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**Change History Log**

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**Contents**

|        |   |                                     |
|--------|---|-------------------------------------|
| 1.     | Purpose   | 2                                   |
| 2.     | Scope   | 2                                   |
| 3.     | Definitions   | 3                                   |
| 3.1.   | Acronyms  | 3                                   |
| 3.2.   | Definitions   | 4                                   |
| 4.     | Applicable Documents  | 4                                   |
| 5.     | LAT Materials, Process, and Parts Plan                              | 5                                   |
| 5.1.   | Part and Material Assurance   | 5                                   |
| 5.1.1. | Overview .....  | 5                                   |
| 5.1.2. | Mechanical Part Review Board .....                                  | 5                                   |
| 5.1.3. | Assurance Methodology .....   | 6                                   |
| 5.2.   | Mechanical Parts Control Procedure                                  | 8                                   |
| 5.2.1. | General Information .....   | 8                                   |
| 5.2.2. | Part and Assembly Information .....                                 | 9                                   |
| 5.2.3. | Application Information .....                                       | 10                                  |
| 5.2.4. | Part Quality Assurance .....  | 10                                  |
| 5.3.   | Materials Control Procedure   | 12                                  |
| 5.3.1. | General Material Control Procedures .....                           | 12                                  |
| 5.3.2. | Polymer and Composite Control Procedure .....                       | 14                                  |
| 5.3.3. | In-Organic Material Control Procedure .....                         | 17                                  |
| 5.3.4. | Lubricant Control Procedure .....                                   | 20                                  |
| 5.4.   | Process Control Procedure   | 24                                  |
| 5.4.1. | Scope of Processes Covered .....                                    | 24                                  |
| 5.4.2. | General .....   | 24                                  |
| 5.4.3. | Process Information .....   | 24                                  |
| 5.4.4. | Approval Requirements for Compliant Processes .....                 | 25                                  |
| 5.4.5. | Requirements for Non-Compliant Metallic Weldments .....             | 25                                  |
| 5.4.6. | Tracking and Records Management .....                               | 26                                  |
| 5.5.   | Specialized Mechanical Parts Control Procedure                      | 26                                  |
| 5.5.1. | Fastener Control Procedure .....                                    | 26                                  |
| 5.5.2. | Control Procedure for Pressurized and Stored-Energy Components .... | 29                                  |
| 6.     | Records Management  | 30                                  |
| 7.     | Appendix A: Material Usage Agreement Template                       | 31                                  |
| 8.     | Appendix B: Limited Life Procedure Template                         | <b>Error! Bookmark not defined.</b> |

**1. Purpose**

This document defines the plan for managing all mechanical parts, materials, and processes for the GLAST LAT project. It delineates the information needed to be collected for the parts, materials, and processes, and the criteria by which they will be evaluated.

**2. Scope**

This scope of this Plan includes the selection, approval, and use of all mechanical parts and assemblies for all flight hardware and critical Gorund Support Equipment (GSE) for the GLAST Large Area Telescope (LAT). It includes the parts and their application or use, as well as the

materials and processes used in their fabrication. This Plan is responsive to the GLAST MAR, in that it encompasses the following deliverable materials plans:

- Materials and Processes Plan (section 5.1)
- Material Usage Agreement (MUA) template (section 7)
- Polymeric Materials and Composites Usage Procedure (section 5.3.2)
- Inorganic Materials and Composites Usage Procedure (section 5.3.3)
- Lubrication Usage Procedure (section 5.3.4)
- Fastener Control Plan (section 5.5.1)
- Material Process Utilization Procedure (section 5.4)

This Plan does not cover electronic, electromagnetic, or electromechanical (EEE) parts, or wiring and cabling used for EEE parts.

### 3. Definitions

#### 3.1. Acronyms

|      |   |
|------|---|
| CDR  | Critical Design Review  |
| CVCM | Collected Volatile Condensable Mass                                     |
| EEE  | Electronic, electromagnetic, or electromechanical                       |
| EM   | Engineering Model   |
| GEVS | General Environmental Verification Specification for STS & ELV Payloads |
| GSE  | Ground Support Equipment  |
| GSFC | NASA Goddard Space Flight Center, Greenbelt MD                          |
| IPO  | LAT Instrument Project Office   |
| ISO  | International Organization for Standardization                          |
| IRD  | GLAST Science Instrument—Spacecraft Interface Requirements Document     |
| LAT  | Large Area Telescope  |
| LLP  | Limited Life Plan   |
| MAR  | Mission Assurance Requirements  |
| MPRB | Mechanical Part Review Board  |
| MSE  | Mechanical Systems Engineer   |
| MSS  | GLAST Mission System Specification                                      |
| MUA  | Material Usage Agreement  |
| NCR  | Non-Conformance Report  |
| NDE  | Non-Destructive Examination   |
| PAIP | Performance Assurance Implementation Plan                               |
| PDR  | Preliminary Design Review   |
| PPG  | Delta II Payload Planners Guide   |
| PSAM | Performance and Safety Assurance Manager                                |
| QA   | Quality Assurance   |
| QCM  | Quartz Crystal Microbalance   |
| SLAC | Stanford Linear Accelerator Center                                      |
| TML  | Total Mass Loss   |
| T/V  | Thermal-Vacuum test   |
| UV   | Ultra-violet  |

### 3.2. Definitions

Next Assembly—the “parent” for a given part, or the assembly in which the part is used.

Technically, it is the assembly in which a part is listed in the parts list. There may be more than one next assembly for the same part.

Off-the-shelf—purchased hardware. In the context of this Plan, it refers specifically to purchased assemblies.

### 4. Applicable Documents

The documents listed below, and all applicable documents referenced by them, form a part of this specification. Should any conflict arise between anything in these documents and this specification, this specification supersedes the published document.

GLAST00038, “GLAST Science Instrument—Spacecraft Interface Requirements Document”, Draft July 14, 2000

GLAST00074, “GLAST Mission System Specification”, Draft, June 30, 2000

GLAST00110, “Mission Assurance Requirements (MAR) for Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)”, June 9, 2000

GEVS-SE Rev A, “General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components,” revised June 1996,  
<http://arioch.gsfc.nasa.gov/302/gevs-se/toc.htm>

MDC H3224D “Delta II Payload Planners Guide,” revised April 1996,  
<http://www.boeing.com/defense-space/space/delta/delta2/guide/index.htm>

LAT-SS-00010-1, “LAT Performance Specification - Level II(b) Specification”

LAT-MD-00039-1, “GLAST LAT Performance Assurance Implementation Plan (PAIP),” revised 12 December 2000.

GSFC 731-0005-83, “General Fracture Control Plan for Payloads Using the Space Transportation System (STS),” revised 25 November 1988.

