MetOp-SG Product Assurance Requirements for Suppliers

[DRL SAC-PA-02]

DOCUMENT TYPE	CI #	WBS #	KEYWORDS
Specification			Product Assurance

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Summary

This document defines the Product Assurance requirements to be applied to the Suppliers in the frame of all METOP-SG programme phases.

Document change log

ISSUE/ REVISION	DATE	MODIFICATION NB	MODIFIED PAGES	OBSERVATIONS
DRAFT	29/05/2013	-	-	
01/00	15/11/2013			-
02 draft	05/06/2014		All for Astrium Pages 104/176 for silver coating Page 92 Pages 6,26,52 for ECSS Q ST 20-08	
02	31/07/2014		Page 7 Page 14 Page 17 Page 60	

ISSUE/ REVISION	DATE	MODIFICATION NB	MODIFIED PAGES	OBSERVATIONS
			Page 124 Pages 131/132 Section 7.3.8 page 117 Various pages	
03	13/10/2014		Page 5, 177, Annex H Page 432 Page 73 Pages 5,6,33,59 transferred to p. 21 onwards	

ISSUE/ REVISION	DATE	MODIFICATION NB	MODIFIED PAGES	OBSERVATIONS
			3,6,48,159	
			59,60	
			100	
			Annex A	
			Annex B	
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1 SCOPE

This document defines the Product Assurance requirements applicable to Suppliers for the METOP-SG programme.

All products (equipment or services) procured in the frame of METOP-SG programme are required to conform to these Product Assurance requirements.

For Suppliers delivering **software**, a specific requirement document is provided, in addition to this one: **Software PA Requirements for Suppliers ref. MOS.SP.ASF.SYS.00402**.

These requirements are based on the ECSS series of documents or on the end customers documents when no equivalent ECSS is available. They amend the applicable documents when necessary to address some specific points.

When ESA is quoted, this means the ESA organisation placing the contract on the end customer.

1.1 APPLICABILITY

The requirements defined in this document are applicable to METOP-SG Project phases B2 & C/D.

These requirements are applicable to:

- All delivered Hardware models of the product
- Elements of the GSE which interface directly with flight hardware (e.g. connectors, cooling devices…) or which can have an impact on safety (e.g. EGSE, MGSE, lifting devices).

In this document, each requirement is identified as displayed in the following table.

Requirement Identifier	Source Identifier	Tailoring Status
Requirement Statement		

➔ The **Requirement Identifier** indicates the reference of the standard (ECSS) & is associated to the customers internal DS number, as described in the table below.

➔ The **Source Identifier** indicates the paragraph of the standard document (ECSS) where the requirement is placed. When in the PARD, a requirement calls another requirement, the source identifier is used & it is always a requirement from the same ECSS (example: if in a requirement from ECSS-Q-ST-20, you can read “see requirement 5.4.2a”, it means to refer to the requirement associated to the paragraph 5.4.2a from ECSS-Q-ST-20).

➔ The **Tailoring Status** details the statement of initial requirement in accordance with the table below.

Tailoring Status	Description	Requirement Identifier	Source Identifier
A	The requirement is used **A**s per reference standard and is applicable	**ECSS-Q-ST-YY_XXXXXX**	**5.1.1.2a**
N	The requirement is **N**ew with respect to the standard. It is - an internal DS requirement of the end customer or - a MetOp-SG requirement	**ECSS-Q-ST-YY_REQ-XXX** **ECSS-Q-ST-YY_MOS-XXX**	None
M	The requirement is **M**odified and is applicable. It is a modified - ECSS requirement or - MetOp-SG requirement	**ECSS-Q-ST-YY_XXXXXX** **ECSS-Q-ST-YY_MOS-XXX**	**5.5.2a**

YY: number of the associated ECSS (10, 20, 30, 40, 60 or 70)

XXX: chronological number

For **modified requirements**: all modified requirements are identified by “M” in the tailoring status case but the modifications due to tailoring are not identified in the text of the requirements (no bold or barred text for instance).

For **deleted requirements**: when a requirement from standard (ECSS) is deleted in the tailored PARDs, all associated information are removed from the document: no numbering, no text, no tailoring status, on indication at the place of the deleted requirement.

1.2 DOCUMENTS

1.2.1 APPLICABLE DOCUMENTS

The following documents are applicable together with the Product Assurance Requirement Specification.

AD ref	Reference	Title
[AD1]	Specific to supply	Contract
[AD2]	Specific to supply	Statement of Work (SoW)
[AD3]	Specific to supply	Technical Requirements Specification
[AD13a]	MOS.SP.ASF.SYS.00816	MetOp-SG Instrument General Design And Interface Requirements
[AD13b]	MOS.SP.ASF.SYS.00349	MetOp-SG Units General Design And Interface Requirements
[AD13c]	ENS.06.00123.ASTR	General Design And Interface Requirements (Generic GDIR)
[AD15]	MOS-RS-ESA-INS-0435	MetOp-SG Instruments Management Requirements
[AD14e]	MOS.SP.ASF.SYS.00770	MetOp-SG Cleanliness Requirement Specification
[AD14c]	MOS.SP.ASF.SYS.00402	MetOp-SG Software Product Assurance Requirements for suppliers
NDPA66	CSG-RS-09A-CN, Issue 5, Revision 6; 2.12.2002	CSG Safety Regulations: Volumes and Parts List
NDPA67	CSG-RS-10A-CN, Issue 5, Revision 5; 6.11.2006	CSG Safety Regulations: General Rules Vol 1
NDPA68	CSG-RS-21A-CN, Issue 5, Revision 5; 6.11.2006	CSG Safety Regulations: Specific Rules Vol 2, Part 1 (Ground Installations)
NDPA69	CSG-RS-10A-CN, Issue 5/Revision 7; June 2008	CSG Safety Regulations: Specific Rules Vol 2, Part 2 (Spacecraft)
NDPA70	SCM 2008-010	Falcon 9 Launch Vehicle Payload User's Guide
NDPA71	AFSPCMAN 91-710	Range Safety User Requirements Manual (http://www.e-publishing.af.mil)

Note: AD13a and AD15 are applicable to Instruments level only

1.2.2 APPLICABLE NORMATIVE REFERENCES

The following standards shall be applicable to the extent and with the modifications specified in this document. When no issue is quoted, latest issue at contract signature shall apply.

AD ref	**Full reference**	Title
SDS01	ECSS-E-ST-10	Space engineering - System engineering general requirements

SDE03	ECSS-E-ST-20-06	Space engineering -Spacecraft charging
SDM11	ECSS-E-ST-33-11	Space engineering - Explosive systems and devices
SDM04	ECSS-E-ST-32-01	Space engineering – Fracture Control
SDM08	ECSS-E-ST-32-10	Space engineering - Structural factors of safety for spaceflight hardware
SDSW01	ECSS-E-ST-40	Space engineering - Software
NDMA1	ECSS-M-ST-10	Space project management - Project planning and implementation
NDMA3	ECSS-M-ST-40	Space project management - Configuration and information management
NDMA6	ECSS-M-ST-80	Space project management - Risk management
NDPA5	ECSS-Q-ST-10	Space product assurance - Product assurance management
NDPA6	ECSS-Q-ST-10-04	Space product assurance - Critical-item control
NDPA7	ECSS-Q-ST-10-09	Space product assurance - Non-conformance control system
NDPA8	ECSS-Q-ST-20	Space product assurance - Quality assurance
NDPA9	ECSS-Q-ST-20-07	Space product assurance - Quality assurance for test facilities
NDPA73	ECSS-Q-ST-20-10	Space product assurance - Off-the-shelf utilisation in space systems
NDPA10	ECSS-Q-ST-30	Space product assurance - Dependability
NDPA11	ECSS-Q-ST-30-02	Space product assurance - Failure modes, effects (and criticality) analysis (FMEA/FMECA)
NDPA12	ECSS-Q-ST-30-09	Space product assurance - Availability analysis
NDPA13	ECSS-Q-ST-30-11	Space product assurance - Derating - EEE components
NDPA14	ECSS-Q-ST-40	Space product assurance - Safety
NDPA15	ECSS-Q-ST-40-02	Space product assurance – Hazard Analysis
NDPA16	ECSS-Q-ST-60	Space product assurance - Electrical, electronic and electromechanical (EEE) components
NDPA26	ECSS-Q-ST-60-02	Space product assurance - ASIC and FPGA development
NDPA27	ECSS-Q-ST-60-05	Space product assurance - Generic procurement requirements for hybrid microcircuits
NDPA28	ECSS-Q-ST-60-12	Space product assurance - Design, selection, procurement and use of die form monolithic microwave integrated circuits (MMICs)
NDPA76	ECSS-Q-ST-60-13	Space product assurance - Commercial Electrical, electronic and electromechanical (EEE) components
NDPA29	ECSS-Q-ST-60-14	Space product assurance - Relifing Procedure – EEE components
	ECSS-Q-ST-60-15	Radiation hardness assurance – EEE components
NDPA30	ECSS-Q-ST-70	Space product assurance - Materials, mechanical parts and processes

NDPA31	ECSS-Q-ST-70-01	Space product assurance - Cleanliness and contamination and control
NDPA32	ECSS-Q-ST-70-02	Space product assurance - Thermal vacuum outgassing test for the screening of space materials
NDPA33	ECSS-Q-ST-70-03	Space product assurance – Black-anodizing of metals with inorganic dyes
NDPA34	ECSS-Q-ST-70-04	Space product assurance - Thermal testing for the evaluation of space materials, processes, mechanical parts and assemblies
NDPA35	ECSS-Q-ST-70-05	Space product assurance - Detection of organic contamination of surfaces by infrared spectroscopy
NDPA36	ECSS-Q-ST-70-06	Space product assurance - Particle and UV radiation testing of space materials
NDPA37	ECSS-Q-ST-70-07	Space product assurance - Verification and acceptance of automatic machine wave soldering
NDPA38	ECSS-Q-ST-70-08	Space product assurance - The manual soldering of high-reliability electrical connections
NDPA39	ECSS-Q-ST-70-09	Space product assurance - Measurements of thermo-optical properties of thermal control materials
NDPA40	ECSS-Q-ST-70-10	Space product assurance - Qualification of printed circuit boards
NDPA41	ECSS-Q-ST-70-11	Space product assurance - Procurement of printed circuit boards
NDPA75	ECSS-Q-ST-70-12	Space product assurance - Design rules for printed circuit boards
NDPA42	ECSS-Q-ST-70-13	Space product assurance - Measurement of the peel and pull-off strength of coatings and finishes using pressures-sensitive tapes
NDPA43	ECSS-Q-ST-70-18	Space product assurance - Preparation, assembly and mounting of RF coaxial cables
NDPA44	ECSS-Q-ST-70-20	Space product assurance - Determination of the susceptibility of silver plated copper wire and cable to “red-plague” corrosion
NDPA45	ECSS-Q-ST-70-21	Space product assurance - Flammability testing for the screening of space materials
NDPA46	ECSS-Q-ST-70-22	Space product assurance - Control of limited shelf life materials
NDPA47	ECSS-Q-ST-70-26	Space product assurance - Crimping of high-reliability electrical connections
NDPA48	ECSS-Q-ST-70-28	Space product assurance - Repair and modification of printed circuits board assemblies for space use
NDPA49	ECSS-Q-ST-70-30	Space product assurance - Wire wrapping of high reliability electrical connections
NDPA50	ECSS-Q-ST-70-31	Space product assurance - Application of paints and coating on space hardware
NDPA51	ECSS-Q-ST-70-36	Space product assurance - Material selection for controlling stress-corrosion cracking

NDPA52	ECSS-Q-ST-70-37	Space product assurance - Determination of the susceptibility of metals to stress-corrosion cracking
NDPA53	ECSS-Q-ST-70-38	Space product assurance - High-reliability soldering for surface-mount and mixed technology
NDPA54	ECSS-Q-ST-70-45	Space product assurance - Mechanical testing of metallic materials
NDPA55	ECSS-Q-ST-70-46	Space product assurance - Requirements for manufacturing and procurement of threaded fasteners
NDPA60	ECSS-Q-ST-70-50	Space product assurance - Particulate contamination monitoring for spacecraft systems and cleanrooms
NDPA56	ECSS-Q-70-71	Space product assurance - Data for selection of space materials and processes
NDPA57	ECSS-Q-ST-80	Space product assurance - Software product assurance
NDPA59	ECSS Q-ST-20-08 (note 1)	Storage, handling and transportation of spacecraft hardware
NDPA20	ESCC 9000	ESCC Generic Specification for Integrated circuits, monolithic, hermetically sealed
NDPA21	ESCC 20200	ESCC: Component Manufacturer Evaluation
NDPA22	ESCC 22800	ESCC: ESA/SCC Non conformance Control System
NDPA23	ESCC 22900	ESCC Basic Specification: Total Dose Steady-State Irradiation Test Method
NDPA24	ESCC 24900	Minimum requirements for controlling environmental contamination of components
NDPA25	ESCC 25100	Single Event Effects test method and guidelines
NDPA18	ESCC EPPL	ESCC European preferred parts list (https://escies.org)
NDPA19	ESCC QML	ESCC qualified manufacturers list (https://escies.org)
NDPA17	ESCC QPL	ESCC qualified part list (https://escies.org)
	MIL STD 981	Design, Manufacturing and Quality Standards for Custom Electromagnetic Devices for Space Applications

Note 1: ECSS Q-ST-20-08C has now been officially released, superseding PSS-01-202. Reference to PSS-01-202 therefore suppressed.

1.2.3 REFERENCE AND SUPPORT DOCUMENTS

The following documents have been used to derive these PA requirements or provide reference material for understanding of these PA requirements. They do not constitute requirements as such.

AD25: MOS-RS-ESA-SYS-0495	Metop Second Generation Satellites Product Assurance and Safety Requirements
AD28: MOS-LI-ESA-SYS-0498	Metop-SG Satellites Document Requirements List
AD29: MOS-LI-ESA-SYS-0499	Metop-SG Satellites Document Requirements Definition
ECSS-E-ST-10-02	Space engineering - Verification
ECSS-E-ST-10-03	Space engineering - Testing
ECSS-E-ST-10-04	Space engineering - Space environment
ECSS-E-ST-10-12	Space engineering - Methods for Calculation of Radiation Received and its Effects, and a Policy for Design Margins
ECSS-E-ST-70-11	Space Segment Operability
ECSS-M-ST-10-01	Space project management - Organization and conduct of reviews
ECSS-Q-HB-30-01	Space product assurance - Worst Case Analysis
ECSS-Q-HB-30-08	Space product assurance - Components Reliability Data Sources And Their Use
ECSS-Q-ST-40-12	Fault tree analysis – Adoption notice ECSS/IEC 61025
ECSS-Q-TM-30-12	End-of-life parameter drifts – EEE Components
ECSS-S-ST-00	Description, implementation & general requirements
ECSS-S-ST-00-01	ECSS system – Glossary of terms
ISO 9001:2008	Quality management system: Requirements
MIL STD 883	Test methods and procedures for microelectronics
NASA STD 8739.1	Workmanship Standard for Polymeric Application on Electronic Assemblies
ASTM E 595 90 6 ANSI/ASTM E 595-77	TML, CVCM from outgassing in a vacuum environment

2 ACRONYMS

Abbreviation	Meaning
AIV	Assembly, Integration, Verification
AQL	Acceptable Quality Level
ARB	Acceptance Review Board
ASIC	Application Specific Integrated Circuit
ATOX	Atomic Oxygen
CCB	Configuration Control Board
CCD	Charge Coupled Device
CCP	Component Control Plan
CCCP	Cleanliness and Contamination Control Plan
CDR	Critical Design Review
CFRP	Carbon Fibre Reinforced Polymer
CI	Conformance Inspection
CIDL	Configuration Item Data List
CIL	Critical Items List
CN	Change Notice
CoC	Certificate of Conformance
CPPA	Centralized Parts Procurement Agent
CR	Change Request
CRS	Cleanliness Requirement Specification
CSI	Customer Source Inspection
DCL	Declared Components List
DML	Declared Material List
DMPL	Declared Mechanical Part List
DPA	Destructive Physical Analysis
DPL	Declared Process List
DRB	Delivery Review Board
DRD	Document Requirements Definition, as per ESA document **MOS-LI-ESA-SYS-0499**
ECSS	European Cooperation for Space Standardization
EEE	Electrical, Electronic and Electromechanical
EGSE	Electrical Ground Support Equipment
EIDP	End Item Data Package
EPPL	European Preferred Parts List
EQM	Engineering Qualification Model
ESA	European Space Agency
ESCC	European space components coordination
FDIR	Failure Detection Isolation and Recovery
FM	Flight Model
FMEA	Failure Modes and Effects Analysis
FPGA	Field Programmable Gate Arrays
FTA	Fault Tree Analysis
GOX	Gaseous Oxygen

Abbreviation	Meaning
GSE	Ground Support Equipment
HSIA	Hardware-Software Interaction Analysis
JD	Justification Document
KIP	Key Inspection Point
LAT	Lot Acceptance Test
LED	Light Emitting Diode
LEO	Low Earth Orbit
LOX	Liquid Oxygen
LVT	Lot Validation Testing
MIP	Mandatory Inspection Point
MMIC	Microwave Monolithic Integrated Circuit
MMPP	Materials, Mechanical Parts and Processes
MPCB	Materials, Mechanical Parts and Processes Control Board
MRAD	Material Radiation Approval Document
NASA	National Aeronautics and Space Administration
NCR	Non-conformance Report
NCTS	Non-Conformance Tracking System
NPSL	NASA Parts Selection List
NRB	Non-conformance Review Board
PA	Product Assurance
PAD	Part Approval Document
PCB	Parts Control Board
PCN	Process Change Notice
PDR	Preliminary Design Review
PIND	Particle Impact Noise Detection
PVC	Polyvinyl Chloride
QA	Quality Assurance
QCI	Quality Conformance Inspection
QML	Qualified Manufacturers List
QPL	Qualified Parts List
QR	Qualification Review
REACH	Regulation of Registration, Evaluation, Authorisation and Restriction of Chemicals
RFA	Request For Approval
RFD	Request For Deviation
RFW	Request For Waiver
RVT	Radiation Verification Testing
SDP	Safety Data Package
SEE	Single Event Effect
SOW	Statement Of Work
SPF	Single Point Failure
SVTL	Safety Verification Tracking Log
TCI	Technology Conformance Inspection

Abbreviation	Meaning
TRB	Test Review Board
TRR	Test Readiness Review
UV	Ultra Violet
WCA	Worst Case Analysis

3 PRODUCT ASSURANCE MANAGEMENT REQUIREMENTS (Q-ST-10)

3.1 PRINCIPLES

3.1.1 GENERAL PRINCIPLES

The prime objective of Product Assurance is to ensure that space products accomplish their defined mission objectives in a safe, available and reliable way.

Commitment to quality of the entire organization is key to the Quality of the product and success of the space mission. The management of Product Assurance is fully embedded in the management of the project and receives the highest priority from the organization management.

The early identification of aspects potentially detrimental for safety and mission success, and the cost-effective prevention of any adverse consequence of such aspects are the basic principles for the ECSS Product Assurance requirements.

Product Assurance Management ensures the integration of activities from the Product Assurance disciplines defined in the other ECSS standards of the Q branch, namely:

- *Q-ST-20 Quality assurance*
- *Q-ST-30 Dependability*
- *Q-ST-40 Safety*
- *Q-ST-60 Electrical, electronic, electromechanical (EEE) components*
- *Q-ST-70 Materials, mechanical parts and processes*
- *Q-ST-80 Software product assurance*

3.1.2 PA PROGRAMME PLANNING

The requirements for Product Assurance planning address the following aspects:

- *Definition of a Product Assurance organization with the allocation of adequate resources, personnel and facilities,*
- *Definition of Product Assurance requirements for lower tier Suppliers,*
- *Definition of a Product Assurance Plan describing the Product Assurance programme and how it fulfils project objectives and requirements.*

3.1.3 PA PROGRAMME IMPLEMENTATION

The requirements for Product Assurance programme implementation address the following aspects:

- *Management and control of the PA tasks performed by the PA disciplines*
- *Progress reporting of all Product Assurance matters,*
- *Management of audits, critical items, non-conformances and alerts,*
- *Support to the risk management, in coordination with the Project Management functions,*
- *Support to the documentation and data control, quality records and to configuration management,*
- *Lower-tier Supplier control for ensuring implementation of PA requirements by the Suppliers,*

3.2 REQUIREMENTS

3.2.1 PA PROGRAMME PLANNING

3.2.1.1 Product Assurance organization and responsibilities

ECSS-Q-ST-10_MOS-001	5.1.1a	N - esa
a. The Supplier PA Manager shall provide the information requested in chapters 5.1.1 and 5.1.2 within the PA plan as per Annex A of ECSS-Q-ST-10C.		

