing devices, pneumatic logic controls, etc.	o Reliability requirements are based on user mission needs and system life cycle requirements and specified in terms of MTBF at system and component levels o Qualification tests and growth monitoring used to assure requirements are met	o Used to determine if design objectives can be achieved o Effective if in-house data is available	o Effective at higher levels o Performed only if deemed beneficial to particular contract	o Effective at part level on metallic items and plastics o Computer analyses used for mechanical strength of piece parts, e.g., finite element analysis	o Functional environmental profiles deve for component o Tests desi detect wearo rarely test ure
78.	Wide range of military electronic systems		o 785B is gradually being phased into development contracts	o Marginal effectiveness due to problems in transferability of historical data from system to system	o Cost effective for directing further reliability analysis and maintenance planning	o Essential - especially for novel designs or novel applications of existing designs o NASTRAN used on some critical structural designs	

AIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

ALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
ness safety omponents			o Incorporated in proposed programs at system level and for major components	o Use standard parts manual			o 785 good-presents standard tasks to be selectively tailored
ost ele- tandard- re not yzed used s	o 781 used only within system context o 781 needs Weibull distribution based testsing coupled with adequate stress/thermal/fatigue analysis		o Not performed for nonelectronics	o Only by federal part number	o Constant failure rate assumed		o 785 sketchy since it does not include analytical and experimental background in mechanical reliability o RADC NPRD used extensively
	o Accept/reject criteria per 781	o Perform increased temperature and vibration tests		o Use TCI PPSL-5C	o Constant failure rate assumed - mechanical components are not a major part of systems	o Field performance of a complex system that meets 80% of reliability prediction or testing is considered good	o When only small sample sizes available use fixed length test plans; testing approximately 3X the minimum MTBF
	o Accept/reject determined by number of failures per number of hours				o Constant failure rate assumed	o Reliability predictions are better than actual performance o Test MTBF close to field MTBF	o A warranty provision would be best in 785 o Add 781 test to increase cycling and temperature extremes for springs, valves and linkages
at part allic astics analyses chanical piece finite ysis	o Functional and environmental mission profiles developed for components o Tests designed to detect wearout - rarely test to failure	o Effective only for corrosion, overstress metal strength testing and the like	o Predict a reasonable growth curve, then track it based on test data			o Due to sparse data in meager or non-existing data banks, predictions are useless - tests are reality o Good correlations obtained between test results and field performance	o System level fault tree analysis useful for preliminary information
espe- vel vel of igns ed on l struc- s		o Effective for new designs, especially at component level and early in the life cycle	o Useful management technique for complex systems-emphasize TAAF		o Constant failure rate assumed		

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SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RELIA

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TEST
79.	Radar systems	Synchros, motors	o 785 used and applicable		o Performed in accordance with 1629		o 781 use applicabl improveme
80.	Ammunition production lines, conveyors, air logic controllers, fluidics, packaging lines	Piece parts for referenced systems	o 785 used, and applicable - the intent, purpose, techniques, etc. are generally applicable across the board o Reliability requirements established in terms of system/component MTBF	o 756 satisfactory o Uses computer simulation of production lines o Data from previous tests used to determine spares requirements and logistic support costs	o Performed if confidence in a design needs to be improved	o Effective only for critical applications o Uses mechanical strength type analysis	o 781 use ble, and fit indivi sample si from econo erations o Equipmen a demonstr or manufac feits rema portion of already pa
81.	Ground support equipment for space shuttle	Regulators, valves, transducers, motors, etc.	o 785 not used; uses GP 863 or JSC SW-E-0002	o 756 satisfactory execpt for difficulty with operational environmental factors o Cost effective for determining if goals are attainable	o Performed per KSC-STD-118(D) o Cost effective for identifying critical components or failure points		o 781 not o Test pro designed expected environmen
82.	Navy sonar, fire control, weapons, launcher systems	Components unique to listed systems	o 785 used and applicable if tailored to address load, environment, stress analysis and derating o Reliability requirements established in terms of failure rates, specified life/cycles and availability	o 756 satisfactory but of limited value o NAVSEA "TIGER" program used for simulators and assessment	o Performed per 1629	o Static and dynamic analyses including NASTRAN used	o 781 used appropria procedures quired ine dynamic st complex lo
83.	Vehicles, landing craft		o 785 adopted to programs - applicable with tailoring o Reliability requirements established in terms of system level failure rate; qualification and growth monitoring used to ensure that requirements are met		o Maximum benefit for complex systems		o 781 appr required for compl
84.	Mechanical equipment used in space craft	Gyros, slip rings, bearings, springs, valves	o 785 not used but applicable when tailored to specific hardware o Internal documents similar to 785 are used to ensure subcontractor compliance o Requirements based on mission life and mission success probability	o 756 not used o Performed but normally limited data is available; not very cost effective	o Performs a product design FMEA which also includes a review of processes and materials o A matrix form FMEA is used - very effective	o Required to isolate potential design problems - very cost effective	o 781 not to space o Test pr developed mission m and inclu taneous p and envir profiles o Emphasis on meetin level req

ONNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

STRESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
	o 781 used and applicable but needs improvement				o Constant failure rate assumed		
Effective only for ritical applications Uses mechanical trength type nalysis	o 781 used, applicable, and tailored to fit individual test - sample sizes derived from economic considerations o Equipment must pass a demonstration test or manufacturer forfeits remaining portion of funds not already paid		o Growth projections are not revised during development program unless a major requirements change has occurred			o Field performance correlates satisfactory with analysis results	o Expanded effort for nonelectronic data base is needed
	o 781 not used o Test procedures are designed to duplicate expected operational/environmental profile			o Uses GP-864 which is a listing of parts with past usage experience			o A handbook with application examples would be helpful in combining into one series of documents the different procedures currently used
Static and dynamic nalyses including ASTRAN used	o 781 used and appropriate but new procedures are required including dynamic stressing in complex loading	o Performed - effective where results are clearly translatable	o Tailored TAAF for maturing equipment used, especially during early deployment and for high reliability systems	o Parts selection procedures are unique to each design contract; parts may be standard, preferred, specially screened, etc.	o Distribution is defined by data base	o Correlation sufficiently good to aid in locating design, quality and maintenance problems	o Handbook should stress trade-off of derating versus risks o Data base for repair/human error poor
	o 781 appropriate, required in contract for complex systems	o Not effective - too difficult to extrapolate			o Constant failure rate assumed		
Required to iso- te potential sign problems - ry cost effective	o 781 not applicable to space usage o Test procedures are developed from mission requirements and include simultaneous performance and environmental profiles if possible o Emphasis is placed on meeting system level requirement			o Parts selection is limited to an "Approved Parts List" containing only parts which are qualified and have a known failure rate	o Constant failure rate normally assumed - Weibull considered in some cases	o Most problems are not "random" failures but are design problems, i.e. very poor correlations	

SUMMARY OF RESPONSE TO QUESTIONNAIRE ON RELIABILIT

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TEST PROGRAM
85.	Missile steering hydraulic and warm gas subsystems	Gas/hydraulic units	o 785 not used, not applicable o Design reviews, qualification testing and accelerated testing are the areas to concentrate reliability effort	o 756 not used, not applicable o Predictions used to determine spares requirements; locating data which represents loading, duty cycle, environment is the chief problem	o Selectively applied to mission critical subsystems, components or parts	o Performed on safety critical hardware at the part level with statistical emphasis (probabilistic analysis)	o Testing proce designed to dete metal or insulat degradation whic causes field los no statistics involved
86.		Refrigeration compressors, condensers, evaporators, valves, switches, etc.	o Reliability program invoked only when specifically required by contract o 785 applicable, tailored to fit each contract	o 756 is an excellent base-may have to be tailored for some contractx	o Performed during initial design in accordance with MIL-STD-1543	o Computer programs used for frame structural stress analysis o Stress analysis results compared with safety factor desired - redesign to reach desired safety margins	o 781 not used; fomal reliabili testing not perf
87.	All aircraft systems	All associated components purchased from subcontractors and suppliers	o 785 used and applicable o Reliability requirements specified in terms of MTBUR and mission success probability; suppliers must supply free spares until requirements are met	o 756 used and satisfactory o Uses fielded product data of company and competitor products o Predictions necessary for trade studies and system evaluation	o Performed as part of every design effort in accordance with internal procedures compatible with ARP-926 and 1629A o Currently the most cost effective technique available for design analysis at all levels		o 781 not used a not applicable - (proposed) is a reasonable start needs much more
88.	Mechanical remote controls for military and commercial aircraft	Push-pull cable assemblies, rolling friction control assemblies, rack and pinion gear boxes	o 785 applicable o Reliability requirements specified in terms of system level failure rate; qualification tests and RIW used to ensure requirements are met	o 756 not satisfactory - reliability predictions not performed	o Petormed only if required under contract o Limited number of detail parts permits analysis of every part in assembly - very cost effective		o Operational/en ronmental profil established pri testing usually accordance with o Equipment perf ance requirement must be met thro out and at compl of simulated li testing
89.	Aircraft systems		o 785 used and applicable o Reliability requirements established in terms of MTBF or MTBMA; reliability growth monitoring used to ensure requirements are met	o 756 not satisfactory o Predictions are optimistic and do not include workmanship or design deficiencies		o Stress derating used to assure fail-safe design	o 781 appropria and used as a g to modify tests particular item o Economics and scheduling dete test samples o Bayesian meth used to establi reliability fro results
90.	Space and undersea life support equipment and hydraulic rocket engines	Pumps, fans, motors, valves, actuators, batteries, etc.	o 785 used and applicable o Reliability requirements established in terms of system level failure rate, safety and mission success probability	o Predictions used to determine if requirements have been met-change design until goal is met via redundancy, component improvement, etc.	o Performed as part of every design effort in accordance with 1629 o Vital at both system and component level	o Cost effectivo and generally a necessity o RADC Nonelectronic Reliability Notebook especially useful	o 781 not used o Qualification used to ensure quirements are

AIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
d on itical at the part statisti- is (proba- analysis)	o Testing procedures designed to detect metal or insulation degradation which causes field loss; no statistics involved	o Perform overload, extended limits and severe environment tests					o Sufficient information exists but is too widely scattered - a handbook would help o FMEA, Reliability Prediction and Stress Analysis are cost ineffective - often duplication of effort exists
programs frame stress analysis mpared ty factor redesign desired rgins	o 781 not used; fomal reliability testing not performed			o Design engineer, in contact with potential vendors, specifies actual parts to be used for major components		o Field performance MTBF 2-3 times better than analysis	o Vendor information is the most reliable source for predictions - when vendors will cooperate o Field information from the Armed Services needs to be fed back to subcontractor level where it is needed
	o 781 not used and not applicable - 781D (proposed) is a reasonable start but needs much more work		o Monitors in-service performance according to anticipated improvement and take corrective action when progress is not satisfactory in both dispatch reliability and MTBUR	o Internal procedures used by standards group	o Constant failure rate usually assumed		o Primarily need failure rate information
	o Operational/environmental profiles established prior to testing usually in accordance with 810 o Equipment performance requirements must be met throughout and at completion of simulated life testing	o Individual accelerated tests are tailored to complete tests in reasonable time without producing detrimental effects		o All materials to military or industrial specifications	o Constant failure rate assumed	o Field reliability well beyond predictions - specified environments are not indicative of actual field usage	o A compilation of the material typically used in determining reliability would simplify the task in firms not in a position to establish reliability departments
derating assure fail- ign	o 781 appropriate and used as a guide to modify tests for particular items o Economics and scheduling determine test samples o Bayesian methods used to establish reliability from test results			o Company preferred parts manual	o Constant failure rate assumed	o Predictions are generally optimistic - don't include workmanship or design deficiencies o Test results/field use correlations good if all laboratory failures (relevant and nonrelevant) are counted	
ffective and y a necess- onelectronic ity Notebook ly useful	o 781 not used o Qualification tests used to ensure requirements are met	o Acceleration factor of cycle rate used which does not usually affect failure mechanism o Highly cost effective if acceleration parameters and factors are well established		o Fittings, fasteners, etc. are selected from standard parts list	o Constant failure rate usually assumed	o Not enough field experience recorded to verify the very high reliability requirements	

2

SUMMARY OF RESPONSE TO QUESTIONAIRE ON

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS
91.	HVAC	Pneumatic relays, temperature transmitters, controllers, switches	o No experience with 785 o Reliability requirements established in terms of system level failure rate; qualification tests performed to ensure requirements are met	o 756 not used o In-house data base used primarily	o Not performed - the uniqueness of each system design prevents FMEA from being effective	
92.	Armament systems - tanks, artillery, mortar	Fuzes, explosive trains, hydraulic components	o 785 used, applicable o Reliability requirements established in terms of failure rate; qualification test and growth monitoring used to ensure requirements are met	o 756 used, satisfactory o Worth the effort if done properly, but can be difficult for nonelectronic devices o Published data must be supported or modified by valid data from actual tests	o Performed as a part of every design effort; always worth the money	
93.	Aircraft procurement in general		o 785 called out in all programs o 785 applicable, cannot separate electronic and nonelectronic	o 756 can be satisfactory with tailoring o Prediction is only as good as the initial data; need more feedback into GIDEP to verify reports	o Specified as part of every design effort; however, requirement gets deleted one-third of the time	
94.	Radar antennas, pedestals, gun systems, missile launchers		o 785 used, applicable o Reliability requirements established in terms of failure rate; incentives for meeting numerical requirements	o 756 used but not satisfactory		
95.	Sonars, missiles, ships	Winches and hoists, transducers, propulsion units	o 785 used, applicable o Reliability goals specified by MTBF; qualification tests and growth monitoring used to ensure requirements are met	o 756 used, applicable o Predictions good if used in conjunction with stress analysis o 217 used and good	o Performed as part of every design effort using 1629 with top down approach	o Mechanical and thermal stress analyses performed
96.	Aircraft FIREX systems	Pneumatic regulators, fire extinguisher containers for aircraft, pressure gauges, pressure vessels, pressure switches, explosive cartridge	o 785 not used but considered applicable o Reliability requirements specified in terms of system level failure rates; control through testing to meet specific numerical requirements or is not accepted	o 756 satisfactory o Predictions provide confidence the design will meet contractual obligation o Published failure data requires interpretation to apply to specific use and derating	o Performed if required under contract o Helps to fully understand weaknesses in the components before manufacturing begins	o Absolutely essential; starts at piece part level (fittings) for pressure vessels

TIONAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

STRESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MIS('US CO
	o No experience with 781 o Laboratory reliability adjusted to field life by determining an acceleration factor based on previous testing of similar type products and usage environment	o Accelerated cycle, stress, and environmental testing performed o Most cost effective method when analyzing nonelectronic designs where physical wear characteristics are a determining factor for component life		o Results of vendor component qualification testing	o Constant failure rate assumed		o Handbook . isify groups of products in similar applications would help
	o 781 used and appropiate when wear does not become a factor o 781 needs improvement; more flexibility and consideration of nonconstant failure rate o Bayesian approaches used for small sample sizes	o Results are never conclusive - probably a waste of resources	o Predictions of ultimate reliability are made. Based on planned reliability growth tests, milestones are established. Major tests are conducted at these milestones to measure growth		o Constant failure rate assumed	o Analysis are usually optimistic in comparison to field performance testing; often consistent with field results	
				o MIL-STD-965 with help from DISC		o Actual field performance is 1/3 to 1/2 of the predicted rate o Prediction and test results are closely correlated	o Strong proponent of CERT testing to expected operational environment
	o 781 not used, not applicable o Test under worst operational and environmental conditions o TAAF testing used			o Company preferred parts list			
o Mechanical and thermal stress analyses performed	o 781C used but not appropriate - new procedures required o Laboratory test results divided by 2 to estimate field reliability				o Constant failure rate assumed		
o Absolutely essential; starts at piece part level (fittings) for pressure vessels		o Accelerated aging for leakage rate determination performed o Helpful if acceleration is meaningful in real world, e.g., hot and cold excursions of environment for accelerated aging		o Use standard hardware - parts and assemblies that have had qualification tests on other programs	o Constant failure rate assumed		o Inherent design reliability is preserved during production by scrupulous attention to tolerances