GSFC-S-313-100-B, “GSFC Fastener Integrity Requirements,” revised 13 Feb 1998.

Eastern and Western Range 127-1 Range Safety Requirements

NASA-STD-5001, “Structural Design and Test Factors of Safety for Spaceflight Hardware,” revised 21 June 1996.

MSFC-SPEC-522, “Design Criteria for Controlling Stress Corrosion Cracking,” revised 1 July 1987

NASA-STD-6001, Flammability, Odor, Off-gassing and Compatibility Requirements & Test Procedures for Materials in Environments That Support Combustion,” 9 Feb 1998.

ASTM E-595, “Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment,” reapproved 1999.

MIL-HDBK-5H, “Metallic Materials and Elements for Aerospace Vehicle Structures,” revised 1 December 1998.

## **5. LAT Materials, Process, and Parts Plan**

### **5.1. Part and Material Assurance**

#### **5.1.1. Overview**

##### **5.1.1.1. *Role of Mechanical Parts Control in the LAT Project***

The goal of this Plan is to assure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials employed to meet the operational requirements for the GLAST Large Area Telescope (LAT) instrument. To achieve that goal, the following plan describes the methodology by which candidate materials and processes are chosen, reviewed, and used in the development and fabrication of the LAT.

This Plan describes a part-based system for implementing the material and process requirements described. Information is managed by physical part/component, and sub-assembly. Information gathered for each part/sub-assembly will describe:

The material from which it is made

The processes used to fabricate it

The process, test, and operational environments to which it will be subjected.

The mechanical parts, materials and process control function resides in the Mechanical Systems element of the LAT project. This element is under the auspices of the LAT System Engineer, who reports directly to the LAT Project Manager. The Mechanical Systems Engineer is responsible to implement this Plan, manage the information needed to carry out the plan, and verify compliance with the Plan at all levels of the LAT project. This includes collecting, bookkeeping, and dispositioning the material and process data, and assuring that it is current and validated. It also includes submitting part information to the GLAST project office for approval.

##### **5.1.1.2. *Relationship to Other Institutions***

This Plan is part of a larger body of LAT project control plans. The LAT Instrument Project Office (IPO) is responsible to flow down requirements from these plans to all institutions involved in the design, analysis, fabrication, or testing of flight hardware for the LAT.

All part, material, and process information is organized by hardware subsystem, and the Subsystem Manager is the primary agent to assure that this Plan is implemented within the subsystem, and he or a designate will serve as the primary contact with the IPO to assure that all provisions of this Plan are met.

#### **5.1.2. Mechanical Part Review Board**

##### **5.1.2.1. *Authority of Board***

The primary means by which parts, materials and processes are approved for use on the LAT is the Mechanical Part Review Board (MPRB). This board consists of the following members:

Mechanical Systems Engineer (MSE)—Chair

Materials Coordinator

Performance and Safety Assurance Manager (PSAM)

EEE Parts Engineer

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*Ad hoc* members as needed and requested

Minutes of the meetings and reports of approval/disapproval decisions will be retained and made available for review.

The MPRB collectively authorizes use of all materials on the LAT which are considered “compliant” (see Section 5.3.1.2, below). While these decisions are subject to review by the GSFC project, they are generally not controversial.

Furthermore, the MPRB can provisionally approve a non-compliant material based on information in its Material Usage Agreement (MUA). This is then forwarded to the GSFC project Materials Engineer for review and dis-/approval. As delineated in the GLAST MAR, the LAT MPRB must receive authorization from GSFC for use of all non-compliant materials.

#### ***5.1.2.2. Technical Skill Mix***

The MPRB includes representatives from the following disciplines and functions:

- Performance Assurance
- System Engineering
- Design Engineering

#### ***5.1.2.3. MPRB Involvement Over Life of Project***

The MPRB is continually involved in the development, fabrication, and testing of the LAT. This begins in the development phase, when material choices are being made, and continues through fabrication of parts to final assembly, integration, and testing of subsystem sub-assemblies. The following section describes the methodology used by the MPRB to assure a consistent implementation of this Plan.

#### ***5.1.3. Assurance Methodology***

##### ***5.1.3.1. Assurance Philosophy***

The MSE is responsible to anticipate and minimize risks associated with materials problems during flight hardware development and operation. To that end, the MPRB reviews and approves the implementation of all mechanical parts and components. This includes reviewing the materials and processes used for fabrication/use of the part, considering both information about the material as well as about the application and environment in which it is used. Part information covers four key areas:

Materials: materials used to make the part

Processes: manufacturing processes the material undergoes during part fabrication

Application: operation and test environments to which the part is submitted

Special parts: unique operation and fabrication conditions regarding specialized component types (e.g.: bolts)

Activities directed at assuring the quality of parts, materials, and processes run through the length of the project. The following sub-sections detail a five-step process methodology that will be used for material and process assurance.

### ***5.1.3.2. Initial Submittals***

Subsystem Managers or their designates compile a list of parts, materials, and processes that potentially will be used in their flight hardware. The required information for this list is detailed in the sections below. This will be assembled into a Mechanical Parts Database for PDR.

### ***5.1.3.3. Preliminary Review for PDR***

The MPRB reviews all submittals for conformance to required standards. Materials and processes will be dispositioned to one of three status levels. First, a material may be approved for use (subject to review by GSFC). Second, a material may be put on hold pending further work. This work may involve further qualification testing, writing an MUA, or gathering additional information. The hold status will be clearly identified, along with an explanation for the reason. Finally, a material may be rejected for use. Disapproved materials will remain on the materials list for future reference, but will be clearly labeled. The reason for the rejection will be shown, as well.

### ***5.1.3.4. Final Review for CDR***

Following PDR, the Mechanical Parts Database will be continuously revised as EM development proceeds. Then, prior to CDR, the information will be updated to reflect the final configuration of the subsystem. Results of this final update and review will be used for the CDR, and the approved parts and materials will be used for flight hardware fabrication.

### ***5.1.3.5. Process Specification Review***

As final drawings, process and procurement specifications are being written, they will be reviewed to assure compliance with the approved materials list. Responsibility for this review lies with the Subsystem Manager, who will be aided by the PSAM and Materials Manager.

### ***5.1.3.6. Records Review***

Finally, following procurement, fabrication, assembly, and testing of materials, parts, and sub-assemblies, records of this work will be reviewed to assure that plans were carried out. These activities will be under surveillance of the PSAM and Materials Manager during fabrication.

Following completion of a subsystem module, a pre-ship review will certify that all records are intact, and that the module is ready for integration. Part of this certification will involve review of the materials and process data records.