ECSS-Q-ST-10_MOS-002	5.1.1b	N - esa
b. The Supplier PA Manager shall ensure the coverage of PA aspects within Product Assurance Requirements for their suppliers. The Suppliers Product Assurance Requirements for their suppliers shall be provided as part of the document data pack for project reviews (SRR, PDR etc.).		

ECSS-Q-ST-10_MOS-003	5.1.1c	N - esa
c. The Supplier PA Manager shall ensure the coverage of PA within the technical specifications.		

ECSS-Q-ST-10_MOS-004	5.1.1f	N - esa
e. The Supplier PA Manager shall decide on the usage of standards, handbooks, procedures and tools.		

ECSS-Q-ST-10_MOS-005	5.1.1i	N - esa
f. The Supplier PA Manager shall audit referenced in-house standards for their adequacy for the Project.		

ECSS-Q-ST-10_MOS-006	5.1.1j	N - esa
g. The Supplier shall ensure PA representation in progress meetings and CCBs.		

3.2.1.1.1 Organization

ECSS-Q-ST-10_036001	5.1.1.1a	A
a. The Supplier shall identify the personnel responsible for implementing and performing PA management and other PA disciplines.		

ECSS-Q-ST-10_036002	5.1.1.1b	A
b. The Supplier shall assign a project PA manager reporting to the project manager and having unimpeded access to higher management.		

ECSS-Q-ST-10_036003	5.1.1.1c	M - esa
c. The appointed Supplier PA Manager, irrespective of other responsibilities, shall have organizational authority to: • Establish and implement a Product Assurance Programme in accordance with the project product assurance requirements, • Prevent implementation of lower tier suppliers' project decisions, which can adversely affect the quality of products.		

ECSS-Q-ST-10_036004	5.1.1.1d	A
d. The project PA Manager shall act as the focal point of contact within the project concerning Product Assurance matters.		

NOTE The project PA manager is referred to as "PA manager" in the rest of this document.

ECSS-Q-ST-10_MOS-007	5.1.1.1e	N - esa
e. The Supplier PA programme shall cover customer furnished items.		

3.2.1.1.2 Responsibility and authority

ECSS-Q-ST-10_036005	5.1.1.2a	A
a. The Supplier shall define and document the responsibility, the authority and the interrelation of personnel who manage, perform and verify work affecting product assurance.		

ECSS-Q-ST-10_036006	5.1.1.2b	A
b. The Supplier shall define and document the responsibilities and the interfaces of the PA functions, either external or internal, involved in a project.		

ECSS-Q-ST-10_036007	5.1.1.2c	A
c. When the supplier PA organization delegates their product assurance tasks to another organization it shall be done in a documented and controlled way monitored by the supplier PA organization.		

NOTE The Supplier PA organization retains the responsibility towards the end customer.

3.2.1.1.3 Resources

ECSS-Q-ST-10_036008	5.1.1.3a	M - esa
a. The Supplier PA manager shall identify, allocate and monitor the PA resources needed to implement the PA programme.		

NOTE Identification consists in establishing the list of nominated people, their experience, and percentage of their time allocated to the programme.

ECSS-Q-ST-10_036009	5.1.1.3b	A
b. The Supplier shall provide resources capable to perform the PA tasks identified in the PA programme.		

ECSS-Q-ST-10_036010	5.1.1.3c	A
c. Reviews and audits of the product assurance programme, of processes or of product shall be carried out by personnel not directly involved in the work being performed.		

3.2.1.2 PA management interfaces

ECSS-Q-ST-10_036011	5.1.2a	A
a. The PA manager shall interface with project management, ensuring that the contractual provision and schedule planning for the definition and phasing of PA activities are met.		

ECSS-Q-ST-10_036012	5.1.2b	A
b. The PA manager shall interface with risk management, configuration management, engineering, procurement and AIV for the definition and execution of tasks in which PA activities are involved.		

ECSS-Q-ST-10_036013	5.1.2c	A
c. The PA manager shall interface with end customer regarding all Product Assurance matters.		

ECSS-Q-ST-10_036014	5.1.2d	A
d. The PA manager shall interface with lower-tier Suppliers regarding all Product Assurance matters.		

ECSS-Q-ST-10_REQ-001	-	N – End customer
e. Suppliers shall impose these requirements upon their lower tier Suppliers as appropriate to the procured item.		

3.2.1.3 PA plan

ECSS-Q-ST-10_036015	5.1.3a	A
a. The Supplier shall prepare, maintain and implement a plan of the PA activities in accordance with Airbus DS PA requirements.		

ECSS-Q-ST-10_036016	5.1.3b	A
b. The Product Assurance plan shall be prepared in conformance with DRD in ECSS-Q-ST-10 / Annex A.		

ECSS-Q-ST-10_036017	5.1.3c	M – End customer
c. The Product Assurance plan shall be submitted to Airbus DS for approval		

NOTE 1 Ref Requirements 036015 and 036016, subject to Airbus DS approval, the supplier may propose to use its own Company Quality manual and procedures subject to completion of an acceptable fully traceable Statement of Compliance to this PARD.

NOTE 2 Information on the schedule for delivery of PA management documents is given in ECSS-Q-ST-10 / Annex C.

ECSS-Q-ST-10_REQ-002	-	N – End customer
d. The supplier shall also provide a conformity matrix to the current PA requirements.		

ECSS-Q-ST-10_REQ-003	-	N – End customer
e. The conformity matrix shall be submitted to the end customer for approval.		

3.2.2 PA PROGRAMME IMPLEMENTATION

3.2.2.1 Product assurance management

ECSS-Q-ST-10_036018	5.2.1a	A
a. The PA manager shall ensure that PA disciplines are organized at the beginning of the project according to the end customers contractual requirements.		

ECSS-Q-ST-10_036019	5.2.1b	A
b. The PA manager shall ensure that the inputs used by the PA disciplines are consistent and complete, and available in line with the project schedule.		

ECSS-Q-ST-10_036020	5.2.1c	A
c. The PA manager shall ensure that the PA disciplines perform the tasks described in the PA Plan in line with the project schedule.		

ECSS-Q-ST-10_036021	5.2.1d	A
d. The PA manager shall ensure that the outputs produced by the PA disciplines are consistent and complete, and delivered in line with the project schedule.		

ECSS-Q-ST-10_036022	5.2.1e	A
e. The PA manager shall ensure the application of processes defined in applicable project plans and documents.		

ECSS-Q-ST-10_036023	5.2.1f	A
f. The PA manager shall control the quality of his Supplier's products by: 1. issuing product assurance requirements applicable to the Supplier, 2. ensuring the implementation of the PA requirements by the Supplier.		

ECSS-Q-ST-10_036024	5.2.1g	A
g. The PA manager shall ensure that PA contributions to verification are defined and provided.		

ECSS-Q-ST-10_036025	5.2.1h	A
h. The PA manager shall ensure that a qualification programme is defined, approved and maintained by the relevant organization.		

NOTE *Requirements for the qualification programme are addressed in ECSS-Q-ST-20, ECSS-Q-ST-60, ECSS-Q-ST-70, ECSS-E-ST-10-02 and ECSS-E-10-03.*

ECSS-Q-ST-10_036026	5.2.1i	A
i. The PA manager shall ensure that the qualification programme is implemented and the qualification results are recorded, evaluated and documented.		

ECSS-Q-ST-10_036027	5.2.1j	A
j. The PA manager shall ensure that a Qualification Status List of the programme items is maintained in conformance with ECSS-Q-ST-10 / Annex B.		

ECSS-Q-ST-10_036028	5.2.1k	A
k. The PA manager shall review and approve the achieved qualification status.		

ECSS-Q-ST-10_036029	5.2.1l	M - esa
l. The Supplier PA manager shall accept all products as per DIL during Acceptance or Delivery Reviews with lower tier suppliers.		

3.2.2.2 PA reporting

ECSS-Q-ST-10_036030	5.2.2a	A
a. The Supplier shall report on the status and progress of the product assurance program implementation.		

ECSS-Q-ST-10_036031	5.2.2b	M - esa
b. The PA progress report shall include: • Progress and accomplishment of each major product assurance task including resolved and new problems, future planning of major activities and events; • Status of PA reviews: audits and inspections (MIPs etc), Critical items Control (including mitigation action plan status); • Status of Documentation: Deviations, Waivers, Non-Conformances (Majors), Documentation Configuration Status (Received, Approval in Progress, Approved, Issued etc); • Accomplishments during the Reporting Period; • Planned PA Activities in the next Reporting Period; • Activities planned to control identified problems & risks.		

ECSS-Q-ST-10_036032	5.2.2c	A
c. The PA progress report may be part of the project progress report.		

NOTE The general contents of the project progress report are detailed in ECSS-M-ST-10 / AnnexE.

3.2.2.3 Project PA audits

ECSS-Q-ST-10_036033	5.2.3a	A
a. The Supplier shall perform audits on his own performance to verify the implementation and effectiveness of the provisions defined in the PA plan.		

NOTE 1 Audits can be performed by sampling on various projects or by periodic audits of the Supplier quality system.

NOTE 2 The general contents of project audits are detailed in ECSS-M-ST-10 clause 5.2.3.

ECSS-Q-ST-10_036034	5.2.3b	M - esa
b. The Supplier shall establish and maintain an audit plan as per DRD {sat-PA-03} for procurement activities on the Project, designating the lower tier suppliers to be audited, including the current status and the schedule for auditing. •		

ECSS-Q-ST-10_036035	5.2.3c	M - esa
c. In addition to the planned audits, extra audits shall be performed when necessary to overcome failure, consistent poor quality, or other problems.		

NOTE : The Supplier may tailor their audit plans of suppliers & sub-contractors based on heritage performance of their supplier & sub-contractor and current performance on the MetOp-SG programme.

ECSS-Q-ST-10_036036	5.2.3d	A
d. The Supplier shall plan and perform audits using established and maintained procedures.		

ECSS-Q-ST-10_MOS-008	5.2.3e	N - esa
e. The Supplier shall perform and document audits in accordance with ECSS-M-ST-10C Rev 1, chapter 5.2.3, based on the guidelines of ISO 19011:2002.		

ECSS-Q-ST-10_MOS-009	5.2.3f	N - esa
f. The Supplier shall prepare an audit checklist for each intended audit as per DRD {sat-PA-04}.		

ECSS-Q-ST-10_MOS-010	**5.2.3g**	**N - esa**
g. The Supplier shall notify the end customer and ESA of their intention to conduct an audit (external or internal), and shall provide the audit checklist to Airbus DS and ESA for approval, ten (10) days before the audit is due.		

ECSS-Q-ST-10_MOS-011	**5.2.3h**	**N - esa**
h. A copy of the audit report (as per DRD {sat-PA-04}) shall be sent to Airbus DS and ESA within two (2) weeks after the audit has taken place.		

ECSS-Q-ST-10_MOS-012	**5.2.3i**	**N - esa**
i. The audit report shall comply with DRD {sat-PA-04}.		

ECSS-Q-ST-10_MOS-013	**5.2.3j**	**N - esa**
j. The Supplier shall accept audits by the end customer and ESA initiated in accordance to above		

ECSS-Q-ST-10_REQ-006	**-**	**N – End customer**
k. The Supplier shall include in its audits the facilities, equipment, personnel, procedures, services and operations employed in the programme.		

3.2.2.4 Critical items control and PA interfaces to project risk management

ECSS-Q-ST-10_036037	**5.2.4a**	**A**
a. The Supplier shall establish a critical items control programme in conformance with ECSS-Q-ST-10-04.		

ECSS-Q-ST-10_036038	**5.2.4b**	**A**
b. The PA manager shall identify and evaluate critical items in support of the overall project risk management activities.		

ECSS-Q-ST-10_036039	**5.2.4c**	**A**
c. The PA manager shall ensure that a critical item control programme is implemented to eliminate or mitigate associated risks.		

ECSS-Q-ST-10_REQ-012	**-**	**N – End customer**
d. Specific to Metop SG constraints, all items identified as critical vs long term storage shall be reported in a dedicated section of the critical items list, together with life limited items, and mitigation actions reported		

3.2.2.5 Documentation and data control

ECSS-Q-ST-10_036040	**5.2.5a**	**A**
a. The PA manager shall ensure that the applicable issues of all documents and data are available at all locations where activities required for the implementation of the PA programme are performed.		

ECSS-Q-ST-10_036041	**5.2.5b**	**A**
b. The PA manager shall ensure that invalid or obsolete documents and data are removed from all points of issue or use, or assured against unintended use.		

ECSS-Q-ST-10_036042	**5.2.5c**	**A**
c. The PA manager shall ensure that obsolete documents and data retained for legal or knowledge preservation purposes are identified as such.		

ECSS-Q-ST-10_036043	5.2.5d	M – End customer
d. The PA manager shall ensure that project documents approvals are defined by the project including those requiring approval by PA.		

3.2.2.6 Quality records

ECSS-Q-ST-10_036044	5.2.6a	M - esa
a. The Supplier shall establish and maintain quality records, based for example on the Product Assurance File definition of ECSS-E-ST-40C, Annex A, to provide objective evidence of complete and successful performance of all PA discipline tasks and to demonstrate compliance with requirements.		

3.2.2.7 PA contribution to configuration management

ECSS-Q-ST-10_036045	5.2.7a	A
a. The PA manager shall verify during Configuration Control Boards the suitability for release of drawings, plans, specifications, procedures and changes thereto.		

NOTE The operation of Configuration Control Boards is detailed in ECSS-M-ST-40.

ECSS-Q-ST-10_036046	5.2.7b	A
b. The PA manager shall ensure that: 1. the as-designed status is defined and released prior to manufacturing; 2. the as-built documentation is properly defined, identified and maintained in order to reflect approved modifications; and 3. items delivered comply with the as-built documentation.		

ECSS-Q-ST-10_MOS-014	5.2.7c	N - esa
c. The Supplier Product Assurance Manager shall ensure a consistent approach to the management of deviations and waivers throughout the contractual chain in accordance with ECSS-M-ST-40C Rev.1 e.g. by the use of standard document templates etc.		

ECSS-Q-ST-10_MOS-015	5.2.7d	N - esa
d. The Supplier PA Manager shall ensure that a 'Justification for Acceptance/Rejection' is included within RFDs/RFWs, which shall be completed before submitting the RFD/RFW for approval by the end customer (in the case of Acceptance by the Supplier).		

3.2.2.8 Non-conformance control

ECSS-Q-ST-10_036047	5.2.8a	A
a. The Supplier shall establish and maintain a non-conformance control system in conformance with ECSS-Q-ST-10-09.		

ECSS-Q-ST-10_MOS-016	5.2.8b	N - esa
b. The Supplier shall provide visibility of all Project NCRs (Major and Minor) to the end customer and ESA using the web based NCTS database throughout the industrial organisation.		

NOTE 1 Due to the long storage requirements and mission duration for the MetOp-SG system, it is necessary to retain full visibility of ALL historical NCR's in case of future anomalies and for future reference.

NOTE 2 More detailed requirements can be found in ECSS-Q-ST-10-09C.

ECSS-Q-ST-10_REQ-010	-	N – End customer
c. A summary list of all NCR's (Major and minor) shall be provided to the end customer monthly (e.g. together with the progress report).		

ECSS-Q-ST-10_REQ-011	-	N – End customer
d. The Supplier shall notify the end customer of all major non-conformances within two working days of their detection.		

3.2.2.9 Management of alerts

ECSS-Q-ST-10_036048	5.2.9a	A
a. The Supplier shall notify the end customer of preliminary information on failures or problems that can result in an alert.		

NOTE 1 The above is applicable to failure or problems detected by the Supplier or by one of his lower tier Suppliers.

NOTE 2 The above is only applicable to failures or problems meeting all of the following criteria:

- *The item with the observed failure or problem has multiple applications, which can have implications for more than one project, thus requiring prompt action.*
- *The failure or problem has occurred in the application of an item within the specified design and usage limitations.*
- *Failures or problems due to usage within reasonably expected limits of performance, but where these limits were not specified precisely.*
- *A preliminary investigation has provided evidence of the root cause of the failure or problem.*
- *Failure or problems are confirmed not to be of a random nature.*

ECSS-Q-ST-10_036049	5.2.9b	M - esa
b. The Supplier PA manager shall investigate in cooperation with the originator of the failure or problem to define the immediate measures to be taken, to identify the causes, and to recommend corrective actions for similar items.		

ECSS-Q-ST-10_MOS-017	5.2.9c1	N - esa
c1. The supplier PA manager shall ensure the assessment of any failure having the potential to lead to an alert by the end customer.		

ECSS-Q-ST-10_MOS-018	5.2.9c2	N - esa
c2. The supplier PA manager shall ensure the investigation, until disposition of the items subject of the potential alert.		

ECSS-Q-ST-10_MOS-019	5.2.9c3	N - esa
c3. The supplier PA manager shall ensure the assessment of incoming alerts for the definition, implementation and follow-up of necessary actions.		

ECSS-Q-ST-10_MOS-020	5.2.9d1	N - esa
d1. The Supplier shall participate in the ESA and the end customer alert systems, by assessing the impact of incoming alerts to Project work, and definition, implementation and follow-up of necessary corrective actions at any contractual level.		

ECSS-Q-ST-10_MOS-021	5.2.9d2	N - esa
f. The Supplier shall distribute all ESA and the end customer alerts to the lower tier suppliers and shall establish a process to collect and assess inputs from lower tier suppliers to provide inputs to the ESA and the end customer Alert Systems.		

ECSS-Q-ST-10_MOS-022	5.2.9e	N - esa
g. The Supplier shall maintain an Alert status list as per DRD {sat-PA-10} and deliver as defined in the DRL.		

NOTE The alert system is set up for the prompt interchange of information on failures or problems which can affect more than one user, or can recur in other projects or circumstances, if no preventive actions are taken.

3.2.2.10 PA Database

ECSS-Q-ST-10_MOS-023	5.2.10a	N - esa
a. All PA-related data and PA documents required by the PA Programme (such as RFW/RFD, DCLs, PADs, Declared Materials, Mechanical Parts and Processes lists, reliability/safety analysis, photographs etc.) shall be stored in an electronic database by the Supplier.		

ECSS-Q-ST-10_MOS-024	5.2.10b	N - esa
b. The import and export data from and to Suppliers/sub-contractors and the Customer shall be in Microsoft excel format or, as a minimum, in CSV (‘Character/Comma Separated Values’). The CSV format option must be agreed with the Customer.		

ECSS-Q-ST-10_MOS-025	5.2.10c	N - esa
c. In addition to submitting documents as required by the project reviews etc. all tabular listings (Qualification Status List, Long Lead Items List etc.) shall be provided at the request of the end customer or ESA in excel format.		

ECSS-Q-ST-10_MOS-026	5.2.10d	N - esa
d. The database format and content shall be agreed with the end customer and ESA.		

ECSS-Q-ST-10_MOS-027	5.2.10e	N - esa
e. With the exception of scanned pages containing signatures, all documentation shall be electronically searchable.		

3.2.2.11 Right of Access

ECSS-Q-ST-10_MOS-028	5.2.11a	N - esa
a. AThe end customer and ESA reserve the right of access to: 1: all data and documentation relevant to the Project and any contractual level; 2: all areas and operations within the Suppliers facilities (at any contractual levels) in which work is performed or items are stored relevant to the MetOp-SG programme, even if the information is considered proprietary.		

ECSS-Q-ST-10_MOS-029	5.2.11b	N - esa
b. The end customer and ESA reserve the right to perform or participate in any or all audits, surveys, inspections, reviews, etc. relevant to the MetOp-SG programme.		

ECSS-Q-ST-10_MOS-030	5.2.11c	N - esa
c. AThe end customer or ESA’s participation shall not in any way replace or relieve the Supplier of their responsibilities, or that of their sub-contractors and/or suppliers.		

3.2.3 DELIVERABLE PA DOCUMENTS

ECSS-Q-ST-10_REQ-012	**-**	**N – End**
a. All documents relative to evaluation, validation, qualification and LAT (for EEE Components and for Materials and Processes) in the frame of METOP-SG project shall be delivered to Airbus DS.		

ECSS-Q-ST_REQ-013	**-**	**N – End**
b. All deliverable Product assurance documents shall be as defined per Statement of Work.		

Note: The following table provides the list of deliverable PA documents, based on ESA MetOp SG DRL and DRD. When no deliverable PA documentation is specified by the Statement of Work, this list applies.