SUMMARY OF RESPONSE TO QUESTIONAIRE ON RELI

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TE
97.	Jet engines	Jet engine components	o 785 used, applicable o Reliability requirements established in terms of safety, system level failure rates and mission success probability; reliability control by growth monitoring	o 756 unsatisfactory o Reliability predictions are strongly rooted in available data bases	o Performed and cost effective for control systems where effects are not obvious in accordance with 1629		o 781 should cover distri Acceler Testin o Miss perform engine profile proport accumul
98.		Antenna and solar panel deployment mechanisms, air conditioners, hand held power tools	o 785 applicable and cost effective when properly tailored; safety margins specified when required o Reliability requirements specified in terms of MTBF and probability of mission accomplishment	o 756 unsatisfactory o Effective if based on stress/strain life data or fatigue life data	o Performed only if required by contract		o 781 appropr o Tests failure cal to adequat margins
99.	Satellites	Satellite subsystems and assemblies	o Suspects 785 would need some rather violent tailoring/modification o Reliability requirements specified in terms of Mean Mission Duration and MTBF; reliability control by 100% sample testing and on-orbit performance incentives				o Qualif for sate levels case pre
100.	Antennae, attitude control subsystems, solar array booms, propulsion subsystems	Components of referenced systems	o 785 program requirements used on both electronic and nonelectronic gear; most control and analysis tasks could apply to any sort of system	o Poor effectiveness; stress/strength assumed distributions is common model o Reliability prediction is often a function of small variations in radius, finish, etc. o 217 data used	o Performed in accordance with ARP-926, MIL-STD-1543 and SAMSO-STD 77-2 for spacecraft; depth for non-space gear in a function of mission criticality	o Good effectiveness; define margins of each part o Major method used to date	o 781 not appropri
101.	Solar panels, deployment mechanisms, reaction control systems, structures	Honey comb metal, valves, lines	o 785 used; applicable and cost effective when appropriately tailored o Reliability requirements specified in terms of safety, failure rates and mission accomplishment probability; control by acceptance tests and continuous monitoring	o 756 satisfactory	o Not performed		o 781 not appropria o MIL-STD posed in box diagr space cra develop environme files
102.	Space launch vehicles, missiles	Components of referenced systems	o MIL-STD-1543 used mostly for reliability program o Reliability requirements specified in terms of safety and identification and mitigration of single point failures by FMEA o 785B is a very good tailorable document	o 756 used, satisfactory o Very good for electronic equipment with prescribed quantifiable operating environments, less benefit to nonelectronic, cyclic, low usage equipment	o Performed as part of every design effort per 1543; very cost effective to identify where to spend resources for all types of equipment		o 781 used appropria o Extensiv cation te gram and control u ensure rel

RE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

ALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
	o 781 not used; scope should be expanded to cover non-exponential distributions and Accelerated Mission Testing o Mission analysis performed to develop engine cyclic usage profile; part life is proportional to cycle accumulation	o Accelerated Mission Testing for engine hot section parts is used to establish durability o Effective on durability limited parts	o Component improvement program impact on reliability is assessed and future reliability growth is projected and compared to field date		o Constant failure rate not assumed o Use Weibull paper; $R= 1-e^{-t}$ to establish quantitative reliability	o Correlations between predictions and test results are poor due to difference in data base engine and test engine design, maintenance and environment	o Maintenance intervals are chosen for engines to optimize cost, engine removals and other parameters o A handbook with sections by industry or equipment types is possible
	o 781 not used, not appropriate o Tests are run to failure when practical to assure adequate safety margins	o Perform increased duty cycle tests with artificial cooling	o Not effective unless item is very complicated		o Non parametric, Poisson, normal or binomial distribution assumed depending on item	o Correlation generally good except for quality problems and where environment was not adequately considered	o A set of manuals would be necessary for reliability programs for nonelectronic designs
	o Qualification tests for satellites are at levels above worst case predicted	o Higher cycling rates and elevated temperature tests performed	o Seldom performed; not seen as germane or productive for one-of-a-kind or very few of a kind items		o Constant failure rate not assumed; curve unknown but distinctly non-linear both in qualification and acceptance testing		o Proliferation of standards tends to create confusion not precision o System/subsystem environments defined by MIL-STD-1540A; moving mechanical assemblies per DOD-A-83577A
ective- ne margins rt thod used	o 781 not used, not appropriate	o Use accelerated cycle rate o Questionable effectiveness - good if simply accelerate cycles, but often the acceleration factors are not known	o Satellite growth is difficult to define and especially to measure due to few items and long lives		o Constant failure rate assumed	o Major source of problems is with interpretation of MTBF, MTBMA definition	o Handbook useful to standardize saftey factor terms and stress/strength margin analysis
	o 781 not used, not appropriate o MIL-STD-1540 imposed in all black box diagrams for space craft use to develop operational/environmental profiles	o Not performed; there has been no in-depth correlation between accelerated and normal testing	o Growth requirements specified in ground/air/sea user segments but not in space segments		o Constant failure rate assumed	o Analytical results very conservative compared to actual field performance	o DID's effective; identify exactly how the contractor will be monitored
	o 781 used but not appropriate o Extensive qualification testing program and process control used to ensure reliability					o Nonelectronic equipment is sensitive to actual use environment (weather, neglect, poor maintenance) versus design scenarios which adversely effects analysis and field use correlations	

2

SUMMARY OF RESPONSE TO QUESTIONAIRE ON REL

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS
103.	Propulsion systems	Inertial guidance components	o 785 used and applicable o Reliability requirements specified in terms of system level failure rates and mission accomplishment probability	o 756 used and satisfactory o Important and cost effective at component level for design alternatives and as comparison to other similar systems o 217C and GIDEP used	o Performed as part of every design effort; extremely important and cost effective at all levels to establish critical failures that begin at component level and propagate through system	o Cost effective; can locate overstressed components and should be coordinated with designer
104.	Explosive ordnance, emergency escape systems, energy transfer systems	Explosive transfer lines, initiators, bolts, cord	o 785 not used and not applicable o Reliability requirements specified in terms of mission accomplishment probability; controlled by qualification tests to meet specific numerical requirements	o 756 unsatisfactory	o Very useful; perfomed if required under contract	
105.	Turbo machinery, hydraulic and pneumatic systems, structures, mechanical drives, flight controls, fuel systems, landing and arresting gear	Pumps, valves, gearboxes, gas turbines, regulators, mechanical linkages, actuators, structural members, reservoirs and accumulators	o 785 applicable and used; requirements tailored depending upon criticality, cost, state-of-the-art with 785 used as a shopping list	o 756 satisfactory o Good for ball park estimates and for determining the improvement required over existing items to meet reliability goals	o Performed as part of every design effort for comparing reliabilities of alternate system designs or two components and for troubleshooting	o Very cost effective when operating environments are well defined and results are verified by test
106.	Process systems for nuclear power stations	Process system components for nuclear power stations	o 785 applicable and used indirectly o Reliability requirements specified in terms of safety, system level failure rates and mission accomplishment probability; controlled by qualification tests to meet a numerical requirement or not accepted	o 756 unsatisfactory	o Performed as part of every design effort with 1629 tailored to nuclear industry	o Stress/strength reliability models used for critical items (earthquake analysis)
107.	Missiles	Missile components	o 785 can be cost effective with additional specific requirements o Reliability requirements specified in terms of system level failure rates and mission accomplishment probability; controlled by testing to meet numerical requirements	o 756 unsatisfactory; too sketchy to be of any value, needs revision to include reliability block diagrams and redundancy and availability equations o Useful for comparing alternatives and establishing spares requirements	o Recommended as part of every design effort; performed in accordance with 1629 o Vital during design phase to detect potential problem areas and to permit remedial design changes	o Vital during design phase to detect potential problem areas and permit remedial design changes
108.	Electromechanical devices for space/satellite applications such as solar array drive assemblies, gimbals, antenna drive mechanisms, etc.	Drive motors, sliprings, actuators	o 785 not used and not applicable; not an effective program document o Reliability requirements specified in terms of safety, system level failure rates and mission accomplishment probability; controlled by testing to meet numerical requirements	o 756 satisfactory; nonelectronic section should be expanded	o Performed if required under contract per 1543 o Good means of quickly identifying components that are single point failures	o Necessary to assure adequate design margins

NAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

RESS ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
st effective; locate over- ssed components should be coord- ed with designer	o 781 used, no comment on application o Amplitudes and sequences of environments are given to test labs for application during test	o May or may not be effective depending on accuracy of simulation o Increased test time or accelerated environment testing used when only small sample sizes are available	o Reliability demonstration tests used to monitor growth o Cost effective if there are many copies of the same component being produced	o PPSL books used	o Constant failure rate assumed	o No experience with analysis to field correlations; 3-4 years difference between design and operations o Test and field correlation not good due to different definitions of failures	o Series reliability models used for logistics support, redundant models for mission o A handbook similar to 217 should be prepared for nonelectronic parts
	o 781 not appropriate; new procedures required o Lot acceptance tests used to confirm reliability progress	o Used and effective occasionally		o Selection and surveillance rules utilized	o Constant failure rate assumed	o All correlations inadequate	o The entire area of single function (onetime) systems is inadequately addressed
y cost effec- when operating ronments are defined and lts are verified est	o 781 not used and not appropriate; test levels are OK as guidelines but actual environments should be known; test plans are too lengthy for high MTBF components	o Performed in early prototype testing phase o Very cost effective in development phase to uncover inherent design weakness; operating mission environment knowledge is necessary	o Helpful for projecting expected reliability to be attained at future date; must be accompanied by TAAF	o Preferred Parts Lists utilized		o Correlations not made; testing is to identify and fix problems o System level predictions, tests, and field results appear to be close	o Failure reporting systems with closed loop corrective actiun required and continuous production line monitoring used to monitor and ensure reliability
ess/strength ability models for critical (earthquake ysis)			o Planned reliability growth is not included in programs; if failures occur thu causes are stuiied and a remedy attempted			o In general, analysis and field results correlate well, but the human factor is not always predictable	o A general recognized failure data base of nonelectronic equipment would be most useful; similar to IEEE STD 500-1977
al during n phase to t potential em areas and t remedial n changes	o Recommend 781C and MIL-STD-202 o New procedures required for wear out items o Environmental Pi factors and Arrhenius equations used to estimate field reliability from laboratory test results	o Used where practical	o Duane plot utilized; straight line on log-log paper		o Weibull distribution used for components subject to wearout		o Mechanical reliability failure rates are at the level electronic parts were in 1960; suggests trucking, airline and food processing firms must have info on breakdown and repair characteristics
essary to adequate margins	o 781 not used; similar procedures used for running several life tests to qualify nonelectronic parts	o Higher cyclic rate (RPM) tests performed o Can not always validly accelerate the actual failure modes of interest in a reasonable time	o Not valid for programs that only build 1 or 2 of a type of hardware	o Restricted use of many materials by a thorough Materials List Review	o Constant failure rate assumed	o Sliprings perform 100 x better than predicted industrial failure rates	o Recommends award incentives for reliability and quality, not just cost and schedule o A handbook like 217D is needed for nonelectronic component reliability predictions

1 2

SUMMARY OF RESPONSE TO QUESTIONAIRE ON RELIA

RESPONSE CODE	SYSTEM	COMPONENTS	MANAGEMENT PROGRAM	PREDICTION	FMEA	STRESS ANALYSIS	TEST
109.	Tracked military vehicle systems	Track, road wheels, roadwheel arms, torsion bars, bearings, hydraulic valves, diesel engines, mechanical controls, transmissions, gear boxes	o 785B used and applicable o Reliability requirements are specified in terms of system level failure rates, mission accomplishment and availability; control by testing to meet numerical requirements	o 756 not generally used, not satisfactory o Prediction is compared to the reliability allocation for differences; should be required	o Performed if required under contract per 1629 o Useful to identify reliability critical components and safety hazards - this effort should be required	o Performed by Design Engineering; more stress analysis should be performed	o 781 no appropri procedur
110.	Missiles, spacecraft	Actuators, propulsion components, etc.	o 785 used and applicable; adjustments required to models, testing and other sub-disciplines o Reliability requirements are specified in terms of MTBF and mission accomplishment probability; control by test to numerical requirements	o 756 satisfactory, used for approximate constant failure rates	o Performed as part of every design effort per 1629 and reference SAE procedures	o Stress versus strength analysis effective for simpler mechanisms	o 781 use level; as long rate dist is not r different, stant ove life
111.	AWACS, generators	Switches, relays, connectors, PCB's, I.C. sockets, etc.	o 785 not used, not applicable o Reliability requirements specified in terms of system level failure rates and mission accomplishment probability	o 756 unsatisfactory	o Performed according to customer's wishes	o Sometimes useful; only cust effective for specific troublesome components	
112.	Electo-mechanical systems such as spin systems, scan actuators, linear drive systems, spacecraft orbital injection modules	Pyrotechnically actuated devices, liquid propellant devices, valves, regulators	o 785 used o Reliability requirements specified in terms of safety and redundancy to eliminate single point failure probability; control by test to meet numerical requirements		o Performed as part of every design effort; Fault Mode Failure Trees are broken down on matrix sheets which cross-reference the preventive measures to be performed	o Not directly applicable unless you consider Fracture Mechanics as an equivalent	o Extreme ments and testing c extrapola to adjust results in field rel

AIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

S ANALYSIS	TEST PROGRAM	ACCELERATED TESTING	RELIABILITY GROWTH	PARTS SELECTION	FAILURE RATE DISTRIBUTION	ANALYSIS/TEST/FIELD-USE CORRELATIONS	MISCELLANEOUS COMMENTS
ormed by Engineering; tress analysis be performed	o 781 not used, not appropriate; new procedures required	o Not performed; not enough is known about the relationship between accelerated testing and normal service	o Planned growth must ultimately meet requirements; Duane curves are used to project growth at system level		o Weibull distribution assumed	o Receive practically no information on actual field performance but prediction correlates well with test program experience	o Design function has practically no contact with production; should be corrected
s versus h analysis ve for simp- hanisms	o 781 used at system level; appropriate as long as failure rate distribution is not radically different from constant over useful life	o Useful for parameters like fatigue and wearout	o Performed on newer systems; used only for monitoring purposes	o Uses a restricted list - not comprehensive	o Constant failure rate assumed with some exceptions	o Field performance usually measured in different terms than predicted performance - where this has been unscrambled correlation has been good	o Most electronics based methods can be used for nonelectronic components; lack of an adequate data base hinders the use of more sophisticated models
imes useful; st effective cific some compo-		o Only cost effective for specific troublesome components	o Use test results (such as life test) to develop reliability growth curves	o No formalized parts selection procedures; this is an area of particular weakness throughout industry/military	o Constant failure rate assumed; no other alternatives		o A handbook is badly needed; the RDH and other such texts don't really cover "nonelectronics"
rectly ble unless ider Frac- hanics as an nt	o Extreme environments and accelerated testing coupled with extrapolation is used to adjust lab test results in estimating field reliability	o Tests such as bearings run at higher speeds than that intended in flight o Effective if attention is paid to failure modes either induced or precluded by test acceleration	o Used only as applicable through inherent hardware design improvement from past projects		o Constant failure rate assumed in margins testing		

