General

# Handbook of the use of Commercial EEE Parts in Space Applications (Small Satellite, Nanosatellite)

March 21, 2025

Japan Aerospace Exploration Agency

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Published by
Japan Aerospace Exploration Agency
Safety and Mission Assurance Department
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**Introduction**

This handbook, " Handbook of the use of Commercial EEE Parts in Space Applications (Small Satellite, Nanosatellite)", was newly established in response to the addition of new classification for small satellite and nanosatellite, which was introduced during the B revision of "Handbook of the use of Commercial EEE Parts in Space Applications (General Purpose) (JERG-0-052)" in FY2023. The fundamental policy of this handbook is not to position commercial-off-the-shelf (COTS) parts as mere supplements to space parts, but rather to emphasize utilizing COTS parts effectively. Based on this policy, the handbook provides guidelines regarding precautions and considerations for the use of COTS parts.

In recent years, there has been growing demand for the rapid development and utilization of small satellite/nanosatellite (small/micro/nano/picosatellites). However, there is no clear consensus on what constitutes a "small" or "nanosatellite" (micro, nano, pico) and no globally accepted definition currently exists.

As a premise for preparing this handbook, satellites weighing 100 kg or more were classified as small satellite and those weighing less than 100 kg as nanosatellite, as shown in Table 1, referring to "About the benefits and features of the nano-satellite" by Dr. Shigeru Aso, Journal of The Remote Sensing Society of Japan Vol. 34 No. 1 (2014), PP 33-35. The mission life was assumed to be one to three years, referring to "Small Spacecraft Overview" by NASA Ames Research Center.

Table 1 Classification of small and nanosatellites and their purposes and applications (examples)

| Size (approximate) | Name | Main players | Purpose and use (example) | Classification |
|---|---|---|---|---|
| 100 to 1000Kg | Smallsat | Satellite-related companies, Ventures, National organizations | Remote sensing, Environmental observation, Disaster monitoring, Data collection, Space science, Communication and navigation | Small satellite |
| 20 to 100 kg | Microsat | Universities, Ventures | University educational use, Technical testing, Demonstration, Remote sensing, Disaster monitoring, Communication and navigation | Nanosatellite |
| 1 to 20 kg | Nanosat (CubeSat) (Note) | Universities, Ventures | University educational use, Technical testing, Partial operational use (space science, environmental monitoring, etc.) | |
| 1 kg or less | Picosat | Universities | University educational use | |

(Note) CubeSat is a generic term for rectangular-shaped nano satellites standardized in "Space Systems-Cube Satellites (Cube Sats)" (ISO17770).

These satellites tend to focus on low-cost and rapid development and are characterized by their extensive use of COTS parts, which are not designed, manufactured, or quality-assured as space parts, and by their high functionality, yet small size, low cost, and short development time.
Therefore, not only parts used in industrial applications, but also parts used in ground commercial equipment (mobile PCs, cellular phones, automotive electronics, etc.) may be adapted for space use.
Compared to large satellites, small and nanosatellites are currently being researched and developed by many universities and companies because of their lower development costs and shorter development time, typically two to three years.

As shown in Figure 1, this document is positioned as an individual handbook complementing " JERG-0-052 Handbook of the use of Commercial EEE Parts in Space Applications (General Purpose)".
The purpose of this handbook is to be utilized as a guideline for part selection in small and nanosatellites development projects at JAXA, and to share knowledge, precautions and considerations when using COTS parts among the parties involved in the development of small satellites and nanosatellites.

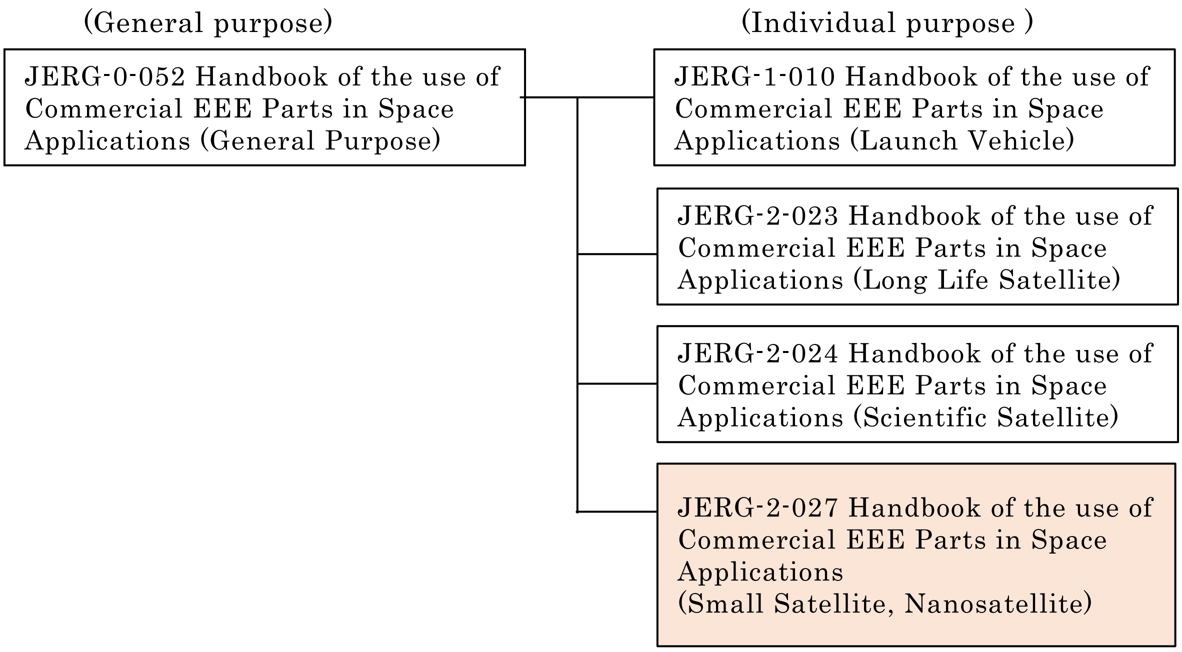


Figure 1 Positioning of JERG-2-027 Handbook of the use of Commercial EEE Parts in Space Applications (Small Satellite, Nanosatellite)

# 1. GENERAL

## 1.1 Purpose

In small satellite and nanosatellite development projects, it is often technically, economically, and schedule-wise difficult to select EEE parts (hereinafter, referred to as "parts") used in system equipment from standard parts (officially qualified parts by JAXA, MIL/NASA, ESCC/ESA) or non-standard parts with flight heritage. The purpose of this handbook is to describe general procedures, recommendations, precautions, explanations, and related information necessary for the selection, evaluation, procurement, and use of parts used outside the space industry.

## 1.2 Scope

The scope of non-standard space-applicable parts covered in this handbook includes EEE parts specified in section 3 (1) of JMR-012, plus optical-related and MEMS parts. The following 21 items are domestically produced parts/imported parts.

The quality assurance levels of non-standard space-applicable parts are classified into three classes (equivalent to Class I, Class II, and Class III) as in section 5.1.2 of JMR-012, and common selection and application guidelines are also provided in relation to the risk response policy of the system.

(1) integrated circuits (including hybrid integrated circuits)
(2) transistor
(3) diode
(4) capacitor
(5) resistor
(6) connectors
(7) crystal/crystal oscillator
(8) filter (RFI filter, EMI filter, feed-through filter, etc.)
(9) relay
(10) switch
(11) transformer/coil
(12) wires and cables
(13) solar cells
(14) printed wiring board
(15) thermistor
(16) heater
(17) sensor (platinum temperature sensor, pressure sensor, CCD sensor, etc.)
(18) fuse
(19) RF devices (RF isolators, attenuators, couplers, mixers, circulators, SAW filters, terminators, dividers/combiners, LPFs, HPFs, BPFs, etc.)
(20) Optical (optical modules, fibers, etc.)
(21) MEMS (micro-electro-mechanical systems) parts (switches, gyros, etc.)

## 2. RELATED DOCUMENTS

### 2.1 Reference documents

The latest editions of the following documents are applied to this handbook as reference documents.

(1) AFNOR A89-400: EN-Soldering. measurement of solderability. wetting balance tests method.

(2) ASTM E 595: STANDARD TEST METHOD FOR TOTAL MASS LOSS AND COLLECTED VOLATILE CONDENSABLE MATERIALS FROM OUTGASSING IN A VACUUM ENVIRONMENT

(3) CREME-MC: Cosmic Ray Effects on Micro-Electronics-Monte Carlo

(4) ECSS-Q-ST-30-11: Space Product Assurance - Derating - EEE parts

(5) ECSS-Q-ST-60-13: Space product assurance - Commercial electrical, electronic and electromechanical (EEE) parts

(6) EEE-INST-002: Instructions for EEE Parts Selection, Screening, Qualification, and Derating

(7) ESCC 22900: TOTAL DOSE STEADY-STATE IRRADIATION TEST METHOD

(8) ESCC 24800: Permanence of marking

(9) ESCC 25100: Single Event Effects test method and guidelines

(10) IEC 60068-2-69: Part 2-69: Tests -Test: Solderability testing of electronic parts for surface mounting devices (SMD) by the wetting balance method

(11) J-STD-033: Handling, packing, shipping and use of moisture/reflow sensitive surface mount devices

(12) JAXA QPL/QML: Japan Aerospace Exploration Agency Qualified Parts List/Qualified Manufacturers List

(13) JEDEC JESD57: Test Procedures for the Measurement of Single-Event Effects in Semiconductor Devices from Heavy Ion Irradiation

(14) JERG-0-034: Space Use Organic Materials Outgassing Data Collection

(15) JERG-0-036: Static Electricity Prevention Handbook

(16) JERG-0-039: Standard for Soldering Process for Space Use

(17) JERG-0-040: Standard for Electronic Bonding Process for Space Use - Bonding, Conformal Coating and Potting

(18) JERG-0-041: Standard for Electrical Wiring Process for Space Use

(19) JERG-0-042: Standard for Printed Wiring Boards and Assemblies for Space Use

(20) JERG-0-064: Process standard for space application of lead-free parts

(21) JERG-0-050: Quality Assurance Handbook for Overseas Parts

(22) JERG-0-052: Handbook of the use of Commercial EEE Parts in Space Applications (General Purpose)

(23) JERG-1-010: Handbook for the use of Commercial EEE Parts in Space Applications (Launch Vehicle)

(24) JERG-2-023: Handbook of the use of Commercial EEE Parts in Space Applications (Long Life Satellite)

(25) JERG-2-024: Handbook of the use of Commercial EEE Parts in Space Applications (Scientific Satellite)
(26) JERG-2-212: Wire Derating Standard
(27) JESD22-A101: Steady state temperature humidity bias life test
(28) JESD22-A110: Highly accelerated temperature and humidity stress test
(29) JESD22-A112: MOISTURE-INDUCED STRESS SENSITIVITY FOR PLASTIC SURFACE MOUNT DEVICES
(30) JESD22-A113: Preconditioning of plastic surface mount devices prior to reliability testing
(31) JESD22-B106: Resistance to soldering temperature for through hole mounted devices
(32) JESD22-B116: WIRE BOND SHEAR TEST
(33) JESD26-A : GENERAL SPECIFICATION FOR PLASTIC ENCAPSULATED MICROCIRCUITS FOR USE IN RUGGED APPLICATIONS – RESCINDED
(34) JMR-012: Electrical, Electronic and Electromechanical Parts Program Standard
(35) MIL-HDBK-217: Reliability Prediction of Electronic Equipment
(36) MIL-STD-750: TEST METHOD FOR STANDARD SEMICONDUCTOR DEVICES
(37) MIL-STD-883: TEST METHOD STANDARD MICROCIRCUITS
(38) MIL-STD-1580: DESTRUCTIVE PHYSICAL ANALYSIS FOR ELECTRONIC, ELECTROMAGNETIC, AND ELECTROMECHANICAL PARTS
(39) NPSL: NASA Parts Selection List
(40) NASA-RP-1124: Outgassing Data for Selecting Spacecraft Materials
(41) ISO 19683: Space systems -Design qualification and acceptance tests of small spacecraft and units
(42) UNISEC Outer No. 22-22: Nano-Satellite Mission Assurance Handbook Ver 2.0
(43) ISO17770: Space Systems-Cube Satellites (Cube Sats)

## 3. TERMS, DEFINITIONS AND ABBREVIATIONS

### 3.1 Terms and definitions

The definitions of terms used in this handbook are as follows, and Appendix 1 (Terms and abbreviations) of JMR-012 is also applied.

