General

Handbook of the use of Commercial EEE Parts in Space Applications (General Purpose)

May 24, 2024

Japan Aerospace Exploration Agency

Published by
Japan Aerospace Exploration Agency
Safety and Mission Assurance Department
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1.1 Purpose

EEE parts (hereinafter referred to as "parts") used for spacecraft and launch vehicle assembly equipment are usually selected from space parts consisting of standard parts (parts officially qualified by JAXA, MIL/NASA, and ESCC), JAXA development strategy parts, and project-approved non-standards parts (NSPAR parts)".
However, there are cases where it is technically and economically impossible to select from space parts.
This handbook describes general procedures, recommendations, precautions, explanations, and related information for selecting, evaluating, procuring, and using as "non-standard space-applicable parts" that are space-applicable 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) CREME96 : Cosmic Ray Effects on Micro-Electronics(1996 Revision)
(4) ECSS-Q-ST-30-11 : Space Product Assurance – Derating - EEE components
(5) ECSS-Q-ST-60 : Space product assurance - Electrical, Electronic and Electromechanical(EEE) components
(6) ECSS-Q-ST-60-13 : Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components
(7) ECSS-Q-ST-60-14 : Space product assurance- Relifing procedure- EEE components
(8) EEE-INST-002 : Instructions for EEE Parts Selection, Screening, Qualification, and Derating
(9) ESCC 22900 : TOTAL DOSE STEADY-STATE IRRADIATION TEST METHOD
(10) ESCC 24800 : Permanence of marking
(11) ESCC 25100 : Single Event Effects test method and guidelines
(12) GSFC PPL-21 : GSFC Preferred Parts List
(13) IEC60068-2-69 : Part 2-69:Tests-Test Te: Solderability testing of electronic components for surface mounting devices(SMD)by the wetting balance method
(14) J-STD-033 : Handling, packing, shipping and use of moisture/ reflow sensitive surface mount devices
(15) JAXA QPL/QML : Japan Aerospace Exploration Agency Qualified Parts List/ Qualified Manufacturers List
(16) JEDEC JESD57 : Test Procedures for the Measurement of Single-Event Effects in Semiconductor Devices from Heavy Ion Irradiation

(17) JERG-0-034 : Organic Material Outgassing Data Collection for Space Applications
(18) JERG-0-039 : Standard for Soldering Process for Space Use
(19) JERG-0-040 : Requirements for Bonding Process of Electronic Assemblies of Space Use Staking, Conformal Coating and Potting
(20) JERG-0-041 : Standards for Electrical Wiring Process for Space Applications
(21) JERG-0-042 : Design standards for rigid printed wiring boards and assemblies
(22) JERG-0-043 : Standard for Surface Mount Soldering Process for Space Use
(23) JERG-0-050 : Standard Statement of Work for Flight Parts Procurement from Overseas
(24) JERG-1-009 : Lead Free Parts application Standard for Onboard Equipment of Launch Vehicle
(25) JERG-1-010 : Handbook of the use of Commercial EEE Parts in Space Applications (Launch Vehicle)
(26) JERG-2-023 : Handbook of the use of Commercial EEE Parts in Space Applications (Long Life Satellite)
(27) JERG-2-024 : Handbook of the use of Commercial EEE Parts in Space Applications (Scientific Satellite)
(28) JESD22-A101 : Steady state temperature humidity bias life test
(29) JESD22-A110 : Highly accelerated temperature and humidity stress test
(30) JESD22-A112 : MOISTURE-INDUCED STRESS SENSITIVITY FOR PLASTIC SURFACE MOUNT DEVICES
(31) JESD22-A113 : Preconditioning of plastic surface mount devices prior to reliability testing
(32) JESD22-A121 : Test method for measuring whisker growth on tin and tin alloy surface finishes
(33) JESD22-B106 : Resistance to soldering temperature for through hole mounted devices
(34) JESD22-B116 : WIRE BOND SHEAR TEST
(35) JESD26-A : GENERAL SPECIFICATION FOR PLASTIC ENCAPSULATED MICROCIRCUITS FOR USE IN RUGGED APPLICATIONS – RESCINDED
(36) JMR-012 : Electrical, Electronic And Electromechanical Parts Program Standard
(37) JMR-004 : Reliability Program Standards
(38) MIL-HDBK-217 : Reliability Prediction of Electronic Equipment
(39) MIL-STD-750 : TEST METHOD STANDARD SEMICONDUCTOR DEVICES
(40) MIL-STD-883 : Test Methods Standard, Microcircuits
(41) MIL-STD-1580 : DESTRUCTIVE PHYSICAL ANALYSIS FOR ELECTRONIC, ELECTROMAGNETIC, AND ELECTROMECHANICAL PARTS

(42) NPSL : NASA Parts Selection List
(43) NASA-RP-1124 : Outgassing Data for Selecting Spacecraft Materials
(44) RQA-X0001 : Scientific Satellite Parts Program
(45) ECSS-Q-ST-60-15 : Space product assurance - Radiation hardness assurance - EEE components

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 (parts officially qualified by JAXA, MIL/NASA, and ESCC), JAXA development strategy parts, and project approved non-standard parts (NSPAR 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) Non-Standard Parts Approval Request (NSPAR): An approval request from a user (system/equipment) manufacturer to JAXA's project department for the purpose of using a relevant part as a non-standard part in a designated project.
(6) Project-approved non-standard parts: Non-standard parts that are designed, manufactured, and quality-assured in accordance with military or space standards applicable to standard parts and approved by JAXA's project responsible department for project limited use by NSPAR.
(7) 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.
(8) Non-standard space-applicable parts: This is a designation for parts that have been made space-applicable in accordance with this handbook from candidate parts. It is distinguished from conventional non-standard parts that are designed, manufactured, and quality-assured in accordance with military or space-applied standards.
(9) System risk response policy: A generic term for risk response classifications such as for long-life satellites, short-life satellites, scientific satellites, and launch vehicles.

(10) 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.

(11) EEE (Electrical, Electronic, Electromechanical) parts: A generic term for "electrical, electronic and electromechanical parts.

(12) 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, definitions and abbreviations) of JMR-012 is also applied.

Abbreviations	meaning
C-SAM	Constant-depth mode Scanning Acoustic Microscope
CA	Construction Analysis
CDR	Critical Design Review
CNES	Centre National d'Études Spatiales = French National Space Agency
COTS	Commercial Off The Shelf
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
EDX	Energy Dispersive X-ray spectroscopy
EEE	Electrical, Electronic, Electromechanical
EFR	Established Failure Rate
ELDRS	Enhanced Low Dose Rate Sensitivity
ESCC	European Space Components Coordination
FPGA	Field-Programmable Gate Array
GSFC	Goddard Space Flight Center
HAST	Highly Accelerated Stress Test
HSD	Hot Solder Dip
ITAR	International Traffic in Arms Regulations
JAXA	Japan Aerospace exploration Agency
JEDEC	Joint Electron Device Engineering Council

JESD	JEDEC Standards
LAT	Lot Acceptance Test
LET	Linear Energy Transfer
LETth	ThresHold for Linear Energy Transfer
MIL	MILitary
NASA	National Aeronautics and Space Administration
NDA	Non-Disclosure Agreement
NPSL	NASA Parts Selection List
NSPAR	Non-Standard Parts Approval Request
OTP	One Time Programmable devices
PAPDB	Project Approved Parts Data Base
PDA	Percent Defective Allowable
PED	Plastic Encapsulated Device
PEM	Plastic Encapsulated Microcircuit
PIND	Particle Impact Noise Detection
PLD	Programmable Logic Device
PQR	Post Qualification test Review
PROM	Programmable Read Only Memory
PSR	Pre Shipment Review
PWB	Printed Wiring Board
QML	Qualified Manufacturer Listing
RH	Relative Humidity
RoHS	Restriction of the use of certain Hazardous Substances
RVT	Radiation Verification Testing
SDR	System Definition Review
SEE	Single Event Effect（Classified as SEU, SEL, SEB, SEDR, SEFI,SEGR, SET etc.）
SEU	Single Event Upset
SEL	Single Event Latch up
SEB	Single Event Burnout
SEDR	Single Event Dielectric Rapture
SEFI	Single Event Functional Interrupt
SEGR	Single Event Gate Rapture
SET	Single Event Transient
SEM	Scanning Electron Microscope
SMD	Surface Mount Device
Ta	Ambient Temperature
Tg	Glass transition Temperature
THB	Temperature Humidity Bias

TID	Total Ionizing Dose
TML	Total Mass Loss
Tstg	Storage Temperature

4. GENERAL (COMMON) ITEMS

It is desirable that user (system/equipment) manufacturers conduct parts program activities to ensure that the parts are non-standard space-applicable parts by referring to this handbook, in accordance with customer project requirements and business transactions with parts manufacturers.
It is desirable that this activity is performed in accordance with the basic requirements in Section 4.1 and the parts program management in Section 4.2 of JMR-012 throughout the agreed period of commercial transactions.

4.1 Concept and basic flow of space application

Many parts used outside the space industry are supplied with the latest technologies applied to them, as a result of meeting various market requirements such as high functionality, high density, small size, light weight, and low power consumption. However, the supply of space parts is rapidly declining due to low demand and extremely strict environmental, quality, and reliability requirements.
Overseas, the COTS (Commercial Off The Shelf) parts used outside of the space industry are considered and promoted to space applications. In Europe, ECSS-Q-ST-60-13: Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components have been established.

In 2010, JAXA also resumed a study group to establish guidelines for promoting the commercial parts in space applications from the perspective of enhancing the functionality and performance of satellites, reducing costs, reducing size and weight, and strengthening international competitiveness.
It was confirmed that part manufacturers participating in the study group were willing to make adjustments responsibly to the extent possible if they clarify in advance that their customers intend to use the parts for space application.
All parts other than space parts are classified as follows, and parts (1), (2), and (3), excluding (4), are referred to as “space-applicable parts”.

(1) High-reliability parts: submarine cable parts, nuclear power parts, aircraft parts, radiation-hardness PEM parts, etc. → Space-applicable parts
(2) Automotive parts: Powertrain, brakes, airbags, etc. (parts directly affect safety) → Space-applicable parts
(3) Industrial parts: Plant equipment/infrastructure, etc. (large impact in case of failure) → Space-applicable parts

(4) Consumer-use parts: Home appliances, etc. (small impact in case of failure)
→ Non-space-applicable parts

In principle, the field of consumer-use parts described in (4) above is defined as non-space-applicable parts that are not used for space applications, but this does not apply when (4) consumer-use parts are used, after considering the risks at the discretion of the project.
Parts selected by this handbook for space application are treated in the same manner as conventional non-standard parts for space use and are therefore referred to as "non-standard space-applicable parts". Their quality assurance levels are classified as equivalent to Class I, II, or III as in JMR-012.

Conventional space parts consisted of
(1) standard parts (parts officially qualified by JAXA, MIL/NASA, and ESCC) and JAXA development strategy parts and
(2) Non-standard parts approved by projects (NSPAR parts).
However, there are cases where it is technically and economically impossible to select from space parts. For this reason, space-applicable parts which are used outside the space industry are selected, evaluated, and procured for space use as non-standard space-applicable parts.

Figure 4.1-1 summarizes the relationship between the above standard/NSPAR parts and non-standard space-applicable parts according to this handbook as the applicable concept for space-applicable parts.
Here, conventional NSPAR parts are parts whose quality is built in by being "designed, manufactured, and quality assured according to non-standard part specifications established in accordance with military or space standards applicable to standard parts," as defined by the terminology in Section 3.1.

However, the "non-standard space-applicable parts" specified in this handbook will be quality- and reliability-assured for space use provided that the necessary evaluation tests according to the quality assurance level (equivalent to Class I, II, or III) are performed on the parts that have already been manufactured and quality-assured. Additionally, screening and lot assurance tests will also be performed by the user, or the parts manufacturer or responsibility for the tests may be shared by both parties.

The approach used to assure quality and reliability of "Non-standard space-applicable parts" differ from that of conventional space parts. However, non-standard space-

applicable parts are used for space applications after going through the process of evaluation of space applicability, NSPAR review, procurement, additional testing for quality assurance, and usage, through information and coordination necessary for agreement (cooperation) between parts manufacturer as a supplier and user (system/equipment) manufacturer as a user for space application.
A series of basic flows are summarized in Figure 4.1-2 Basic Flow of Space Application of Space-Applicable Parts.

These non-standard parts specifications (NSPAR specifications) are usually set for a specific project. However, there are cases where they can be commonly used independent of the project/user, such as for continued use in other projects/users. In such cases, the user (system/equipment) manufacturer and/or parts manufacturer may propose to JAXA to make the "non-standard space-applicable parts" as standard parts with a view to JAXA-QML certification.