## 5.2. Mechanical Parts Control Procedure

### 5.2.1. General Information

Material and process information for all mechanical parts and assemblies shall be submitted to the centralized Mechanical Parts Database at the LAT IPO. The information shall be organized by part or assembly, and parsed down to the detailed process level, allowing individual processes to be uniquely identified and evaluated. Part information is organized into five unique groups of information about the part. These are:

Part: description of the part or sub-assembly and its developer.

Application: description of the subsystem and assembly in which the part is used, and the operation and test environments to which the part is submitted in that assembly.

Material: the constituent materials used to make the part. Material information varies depending on the category of material. This Plan describes three unique categories of materials: polymers and composites, in-organic materials, and lubricants. Two sub-categories are also established for materials with limited shelf life, and for metallic materials susceptible to stress corrosion cracking.

Process: manufacturing processes the material undergoes during part fabrication. This includes all fabrication, surface treatment, and assembly processes which are used in the fabrication of the part.

Specialized Parts: unique operation and fabrication conditions regarding specialized component types. There are two types of specialized parts: fasteners and pressurized or stored-energy parts and assemblies. Information and approval requirements vary for these types.

Information from each of these five groups uniquely defines a part, its application, and the materials and processes used in its fabrication. This unique combination of part information is reviewed and approved as needed. This allows for mixing and matching of different materials or parts for different applications, while still assuring that a unique application record is configuration controlled. Information about the part itself is distinct from that about the application, since a given part may be used in more than one application or assembly. Thus, a stand-alone part is not approved or rejected. However, a part, used in a given assembly is what is approved. For example, a bolt made from a certain material with a given set of processes may be approved for one application, but disapproved for another.

Part information for all five groups of information is submitted to the LAT Mechanical Parts Database through the Materials Manager. As described in the following sections, the specific information needed depends on the application, type of part, material, and processes involved. For example, a metallic fastener is subject to the In-Organic Material Control Procedure, while the manufacturing processes used to fabricate it are governed by the Material Processing Control Procedure. Finally, since it is a specialized part, it is also subject to the Fastener Control Procedure. All procedures and information are described in the following sections.

## 5.2.2. Part and Assembly Information

### 5.2.2.1. Part Information

The primary group of information about a part or assembly involves data about the part itself. This information is required for all parts and sub-assemblies. The table below shows the information needed for each part or sub-assembly. Note that this is “generic” information, in that it does not uniquely define how or where the part is to be used.

| Property          | Description  | Example |
|-------------------|--|---------|
| Document Number   | Drawing or assembly number for the part  |         |
| Title             | Name of the part or title of the drawing   |         |
| Type              | Pick one: part, assembly, off-the-shelf assembly   |         |
| Responsible party | Cognizant engineer   |         |
| Institution       | Home institution of the submitters   |         |
| Specialized       | Yes/no, is this a special part (bolt, pin, off-the-shelf assembly, pressurized component, stored-energy component) |         |

Table 1: Part Information

### 5.2.2.2. Assemblies

Information and approval for assemblies and sub-assemblies differ from that of individual parts only in that an assembly has other “child” parts which refer to it as a “Next Assembly”.

### 5.2.2.3. Off-the Shelf Assemblies

Off-the-shelf assemblies or purchased assemblies are treated just like other assemblies. Each piece part of the assembly must be identified as a separate part, and the material information collected. Compliance to this Plan and other LAT specifications should be included as part of the purchase specification, to ensure that all needed information is collected and that the assembly is approved for use prior to its shipment.

Use of 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 require approval of a MUA. The MUA should detail the known parts, materials, and properties for the assembly, and the measures which will be used to ensure that all materials in the hardware are acceptable for use. Such measures might include hermetic sealing, vacuum bake-out, or changing a material for known compliant materials.

When a vacuum bake-out 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 bake-out as well as compliance with the contamination plan.

### 5.2.3. Application Information

The application for a part refers to its use and operation. Application information about a part is related to the assembly on which the part is used. Thus, the next assembly number is the unique identifier by which application information about a part is referenced. The table below shows the information needed about the part's next assembly and operation.

| Property             | Description  | Example   |
|----------------------|--|---|
| Next Assembly Number | Assembly drawing number in which the part is used  |   |
| Subsystem            | LAT subsystem for which the part is used   |   |
| Application          | Details of where on the instrument the part will be used and its function (e.g.: electronics box structure, not hermetically sealed).            |   |
| Environment          | Provide the details of the expected environment that the material will experience as a finished component, both during ground test and on orbit. | 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. Do not list vibration environment |
| Reason for Selection | Provide any special reason why the part/material was selected. If for a particular property, please give the property.                           | Cost, availability, room temperature curing or low thermal expansion  |
| Compliance           | A justification of why an application is considered compliant.   |   |

Table 2: Application Information

### 5.2.4. Part Quality Assurance

#### 5.2.4.1. Non-Conforming Parts, Materials, and Processes

As-built parts, materials, and processes which do not conform to the parameters, specifications and requirements set for in this Plan and approved by the MPRB are considered non-conforming. The use of non-conforming flight parts or assemblies requires initiation and approval of a LAT Non-Conformance Report (NCR). This must be generated at the time the non-conformance is identified, and approved by the PSAM.

**5.2.4.2. *Tracking and Records Management***

As-built part, material, and process information is considered a quality record. Prior to shipping a subsystem component for integration on the LAT, these quality records will be checked for completeness and conformance to their respective specifications.

### 5.3. Materials Control Procedure

#### 5.3.1. General Material Control Procedures

##### 5.3.1.1. *Materials Procedures*

This section describes procedures for the collection of information and approval requirements for three general groups of materials. These are:

Polymers and Composites  
In-Organic Materials  
Lubricants

The procedures and required information are specific for the material type, and cover the aspects of this Plan which are unique to that material. Since material information is organized by part, a material approved for use in one part with a given application must be re-approved for use in another part.

##### 5.3.1.2. *Compliant Materials*

The following material procedures define what is considered a compliant material. In general, compliant materials and processes are those which meet the following requirements:

1. Hazardous materials requirements as specified in Eastern and Western Range 127-1 Range Safety Requirements, Sections 2.10 and 2.12, determined according NASA-STD-6001.
2. Vacuum outgassing requirements as defined in the respective materials procedure.
3. Stress corrosion cracking requirements as defined in MSFC-SPEC-522.
4. Material used in a conventional application, for which there is extensive satisfactory aerospace heritage.

Whenever possible, materials and their usage shall be “compliant”. The precise definition of compliant materials and processes is delineated in the respective materials procedures in the following sections.

##### 5.3.1.3. *Requirements for Non-Compliant Materials—Material Usage Agreement*

A “non-compliant” material is a material that does not meet the general requirements, above, or those of the applicable materials procedures. Furthermore, a material is considered “non-compliant” even if it meets the requirements, but is used in an unconventional application. Specifically, a material or application may be non-compliant for one of three reasons:

A material property does not meet the criteria for compliance (e.g.: outgassing requirements can not be met for a proposed adhesive).

