



**PREFERRED  
RELIABILITY  
PRACTICES**

**PRACTICE NO. GSE-3004  
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October 1995**

## **USE OF DESIGN REVIEW CHECKLISTS FOR SPACE SHUTTLE GSE**

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### **Practice:**

The use of a checklist which delineates specific reliability and maintainability (R&M) considerations during design reviews ensures that no critical R&M consideration will be overlooked during the design phase of a project.

### **Benefits:**

Adherence to a design review checklist ensures that R&M issues, including those requirements necessary to meet the R&M specifications, are considered early in the design phase of a project when the cost is minimal for making changes. This will provide the highest reliability for the minimum cost.

### **Programs Which Certify Use:**

Space Shuttle Program, Ground Support Equipment (GSE)

### **Center to Contact for More Information:**

Kennedy Space Center (KSC)

### **Implementation Method:**

The technical checklist is prepared by Reliability and Maintainability Engineering to ensure that all R&M considerations and issues have been taken into account during the design phase of GSE. The checklist is formatted for ease of use by all engineering disciplines involved. A question format can be used to ensure that critical factors are not overlooked. The following is a list of some of the issues to be considered during a design review:

- o Preliminary Design Review
  1. Identification of critical equipment
  2. Program plans
  3. Preliminary test plans
  4. Progress of the design
  5. Reliability allocations and predictions
  6. Redundancy requirements
  7. Maintenance concept:
    - a. Repair level
    - b. Stock provisions

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- c. Built-in-test features
- d. Predictions
- o Intermediate Design Reviews
  - 1. Reliability analyses:
    - a. Allocations
    - b. Predictions
    - c. FMECA, FMEA
  - 2. Failure data
  - 3. Growth test data
  - 4. Production assurance data
  - 5. Vendor data
- o Critical Design Review
  - 1. Subsystem and component specifications
  - 2. Test plans and procedures
  - 3. Critical component identification and evaluations
  - 4. Final design configuration
  - 5. Reliability analyses:
    - a. Predictions
    - b. Stress Analysis
    - c. FMECA, FMEA
    - d. Worst Case Analysis
  - 6. Test results; Environmental and Operational

At KSC, LSOC R&M Engineering has developed a checklist to cover reliability, maintainability, safety and quality assurance issues for Space Shuttle GSE development. This checklist is used during the design phase of the GSE projects. R&M concerns and requirements for the Shuttle program are addressed in the checklist and brought to the attention of design and project engineering.

### **Technical Rationale:**

The checklists have resulted from operational experience with the Shuttle Program. The document which incorporates the checklist also includes a cross reference which relates items on the Reliability and Maintainability Checklists to Shuttle Program requirements. The table of contents of the document has been included with this practice. A sample is also included of some of the items from the Reliability, Quality, Maintainability and Safety Checklists. There are in excess of 60 pages of checklist items which actually comprise the Checklists for Reliability, Quality, Maintainability, and Safety.

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The format and the topics addressed in the checklist will also work for other applications and the checklist is designed to be tailored to meet the specific needs of the individual programs. The complete checklist is contained in reference 2.

### **Impact of Nonpractice:**

Failure to use a checklist during the design phase could result in an R&M issue or consideration being overlooked. This could have an impact on the final reliability. Also, making reliability improvements later than the design phase, such as in the prototype or production phase, would result in a much greater increase in cost for the improvement than if the change were done earlier.

### **References:**

1. Reliability Engineering for Electronic Design, Norman F. Fuqua, Marcel Dekker, Inc. 1987, pp. 365-366.
2. Lockheed Space Operations Company, Procedure for Performing SPC Design Reviews, S&R-P-003.

