भारतीय मानक

Indian Standard

IS 18915 : 2024
ISO 20188 : 2018

अंतरिक्ष पद्धतियाँ — वाणिज्यिक उपग्रहों के लिए उत्पाद आश्वासन की अपेक्षाएँ

Space Systems — Product Assurance Requirements for Commercial Satellites

ICS 49.140

भारतीय मानक ब्यूरो
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NATIONAL FOREWORD

This Indian Standard which is identical to ISO 20188 : 2018 'Space systems — Product assurance requirements for commercial satellites' issued by International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendations of Air and Space Vehicles Sectional Committee and approval of the Transport Engineering Division Council.

The text of ISO standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminologies and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'; and

b) Comma (,) has been used as a decimal marker, while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 10007 Quality management — Guidelines for configuration management	IS/ISO 10007 : 2017 Quality management — Guidelines for configuration management (*second revision*)	Identical
ISO 10794 : 2011 Space systems — Programme management — Materials, mechanical parts and processes	IS 18326 : 2023/ISO 10794 : 2018 Space systems — Programme management — Material, mechanical parts and processes	Identical
ISO 10795 Space systems — Programme management and quality — Vocabulary	IS 18338 : 2023/ISO 10795 : 2019 Space systems — Programme management and quality — Vocabulary	Identical
ISO 14620-1 : 2018 Space systems — Safety requirements — Part 1: System safety	IS 18328 (Part 1) : 2023/ISO 14620-1 : 2018 Space systems — Safety requirements: Part 1 System safety	Identical
ISO 14621-1 Space systems — Electrical, electronic and electromechanical (EEE) parts — Part 1: Parts management	IS 18329 (Part 1) : 2023/ISO 14621-1 : 2019 Space systems — Electrical, electronic and electromechanical (EEE) parts: Part 1 Parts management	Identical
ISO 14621-2 Space systems — Electrical, electronic and electromechanical (EEE) parts — Part 2: Control programme requirements	IS 18329 (Part 2) : 2023/ISO 14621-2 : 2019 Space systems — Electrical, electronic and electromechanical (EEE) parts: Part 2 Control programme requirements	Identical
ISO 14644-1 Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness by particle concentration	IS 18637 (Part 1) : 2024 Cleanrooms and associated controlled environments: Part 1 Classification of air cleanliness by particle concentration (ISO 14644-1 : 2015, MOD)	Modified

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Introduction

This document is useful to provide the product assurance (PA) activities from the standpoint of commercial business on each phase of the project such as design, procurement, manufacturing, assembly, integration, test, and at launch site. These product assurance requirements are requested by customers for accomplishing the mission successfully and will lead to customer satisfaction.

Commercial satellites are designed, manufactured, assembled, integrated, tested and launched in compliance with these PA requirements, which are applicable to prime contractor, subcontractors and suppliers. The responsibility of the prime contractor is to allocate these requirements to subcontractors and suppliers, and to ensure their implementation.

The prime objective of PA is to ensure that commercial satellites accomplish their defined mission objectives and more specifically, that they are safe and reliable.

A further objective is to achieve more cost-effective space projects and thereby to promote competitiveness by coordinating the development and implementation of appropriate PA methods and standards.

PA requirements defined in this document have been established to prevent potential problems and applicable to all phases of project up to launch of commercial satellite. PA programs also ensure that hardware and software of ground support equipment are also safe, reliable and do not degrade the flight hardware in any way.

The intent of this document is to clarify the best practices and typical requirements dealing with product assurance activities in commercial business, prevent recurrence of problem and realize quality improvement especially for customers having less experience.

The requirements described in this document are created by comparing and mixing experience and practical management methodologies used by main actors of aerospace industry in the world. The framework of PA policy and principles are based on ISO 14300-2, ISO 27025, ISO 14620-1, ISO 23460, ISO 10794 and ISO 14621-2 and unified as one PA process. Detailed requirements of product assurance (PA), quality assurance (QA), dependability, EEE parts, material, mechanical parts and processes, software product assurance and ground support equipment are selected from relevant proven standards.

Indian Standard

SPACE SYSTEMS — PRODUCT ASSURANCE REQUIREMENTS FOR COMMERCIAL SATELLITES

1 Scope

This document provides the recommended practices of product assurance (PA) requirements applicable to commercial satellite.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10007, *Quality management — Guidelines for configuration management*

ISO 10794:2011, *Space systems — Programme management — Material, mechanical parts and processes*

ISO 10795, *Space systems — Programme management and quality — Vocabulary*

ISO 14620-1:2002, *Space systems — Safety requirements — Part 1: System safety*

ISO 14621-1, *Space systems — Electrical, electronic and electromechanical (EEE) parts — Part 1: Parts management*

ISO 14621-2, *Space systems — Electrical, electronic and electromechanical (EEE) parts — Part 2: Control programme requirements*

ISO 14644-1, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness by particle concentration*

ISO 15388, *Space systems — Contamination and cleanliness control*

ISO 27025, *Space systems — Programme management — Quality assurance requirements*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 10795 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
commercial satellite
satellite used for private business

Note 1 to entry: Non-commercial satellite is military satellite or civil satellite developed on behalf of government organization, space agency and/or research organization.

3.2
proto-flight level testing (PFT)
test of the flight quality product subjected to the qualification levels and acceptance duration

4 Abbreviated terms

AT	Acceptance Test
CCB/CRB	Configuration Control Board/Change Review Board
CDR	Critical Design Review
CIL	Critical Item List
DMPL	Declared Mechanical Parts List
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic, and Electromechanical
EIDP	End Item Data Package
EQSR	Equipment Qualification Status Review
ESD	Electrostatic Discharge
FDIR	Failure Detection Isolation and Recovery
FMECA	Failure Mode, Effect and Criticality Analysis
FRR	Flight Readiness Review
FTA	Fault Tree Analysis
GSE	Ground Support Equipment
HSIA	Hardware-Software Interaction Analysis
LAT	Lot Acceptance Test
MIP	Mandatory Inspection Point
MMPP	Materials, Mechanical Parts and Processes
MMPPCB	Materials, Mechanical Parts and Processes Control Board
MRB	Material Review Board
MRR	Manufacturing Readiness Review
PAD	Parts Approval Document
PCB	Parts Control Board
PDA	Percent Defective Allowable
PDR	Preliminary Design Review
PIND	Particle Impact Noise Detection
PSR	Pre-Shipment Review
QCI	Quality Conformance Inspection
QSL	Qualification Status List

RVT	Radiation Verification Test
SCCB	Software Configuration Control Board
SCM	Software Configuration Management
SCMS	Software Configuration Management system
SEE	Single Event Effect
SEU	Single Event Upset
SET	Single Event Transient
SDR	Special Design Review
SOW	Statement Of Work
TRB	Test Review Board
TRR	Test Readiness Review
WCA	Worst Case Analysis

5 Product assurance

5.1 PA management

Product assurance management policy for commercial satellite project is that PA plan which is implemented throughout all phases, coordinated with involved parties, and is managed in such a way as to:

a) ensure that project and PA organization, requirements, methods, tools and resources are well-defined before development and implemented at each level from system down to piece part;

b) ensure that aspects are identified, which could affect project requirements having major impacts on safety, mission success and the related cost and schedule consequences;

c) ensure that adverse consequences of these aspects are prevented by the early detection, characterization, elimination, minimization and containment of problem contributors and initiators;

d) ensure that risks are assessed and controlled, and that acceptability of the residual ones is evaluated;

e) provide at any time the necessary visibility of the quality status of the product;

f) ensure that the end product conforms to its specifications and that observed non-conformances are properly disposed.

Contractor shall designate a PA manager who shall have prime responsibility for the management and direction of the PA program.

The PA manager shall act as the focal point of contact within the project for customer.

The PA manager, irrespective of other responsibilities, shall have sufficient organizational authority and independence:

a) to propose, establish and implement the product assurance program in accordance with project product assurance requirements;

b) to have unimpeded access to top management through the company PA executive as necessary to fulfill the duties.

Contractor shall report on a regular basis as specified in the applicable statement of work (SOW) on the status of the product assurance program implementation. Contractor shall plan and perform quality audits using established and maintained procedures. Contractor shall prepare and implement a project product assurance plan that shall be maintained throughout the project life cycle.

The role of the PA manager is to provide to the top management and to the customer the guaranties (i.e. confidence) of the compliance of the product at each stage of product life cycle (i.e. specified, designed, manufactured, in use).

5.2 PA plan

The detailed implementation of this program shall be defined in PA plan which shall be based on normal commercial practices and comply with the requirements defined herein. Conformity with AS 9100 [29] or equivalent standards should be indicated. This plan shall describe the task descriptions, responsibilities and implementation methods in accordance with product assurance requirements described in the applicable SOW. The plan shall also identify any relevant specifications, procedures, standards and manuals that shall be applicable to the implementation of this plan. The plan shall clearly identify and define contractor's product assurance organization and its relationship with contractor's overall organizational interfacing functions and activities.

The PA plan should cover, as a minimum, the following disciplines:

a) product assurance management;

b) quality assurance;

c) dependability;

d) safety;

e) selection, procurement and control of materials, EEE parts, mechanical parts and processes;

f) software product assurance;

g) ground support equipment (design reviews and controls including dependability and safety).

5.3 Audit

Contractor shall perform internal and external audits to ensure appropriate implementation of the requirements of the PA program. Customer shall be informed of the conclusion of the audits initiated in the area of the project. Audit reports shall be delivered to customer for review on site.

Contractor shall perform external audits over the facilities of the supplier, sub-tier supplier, parts/materials manufacturer, and/or outside manufacturer facilities to confirm that the procured items are in compliance with PA requirements specified in the applicable SOW. The representative of contractor shall confirm the following items as the surveillance:

1) contents of each design, quality assurance program task and performance meet these PA requirements;

2) the activities of supplier satisfy the requirements in this document and SOW.

