MAG - 1
SEPTEMBER 1996

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# Mission Assurance Guidelines

For

Goddard Space Flight Center Orbital Projects

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Changes* to
MISSION ASSURANCE GUIDELINES FOR
GODDARD SPACE FLIGHT CENTER ORBITAL PROJECTS

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* Recipients of the original distribution of this document will automatically receive changes. Others can request changes in a memorandum to the Assurance Requirements Office Information Center, Code 300.1, NASA/GSFC, Greenbelt, Maryland 20771

# Mission Assurance Guidelines

This Document has been prepared by the Office Of Flight Assurance (OFA) in accordance with GMI 2602.3 Guidelines for Mission Assurance Requirements for GSFC Managed Flight Missions. **The purpose of this document is to serve as a resource to the GSFC Project Manager in developing a realistic set of mission assurance requirements tailored to the specific needs of the individual project**. As delineated in the GMI 2602.3, the Project Manager has the responsibility to establish those mission unique assurance requirements. It is intended by the OFA that the project will select, tailor and then place the appropriate mission assurance requirements directly into the contract Statement Of Work, thereby eliminating the need for a standalone Performance Assurance Requirements document as in the past.

Goddard is assigned a wide variety of missions that range in complexity from relatively simple to extremely complex; from short duration to many years; and from high National interest to narrow specialized interest. The guidelines presented in this document have been prepared to address this wide range of programs and to reflect Agency adoption of commercial practices, such as ISO 9001 quality management requirements in the hardware and software quality assurance sections of this document, where suitable for spacecraft applications. The remaining assurance areas (reviews, verification, electronic packaging and processes, parts, materials, reliability, and contamination) are not currently covered by ISO requirements. Therefore, flight projects must tailor their programs in these areas to satisfy mission needs; some augmentation of ISO requirements are recommended in the quality and software assurance sections. The General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components (GEVS-SE) should be used as a baseline guide for developing verification requirements tailored to a specific mission.

One area of Mission Assurance not included in this document, because it is not negotiable as a guideline, is the Flight System Safety Requirements. The Safety requirements are levied by the launch range and the launch vehicle provider and are mandatory compliance requirements for all space flight hardware developers. The GSFC OFA provides assistance to the Flight Projects in meeting those requirements. The GSFC Project Manager must ensure that the applicable safety requirements are included into the contract SOW, the OFA Project Safety Manager assigned to each GSFC flight project will assist in providing the appropriate contract language.

In all cases the guidelines are targeted at the **optimum** set of principles that have been proven in previous low-risk GSFC missions to achieve success. When selecting any particular guideline, the Project Manager should assess whether that guideline needs to be given increased or decreased emphasis to suit the specific mission needs. The Project Manager should exercise flexibility in choosing those guidelines that will add value to the mission. The Project Manager may choose to accept a developer's proposed mission assurance program. These guidelines should be used as a reference for the Project Manager's assessment of the adequacy of the developer's mission assurance program.

**The language of the specific sections in the appendices has been prepared so that it can be lifted directly for inclusion into a contract Statement of Work (SOW) or other appropriate contract document such as the project mission assurance requirements required by GMI 2602.3) with only minor changes. The language states the guidelines as requirements, this was done solely to assist the Project Manager's team in preparing the SOW document.** Each specific guideline selected may be reworded to provide the specific emphasis desirable for the particular mission.

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# APPENDIX 1

# OVERALL REQUIREMENTS

## 1.1 DESCRIPTION OF OVERALL REQUIREMENTS

The developer is required to plan and implement an organized Assurance and Safety Program that encompasses (1) all flight hardware from program initiation through launch operations, either developed by developers or furnished by the government, (2) to the extent necessary to assure the integrity and safety of flight items, the ground system that interfaces with flight equipment items, and (3) all software critical for mission success as defined in Section 10.1.

Managers of the assurance activities will have direct access to developer management independent of project management, with the functional freedom and authority to interact with all other elements of the project. Issues requiring project management attention should be addressed with the developer's through the Project Manager and/or Contracting Officer Technical Representative.

The Assurance and Safety Program is applicable to the project and its associated contractors, subcontractors and developers.

## 1.2 USE OF MULTI-MISSION OR PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

When hardware that was designed, fabricated, or flown on a previous program, or is being reflown in a multi-mission application, is considered to have demonstrated compliance with some or all of the requirements of this document such that certain tasks need not be repeated, the developer is required to demonstrate how the hardware complies with requirements. The developer will submit substantiating documentation in accordance with the Contract Schedule (refer to Appendix 13, DID 1-1).

## 1.3 SURVEILLANCE OF THE CONTRACTOR

The work activities, operations, and documentation performed by the developer or his suppliers are subject to evaluation, review, audit, and inspection by government-designated representatives from GSFC, the Government Inspection Agency (GIA), or an independent assurance contractor (IAC). GSFC will delegate in-plant responsibilities and authority to those agencies via a letter of delegation, or the GSFC contract with the IAC.

The developer, upon request, will provide government assurance representatives with documents, records, and equipment required to perform their assurance and safety activities. The developer will also provide the government assurance representative(s) with an acceptable work area within developer facilities.

## 1.4 APPLICABLE DOCUMENTS (Appendix 11)

To the extent referenced herein, applicable portions of the documents listed in Appendix 11 form a part of this document.

## 1.5 GLOSSARY (Appendix 12)

Appendix 12 defines acronyms and terms as applied in this document.

## 1.6 CONTRACT SCHEDULE (Appendix 13)

Appendix 13 identifies Data Item Descriptions (DIDs) describing data deliverable to the GSFC Project Office. **The DIDs will be tailored to meet specific project needs and will be included into applicable Contract Delivery Requirements Lists (CDRL**).

The following definitions apply with respect to assurance deliverables:

Deliver for Approval: The GSFC Project approves within the period of time that has been negotiated and specified in the contract before the developer may proceed with associated work.

Deliver for Review: The GSFC Project reviews and may comment within 30 days. The developer may continue with associated work while preparing a response to GSFC comments unless directed to stop.

Deliver for Information: For GSFC Project information only. The developer's associated work schedule is not normally affected.

**APPENDIX 2**

**ASSURANCE DESIGN REVIEW REQUIREMENTS**

# THE REVIEW PROGRAM SHOULD BE TAILORED TO SATISFY PROJECT NEEDS

## 2.0 INTRODUCTION

**The purpose of this document is to serve as a resource to the GSFC Project Manager in developing a realistic set of mission assurance requirements tailored to the specific needs of the individual project. The review program should be tailored to meet the needs of the project.**

## 2.1 GENERAL REQUIREMENTS

The developer will support a series of comprehensive system-level design reviews that are conducted by the GSFC Systems Review Office (SRO). The reviews cover all aspects of flight and ground hardware, software, and operations for which the developer has responsibility (see Section 2.3). In addition, each developer will conduct a program of planned, scheduled and documented component and subsystem reviews of all aspects of his area of responsibility.

## 2.2 GSFC FLIGHT ASSURANCE DESIGN REVIEW REQUIREMENTS

For each specified system-level review conducted by the GSFC SRO, the developer will:

a. Develop and organize material for oral presentation to the GSFC review team. Copies of the presentation material will be available at each review.

b. Support splinter review meetings resulting from the major review.

c. Produce written responses to recommendations and action items resulting from the review.

d. Summarize, as appropriate, the results of the Developer Reviews at the component and subsystem level.

## 2.3 GSFC FLIGHT ASSURANCE DESIGN REVIEW PROGRAM

The Office of Flight Assurance (OFA) Design Review Program (DRP) guidelines, as defined by GMI 2604.4, consists of individual, periodic reviews of all GSFC managed flight missions, flight instruments, flight spacecraft, ground systems which interface with flight hardware, unique flight support equipment, and their associated software including hardware supplied to GSFC-managed flight missions by other organizations, by another NASA Center, and by JPL to GSFC for a GSFC mission. Both the Sounding Rocket and Balloon flight programs from Code 800 are exempted from the OFA DRP. The SRO will support any reviews considered appropriate by the Director, Office of Flight Assurance and the Director, Suborbital Projects and Operations.

## 2.4 IMPLEMENTATION

### 2.4.1 Design Review Program (DRP)

The primary objective of the DRP is to enhance the probability of success of GSFC missions. This objective will be achieved by bringing to bear on each GSFC-managed flight mission the cumulative knowledge of a team of engineers and scientists who have had extensive prior experience with the particular tuypes of systems and functions involved. While the design review is technically oriented, proper consideration will be given to

constraints operating on the mission. These reviews will assure that each mission has the benefit of Center-wide experience gained on other missions.

2.4.2 Structure and Function of the Design Review Program

2.4.2.1 Design Review Plan

The Chief of the Systems Review Office, OFA, in conjunction with the individual Project Manager, and/or PI's will develop design review requirements to be documented in the project mission assurance requirements per GMI 2602.3. The Chief of the Systems Review Office may waive the requirement for some of these reviews based primarily on considerations of system complexity, criticality, extent of technological design, (i.e., state-of-the-art), previous flight history, mission objectives, and any mandated constraints.

2.4.2.2 The Design Review Team (DRT)

The DRT will include personnel experienced in subsystem design, systems engineering and integration, testing, and all other applicable disciplines. The review chairperson, in concert with the Project Manager and/or PI's, and other Directorates, appoints independent key technical experts as review team members. Personnel outside the Center may be invited as members or co-chairperson of the DRT if it is felt their expertise will enhance the DRT. The reviews will be based upon an appropriate selection from the following system reviews:

(a) System Concept Review (SCR)--This review is keyed to the end of the definition study phase and will evaluate the design approaches, hardware/software tradeoffs, software requirements, and the operational concepts.

(b) Preliminary Design Review (PDR)--This review occurs early in the design phase by prior to manufacture of engineering hardware and the detail design of associated software. Where applicable, it should include the results of test bedding, breadboard testing, and software prototyping. It should also include the status of the progress in complying with the launch range safety requirements. At PDR the flight hardware developer should have identified and documented all of the hazards associated with the flight hardware.

(c) Critical Design Review (CDR)--This review occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software. It will emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing. The developer is also required to present the status of the controls for the safety hazards presented in the PDR and the status of all presentations to the launch range.

(d) Mission Operations Review (MOR)--This mission-oriented review will normally take place prior to significant integration and test of the flight system and ground system. Its purpose is to review the status of the system components, including the ground system and its operational interface with the flight system. Discussions will include mission integration, test planning and the status of preparations for flight operations.

(e) Pre-Environmental Review (PER)--This review occurs prior to the start of environmental testing of the protoflight or flight system. The primary purpose of this review is to establish the readiness of the system for test and evaluate the environmental test plans.

(f) Pre-Shipment Review (PSR)--This review will take place prior to shipment of the instrument for integration with the spacecraft and for shipment of the spacecraft to the launch range. The PSR will concentrate on system performance during

qualification or acceptance testing. The flight hardware developer is also required to present the status of the tracking of the safety items listed in the verification tracking log, the status of deliverable documents to the launch range and the status of presentations and any subsequent launch range issues or approvals prior to sending flight hardware to the range.

(g) Flight Operations Review (FOR)--While all of the previous reviews involve operations, this review will emphasize the final orbital operation plans as well as the compatibility of the flight components with ground support equipment and ground network, including summary results of the network compatibility tests.

(h) Launch Readiness Review (LRR)--This review is to assess the overall readiness of the total system to support the flight objectives of the mission. The LRR is usually held at the launch site 2 to 3 days prior to launch.

2.4.2.4 The DRP for each instrument will generally consist of PDR, CDR, PER, and PSR. Where applicable, the DRP for identical follow-on instruments will generally consist of PER and PSR.

The GSFC policies and practices will not be imposed on instruments provided by other NASA Centers and/or the Jet Propulsion Laboratory (JPL) which are not in-line with mission success. The other NASA Centers and/or JPL will have the sole responsibility for the instruments performance and longevity. GSFC will only insure system safety and that the system interfaces are such that an instrument failure will not adversely affect other elements of the spacecraft or GSE.

The review program for instruments provided by the other NASA Centers and/or JPL that are in-line with mission success will tailored as appropriate.

2.4.2.3 The DRP for each spacecraft will generally consist of PDR, CDR, MOR, PER, PSR, FOR, and LRR. When applicable, the DRP for identical follow-on spacecraft will generally consist of MOR, PER, PSR. FOR, and LRR.

2.4.2.5 The DRP for GSFC supplied Shuttle small payloads such as GAS, Hitchhiker, and Spartan, will consist of a PDR, CDR, PER, and PSR. This will be applicable to all new designs for the small payload carrier systems including structural support hardware, separation devices, canisters, ACS, C&DH, power, and thermal subsystems. The review of instruments, during these reviews, will be limited to safety and compatibility status. Instruments, if supplied by GSFC, will receive an independent CDR and PER. No DRP activity is required for contained GAS instruments.

Upon successful completion of the review program, small payload carrier systems will be considered certified for the number of flights defined by the design and qualification criteria. After the first flight, the OFA will conduct an independent PSR prior to each subsequent flight. Recertification will be required after the certified number of flights has been completed. When changes from the baseline certified design are proposed, the project will consult the SRO to determine the appropriate independent reviews necessary for recertification.

2.4.2.6 The DRP for flight equipment supplied by GSFC to another NASA Center's spacecraft, DoD spacecraft, or foreign spacecraft will be treated as if they were to fly on a Goddard spacecraft and will be subject to the requisite review program.

In the event the other party involved has an independent review program essentially equivalent to the GSFC program, their program may be substituted after supplying

acceptable justification to the Chief of the Systems Review Office, OFA. In return, GSFC will make a reasonable attempt to comply with the review requirements of the other organization.

2.4.2.7 The DRP for flight equipment supplied to GSFC by another organization (non NASA or JPL) will be treated as if it were GSFC equipment to fly on a GSFC spacecraft and will be subject to the same requisite GSFC review program.

In the event that the other organization has an independent review program equivalent to the GSFC program, their program may be substituted after supplying acceptable justification to the Chief of the Systems Review Office, OFA.

Tailoring of the review program is permitted by mutual agreement to meet the intent of the GSFC DRP. Tailoring is subject to approval of the Chief of the Systems Review Office, OFA.

2.4.2.8 The DRP for new, project unique ground systems will consist of PDR and CDR. The ground system is also a major subject of the mission oriented reviews SCR, MOR, FOR, and LRR.

Generic facilities newly developed or significantly modified by the Mission Operations and Data Systems Directorate (MO&DSD) will normally be reviewed by an appropriate Directorate review team.

Readiness of the "new" system for mission support will be reviewed through the mission LRR conducted by the SRO the first time the generic system is to be used in a prime support mode.

2.4.3 Design Review Schedule

The design reviews will be conducted on a schedule determined by the Chief, Systems Review Office, after consultation with the appropriate Project Manager and/or PI's. The reviews will be depicted in the GSFC Project Management Status Report (MSR).

2.4.4 System Safety

The safety aspects of the systems being reviewed are a normal consideration in the design evaluations conducted by the DRP. At each appropriate review, the project will demonstrate understanding of and compliance with the applicable launch range requirements, list any known noncompliances and provide justification for any expected waiver conditions. In addition, the project will present the results of any safety reviews held with either the Johnson Space Center Payload Safety Review Panel, the Eastern, Western, Wallops, or other appropriate launch ranges.

## 2.5 DEVELOPER REVIEW REQUIREMENTS

The developer will implement a program of peer reviews for missions at the component and subsystem levels. The program will, as a minimum, consist of a Preliminary Design Review and a Critical Design Review. In addition, packaging reviews will be conducted on all electrical and electromechanical components in the flight system.