Material property information is missing or incomplete (e.g.: flammability rating is not known for an epoxy material).

The material is used in an unconventional application, for which there is limited or no experience of satisfactory aerospace flight usage.

The proposed use of a non-compliant material requires that a Materials Usage Agreement (MUA) be developed, and compliance testing be completed. In general, approval for the use of non-compliant materials requires that the material usage be qualified and/or verified for the desired application on the basis of existing data, similarity, analyses, inspection, test, or a combination of those methods.

For materials with incomplete property information, an analysis and test plan must be included in the MUA. This should include the plan to collect all relevant information from testing.

For materials which do not meet the criteria specified or which are used in an unconventional manner, the material must be justified for use based on one or more of the following:

**Existing Data:** Use justified based on other material information not included in the basic set of material properties. This justification should include a rationale for how these additional properties override the non-complying aspects of the material.

**Similarity:** Use justified based on history of similar non-compliant use on other flight projects. This is also a suitable justification for un-conventional applications of a material.

**Analysis:** Use qualified by analysis. This is applicable for materials used in unconventional applications, where analysis can show that the risk of this unconventional use is suitably low to render it acceptable for use.

**Inspection:**

**Test:** Use qualified and/or verified by testing. For non-compliant or missing material properties, this may include testing of material properties. For an unconventional application, testing may include qualification testing of a prototype application to verify that it behaves as planned. This may also require verification testing of the flight component(s) to check that the materials and processes have been implemented as specified.

All relevant analysis and test plans must be included in the MUA. Qualification analysis or testing must be completed before a material is approved for flight use. Any needed verification testing must be documented and included in the subsystem verification plan.

#### ***5.3.1.4. Material Procurement***

Purchased raw materials must be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance. For raw materials used in purchased products, the purchaser will require that suppliers provide, upon request, the results of acceptance tests and analyses performed on the constituent raw materials.

#### ***5.3.1.5. Material Use***

As detailed in the specific material plans below, the use of certain materials calls for and requires the use of specific procedures for their use. These are:

Composite Material Usage Procedure  
Composite Material Damage Control Plan

### Limited Life Material Usage Procedure

The use of these materials requires developing process specifications which comply with the control procedures, above. Compliance to the Usage Procedures will be monitored by the PSAM.

#### **5.3.2. Polymer and Composite Control Procedure**

##### ***5.3.2.1. Scope of Materials Covered in This Category***

This Procedure covers parts using materials which are polymers or composites. This includes epoxy, silicone, carbon-fiber and other composites, any other glues or adhesive. A polymer that is used as a lubricant is classified as a lubricant, and is covered in section 5.3.4, below.

##### ***5.3.2.2. Required Material Property Information—Polymers and Composites***

The following is a list of the information which must be collected and submitted for each polymer or composite material used. This will be used in the evaluation of materials for their suitability.

| <b>Property</b>         | <b>Description</b>   | <b>Example</b>                                |
|-------------------------|--|---|
| Type                    | Type of material. Pick one: epoxy, silicone, other adhesive, composite, TBD  |   |
| Material Identification | Give the name of the material, identifying number and manufacturer   | Epoxy, Epon 828, E. V. Roberts and Associates |
| Mix Formula             | Provide proportions and name of resin, hardener (catalyst), filler, etc  | 828/V140/Silflake 135 as 5/5/38 by weight     |
| Cure                    | Provide cure cycle details.  | 8 hrs. at room temperature + 2 hrs. at 150C   |
| Limited Life            | Flag yes/no of whether material has limited shelf life requirements or special storage requirements. If checked, then a Limited Life Plan must be submitted with the material information (see below). |   |
| TML Outgassing Value    | Total Mass Loss (TML) value for the material, determined according to ASTM E-595.  |   |
| CVCM Outgassing Value   | Collected Volatile Condensable Mass (CVCM) value for the material, determined according to ASTM E-595.   |   |
| Flammability            | Material flammability rating, determined according to NASA-  |   |

|                  |  |
|------------------|--|
|                  | STD-6001.  |
| Toxic Offgassing | Material toxic offgassing rating, determined according to NASA-STD-6001.                             |
| Area             | Exposed surface area of the material (cm <sup>2</sup> )<br>1 0-1<br>2 2-100<br>3 101-1000<br>4 >1000 |
| Volume           | Total volume of the cured material (cc)<br>A 0-1<br>B 2-50<br>C 51-500<br>D >500                     |
| Weight           | Total weight of the cured material (gm)<br>a 0-1<br>b 2-50<br>c 51-500<br>d >500                     |

Table 3: Polymer and Composite Material Information

### 5.3.2.3. Approval Requirements for Compliant Materials—Polymers and Composites

Polymeric and composite materials acceptability will be determined on the basis of the following criteria.

| Property              | Minimum Criteria for Approval  | Comments   |
|-----------------------|--|--|
| Flammability          | Material must meet the requirements of Eastern and Western Range 127-1 Range Safety Requirements, Sections 2.10 and 2.12 | Material flammability rating, determined according to NASA-STD-6001.     |
| Toxic Offgassing      | Material must meet the requirements of Eastern and Western Range 127-1 Range Safety Requirements, Sections 2.10 and 2.12 | Material toxic offgassing rating, determined according to NASA-STD-6001. |
| TML Outgassing Value  | Materials that have a total mass loss (TML) less than 1.00%  | Determined according to ASTM E-595.                                      |
| CVCM Outgassing Value | Collected volatile condensable mass (CVCM) less than 0.10%   | Determined according to ASTM E-595.                                      |
| Limited Life          | Justification for use of a limited-life material, including other options. Submittal of a Limited Life Plan,             |  |

|                  |   |
|------------------|---|
|                  | as described above.   |
| Other Properties | Properties evaluated relative to the proposed application requirements and usage environment for the part |

Table 4: Polymer and Composite Material Approval Criteria

**5.3.2.4. Requirements for Non-Compliant Materials**

The use of a non-compliant polymer or composite material requires the completion of an MUA. The contents of this are described in Section 5.3.1.3, above. Specifically, the MUA should include a detailed description of the non-compliant material properties, the reason these non-compliances are considered an acceptable risk for the part and application, and an alternate, compliant candidate materials, and why they were rejected.

Non-compliant polymer or composite materials require approval by the GLAST project office.