Doc No.	ESA DRL	CAT	PRODUCT ASSURANCE	MILESTONES					COMMENTS
				Proposal/SRR	PDR	CDR	QR	DRB	
	PA / QA Documentation								
1	Sat-PA-01	A	Product Assurance & Safety Plan	X	X	X			
2	Sat-PA-02	A	PA Requirements for Subcontractors	X	X	X			
3	Sat-PM-02	R	PA Progress Report	X					As part of periodic project progress report
4	Sat-PA-03	R	Audit Plan		X	X			Including Safety audits.
5	Sat-PA-04	R	Audit Checklists and reports	X					
6	Sat-PA-05	R	Critical Items List	X	X	X	X	X	As per ECSS-Q-ST-10-04C, Annex A.
7	Sat-PA-06	A/R	Non Conformance Reports (NCR)			X	X	X	To be available on-line on the NCTS database.
8	Sat-PA-07	R	NCR Status List			X	X	X	As per ECSS-Q-ST-10-09C, Annex B.
9	Sat-PA-08	R	Qualification Status List		X	X	X	X	As per ECSS-Q-ST-10C, Annex B.
10	Sat-PA-09	R	MIP/KIP List		X	X			
11	Sat-PA-10	R	Alert Status List		X	X	X	X	
12	Sat-PA-11	R	End Item Data Packages (EIDP)				X	X	To be provided together with each physical item delivered (i.e. STM, EM, PFM, FMs, GSE, etc.); As per ECSS-Q-ST-20C, Annex B and section 4.2.7.2 of this PA reqts specification
13	Sat-PA-12	R	Long Lead Items list	X	X	X			
14	n/a	A/R	RFD Status list		X	X	X	X	
15	Sat-PM-23A	A	Request For Deviation (RFD)				X	X	
16	n/a	A/R	RFW Status list		X	X	X	X	
17	Sat-PM-23B	A	Request For Waiver (RFW)				X	X	
18	Sat-PA-32	A/R	MIP Reports	X					.
19	Sat-PA-33	A	Certificate of Conformity					X	*Shall be part of EIDP*; As per ECSS-Q-ST-20C, Annex D.
20	Sat-PA-35	R	Logbook					X	As per ECSS-Q-ST-20C, Annex C.
21	Sat-PA-36	A	OTS Plan	X	X				As per ECSS-Q-ST-20-10C Annex A.

Doc No.	ESA DRL	CAT	PRODUCT ASSURANCE	MILESTONES					COMMENTS
				Proposal/SRR	PDR	CDR	QR	DRB	
22	Sat-PA-37	R	OTS Item Evaluation Dossier		X	X	X		As per ECSS-Q-ST-20-10C Annex B.
	Dependability Documentation								
23	n/a	A	Dependability Plan	X	X	X			Part of PA Plan
24	Sat-PA-15	R	Reliability & Availability Prediction Report	X	X	X	X	X	As per ECSS-Q-ST-30C, Annex E.
25	Sat-PA-16	R	FMEA report		X	X	X		As per ECSS-Q-ST-30-02C, Annex A (including Annexes B, C and D).
26	Sat-PA-18	R	FDIR Implementation Report		X	X	X		As per ECSS-Q-ST-30C, Annex F.
27	Sat-PA-19	R	Worst Case Analysis report		X	X	X		As per ECSS-Q-ST-30C, Annex J.
28	n/a	R	HSIA Report		X	X	X		May be part of FMEA
29	n/a	R	Contingency Report		X	X	X		
30	n/a	R	Fault Tree Analysis (FTA) Report		X	X	X		
31	Sat-PA-23	R	Part Stress/Derating Analysis Report		X	X	X		
32	n/a	R	Maintainability Report		X	X	X		
	Safety Documentation								
33	PA - 28	A	Safety Plan	X	X	X			*May be part of PA Plan*
34	Sat-PA-17	R	Safety Data Package : *1. Safety analysis report,* *2. Supporting analysis (if applicable),* *3. Safety risk assessment (if applicable),* *4. Hazardous ground operations list and procedures,* *5. Safety verification tracking log (SVTL).*		X	X	X	X	As per launch authority requirements; Including ECSS-Q-ST-40C Annex C+D.
35	n/a	R	Safety Assessment Report		X	X	X	X	
36	n/a	R	Hazard Identification Document		X	X	X	X	
37	n/a	R	Safety Verification Tracking Log		X	X	X	X	
	EEE Components Documentation								

Doc No.	ESA DRL	CAT	PRODUCT ASSURANCE	MILESTONES					COMMENTS
				Proposal/SRR	PDR	CDR	QR	DRB	
-	***For EEE deliverable documentation: see details in Table 7-7***								
38	Sat-PA-34	A	Component Control Plan (CCP)	X	X				*May be part of PA Plan;* As per ECSS-Q-ST-60C, Rev1, Annex A.
39	Sat-PA-20	A	Parts Approval Document (PAD)			X			As per ECSS-Q-ST-60C, Rev.1, Annex D; As required.
40	Sat-PA-21	A	Declared Component List (DCL)		X	X	X	X	As per ECSS-Q-ST-60C, Rev.1, Annex B.
41	Sat-PA-22	R	Radiation Analysis and Test Report		X	X	X	X	As per ECSS-Q-ST-70-06C, Rev.1, Annex C.
42			Deleted						
	Materials, Mechanical Parts and Processes Documentation								
43	n/a	A	Materials, Mechanical Parts and Processes (MMPP) Plan	X	X	X			May be part of PA Plan
44	Sat-PA-13	A	Cleanliness and Contamination Control Plan (CCCP)	X	X	X			As per ECSS-Q-ST-70-01C, Annex B.
45	Sat-PA-14	R	Cleanliness Requirement Specificaton (CRS)		X	X			As per ECSS-Q-ST-70-01C, Annex A.
46	Sat-PA-24	A	Request For Approval (RFA)			X			As per ECSS-Q-ST-70C, Annex D; As required.
47	Sat-PA-25	R	Declared Mechanical Parts List (DMPL)		X	X	X	X	As per ECSS-Q-ST-70C, Annex B.
48	Sat-PA-26	R	Declared Material List (DML)		X	X	X	X	As per ECSS-Q-ST-70C, Annex A.
49	Sat-PA-27	R	Declared Process List (DPL)		X	X	X	X	As per ECSS-Q-ST-70C, Annex C.
	PA/QA Software Documentation								
-	***See also Software Product Assurance Requirements document ref. MOS.SP.ASF.SYS.00402***								
50	sat-PA-28	R	Software Maintenance File			X	X	X	
51	sat-PA-29	R	Software Criticality Analysis Report		X	X	X		

Doc No.	ESA DRL	CAT	PRODUCT ASSURANCE	MILESTONES					COMMENTS
				Proposal/SRR	PDR	CDR	QR	DRB	
52	sat-PA-30	R	Software Product Assurance Milestone Report (SPAMR)		X	X	X	X	As per ECSS-Q-ST-80C, Annex C.
53	sat-PA-31	A	Software Product Assurance Plan	X	X	X			As per ECSS-Q-ST-80C, Annex B.
54	sat-PA-38	R	Declared Software Tool List		X	X	X	X	
55	sat-PA-40	R	ASIC and FPGA Control Plan		X ++	##	§§		According to ECSS-Q-ST-60-02C Annex A.
56	sat-PA-41	I	ASIC and FPGA Development Plan		X ++	##			According to ECSS-Q-ST-60-02C Annex B.
57	sat-PA-42	R	ASIC and FPGA Requirements Specification		X ++	##	§§		According to ECSS-Q-ST-60-02C Annex C.
58	sat-PA-43	I	ASIC and FPGA Verification Plan		++ RTLlevel	## Gate level			According to ECSS-Q-ST-60-02C Annex E.
59	sat-PA-44	R	ASIC and FPGA Verification Report		++ RTLlevel	## Gate level			According to ECSS-Q-ST-60-02C.
60	sat-PA-45	I	ASIC and FPGA Validation Plan			##			According to ECSS-Q-ST-60-02C Annex F.
61	sat-PA-46	R	ASIC and FPGA Validation Report				X §§		According to ECSS-Q-ST-60-02C.
62	sat-PA-47	R	ASIC and FPGA Risk Assessment and Feasibility Plan		X ++				According to ECSS-Q-ST-60-02C Annex D.
63	sat-PA-48	R	Traceability Matrix of ASIC and FPGA Requirements		++	##	§§		
64	sat-PA-49	R	ASIC and FPGA Burn-in Procedure			X			Also to be delivered with PAD sheet release.
65	sat-PA-50	R	ASIC and FPGA Post Burn-in Report				X		

Table 3.2.3-1: PA Deliverable Documentation for METOP-SG Programme

Category

- *A: for Approval*
- *R: for Review*
- *I: for Information only*

Notes:

Where "++", "##","§§" marks are used with respect to ASIC/FPGA documents, it means that documents shall be delivered during the ASIC/FPGA development reviews; in some cases, these documents shall be delivered in addition to the delivery required for the instrument level review ("X" mark):

4 QUALITY ASSURANCE REQUIREMENTS (Q-ST-20)

4.1 QUALITY ASSURANCE PRINCIPLES

4.1.1 QA MANAGEMENT PRINCIPLES

The prime objective of Quality Assurance (QA) management is to ensure that a QA programme for projects covering mission definition, design, development and production of space systems is established, maintained and implemented.

All QA requirements are specified through definition and implementation of adequate methods and procedures.

Personnel whose performance determines or affects product quality are trained and certified in accordance with project needs.

4.1.2 GENERAL PRINCIPLES

The implementation of the following phase-independent activities is ensured by the QA function throughout the lead-time of projects:

- *critical-items control*
- *non-conformance control*
- *alert management*
- *stamp control*
- *traceability*
- *metrology and calibration*
- *handling, storage and preservation*
- *statistical quality control (if required by the business agreement).*

4.1.3 DESIGN AND VERIFICATION PRINCIPLES

The objective of the QA function is to ensure that:

a. a set of design rules and methods has been set up and is consistent with the project techniques and technologies;

b. methods, procedures and tools have been defined and are implemented in order to prove that each applicable requirement is verified through one or more of the following methods: analysis, inspection, test, review of design, audits;

c. the design is producible and repeatable and that the resulting product can be verified and operated within the required operating limits;

d. design and verification activities are planned in a consistent and logical way;

e. the verification process is complete and includes clear test, test model and verification logic;

f. a defined qualification approach is implemented to demonstrate that the item performs satisfactorily in the intended environment.

4.1.4 PROCUREMENT PRINCIPLES

All procurement activities including selection of procurement sources, procurement documents, procurement source surveillance and receiving inspection are controlled to ensure that all procured items and services conform to requirements.

4.1.5 MANUFACTURING, ASSEMBLY AND INTEGRATION PRINCIPLES

All manufacturing, assembly and integration operations are planned and performed in coordination with inspections and tests to ensure that the deliverables are built, assembled and integrated to the approved configuration baseline.

Special processes and new technologies are identified in a timely manner and adequate evaluation or qualification activities should be implemented in line with the overall schedule.

4.1.6 TESTING PRINCIPLES

Test facilities and test equipment are validated prior to their use to ensure conformance to project requirements.

All tests are performed in accordance with documented and released procedures and results are comprehensively recorded.

4.1.7 ACCEPTANCE AND DELIVERY PRINCIPLES

The objective is to ensure that an acceptance and delivery process is implemented which allows demonstrating and documenting the conformance of the delivered item.

4.1.8 GSE PRINCIPLES

Design, production, delivery and maintenance requirements for GSE are defined and implemented allowing for testability, availability, safety, life duration, operability and ability to interface as necessary with space segment in a safe way

4.2 QUALITY ASSURANCE REQUIREMENTS

4.2.1 QA MANAGEMENT REQUIREMENTS

4.2.1.1 Quality assurance plan

ECSS-Q-ST-20_038001	5.1.1a	A
a. The Supplier shall prepare, maintain and implement a QA plan in conformance with the DRD in ECSS-Q-ST-20 / Annex A.		

ECSS-Q-ST-20_038002	5.1.1b	M – End customer
b. The QA plan shall be submitted to the end customer for approval.		

NOTE 1 Information on the schedule for delivery of the QA plan is given in ECSS-Q-ST-20 / Annex I.

NOTE 2 The QA Plan may be implemented as part of the Product Assurance Plan.

4.2.1.2 Personnel training and certification

ECSS-Q-ST-20_038003	5.1.2a	A
a. The Supplier shall establish a documented training programme for the personnel whose performance determines or affects product quality.		

ECSS-Q-ST-20_038004	5.1.2b	M – End customer
b. Personnel performing or evaluating special processes shall be trained and certified according to standards defined by the supplier and accepted by the end customer		

NOTE The term “special process” is defined in ECSS-S-ST-00-01, NOTE 3 of the definition of “process”.

ECSS-Q-ST-20_038005	5.1.2c	M – End customer
c. Personnel performing non-destructive testing and evaluation shall be trained and certified according to standards defined by the supplier and accepted by the end customer		

ECSS-Q-ST-20_038006	5.1.2d	A
d. The Supplier shall maintain records of the training.		

4.2.2 QA GENERAL REQUIREMENTS

4.2.2.1 Critical-items control

ECSS-Q-ST-20_038007	5.2.1a	A
a. The Supplier shall implement Critical-items control in conformance with ECSS-Q-ST-10-04.		

4.2.2.2 Non-conformance control system

ECSS-Q-ST-20_038008	5.2.2a	A
a. The Supplier shall implement a non-conformance control system in conformance with ECSS-Q-ST-10-09.		

4.2.2.3 Management of alerts

ECSS-Q-ST-20_038009	5.2.3a	A
a. The Supplier shall manage alerts in conformance with ECSS-Q-ST-10, clause 5.2.9.		

4.2.2.4 Acceptance authority media

ECSS-Q-ST-20_038010	5.2.4a	A
a. The Supplier shall establish and maintain a documented acceptance authority media control system to ensure the correct and legitimate use of all fabrication and inspection authority media.		

ECSS-Q-ST-20_038011	5.2.4b	A
b. acceptance authority media shall be used to: 1. signify the completion of operations and processes, and 2. indicate inspection performance at source and incoming inspection, in process inspection and tests, final inspection, end point testing, storage and shipment.		

ECSS-Q-ST-20_038012	5.2.4c	A
c. The use of acceptance authority media shall be restricted to authorized personnel as identified in the acceptance authority media control system.		

ECSS-Q-ST-20_038013	5.2.4d	A
d. Acceptance authority media shall be traceable to individuals responsible for their use.		

ECSS-Q-ST-20_038014	5.2.4e	A
e. Acceptance authority media shall be applied directly to parts and materials, when specified by engineering drawings and specifications, and associated documents, records, labels.		

ECSS-Q-ST-20_038015	5.2.4f	A
f. Acceptance authority media materials and methods shall be compatible with the articles and their use.		

NOTE Acceptance authority media include stamps and signatures as defined in EN9100.

4.2.2.5 Traceability

ECSS-Q-ST-20_038017	5.2.5a	A
a. The Supplier shall ensure that a bidirectional and unequivocal relationship between parts, materials or products and associated documentation or records is established and maintained.		

ECSS-Q-ST-20_038018	5.2.5b	A
b. The Supplier shall be capable to trace data, personnel and equipment related to procurement, manufacturing, inspection, test, assembly, integration and operations activities.		

ECSS-Q-ST-20_038019	5.2.5c	A
c. The Supplier shall be capable to trace backward the locations of materials, parts, sub-assemblies.		

ECSS-Q-ST-20_038020	5.2.5d	A
d. The Supplier shall be capable to trace forward the locations of materials from raw stock.		

ECSS-Q-ST-20_038021	5.2.5e	A
e. The Supplier shall establish controls to ensure that: 1. identification numbers are assigned in a systematic and consecutive manner, 2. identification numbers of scrapped or destroyed items are not used again, 3. identification numbers, once allocated, are not changed, unless the change is authorized by the end customer DS.		

NOTE Requirements for identification are addressed in ECSS-M-ST-40.

4.2.2.6 Metrology and calibration

ECSS-Q-ST-20_038022	5.2.6a	A
a. The Supplier shall control, calibrate and maintain inspection, measuring and test equipment, whether owned by the Supplier, on loan, or provided by the end customer to demonstrate the conformance of product to the specified requirements.		

ECSS-Q-ST-20_038023	5.2.6b	A
b. The Supplier shall use equipment in a manner which ensures that measurement uncertainty is known and is consistent with the specified measurement capability.		

ECSS-Q-ST-20_038024	5.2.6c	A
c. The Supplier shall include in the calculations of all measurements the total error in the measurement process attributable to the cumulative error from the calibration chain, measuring equipment and those contributed by personnel, procedures and the environment.		

ECSS-Q-ST-20_038025	5.2.6d	A
d. The Supplier shall record the basis for the calculation of the cumulative errors as specified in requirement 5.2.6c.		

ECSS-Q-ST-20_038026	5.2.6e	A
e. The Supplier shall select inspection, measuring and test equipment in conformance with the required measurement accuracy and precision.		

ECSS-Q-ST-20_038027	5.2.6f	A
f. The Supplier shall identify, calibrate and adjust all inspection, measuring and test equipment and devices that can affect product quality at prescribed intervals, or prior to use, against certified equipment.		

ECSS-Q-ST-20_038028	5.2.6g	A
g. The Supplier shall establish, document and maintain calibration procedures, including details of equipment type, identification number, location, frequency of checks, check method, acceptance criteria and the action to be taken when results exceed the specified accuracy.		

ECSS-Q-ST-20_038029	5.2.6h	A
h. The Supplier shall ensure that the inspection, measuring and test equipment is capable of the specified accuracy and precision.		

ECSS-Q-ST-20_038030	5.2.6i	A
i. The Supplier shall identify inspection, measuring and test equipment with a suitable indicator or approved identification record to show the calibration status.		

ECSS-Q-ST-20_038031	5.2.6j	A
j. The Supplier shall maintain calibration records for inspection, measuring and test equipment.		

ECSS-Q-ST-20_038032	5.2.6k	A
k. The Supplier shall assess and document the validity of previous inspection and test results when inspection, measuring or test equipment is found to be out of calibration.		

ECSS-Q-ST-20_038033	5.2.6l	A
l. The Supplier shall ensure that the environmental conditions are suitable for the calibrations, inspections, measurements and tests being carried out.		

ECSS-Q-ST-20_038034	5.2.6m	A
m. The Supplier shall ensure that inspection, measuring and test facilities, including both test hardware and test software are protected against adjustments, which can invalidate the calibration setting.		

ECSS-Q-ST-20_038035	5.2.6n	A
n. The Supplier shall ensure that the inspection, measuring and test equipment is handled, preserved and stored such that the accuracy and fitness for use is maintained.		

ECSS-Q-ST-20_038036	5.2.6o	A
o. The Supplier shall check the test hardware or test software used for inspection to prove that it is capable of verifying the acceptability of the product prior to release for use during production and installation, and recheck it at specified intervals.		

NOTE 1 Examples of test hardware are: jigs, fixtures, templates and patterns.

NOTE 2 Test aids such as test leads, break-out boxes, mains leads and similar items are not subject to the entire set of requirements defined in this clause, but are validated in a way appropriate to their usage.

ECSS-Q-ST-20_038037	5.2.6p	A
p. The Supplier shall establish the extent and frequency of such checks and shall maintain records as evidence of control.		

ECSS-Q-ST-20_038038	5.2.6q	A
q. The Supplier shall make the measurement design data available to the end customer upon request.		

4.2.2.7 Handling, storage and preservation

ECSS-Q-ST-20_MOS-001	5.2.7.4a	N - esa
a. The Supplier shall implement the detailed requirements for handling, storage, transportation and preservation of ECSS Q-ST-20-08 (NDPA 59).		

4.2.2.7.1 Handling

ECSS-Q-ST-20_038039	5.2.7.1a	M – End customer
a. The Supplier shall implement the necessary precautions to prevent handling damage during all phases of manufacturing, assembly, integration, testing, storage, transportation and operation.		

NOTE Possible prevention measures are:

- *protection of items during handling,*
- *handling devices, or*
- *procedures and instructions.*

4.2.2.7.2 Storage

ECSS-Q-ST-20_038040	5.2.7.2a	A
a. The Supplier shall place the following items in secure storage areas: 1. incoming materials, 2. intermediate items needing temporary storage, and 3. end items before shipping.		

NOTE Security of the storage is defined according to specific customer requirements.

ECSS-Q-ST-20_038041	5.2.7.2b	A
b. The Supplier shall place the following items in designated segregated areas: 1. limited life materials, 2. suspended limited life materials, 3. non-conforming items awaiting NRB disposition, 4. scrapped items, 5. items designated to be stored separately for health or safety reasons.		

ECSS-Q-ST-20_038042	5.2.7.2c	A
c. Each segregated area shall be identified and labelled for its intended use.		

ECSS-Q-ST-20_038043	5.2.7.2d	A
d. The Supplier shall maintain control over acceptance into and withdrawal from storage areas.		

ECSS-Q-ST-20_038044	5.2.7.2e	A
e. The Supplier shall maintain records to ensure that all stored items are within the usable life limits, controlled and retested, and to provide traceability within the storage or segregated area.		

ECSS-Q-ST-20_038225	5.2.7.2f	A
f. The supplier shall ensure that no deterioration, damage or unexpected performance degradation occur to stored items due to storage conditions.		