Contractor shall cooperate when customer personnel or its designated representatives perform surveillance of contractor's facilities. Contractor shall include provisions to accommodate such representatives.

Contractor shall perform audits of subcontractors and suppliers to ensure that the required quality standards and contractual requirements are appropriately implemented.

As necessary, customer may participate in the surveillance.

Contractor shall establish and maintain an audit plan for procurement activities on the project, designating the lower tier subcontractors and suppliers to be audited, the current status and the schedule for auditing. In addition to the planned audits, extra audits shall be performed when necessary to overcome failure, inconsistent poor quality, or other problems.

5.4 Customer right of access

Authorized representatives of customer will have the right of access at any reasonable time to all areas where the work is performed under the contract. This includes access to relevant documentation and records. Proprietary and governmental protected areas will not be accessible in accordance with contractual regulations.

If the contract is for the entire satellite system or subsystem level rather than a unit level, then a visibility agreement which defines the implementation procedure of the customer's right of access to the test witness, document review and material review board will be identified project to project.

5.5 PA progress reports

Contractor shall prepare and submit a periodic progress report as defined in the applicable SOW.

PA progress report should include the following items:

a) current status of dependability and safety programs;

b) status summary of critical items control;

c) review board activities;

d) status of parts, materials, and processes concerns;

e) significant problems in hardware quality assurance, software development, design reviews, configuration management and the safety program;

f) program product assurance audits and action items status;

g) class I (major) changes and waiver/deviation status;

h) summary of any planned activities in the forthcoming period.

PA progress status could be done by meetings and/or reviews, not only by reports, with project manager, PA manager, customer participation, depending on the subjects under concern.

5.6 Risk management

Contractor shall perform a systematic risk assessment, reduction and control of risks in achievement of required technical performance, within the project cost and schedule constraints. The methodology for risk management shall cover all areas of the project such as technology, management, customer relationship, supplier relationship, manufacturing, design, parts, materials, processes, qualification, resources, etc.

Risk assessment, reduction and control process shall include inputs from all PA disciplines and shall contribute to the overall project risk management process.

Risk management shall take into account the requirements defined in ISO 17666.

5.7 Critical item management

The following items will be classified as critical item for project:

a) items not qualified;

b) items with highly sensitive processes;

c) items which are difficult to test on ground;

d) items containing limited life parts;

e) items which are radiation-sensitive;

f) items using new technologies;

g) items causing critical or catastrophic hazards;

h) critical single point failures;

i) other items identified by the risk assessment analysis;

j) excessive long lead parts;

k) EEE components subject to export license constraints;

l) EEE components containing dangerous elements;

m) material with particular constraints for storage;

n) software critical items.

Contractor shall submit a critical item list (CIL) as required by the applicable SOW and update issues periodically and at least for each design review. As part of the CIL, PA program shall be defined to establish provisions which will ensure proper control of critical items.

5.8 Subcontractor product assurance

Contractor shall establish and maintain subcontractor PA program which shall ensure that the subcontractors/suppliers requirements are clearly defined and consistent with the overall PA program requirements. Subcontractors shall ensure that program PA requirements, including configuration control requirements, are achieved during design, procurement, manufacture, assembly and test phases.

Subcontractors/suppliers shall be selected in accordance with the contractor’s requirements for quality and management systems and facilities. When there is a change of subcontractor/supplier for critical deliverable item, customer's formal concurrence shall be requested with respect to the contractor’s intended choice of replacement.

5.9 End item data package

Contractor shall compile end item data package (EIDP) for each unit as defined in the applicable SOW. These data packages shall be maintained during manufacturing and test activities and shall be delivered to customer on satisfactory completion of testing after approval by PA. Each end item delivered to customer shall be accompanied by EIDP containing the following as a minimum:

a) configuration identification list;

b) mate/de-mate log;

c) log sheets (including turn-on time for each unit);

d) non-conformance list and MRB;

e) deviations/waivers;

f) test data (includes electrical and mechanical test data);

g) MIP reports, photos and final inspection reports;

h) test procedures.

A copy of the original EIDP shall remain with the equipment at all times. Updates for EIDPs shall be provided if units are returned for any modification/corrective action.

Contractor shall compile EIDP for each complete integrated commercial satellite, as defined in the applicable SOW. These packages shall be delivered to customer on satisfactory completion of testing, after approval by PA, following pre-shipment review (PSR), and an addendum shall be provided to cover the launch site activities.

5.10 Organizational capability aspects

At least, prime contractor shall be certified to the applicable space standards (e.g. AS 9100, EN 9100 or JIS Q 9100) or equivalent standards. The certificate of registration or a current conformity status relative to the standards will be closely monitored by prime contractor's PA team.

6 Quality assurance

6.1 Quality assurance program

As part of the PA program, the contractor shall document and maintain an effective and timely quality assurance program in accordance with ISO 27025 or equivalent standards (e.g. Reference [29]), which will be planned in conjunction with other project functions. Quality program shall be implemented in a manner which permits the detection and correction of deficiencies and other associated non-compliances at the earliest practical point. Inclusion of provisions for ascertaining product quality from procurement through fabrication and testing, and the delivery of the completed deliverable system, as well as launch activities, shall be incorporated. Quality assurance program shall provide recorded evidence of quality in the form of inspection and test results as well as systematic audit findings. This record shall be documented in sufficient detail, accuracy and completeness to permit analysis. Records of detected discrepancies shall include root causes and corrective actions implemented as remedy. This record shall be made readily available for review by customer's representative upon request. Subcontractor quality reports will be reviewed at subcontractor's sites when not available at contractor's site.

6.2 Equipment qualification status review

Contractor shall convene equipment qualification status review (EQSR) to verify qualification status of heritage designs with mission requirements. These reviews shall be held at the beginning of the project after categorization of equipment has been determined according to the categories defined in 7.12. The EQSR shall assess qualification status of equipment with particular attention given to any possible design and process changes since the last qualification and to mission-specific requirements. When mutually agreed, the requirement for a unit PDR and/or CDR may be waived by customer in exchange of delivery of a data package and holding an EQSR with mutually acceptable contents. Qualification or proto-flight test reports, and qualification by similarity reports shall be provided to customer in accordance with the applicable SOW.

6.3 Review meeting and control boards

Contractor shall conduct a series of formal technical review meetings and establish control boards to ensure the identification and resolution of issues and verify that appropriate controls are implemented. These meetings shall include reviews and control boards such as design review,

Contractor PA shall participate in review meetings and control boards as required to verify appropriate actions have been implemented to satisfy all quality issues and concerns. Control board and review meetings records shall be recorded, signed off and appropriately distributed. The representative of customer shall be invited to participate in all program-specific PA review meetings and control boards in accordance with the applicable SOW.

6.4 Design review

Contractor shall conduct preliminary and critical design reviews. contractor PA shall participate in all design reviews to verify that reliability, quality, and safety requirements under all expected environments are appropriately addressed, and to assess that adequate evaluations of the hardware capability in meeting the specified performance requirements have been conducted. Contractor PA shall verify that, in accordance with the design review plan for the project, preliminary design reviews (PDR) are basically conducted from system level down to unit level concurrently with the release of design specifications to evaluate conformance of the conceptual design to performance and environmental requirements. Critical design reviews (CDR) shall be basically conducted from unit level up to system level to verify the completeness of detailed design and planning for fabrication and test of the flight hardware. When required, a special design review (SDR) shall be called to solve or evaluate special or unique design problems that present unusual difficulties for which solution(s) must be found. Any proposed design change after completion of CDR shall be formally evaluated to determine if the modified item should be resubmitted to the design review cycle and/or be subject to a new series of qualification tests.

6.5 Pre-shipment review

Pre-shipment review (PSR) shall be convened by contractor. Contractor PA manager shall participate in PSR.

The objective of the review shall be to verify, as a minimum, the satisfactory completion of the test program, status of open issues, reconcile the as-built to the as-designed status, and verify that contractual requirements have been met. Contractor PA shall verify that the contents of PSR satisfies the requirements as specified in the applicable SOW. PA shall also participate in all major subsystem/component PSRs as required.

PSR will be held at the factory of contractor before shipment of commercial satellite to customer’s designated launch site. At the completion of PSR, customer will authorize at the completion of PSR for contractor to ship commercial satellite to customer’s designated launch site.

6.6 Flight readiness review

Flight readiness review (FRR) shall be convened by contractor. Contractor PA shall participate in FRR to verify that all quality issues have been satisfactorily resolved, all relevant product assurance data required by contract has been provided, and to concur that delivered commercial satellite is ready for launch.

6.7 Procurement control

6.7.1 General

Contractor shall implement a system for the selection, evaluation and approval of procurement sources. Supplier’s quality records shall be made available for review on site when not available at the contractor’s site by customer's representative upon request. Qualified procurement sources shall be documented in contractor's list of qualified suppliers. In cases where contractor’s intended suppliers are not recorded in these documents, performance of a supplier survey shall be a mandatory quality assurance task prior to selection.

6.7.2 Sub-tier source selection and evaluation

Prior to awarding a subcontract, contractor will evaluate and document each prospective supplier or sub-tier sub-contractor of sub-assemblies with regard to their manufacturing and test facilities, reliability procedures used, drawing and material controls, incoming inspections, and quality control methods employed. Prior to subcontract award, improper performance on previous procurements may disqualify a lower tier subcontractor.

Procurement department will evaluate and approve these suppliers based on either:

a) previous satisfactory quality assurance level, or

b) survey of supplier's facility and quality assurance system.