The PDR and CDR will evaluate the ability of the component or subsystem to successfully perform its function under operating and environmental conditions during both testing and flight. The results of parts stress analyses and component packaging reviews, including the results of associated tests and analyses, will be discussed at the component PDRs and CDRs.

The packaging reviews will specifically address the following:

a. Placement, mounting, and interconnection of EEE parts on circuit boards or substrates.

b. Structural support and thermal accommodation of the boards and substrates and their interconnections in the component design.

c. Provisions for protection of the parts and ease of inspection.

Developer reviews will be conducted by personnel who are not directly responsible for design of the hardware under review. GSFC reserves the right to attend the peer reviews and requires 10 working days notification. The results of the reviews will be documented and the documents will be made available for review at the developer's facility.

**APPENDIX 3**

**VERIFICATION REQUIREMENTS**

# THE VERIFICATION PROGRAM SHOULD BE TAILORED TO SATISFY SPECIFIC HARDWARE AND MISSION REQUIREMENTS

## 3.0 INTRODUCTION

**The verification program, including environmental test, should be tailored to reflect hardware criticality, mission objectives, hardware characteristics such as physical size and complexity, and the level of risk accepted by the project.**

**The project verification philosophy and test requirements should be developed and agreed to early in the program to avoid costly iterations.**

## 3.l GENERAL REQUIREMENTS

A system performance verification program documenting the overall verification plan, implementation, and results is required to ensure that the payload meets the specified mission requirements, and to provide traceability from mission specification requirements to launch and on-orbit capability. The program consists of a series of functional demonstrations, analytical investigations, physical property measurements, and tests that simulate the environments encountered during handling and transportation, prelaunch, launch, in-orbit, and, where appropriate, retrieval, reentry, and landing. All prototype or protoflight hardware will undergo qualification to demonstrate compliance with the verification requirements of this section. In addition, all other hardware (flight, follow-on, spare and reflight as defined in Appendix 12, "Hardware") will undergo acceptance in accordance with the verification requirements of this appendix.

The Verification Program begins with functional testing of assemblies; it continues through functional and environmental testing supported by appropriate analysis, at the unit/component, subsystem/instrument, and spacecraft/payload levels of assembly; the program concludes with end-to-end testing of the entire operational system including the payload, the Payload Operations Control Center (POCC), and the appropriate network elements.

The General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components (GEVS-SE) (refer to Appendix 11), should be used as a baseline guide for developing the verification program. Alternative methods are acceptable provided that the net result demonstrates compliance with the intent of the requirements.

## 3.2 Documentation Requirements

The following documentation requirements should be tailored to meet program needs, and will be delivered and approved in accordance with the Contract Schedule.

### 3.2.1 System Performance Verification Plan

A system (or Instrument) performance verification plan (refer to appendix 13, DID 3-1) will be prepared defining the tasks and methods required to determine the ability of the system (or instrument) to meet each program-level performance requirement (structural, thermal, optical, electrical, guidance/control, RF/telemetry, science, mission operational, etc.) and to measure specification compliance. Limitations in the ability to verify any performance requirement will be addressed, including the addition of supplemental tests and/or analyses that will be performed and a risk assessment of the inability to verify the requirement.

The plan will address how compliance with each specification requirement will be verified. If verification relies on the results of measurements and/or analyses performed at lower (or other) levels of assembly, this dependence will be described.

For each analysis activity, the plan will include objectives, a description of the mathematical model, assumptions on which the models will be based, required output, criteria for assessing the acceptability of the results, the interaction with related test activity, if any, and requirements for reports. Analysis results will take into account tolerance build-ups in the parameters being used.

The following documents may be included as part of the System Performance Verification Plan or as separate documents to meet program needs

3.2.1.1 Environmental Verification Plan

An environmental verification plan will be prepared, as part of the System Verification Plan or as a separate document, that prescribes the tests and analyses that will collectively demonstrate that the hardware and software comply with the environmental verification requirements.

The environmental verification plan will provide the overall approach to accomplishing the environmental verification program. For each test, it will include the level of assembly, the configuration of the item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, necessary functional operations, personnel responsibilities, and requirement for procedures and reports. It will also define a rationale for retest determination that does not invalidate previous verification activities. When appropriate, the interaction of the test and analysis activity will be described.

Limitations in the environmental verification program which preclude the verification by test of any system requirement will be documented. Alternative tests and analyses will be evaluated and implemented as appropriate, and an assessment of program risk will be included in the System Performance Verification Plan.

Because of the intended tailoring of the verification program, the preliminary plan must provide sufficient verification philosophy and detail to allow assessment of the program. For example, for the environmental test portion of the verification, it is not sufficient to state that the GSFC GEVS requirements will be met. A program philosophy must be included (i.e., all components will be subjected to random vibration, or random vibration will be performed at the subsystem or section level of assembly rather then at the component level, all instruments will be subjected to acoustics tests, and 3-axis sine and random vibration, all components will be subjected to EMC tests, all flight hardware will see 8-thermal-vacuum cycles prior to integration on the spacecraft, etc.).

3.2.1.2 System Performance Verification Matrix

A System Performance Verification Matrix will be prepared and maintained, to show each specification requirement, the reference source (to the specific paragraph or line item), the method of compliance, applicable procedure references, results, report reference numbers, etc. This matrix will be included in the system review data packages showing the current verification status as applicable. (Refer to Appendix 2 of this document).

3.2.1.3 Environmental Test Matrix

As an adjunct to the system/environmental verification plan, an environmental test matrix will be prepared that summarizes all tests that will be performed on each component, each subsystem or instrument, and the payload. The purpose is to provide a ready reference to

the contents of the test program in order to prevent the deletion of a portion thereof without an alternative means of accomplishing the objectives; All flight hardware, spares and prototypes (when appropriate) will be included in the matrix. The matrix will be prepared in conjunction with the initial environmental verification plan and will be updated as changes occur.

A complementary matrix will be kept showing the tests that have been performed on each component, subsystem, instrument, or payload (or other applicable level of assembly). This should include tests performed on prototypes or engineering units used in the qualification program, and should indicate test results (pass/fail or malfunctions).

#### 3.2.1.4 Environmental Verification Specification

As part of the System Performance Verification Plan, or as a separate document, an environmental verification specification will be prepared that defines the specific environmental parameters that each hardware element is subjected to either by test or analysis in order to demonstrate its ability to meet the mission performance requirements. Such things as payload peculiarities and interaction with the launch vehicle (STS or ELV) will be taken into account.

### 3.2.2 Performance Verification Procedures

For each verification test activity conducted at the component, subsystem, and payload levels (or other appropriate levels) of assembly, a verification procedure will be prepared that describes the configuration of the test article, how each test activity contained in the verification plan and specification will be implemented.

Test procedures will contain details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, pass/fail criteria, quality control checkpoints, data collection and reporting requirements. The procedures also will address safety and contamination control provisions (refer to appendix 13, DID 3-2).

### 3.2.3 Verification Reports

After each component, subsystem, payload, etc. verification activity has been completed, a report will be submitted in accordance with the Contract Schedule (refer to appendix 13, DID 3-3). For each analysis activity, the report will describe the degree to which the objectives were accomplished, how well the mathematical model was validated by related test data, and other such significant results. In addition, as-run verification procedures and all test and analysis data will be retained for review.

#### 3.2.3.1 System Performance Verification Report

At the conclusion of the verification program, a final System Performance Verification Report will be delivered comparing the hardware/software specifications with the final verified values (whether measured or computed). It is recommended that this report be subdivided by subsystem/instrument (refer to appendix 13, DID 3-3).

The System Performance Verification Report should be developed and maintained "real-time" throughout the program summarizing the successful completion of verification

activities, and showing that the applicable system performance specifications have been acceptably complied with prior to integration of hardware/software into the next higher level of assembly.

## 3.3 Instrument Verification Documentation

The documentation requirements of section 3.2 also apply to instruments. Following integration of the instruments onto the spacecraft, the spacecraft System Verification Report will include the instrument information.

**APPENDIX 4**

**ELECTRONIC PACKAGING AND PROCESSES**

# THE ELECTRONIC PACKAGING AND PROCESSES PROGRAM SHOULD BE TAILORED TO SATISFY SPECIFIC HARDWARE AND MISSION REQUIREMENTS

## 4.0 INTRODUCTION

**The purpose of this document is to serve as a resource to the GSFC Project Manager in developing a realistic set of mission assurance requirements tailored to the specific needs of the individual project. This appendix provides recommended requirements for electronic packaging and processes. These requirements should be tailored to meet the needs of the project.**

## 4.1 GENERAL

The developer will plan and implement an Electronic Packaging and Processes Program to assure that all electronic packaging technologies, processes, and workmanship activities selected and applied meet mission objectives for quality and reliability.

## 4.2 WORKMANSHIP

The developer will use the NHB/NAS 5300.4 series workmanship standards for: Requirements for Soldered Electrical Connections NHB 5300.4(3A-2); Requirements for Interconnecting Cable, Harnesses, and Wiring NAS 5300.4(3G); Requirements for Crimping and Wire Wrap NHB 5300.4(3H); Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies NAS 5300.4(3J); and Requirements for Electrostatic Discharge Control NHB 5300.4(3L); and Workmanship Requirements for Surface Mount Technology NAS 5300.4(3M).

The developer will use the industry standard for rigid printed wiring board design IPC-D-275 and Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses, GSFC S312-P-003, along with Workmanship for Rigid Wiring Board Qualification and Performance, IPC-RB-276, class III.

Alternate workmanship standards may be used when approved by the project. The developer will submit, for review and acceptance, the alternate standard and the differences between the alternate standard and the required standard prior to project approval.

The developer will provide printed wiring board coupons and associated test reports in accordance with the contract delivery requirements. Coupons and test reports are not required for delivery to the GSFC Project Office if the developer has coupons evaluated by a laboratory which has been approved by the GSFC Project Office, in writing before the coupons are released for evaluation. (Refer to Appendix 13, DID 4-1)

## 4.3 NEW/ADVANCED PACKAGING TECHNOLOGIES

New and/or advanced packaging technologies (e.g.,. MCMs, stacked memories, chip on board) that have not previously been used in space flight applications will be reviewed and approved through the Parts Control Board (PCB) as defined in MAG Section 5.2. The developer will provide a detailed Technology Validation Assessment Plan (refer to Appendix 13, DID 4-2) for each new technology which identifies the evaluations and data necessary for acceptance of the new/advanced technology for reliable use and conformance to program requirements. New/advanced technologies will be part of the Parts Identification List (PIL) and Program Approved Parts List (PAPL) defined in MAG Section 5.3

**APPENDIX 5**

**PARTS**

# THE PARTS PROGRAM SHOULD BE TAILORED TO SATISFY SPECIFIC HARDWARE AND MISSION REQUIREMENTS

## 5.0 INTRODUCTION

**The purpose of this document is to serve as a resource to the GSFC Project Manager in developing a realistic set of mission assurance requirements tailored to the specific needs of the individual project. This appendix provides recommended parts requirements. These requirements should be tailored to meet the needs of the project.**

## 5.1 GENERAL

The developer will plan and implement an Electrical, Electronic, and Electromechanical (EEE) Parts Control Program to assure that all parts selected for use in flight hardware meet mission objectives for quality and reliability (refer to Appendix 13, DID 5-1).

The developer will prepare a Parts Control Plan (PCP) describing the approach and methodology for implementing the Parts Control Program. The PCP will also define the developer's criteria for parts selection and approval based on the guidelines of this section. The PCP will be made a part of the proposal for review in accordance with contract delivery requirements.

## 5.2 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS

All part commodities identified in the GSFC Preferred Parts List (PPL) are considered EEE parts and will be subjected to the requirements set forth in this section. Custom or advanced technology devices such as custom hybrid microcircuits, detectors, Application Specific Integrated Circuits (ASIC), and Multi-Chip Modules (MCM) will also be subject to parts control appropriate for the individual technology (see 5.2.2.1).

### 5.2.1 Parts Control Board

The developer will establish a Parts Control Board (PCB) or a similar documented system to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. The PCB will be responsible for the review and approval of all parts for conformance to established criteria, and for developing and maintaining a Program Approved Parts List (PAPL). In addition, the PCB will be responsible for all parts activities such as failure investigations, disposition of non-conformances, and problem resolutions. PCB operating procedures will be included as part of the PCP.

#### 5.2.1.1 PCB Meetings

PCB meetings will be convened on a regular basis or as needed. GSFC may participate in PCB meetings and will be notified in advance of all upcoming meetings. If participating, GSFC will have voting rights at PCB meetings. Meeting minutes or records will be maintained by the developer to document all decisions made and a copy provided to GSFC within three days of convening the meeting. GSFC will retain the right to overturn decisions involving non-conformances within ten days after receipt of meeting minutes. PCB activities may be audited by GSFC on a periodic basis to assess conformance to the developer's PCP.

### 5.2.2 Parts Selection and Processing

All parts will be selected and processed in accordance with the GSFC 311-INST-001 Instructions for EEE Parts Selection, Screening and Qualification. All application notes in 311-INST-001 will apply. The appropriate parts quality level defined in 311-INST-001 will be based on system redundency or criticality as determined by the Project Manager. The requirements of 311-INST-001 may be further tailored as appropriate to specific missions. Developer's internal selection and processing documentation may be used to define these requirements. The requirements will then become the established criteria for parts selection, testing, and approval for the duration of the program, and will be documented in the PCP. Parts selected from the GSFC Preferred Parts List (PPL) or MIL-STD-975 NASA Standard Electrical, Electronic, and Electromechanical Parts List are considered to have met all criteria of 311-INST-001 for the appropriate parts quality level, and may be approved by the PCB provided all mission application requirements (performance, derating, radiation, etc.) are met.

#### 5.2.2.1 Custom Devices

In addition to applicable requirements of 311-INST-001, custom microcircuits, hybrid microcircuits, MCM, ASIC, etc. planned for use by the developer will be subjected to a design review. The review may be conducted as part of the PCB activity. The design review will address, at a minimum, derating of elements, method used to assure each element reliability, assembly process and materials, and method for assuring adequate thermal matching of materials.

### 5.2.3 Derating

All EEE parts will be used in accordance with the derating guidelines of the PPL. The developer's derating policy may be used in place of the PPL guidelines and will be submitted with the PCP. The developer will maintain documentation on parts derating analysis and will make it available for GSFC review.

### 5.2.4 Radiation Hardness

All parts will be selected to meet their intended application in the predicted mission radiation environment. The radiation environment consists of two separate effects, those of total ionizing dose and single-event effects. The developer will document the analysis for each part with respect to both effects.

### 5.2.5 Verification Testing

Verification of screening or qualification tests by retesting is not required unless deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. If required, testing will be in accordance with 311-INST-001 as determined by the PCB. The developer, however, will be responsible for the performance of supplier audits, surveys, source inspections, witnessing of tests, and/or data review to verify conformance to established requirements.

### 5.2.6 Destructive Physical Analysis

A sample of each lot date code of microcircuits, hybrid microcircuits, and semiconductor devices will be subjected to a Destructive Physical Analysis (DPA). All other parts may require a sample DPA if it is deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. DPA tests, procedures, sample size and criteria will be as specified in GSFC specification S-311-M-70, Destructive Physical Analysis. Developer's procedures for DPA may be used in place of S-311-M-70 and will be submitted with the PCP. Variation to the DPA sample size requirements, due to part complexity, availability or cost, will be determined and approved by the PCB on a case-by-case basis.