2

APPENDIX D

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES TO QUESTIONNAIRE ON RELIABILITY PROGRAMS FOR NONELECTRONIC DESIGNS

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

1. AIRCRAFT/FLIGHT CONTROL SYSTEMS

Question	Subject	Government/Industry (G/I) Respondee	I 04	I 06	I 08	I 11	I 36	I 49	I 59	I 63	I 73	I 89	I 96
4a	Utilization of 785		0	1	0	0	0	0	1	-	1	1	0
4b	Requirements Similar to 785 Used		-	-	0	-	-	0	-	-	0	0	-
10	Mission vs. Logistics Reliability Considered		1	1	1	0	1	1	1	1	1	1	0
11a	785 Applicable to Nonelectronic Equipment		1	-	1	-	0	1	1	-	1	1	1
11b	785 Cost Effective for Nonelectronic Equipment		1	1	-	-	0	1	1	-	1	1	1
18	FMEA Performed on Nonelectronic Equipment		1	1	1	1	1	1	1	1	1	1	1
22	Reliability Predictions Used to Monitor Design		1	1	0	-	0	0	-	0	1	1	0
24	Overhaul/Maintenance Actions Included		1	0	1	1	1	1	0	0	1	1	1
25	756 Satisfactory to Nonelectronic Equipment		-	0	-	1	-	-	0	-	1	0	1
27a	MIL-HDBK-5 Used to Assess Reliability		0	0	0	0	-	0	-	1	-	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties		1	-	-	-	-	-	-	0	-	-	-
29	Planned Reliability Growth Included in Program		1	1	1	1	0	1	1	0	1	1	0
32	Internal Parts Selection Procedures Utilized		1	-	0	1	-	0	1	1	1	1	1
33	Operational/Environmental Test Profiles Dev.		0	0	1	1	1	1	0	1	-	1	1
34	Utilization of 781		0	0	1	1	-	-	1	-	-	1	0
35	Procedures Similar to 781 Used		0	-	0	0	-	-	0	-	-	0	0
39	Constant Failure Rate Assumed for Testing		0	-	1	1	1	1	1	1	-	1	1
40	781 Appropriate for Nonelectronic Equipment		-	0	1	0	0	-	0	-	-	1	-
47	Accelerated Testing Methods Utilized		0	0	0	-	1	1	1	1	-	0	1
52	Any Government Contracts Specify a RCM Program		-	1	0	-	-	1	1	-	0	1	0
53	DID's Add to Effectiveness of Reliability Req.		-	1	1	-	1	1	1	1	0	0	1
54	Lack of Standardization of Nonelectronic Parts		-	-	1	1	1	1	1	1	-	-	-
55	Separate Rel. Specs. for Large and Small Items		-	1	1	0	1	1	0	0	0	1	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.		0	0	0	-	1	0	0	0	0	1	1
57	Does Ruggedization Requirements Affect Rel.		-	1	1	-	1	1	1	1	-	1	1
58a	Nonelectronic Info. Available for Rel. Analysis		-	0	0	-	-	1	-	0	-	-	-
58b	Handbook with Procedures/Guidance Possible		1	1	1	1	0	1	1	-	-	-	-

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

1. AIRCRAFT/FLIGHT CONTROL SYSTEMS

	Government/Industry (G/I)	G	G	G	G	G	TOTALS					
							1		0		-	
Question	Subject Respondee	10	43	53	67	111	I	G	I	G	I	G
4a	Utilization of 785	-	1	0	0	0	4	1	6	3	1	1
4b	Requirements Similar to 785 Used	-	-	-	1	0	0	1	4	1	7	3
10	Mission vs. Logistics Reliability Considered	1	1	1	1	-	9	4	2	0	0	1
11a	785 Applicable to Nonelectronic Equipment	-	-	1	-	0	7	1	1	1	3	3
11b	785 Cost Effective for Nonelectronic Equipment	-	-	-	-	-	7	0	1	0	3	5
18	FMEA Performed on Nonelectronic Equipment	0	1	0	1	1	11	3	0	2	0	0
22	Reliability Predictions Used to Monitor Design	0	-	-	1	-	4	1	5	1	2	3
24	Overhaul/Maintenance Actions Included	-	-	-	0	0	8	0	3	2	0	3
25	756 Satisfactory to Nonelectronic Equipment	-	-	-	-	0	3	0	3	1	5	4
27a	MIL-HDBK-5 Used to Assess Reliability	-	0	-	0	0	1	0	7	3	3	2
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	0	-	-	-	1	0	1	1	9	4
29	Planned Reliability Growth Included in Program	-	-	-	1	-	8	1	3	0	0	4
32	Internal Parts Selection Procedures Utilized	-	-	0	1	0	7	1	2	2	2	2
33	Operational/Environmental Test Profiles Dev.	-	-	1	-	0	7	1	3	1	1	3
34	Utilization of 781	-	-	0	0	0	4	0	3	3	4	2
35	Procedures Similar to 781 Used	-	-	-	-	-	0	0	5	0	5	5
39	Constant Failure Rate Assumed for Testing	-	-	1	1	1	8	3	1	0	2	2
40	781 Appropriate for Nonelectronic Equipment	-	-	-	-	-	2	0	4	0	5	5
47	Accelerated Testing Methods Utilized	-	-	-	0	0	5	0	4	2	2	3
52	Any Government Contracts Specify a RCM Program	-	1	-	-	-	4	2	3	0	4	3
53	DID's Add to Effectiveness of Reliability Req.	-	-	-	-	1	7	1	2	0	2	4
54	Lack of Standardization of Nonelectronic Parts	-	1	-	-	1	6	2	0	0	5	3
55	Separate Rel. Specs. for Large and Small Items	-	0	-	-	1	6	1	4	1	1	3
56	Effort by Eng. Societies to Upgrade Rel. Specs.	-	0	-	0	0	3	0	7	3	1	2
57	Does Ruggedization Requirements Affect Rel.	-	-	-	-	-	8	0	0	0	3	5
58a	Nonelectronic Info. Available for Rel. Analysis	-	-	-	1	0	1	1	3	1	7	3
58b	Handbook with Procedures/Guidance Possible	-	-	-	-	1	6	1	1	0	4	4

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES 0 = NO - = NO RESPONSE

2. ARMORED/WHEELED VEHICLES

Question	Subject	Government/Industry (G/I) Respondee	I 45	I 58	I 109	G 01	G 13	G 20	G 25	G 40	G 68	G 83
4a	Utilization of 785		-	1	1	0	-	-	0	-	1	-
4b	Requirements Similar to 785 Used		-	0	0	1	-	-	0	-	0	-
10	Mission vs. Logistics Reliability Considered		0	1	1	0	1	0	1	1	1	1
11a	785 Applicable to Nonelectronic Equipment		1	1	1	1	1	1	-	1	1	1
11b	785 Cost Effective for Nonelectronic Equipment		-	1	1	1	1	1	-	1	-	1
18	FMEA Performed on Nonelectronic Equipment		1	1	1	0	-	1	0	1	1	-
22	Reliability Predictions Used to Monitor Design		1	1	0	0	0	1	-	0	1	-
24	Overhaul/Maintenance Actions Included		-	0	0	0	-	0	-	0	1	-
25	756 Satisfactory to Nonelectronic Equipment		-	0	0	0	-	0	-	1	0	-
27a	MIL-HDBK-5 Used to Assess Reliability		-	1	0	0	-	0	-	0	0	-
27b	MIL-HDBK-5 Satisfactory for Material Properties		-	0	-	0	-	-	-	-	-	-
29	Planned Reliability Growth Included in Program		1	1	1	1	-	1	0	1	1	-
32	Internal Parts Selection Procedures Utilized		-	1	0	0	-	0	-	0	0	-
33	Operational/Environmental Test Profiles Dev.		-	1	0	0	0	1	0	0	1	-
34	Utilization of 781		-	1	0	1	-	1	0	0	0	1
35	Procedures Similar to 781 Used		-	0	0	0	-	0	0	0	0	-
39	Constant Failure Rate Assumed for Testing		0	1	0	1	-	0	1	1	1	1
40	781 Appropriate for Nonelectronic Equipment		-	-	0	1	-	-	-	0	0	1
47	Accelerated Testing Methods Utilized		1	1	0	0	-	1	0	0	0	-
52	Any Government Contracts Specify a RCM Program		-	1	1	-	-	1	-	1	1	-
53	DID's Add to Effectiveness of Reliability Req.		-	1	1	0	-	1	-	1	1	-
54	Lack of Standardization of Nonelectronic Parts		1	1	1	1	1	1	1	0	1	-
55	Separate Rel. Specs. for Large and Small Items		-	-	1	0	1	-	1	0	1	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.		-	1	0	0	0	0	0	0	0	0
57	Does Ruggedization Requirements Affect Rel.		-	0	-	-	1	1	1	1	0	-
58a	Nonelectronic Info. Available for Rel. Analysis		-	-	-	0	-	0	-	-	0	0
58b	Handbook with Procedures/Guidance Possible		1	-	1	0	1	1	1	-	1	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES 0 = NO - = NO RESPONSE

2. ARMORED/WHEELED VEHICLES

		TOTALS					
		1		0		-	
Question	Subject Government/Industry (G/I) Respondee	I	G	I	G	I	G
4a	Utilization of 785	2	1	0	2	1	4
4b	Requirements Similar to 785 Used	0	1	2	2	1	4
10	Mission vs. Logistics Reliability Considered	2	5	1	2	0	0
11a	785 Applicable to Nonelectronic Equipment	3	6	0	0	0	1
11b	785 Cost Effective for Nonelectronic Equipment	2	5	0	0	1	2
18	FMEA Performed on Nonelectronic Equipment	3	3	1	2	0	2
22	Reliability Predictions Used to Monitor Design	2	2	2	3	0	2
24	Overhaul/Maintenance Actions Included	0	1	2	3	1	3
25	756 Satisfactory to Nonelectronic Equipment	0	1	1	3	1	3
27a	MIL-HDBK-5 Used to Assess Reliability	1	0	0	4	2	3
27b	MIL-HDBK-5 Satisfactory for Material Properties	0	0	1	1	1	6
29	Planned Reliability Growth Included in Program	3	4	1	1	0	2
32	Internal Parts Selection Procedures Utilized	1	0	1	4	1	3
33	Operational/Environmental Test Profiles Dev.	1	2	1	4	1	1
34	Utilization of 781	1	3	1	3	1	1
35	Procedures Similar to 781 Used	0	0	2	5	1	2
39	Constant Failure Rate Assumed for Testing	1	5	2	1	0	1
40	781 Appropriate for Nonelectronic Equipment	0	2	1	2	2	3
47	Accelerated Testing Methods Utilized	2	1	1	4	0	2
52	Any Government Contracts Specify a RCM Program	2	3	0	0	1	4
53	DID's Add to Effectiveness of Reliability Req.	2	3	0	1	1	3
54	Lack of Standardization of Nonelectronic Parts	3	5	0	1	0	1
55	Separate Rel. Specs. for Large and Small Items	1	4	0	2	2	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	0	1	7	1	0
57	Does Ruggedization Requirements Affect Rel.	0	4	1	1	2	2
58a	Nonelectronic Info. Available for Rel. Analysis	0	0	0	4	3	3
58b	Handbook with Procedures/Guidance Possible	2	5	0	1	1	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

3. MISSILE/SPACE CRAFT SYSTEMS

	Government/Industry (G/I)	I	I	I	I	I	G	G	G	G	G	G
Question	Subject Respondee	14	52	108	110	112	13	18	24	25	40	53
4a	Utilization of 785	1	1	0	1	1	-	-	1	0	-	0
4b	Requirements Similar to 785 Used	-	-	-	1	1	-	-	0	0	-	-
10	Mission vs. Logistics Reliability Considered	1	1	0	1	1	1	0	1	1	1	1
11a	785 Applicable to Nonelectronic Equipment	1	0	0	1	-	1	1	1	-	1	1
11b	785 Cost Effective for Nonelectronic Equipment	1	0	0	1	-	1	1	1	-	1	-
18	FMEA Performed on Nonelectronic Equipment	1	1	1	1	1	-	1	1	0	1	0
22	Reliability Predictions Used to Monitor Design	1	1	1	1	0	0	1	1	-	0	-
24	Overhaul/Maintenance Actions Included	0	1	-	1	-	-	0	1	-	0	-
25	756 Satisfactory to Nonelectronic Equipment	-	0	1	1	-	-	1	0	-	1	-
27a	MIL-HDBK-5 Used to Assess Reliability	0	1	0	0	1	-	0	0	-	0	-
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	1	-	-	1	-	-	-	-	-	-
29	Planned Reliability Growth Included in Program	0	1	0	1	0	-	1	1	0	1	-
32	Internal Parts Selection Procedures Utilized	1	1	1	1	1	-	0	1	-	0	0
33	Operational/Environmental Test Profiles Dev.	0	1	1	1	1	0	1	1	0	0	1
34	Utilization of 781	0	0	0	1	-	-	0	1	0	0	0
35	Procedures Similar to 781 Used	1	0	1	0	-	-	0	0	0	0	-
39	Constant Failure Rate Assumed for Testing	0	1	1	1	1	-	-	-	1	1	1
40	781 Appropriate for Nonelectronic Equipment	-	0	-	0	-	-	0	0	-	0	-
47	Accelerated Testing Methods Utilized	1	1	1	1	1	-	0	0	0	0	-
52	Any Government Contracts Specify a RCM Program	-	1	0	-	-	-	0	0	-	1	-
53	DID's Add to Effectiveness of Reliability Req.	1	1	1	1	-	-	1	1	-	1	-
54	Lack of Standardization of Nonelectronic Parts	-	1	1	-	1	1	1	1	1	0	-
55	Separate Rel. Specs. for Large and Small Items	1	1	-	0	-	1	0	1	1	0	-
56	Effort by Eng. Societies to Upgrade Rel. Specs.	-	1	0	1	-	0	0	-	0	0	-
57	Does Ruggedization Requirements Affect Rel.	-	-	1	-	-	1	-	1	1	1	-
58a	Nonelectronic Info. Available for Rel. Analysis	1	-	1	-	-	-	0	0	-	-	-
58b	Handbook with Procedures/Guidance Possible	-	1	1	-	1	1	-	1	1	-	-