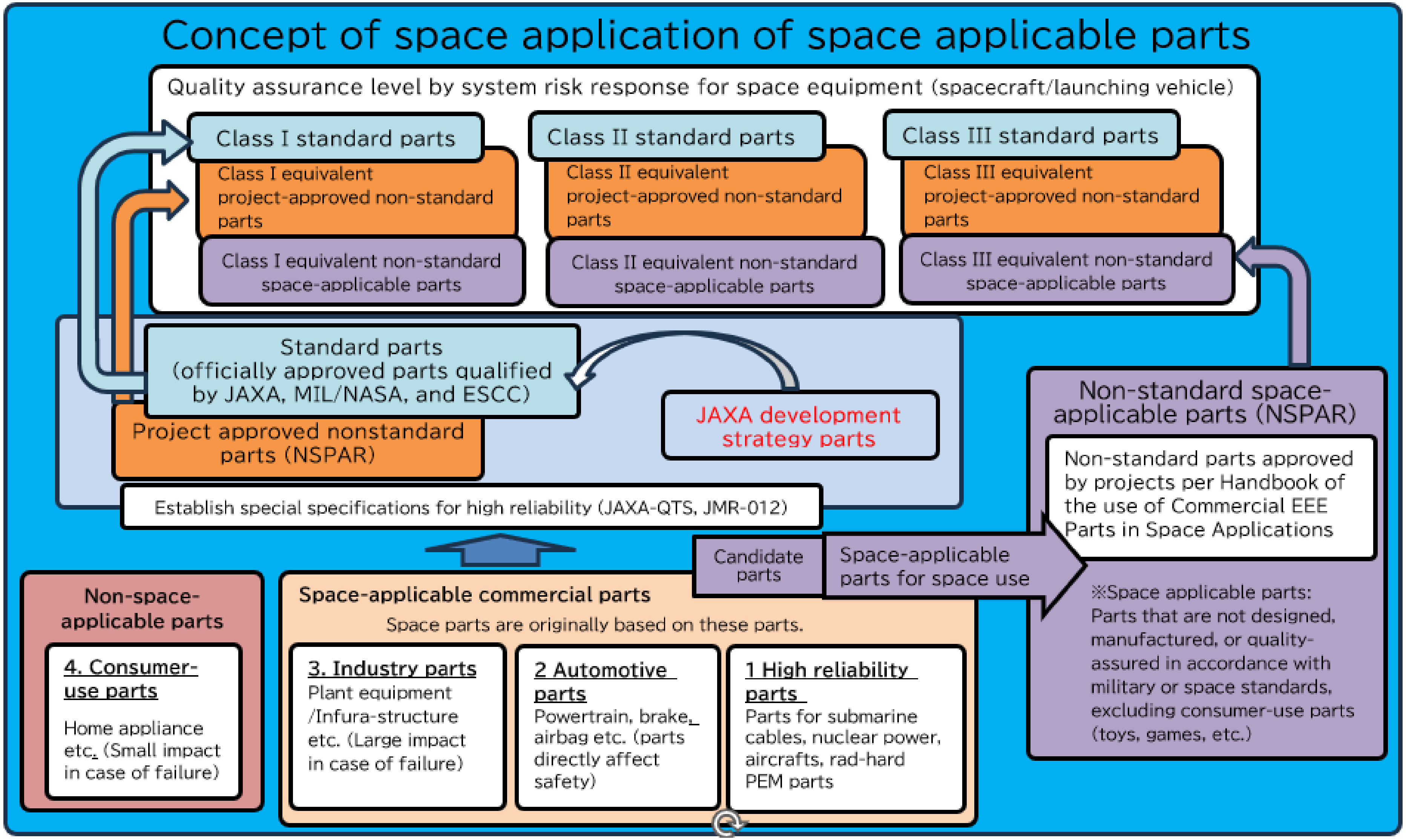

Figure 4.1-1 Concept of space application for space-applicable parts

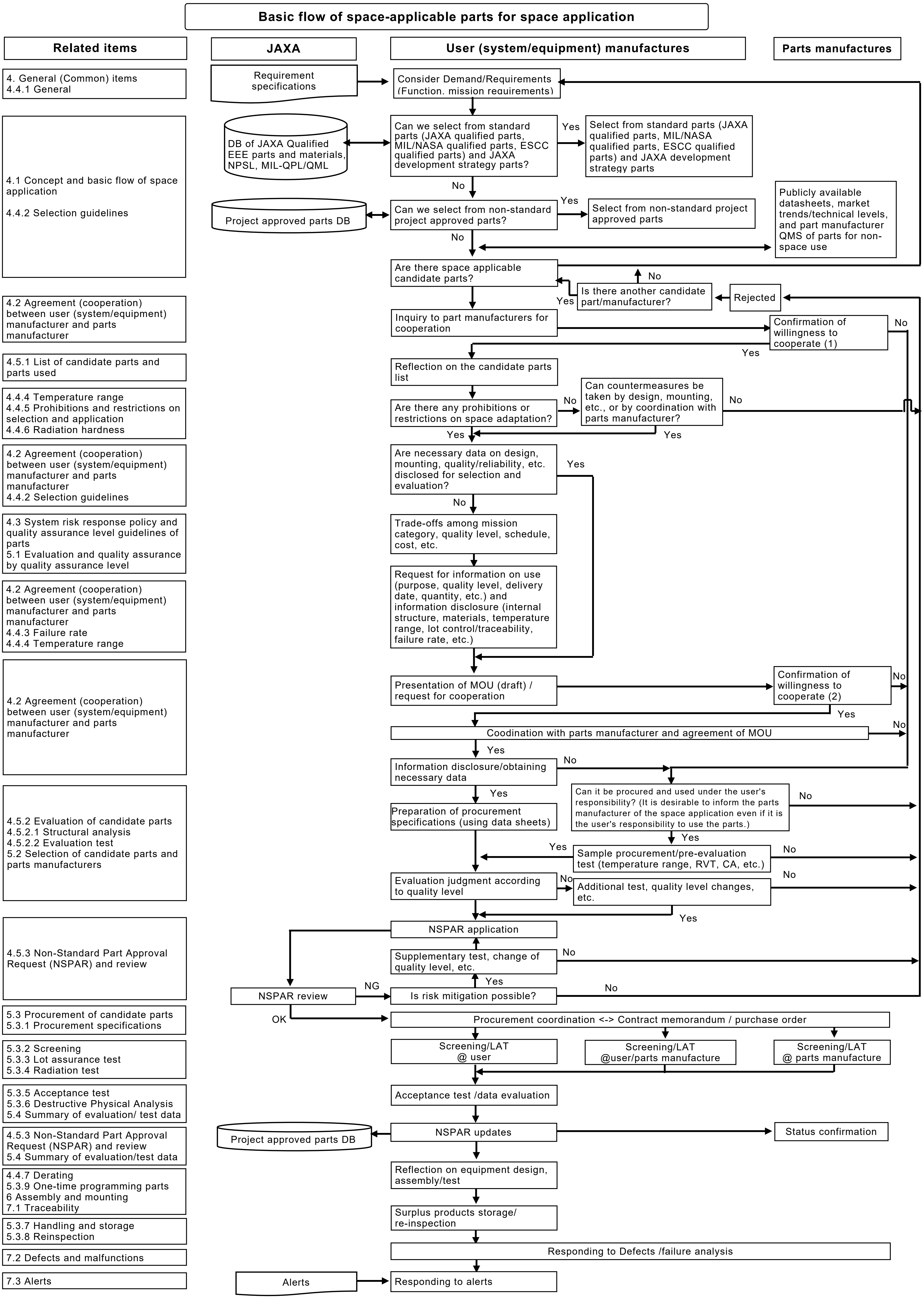

Figure 4.1-2 Basic flow of space-applicable parts for space application

4.2 Agreement (cooperation) between user (system/equipment) manufacturer and part manufacturer

Even for space-applicable parts, the part manufacturers prepare handling instructions as shown in Figure 4.2-1 and Figure 4.2-2 due to product liability (PL) and other related laws and regulations. As described in this case study, prior written approval is required for use in specific applications such as space equipment.

On the other hand, from the user (system/equipment) manufacturer's point of view, in many cases, detailed data necessary for selection and evaluation of candidate parts for space applications, such as design, mounting, quality/reliability, etc., are not disclosed. In such cases, it is necessary to present information on the use of parts in space equipment and to obtain the necessary information for preliminary evaluation from the part manufacturer. Then, the assumption is that work is proceeded only after an agreement is reached, by presenting memorandum of understanding (draft) to confirm willingness to cooperate and make adjustment.

(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 part manufacturer” and “survey sheet for evaluation of space application” required for prior evaluation, “integrated circuits/discrete semiconductors” and “printed wiring boards are shown in the following table as typical examples.

	Integrated circuits/discrete semiconductors	Printed wiring board
Specific coordination and consultation procedures for information disclosure	Refer to Table 4.2-1	Refer to Table 4.2-4
Information to be provided by the user (system/equipment) manufacturer to the parts manufacturer	Refer to Table 4.2-2	Refer to Table 4.2-5
Evaluation of space application, survey sheet	Refer to Table 4.2-3	Refer to Table 4.2-6

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 part 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 essential to clarify the following items, to incorporate the necessary items into a memorandum of understanding, and to establish cooperative relationship between the two parties.

(1) Target part number
(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 part 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

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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 1: As used in this document, “the Company” refers to Renesas Electronics Corporation and companies in which Renesas Electronics Corporation directly or indirectly holds a majority of the voting rights of all shareholders.

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 Case 1 (Underlined parts refer to specific applications)

Restrictions on product use

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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 Precautions for handling 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 (system/equipment) 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	Coordination for the conclusion of the Memorandum of Understanding (MOU)	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). Then, present information which is necessary to evaluate usability in space application (survey sheet: refer to Table 4.2-3) and coordinate its availability.
6	Conclusion of MOU	Conclude MOU with an expiration date after documenting what was coordinated.
7	Survey sheet for evaluation of usability in space application (Refer to Table 4.2-3)	The user (system/equipment) manufacturer requests information limited to the contents which is defined in the MOU by using the survey sheet to determine usability in space application. Parts manufacturer responds to the survey sheet.
8	Information provided by parts manufacturer	The user (system/equipment) manufacturer obtains the response of the survey sheet from the parts manufacturer and determines usability in space application.
9	Pre-evaluation of samples	Obtain pre-evaluation samples from parts manufacturer and evaluate the usability in space application. (Including structural analysis to obtain information not available from parts manufacturer)
10	Evaluation test	Conduct necessary evaluation tests to verify parts usability in space application. (including structural analysis to obtain information not available from parts manufacturer)
11	Procurement of parts for EM	Conduct general acceptance inspection and verify system usability by applying to the EM.
12	Procurement of parts for FM	Conduct screening test and lot assurance test. The lot assurance test may be omitted if the lot is same as the one evaluated in Step No.10.

Table 4.2-2 Example of information presented by user (system/equipment) manufacturer to parts manufacturer

№	Item	Contents, etc.
1	Purpose of use	Type of satellite, launch vehicle, etc. (refer to Table 4.3-1, Classification column for each space equipment)
2	Quality assurance level of target parts	Classification in catalogs of parts manufacturers for aircraft, automotive, infrastructure equipment (industrial), etc.
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	-55～+125℃, etc.
	② Storage temperature range (non-operating)	-65～+150℃, etc.
	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 for pre-evaluation samples, EM and FM
6	Quantity	Quantity for pre-evaluation samples, EM and FM
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. (MIL Spec., etc.)
9	Export of equipment Whether the equipment used is exported or not	Whether the equipment used is exported or not (including spare parts)

Table 4.2-3 Example of survey sheet for evaluation of usability in space application (for Integrated circuits/Discrete semiconductors)/ filled out by parts manufacture

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	Certification Status	① Certified company and Certification Body	
		② Standard number	
		③ Date of certification	
		④ Certification number	
		⑤Copy of the certificate (latest version)	
4	Development and production status	① Main applications	
		② Delivery or production history	Production started in MM/YY Quantity of current monthly production:
		③ Delivery record for space use	Planned production / production on order
		④ Production method (planned production-ship from inventory or production on order)	
		⑤ Factory location (If there are different factories in the main processes of manufacturing and inspection, list each factory separately.)	- Wafer fab process: - Dicing process: - Assembly process: - Testing and inspection process:
		⑥ Typical delivery time	Months, weeks
		⑦Continuation of production - Product with identical design (supply period with the same mask) - Product with equivalent performance (supply period with the same function or upward compatibility in consideration of chip shrinkage, etc.)	- Identical design: Until year_____ - Equivalent performance: Until year_____
		⑧ Other special notes	
5	Available quality assurance	-Choose one of the following. - A: Catalog type; only the quality specifications provided by the part manufacturer - 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. -C: Other (Describe specifically)	
6	Quality control process diagram (QC process diagram)	Process flowchart from receipt of parts/materials to shipment of products, and associated quality control (including in-process inspection, screening test process conditions(100% or sampling), and lot assurance test if applicable).	Attachment:

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

№	Item	Contents, etc.	Parts manufacturer's response (Note)
7	Acceptance for Quality audit (Yes or No)	Is quality audit involving observation of manufacturing process accepted? Can the manufacturing documents, and management regulations, etc be disclosed?	Quality audit: Yes / No Disclosure: Yes / No
8	Submission of visual inspection criteria (Yes or No)	Can visual inspection criteria such as reject criteria be submitted? (if criteria other than publicly known criteria such as MIL Spec are applied)	Yes / No
9	Acceptance for Source inspection (Yes or No)	Is witness inspection per lot accepted?; Inspection prior to shipment per lot (dimensions, external inspection, electrical test, record reviewing)	Before shipping Yes / No
10	Submission of delivery specifications	Can delivery specifications describing externals, dimensions, functions, characteristics, inspection reports, packaging specifications, etc. be submitted?	Yes / No
11	Exports	Is export of spare parts alone or of embedded equipment possible? Are there any restrictions on such export?	Yes / No (Attach separate sheet if the export is restricted)
12	Maintenance of design, structure, process, etc. (Yes or No)	Can the design, manufacturing process, materials, etc. remain unchanged at the time of evaluation testing, procurement for EM, and FM?	Yes / No
13	Change control I (Accept or Not)	Notification of changes and the need for re-evaluation of in-process inspections, screening tests, lot assurance tests etc.,	Accept / Not accept
	Change control II (Accept or Not)	Notification of changes and the need for re-evaluation of design and structure, manufacturing processes, materials (including materials shipped in parts), etc.,	Accept / Not accept
14	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
15	Packaging lable	Model number, lot number, shipping date, etc.	Separate sheet should be attached
16	Definition of inspection lot	Composition and definition of each process work lot, material lot, etc. included in the same inspection lot, such as wafer (uniform), diffusion batch, deposition batch, package parts (including lead frame), assembly work, etc.	Separate sheet should be attached

Table 4.2-3 Example of survey sheet for evaluation of space application (for Integrated circuits/Discrete semiconductors)/ filled out by parts manufacture (Cont.)