5.2.7 Parts Age Control

Parts drawn from controlled storage after 5 years from the date of the last full screen will be subjected to a full 100 percent rescreen and sample DPA. Alternate test plans may be used as determined and approved by the PCB on a case-by case basis. Parts over 10 years from the date of the last full screen or stored in other than controlled conditions where they are exposed to the elements or sources of contamination will not be used.

## 5.3 PARTS LISTS

The developer will create and maintain a Program Approved Parts List (PAPL) and a Parts Identification List (PIL) for the duration of the program. The developer may choose to incorporate the PAPL and PIL into one list, which will be submitted to GSFC as a PIL, provided clear distinctions are made as to parts approval status and whether parts are planned for use in flight hardware (refer to Appendix 13, DID 5-2).

5.3.1 Program Approved Parts List

The Program Approved Parts List (PAPL) will be the only source of approved parts for flight hardware, and as such may contain parts not actually in flight design. Only parts that have been evaluated and approved by the PCB will be listed in the PAPL. Parts must be approved for listing on the PAPL before initiation of procurement activity. The criteria for PAPL listing will be based on 311-INST-001 and as specified herein (see 5.2.2). The PCB will assure standardization and the maximum use of parts listed in the PAPL. The PAPL and all subsequent revisions will be available for GSFC review upon request.

5.3.1.1 Parts Approved on Prior Programs

Parts previously approved by GSFC via the developer's Nonstandard Parts Approval Request (NSPAR) on the preceding contract for a system similar to the one being procured will be evaluated by the PCB for continued compliance to current program requirements prior to listing in the PAPL. This will be accomplished by determining that:

a. No changes have been made to the previously approved NSPAR, Source Control Drawing (SCD) or vendor list.

b. All stipulations cited in the previous NSPAR approval have been implemented on the current flight lot, including performance of any additional testing.

c. The previous program's parts quality level is identical to the current program.

5.3.2 Parts Identification List

As opposed to the PAPL, the Parts Identification List (PIL) will list all parts planned for use in flight hardware, regardless of their approval status. The initial PIL and subsequent updates will be submitted to GSFC in accordance with the contract delivery requirements. An As-Built Parts List (ABPL) will also be prepared and submitted to GSFC in accordance with the contract delivery requirements. The ABPL is generally the final PIL with additional as-built information.

## 5.4 Alerts

The developer will be responsible for reviewing and dispositioning all Government Industry Data Exchange Program (GIDEP) Alerts for applicability to the parts proposed for use. In addition, any NASA Alerts and Advisories provided to the developer by GSFC will be reviewed and dispositioned. Alert applicability, impact, and corrective actions will be document and be made available for GSFC review.

**APPENDIX 6**

**MATERIALS , PROCESSES AND LUBRICATION REQUIREMENTS**

# THE MATERIALS, PROCESSES AND LUBRICATION PROGRAM SHOULD BE TAILORED TO SATISFY SPECIFIC HARDWARE AND MISSION REQUIREMENTS

## 6.0 INTRODUCTION

**The purpose of this document is to serve as a resource to the GSFC Project Manager in developing a realistic set of mission assurance requirements tailored to the specific needs of the individual project. This appendix provides recommended requirements for materials, processes and lubrication. These requirements should be tailored to meet the needs of the project.**

## 6.1 GENERAL REQUIREMENTS

The developer will implement a comprehensive Materials and Processes Plan (Appendix 13, DID 6-1) beginning at the design stage of the hardware. The program will help ensure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials and lubricants employed to meet the operational requirements for the satellite system or payload. Materials and lubrication assurance approval is required for each usage or application in spaceflight hardware

## 6.2 MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, the developer will, when selecting materials and lubricants, consider potential problem areas such as radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, toxic offgassing, flammability and fracture toughness, as well as the properties required by each material usage or application.

### 6.2.1 Compliant Materials

The developer will use compliant materials in the fabrication of flight hardware to the extent practicable.

In order to be compliant, a material must be used in a conventional application and meet the applicable selection criteria identified in Table 6.1. A compliant material does not require a Materials Usage Agreement (MUA) (Appendix 13, DID 6-2) (Figure 6.1).

### 6.2.2 Noncompliant Materials

A material that does not meet the requirements of the applicable selection criteria of Table 6.1, or meet the requirements of Table 6.1 but is used in an unconventional application, will be considered to be a noncompliant material. The proposed use of a noncompliant material requires that a Materials Usage Agreement (MUA) and/or a Stress Corrosion Evaluation Form or developer's equivalent forms (DIDs 6-2 & 6-3) (Figures 6.1 and 6.2), be submitted to GSFC for approval in accordance with the Contract Schedule.

#### 6.2.2.1 Materials Used in "Off-the-Shelf-Hardware"

"Off-the-shelf hardware" for which a detailed materials list is not available and where the included materials cannot be easily identified and/or changed will be treated as noncompliant. The developer will define on a MUA (DID 6-2), what measures will be used to ensure that all materials in the hardware are acceptable for use. Such measures might include any one, or a combination, of the following: hermetic sealing, vacuum bakeout, material changes for known noncompliant materials, etc. When a vacuum bakeout is the

selected method, it must incorporate a quartz crystal microbalance (QCM) and cold finger to enable a determination of the duration and effectiveness of the bakeout as well as compliance with the satellite contamination plan and error budget.

TABLE 6-1
MATERIAL SELECTION CRITERIA

| Type Launch | Payload Location | Flammability and Toxic Offgassing | Vacuum Outgassing | Stress Corrosion Cracking (SCC) |
|---|---|---|---|---|
| STS | Orbiter Crew Compartment | Note 1 | No Requirement | Note 5 |
| STS | Cargo Bay | Note 2 | Note 4 | Note 5 |
| ELV | All | Note 3 | Note 4 | Note 5 |

NOTES:

1. Flammability and toxic offgassing requirements as defined in NHB 8060.1.
2. Flammability and toxic offgassing requirements specified in NHB 1700.7, Paragraph 209.
3. Hazardous materials requirements, including flammability, toxicity and compatiibility as specified in Eastern and Western Range 127-1 Range Safety Requirements, Sections 3.10 and 3.12.
4. Vacuum Outgassing requirements as defined in paragraph 6.2.5.2.
5. Stress corrosion cracking requirements as defined in MSFC-SPEC-522.

### 6.2.3 Conventional Applications

Conventional applications or usage of materials is the use of compliant materials in a manner for which there is extensive satisfactory aerospace heritage.

### 6.2.4 Nonconventional Applications

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage will be considered a nonconventional application (DID 6-4). In that case, the material usage will be verified for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those methods.

| **MATERIAL USAGE AGREEMENT** | | USAGE AGREEMENT NO.: | PAGE OF |
|---|---|---|---|
| PROJECT: | SUBSYSTEM: | ORIGINATOR: | ORGANIZATION: |

| DETAIL DRAWING | NOMENCLATURE | USING ASSEMBLY | NOMENCLATURE |
|---|---|---|---|
| | | | |

| MATERIAL & SPECIFICATION | MANUFACTURER & TRADE NAME |
|---|---|
| | |

| USAGE | THICKNESS | WEIGHT | EXPOSED AREA | ENVIRONMENT | | |
|---|---|---|---|---|---|---|
| | | | | PRESSURE | TEMPERATURE | MEDIA |
| | | | | | | |

APPLICATION:

RATIONALE:

| ORIGINATOR: | PROGRAM MANAGER: | DATE: |
|---|---|---|
| | | |

FIGURE 6-1 MUA

STRESS CORROSION EVALUATION FORM

1. Part Number _____
2. Part Name _____
3. Next Assembly Number _____
4. Manufacturer _____
5. Material _____
6. Heat Treatment _____
7. Size and Form _____
8. Sustained Tensile Stresses-Magnitude and Direction

a. Process Residual _____
b. Assembly _____
c. Design, Static _____

9. Special Processing _____
10. Weldments

a. Alloy Form, Temper of Parent Metal _____
b. Filler Alloy, if none, indicate _____
c. Welding Process _____
d. Weld Bead Removed - Yes ( ), No ( ) _____
e. Post-Weld Thermal Treatment _____
f. Post-Weld Stress Relief _____

11. Environment _____
12. Protective Finish _____
13. Function of Part _____

_____

14. Effect of Failure _____

_____

15. Evaluation of Stress Corrosion Susceptibility _____

_____

16. Remarks: _____

_____

Figure 6-2 Stress Corrosion Evaluation Form

### 6.2.5 Polymeric Materials

The developer will prepare and submit a polymeric materials and composites usage list or the developer's equivalent (DID 6-5) (Figure 6.3). The list will be submitted to GSFC for review/approval. Material acceptability will be determined on the basis of flammability, toxic offgassing, vacuum outgassing and all other materials properties relative to the application requirements and usage environment.

#### 6.2.5.1 Flammability and Toxic Offgassing

Material flammability and toxic offgassing will be determined in accordance with the test methods described in NHB 8060.1 (DIDs 6-6 & 6-7). STS payload materials which will be located in the orbiter crew cabin will meet the requirements of NHB 8060.1 (DID 6-7). Materials for payload elements located in the orbiter cargo bay will meet the requirements of NHB 1700.7, Paragraph 209 (DID 6-6). Expendable launch vehicle (ELV) payload materials will meet the requirements of Eastern and Western Range 127-1 Range Safety Requirements, Sections 3.10 and 3.12.

#### 6.2.5.2 Vacuum Outgassing

Material vacuum outgassing will be determined in accordance with ASTM E-595. In general, a material is qualified on a product-by-product basis. However, GSFC may require lot testing of any material for which lot variation is suspected. In such cases, material approval is contingent upon lot testing. Only materials that have a total mass loss (TML) <1.00% and a collected volatile condensable mass (CVCM) <0.10% will be approved for use in a vacuum environment unless application considerations listed on a MUA dictate otherwise (DID 6-2). The overall mission contamination control requirements may demand more stringent outgassing criteria.

#### 6.2.5.3 Shelf-Life-Controlled Materials

Polymeric materials that have a limited shelf-life will be controlled by a program that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf-life, and expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings and paints will be included. The use of materials whose date code has expired requires that the developer demonstrate by means of appropriate tests that the properties of the materials have not been compromised for their intended use; such materials must be approved by GSFC by means of a waiver (DID 6-8). When a limited-life piece part is installed in a subassembly, the subassembly item will be included in the Limited-Life Plan (DID 6-9).

## POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC T/O _____

DEVELOPER/CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

| Area, $cm^2$ | Vol., cc | Wt., gm |
|---|---|---|
| 1 0-1 | A 0-1 | a 0-1 |
| 2 2-100 | B 2-50 | b 2-50 |
| 3 101-1000 | C 51-500 | c 51-500 |
| 4 >1000 | D >500 | d >500 |

| ITEM NO. | MATERIAL IDENTIFICATION(2) | MIX FORMULA(3) | CURE(4) | AMOUNT CODE | EXPECTED ENVIRONMENT(5) | REASON FOR SELECTION(6) | OUTGASSING VALUES | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | TML | CVCM |
| | | | | | | | | |

**NOTES**

1. List all polymeric materials and composites applications utilized in the system except lubricants which should be listed on polymeric and composite materials usage list.

2. Give the name of the material, identifying number and manufacturer.
   Example: Epoxy, Epon 828, E. V. Roberts and Associates

3. Provide proportions and name of resin, hardener (catalyst), filler, etc.
   Example: 828/V140/Silflake 135 as 5/5/38 by weight

4. Provide cure cycle details.
   Example: 8 hrs. at room temperature + 2 hrs. at 150C

5. Provide the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. List all materials with the same environment in a group.
   Example: T/V : -20C/+60C, 2 weeks, 10E-5 torr, ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 mile altitude, UV, electron, proton, atomic oxygen

6. Provide any special reason why the materials was selected. If for a particular property, please give the property.
   Example: Cost, availability, room temperature curing or low thermal expansion.

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FIGURE 6-3 POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

### 6.2.6 Inorganic Materials

The developer will prepare and document an inorganic materials and composites usage list (Figure 6.4) or the developer's equivalent (DID 6-10). The list will be submitted to GSFC for review/approval. In addition, the developer may be requested to submit supporting applications data. The criteria specified in MSFC-SPEC-522 will be used to determine that metallic materials meet the stress corrosion cracking criteria. An MUA and a stress corrosion cracking evaluation form will be submitted for each material usage that does not comply with the MSFC 522 SCC requirements (DID 6-2 & 6-3). Nondestructive evaluation requirements are contained in the STS fracture control requirements and the ELV structure integrity requirements.

#### 6.2.6.1 Fasteners

For STS and ELV launched payloads, the developer will comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in GSFC S-313-100, Goddard Space Flight Center Fastener Integrity Requirements (DID 6-11). Material test reports for fastener lots will be submitted for information (DID 6-12).

Fasteners made of plain carbon or low alloy steel will be protected from corrosion. When plating is specified, it will be compatible with the space environment. On steels harder than RC 33, plating will be applied by a process that is not embrittling to the steel.

The developer will provide its Fastener Control Plan (DID 6-11).

### 6.2.7 Lubrication

The developer will prepare and document a lubrication usage list (Figure 6.5) or the developer's equivalent (DID 6-13). the list will be submitted to GSFC for review/approval in accordance. In addition, the developer may be requested to submit supporting applications data.

Lubricants will be selected for use with materials on the basis of valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination effects.

All lubricated mechanisms will be qualified by life testing in accord with the life test plan or heritage of an identical mechanism used in identical applications. (DID 6-9).

## 6.3 PROCESS SELECTION REQUIREMENTS

The developer will prepare and document a material process utilization list or the developer's equivalent (DID 6-14) (Figure 6.6). The list will be submitted to GSFC for review/approval. A copy of any process will be submitted for review upon request. Manufacturing processes (e.g., lubrication, heat treatment, welding, chemical or metallic coatings), will be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

INORGANIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC T/O _____

DEVELOPER/CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

| ITEM NO. | MATERIAL IDENTIFICATION(2) | CONDITION(3) | APPLICATION(4) OR OTHER SPEC. NO. | EXPECTED ENVIRONMENT(5) | S.C.C. TABLE NO. | MUA NO. | NDE METHOD |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

NOTES:

1. List all inorganic materials (metals, ceramics, glasses, liquids and metal/ceramic composites) except bearing and lubrication materials which should be listed on Form 18-59C.
2. Give materials name, identifying number manufacturer.
   Example: a. Aluminum 6061-T6
   b. Electroless nickel plate, Enplate Ni 410, Enthone, Inc
   c. Fused silica, Corning 7940, Corning Class Works
3. Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.
   Example: a. Heat treated to Rockwell C 60 hardness, gold electroplated, brazed.
   b. Surface coated with vapor deposited aluminum and magnesium fluoride
   c. Cold worked to full hare condition, TIG welded and electroless nickel plated.
4. Give details of where on the spacecraft the material will be used (component) and its function.
   Example: Electronics box structure in attitude control system, not hermetically sealed.
5. Give the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
   Example: T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxyen

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FIGURE 6-4 INORGANIC MATERIALS AND COMPOSITES USAGE LIST

## LUBRICATION USAGE LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC T/O _____

DEVELOPED/CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

| ITEM NO. | COMPONENT TYPE, SIZE MATERIAL(1) | COMPONENT MANUFACTURER & MFR. IDENTIFICATION | PROPOSED LUBRICATION SYSTEM & AMT. OF LUBRICANT | TYPE & NO. OF WEAR CYCLES(2) | SPEED, TEMP., ATM. OF OPERATION(3) | TYPE OF LOADS & AMT. | OTHER DETAILS(5) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

**NOTES**

(1) BB = ball bearing, SB = sleeve bearing, G = gear, SS = sliding surfaces, SEC = sliding electrical contacts. Give generic identification of materials used for the component, e.g., 440C steel, PTFE.