6.7.3 Sub-tier source surveillance

Contractor will conduct quality surveys and quality audits to ensure that sub-tier maintains quality control system that meets the requirements of quality assurance program, as well as close-out surveys by reports and follow-ups to ensure that proper corrective actions are taken. In case of where contractual document requires sub-tier quality audits, customer will be invited to contractor’s sub-tier quality audits for major subcontractors from which contractor procures subsystem or critical units.

6.7.4 Sub-tier source inspection

Contractor will perform source inspections based on purchasing specifications. Inspections will be performed at sub-tier’s facility for the following items:

a) items that cannot have inspections or tests performed at contractor's facility;

b) equipment, fixtures, tools or jigs that cannot be available at contractor's facility for inspections.

6.7.5 Procurement document review

QA provisions of contractor will be included in all procurement specifications and purchase orders. Prior to purchase order preparation and subsequent procurement, each purchasing documents shall be reviewed based on the internal regulations by QA personnel who will be required to review and ensure that the completeness and accuracy of customer requirements which are completely and accurately flowed down to procurement document and applicable QA requirements. Based on internal regulations prior to preparation of a purchase order and subsequent procurement, the contractor's source inspection requirements will be completed as purchasing documents including customer’s source inspection availability.

6.7.6 Incoming inspection

Contractor will perform incoming inspection and test to verify that all parts and materials conform to contractual requirements. Contractor will ensure that the performance of 100 % functional testing performed on parts at either subcontractor's or manufacturer's facility in accordance with the requirements specified in Clauses 9 and 10. Incoming inspection shall be carried out in accordance with the procurement documents and applicable engineering and QA requirements. When required, special handling instructions shall be provided for incoming inspections to inspect, such as critical items and/or sensitive parts and materials. Special cardboard, box or container will be used as necessary to prevent damage during handling. Each lot of flight parts and materials received shall be identified for subsequent handling by an identification tag that includes procurement order number. The articles and materials processed through incoming inspection shall be identified with incoming inspection records.

6.8 Manufacturing and storage control

Contractor will perform in-process inspections based on in-process inspection specifications and procedures to ensure that manufactured and assembled equipment meet applicable drawings

and specifications. Manufacturing and assembly records include travelling tags, shop orders and supplementary process sheets. These records will be issued by technicians with inspector's participation well in advance of their actual use in manufacturing or assembly operations. A list of the tools, jigs, fixtures, non-standard inspection equipment and manufacturing equipment shall be also utilized. Characteristics and tolerances to be obtained will be reflected on the drawing, including the applicable workmanship standards that detail the procedures for process control.

Additionally, a drawing will include the special conditions to be maintained such as environmental conditions or precautions. Detailed instructions and directions will be documented in inspection instructions.

Kitting list will be attached and updated for maintaining traceability. On drawings and in environment control standards, conditions and control methods of handling and storage shall be clearly specified to prevent damage, quality degradation or drift.

Life-limited materials and articles shall be clearly labelled to show their due life date (or expiration date).

6.9 Manufacturing readiness review

Contractor shall hold manufacturing readiness review (MRR) before the manufacturing of flight equipment. The purpose of MRR should be, at least, as follows:

— review flight manufacturing drawing release status and plan of final release;

— review manufacturing specification, inspection specification;

— review production plan and manufacturing and inspection flow chart;

— review preparation status of manufacturing and testing resource and availability for contractual equipment;

— review production schedule;

— review status of corrective action with respect to a non-conformance occurring in similar program.

As for the last item above, the customer should have a right of access to review of implementation status of corrective actions from non-conformances occurred in similar programs. Implementation of corrective action on assembly drawing, procedure and specification, etc. should be reviewed within the contractual constrains during MRR. Organization should communicate and implement actions across various entities and other organizations.

6.10 In-process inspection

Contractor will perform in-process inspection for all sub-assemblies, assemblies and components. Configuration control logs and discrepancies will be maintained. Inspection and/or test specifications shall be planned and conducted to ensure compliance with required specifications. QA representative will participate in planning and reviewing deliverable items' manufacturing, inspection and test procedures, and test flow chart for deliverable items. QA representative will review all program requirements and design data to ensure that completion of all tests and inspections will be completed to verify that deliverable items meet program requirements. The following criteria shall be applied, as a minimum, into the development of required manufacturing and test points:

a) inspection and test points are to ensure that all items meet requirements;

b) inspection and test from the lowest to higher indenture level;

c) inspection for contamination;

d) inspection of packaging;

e) inspections to ascertain workmanship by applicable standards should be required. Training and/or certification of process for each operation or inspection shall be performed, including rejection criteria and methods of measurement, when required;

f) critical items will be treated with special attention during inspection and test;

g) visual aids will be provided for inspection and assembly personnel, as required;

h) inspection to verify adequacy of facilities' cleanliness.

The customer should be informed of MIP planning or should receive the MIP report.

6.11 Process control

All metallurgical, chemical, material cleaning, potting, welding, soldering, coating, and plating processes, and other processes where uniform, high quality cannot be completely ensured solely by inspection of the end articles, are controlled according to QA procedures and respective process specifications. QA procedures are documents which define methods and requirements for the certification of the equipment, materials, and personnel. Inspection criteria and acceptance limits are included in inspection instructions. Process specifications are available for process to be applied during fabrication and assembly.

These specifications prescribe the preparation of articles and materials to be processed; the detailed processing operations; the conditions to be maintained during each phase of the process including environmental controls; the methods of verifying the adequacy of processing materials, solutions, equipment, environments, and their associated control parameters; and the required records for documenting the results of process inspection, test and verification.

QA representative will ensure that the technician shall be sufficiently skilled to meet contract requirements by personnel certification or personnel indoctrination.

6.12 Mandatory inspection points

Contractor shall establish mandatory inspection points (MIP) as necessary to ensure maximum visibility of hardware quality-related aspects. Contractor shall consider criteria such as required verification of critical processes, aspects of critical items, irreversible operations, visibility of problem areas, and results of previous trend analyses to select MIP. Customer shall have the right to recommend and witness mandatory inspections. Contractor shall notify designated customer’s representative of hardware and its documentation readiness for mandatory inspections, and acceptance tests/first article verification at the unit, subsystem, and system level. The time period required for advance notification shall be in accordance with the applicable SOW.

6.13 Workmanship standards

Contractor shall employ workmanship standards throughout all phases of manufacturing, assembly, integration and test to ensure acceptable and consistent workmanship quality levels. Workmanship standards shall be in accordance with engineering drawings by reference to the approved contractor process specifications and industry or government standards. Contractor and subcontractor/supplier workmanship standards and procedures employed on project shall be identified and made available to customer on site.

Workmanship standards shall identify acceptance or rejection criteria. Physical samples or visual aids should be reviewed and agreed by customer when they are used for the purpose of acceptance or rejection of items.

6.14 Personnel training and competence

Contractor shall establish and maintain a training and competence program of manufacturing and quality personnel. This program shall be described in a plan and address the evaluation of workmanship

and personnel skills. Contractor shall ensure that the personnel working on the project are sufficiently skilled to meet the project requirements. Contractor shall ensure that manufacturing quality personnel are trained and certified in accordance with the defined program. Records of personnel competence and training shall be available to customers, if required. The training and competence program shall address the following as a minimum:

a) Ensure that the personnel skills required to conduct necessary tasks are identified and provided as needed.

b) Ensure that the status of personnel training is reviewed on a regular basis and appropriate records are maintained.

c) Address equipment and process certification and identify the review periods for re-certification.

d) List any special processes that require training and competence.

e) List authorized technical personnel to perform special processes.

6.15 Ground support equipment certification

Contractor shall establish controls to ensure that ground support equipment (GSE), as well as the test software, are validated for use with qualification and flight hardware. The GSE shall be designed and manufactured in compliance with PA requirements including safety, cleanliness and calibration to ensure compatibility with flight hardware. An analysis shall be performed on the interface circuits of test equipment that directly interfaces with a commercial satellite to ensure that potential test equipment failures will not cause damage to the flight equipment under test. Adequate protection for flight hardware shall be implemented in the equipment and validated before use. Contractor shall establish a program for certification of requirement. Records of equipment certification shall be made available for customer's review as required. For the GSE delivered by contractor to customer, certification records shall be delivered to customer on request. For equipment used for manufacturing by contractor and subcontractors, the certification records are available on site for review.

6.16 Electrostatic discharge control plan

Contractor shall establish and maintain electrostatic discharge (ESD) control plan to define specific provisions for identification of ESD sensitive devices, personnel training, and work area procedures. ESD control should be prepared on the basis of Reference [2] or equivalent standards as a guideline.

ESD control shall be implemented for manufacturing, storage, inspection, assembly and test activities under contractor's responsibility.

ESD control shall be implemented where it is necessary. Customer should identify too, where ESD control is necessary.

6.17 Contamination/cleanliness control plan

Contractor should establish and maintain approved contamination/cleanliness control plan for flight hardware, with requirements for conformance specifically defining cleanliness, contamination and debris control requirements in accordance with ISO 15388, ISO 14644–1, MIL-STD 1246C [28] or their equivalent to prevent contamination of components, and contractor shall maintain a cleanliness record, which subcontractor shall show the customer if required. This plan shall encompass provisions for handling, storage, cleaning, assembly and packaging of deliverable qualification and flight items. The minimum level from contamination cleanliness shall be defined in this plan.

6.18 Testing

6.18.1 Test facilities and equipment

Contractor shall ensure that test facilities, either internal or external, comply with project requirements.

Contractor shall ensure that testing techniques and data are validated prior to use and controlled during their use in testing. In particular, provisions shall be made for testing, approval and configuration control of the software involved and prevention of it being tampered with.

It shall be possible to verify the correct operation of all items of test equipment without having to apply them to the test item.