№	Item	Contents, etc.	Parts manufacturer's response (Note)
17	Packing method (Yes or No)	Can actions be taken for ESD (electrostatic discharge)?	Yes / No
18	Design and Structure (Element Design) In case of bare die procurement, answer on a separate sheet.	① Nominal design rule and applicable process (half pitch or generation, CMOS, etc.)	Design rule: Applicable process:
		② Die dimensions (length, width, height)	
		③ Enlarged photo of the die (die externals and internal connection state must be identifiable)	
		④ Guaranteed operating temperature range Reference area and temperature range (Tc, -55°C to +125°C, etc.)	Temperature range: Reference area:
		⑤ Electrical characteristics (low temperature, normal temperature, high temperature) Absolute maximum ratings and recommended operating conditions	Separate sheet should be attached
		⑥ Maximum power consumption Maximum value in the entire guaranteed operating temperature range	
		⑦ Maximum junction temperature	
		⑧ Maximum current per pad (wire, bump, pillar, etc.)	
19	Design and Structure (PKG design) *No response required for bare die procurement.	① Internal structure (details such as dimensions, tolerances, etc. are not required) However, for the lid and base, specify the material, thickness, potential, and presence or absence of floating metal conductors.	Separate sheet should be attached
		② Case outline Main dimensions and tolerances, lead numbers, and external view	Separate sheet should be attached
		③ Storage temperature range (-65°C to +150°C, etc.)	
		④ Die mounting material (conductive adhesive, AuSn, AuSi, etc.)	
		⑤ Internal lead wire material and diameter (e.g., Al-1%Si wire, 25μmφ)	
		⑥ Case material classification (e.g., iron/nickel/cobalt alloy)	
		⑦ Lead material classification (e.g., iron/nickel/cobalt alloy)	
		⑧ Lead finish Control limit of plating thickness including underplating, and purity in case of Au	
		⑨ Maximum terminal temperature (temperature, time)	
		⑩Heat resistance (recommended reflow profile and cycles)	
		⑪ Thermal resistance or maximum ΔTjc at maximum power consumption	

Table 4.2-3 Example of survey sheet for evaluation of space application (for Integrated circuits/Discrete semiconductors)/ filled out by parts manufacture (Cont.)

№	Item	Contents, etc.	Parts manufacturer's response (Note)
20	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
21	Failure rate estimation	Specify total conditions (calculated or actual) such as number of fits required for reliability calculation	
22	Recommended derating value	Not required if presented as recommended operating conditions	
23	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.	
24	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
25	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
26	Failure analysis at the time of failure	Can advice in failure analysis be provided, can functional testing, DPA, etc.be performed?	
27	Legally regulated substances	Existence of substances to be handled with caution, such as BeO, Cd, Li, Mg, Hg, Zn, radioactive substances, etc.	
28	Others	- Special precautions (if necessary) ・Fixing method (e.g. tightening torque, etc.) ・Cleaning method (e.g. no water rinsing) ・Soldering method (e.g. no reflow)	

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

Table 4.2-3 Appendix: Example of survey sheet for evaluation of space application (bare die or wafer procurement version)/filled out by parts manufacturer

* In case of bare die procurement, the following items are answered in addition to the survey sheet in Table 4.2-3.
(It is necessary when the assembly is outsourced to a space-qualified line manufacturer)

№	Item	Contents	Parts manufacturer's response (Note)
1	Part number (model name)	The numbers to be written on packaging and shipping slips	
2	Supply form	Wafer or Die	
3	Packaging specification	Chip tray or wafer container, etc.	
4	Packaging label	Model number, lot number, shipping date, etc.	
5	Die material	Si, SiC, GaN, etc.	
6	Die dimensions	Length, width, thickness (including tolerances)	
7	Pad dimensions	Vertical, width (effective area design value), minimum pitch	
		Position coordinates (including pin number)	
		Recommended bonding wire diameter and material	
8	Bonding length restriction	Maximum bond length constraint (if necessary)	
9	Metallization	Bonding pad material (Al or Au, etc.)	
		Backside metallization material including underplating (None, Ti/Ni/Au, etc.)	
		Recommended die mounting material (conductive adhesive, AuSn, AuSi, etc.)	
		Backside potential (GND, +V, -V, floating, etc.)	
10	Gracivation (protective film)	Material (Si3N4, SiO2, Polyimide, etc.)	
11	Dicing or scribing	Saw (full cut or half cut)	
		Laser, diamond, etc.	
12	Guard ring spacing (wafer)	Spacing and recommended blade thickness	
13	Bad mark (wafer)	Ink or scribing, etc.	
14	Map data (wafer)	Electronic or printed data	
15	Heat resistance temperature	Heat resistance temperature (350°C or less)	
16	Enlarged photograph of die	(Pad layout and orientation must be identifiable)	
17	Die appearance Inspection standard	Applicable publicaly known standards (MIL-STD-883 Method 2010, etc.)	
18	Others	- Special precautions (if necessary) ・Precautions for handling die pickups, etc. ・Precautions for storage ・Precautions on heat or ultrasonic conditions during bonding ・Precautions for heat or atmosphere conditions during die bonding ・Precautions on withstanding voltage	

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

Table 4.2-4 Example of specific coordination and consultation procedures for information disclosure (Printed Wiring Board (PWB))

№	Item	Contents, etc.
1	Inquiries to PWB 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 (system/equipment) manufacturer	Provide all the information listed in Table 4.2-2 and inquire about supply availability or recommended parts.
4	First response from parts manufacturer	Verify availability of supply or availability of information.
5	Coordination for the conclusion of Memorandum of Understanding (MOU)	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),. Then, present information which is necessary to evaluate usability in space application (survey sheet: refer to Table 4.2-6) and coordinate its availability.
6	Conclusion of MOU	Conclude MOU with an expiration date after documenting what was coordinated.
7	Survey sheet for space application evaluation (Refer to Table 4.2-6)	The user (system/equipment) manufacturer requests information limited to the contents which is defined in the MOU by using the survey sheet to determine usability in space application. PWB manufacturer responds to the survey sheet.
8	Information provided by PWB manufacturer	The user (system/equipment) manufacturer obtains the response of the survey sheet from PWB manufacturer and determines usability in space application.
9	Pre-evaluation of samples	Obtain pre-evaluation samples from PWB manufacturer and evaluate the usability in space application. (Including solderability, reliability evaluation for solder joint, etc.)
10	Evaluation tests	Conduct necessary evaluation tests to verify usability in space application concerning material system and processing quality corresponding to the design standards. (The PWB manufacturer conducts the tests. The user (system/equipment) manufacturer receives a report of the results, verifies the usability in space application and requests additional information to the PWB manufacturer as necessary.)
11	Procurement of PWB for EM	Procure PWBs for EM as needed.
12	Procurement of PWB for FM	Conduct quality conformance inspection (Group A).

Table 4.2-5 Examples of information presented by user (system/equipment) manufacturer to PWB manufacturer

№	Item	Contents, etc.
1	Purpose of use/Equipment type to be applied, etc.	Type of spacecraft, launch vehicle, etc. (Refer to Table 4.3-1, Classification of space equipment)
2	Quality assurance level of target PWB	Classification of the PWB manufacturer, such as aircraft onboard, military (aircraft, ships, vehicles, missiles, etc.), etc.
3	Target PWB number (model number)	Material, dimensions (including thickness), number of layers, impedance control, etc.
4	Conditions of operating environment	-30 to +125°C x 1000 cycles, etc.
	① Operating temperature range	Thermal and mechanical environmental conditions and test items/methods, etc.
	② Environmental conditions ③ Mounting method	Manufacturing method such as hand or reflow soldering and applicable solder material (including, surface finish)
5	Delivery date	Procurement period for pre-evaluation samples, for EM and FM
6	Quantity	Quantity for pre-evaluation samples, EM and FM
7	Prospects of continuous use	Indicate prospects of re-procurement after the procurement period indicated by the delivery day.
8	Applicable documents	Provide applicable documents as necessary (e.g. MIL Spec. (MIL Spec. IPC, etc.)
9	Export of equipment	Whether the equipment used is to be exported (including spare parts)

Table 4.2-6 Example of survey sheet for space application evaluation (for PWBs) / filled out by PWB manufacturer

№	Item	Contents	PWB manufacturer's response (Note)
1	Company name	Company holding sales rights and company in charge of manufacturing	
2	PWB classification	Rigid/flexible/flex rigid/cored, etc.	
3	Certification status	① Certified company and Certification Body	
		② Standard number	
		③ Date of certification	
		④ Certification number	
		⑤ Copy of certificate (latest version)	Separate sheet should be attached
4	Development and production status	① Main applications	
		② Delivery or production history	Production started in MM/YY Quantitiy of Current monthly production: _____boards, _____m^2 per month
		③ Delivery record for space use	Yes / No
		④ Pattern design	Available / Not available
		⑤ Factory location (If there are different factories in the main processes of manufacturing and inspection, list each factory separately.)	- Drilling process: - Plating process: - Multi-layer lamination process: - External processing: - Testing and inspection: - Others:
		⑥ Typical delivery time	_____Months,_____Weeks
		⑦ Continuation of production - Production with identical design (artwork or data storage period) - Production with the equivalent performance (guaranteed supply period by the material manufacturer)	- Identical design: For___years after production - Equivalent performance: Up to year_____
		⑧ Other special notes	
5	Available Quality assurance	Choose one of the following. - A: For industrial use only; PWB manufacturer can provide only self-declared quality specifications. - B: For space use; Manufacturing is the same as for catalog products, but special tests or control systems required for space use can be implemented for some or all in-process inspections, etc. - C: Other (Describe specifically)	

Table 4.2-6 Example of survey sheet for space application evaluation (for PWBs) / filled out by PWB manufacturer (Cont.)

№	Item	Contents	PWB manufacturer's response (Note)
6	Quality control process diagram (QC Process Diagram)	Process flowchart from receipt of materials to shipment of products and associated quality control (items and conditions (incl.100%/sampling)of in-process inspections and final inspections	Separate sheet should be attached
7	Acceptance for quality audit (Yes or No)	- Is quality audit audit involving observation of manufacturing process accepted? - Can the manufacturing documents, management regulations, etc. be disclosed?	- Quality audit: Yes / No - Disclosure: Yes / No
8	Submission of visual inspection criteria (Yes or No)	Can visual inspection criteria such as reject criteria be submitted? (If criteria other than publicly known standards such as MIL Spec are applied)	Available , Not available
9	Acceptance for source inspection (Yes or No)	Availability of on-site inspections to be performed for each lot - Inspection prior to shipment per lot (dimensions, external inspection, wire test, record reviewing)	Before shipping: Yes / No
10	Submission of delivery specifications	Can delivery specifications describing externals, dimensions, inspection reports, etc. can be submitted?	Yes / No
11	Export	If export of spare PWB alone or of embedded equipment possible? Are there any restrictions on such export?	Yes / No (Attach separate sheet if the export is restricted)
12	Maintenance of design, structure, process, etc. (Yes or No)	Can the design, manufacturing process, materials, etc. remain unchanged from the time of evaluation tests, to procurement for EM and FM?	Yes / No
13	Change control I (Accept or Not)	Notification of changes and the need for re-evaluation of in-process inspections and final inspections (quality conformance inspectin), etc.	Accept / Not accept
	Change control II (Accept or Not)	Notification of changes and the need for re-evaluation of design and structure, manufacturing processes, materials (including materials shipped as part of PWB), etc.	Accept / Not accept

Table 4.2-6 Example of survey sheet for space application evaluation (for PWs) / filled out by PWB manufacturer (Cont.)

№	Item	Contents	PWB manufacturer's response (Note)
14	Marking on products	Part number, inspection lot number, serial number, etc., and deciphering method of lot symbols, etc.	Separate sheet should be attached
15	Packaging marking contents	Part name, part number, year and month of manufacture and serial number or lot identification number, packaging quantity, inspection date, inspection result, etc.	Separate sheet should be attached
16	Definition of inspection lot	Composition and definition of each process work lot, material lot, etc. included in the same inspection lot, such as material, laminated batch, plated panel, etc.	Separate sheet should be attached
17	Packaging method (Yes or No)	Can actions be taken for moisture-proofing, ESD (electrostatic discharge)?	
18	Design and structure (Treat as design limits)	① Structure (rigid, flexible, flex-rigid, cored, HDI, etc.)	
		② Maximum board thickness	
		③ Maximum number of layers	
		④ Material	
		④-1 Metal clad laminates, prepregs, insulating materials	
		④-2 Solder resist	
		④-3 Surface finish (HAL, ENIG, etc.)	
		④-4 Plating (purity of copper plating and other characteristics)	
		④-5 Core materials (board with core)	
		④-6 Others (PTH filled resin, resistor layer, etc.)	
		⑤ Minimum conductor thickness (inner layer)	
		⑥ Minimum conductor width (outer layer, inner layer)	Outer Layer , Inner Layer
		⑦ Minimum conductor gap (outer layer, inner layer)	Outer Layer , Inner Layer
		⑧ Minimum drill diameter (in case of HDI structure, including minimum via diameter)	φ
		⑨ Minimum land diameter	φ
		⑩ Thickness of plating, etc. (minimum plating thickness for through-holes, vias, and surface finish)	
		⑪ Temperature range and number of cycles	
		⑫ Maximum operating temperature of material	
		⑬ Glass transition temperature (Tg) of the material	
		⑭ Coefficient of linear (thermal) expansion (CTE): For cored boards only	
		⑮ Resistance to soldering heat	

Table 4.2-6 Example of survey sheet for space application evaluation (for PWBs) / filled out by PWB manufacturer (Cont.)