(2) CUR = continuous unidirectional rotation, CO = continuous oscillation, IR = intermittent rotation, IO = intermittent oscillation, SO = small oscillation, (<30°), LO = large oscillation (>30°), CS = continuous sliding, IS = intermittent sliding.
No. of wear cycles: A(1-$10^2$), B($10^2$-$10^4$), C($10^4$-$10^6$), D(>$10^6$)

(3) Speed: RPM = revs./min., OPM = oscillations/min., VS = variable speed
CPM = cm/min. (sliding applications)
Temp. of operation, max. & min., °C
Atmosphere: vacuum, air, gas, sealed or unsealed & pressure

(4) Type of loads: A = axial, R = radial, T = tangential (gear load). Give amount of load.

(5) If BB, give type and material of ball cage and number of shields and specified ball groove and ball finishes. If G, give surface treatment and hardness. If SB, give dia. of bore and width. If torque available is limited, give approx. value.

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FIGURE 6-5 LUBRICATION USAGE LIST

## 6.4 PROCUREMENT REQUIREMENTS

### 6.4.1 Purchased Raw Materials

Raw materials purchased by the developer will be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance (DID 6-15).

### 6.4.2 Raw Materials Used in Purchased Products

The developer will require that the supplier meet the requirements of 6.4.1 and provide on request the results of acceptance tests and analyses performed on raw materials.

## MATERIALS PROCESS UTILIZATION LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC T/O _____

DEVELOPER/CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

| ITEM NO. | PROCESS TYPE(1) | CONTRACTOR SPEC. NO.(2) | MIL., ASTM., FED. OR OTHER SPEC. NO. | DESCRIPTION OF MAT'L PROCESSED(3) | SPACECRAFT/EXP. APPLICATION(4) |
|---|---|---|---|---|---|
| | | | | | |

**NOTES**

(1) Give generic name of process, e.g., anodizing (sulfuric acid).

(2) If process if proprietary, please state so.

(3) Identify the type and condition of the material subjected to the process.
E.g., 6061-T6

(4) Identify the component or structure of which the materials are being processed.
E.g., Antenna dish

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FIGURE 6-5 MATERIALS PROCESS UTILIZATION LIST

**APPENDIX 7**

**RELIABILITY REQUIREMENTS**

# THE RELIABILITY PROGRAM SHOULD BE TAILORED TO SATISFY SPECIFIC HARDWARE AND MISSION REQUIREMENTS

## 7.0 INTRODUCTION

**The purpose of this document is to serve as a resource to the GSFC Project Manager in developing a realistic set of mission assurance requirements tailored to the specific needs of the individual project. This appendix provides recommended reliability requirements. These requirements should be tailored to meet the needs of the project.**

## 7.1 GENERAL REQUIREMENTS

The developer will plan and implement a reliability program that interacts effectively with other program disciplines, including safety, systems engineering, hardware design, and product assurance. The program will be tailored according to the risk level in order to:

a. Demonstrate that redundant functions, including alternative paths and work-arounds, are independent to the extent practicable.

b. Demonstrate that stress applied to parts is not excessive.

c. Identify single failure items (points), their effect on the attainment of mission objectives, and possible safety degradation.

d. Show that reliability design is in keeping with mission design life and that it is consistent among systems, subsystems, instruments and components.

e. Identify limited-life items and ensure that special precautions are taken to conserve their useful life for on-orbit operations.

f. Select significant engineering parameters for the performance of trend analysis to identify performance trends during prelaunch activities.

g. Ensure that the design allows for ease of replacement of parts and components and that redundant paths are easily monitored.

## 7.2 RELIABILITY ANALYSES

Reliability analyses will be performed concurrently with design so that identified problem areas can be addressed for timely consideration of corrective action.

### 7.2.1 Failure Modes and Effects Analysis and Critical Items List

A Failure Modes and Effects Analysis (FMEA) will be performed early in the design phase to identify system design problems. As additional design information becomes available the FMEA will be refined.

Failure modes will be assessed at the component interface level. Each failure mode will be assessed for the effect at that level of analysis, the next higher level and upward. The failure mode will be assigned a severity category based on the most severe effect caused by a failure. Mission phases, for example, launch, deployment, on-orbit operation and retrieval, will be addressed in the analysis.

Severity categories will be determined in accordance with Table 7-1:

TABLE 7-1

SEVERITY CATEGORIES

| Category | Severity Definition |
|---|---|
| 1 | Catastrophic Failure modes that could result in serious injury or loss of life (flight or ground personnel), or loss of launch vehicle. |
| 1R | Failure modes of identical or equivalent redundant hardware items that, if all failed, could result in category 1 effects. |
| 1S | Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition or fail to operate during such condition and leads to Severity Category 1 consequences. |
| 2 | Critical Failure modes that could result in loss of one or more mission objectives as defined by the GSFC project office. |
| 2R | Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed. |
| 3 | Significant Failure modes that could cause degradation to mission objectives. |
| 4 | Minor Failure modes that could result in insignificant or no loss to mission objectives |

.

FMEA analysis procedures and documentation will be performed in accordance with documented procedures. Failure modes resulting in Severity Categories 1, 1R, 1S or 2 will be analyzed at greater depth, to the single parts if necessary, to identify the cause of failure.

Results of the FMEA will be used to evaluate the design relative to requirements (for example, no single instrument failure will prevent removal of power from the instrument). Identified discrepancies will be evaluated by management and design groups for assessment of the need for corrective action.

The FMEA will analyze redundancies to ensure that redundant paths are isolated or protected such that any single failure that causes the loss of a functional path will not affect the other functional path(s) or the capability to switch operation to that redundant path.

All failure modes that are assigned to Severity Categories 1, 1R, 1S and 2, will be itemized on a Critical Items List (CIL) and submitted with the FMEA report. Rationale for retaining the items will be included on the CIL.

The FMEA will be submitted to GSFC for review in accordance with the Contract Schedule (Appendix 13, DID 7-1).

### 7.2.2 Parts Stress Analyses

Each application of electrical, electronic, and electromechanical (EEE) parts, will be subjected to stress analyses for conformance with the applicable derating guidelines (see 5.2.3). The analyses will be performed at the most stressful values that result from specified performance and environmental requirements (e.g. temperature, voltage) on the assembly or component. The analyses will be performed in close coordination with the packaging reviews (2.5) and thermal analyses, and it will be required input data for component-level design reviews (2.5). The analyses with summary sheets and updates will be submitted to GSFC for review in accordance with the Contract Schedule (refer to Appendix 13, DID 7-2)

### 7.2.3 Worst Case Analyses

Worst Case Analyses will be performed on circuits where failure results in a severity category of 2 or higher. The most sensitive design parameters, including those that are subject to variations that could degrade performance, will be subjected to the analysis. Adequacy of margins in the design of electronic circuits, optics, electromechanical and mechanical items will be demonstrated by analyses or test or both.

The analyses will consider all parameters set at worst case limits and worst case environmental stresses for the parameter or operation being evaluated. Depending on mission parameters and parts selection methods, part parameter values for the analysis typically include the following: manufacturing variability, variability due to temperature, aging effects of environment, and variability due to cumulative radiation. The analyses will be updated in keeping with design changes. The analyses and updates will be made available to GSFC for information upon request.

### 7.2.4 Reliability Assessments

The developer will perform comparative numerical reliability assessments in order to:

(a) evaluate alternative design concepts, redundancy and cross-strapping approaches, and part substitutions; and identify the elements of the design which are the greatest detractors of system reliability

(b) Identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations

(c) assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable; and

(d) evaluate the impact of proposed engineering change and waiver requests on reliability.

The developer will specify, in the plan, how reliability assessments will be integrated with the design process and other assurance practices so as to maximize the probability of meeting mission success criteria. The developer will describe how the reliability assessments will incorporate definitions of failure as well as alternate and degraded operating modes which clearly describe plausible acceptable and unacceptable levels of performance. Degraded operating modes will include failure conditions that could be alleviated or reduced in significance through the implementation of work-arounds, via telemetry.

The developer will describe, in the plan, the level of detail of the model suitable for performing the intended functions enumerated above. The assessments and updates will be submitted to GSFC for information in accordance with the Contract Schedule (Appendix 13, DID 7-3). The results of reliability assessment results will be reported at PDR and CDR.

## 7.3 ANALYSIS OF TEST DATA

The developer will fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas.

### 7.3.1 Trend Analyses

The developer will assess all subsystems and components to determine measurable parameters that relate to performance stability. Selected parameters will be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring will be accomplished within the normal test framework; i.e., during functional tests, environmental tests, etc. The developer will establish a system for recording and analyzing the parameters as well as any changes from the nominal even if the levels are within specified limits. Trend analysis data will be reviewed with the operational personnel prior to launch, and the operational personnel will continue recording trends throughout mission life. A list of subsystem and components to be assessed and the parameters to be monitored and the trend analysis reports will be submitted for information in accordance with the Contract Schedule (refer to Appendix 13, DID 7-4).

### 7.3.2 Analysis of Test Results

The developer will analyze test information, trend data, and failure investigations to evaluate reliability implications (see 8.10.2). Identified problem areas will be documented and directed to the attention of developer management for action. Results will be summarized in the Assurance Status Report (1.4).

## 7.4 LIMITED-LIFE ITEMS

Limited-Life items will be identified and managed by means of a Limited-Life Plan, which will be submitted for approval in accordance with the Contract Schedule (Appendix 13, DID 7-5)). The plan will present definitions, the impact on mission parameters, responsibilities, and a list of limited-life items, including data elements as follows: expected life, required life, duty cycle, and rationale for selection. The useful life period starts with fabrication and ends with the completion of the final orbital mission.

The list of limited-life items should include selected structures, thermal control surfaces, solar arrays and electromechanical mechanisms. Atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue should be used to identify limited-life thermal control surfaces and structure items. Mechanisms such as batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators, and scan devices should be included when aging, wear, fatigue and lubricant degradation limit their life. Records will be maintained that allow evaluation of the cumulative stress (time and/or cycles) for limited-life items, starting when useful life is initiated and indicating the program activity that stressed the items. The use of an item whose expected life is less than its mission design life must be approved by GSFC by means of a waiver in accordance with the Contract Schedule.

# APPENDIX 8

# QUALITY ASSURANCE REQUIREMENTS

## 8.0 QUALITY MANAGEMENT SYSTEM

The developer will have a Quality Management System in accordance with ANSI/ASQC Q9001-l994. The developer's Quality Manual will be provided in accordance with the Contract Schedule (refer to Appendix 13, DID 8-1).

### 8.1 QA MANAGEMENT SYSTEM REQUIREMENTS AUGMENTATION

The following requirements augment identified portions of ANSI/ASQC Q9001-1994.

8.1.1 Paragraph 4.13.2 of ANSI/ASQC Q9001-1994 is augmented as follows:

A problem/failure report (PFR) will be written for any departure from design, performance, testing, or handling requirement that affects the function of flight equipment, ground support equipment that interfaces with flight equipment, or that could compromise mission objectives.

Reporting of failures will begin with the first power application at the lowest level of assembly or the first operation of a mechanical item; it will continue through formal acceptance by the GSFC project office.

Failures will be reported in accordance with the Contract Schedule (refer to Appendix 13, DID 8-2). Developer review/disposition/approval of failure reports will be described in applicable procedure(s) included or referenced in the Quality Manual.

8.1.2 Following launch, flight hardware/software anomalies, problems, and/or failures will be reported using the Spacecraft Orbital Anomaly Report (SOAR) in accordance with GMI 5310.1B, GSFC Problem/Failure Anomaly Reporting.

**APPENDIX 9**

**CONTAMINATION CONTROL**

# THE CONTAMINATION CONTROL PROGRAM SHOULD BE TAILORED TO SATISFY SPECIFIC HARDWARE AND MISSION REQUIREMENTS

## 9.0 INTRODUCTION

**The purpose of this document is to serve as a resource to the GSFC Project Manager in developing a realistic set of mission assurance requirements tailored to the specific needs of the individual project. This appendix provides recommended contamination control requirements. These requirements should be tailored to meet the needs of the project.**

## 9.1 GENERAL

The developer will plan and implement a contamination control program applicable to the hardware. The program establishes the specific cleanliness requirements and delineates the approaches in a Contamination Control Plan (CCP) (refer to Appendix 13, DID 9-1).

## 9.2 CONTAMINATION CONTROL PLAN

The developer will prepare a CCP that describes the procedures that will be followed to control contamination. The CCP will define a contamination allowance for performance degradation of contamination sensitive hardware such that, even in the degraded state, the hardware will meet its mission objectives. The CCP will establish the implementation and describe the methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the hardware's lifetime. In general, all mission hardware should be compatible with the most contamination-sensitive instruments and components.

## 9.3 MATERIAL OUTGASSING

All materials will be screened in accordance with NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data will be established based on hardware’s operating conditions and reviewed by GSFC.

## 9.4 THERMAL VACUUM BAKEOUT

The developer will perform thermal vacuum bakeouts of all hardware. The parameters of such bakeouts (e.g., temperature, duration, pressure) must be individualized depending on materials used, the fabrication environment, and the established contamination allowance.

## 9.5 HARDWARE HANDLING

The developer will practice cleanroom standards in handling hardware. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., antistatic film materials), and purging will be addressed.

**APPENDIX 10**

**SOFTWARE ASSURANCE**

# THE SOFTWARE ASSURANCE PROGRAM SHOULD BE TAILORED TO SATISFY SPECIFIC HARDWARE AND MISSION REQUIREMENTS

## 10.0 INTRODUCTION

**The purpose of this document is to serve as a resource to the GSFC Project Manager in developing a realistic set of mission assurance requirements tailored to the specific needs of the individual project. This appendix provides recommended software assurance requirements. These requirements should be tailored to meet the needs of the project.**

## 10.1 General

The developer will have a Software Quality Management System (SQMS) that is compliant with ANSI/ASQC Q9001. The SQMS willbe applied to flight software and firmware, ground support equipment software, key parameter and orbital checkout software, and any software developed under this contract that is related to flight mission operations.

The developer's Quality Manual will be provided in accordance with the RFP or Contract Schedule. The developer will allow NASA audits to assure compliance of the developer's SQMS with ANSI/ASQC Q9001 and to assure that the SQMS is applied to the contracted software activities.

## 10.2 Quality System Augmentations

The developer's compliant SQMS will be augmented as shown in the following numbered sections. References are to paragraphs in ANSI/ASQC Q9000-3, which provides guidance on the development of a SQMS that is compliant with the ANSI/ASQC Q9001.

10.2.1 Augmentation to Paragraph 4.1.3, ANSI/ASQC Q9000-3, Joint Reviews

There will be a series of formal reviews with developer presentations of the review material. The reviews will be conducted by GSFC with a review panel that will include independent experts in software of the type being reviewed. The formal reviews will consist of, as a minimum, a Software Requirements Review (SRR), a Preliminary Design Review (PDR), a Critical Design Review (CDR), a Test Readiness Review (TRR), and an Acceptance Review (AR).

10.2.2 Augmentation to Paragraph 4.4, ANSI/ASQC Q9000-3, Corrective Action

The corrective action process will start at the establishment of a Configuration Management (see 10.2.3) baseline that includes the product. In no case will the use of the formal software corrective action process be delayed beyond the use of the software in hardware for which formal problem reporting is required ( see 8.1.2)

The GSFC will be allowed access to the problem reports and the corrective action information as they are developed.