(1) Space parts: A generic term for parts consisting of standard parts and non-standard parts.
(2) Standard parts: Parts officially qualified by JAXA, MIL/NASA, or ESCC. These parts meet the quality assurance levels (Class I, Class II, Class III) required in the relevant program.
(3) Non-standard parts: Space parts other than standard parts.

(4) Officially qualified parts: Space parts approved by official organizations such as JAXA, MIL/NASA, and ESCC, etc. These parts are registered in the qualified parts list (QPL/QML) published by the respective organizations.

(5) Quality assurance level of parts: A designation that expresses the quality assurance level of parts, which are classified into Class I, Class II, and Class III according to their level of quality assurance.

(6) Memorandum of Understanding: A document that accompanies or precedes the sales contract at the time of a transaction, and is separate from the basic contract, and is written as an agreement between the two parties with a limited scope of details (including partial changes to the contractual content) that are the premise of the transaction, such as the framework for development and quality assurance. Usually signed and sealed by both parties.

(7) EEE parts: An abbreviation of electrical, electronic and electromechanical parts

(8) NDA (Non-Disclosure Agreement): A memorandum of understanding or contract that stipulates the handling of information. (It is desirable that it be a bilateral agreement.)

### 3.2 Abbreviations

Abbreviations used in this handbook are as follows, and Appendix 1 (Terms and Abbreviations) of JMR-012 is also applied.

| Abbreviation | Meaning |
|---|---|
| AEC-Q | Automotive Electronics Council-Qualification |
| APL | Approved Parts List |
| BPF | Band-Pass Filter |
| C-SAM | Constant-depth mode Scanning Acoustic Microscope |
| COTS | Commercial Off The Shelf |
| CTE | Coefficient of Thermal Expansion |
| CVCM | Collected Volatile Condensable Materials |
| DD | Displacement Damage |
| DPA | Destructive Physical Analysis |
| DSC | Differential Scanning Calorimetry |
| Ea | Activation Energy |
| ECSS | European Coordination for Space Standardization |
| EEE | Electrical, Electronic, Electromechanical |
| EPPL | European Preferred Parts List |
| ESCC | European Space Parts Coordination |
| HAST | Highly Accelerated Stress Test |
| HPFilter | High Pass Filter |
| HSD | Hot Solder Dip |
| ITAR | International Traffic in Arms Regulations |

| | |
|---|---|
| ISO | International Organization for Standardization |
| JAXA | Japan Aerospace Exploration Agency |
| JEDEC | Joint Electron Device Engineering Council |
| JESD | JEDEC Standards |
| JIS | Japanese Industrial Standards |
| LAT | Lot Acceptance Test |
| LET | Linear Energy Transfer |
| LETth | Threshold for Linear Energy Transfer |
| LPF | Low Pass Filter |
| MIL | Military |
| MOSFET | Metal Oxide Semiconductor Field Effect Transistor |
| NASA | National Aeronautics and Space Administration |
| NDA | Non-Disclosure Agreement |
| NPSL | NASA Parts Selection List |
| PAPDB | Project Approved Parts Data Base |
| PCT | Pressure Cooker Test |
| PDA | Percent Defective Allowable |
| PED | Plastic Encapsulated Device |
| PEM | Plastic Encapsulated Microcircuit |
| PIND | Particle Impact Noise Detection |
| QMS | Quality Management System |
| PL | Product Liability |
| RF | Radio Frequency |
| RH | Relative Humidity |
| RoHS | Restriction of the use of certain Hazardous Substances |
| RVT | Radiation Verification Testing |
| SAW | Surface Acoustic Wave |
| SDR | System Definition Review |
| SEB | Single Event Burnout |
| SEDR | Single Event Dielectric Rapture |
| SEE | Single Event Effect (classified as SEU, SEL, SEB, SEDR, SEFI, SEGR, SET, etc.) |
| SEFI | Single Event Functional Interrupt |
| SEGR | Single Event Gate Rapture |
| SEL | Single Event Latch up |
| SEM | Scanning Electron Microscope |
| SET | Single Event Transient |
| SEU | Single Event Upset |
| SMD | Surface Mount Device |
| Ta | Ambient Temperature |
| Tg | Glass transition Temperature |

| | |
|---|---|
| THB | Temperature Humidity Bias |
| TID | Total Ionizing Dose |
| TML | Total Mass Loss |

## 4. GENERAL (COMMON) ITEMS

In the development of small satellite and nanosatellites, COTS parts and units originally used in ground commercial equipment are frequently employed. In commercial transactions with part and unit manufacturers, user manufacturers (system and equipment manufacturers) (hereinafter referred to as "user manufacturers") conduct program activities for parts and units to meet mission objectives.

For the use of COTS parts and units that are used in ground commercial equipment, coordination with part and unit manufacturers (hereafter referred to as “parts manufacturers”) is conducted on the premise that the user manufacturer assumes full responsibility for their use in the space environment.

### 4.1 Concept and basic flow of space application

In the revision of JERG-0-052B in FY2023, previous positioning of COTS parts as supplements to standard parts was redefined, and guidelines for the space application of COTS parts were provided. In the revision, small satellite and nanosatellites were added to the satellite classification, which led to the establishment of this guideline.

In small satellites and nanosatellites as well, in order to improve mission success rates, highly reliable parts and units are selected from among those used for ground applications. Therefore, it is desirable to select parts by referring to the space-applicable parts described below.

All parts other than space parts are classified as follows, and all parts except (4), are referred to as “space-applicable parts”. (Note1)

In addition, the following (4) consumer-use parts can be applicable for small satellite and nanosatellite, by considering circuit design (current limiting circuits, error correction code, etc.), operating environment and proven parts (Note2) etc., although they are classified as non-space-applicable parts in JERG-0-052.

(1) High-reliability parts: submarine cable parts, nuclear power parts, aircraft parts, radiation hardness PEM parts (Note3)
(2) Automotive parts: Powertrain, brakes, airbags, etc. (parts directly affect safety)
(3) Industrial parts: Plant equipment/infrastructure, etc. (large impact in case of failure)
(4) Consumer-use parts: Home appliances, etc. (small impact in case of failure)

(Note1) Refer to Figure 4.1-1 “Concept of space applications for space-applicable parts” of JERG-0-052 “Handbook of the use of Commercial EEE Parts in Space Applications (General Purpose)”

(Note2) Proven parts are those that have been selected as flight parts or flight candidate parts and have similar circuit designs and operating environments (hereinafter referred to as “proven parts”).

(Note3) This also includes enhanced plastic (EP) parts developed by semiconductor manufacturers for use in low-earth orbit satellites, based on automotive parts and enhanced with radiation hardness and other space-relevant features.

Figure 4.1-1, " Basic flow of space-applicable parts for space applications (reference)," is a reference for conducting commercial transactions with part and unit manufacturers. In this flow, it is desirable to inform the part manufacturer that the space-applicable parts are under the user manufacturer's responsibility.
Note that "user (system manufacturer/equipment manufacturer)" in Figure 4.1-1 should be read as "user manufacturer”.
In addition, although this figure shows the flow to apply for NSPAR, another method of approval or omission is possible depending on the project policy.

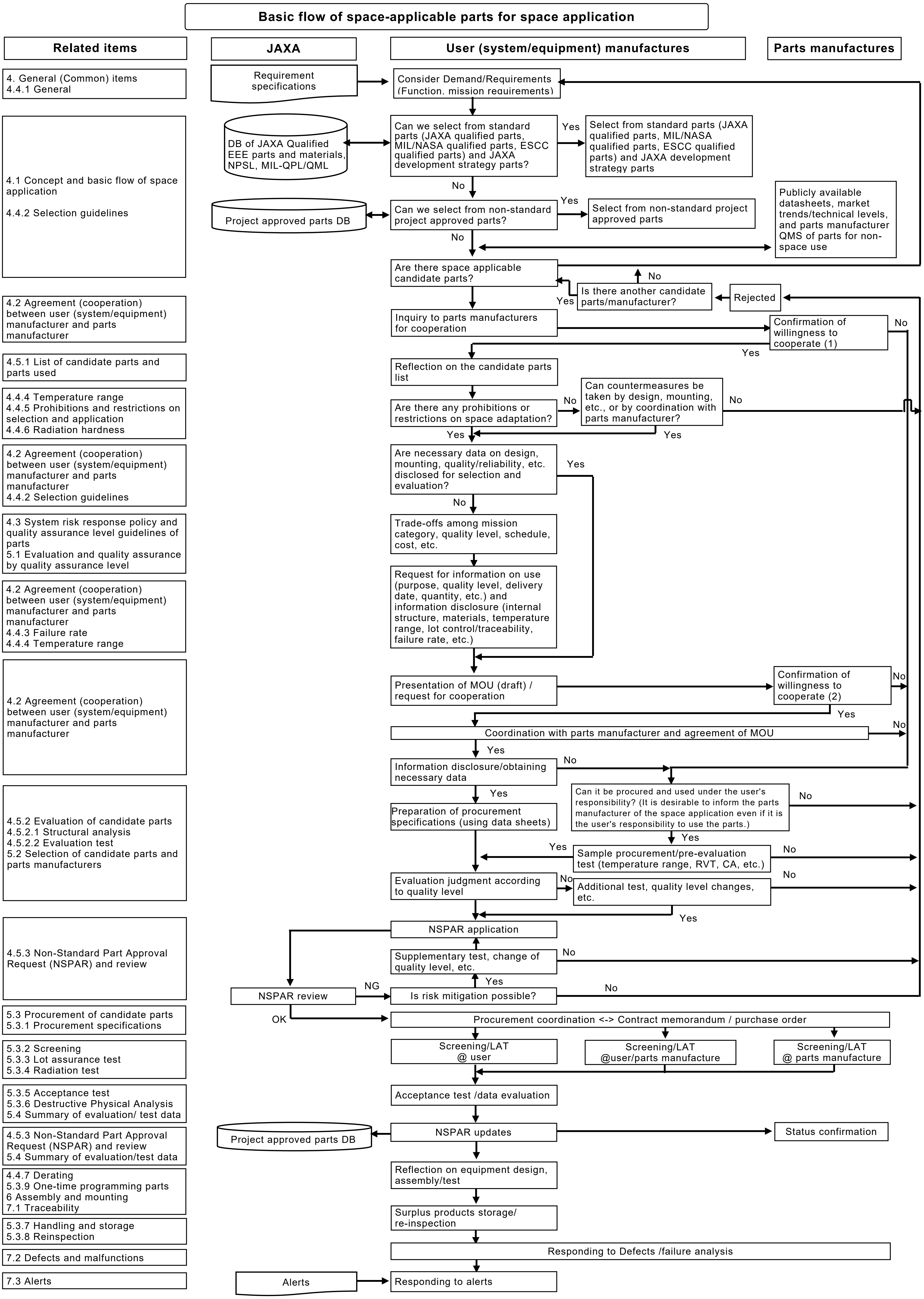


Figure 4.1-1 Basic flow of space-applicable parts for space application (reference)

### 4.2 Agreement (cooperation) between user manufacturer and parts manufacturer (supplier)

The parts manufacturers have prepared handling instructions as shown in Figure 4.2-1 and Figure 4.2-2, in accordance with customary regulations such as the Product Liability (PL) Law. Since prior written approval is required for use in specific applications such as space equipment, it is desirable for user manufacturers to respond to the requests from parts manufactures.

On the other hand, user manufacturers often face situations where detailed data necessary for selecting and evaluating candidate parts, such as design, implementation, quality/reliability, etc., are not publicly available. Therefore, when considering use in space equipment, it is desirable for user manufacturers to provide the information listed below to the parts manufacturers and to request relevant data for preliminary evaluation.