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

3. MISSILE/SPACE CRAFT SYSTEMS

Question	Subject Government/Industry (G/I) Respondee	G	G	G	G	G	G	TOTALS 1		TOTALS 0		TOTALS -	
		98	99	100	101	102	103	I	G	I	G	I	G
4a	Utilization of 785	-	-	-	1	-	1	4	3	1	2	0	7
4b	Requirements Similar to 785 Used	-	-	-	-	-	-	2	0	0	2	3	10
10	Mission vs. Logistics Reliability Considered	1	1	-	-	0	1	4	8	1	2	0	2
11a	785 Applicable to Nonelectronic Equipment	1	-	1	1	1	1	2	10	2	0	1	2
11b	785 Cost Effective for Nonelectronic Equipment	1	-	1	1	1	1	2	9	2	0	1	3
18	FMEA Performed on Nonelectronic Equipment	-	-	1	0	1	1	5	6	0	3	0	3
22	Reliability Predictions Used to Monitor Design	-	-	1	0	1	1	4	5	1	3	0	4
24	Overhaul/Maintenance Actions Included	1	-	1	-	-	0	2	3	1	3	2	6
25	756 Satisfactory to Nonelectronic Equipment	0	-	-	1	1	1	2	5	1	2	2	5
27a	MIL-HDBK-5 Used to Assess Reliability	-	-	-	1	-	0	2	1	3	4	0	7
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	-	-	1	-	-	2	1	0	0	3	11
29	Planned Reliability Growth Included in Program	-	-	-	1	0	1	2	5	3	2	0	5
32	Internal Parts Selection Procedures Utilized	-	-	0	0	-	1	5	2	0	5	0	5
33	Operational/Environmental Test Profiles Dev.	1	1	-	1	1	1	4	8	1	3	0	1
34	Utilization of 781	0	-	0	0	1	1	1	3	3	7	1	2
35	Procedures Similar to 781 Used	0	-	-	0	-	0	4	0	1	7	0	5
39	Constant Failure Rate Assumed for Testing	0	0	1	1	-	1	4	6	1	2	0	4
40	781 Appropriate for Nonelectronic Equipment	0	-	0	0	0	-	0	0	2	7	3	5
47	Accelerated Testing Methods Utilized	1	1	1	0	-	1	5	4	0	5	0	3
52	Any Government Contracts Specify a RCM Program	-	-	0	0	0	0	1	1	1	6	3	5
53	DID's Add to Effectiveness of Reliability Req.	1	1	1	1	1	1	4	9	0	0	1	3
54	Lack of Standardization of Nonelectronic Parts	-	-	1	-	1	1	3	7	0	1	2	4
55	Separate Rel. Specs. for Large and Small Items	1	0	-	-	-	0	2	4	1	4	2	4
56	Effort by Eng. Societies to Upgrade Rel. Specs.	-	1	-	0	0	1	2	2	1	6	2	4
57	Does Ruggedization Requirements Affect Rel.	-	1	-	1	-	1	1	7	0	0	4	5
58a	Nonelectronic Info. Available for Rel. Analysis	-	-	-	0	-	-	2	0	0	3	3	9
58b	Handbook with Procedures/Guidance Possible	1	-	1	0	-	1	3	6	0	1	2	5

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES 0 = NO - = NO RESPONSE

4. TRANSIT SYSTEMS

Question	Subject	Government/Industry (G/I) Respondee	
		I 63	G 48
4a	Utilization of 785	-	0
4b	Requirements Similar to 785 Used	-	-
10	Mission vs. Logistics Reliability Considered	1	1
11a	785 Applicable to Nonelectronic Equipment	-	0
11b	785 Cost Effective for Nonelectronic Equipment	-	0
18	FMEA Performed on Nonelectronic Equipment	1	0
22	Reliability Predictions Used to Monitor Design	0	0
24	Overhaul/Maintenance Actions Included	0	1
25	756 Satisfactory to Nonelectronic Equipment	-	0
27a	MIL-HDBK-5 Used to Assess Reliability	1	0
27b	MIL-HDBK-5 Satisfactory for Material Properties	0	-
29	Planned Reliability Growth Included in Program	0	0
32	Internal Parts Selection Procedures Utilized	1	1
33	Operational/Environmental Test Profiles Dev.	1	1
34	Utilization of 781	-	0
35	Procedures Similar to 781 Used	-	1
39	Constant Failure Rate Assumed for Testing	1	1
40	781 Appropriate for Nonelectronic Equipment	-	-
47	Accelerated Testing Methods Utilized	1	1
52	Any Government Contracts Specify a RCM Program	-	-
53	DID's Add to Effectiveness of Reliability Req.	1	-
54	Lack of Standardization of Nonelectronic Parts	1	1
55	Separate Rel. Specs. for Large and Small Items	0	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.	0	-
57	Does Ruggedization Requirements Affect Rel.	1	1
58a	Nonelectronic Info. Available for Rel. Analysis	0	-
58b	Handbook with Procedures/Guidance Possible	-	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

5. CONSTRUCTION EQUIPMENT

Question	Subject	Government/Industry (G/I) Respondee I 9	I 21	G 31	TOTALS 1 I	1 G	0 I	0 G	- I	- G
4a	Utilization of 785	0	0	0	0	0	2	1	0	0
4b	Requirements Similar to 785 Used	1	0	0	1	0	1	1	0	0
10	Mission vs. Logistics Reliability Considered	1	-	1	1	1	0	0	1	0
11a	785 Applicable to Nonelectronic Equipment	1	-	0	1	0	0	1	1	0
11b	785 Cost Effective for Nonelectronic Equipment	1	-	0	1	0	0	1	1	0
18	FMEA Performed on Nonelectronic Equipment	1	-	1	1	1	0	0	1	0
22	Reliability Predictions Used to Monitor Design	0	1	1	1	1	1	0	0	0
24	Overhaul/Maintenance Actions Included	1	0	1	1	1	1	0	0	0
25	756 Satisfactory to Nonelectronic Equipment	0	-	-	0	0	1	0	1	1
27a	MIL-HDBK-5 Used to Assess Reliability	0	-	0	0	0	1	1	0	1
27b	MIL-HDBK-5 Satisfactory for Material Properties	0	-	0	0	0	1	1	1	0
29	Planned Reliability Growth Included in Program	1	1	0	2	0	0	1	0	0
32	Internal Parts Selection Procedures Utilized	1	-	-	1	0	0	0	1	1
33	Operational/Environmental Test Profiles Dev.	1	-	1	1	1	0	0	1	0
34	Utilization of 781	0	-	1	0	1	1	0	1	0
35	Procedures Similar to 781 Used	1	-	1	1	1	0	0	1	0
39	Constant Failure Rate Assumed for Testing	0	-	1	0	1	1	0	1	0
40	781 Appropriate for Nonelectronic Equipment	-	-	0	0	0	0	1	2	0
47	Accelerated Testing Methods Utilized	1	1	0	2	0	0	1	0	0
52	Any Government Contracts Specify a RCM Program	0	0	1	0	1	2	0	0	0
53	DID's Add to Effectiveness of Reliability Req.	0	-	1	0	1	1	0	1	0
54	Lack of Standardization of Nonelectronic Parts	1	-	1	1	1	0	0	1	0
55	Separate Rel. Specs. for Large and Small Items	1	-	0	1	0	0	1	1	0
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	-	-	1	0	0	0	1	1
57	Does Ruggedization Requirements Affect Rel.	-	-	1	0	1	0	0	2	0
58a	Nonelectronic Info. Available for Rel. Analysis	-	-	0	0	0	0	1	2	0
58b	Handbook with Procedures/Guidance Possible	1	-	1	1	1	0	0	1	0

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

6. ENGINES/POWER PLANTS

		Government/Industry (G/I)	I	I	I	I	G	G	G	G	G	G	G	G
Question	Subject	Respondee	45	54	74	97	10	31	43	46	51	53	55	68
4a	Utilization of 785		-	0	1	1	-	0	1	1	1	0	0	1
4b	Requirements Similar to 785 Used		-	0	-	0	-	0	-	-	0	-	0	0
10	Mission vs. Logistics Reliability Considered		0	1	1	1	1	1	1	0	1	1	1	1
11a	785 Applicable to Nonelectronic Equipment		1	1	0	1	-	0	-	1	1	1	1	1
11b	785 Cost Effective for Nonelectronic Equipment		-	1	0	0	-	0	-	1	1	-	1	-
18	FMEA Performed on Nonelectronic Equipment		1	1	1	1	0	1	1	0	1	0	1	1
22	Reliability Predictions Used to Monitor Design		1	1	0	0	0	1	-	0	1	-	1	1
24	Overhaul/Maintenance Actions Included		-	1	1	1	-	1	-	0	0	-	1	1
25	756 Satisfactory to Nonelectronic Equipment		-	0	0	0	-	-	-	-	-	-	0	0
27a	MIL-HDBK-5 Used to Assess Reliability		-	0	0	0	-	0	0	-	-	-	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties		-	-	1	-	-	0	0	-	-	-	-	-
29	Planned Reliability Growth Included in Program		1	0	0	1	-	0	-	0	1	-	1	1
32	Internal Parts Selection Procedures Utilized		-	1	0	-	-	-	-	0	1	0	-	0
33	Operational/Environmental Test Profiles Dev.		-	0	1	1	-	1	-	1	0	1	0	1
34	Utilization of 781		-	0	1	0	-	1	-	1	1	0	1	0
35	Procedures Similar to 781 Used		-	0	0	0	-	1	-	0	0	-	0	0
39	Constant Failure Rate Assumed for Testing		0	1	1	0	-	1	-	1	1	1	1	1
40	781 Appropriate for Nonelectronic Equipment		-	0	0	0	-	0	-	1	1	-	0	0
47	Accelerated Testing Methods Utilized		1	-	0	1	-	0	-	0	0	-	-	0
52	Any Government Contracts Specify a RCM Program		-	0	0	1	-	1	1	0	-	-	0	1
53	DID's Add to Effectiveness of Reliability Req.		-	0	-	0	-	1	-	1	-	-	1	1
54	Lack of Standardization of Nonelectronic Parts		1	-	-	-	-	1	1	0	1	-	1	1
55	Separate Rel. Specs. for Large and Small Items		-	1	-	-	-	0	0	0	-	-	1	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.		-	-	0	1	-	-	0	0	-	-	0	0
57	Does Ruggedization Requirements Affect Rel.		-	-	-	-	-	1	-	1	-	-	1	0
58a	Nonelectronic Info. Available for Rel. Analysis		-	-	0	1	-	0	-	-	-	-	0	0
58b	Handbook with Procedures/Guidance Possible		1	1	1	1	-	1	-	-	-	-	1	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES 0 = NO - = NO RESPONSE

6. ENGINES/POWER PLANTS

Question	Subject Government/Industry (G/I) Respondee	TOTALS					
		1		0		-	
		I	G	I	G	I	G
4a	Utilization of 785	2	4	1	3	1	1
4b	Requirements Similar to 785 Used	0	0	2	4	2	4
10	Mission vs. Logistics Reliability Considered	3	7	1	1	0	0
11a	785 Applicable to Nonelectronic Equipment	3	5	1	1	0	2
11b	785 Cost Effective for Nonelectronic Equipment	1	3	2	1	1	4
18	FMEA Performed on Nonelectronic Equipment	4	5	0	3	0	0
22	Reliability Predictions Used to Monitor Design	2	4	2	2	0	2
24	Overhaul/Maintenance Actions Included	3	3	0	2	1	3
25	756 Satisfactory to Nonelectronic Equipment	0	0	3	2	1	6
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	3	4	1	4
27b	MIL-HDBK-5 Satisfactory for Material Properties	1	0	0	2	3	6
29	Planned Reliability Growth Included in Program	2	3	2	2	0	3
32	Internal Parts Selection Procedures Utilized	1	1	1	3	2	4
33	Operational/Environmental Test Profiles Dev.	2	4	1	2	1	2
34	Utilization of 781	1	4	2	2	1	2
35	Procedures Similar to 781 Used	0	1	3	4	1	3
39	Constant Failure Rate Assumed for Testing	2	6	2	0	0	2
40	781 Appropriate for Nonelectronic Equipment	0	2	3	3	1	3
47	Accelerated Testing Methods Utilized	2	0	1	4	1	4
52	Any Government Contracts Specify a RCM Program	1	3	2	2	1	3
53	DID's Add to Effectiveness of Reliability Req.	0	4	2	0	2	4
54	Lack of Standardization of Nonelectronic Parts	1	5	0	1	3	2
55	Separate Rel. Specs. for Large and Small Items	1	2	0	3	3	3
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	0	1	4	2	4
57	Does Ruggedization Requirements Affect Rel.	0	3	0	1	4	4
58a	Nonelectronic Info. Available for Rel. Analysis	1	0	1	3	2	5
58b	Handbook with Procedures/Guidance Possible	4	3	0	0	0	5

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES 0 = NO - = NO RESPONSE

7. HYDRAULIC/ROCKET ENGINES

Question	Subject	I	I	I	I	G	G	TOTALS 1		0		-	
	Government/Industry (G/I) Respondee	17	39	52	90	5	53	I	G	I	G	I	G
4a	Utilization of 785	0	0	1	1	-	0	2	0	2	1	0	1
4b	Requirements Similar to 785 Used	-	0	-	0	-	-	0	0	2	0	2	2
10	Mission vs. Logistics Reliability Considered	0	1	1	0	1	1	2	2	2	0	0	0
11a	785 Applicable to Nonelectronic Equipment	-	-	0	1	-	1	1	1	1	0	2	1
11b	785 Cost Effective for Nonelectronic Equipment	-	1	0	1	-	-	2	0	1	0	1	2
18	FMEA Performed on Nonelectronic Equipment	1	1	1	1	0	0	4	0	0	2	0	0
22	Reliability Predictions Used to Monitor Design	1	1	1	1	1	-	4	1	0	0	0	1
24	Overhaul/Maintenance Actions Included	0	0	1	1	1	-	2	1	2	0	0	1
25	756 Satisfactory to Nonelectronic Equipment	-	0	0	1	-	-	1	0	2	0	1	2
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	1	1	0	-	2	0	2	1	0	1
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	0	1	1	-	-	2	0	1	0	1	2
29	Planned Reliability Growth Included in Program	0	1	1	0	1	-	2	1	2	0	0	1
32	Internal Parts Selection Procedures Utilized	1	0	1	1	-	0	3	0	1	1	0	1
33	Operational/Environmental Test Profiles Dev.	0	0	1	1	1	1	2	2	2	0	0	0
34	Utilization of 781	-	1	0	0	1	0	1	1	2	1	1	0
35	Procedures Similar to 781 Used	0	0	0	0	-	-	0	0	4	0	0	2
39	Constant Failure Rate Assumed for Testing	0	1	1	1	1	1	3	2	1	0	0	0
40	781 Appropriate for Nonelectronic Equipment	-	-	0	0	0	-	0	0	2	1	2	1
47	Accelerated Testing Methods Utilized	1	1	1	1	0	-	4	0	0	1	0	1
52	Any Government Contracts Specify a RCM Program	0	0	1	0	-	-	1	0	3	0	0	2
53	DID's Add to Effectiveness of Reliability Req.	0	0	1	1	-	-	2	0	2	0	0	2
54	Lack of Standardization of Nonelectronic Parts	1	-	1	1	-	-	3	0	0	0	1	2
55	Separate Rel. Specs. for Large and Small Items	0	-	1	0	-	-	1	0	2	0	1	2
56	Effort by Eng. Societies to Upgrade Rel. Specs.	0	1	1	-	0	-	2	0	1	1	1	1
57	Does Ruggedization Requirements Affect Rel.	0	-	-	-	-	-	0	0	1	0	3	2
58a	Nonelectronic Info. Available for Rel. Analysis	1	0	-	1	1	-	2	1	1	0	1	1
58b	Handbook with Procedures/Guidance Possible	0	1	1	-	1	-	2	1	1	0	1	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