№	Item	Contents	PWB manufacturer's response (Note)
19	Reliability evaluation results	Test items, conditions, and pass/fail criteria, test result of Electrical performance (withstand voltage, etc.) mechanical performance (through-hole pull strength, etc.), environmental performance (thermal shock, moisture resistance, radiation hardness etc.)	Separate sheet should be attached
20	Long-term storage	Storage period from shipment to soldering and storage conditions. Is reprocessing acceptable?	
21	Performing testing, etc. (Yes or No)	Can additional evaluation tests set by the procurer be accepted? (e.g., high-temperature exposure test, PCT test, DPA, etc.)	Yes / No
22	Support at the time of WCA study (Yes or No)	Can the support be provided when specific events are presented from the procurer (specific details will be requested after the design is in progress).	Yes / No
23	Failure analysis at the time of failure	Can advice on failure analysis be provided? Can functional testing, DPA, etc.be performed?	
24	Legally Regulated substances	Presence of substances to be handled with caution such as BeO, Cd, Li, Mg, Hg, Zn, radioactive materials, etc.	
25	Other	Special caution if any. - At the time of soldering (e.g., dehumidification before soldering)	

Note: If you wish to refrain from responding, please type "non-disclosure".

4.3 System risk response policy and part quality assurance level guidelines

The following points should be considered when using candidate parts that can be applicable to space. First, a system FMEA (Failure Modes and Effects Analysis) should be performed to clarify the risk response policy for the entire system. Then, it is necessary to carefully consider the operational period, part selection, and the type of spacecraft (e.g., long-life satellite, scientific satellite and small/nanosatellite etc.) and launch vehicle for which the parts will be used. For this purpose, "Applications of parts" described in the "Handbook of the use of Commercial EEE Parts in Space Application" for each satellite and launch vehicle are referred. Finally, based on these considerations, the quality assurance level of the applicable part should be selected.

An example as a guide is shown in Table 4.3-1, "System Risk Response Policy and Part Quality Assurance Level Guideline". 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. The quality assurance level details of the parts depend on the equipment requirements.

(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).

Figure 4.3-1 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 evaluation test described later (Tables 4.5.2.2-1 to -3, Figures 4.5.2.2-1 to -3), screening test (Tables 5.3.2-1 to -3), and lot assurance test (Tables 5.3.3-1 to -3, Figures 5.3.3-1 to -3). Refer to these tables and figures for details.

The various test conditions shown in this summary are examples and can be changed according to the risk response policy of the system.

Refer to the applicable documents (25) to (27) for details. In addition, future spacecraft such as planetary probes in manned spacecraft will be an issue for future study.
Reference: The guidelines are described in Section 5 of the Annex to JMR-012 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.

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)	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)	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	Class I, II, III non-standard parts	Class II, III non-standard parts	Class I, II, III non-standard parts	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)	None	None	JERG-1-010(Launch vehicle)	None

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

	Class I	Class II	Class III
Evaluation test	**All** - Structure analysis - Electrical characteristics (room, high and low temperatures +10°C margin) - Pre-condition + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1] - Life test 2000h, 125°C +DPA - Preconditioning + 500 thermal cycling -55°C /+125°C - Radiation hardness evaluation (TID, SEE) - Outgassing test	**All** - Structure analysis - Electrical characteristics (room, high and low temperatures +10°C margin) - Pre-condition + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1] - Life test 2000h, 125°C +DPA - Preconditioning + 500 thermal cycling -55°C/+125°C - Radiation hardness evaluation (TID, SEE) - Outgassing test	**Limited** - Structure analysis - Radiation hardness evaluation (TID, SEE) - Outgassing test
Support documents	Data collection - Part manufacturer data - Approval status - Evaluation test - Procurement Inspection & Testing - Lot assurance testing - Radiation hardness test data and RVT	Data collection - Part manufacturer data - Approval status - Evaluation test - Procurement Inspection & Testing - Lot assurance testing - Radiation hardness test data and RVT	Data collection - Part manufacturer data - Approval status - Evaluation test - Procurement Inspection & Testing - Lot assurance testing - Radiation hardness test data and RVT
		Data collection Various test data used for reducing screening test (life test, etc.)	Data collection Various test data used for reducing lot assurance test (life test, etc.)

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

	Class I	Class II	Class III
Screening test	**ALL** - X-ray examination - Serial numbering - 10 Thermal cycling-55°C/+125°C - PIND test [2] - Intermediate electrical test @25°C - Dynamic Burn-in 240h, 125°C - Final electrical tests (room, high and low) - PDA (5%) - Hermeticity[2] - External visual inspection Depending on the applied part, only X-rays and external visual inspection may be necessary (Note)	**Limited (if data available)** - PIND test (if applicable) - Hermeticity (if applicable) +If there is no data - Serial numbering - 10 Thermal cycling -55°C/+125°C - PIND test [2] - Intermediate electrical test @25°C - Dynamic Burn-in 240h, 125°C - Final electrical tests (room, high and low) - PDA (5%) - External visual inspection Depending on the applied part, external visual inspection may be necessary (Note)	**Limited (if data available)** - PIND test (if applicable) - Hermeticity (if applicable)
Lot assurance test (When applied to parts used in screening tests)	**All** - Structure analysis - Precondition + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1] - Life test 2000h, 125℃+DPA - Preconditioning + 100 thermal cycling -55℃/+125℃ - RVT(Radiation verification test)	**All** (However, the life test is 1000h) - Structure analysis - Precondition + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1] - Lifetime test 2000h, 125℃+DPA - Preconditioning + 100 thermal cycling -55℃/+125℃ - RVT(Radiation verification test)	**Limited (if data available)** - Structure analysis - RVT(Radiation verification test) +If there is no data - Precondition + high accelerated stress test (HAST) 96h or high temperature and high humidity bias test (THB) 1000h [1] - Life test 2000h, 125℃+DPA - Preconditioning + 100 thermal cycling -55℃/+125℃

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

Figure 4.3-2 Comparative summary of quality assurance levels (Class I, II, III Equivalent) (Typical examples of integrated circuits and Discrete semiconductors) (Cont.)

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 4.5.2.2 Evaluation test (Tables 4.5.2.2-1 to -3, Figures 4.5.2.2-1 to -3), Section 5.3.2 Screening test (Tables 5.3.2-1 to -3), and Section 5.3.3 Lot assurance test (Tables 5.3.3-1 to -3, Figures 5.3.3-1 to -3) described below.

Refer to the tables and figures for details.

In addition, each test condition shown in this summary can be changed according to the risk response policy of the system.

Refer to the applicable document (25) to (27) for details.

Figure 4.3-3 Comparative Summary of Quality Assurance Levels (Class I, II, III) (Typical Examples of Integrated Circuits and Discrete Semiconductors) (Cont.)

4.4 Common items regarding selection guidelines and prohibitions/restrictions

4.4.1 General

The user (system/equipment) manufacturer should be responsible for the selection of candidate parts so that the following requirements are satisfied at the initial stage of selection of 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

(1) Space-applicable parts should be selected as candidate parts only if it is technically and economically difficult to select from space parts consisting of "standard parts (officially qualified parts such as JAXA-qualified, MIL/NASA-qualified, ESCC-qualified)", JAXA development strategy parts, and project-approved non-standard parts (NSPAR parts).
(2) 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 types and standardization should be promoted.
(3) When selecting candidate parts, the latest data of the parts manufacturer, information on the applicability of qualification, 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.
(4) For the evaluation of candidate parts, data on the parts and part manufacturers necessary for the NSPAR review should be collected. (Note: It is important to verify the completeness of the part manufacturer and the data sheets for the following items:)
  (a) Indication of parts
  (b) Mechanical details
  (c) Electrical and thermal details
  (d) Others
(5) 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.

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

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

(8) Investigate information on depleted parts, and in principle, parts that are likely to be depleted should not be selected.

(9) 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. (The test conditions should be as close to actual use as possible.)

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.
When MIL-HDBK-217F is used, the following quality factor (πQ) may be applied.
πQ = 1 (equivalent to Class I), πQ = 2 (equivalent to Class II), πQ = 5 (equivalent to Class III)

4.4.4 Temperature Range

(1) The candidate parts should be selected from those in the appropriate operating temperature range in accordance with paragraph 2.

(2) 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 part manufacturer. (Example: If the maximum/minimum operating temperature range specified by the part 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.)

(3) It is not recommended to use the product outside the operating temperature range assured by the part manufacturer. If it is absolutely unavoidable to use it under such condition, coordinate with the parts manufacturer, conduct sufficient verification in the electrical characteristics and thermal evaluation of the evaluation test in Section 4.5.2, and specify the temperature range and test conditions extended in the procurement specifications in Paragraph 5.3 and confirm it through screening tests and lot assurance tests. Obtain the parts manufacturer's opinion if it is available. Even in the case of an extended

temperature range, it is recommended to consider a margin of 10°C above and below the actual temperature range (including the worst case).

4.4.5 Prohibitions and restrictions on selection and application

(1) If applicable restrictions are stipulated in the part specifications, NPSL, etc., the restrictions should be applied. The restrictions on the application of NPSL are listed in the NPSL (http://nepp.nasa.gov/npsl/) for each part type of "Important! Application Notes" for reference.

(2) If there are restrictions on the application of parts in the design specifications of the equipment, etc., the restrictions should be applied.

(3) The restrictions should be applied by considering the required conditions so that the function and performance of the equipment will not be impaired by wear and deterioration of the parts due to operation, thermal cycling, radiation environment, etc. during the required life of the equipment. Properly manage limited life items.

(4) Due to reasons such as limited lifetime, known instability, safety hazards, and reliability risks, the following parts should not be selected or used.

(a) Parts that use pure tin (or tin-lead alloy containing less than 3% lead) for plating on leads, terminals, external surfaces and packaging. If it is unavoidable to use them, follow (8).

(b) Hollow core resistor

(c) Potentiometers (except mechanical position monitoring type)

(d) Non-metallic bonded (non-metallurgically bonded) diodes

(e) Semiconductors and integrated circuits with non-gracivated active regions

(f) Wet slag tantalum capacitors other than double-sealed, tantalum case structures (aluminum electrolytic capacitors, silver case wet slag tantalum capacitors, etc.)

(g) Parts whose internal structure is metal-bonded at a melting temperature that does not conform to the mounting conditions of the end application.

(h) Wire-link fuses less than 5A

(i) TO5 relays in which armature/coil assemblies and headers not double-welded or integrated diodes are included

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

(k) Parts using TO3 and DO4/DO5 packages

(5) Mesa junction or alloy junction type transistors should not be used.

(6) Except for microwave diodes and solar cells, parts made of germanium should not be used.

(7) As a general rule, variable resistors should not be used.

(8) Pure tin 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, pure tin should not be used.

In case of using pure tin, it should be approved on a case-by-case basis based on demonstration backed by technical justification that there are no substitutes and no risks. (Refer to JERG-1-009 Lead Free Parts application Standard for Rocket Avionics)

(9) For health and safety reasons, beryllium oxide (except as specified in the procurement specifications), cadmium, lithium, magnesium, mercury, zinc, radioactive materials, and any materials that may pose a safety hazard should not be used. However, this excludes cases where it is contained in the alloy used as a mechanical material.

(10) Hermetically sealed type should be used for relays, thermostats and switches. (Excluding coaxial switches and waveguide switches)

(11) Organic materials with low outgassing should be used 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, use the following values or less. If materials larger than this value are used, or if adverse effects from outgassing are expected, effective protective measures should be applied. If there is no outgassing data, outgassing test should be performed to acquire the necessary outgassing data.

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

(b) Collectable Volatile. Condensable Materials (CVCM): 0.1%

(12) Materials that are not sealed hermetically should be used with caution for off-gassing, flammability, and toxicity.

(13) One-time programming parts (OTPs) such as FPGAs (PLDs) and PROMs are screened after programming. If there is a track record, test may be omitted.

(14) The robustness to stress caused by the mounting and assembly techniques used for candidate parts should be evaluated.

(15) In non-hermetic semiconductor parts, 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 a 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.

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.

(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-intensity 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 should be used.
When using a part with a lower threshold LET, protective measures such as a latch-up protection circuit should be implemented.
For scientific missions, the lower limit should be set at 75 MeV·cm^2/mg.

(b) Parts with a threshold LET for SEU less than 25 MeV·cm^2/mg should be protected (including no countermeasures) according to the results of the mission impact assessment.
Parts with threshold LET values ranging from 25 MeV·cm^2/mg to the upper limit specified in the individual project requirements should be selected by predicting the probability of SEU occurrence.
In predicting the probability of SEU occurrence, the solar quiet condition defined in the CREME96 should be used when no solar flare has occurred, and the worst-week model should be used when a solar flare has occurred.
The predicted value for the number of solar flares should be used by considering the solar flare activity cycle.

(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.

(3) Extraction of radiation-sensitive parts
The user (system/equipment) manufacturer collects and evaluates relevant information about radiation-sensitive parts prior to ordering parts. Then, the data on the radiation hardness of each part and its source should be identified, and be used for part procurement, test planning, and radiation hardness analysis of equipment.

4.4.7 Derating

When using parts, derating design which is necessary to meet the reliability, lifespan, etc. required for the equipment should be performed.
It is desirable to set derating standards in accordance with EEE-INST-002, GSFC PPL-21 Appendix B, or ECSS-Q-ST-30-11.

4.4.8 Points to note in selection and application

(1) Materials that are not sealed hermetically should be used with caution for off-gassing, flammability, and toxicity.