(1) Presentation of information on use (purpose of use, quality assurance level, application conditions, delivery date, quantity, etc.)

(2) Request for disclosure of information necessary for prior evaluation (internal structure, materials used, temperature range, lot control/traceability, failure rate, etc.)

For “specific coordination and consultation procedures for information disclosure”, “information to be presented by the user (system/equipment) manufacturer to the parts manufacturer” and “Survey sheet for space application evaluation” required for prior evaluation, “integrated circuits/discrete semiconductors” are shown in the following table as typical examples.

| Discussion details | Integrated circuits/discrete semiconductors |
|---|---|
| Specific coordination and consultation procedures for information disclosure | Refer to Table 4.2-1 |
| Information to be provided by the user (system/equipment) manufacturer to the parts manufacturer | Refer to Table 4.2-2 |
| Survey sheet for space application evaluation | Refer to Table 4.2-3 |

However, these are only examples, and the survey items required by the risk response policy classification of the system and the survey items that can be handled by each parts manufacturer are considered to be different. Therefore, it is desirable to consider the necessary survey items and to coordinate with parts manufacturer. Furthermore, it is desirable to clarify the following items to establish cooperative relationship between the two parties.

(1) Target part number or the series and/or identical structural components
(2) Purpose of use for space applications, quality assurance level, and application conditions
(3) Delivery date, quantity (minimum sales quantity), and whether it is a one-time (bulk purchase) or repeated purchase
(4) Information disclosure (internal structure, materials used, operating temperature range, process flow, lot control/traceability, failure rate, reliability data, radiation hardness, lead finish, etc.)
(5) Establishment of part specifications (including lot definition, traceability, etc.) according to quality assurance level
(6) Screening test/Lot Assurance Test (LAT) and cost sharing (user, user/ parts manufacturer sharing the cost, and parts manufacturer dependent)
(7) Contracts between manufacturers/sharing of responsibility, disclaimers, etc.
(8) Defects/complaints/failure analysis
(9) Handling, storage, reinspection, advice on mounting technology (e.g., handling of lead-free terminal)
(10) Notification of design and manufacturing process changes (and manufacturing discontinuation)
(11) Confidentiality

Cautions

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Standard level: Computers, OA equipment, communication equipment, measuring equipment, AV equipment, home appliances, machine tools, personal equipment, industrial robots

High quality level: Transportation equipment (automobiles, trains, ships, etc.), traffic signal equipment, disaster prevention/crime prevention equipment, various safety devices, medical devices not designed for artificial life support (equivalent to controlled medical devices as defined by the Ministry of Health, Labor and Welfare)
Specific level: Aeronautical equipment, aerospace equipment, submarine relay equipment, nuclear power control systems, medical devices for artificial life support (life-support devices, devices to be implanted in the human body, devices to perform therapeutic actions (such as cutting out affected areas), and other devices that directly affect human life) (equivalent to highly controlled medical devices defined by the MHLW) or System, etc.
8. Ensure that usage conditions are within the ranges specified by the Company with respect to maximum ratings, operating power supply voltage range, heat radiation characteristics, mounting conditions, and other various conditions must be used within the range of our warranty. We disclaim any and all liability for any failure or accident arising out of the use of our products beyond such specified ranges.
9. Although we endeavor to improve the quality and reliability of our products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. In addition, our products are not designed for radiation hardness. In the event of failure or malfunction of our products, customers are responsible for safety design such as redundancy, fire control, malfunction prevention, and appropriate treatment for aging process, etc., to prevent accidents resulting in death, fire, or social damage, and to ensure that the equipment or system is guaranteed to be shipped properly. Since it is difficult to evaluate microcomputer software alone, we request that customers evaluate the safety of the final products or systems manufactured by the customer.
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Note 2: “Our products” as used in this document refers to products developed and manufactured by Renesas as defined in Note 1.

Source: Renesas Electronics Corporation, from the notes in the catalog.
https://www.renesas.com/jp/ja/document/oth/680296

Figure 4.2-1 Handling precautions example 1 (Underlined parts refer to specific applications)

- Unless otherwise agreed to in a separate written agreement or specification agreed to by you and us, we make no warranties of any kind, either express or implied, with respect to the Product and the Technical Information, including, but not limited to, warranties of functional operation, merchantability, fitness for a particular purpose, accuracy of information, or non-infringement of third party rights.
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Source: Toshiba Corporation, Requests for Product Handling in Product Catalog
https://toshiba.semicon-storage.com/info/2SC5065_datasheet_ja_20140301.pdf?did=17645&prodName=2SC5065

Figure 4.2-2 Handling precautions example 2 (Underlined parts refer to specific applications)

Table 4.2-1 Example of specific coordination and consultation procedures for information disclosure (integrated circuits/discrete semiconductors)

| Step No. | Item | Contents, etc. |
|---|---|---|
| 1 | Inquiries to parts manufacturer | Inquire about the availability of the product by presenting the items listed in Table 4.2-2 (1, 2, and 3) at minimum. |
| 2 | Conclusion of NDA (Non-Disclosure Agreement) | Conclude NDA to provide more specific mutual information. |
| 3 | Presentation of information from user manufacturer | Provide all the information listed in Table 4.2-2 and inquire about supply availability or recommended parts. |
| 4 | First response from the parts manufacturer | Verify availability of supply or information. |
| 5 | （As needed）<br>Coordination for the conclusion of the Memorandum of Understanding (MOU) | As needed, conduct verification and coordination of responsibility sharing, disclaimers, cost sharing, and whether the same information as the information requested for disclosure can be maintained (i.e., whether it will be changed in the future).<br>In this case, it is at the level of a series/item with the same structure, not an individual part.<br>Then, present information which is necessary to evaluate usability in space applications (survey sheet: refer to Table 4.2-3) and coordinate its availability. |
| 6 | (As needed)<br>Conclusion of MOU | As needed, it is desirable to conclude MOU with an expiration date after documenting what was coordinated. |
| 7 | Survey sheet for space application evaluation (Refer to Table 4.2-3) | It is desirable that the user manufacturer requests information limited to the contents which is defined in the MOU by using the survey sheet to determine usability in space applications.<br>It is desirable that parts manufacturer responds to the survey sheet to the extent possible. |
| 8 | Information provided by parts manufacturer | The user manufacturer obtains the response of the survey sheet from the parts manufacturer and determines usability in space applications. |
| 9 | Evaluation of samples<br>(If possible) | It is desirable to obtain pre-evaluation samples from parts manufacturer and evaluate the usability in space applications. (Including structural analysis to obtain information not available from parts manufacturer) |
| 10 | Evaluation test<br>(If possible) | Conduct necessary evaluation tests to verify parts usability in space applications.<br>This test is conducted when it is determined from the results of No. 9 that the reliability of the equipment will be affected. |
| 11 | Parts procurement | As needed, conduct screening test and lot assurance test.<br>However, it may be at the level of a series/item with the same structure, rather than at the level of individual parts. Based on the data obtained from the evaluation test No. 10, this proof test can be omitted. |

Table 4.2-2 Example of information presented by user manufacturer to parts manufacturer

| No. | Item | Contents, etc. |
|---|---|---|
| 1 | Purpose of use | Small satellite and nanosatellite types (refer to Table 4.3-1, system risk response policy and parts quality assurance level guidelines) |
| 2 | Quality assurance level of target parts | Classification in catalogs of parts manufacturers for high reliability, automotive, industrial and consumer-use parts. |
| 3 | Target part number (model number) | Part numbers, etc. as listed in the parts manufacturer's catalog |
| 4 | Conditions of operating environment | |
| | (1) Operating temperature range | -30 to +60℃, etc. However, this depends on the requirements of the equipment. |
| | (2) Storage temperature range (non-operating) | -40 to +105℃, etc. However, this depends on the requirements of the equipment. |
| | (3) Environmental conditions | Thermal and mechanical environmental conditions, test items and methods, etc. |
| | (4) Mounting method | Manufacturing methods and applicable solder materials of hand-applied or reflow |
| 5 | Delivery date | Procurement period |
| 6 | Quantity | Procurement quantity |
| 7 | Prospects for continuous use | Indicates the estimated re-procurement after the procurement period indicated by the delivery date. |
| 8 | Applicable documents, etc. | Provide applicable documentation as needed. (AEC-Q, etc.) |
| 9 | Export of equipment used | Whether the equipment used is exported or not (including spare parts) |

Table 4.2-3 Example of survey sheet for space application evaluation (for integrated circuits/discrete semiconductors)/ filled out by parts manufacturer

| No. | Item | Contents | Parts manufacturer's response (Note) |
|---|---|---|---|
| 1 | Company name | Companies holding sales rights and companies in charge of manufacturing | |
| 2 | Part number (Model name) | Catalog part Number or model name | |
| 3 | Development and production status | (1) Main applications | |
| | | (2) Delivery or production history | Production started in MM/YY<br>Quantity of current monthly production: |
| | | (3) Production method (planned production-ship from inventory or production on order) | |
| | | (4) Typical delivery time | months, weeks |
| | | (5) Continuation of production<br>- Product with identical design<br>- Product with equivalent performance | - Identical design: Until year_____<br>- Equivalent performance: Until year__ |
| 4 | Available quality assurance | Choose one of the following.<br>A: Catalog type; only the quality specifications provided by the parts manufacturer<br>B: Semi-custom; Design and manufacturing are the same as for catalog products, but special testing or control systems required for space applications can be implemented for some or all in-process inspections, etc.<br>C: Other (Describe specifically) | |
| 5 | Submission of delivery specifications | Can delivery specifications describing externals, dimensions, functions, characteristics, inspection reports, packaging specifications, etc. be submitted? | Yes / No |
| 6 | Exports | Is export of spare parts alone or of embedded equipment possible? Are there any restrictions on such export? | Yes / No<br>If there are any restrictions, Separate sheet should be attached |
| 7 | Product marking | Including indicators, part numbers, inspection lot numbers, serial numbers, etc., and the assigning method of lot symbols, etc. | Separate sheet should be attached |
| 8 | Packaging label | Model number, lot number, shipping date, etc. | Separate sheet should be attached |
| 9 | Packing method (Yes or No) | Can actions be taken for ESD (electrostatic discharge)? | Yes / No |

(Note) If you wish to refrain from responding, please write "non-disclosure".

Table 4.2-3 Example of survey sheet for space application evaluation (for integrated circuits/discrete semiconductors)/ filled out by parts manufacturer (Cont.)

| № | Item | Contents | Parts Manufacturer's Response Column (Note) |
|---|---|---|---|
| 10 | Reliability evaluation results | Test items, conditions, pass/fail criteria, and test results for thermal and mechanical environment, life, electrostatic strength, radiation hardness, etc. | Separate sheet should be attached |
| 11 | Failure rate estimation | Specify total conditions (calculated or actual) such as number of fits required for reliability calculation | |
| 12 | Recommended derating value | Not required if presented as recommended operating conditions | |
| 13 | Long-term storage | The period of re-inspection of inventory items stored for a long period of time after completion of final inspection or quality conformance inspection, and the inspection items and their conditions to be conducted at the time of shipment. | |
| 14 | Performing testing, etc. (Yes or No) | Can additional evaluation tests set by the procurer be accepted? (Burn-in (screening), life test, functional test, DPA, etc.) | Yes / No |
| 15 | Support at the time of WCA study (Yes / No) | Can the support be provided when specific events are presented by the procurer. (Specific details will be requested after the design is in progress.) | Yes / No |
| 16 | Failure analysis at the time of failure | Can advice in failure analysis be provided, can function test, DPA, etc.be performed? | |
| 17 | Legally regulated substances | Existence of substances to be handled with caution, such as BeO, Cd, Li, Mg, Hg, Zn, radioactive substances, etc. | |
| 18 | Others | - Special precautions (if necessary)<br>・Fixing method (e.g. tightening torque, etc.)<br>・Cleaning method (e.g. no water rinsing)<br>・Soldering method (e.g. no reflow) | |

(Note) If you wish to refrain from responding, please write "non-disclosure".