6.18.2 Test documentation

Test procedures and reports shall be reviewed and approved by the QA team. Contractor shall ensure that tests are performed in accordance with the approved test procedures. Contractor shall implement QA program to ensure that tests are performed in accordance with documented test procedures.

Contractor shall ensure that all test are comprehensively documented in test reports, and that they include, as a minimum:

— reference of tested item;

— reference to applicable test procedure and description of deviations from it during actual testing;

— test data records and evaluation;

— summary of test results including non-conformances.

6.18.3 Test performance monitoring

Contractor QA function shall define within test plan the most effective way to monitor the performance of test activities, to ensure the adherence to the test procedures. Test witnessing by QA personnel shall be considered when manual intervention is performed, at the setting-up, start and end of continuous fully automated test sequences, or when no automatic recording of test parameters or results is available. Special precautions shall be taken for all testing activities related to critical characteristics as identified in the critical items control program

Testing activities or results to be subject to formal QA certification shall be identified as such in the relevant test procedure. Customer may witness test activities as specified in the applicable SOW.

6.19 Test reviews

Contractor shall implement QA program to ensure that formal reviews are performed before and after major portions of qualification or acceptance tests, according to the applicable SOW requirements. The QA team shall be represented in the formal boards established for the review of readiness for testing and testing accomplishment. Customer participation in the test reviews is defined in the applicable SOW.

Contractor shall ensure that a test readiness review (TRR) is held to authorize the test before each phase of satellite testing activities.

Contractor shall ensure that a test review board (TRB) is held after major portions of qualification or acceptance tests to review test results and to give the go ahead for the next phase.

6.20 Quality records and traceability

Contractor shall implement and maintain an effective identification and data retrieval system for parts and materials in conjunction with the deliverable end items. This traceability system will provide identification relevant to procurement, fabrication processing, inspection, test and operating records. Quality history records shall contain the results of inspections and tests, discrepancies, rework history, as well as the acceptance of each inspection and test operation, and shall be authenticated by authorized and controlled quality approval stamp or by entry in a controlled electronic system. Contractor shall maintain a system for the control of quality assurance approval stamps or signatures used to signify acceptance of qualification and flight items as well as documentation. Such system shall be traceable to the assigned individuals. Customer shall have the right to review such records from unit level assembly

and test to satellite level integration. Quality records shall be maintained to demonstrate conformance to specific requirements. Contractor shall maintain and implement documented procedures for storage, maintenance, and retention of qualified records. Quality records shall be retained by contractor for a minimum of five (5) years subsequent to program completion, or as specified by contract.

6.21 Non-conformance control

6.21.1 Non-conformance reporting

Contractor shall establish and implement a formal non-conformance reporting system which includes effective analysis, formal feedback of failure data, failures that are analysed and reviewed, and proper corrective actions that are taken with accurate and timely closures. Non-conformance reporting system should take into account requirements defined in ISO 23461.

Contractor shall notify customer of major non-conformances that occur on qualification or flight equipment at the unit, subsystem, or system level in accordance with the applicable SOW.

Major non-conformance reports shall be issued and delivered to customer by contractor on all non-conformances for qualification, proto-flight or flight acceptance testing at unit, subsystem and system levels. Listings of lower level non-conformance reports, as well as selected reports, shall be made accessible on site to customer upon request. Identified applicable alerts shall be made accessible to customer via electronic online media, hard copy distribution or their equivalent. Contractor shall establish and implement a corrective actions system with clearly defined methods and responsibilities for timely resolution of systematic non-compliances and specific discrepancies, non-conformances and failures, which are detected during procurement, manufacture and test of the deliverable qualification and flight articles. The methods employed shall include preventive measures to preclude future repetition of similar substandard conditions. Corrective actions reports shall be generated which will document follow-up actions until adequate correction and verification have been satisfactorily achieved.

6.21.2 Non-conformance definition

A major non-conformance shall be those which can have an impact on contractor requirements in the following areas:

— safety of people or equipment;

— operational, functional or any technical requirements imposed by the contract;

— reliability, maintainability, availability;

— lifetime;

— functional or dimensional interchangeability;

— interfaces with hardware or software regulated by different contracts;

and in the following cases:

— changes to or deviations from approved qualification or acceptance test procedures;

— project-specific items which are proposed to be scrapped;

— for EEE components, in case of:

  — lot or batch rejection during manufacturing, screening or testing at the manufacturer's facilities, if contractor proposes to use as is the rejected lot or batch, or to continue processing, rework or testing, although the lot or batch does not conform to the specified requirements;

— non-conformance detected after delivery from the EEE parts manufacturer (if the lot/batch is used):

  — fit, form and function;

  — any failure during lot validation at procurement responsible level (LAT, QCI, DPA, RVT);

— EEE part failure in use at equipment level (manufacturing or testing).

6.21.3 Non-conformance disposition

Non-conformance control system shall include procedures for the identification and control of major and minor discrepancies. Rework-to-procedure dispositions and authorized standard repair dispositions of minor non-conformances may be processed subsequent to contractor's preliminary engineering review. Major non-conformances which cannot be disposed by such preliminary reviews shall be resolved by the contractor's material review board (MRB). All major deviations and waivers or engineering changes documenting a non-compliance to contract requirements, shall be processed in accordance with contractor's configuration management procedures and, if not in compliance with contract requirements, shall be submitted to customer for review and approval as contractually required. QA shall provide for the effective segregation and identification of articles and materials that, as a result of inspection or test, do not conform to acceptance criteria or contractual requirements. Continual processing of these non-conformances shall be permitted in accordance with analysis by MRB.

6.22 Alert system

Contractor shall review alerts and problems occurring on other projects whether on ground or in orbit, and take necessary actions to eliminate their effects on the deliverable hardware. Any alerts and problem notifications that impact the project shall be identified and reported to customer.

6.23 Handling, storage, preservation, packaging and shipping

6.23.1 General

Contractor shall have procedures and appropriate facilities for avoiding deterioration, loss or damage to the items during storage, handling, preservation, packaging and shipping.

6.23.2 Handling, storage and preservation

Contractor shall take all relevant precautions during handling operations to prevent damage to items and protect them from natural and induced environments. Particular attention shall be given to electrostatic discharge prevention. Contractor shall provide an ESD protected area and implement ESD control process. Quality assurance team shall verify that manufacturing, assembly and test documents contain relevant handling instructions when and where necessary. Contractor shall also verify certification of ground handling equipment prior to any handling or transportation of flight hardware. Stored items shall be protected against contamination, deterioration, and damage. Adequate safety, cleanliness and age control of stored items shall be provided. Life limited items shall be specifically identified and controlled with respect to shelf life time. Contractor shall ensure that items subject to deterioration, corrosion or contamination through exposure to air, moisture or other environmental elements are preserved by methods which ensure maximum protection consistent with life and usage.

6.23.3 Packaging and shipping

Contractor shall implement and control packaging operations to ensure qualified protection for items from natural and induced destructive mechanical and environmental elements, ESD and contamination. Shipping activities shall be monitored by QA to ensure conformance with established procedures and specifications. Shipping containers for flight hardware susceptible to shock damage

shall be instrumented with shock detectors. Provisions shall be made for inspection and control of all equipment shipped to ensure that:

a) all equipment has been subjected to and have satisfactorily passed all applicable inspections and tests. Emphasis shall be given to physical segregation of conforming equipment from those awaiting test results or final dispositions;

b) all equipment is complete and assembled as required and documentation is complete;

c) all equipment has been preserved and packed in accordance with applicable procedures and specifications;

d) all packed equipment has been identified and marked in accordance with applicable procedures and specifications;

e) equipment is accompanied by the EIDP or as a minimum necessary technical document, e.g. handling instructions, operating manuals, installation manuals, historical records, drawings, indication of remaining useful life of limited life items;

f) handling devices and transportation vehicles are adequate for the items involved. Loading and transportation methods conform to agreed requirements. Shipping container shall identify the location of the documentation package;

g) a shipment notification prior to the arrival of any item has to be given to the next user in a timely manner which shall contain as a minimum:

    1) project title;

    2) item identification;

    3) quantity;

    4) flight or other transportation details, such as flight no.;

    5) time and place of arrival;

    6) airway bill no.

6.24 Preparation for delivery

Contractor shall ensure that packaging materials, methods, procedures and instructions provide for protection of items while at the contractor's plant, during transportation and, as far as it is practicable, after arrival at destination.

Before packing, connectors shall be inspected to avoid any issue on damage and cleanliness. Contractor shall ensure that appropriate marking and labelling for packaging, storage, transportation and shipping of items are performed in accordance with applicable specifications.

6.25 QA role in configuration management

Contractor shall maintain the satellite hardware, software and documentation configuration during the assembly, integration and testing of the component/subsystem/system. Contractor shall prepare and implement a configuration management process in accordance with ISO 10007 or approved equivalent standards.

QA representative shall review that this process identifies activities to ensure that configuration identification and configuration change control are achieved and maintained. Responsibilities and decision points in the configuration management system shall be clearly delineated. Interfaces with other systems affecting configuration management activities shall be described. The contractor's internal procedures required to implement this process shall be made available on site to customer for review upon request.

6.26 Configuration identification

Configuration identification shall identify specifications, standards, drawings and software that define a system or article of equipment. Release of approved drawings and other associated documentation shall establish the configuration identification. The initial configuration identification shall be established by a group of specifications that define the technical requirements from the system level down to a subsystem or control item level. A master index shall identify the list of control items which comprise the contract deliverable items. The master index shall show the control items in terms of top drawing number, indentured level, and quantity required for next assembly, along with revision affectivity.