(2) The resin used in resin molded parts such as semiconductor parts contain 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.

(3) General vibration and shock tests may reduce the adhesion of the inter-chip insulating layer (Low-k layer) of semiconductor parts. In addition, the Low-k layer is peeled and cracked by the load during cross-sectional processing. (Evaluation data: JERG-0-052-TM001) For this reason, when performing vibration and shock tests on semiconductor parts, it is recommended to verify for peeling and cracks inside the chip with C-SAM, etc. after the test.

4.5 Candidate parts screening process

4.5.1 List of candidate parts and parts used

After selecting candidate parts to be used in the project, the user (system/equipment) manufacture should create and maintain a list of parts that are used in the system/equipment to be reviewed.

Since the parts used in the project are factors that impose constraints on the function, performance, and reliability of onboard equipment of spacecraft and launch vehicle, all parts should be selected systematically from the initial stage of the project as much as possible. In addition, candidate parts that can be applicable to space should be included in the list of parts used as follows and be maintained and updated.

(1) At the initial design stage (JAXA's System Definition Review (SDR)), candidate parts that can be applicable to space according to mission requirements should be identified and the procurement management policy should be clarified.

(2) At the basic design stage, candidate parts to be used in the target equipment should be selected and be maintained appropriately by adding the list of parts to be used.

It is recommended that this parts list is registered in the Project Approved Parts Database (PAPDB).

(3) At the critical design stage, the parts list should be updated by identifying them as " non-standard space-applicable parts " including the added candidate parts.

This parts list which is included in the Critical Design Review (CDR) input package should be submitted to JAXA for review.

In addition, it should be reviewed by JAXA's NSPAR as a "non-standard space-applicable parts".

(4) If additional items are requested during the sustaining design stage, the validity of specifications, evaluation, and application should be verified and

approved by JAXA. Then, it should be reported at the post-test review (PQR, PSR, etc.) after adding to the parts list.

4.5.2 Evaluation of candidate parts

If the candidate part does not have proof to meet the project requirements of functional performance, quality, reliability, and environmental resistance (information required for pre-evaluation from the parts manufacturer), the user (system/equipment) manufacturer should plan and perform the following evaluation for the candidate part. (Refer to Section 5.3 of JMR-012)

(1) The evaluation scope and plan of the candidate parts should be formulated based on the design of the parts and the evaluation data of the intended use.

(2) The evaluation plan should include the following items, and the evaluation results report should also be reviewed by JAXA.

(a) QMS evaluation by parts manufacturers

(b) Structural analysis

(c) Evaluation test

(d) Radiation hardness verification

(3) The evaluation program should be taken into account information such as relevant reliability, analysis and test data from part manufacturers, and similar precedents for use.

(4) All tests and inspections should be performed on a representative sample of each part type, which are extracted from the latest products, selected for the procurement of flight hardware parts.

(5) For programmable devices, their representativeness includes compatibility with programming hardware tools and software.

(6) It should be verified that whether the evaluation results affect the content of the procurement specifications, and the procurement specifications, etc. should be revised as necessary.

4.5.2.1 Structural Analysis

(1) Structural analysis should be performed on 5 sample parts.

Note: The main objective is to conduct an initial confirmation of structural conformity with the specified performance for application in space projects.

(2) The structural analysis procedure should be performed by documenting the evaluation contents in an evaluation plan, etc., with reference to Table 4.5.2.1-1 structural analysis (CA), when integrated circuits and discrete semiconductors are typical examples.

(3) The results of the analysis should be summarized in the structural analysis report and be included in the evaluation result report.

(4) Structural analysis is a part of the evaluation test. (Refer to Section 4.5.2.2)

Table 4.5.2.1-1 Typical examples of structural analysis (CA) integrated circuits and discrete semiconductors

Test	Sample					Procedure	Remarks
	No.1	No.2	No.3	No.4	No.5		
External visual inspection	X	X	X	X	X	MIL-STD-750 Method 2071-4 MIL-STD-883 Method 2009-9	MIL specs do not apply visual inspection of PEM (plastic packages), but can be used as a reference document (*1)
X-ray inspection	X	X	X	X	X	MIL-STD-750 Method 2076-3 MIL-STD-883 Method 2012-7	It is desirable to perform with a microfocus X-ray system
marking	X	X	X	X	X	ESCC 24800	
PIND test (internal cavity package)	X	X	X	X	X	MIL-STD-750 Method 2052-3 MIL-STD-883 Method 2020-7	
Hermeticity (if applicable)			X	X	X	MIL-STD-750 Method 1071-6 MIL-STD-883 Method 1014-10	
Lead finish analysis and pure tin identification	X	X				Energy dispersive X-ray analysis (EDX), X-ray fluorescence, microfluorescence, differential scanning calorimetry (DSC)	Analysis to identify lead finishes for RoHS issues
Solderability	X	X				IEC60068-2-69 or AFNOR A 89-400	Solder wettability test methods are recommended. Verify feasibility on specific packages
Opening sealed package	X	X	X	X			
Internal visual inspection	X	X	X	X		MIL-STD-750 Method 2074-4, 2072-6, 2069 MIL-STD-883 Method 2010-10 MIL-STD-883 Method 2013	For plastic encapsulated parts, particularly check the adhesion of the interface between the die and the lead frame (delamination), and between the external connection and the resin.
SEM inspection	X	X				MIL-STD-883 Method 2018	To verify the quality of wire bonding, integrity of gracivation, and metallization of die connections

Table 4.5.2.1-1 Typical examples of structural analysis (CA) integrated circuits and discrete semiconductors (Cont.)

Test	Sample					Procedure	Remarks
	No.1	No.2	No.3	No.4	No.5		
Bond strength	[1]	[2]	[2]			MIL-STD-750 Method 2037 MIL-STD-883 Method 2011-7 JEDEC 22-B116	[1] Bond and peel test [2] Bond test
Passivation consistency		X	X	X		MIL-STD-883 Method 2021-3	Ensure chemical etchant is suitable for metallization
Bond crater formation test (ball bonding)		X	X	X			If applied
Die peel test (internal cavity package)	X	X	X			MIL-STD-750 Method 2017-2 MIL-STD-883 Method 2019-5	
Cross-sectional observation at package level					X		
Visual and SEM					X		

(*1) In addition to the standards of MIL specifications, the following items should be inspected:

- Package deformation
- Foreign matter in the Package, voids and cracks in the plastic capsule material
- Lead deformation, peeling, corrosion and swelling of the finish
- Visibility and accuracy of markings

The above analysis procedures, 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

The various analysis procedures shown in this table may be modified according to the risk response policy of the system.

Refer to the applicable documents (25) to (27) for details.

4.5.2.2 Evaluation Test

(1) When a candidate part is manufactured and tested in accordance with procurement specifications, what inspections and tests are necessary to provide reliability that meets the project requirements should be determined by evaluation.

(2) In order to minimize the evaluation tests, the existing data related to the followings (corresponding to (1), (2), and (3) of space-applicable parts in Section 4.1) should be verified.

(a) Durability test (under high temperature and electrical stress)

(b) Mechanical stress (shock, vibration, constant acceleration)

(c) Environmental stress (thermal shock, thermal cycling, high/low temp. storage, humidity)

(d) Test related to mounting reliability

(e) Radiation hardness test (total dose and single event)

(f) Outgassing test

(g) Whisker test (e.g., tin plating, if applicable)

(3) Evaluation tests should be performed for each candidate part (for each parts manufacturer).

(4) The evaluation results are used to determine the pass/fail criteria for screening and lot assurance tests (LAT).

(5) Regarding the evaluation test, when integrated circuits and discrete semiconductors are representative examples, the contents of each quality assurance level (equivalent to Class I, II, III) described in Tables 4.5.2.2-1 to -3 and Figures 4.5.2.2-1 to -3 are recommended.

For automotive parts (AEC-Q grade), the necessity of evaluation test items and implementation items should be considered by referring to paragraph 8 of ECSS-Q-ST-60-13. In addition, parts based on other official specifications may be evaluated in the same way.

Table 4.5.2.2-1 Class I equivalent evaluation test

Subgroup test	Test	Number of samples (pcs)	Test method/evaluation criteria	Comments
1	Structural Analysis (CA)	5	Refer to Table 4.5.2.1-1 Structural Analysis (CA)	
2	Electrical Characteristics	10 minimum	Electrical tests should be performed under 3T° conditions (minimum, standard, maximum) or operating range +10°C (whichever is higher) as specified in the data sheet.	Electrical tests should be read and recorded.
3	Preconditioning + High Accelerated Stress Test (HAST) (or 1000 hours of high temperature and humidity bias test (85°C/85%RH))	10 minimum	Preconditioning (*) +130°C/85%RH for 96 hours (or 1000 hours high temperature/humidity bias test 85/85) JESD22-A110 Continuous Bias (JESD22-A101 for THB) Electrical tests before and after the test should be performed at 25°C as specified in the data sheet (parameters & functions) (*) Preconditioning: JESD-22-A113: SMD JESD-22-B106: Through-hole terminals	Only applicable to PEM (plastic package). Electrical tests should be read and recorded.
4	Life test [1]	10 minimum	Ta: 2000 hours at 125°C MIL-STD-883, Condition D of Test method 1005 Electrical tests before, during (1000 hours), and after the test should be performed under 3T° conditions (minimum, standard, and maximum) as specified in the data sheet (parameters & functions). Three DPAs should be performed. Refer to Table 5.3.6-1 Destructive Physical Analysis (DPA)	- Ta: 125°C or maximum operating temperature, whichever is lower. - Electrical tests should be read and recorded. Result may be used to verify electrical specifications and test conditions (terminal integrity for oxidation).

Table 4.5.2.2-1 Class I equivalent evaluation test (Cont.)

Subgroup test	Test	Number of samples (pcs)	Test method/evaluation criteria	Comments
5	Preconditioning + Thermal cycling [1] [2]	10 minimum	Preconditioning (*) + (-55/+125°C) for 500 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) Electrical tests before, during (100 cycles) and after the test should be performed at 25°C as specified in the data sheet (Parameters & Functions) (*) Preconditioning: Refer to subgroup 3.	Electrical tests should be read and recorded.
6	Radiation evaluation [1]	Refer to ECSS-Q-ST-60-15	Refer to ECSS-Q-ST-60-15	If TID, non-ionizing radiation exposure, and single-event effect sensitivity data are not available.
7	Outgassing test	Refer to ASTM E 595, JERG-0-034	Refer to ASTM E 595, JERG-0-034	

[1] When flight parts are screened, life test, thermal cycling, TID, and non-ionization radiation test on the parts should be performed after the screening test.
[2] Perform C-SAM (PEM) after thermal cycling.
The above test conditions are described as representative examples of integrated circuits and discrete semiconductors with reference to the following document.
- ECSS-Q-ST-60-13 Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components
In addition, the various test conditions shown in this summary can be changed according to the risk response policy of the system.
Refer to the applicable documents (25) to (27) for details.