### 4.3 System risk response policy and part quality assurance level guidelines

When applying candidate parts for small satellite and nanosatellite to space applications, it is necessary conduct system FMEA (Failure Modes and Effects Analysis) and to select parts and determine their quality assurance levels, taking into consideration system risk response, operational lifetime, short development schedules, and cost reduction.

Based on the risk response policy that only critical risks are managed, it is desirable to apply the Class I to Class III (including standard and non-standard parts) indicated below.

Parts selection and evaluation may be made more efficient by taking into consideration the development period and by making use of proven heritage and data already obtained by the part manufacturers.

"Proven parts" refer to parts that have been selected either as flight-proven or flight-candidate parts, and whose circuit design and operating environment are similar to the intended application. This approach is also desirable when selecting internal parts of a unit.

Table 4.3-1 "Guidelines of system risk response policy and parts quality assurance level" is provided as a reference for parts selection.

Small satellite and nanosatellite are categorized under classification D-1 and D-2. Based on risk assessments conducted for each equipment, quality assurance levels with three classes (Class I to Class III) are defined.

The quality assurance level of parts in this table corresponds to JMR-012 (Class I, Class II, and Class III specified in section 5.1.2), and the quality assurance level of non-standard space-applicable parts are also classified into the following three types.

(1) Class I equivalents are at the highest assurance level with the lowest risk. Procurement costs are generally the highest in Class I (Class I: Minimal risk, evaluated and thoroughly tested at the time of evaluation/procurement, and the basic quality and reliability level of non-standard space-applicable parts in this class is comparable to that of space parts).

(2) Class II equivalents are intermediate between Class I and Class III (in accordance with Class II (risk/cost compromise), limited screening tests are performed).

(3) Class III equivalents are at the lowest assurance level with the highest risks. Procurement costs are lowest in Class III (in accordance with Class III (Cost Control), evaluation and procurement testing will be limited).

Comparison of quality assurance levels equivalent to Class I, II, III for typical examples of integrated circuits and discrete semiconductors is shown in Figure 4.3-1 Comparative Summary of Quality Assurance Levels (Class I, II, III Equivalent). This figure summarizes the contents of each screening test (Tables 5.3.2-1 to 5.3.2-3), and lot assurance test (Tables 5.3.3-1 to 5.3.3-3 Figures 5.3.3-1 to 5.3.3-3).

(Reference) The guidelines are described in section 5 of the Annex to JMR-012 "Electrical, Electronic, and Electromechanical Parts Program Standard" for three classes (Class I, Class II, and Class III) stipulated in section 5.1.2 of JMR-012 and the tailoring of the system's risk response policy.

(Note) Please contact the JAXA Safety and Mission Assurance Department to obtain the Annex.

Table 4.3-1 Guidelines of system risk response policy and parts quality assurance level (Details are based on equipment requirements)

| | Classification symbols | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | D-1 | D-2 | E | F |
| System risk response policy | Minimize risks | Reduce risks | Control risks | Control only critical risks | Control only critical risks | Control risks | Control risks |
| Operation period | More than 7 years | 3 to 7 years | 1 to 5 years | 1 to 3 years | About 1 year | Several hours | 1 to 3 years |
| Part selection (Note 1) | Reliability is the top priority. | Emphasizing reliability. | Cost and performance oriented | Cost and performance oriented | Cost top priority | Cost priority | Emphasizing reliability (1 fail-operation, 2 fail-safe as a system) |
| Example of spacecrafts | Long-life spacecraft (communication, positioning, meteorological satellites, etc.) | Medium-lifetime spacecrafts (such as Earth observation and deep space exploration) | Scientific satellites (astronomical observation / planetary exploration, etc.) | Small satellites (e.g., LEO constellation satellites) | Nanosatellites (technology demonstration, research and development satellites, etc.) | Launch vehicle | H-II Transfer vehicle |
| Quality assurance level of parts (Note 1) | Class I standard parts | Class I, II standard parts | Class I, II, III standard parts | Class I, II, III standard parts | Class II, III standard parts | Class I, II, III standard parts | Class I, II, III standard parts |
| | Class I non-standard parts | Class I, II non-standard parts | Class I, II, III non-standard parts<br>Consumer-use parts | Class I, II, III non-standard parts<br>EP parts for LEO<br>Consumer-use parts (Note 2) | Class II, III non-standard parts<br>EP parts for LEO<br>Consumer-use parts (Note 2) | Class I, II, III non-standard parts<br>Consume-use parts (Note 3) | Class I, II, III non-standard parts |
| Handbook of the use of Commercial EEE Parts in Space Applications | JERG-2-023 (long-life spacecrafts) | None | JERG-2-024(Scientific satellite) | JERG-2-027 (Small Satellite, Nanosatellite) | JERG-2-027 (Small Satellite, Nanosatellite) | JERG-1-010(Launch vehicle) | None |

(Note 1) Judgments are made according to criticality based on the implementation of FMEA (Failure Modes and Effects Analysis).

(Note 2) Consumer-use parts classified as non-space-applicable parts in JERG-0-052 may be applicable for space use under JERG-2-027 considering the circuit design and usage environment.

(Note 3) For the scientific satellite and launch vehicle editions, commercial parts may also be adapted for space use, depending on the project's judgment.

| | Class I | Class II | Class III |
|---|---|---|---|
| **Evaluation test (The temperature conditions for each test should depend on the rating of the applicable part.)** | All<br>- Structure analysis<br>- Electrical characteristics (room, high and low temperatures +10°C margin)<br>- Pre-condition + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1]<br>- Life test 2000h, 125°C +DPA<br>- Preconditioning + 500 thermal cycling -55°C /+125°C<br>- Radiation hardness evaluation (TID, SEE)<br>- Outgassing test | All<br>- Structure analysis<br>- Electrical characteristics (room, high and low temperatures +10°C margin)<br>- Pre-condition + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1]<br>- Life test 2000h, 125°C +DPA<br>- Preconditioning + 500 thermal cycling -55°C/+125°C<br>- Radiation hardness evaluation (TID, SEE)<br>- Outgassing test | Limited<br>- Structure analysis<br>- Radiation hardness evaluation (TID, SEE)<br>- Outgassing test |
| **Support documents** | Data collection<br>- Parts manufacturer data<br>- Approval status<br>- Evaluation test<br>- Procurement Inspection & Testing<br>- Lot assurance testing<br>- Radiation hardness test data | Data collection<br>- Parts manufacturer data<br>- Approval status<br>- Evaluation test<br>- Procurement Inspection & Testing<br>- Lot assurance testing<br>- Radiation hardness test data<br>Data collection<br>Various test data (life tests, etc.) used to reduce the screening tests.<br>Data at the series or same-structure level is acceptable, rather than for individual parts. | Data collection<br>- Parts manufacturer data<br>- Approval status<br>- Evaluation test<br>- Procurement Inspection & Testing<br>- Lot assurance testing<br>- Radiation hardness test data<br>Data collection<br>Various test data (life tests, etc.) used to reduce screening tests.<br>Data at the series or same-structure level is acceptable, rather than for individual parts. |
| **Screening test (The temperature conditions for each test shall depend on the rating of the applicable part.)** | ALL<br>- X-ray examination<br>- 10 Thermal cycling -55°C/+125°C<br>- PIND test [2]<br>- Intermediate electrical test @25°C<br>- Dynamic Burn-in 240h, 125°C<br>- Final electrical tests (room, high and low)<br>- PDA (5%)<br>- Hermeticity [2]<br>- External visual inspection<br>Depending on the parts concerned, it may be considered only X-rays examination and external visual inspection as test items (Note). | Limited (if data available)<br>- PIND test (if applicable)<br>- Hermeticity (if applicable)<br>+If there is no data<br>- 10 Thermal cycling -55°C/+125°C<br>- Intermediate electrical test @25°C<br>- Dynamic Burn-in 240h, 125°C<br>- Final electrical tests (room, high and low)<br>- PDA (5%)<br>- External visual inspection<br>Depending on the parts concerned, it may be considered only external visual inspection as test items (Note). | Limited (if data available)<br>- PIND test (if applicable)<br>- Hermeticity (if applicable) |
| **Lot assurance test** (When applied to parts used in screening tests) **(The temperature conditions for each test shall depend on the rating of the applicable part.)** | **All**<br>- Structure analysis<br>- Preconditioning + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1]<br>- Life test 2000h, 125℃+DPA<br>- Preconditioning + 100 thermal cycling -55℃/+125℃<br>- Radiation hardness test | **All** (However, the life test is 1000h)<br>- Structure analysis<br>- Preconditioning + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1]<br>- Life test 1000h, 125℃+DPA<br>- Preconditioning + 100 thermal cycling -55℃/+125℃<br>- Radiation hardness test | **Limited (if data available)**<br>- Structure analysis<br>- Radiation hardness test<br>+If there is no data<br>- Preconditioning + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1]<br>- Life test 1000h, 125℃+DPA<br>- Preconditioning + 100 thermal cycling -55℃/+125℃ |

[1] Applicable to PEM (Plastic Package) [2] Applicable to Hermetic Package

Note: Depending on the applicable parts, the items shown in the example (dynamic burn-in, etc.) may not be implemented, and the test items need to be thoroughly examined.
The above test conditions are described as a representative example with reference to the following document.
・ECSS-Q-ST-60-13 : Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components

This figure is a summary of the contents of each quality assurance level (equivalent to Class I, II, III) described in section 5.3.2 “Screening test” (Tables 5.3.2-1 to 5.3.2-3), and section 5.3.3 “Lot assurance test” (Tables 5.3.3-1 to 5.3.3-3, Figures 5.3.3-1 to 5.3.3-3) described below.
Refer to the tables and figures for details.

Figure 4.3-1 Comparative summary of quality assurance levels (Class I, II, III equivalent) (Typical examples of integrated circuits and discrete semiconductors)

### 4.4 Common items regarding selection guidelines and prohibitions/restrictions

#### 4.4.1 General

It is desirable for user manufacturers to check the following items at the initial stage of selecting candidate parts.

(1) Project requirements (e.g., quality assurance level, parts selection policy, manufacturing and shipping schedules and budgets, quantity)

(2) Design requirements (e.g., part type, function/performance, temperature range, package, dimensions, materials)

(3) Manufacturing requirements (e.g., packaging, heat and storage constraints, parts mounting processes)

(4) Operational requirements (e.g., electrical, mechanical, thermal, radiation hardness, reliability, assembly, and service life)

#### 4.4.2 Selection guidelines

It is desirable that user manufacturers refer to the following items as guidelines for selecting candidate parts.

(1) From the initial design stage of the project, the necessity, evaluation factors, and procurement and quality assurance plans will be examined, and effective reduction of parts type and standardization should be promoted.

(2) When selecting candidate parts, the latest data of the parts manufacturer, information on the applicability of qualification including AEC-Q, defect notifications, warnings, and the appropriateness of use should be verified, and parts that require less effort for evaluation and quality assurance should come first.

(3) For the evaluation of candidate parts, data on the parts and parts manufacturers should be collected.

(a) Indication of parts

(b) Mechanical details

(c) Electrical and thermal details

(d) Others

(4) Parts and technologies with a commercialization maturity of less than one year should be selected with due consideration given to their specificity. Then, an evaluation plan should be examined in consideration of potential failure modes and failure mechanisms.

(5) The procurement of imported parts subject to export restrictions or regulations of the country of origin is not recommended.

(6) For procurement of imported parts, JERG-0-050 Quality Assurance Handbook for Imported Parts should be used.

(7) When procuring parts continuously such as for constellation satellites, investigate information on depleted parts, and in principle, parts that are likely to be depleted should not be selected.

(8) Even though the general approach of this handbook is applied, the techniques and practical conditions obtained from the structural analysis should be considered for the details of additional test such as screening test, etc. (The test conditions are desirable to be as close to actual use as possible.)

(9) When using parts that are expected to generate high heat, consider heat dissipation in a vacuum environment.

### 4.4.3 Failure rate

The failure rate data (e.g., reliability test and/or field failure rate data) of candidate parts used for reliability analysis and their sources should be identified.

### 4.4.4 Temperature range

The operating temperature range of candidate parts should be determined with consideration of the following items.