4.2.2.7.3 Preservation

ECSS-Q-ST-20_038045	5.2.7.3a	A
a. The Supplier shall ensure that items subject to deterioration, corrosion or contamination through exposure to any environmental elements are preserved by methods that ensure maximum protection consistent with life and usage.		

NOTE Examples of such environmental elements are: air and moisture.

4.2.2.8 Statistical quality control and analysis

4.2.2.8.1 General

ECSS-Q-ST-20_038046	5.2.8.1a	A
a. Statistical quality control and analysis methods shall be used to maintain or improve the specified control of quality, when statistically significant with respect to the product characteristics and to quantities produced.		

NOTE Examples of statistical quality control and analysis methods are sample inspection plans, determination of quality levels, statistical process control and process capabilities studies.

ECSS-Q-ST-20_038047	5.2.8.1b	A
b. When employing statistical quality control and analysis methods, the Supplier shall ensure that all the conditions for use are enforced.		

NOTE Example of such conditions are sample significance, recording and elaboration of data, and formulation of clear decision rules.

ECSS-Q-ST-20_038048	5.2.8.1c	A
c. Statistical quality control applications, when used by the Supplier for acceptance of materials, parts, processes and products, shall be submitted to the end customer for approval.		

ECSS-Q-ST-20_REQ-005	-	N – Aend customer
d. The Supplier shall ensure that any abnormal change from the nominal trend given within the specified limit is identified and analysed.		

ECSS-Q-ST-20_REQ-006	-	N – End customer
e. Content format, trend analysis and exportable data selection shall be made available for review by the end customer		

4.2.2.8.2 Sampling plans

ECSS-Q-ST-20_038049	5.2.8.2a	A
a. When sampling plans are used the Supplier shall define and justify the following: 1. sample size, sample selection methods and criteria for inspection severity, 2. acceptance / rejection criteria, and 3. screening of rejected lots.		

ECSS-Q-ST-20_038050	5.2.8.2b	A
b. The Supplier shall maintain records of the sampling tests, together with the identification of the characteristics to which sampling is applied.		

4.2.3 QA REQUIREMENTS FOR DESIGN AND VERIFICATION

4.2.3.1 Design rules

4.2.3.1.1 Producibility

ECSS-Q-ST-20_038051	5.3.1.1a	A
a. The Supplier shall ensure that the product is designed such that it can be produced with the specified level of quality.		

4.2.3.1.2 Repeatability

ECSS-Q-ST-20_038052	5.3.1.2a	A
a. The Supplier shall ensure that the product is designed such that its performances and characteristics can be reproduced over different models and serial production.		

4.2.3.1.3 Inspectability and testability

ECSS-Q-ST-20_038053	5.3.1.3a	A
a. The Supplier shall ensure that the product is designed such that it can be inspected and tested under representative conditions, for production, AIV and operational environment.		

4.2.3.1.4 Operability

ECSS-Q-ST-20_038054	5.3.1.4a	A
a. The Supplier shall ensure that the product is designed such that it can be operated in accordance with programme constraints and requirements, throughout its whole life cycle including handling, storage, transportation, integration and operations.		

4.2.3.2 Verification

4.2.3.2.1 General

ECSS-Q-ST-20_038055	5.3.2.1a	A
a. The Supplier shall ensure that requirement verification is performed progressively, as each stage of the project is completed, and provides the organized base of data upon which qualification and acceptance is incrementally declared.		

ECSS-Q-ST-20_038056	5.3.2.1b	A
b. The Supplier shall ensure that top-down requirement allocations and bottom-up requirement verifications are complete and consistent.		

ECSS-Q-ST-20_038057	5.3.2.1c	A
c. The Supplier shall ensure that a system for tracking requirements and verification of results is established and maintained during the whole project life cycle.		

ECSS-Q-ST-20_038058	5.3.2.1d	A
d. The Supplier shall ensure that verification methods are adequate and consistent with the type and criticality of the requirements.		

ECSS-Q-ST-20_038059	5.3.2.1e	A
e. The Supplier shall ensure that appropriate reference to the verification documentation is recorded and status updated at project reviews up to final acceptance.		

4.2.3.2.2 Design verification analysis

ECSS-Q-ST-20_038060	5.3.2.2a	A
a. The Supplier shall ensure that the objectives of the analysis are defined in relation with the development logic defined in the verification plan.		

ECSS-Q-ST-20_038061	5.3.2.2b	A
b. The following items shall be identified: 1. reference of the configuration item definition under analysis; 2. environmental constraints considered in the analysis; 3. basic assumptions, analysis methods, mathematical models.		

4.2.3.2.3 Design reviews

ECSS-Q-ST-20_038062	5.3.2.3a	A
a. The Supplier shall ensure that design reviews are conducted in accordance with project requirements and written procedures.		

NOTE Design reviews address the following items:

- *Quality requirements and criteria for design, producibility, repeatability, testability and operability are adequately considered in design documentation.*
- *Methods and data required for procurement, manufacturing, inspection and test are available and validated.*
- *Risks of not achieving requirements are highlighted and adequately controlled.*

4.2.3.2.4 Qualification process

4.2.3.2.4.1 Qualification

ECSS-Q-ST-20_038063	5.3.2.4.1a	A
a. The Supplier shall ensure that all configuration items and their constituent items, either off-the-shelf or specifically designed, are properly qualified with margins commensurate with the application and use environment.		

NOTE For equipment with heritage, an Equipment Qualification Status Review can be organised to assess qualification status.

ECSS-Q-ST-20_REQ-007	-	N – End customer
b. For the off the shelf equipment, requirements of chapter 4.2.9 of this document shall apply.		

ECSS-Q-ST-20_038064	5.3.2.4.1b	A
c. The Supplier QA shall review and approve the qualification plan.		

NOTE The qualification plan is a subset of the VCD as defined in ECSS-E-ST-10-02.

ECSS-Q-ST-20_038065	5.3.2.4.1c	A
d. The Supplier QA shall review and approve the qualification results.		

NOTE Qualification results are a subset of Verification Control Document (VCD) as defined in ECSS-E-ST-10-02.

ECSS-Q-ST-20_038226	5.3.2.4.1d	A
e. The supplier QA manager shall ensure that a Verification Control Board (VCB) is established to monitor the qualification process.		

NOTE Verification Control Board (VCB) is defined in ECSS-E-ST-10-02.

4.2.3.2.4.2 Qualification by similarity

ECSS-Q-ST-20_038066	5.3.2.4.2a	A
a. Qualification by similarity with an identical or similar product shall be justified by providing evidence that the new application is within the limits of the previously qualified design.		

ECSS-Q-ST-20_038067	5.3.2.4.2b	A
b. Any difference in definition with respect to the reference product and any difference in the required qualification tests shall be identified.		

ECSS-Q-ST-20_038068	5.3.2.4.2c	A
c. The need for complementary qualification tests shall be analysed and the decision justified and submitted to the end customer for approval.		

ECSS-Q-ST-20_038069	5.3.2.4.2d	A
d. For this purpose the Supplier shall: 1. evaluate the as-designed or as-built configuration and related non-conformances, 2. ensure that qualification requirements and qualification ranges are compatible with project requirements, 3. ensure that qualification test results meet the requirements and any non-conformances are available for evaluation, and 4. ensure that a logbook of the selected model is available for review.		

4.2.3.2.4.3 Qualification testing

ECSS-Q-ST-20_038070	5.3.2.4.3a	A
a. The product used for qualification testing shall be produced in accordance with a full and clearly identified manufacturing and inspection file.		

ECSS-Q-ST-20_038071	5.3.2.4.3b	M – End customer
b. To obtain authorization to initiate qualification tests the Supplier shall demonstrate through a Test Readiness Review that: 1. the qualification model is fully representative of the flight model and any differences have been analysed to evaluate their effect on the qualification status; 2. inspection and test requirements are expressed in an unambiguous and quantified manner including: (a) test sequence; (b) test conditions; (c) test standards, if any; (d) applicable test levels, durations and tolerances; (e) accuracy in measurement. 3. the qualification test procedures and facilities are defined, available and conforming to requirements of clause 5.6.		

4.2.3.2.4.4 Qualification status

ECSS-Q-ST-20_038072	5.3.2.4.4a	A
a. The Supplier shall report the qualification status in conformance with the “Qualification status list” DRD as defined in ECSS-Q-ST-10.		

4.2.3.2.4.5 Maintenance of qualification

ECSS-Q-ST-20_038073	5.3.2.4.5a	A
a. Once the design is qualified, the Supplier shall assess all subsequent changes, deviations and anomalies for their impact on the qualification status and shall perform requalification as necessary.		

4.2.3.2.5 Design changes

ECSS-Q-ST-20_038074	5.3.2.5a	M – End customer
a. The Supplier shall ensure that all design changes and modifications are identified, documented, including design analyses, reviewed and approved before their implementation.		

4.2.4 QA REQUIREMENTS FOR PROCUREMENT

4.2.4.1 Selection of procurement sources

4.2.4.1.1 General

ECSS-Q-ST-20_038075	5.4.1.1a	A
a. The Supplier QA shall participate in the approval and the selection of procurement sources.		

NOTE The selection of procurement sources for EEE components is defined in ECSS-Q-ST-60.

4.2.4.1.2 Selection criteria

ECSS-Q-ST-20_038076	5.4.1.2a	A
a. The supplier shall select its suppliers on the basis of one of the following criteria: 1. The supplier has been certified by the ESA, and has a current approval to furnish items or services of the type and quality level being procured. 2. The supplier is furnishing, or has furnished within the past two years, items or services of the type and quality level being procured under other contracts with the ESA. 3. The supplier has demonstrated continuous capability to furnish items or services of the type and quality level being procured, supported by objective documentation. 4. Supplier's capability of satisfying business agreement requirements is demonstrated by a pre-award audit by the relevant customer.		

NOTE 1 Note to item 1: Third party certification (for instance against ISO 9001) can be also considered.

NOTE 2 Note to item 3: This criterion does not apply if the supplier has not furnished items or services of the type being procured for more than two years.

ECSS-Q-ST-20_REQ-008	-	N – End customer
b. If the Supplier intends to sub-contract a part of the work to a Lower Tier Supplier, this shall be formally notified to the end customer for approval.		

ECSS-Q-ST-20_REQ-009	-	N – End customer
c. The Supplier shall identify all Lower Tier Suppliers down to the lowest level in a list identifying the name, the location, the part of the work sub-contracted and the heritage.		

NOTE Approval will be given by the end customer on the basis of:

- *Clear evidence that all requirements applicable to the project are transmitted to the Lower Tier Supplier.*
- *Evaluation of the ability of the Lower Tier Supplier to do the work and to fulfil the requirements and availability of a validation file for review by the end customer. If needed, the end customer may request an audit.*

ECSS-Q-ST-20_038077	5.4.1.2b	A
d. The Supplier shall document and maintain on file results of suppliers selection process.		

4.2.4.1.3 Record and list of procurement sources

ECSS-Q-ST-20_038078	5.4.1.3a	A
a. The Supplier shall establish and maintain records of all procurement sources involved in business agreement performance.		

ECSS-Q-ST-20_038079	5.4.1.3b	A
b. The Supplier shall submit to the end customer, upon request, the list of procurement sources, including all the information in the records 5.4.1.3a, for information.		

4.2.4.2 Procurement documents

ECSS-Q-ST-20_038080	5.4.2a	A
a. The Supplier shall ensure that supplies are identified and that all applicable requirements are defined in the procurement documents.		

ECSS-Q-ST-20_038081	5.4.2b	A
b. The Supplier shall ensure that requirements to those contained in lower tier procurement documents are traceable.		

ECSS-Q-ST-20_038082	5.4.2c	A
c. The procurement documents shall contain, by statement or reference: 1. comprehensive technical descriptions of the items and services to be procured, 2. details of the applicable requirements, such as requirements for preservation, packaging, marking, shipping, accompanying documentation and provisions for limited-life items, 3. details of QA activities to be performed, such as inspection and test characteristics, records and reports, 4. details of Supplier's QA activities at source, and 5. special acceptance conditions.		

ECSS-Q-ST-20_038083	5.4.2d	A
d. The Supplier's quality assurance organization shall review procurement documents prior to release, to verify the correct selection of procurement sources and appropriateness of their content.		

4.2.4.3 Surveillance of procurement sources

ECSS-Q-ST-20_038084	5.4.3a	A
a. The Supplier shall exercise surveillance over all the activities carried out by lower level Suppliers during business agreement performance.		

ECSS-Q-ST-20_038085	5.4.3b	A
b. The surveillance programme shall address audits, reviews, mandatory inspection points, as well as direct supervision by Supplier's resident personnel at his Suppliers' facilities and source inspection.		

NOTE Example of review is the manufacturing readiness review.

ECSS-Q-ST-20_038086	5.4.3c	A
c. The Supplier shall define the type and extent of surveillance by reviewing the following criteria: 1. Testing or inspections cannot be accomplished by the Supplier. 2. Verification tests are destructive in nature and the quality cannot be verified solely by inspection or test at Supplier's facility. 3. Supplies are designated for direct shipment from source to the end customers site or the using site. 4. Manufacturing and AIV of complex equipment or subsystems. 5. Past performance or quality history of the lower level Supplier is marginal. 6. Functional criticality and technical complexity of the supplies. 7. The degree of responsibility placed on the procurement source.		

NOTE 1 Examples for item 1: environments or test equipment not available at Supplier's facility.

NOTE 2 Example for item 4 : payloads.

ECSS-Q-ST-20_REQ-010	-	N – End customer
d. Any change to the list of Lower Tier Suppliers shall be submitted to the end customer for approval.		

ECSS-Q-ST-20_038087	5.4.3d	A
e. The Supplier shall ensure that each of his Suppliers implements surveillance on their lower level Suppliers, in accordance with the same criteria.		

	5.4.3e	A
f. Surveillance may be delegated by the end customer to third parties.		

4.2.4.4 Receiving inspection

4.2.4.4.1 General

ECSS-Q-ST-20_038089	5.4.4.1a	A
a. The Supplier shall ensure that all incoming supplies, including documentation and packaging, whether delivered on his own premises or elsewhere, conform to the requirements of the procurement documents.		

ECSS-Q-ST-20_038090	5.4.4.1b	A
b. The Supplier shall perform inspections in accordance with established procedures and instructions, to ensure that quality level is properly determined.		

NOTE 1 Sampling plans in receiving inspection are defined in requirements 5.2.8.2.

NOTE 2 Receiving inspection of components is defined in ECSS-Q-ST-60.

NOTE 3 Lot or batch acceptance of materials and mechanical parts is defined in ECSS-Q-ST-70.

ECSS-Q-ST-20_038091	5.4.4.1c	A
c. Receiving inspectors shall have available the procurement documents, specifications, drawings and any other document relevant to incoming supplies as required in the procurement documents.		

4.2.4.4.2 Receiving inspection activities

ECSS-Q-ST-20_038092	5.4.4.2a	A
a. Receiving inspection activities shall include: 1. verification of the packaging conditions and of the status of environmental sensors, 2. visual inspection of the delivered items, 3. verification of correct identification and, where appropriate, configuration identification for conformance to the ordering data, 4. verification of the evidence of inspection and tests performed by the Supplier and associated documentation, 5. verification of the performance of Supplier's source inspection, when required, 6. performance of inspections and tests on selected characteristics of incoming supplies or test specimens submitted with the supplies, 7. identification of the shelf life of limited-life items, 8. identification of the inspection status and physical separation of the supplies in the receiving inspection area according to the following categories: (a) items for which the receiving inspection has not been completed; (b) conforming items; (c) non-conforming items. 9. prevention of unauthorized use of uninspected items, 10. identification of the items to be released for production with conformance status and traceability data to be recorded in manufacturing documents, 11. maintenance of receiving inspection records in conformance with requirements 5.4.4.4.		

4.2.4.4.3 Customer furnished items

ECSS-Q-ST-20_038093	5.4.4.3a	A
a. Receiving inspection of items supplied by the end customer shall consist of the verification of identity and integrity after transportation.		

NOTE Additional inspections and tests, if any, are specified in the business agreement.

4.2.4.4.4 Receiving inspection records

ECSS-Q-ST-20_038094	5.4.4.4a	A
a. The Supplier shall maintain receiving inspection records to ensure traceability and the availability of historical data to monitor Supplier performance and quality trends.		

4.2.5 QA REQUIREMENTS FOR MANUFACTURING, ASSEMBLY AND INTEGRATION

4.2.5.1 Planning of manufacturing, assembly and integration activities and associated documents

ECSS-Q-ST-20_038095	5.5.1a	A
a. The Supplier shall document the planning of manufacturing, assembly and integration operations and inspections in the manufacturing plan or flow chart for the product, including the sequence of operations and associated inspections and tests.		

ECSS-Q-ST-20_038096	5.5.1b	A
b. The planning shall include the identification of MIPs in conformance with requirements 5.5.8, together with the reference to the procedures by which the various activities are performed and the required cleanliness levels and temperature and humidity requirements of the facilities.		

ECSS-Q-ST-20_038097	5.5.1c	A
c. Instructions shall direct the actual performance of manufacturing, assembly and integration operations and inspections, to ensure that the activities proceed in an orderly manner and according to the planned sequence.		

NOTE For example: shop travellers.

ECSS-Q-ST-20_038098	5.5.1d	A
d. The Supplier shall issue and maintain manufacturing, assembly, integration and inspection documents in accordance with established and released procedures.		

ECSS-Q-ST-20_038099	5.5.1e	A
e. The QA organization shall review and approve such documents, and any modifications thereof, to ensure that they include or refer to: 1. Identification of the item to be manufactured or equipment to be used. 2. Configuration data, including parts lists, drawings, changes and specifications. 3. Identification of the production and inspection equipment to be used for the manufacturing, assembly and integration of the item. 4. Identification of critical characteristics. 5. Detailed definition, by description or reference, of manufacturing, assembly, integration, inspections and test operations to be performed, and special conditions to be maintained. 6. Provisions for inspections and tests to be witnessed by a representative from the end customer. 7. Accept or reject criteria (with tolerances) and workmanship standards. 8. Details of sampling inspection procedures to be used, if any. 9. Detailed procedures for the activities to be performed.		

NOTE 1 Examples for item 3, of production and inspection equipment are tools, jigs and fixtures.

NOTE 2 Critical characteristics, for item 4, are defined in ECSS-Q-ST-30.

ECSS-Q-ST-20_038100	5.5.1f	A
f. Only “first off” shop travellers shall be reviewed unless subsequent travellers incorporate a significant change of inspection requirements or order of events.		

ECSS-Q-ST-20_038101	5.5.1g	A
g. The Supplier shall also provide for detail support documents and instructions, such as drawings, procedure and instruction sheets, to enable operations to be correctly performed.		

4.2.5.2 Manufacturing readiness reviews

ECSS-Q-ST-20_038102	5.5.2a	M – End customer
a. The Supplier shall perform a review of the readiness for manufacturing, prior to starting the manufacture of the qualification model or / and first flight-standard product.		

ECSS-Q-ST-20_038103	5.5.2b	M – End customer
b. The Manufacturing Readiness Review (MRR) shall evaluate the following aspects: 1. status of product definition and requirements, differences with the status of the qualification model, and impacts of these differences; 2. status of manufacturing, assembly, inspection and test documentation, differences with the status of the qualification model, and impacts of these differences; 3. verification status of manufacturing processes, with particular emphasis on critical processes; 4. implementation of dispositions for risk reduction, as defined by risk assessment, into the manufacturing, assembly, integration, inspection and test procedures; 5. availability of personnel and of specified materials and parts, production, measuring and inspection equipment, and calibration status, when relevant; 6. cleanliness of facilities, with respect to the specified cleanliness levels; 7. facility temperature and humidity with respect to requirements, 8. previous space use for all processes.		

ECSS-Q-ST-20_MOS-002	5.5.2c	N - esa
c. The Supplier shall invite the end customer to Manufacturing Readiness Reviews (MRRs) at all contractual levels by providing ten (10) working days' notice before the event (and confirmed three (3) working days before the event) and shall require end customer S participation, or their written agreement to proceed without participation from the end customer.		

4.2.5.3 Control of processes

4.2.5.3.1 General

ECSS-Q-ST-20_038104	5.5.3.1a	A
a. The Supplier shall monitor all processes used for manufacturing, assembly and integration, and enforce all applicable process requirements.		

ECSS-Q-ST-20_038105	5.5.3.1b	A
b. The Supplier shall ensure that all manufacturing processes are covered by documented process specifications or standards.		

NOTE the definition of manufacturing process specifications is given in ECSS-Q-ST-70.

ECSS-Q-ST-20_038106	5.5.3.1c	A
c. Process specifications shall include QA provisions, methods for inspection and test, number of samples, accept or reject criteria.		