6.27 Configuration control

Configuration control shall be maintained by means of a Configuration Control Board/Change Review Board (CCB/CRB). Contractor shall submit Class I approved changes from the CCB/CRB on this project to customer, and shall include engineering changes from heritage projects which are considered relevant. Summary minutes of these meetings shall be reported to customer.

Contractor shall develop procedures for the administration, analysis coordination, and processing of engineering change proposals as well as deviations and waivers, from origination of the change request through required approvals or rejection. Additionally, the contractor's method of control for deviations and waivers shall provide the means for departing from requirements contained in configuration identification without permanently altering the technical documentation.

6.28 Change classification

Contractor's configuration management system shall formally classify all program engineering changes as Class I (major) and Class II (minor) changes. This system shall be established to control and document all changes affecting specification, drawing and software. A Class I change shall require submission of a change proposal to customer for formal approval and a formal change to the contract.

A Class I change is a change that impacts the contractual/technical agreement by affecting items including one or more of the following:

a) established technical baseline after agreement;

b) operational or performance aspects;

c) mission objectives;

d) interfaces/interchangeability;

e) safety, reliability, maintainability;

f) fit, form, and function of final delivered satellite;

g) non-technical contractual provisions.

A Class II change is an engineering change that does not fall within the definition of a Class I change.

6.29 Configuration status accounting

Contractor shall establish and maintain an as-designed versus as-built configuration verification list. This list shall include details such as item name, part number, serialization, revision status, and applicable change information. Contractor shall ensure that the manufactured as-built configuration of hardware will accurately correspond to the configuration described in the released engineering as-designed documentation. Differences identified between the as-designed report and the as-built report shall be resolved prior to final acceptance for each control item and higher level assembly, as applicable.

Contractor shall implement configuration status accounting, which involves the recording, and reporting of the information required to manage configuration effectively. This area includes the status of proposed changes to configuration as well as implementation of approved changes governing the as-built versus as-designed configuration.

7 Dependability

7.1 General

The International Standards for space systems define the requirements of dependability (reliability, availability and maintainability), as specified in ISO 23460. In the application to commercial satellite that cannot be repaired in orbit, the requirements with regard to reliability, availability and mission life are generally required. The methods and techniques shown in 7.2 to 7.7 should be applied and/or tailored to meet the requirements of each project.

7.2 Reliability prediction

Reliability prediction should be performed to implement a reliability designs trade-off, if applicable, and demonstrate that the failure rate of the equipment can meet reliability requirement. During preliminary design phase, this analysis should be performed using the parts count method of Reference [1] or equivalent method. During critical design phase, this analysis should be performed and updated using the stress analysis method of Reference [1] or equivalent. Failure rate of each part should use data from Reference [1] or equivalent information. If other data, such as manufacturer's test data and/or data used in previous space projects, is necessary, then the customer review the adequacy. As for the method of parts stress on Reference [1] or equivalent, the result of the parts stress analysis should be applied for the electrical stress. Also, the temperature stress used in this analysis should also be taken from the result of the parts stress analysis based on average temperature in orbit. If average temperature in orbit is not defined clearly, average temperature should be estimated by Formula (1):

$$\text{Average Temp.} = \text{Minimum Temp. at BOL } /2 + \text{Maximum Temp. at EOL}/2 \quad (1)$$

Non-operating multiplication factors shall be used to assess the reliability of non-operational equipment:

— electrical or electronic items shall be assumed to have 1/10 (one tenth) of the failure rate of active items;

— mechanical items shall be assumed to have 1/100 (one hundredth) of the failure rate of active items.

Also, analysis data package shall include the following as a minimum:

a) reliability block diagram;

b) failure rates for each block of reliability block diagram;

c) mathematical models or applicable dynamic model data;

d) probability of success results;

e) comparison of results with specified requirements.

The analysis shall be submitted to customer as a part of the design review data package.

7.3 Parts derating and application review analysis

Parts derating and qualification should take into account the requirements defined in Reference [4] or equivalent. Parts derating and application review for all equipment on commercial satellite should be performed to ensure that application of each part meets the derating criteria under maximum

temperature of acceptance test (AT) condition. As a minimum, the following should be reported in stress analysis work sheet:

a) parts description;

b) parts type;

c) parts number;

d) assembly name;

e) drawing number;

f) temperature range (both rated and applied temperatures);

g) electrical value (both rated value, applied value and stress ratio).

This analysis should include stress during transient under worst case condition. Derating criteria of each part type should be as is required in the appropriate performance specification.

Subcontractor of equipment may propose alternative derating criteria based on success experience for prime contractor's review, if necessary.

All parts stress that exceeds derating criteria shall be reviewed internally and corrective action shall be considered. Subcontractor shall require prime contractor's review if parts that exceed derating criteria were used and/or design changes were not practical with technical justification. The analysis shall be submitted to the customer as part of the design review data package.

7.4 Worst case analysis (WCA)

WCA should be performed to ensure that satellite performance can meet requirements under the worst case condition during its design lifetime that is specified in performance specification. The tolerances of parts, temperature, aging and radiation effects should be considered in the analysis. Source of these data shall be clarified in the analysis. Where analysis or source of data are not practical, the test data shall substitute for the analysis.

In particular, three (3) sigma approaches should be taken for the drift parameter by radiation effects. For the random term, the RSS method should be used for the calculation of parameters. For the bias term, the linear sum method should be used. Contractor can propose alternative WCA approach. The analysis shall be submitted to the customer as part of the design review data package.

7.5 Wear-out assessment

Parts, materials and processes subjected to wear-out or degradation due to environment, application stresses or inherent physical processes should be designed, fabricated, selected and used such that they can provide full required performance over their intended design life time with a justifiable margin. Design margin of such items for operation in orbit should be as is required in the appropriate performance specification. Such items should be analysed, and prediction should be made of their satisfactory design lifetime. Data shall be submitted to customer for review regarding the justification for selecting such limited life items, especially travelling wave tubes, mechanical devices/items, lubrication systems, etc. The analysis shall be submitted to the customer as part of the design review data package.

7.6 Failure mode, effect and criticality analysis (FMECA) and single point failure (SPF) summary

FMECA should be performed to analyse the failure modes of the electric parts, their effects on equipment and/or subsystem/system performance, and the severity of the failure modes. In order to prevent failure propagation to interfacing equipment, special emphasis should be placed on the input/output interface such as the power input line, telemetry and command interface, and signal line.

Effects of failure modes should be analysed to determine the need for design change or other action. Failure modes or effects that require corrective action shall be followed up and documented in a formal way to ensure appropriate corrective action.

At preliminary design phase, an assembly level (unit level) and subsystem and/or system level, FMECA should be performed. At critical/detail design phase, a detailed analysis including design modification should be performed and an assembly level and subsystem and/or system level should be updated with any change points. For a piece parts level FMEA, interface failure effects (i.e. between power lines, telemetry and command lines, any signal line, etc.) should also be performed.

Each failure mode will be categorized according to the severity of the failure effects. The severity categories are defined in Table 1. Additionally, the single point failure (SPF) items will be identified and summarized based on the FMECA. Corrective action to eliminate or mitigate the cause of the SPF effects will be a key activity of FMECA. The SPF with severity categories is defined in Table 2. As specified in 5.7, identified SPF items shall be identified and shall be reported to customer for review. The analysis shall be submitted to customer as part of the design review data package.

Table 1 — FMECA Severity Categories for Commercial Satellite

Severity categories	Assembly/ Equipment level	Subsystem level	Satellite system level
1 (Catastrophic)	Failure mode results in risk of loss or degradation of other equipment (risk of failure propagation).	Failure mode results in risk of loss or degradation of other functional subsystems (risk of failure propagation) or constitutes a hazard.	Failure mode results in complete loss of the satellite system and all its missions (referring to specified requirements) or constitutes a catastrophic safety hazard.
2 (Critical)	Failure mode results in complete loss of operational capability of equipment under consideration.	Failure mode results in complete loss of operational capability of subsystems under consideration.	Failure mode results in partial loss or severe degradation of mission.
3 (Major)	Failure mode results in severe degradation of operational capability of equipment under consideration.	Failure mode results in severe degradation of operational capability of subsystems under consideration.	Failure mode results in only minor or negligible degradation of mission.
4 (Minor or Negligible)	Failure mode results in only minor or negligible degradation of equipment under consideration.	Failure mode results in only minor or negligible degradation of subsystems under consideration.	No category 4 for a satellite system level

Table 2 — Definition of SPF with Severity

Assembly / Equipment Level	Category 1
Subsystem Level	Category 1
Satellite System Level	Category 1

7.7 Hardware-software interaction analysis (HSIA)

HSIA should be performed to ensure that the software reacts in an acceptable way to hardware failure. HSIA should take into account the requirements defined in Reference [26] or equivalent.

7.8 Fault tree analysis (FTA)

FTA should be performed to ensure that the design conforms to the failure tolerance requirements for combinations of failures. FTA should take into account the requirements defined in Reference [26] or equivalent.

7.9 Common-cause analysis

Common-cause analysis should be performed on reliability and safety critical items to identify the root cause of failures that have a potential to negate failure tolerance levels. Common-cause analysis should take into account the requirements defined in Reference [26] or equivalent.

7.10 Failure detection isolation and recovery (FDIR) analysis

FDIR analysis should be performed at system level to ensure that the autonomy and failure tolerance requirements are fulfilled. FDIR analysis should take into account the requirements defined in Reference [26] or equivalent

7.11 Availability analysis

Availability analysis or simulation should be performed to assess the availability of the system. Availability analysis should take into account the requirements defined in Reference [26] or equivalent.