10.2.3 Augmentation to Paragraph 6.1, ANSI/ASQC Q9000-3, Configuration management

The developer will establish an Software Configuration Management (SCM) baseline after each formal software review defined in 10.2.1. Software products will be placed under Configuration Management immediately after the successful conclusion of the review Informal control will be used on preliminary versions of all products before being placed under control in the formal SCM system.

The developer's SCM system will have a change classification and impact assessment process that results in Class 1 changes being forwarded to GSFC for disposition. Class 1 changes are defined as those which affect system requirements, software requirements, system safety, reliability, cost, schedule, and external interfaces.

## 10.3 GFE, Existing and Purchased Software

If the developer will be provided software as government-furnished equipment (GFE), or will use existing or purchased software, the developer is responsible for the software meeting the functional, performance, and interface requirements placed upon it. The developer is responsible for ensuring that the software meets all applicable standards, including those for design, code, and documentation, or for securing a GSFC project waiver to those standards. Any significant modification to any piece of the existing software will be subject to all of the provisions of the developer's SQMS and the provisions of this document. A significant modification is defined as the change of twenty percent of the lines of code in the software.

## 10.4 Software Safety

If any software component is identified as safety critical, the developer will conduct a software safety program on that component that complies with NSS 1740.13 "Software Safety Standard".

**APPENDIX 11**

**APPLICABLE DOCUMENTS**

# THESE DOCUMENTS ARE APPLICABLE TO THE EXTENT REQUIRED BY THE TAILORED PROJECT REQUIREMENTS

| DOCUMENT | DOCUMENT TITLE |
|---|---|
| ANSI/ASQC Q9001-1994 | Model for Quality Assurance in Design, Development, Production, Installation, and Servicing |
| ANSI/ASQOC Q9000-3 | Quality Management and Quality Assurance Standards |
| ANSI/IPC-A-600 | Acceptance Criteria for Printed Wiring Boards |
| ANSI/IPC-D-275 | Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies |
| ANSI/IPC-HF 318 | Microwave End Product Board Inspection and Test |
| ANSI/IPC-RB-276 | Qualification and Performance Specification for Rigid Printed Boards |
| ASTM E-595 | Total Mass Loss (TML) and Collected Volatile Condensable Materials (CVCM) from Outgassing in a Vacuum Environment |
| EWR 127-1 | Eastern and Western Range Safety Requirements |
| GEVS-SE | General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components, rev A, dated June 1996 |
| GMI 1700.3B | Flight System Safety Requirements |
| GMI 2602.3 | Guidelines for Mission Assurance Requirements for GSFC Managed Flight Missions |
| GMI 2604.1 | Flight Assurance Design Review Program |
| GMI 5310.1B | GSFC Problem/Failure Anomaly Reporting |
| GSFC 311-INST-001 | Instructions for EEE Parts Selection, Screening, and |

| DOCUMENT | DOCUMENT TITLE |
|---|---|
| | Qualification |
| GSFC 731-0005-83 | General Fracture Control Plan for Payloads Using the Space Transportation System (STS) |
| GSFC PPL | Goddard Space Flight Center Preferred Parts List |
| GSFC S-312-P003 | Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses |
| GSFC S-313-100 | Goddard Space Flight Center Fastener Integrity Requirements |
| ICD-2-19001 | Shuttle Orbiter/Cargo Standard Interfaces |
| JSC 07700, Volume XIV, Attachment I (ICD 2-19001) | Shuttle Orbiter/Cargo Standard Interfaces |
| KHB 1700.7 | Space Transportation System Payload Ground Safety Handbook |
| MIL-STD 1629A | Procedures for Performing a Failure Mode Effects and Criticality Analysis |
| MIL-STD-756B | Reliability Modeling and Prediction |
| MIL-STD-975 | NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List |
| MSFC CR 5320.9 | Payload and Experiment Failure Mode Effects Analysis and Critical Items List Groundrules |
| MSFC-HDBK-527 | Material Selection List for Space Hardware Systems |
| MSFC-SPEC-522 | Design Criteria for Controlling Stress Corrosion |

| DOCUMENT | DOCUMENT TITLE |
|---|---|
| | Cracking |
| NAS 5300.4(3G) | Requirements for Interconnecting Cable Harnesses, and Wiring |
| NAS 5300.4(3J) | Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies |
| NAS 5300.4(3M) | Workmanship Requirements for Surface Mount Technology |
| NASA Reference Publication (RP) 1124 | Outgassing Data for Selecting Spacecraft Materials |
| NASA RP-1161 | Evaluation of Multilayer Printed Wiring Boards by Metallographic Techniques |
| NHB 1700.7 | Safety Policy and Requirements for Payloads using the Space Transportation System |
| NHB 5300.4(3A-2) | Requirements for Soldered Electrical Connections |
| NHB 5300.4(3H) | Requirements for Crimping and Wire Wrap |
| NHB 5300.4(3L) | Requirements for Electrostatic Discharge Control |
| NHB 8060.1 | Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion |
| NSS 1740.13 | Software Safety Standard |
| NSTS 1700.7B | Safety Policy and Requirements for Payloads using the International Space Station |
| NSTS 22648 | Flammability Configuration Analysis for Spacecraft |

| DOCUMENT | DOCUMENT TITLE |
|---|---|
| | Applications |
| S-302-89-01 | Procedures for Performing a Failure Mode and Effects Analysis (FMEA) |
| S-311-M-70 | Specification for Destructive Physical Analysis |

# APPENDIX 12

# GLOSSARY

| ACRONYM | DEFINITION |
|---|---|
| ABPL | As-Built Parts List |
| ANSI | American National Standards Institute |
| AR | Acceptance Review |
| ASQC | American Society for Quality Control |
| ASIC | Application Specific Integrated Circuits |
| BOL | Beginning of Life |
| CCP | Contamination Control Plan |
| CDR | Critical Design Review |
| CDRL | Contract Delivery Requirements List |
| CIL | Critical Items List |
| CPT | Comprehensive Performance Test |
| CVCM | Collected Volatile Condensable Mass |
| DID | Data Item Description |
| DoD | Department of Defense |
| DPA | Destructive Physical Analysis |
| DRP | Design Review Program |
| DRT | Design Review Team |
| EEE | Electrical, Electronic, and Electromechanical |
| ELV | Expendable Launch Vehicle |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| EOL | End of Life |
| FMEA | Failure Modes and Effects Analysis |
| FOR | Flight Operations Review |
| GAS | Get Away Special |
| GEVS | General Environmental Verification Specification |
| GEVS-SE | General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components |
| GFE | Government-Furnished Equipment |
| GIA | Government Inspection Agency |
| GIDEP | Government Industry Data Exchange Program |
| GMI | Goddard Management Instruction |
| GSE | Ground Support Equipment |
| GSFC | Goddard Space Flight Center |
| IAC | Independent Assurance Contractor |
| ICD | Interface Control Document |
| JPL | Jet Propulsion Laboratory |
| JSC | Johnson Space Center |
| LPT | Limited Performance Test |
| LRR | Launch Readiness Review |
| MAG | Mission Assurance Guidelines |
| MCM | Multi-Chip Module |
| MO&DSD | Mission Operations and Data Systems Directorate |
| MOR | Mission Operations Review |
| MSFC | Marshall Space Flight Center |
| MSR | Management Status Report |
| MUA | Materials Usage Agreement |
| NAS | NASA Assurance Standard |
| NASA | National Aeronautics and Space Administration |
| Nascom | NASA Communications Network |
| NHB | NASA Handbook |
| NSTS | National Space Transportation System |
| OFA | Office of Flight Assurance |
| PAPL | Program Approved Parts List |

| ACRONYM | DEFINITION |
|---|---|
| PCB | Parts Control Board |
| PCP | Parts Control Plan |
| PDR | Preliminary Design Review |
| PER | Pre-Environmental Review |
| PFR | Problem/Failure Report |
| PI | Principal Investigator |
| PIL | Parts Identification List |
| POCC | Payload Operations Control Center |
| PPL | Preferred Parts List |
| PSR | Pre-Shipment Review |
| PWB | Printed Wiring Board |
| QCM | Quartz Crystal Microbalance |
| RFP | Request for Proposal |
| RH | Relative Humidity |
| SCC | Stress Corrosion Cracking |
| SCD | Source Control Drawing |
| SCM | Software Configuration Management |
| SCR | System Concept Review |
| SOCC | Simulations Operations Control Center |
| SOW | Statement of Work |
| SOW | Statement of Work |
| SQMS | Software Quality Management System |
| SRO | Systems Review Office |
| SRR | Software Requirements Review |
| STS | Space Transportation System (Shuttle) |
| TML | Total Mass Loss |
| TR | Torque Ratio |
| TRR | Test Readiness review |

# DEFINITIONS

The following definitions apply within the context of this document:

**Acceptance Tests**: The verification process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract.

**Assembly**: See Level of Assembly.

**Audit:** A review of the developer's, contractor's or subcontractor's documentation or hardware to verify that it complies with project requirements.

**Collected Volatile Condensable Material (CVCM):** The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time.

**Component**: See Level of Assembly.

**Configuration**: The functional and physical characteristics of the payload and all its integral parts, assemblies and systems that are capable of fulfilling the fit, form and functional requirements defined by performance specifications and engineering drawings.

**Configuration Control:** The systematic evaluation, coordination, and formal approval/disapproval of proposed changes and implementation of all approved changes to the design and production of an item the configuration of which has been formally approved by the contractor or by the purchaser, or both.

**Configuration Management:** The systematic control and evaluation of all changes to baseline documentation and subsequent changes to that documentation which define the original scope of effort to be accomplished (contract and reference documentation) and the systematic control, identification, status accounting and verification of all configuration items.

**Contamination**: The presence of materials of molecular or particulate nature which degrade the performance of hardware.

**Derating:** The reduction of the applied load (or rating) of a device to improve reliability or to permit operation at high ambient temperatures.

**Design Specification**: Generic designation for a specification that describes functional and physical requirements for an article, usually at the component level or higher levels of assembly. In its initial form, the design specification is a statement of functional requirements with only general coverage of physical and test requirements. The design specification evolves through the project life cycle to reflect progressive refinements in performance, design, configuration, and test requirements. In many projects the end-item specifications serve all the purposes of design specifications for the contract end-items. Design specifications provide the basis for technical and engineering management control.

**Designated Representative:** An individual (such as a NASA plant representative), firm (such as assessment contractor), Department of Defense (DOD) plant representative, or other government representative designated and authorized by NASA to perform a specific

function for NASA. As related to the contractor's effort, this may include evaluation, assessment, design review, participation, and review/approval of certain documents or actions.

**Destructive Physical Analysis (DPA):** An internal destructive examination of a finished part or device to assess design, workmanship, assembly, and any other processing associated with fabrication of the part.

**Discrepancy:** See Nonconformance.

**Design Qualification Tests**: Tests intended to demonstrate that the test item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch, and orbital operations. Their purpose is to uncover deficiencies in design and method of manufacture. They are not intended to exceed design safety margins or to introduce unrealistic modes of failure. The design qualification tests may be to either “prototype” or “protoflight” test levels.

**Discrepancy:** See Nonconformance

**Electromagnetic Compatibility (EMC)**: The condition that prevails when various electronic devices are performing their functions according to design in a common electromagnetic environment.

**Electromagnetic Interference (EMI)**: Electromagnetic energy which interrupts, obstructs, or otherwise degrades or limits the effective performance of electrical equipment.

**Electromagnetic Susceptibility**: Undesired response by a component, subsystem, or system to conducted or radiated electromagnetic emissions.

**End-to-End Tests**: Tests performed on the integrated ground and flight system, including all elements of the payload, its control, stimulation, communications, and data processing to demonstrate that the entire system is operating in a manner to fulfill all mission requirements and objectives.

**Failure**: A departure from specification that is discovered in the functioning or operation of the hardware or software. See nonconformance.

**Failure Modes and Effects Analysis (FMEA):** A procedure by which each credible failure mode of each item from a low indenture level to the highest is analyzed to determine the effects on the system and to classify each potential failure mode in accordance with the severity of its effect.

**Flight Acceptance: See Acceptance** Tests.

**Fracture Control Program**: A systematic project activity to ensure that a payload intended for flight has sufficient structural integrity as to present no critical or catastrophic hazard. Also to ensure quality of performance in the structural area for any payload (spacecraft) project. Central to the program is fracture control analysis, which includes the concepts of fail-safe and safe-life, defined as follows:

a. **Fail-safe**: Ensures that a structural element, because of structural redundancy, will not cause collapse of the remaining structure or have any detrimental effects on mission performance.

b. **Safe-life**: Ensures that the largest flaw that could remain undetected after non-destructive examination would not grow to failure during the mission.

**Functional Tests:** The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

**Hardware**: As used in this document, there are two major categories of hardware as follows:

a. **Prototype Hardware**: Hardware of a new design; it is subject to a design qualification test program; it is not intended for flight.

b. **Flight Hardware**: Hardware to be used operationally in space. It includes the following subsets:

(1) **Protoflight Hardware**: Flight hardware of a new design; it is subject to a qualification test program that combines elements of prototype and flight acceptance verification; that is, the application of design qualification test levels and flight acceptance test durations.

(2) **Follow-On Hardware**: Flight hardware built in accordance with a design that has been qualified either as prototype or as protoflight hardware; follow-on hardware is subject to a flight acceptance test program.

(3) **Spare Hardware**: Hardware the design of which has been proven in a design qualification test program; it is subject to a flight acceptance test program and is used to replace flight hardware that is no longer acceptable for flight.

(4) **Reflight Hardware**: Flight hardware that has been used operationally in space and is to be reused in the same way; the verification program to which it is subject depends on its past performance, current status, and the upcoming mission.

**Inspection:** The process of measuring, examining, gaging, or otherwise comparing an article or service with specified requirements.

**Instrument:** See Level of Assembly.

**Level of Assembly**: The environmental test requirements of GEVS generally start at the component or unit level assembly and continue hardware/software build through the system level (referred to in GEVS as the payload or spacecraft level). The assurance program includes the part level. Verification testing may also include testing at the assembly and subassembly levels of assembly; for test recordkeeping these levels are combined into a "subassembly" level. The verification program continues through launch, and on-orbit performance. The following levels of assembly are used for describing test and analysis configurations:

**Part**: A hardware element that is not normally subject to further subdivision or disassembly without destruction of design use. Examples include resistor, integrated circuit, relay, connector, bolt, and gaskets.

**Subassembly**: A subdivision of an assembly. Examples are wire harness and loaded printed circuit boards.

**Assembly**: A functional subdivision of a component consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole. Examples are a power amplifier and gyroscope.

**Component or unit**: A functional subdivision of a subsystem and generally a self-contained combination of items performing a function necessary for the subsystem's operation. Examples are electronic box, transmitter, gyro package, actuator, motor, battery. For the purposes of this document, "component" and "unit" are used interchangeably.

**Section**: A structurally integrated set of components and integrating hardware that form a subdivision of a subsystem, module, etc. A section forms a testable level of assembly, such as components/units mounted into a structural mounting tray or panel-like assembly, or components that are stacked.

**Subsystem**: A functional subdivision of a payload consisting of two or more components. Examples are structural, attitude control, electrical power, and communication subsystems. Also included as subsystems of the payload are the science instruments or experiments.

**Instrument**: A spacecraft subsystem consisting of sensors and associated hardware for making measurements or observations in space. For the purposes of this document, an instrument is considered a subsystem (of the spacecraft).