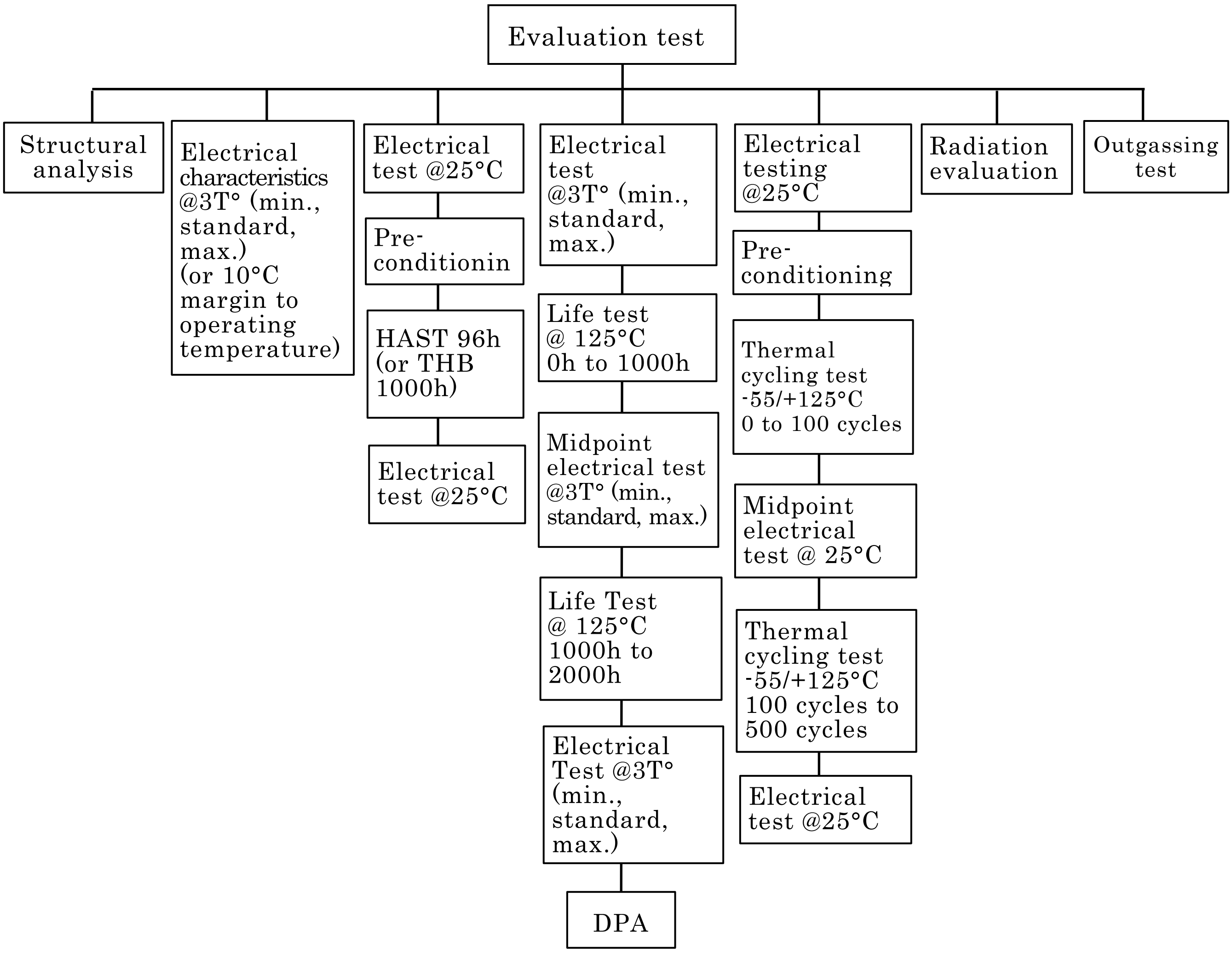


Figure 4.5.2.2-1 Class I equivalent evaluation test diagram

Table 4.5.2.2-2 Class II equivalent evaluation test

Subgroup test	Test	Number of samples (pcs)	Test method/evaluation criteria	Comments
1	Structural Analysis (CA)	5	Refer to Table 4.5.2.1-1 Structural Analysis (CA)	
2	Electrical Characteristics	10 minimum	Electrical tests should be performed under 3T° conditions (minimum, standard, maximum) or operating range +10°C (whichever is higher) as specified in the data sheet.	Electrical tests should be read and recorded.
3	Preconditioning + High accelerated stress test (HAST) (or 1000 hours of high temperature and humidity bias test (THB) 85/85)	10 minimum	Preconditioning (*) + 130°C/85%RH for 96 hours (or 1000 hours high temperature/humidity bias test 85/85) JESD22-A110 continuous bias (JESD22-A101 for THB) Electrical tests before and after the test are performed at 25°C as specified in the data sheet (parameters & functions) (*) Preconditioning: JESD-22-A113: SMD JESD-22-B106: Through-hole terminals	Only applicable to PEM (plastic package). Electrical tests should be read and recorded.
4	Life test [1]	10 minimum	Ta: 2000 hours at 125°C MIL-STD-883, Condition D of Test Method 1005 Electrical tests before, during (1000 hours), and after the test are performed under 3T° conditions (minimum, standard, and maximum) as specified in the data sheet (parameters & functions). Three DPAs are performed. Refer to Table 5.3.6-1 Destructive Physical Analysis (DPA)	- Ta: 125°C or maximum operating temperature, whichever is lower. - Electrical tests should be read and recorded. Result may be used to verify electrical specifications and test conditions (terminal integrity for oxidation).

Table 4.5.2.2-2 Class II equivalent evaluation test (Cont.)

Subgroup test	Test	Number of samples (pcs)	Test method/evaluation criteria	Comments
5	Preconditioning + Thermal cycling [1] [2]	10 minimum	Preconditioning (*) + (-55/+125°C) for 500 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) Electrical tests before, during (100 cycles) and after the test are performed at 25°C as described in the data sheet (Parameters & Functions) (*) Preconditioning: Refer to subgroup 3.	Electrical tests should be read and recorded.
6	Radiation evaluation [1]	Refer to ECSS-Q-ST-60-15	Refer to ECSS-Q-ST-60-15	If TID, non-ionizing radiation exposure, and single-event effect sensitivity data are not available.
7	Outgassing test	Refer to ASTM E 595, JERG-0-034	Refer to ASTM E 595, JERG-0-034	

[1] When flight parts are screened, life test, thermal cycling, TID and non-ionizing radiation irradiation test on the parts should be performed after the screening test.
[2] Perform C-SAM (PEM) after thermal cycling.
The above test conditions are described as representative examples of integrated circuits and discrete semiconductors with reference to the following document.
- ECSS-Q-ST-60-13 Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components

In addition, the various test conditions shown in this summary can be changed according to the risk response policy of the system.
Refer to the applicable documents (25) to (27) for details.

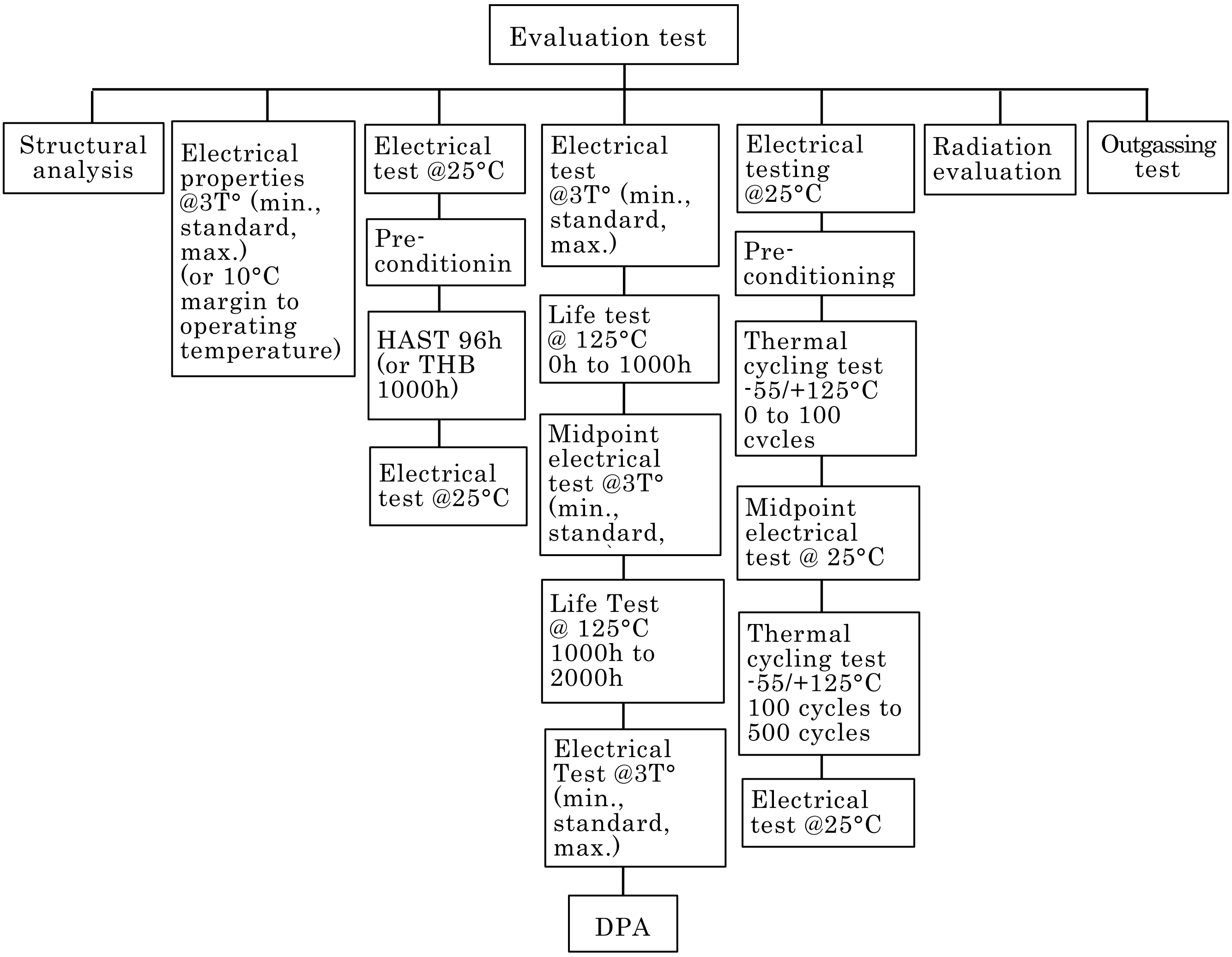


Figure 4.5.2.2-2 Class II equivalent evaluation test diagram

Table 4.5.2.2-3 Class III equivalent evaluation test

Subgroup test	Test	Number of samples (pcs)	Test method/evaluation criteria	Comments
1	Structural Analysis (CA)	5	Refer to Table 4.5.2.1-1 Structural Analysis (CA)	
2	Radiation evaluation [1]	Refer to ECSS-Q-ST-60-15	Refer to ECSS-Q-ST-60-15	If TID, non-ionizing radiation exposure, and single-event effect sensitivity data are not available.
3	Outgassing test	Refer to ASTM E 595, JERG-0-034	Refer to ASTM E 595, JERG-0-034	

[1] When flight parts are screened, TID and non-ionizing radiation irradiation tests on parts should be performed after screening test.
The above test conditions are described as representative examples of integrated circuits and discrete semiconductors with reference to the following document.
- ECSS-Q-ST-60-13 Space product assurance - Commercial electrical, Electronic and Electromechanical (EEE) components
In addition, the various test conditions shown in this summary can be changed according to the risk response policy of the system.
Refer to the applicable documents (25) to (27) for details.

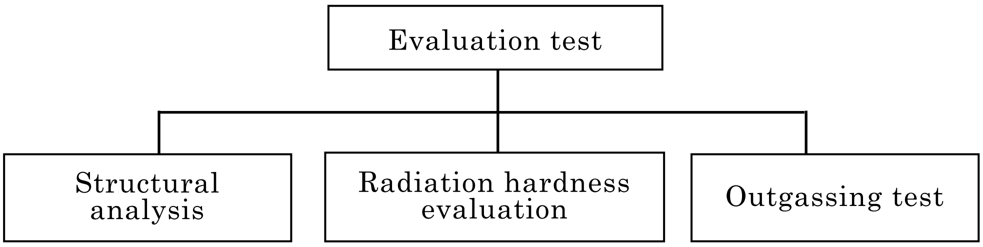


Figure 4.5.2.2-3 Class III equivalent evaluation test diagram

4.5.3 Non-standard parts approval request (NSPAR) and review

(1) When a user (system/equipment) manufacturer intends to use non-standard space-applicable parts, the user (system/equipment) manufacturer should submit a non-standard parts approval request (NSPAR) with the necessary information to the project at JAXA for review and approval (Note). However, if it is not feasible to apply the NSPAR, it should be based on the review of the candidate part list for use according to Section 4.5.1.

(2) In principle, the preparation and submission of NSPARs should be based on the use of PAPDB. If it is difficult to do so, follow the instructions of the project.

(3) Approval of a previously approved NSPAR may be valid for non-standard space-applicable parts that meet the following conditions

(a) The part for which NSPAR has been submitted and approved in the past, and there are no reliability issues in the design, construction, or manufacturing conditions. Since design, processing conditions, processing processes, materials, etc. may be changed for both automotive and industrial parts, be sure to confirm with the part manufacturer before using the part again. In such cases, it is desirable to provide product information (e.g., part manufacturer's part number, lot NO., etc.) that was used at the first time.

(b) It can be proved by the specifications, test data, etc. at the time of approval that the application conditions of the parts at the time of approval are equivalent or superior to the requirements for the service life, environmental conditions, etc. of the launch vehicle or spacecraft to which the part is to be applied.

(4) In accordance with the NSPAR, Figure 4.1-2 Basic flow of space-applicable parts for space application, in principle, an application should be made before procurement of the part concerned. If subsequent test results indicate the need for updating, it is desirable to submit a revision request of NSPAR.

(Note) For the entry in the NSPAR (including attachments) as non-standard space-applicable parts, select "Other ( )" for the following applicable columns of the NSPAR in accordance with Section 4.5.3 of JMR-012A, and enter "(Class I equivalent non-standard space-applicable parts), (Class II equivalent non-standard space-applicable parts), (Class III equivalent non-standard space-applicable parts)" in parentheses to distinguish them from the conventional project-approved non-standard parts.

- Quality assurance level column
- Design/Structure column
- Manufacturing process control column
- Screening test column
- Qualification test column
- Quality conformance inspection column

5. QUALITY ASSURANCE

5.1 Evaluation and quality assurance by quality assurance level

The user (system/equipment) manufacturer selects the quality assurance level of the part to be applied by carefully considering the risk response policy, operation period, part selection, etc. of the system for which the system FMEA (Failure Modes and Effects Analysis) , etc., has been implemented based on the system risk response policy and the quality assurance level of the parts specified in Section 4.3.
Then, evaluation and quality assurance corresponding to Class I, II, and III equivalent are performed, and the parts should be assured as non-standard space-applicable parts.

For an overview of the evaluation, screening, and lot assurance tests corresponding to Class I, II, and III equivalent, the comparison of each quality assurance level with integrated circuits and 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 other parts, it is recommended to evaluate candidate parts and develop a test plan by referring to EEE-INST-002(*) for details of screening tests and qualification tests for Level 1, 2, and 3, which are nearly corresponding to Class I, II, and III equivalent, for Commercial parts.
(*) https://nepp.nasa.gov/DocUploads/FFB52B88-36AE-4378-A05B2C084B5EE2CC/EEE-INST-002_add1.pdf

Furthermore, for details of evaluation tests, screening tests, and lot assurance tests, refer to Section 4.5.2.2 Evaluation test (Tables 4.5.2.2-1 to -3, Figures 4.5.2.2-1 to -3), Section 5.3.2 Screening test (Tables 5.3.2-1 to -3), and Section 5.3.3 Lot assurance test (Tables 5.3.3-1 to -3, Figures 5.3.3-1 to -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 manufacture

With respect to multiple candidate parts selected based on the common items regarding the selection guidelines and prohibitions/restrictions in Section 4.4, the user (system/equipment) manufacturer should give priority to the parts manufacturer who has reached an agreement (cooperation) with the user (system/equipment) manufacturer in accordance with Section 4.2.