8. RADAR SYSTEMS

Question	Subject	Government/Industry (G/I) Respondee	I 22	I 79	G 19	TOTALS 1 I	TOTALS 1 G	TOTALS 0 I	TOTALS 0 G	TOTALS - I	TOTALS - G
4a	Utilization of 785		-	1	1	1	1	0	0	1	0
4b	Requirements Similar to 785 Used		-	0	-	0	0	1	0	1	1
10	Mission vs. Logistics Reliability Considered		1	1	1	2	1	0	0	0	0
11a	785 Applicable to Nonelectronic Equipment		0	1	1	1	1	1	0	0	0
11b	785 Cost Effective for Nonelectronic Equipment		0	1	1	1	1	1	0	0	0
18	FMEA Performed on Nonelectronic Equipment		0	1	0	1	0	1	1	0	0
22	Reliability Predictions Used to Monitor Design		0	1	1	1	1	1	0	0	0
24	Overhaul/Maintenance Actions Included		1	1	1	2	1	0	0	0	0
25	756 Satisfactory to Nonelectronic Equipment		0	1	1	1	1	1	0	0	0
27a	MIL-HDBK-5 Used to Assess Reliability		0	0	0	0	0	2	1	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties		-	-	-	0	0	0	0	2	1
29	Planned Reliability Growth Included in Program		1	1	0	2	0	0	1	0	0
32	Internal Parts Selection Procedures Utilized		1	1	0	2	0	0	1	0	0
33	Operational/Enviromental Test Profiles Dev.		1	1	1	2	1	0	0	0	0
34	Utilization of 781		1	1	1	2	1	0	0	0	0
35	Procedures Similar to 781 Used		-	0	0	0	0	1	1	1	0
39	Constant Failure Rate Assumed for Testing		1	1	1	2	1	0	0	0	0
40	781 Appropriate for Nonelectronic Equipment		0	1	1	1	1	1	0	0	0
47	Accelerated Testing Methods Utilized		1	0	0	1	0	1	1	0	0
52	Any Government Contracts Specify a RCM Program		0	0	0	0	0	2	1	0	0
53	DID's Add to Effectiveness of Reliability Req.		-	0	1	0	1	1	0	1	0
54	Lack of Standardization of Nonelectronic Parts		-	1	0	1	0	0	1	1	0
55	Separate Rel. Specs. for Large and Small Items		1	0	-	1	0	1	0	0	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.		0	1	0	1	0	1	1	0	0
57	Does Ruggedization Requirements Affect Rel.		1	-	1	1	1	0	0	1	0
58a	Nonelectronic Info. Available for Rel. Analysis		-	-	0	0	0	0	1	2	0
58b	Handbook with Procedures/Guidance Possible		1	1	1	2	1	0	0	0	0

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

9. COMPUTER/AVIONICS/COMMUNICATIONS

Question	Subject	Government/Industry (G/I) Respondee						TOTALS					
								1		0		-	
		I 9	I 16	I 22	I 27	I 57	G 24	I	G	I	G	I	G
4a	Utilization of 785	0	0	-	0	0	1	0	1	4	0	1	0
4b	Requirements Similar to 785 Used	1	0	-	1	-	0	2	0	1	1	2	0
10	Mission vs. Logistics Reliability Considered	1	1	1	0	0	1	3	1	2	0	0	0
11a	785 Applicable to Nonelectronic Equipment	1	-	0	1	1	1	3	1	1	0	1	0
11b	785 Cost Effective for Nonelectronic Equipment	1	-	0	1	1	1	3	1	1	0	1	0
18	FMEA Performed on Nonelectronic Equipment	1	0	0	0	1	1	2	1	3	0	0	0
22	Reliability Predictions Used to Monitor Design	0	0	0	0	1	1	1	1	4	0	0	0
24	Overhaul/Maintenance Actions Included	1	1	1	0	0	1	3	1	2	0	0	0
25	756 Satisfactory to Nonelectronic Equipment	0	-	0	-	0	0	0	0	3	1	2	0
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	0	0	0	0	0	0	5	1	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties	0	-	-	-	-	-	0	0	1	0	4	1
29	Planned Reliability Growth Included in Program	1	1	1	0	1	1	4	1	1	0	0	0
32	Internal Parts Selection Procedures Utilized	1	1	1	1	1	1	5	1	0	0	0	0
33	Operational/Environmental Test Profiles Dev.	1	0	1	1	-	1	3	1	1	0	1	0
34	Utilization of 781	0	0	1	1	1	1	3	1	2	0	0	0
35	Procedures Similar to 781 Used	1	0	-	1	0	0	2	0	2	1	1	0
39	Constant Failure Rate Assumed for Testing	0	-	1	1	1	-	3	0	1	0	1	1
40	781 Appropriate for Nonelectronic Equipment	-	-	0	0	0	0	0	0	3	1	2	0
47	Accelerated Testing Methods Utilized	1	0	1	1	1	0	4	0	1	1	0	0
52	Any Government Contracts Specify a RCM Program	0	0	0	0	1	0	1	0	4	1	0	0
53	DID's Add to Effectiveness of Reliability Req.	0	0	-	-	1	1	1	1	2	0	2	0
54	Lack of Standardization of Nonelectronic Parts	1	-	-	1	-	1	2	1	0	0	3	0
55	Separate Rel. Specs. for Large and Small Items	1	-	1	-	0	1	2	1	1	0	2	0
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	-	0	-	1	-	2	0	1	0	2	1
57	Does Ruggedization Requirements Affect Rel.	-	-	1	1	1	1	3	1	0	0	2	0
58a	Nonelectronic Info. Available for Rel. Analysis	-	-	-	0	0	0	0	0	2	1	3	0
58b	Handbook with Procedures/Guidance Possible	1	-	1	1	1	1	4	1	0	0	1	0

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES 0 = NO - = NO RESPONSE

10. AIR CONDITIONING SYSTEMS

										TOTALS					
										1		0		-	
	Government/Industry (G/I)	I	I	I	G	G	G	G	G	I	G	I	G	I	G
Question	Subject / Respondee	38	57	86	19	40	55	70	75						
4a	Utilization of 785	0	0	0	1	-	0	0	-	0	1	3	2	0	2
4b	Requirements Similar tc 785 Used	0	-	0	-	-	0	1	-	0	1	2	1	1	3
10	Mission vs. Logistics Reliability Considered	1	0	0	1	1	1	0	1	1	4	2	1	0	0
11a	785 Applicable to Nonelectronic Equipment	0	1	1	1	1	1	1	-	2	4	1	0	0	1
11b	785 Cost Effective for Nonelectronic Equipment	0	1	1	1	1	1	1	-	2	4	1	0	0	1
18	FMEA Performed on Nonelectronic Equipment	1	1	1	0	1	1	1	0	3	3	0	2	0	0
22	Reliability Predictions Used to Monitor Design	1	1	0	1	0	1	0	1	2	3	1	2	0	0
24	Overhaul/Maintenance Actions Included	1	0	1	1	0	1	1	0	2	3	1	2	0	0
25	756 Satisfactory to Nonelectronic Equipment	0	0	1	1	1	0	-	-	1	2	2	1	0	2
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	0	0	0	0	0	0	0	0	3	5	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	-	-	-	-	-	-	-	0	0	0	0	3	5
29	Planned Reliability Growth Included in Program	-	1	0	0	1	1	0	0	1	2	1	3	1	0
32	Internal Parts Selection Procedures Utilized	1	1	1	0	0	-	0	1	3	1	0	3	0	1
33	Operational/Environmental Test Profiles Dev.	-	-	1	1	0	0	0	0	1	1	0	4	2	0
34	Utilization of 781	1	1	0	1	0	1	0	1	2	3	1	2	0	0
35	Procedures Similar to 781 Used	0	0	0	0	0	0	-	0	0	0	3	4	0	1
39	Constant Failure Rate Assumed for Testing	1	1	-	1	1	1	-	1	2	4	0	0	1	1
40	781 Appropriate for Nonelectronic Equipment	0	0	-	1	0	0	-	0	0	1	2	3	1	1
47	Accelerated Testing Methods Utilized	-	1	1	0	0	-	0	1	2	1	0	3	1	1
52	Any Government Contracts Specify a RCM Program	1	1	0	0	1	0	0	0	2	1	1	4	0	0
53	DID's Add to Effectiveness of Reliability Req.	0	1	1	1	1	1	1	1	2	0	1	0	0	5
54	Lack of Standardization of Nonelectronic Parts	1	-	1	0	0	1	-	-	2	1	0	2	1	2
55	Separate Rel. Specs. for Large and Small Items	-	0	0	-	0	1	-	1	0	2	2	1	1	2
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	1	0	0	0	0	0	-	2	0	1	4	0	1
57	Does Ruggedization Requirements Affect Rel.	1	1	1	1	1	1	-	1	3	4	0	0	0	1
58a	Nonelectronic Info. Available for Rel. Analysis	0	0	0	0	-	0	0	0	0	0	3	4	0	1
58b	Handbook with Procedures/Guidance Possible	1	1	1	1	-	1	1	1	3	4	0	0	0	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

11. TRANSMISSIONS/POWER TRAINS/GEAR BOXES

	Government/Industry (G/I)	I	I	I	I	I	I	I	G	G	G	G	G
Question	Subject Respondee	2	35	38	42	45	58	88	19	23	31	55	68
4a	Utilization of 785	1	0	0	0	-	1	0	1	0	0	0	1
4b	Requirements Similar to 785 Used	1	0	0	1	-	0	0	-	1	0	0	0
10	Mission vs. Logistics Reliability Considered	-	0	1	1	0	1	0	1	0	1	1	1
11a	785 Applicable to Nonelectronic Equipment	1	1	0	1	1	1	1	1	1	0	1	1
11b	785 Cost Effective for Nonelectronic Equipment	1	1	0	1	-	1	1	1	1	0	1	-
18	FMEA Performed on Nonelectronic Equipment	1	1	1	1	1	1	1	0	1	1	1	1
22	Reliability Predictions Used to Monitor Design	1	1	1	0	1	1	0	1	0	1	1	1
24	Overhaul/Maintenance Actions Included	1	0	1	0	-	0	0	1	0	1	1	1
25	756 Satisfactory to Nonelectronic Equipment	0	1	0	1	-	0	0	1	-	-	0	0
27a	MIL-HDBK-5 Used to Assess Reliability	-	0	0	0	-	1	0	0	1	0	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	0	-	-	-	0	1	-	1	0	-	-
29	Planned Reliability Growth Included in Program	1	1	-	0	1	1	0	0	0	0	1	1
32	Internal Parts Selection Procedures Utilized	-	0	1	0	-	1	1	0	1	-	-	0
33	Operational/Environmental Test Profiles Dev.	1	0	-	0	-	1	1	1	1	1	0	1
34	Utilization of 781	-	1	1	0	-	1	0	1	0	1	1	0
35	Procedures Similar to 781 Used	-	0	0	0	-	0	0	0	0	1	0	0
39	Constant Failure Rate Assumed for Testing	0	1	1	1	0	1	1	1	0	1	1	1
40	781 Appropriate for Nonelectronic Equipment	1	1	0	0	-	-	1	1	1	0	0	0
47	Accelerated Testing Methods Utilized	1	1	-	0	1	1	1	0	0	0	-	0
52	Any Government Contracts Specify a RCM Program	1	0	1	0	-	1	0	0	0	1	0	1
53	DID's Add to Effectiveness of Reliability Req.	1	0	0	0	-	1	1	1	1	1	1	1
54	Lack of Standardization of Nonelectronic Parts	1	1	1	1	1	1	1	0	1	1	1	1
55	Separate Rel. Specs. for Large and Small Items	1	1	-	1	-	-	0	-	-	0	1	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	0	1	1	-	1	0	0	0	-	0	0
57	Does Ruggedization Requirements Affect Rel.	1	-	1	-	-	0	-	1	-	1	1	0
58a	Nonelectronic Info. Available for Rel. Analysis	0	-	0	-	-	-	1	0	-	0	0	0
58b	Handbook with Procedures/Guidance Possible	1	1	1	-	1	-	1	1	-	1	1	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

11. TRANSMISSIONS/POWER TRAINS/GEAR BOXES

Question	Subject	Government/Industry (G/I) Respondee	TOTALS 1		0		-	
			I	G	I	G	I	G
4a	Utilization of 785		2	2	4	3	1	0
4b	Requirements Similar to 785 Used		2	1	4	3	1	1
10	Mission vs. Logistics Reliability Considered		3	4	3	1	1	0
11a	785 Applicable to Nonelectronic Equipment		6	4	1	1	0	0
11b	785 Cost Effective for Nonelectronic Equipment		5	3	1	1	1	1
18	FMEA Performed on Nonelectronic Equipment		7	3	0	1	0	1
22	Reliability Predictions Used to Monitor Design		5	4	2	1	0	0
24	Overhaul/Maintenance Actions Included		2	4	4	1	1	0
25	756 Satisfactory to Nonelectronic Equipment		2	1	4	2	1	2
27a	MIL-HDBK-5 Used to Assess Reliability		1	1	4	4	2	0
27b	MIL-HDBK-5 Satisfactory for Material Properties		1	1	2	1	4	3
29	Planned Reliability Growth Included in Program		4	2	2	3	1	0
32	Internal Parts Selection Procedures Utilized		3	1	2	2	2	2
33	Operational/Environmental Test Profiles Dev.		3	4	2	1	2	0
34	Utilization of 781		3	3	2	2	2	0
35	Procedures Similar to 781 Used		0	1	5	4	2	0
39	Constant Failure Rate Assumed for Testing		5	4	2	1	1	0
40	781 Appropriate for Nonelectronic Equipment		3	2	2	3	2	0
47	Accelerated Testing Methods Utilized		5	0	1	4	1	1
52	Any Government Contracts Specify a RCM Program		3	2	3	3	1	0
53	DID's Add to Effectiveness of Reliability Req.		3	5	3	0	1	0
54	Lack of Standardization of Nonelectronic Parts		7	4	0	1	0	0
55	Separate Rel. Specs. for Large and Small Items		3	2	1	1	3	2
56	Effort by Eng. Societies to Upgrade Rel. Specs.		4	0	1	4	1	1
57	Does Ruggedization Requirements Affect Rel.		2	3	1	1	4	1
58a	Nonelectronic Info. Available for Rel. Analysis		1	0	2	4	4	1
58b	Handbook with Procedures/Guidance Possible		5	4	0	0	2	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