**5.3.2.5. Composite Material Requirements**

If deemed necessary by the MPRB, a Composites Process Control Plan will be required, to ensure uniformity of processing among test coupons, test articles, and flight hardware. (GEVS 2.4.1.4.1.b.1)

Furthermore, a Damage Control Plan may be required for particular composite applications to establish procedures and controls to prevent and/or identify non-visible impact damage which may cause premature failure of composite elements. (GEVS 2.4.1.4.1.b.2)

**5.3.2.6. Limited-Life Material Requirements**

Polymer or composite materials with a limited shelf life shall be identified in the materials database. A Limited Life Procedure (LLP) shall be developed to track the procurement, storage, and use of the material. Examples of such materials are o-rings, rubber seals, tape, uncured polymers, lubricated bearings and paints.

Beyond the material information described above, the following additional information must be submitted for review:

| Property | Description  | Example |
|----------|--|---------|
| LLP #    | Limited Life Procedure document number   |         |
| Life     | Material useable life. Describe life both before and after any application or curing, if applicable. |         |
| Storage  | The required storage conditions associated with a specified shelf-life.                              |         |

|               |  |
|---------------|--|
| Justification | Reason for selecting a limited shelf-life material, and possible alternatives. |
|---------------|--|

*Table 5: Limited Life Material Information*

Approval of limited-shelf life materials requires implementation of a LLP for the material and any component in which it is used. This LLP must identify the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the required storage conditions associated with a specified shelf-life, and the expiration date. Sub-assemblies which contain limited-life components must be included in the Limited Life Procedure for the material.

The use of materials whose date code has expired requires a demonstration, by means of appropriate tests, that the properties of the materials have not been compromised for their intended use. The use of any expired materials requires prior review and approval by the MPRB. This is considered a non-conforming application, so the mechanism for approval is through a Non-Conformance Report (NCR).

### **5.3.3. In-Organic Material Control Procedure**

#### ***5.3.3.1. Scope of Materials Covered in This Category***

This procedure covers parts using inorganic materials. This includes metals, ceramics, glasses, liquids, and metal/ceramic composites.

This procedure does not include bearings and lubricants, and comprises only the materials portion of requirements for fasteners, weldments, and pressure vessels/components.

#### ***5.3.3.2. General***

The design and analysis of a part shall comply with the following references for the specific application or type of in-organic materials:

Metals: MIL Handbook 5-H shall be used for the analysis and design of all metallic flight and GSE components, unless specific test data about the material or application at hand is used.

Metal castings: Fracture control requirements (per GSFC 731-0005-83 "General Fracture Control Plan for Payloads Using the Space Transportation System (STS)") shall apply to all castings, independent of the metals involved. (GEVS 2.4.1.4.1) (GEVS 1.7.4)

Glasses: All glass elements that are stressed above 10% of their ultimate tensile strength, shall be shown by fracture analysis (per GSFC 731-0005-83 "General Fracture Control Plan for Payloads Using the Space Transportation System (STS)") to satisfy "Safe-life" or "Fail-safe" conditions or be subjected to a proof load test at 1.0 times limit level. (GEVS 2.4.1.4.1) (GEVS 1.7.4)

#### ***5.3.3.3. Required Material Property Information—In-organic Materials***

The following is a list of the information which must be collected and submitted for each material used for a given part.

| <b>Property</b>         | <b>Description</b>  | <b>Example</b>   |
|-------------------------|---|--|
| Type                    | Material type, pick one: metallic, ceramic, glass or glass-like, liquid, metal/ceramic composite, other.  |  |
| Material Identification | Give the name of the material, identifying number, and manufacturer.  | Aluminum 6061-T6; Fused silica, Corning 7940, Corning Glass Works        |
| Fab Method              | Fabrication method, pick one: hot-roll, cold-roll, extruding, extruding and drawing, rolling, forging, casting, hot isostatic pressing, other   |  |
| Temper                  | Heat treat designation and/or cold worked state of the base material before and after fabrication.  | Cold worked to full hard condition                                       |
| Condition               | Details of the finished condition of the material, such as surface hardness or material strength.<br>Note: any final material treatment, hardening, cleaning, or coating should NOT be included here, but considered as a follow-on process, and included as a Process. | Heat treated to Rockwell C 60 hardness                                   |
| NDE Method              | Non-Destructive Examination method(s) used to inspect material quality before, during, and after fabrication.   | X-ray of base metal before machining; dye-penetrant test after machining |

*Table 6: Inorganic Material Information*

#### **5.3.3.4. Approval Requirements for Compliant Materials—In-Organic Materials**

In-organic materials compliance will be determined on the basis of the following criteria.

| <b>Property</b>         | <b>Minimum Criteria for Approval</b>  | <b>Comments</b>   |
|-------------------------|---|---|
| Type—metallic materials | Metallic materials must be listed in Table I of MSFC-SPEC-522B  | Table I materials have been shown to possess high resistance to stress corrosion cracking |
| Application             | Alloys used for electrical wiring, thermocouple wires, and similar non-structural electrical or electronic applications are not subject to the stress-corrosion cracking requirements of MSFC-SPEC-522B |   |
| Usage                   | Sheet metals (< 0.250 inch or 6 mm thick) of the aluminum alloys and  |   |

|           |   |
|-----------|---|
|           | conditions listed in MSFC-SPEC-522B Table II is considered resistant to stress corrosion and thus compliant   |
| Usage     | Glasses designed with safety factors as specified in NASA-STD-5001  |
| Condition | Materials must not have any surface treatment (e.g.: carburising or nitriding) as it may adversely affect the stress corrosion rating of materials to which it is applied |

*Table 7: Inorganic Material Approval Criteria*

The criteria specified in MSFC-SPEC-522 will be used to determine that metallic materials meet the stress corrosion cracking criteria.

#### **5.3.3.5. Requirements for Non-Compliant Metallic Alloys**

All metallic alloys and weldments not listed in MSFC-SPEC-522B Table I are considered non-compliant, and require that an MUA be submitted for approval.

Alloys and tempers listed in MSFC-SPEC-522B Table II are moderately resistant to stress corrosion cracking. They should be considered for use only for cases where a suitable alloy cannot be found in Table I. Proposed utilization of materials from Table II in applications involving high installation stress, such as springs or fasteners, will not be approved.

The alloys listed in MSFC-SPEC-522B Table III have been found to be highly susceptible to stress corrosion cracking. They should be considered for use only in applications where it can be demonstrated conclusively that the probability of stress corrosion is remote because of low sustained tensile stress (whatever its origin) in critical grain directions, suitable protective measures, or an innocuous environment. The use of these materials may require additional analysis and testing, and will be considered on a case-by-case basis.

Besides the information listed in Section 5.3.1.3, the MUA must include a summary of the part, application, and material information for the non-compliant material, and an evaluation of the susceptibility of the material to stress-corrosion cracking. The minimum information to be included is listed in Table 8.