(1) It is recommended to provide a margin of 10°C above and below between the actual operating temperature range (including the worst case) and the maximum/minimum operating temperature range specified by the parts manufacturer. (Example: In JERG-0-052, ff the maximum/minimum operating temperature range specified by the parts manufacturer is -20°C to +85°C, the actual operating temperature range of the part will be -10°C to +75°C by setting a margin of 10°C above and below.)

(2) Use outside the operating temperature range guaranteed by the part manufacturer is not recommended.

### 4.4.5 Prohibitions and restrictions on selection and application

It is desirable to refer to the following items when selecting candidate parts and considering operational prohibitions or constraints; however, omission of these items may involve risks.

(1) If application restrictions are specified in the part specification, NPSL, etc., it is preferable to apply those restrictions. Application restrictions in the NPSL can be found in the "Important! Application Notes" of the NPSL (http://nepp.nasa.gov/npsl/) for each applicable part type.

(2) If restrictions on part application are specified in equipment design specifications or related documents, it is preferable to apply those restrictions.

(3) It is preferable to apply parts with consideration of the required conditions so that equipment functions and performance are not degraded by wear or deterioration due to operation, thermal cycling, radiation environment, or other factors during the required service life. Limited-life items are preferably managed appropriately.

(4) Due to limited lifetime, known instability, safety concerns, or reliability risks, it is preferable not to select or use the following parts.

(a) Hollow-core resistor: Due to the corrosive effects of contamination

(b) Potentiometers (except mechanical position monitoring type): Due to fluctuation with mechanical temperature changes.

(c) Non-metallic bonded (non-metallurgically bonded) diodes: Since the connection is unstable and there is a risk of open failure.

(d) Semiconductors and integrated circuits with unprotected active regions: Due to changes in characteristics occur during use

(e) Wet slag tantalum capacitors other than double-sealed, tantalum case structures (aluminum electrolytic capacitors, silver case wet slag tantalum capacitors, etc.): Since there is a risk of loss of capacity due to evaporation of the liquid

(f) Parts whose internal structure is metal bonded at a melting temperature that does not conform to the mounting conditions of the end application.: Since there is a risk that the internal connections may melt due to heat during mounting.

(g) Prohibited from use of wire-link fuses less than 5A: Since it is a thin wire and tends to melt easily.

(h) Relays in which armature/coil assemblies and headers not double-welded: Susceptible to mechanical influences

(i) Use of TO5 relays in which integrated diodes are included: Since it is susceptible to radiation in the space environment

(j) RNC90 type resistors of 100 kΩ or more: Since highly reliable manufacturing is difficult (Refer to Application Notes For MIL-PRF-55182-5 of NPSL) (http://nepp.nasa.gov/npsl/Resistors/55182/55182aps.htm)

(5) Since terminals of the ground use parts are finished with pure tin plating, it may cause whiskers. It should be verified that the suppression of whisker generation is evaluated. If appropriate treatment to prevent whisker generation (such as solder coat "HSD" or "over-plating") is not performed, it is necessary to consider using the above-mentioned parts with conformal coating in accordance with the " Process standard for space application of lead-free parts " (JERG-0-064), which evaluates the effectiveness of coating in suppressing whisker formation.

(6) For health and safety reasons, it is preferable to avoid the use of beryllium oxide (unless specified in procurement specifications), cadmium, lithium, magnesium, mercury, zinc, radioactive materials, and any materials that may pose safety concerns. This does not apply to cases where such materials are contained in alloys used as a mechanical material.

(7) It is desirable to use hermetically sealed type for relays, thermostats and switches to avoid contact failure due to contact oxidation. (Excluding coaxial switches and waveguide switches).

(8) Materials that are not hermetically sealed should be used with caution regarding off-gassing, flammability, and toxicity. Especially, organic materials

with low outgassing are desirable for use in a vacuum, unless those materials are hermetically sealed. Refer to JERG-0-034 "Data on Outgassing of Organic Materials for Space Use" and NASA-RP-1124, etc., and in principle, it is desirable to use the following values or less. If materials larger than this value are used, or if adverse effects from outgassing are expected, it is desirable to implement effective protective measures.

(a) Total Mass Loss (TML): 1.0%

(b) Collected Volatile Condensable Materials (CVCM): 0.1%

If there is no outgassing data, it is desirable to perform outgassing test to acquire the necessary outgassing data.

(Note) JAXA Material Database: https://matdb.jaxa.jp/

(9) When conformal coating is applied to surface-mounted parts, it is necessary to consider spray coating instead of brush coating, etc., because cracks may occur due to stress caused by uneven thickness.

(10) In non-hermetic semiconductor devices, if there are voids or un-joined parts at the junction (primary mounting part) of the semiconductor chip-bonding wire or bump, moisture is likely to penetrate, and corrosion may be noticeable (evaluation data: JERG-0-052-TM001). Therefore, it is recommended to refer to section 5.3.7 “Handling and Storage in humidity environment” at the time of storage, and to appropriately control the humidity. If there is any doubt about the humidity environment, SEM observation of the joint cross-section is recommended as a method to verify the presence of voids and un-joined parts at the joint. As a result, if there are voids or un-joined parts at the joints and the possibility of part defects due to corrosion cannot be eliminated, it is recommended to evaluate the progress of corrosion and confirm whether there is a problem in the operation of the spacecraft to be installed.

(11) If payload requirements are specified by the launch vehicle, they should be complied with.

(e.g.) Metal material corrosion, particulate generation, etc.

### 4.4.6 Radiation hardness

Radiation sensitive parts should be selected and applied with sufficient consideration of degradation due to radiation environment in orbit (cosmic rays (heavy particles), electromagnetic radiation, captured radiation (charged particles - electrons and protons in the radiation belt), and solar radiation (flares)).

Special consideration is needed for the following matters, but since the radiation environment varies depending on the orbit, mission duration, etc., details should follow the project-specific requirements.

If a radiation test is determined to be necessary, section 5.3.4 should be followed.

(1) Total dose (TID) and displacement damage (DD)

(a) Total dose

The total dose is based on the dose-depth curve of the project-specific requirements, and the parts that can withstand the total dose (in consideration of Al equivalent shield thickness) applied with a safety factor of 1.25 times (Note) as a design margin, (in the Stress-strength model, the lower limit of 3σ strength divided by the upper limit of 3σ stress) should be selected. In addition, bipolar and BICMOS, which may be sensitive to ELDRS (Enhanced Low Dose Rate Sensitivity), should be selected in consideration of their TID tolerance.

(Note) The consideration of the safety factor depends on the individual project requirements.

(b) Displacement damage (DD)

Caution must be taken regarding the effects of parts (optocouplers, etc.) that cause displacement damage due to protons.

(2) Single Event Effects (SEE)

For single event effects, parts that will not affect mission under the heavy particles in orbit, proton environments, and applied derating condition should be selected.

SEE: includes the following:
SEL: Single Event Latchup
SEU: Single Event Upset
SEB: Single Event Burnout
SEGR: Single Event Gate Rupture
SET: Single Event Transient
SEFI: Single Event Functional Interrupt.

(a) For SEL, parts with a threshold LET (Linear Energy Transfer) higher than the lower limit specified in the project-specific requirements are desirable for use. When using a part with a lower threshold LET, it is desirable to implement either latch-up protection circuits or a watchdog timer function capable of recovering from processor latch-up before the event results in a complete and permanent failure, as a protective measure.

(b) For SEU mitigation, parts with a threshold LET higher than the minimum value specified in the project-specific requirements are used. When using parts with a lower threshold LET, it is desirable to take protective measures (including no measures) according to the predicted SEU occurrence probability (Note) and the assessment results of the impact on the mission.

(Note): CRÈME-MC published by Vanderbilt University or SPENVIS published by ESA can be used as tools for SEU occurrence probability prediction. For analysis during periods when solar flares do not occur, it is recommended to use the CREME96 solar quiet condition model, the worst-week model for solar flare occurrences, and SPENVIS JPL91 or ESP-PSYCHIC for long-term analysis that includes the presence of solar flares. For long-term analysis including the presence of solar flares, it is recommended to use SPENVIS' JPL91 or ESP-PSYCHIC.

(c) The power MOSFETs in which SEB and SEGR occur should be within the SEE safe operating area and within the applicable derating standards, and parts should be selected so as not to affect the mission.

(d) Linear integrated circuits in which SET and SEFI occur should be selected in consideration of the effects of temporary transients and functional interruptions, or countermeasures should be taken in the circuit design. (current limiting circuits, Error Correction Code, etc.).

(3) Extraction of radiation-sensitive parts

Prior to part procurement, the user manufacturer is recommended to collect and evaluate information related to radiation-sensitive parts. For each part, radiation hardness data and their sources should be identified and used for part procurement, test planning, and radiation hardness analysis of the equipment.

### 4.4.7 Derating

Derating is intended to improve the reliability of parts and extend their operational lifetime (i.e., to reduce the failure rate). It refers to the practice of operating parts with additional margin relative to their allowable limits (rated conditions).

By applying appropriate derating, in addition to the aforementioned purpose, the design can withstand unexpected situations such as momentary increases in current or voltage.

Therefore, in order to satisfy the reliability and lifetime requirements of the equipment, it is desirable to apply appropriate derating design to the parts.

It is desirable to establish derating criteria with reference to EEE-INST-002, GSFC PPL-21 Appendix B or ECSS-Q-ST-30-11 considering circuit design (current limiting circuit, Error Correction Code) and mission life, and other relevant factors.

Furthermore, for small and nanosatellites, it is desirable to refer to standards such as JIS, JEITA, EIA, and other standards when determining these criteria.

### 4.4.8 Points to note in selection and application

The following items provide important considerations for the selection and operation of candidate parts.

(1) The resin used in resin-molded parts such as semiconductor parts contains a certain amount of halogen, which has the effect of promoting the corrosion of metals. When using parts with resin molds, it is recommended to use them with caution after considering the impact of corrosion on the performance of the parts.

(2) General vibration and shock tests may reduce the adhesion of the interlayer dielectric (Low-k layer) within semiconductor devices. In addition, the Low-k

layer may experience delamination or cracking due to mechanical stress applied during cross-sectional preparation (Evaluation data: JERG-0-052-TM001).

For this reason, when performing vibration and shock tests on semiconductor devices, it is recommended to confirm the presence or absence of internal delamination or cracking with C-SAM, etc. after the test.

### 4.5 Candidate parts screening process

It is desirable to review candidate parts appropriately by organizing their quality assurance level and whether additional evaluation tests are required.

Refer to the conventional review process for candidate parts described in JERG-0-052.

## 5. QUALITY ASSURANCE

### 5.1 Evaluation and quality assurance by quality assurance level

With respect to candidate parts, the user manufacturer obtains evaluation data, etc. from the parts manufacturer, based on the risk response policy (Manage only significant risks) implemented in section 4.3, as well as operational lifetime and parts selection criteria.

If evaluation data cannot be obtained, it is desirable to conduct evaluation and quality assurance in accordance with the applicable quality assurance level of the parts. However, in cases where system reliability is ensured through multiple-unit operation or short-duration missions, these requirements may be relaxed.

For reference, the comparison of each quality assurance level with integrated circuits or discrete semiconductors specified in ECSS-Q-ST-60-13 as representative examples is shown in Figure 4.3-1 Comparative Summary of Quality Assurance Levels (Class I, II, III equivalent).

For parts other than those described above, EEE-INST-002(*) is a reference for test planning.

(*)https://nepp.nasa.gov/DocUploads/FFB52B88-36AE-4378-A05B2C084B5EE2CC/EEE-INST-002_add1.pdf

Furthermore, for details of screening tests, and lot assurance tests, refer to section 5.3.2 “Screening test” (Tables 5.3.2-1 to 5.3.2-3), and section 5.3.3 “Lot assurance test” (Tables 5.3.3-1 to 5.3.3-3, Figures 5.3.3-1 to 5.3.3-3) for each quality assurance level (Class I, II, III equivalent), using the integrated circuit and discrete semiconductor as representative examples specified in ECSS-Q-ST-60-13.