12. MOTOR/GENERATOR SETS

	Government/Industry (G/I)	I	I	I	I	I	G	G	G	G
Question	Subject Respondee	22	33	42	57	79	46	47	55	81
4a	Utilization of 785	-	0	0	0	1	1	0	0	0
4b	Requirements Similar to 785 Used	-	0	1	-	0	-	0	0	1
10	Mission vs. Logistics Reliability Considered	1	0	1	0	1	0	1	1	0
11a	785 Applicable to Nonelectronic Equipment	0	1	1	1	1	1	1	1	1
11b	785 Cost Effective for Nonelectronic Equipment	0	1	1	1	1	1	1	1	-
18	FMEA Performed on Nonelectronic Equipment	0	1	1	1	1	0	0	1	1
22	Reliability Predictions Used to Monitor Design	0	1	0	1	1	0	0	1	0
24	Overhaul/Maintenance Actions Included	1	0	0	0	1	0	1	1	0
25	756 Satisfactory to Nonelectronic Equipment	0	1	1	0	1	-	1	0	1
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	0	0	0	-	0	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	-	-	-	-	-	-	-	-
29	Planned Reliability Growth Included in Program	1	0	0	1	1	0	0	1	0
32	Internal Parts Selection Procedures Utilized	1	0	0	1	1	0	0	-	1
33	Operational/Environmental Test Profiles Dev.	1	1	0	-	1	1	0	0	1
34	Utilization of 781	1	0	0	1	1	1	0	1	0
35	Procedures Similar to 781 Used	-	0	0	0	0	0	0	0	0
39	Constant Failure Rate Assumed for Testing	1	1	1	1	1	1	1	1	-
40	781 Appropriate for Nonelectronic Equipment	0	0	0	0	1	1	0	0	-
47	Accelerated Testing Methods Utilized	1	-	0	1	0	0	0	-	0
52	Any Government Contracts Specify a RCM Program	0	0	0	1	0	0	0	0	0
53	DID's Add to Effectiveness of Reliability Req.	-	1	0	1	0	1	1	1	1
54	Lack of Standardization of Nonelectronic Parts	-	-	1	-	1	0	0	1	0
55	Separate Rel. Specs. for Large and Small Items	1	1	1	0	0	0	0	1	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.	0	0	1	1	1	0	0	0	0
57	Does Ruggedization Requirements Affect Rel.	1	1	-	1	-	1	0	1	-
58a	Nonelectronic Info. Available for Rel. Analysis	-	-	-	0	-	-	-	0	1
58b	Handbook with Procedures/Guidance Possible	1	-	-	1	1	-	-	1	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

12. MOTOR/GENERATOR SETS

Government/Industry (G/I) Respondee

		TOTALS					
		1		0		-	
Question	Subject	I	G	I	G	I	G
4a	Utilization of 785	1	1	3	3	1	0
4b	Requirements Similar to 785 Used	1	1	2	2	2	1
10	Mission vs. Logistics Reliability Considered	3	2	2	2	0	0
11a	785 Applicable to Nonelectronic Equipment	4	4	1	0	1	0
11b	785 Cost Effective for Nonelectronic Equipment	4	3	1	0	1	1
18	FMEA Performed on Nonelectronic Equipment	4	2	1	2	1	0
22	Reliability Predictions Used to Monitor Design	3	1	2	3	0	0
24	Overhaul/Maintenance Actions Included	2	2	3	2	0	0
25	756 Satisfactory to Nonelectronic Equipment	3	2	2	1	0	1
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	5	3	0	1
27b	MIL-HDBK-5 Satisfactory for Material Properties	0	0	0	0	5	4
29	Planned Reliability Growth Included in Program	3	1	2	3	0	0
32	Internal Parts Selection Procedures Utilized	3	1	2	2	0	1
33	Operational/Environmental Test Profiles Dev.	3	2	1	2	1	0
34	Utilization of 781	3	2	2	2	0	0
35	Procedures Similar to 781 Used	0	0	4	4	1	0
39	Constant Failure Rate Assumed for Testing	5	3	0	0	0	1
40	781 Appropriate for Nonelectronic Equipment	1	1	4	2	0	1
47	Accelerated Testing Methods Utilized	2	0	2	3	1	1
52	Any Government Contracts Specify a RCM Program	1	0	4	4	0	0
53	DID's Add to Effectiveness of Reliability Req.	2	4	2	0	1	0
54	Lack of Standardization of Nonelectronic Parts	2	1	0	3	3	0
55	Separate Rel. Specs. for Large and Small Items	3	2	2	2	0	0
56	Effort by Eng. Societies to Upgrade Rel. Specs.	3	0	2	4	0	0
57	Does Ruggedization Requirements Affect Rel.	3	2	0	1	2	1
58a	Nonelectronic Info. Available for Rel. Analysis	0	1	1	1	4	2
58b	Handbook with Procedures/Guidance Possible	3	2	0	0	2	2

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

13. GROUND SUPPORT EQUIPMENT

	Government/Industry (G/I)	I	G	G	G	TOTALS					
						1		0		-	
Question	Subject / Respondee	8	10	24	81	I	G	I	G	I	G
4a	Utilization of 785	0	-	1	0	0	1	1	1	0	1
4b	Requirements Similar to 785 Used	0	-	0	1	0	1	1	1	0	1
10	Mission vs. Logistics Reliability Considered	1	1	1	0	1	2	0	1	0	0
11a	785 Applicable to Nonelectronic Equipment	1	-	1	1	1	2	0	0	0	1
11b	785 Cost Effective for Nonelectronic Equipment	-	-	1	-	0	1	0	0	1	2
18	FMEA Performed on Nonelectronic Equipment	1	0	1	1	1	2	0	1	0	0
22	Reliability Predictions Used to Monitor Design	0	0	1	0	0	1	1	2	0	0
24	Overhaul/Maintenance Actions Included	1	-	1	0	1	1	0	1	0	1
25	756 Satisfactory to Nonelectronic Equipment	-	-	0	1	0	1	0	1	1	1
27a	MIL-HDBK-5 Used to Assess Reliability	0	-	0	0	0	0	1	2	0	1
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	-	-	-	0	0	0	0	1	3
29	Planned Reliability Growth Included in Program	1	-	1	0	1	1	0	1	0	1
32	Internal Parts Selection Procedures Utilized	0	-	1	1	0	2	1	0	0	1
33	Operational/Environmental Test Profiles Dev.	1	-	1	1	1	2	0	0	0	1
34	Utilization of 781	1	-	1	0	1	1	0	1	0	1
35	Procedures Similar to 781 Used	0	-	0	0	0	0	1	2	0	1
39	Constant Failure Rate Assumed for Testing	1	-	-	-	1	0	0	0	0	3
40	781 Appropriate for Nonelectronic Equipment	1	-	0	-	1	0	0	1	0	2
47	Accelerated Testing Methods Utilized	0	-	0	0	0	0	1	2	0	1
52	Any Government Contracts Specify a RCM Program	0	-	0	0	0	0	1	2	0	1
53	DID's Add to Effectiveness of Reliability Req.	1	-	1	1	1	2	0	0	0	1
54	Lack of Standardization of Nonelectronic Parts	1	-	1	0	1	1	0	1	0	1
55	Separate Rel. Specs. for Large and Small Items	1	-	1	1	1	2	0	0	0	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.	0	-	-	0	0	0	1	1	0	2
57	Does Ruggedization Requirements Affect Rel.	1	-	1	-	1	1	0	0	0	2
58a	Nonelectronic Info. Available for Rel. Analysis	0	-	0	1	0	1	1	1	0	1
58b	Handbook with Procedures/Guidance Possible	1	-	1	1	1	2	0	0	0	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES 0 = NO - = NO RESPONSE

14. POWER PLANT GENERATORS/ NUCLEAR POWER PLANT SYSTEMS

Question	Subject	Government/Industry (G/I) Respondee					TOTALS					
		I 2	I 33	I 42	I 106	G 46	1		0		-	
							I	G	I	G	I	G
4a	Utilization of 785	1	0	0	-	-	1	0	2	0	1	1
4b	Requirements Similar to 785 Used	1	1	1	-	-	3	0	0	0	1	1
10	Mission vs. Logistics Reliability Considered	-	0	1	0	1	1	1	2	0	1	0
11a	785 Applicable to Nonelectronic Equipment	1	1	1	1	1	4	1	0	0	0	0
11b	785 Cost Effective for Nonelectronic Equipment	1	1	1	1	1	4	1	0	0	0	0
18	FMEA Performed on Nonelectronic Equipment	1	1	1	1	1	4	1	0	0	0	0
22	Reliability Predictions Used to Monitor Design	1	1	0	1	0	3	0	1	1	0	0
24	Overhaul/Maintenance Actions Included	1	1	0	-	0	2	0	1	1	1	0
25	756 Satisfactory to Nonelectronic Equipment	0	0	1	0	1	1	1	3	0	0	0
27a	MIL-HDBK-5 Used to Assess Reliability	-	0	0	0	0	0	0	3	1	1	0
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	-	-	0	-	0	0	1	0	3	1
29	Planned Reliability Growth Included in Program	1	1	0	0	1	2	1	2	0	0	0
32	Internal Parts Selection Procedures Utilized	-	1	0	0	0	1	0	2	1	1	0
33	Operational/Environmental Test Profiles Dev.	1	1	0	0	0	2	0	2	1	0	0
34	Utilization of 781	-	0	0	1	0	1	0	2	1	1	0
35	Procedures Similar to 781 Used	-	0	0	0	0	0	0	3	1	1	0
39	Constant Failure Rate Assumed for Testing	0	0	1	1	1	2	1	2	0	0	0
40	781 Appropriate for Nonelectronic Equipment	1	0	0	-	0	1	0	2	1	1	0
47	Accelerated Testing Methods Utilized	1	1	0	-	0	2	0	1	1	1	0
52	Any Government Contracts Specify a RCM Program	1	0	0	1	1	2	1	2	0	0	0
53	DID's Add to Effectiveness of Reliability Req.	1	0	0	1	1	2	1	2	0	0	0
54	Lack of Standardization of Nonelectronic Parts	1	1	1	1	0	4	0	0	1	0	0
55	Separate Rel. Specs. for Large and Small Items	1	1	1	-	0	3	0	0	1	1	0
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	1	1	-	0	3	0	0	1	1	0
57	Does Ruggedization Requirements Affect Rel.	1	-	-	-	1	1	1	0	0	3	0
58a	Nonelectronic Info. Available for Rel. Analysis	0	1	-	-	-	1	0	1	0	2	1
58b	Handbook with Procedures/Guidance Possible	1	-	-	1	-	2	0	0	0	2	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

15. STRUCTURES

	Government/Industry (G/I)	I	I	I	G	G	G	G	G	G
Question	Subject Respondee	52	67	74	28	29	30	43	75	83
4a	Utilization of 785	1	0	1	1	-	0	1	-	-
4b	Requirements Similar to 785 Used	-	1	-	0	-	0	-	-	-
10	Mission vs. Logistics Reliability Considered	1	1	1	1	1	1	1	1	1
11a	785 Applicable to Nonelectronic Equipment	0	-	0	-	1	-	-	-	1
11b	785 Cost Effective for Nonelectronic Equipment	0	-	0	-	1	-	-	-	1
18	FMEA Performed on Nonelectronic Equipment	1	1	1	0	1	1	1	0	-
22	Reliability Predictions Used to Monitor Design	1	1	0	1	0	1	-	1	-
24	Overhaul/Maintenance Actions Included	1	0	1	-	0	1	-	0	-
25	756 Satisfactory to Nonelectronic Equipment	0	-	0	-	1	-	-	-	-
27a	MIL-HDBK-5 Used to Assess Reliability	1	0	0	-	0	1	0	0	-
27b	MIL-HDBK-5 Satisfactory for Material Properties	1	-	1	-	-	0	0	-	-
29	Planned Reliability Growth Included in Program	1	1	0	-	1	1	-	0	-
32	Internal Parts Selection Procedures Utilized	1	1	0	1	0	1	-	1	-
33	Operational/Environmental Test Profiles Dev.	1	-	1	1	1	1	-	0	-
34	Utilization of 781	0	0	1	1	1	0	-	1	1
35	Procedures Similar to 781 Used	0	-	0	-	-	-	-	0	-
39	Constant Failure Rate Assumed for Testing	1	1	1	0	1	0	-	1	1
40	781 Appropriate for Nonelectronic Equipment	0	-	0	0	1	-	-	0	1
47	Accelerated Testing Methods Utilized	1	0	0	0	-	1	-	1	-
52	Any Government Contracts Specify a RCM Program	1	1	0	0	-	-	1	0	-
53	DID's Add to Effectiveness of Reliability Req.	1	-	-	0	1	1	-	1	-
54	Lack of Standardization of Nonelectronic Parts	1	-	-	-	1	-	1	-	-
55	Separate Rel. Specs. for Large and Small Items	1	-	-	1	1	1	0	1	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	0	0	0	-	-	0	-	0
57	Does Ruggedization Requirements Affect Rel.	-	-	-	1	1	-	-	1	-
58a	Nonelectronic Info. Available for Rel. Analysis	-	1	0	0	-	-	-	0	0
58b	Handbook with Procedures/Guidance Possible	1	-	1	0	-	-	-	1	-

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES 0 = NO - = NO RESPONSE

15. STRUCTURES

		TOTALS					
	Government/Industry (G/I) Respondee	1		0		-	
Question	Subject	I	G	I	G	I	G
4a	Utilization of 785	2	2	1	1	0	3
4b	Requirements Similar to 785 Used	1	0	0	2	2	4
10	Mission vs. Logistics Reliability Considered	3	6	0	0	0	0
11a	785 Applicable to Nonelectronic Equipment	0	2	2	0	1	4
11b	785 Cost Effective for Nonelectronic Equipment	0	2	2	0	1	4
18	FMEA Performed on Nonelectronic Equipment	3	3	0	2	0	1
22	Reliability Predictions Used to Monitor Design	2	3	1	1	0	2
24	Overhaul/Maintenance Actions Included	2	1	1	2	0	3
25	756 Satisfactory to Nonelectronic Equipment	0	1	2	0	1	5
27a	MIL-HDBK-5 Used to Assess Reliability	1	1	2	3	0	2
27b	MIL-HDBK-5 Satisfactory for Material Properties	2	0	0	2	1	4
29	Planned Reliability Growth Included in Program	2	2	1	1	0	3
32	Internal Parts Selection Procedures Utilized	2	3	1	1	0	2
33	Operational/Environmental Test Profiles Dev.	2	3	0	1	1	2
34	Utilization of 781	1	4	2	1	0	1
35	Procedures Similar to 781 Used	0	0	2	1	1	5
39	Constant Failure Rate Assumed for Testing	3	3	0	2	0	1
40	781 Appropriate for Nonelectronic Equipment	0	2	2	2	1	2
47	Accelerated Testing Methods Utilized	1	2	2	1	0	3
52	Any Government Contracts Specify a RCM Program	2	1	1	2	0	3
53	DID's Add to Effectiveness of Reliability Req.	1	3	0	1	2	2
54	Lack of Standardization of Nonelectronic Parts	1	2	0	0	2	4
55	Separate Rel. Specs. for Large and Small Items	1	5	0	1	2	0
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	0	2	3	0	3
57	Does Ruggedization Requirements Affect Rel.	0	3	0	0	3	3
58a	Nonelectronic Info. Available for Rel. Analysis	1	0	1	3	1	3
58b	Handbook with Procedures/Guidance Possible	2	1	0	1	1	4