7.12 Qualification status

Contractor should ensure that all flight hardware is qualified for flight. All items subject to qualification testing should not be used as flight hardware. Contractor should prepare and maintain a current qualification status list (QSL) of units designated. The QSL shall be provided to customer. Any deletion and/or addition to the list shall be subject to review and approval by customer. The QSL shall identify items such as unit name, part number, specification number, supplier, test type, test status, report status for qualifications on the project, report number, heritage and any supplementary comments.

Contractor should demonstrate that flight units supplied to the project have been identified and qualified. The following categorization and associated qualification test methods should be applied.

a) Existing fully qualified unit: Only requires documentation review to substantiate status.

b) Existing unit qualified or proto-qualified on another project and whose design, manufacturing and control procedures, as well as parts, materials and processes need no modification for the present project, but which are subject to more stringent environmental conditions: Requires proto-flight level testing for first unit.

c) Unit derived from an earlier qualified design but with design, manufacturing and/or control procedures or with parts, materials and processes changes: Delta qualification by test, or analysis with customer agreement and approval, is required for flight units, previously qualified or proto-qualified on other projects by contractor, to levels appropriate to application.

d) New design: Requires full qualification test.

The categorization of equipment shall be mutually agreed to by customer and contractor at the EQSR. The qualification status of all flight units shall be regularly reviewed as both design and environmental requirements evolve. In the event that a unit has undergone design changes that do not warrant full qualification testing, proto-flight testing may be warranted as mutually agreed with customer. If a unit is designated for proto-flight testing, the proto-flight tests may replace the unit acceptance tests. Customer shall have the right to monitor all qualification tests in progress during contract or specifically performed for contract applicable to project equipment at contractor's facilities and its subcontractors and suppliers.

8 Safety

8.1 System safety control

Contractor shall establish and implement system safety program as part of PA plan in accordance with ISO 14620-1 or approved equivalent standards to ensure that safety is designed into a satellite

system and is maintained throughout the life cycle from design, manufacture, assembly, test, storage, transportation, launch support and launch. This safety program shall also ensure operational control over identified hazards and ensure that malfunctions of equipment or human operating errors shall not result in injury to personnel, including customer and visitors, or damage to flight equipment, facilities, property or its associated infrastructure, and that delay.

PA team shall review all test documentation to ensure that test procedures reflect conformance to safety requirements for the protection of personnel, facilities and equipment, and to minimize the hazards associated with the test performance.

System safety program shall be done in accordance with (by order of priority):

a) safety launch site regulations;

b) ISO 14620-1.

A safety representative shall be designated. Contractor shall demonstrate to customer that the safety program or manual is implemented.

8.2 Safety and hazard analysis

Systematic analyses shall be performed to identify conditions which may propagate hazards. These shall be initiated early in design phase and shall be updated to include adequate control measures as required.

Safety and hazard analysis plan shall be prepared and presented, in accordance with the SOW agreements, including equipment, assembly, subsystem, system safety, for the elimination and/or control of hazards.

8.3 Safety design

Contractor will clarify design philosophy and function for the criticality prevention function for safety critical systems. The following sequence of activities specified in ISO 14620-1:2002, 5.2.3 shall be applied:

a) hazard elimination;

b) hazard minimization;

c) hazard control — safety devices;

d) hazard control — warning devices;

e) hazard control — special procedures.

Failure tolerance is one of the basic safety requirements that is used to control hazards. The design of the system shall meet the following failure tolerance requirements:

a) no single failure or operator error shall have critical (or catastrophic) consequences;

b) no combination of:

   1) two failures;

   2) two operator errors;

   3) one failure and one operator error for they shall have catastrophic consequences.

c) All hazards not controlled by conformance to failure tolerance shall be controlled by conformance to design to minimum risk or by meeting probabilistic safety targets.

d) Technical requirements for areas of design for minimum risk shall be identified and approved by the relevant safety approval authorities.

8.4 Training

Contractor will perform training for engineering, technician, operator and maintenance personnel to maintain safety for hazardous work, personnel and payload/GSE. The training will be based on training plan, which will include the following items:

a) to identify hazardous work which is required training;

b) to clarify required certification;

c) to clarify hazardous situation:

   1) identified hazard, hazard cause, risk estimation, prevention and control methods;

   2) relevant procedure, check list and/or contingency procedure;

   3) safety devices, protection devices and/or alarm devices;

   4) residual risk;

d) to clarify emergency contact;

e) to clarify training schedule;

f) to record participant and result of training.

9 EEE parts

9.1 Program plan

Contractor shall establish and maintain a comprehensive program for controlling the specification, selection, approval, application, qualification, screening and burn-in as well as acceptance of all high reliability electrical, electronic and electromechanical (EEE) parts, as applicable to their usage in the manufacture of deliverable flight and qualification items.

9.2 Parts control board

Parts control board (PCB) will be established and implemented in order to control, review and approve the selection and application of parts. The members of PCB will be parts specialist, PA staff, design engineer and the member of the project office. PCB will review the following items:

a) parts selection and standardization;

b) review of parts problems and resolution actions taken including alerts, and non-conforming DPA results;

c) establishment and maintenance of parts qualification status;

d) updating the parts list;

e) review and approval of the qualification test plan and radiation test plan;

f) review and approval of the parts specifications;

g) review government alerts and/or other alerts.

Customer can participate as a member of PCB when specified in the applicable SOW. The findings of PCB will be transmitted to customer in accordance with the applicable SOW.

9.3 Parts selection

The general guidelines for parts selection and control are described in ISO-14621-1 and ISO-14621-2. The parts shall be selected so that the equipment meets the reliability, performance and environmental requirements specified in the engineering specification and the SOW. Unless otherwise specified, preference should be given to parts selected from the following lists or their equivalent:

a) Level 1 Parts listed in NPSL[1)];

b) Level B parts listed in ESCC QPL[2)];

c) parts listed in Part I of EPPL;

d) Level 1 parts listed in GSFC EEE-INST-002[1)];

e) Grade 1 parts listed in GSFC PPL-21[1)];

f) parts (a quality level is based on the NPSL level 1) listed in MIL QPL[1)];

g) parts approved for other equivalent space programs;

h) parts, which are demonstrated to meet the requirements of intended use by qualification testing, materials testing or similarity.

The parts that meet the selection criteria above, a) to f), are considered as space qualified parts. Parts that are not included in the selection criteria above, a) to f), should be regarded as non-space qualified parts, and parts approval document (PAD) shall be submitted to the customer for approval (see Annex A for an example). The parts specification can be available at contractor's facility upon request for review. The manufacturer of non-space qualified parts should be requested to have established, high reliability parts manufacturing program and good experience in supplying parts for space use. The following considerations should be applied to parts selection.

a) Solid tantalum capacitors require 100 % surge current test as specified in Reference [7] or equivalent.

b) Semiconductor devices using eutectic alloys for die mounting are preferred.

c) The use of diodes, transistors and microcircuits with die protection through glass case is preferred.

d) The use of monometallic internal bonding of semiconductor devices is preferred as much as possible.

e) Microcircuit design and construction shall be in accordance with Reference [9], Reference [10] or equivalent requirements.

f) Hybrid microcircuits shall be qualified and screened. The requirements of Reference [12] or equivalent shall be used.

g) The following parts shall NOT be used:

   1) variable resistor and capacitor;

   2) aluminium electrolyte capacitor;

   3) wet-slug capacitors with silver case;

   4) relay which is not sealed by welding;

   5) Germanium and GaAs semiconductor (not including microwave application);

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1) All application notes in NPSL, GSFC EEE-INST-002 and GSFC PPL-21 apply.

2) As for a lot acceptance test, LAT2 or LVT subgroup2 will be performed on each lot.

6) plastic-encapsulated semiconductor;

7) dice without glassivation;

8) unpassivated power transistor;

9) discrete semiconductor with organic and/or polymeric materials as a package and/or package seal;

10) semiconductor devices with glass die mounting except CMOS integrated circuit;

11) mesa or alloy type transistor;

12) parts and materials using pure tin, cadmium and zinc;

13) mechanical micro switch (in the case of one shot operation or only monitor purpose, the part may be acceptable);

14) non-hermetically sealing parts (semiconductor and microcircuit), hybrid IC/module and RF module;

15) thin-film nichrome resistor;

16) non-over coated silver epoxy in non-hermetic applications;

17) Polytetrafluoroethylene (PTFE) wire insulation for external application (exposure to space).

h) If the following parts are used, then technical justification for their usage shall be provided to customer for approval. The technical justification shall include, as a minimum, how to control, manufacture, screen, inspect and handle by contractor after receipt of them:

1) tunnel diode;

2) gun diode;

3) flip chip or beam lead device;

4) LCC device;

5) semiconductor device without hermetic sealing;

6) CMOS device that is non-radhard or has not had radiation verification testing performed.

Parts selected for use should be reviewed and listed in the parts lists. These lists should be maintained and controlled, and submitted to customer for review. For non-space qualified parts, the contractor shall submit the parts approval document (PAD) (see Table A.1) for approval. The contractor may propose their own standard PAD format. The customer's formal approval is required for the use of each non-standard part.

9.4 Parts screening

All EEE parts should be screened by 100 % testing at the contractor, manufacturer or supplier. Parts screening corresponding to the following parts quality levels or their equivalent should be applied, and any changes or deviations shall be strictly approved by the customer:

a) resistors and capacitors: failure rate S of ER-MIL specification[3)];

b) transistors and diodes: JAN S of Reference [8] or equivalent[3)] or ESA Level B;

c) microcircuits: Class V/S of Reference [10] or equivalent or ESA Level B;

d) hybrid microcircuits: Class K of Reference [11] or equivalent[3)];

e) for the other parts: Level 1 of Reference [4] or equivalent[3)].

For programmable devices (e.g. PROMs, PLAs, and FPGAs), a dynamic burn-in (duration time: 240 h) should be conducted after programming if the manufacturer recommend to do so. The post burn-in should include DC/AC, and functional test for user's program verification.