**Module**: A major subdivision of the payload that is viewed as a physical and functional entity for the purposes of analysis, manufacturing, testing, and recordkeeping. Examples include spacecraft bus, science payload, and upper stage vehicle.

**Payload**: An integrated assemblage of modules, subsystems, etc., designed to perform a specified mission in space. For the purposes of this document, "payload" and "spacecraft" are used interchangeably. Other terms used to designate this level of assembly are Laboratory, Observatory, and satellite.

**Spacecraft**: See Payload. Other terms used to designate this level of assembly are Laboratory, Observatory, and satellite.

**Limit Level**: The maximum expected flight.

**Limited Life Items:** Spaceflight hardware (1) that has an expected failure-free life that is less than the projected mission life, when considering cumulative ground operation, storage and on-orbit operation, (2) limited shelf life material used to fabricate flight hardware.

**Margin:** The amount by which hardware capability exceeds mission requirements

**Module**: See Level of Assembly.

**Monitor:** To keep track of the progress of a performance assurance activity; the monitor need not be present at the scene during the entire course of the activity, but he will review resulting data or other associated documentation (see Witness).

**Nonconformance**: A condition of any hardware, software, material, or service in which one or more characteristics do not conform to requirements. As applied in quality assurance, nonconformances fall into two categories--discrepancies and failures. A discrepancy is a departure from specification that is detected during inspection or process control testing, etc., while the hardware or software is not functioning or operating. A failure is a departure from specification that is discovered in the functioning or operation of the hardware or software.

**Offgassing**: The emanation of volatile matter of any kind from materials into a manned pressurized volume.

**Outgassing**: The emanation of volatile materials under vacuum conditions resulting in a mass loss and/or material condensation on nearby surfaces.

**Part**: See Level of Assembly.

**Payload**: See Level of Assembly.

**Performance Verification**: Determination by test, analysis, or a combination of the two that the payload element can operate as intended in a particular mission; this includes being satisfied that the design of the payload or element has been qualified and that the particular item has been accepted as true to the design and ready for flight operations.

**Protoflight Testing**: See Hardware.

**Prototype Testing**: See Hardware.

**Qualification**: See Design Qualification Tests.

**Redundancy** (of design): The use of more than one independent means of accomplishing a given function.

**Repair:** A corrective maintenance action performed as a result of a failure so as to restore an item to op within specified limits.

**Rework:** Return for completion of operations (complete to drawing). The article is to be reprocessed to conform to the original specifications or drawings.

**Section**: See Level of Assembly.

**Similarity, Verification by,:** A procedure of comparing an item to a similar one that has been verified. Configuration, test data, application, and environment should be evaluated. It should be determined that design-differences are insignificant, environmental stress will not be greater in the new application, and that manufacturer and manufacturing methods are the same.

**Single Point Failure:** A single element of hardware the failure of which would result in loss of mission objectives, hardware, or crew, as defined for the specific application or project for which a single point failure analysis is performed.

**Spacecraft**: See Level of Assembly.

**Subassembly**: See Level of Assembly.

**Subsystem**: See Level of Assembly.

**Temperature Cycle**: A transition from some initial temperature condition to temperature stabilization at one extreme and then to temperature stabilization at the opposite extreme and returning to the initial temperature condition.

**Temperature Stabilization**: The condition that exists when the rate of change of temperatures has decreased to the point where the test item may be expected to remain within the specified test tolerance for the necessary duration or where further change is considered acceptable.

**Thermal Balance Test**: A test conducted to verify the adequacy of the thermal model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

**Thermal-Vacuum Test**: A test conducted to demonstrate the capability of the test item to operate satisfactorily in vacuum at temperatures based on those expected for the mission. The test, including the gradient shifts induced by cycling between temperature extremes, can also uncover latent defects in design, parts, and workmanship.

**Torque Margin:** Torque margin is equal to the torque ratio minus one.

**Torque Ratio:** Torque ratio is a measure of the degree to which the torque available to accomplish a mechanical function exceeds the torque required.

**Total Mass Loss (TML):** Total mass of material outgassed from a specimen that is maintained at a specified constant temperature and operating pressure for a specified time.

**Unit**: See Level of Assembly.

**Verification:** See Performance Verification.

**Vibroacoustics**: An environment induced by high-intensity acoustic noise associated with various segments of the flight profile; it manifests itself throughout the payload in the form of directly transmitted acoustic excitation and as structure-borne random vibration.

**Workmanship Tests**: Tests performed during the environmental verification program to verify adequate workmanship in the construction of a test item. It is often necessary to impose stresses beyond those predicted for the mission in order to uncover defects. Thus random vibration tests are conducted specifically to detect bad solder joints, loose or missing fasteners, improperly mounted parts, etc. Cycling between temperature extremes during thermal-vacuum testing and the presence of electromagnetic interference during EMC testing can also reveal the lack of proper construction and adequate workmanship.

**Witness:** A personal, on-the-scene observation of a performance assurance activity with the purpose of verifying compliance with project requirements (see Monitor).

**APPENDIX 13**

**CONTRACT SCHEDULE - DATA ITEM DESCRIPTIONS**

# THE DATA ITEM DESCRIPTIONS WILL BE TAILORED TO MEET PROJECT AND MISSION REQUIREMENTS

| REFERENCED PARAGRAPH | DESCRIPTION | DID NUMBER |
|---|---|---|
| 1.2 | Use of Multi-Mission of Previously Designed, Fabricated, or Flown Hardware | 1-1 |
| 3.2.1 | System Performance Verification Plan | 3-1 |
| 3.2.1.1 | Environmental Verification Plan | 3-1 |
| 3.2.1.2 | System Performance Verification Matrix | 3-1 |
| 3.2.1.3 | Environmental Test Matrix | 3-1 |
| 3.2.1.4 | Environmental Verification Specification | 3-1 |
| 3.2.2 | Performance Verification Procedure | 3-2 |
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| Title: Use of Multi-Mission or Previously Designed, Fabricated, or Flown Hardware | CDRL No.: 1-1 |
|---|---|

Reference:
MAG, Paragraph 1.2

Use:
Demonstrates how existing design/hardware complies with current assurance and performance requirements, thereby eliminating the need to perform identified tasks otherwise required.

Related Documents:
None

Place/Time/Purpose of Delivery:
Provide with proposal for GSFC review and updates at PDR for GSFC approval.

Preparation Information:

For each identified existing design or hardware configuration considered to be in some degree of compliance with current requirements as a result of demonstrated compliance with previous requirements:

1. Compare each performance, design, environmental, and interface requirement, including margins, for this Project (as delineated in other documents related to this procurement) with the corresponding previous requirement. For any mission requirement or environmental difference from the previous use, either describe the modifications to be made to the hardware and/or software to meet Project requirements, or provide a rationale and supporting information demonstrating why use without modification is considered acceptable.

2. Compare each performance assurance requirement for this Project with the corresponding previous requirement. Also, identify all waivers and deviations from the performance assurance requirements accepted on the previous program. For any requirement of the previous program that does not comply with the requirements of this Project, or for any previous deviation or waiver, describe what will be done to achieve compliance or provide a rationale and supporting information demonstrating why the difference is acceptable. In addition, indicate how any modifications proposed as a result of (1) above will be shown to comply with the performance assurance requirements of this Project.

3. Compare the manufacturing information for the hardware proposed for this Project with that of the existing hardware. This will include, as a minimum, the name and location of the manufacturer, the date of manufacture, any design changes, any changes to parts or materials, any modification to packaging techniques, and any changes to fabrication or assembly controls or processes.

4. Describe all ground and flight experience with the proposed hardware and software including, in particular, a description of all failures or anomalies, their cause, and any corrective action that was taken as a result.

| Title:<br><br>System Performance Verification Plan | CDRL No.:<br>3-1 |
|---|---|
| Reference:<br>Paragraph 3.2.1 | |
| Use:<br>Provides the overall approach for accomplishing the verification program. Defines the specific tests, analyses, calibrations, alignments, etc. that will demonstrate that the hardware complies with the mission requirements | |
| Related Documents | |
| Place/Time/Purpose of Delivery:<br>Preliminary with proposal for GSFC review.<br>Final at CDR for GSFC approval.<br>Updates as required. | |
| Preparation Information:<br><br>Describes the approach (test, analysis, etc.) that will be utilized to verify that the hardware/software complies with mission requirements. If verification relies on tests or analyses at other level of assemblies, describe the relationships.<br><br>A section of the plan will be a "System Performance Verification Matrix" summarizing the flow-down of system specification requirements that stipulates how each requirement will be verified, and summarizes compliance/non-compliance with requirements. It will show each specification requirement, the reference source (to the specific paragraph or line item), the method of compliance, applicable procedure references, report reference numbers, etc. The System Performance Verification Matrix may be made a separate document.<br><br>The System Performance Verification Plan will include a section describing the environmental verification program. This will include level of assembly, configuration of item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, appropriate functional operations, personnel responsibilities, and requirements for procedures and reports. For each analysis activity, include objectives, a description of the mathematical model, assumptions on which the model will be based, required output, criteria for assessing the acceptability of the results, interaction with related test activity, and requirements for reports. Provide for an operational methodology for controlling, documenting, and approving activities not part of an approved procedure. Plan controls that prevent accidents that could damage or contaminate hardware or facilities, or cause personal injury. The controls will include real-time decision-making mechanisms for continuation or suspension of testing after malfunction, and a method for determining retest requirements, including the assessment of the validity of previous tests. Include a test matrix that summarizes all tests to be performed on each component, each subsystem, and the payload. Include tests on engineering models performed to satisfy qualification requirements. Define pass/fail criteria. The Environmental Verification. The Environmental Test Plan section will include a Environmental Test Matrix which summarizes all environmental tests that will be performed showing the test and the level of assembly. Tests on development/engineering models performed to satisfy qualification requirements will be included in this matrix. The Environmental Verification Plan may be made a separate document rather than be a section of the System Performance Verification Plan. As an adjunct to the environmental verification program, a Environmental Test Tracking Matrix Summarizing all tests performed and showing the test and the level of assembly will be maintained. | |

| Title:<br><br>System Performance Verification Plan (cont.) | CDRL No.:<br>3-1 (cont.) |
|---|---|
| Reference:<br>Paragraph 3.2.1 | |
| Use:<br>Provides the overall approach for accomplishing the verification program. Defines the specific tests, analyses, calibrations, alignments, etc. that will demonstrate that the hardware complies with the mission requirements | |
| Related Documents | |
| Place/Time/Purpose of Delivery:<br>Preliminary with proposal for GSFC review.<br>Final at CDR for GSFC approval.<br>Updates as required. | |
| Preparation Information: (cont.)<br><br>The System Performance Verification Plan will include a Environmental Verification Specification section which stipulates the specific environmental parameters used in each test or analysis required by the verification plan. Contains the specific test and analytical parameters associated with each of the tests and analyses required by the Verification Plan. Payload peculiarities and interactions with the launch vehicle will be considered when defining quantitative environmental parameters under which the hardware elements must meet their performance requirements. The Environmental Verification Specification may be included as part of the System Performance Verification Plan | |

| Title:<br><br>Performance Verification Procedure | CDRL No.:<br>3-2 |
|---|---|
| Reference:<br>Paragraph 3.2.6 | |
| Use:<br>Describes how each test activity defined in the Verification Plan will be implemented | |
| Related Documents | |
| Place/Time/Purpose of Delivery:<br>30 days prior to test for GSFC approval. | |
| Preparation Information:<br><br>Describe the configuration of the tested item and the step-by-step functional and environmental test activity conducted at the unit/component, subsystem/instrument, and payload levels. Give details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, quality control checkpoints, pass/fail criteria, data collection and reporting requirements. Address safety and contamination control provisions. A methodology will be provided for controlling, documenting and approving all activities not part of an approved procedure and establish controls for preventing accidents that could cause personal injury or damage to hardware and facilities. | |

| Title:<br><br>Verification Reports | CDRL No.:<br>3-3 |
|---|---|
| Reference:<br>Paragraph 3.2.7 | |
| Use:<br>Summarize compliance with system specification requirements and/or provide a summary of testing and analysis results, including conformance, nonconformance, and trend data. | |
| Related Documents | |
| Place/Time/Purpose of Delivery:<br>Verification Reports: Preliminary report 72 hours after test for GSFC information.<br>Final report 30 days after verification activity for GSFC information<br><br>System Performance Verification Report: Preliminary at CDR.<br>Final report 30 days following on-orbit check out. | |
| Preparation Information:<br><br>Verification Report: Provide after each unit/component, subsystem/instrument, and payload verification activity. For each analysis activity the report will describe the degree to which the objectives were accomplished, how well the mathematical model was validated by the test data, and other significant results.<br><br>System Performance Verification Report: Compare hardware/software specifications with the verified values (whether measured or computed). It is recommended that this report be subdivided by subsystem/instrument. | |

| Title: Printed Wiring Board (PWB) Coupons | CDRL No.: 4-1 |
|---|---|
| Reference: MAG, Paragraph 4.2 | |
| Use: For independent evaluation of the quality of PWBs used in the hardware | |
| Related Documents: IPC-D-275, GSFC S-312-P003, ANSI/IPC-HF 318, ANSI/IPC-A-600, NASA RP 1161 | |
| Place/Time/Purpose of Delivery: Provide to the GSFC Project Office for approval as a precondition to board population. | |

Preparation Information:

Provide a test coupon for each PWB used in the flight hardware and note the following:

1. The coupon will be per the design requirements of GSFC S-312-P-003 and will only be removed from the flight PWB panel after the panel has been through all manufacturing processes.
2. The coupon will be "as produced" by the vendor; that is, it will not have seen any processes not experienced by the PWB panel (including metallographic preparation techniques or thermal excursions).
3. The coupon will be clearly identified with the part number, serial number, vendor identification an date code or production lot number.
4. The paperwork accompanying the coupon will include the part number, serial number, vendor identification and date code or production lot number as well as the flight experiment to which the coupon pertains and the shipper identification and tracking number.
5. A FAX will precede the coupon receipt by one day. This FAX will be sent to the evaluation lab, and will include the part number, serial number, vendor identification and date code or production lot number as well as the flight experiment to which the coupon pertains and the shipper identification and tracking number.

Two weeks prior to shipping the coupons, the hardware provider will notify the Flight Assurance support contractor or the independent evaluation laboratory of the coupons that they plan to ship for evaluation.

Flight PWB will not be assembled prior to notification that the representative coupon has passed laboratory evaluation by the GSFC-approved laboratory.

The Flight Assurance Manager for the project will be provided with a preliminary FAX of the coupon test results and the final report.