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

16. HOME APPLIANCES/HAND HELD MECHANISMS

	Government/Industry (G/I) Respondee	I	I	I
Question	Subject	3	9	69
4a	Utilization of 785	1	0	0
4b	Requirements Similar to 785 Used	0	1	0
10	Mission vs. Logistics Reliability Considered	0	1	1
11a	785 Applicable to Nonelectronic Equipment	1	1	1
11b	785 Cost Effective for Nonelectronic Equipment	1	1	1
18	FMEA Performed on Nonelectronic Equipment	1	1	1
22	Reliability Predictions Used to Monitor Design	0	0	1
24	Overhaul/Maintenance Actions Included	0	1	1
25	756 Satisfactory to Nonelectronic Equipment	0	0	1
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	0	-
29	Planned Reliability Growth Included in Program	0	1	1
32	Internal Parts Selection Procedures Utilized	0	1	1
33	Operational/Environmental Test Profiles Dev.	1	1	1
34	Utilization of 781	1	0	1
35	Procedures Similar to 781 Used	0	1	0
39	Constant Failure Rate Assumed for Testing	1	0	1
40	781 Appropriate for Nonelectronic Equipment	1	-	1
47	Accelerated Testing Methods Utilized	0	1	1
52	Any Government Contracts Specify a RCM Program	0	0	0
53	DID's Add to Effectiveness of Reliability Req.	1	0	1
54	Lack of Standardization of Nonelectronic Parts	1	1	1
55	Separate Rel. Specs. for Large and Small Items	1	1	0
56	Effort by Eng. Societies to Upgrade Rel. Specs.	-	1	0
57	Does Ruggedization Requirements Affect Rel.	-	-	1
58a	Nonelectronic Info. Available for Rel. Analysis	0	-	0
58b	Handbook with Procedures/Guidance Possible	1	1	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

17. HYDRAULIC/PNEUMATIC COMPONENTS

	Government/Industry (G/I)	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Question	Subject Respondee	2	4	6	8	9	12	14	26	77	41	42	44	52	54	58	66	73
4a	Utilization of 785	1	0	1	0	0	0	1	0	0	-	0	0	1	0	1	0	1
4b	Requirements Similar to 785 Used	1	-	-	0	1	1	-	1	1	-	1	0	-	0	0	-	0
10	Mission vs. Logistics Reliability Considered	-	1	1	1	1	0	1	1	-	1	1	-	1	1	1	1	1
11a	785 Applicable to Nonelectronic Equipment	1	1	-	1	1	1	1	1	0	-	1	-	0	1	1	1	1
11b	785 Cost Effective for Nonelectronic Equipment	1	1	1	-	1	1	1	1	-	-	1	-	0	1	1	1	1
18	FMEA Performed on Nonelectronic Equipment	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1
22	Reliability Predictions Used to Monitor Design	1	1	1	0	0	1	1	1	1	1	0	-	1	1	1	1	1
24	Overhaul/Maintenance Actions Included	1	1	0	1	1	1	0	0	1	1	0	0	1	1	0	1	1
25	756 Satisfactory to Nonelectronic Equipment	0	-	0	-	0	0	-	0	0	-	1	-	0	0	0	1	1
27a	MIL-HDBK-5 Used to Assess Reliability	-	0	0	0	0	0	0	0	0	-	0	-	1	0	1	0	-
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	1	-	-	0	-	-	-	-	-	-	-	1	-	0	-	-
29	Planned Reliability Growth Included in Program	1	1	1	1	1	1	0	1	1	1	0	-	1	0	1	1	1
32	Internal Parts Selection Procedures Utilized	-	1	-	0	1	1	1	0	1	1	0	1	1	1	1	1	1
33	Operational/Environmental Test Profiles Dev.	1	0	1	1	1	0	0	1	1	0	1	1	0	1	1	-	1
34	Utilization of 781	-	0	0	1	0	0	0	1	0	0	0	-	0	0	1	1	-
35	Procedures Similar to 781 Used	-	0	-	0	1	0	1	0	1	0	0	1	0	0	0	0	-
39	Constant Failure Rate Assumed for Testing	0	0	-	1	0	0	0	-	0	1	1	1	1	1	1	0	-
40	781 Appropriate for Nonelectronic Equipment	1	-	0	1	-	0	-	1	0	-	0	-	0	0	-	0	-
47	Accelerated Testing Methods Utilized	1	0	0	0	1	1	1	0	1	1	0	1	1	-	1	0	-
52	Any Government Contracts Specify a RCM Program	1	-	1	0	0	0	-	0	0	-	0	-	1	0	1	0	0
53	DID's Add to Effectiveness of Reliability Req.	1	-	1	1	0	0	1	0	0	-	0	-	1	0	1	1	0
54	Lack of Standardization of Nonelectronic Parts	1	-	-	1	1	1	-	0	1	-	1	1	1	-	1	-	-
55	Separate Rel. Specs. for Large and Small Items	1	-	1	1	1	1	1	-	-	1	1	0	1	1	-	1	0
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	0	0	0	1	1	-	1	1	1	1	1	1	-	1	0	0
57	Does Ruggedization Requirements Affect Rel.	1	0	0	0	1	1	-	1	1	1	1	1	1	-	1	0	0
58a	Nonelectronic Info. Available for Rel. Analysis	1	-	1	1	-	-	-	-	-	1	-	-	-	-	0	-	-
58b	Handbook with Procedures/Guidance Possible	0	-	0	0	-	1	1	-	-	-	-	-	-	-	-	1	-

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES 0 = NO - = NO RESPONSE

17. HYDRAULIC/PNEUMATIC COMPONENTS

	Government/Industry (G/I)	I	I	I	I	I	I	G	G	G	G	G	G	G	G	G
Question	Subject Respondee	74	84	85	86	90	105	3	15	18	20	23	31	51	55	70
4a	Utilization of 785	1	0	0	0	1	1	-	-	-	-	0	0	1	0	0
4b	Requirements Similar to 785 Used	-	1	0	0	0	0	-	-	-	-	1	0	0	0	1
10	Mission vs. Logistics Reliability Considered	1	-	1	0	0	1	1	1	0	0	0	1	1	1	0
11a	785 Applicable to Nonelectronic Equipment	0	1	0	1	1	1	1	1	1	1	1	0	1	1	1
11b	785 Cost Effective for Nonelectronic Equipment	0	1	0	1	1	1	1	1	1	1	1	0	1	1	1
18	FMEA Performed on Nonelectronic Equipment	1	1	1	1	1	1	-	0	1	1	1	1	1	1	1
22	Reliability Predictions Used to Monitor Design	0	0	0	0	1	0	0	0	1	1	0	1	1	1	0
24	Overhaul/Maintenance Actions Included	1	-	0	1	1	0	-	0	0	0	0	1	0	1	1
25	756 Satisfactory to Nonelectronic Equipment	0	-	0	1	1	1	-	0	1	0	-	-	-	0	-
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	0	0	1	0	-	0	0	0	1	0	-	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties	1	0	0	-	1	1	-	-	-	-	1	0	-	-	-
29	Planned Reliability Growth Included in Program	0	0	0	0	0	1	-	-	1	1	0	0	1	1	0
32	Internal Parts Selection Procedures Utilized	0	1	1	1	1	1	-	-	0	0	1	-	1	-	0
33	Operational/Environmental Test Profiles Dev.	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0
34	Utilization of 781	1	0	0	0	0	0	-	0	0	1	0	1	1	1	0
35	Procedures Similar to 781 Used	0	-	-	0	0	0	-	-	0	0	0	1	0	0	-
39	Constant Failure Rate Assumed for Testing	1	1	-	-	1	0	-	-	-	0	0	1	1	1	-
40	781 Appropriate for Nonelectronic Equipment	0	-	-	-	0	0	-	0	0	-	1	0	1	0	-
47	Accelerated Testing Methods Utilized	0	0	1	1	1	1	-	-	0	1	0	0	0	-	0
52	Any Government Contracts Specify a RCM Program	0	0	0	0	0	0	-	-	0	1	0	1	-	0	0
53	DID's Add to Effectiveness of Reliability Req.	-	0	0	1	1	1	-	-	1	1	1	1	-	1	1
54	Lack of Standardization of Nonelectronic Parts	-	1	1	1	1	1	1	-	1	1	1	1	1	1	-
55	Separate Rel. Specs. for Large and Small Items	-	1	1	0	0	1	1	-	0	-	-	0	-	1	-
56	Effort by Eng. Societies to Upgrade Rel. Specs.	0	0	-	0	-	1	0	0	0	0	0	-	-	0	0
57	Does Ruggedization Requirements Affect Rel.	0	0	-	0	-	1	0	0	0	0	0	-	-	0	0
58a	Nonelectronic Info. Available for Rel. Analysis	-	-	-	1	-	1	1	-	-	1	-	1	-	1	-
58b	Handbook with Procedures/Guidance Possible	0	0	1	0	1	0	-	-	0	0	-	0	-	0	0

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

17. HYDRAULIC/PNEUMATIC COMPONENTS

	Government/Industry (G/I)	G	G	G	TOTALS					
					1		0		-	
Question	Subject Respondee	72	77	81	I	G	I	G	I	G
4a	Utilization of 785	1	1	0	9	3	13	5	1	4
4b	Requirements Similar to 785 Used	0	-	1	7	3	9	4	7	5
10	Mission vs. Logistics Reliability Considered	0	1	0	16	6	3	6	4	0
11a	785 Applicable to Nonelectronic Equipment	-	1	1	16	10	4	1	3	1
11b	785 Cost Effective for Nonelectronic Equipment	0	1	-	16	9	3	2	4	1
18	FMEA Performed on Nonelectronic Equipment	1	1	1	21	10	2	1	0	1
22	Reliability Predictions Used to Monitor Design	0	-	0	14	5	8	6	1	1
24	Overhaul/Maintenance Actions Included	1	0	0	14	4	8	7	1	1
25	756 Satisfactory to Nonelectronic Equipment	0	1	1	6	3	11	4	6	5
27a	MIL-HDBK-5 Used to Assess Reliability	-	0	0	3	1	16	8	4	3
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	1	-	5	2	4	1	14	9
29	Planned Reliability Growth Included in Program	0	1	0	14	5	8	5	1	2
32	Internal Parts Selection Procedures Utilized	0	-	1	17	3	4	4	2	5
33	Operational/Environmental Test Profiles Dev.	1	1	1	16	7	14	5	3	1
34	Utilization of 781	1	1	0	5	6	15	5	3	1
35	Procedures Similar to 781 Used	1	0	0	4	2	14	7	5	3
39	Constant Failure Rate Assumed for Testing	1	0	-	10	4	8	3	5	5
40	781 Appropriate for Nonelectronic Equipment	-	1	-	3	3	9	6	2	3
47	Accelerated Testing Methods Utilized	1	1	0	5	2	14	6	4	4
52	Any Government Contracts Specify a RCM Program	-	0	0	9	8	10	0	4	4
53	DID's Add to Effectiveness of Reliability Req.	-	1	1	10	8	9	0	4	4
54	Lack of Standardization of Nonelectronic Parts	-	0	0	14	7	2	2	7	3
55	Separate Rel. Specs. for Large and Small Items	-	0	1	14	3	4	3	5	6
56	Effort by Eng. Societies to Upgrade Rel. Specs.	1	0	0	11	1	8	9	4	2
57	Does Ruggedization Requirements Affect Rel.	1	0	0	6	6	1	0	16	6
58a	Nonelectronic Info. Available for Rel. Analysis	1	1	-	6	2	6	5	11	5
58b	Handbook with Procedures/Guidance Possible	-	1	1	11	6	2	0	10	6

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

18. ELECTRICAL COMPONENTS

Question	Subject	I	I	I	I	I	I	I	I	I	I
	Government/Industry (G/I) Respondee	06	08	11	34	57	66	69	79	86	90
4a	Utilization of 785	1	0	0	1	0	0	0	1	0	1
4b	Requirements Similar to 785 Used	-	0	-	0	-	-	0	0	0	0
10	Mission vs. Logistics Reliability Considered	1	1	0	0	0	1	1	1	0	0
11a	785 Applicable to Nonelectronic Equipment	-	1	-	1	1	1	1	1	1	1
11b	785 Cost Effective for Nonelectronic Equipment	1	-	-	1	1	1	1	1	1	1
18	FMEA Performed on Nonelectronic Equipment	1	1	1	1	1	1	1	1	1	1
22	Reliability Predictions Used to Monitor Design	1	0	-	0	1	1	1	1	0	1
24	Overhaul/Maintenance Actions Included	0	1	1	1	0	1	1	1	1	1
25	756 Satisfactory to Nonelectronic Equipment	0	-	1	0	0	1	1	1	1	1
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	0	0	0	0	0	0	0	1
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	-	-	-	-	-	-	-	-	1
29	Planned Reliability Growth Included in Program	1	1	1	1	1	1	1	1	0	0
32	Internal Parts Selection Procedures Utilized	-	0	1	1	1	1	1	1	1	1
33	Operational/Environmental Test Profiles Dev.	0	1	1	1	-	1	1	1	1	1
34	Utilization of 781	0	1	1	0	1	1	1	1	0	0
35	Procedures Similar to 781 Used	-	0	0	0	0	0	0	0	0	0
39	Constant Failure Rate Assumed for Testing	-	1	1	1	1	0	1	1	-	1
40	781 Appropriate for Nonelectronic Equipment	0	1	0	-	0	0	1	1	-	0
47	Accelerated Testing Methods Utilized	0	0	-	0	1	0	1	0	1	1
52	Any Government Contracts Specify a RCM Program	1	0	-	0	1	0	0	0	0	0
53	DID's Add to Effectiveness of Reliability Req.	1	1	-	1	1	1	1	0	1	1
54	Lack of Standardization of Nonelectronic Parts	-	1	1	-	-	-	1	1	1	1
55	Separate Rel. Specs. for Large and Small Items	1	1	0	0	0	1	0	0	0	0
56	Effort by Eng. Societies to Upgrade Rel. Specs.	0	0	-	1	1	0	0	1	0	-
57	Does Ruggedization Requirements Affect Rel.	1	1	-	0	1	-	1	-	1	-
58a	Nonelectronic Info. Available for Rel. Analysis	0	0	-	-	0	1	0	-	0	1
58b	Handbook with Procedures/Guidance Possible	1	1	1	-	1	-	1	1	1	-