### 5.2 Selection of candidate parts and parts manufacturer

With respect to multiple candidate parts selected based on the common items regarding the selection guidelines and prohibitions/restrictions in section 4.4, it is preferable for the user manufacturer to give priority to parts manufacturers with whom agreement or cooperation has been established in accordance with section 4.2. Regarding the selected parts manufacturer, it is preferable for the user manufacturer to verify that the manufacturer's quality management system (QMS) is certified to the recognized standards such as ISO, JIS, or AEC-Q.

If the parts manufacturer's agreement (cooperation) cannot be obtained, the user manufacturer is responsible for procurement and use of the parts.

### 5.3 Procurement of candidate parts

The user manufacturer is encouraged to procure candidate parts with consideration of the following items.

(1) It is desirable to procure directly from parts manufacturers. If direct procurement is not possible, it is desirable to procure parts from vendors that have an authorized distributor agreement with the parts manufacturer. When parts are procured by methods other than those described above, the risk of acquiring counterfeit parts should be taken into account, and it is necessary to consider post-assembly countermeasures (e.g., burn-in).

(2) To the extent possible, parts should be ordered in the parts manufacturer's minimum order quantity or multiples thereof. This helps prevent repackaging and split handling by distributors and enables retention of the traceability information normally included in the parts manufacturer's original packaging.

#### 5.3.1 Procurement specifications (if prepared)

When procuring parts, the user manufacturer is encouraged to prepare procurement specifications that specify the candidate parts and to procure the parts in accordance with those specifications.

In the procurement specifications, it is encouraged to define the minimum necessary items by referring to the parts manufacturer's delivery specification drawings or data sheets, and to include at least the following.

(1) Item and part number

(2) Maximum ratings, operating temperature range, environmental conditions, electrical characteristics, outline drawings, markings, terminal connections, etc.

(3) Reliability and quality assurance

(4) Traceability

(5) Packaging

(6) Documents to be submitted

(7) Change Notification

### 5.3.2 Screening test

Since ground use parts are generally subjected to periodic quality assurance evaluation using a sampling method within the manufacturing process, 100% inspection is not conducted as a shipping inspection. Accordingly, based on the risk response policy, it is encouraged to conduct screening tests on selected parts, as necessary, among those incorporated into flight hardware for which only significant risks are managed.

When establishing screening tests, care is taken to avoid degrading part reliability, such as lead solderability, due to stresses applied during testing. If it is determined that screening tests cannot be conducted on individual part, it is necessary to consider additional tests (burn-in and wear-in test, etc.) after the parts are mounted (upper-level assembly, etc.).

For screening tests, when integrated circuits and discrete semiconductors are representative examples (as specified in ECSS-Q-ST-60-13), the contents shown for each quality assurance level (equivalent to Class I, II, III) in Tables 5.3.2-1 to 5.3.2-3 and Figures 5.3.2-1 to 5.3.2-3 screening tests are recommended.

For other parts, details of screening tests by Level 1, 2, and 3 corresponding to Class I, II and III are summarized in EEE-INST-002 (*) as commercial parts.

It is recommended to apply the screening tests in the applicable specifications of equivalent or similar officially qualified parts as a guideline.

(*)https://nepp.nasa.gov/DocUploads/FFB52B88-36AE-4378-A05B2C084B5EE2CC/EEE-INST-002_add1.pdf

For automotive parts (AEC-Q grade), refer to Clause 8 of ECSS-Q-ST-60-13 and consider whether screening tests are required and the items to be performed. The same consideration should also be made for parts based on other official specifications.

Table 5.3.2-1 Class I equivalent screening test

Temperature conditions for burn-in and thermal cycling tests should be based on the rating of the applicable parts.

| Step | Test | Samples | Test method/evaluation criteria | Comments |
|---|---|---|---|---|
| 1 | X-ray | 100% | MIL-STD-883, Test method 2012<br>Wire flow is inspected from the top. The lot will be rejected if the parts do not remain in sufficient quantity as required by the project. | Accumulated total dose should be less than one-tenth of the allowable product dose |
| 2 | Serial numbering | 100% | N/A | |
| 3 | Thermal cycling | 100% | -55/+85°C for 10 cycles (or manufacturer's storage temperature T° range, whichever is lower) MIL-STD-883, Condition A of Test method 1010 | |
| 4 | PIND test | 100% | If applicable (internal cavity package), MIL-STD-883, Condition A of Test method 2020 / MIL-STD-750, Condition A of Test method 2052 (discrete semiconductor) | |
| 5 | Electrical characteristics before burn-in test | 100% | Electrical test is performed at 25°C as specified in the data sheet (parameters & functions) | Selected parameters and electrical defects should be read and recorded. |
| 6 | Dynamic burn-in | 100% | 1MIL-STD-883, Test method 1015, Condition B<br>240 hours at 125°C<br>445 hours at 105°C<br>or 85°C for 885 hours<br>Also, additional conditions other than temperature and time, such as voltage<br><br>The above temperature and time conditions are based on the ratings of the applicable parts. | - The temperature should be < Tjmax-10℃ or Tg-10℃, whichever is lower.<br>- If Tj or Tg is not known, the maximum temperature should be 105°C.<br>- Unless another value is proven for the part, Ea=0.4eV should be used as a reference value when calculating acceleration coefficients in the test.<br>- The risk of oxidation of terminals, etc. should be checked after burn-in. |

Table 5.3.2-1 Class I equivalent screening test (Cont.)

| Step | Test | Samples | Test method/evaluation criteria | Comments |
|---|---|---|---|---|
| 7 | Electrical characteristics after burn-in test | 100% | Electrical test as specified in the data sheet, performed at 3 T° (minimum, standard, maximum) | Read and record selected parameters and calculate drift. Electrical defects should be read and recorded. |
| 8 | PDA | N/A | Steps 5 and 7<br>PDA: 5% max. | |
| 9 | Hermeticity | 100% | If applicable (hermetically packaged), MIL-STD-883, Test method 1014, Conditions A or B and C/MIL-STD-750, Test method 1071, Conditions H1 or H2 and C or K (discrete semiconductor) | |
| 10 | External visual inspection | 100% | MIL-STD-883, Test method 2009/<br>MIL-STD- 750, Test method 2071 (discrete semiconductor) | The MIL specs do not apply to visual inspection of PEM (plastic packages), but can be used as a reference (mainly for corrosion of connections and acceptance of marking). In addition, plastic packages are tested for the following defects: package deformation/foreign matter in the package, plastic voids and cracks/deformed leads |

The above test conditions, etc. are described using integrated circuits and discrete semiconductors as representative examples with reference to the following document.
- ECSS-Q-ST-60-13 Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components

Table 5.3.2-2 Class II equivalent screening test

Temperature conditions for burn-in and thermal cycling tests should be based on the rating of the applicable parts.

| Step | Test | Sample | Test Method/Evaluation Criteria | Comment |
|---|---|---|---|---|
| 1 | Serial numbering | 100%. | N/A | |
| 2 | Thermal cycling | 100%. | -55/+85°C for 10 cycles (or manufacturer's storage temperature T° range, whichever is lower) MIL-STD-883, Condition A of Test Method 1010 | |
| 3 | PIND examination | 100%. | If applicable (internal cavity package), MIL-STD-883, Condition A of Test Method 2020 / MIL-STD-750, Condition A of Test Method 2052 (discrete semiconductor) | |
| 4 | Burn-in pre-test electrical characteristics | 100%. | Electrical testing is performed at 25°C as described in the data sheet (parameters & functions) | Read and record selected parameters and electrical defects. |
| 5 | Dynamic burn-in | 100%. | MIL-STD-883, Test Method 1015, Condition B<br>160 hours at 125°C<br>300 hours at 105°C<br>or 590 hours at 85°C<br><br>The above temperature and time conditions shall be based on the rating of the applicable part tail. | The temperature shall be < Tjmax-10℃ and Tg-10℃, whichever is lower.<br>If Tj or Tg is not known, the maximum value shall be 105℃.<br>Ea=0.4eV should be used as a reference value when calculating acceleration factors, etc. in testing, unless another value has been demonstrated for the part.<br>The risk of oxidation of terminals, etc. should be checked after burn-in. |
| 6 | Burn-in Post-test electrical characteristics | 100%. | Electrical tests as described in the datasheet, Implemented in 3 T° (minimum, standard, maximum) | Selected parameters shall be read and recorded and drift calculations shall be made. Electrical defects shall be recorded. |
| 7 | PDA | N/A | Steps 4 and 6<br>PDA: 5% max. | |

Table 5.3.2-2 Class II equivalent screening test (Cont.)

| Step | Test | Sample | Test Method/Evaluation Criteria | Comment |
|---|---|---|---|---|
| 8 | Airtightness | 100%. | If applicable (hermetically packaged), MIL-STD-883, Test Method 1014, Conditions A or B and C/MIL-STD-750, Test Method 1071, Conditions H1 or H2 and C or K (discrete semiconductor) | |
| 9 | External visual inspection | 100%. | MIL-STD-883, Test Method 2009/ MIL-STD-750, Test Method 2071 (discrete semiconductor) | The MIL spec does not apply to visual inspection of PEM (plastic packages), but can be used as a reference (mainly for acceptance of corrosion and marking of connections). In addition, plastic packages are tested for the following defects: package deformation/foreign objects in the package, plastic voids and cracks/deformed leads |

The above test conditions, etc. are described using integrated circuits and discrete semiconductors as representative examples with reference to the following document.
- ECSS-Q-ST-60-13 Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components

Table 5.3.2-3 Class III equivalent screening test

| Step | Test | Samples | Test method/evaluation criteria | Comments |
|---|---|---|---|---|
| 1 | PIND test | 100% | If applicable (internal cavity package), MIL-STD-883, Condition A of Test method 2020 / MIL-STD-750, Condition A of Test method 2052 (discrete semiconductor) | |
| 2 | Hermeticity | 100% | If applicable (hermetic package), MIL-STD-883, Test method 1014, Conditions A or B and C/MIL-STD-750, Test method 1071, Conditions H1 or H2 and C or K (discrete semiconductor) | |

The above test conditions, etc. are described using integrated circuits and discrete semiconductors as representative examples with reference to the following document.
- ECSS-Q-ST-60-13 Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components

### 5.3.3 Lot assurance test

Based on the risk response policy, it is recommended that the user manufacturer and/or the parts manufacturer perform lot acceptance test on the procured lots to verify lot acceptance or rejection.

Ground-use parts are generally subject to periodic quality assurance evaluations based on sampling methods during the manufacturing process. By making use of the results of these evaluations, the scope of lot assurance testing may be reduced or simplified.

For lot assurance test, it is recommended that the contents of each quality assurance level (equivalent to Class I, II, III) described in Tables 5.3.3-1 to 5.3.3-3 and Figures 5.3.3-1 to 5.3.3-3 be used for lot assurance test for integrated circuits and discrete semiconductors as representative examples (specified in ECSS-Q-ST-60-13).

For other parts, EEE-INST-002 (*) summarizes the details of certification tests by Level 1, 2 and 3, which nearly correspond to Class I, II and III equivalent, as Commercial parts.

It is recommended to apply the quality conformance inspection (lot assurance test) of applicable specifications in equivalent or similar officially qualified parts as a guideline.
(*)https://nepp.nasa.gov/DocUploads/FFB52B88-36AE-4378-A05B2C084B5EE2CC/EEE-INST-002_add1.pdf

For automotive parts (AEC-Q grade), refer to Clause 8 of ECSS-Q-ST-60-13 and consider whether lot assurance tests are required and the items to be performed. The same consideration should also be made for parts based on other official specifications.