Fracture control requirements (per GSFC 731-0005-83 “General Fracture Control Plan for Payloads Using the Space Transportation System (STS)”) shall apply to all parts made of materials on Tables II or III of MSFC-SPEC-522B if under sustained tensile stress. (GEVS 2.4.1.4.1) (GEVS 1.7.4). A fracture analysis report must be included in the MUA.

Protective coatings and surface treatments must be identified and detailed in the MUA for non-compliant materials. A protective coating (e.g.: electroplate, anodize or chemical conversion coating) does not change the stress corrosion rating of alloys to which they are applied. Furthermore, surface treatments (e.g.: carburising or nitriding) may adversely affect the stress corrosion rating of materials to which they are applied. Thus, these processes must be detailed in the MUA, and a justification for why the material is suitable for use should be presented.

| <b>Property</b> | <b>Description</b>   | <b>Example</b> |
|-----------------|--|----------------|
| Manufacturer    | Source of material   |                |
| Stresses        | Sustained tensile stress magnitude and direction. This includes process residual, assembly, design, and static stresses and orientations |                |
| Special         | Special processing   |                |
| Finish          | Protective finish, if any  |                |
| Function        | Function of part   |                |
| Failure         | Effect of failure of the part, including a discussion of potential failure modes   |                |
| Susceptibility  | Evaluation of stress corrosion susceptibility  |                |
| Remarks         | Other issues not addressed   |                |

*Table 8: Information for Non-Compliant Metallic Materials to be Included in the MUA*

#### ***5.3.3.6. Requirements for Non-Compliant Non-Metallic Materials***

Non-metallic materials, notably ceramics and ceramic-metal matrix composites, are by definition non-compliant, since they have not been pre-approved for use in flight hardware. Thus, an MUA must be developed which describes the material, its intended use, stress analysis, fracture analysis, and any other test or analysis data needed to justify its use.

These materials and their application will be evaluated on a part-by-part basis, and final approval must be given by the GLAST project office prior to fabrication.

#### ***5.3.3.7. Requirements for Non-Compliant Liquids/Gases***

Liquids and gases are, by definition, non-compliant. Their use requires development of an MUA. This should justify the need for the material, its purpose, its effect on structural components it contacts, a hazard analysis (if applicable), and a risk analysis evaluating the risk of release of the material and the potential effect of such a release.

These materials and their application will be evaluated on a case-by-case basis, and final approval must be given by the GLAST project office prior to use.

#### ***5.3.4. Lubricant Control Procedure***

Lubricants are classified as a material, but their use is tied strongly to the parts on which they will be used and the assembly processes where they are applied. Thus, lubricants will typically be referred to at the sub-assembly level, where two parts are assembled together, and a lubricant is applied. For lubricants applied to piece parts, the lubricant will be considered as another material from which the part is made. Thus, a bolt with plated-on lubricant will refer to the material from which the bolt is made, and to the lubricant used for the bolt.

### 5.3.4.1. *Scope of Materials Covered in This Category*

This Procedure covers any material used specifically as a lubricant. This includes polymeric lubricants, dry-film lubricants, and metal plating used primarily as a lubricant. A material used as a lubricant is classified as a lubricant, and not as a polymer or metal. Note that for lubricants applied by plating or coating processes which affect the surface of the part, a process control entry must also be used.

### 5.3.4.2. *General*

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 or heritage of an identical mechanism used in identical applications. In either circumstance, evidence of qualification must be provided.

### 5.3.4.3. *Required Material Property Information*

The following is a list of the information which must be collected and submitted for each application usage of a lubricant. This will be used in the evaluation of materials for their suitability.

| Property                | Description  | Example                                       |
|-------------------------|--|---|
| Type                    | Type of lubricant. Pick one: organic, metallic, other  |   |
| Material Identification | Give the name of the lubricant, identifying number and manufacturer  |   |
| Component               | Type of component needing lubrication. BB = ball bearing, SB = sleeve bearing, G = gear, SS = sliding surfaces, SEC = sliding electrical contacts.   |   |
| Motion                  | Type of motion needing lubrication: IS = intermittent sliding, CS = continuous sliding, CUR = continuous unidirectional rotation, CO = continuous oscillation, IR = intermittent rotation, IO = intermittent oscillation, SO = small oscillation, (<30°), LO = large oscillation (>30°). | “IS” should be used for lubricated fasteners. |
| Size                    | Representative size of the component. E.g.: diameter of a bolt or bearing race   |   |
| Material                | Give generic identification of materials used for the component.   | 440C steel, PTFE                              |
| Method                  | Lubrication system method  |   |
| Cycles                  | No. of wear cycles: A(1-102), B(102-104), C(104-106), D(>106)  |   |
| Speed                   | RPM = revs./min., OPM = oscillations/min., VS = variable speed, CPM = cm/min. (sliding applications). Use 0 for nominally static uses like a bolt.   |   |
| Temperature             | Temperature of operation, max. & min., °C  |   |
| Atmosphere              | end use operational atmosphere. Pick one: vacuum, air,   |   |

|                             |  |
|-----------------------------|--|
|                             | gas, sealed or unsealed & pressure   |
| Load.                       | Type of primary loads: A = axial, R = radial, T = tangential (gear load).  |
| Amount                      | Amount of load (N)   |
| Other                       | 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 diameter of bore and width. If torque available is limited, give approx. value. |
| Area                        | Approximate surface area of lubricant, per application (cm <sup>2</sup> )  |
| Limited Life                | Flag yes/no of whether material has limited shelf life requirements or special storage requirements. If checked, then a Limited Life Plan must be submitted with the material information (see below).   |
| TML<br>Outgassing<br>Value  | Total Mass Loss (TML) value for the material, determined according to ASTM E-595.  |
| CVCM<br>Outgassing<br>Value | Collected Volatile Condensable Mass (CVCM) value for the material, determined according to ASTM E-595.   |

Table 9: Lubricant Material Information

#### 5.3.4.4. Approval Requirements for Compliant Materials—Lubricants

Lubricant use will be approved on a case-by-case basis. Since appropriate use of a lubricant is related strongly to the materials with which it comes in contact, and the load and configuration of the lubricated joint, there are no standard or pre-approved lubricants. For lubricants used in applications with previous flight heritage, approval will be based on the information in Table 9.

#### 5.3.4.5. Requirements for Non-Compliant Materials—Lubricants

The use of a lubricant in a non-conventional application or one with no flight heritage requires the completion of an MUA. The contents of this are described in Section 5.3.1.3, above. Specifically, for lubricants this should describe the non-compliant material properties, and any non-conventional application environments to which the lubricant is exposed. This may include using the lubricant in applications without flight heritage or which are not recommended by the manufacturer.