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## PROCEDURE FOR PERFORMING SPC DESIGN REVIEWS, S&R-P-003 TABLE OF CONTENTS (Reference Only)

### INTRODUCTION

- 1.0 PROGRAM REQUIREMENTS
- 2.0 GROUND SUPPORT EQUIPMENT DESIGN REQUIREMENTS
- 3.0 REFERENCE DOCUMENTS
- 4.0 RELIABILITY & QUALITY ASSURANCE DESIGN REQUIREMENTS
  - 4.1 GENERAL
  - 4.2 DESIGN FOR RELIABILITY
  - 4.3 BASIC RELIABILITY DESIGN PRINCIPLES
    - 4.3.1 Design Simplicity
    - 4.3.2 Redundancy
    - 4.3.3 Derating
    - 4.3.4 Environmental Design
    - 4.3.5 Self-Healing Items
    - 4.3.6 Parts Selection and Control
  - 4.4 RELIABILITY & QUALITY ASSURANCE DESIGN REVIEW CHECKLIST
- 5.0 MAINTAINABILITY DESIGN CHARACTERISTICS
  - 5.1 GENERAL
  - 5.2 MAINTAINABILITY DESIGN GUIDELINES
    - 5.2.1 Electrical/Electronic Equipment Design
      - 5.2.1.1 Cables and Connectors
      - 5.2.1.2 Miniaturization And Modular Design
    - 5.2.2 Mechanical Equipment Design
    - 5.2.3 Fluid Equipment Design
    - 5.2.4 Interchangeability
  - 5.3 MAINTAINABILITY DESIGN REVIEW CHECKLIST
- 6.0 SAFETY DESIGN REVIEW CHECKLISTS
  - 6.1 GENERAL
  - 6.2 SAFETY DESIGN GUIDELINES
  - 6.3 DESIGN SAFETY CHECKLIST

### TABLES

- Table 1 Shuttle Program RM&QA Requirements for Ground System Design
- Table 2 Shuttle Program RM&QA Technical Requirements and Criteria for GSE Design
- Table 3 Reliability Design Review Checklist
- Table 4 Quality Assurance Design Review Checklist
- Table 5 Maintainability Design Review Checklist
- Table 6 Generic Hazard Checklist
- Table 7 Design Safety Checklist

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RELIABILITY DESIGN REVIEW CHECKLIST					Title:	
					RE:	
					DE:	
					SAA:	B/L:                      Date:
Questions	Appli- cable		Compli- ance		Comments	
	Yes	No	Yes	No		
1. Are requirements of performance, environment, testing, life and reliability established for each component?						
2. Has criticality of equipment/system been established?						
3. Has FMEA been performed?						
4. Has a Critical Items List been prepared?						

QUALITY ASSURANCE DESIGN REVIEW CHECKLIST					Title:	
					RE:	
					DE:	
					SAA:	B/L:                      Date:
Questions	Appli- cable		Compli- ance		Comments	
	Yes	No	Yes	No		
1. Have references to applicable construction/ manufacture specifications/drawings and special processes been included (welding, soldering, cleaning, potting, molding, heat treating, etc.)?						
2. Do specifications provide for adequate inspection, tests, and performance validations? (Process checks, certifications, proof loading, etc.)						

MAINTAINABILITY DESIGN REVIEW CHECKLIST					Title:	
					RE:	
					DE:	
					SAA:	B/L:                      Date:
Questions	Appli- cable		Compli- ance		Comments	
	Yes	No	Yes	No		
<b>MAINTANANCE APPROACH</b>						
1. Is the level of maintenance (organizational/inhouse intermediate or vendor/depot) and/or repair location for each repairable unit identified?						
2. Are maintenance facility, resources requirements, manpower and personnel skills defined?						

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DESIGN SAFETY CHECKLIST					Title:	
					RE:	
					DE:	
					SAA:	B/L:                      Date:
Questions	Appli- cable		Compli- ance		Comments	
	Yes	No	Yes	No		
<b>HANDLING AND TRANSPORTATION</b>						
<b>GENERAL</b>						
1.	Handling and transportation equipment shall include provisions for protecting shock sensitive equipments that do not have shock mounting provisions.					
2.	Proof-load diagrams or other instructions shall be incorporated in the design documentation of all lifting and handling equipment to indicate test points and methods required for proof test.					
3.	Load test and inspection requirements shall be specified in the design documentation for stands, ladders, hoists, slings and handling equipment. Equipment in this class shall meet the requirements of OSHA.					