Table 5.3.3-1 Class I equivalent lot assurance test

Temperature conditions for life test and thermal cycling test should be based on the rating of the applicable parts.

| Subgroup test | Test | Number of samples /Acceptance standard number | Test method/evaluation criteria | Comments |
|---|---|---|---|---|
| 1 | Structural Analysis (CA) | 5 | Refer to Table 4.5.2.1-1 Structural Analysis (CA) | |
| 2 | Preconditioning + HAST (or 1000 hours THB 85/85) | 10/0 | Preconditioning (*) +130°C/85%RH for 96 hours (or 1000 hours THB 85/85) JESD22-A110 Continuous bias (JESD22-A101 for THB)<br>Pre-test and post-test electrical test at 25°C as specified in the data sheet (parameters & functions)<br><br>(*) Preconditioning:<br>JESD-22-A113: SMD<br>JESD-22-B106: Through-hole terminals | Applicable to PEM (plastic package) only<br><br>Electrical tests should be read and recorded. |
| 3 | Life test | 15/0 | Ta: 2000 hours at 125°C MIL-STD-883, Condition D of Test method 1005<br>Electrical tests before, during (1000 hours), and after the test are performed under 3 T° conditions (minimum, standard, and maximum) as specified in the data sheet (parameters & functions). | - Ta: 125°C or maximum operating temperature, whichever is lower.<br>- If 2000 hours data within 2 years of the date code is available and no technical changes have been made, the life test can be reduced to 1000 hours.<br>- Electrical defects should be read and recorded. |
| 4 | Preconditioning + Thermal cycling | 10/0 | Preconditioning (*) +(-55/+125°C) for 100 cycles (or manufacturer's storage temperature T° range, whichever is lower) MIL-STD-883, Condition B of Test method 1010 /MIL-STD-750, Condition B of Test method 1051 (discrete semiconductor)<br>Electrical tests before and after the test should be performed at 25°C as specified in the data sheet (Parameters & Functions)<br><br>(*) Preconditioning:<br>Refer to subgroup 2. | Electrical tests should be read and recorded. |

Table 5.3.3-1 Class I equivalent lot assurance test (Cont.)

| Subgroup testing | Test | Number of samples /Acceptance Standard number | Test Method/Evaluation Criteria | Comment |
|---|---|---|---|---|
| 5 | Radiation hardness test | Refer to ECSS-Q-ST-60-15 | Refer to ECSS-Q-ST-60-15 | |

The above test conditions, etc. are described using integrated circuits and discrete semiconductors as representative examples with reference to the following document.
- ECSS-Q-ST-60-13 Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components

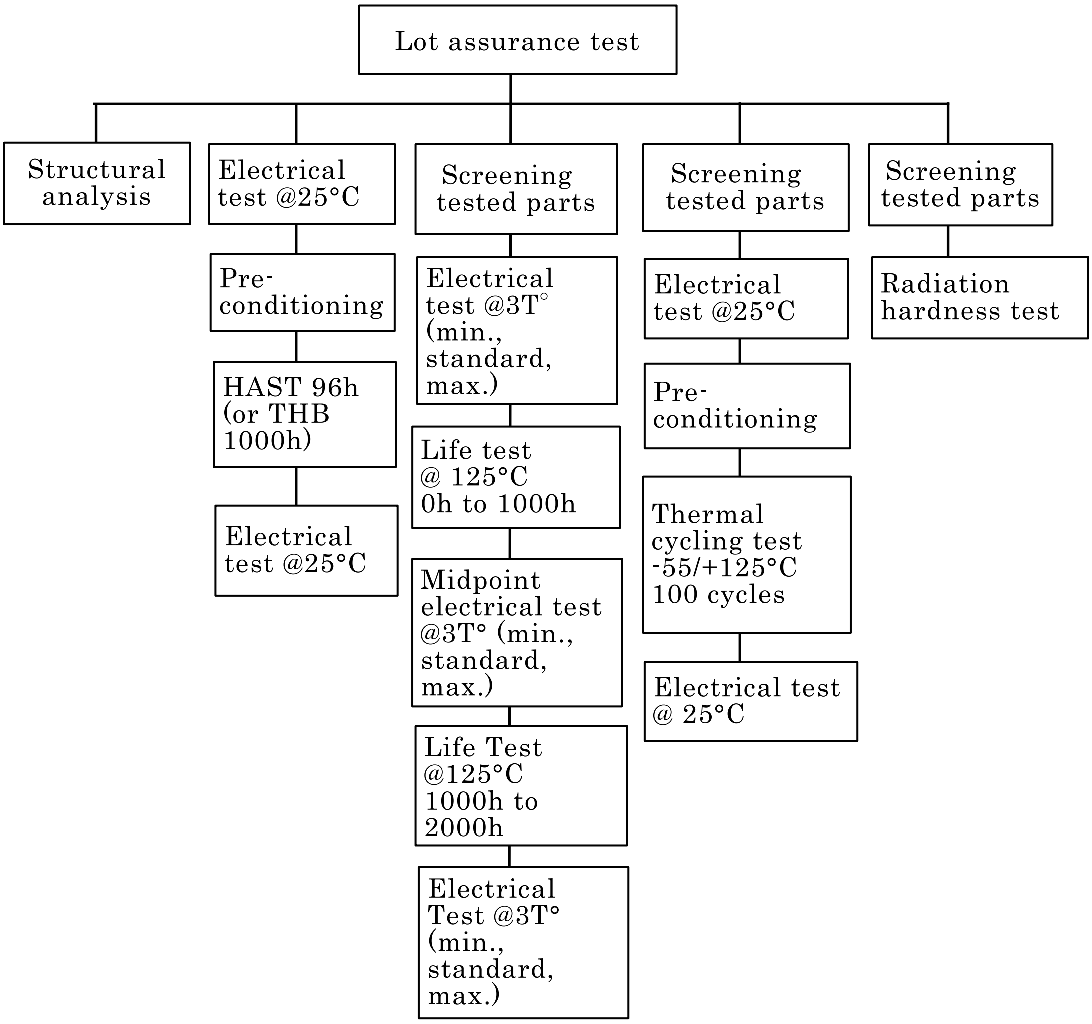



Figure 5.3.3-1 Class I equivalent lot assurance test diagram

(Temperature condition for each test should be based on the rating of the applicable parts.)

Table 5.3.3-2 Class II equivalent lot assurance test

| Subgroup test | Test | Number of samples /Acceptance standard number | Test method/evaluation criteria | Comments |
|---|---|---|---|---|
| 1 | Structural Analysis (CA) | 5 | Refer to Table 4.5.2.1-1 Structural Analysis (CA) | |
| 2 | Preconditioning + HAST (or 1000 hours THB 85/85) | 10/0 | Preconditioning (*)<br>+130°C/85%RH for 96 hours (or 1000 hours THB 85/85)<br>JESD22-A110 Continuous bias (JESD22-A101 for THB)<br>Electrical tests before and after the test are performed at 25°C as described in the data sheet (parameters & functions)<br><br>(*) Preconditioning:<br>JESD-22-A113: SMD<br>JESD-22-B106: Through-hole terminals | Applicable to PEM (plastic package) only.<br><br>Electrical tests should be read and recorded. |
| 3 | Life test [1] | 15/0 | Ta: 2000 hours at 125°C<br>MIL-STD-883, Condition D of Test method 1005<br>Electrical tests before and after the test are performed at 25℃ as specified in the data sheet (parameters & functions). | - Ta: 125℃ or maximum operating temperature, whichever is lower.<br>- Electrical defects should be read and recorded. |
| 4 | Preconditioning + Thermal cycling [1] | 10/0 | Preconditioning (*)<br>+(-55/+125°C) for 100 cycles (or manufacturer's storage temperature T° range, whichever is lower)<br>MIL-STD-883, Condition B of Test method 1010 /MIL-STD-750, Condition B of Test method 1051 (discrete semiconductor)<br><br>Electrical tests before and after the test should be performed at 25℃ as specified in the data sheet (Parameters & Functions)<br>(*) Preconditioning:<br>Refer to subgroup 2. | The decision to conduct this subgroup test depends on the mission profile.<br><br>Electrical tests should be read and recorded. |
| 5 | Radiation hardness test | Refer to ECSS-Q-ST-60-15 | Refer to ECSS-Q-ST-60-15 | |

The above test conditions, etc. are described using integrated circuits and discrete semiconductors as representative examples with reference to the following document.

- ECSS-Q-ST-60-13 Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components

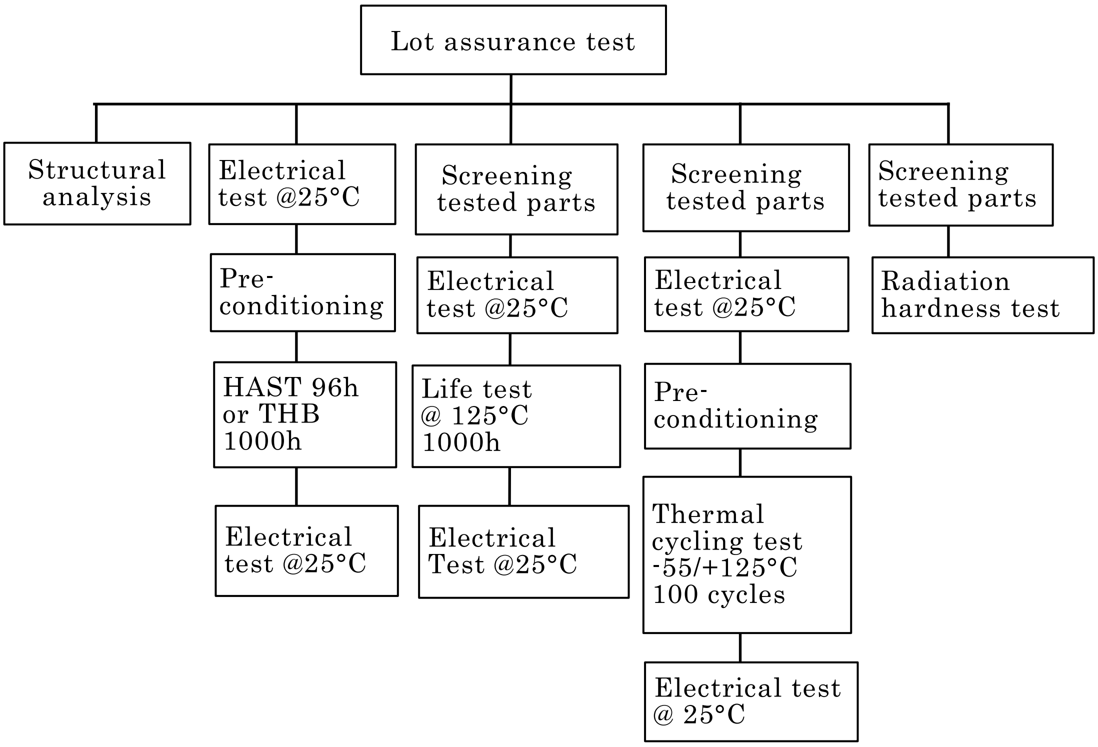



Figure 5.3.3-2 Class II equivalent lot assurance test diagram
(The temperature condition for each test should depend on the rating of the applicable part.)

Table 5.3.3-3 Class III equivalent lot assurance test

Temperature condition for life test and thermal cycling tests should be based on the rating of the applicable part.