The use of non-compliant lubricant require approval by the GLAST project office.

#### 5.3.4.6. Limited-Life Material Requirements

Lubricants with a limited shelf life shall be identified. A Limited Life Procedure (LLP) shall be developed to track the procurement, storage, and use of the material.

Beyond the material information described above, the following additional information must be submitted for review:

| <b>Property</b> | <b>Description</b>   | <b>Example</b> |
|-----------------|--|----------------|
| LLP #           | Limited Life Procedure document number   |                |
| Life            | Material useable life. Describe life both before and after any application or curing, if applicable. |                |
| Storage         | The required storage conditions associated with a specified shelf-life.                              |                |
| Justification   | Reason for selecting a limited shelf-life material, and possible alternatives.                       |                |

*Table 10: Limited Life Material Information*

Approval of limited-shelf life materials requires implementation of a LLP for the material and any component in which it is used. This LLP must identify the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the required storage conditions associated with a specified shelf-life, and the expiration date. Sub-assemblies which contain limited-life components must be included in the Limited Life Procedure for the material.

The use of materials whose date code has expired requires a demonstration, by means of appropriate tests, that the properties of the materials have not been compromised for their intended use. The use of any expired materials requires prior review and approval by the MPRB. This is considered a non-conforming application, so the mechanism for approval is through a Non-Conformance Report (NCR).

## 5.4. Process Control Procedure

### 5.4.1. Scope of Processes Covered

Materials processing is by definition a product-based activity, since its purpose is to produce a component or assembly. Thus, material process information is tied to the component or sub-assembly in which it is used. This includes three general categories of processes:

**Fabrication:** forming/shaping, curing, heat treating. Typically, this includes any process done to a parent material, like a plate, but does not include the fabrication process of the parent material, such as extruding or curing of a single-material pre-preg composite. Such “bulk material” processes are considered part of the “Material” information.

**Surface treatment:** coating, plating, cleaning, lubrication. If the material added is expressly for the purpose of lubrication, then it should be included as a lubricant, also. Otherwise, the added material is accounted-for only in this process description.

**Joining and assembling:** welding, brazing, bonding, mechanical fastening. For an assembly which includes multiple assembly processes, a separate entry is required for each process.

### 5.4.2. General

Fracture control requirements (per GSFC 731-0005-83 “General Fracture Control Plan for Payloads Using the Space Transportation System (STS)”) shall apply to all weldments, independent of the metals involved. (GEVS 2.4.1.4.1) (GEVS 1.7.4). These requirements shall govern the design, analysis, and testing of all welded joints.

### 5.4.3. Process Information

The following is a list of the information which must be collected and submitted for each process being used for a given component or sub-assembly.

| Property     | Description   | Example  |
|--------------|---|--|
| Type         | General type of process.  | forming/shaping, curing/baking, heat treating, coating, plating, cleaning, lubrication, anodizing, welding, brazing, bonding, mechanical fastening |
| Process      | Description of specifics of how process is used in fabrication of component | electroless nickel plate, Enplate Ni 410, Enthone, Inc   |
| Related Part | Numbers for other components involved in the                                | part numbers for parts   |

|                         |  |   |
|-------------------------|--|---|
| Numbers                 | process.   | being welded together;<br>part number for<br>hardware being<br>lubricated in an<br>assembly process |
| Material Identification | Give the name(s) and condition of the material(s), identifying number, and manufacturer. | Aluminum 6061-T6  |
| Specification Number    | Process spec by which process is done. State if process is proprietary.                  |   |
| Other Spec's            | MIL., ASTM., Federal or other specifications used to control process                     |   |

Table 11: Process Information

#### 5.4.4. Approval Requirements for Compliant Processes

Processes involving in-organic materials will be determined on the basis of the following criteria.

| Property               | Minimum Criteria for Approval   | Comments   |
|------------------------|---|--|
| Type—weldments         | Metallic weldments must be listed in Table I of MSFC-SPEC-522B  | Table I weldments have been shown to maintain high resistance to stress corrosion cracking |
| Type—surface treatment | Surface treatment can not be carburising or nitriding, as they may adversely affect the stress corrosion rating of materials to which they are applied              |  |
| Application            | Processes will be judged as to their ability to produce changes to material properties that could adversely effect the performance of the component or subassembly. |  |

Table 12: Process Approval Criteria

Since Processes are so variable, few are considered automatically compliant. Thus, most processes are approved on a case-by-case basis, based on the information provided.

#### 5.4.5. Requirements for Non-Compliant Metallic Weldments

All metallic weldments not listed in MSFC-SPEC-522B Table I are considered non-compliant, and require that an MUA be submitted for approval. The MUA must include the information described below, to permit evaluation of the susceptibility of the weldment to stress corrosion cracking.

Information required in the MUA:

Assembly information: assembly drawing number and weldment process specification number. Information about the use and function of the assembly, and the stresses seen by the welded joint. This includes sustained tensile stress magnitude and direction, as well as process residual, assembly, design, and static stresses and orientations. Also needed is an analysis of the effect of failure of the part, including a discussion of potential failure modes, and an evaluation of stress corrosion susceptibility.

Part information: information about the piece parts being welded together. This includes part numbers, constituent materials, manufacturers, sources of materials, heat treatment, and the parts' general size and form.

Weld or braze information: filler alloys, if any, environment, and details of the exact process being used, including specification numbers for the process. This includes any weld bead removal process, and post-weld thermal or stress-relief process. For brazes, this includes time/temperature profiles.

Post-weld process information: description of any special processing after welding, such as plating, coating, or application of any protective finishes.

#### **5.4.6. Tracking and Records Management**

As-built process information is considered a quality record. Prior to shipping a subsystem component for integration on the LAT, these quality records will be checked for completeness and conformance to their respective specifications.

### **5.5. Specialized Mechanical Parts Control Procedure**

#### **5.5.1. Fastener Control Procedure**

This Fastener Control Procedure forms a subset of the overall Mechanical Parts Plan. Fasteners are one type of specialized parts, which require additional attention during all phases of design, procurement, and use. This procedure describes the additional requirements.

##### **5.5.1.1. Scope**

This Procedure governs the design, procurement, and use of all nuts and bolts for flight hardware and critical GSE applications, as well as all flight hardware rivets, helical and cylindrical inserts, shear pins, and setscrews. This includes custom manufactured fasteners, pyrotechnic fasteners, eyebolts, clevises, hooks, wire rope, turnbuckles.

##### **5.5.1.2. General Requirements**

All fasteners and fastening components used for flight hardware and critical ground support equipment shall comply with the material, design, procurement, and test requirements of GSFC-S-313-100-B, "Goddard Space Flight Center Fastener Integrity Requirements." All such fasteners shall be logged in the parts and materials database, along with the additional information listed below. Review of all fasteners is required, however approval is common for fasteners which meet the criteria listed below.