A list of certified laboratories, their addresses and phone and FAX numbers will be provided by the GSFC Materials Engineering Branch.

| Title:<br><br>Technology Validation Assessment Plan (TVAP) | CDRL No.:<br>4-2 |
|---|---|
| Reference: | |
| Use: | |
| Related Documents | |
| Place/time/purpose of delivery:<br><br>Provide the TVAP to the Parts Control Board for review and approval within 30 days after technology selection or initiation of development. A copy is to be sent to the GSFC Project Office. Updates for major changes will be provided for approval prior to performing validation steps, screens, and tests. | |
| Preparation Information:<br><br>1. A TVAP will be prepared for each new and advanced packaging technology being used. The TVAP will provide validation process steps used to assure the new technology meets the performance requirements of the flight environment and application.<br><br>2. The TVAP will consist of the following as a minimum:<br><br>a) Packaging/advanced interconnection description, generic type, and manufacturer<br>b) Identification of TVAP validation steps, screens, and tests to be imposed to validate the technology<br>c) Schematics of the internal and external dimensions of the technology<br>d) Identification of the types of materials used in the manufacture of the technology<br>e) Description of the design application for the technology and critical performance parameters<br><br>3. Any format may be used provided all the required information is included. All submissions to the GSFC Project Office will be in computer readable form and easily printable.<br><br>4. Updates to previously submitted TVAPs will identify changes from the previous submission. Updates will be provided when major changes to items 2(b), 2(c), 2(d), or 2(e) occur. | |

| Title:<br>Parts Control Plan (PCP) | CDRL No.:<br>5-1 |
|---|---|
| Reference:<br>Paragraph 5.1, 5.2.1, 5.2.2, 5.2.3, 5.2.6 | |
| Use:<br>Description of developer's approach and methodology for implementation of the Parts Control Program | |
| Related Documents<br>Parts Identification List (PIL) | |
| Place/Time/Purpose of Delivery:<br>The PCP will be developed and delivered as part of the proposal for GSFC review | |

Preparation Information:

The PCP will be prepared and will address all EEE parts program requirements. The PCP will contain, as a minimum, detailed discussions of the following:

1. The developer's plan or approach for conforming to the EEE parts requirements.

2. The developer's parts control organization, identifying key individuals and specific responsibilities.

3. Detailed Parts Control Board (PCB) procedures, to include PCB membership, designation of Chairperson, responsibilities, review and approval procedures, meeting schedules and method of notification, meeting minutes, etc.

4. Parts tracking methods and approach, including tools to be used such as databases, reports, PIL, etc. Describe system for identifying and tracking parts approval status.

5. Parts procurement, processing and testing methodology and strategies. Identify internal operating procedures to be used for incoming inspections, screening, qualification testing, derating, testing of parts pulled from stores, Destructive Physical Analysis, radiation assessments, etc.

| Title:<br>Parts Identification List (PIL) | CDRL No.:<br>5-2 |
|---|---|
| Reference:<br>Paragraph 5.3, 5.3.2 | |
| Use:<br>Listing of all EEE parts intended for use in spaceflight hardware | |
| Related Documents<br>Parts Control Plan (PCP) | |
| Place/Time/Purpose of Delivery:<br>The ABPL will be submitted to GSFC for review 60 days prior to delivery of the end item. | |

Preparation Information:

1. The PIL will be prepared and maintained throughout the life of the program. The PIL will be compiled by instrument, instrument component, or spacecraft component, and will include the following information, as a minimum:

Part name
Part number
Manufacturer
Manufacturer's generic part number
Procurement specification

2. An As-Built Parts List (ABPL) will also be prepared and will include the following information in addition to the above list:

Lot date code
Quantities
Parts use location to the sub-assembly level

3. Any format may be used provided the required information are included. All submissions to GSFC will include a paper copy and a computer readable form.

4 Updates to PIL will identify changes from the previous submission.

A preliminary PIL will be submitted for information 90 days after contract award. Updates to PIL will be available at the developer's facility for review.

| Title: Materials, Processes and Lubrication Assurance Plan | CDRL No.: 6-1 |
|---|---|
| Reference: MAG, Paragraph 6.1 | |
| Use: Documents the developer's materials engineering and assurance program | |
| Related Documents: None | |
| Place/Time/Purpose of Delivery: Provide with proposal for GSFC review and 30 days before the PDR for approval. | |

Preparation Information:

The Materials, Processes and Lubrication Assurance Plan will contain:

(a) Table of contents.

(b) Organization of materials group, project management group and connecting organization.

(c) Authority and methods of material and lubrication assurance control of hardware
- drawing signatures
- failure analysis participation
- materials review board participation

(d) Technical skill mix and laboratory capabilities

(e) The responsibility of materials and lubrication engineering in the design, drawing and process control in the engineering, fabrication and testing control system utilized by the developer.

(f) Limited shelf-life materials control program.

| Title: Materials Usage Agreement | CDRL No.: 6-2 |
|---|---|

Reference:
MAG, Paragraphs 6.2.1, 6.2.2, 6.2.2.1, 6.2.5.2 and 6.2.6

Use:
For usage evaluation and approval of noncompliant materials or lubrication usage.

Related Documents:
MSFC -SPEC-522, MSFC-HDBK-527, NHB 8060.1, NHB 1700.7, GMI 1700.3

Place/Time/Purpose of Delivery:
Provide to the GSFC Project Office with the polymeric and composite materials usage list, flammable materials usage list, odor and toxic offgassing materials usage list or the inorganic materials usage list for GSFC approval.

Preparation Information:

A Materials Usage Agreement (MUA) will be provided for each noncompliant off-the-shelf-hardware material usage, noncompliant polymeric material outgassing, flammability or toxicity usage and noncompliant inorganic material stress corrosion cracking usage.

The MUA will be provided on a Material Usage Agreement form, a contractor's equivalent form or the contractor's electronically transmitted form. The form is available in the Mission Assurance Guide.

The MUA form requires the minimum following information: MSFC 527 material rating, usage agreement number, page number, drawing numbers, part or drawing name, assembly, material name and specification, manufacturer and trade name, use thickness, weight, exposed area, pressure, temperature, exposed media, application, rationale for safe and successful flight, originator's name, program manager's name and date.

The off-the-shelf-hardware usage must identify the measures to be used to ensure the acceptability of he hardware such as hermetic sealing, material changes to known compliant materials, vacuum bakeout to the error budget requirements listed in the contamination control plan.

| Title: Stress Corrosion Evaluation Form | CDRL No.: 6-3 |
|---|---|

Reference:
MAG, Paragraphs 3.4.1.1, 6.2.2 and 6.2.6

Use:
Provide detailed stress corrosion cracking engineering information required to demonstrate the successful flight of the material usage.

Related Documents:
MSFC -SPEC-522, MSFC-HDBK-527, NHB 1700.7, GMI 1700.3

Place/Time/Purpose of Delivery:
Provide to the GSFC Project Office with the Inorganic Materials Usage list 30 days before contractor ‘s PDR for review, 30 days before contractor’s CDR for approval and 30 days before acceptance with the Inorganic materials usage list for GSFC approval.

Preparation Information:

The developer will provide the information requested on the stress corrosion evaluation form, the equivalent information on the developer’s form or the equivalent information electronically. The form is available in the Mission Assurance Guide.

The stress corrosion evaluation form requires, as a minimum, the following information: part number, part name next assembly number, manufacturer, material heat treatment, size and form, sustained tensile stresses, magnitude and direction, process residual stress, assembly stress, design stress, static stress, special processing, weld alloy form, temper of parent weldment metal, weld filler alloy, welding process, weld bead removal if any, post-weld thermal treatment, post-weld stress relief, environment, protective finish, function of part, effect of failure, evaluation of stress corrosion susceptibility.

| Title:<br>Nonconventional Material and Lubrication Report | CDRL No.:<br>6-4 |
|---|---|
| Reference:<br>MAG, Paragraph 6.2.4 | |
| Use:<br>For approval of a nonconventional material or lubricant usage. | |
| Related Documents<br>None | |
| Place/Time/Purpose of Delivery:<br>Provide to the GSFC Project Office for approval 30 days prior to CDR. | |
| Preparation Information:<br><br>If a compliant material is proposed for a first time usage or application in space or an application with limited heritage, it is considered a nonconventional material application and a non-compliant material. For example, a beryllium instrument frame or a silicone carbide spacecraft structure are nonconventional applications. A nonconventional material application report or presentation will contain:<br>1. Description of the application.<br>2. Thermal, stress and fracture analysis.<br>3. Heritage and test environment.<br>4. Rationale for not using a conventional material application with extensive heritage.<br>5. List of chemical and mechanical materials properties available and needed for design.<br>6. Extreme environments such high stresses, temperature, corrosive environments, high atomic oxygen fluxes at low earth orbit. | |

| Title: Polymeric Materials and Composites Usage List | CDRL No.: 6-5 |
|---|---|

Reference:
MAG, Paragraph 6.2.5

Use:
For usage evaluation and approval of all polymeric and composite materials applications.

Related Documents:
NASA RP-1124, ASTM E 595, MSFC-HDBK-527, NHB 1700.7, NHB 8060.1, EWR 127.1
GMI 1700.3

Place/Time/Purpose of Delivery:
Provide to the GSFC Project Office 30 days before developer PDR for review, 30 days before developer CDR for approval and 30 days before acceptance for approval.

Preparation Information:

The developer will provide the information requested on the polymeric materials and composites usage list form, the equivalent information on the developer's form or the equivalent information electronically. The form is in the Mission Assurance Guide.

The polymeric materials and composites usage list (1) form requires, as a minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, contractor, address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, date evaluated, item number, material identification (2), mix formula (3), cure (4), amount code, expected environment (5), outgassing values and reason for selection (6). Notes 1 through 6 are listed below:

1. List all polymeric materials and composites applications utilized in the system except lubricants which should be listed on polymeric and composite materials usage list.
2. Give the name of the material, identifying number and manufacturer.
   Example: Epoxy, Epon 828, E. V. Roberts and Associates
3. Provide proportions and name of resin, hardener (catalyst), filler, etc.
   Example: 828/V140/Silflake 135 as 5/5/38 by weight
4. Provide cure cycle details.
   Example: 8 hrs. at room temperature + 2 hrs. at 150C
5. Provide the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. List all materials with the same environment in a group.
   Example: T/V : -20C/+60C, 2 weeks, 10E-5 torr, ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 mile altitude, UV, electron, proton, atomic oxygen
6. Provide any special reason why the materials was selected. If for a particular property, please give the property.
   Example: Cost, availability, room temperature curing or low thermal expansion.

| Title:<br>Flammable Materials Usage List | CDRL No.:<br>6-6 |
|---|---|
| Reference:<br>MAG, Paragraph 6.2.5.1 | |
| Use:<br>For usage evaluation and approval of all flammable materials applications for STS. | |
| Related Documents<br>MSFC-HDBK-527, NHB 8060.1, NSTS 22648, NHB 1700.7, GMI 1700.3 | |
| Place/Time/Purpose of Delivery:<br>Provide to the GSFC Project Office 30 days before contractor PDR for review, 30 days before contractor CDR for approval and 30 days before acceptance for approval. | |
| Preparation Information:<br><br>The flammability rating of all materials on the polymeric and composite materials usage list (DID 4) will be provided on the flammable materials usage list. Each material usage will be examined for flammability characteristics for use on the STS. For the orbiter payload bay area, an oxygen value of 20.9% should be examined. For the crew compartment area, oxygen values of 30% should be examined.<br><br>The flammable materials lists will contain STS stowage location for the assembled piece of flight hardware (i.e., crew compartment or payload bay), and the listing of materials with an associated flammability rating. MSFC-HDBK-527 gives a partial listing of flammability ratings for various materials. Marshall Space Flight Center also has a resource, the Materials And Processes Technical Information Service (MAPTIS), which is available to help in gathering flammability ratings. This service is available through computer Telnet applications. The materials lists should also state if a material is not rated, or has not yet been tested. Depending on the operational requirements of the flight hardware, flammability testing may be required. NHB 8060.1C details the requirements of the flammability tests.<br><br>The routine and non-routine operation of the hardware will not result in a release of flammable materials any area of the STS. Orbiter entry, landing and post landing operations will not cause ignition of a flammable atmosphere in the payload bay area.<br><br>If flammable or untested materials are listed in the materials list, a flammability assessment should then be performed. NSTS 22648 guides the Materials Engineer through the configuration analysis. Flammable materials can be acceptable for STS application provided the flammability reduction methods and container guidelines of NSTS 22648 are used. | |

| Title:<br>Odor and Toxic Offgassing Materials Usage List | CDRL No.:<br>6-7 |
|---|---|
| Reference:<br>MAG, Paragraph 6.2.5.1 | |
| Use:<br>For usage evaluation and approval of all odor and toxic offgassing material applications in habitable areas of STS. | |
| Related Documents<br>MSFC-HDBK-527, NHB 8060.1, KHB 1700.7 | |
| Place/Time/Purpose of Delivery:<br>Provide to the GSFC Project Office 30 days before contractor PDR for review, 30 days before contractor CDR for approval and 30 days before acceptance for approval. | |
| Preparation Information:<br><br>The toxicity rating of all materials on the polymeric and composite materials usage list and the lubrication list that are operated or stowed in the crew compartments will be provided on the Odor and Toxic Offgassing Materials Usage list. The odor and toxic characteristics of each material on the list will be evaluated.<br><br>The materials lists will contain STS stowage location for the assembled piece of flight hardware and associated odor and toxicity values. MSFC-HDBK-527 gives a partial listing of these values. Marshall Space Flight Center also has a resource, the Materials And Processes Technical Information Service (MAPTIS), which is available to help in gathering odor and toxicity ratings. This service is available through computer Telnet applications. The materials lists should also state if a material is not rated, or has not yet been tested.<br><br>For unavailable ratings, or for materials which have not been tested, odor and toxicity values should be measured at the NASA White Sands Test Facility (WSTF). Goddard Materials Engineering personnel will be available to arrange this WSTF testing. WSTF can test individual materials up to entire hardware assemblies. Flight materials or assemblies are required for this test. | |

| Title: Waiver | CDRL No.: 6-8 |
|---|---|
| Reference: MAG, Paragraph 6.2.5.3 | |
| Use: For usage evaluation and approval of a material that has exceeded its shelf life or expiration date. | |
| Related Documents: None | |
| Place/Time/Purpose of Delivery: Provide to the GSFC Project Office for approval 30 days prior to the CDR or use. | |

Preparation Information:

A waiver should be submitted for approval of uncured polymers that exceeded their expiration date or for flight approval of cured polymers and lubricated mechanism that have a limited shelf life.

For uncured polymers, mechanical and physical properties of polymer or paint samples made from same batch of expired uncured material or test data on identical expired uncured polymer or paint must be submitted to demonstrate that the cured paint or polymer is acceptable.

For lubricated mechanisms and old polymer products such and o-rings, propellant tank diaphragms, seals dampers and tapes, mechanical and physical property data, test results and heritage performance information must be submitted to demonstrate the flight acceptability of the hardware.

| Title:<br>Life Test Plan for Lubricated Mechanisms | CDRL No.:<br>6-9 |
|---|---|
| Reference:<br>MAG, Paragraphs 6.2.7 and 7.4 | |
| Use:<br>For evaluation and approval of all lubricated mechanisms. | |
| Related Documents<br>None | |
| Place/Time/Purpose of Delivery:<br>Provide to the GSFC Project Office 30 days before contractor PDR for review, 30 days before contractor CDR for approval and 30 days before acceptance for approval. | |
| Preparation Information:<br><br>The Life Test Plan for Lubricated Mechanisms will contain:<br>(a) Table of Contents<br>(b) Description of all lubricated mechanisms, performance functions, summary of subsystem specifications and life requirements.<br>(c) Heritage of identical mechanisms and descriptions of identical applications.<br>(d) Design, drawings and lubrication system utilized by the mechanism.<br>(e) Test plan including vacuum, temperature and vibration test environmental conditions of the test.<br>(f) Criteria for a successful test.<br>(g) Delivery of test hardware to GSFC after a successful test.<br>(g) Final Report. | |

| Title: Inorganic Materials and Composites Usage List | CDRL No.: 6-10 |
|---|---|

Reference:
MAG, Paragraph 6.2.6

Use:
For usage evaluation and approval of all metal, ceramic and metal/ceramic composite material applications.

Related Documents:
MSFC-HDBK-527, NHB 1700.7, MSFC-SPEC-522

Place/Time/Purpose of Delivery:
Provide to the GSFC Project Office 30 days before contractor PDR for review, 30 days before contractor CDR for approval and 30 days before acceptance for approval.