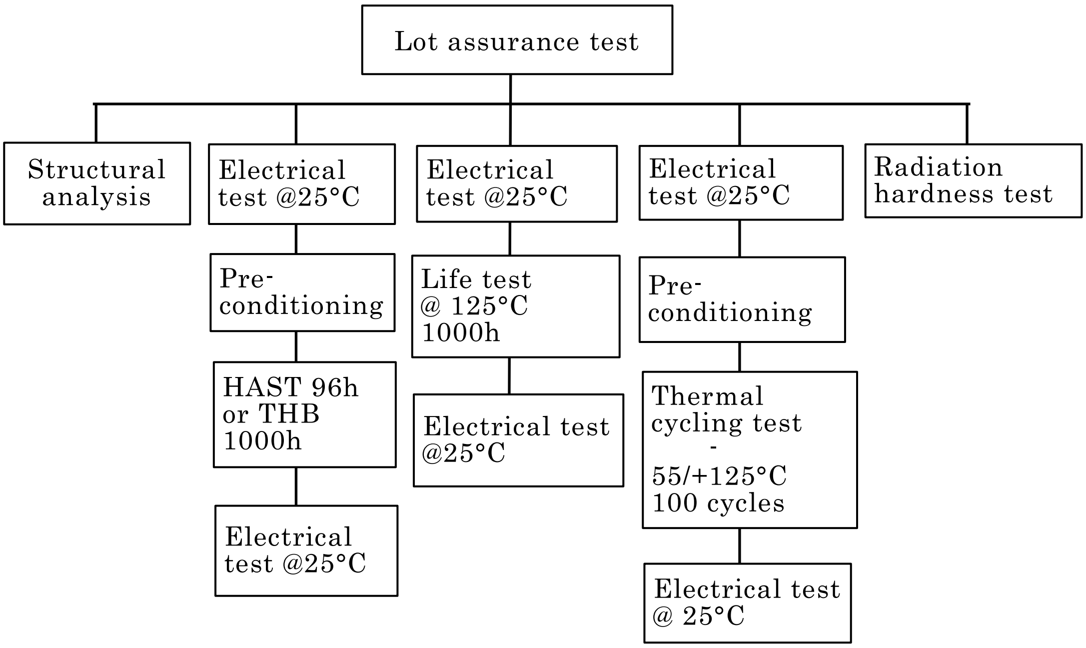
| Subgroup test | Test | Number of samples /Acceptance standard number | Test method/evaluation criteria | Comments |
|---|---|---|---|---|
| 1 | Structural Analysis (CA) | 5 | Refer to Table 4.5.2.1-1 Structural Analysis (CA) | |
| 2 | Preconditioning + HAST (or 1000 hours THB 85/85) | 10/0 | Preconditioning (*) +130℃/85%RH for 96 hours (or 1000 hours THB 85/85) JESD22-A110 Continuous bias (JESD22-A101 for THB) Electrical tests before and after the test are performed at 25℃ as specified in the data sheet (parameters & functions)<br><br>(*) Preconditioning:<br>JESD-22-A113: SMD<br>JESD-22-B106: Through-hole terminals | Applicable to PEM (plastic package) only<br><br>Electrical tests should be read and recorded. |
| 3 | Life test | 15/0 | Ta: 1000 hours at 125℃ MIL-STD-883, Condition D of Test method 1005 Electrical tests before and after the test should be performed at 25℃ as specified in the data sheet (parameters & functions). | - Ta: 125℃ or maximum operating temperature, whichever is lower.<br>- Electrical defects should be read and recorded. |
| 4 | Preconditioning + Thermal cycling | 10/ | Preconditioning (*) + (-55/+125℃) for 100 cycles (or manufacturer's storage temperature T° range, whichever is lower) MIL-STD-883, Condition B of Test method 1010 /MIL-STD-750, Condition B of Test method 1051 (discrete semiconductor)<br><br>Electrical tests before and after the test should be performed at 25℃ as specified in the data sheet (Parameters & Functions)<br>(*) Preconditioning:<br>Refer to subgroup 2. | The decision to conduct this subgroup test depends on the mission profile.<br><br>Electrical tests should be read and recorded. |

Table 5.3.3-3 Class III equivalent lot assurance test (Cont.)

(The temperature condition for each test should depend on the rating of the applicable part.)

| Subgroup testing | Test | Number of samples /Acceptance Standard number | Test Method/Evaluation Criteria | Comment |
|---|---|---|---|---|
| 5 | Radiation hardness test | Refer to ECSS-Q-ST-60-15 | Refer to ECSS-Q-ST-60-15 | |

The above test conditions, etc. are described using integrated circuits and discrete semiconductors as representative examples with reference to the following documents.
ECSS-Q-ST-60-13 Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components




HAST, life test and thermal cycling are applicable when sufficient quality and reliability cannot be confirmed by available evidence data, evaluation test data, etc.

Figure 5.3.3-3 Class III equivalent lot assurance test diagram

### 5.3.4 Radiation hardness test

It is desirable to develop a test plan and to conduct radiation hardness tests in accordance with that plan for radiation-sensitive parts identified in section 4.4.6 (3), as well as for parts for which existing test data are insufficient.

This test should be thoroughly examined whether the test can be avoided by relying on demonstrated flight heritage, circuit design (current limiting circuit, Error Correction Code), existing data, or verification at higher-level equipment, etc.

Radiation hardness test is performed in accordance with internationally recognized standards, ESCC 22900, MIL-STD-750 Test Method 1080, MIL-STD-883 Test Method 1019, or JEDEC JESD57. It is desirable that samples submitted for radiation hardness test be selected, in accordance with section 5.3.2, from parts that have undergone screening tests so as to be representative of the flight-parts lot.

Samples subjected to radiation hardness test should not be used for flight.

### 5.3.5 Acceptance inspection

As necessary, it is desirable for the user manufacturer to conduct acceptance inspections that include the following items.

(1) Verification of markings (part number, lot identification, manufacturer name, etc.)

(2) Verification of quantity

(3) Verification of packaging

(4) Verification of documents provided by the parts manufacturer

(5) Additional tests (e.g. solderability test, electrical test, etc.) according to the type and criticality of the parts

### 5.3.6 Destructive physical analysis (DPA)

As necessary, it is desirable for the user manufacturer to perform a DPA on a lot-by-lot basis verify that the procured parts are the same as those evaluated and that their materials, design, workmanship and construction meet the requirements of the relevant procurement documents and are suitable for the application.

The DPA may be performed by a specialized test house or by the parts manufacturer; however, it is desirable that the results be reviewed and confirmed by the user manufacturer as well.

For DPA, the contents of Table 5.3.6-1 are recommended when considering typical examples such as integrated circuits and discrete semiconductors.

Table 5.3.6-1 Typical examples of destructive physical analysis (DPA) integrated circuits and discrete semiconductors

| Test | Samples | | | Procedures | Remarks |
|---|---|---|---|---|---|
| | No.1 | No.2 | No.3 | | |
| External visual inspection | X | X | X | MIL-STD-750 Method 2071-4<br>MIL-STD-883 Method 2009-9 | MIL specifications do not apply to visual inspection of PEM (plastic packages), but can be used as a reference document. (1) |
| PIND test (internal cavity package) | X | X | X | MIL-STD-750 Method 2052-3<br>MIL-STD-883 Method 2020-7 | |
| Hermeticity (if applicable) | X | X | X | MIL-STD-750 Method 1071-6<br>MIL-STD-883 Method 1014-10 | |
| Solderability test | X | X | | IEC60068-2-69 or AFNOR A 89-400 | Solder wettability test methods are recommended.<br>Verify feasibility on specific packages |
| Decapsulation | X | X | X | N/A | |
| Internal visual inspection | X | X | X | MIL-STD-750 Method 2074-4, 2072-6, 2069<br>MIL-STD-883 Method 2010-10 | For PEM (plastic package), particularly check the adhesion of the interface between die and lead frame (delamination) and between the external connection and resin. |
| Bond strength | [1] | [2] | [3] | MIL-STD-750 Method 2037<br>MIL-STD-883 Method 2011-7<br>JEDEC 22-B116 | [1] Bond and peel test<br>[2] Bond test |
| Passivation integrity | | X | X | MIL-STD-883 Method 2021-3 | Ensure chemical etchant is suitable for metallization |
| Bond crater formation test (ball bonding) | | X | X | | If applicable |
| Die shear test (internal cavity package) | X | X | X | MIL-STD-750 Method 2017-2<br>MIL-STD-883 Method 2019-5 | |

Explanation of Table 5.3.6-1 Typical examples of destructive physical analysis (DPA) integrated circuits and discrete semiconductors

In addition to the criteria of MIL specifications, the following items should be inspected:
- Package deformation
- Foreign objects in the package, voids and cracks
- Lead deformation, peeling, corrosion and swelling of the finish
- Legibility and accuracy of markings

The above test conditions are described using integrated circuits and discrete semiconductors as representative examples with reference to the following document.
- ECSS-Q-ST-60-13; Space product assurance - Commercial electrical, electronic and electromechanical (EEE) components

### 5.3.7 Handling and storage

It is desirable that user manufacturers handle and store parts in accordance with their handling and storage procedures, including, at a minimum, the following items.

(1) The environment of the facility and equipment where the parts are handled and stored.

(2) Packaging methods when storing parts.

(3) Identification and handling of parts susceptible to electrostatic discharge.

(4) PEM (PED) should be stored under the control conditions appropriate to the MSL (Note).

(Note) MSL: Moisture Sensitivity Level, a standard defined by IPC/JEDEC J-STD-020.

### 5.3.8 Reinspection

For parts that have been stored for seven years (refer to section 5.3.7) after completion of screening tests (refer to section 5.3.2), lot assurance tests (refer to section 5.3.3), or acceptance tests by the user, it is recommended that the parts be used only after confirming the items listed below.
Thereafter, it is desirable to perform re-inspection at intervals of every four years. It is desirable to conduct re-inspections every 4 years thereafter.

(1) The uniformity and traceability of the lot can be verified and there are no unresolved defects/failures (refer to section 7.2) and alerts (refer to section 7.3) for the lot in question.

(2) Test/inspection data per section 5.4 is available for the project. (including radiation hardness test results)

(3) Re-inspection should include at least the following inspection items

(a) External visual inspection

(b) Solderability test (If a mounting method other than soldering is used, verification testing shall be performed using that mounting method.)

### 5.4 Summary of evaluation and test data

After obtaining test and inspection data as specified in section 5.3 from the parts manufacturer, it is desirable for the user manufacturer to retain these documents until the end of the mission.

## 6. ASSEMBLY AND MOUNTING

As necessary, user manufacturer is encouraged to consider assembly and mounting methods by referring to JAXA mounting process standards (Note), in-house assembly standards with proven heritage, or commercial assembly standards such as IPC J-STD-001 and IPC-A-610, etc.

(Note)

JERG-0-039 Standard for Soldering Process for Space Use
JERG-0-040 Standard for Electronics Bonding Process for Space Use
JERG-0-041 Standard for Electrical Wiring Process for Space Use
JERG-0-042 Standard for Printed Wiring Boards and Assemblies for Space Use
JERG-0-043 Standard for Surface Mount Soldering Process Standard for Space Use
JERG-0-064 Process Standard for Space Application of Lead-Free Parts

## 7. TRACEABILITY DEFECT HANDLING

### 7.1 Traceability

As necessary, it is desirable to confirm that all parts used for flight are traceable to the quality records of parts manufacturing, testing, etc., either by serial number and/or lot number/date code or order number according to the quality assurance level.

It is desirable that traceability be maintained throughout the entire manufacturing, testing, etc., receiving, mounting, assembly/testing, and storage of the parts by the parts manufacturer.

If traceability cannot be fully ensured, it is desirable to manage available records, such as the timing of parts procurement, in accordance with the degree of associated risk.

### 7.2 Failures and defects

It is desirable for user manufacturers to investigate the cause of any defects/failures that occur after parts acceptance or mounting, and to implement corrective actions and recurrence prevention measures.

### 7.3 Alerts

Through the selection, evaluation, procurement, assembly/testing, and storage of candidate parts, the user manufacturer should collect information on the following items to confirm the integrity of the parts.

(1) Investigate information obtained from the JAXA Reliability Engineering Information System (Shinraisei Gijutsu Joho), other alert information, etc., and verify that no alert or failure information has been issued.

(2) If alert/failure information is subsequently obtained, analyze the relevant information, examine the affected area, and take appropriate measures.

## 8. UTILIZATION OF PARTS INFORMATION

The following databases are related to parts used for space applications.

(1) “Database of JAXA Qualified EEE Parts and Materials”
Data and information on JAXA qualified parts and parts under development.
(User and parts manufacturers can view the data by registering as users.)
URL https://ssl.tksc.jaxa.jp/eeepitnl/en/

(2) "JAXA Material Database: Material database (outgas data of various materials)
URL https://matdb.jaxa.jp/

(3) “Database of commercial parts for microsatellites”: A database of information on the use of commercial parts onboard microsatellites developed by Japanese universities and other organizations, operated by the Kyushu Institute of Technology and other organizations.
URL https://space-cots-data.jp/

(4) "GSFC Radiation Data Base": Radiation test data from NASA Goddard Space Flight Center
URL https://radhome.gsfc.nasa.gov/radhome/RadDataBase/RadDataBase.html

(5) "ESA Radiation Reports": Irradiation test reports from ESCC
URL https://escies.org/labreport/radiationList