If the QMS of the selected part manufacturer is not certified by an official organization such as ISO or JIS, the user (system/equipment) manufacturer should verify the following items. Even if an official certification has been obtained, it is desirable to verify whether the following items are included in the scope of certification and whether they are implemented.

(1) An effective system for process characteristics and process control should be implemented and maintained.
(2) An effective system for qualification and quality assurance of processes and parts should be implemented and maintained.
(3) A reliability test system should be in place to generate reliability data of processes and parts.
(4) Effective policies should be in place to ensure continuous improvement of processes.

These should be evaluated based on evidence or by conducting a quality review/factory audit at the part manufacturer's factory.

If the part manufacturer's agreement (cooperation) cannot be obtained, but the use of the candidate part is essential, the user (system/equipment) manufacturer should take full responsibility for evaluation tests, procurement, screening tests, and lot assurance tests according to the “procurement and use at user's own risk” flow shown in Figure 4.1-2 Basic flow of space-applicable parts for space application.

5.3 Procurement of candidate parts

The user (system/equipment) manufacturer should procure candidate parts from the parts manufacturer selected in Section 5.2, considering the following items

(1) To minimize the variation in the performance characteristics of the parts and the risk of jeopardizing the success of the mission, user (system/equipment) manufacture should define lot definition with the parts manufacturer in advance. And the parts which are to same lot should be ordered as much as possible.
(2) Parts with the latest date code should be procured.
(3) If it is not possible to procure directly from the parts manufacturer, parts should be procured only from distributor who has an authorized distributor agreement with the parts manufacturer to reduce the risk of counterfeit parts procurement.
(4) To the extent possible, orders should be in the part manufacturer's minimum sales quantity or multiples thereof to prevent repackaging and split handling by the distributor. Thereby the traceability of information normally contained in the part manufacturer's original packaging should be ensured.

In procurement, it is important to refer to the following items, etc., as described in Section 4.2 Agreement (cooperation) between the user (system/equipment) manufacturer and the part manufacturer, and both sides should agree to include necessary items in the MOU to establish a cooperative relationship.

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

5.3.1 Procurement specifications

When procuring parts, user (system/equipment) manufacturers should prepare procurement specifications that specify candidate parts and procure them based on these specifications.

The procurement specifications should specify at least the following items by using the delivery specification drawings or data sheets of the part manufacturers.

(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

Screening test should be performed on all parts incorporated into the flight hardware. In setting up the screening test, care should be taken to ensure that the reliability of the parts is not compromised by the stresses caused by the test. Note that the solderability of leads may deteriorate due to the temperature and time involved in the screening test.

All screening tests should be performed at the part manufacturer's facility or at a facility that has been verified to have the capability to conduct screening tests.

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 -3 and Figures 5.3.2-1 to -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 Section 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

Step	Test	Samples (pcs)	Test method/evaluation criteria	Comments
1	X-ray	100%	MIL-STD-883, Test method 2012 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 240 hours at 125°C 445 hours at 105°C or 85°C for 885 hours Also, additional conditions other than temperature and time, such as voltage	- The temperature should be < Tjmax-10℃ or Tg-10℃, whichever is lower. - If Tj or Tg is not known, the maximum temperature should be 105°C. - 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. - 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 (pcs)	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 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/ 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
The test conditions shown in this summary can be changed according to the risk response policy of the system.
Refer to the applicable documents (25) to (27) for details.

Table 5.3.2-2 Class II equivalent screening test

Step	Test	Samples (pcs)	Test method/evaluation criteria	Comments
1	Serial numbering	100%	N/A	
2	Thermal cycling [1]	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 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)	
4	Before burn-in test Electrical characteristics [1]	100%	Electrical test is performed at 25°C as specified in the data sheet (parameters & functions)	Read and record selected parameters and electrical defects.
5	Dynamic burn-in [1]	100%	1MIL-STD-883, Test method 1015, Condition B 160 hours at 125°C 300 hours at 105°C or 85°C for 590 hours Also, additional conditions other than temperature and time, such as voltage	- The temperature should be < Tjmax-10℃ or Tg-10℃, whichever is lower. - If Tj or Tg is not known, the maximum temperature should be 105°C. - Unless another value is proven for the part, Ea = 0.4eV should be used as a reference value when calculating acceleration coefficients and the like in the test. - The risk of oxidation of terminals, etc. should be checked after burn-in.
6	After burn-in test Electrical characteristics [1]	100%	Perform electrical test as specified in the data sheet, 3T° (minimum, standard, maximum)	Read and record selected parameters and calculate drift. Electrical defects should be read and recorded.
7	PDA {1]	N/A	Steps 4 and 6 PDA: 5% max.	

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

Step	Test	Samples	Test method/evaluation criteria	Comments
8	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)	
9	External visual Inspection [1]	100%	MIL-STD-883, Test method 2009/ 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

[1] Applicable when sufficient quality and reliability cannot be confirmed by available evidence data, evaluation test data, etc.
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

The test conditions shown in this summary can be changed according to the risk response policy of the system.
Refer to the applicable documents (25) to (27) for details.

Table 5.3.2-3 Class III equivalent screening test

Subgroup test	Test	Number of samples (pcs)	Test method/evaluation criteria	Comments
1	PIND test [1]	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 [1]	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)	

[1] If clear quality concerns, problematic failure rate data or actual performance, etc. are reported or confirmed, further test studies are required.
The above test conditions are described for 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
The test conditions shown in this summary can be changed according to the risk response policy of the system.
Refer to the applicable documents (25) to (27) for details.

5.3.3 Lot Assurance test

The user (system/equipment) manufacturer and/or part manufacturer should perform lot assurance test on the lots screened and tested in clause 5.3.2 to verify lot acceptance or rejection.

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~-3 and Figures 5.3.3-1 to -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 Section 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

Subgroup test	Test	Number of samples / Acceptance 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) Pre-test and post-test electrical test at 25°C as specified in the data sheet (parameters & functions) (*) Preconditioning: JESD-22-A113: SMD JESD-22-B106: Through-hole terminals	Applicable to PEM (plastic package) only Electrical tests should be read and recorded.
3	Life test [1]	15/0	Ta: 2000 hours at 125°C MIL-STD-883, Condition D of Test method 1005 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. - 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. - Electrical defects should be read and recorded.
4	Preconditioning + Thermal cycling [1]	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) Electrical tests before and after the test should be performed at 25°C as specified in the data sheet (Parameters & Functions) (*) Preconditioning: Refer to subgroup 2.	Electrical tests should be read and recorded.

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

Subgroup test	Test	Number of samples (pcs)	Test method/evaluation criteria	Comments
5	Radiation hardness demonstration test (RVT) [1]	Refer to ECSS-Q-ST-60-15	Refer to ECSS-Q-ST-60-15	

[1] Provide screened tested parts for life tests, thermal cycling, and radiation hardness demonstration tests.

The above test conditions are described for 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

The test conditions shown in this summary can be changed according to the risk response policy of the system.

Refer to the applicable documents (25) to (27) for details.

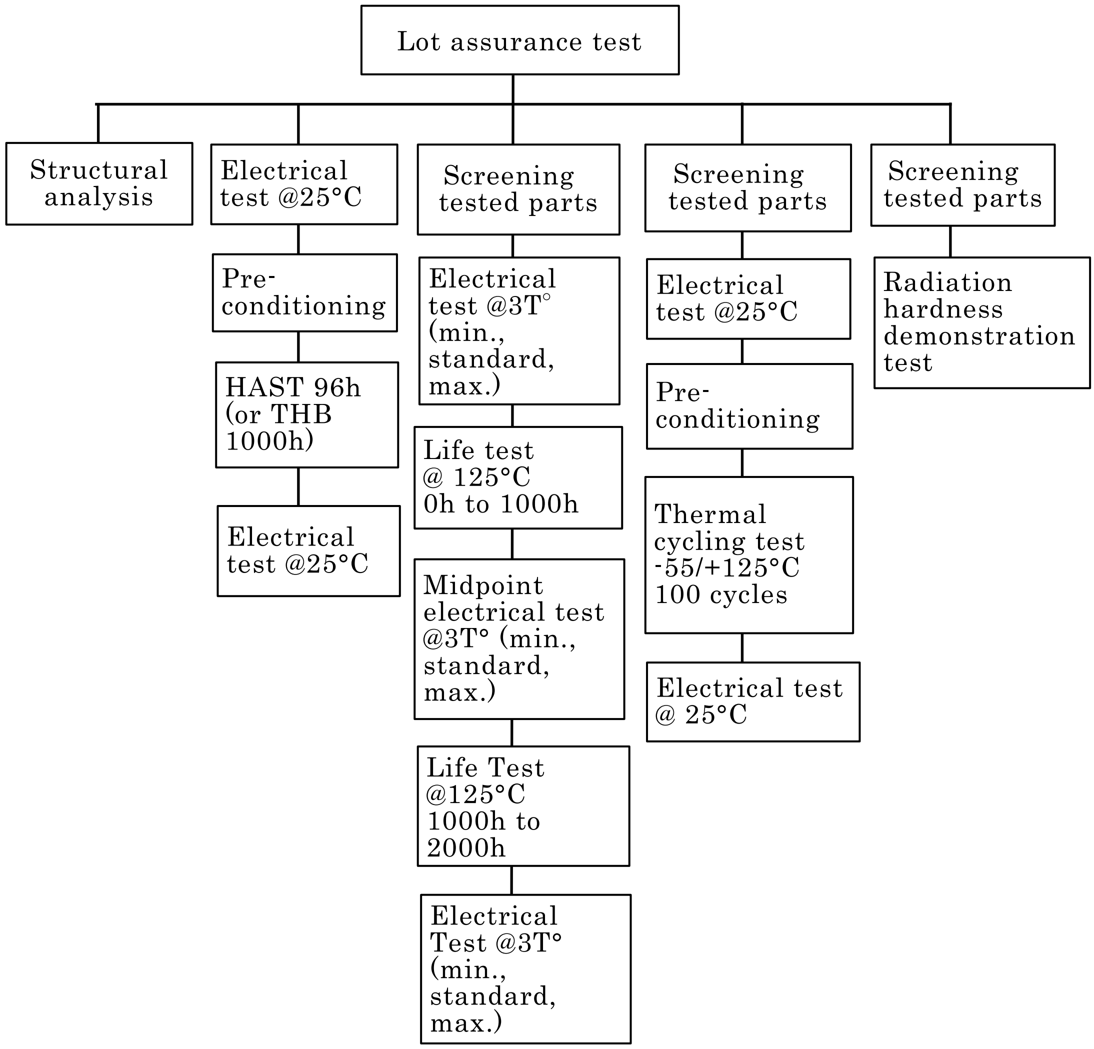


Figure 5.3.3-1 Class I equivalent lot assurance test diagram

Table 5.3.3-2 Class II equivalent lot assurance test

Subgroup test	Test	Number of samples / Acceptance 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) Electrical tests before and after the test are performed at 25°C as described in the data sheet (parameters & functions) (*) Preconditioning: JESD-22-A113: SMD JESD-22-B106: Through-hole terminals	Applicable to PEM (plastic package) only. Electrical tests should be read and recorded.
3	Life test [1]	15/0	Ta: 2000 hours at 125°C MIL-STD-883, Condition D of Test method 1005 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. - Electrical defects should be read and recorded.
4	Preconditioning + Thermal cycling [1]	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) Electrical tests before and after the test should be performed at 25℃ as specified in the data sheet (Parameters & Functions) (*) Preconditioning: Refer to subgroup 2.	The decision to conduct this subgroup test depends on the mission profile. Electrical tests should be read and recorded.

Table 5.3.3-2 Class II equivalent lot assurance test (Cont.)

Subgroup test	Test	Number of samples / Accepted standard number	Test method/evaluation criteria	Comments
5	Radiation hardness demonstration test (RVT) [1]	Refer to ECSS-Q-ST-60-15	Refer to ECSS-Q-ST-60-15	

[1] Provide screened parts for life tests, thermal cycling, and radiation hardness demonstration tests.

The above test conditions are described for 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

The test conditions shown in this summary can be changed according to the risk response policy of the system.

Refer to the applicable documents (25) to (27) for details.