ECSS-Q-ST-20_038107	5.5.3.1d	A
d. Process witness samples shall be stored in controlled conditions.		

4.2.5.3.2 Special processes

ECSS-Q-ST-20_038108	5.5.3.2a	A
a. The Supplier shall establish and implement procedures and controls for special processes, to ensure that: 1. Special processes are validated for the intended application. 2. Personnel who perform and inspect special processes are trained and certified according to requirements 5.1.2b and 5.1.2c. 3. Materials, equipment, computer systems and software, and procedures involved in the performance of the special process are validated and monitored. 4. Coordination is maintained with the cognizant engineering function to ensure proper selection of the non-destructive or destructive methods for the evaluation of process performance.		

NOTE Validation of special processes, as mentioned in item 1, is defined in ECSS-Q-ST-70.

4.2.5.3.3 Statistical process control

ECSS-Q-ST-20_038109	5.5.3.3a	A
a. Statistical methods for process control should be used for early detection of significant variations in manufacturing processes, in order to determine, analyse and eliminate the causes of undesirable variations.		

4.2.5.4 Workmanship standards

ECSS-Q-ST-20_038110	5.5.4a	A
a. The Supplier shall employ workmanship standards throughout all phases of manufacturing, assembly and integration, to ensure acceptable and consistent workmanship quality levels.		

ECSS-Q-ST-20_038111	5.5.4b	A
b. Workmanship standards shall identify acceptance or rejection criteria.		

ECSS-Q-ST-20_038112	5.5.4c	A
c. Physical samples or visual aids shall be reviewed and agreed by the end customer when they are used for the purpose of acceptance or rejection of items.		

4.2.5.5 Materials and parts control

ECSS-Q-ST-20_038113	5.5.5a	A
a. The Supplier shall ensure that only conforming items are released and used, and that those not required for the operation involved are removed from work operation areas.		

ECSS-Q-ST-20_038114	5.5.5b	A
b. Items having limited-life or definite characteristics of quality degradation or drift with age or use shall be marked to indicate the dates, test times or cycles at which life was initiated and at which the useful life expires.		

ECSS-Q-ST-20_038115	5.5.5c	A
c. Sensitive items shall be processed or manufactured, inspected and tested in a controlled environment to prevent any degradation.		

4.2.5.6 Equipment control

4.2.5.6.1 Tooling

ECSS-Q-ST-20_038116	5.5.6.1a	A
a. The Supplier shall make provisions for accountability, identification and maintenance of manufacture, assembly and integration tooling.		

ECSS-Q-ST-20_038117	5.5.6.1b	A
b. Manufacture, assembly and integration tooling shall be checked for its dimensional accuracy, regarding the product drawings, and correct function.		

ECSS-Q-ST-20_038118	5.5.6.1c	A
c. The QA organization shall approve tooling prior to use.		

ECSS-Q-ST-20_038119	5.5.6.1d	A
d. The approval shall be marked in conformance with requirements 5.2.4, and recorded.		

ECSS-Q-ST-20_038120	5.5.6.1e	A
e. Tools shall be checked for accuracy during the production life at adequate intervals.		

ECSS-Q-ST-20_038121	5.5.6.1f	M ,- End customer
f. Tools shall be submitted to re-approval and validation following modification.		

ECSS-Q-ST-20_038122	5.5.6.1g	A
g. Tools shall be properly stored to prevent misuse, damage and deterioration.		

ECSS-Q-ST-20_038123	5.5.6.1h	A
h. Unnecessary tools shall be removed from working areas.		

ECSS-Q-ST-20_038124	5.5.6.1i	A
i. Records shall be kept of all manufacturing equipment.		

4.2.5.6.2 Equipment for computer-aided manufacturing

ECSS-Q-ST-20_038125	5.5.6.2a	A
a. The Supplier shall ensure that computer-aided techniques and data for processing and machining are validated prior to use and controlled during their use in manufacturing.		

ECSS-Q-ST-20_038126	5.5.6.2b	A
b. The Supplier shall ensure that provisions are made for the testing, approval and configuration control of the software involved and prevention of its being tampered with.		

4.2.5.7 Cleanliness and contamination control

4.2.5.7.1 General

ECSS-Q-ST-20_038127	5.5.7.1a	A
a. The Supplier shall establish controls for cleanliness of spacecraft hardware and facilities, and the limitation of sources of contamination.		

NOTE Cleanliness and contamination control methods and processes are detailed in ECSS-Q-ST-70-01.

ECSS-Q-ST-20_MOS-003	5.5.7.1b	N - esa
b. The Supplier shall identify the hardware and facilities that require specific controls for molecular or particulate contamination.		

4.2.5.7.2 Cleanliness levels

ECSS-Q-ST-20_038128	5.5.7.2a	A
a. Contamination-sensitive items shall be cleaned, controlled and maintained to the required cleanliness levels.		

ECSS-Q-ST-20_038129	5.5.7.2b	A
b. The required cleanliness levels for all levels of flight hardware shall be indicated on drawings, specifications, procedures, or other documents controlling the manufacture, assembly, integration and test of the items.		

ECSS-Q-ST-20_REQ-011	-	N – End customer
c. The allowed particulate and molecular contamination levels at each step of the equipment / instrument life cycle (manufacture, delivery to AIT, AIT activities, storage, launch campaign and operations) shall be in accordance with MetOp-SG prime Cleanliness Requirements Specification document [AD14e].		

4.2.5.7.3 Cleaning materials and methods

ECSS-Q-ST-20_038130	5.5.7.3a	A
a. The Supplier shall develop detailed methods for attaining the cleanliness levels specified for the hardware.		

4.2.5.7.4 Contamination control

ECSS-Q-ST-20_038131	5.5.7.4a	A
a. Contamination shall be minimized by operating in clean working areas and by proper handling, preservation, packaging and storage.		

ECSS-Q-ST-20_038132	5.5.7.4b	A
b. Contamination-sensitive items fabricated or processed in contamination-controlled environments shall be inspected, tested, modified or repaired in identical or cleaner environments, unless specific precautions are taken to protect the items concerned from contamination.		

ECSS-Q-ST-20_038133	5.5.7.4c	A
c. Specific protection measures, such as protective dust covers, shall be implemented to protect contamination-sensitive items when they are integrated in a higher level of assembly.		

ECSS-Q-ST-20_MOS-004	5.5.7.4d	N - esa
d. The Supplier shall define the specific controls for molecular and particulate contamination required during storage to ensure the system, associated units and equipment, achieve their End-Of-Life (EOL) performance requirements. These controls shall be subject to Customer approval.		

NOTE The MetOp-SG follow-on systems will spend a significant amount of time in storage in readiness for operations

ECSS-Q-ST-20_REQ-012	-	N – End customer
e. The Supplier shall provide a Cleanliness Control Plan including a contamination analysis to define the cleanliness conditions of the hardware environment during manufacturing, assembly and tests (clean room class), the associated control of cleanliness (particle counter, witness samples), the personal clothing, the potential protection devices (covers, bags) and the cleaning methods.		

ECSS-Q-ST-20_REQ-013	-	N – End customer
f. The contamination sensitive components shall be identified in the Critical Item List.		

4.2.5.7.5 Cleanliness of facilities

ECSS-Q-ST-20_038134	5.5.7.5a	A
a. Fabrication, assembly and integration of contamination sensitive items shall be conducted in facilities that provide cleanliness levels compatible with the specified product cleanliness.		

4.2.5.8 Inspection

ECSS-Q-ST-20_038135	5.5.8a	A
a. Inspection and tests shall be planned at the points of the manufacturing, assembly and integration flow where maximum assurance for correct processing and prevention of unrecoverable or costly non-conformances can be obtained.		

ECSS-Q-ST-20_038136	5.5.8b	A
b. All identified critical characteristics shall be inspected as defined in the critical-item control programme.		

ECSS-Q-ST-20_038137	5.5.8c	A
c. Self-inspection by the operators performing the associated manufacturing, assembly and integration activities shall not be considered sufficient for critical characteristics.		

ECSS-Q-ST-20_038138	5.5.8d	A
d. Among the inspections and tests as part of the manufacturing, assembly and integration flow, Mandatory Inspection Points (MIPs) shall be performed with participation of the end customer.		

ECSS-Q-ST-20_038139	5.5.8e	M - esa
e. MIPs shall be agreed with the end customer on the basis of a list prepared by the Supplier in accordance with DRD {sat-PA-09}, which shall be maintained throughout the life cycle to document the status achieved.		

NOTE The MIP list may form a section of, or be incorporated within, the MAIT Plan.

ECSS-Q-ST-20_038140	5.5.8f	A

f. MIPs shall be selected in accordance with the criteria as defined below, when one or more of the following conditions apply:

1. When maximum visibility of quality is given.
2. When critical processes are performed.
3. Where the next step of the manufacturing sequence:
   (a) is irreversible, or
   (b) makes the item difficult and costly to disassemble for inspection, or
   (c) renders the location inaccessible for inspection.
4. When the item, once installed in the next higher assembly damages by its failure the higher assembly.
5. When previous failure history of the item indicates a need for inspection.
6. When a potential adverse impact on the properties and integrity of the end product could result, owing to the criticality or complexity of the manufacturing step.
7. When testing or critical inspections cannot be accomplished by the Supplier.
   NOTE: For example, environments or test equipment not available at Supplier's facility.
8. When verification tests are destructive in nature and the quality cannot be verified solely by inspection or test at the Supplier's facility.
9. When manufacturing and AIV of complex equipment or subsystems is planned.
   NOTE: For example, for payloads.
10. When past performance or quality history of the lower level Supplier is marginal.
11. When an item is going to final inspection.

ECSS-Q-ST-20_038141	5.5.8g	A

g. Criteria 5.5.8f 7 to 10 shall be considered together with the criticality and complexity of the supplies and the Supplier's experience with the lower level Supplier.

ECSS-Q-ST-20_038142	5.5.8h	M - esa

h. A MIP shall require an invitation with ten (10) working days notice before the event (and confirmed three (3) working days before the event), and shall require participation from the end customer, or their written agreement to proceed without participation from the end customer.

ECSS-Q-ST-20_038143	5.5.8i	A

i. The Supplier shall make provisions for a positive identification of the inspection and test status of any items at any stage of the manufacturing, assembly and integration cycle, starting from the incoming inspection up to shipping of the end item.

ECSS-Q-ST-20_038227	5.5.8j	A

j. MIP information shall include as a minimum:

1. Purpose and subject of the inspections,
2. Criteria for the selection,
3. Notification period,
4. MIP identifier,
5. MIP description,
6. Reference of procedures necessary to perform the MIP, and
7. MIP location in the manufacturing and Inspection flow chart or the AIV flow chart.

ECSS-Q-ST-20_REQ-014	-	N – End customer

k. MIPs shall include at least the review of the following items: hardware identification, CIDL evolution status, As designed/As built discrepancies, assembly process documentation, RFD/RFW and NCR status, test procedure reference, list of repairs.

ECSS-Q-ST-20_MOS-005	-	N - esa
l. In case of the end customer MIP delegation to the Supplier QA, the MIP report shall be provided to Athe end customer within 48 hours after the MIP.		

4.2.5.9 Specific requirements for assembly and integration

4.2.5.9.1 Control of temporary installations and removals

ECSS-Q-ST-20_038144	5.5.9.1a	A
a. The Supplier shall ensure the control of flight items which are temporarily removed or non-flight items which are temporarily installed to facilitate assembly, integration, testing, handling or preservation of the end item.		

ECSS-Q-ST-20_038145	5.5.9.1b	A
b. The control shall be initiated upon installation or removal of the first temporarily installed or removed item and be maintained through delivery and use of the end item.		

ECSS-Q-ST-20_038146	5.5.9.1c	A
c. The Supplier shall establish and maintain records of temporary installations and removals.		

ECSS-Q-ST-20_038147	5.5.9.1d	A
d. Temporarily installed items shall be accounted for to prevent their being incorporated in the final flight configuration.		

NOTE Temporary installations and removals are also called respectively, red tag items and green tag items.

ECSS-Q-ST-20_REQ-016	-	N – End customer
e. Non flight items i.e. connector savers, covers, etc shall be clearly identified as “NOT FOR FLIGHT” and/or clearly highlighted by colour coding in RED.		

4.2.5.9.2 Logbooks

ECSS-Q-ST-20_038148	5.5.9.2a	A
a. The Supplier shall prepare and maintain system, subsystem and equipment logbooks in conformance with the DRD in ECSS-Q-ST-20 / Annex C for all operations and tests performed on the item.		

ECSS-Q-ST-20_038149	5.5.9.2b	M – End customer
b. Equipment logbooks shall start with the first qualification or flight acceptance test after assembly.		

ECSS-Q-ST-20_038150	5.5.9.2c	A
c. Subsystem and system logbooks shall follow-on from the individual equipment logbooks to form a full record.		

ECSS-Q-ST-20_038151	5.5.9.2d	A
d. The logbook shall accompany the hardware whenever it is placed in the custody of another organization		

ECSS-Q-ST-20_038152	5.5.9.2e	A
e. The receiving organization shall maintain the logbook up-to-date.		

ECSS-Q-ST-20_REQ-017	-	N – End customer
f. The logbooks shall contain historical and quality data and information which is significant for operation of the item, including non-conformances, deviations and open tasks.		

4.2.5.10 Manufacturing, assembly and integration records

ECSS-Q-ST-20_038153	5.5.10a	A
a. The Supplier shall establish and maintain manufacturing, assembly and integration records to provide all manufacturing, assembly, integration and inspection data required for traceability.		

ECSS-Q-ST-20_MOS-006	5.5.10b	N - esa
b. High definition digital photographs (e.g. 10 Mega Pixels) shall be taken of the inside and outside of all flight units.		

NOTE In case of anomalies, the photographs will be used as reference; good lighting conditions must be used to ensure digital zooming.

ECSS-Q-ST-20_MOS-007	5.5.10c	N - esa
c. High definition digital photographs (e.g. 10 Mega Pixels) shall be taken of both sides of all PCBs prior to conformal coating.		

NOTE In case of anomalies, the photographs will be used as reference; good lighting conditions must be used to ensure digital zooming to component & PCB track level.

ECSS-Q-ST-20_MOS-008	5.5.10d	N - esa
d. The Supplier shall maintain all photographs within the PA database and the high definition files included in the relevant End Item Date Pack (EIDP).		

4.2.5.11 Electrostatic discharge control (ESD)

ECSS-Q-ST-20_038228	5.5.11a	A
a. The supplier shall establish and maintain an ESD protection programme during the design, manufacture, test and storage/transport of flight hardware.		

ECSS-Q-ST-20-038229	5.5.11b	A
b. The supplier shall provide an ESD control plan in conformance with EN 61340-5-1 or ANSI-ESD S20.20.		

NOTE ANSI-ESD S20.20 is the US equivalent of EN 61340-5-1.

ECSS-Q-ST-20_REQ-018	-	N – End customer
c. The ESD Control Plan shall contain as a minimum: 1. Scope of ESD control program, 2. Tasks, activities and procedures necessary to protect USD items, 3. Identification of organisations responsible for the tasks and activities, 4. Listing of directive or guidance documents in the ESD Control program, 5. Description of ESD control requirements imposed on subcontractors and suppliers, 6. Listing of the specific ESD protection tools materials and equipment, 7. Identification or reference to training and certification of personnel.		

ECSS-Q-ST-20_REQ-019	-	N – End customer
d. The required ESD Control levels for all levels of flight hardware shall be indicated on drawings, specifications, procedures, or other documents controlling the manufacture, assembly, integration and test of the items.		

ECSS-Q-ST-20_REQ-020	-	N – End customer
e. ESD classes shall be as defined within ANSI/ESD STM5.1, MIL-STD 883/MIL STD 750 or equivalent.		

ECSS-Q-ST-20_REQ-021	-	N – End customer
f. During design of equipment and its sub-assemblies, the susceptibility of the product and its parts shall be reviewed to ensure sufficient protection has been put in place to mitigate and risk of ESD exceeding the allowable limit.		

ECSS-Q-ST-20_REQ-022	-	N – End customer
g. ESD protective areas shall be used when handling flight hardware.		

4.2.5.11.1 Ultra Sensitive Devices (USD)

ECSS-Q-ST-20_REQ-023	-	N – End customer
a. Classes 0 & 1a shall be classed as Ultra Sensitive Devices (USD).		

NOTE A USD is classified as a device which has a damage threshold of less than 500 volts Human Body Model (HBM).

ECSS-Q-ST-20_REQ-024	-	N – End customer
b. Where possible, the part/assembly shall be labelled clearly identifying that it is classed as an USD. In some instances due to real-estate on the part/assembly this may not be possible: in this instance, the packaging of the device/assembly shall clearly identify its USD classification.		

ECSS-Q-ST-20_REQ-025	-	N – End customer
c. Device / Equipment packaging shall clearly identify parts which are USD.		

ECSS-Q-ST-20_REQ-026	-	N – End customer
d. Additional controls shall be used when handling USD parts, assemblies and equipment outside of their ESD protective covering or packaging: - ESD Protective areas for handling USD parts shall be clearly identified, - the protective area shall limit ESD voltages below the sensitivity level of USD items handled therein.		

ECSS-Q-ST-20_REQ-027	-	N – End customer
e. In addition to the general ESD controls identified in EN61340-5.1, the additional requirements of Table 3, EN61340-5.1 shall also be applied.		

NOTE For USD constant monitoring of the wrist strap is recommended.

4.2.6 QA REQUIREMENTS FOR TESTING

4.2.6.1 Test facilities

ECSS-Q-ST-20_038154	5.6.1a	M - esa
a. The Supplier shall ensure that test facilities, either internal or external, are ESA certified to ECSS-Q-ST-20-07C.		

ECSS-Q-ST-20_MOS-009	5.6.1b	N - esa
b. The Supplier shall ensure that test facilities are suitably qualified to perform the tests to be conducted, and do not cause any degradation to the test article or its interface.		

4.2.6.2 Test equipment

ECSS-Q-ST-20_038155	5.6.2a	A
a. The Supplier shall ensure that computer-aided testing techniques and data are validated prior to use and controlled during their use in testing.		

ECSS-Q-ST-20_038156	5.6.2b	A
b. The Supplier shall ensure that provisions are made for testing, approval and configuration control of the software involved and prevention of its being tampered with.		

ECSS-Q-ST-20_038157	5.6.2c	A
c. The Supplier shall ensure that test equipment are designed such that their correct operation can be verified without having to apply them to the test item.		

4.2.6.3 Test documentation

4.2.6.3.1 Test procedures

ECSS-Q-ST-20_038158	5.6.3.1a	A
a. The Supplier shall ensure that tests are performed in accordance with documented procedures.		

NOTE Test procedure DRDs are defined in ECSS-E-ST-10-03.

ECSS-Q-ST-20_038159	5.6.3.1b	A
b. The QA organization shall review and approve test procedures.		

4.2.6.3.2 Test reports

ECSS-Q-ST-20_038160	5.6.3.2a	M - esa
a. The Supplier shall ensure that all tests are documented in test reports as per ECSS-E-ST-10-02C, Annex C.		

ECSS-Q-ST-20_MOS-010	5.6.3.2a4	N - esa
b. Test Reports shall contain references to NCR's raised during the test and highlight the point during the test when the subject of the NCR was observed.		

ECSS-Q-ST-20_038161	5.6.3.2b	M - esa
c. The supplier PA manager shall review and approve all test reports.		

NOTE Product Assurance shall assure the accuracy of the report, ensure it reflects deviations to the test procedure, and confirm that all NCR's and test anomalies are reflected within the report.

4.2.6.4 Test performance monitoring

ECSS-Q-ST-20_038162	5.6.4a	A
a. On the basis of an analysis of the test plan, the QA organization shall define within the test plan the way to monitor the performance of test activities, to ensure the adherence to the test procedures, and that any deviations are properly documented and treated.		

ECSS-Q-ST-20_038163	5.6.4b	A
b. 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.		

ECSS-Q-ST-20_038164	5.6.4c	A
c. All testing activities related to critical characteristics as identified in the critical-items control programme shall be verified by QA.		

ECSS-Q-ST-20_038165	5.6.4d	A
d. Self-verification by the operators performing the test activities shall not be considered sufficient for critical characteristics.		

ECSS-Q-ST-20_038166	5.6.4e	A
e. Testing activities or results to be subject to QA verification shall be identified as such in the relevant test procedure.		

ECSS-Q-ST-20_038167	5.6.4f	A
f. Testing shall be subject to the requirements for the control of hazardous operations.		

NOTE Definition of hazardous operations is given in ECSS-Q-ST-40.

ECSS-Q-ST-20_038168	5.6.4g	M – End customer
g. Where safety of personnel is affected or damage to items or associated test equipment is possible, QA personnel shall have the authority to stop the test.		

4.2.6.5 Test reviews

ECSS-Q-ST-20_038169	5.6.5a	A
a. The Supplier shall ensure that reviews are performed before and after defined points during qualification or acceptance tests.		