Preparation Information:

The hardware provider will provide the information requested on the inorganic materials and composites usage list, the equivalent information on the hardware developer's forms or the equivalent information electronically.

The inorganic materials and composite usage list (1) form requires, as a minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, contractor, contractor address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, item number, materials identification (2), condition (3), application or usage (4), expected environment (5), stress corrosion cracking table number, MUA number and NDE method. Notes 1 through 5 are listed below:

1. List all inorganic materials (metals, ceramics, glasses, liquids and metal/ceramic composites) except bearing and lubrication materials which should be listed on Form 18-59C.
2. Give materials name, identifying number manufacturer.
   Example: a. Aluminum 6061-T6
   b. Electroless nickel plate, Enplate Ni 410, Enthone, Inc
   c. Fused silica, Corning 7940, Corning Class Works
3. Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.
   Example: a. Heat treated to Rockwell C 60 hardness, gold electroplated, brazed.
   b. Surface coated with vapor deposited aluminum and magnesium fluoride
   c. Cold worked to full hare condition, TIG welded and electroless nickel plated.
4. Give details of where on the spacecraft the material will be used (component) and its function.
   Example: Electronics box structure in attitude control system, not hermetically sealed.
5. Give the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
   Example: T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxyen

| Title: Fastener Control Plan | CDRL No.: 6-11 |
|---|---|
| Reference: MAG, Paragraph 6.2.6.1 | |
| Use: For evaluation and approval. | |
| Related Documents: GSFC S-313-100, NHB 1700.7, GSFC 731-0005-83, GMI 1700.3 | |
| Place/Time/Purpose of Delivery: Provide with proposal for GSFC review and 30 days before the PDR for approval. | |

Preparation Information:

The developer's fastener control plan will address the following for flight hardware threaded fasteners that are used in structural or critical applications:

- acquisition
- receiving inspection
- testing
- traceability

| Title:<br>Material Test Report for Fastener Lots | CDRL No.:<br>6-12 |
|---|---|
| Reference:<br>MAG, Paragraph 6.2.6.1 | |
| Use:<br>For evaluation and approval. | |
| Related Documents:<br>GSFC S-313-100 | |
| Place/Time/Purpose of Delivery:<br>Provide 15 days after GSFC request for approval. | |
| Preparation Information: | |

| Title: Lubrication Usage List | CDRL No.: 6-13 |
|---|---|

Reference:
MAG, Paragraph 6.2.7

Use:
For evaluation and approval of all lubricant usage and applications.

Related Documents:
None

Place/Time/Purpose of Delivery:
Provide to the GSFC Project Office 30 days before contractor PDR for review, 30 days before contractor CDR for approval and 30 days before acceptance for approval.

Preparation Information:

The hardware provider will provide the information requested on the lubricant usage list, the equivalent information on the hardware developer's forms or the equivalent information electronically. The form is in the Mission Assurance Guide.

The lubricant usage list form requires, as the minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, contractor, contractor address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, item number, component type, size, material (1); component manufacturer and manufacturer identification; proposed lubrication system and amount of lubrication; type and number of wear cycles (2); speed, temperature and atmosphere of operation (3); type and magnitude of loads (4) and other details (5). Notes 1 through 5 are listed below:

1. Ball bearing (BB), Sleeve bearing (SB), Gear (G), Sliding surfaces (SS), Sliding electrical contacts (SEC), Give generic identification of materials used for the component, (Examples: 440C steel, PTFE)
2. Continuous unidirectional rotation (CUR), Continuous oscillation (CO), intermittent rotation (IR), intermittent oscillation (IO), Small angle oscillation (< 30 degrees) SAM, large angle oscillation (> 30 degrees) (LAM), Continuous sliding (CS), Intermittent sliding (IS)
   Number of wear cycles: 1 to 1E2 (A), 1E2 to 1E4 (B), 1E4 to 1E6 (C), >1E6 (D)
3. Speed: revolution per min. (RPM), oscillation per min. (OPM), variable speed (VS), sliding speed in cm. per min. (CPM)
   Operational temperature range
   Atmosphere: vacuum, air, gas sealed or unsealed and pressure
4. Type of loads: Axial, radial, tangential (gear load). Give magnitude of load.
5. For ball bearings, give type and material of ball cage, number of shields, type of ball groove surface finishes.
   For gears, give surface treatment and hardness.
   For sleeve bearings, give the bore diameter and width.
   Provide the torque and torque margins.

| Title: Material Process Utilization List | CDRL No.: 6-14 |
|---|---|
| Reference: MAG, Paragraph 6.3 | |
| Use: For usage evaluation and approval of all material processes that are used to fabricate, clean, store, integrate and test the space flight hardware. | |
| Related Documents: None | |
| Place/Time/Purpose of Delivery: Provide to the GSFC Project Office 30 days before contractor PDR for review, 30 days before contractor CDR for approval and 30 days before acceptance for approval. . A copy of any process will be submitted to the GSFC Project Office upon request. | |
| Preparation Information:<br><br>The provider will provide the information requested on the material process utilization list form, the equivalent information developer's forms or the equivalent information electronically. The form is in the Mission Assurance Guide.<br><br>The material process utilization list requires, as a minimum, the following information: spacecraft, subsystem or instrument name, GSFC technical officer, contractor, address, prepared by, phone number, date of preparation, GSFC materials evaluator, evaluator's phone number, date received, date evaluated, item number, process type (1), contractor spec. number (2), Military, ASTM, Federal or other specification number, description of material processed (3) and spacecraft/instrument application (4). Notes 1 through 4 are listed below:<br>1. Give generic name of the process.<br>Example: anodizing (sulfuric acid)<br>2. If process is proprietary, please state so.<br>3. Identify the type and condition of the material subjected to the process.<br>Example: 6061-T6<br>4. Identify the component or structure for which the materials are being processed.<br>Example: Antenna dish | |

| Title:<br>Certificate of Raw Material Compliance | CDRL No.:<br>6-15 |
|---|---|
| Reference:<br>MAG, Paragraph 6.4.1 | |
| Use:<br>For information assuring acceptable flaw content, chemical composition and physical properties of raw material. | |
| Related Documents:<br>None | |
| Place/Time/Purpose of Delivery:<br>Provide to the GSFC project 15 days after request. | |
| Preparation Information: | |

| Title: | CDRL No.: |
|---|---|
| Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL) | 7-1 |

Reference:
7.2.1

Use:
Reliability analysis to evaluate design relative to requirements, identify single point failures, and identify hazards.

Related Documents

Procedures for Performing an FMEA, S-302-89-01, February 1990.

CR 5320.9, Payload and Experiment Failure Mode Effects Analysis and Critical Items List Groundrules, MSFC.

MIL-STD 1629A, Procedures for Performing an FMECA, DoD.

Place/Time/Purpose of Delivery:
Preliminary 30 days before contractor PDR for GSFC review.
Final 30 days before contractor CDR for GSFC review.
Updates as required to include changes for GSFC review.

Preparation Information:

6. Preparation Information:

The FMEA report will document the study including the approach, methodologies, results, conclusions, and recommendations. The report will include objectives, level of the analysis, ground rules, functional description, functional block diagrams, reliability block diagrams, bounds of equipment analyzed, reference to data sources used, identification of problem areas, single-point failures, recommended corrective action, and work sheets as appropriate for the specific analysis being performed.

The Critical Items List will include item identification, cross-reference to FMEA line items, and retention rationale. Appropriate retention rationale may include design features, historical performance, acceptance testing, manufacturing product assurance, elimination of undesirable failure modes, and failure detection methods.

| Title:<br><br>Parts Stress Analysis | CDRL No.:<br>7-2 |
|---|---|
| Reference:<br>7.2.2 | |
| Use:<br>Provides EEE parts stress analyses for evaluating circuit design and conformance with derating guide-lines. | |
| Related Documents<br>GSFC Preferred Parts List PPL | |
| Place/Time/Purpose of Delivery:<br>Final 45 days before GSFC CDR for GSFC review<br>Updates to include changes as required for GSFC review | |
| Preparation Information:<br><br>The stress analysis report will contain the ground rules for the analysis, references to documents and data used, a statement of the results and conclusions, and the analysis worksheets. The worksheets at a minimum will include part identification (traceable to circuit diagrams), environmental conditions assumed, rated stress, applied stress, and ratio of applied-to-rated stress. | |

| Title:<br>Reliability Assessments | CDRL No.:<br>7-3 |
|---|---|
| Reference:<br>7.2.4 | |
| Use:<br>Reliability analysis to assist in evaluating alternative designs and to identify potential mission limiting elements that may require special attention. | |
| Related Documents:<br>MIL-STD-756B, Reliability Modeling and Prediction | |
| Place/Time/Purpose of Delivery:<br>Available at PDR and CDR for information.<br>Available on request | |
| Preparation Information:<br>The assessment report will document the methodology and results of the comparative reliability assessment guidelines delineated in Section 7.2.4 including mathematical models, reliability block diagrams, failure definitions, degraded operating modes, trade-offs, assumptions, and any other pertinent information used in the assessment process.<br><br>Format of the report is not important but it should incorporate good engineering practices and clearly show how reliability was considered as a discriminator in the design process. | |

| Title:<br><br>Trend Analysis | CDRL No.:<br>7-4 |
|---|---|
| Reference:<br>7.3.1 | |
| Use:<br>To monitor parameters on components and subsystems throughout the normal test program that relate to performance stability (any deviations from the nominal that could indicate trends). Operational personnel continue monitoring trends through mission duration. | |
| Related Documents | |
| Place/Time/Purpose of Delivery:<br>List of parameters to be monitored at time of GSFC Flight Assurance CDR for information.<br>Trend Analysis Reports at time of GSFC Flight Assurance PER and FRR for information. | |
| Preparation Information:<br><br>List the parameters to be monitored, updates to the list and trend reports will be prepared in accordance with the referenced paragraph 7.3.1. In addition a log will be kept for each black box or unit (e.g. tape recorder) of the accumulated operating time. The log will include the following minimum information:<br><br>o Identification<br>o Serial Number<br>o Total operating time since assembly of unit<br>o Total operating time since last failure<br>o Total additional operating time projected for the unit prior to launch | |

| Title:<br>Limited-Life Items | CDRL No.:<br>7-5 |
|---|---|
| Reference:<br>7.4 | |
| Use:<br>Defines and tracks the selection, use and wear of limited-life items, and the impact on mission operations | |
| Related Documents | |
| Place/Time/Purpose of Delivery:<br>Preliminary 30 days before contractor PDR for review.<br>Final 30 days before contractor CDR for approval.<br>Updates as changes are made; between contractor CDR and delivery, for approval. | |
| Preparation Information:<br><br>List life-limited items and their impact on mission parameters. Define expected life, required life, duty cycles, and rationale for selecting and using the items. Include selected structures, thermal control surfaces, solar arrays, and electromechanical mechanisms. Atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue are used to identify limited-life thermal control surfaces and structural items. When aging, wear, fatigue and lubricant degradation limit their life, include batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators and scan devices. Assign responsibilities and describe managerial, and reporting activities. | |

| Title:<br><br>Quality Manual | CDRL No.:<br>8-1 |
|---|---|
| Reference:<br>MAG, Paragraph 8.0 | |
| Use:<br>Documents the developer's quality management system. | |
| Related Documents<br>ANSI/ASQC Q9001-1994, paragraph 4.2.1 | |
| Place/Time/Purpose of Delivery:<br>Provide with proposal for GSFC review. Provide Quality Manual updates to GSFC Project Office for review prior to implementation<br>., or<br><br>Provide with proposal for information along with evidence of third party certification/registration of the developer's quality management system by an accredited registrar. | |

Preparation Information:

Preparation Information:

Prepare a Quality Manual addressing all applicable requirements (from the 20 total elements) of ANSI/ASQC Q9001-1994. Refer to ISO 10013 for further guidelines on preparation of a quality manual.

The Quality Manual will contain:

(a) the title, approval page, scope and the field of application;
(b) table of contents;
(c) introductory pages about the organization concerned and the manual itself;
(d) the quality policy and objectives of the organization;
(e) the description of the organization, responsibilities and authorities, including the organization responsible for the EEE parts, materials, reliability, safety and test requirements implementation;
(f) a description of the elements of the quality system, developer policy regarding each element and developer implementation procedure for each Q9001 element or reference(s) to approved quality system procedures; system level procedures will address the implementation of all requirements cited in this document.
(g) a definitions section, if appropriate;
(h) an appendix for supportive data, if appropriate.

Quality Manual issue and change will be implemented by a controlled process.

The Quality Manual will be maintained/updated by the developer throughout the life of the contract.

| Title:<br><br>Problem Failure Reports (PFRs) | CDRL No.:<br><br>8-2 |
|---|---|
| Reference:<br>MAG Paragraph 8.1.2 | |
| Use:<br>To report failures promptly to the Failure Review Board (FRB) for determination of cause and corrective action. | |
| Related Documents<br>GSFC Form 4-2 | |
| Place/Time/Purpose of Delivery:<br>- Provide for information to the GSFC Project Office within 24 hours of each occurrence;<br>- Provide updates for review to the GSFC Project Office at the completion of analysis and assignment of corrective action;<br>- Provide to GSFC Project Office for approval immediately after developer closure. | |
| Preparation Information:<br><br>Reporting of failures will begin with the first power application at the major component, subsystem, or instrument level (as applicable to the hardware level for which the developer is responsible) or the first operation of a mechanical item; it will continue through formal acceptance by the GSFC project office and the postlaunch operations, commensurate with developer presence and responsibility at GSFC and launch site operations.<br><br>All failures will be documented on GSFC Form 4-2 or an existing developer form which identifies equivalent information. Developers with access to the GSFC PFR Database will generate Problem Failure reports electronically via that program in lieu of hard copies. Developers may also request, from the GSFC Project Office, complimentary electronic copies of the GSFC PFR system for implementation within their own facility.<br><br>PFRs and updated information will be submitted to GSFC by hard copy or electronically updated via the developer-accessible PFR Database. PFRs submitted to the GSFC for closure will include a copy of all referenced data and will have had all corrective actions accomplished and verified. | |

| Title:<br>Contamination Control Plan | CDRL No.:<br>9-1 |
|---|---|
| Reference:<br>MAG, Paragraph 9.1, 9.2, 9.3, 9.4, 9.5 | |
| Use:<br>To establish contamination allowances and methods for controlling contamination | |
| Related Documents<br>None | |
| Place/Time/Purpose of Delivery:<br>Provide to the Project Office 30 days before PDR for GSFC review and 30 days before the CDR for approval. | |

Preparation Information:

Data on material properties, on design features, on test data, on system tolerance of degraded performance, on methods to prevent degradation will be provided to permit independent evaluation of contamination hazards. The items should be included in the plan for delivery:

1. Materials
   a. Outgassing as a function of temperature and time.
   b. Nature of outgassing chemistry.
   c. Areas, weight, location, view factors of critical surfaces.
2. Venting: size, location and relation to external surfaces.
3. Thermal vacuum test contamination monitoring plan including vacuum test data, QCM location and temperature, pressure data, system temperature profile and shroud temperature.
4. On orbit spacecraft and instrument performance as affected by contamination deposits.
   a. Contamination effect monitor.
   b. Methods to prevent and recover from contamination in orbit.
   c. How to evaluate in orbit degradation.
   d. Photopolymerization of outgassing products on critical surfaces.
   e. Space debris risks and protection.
   f. Atomic oxygen erosion and redeposition.
5. Analysis of contamination impact on the satellite on orbit performance.
6. In orbit contamination impact from other sources such as STS, space station, adjacent instruments.