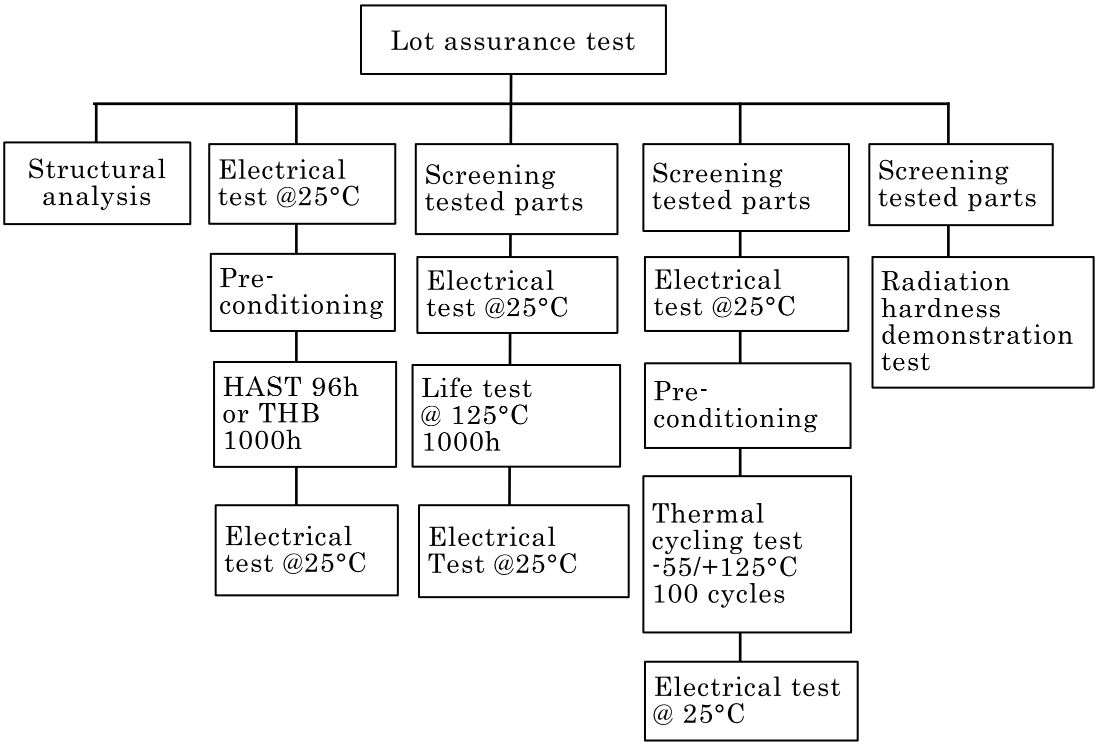


Figure 5.3.3-2 Class II equivalent lot assurance test diagram

Table 5.3.3-3 Class III equivalent lot assurance test

Subgroup test	Test	Number of samples / Acceptance 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) (*) Preconditioning: JESD-22-A113: SMD JESD-22-B106: Through-hole terminals	Applicable to PEM (plastic package) only Electrical tests should be read and recorded.
3	Life test [1]	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. - Electrical defects should be read and recorded.
4	Preconditioning + Thermal cycling [1]	10/0	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) Electrical tests before and after the test should be performed at 25℃ as specified in the data sheet (Parameters & Functions) (*) Preconditioning: Refer to subgroup 2.	The decision to conduct this subgroup test depends on the mission profile. Electrical tests should be read and recorded.

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

Subgroup test	Test	Number of samples / Acceptance number	Test method/evaluation criteria	Comments
5	Radiation hardness demonstration test (RVT) [1]	Refer to ECSS-Q-ST-60-15	Refer to ECSS-Q-ST-60-15	

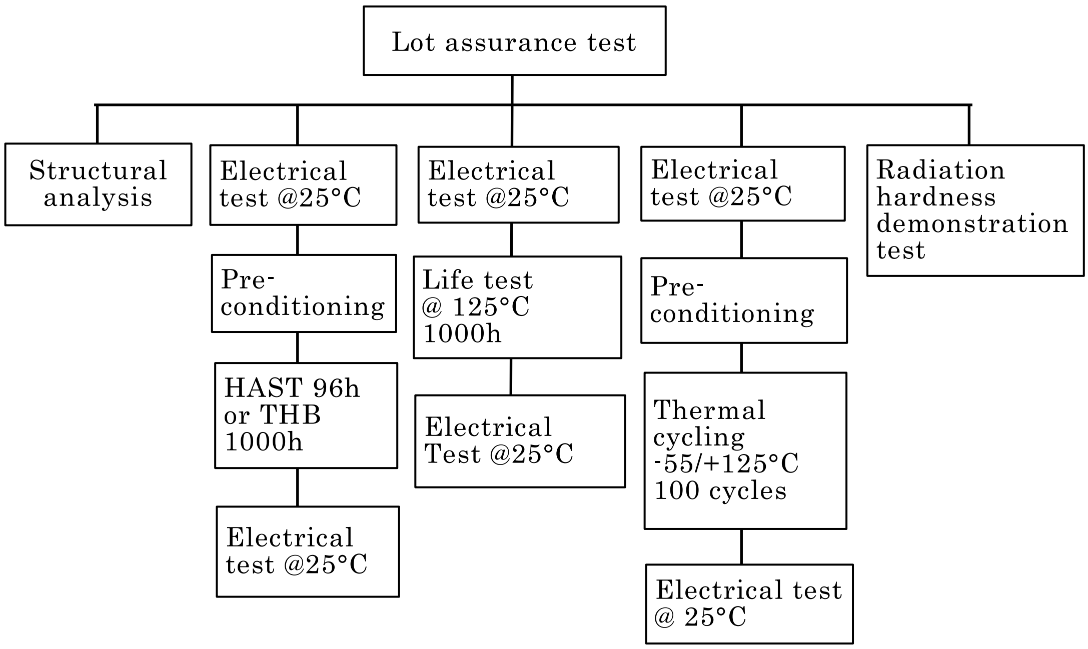
[1] Applicable when sufficient quality and reliability cannot be confirmed by available evidence data, evaluation test data, etc.

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

The test conditions shown in this summary can be changed according to the risk response policy of the system.

Refer to the applicable documents (25) to (27) for details.



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

The user (system/equipment) manufacturer should develop a test plan and conduct radiation hardness tests in accordance with the test plan for radiation-sensitive parts identified in Section 4.4.6 (3) and for parts for which data from existing tests are insufficient. 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. Samples of parts submitted for radiation hardness test should be selected from parts that have been subjected to screening test in accordance with Section 5.3.2 to be representative of the flight parts lot.

5.3.5 Acceptance inspection

The user (system/equipment) manufacturer should document the acceptance inspection procedures (including 5 methods and pass/fail criteria) including the following items, and conduct acceptance inspection accordingly.

(1) Marking (part number, lot identification, manufacturer's name, etc.) verification
(2) Quantity verification
(3) Packaging verification
(4) Verification of documents attached from the parts manufacturer
(5) Additional tests (e.g. solderability test, electrical test, etc.) according to the type and criticality of the parts

If the user (system/equipment) manufacturer or its agent conducts source inspection, the acceptance inspection may only include the following items as a minimum.
(1) Verification of packaging condition
(2) Verification of the number of items

5.3.6 Destructive physical analysis (DPA)

The user (system/equipment) manufacturer should perform a DPA for each lot to 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 the part manufacturer, but the results should be verified not only by the part manufacturer but also by the user (system/equipment) manufacturer.

This DPA verification is mandatory for active parts, and the DPA procedure should be documented with reference to the typical examples of integrated circuits and discrete semiconductors (as specified in ECSS-Q-ST-60-13) shown in Table 5.3.6-1 Destructive Physical Analysis (DPA).

It is desirable that the number of samples, applicable tests and inspections, and pass/fail criteria are performed by reference to MIL-STD-1580 for each part type based on engineering judgment.
The DPA should be completed before the part is incorporated into the flight hardware.

For health and safety reasons, tests that generate beryllium oxide (BeO) dust should not be performed. The DPA should be performed even when used for re-inspection. (Refer to Section 5.3.8)

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 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 MIL-STD-883 Method 2020-7	
Hermeticity (if applicable)	X	X	X	MIL-STD-750 Method 1071-6 MIL-STD-883 Method 1014-10	
Solderability test	X	X		IEC60068-2-69 or AFNOR A 89-400	Solder wettability test methods are recommended. Verify feasibility on specific packages
Decapsulation	X	X	X	N/A	
Interior visual inspection	X	X	X	MIL-STD-750 Method 2074-4, 2072-6, 2069 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 MIL-STD-883 Method 2011-7 JEDEC 22-B116	[1] Bond and peel test [2] Bond test
Passivation consistency		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 peel test (internal cavity package)	X	X	X	MIL-STD-750 Method 2017-2 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

(1) 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
- Visibility 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

The various analysis procedures shown in this table can be modified according to the risk response policy of the system.
Refer to the applicable documents (25) to (27) for details.

5.3.7 Handling and Storage

It is desirable that user (system/equipment) 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.

5.3.8 Reinspection

In principle, parts that have been stored (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 at the user may be used if the following items are satisfied.

(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

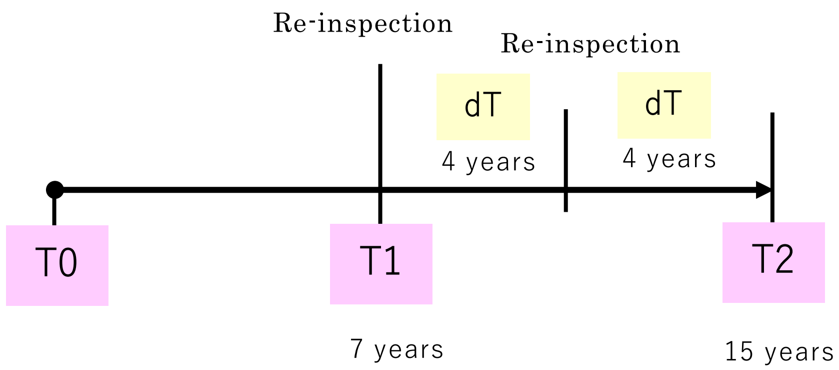
(a) External visual inspection
(b) Solderability test

(4) After the screening test (refer to Section 5.3.2) and lot assurance test (refer to Section 5.3.3) are completed or after the acceptance inspection at the user is completed, it is desirable that the product is re-inspected after 7 years of storage, and every 4 years thereafter. (Note)

(5) This does not apply to parts that have been stored for more than 15 years, if they are used at the project's discretion, including the risks involved.

(Note) According to the re-inspection provisions of ECSS-Q-ST-60-14 (Sections 4.3.10, 5.3.10, and 6.3.10), parts stored for more than 7 years after the lot date code are to be re-inspected, and every 4 years thereafter. There is no provision for re-inspection after 15 years (according to Table 5.3.8-1; reference). Regarding storage, this handbook refers to ECSS-Q-ST-60-14 because it is considered that the deterioration of pars (especially oxidation of terminals and moisture absorption of PEM) from the external environment can be slowed down by improving packaging and storage techniques (degassing systems, storage techniques, etc.).

Table 5.3.8-1 ECSS re-inspection timing parameters (for reference)



T0: Manufacturer's LDC
T1: Maximum allowable storage period from T0 (without re-inspection; 7 years)
T2: Maximum time of parts from manufacturer's LDC to installation (15 years)
δT: Maximum allowable storage period after one re-inspection (4 years)

5.3.9 One-time programming parts

For one-time programming parts (OTP) such as FPGAs (PLDs) and PROMs, post-programming screening tests should be performed according to the quality assurance level to confirm the stability, quality and reliability of the parts after programming, and to eliminate programming defects. Omission of this test may be considered in cases where proven results are available.

5.4 Summary of evaluation and test data

The documents recording test/inspection data, etc. as specified in Section 4.5 and 5.3 must be kept for at least 7 years after procurement from the part manufacturer, and it is desirable to keep for 15 years.
These documents recording inspection data, etc. should clearly indicate at least the part number, lot number, number of tests/inspections, number of samples/pass/fail criteria and their results (including PDA), and dates of tests/inspections.
When the NSPAR is applied prior to the parts procurement in accordance with Section 4.5.3, it is desirable to submit a revision request of NSPAR, if the test results after the procurement indicate need for updating the NSPAR.

6. ASSEMBLY AND MOUNTING

For new packages and materials to which the JAXA mounting process standards (refer to (*)) or already proven in-house mounting standards are not applicable, it is desirable that the user (system/equipment) manufacturer confirms the conformance to thermal cycling, life, etc. at the assembly/mounting level by proceduralizing the following items.

(1) Design of printed wiring boards or support for EEE parts (thermal requirements, placement rules for EEE parts, etc.)
(2) Storage and handling on the assembly line
(3) Preparation of parts prior to mounting (refer to JEDEC standards JESD22-112A, JESD22-113A and JESD26-A as guidelines for baking and other pretreatment in the PEM (PED) stage)
(4) Mounting process
(5) Criteria for visual inspection after mounting
(6) Storage conditions for printed wiring boards

(*); JERG-0-039 Soldering Process Standard for Space Applications
JERG-0-040 Requirements for Bonding Process of Electronic Assemblies of Space Use Staking, Conformal Coating and Potting
JERG-0-041 Standards for Electrical Wiring Process for Space Applications
JERG-0-042 Design standards for rigid printed wiring boards and assemblies
JERG-0-043 Standard for Surface Mount Soldering Process for Space Use

Pure tin is susceptible to whisker generation. It is desirable that should not be used if whisker generation has not been evaluated to be inhibited or if an appropriate treatment (such as solder coat “HSD,” or over-plating) has not been applied to prevent whisker generation.
The use of pure tin can be approved on a case-by-case basis with a demonstration, supported by technical justification, that there are no alternatives and no hazards (refer to JERG-1-009 Lead Free Parts application Standard for Rocket Avionics.

7. TRACEABILITY DEFECT HANDLING

7.1 Traceability

All parts used for flight should be verified to be 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.
Traceability should be maintained throughout the entire manufacturing, testing, etc., receiving, mounting, assembly/testing, and storage of the parts by the part manufacturer.

7.2 Failures and defects

The user (system/equipment) manufacturer should, in accordance with the quality and reliability program plan, investigate the cause, take action/measures, and prevent recurrence of failures/failures that occur after parts are received and mounted.
The effect of the failures on the part in question and on similar parts, as well as the possibility of occurrence of subordinate failures should also be evaluated.

7.3 Alerts

Through the selection, evaluation, procurement, assembly/testing, and storage of candidate parts, the user (system/equipment) 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.
User (system/equipment) manufacturers and part manufacturers can browse and utilize this information by registering as a user.

(1) "Database of JAXA Qualified EEE Parts and Materials": Data and information on JAXA qualified parts and parts under development.
URL https://ssl.tksc.jaxa.jp/eeepitnl/en/

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

User (system/equipment) manufacturers are encouraged to share information with JAXA based on their experiences and lessons learned in space application of space-applicable parts, and to make improvements and suggestions to this handbook.
JAXA makes effective use of the Project Approved Parts Data Base (PAPDB) to conduct statistical analysis of space-applicable parts in space applications and provide information to user (system/equipment) manufacturers and parts manufacturers.