NOTE 1 Test Reviews are defined in ECSS-E-ST-10-03.

NOTE 2 Reviews before tests are called Test Readiness Reviews and reviews after tests are called Post Test Reviews or Test Review Boards.

ECSS-Q-ST-20_038170	5.6.5b	A
b. The QA organization shall be represented in the formal boards established for the review of readiness for testing and testing accomplishment.		

ECSS-Q-ST-20_MOS-011	5.6.5c	N - esa
c. The Supplier shall implement the following test review process for qualification and acceptance tests at all levels: • Test Readiness Reviews (TRR), • Post Test Reviews (PTR), • Test Review Boards (TRB).		

ECSS-Q-ST-20_MOS-012	5.6.5d	N - esa
d. A Test Review (TRR, PTR or TRB) shall require an invitation with ten (10) working days notice before the event (and confirmed three (3) working days before the event) and shall require participation from the end customer, or their written agreement to proceed without participation from the end customer.		

NOTE 1 It is recognised that PTRs, and/or interim reviews, may be fluidic in nature due to schedule constraints, anomalies and/or unexpected events.

NOTE 2 The end customer will consider a reduced notice period for PTRs and/or interim test reviews commensurate with the schedule and the particular circumstances applicable to the test.

ECSS-Q-ST-20_MOS-013	5.6.5e	N - esa
e. The Test Readiness Review (TRR) shall address the points referenced in ECSS-E-ST-10-03C, clause 4.3.2.2. A project specific TRR agenda may be proposed and accepted with the end customer approval.		

ECSS-Q-ST-20_MOS-014	5.6.5f	N - esa
f. For large scale, system level tests (including STM, SM etc.) a separate, dedicated, Facility Readiness Review shall be undertaken and the findings reported to the TRR via a Facility Readiness Report as defined in ECSS-Q-ST-20-07C.		

ECSS-Q-ST-20_MOS-015	5.6.5g	N - esa
g. A Facility Readiness Review shall assess: • Handling Procedures; • Environmental control & cleanliness; • Facility calibration status; • Personnel suitability and qualification; • Safety procedures & processes for the test; • Facility test documentation; • Test authority & organisation.		

ECSS-Q-ST-20_MOS-016	5.6.5h	N - esa
h. A Post Test Review (PTR) shall be convened immediately after formal tests in accordance with ECSS-E-ST-10-03C, clause 4.3.2.3. A project specific PTR agenda may be proposed and accepted with the end customer approval.		

ECSS-Q-ST-20_MOS-017	5.6.5i	N - esa
i. A Test Review Board (TRB) shall be convened in accordance with ECSS-E-ST-10-03C, clause 4.3.2.4. A project specific TRB agenda may be proposed and accepted with the end customer approval.		

ECSS-Q-ST-20_MOS-018	5.6.5j	N - esa
j. The PTR and TRB may be combined when the analysis of the test data is available at the time of the PTR.		

NOTE When the PTR & TRB are held as a single, combined review, that review shall address the objectives of 5.6.5h and 5.6.5i above.

4.2.6.6 Quality Assurance for Test

ECSS-Q-ST-20_MOS-019	5.6.6	N - esa
a. All Qualification and Acceptance Tests shall be undertaken immediately after manufacture and/or integration at all levels – units, equipment, sub-system, instrument and at system level.		

NOTE This shall ensure the early identification of anomalies, failures or erroneous behaviour, which may then be rectified via the NCR process with the lowest potential impact to the overall schedule.

4.2.7 QA REQUIREMENTS FOR ACCEPTANCE AND DELIVERY

4.2.7.1 Acceptance and delivery process

ECSS-Q-ST-20_038171	5.7.1a	A
a. The Supplier shall establish a formal acceptance process for all deliverable items, at any contractual level, to ensure that conformance of the items to be delivered is fully assessed and documented.		

ECSS-Q-ST-20_038172	5.7.1b	A
b. The Supplier shall ensure that the preparation of the items for delivery and the physical delivery itself are performed in such a way that degradation is prevented.		

4.2.7.2 End item data package

ECSS-Q-ST-20_038173	5.7.2a	M - esa
a. The Supplier shall provide an End Item Data Pack (EIDP) for each deliverable end item to the Customer and to the Supplier from their own suppliers/sub-contractors in conformance with the DRD in Annex B (of ECSS-Q-ST-20C Rev. 1) AND including the following items: • (Un)Packing, Handling & Shipping Documentation; • Open and/or Deferred Work; • Temporary Installations (items to be removed at another contractual level); • Limited Life Items, including mate/de-mate log together with maximum allowed mate/de-mate cycles; • Maintenance Manual; • Interface Control Documentation & Drawings; • “Red Flag” Items List (items to be removed as part of the launch campaign); • Cleanliness Certificate; • All formal Qualification and/or Acceptance Test Reports; • Completed Verification Control Document; • Copies of approved & closed RFDs & RFWs (fully signed-off copies; unsigned copies may be included for interim purposes); • MIP Reports; • Photographs (also refer to section 5.7 herein); • As-Built / As-Designed Configuration Status; • Critical Items List completed to show mitigation, acceptance and close-out; • “CE - Declaration of Conformity” for applicable equipment; • Proof Load certificates for applicable equipment.		

NOTE 1 (Un)Packing, Handling & Shipping Documentation must also be available & accessible prior to unpacking activities.

NOTE 2 Shipping hazard warnings must be visible on the outside of the outer container (e.g. high magnetic field strength etc.).

NOTE 3 The delivered item must contain sufficient mate/de-mate margin to allow further planned activity of the connectors.

ECSS-Q-ST-20_038174	5.7.2b	A
b. The EIDP shall constitute the basis for formal acceptance reviews.		

ECSS-Q-ST-20_038175	5.7.2c	A
c. EIDPs shall be maintained and integrated into higher level EIDPs during subsystem or system integration and testing.		

ECSS-Q-ST-20_MOS-020	5.7.2d	N - esa
d. An EIDP shall not be considered as “Final Issue” until all documents contained therein have been fully approved and, where applicable, closed. For example, all deviations, waivers etc. must be fully approved at all relevant contractual levels and contained within the relevant EIDP.		

ECSS-Q-ST-20_MOS-021	5.7.2e	N - esa
e. The Supplier, and their suppliers and sub-contractors, shall provide the EIDP ten (10) working days before the formal Acceptance Review (i.e. Delivery Review Board) and confirmed three (3) working days before the review.		

ECSS-Q-ST-20_MOS-022	5.7.2f	N - esa
f. The Supplier shall provide a minimum of ten (10) EIDPs to the end customer in electronic form only, e.g. memory sticks, hard drives etc.		

ECSS-Q-ST-20_MOS-023	5.7.2g	N - esa
g. The Supplier shall ensure the EIDP is navigable from a contents page to all contained documentation (via hyper-links or other) and that all documentation is electronically searchable (unlocked .pdf for example) with the exception of scanned signature pages (limited to a single page per document).		

4.2.7.3 Delivery review board (DRB)

ECSS-Q-ST-20_038176	5.7.3a	A
a. The Supplier shall ensure that a DRB is convened prior to the delivery of equipment, separately assembled subsystems, test equipment or handling equipment for higher level activities.		

ECSS-Q-ST-20_038177	5.7.3b	A
b. The DRB functions at system level shall be fulfilled by the final acceptance review and chaired by the end customer		

ECSS-Q-ST-20_038178	5.7.3c	A
c. The DRB shall be composed, at least, of the following members: 1. Representatives of the receiving organization: (a) Project manager, or authorized representative, as chairman; (b) PA manager, or authorized representative; (c) Engineering or design manager, or authorized representative. 2. Submitting Supplier’s representatives: (a) Project manager, or authorized representative; (b) PA manager, or authorized representative; (c) Engineering or design manager, or authorized representative. 3. Higher level Customers’ representative(s), as observers (not required for separate subsystems).		

ECSS-Q-ST-20_038179	5.7.3d	A
d. If the ESA reserves the right to attend DRBs at any lower level as an observer, he shall be given due notice of such a DRB meeting.		

ECSS-Q-ST-20_038180	5.7.3e	A
e. The DRB shall be responsible for authorising the shipment of the items under acceptance, and certifying in writing that: 1. the items conform to the contractual requirements and to an approved design configuration; 2. the items are free from material and workmanship deficiencies; 3. all non-conformances are closed-out, or corresponding plans, compatible with the delivery, are accepted; 4. the relevant EIDP is complete and accurate.		

ECSS-Q-ST-20_038181	5.7.3f	A
f. Delivery shall only be authorized by the unanimous agreement of the DRB members.		

ECSS-Q-ST-20_038182	5.7.3g	M – End customer
g. For the delivery a certificate of conformity, in conformance with ECSS-Q-ST-20 / Annex D, shall be made available and signed by the PA Supplier or its representative.		

NOTE Certificate of Conformity is also known as Declaration of Conformity.

4.2.7.4 Preparation for delivery

4.2.7.4.1 Packaging

ECSS-Q-ST-20_038183	5.7.4.1a	M - esa
a. Detailed requirements of ECSS Q-ST-20-08 (NDPA 59) for packing, marking and labelling, and transportation shall apply.		

4.2.7.4.2 Marking and labelling

ECSS-Q-ST-20_REQ-030	-	N – End customer
a. The identification label shall be legible with unaided eye from 0.5m distance.		

ECSS-Q-ST-20_REQ-031	-	N – End
b. The identification label shall meet all the requirements applicable to the item.		

ECSS-Q-ST-20_REQ-032	-	N – End
An identification label shall be completed as per the template hereafter, and attached to the exterior packaging.		

<MetOp-SG>

Equipment Shipping Information

Shipping Information	
Courier	<Supplier to complete>
Tracking number	<Supplier to complete>
Air Waybill number	<Supplier to complete>
Expected delivery date	<Supplier to complete>
Requestor / Recipient	<AEnd Customer Representative>
Telephone number	< end Customer Representative Tel. No.>
Special Instructions (if any)	<Supplier to complete>
Equipment Identification	
Equipment Supplier	< End Customer to complete>
Equipment Name	< End Customer to complete>
Description of Equipment	< End Customer to complete>
End Customer PO Number	< End Customer to complete>
End Customer Part Number	< End Customer to complete>
Supplier Part Number	<Supplier to complete>
Supplier Serial number(s)	<Supplier to complete>
Quantity	<Supplier to complete>
Documentation	
DRB MoM	<Supplier to complete>
CoC Ref	<Supplier to complete>
EIDP	<Supplier to complete>
Packaging/Handling procedure	<Supplier to complete>
Logbook	<Supplier to complete>
User Manual	<Supplier to complete>
Export Control	
ITAR or Other Export Control Conditions (Y/N)	<Supplier to complete>
License No. or Exclusion Ref	<Supplier to complete>

PLEASE ATTACH THIS FORM TO OUTERMOST SHIPMENT PACKAGING ALLOWING IT TO BE CLEARLY VISIBLE BEFORE ANY UNPACKAGING

4.2.7.5 Delivery

4.2.7.5.1 Shipping control

ECSS-Q-ST-20_038185	5.7.5.1a	A
a. The Supplier shall ensure that the items to be shipped from his plant are inspected before release and found to be complete, adequately preserved and packaged, correctly marked and accompanied by all the required documentation.		

ECSS-Q-ST-20_038186	5.7.5.1b	A
b. Accompanying documentation shall include the EIDP and, attached to the outside of the shipping container, the handling and packing or unpacking procedure and any relevant safety procedures.		

4.2.8 QA REQUIREMENTS FOR GROUND SUPPORT EQUIPMENT (GSE)

ECSS-Q-ST-20_MOS-024	5.8a	N - esa
a. The Supplier shall define a quality assurance programme for Ground Support Equipment (GSE) items based on chapters 5.1 to 5.7 of ECSS-Q-ST-20C as tailored above.		

ECSS-Q-ST-20_038191	5.8.2a	M - ESA
b. The Supplier shall ensure that GSE software and interface items are configuration controlled from the point of delivery acceptance onwards.		

ECSS-Q-ST-20_038194	5.8.3.2a	M – End customer
c. The supplier and his lower level suppliers shall not deviate from their standard practices when these are already documented and recognized for similar items.		

ECSS-Q-ST-20_MOS-025	5.8.3.2b	N - esa
d. The Supplier shall ensure that GSE items that make direct contact with flight hardware are manufactured and made of materials that are flight standard.		

ECSS-Q-ST-20_038195	5.8.4.1a	M - esa
e. The acceptance data package shall include : • Interface definition; • Certificate of conformance to requirements; • Operations and maintenance documentation, including life limited items; • Declaration of Conformity (as per European Law).		

ECSS-Q-ST-20_038210	5.8.4.2a	M - esa
f. Acceptance shall be achieved through a review process; this may be via a simple inspection process if agreed between the Supplier and end customer.		

ECSS-Q-ST-20_MOS-026	5.8.4.2d	N - esa
g. As part of the Acceptance process, the Supplier shall ensure that all GSE complies with national and European law (e.g. CE labelling), and shall ensure that such equipment is certified and labelled accordingly.		

ECSS-Q-ST-20_038202	5.8.8a	A
h. The following requirements shall be tailored in accordance with the complexity and criticality of the GSE item: 1. traceability requirements in 5.2.5, and 2. metrology and calibration requirements in 5.2.6.		

ECSS-Q-ST-20_038203	5.8.9a	A
i. The Supplier shall ensure that maintenance activities are planned.		

ECSS-Q-ST-20_038204	5.8.9b	A
j. The Supplier shall ensure that maintenance demonstration is performed in order to prove that maintainability requirements are satisfied in the real operational environment.		

ECSS-Q-ST-20_MOS-027	5.8.10	N - esa
k. The Supplier shall ensure that GSE required for MetOp-SG systems is handled, stored, preserved and maintained, including calibration, in accordance with 5.2.7 of ECSS-Q-ST-20C Rev 1.		

ECSS-Q-ST-20_REQ-033	-	N – End customer
l. The GSE shall be designed and manufactured in compliance with safety, cleanliness and calibration requirements and shall be compatible with flight hardware.		

ECSS-Q-ST-20_REQ-034	-	N – End customer
m. Absence of any failure propagation from GSE to the flight hardware shall be demonstrated by analysis or test.		

4.2.9 OFF-THE-SHELF EQUIPMENTS

ECSS-Q-ST-20-10_MOS-001	-	N - esa
a. The requirements of ECSS-Q-ST-20-10C shall apply with the modifications listed in this chapter 4.2.9.		

ECSS-Q-ST-20-10_MOS-002	5.5d	N - esa
b. For each selected OTS Item, a dedicated Equipment Qualification Status Review (EQSR) shall be held to determine: • The category of the OTS item with respect to ECSS-E-10-02C, Table 5-1; • The necessary (delta) qualification for the OTS item to ensure compliance with the MetOp-SG Programme.		

ECSS-Q-ST-20-10_MOS-003	5.5e	N - esa
c. The Supplier shall invite the Customer to the EQSR at least ten (10) working before the review, providing all pertinent documentation, and shall be confirmed three (3) working days before the review.		

ECSS-Q-ST-20-10_MOS-004	5.5f	N - esa
d. If an OTS item is categorised as C or D as defined in ECSS-E-10-02C, Table 5-1, then the OTS item shall be submitted to the PDR and CDR design review process and the Qualification and Acceptance Review.		

ECSS-Q-ST-20-10_MOS-005	5.5g	N - esa
e. The Supplier shall document the results of the EQSR and the information reflected within the OTS item evaluation dossier.		

ECSS-Q-ST-20-10_MOS-006	5.6.2e	N - esa
f. The OTS item delta qualification programme shall be completed prior to the qualification review at the next higher level.		

5 DEPENDABILITY REQUIREMENTS (Q-ST-30)

5.1 DEPENDABILITY PROGRAMME

5.1.1 GENERAL

ECSS-Q-ST-30_041001	**4.1a**	**A**
a. The dependability assurance shall be implemented by means of a systematic process for specifying requirements for dependability and demonstrating that these requirements are achieved.		

ECSS-Q-ST-30_041002	**4.1b**	**A**
b. The dependability assurance process shall be in conformance with the dependability assurance programme plan for the project.		

5.1.2 ORGANIZATION

ECSS-Q-ST-30_041003	**4.2a**	**A**
a. The Supplier shall coordinate, implement and integrate the dependability programme management with the PA programme management.		

5.1.3 DEPENDABILITY PROGRAMME PLAN

ECSS-Q-ST-30_041004	**4.3a**	**A**
a. The Supplier shall develop, maintain and implement a dependability plan for all project phases in conformance with the DRD in ECSS-Q-ST-30 / Annex C.		

ECSS-Q-ST-30_041005	**4.3b**	**A**
b. The plan shall address the applicable requirements of this document.		

NOTE The plan can be included in the PA programme plan.

ECSS-Q-ST-30_041006	**4.3c**	**A**
c. The extent that dependability assurance is applied shall take account of the severity (as defined in requirement **ECSS-Q-ST-30_MOS-001** of chapter 5.2.3.2) of the consequences of failures.		

ECSS-Q-ST-30_041007	**4.3d**	**A**
d. The establishment and implementation of the dependability programme plan shall be considered in conjunction with the safety aspects of the programme.		

ECSS-Q-ST-30_041008	**4.3e**	**A**
e. The Supplier shall ensure that any potential conflict between dependability and safety requirements are managed.		

ECSS-Q-ST-30_041009	**4.3f**	**A**
f. Responsibilities for carrying out all dependability tasks within each phase of the lifecycle shall be defined.		

5.1.4 DEPENDABILITY RISK ASSESSMENT AND CONTROL

ECSS-Q-ST-30_041010	4.4a	A
a. As part of the risk management process implemented on the project, the Dependability engineer shall be responsible for identifying and reporting dependability associated risks .		

NOTE ECSS-M-ST-80 describes the risk management process.

ECSS-Q-ST-30_041011	4.4b	A
b. Dependability risk analysis reduction and control shall include the following steps: 1. identification and classification of undesirable events according to the severity of their consequences; 2. analysis of failure scenarios, determination of related failure modes, failure origins or causes; 3. classification of the criticality of the functions and associated products according to the severity of relevant failure consequences; 4. definition of actions and recommendations for detailed risk assessment, risk elimination, or risk reduction and control to an acceptable level; 5. status of risk reduction and risk acceptance; 6. implementation of risk reduction; 7. verification of risk reduction and assessment of residual risks.		

NOTE The process of risk identification and assessment implies both qualitative and quantitative approaches.

ECSS-Q-ST-30_041012	4.4c	A
c. Risk reduction measures that are proposed for dependability shall be assessed at system level in order to select the optimum solution to reduce the system level risk.		

NOTE This is for information, only applicable at system level.

5.1.5 DEPENDABILITY CRITICAL ITEMS

ECSS-Q-ST-30_041013	4.5a	A
a. Dependability critical items shall be identified by dependability analyses performed to support the risk reduction and control process performed on the project.		

NOTE The criteria for identifying dependability critical items are given in clause 6.5.

ECSS-Q-ST-30_041014	4.5b	A
b. Dependability critical items, as part of the Critical Items List, shall be subject to risk assessment and critical items control in conformance with ECSS-Q-ST-10-04.		

ECSS-Q-ST-30_041015	4.5c	A
c. The control measures shall include: 1. a review of all design, manufacturing and test documentation related to critical functions, critical items and procedures; 2. dependability representation on relevant Review Boards to ensure that the disposition takes account of their criticality level.		

ECSS-Q-ST-30_041016	4.5d	A
d. The dependability aspects shall be considered during the entire verification process for dependability critical items until closeout.		

5.1.6 DESIGN REVIEWS

ECSS-Q-ST-30_041017	4.6a	A
a. The Supplier shall ensure that all dependability data for a design review are presented to the end customer in accordance with the project review schedule.		

ECSS-Q-ST-30_041018	4.6b	A
b. All dependability data submitted shall indicate the design baseline and shall be coherent with all other supporting technical documentation.		

ECSS-Q-ST-30_041019	4.6c	A
c. All design changes shall be assessed for their impact on dependability and a reassessment of the dependability shall be performed		

5.1.7 DEPENDABILITY LESSONS LEARNT

ECSS-Q-ST-30_041020	4.7a	A
a. Dependability lessons learnt shall be collected during the project life cycle including operational and disposal phases.		

NOTE Dependability lessons learnt consider:

- *the impact of newly imposed requirements;*
- *assessment of all malfunctions, anomalies, deviations and waivers;*
- *effectiveness of strategies of the project;*
- *new dependability tools and methods that have been developed or demonstrated;*
- *effective versus ineffective verifications that have been performed.*

5.1.8 PROGRESS REPORTING

ECSS-Q-ST-30_041021	4.8a	A
a. The Supplier shall report dependability progress to the end customer as part of product assurance activities in conformance with ECSS-Q-ST-10.		