Hybrid devices that contain discrete chip semiconductors should be screened in accordance with the Class K of Reference [11] or equivalent. Additionally, all chips and hybrid devices should be stored, processed, fabricated, assembled, tested and inspected in a clean area or a cleaned work station until they are sealed hermetically in accordance with Reference [11] or equivalent. Inspections should be in accordance with an existing and proven standard such as Reference [12] or equivalent method 2074 for diodes, Reference [12] or equivalent method 2072 for transistors, Reference [13] or equivalent method 2010 for microcircuits, or Reference [13] or equivalent method 2017 for Hybrids IC.

PIND test should be performed on discrete semiconductors and microcircuits having cavity type packaging. This test should be performed in accordance with Reference [13] method 2020 condition A, Reference [12] method 2052 condition A or equivalent. The percent defective allowable (PDA) for PIND test (see Reference [9] or equivalent and Reference [8] or equivalent) should be applied.

Contractor should review the screening test data. This review should contain the test procedures with lot acceptance testing and recorded data. The data review should be conducted to verify the adequacy of the data, accept/reject criteria, delta limit and PDA based on the procurement specification.

The details of the parts screening requirements shall be stated in each parts specification and submitted to customer for approval.

Grade 2 Parts from Reference [3] or equivalent should be upgraded by re-screening. For the re-screening, Reference [4] or equivalent should be used as a guideline. The contractor shall submit the contents of the re-screening with the PAD (see Table 2) for approval.

Parts whose storage duration from being incoming accepted to being assembled is over six years should be re-life tested. The contents of the re-life test should include external visual, sample-based solderability test, and fundamental electrical characteristics as possible.

9.5 Lot acceptance test (LAT)/quality conformance inspection (QCI)

9.5.1 LAT/QCI for space qualified parts (MIL, EU, JAXA, etc.)

The LAT/QCI should be performed on all products purchased according to JAN S, Class S, Class K, Class V, MIL-ER specification, Class I of JAXA specification and Level B of the ESA/SCC for active parts and

3) All application notes in Reference [3], Reference [4] and Reference [5] or equivalent apply.

Level C of ESA/SCC for passive parts or equivalent specification. For ESA/SCC parts, the following criteria, which are specified in Reference [14], or equivalent can be applied.

a) Level LAT1: the part is neither ESA/SCC nor United States Military qualified at the time of procurement and level LAT2 is not applicable.

b) Level LAT2: the part is not space qualified but has successfully supported other long life and/or high reliability space program and the reliability/evaluation data are still valid for the current design.

c) Level LAT3: all cases are not included in level LAT1 or LAT2. Level LAT3 or tests may be replaced by incoming inspection. Level LAT3 tests may be omitted for qualified ranges of components (e.g. 54HC).

9.5.2 LAT/QCI for non- space qualified parts

For non-space qualified parts purchased according to SCD, the LAT or QCI should be performed in accordance with the relevant specification. For European parts, Reference [14], Clause 4.3.5 or equivalent should be applied. Based on past experience with the same parts from the same manufacturer, the LAT or QCI should be decided on a case-to-case basis if no changes have been made to the manufacturing process and part design and construction. The corresponding justification shall be available during the parts specification approval process.

9.5.3 Radiation

Contractor should conduct a radiation effects assessment to assess the radiation characteristics of the selected parts to ensure that they meet their mission application for the predicted radiation environment. Parts, which can survive both the total dose and the high-energy heavy ion radiation environments of a mission for the specified orbital lifetime, should be selected.

Contractor should assess the radiation levels and demonstrate that the radiation resistance of the part has justifiable margin greater than the total dose predicted for the particular part. The commercial satellite should be designed so that its parts survive in a total dose environment for a specified designed radiation design lifetime. The total dose effects analysis should demonstrate that all circuits are designed so that all parts can withstand the specified radiation levels for this period. Where no or insufficient data are available for parts which may be sensitive to radiation, the contractor should perform the radiation verification testing (RVT) and present the results to customer via a test report. Contractor and sub-contractors should implement a radiation hardness policy to demonstrate the commercial satellite will survive to the total dose radiation during the mission lifetime. A PAD should also be submitted for those parts which do not meet the radiation environment but which are retained in the design with additional shielding at unit/equipment level.

Sufficient testing should be performed to demonstrate that electronic parts susceptible to single event effects (SEE) have a low single event upset (SEU) or single event transient (SET) rate and be free of latch-up and burn-out in the application. Circuit designs and software techniques should be chosen so that upset rates will not adversely affect circuit performance.

Contractor shall provide a space radiation hardness assurance plan that should be implemented during the whole project phase.

9.5.4 Destructive physical analysis (DPA)

The DPA should be performed in accordance with Reference [15] or equivalent when specified in the applicable SOW. The quantity of the DPA samples may be reduced for expensive parts after negotiation with customer. The DPA lab or the subcontractor shall perform the DPA. However, if customer approves the delegation of the subcontractor for the DPA, then the parts manufacturer may be able to perform the DPA. The DPA should be required for the parts that are shown in Reference [15] or equivalent.

9.6 Parts qualification

The parts evaluation/qualification program should be performed for non-space qualified parts to verify the validity of the parts. The parts evaluation/qualification program should cover the following elements:

— design and application assessment;

— construction analysis;

— manufacturer assessment;

— evaluation/qualification testing.

The evaluation/qualification plan and its report can be available to customer.

9.7 Incoming inspection and storage condition

Appropriate incoming inspection should be performed. The review of data for compliance to requirements, evidence of traceability, marking and external inspection should be performed at the incoming inspection.

Regulations for parts storage condition shall be described in the parts program plan.

9.8 Parts traceability and lot control

All EEE parts should be traceable to the procurement, screening and manufacturing lots.

9.9 Lot transfer

In principle, all parts should be newly procured for a project. However, if parts from existing stock for other projects are needed for this project, then contractor should review the quality level of the parts to determine whether they meet the minimum screening requirements of the project prior to their transfer to the project. This review should contain the following items as a minimum:

— delivery date and revision status of specifications;

— lot date code;

— comparison of screening requirement;

— determination of necessity of additional screening or test;

— review of existing alerts and review of previous failure and performance history.

If parts stored more than the period that exceed the storage regulation at contractor, then the re-life test should be conducted. The recommended re-life test is the solderability (sampling), 100 % electrical test and visual inspection. Additional screening should be performed if the parts from existing stock do not meet the relevant screening requirements. Regulation at contractor as for storage (storage condition, standard storage period and content of re-life test, etc.) should be described in the parts program plan.

9.10 Non-conforming parts

Any non-conformance part shall be treated. If a failure occurs during LAT/QCI, DPA or qualification test, then contractor shall inform customer of the failure analysis report for approval. The failure analysis report shall contain statements of the root cause, investigation, disposition and corrective actions.

10 Materials, mechanical parts and processes (MMPP)

10.1 Policy of materials selection and control

In the selection of materials, application requirements, environmental requirements, usage restrictions and the following items are to be considered, as applicable:

a) previous successful usage on long life space programs shall be applicable;

b) outgassing requirements shall satisfy TML: 1,0 % and CVCM: 0,1 % specified in Reference [13] or equivalent. Materials close to optical equipment may require an additional evaluation on case by case basis;

c) flammability: the use of flammable materials shall be avoided whenever possible;

d) toxicity: the use of toxic materials shall be avoided whenever possible;

e) radiation resistance shall be considered;

f) stress corrosion resistance (see Reference [17] or equivalent): the use of materials that are susceptible to stress corrosion cracking shall be avoided;

g) dissimilar metals: allowed potential difference is 0,5 V;

h) the use of pure tin, mercury, cadmium and zinc is prohibited;

i) fluid compatibility: materials that will be in contact with an identified fluid shall be compatible with that fluid. If adequate compatibility data are not available then testing shall be done;

j) adequacy of the specifications to which the material is to be procured, including lot testing and controls;

k) trade-off studies: comparisons with alternates;

l) the use of magnetic materials shall be minimized.

Reference [27] should be used as reference for outgassing requirements.

The selected materials shall be recorded in the materials list, which shall be submitted to the customer for review. The materials list shall include fasteners, terminals, wire and cable as well as metallic and non-metallic materials. Mixture ratio, cure time, temperatures, etc., shall be also included in the list. Contents of materials list shall include material designation, materials parts number, conditions (heat treatment, finish, mix ratio, cure, etc.), material specification number, application, heritage, outgassing data and its data source, at least. If materials to be used are not space proven, or has been used on previous space programs but not for the same application or environment and needs additional qualification tests, then the justification for use of the unqualified material and qualification plan and its report can be available to customer.

If government alert and/or other alerts are applicable to the materials used in the equipment, then contractor shall investigate the problem, and the resolution shall be submitted to customer for review. Materials shall be controlled by a detailed specification that will include, as applicable, material configuration and performance requirements, lot identification, lot acceptance/qualification tests, and protective packaging and handling requirements. If an official specification exists, such as US military or federal specification and it is applicable to and satisfactory for the intended use, then that specification shall be used for the procurement of materials. All materials shall be traceable by batch number or purchase order to data code and manufacturer. Age-sensitive materials shall have their shelf-life expiration data marked on each container. The materials that exceed their expiration date shall not be used.

10.2 Policy of mechanical parts selection and control

Contractor shall verify that all materials and processes used in the mechanical parts satisfy the application requirements, environmental requirements and usage restrictions. In the selection, procurement and control of mechanical parts, contractor shall apply the methods specified in ISO 10794:2011, 7.2 to 7.7.5. The declared mechanical parts list (DMPL) shall be submitted.