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

18. ELECTRICAL COMPONENTS

	Government/Industry (G/I)	G	G	G	G	G	G	G	TOTALS 1		TOTALS 0		TOTALS -	
Question	Subject / Respondee	13	18	19	24	53	75	81	I	G	I	G	I	G
4a	Utilization of 785	-	-	1	1	0	-	0	6	2	4	2	0	3
4b	Requirements Similar to 785 Used	-	-	-	0	-	-	1	0	1	6	1	4	5
10	Mission vs. Logistics Reliability Considered	1	0	1	1	1	1	0	5	5	5	2	0	0
11a	785 Applicable to Nonelectronic Equipment	1	1	1	1	1	-	1	8	7	0	0	2	1
11b	785 Cost Effective for Nonelectronic Equipment	1	1	1	1	-	-	-	8	4	0	0	2	3
18	FMEA Performed on Nonelectronic Equipment	-	1	0	1	0	0	1	10	3	0	3	0	1
22	Reliability Predictions Used to Monitor Design	0	1	1	1	-	1	0	6	4	3	2	1	1
24	Overhaul/Maintenance Actions Included	-	0	1	1	-	0	0	8	2	2	3	0	2
25	756 Satisfactory to Nonelectronic Equipment	-	1	1	0	-	-	1	6	3	3	1	1	3
27a	MIL-HDBK-5 Used to Assess Reliability	-	0	0	0	-	0	0	1	0	9	5	0	2
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	-	-	-	-	-	-	1	0	0	0	9	7
29	Planned Reliability Growth Included in Program	-	1	0	1	-	0	0	8	2	2	3	0	2
32	Internal Parts Selection Procedures Utilized	-	0	0	1	0	1	1	8	3	1	3	1	1
33	Operational/Environmental Test Profiles Dev.	0	1	1	1	1	0	1	8	5	1	2	1	0
34	Utilization of 781	-	0	1	1	0	1	0	6	3	4	3	0	1
35	Procedures Similar to 781 Used	-	0	0	0	-	0	0	9	0	0	5	1	2
39	Constant Failure Rate Assumed for Testing	-	-	1	-	1	1	-	7	3	1	0	2	4
40	781 Appropriate for Nonelectronic Equipment	-	0	1	0	-	0	-	3	1	5	3	2	3
47	Accelerated Testing Methods Utilized	-	0	0	0	-	1	0	4	1	5	4	1	2
52	Any Government Contracts Specify a RCM Program	-	0	0	0	-	0	0	2	0	7	5	1	2
53	DID's Add to Effectiveness of Reliability Req.	-	1	1	1	-	1	1	8	5	1	0	1	2
54	Lack of Standardization of Nonelectronic Parts	1	1	0	1	-	-	0	6	3	0	2	4	2
55	Separate Rel. Specs. for Large and Small Items	1	0	-	1	-	1	1	3	4	7	1	0	2
56	Effort by Eng. Societies to Upgrade Rel. Specs.	0	0	0	-	-	-	0	3	0	5	4	2	3
57	Does Ruggedization Requirements Affect Rel.	1	-	1	1	-	1	-	5	4	1	0	4	3
58a	Nonelectronic Info. Available for Rel. Analysis	-	0	0	0	-	0	1	2	1	5	4	3	2
58b	Handbook with Procedures/Guidance Possible	1	-	1	1	-	1	1	7	5	0	0	3	2

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

19. SENSORS/GYROS/INSTRUMENTS

		Government/Industry (G/I)	I	I	I	I	I	I	I	I	I	I	I	G	G	G	G	G
Question	**Subject**	Respondee	22	33	38	41	44	58	60	62	66	69	84	18	72	75	77	81
4a	Utilization of 785		-	0	0	-	0	1	0	1	0	0	0	-	1	-	1	0
4b	Requirements Similar to 785 Used		-	0	0	-	0	0	-	-	-	0	1	-	0	-	-	1
10	Mission vs. Logistics Reliability Considered		1	0	1	1	-	1	1	1	1	1	-	0	0	1	1	0
11a	785 Applicable to Nonelectronic Equipment		0	1	0	-	-	1	1	-	1	1	1	1	-	-	1	1
11b	785 Cost Effective for Nonelectronic Equipment		0	1	0	-	-	1	1	-	1	1	1	1	0	-	1	-
18	FMEA Performed on Nonelectronic Equipment		0	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1
22	Reliability Predictions Used to Monitor Design		0	1	1	1	-	1	1	-	1	1	0	1	0	1	-	0
24	Overhaul/Maintenance Actions Included		1	0	1	1	0	0	0	1	1	1	-	0	1	0	0	0
25	756 Satisfactory to Nonelectronic Equipment		0	1	0	-	-	0	0	0	1	1	-	1	0	-	1	1
27a	MIL-HDBK-5 Used to Assess Reliability		0	0	0	-	-	1	0	0	0	0	0	0	-	0	0	0
27b	MIL-HDBK-5 Satisfactory for Material Properties		-	-	-	-	-	0	-	-	-	-	0	-	-	-	1	-
29	Planned Reliability Growth Included in Program		1	0	-	1	-	1	1	0	1	1	0	1	0	0	1	0
32	Internal Parts Selection Procedures Utilized		1	0	1	1	1	1	1	-	1	1	1	0	0	1	-	1
33	Operational/Environmental Test Profiles Dev.		1	1	-	1	1	1	0	1	1	1	1	1	1	0	1	1
34	Utilization of 781		1	0	1	0	-	1	1	-	1	1	0	0	1	1	1	0
35	Procedures Similar to 781 Used		-	0	0	0	1	0	1	-	0	0	-	0	1	0	0	0
39	Constant Failure Rate Assumed for Testing		1	1	1	1	1	1	1	1	0	1	1	-	1	1	0	-
40	781 Appropriate for Nonelectronic Equipment		0	0	0	-	-	-	1	-	0	1	-	0	-	0	1	-
47	Accelerated Testing Methods Utilized		1	-	-	1	1	1	1	0	0	1	0	0	1	1	1	0
52	Any Government Contracts Specify a RCM Program		0	0	1	-	-	1	0	0	0	0	0	0	-	0	0	0
53	DID's Add to Effectiveness of Reliability Req.		-	1	0	-	-	1	0	0	1	1	0	1	-	1	1	1
54	Lack of Standardization of Nonelectronic Parts		-	-	1	0	1	1	1	-	-	1	1	1	-	-	0	0
55	Separate Rel. Specs. for Large and Small Items		1	1	-	1	0	-	1	1	1	0	1	0	-	1	0	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.		0	0	1	1	1	1	0	-	0	0	0	0	1	-	0	0
57	Does Ruggedization Requirements Affect Rel.		1	1	1	1	-	0	1	1	-	1	-	-	1	1	1	-
58a	Nonelectronic Info. Available for Rel. Analysis		-	-	0	-	-	-	0	-	1	0	0	0	-	0	1	1
58b	Handbook with Procedures/Guidance Possible		1	-	1	0	-	-	1	1	-	1	1	-	-	1	-	1

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

19. SENSORS/GYROS/INSTRUMENTS

Question	Subject Government/Industry (G/I) Respondee	TOTALS 1 I	TOTALS 1 G	TOTALS 0 I	TOTALS 0 G	TOTALS - I	TOTALS - G
4a	Utilization of 785	2	2	7	1	2	2
4b	Requirements Similar to 785 Used	1	1	5	1	5	3
10	Mission vs. Logistics Reliability Considered	8	2	1	3	2	0
11a	785 Applicable to Nonelectronic Equipment	6	3	2	0	3	2
11b	785 Cost Effective for Nonelectronic Equipment	6	2	2	1	3	2
18	FMEA Performed on Nonelectronic Equipment	8	4	3	1	0	0
22	Reliability Predictions Used to Monitor Design	7	2	2	2	2	1
24	Overhaul/Maintenance Actions Included	6	1	4	4	1	0
25	756 Satisfactory to Nonelectronic Equipment	3	3	5	1	3	1
27a	MIL-HDBK-5 Used to Assess Reliability	1	0	8	4	2	1
27b	MIL-HDBK-5 Satisfactory for Material Properties	0	1	2	0	9	4
29	Planned Reliability Growth Included in Program	6	2	3	3	2	0
32	Internal Parts Selection Procedures Utilized	9	2	1	2	1	1
33	Operational/Environmental Test Profiles Dev.	9	4	1	1	1	0
34	Utilization of 781	6	3	3	2	2	0
35	Procedures Similar to 781 Used	2	1	6	4	3	0
39	Constant Failure Rate Assumed for Testing	10	2	1	1	0	2
40	781 Appropriate for Nonelectronic Equipment	2	1	4	2	5	2
47	Accelerated Testing Methods Utilized	6	3	3	2	2	0
52	Any Government Contracts Specify a RCM Program	2	0	7	4	2	1
53	DID's Add to Effectiveness of Reliability Req.	4	4	4	0	3	1
54	Lack of Standardization of Nonelectronic Parts	6	1	1	2	4	2
55	Separate Rel. Specs. for Large and Small Items	7	2	2	2	2	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.	4	1	6	3	1	1
57	Does Ruggedization Requirements Affect Rel.	7	3	1	0	3	2
58a	Nonelectronic Info. Available for Rel. Analysis	1	2	4	2	6	1
58b	Handbook with Procedures/Guidance Possible	6	2	1	0	4	3

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

20. MECHANICAL COMPONENTS

Question	Subject	Government/Industry (G/I) Respondee														
		I 6	I 8	I 14	I 33	I 34	I 35	I 38	I 45	I 52	I 57	I 69	I 74	I 84	I 88	I 104
4a	Utilization of 785	1	0	1	0	1	0	0	-	1	0	0	1	0	0	0
4b	Requirements Similar to 785 Used	-	0	-	0	0	0	0	-	-	-	0	-	1	0	-
10	Mission vs. Logistics Reliability Considered	1	1	1	0	0	0	1	0	1	0	1	1	-	0	0
11a	785 Applicable to Nonelectronic Equipment	-	1	1	1	1	1	0	1	0	1	1	0	1	1	0
11b	785 Cost Effective for Nonelectronic Equipment	1	-	1	1	1	1	0	-	0	1	1	0	1	1	-
18	FMEA Performed on Nonelectronic Equipment	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	Reliability Predictions Used to Monitor Design	1	0	1	1	0	1	1	1	1	1	1	0	0	0	1
24	Overhaul/Maintenance Actions Included	0	1	0	0	1	0	1	-	1	0	1	1	-	0	0
25	756 Satisfactory to Nonelectronic Equipment	0	-	-	1	0	1	0	-	0	0	1	0	-	0	0
27a	MIL-HDBK-5 Used to Assess Reliability	0	0	0	0	0	0	0	-	1	0	0	0	0	0	1
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	-	-	-	-	0	-	-	1	-	-	1	0	1	-
29	Planned Reliability Growth Included in Program	1	1	0	0	1	1	-	1	1	1	1	0	0	0	0
32	Internal Parts Selection Procedures Utilized	-	0	1	0	1	0	1	-	1	1	1	0	1	1	1
33	Operational/Environmental Test Profiles Dev.	0	1	0	1	1	0	-	-	1	-	1	1	1	1	1
34	Utilization of 781	0	1	0	0	0	1	1	-	0	1	1	1	0	0	-
35	Procedures Similar to 781 Used	-	0	1	0	0	0	0	-	0	0	0	0	-	0	-
39	Constant Failure Rate Assumed for Testing	-	1	0	1	1	1	1	0	1	1	1	1	1	1	1
40	781 Appropriate for Nonelectronic Equipment	0	1	-	0	-	1	0	-	0	0	1	0	-	1	0
47	Accelerated Testing Methods Utilized	0	0	1	-	0	1	-	1	1	1	1	0	0	1	1
52	Any Government Contracts Specify a RCM Program	1	0	-	0	0	0	1	-	1	1	0	0	0	0	0
53	DID's Add to Effectiveness of Reliability Req.	1	1	1	1	1	0	0	-	1	1	1	-	0	1	1
54	Lack of Standardization of Nonelectronic Parts	-	1	-	-	-	1	1	1	1	-	1	-	1	1	1
55	Separate Rel. Specs. for Large and Small Items	1	1	1	1	0	1	-	-	1	0	0	-	1	0	1
56	Effort by Eng. Societies to Upgrade Rel. Specs.	0	0	-	0	1	0	1	-	1	1	0	0	0	0	0
57	Does Ruggedization Requirements Affect Rel.	1	1	-	1	0	-	1	-	-	1	1	-	-	-	0
58a	Nonelectronic Info. Available for Rel. Analysis	0	0	1	-	-	-	0	-	-	0	0	0	0	1	1
58b	Handbook with Procedures/Guidance Possible	1	1	-	-	-	1	1	1	1	1	1	1	1	1	-

GENERIC PRODUCT SUMMARY OF YES/NO RESPONSES

1 = YES   0 = NO   - = NO RESPONSE

20. MECHANICAL COMPONENTS

	Government/Industry (G/I)	G	G	G	G	G	G	G	G	G	TOTALS					
											1		0		-	
Question	Subject / Respondee	13	15	18	23	24	32	55	77	107	I	G	I	G	I	G
4a	Utilization of 785	-	-	-	0	1	0	0	1	-	5	2	9	3	1	4
4b	Requirements Similar to 785 Used	-	-	-	1	0	-	0	-	-	1	1	7	2	7	6
10	Mission vs. Logistics Reliability Considered	1	1	0	0	1	0	1	1	1	7	6	7	3	1	0
11a	785 Applicable to Nonelectronic Equipment	1	1	1	1	1	-	1	1	-	10	7	4	0	1	2
11b	785 Cost Effective for Nonelectronic Equipment	1	1	1	1	1	-	1	1	1	9	8	3	0	3	1
18	FMEA Performed on Nonelectronic Equipment	-	0	1	1	1	-	1	1	1	15	6	0	1	0	2
22	Reliability Predictions Used to Monitor Design	0	0	1	0	1	0	1	-	1	10	4	5	4	0	1
24	Overhaul/Maintenance Actions Included	-	0	0	0	1	1	1	0	1	6	4	7	4	2	1
25	756 Satisfactory to Nonelectronic Equipment	-	0	1	-	0	-	0	1	0	3	2	8	4	4	3
27a	MIL-HDBK-5 Used to Assess Reliability	-	0	0	1	0	0	0	0	-	2	1	12	6	1	2
27b	MIL-HDBK-5 Satisfactory for Material Properties	-	-	-	1	-	-	-	1	-	3	2	2	0	10	7
29	Planned Reliability Growth Included in Program	-	-	1	0	1	-	1	1	1	8	5	6	1	1	3
32	Internal Parts Selection Procedures Utilized	-	-	0	1	1	1	-	-	-	9	3	4	1	2	5
33	Operational/Environmental Test Profiles Dev.	0	0	1	1	1	1	0	1	-	9	5	3	3	3	1
34	Utilization of 781	-	0	0	0	1	0	1	1	-	6	3	7	4	2	2
35	Procedures Similar to 781 Used	-	-	0	0	0	-	0	0	-	1	0	10	5	4	4
39	Constant Failure Rate Assumed for Testing	-	-	-	0	-	0	1	0	-	12	1	2	3	1	5
40	781 Appropriate for Nonelectronic Equipment	-	0	0	1	0	-	0	1	-	4	2	7	4	4	3
47	Accelerated Testing Methods Utilized	-	-	0	0	0	0	-	1	1	8	2	5	4	2	3
52	Any Government Contracts Specify a RCM Program	-	-	0	0	0	-	0	0	-	4	0	9	5	2	4
53	DID's Add to Effectiveness of Reliability Req.	-	-	1	1	1	-	1	1	-	10	5	3	0	2	4
54	Lack of Standardization of Nonelectronic Parts	1	-	1	1	1	-	1	0	1	9	6	0	1	6	2
55	Separate Rel. Specs. for Large and Small Items	1	-	0	-	1	-	1	0	1	8	5	4	2	3	3
56	Effort by Eng. Societies to Upgrade Rel. Specs.	0	0	0	0	-	-	0	0	-	4	0	9	6	2	3
57	Does Ruggedization Requirements Affect Rel.	1	-	-	-	1	-	1	1	1	6	5	2	0	7	4
58a	Nonelectronic Info. Available for Rel. Analysis	-	-	0	-	0	-	0	1	0	3	1	7	4	5	4
58b	Handbook with Procedures/Guidance Possible	1	-	0	-	1	-	1	-	1	11	4	0	1	4	4

MISSION
of
Rome Air Development Center

RADC plans and executes research, development, test and selected acquisition programs in support of Command, Control Communications and Intelligence (C^3I) activities. Technical and engineering support within areas of technical competence is provided to ESD Program Offices (POs) and other ESD elements. The principal technical mission areas are communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data collection and handling, information system technology, ionospheric propagation, solid state sciences, microwave physics and electronic reliability, maintainability and compatibility.