5.1.9 DOCUMENTATION

ECSS-Q-ST-30_041022	4.9a	A
a. The Supplier shall maintain all data used for the dependability programme.		

5.2 DEPENDABILITY ENGINEERING

5.2.1 INTEGRATION OF DEPENDABILITY IN THE PROJECT

ECSS-Q-ST-30_041023	5.1a	A
a. Dependability shall be integrated as part of the design process.		

ECSS-Q-ST-30_041024	5.1b	A
b. The dependability characteristics shall be traded off with other system attributes such as mass, size, cost and performance during the optimization of the design in all phases of the project.		

NOTE Dependability is an inherent characteristic of a system or product.

ECSS-Q-ST-30_041025	5.1c	A
c. Manufacture, assembly, integration, test and operations shall not degrade dependability attributes introduced into the design.		

5.2.2 DEPENDABILITY REQUIREMENTS IN TECHNICAL SPECIFICATION

ECSS-Q-ST-30_041026	5.2a	A
a. The dependability requirement specification shall be part of the overall project requirements.		

ECSS-Q-ST-30_041027	5.2b	A
b. Dependability requirements shall be apportioned, in a top-down process, to establish dependability requirements for lower level elements.		

ECSS-Q-ST-30_041028	5.2c	A
c. Dependability requirements shall be applied during the preparation and review of design and test specifications.		

ECSS-Q-ST-30_041029	5.2d	A
d. The dependability requirements shall be included into the technical specifications.		

NOTE The technical specifications typically include:

- *functional, operational and environmental requirements,*
- *test requirements including stress levels, test parameters, and accept or reject criteria,*
- *design performance margins, derating factors, quantitative dependability requirements, and qualitative dependability requirements (identification and classification of undesirable events), under specified environmental conditions,*
- *the identification of human factors and how they can influence dependability during the project lifecycle,*
- *the identification of external, internal and installation factors that can influence dependability during the project lifecycle,*
- *the degree of tolerance to hardware failures or software malfunctions,*
- *the detection, isolation, diagnosis, and recovery of the system from failures and its restoration to an acceptable state,*
- *the requirement for the prevention of failures crossing interfaces with unacceptable consequences,*
- *definition of the maintenance concept,*
- *maintenance tasks and requirements for special skills,*
- *requirements for preventive maintenance, special tools, and special test equipment,*
- *requirements for process and technology margin demonstration and qualification,*
- *requirement on sampling strategy in serial production and for periodical demonstration of qualification preservation.*

5.2.3 DEPENDABILITY DESIGN CRITERIA

5.2.3.1 General

ECSS-Q-ST-30_041030	5.3.1a	A
a. The identification of critical areas of design and the assessment of the severity of failure consequences shall be interpreted by the level at which the analysis is made.		

NOTE The Space System level can be broken down into Space Segment and Ground Segment where separate requirements can be provided. The Space Segment and Ground Segment can be further broken down, dependant on particular contractual requirements, into lower levels elements (e.g. subsystem, equipment…).

ECSS-Q-ST-30_041031	5.3.1b	A
b. The success criteria (sometimes referred to as “mission success criteria”) shall be defined at each level to be analysed.		

5.2.3.2 Consequences

ECSS-Q-ST-30_MOS-001	5.3.2f	N - esa
a. At Unit/Equipment/Instrument Level, the severity classification shall be assigned to each identified failure mode as: **1 - Catastrophic** • The failure effect is not confined to the unit/equipment/instrument and propagates. **2. Critical** • The failure effect is confined within the unit/equipment/instrument and impacts its functionality. **3. Major** • Minor internal unit failure. **4. Minor** • No effect on functionality.		

ECSS-Q-ST-30_041033	5.3.2b	A
b. Severity categories shall be assigned without consideration of existing compensating provisions to provide a qualitative measure of the worst potential consequences resulting from item failure.		

ECSS-Q-ST-30_041034	5.3.2c	A
c. For analyses lower than system level, the severity due to possible failure propagation shall be identified as level 1 for dependability.		

NOTE 1 For example, for analysis at subsystem, and equipment level.

NOTE 2 This requirement is only applicable at system level.

ECSS-Q-ST-30_041035	5.3.2d	A
d. The number identifying the severity category shall be followed by a suffix to indicate either redundancy (R) single point failures (SP) or safety hazards (SH).		

ECSS-Q-ST-30_041036	5.3.2e	M – End customer
e. An understanding to these criteria identified above in requirement **ECSS-Q-ST-30_MOS-001** of chapter 5.2.3.2 shall be agreed between end customer and Supplier.		

ECSS-Q-ST-30_MOS-002	5.3.2g	A
f. Safety Hazards identified within the FMEA shall be cross-referenced to the relevant Hazard Analysis and the cross-reference shown within the FMEA.		

5.2.3.3 Failure tolerance

ECSS-Q-ST-30_041037	5.3.3a	A
a. Failure tolerance requirements shall be defined in the performance specifications.		

ECSS-Q-ST-30_041038	5.3.3b	A
b. The verification of the failure tolerance shall address all failure modes whose severity of consequence is classified as catastrophic, critical and major.		

ECSS-Q-ST-30_REQ-001	5.3.3c	N – End customer
c. Single point failures of severity Category 1 (catastrophic), and Category 2 (critical) limited to equipments and units which implement nominal and redundant functions internally, that cannot be eliminated from the design with reasonable effort (or fault tolerance requirements which cannot be met) shall be summarised with a detailed rationale within the Critical Items list and shall be subject to end customer and ESA approval through Request for Deviation		

ECSS-Q-ST-30_MOS-004	5.3.3d	N - esa
d. Exceptions shall be submitted for end customer and ESA approval and shall be reflected in the MetOp-SG user manuals.		

NOTE Additional failure tolerance requirements may be defined by the Launch Authority or by the applicable safety regulations.

5.2.3.4 Design approach

ECSS-Q-ST-30_041039	5.3.4a	A
a. The Supplier shall confirm that reliability is built into the design using fault tolerance and design margins.		

ECSS-Q-ST-30_041040	5.3.4b	A
b. The Supplier shall analyse the failure characteristics of systems in order to identify areas of design weakness and propose corrective solutions.		

ECSS-Q-ST-30_041041	5.3.4c	A
c. In order to implement dependability aspects into the design, the following approaches shall apply: 1. functional design: (a) the preferred use of software designs or methods that have performed successfully in similar applications; (b) the implementation of failure tolerance; (c) the implementation of fault detection, isolation and recovery, allowing proper failure processing by dedicated flight and ground measures, and considering detection or reconfiguration times in relation with propagation times of events under worst case conditions; (d) the implementation of monitoring of the parameters that are essential for mission performance, considering the failure modes of the system in relation to the actual capability of the detection devices, and considering the acceptable environmental conditions to be maintained on the product. 2. physical design: (a) the application of proven design rules; (b) the selective use of designs that have performed successfully in the same intended mission environment; (c) the selection of parts having a quality level in accordance with project specification; (d) the use of EEE parts derating and stress margins for mechanical parts; (e) the use of design techniques for optimising redundancy (while keeping system design complexity as low as possible); (f) the assurance that built-in equipment can be inspected and tested; (g) the provision of accessibility to equipment.		

NOTE Functional design is intended to imply non-physical design which includes software.

5.2.4 CLASSIFICATION OF CRITICAL FUNCTIONS AND PRODUCTS

ECSS-Q-ST-30_041042	5.4a	A
a. During the preliminary design phase, the contractor shall classify functions, operations and products in accordance with their criticality level.		

ECSS-Q-ST-30_041043	5.4b	A
b. Classification shall be approved by the end customerS.		

ECSS-Q-ST-30_041044	5.4c	A
c. The criticality of functions (hardware and/or software) and operations shall be directly related to the severity of the consequences resulting from failure of the function as defined in requirement **ECSS-Q-ST- 30_MOS-001** of chapter 5.2.3.2.		

NOTE For example, a function whose failure induces a catastrophic consequence is required to be classified with the highest criticality level.

ECSS-Q-ST-30_041045	5.4d	A
d. The criticality of a product (hardware and software) shall be identified at the highest criticality of the functions associated to that product.		

ECSS-Q-ST-30_041046	5.4e	A
e. The classification shall be used to focus efforts on the most critical areas during the project phases.		

5.2.5 INVOLVEMENT IN TESTING PROCESS

ECSS-Q-ST-30_041047	5.5a	A
a. The Supplier shall ensure that dependability aspects are covered in all development, qualification and acceptance test planning and reviews, including the preparation of test specifications and procedures and the evaluation of test results.		

ECSS-Q-ST-30_041048	5.5b	A
b. The dependability discipline shall support: 1. definition of test characteristics and test objectives, 2. selection of measurement parameters, and 3. statistical evaluation of test results.		

5.2.6 INVOLVEMENT IN OPERATIONAL ASPECTS

ECSS-Q-ST-30_041049	5.6a	A
a. The Supplier shall ensure that dependability cognizant and qualified staff: 1. contribute to definition of operations manual and procedures, 2. review operations manual and procedures for verification of consistency with dependability analyses.		

ECSS-Q-ST-30_041050	5.6b	A
b. Procedures for operations shall be analysed to identify and assess the risks associated with operations, sequences and situations that can affect dependability performance.		

ECSS-Q-ST-30_041051	5.6c	A
c. The analyses mentioned in 5.6b shall take into account the technical and human environment, and verify that the procedures: 1. include dispositions to face abnormal situations and supply the necessary safeguard measures; 2. do not compromise equipment reliability; 3. are in accordance with established maintenance dispositions; 4. include dispositions to minimize failures due to human errors.		

5.2.7 DEPENDABILITY RECOMMENDATIONS

ECSS-Q-ST-30_041052	5.7a	A
a. The Supplier shall establish and maintain a system to track the dependability recommendations, in order to support the risk reduction process.		

NOTE *These recommendations are derived from the dependability analyses, and trade-off studies (typically during Phases A and B). The dependability recommendations can be tracked in combination with safety recommendations.*

ECSS-Q-ST-30_041053	5.7b	A
b. All recommendations from 5.7a shall be justified, documented and tracked.		

ECSS-Q-ST-30_041054	5.7c	A
c. Formal evidence of acceptance or rejection of the recommendation by the Supplier's management shall be provided.		

ECSS-Q-ST-30_041055	5.7d	A
d. An accepted dependability recommendation shall be implemented into the relevant corresponding documentation .		

NOTE *Example of corresponding documentation are: design documents, and operation manuals.*

5.3 DEPENDABILITY ANALYSES

5.3.1 IDENTIFICATION AND CLASSIFICATION OF UNDESIRABLE EVENTS

ECSS-Q-ST-30_041056	6.1a	A
a. The Supplier shall identify undesirable events that lead to the loss or degradation of product performances, together with their classification into categories related to the severity of their failures consequences (see requirement **ECSS-Q-ST-30_MOS-001** of chapter 5.2.3.2).		

ECSS-Q-ST-30_041057	6.1b	A
b. Preliminary identification and classification of undesirable events shall be determined from analysis of criteria for mission success, during conceptual and preliminary design phases.		

ECSS-Q-ST-30_041058	6.1c	A
c. All undesirable events, whose occurrence can jeopardize, compromise, or degrade the mission success shall be assessed at the highest product level (overall system including space and ground segments).		

ECSS-Q-ST-30_041059	6.1d	A
d. The undesirable events, at lower levels of the product tree, shall be the product failure effects which can induce the undesirable events identified for the highest product level.		

NOTE *For example, at space segment, ground segment, subsystem, and equipment level.*

ECSS-Q-ST-30_041060	6.1e	A
e. Identification and classification of undesirable events shall be finalised after assessment of failure scenarios (see clause 6.2).		

ECSS-Q-ST-30_REQ-002		N – End customer
f. Effects of Single Event Phenomenon shall be considered.		

5.3.2 ASSESSMENT OF FAILURE SCENARIOS

ECSS-Q-ST-30_041061	6.2a	A
a. The Supplier shall analyse the possible scenarios leading to the occurrence of undesirable events.		

ECSS-Q-ST-30_041062	6.2b	A
b. The Supplier shall identify failure modes, failure origins and causes, detailed failure effects leading to undesirable events.		

5.3.3 DEPENDABILITY ANALYSES AND THE PROJECT LIFE CYCLE

ECSS-Q-ST-30_041063	6.3a	A
a. Dependability analyses shall be performed on all space projects throughout the project life cycle to support the tasks and requirements specified in clause 5.2.		

ECSS-Q-ST-30_041064	6.3b	M – End
b. Dependability analyses shall be performed initially to contribute to the definition of the conceptual design and the product requirements.		

ECSS-Q-ST-30_041065	6.3c	A
c. The analyses shall be performed to support the conceptual, preliminary and detailed development and optimization of the design, including the testing phase that leads to design qualification.		

ECSS-Q-ST-30_041066	6.3d	A
d. Dependability analyses shall be implemented in order to: 1. ensure conformance to reliability, availability and maintainability requirements, and **2.** identify all potential failure modes and technical risks with respect to functional requirements that can lead to non-compliance to the dependability requirements**,** 3. provide inputs to risk assessment and risk reduction and their control measures in line with the risk management process implemented on the project.		

ECSS-Q-ST-30_041067	6.3e	A
e. The results of dependability analyses shall be incorporated into the design justification file in order to support improvements to the design.		

5.3.4 DEPENDABILITY ANALYSES - METHODS

5.3.4.1 General

ECSS-Q-ST-30_041068	6.4.1a	A
a. Dependability analyses shall be conducted on all levels of the space system and be performed in respect of the level that is being assessed i.e. System, Subsystem and Equipment levels.		

NOTE The main purpose of all dependability analyses is to improve the design by providing timely feedback to the designer, to reduce risks within the processes used to realize the products and to verify conformance to the specified dependability requirement.

ECSS-Q-ST-30_041069	6.4.1b	A
b. The analyses identified in clauses 6.4.2 to 6.4.4 shall be: 1. conducted as required by the contract, 2. tailored to match the generic requirements on each project, 3. taking into account the hardware, software and human functions comprising the system.		

NOTE As it is not possible to quantitatively assess the software functions, only a qualitative assessment can be made as the dependability of software is influenced by the software development process.

ECSS-Q-ST-30_041070	**6.4.1c**	**A**
c. A set of analyses selected from clauses 6.4.2 to 6.4.4 shall be defined as part of the contract requirement.		

NOTE The set of analysis is generally included in the Statement Of Work or in the Document Requirements List.

5.3.4.2 Reliability analyses

5.3.4.2.1 Reliability prediction

ECSS-Q-ST-30_041071	**6.4.2.1a**	**A**
a. Reliability prediction techniques shall be used with the following objectives: 1. to optimize the reliability of a design against competing constraints such as cost and mass, 2. to predict the in-service reliability of a product, 3. to provide failure probability data for purposes such as risk assessment.		

ECSS-Q-ST-30_041072	**6.4.2.1b**	**A**
b. The reliability data sources and methods used in reliability predictions shall be as specified by the end customer.		

ECSS-Q-ST-30_041073	**6.4.2.1c**	**A**
c. If the reliability data sources and methods are not specified by the end customer, the Supplier shall justify the selected data sources and methods used, for end customer approval.		

NOTE ECSS-Q-HB-30-08 is a guideline for the selection of reliability data sources and their use.

ECSS-Q-ST-30_041074	**6.4.2.1d**	**M – End customer**
d. Reliability models shall be prepared to support predictions and FMEA.		

ECSS-Q-ST-30_REQ-003	**-**	**N – End customer**
e. When the reliability prediction shows that the reliability target is not met, the item shall be identified as critical and incorporated within the risk management process for criticality reduction.		

5.3.4.2.2 FMEA

ECSS-Q-ST-30_041075	**6.4.2.2a**	**M - esa**
a. Failure Modes and Effects Analysis (FMEA) shall be performed on the functional and physical design (Functional FMEA and Product FMEA respectively).		

NOTE 1 Where FMECA is required by the ECSS, replace with FMEA.

NOTE 2 Reference ECSS-Q-ST-30-02C, clause 5.1a, Note 2.

ECSS-Q-ST-30_041076	**6.4.2.2b**	**M – End customer**
b. All potential failure modes shall be identified and classified according to the severity (FMEA) of their consequences.		

ECSS-Q-ST-30_041077	**6.4.2.2c**	**A**
c. Measures shall be proposed in the analysis and introduced in the product design and in the control of processes to render all such consequences acceptable to the project.		

ECSS-Q-ST-30_041078	6.4.2.2d	M – End customer
d. When any design or process changes are made, the FMEA shall be updated and the effects of new failure modes introduced by the changes shall be assessed.		

ECSS-Q-ST-30_041079	6.4.2.2e	M – End customer
e. Provisions for failure detection and recovery actions shall be identified as part of the FMEA.		

ECSS-Q-ST-30_041080	6.4.2.2f	M – End customer
f. The FMEA shall be used to support the verification of the reliability modelling, the reliability and safety analyses, maintainability analysis, logistic support activity, test and maintenance planning, and the Failure Detection, Isolation and Recovery (FDIR) policy.		

ECSS-Q-ST-30_041081	6.4.2.2g	M – End customer
g. As part of the FMEA, potential failure propagation shall be assessed.		

NOTE For FMEA refer to ECSS-Q-ST-30-02.

ECSS-Q-ST-30_REQ-004	-	N – End
h. The FMEA shall be delivered in an electronic form to be agreed with Airbus DS.		

ECSS-Q-ST-30_REQ-007	-	N – End
i. The FMEA shall be performed at component level. The FMEA report may be presented at component or functional level.		

ECSS-Q-ST-30_REQ-008	-	N – End
j. The component failure modes to be considered in FMEA shall be as per appendix J.		

ECSS-Q-ST-30_REQ-009	-	N – End
k. When FMEA report, as per DRL, is not presented at component level, the supplier shall support a review at its premises and be able to present and justify the analysis made at component level.		

5.3.4.2.3 Hardware-software interaction analysis (HSIA)

ECSS-Q-ST-30_041082	6.4.2.3a	A
a. HSIA shall be performed to ensure that the software reacts in an acceptable way to hardware failure.		

ECSS-Q-ST-30_041083	6.4.2.3b	A
b. HSIA shall be performed at the level of the technical specification of the software.		

NOTE HSIA can be included in the FMEA (refer to ECSS-Q-ST-30-02).

5.3.4.2.4 Contingency analysis

ECSS-Q-ST-30_041084	6.4.2.4a	A
a. Contingency analysis shall be performed in conformance with ECSS-Q-ST-30 / Annex D in order to: 1. identify the failure, identify the cause, control the effect and indicate how recovery of the mission integrity can be achieved 2. identify the methods of recovery of the nominal or degraded functionalities, with respect to project dependability policy.		

NOTE 1 For example, availability targets.

NOTE 2 The contingency analysis is typically a system level task.

NOTE 3 FMEA is an input to contingency analysis.

5.3.4.2.5 Fault tree analysis (FTA)

ECSS-Q-ST-30_041085	6.4.2.5a	A
a. A Fault Tree Analysis shall be performed to ensure that the design conforms to the failure tolerance requirements for combinations of failures.		

NOTE 1 ECSS-Q-ST-40-12 is a guideline for FTA

NOTE 2 The system Supplier performs FTA to identify possible event combinations leading to the undesirable end event (e.g. "loss of mission"). Subsystem Supplier provides input to this activity by establishing FTA at subsystem level with respect to the top events:

- *loss of function of the subsystem, and*
- *inadvertent activation of the subsystem function*

5.3.4.2.6 Common-cause analysis

ECSS-Q-ST-30_041086	6.4.2.6a	M – End customer
a. Common-cause analyses shall be included in the FMEA and shall address all the potential sources of failure propagation.		

NOTE An example of check list of generic common-cause parameters is provided in Annex L of ECSS-Q-ST-30C.

5.3.4.2.7 Worst case analysis (WCA)

ECSS-Q-ST-30_041087	6.4.2.7a	A
a. Worst case analysis shall be performed on electrical equipment in conformance with ECSS-Q-ST-30 / Annex J, to demonstrate that it performs within specification despite variations in its constituent part parameters and the imposed environment.		

ECSS-Q-ST-30_041088	6.4.2.7b	A
b. The WCA report shall contain all baseline information (assumptions, methods and techniques) used for the preparation of the analysis, the results obtained and a comparison of the specified parameters as derived from the specification of the equipment or module.		

ECSS-Q-ST-30_041089	6.4.2.7c	A
c. If not specified in the project requirement, the Supplier shall propose the component aging parameter drifts for end customer approval.		

NOTE 1 The document ECSS-Q-TM-30-12 is a source for component aging parameter drifts, but is to be complemented with others inputs as it does not cover exhaustively the EEE parts.

NOTE 2 ECSS-Q-HB-30-01 describes the WCA methodology.