Mechanical parts are classified into 11 groups depending on their type or their main use as shown in Table 4. If, for a given project, it is considered necessary to create new groups, Table 4 shall have a number over 61.

Table 4 — Mechanical part group numbers

Group number	Description
51	Spacing parts (e.g. washers and spacers)
52	Connecting parts (e.g. bolts, nuts, rivets, inserts and clips)
53	Bearing parts (e.g. ball-bearings and needle bearings)
54	Separating parts (e.g. pyrotechnics, springs and cutters)
55	Control parts (e.g. gears)
56	Fluid-handling parts (e.g. diffusers)
57	Heating parts
58	Measuring instruments (e.g. gauges and thermocouples)
59	Optical passive equipment
60	Magnetic parts
61	Other parts

10.3 Policy of processes selection and control

Also, the process list shall be submitted. The selection of processes shall consider:

a) adequacy of the process specifications, standards and process maintenance program;

b) qualification status of the previous application to long-life space programs and/or certification of personnel by demonstration and test programs;

c) certification of the processes and equipment;

d) use of approved materials;

e) soldering should meet Reference [18] or equivalent;

f) crimping should meet Reference [19] or equivalent.

The selected processes are subject to review by representatives from customer in the design review and/or MRR, etc. The processes used for the manufacturing of the equipment and/or subsystem/system shall be controlled by detailed specifications. These specifications shall include technical and certification requirements as a minimum. The processes to be used shall be those which have been established and qualified for a previous space program. If it is necessary to use not space proven process, or process that was used on previous space programs but not for the same application, or environment/additional qualification tests, then the justification for use of the process and qualification/validation plans and its report can be available to customer.

10.4 Special processes

Contractor shall identify and control processes where quality cannot be completely ensured solely by inspection of the end article only. Processes control shall be ensured by means of adequate procedures and personnel/machine certifications. Provisions for traceability are required in the process

documents. The status of personnel and machine certification shall be recorded and maintained and may be reviewed by customer at the design review and/or MRR, etc.

10.5 Materials, mechanical parts and processes control board

Materials, Mechanical Parts and Processes Control Board (MMPPCB) will be held to manage and control the selection, application, procurement and documentation of items that are used in equipment, subsystems or systems.

The attendance of this board is:

a) design engineers (electrical and mechanical);

b) manufacturing staff, as necessary;

c) product assurance (reliability and quality);

d) inspection section, as necessary;

e) test section, as necessary.

Additionally, as an internal review activity, drawing review meetings are held prior to the release of the drawings. The purpose of this review is to confirm:

a) adequacy of the design, application of materials and processes;

b) design consideration on productivity, reliability, maintainability, test and inspection, parts and materials, and packaging.

During this review, the drawings, parts and materials list, application of parts and materials, and other design documents are also evaluated.

PA representative shall present to the customer the validation status for materials, mechanical parts and processes which have been performed.

11 Software product assurance

11.1 General

Software product assurance should take into account the requirements defined in Reference [24] or equivalent and ISO/IEC 33001.

11.2 Software development

Contractor shall prepare, maintain and implement a software PA program to ensure that all software developed and/or modified incorporates the required elements of quality that are applicable. A software product assurance program plan shall be prepared as a section in the PA program plan and shall identify the software development process, verification and acceptance testing, configuration control, non-conformance control and software documentation. If contractor has many low-tier subcontractors and/or suppliers, then these requirements shall be applied to these low-tier subcontractors and/or suppliers.

Software development tasks such as analysis of system requirements allocated to software, development of software requirements, development of software architecture, software design and coding, integration of software components and software testing to verify compliance to specified requirements, shall be performed in accordance with the contractor's software process. In addition, the use of appropriate methods and tools shall be integrated into the defined software process.

Documentation needed to perform the software development tasks such as software requirements documents, software design documents, test plans and test procedures shall be developed, maintained

and reviewed to ensure consistency across all software work products. Software PA shall conduct reviews and audits, at appropriate phases of the software development process, to verify proper implementation of the contractor's software development process. The reviews and/or audits shall verify that:

a) the software requirements have been reviewed to ensure they are complete, correct, consistent, feasible, and testable;

b) readiness and completion criteria for each software development task have been satisfied;

c) software products comply with specified standards and requirements;

d) required testing has been performed;

e) system and acceptance testing of the software are performed in accordance with documented plans and procedures;

f) tests are satisfactorily completed and recorded;

g) problems and defects detected are documented, tracked and addressed;

h) tracing of the allocated requirements through the software requirements, design, code and test cases is performed;

i) the documentation used to operate and maintain the software is verified against the software baseline and any applicable allocated requirements before the software is released.

Contractor shall document the results of reviews and audits and any resulting action items shall be tracked until all issues have been satisfactorily resolved. The results of reviews and audits shall be made available to customer's representatives for review upon request.

11.3 Software configuration management

Contractor shall establish and implement a software configuration management system (SCMS) to maintain the integrity of the software products produced throughout the software life cycle. The SCMS shall identify the configuration of the software at given points in time, systematically control changes to the configuration, and maintain the traceability of the configuration. Work products placed under configuration control shall include the software products, and software used to program deliverable devices or modules delivered to customer and the items that are identified with or required to create these software products. A software configuration control board (SCCB) shall be formed to authorize the establishment of a software baseline library, the identification of configuration items/units, systematic control of changes to baselines and the release of software products built from the software baseline library. The status of configuration items shall be recorded and reports documenting software configuration management (SCM) activities and the contents of software baselines shall be developed. Software baseline audits shall be conducted periodically by SQA to assess the integrity of the software, verify the completeness and correctness of the software baseline library contents, and verify compliance with applicable SCMS standards and procedures. Results of such audits shall be documented and action items resulting from the audit shall be tracked until issues are satisfactorily resolved. The results of software baseline audits shall be made available to customer's representatives for review on site upon request.

11.4 Software non-conformance reporting and corrective action

Non-conformance control shall be performed after the first release of the software item. After disposition of the non-conforming product, the software QA personnel shall verify the adequacy of the implemented corrective actions and ensure that the associated documentation is updated including the configuration status.

Annex A
(informative)

Parts approval document (PAD)

Table A.1 — Example of PAD format
Non-Space Qualified Parts Approval Request

Family Name		Parts Reference	
Group		Similar Parts	
Characteristics	(See parts specification on summary attached)		
Specification			
Generic Specification, Rev.		Individual Specification, Rev.	
Manufacturer/Country			
Used for: Heritage Usage Remarks			
Inspections SEM/PreCAP DPA/Sample Size Remarks			
RVT Remarks			
Design Engineering		Parts Engineering	
Product assurance		Project Office	
Customer Approval			

Bibliography

[1] MIL-HDBK-217F notice2, *Reliability Prediction of Electronic Equipment, Military Handbook*

[2] MIL-STD-1686, *Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment*

[3] NPSL. *NASA Parts Selection List*

[4] GSFC EEE-INST-002, *Instructions for EEE Parts Selection, Screening, Qualification, and Derating*

[5] GSFC-PPL-21, *GSFC Preferred Parts List*

[6] ESCC QPL, *ESCC Qualified Parts List*

[7] MIL-STD-1547, *Electronic Parts, Materials and Processes for Space and Launch Vehicles*

[8] MIL-PRF-19500, *General Specification for Semiconductor Devices*

[9] MIL-M-38510, *General Specification for Microcircuits*

[10] MIL-PRF-38535, *Microcircuit, General Specification for*

[11] MIL-PRF-38534, *Integrated Circuit (Microcircuits) Manufacturing, General Specification for*

[12] MIL-STD-750, *Semiconductor Devices, Test Methods for*

[13] MIL-STD-883, *Microelectronics, Test Methods and Procedures for*

[14] ECSS-Q-ST-60C Rev.2, *Electrical Electronic and Electromechanical (EEE) Component*

[15] MIL-STD-1580, *Destructive Physical Analysis for Electronic, Electromagnetic, and Electromechanical Parts*

[16] ASTM-E-595, *Standard Test Methods for Total Mass Loss and Collected Volatile C o n d e n s a b l e Materials from Outgassing in Vacuum Environment*

[17] ECSS-Q-70-36, *Material selection for controlling stress corrosion cracking*

[18] NASA-STD-8739.3, *Soldered Electrical Connection*

[19] NASA-STD-8739.4, *Crimping, interconnecting cables, harnesses and wiring*

[20] ISO 14300-2, *Space systems — Programme management — Part 2: Product assurance*

[21] ISO 23460, *Space projects — Programme management — Dependability assurance requirements*

[22] ISO 17666, *Space systems — Risk management*

[23] ISO 23461, *Space systems — Programme management — Non-conformance control system*

[24] ECSS-Q-ST-80C, *Software product assurance*

[25] ISO/IEC 33001, *Information technology — Process assessment — Concepts and terminology*

[26] ECSS-Q-ST-30C, *Dependability*

[27] Outgassing data for selecting spacecraft materials online, NASA

[28] MIL-STD 1246C, *Product Cleanliness Level and Contamination Control Plan*

[29] AS 9100, *Aerospace Quality management system*

(*Continued from second cover*)

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 27025 Space systems — Programme management — Quality assurance requirements	IS 18336 : 2023/ISO 27025 : 2010 Space systems — Programme management — Quality assurance requirements	Identical

The Committee has reviewed the provisions of the following International Standards referred in this adopted standards and has decided that is acceptable for use in conjunction with this standard. For undated references, the latest edition of the referenced document applies, including any corrigenda and amendment:

International Standard	*Title*
ISO 15388 : 2022	Space systems — Contamination and cleanliness control

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. The Bureau of Indian Standards shall not be held responsible for identifying any or all such patent rights.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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This Indian Standard has been developed from Doc No.: TED 14 (22963).

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