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

### 5.5.1.3. Fastener Information to be Tracked

The following is a list of the information which must be collected and submitted for each fastener used. This information summarizes the detailed specifications with which the fastener is procured, tested, and used. Note that material and plating information is collected and reviewed as part of the In-Organic Material and Process Control Procedures, above.

| Property                | Description   | Example                      |
|-------------------------|---|------------------------------|
| Procurement Spec Number | Procurement specification number with which the hardware is procured  |                              |
| Type                    | Fastener type, pick one: nut, bolt, rivet, insert, shear pin, and setscrew, pyrotechnic fastener, eyebolt, clevis, hook, wire rope, turnbuckle, other.  |                              |
| Details                 | Additional details of type  | socket-head cap screw        |
| Size                    | Nominal size, thread pitch, and length  | ¼-20 UNC-2B x 0.75 inch long |
| Loading                 | pick one: redundant load path, single-point failure, GSE critical.  |                              |
| Custom                  | Justification for use of custom manufactured components (e.g.: custom fastener), including discussion of design and analysis considerations, special fabrication and test plans, and proof/qualification testing. |                              |

Table 13: Fastener Additional Information

### 5.5.1.4. Approval Requirements for Fasteners

Requirements for approval of fastener use are discussed in GSFC-S-313-100-B. In specific, the following criteria apply.

| Property           | Minimum Criteria for Approval  | Comments |
|--------------------|--|----------|
| Loading            | Single point failure flight hardware nuts and bolts must be size #10 (5mm) or larger.  |          |
| Loading            | Redundant load path fasteners may be any size.   |          |
| Material Selection | Metallic fastener materials for flight hardware and critical ground support equipment applications must be selected from Table I of MSFC-SPEC-522. |          |
| Custom             | Custom manufactured fasteners, eyebolts,   |          |

|  |  |  |
|--|--|--|
|  | clevises, hooks, wire rope, turnbuckles, and those not otherwise specified require an MUA and special approval |  |
|--|--|--|

*Table 14: Fastener Approval Criteria*

#### **5.5.1.5. Procurement**

Fastener procurement shall be governed by GSFC-S-313-100-B. This requires that all procurement specifications be reviewed by the subsystem QA engineer, and that it contain specific language relating to the ultimate use of the fastener. For single-point failure fasteners, procurement must either be from a manufacturer pre-approved by GSFC, or the proposed manufacturer audited before awarding of contract.

#### **5.5.1.6. Testing and Screening**

Receiving screening, inspection, and special testing is needed for some sizes and applications. See GSFC-S-313-100-B. These tests shall be conducted by a third party testing contractor, not by the manufacturer. Sample sizes and acceptable failure rates are spelled out in GSFC-S-313-100-B.

All manufacturer and third-party test reports are considered quality records, and must be stored either at the receiving institution or at the IPO.

#### **5.5.1.7. Traceability**

Per GSFC-S-313-100-B, the traceability of flight hardware nuts and bolts (size #10 or 5mm and larger), rivets (size 3/16" or 5mm and larger), and critical GSE nuts and bolts shall be maintained into and including stores. Storage of fasteners shall be controlled to assure traceability.

Traceability information shall include vendor, manufacturer, lot number, and screening level (single point failure or redundant load path). Traceability shall be maintained into flight hardware and critical GSE for all single point failure fasteners. Source information for redundant load path fasteners is not required to be traced to the flight hardware. Thus, fastener lot number and information shall be recorded on the assembly traveler for the sub-assembly requiring the fastener. Tracking the location of each fastener in a lot is not required.

#### **5.5.1.8. Discrepant Parts**

For fasteners being tested by sampling methods, the acceptable failure rate is shown in GSFC-S-313-100-B. Lots which are tested and exceed the acceptable failure rate shall be rejected and returned to the manufacturer.

For any test of 100% of the procurement, individual fasteners which fail the test may be discarded. A record must be kept of the total quantity tested, the number which failed (and were discarded) and on which test(s) they failed. This is a quality record.

### 5.5.2. Control Procedure for Pressurized and Stored-Energy Components

#### 5.5.2.1. *Scope of Materials Covered in This Category*

This Procedure covers all parts and assemblies which are under internal or external pressure, or are pre-loaded in their standard operational state. This includes pressure vessels, lines, fittings, and other pressurized components. It also includes some pre-loaded springs.

This Procedure does not include pre-loaded bolts

#### 5.5.2.2. *General*

The design of all pressurized and stored-energy components (defined by NHB-8071.1) shall include fracture control requirements, per GSFC 731-0005-83 “General Fracture Control Plan for Payloads Using the Space Transportation System (STS)”. (GEVS 2.4.1.4.1a)

#### 5.5.2.3. *Required Material Property Information*

The following is a list of the information which must be collected and submitted for each application usage of a pressurized or stored-energy component. This will be used in the evaluation of materials for their suitability.

| Property              | Description   | Example |
|-----------------------|---|---------|
| Type                  | Pick one: pressure vessel, pressurized component, stored-energy component |         |
| Volume                | Volume of pressurized region (cc)   |         |
| Fluid                 | Working fluid   |         |
| Design Pressure /Load | Maximum design operating pressure or design pre-load                      |         |
|                       |   |         |

*Table 15: Pressurized Component Information*

Approval of these components is subject to a review of the design and analysis of the component and its materials and processes.

## 6. Records Management

The following quality records will be/are generated from the plans and procedures described in this Plan:

| <b>Quality Record</b>            | <b>Maintained by...</b>   |
|----------------------------------|---|
| Polymer and Composite Usage List | Material Coordinator at the IPO (part of Mechanical Parts Database) |
| In-Organic Material List         | Material Coordinator at the IPO (part of Mechanical Parts Database) |
| Lubrication Usage List           | Material Coordinator at the IPO (part of Mechanical Parts Database) |
| Process Utilization List         | Material Coordinator at the IPO (part of Mechanical Parts Database) |
| MUA's                            | Material Coordinator at the IPO (part of Mechanical Parts Database) |
| Fastener Control List            | Material Coordinator at the IPO (part of Mechanical Parts Database) |
| MPRB Reports and meeting minutes | Material Coordinator at the IPO (part of Mechanical Parts Database) |
| Fastener certifications          | Sub-system representatives  |
| Material certifications          | Sub-system representatives  |
| Process Work Instruction records | Sub-system representatives  |
| Test and Inspection reports      | Sub-system representatives  |
|                                  |   |

*Table 16: Summary of Quality Records Referenced in this Plan*

7. **Appendix A: Material Usage Agreement Template**

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