5.3.4.2.8 Part stress analysis

ECSS-Q-ST-30_041090	6.4.2.8a	A
a. Part derating shall be implemented in conformance with ECSS-Q-ST-30-11 to assure that the stress levels applied to all EEE parts are within the limits.		

ECSS-Q-ST-30_041091	6.4.2.8b	A
b. Part stress analyses shall be performed at part level to verify that the derating rules have been implemented.		

ECSS-Q-ST-30_REQ-005	-	N – End customer
c. It shall be verified that the conditions of qualification of Surface Mount Technology per ECSS-Q-ST-70- 38 are covering the actual in flight conditions seen by the SMT joints in terms of thermal environment and number of cycles during lifetime of the mission.		

ECSS-Q-ST-30_REQ-006	-	N – End customer
d. The model used to perform this verification shall be submitted to end customer for approval		

5.3.4.2.9 Zonal analysis

ECSS-Q-ST-30_041092	6.4.2.9a	M – End customer
a. Zonal analysis shall be included in the FMEA and shall address all the potential sources of failure propagation due to physical implementation (eg. PCB, wires proximity, connectors…).		

5.3.4.2.10 Failure Detection Isolation and Recovery (FDIR) analysis

ECSS-Q-ST-30_041093	6.4.2.10a	A
a. FDIR analysis shall be performed at System level in conformance with ECSS-Q-ST-30 / Annex F, to ensure that the autonomy and failure tolerance requirements are fulfilled.		

NOTE ECSS-E-ST-70-11 provides the description of FDIR process.

5.3.4.3 Maintainability analyses

ECSS-Q-ST-30_041094	6.4.3a	A
a. Maintainability requirements shall be apportioned to set maintainability requirements for lower level products to conform to the maintenance concept and maintainability requirements of the system.		

NOTE only when maintenance (Ground segment) activities are required.

ECSS-Q-ST-30_041095	6.4.3b	A
b. Maintainability prediction shall be performed at system level in conformance with ECSS-Q-ST-30 / Annex H, and used as a design tool to assess and compare design alternatives with respect to specified maintainability quantitative requirements: 1. the time to diagnose (i.e. detect and isolate) item failures, 2. the time to remove and replace the defective item, 3. the time to return the system or subsystem to its nominal configuration and to perform the necessary checks, and 4. the item failure rates.		

NOTE only when maintenance (Ground segment) activities are required.

ECSS-Q-ST-30_041096	6.4.3c	A
c. Preventive maintenance analysis shall be performed at system level to determine the maintenance plan.		

NOTE Each preventive maintenance action is based on the results of the application of systematic decision logic approved by the end customer.

ECSS-Q-ST-30_041097	6.4.3d	A
d. The maintainability analysis shall identify maintainability critical items.		

NOTE Maintainability critical items include:

- *products that cannot be checked and tested after integration,*
- *limited-life products,*
- *products that do not meet, or cannot be validated as compliant to the maintainability requirements.*

5.3.4.4 Availability analysis

ECSS-Q-ST-30_041098	6.4.4a	A
a. The Supplier shall perform availability analysis or simulations in order to assess the availability of the system.		

NOTE The results are used to:

- *optimize the system concept with respect to design, operations and maintenance,*
- *verify conformance to availability requirements,*
- *provide inputs to estimate the overall cost of operating the system.*

ECSS-Q-ST-30_041099	6.4.4b	A
b. The Supplier shall perform an analysis of outages in order to supply input data for availability analysis.		

ECSS-Q-ST-30_041100	6.4.4c	A
c. The availability analysis output shall include a list of all potential outages identified (as defined in the project), their causes, probabilities of occurrence and duration.		

NOTE Instead of outage probabilities, failure rates associated with outages can be provided.

ECSS-Q-ST-30_041101	6.4.4d	A
d. The means of outage detection and the recovery methods shall be identified in the analysis.		

ECSS-Q-ST-30_041102	6.4.4e	A
e. The availability analysis shall be carried out at system level using the system reliability and maintainability models as well as the data from the outages.		

NOTE For availability analysis, refer to ECSS-Q-ST-30-09.

5.3.5 DEPENDABILITY CRITICAL ITEMS LIST

ECSS-Q-ST-30_041103	6.5a	A
a. The Dependability critical items identified by the dependability analyses shall be documented in conformance with ECSS-Q-ST-10-04.		

ECSS-Q-ST-30_041104	6.5b	A
b. Items identified as Single Point Failure with at least a failure consequence severity classified as catastrophic, critical or major, shall be included in the dependability critical items list.		

ECSS-Q-ST-30_041105	6.5c	A
c. Items that have a criticality number greater than or equal to 6 shall be included in the dependability critical items list in conformance with ECSS-Q-ST-30-02.		

ECSS-Q-ST-30_041106	6.5d	A
d. All items that have failure consequences classified as catastrophic shall be included in the dependability critical items list.		

ECSS-Q-ST-30_041107	6.5e	A
e. Products that cannot be checked and tested after integration, limited-life products, products that do not meet - or cannot be verified as meeting - applicable maintainability requirements, shall be included in the dependability critical items list.		

ECSS-Q-ST-30_041108	6.5f	A
f. The documentation for each dependability critical item shall include a justification for retention of that item and be subject to approval by end customer.		

NOTE Further criteria for the classification of dependability critical items can be specified by the end customer in line with the risk management policy defined on the project.

5.4 DEPENDABILITY TESTING, DEMONSTRATION AND DATA COLLECTION

5.4.1 RELIABILITY TESTING AND DEMONSTRATION

ECSS-Q-ST-30_041109	7.1a	A
a. Reliability testing and demonstration shall be performed according to the product specification and project requirements in order to: 1. validate failure modes and effects, 2. check failure tolerance, failure detection and recovery, 3. obtain statistical failure data to support predictions and risk assessment, 4. consolidate reliability assessments, 5. validate the capability of the hardware to operate with software or to be operated by a human being in accordance with the specifications, 6. demonstrate the reliability of critical items, and 7. validate or justify data bases used for theoretical demonstrations.		

5.4.2 AVAILABILITY TESTING AND DEMONSTRATION

ECSS-Q-ST-30_041110	7.2a	A
a. Availability testing and demonstration shall be performed according to the product specification and project requirements in order to validate or justify data bases used for theoretical demonstrations (duration of outages and probability of occurrence).		

5.4.3 MAINTAINABILITY DEMONSTRATION

ECSS-Q-ST-30_041111	7.3a	A
a. Maintainability demonstration shall be performed according to the product specification and project requirements by verification of the applicable maintainability requirements and by ensuring that preventive and corrective maintenance activities are successfully performed within the scope of the maintenance concept.		

ECSS-Q-ST-30_041112	7.3b	A
b. “The maintainability demonstration” shall verify the ability to: 1. detect, diagnose and isolate each faulty line replaceable unit or orbit replaceable unit; 2. remove and replace each line replaceable unit or orbit replaceable unit; 3. perform mission-essential repairs on units that are not intended to be replaced; 4. check that the product is fully functional after maintenance actions have been completed; 5. demonstrate that no safety hazard is introduced as a result of maintenance actions; 6. demonstrate that the maintenance operations can be performed within the applicable constraints, including the operations necessary to prepare a system during the launch campaign.		

NOTE 1 Example of such a constraints are time and volume or accessibility.

NOTE 2 Example of such operations are “remove-before-flight” items or replacement of batteries.

5.4.4 DEPENDABILITY DATA COLLECTION AND DEPENDABILITY PERFORMANCE MONITORING

ECSS-Q-ST-30_041113	7.4a	A
a. Dependability data as specified in the contract, shall be collected for a period agreed with the end customer from sources such as non-conformance and problem or failure reports, and maintenance		

NOTE Dependability data can be used for dependability performances monitoring through agreed or specified models.

6 SAFETY REQUIREMENTS (Q-ST-40)

6.1 SAFETY PRINCIPLES

6.1.1 OBJECTIVE

The objective of safety assurance is to ensure that all safety risks associated with the design, development, production and operations of space product are adequately identified, assessed, minimized, controlled and finally accepted through the implementation of a safety assurance programme.

6.1.2 POLICY

6.1.2.1 General

The ECSS safety policy is to:

- *ensure that space systems do not cause a hazard to, in order of priority:*
  - *human life,*
  - *the environment,*
  - *public and private property (including launch facilities),*
  - *spacecraft and launcher,*
  - *ground support equipment and facilities,*
- *determine and evaluate the safety risks associated with project activities,*
- *minimize safety risks in a technically effective and cost effective manner,*
- *ensure adequate verification of safety control measures.*

6.1.2.2 Implementation

The ECSS safety policy is implemented by applying a safety programme which ensures that:

- *safety is designed into the system,*
- *safety controls are adequately implemented in the verification plan,*
- *safety requirements including launch centre safety regulations are met,*
- *hazards are identified, and eliminated or, where this is not possible, minimized, ranked and controlled in accordance with project objectives in a manner acceptable to the end customer and to the safety organisations involved in the implementation of the mission.*

6.1.3 SAFETY PROGRAMME

The safety programme comprises the:

- *identification and control of all safety related risks with respect to the design, development and operations of space products,*
- *assessment of the risks based on qualitative and quantitative analysis as appropriate,*
- *application of a hazard reduction precedence and of control measures of the residual risks.*

6.2 SAFETY PROGRAMME

6.2.1 SCOPE

ECSS-Q-ST-40_044001	5.1a	M - esa
a. The Supplier shall establish and maintain a safety programme to ensure conformance with project safety policy and requirements in order to protect: • Ground personnel, • The launch vehicle (including other launcher payloads), • Ground support equipment, • Public and private properties, • The environment from hazards associated with the MetOp-SG instrument hardware/software and operations.		

ECSS-Q-ST-40_044002	5.1b	A
b. The safety programme shall establish a safety management system to implement provisions of this Standard - commensurate with the programme requirements and tailored by the end customer.		

NOTE 1 For tailoring, refer to clause 1.

NOTE 2 The system safety programme requirements are subject to tailoring, without diminishing the intent to protect flight and ground personnel, the launch vehicle, associated payloads, ground support equipment, the general public, public and private property, the space system and associated segments and the environment from hazards associated with space systems.

NOTE 3 As support to tailoring, informative ECSS-Q-ST-40 / Annex F provides a guideline for determining the applicability of this standard depending on the type of project.

ECSS-Q-ST-40_MOS-001	5.1c	N - esa
c. All ground equipment shall be 'CE' marked and supplied with a supporting 'Declaration of Conformity' and User Manual detailing all safety warnings.		

NOTE Details can be found in Annex G of ECSS-Q-ST-40C.

ECSS-Q-ST-40_REQ-001	-	N – End customer
d. The Supplier shall deliver the documentation requested by the launch authorities' safety requirements for LAUNCHERS, and the applicable national and international safety regulations for manufacturing, integration, testing, handling and transportation.		

6.2.2 SAFETY PROGRAMME PLAN

ECSS-Q-ST-40_044003	5.2a	M - esa
a. The Supplier shall establish and maintain a safety programme plan in conformance with the DRD in ECSS-Q-ST-40 / Annex B as part of the overall PA plan.		

ECSS-Q-ST-40_044004	5.2b	A
b. The Supplier shall cover, in his safety programme plan, the safety tasks for the project phases in conformance with 5.7.1.		

6.2.3 CONFORMANCE

ECSS-Q-ST-40_044005	5.3a	A
a. The Supplier shall comply with all applicable national or international safety regulations.		

ECSS-Q-ST-40_044006	5.3b	A
b. The launch site safety regulations and rules shall be applied.		

ECSS-Q-ST-40_044007	5.3c	A
c. The implementation of safety requirements shall not be compromised by other requirements.		

NOTE For example: security requirements.

6.2.4 SAFETY ORGANIZATION

6.2.4.1 Safety manager

ECSS-Q-ST-40_044008	5.4.1a	A
a. Each Supplier shall appoint a safety manager who has appropriate training or experience.		

ECSS-Q-ST-40_044009	5.4.1b	A
b. The safety manager shall have organisational authority and independence to: 1. establish and maintain a safety programme in accordance with the project safety requirements, 2. manage all safety assurance aspects of the design of the system (including software) and its operation in accordance with the Safety Plan, 3. coordinate the interfaces: (a) with the relevant bodies involved in the project in accordance with the safety plan, (b) with the safety launcher authority.		

NOTE Depending on the project safety criticality, the safety manager can be combined with other functions (e.g. PA manager) when agreed with the end customer.

6.2.4.2 Safety manager access and authority

6.2.4.2.1 Access

ECSS-Q-ST-40_044010	5.4.2.1a	A
a. The safety manager shall: 1. have the right of access to safety-related data relevant to project safety in conformance with ECSS-M-ST-40, 2. have unimpeded access to any management level without organizational constraint on any aspect of project safety.		

6.2.4.2.2 Authority

ECSS-Q-ST-40_044011	5.4.2.2a	A
a. The safety manager or safety relevant authority shall have the authority to: 1. reject any project document, or to stop any project activity that does not conform to approved safety requirements or procedures, 2. interrupt hazardous operations when it becomes clear by the Safety Manager that the operation does not conform to the agreed measures defined in the corresponding hazard report and derived approved hazard procedure.		

6.2.4.3 Safety audits

ECSS-Q-ST-40_044012	5.4.3a	A
a. The Supplier shall perform safety audits or reviews to verify compliance to project safety policy and requirements.		

ECSS-Q-ST-40_044013	5.4.3b	A
b. The safety audits shall be in accordance with ECSS-M-ST-10 and ECSS-Q-ST-10.		

NOTE The safety audits can be part of the project audits.

ECSS-Q-ST-40_044014	5.4.3c	A
c. End customer shall be informed of the audit schedule.		

6.2.4.4 Approval of documentation

ECSS-Q-ST-40_044015	5.4.4a	A
a. Documentation related to safety shall be approved by the safety manager upon his verification of completeness, compliance with stated safety requirements and formal closeout of open safety verification items (as defined and agreed during safety audits and reviews).		

6.2.4.5 Approval of hazardous operations

ECSS-Q-ST-40_044016	5.4.5a	A
a. The safety manager (or a designated representative) shall have concluded the review of, and approved, any hazardous operation before it is executed.		

6.2.4.6 Representation on boards

ECSS-Q-ST-40_044017	5.4.6a	A
a. The safety manager or designated delegate shall be represented at configuration control boards (CCBs), non-conformance review boards (NRBs), test review board (TRBs), and at qualification, and acceptance reviews, where safety requirements and safety-critical functions are involved.		

ECSS-Q-ST-40_044018	5.4.6b	A
b. The safety function shall be further represented at all boards dealing with health matters where exposure or endurance limits are defined for flight and ground crews.		

6.2.4.7 Safety approval authority

ECSS-Q-ST-40_044019	5.4.7a	A
a. The safety approval authority shall: 1. review and disposes the safety data submittals, 2. approve the close-out of hazards, 3. decide on deviations and waivers, and finally 4. accept the statement of safety compliance.		

6.2.5 SAFETY RISK ASSESSMENT AND CONTROL

ECSS-Q-ST-40_044020	5.5a	A
a. The safety risk identification, reduction and control shall be part of the project's risk management process as specified in ECSS-M-ST-80.		

ECSS-Q-ST-40_044021	5.5b	A
b. Safety risk identification, reduction and control shall be a continuous and iterative process throughout the project life cycle, encompassing 1. allocation of safety requirements; 2. hazard and safety risk identification; 3. evaluation (including categorisation) of consequence severity; 4. hazard and safety risk reduction and control; 5. close out and acceptance of residual risk.		

ECSS-Q-ST-40_044022	5.5c	A
c. For the identification of hazards and associated safety risks, consideration shall be given to past experience, studies, ground and flight tests, reviews, the industrial process as well as the operational use.		

6.2.6 SAFETY CRITICAL ITEMS

ECSS-Q-ST-40_044023	5.6a	A
a. The safety critical items shall be part of the project's overall critical items control programme as specified in ECSS-Q-ST-10-04.		

ECSS-Q-ST-40_REQ-002	-	N – End customer
b. A Safety Critical Items List shall be established and maintained. Safety critical items are: • Functions that if lost or degraded, or through incorrect or inadvertent operation, result in a catastrophic or critical hazard consequence, • Hardware, software, firmware items or procedures which support a safety critical function and which do not comply to the applicable safety requirements or which cannot be verified as complying with those requirements.		

ECSS-Q-ST-40_REQ-003	-	N – End customer
c. Each retained safety Critical Item shall be supported with a justification for retention subject to ESA / launcher authorities approval.		

6.2.7 PROJECT PHASES AND SAFETY REVIEW CYCLE

6.2.7.1 Safety program tasks and reviews

6.2.7.1.1 Mission analysis/Needs identification - Phase 0

ECSS-Q-ST-40_044024	5.7.1.1a	A
a. Safety analysis shall support the identification of sources of safety risk as well as the performance of preliminary trade-off analyses between alternative system concepts.		

ECSS-Q-ST-40_REQ-004	-	N – End customer
b. The safety analysis shall integrate Ground Support Equipment as part of the analysed system.		

NOTE These tasks should also serve as a guideline for other space programmes.

6.2.7.1.2 Feasibility - Phase A

ECSS-Q-ST-40_044026	5.7.1.2a	A
a. Safety analysis shall support trade-off analyses in arriving at the concept that has acceptable safety risk considering the project and mission constraints.		

ECSS-Q-ST-40_044027	5.7.1.2b	A
b. The design technology selected and the operational concept to be implemented shall be selected based on the analysis data for the safest system architecture to eliminate or reduce hazards to acceptable levels.		

6.2.7.1.3 Preliminary definition - Phase B

ECSS-Q-ST-40_044029	5.7.1.3a	A
a. The safety analysis shall support a continued and more detailed safety optimization of the system design and operations and the identification of technical safety requirements and their applicability.		

ECSS-Q-ST-40_044030	5.7.1.3b	A
b. The analysis shall also provide inputs to safety risk assessment in support of safety risk evaluation, the identification of risk contributors in the design and in the operational concept.		

6.2.7.1.4 Detailed definition, production and qualification testing - Phase C/D

ECSS-Q-ST-40_044032	5.7.1.4a	A
a. Safety analysis shall support detailed design, production, qualification, testing.		

ECSS-Q-ST-40_044033	5.7.1.4b	A
b. Safety analysis shall also support operational safety optimization, safety requirements implementation evaluation, risk reduction verification, and hazard and risk acceptance.		

ECSS-Q-ST-40_044034	5.7.1.4c	A
c. Analysis of operations shall also support the identification of emergency and contingency response planning and training requirements, and the development of procedures.		

6.2.7.2 Progress meetings

ECSS-Q-ST-40_044042	5.7.2a	A
a. The Supplier shall hold regular safety status and progress meetings with end customer and his lower tier Suppliers as part of the project progress meetings as specified in ECSS-M-ST-10.		

ECSS-Q-ST-40_044043	5.7.2b	A
b. The relevant end customer and Supplier specialists shall attend the meetings.		

6.2.7.3 Safety reviews

ECSS-Q-ST-40_044044	5.7.3a	A
a. The customer shall define, conduct and chair the safety reviews to ensure satisfactory implementation of safety programme and technical safety requirements.		

NOTE A Supplier is considered as a Customer vis-à-vis its lower tier Suppliers (as defined in ECSS-S-ST-00).

ECSS-Q-ST-40_044045	5.7.3b	A
b. The Supplier shall support safety reviews by end customer and the relevant safety approval authority, as specified in the relevant review plans.		

ECSS-Q-ST-40_044046	5.7.3c	A
c. Each Supplier participating in a safety review shall prepare, and submit for review, the safety data package.		

ECSS-Q-ST-40_044047	5.7.3d	A
d. Safety reviews shall be performed, and the review objectives achieved, in conformance with clause 5.7.1.		

6.2.8 SAFETY COMPLIANCE DEMONSTRATION

ECSS-Q-ST-40_044048	5.8a	M – End customer
a.The Supplier shall demonstrate safety compliance by submission of a safety assessment report and hazardous items list for flight hardware and a declaration of conformity to applicable safety legislation for non-flight hardware.		

ECSS-Q-ST-40_044049	5.8b	A
b. The Supplier shall include in his statement of compliance a statement that open verifications are followed up in the safety verification tracking log (SVTL), as defined in clause 8.5.1, and do not affect further safe processing.		

6.2.9 SAFETY TRAINING

6.2.9.1 General

ECSS-Q-ST-40_044051	5.9.1a	A
a. Safety training shall be part of the overall training in accordance with ECSS-Q-ST-20.		

ECSS-Q-ST-40_044052	5.9.1b	A
b. All safety related training of any personnel working - permanently or occasionally - with system elements that can have hazardous properties shall have three major aspects: 1. general awareness briefings on safety measures to be taken at a given location or working environment; 2. basic technical training in the required safety techniques and skills which is a prerequisite to fulfil the job function under consideration; *NOTE : For example: inspection, test, maintenance or integration.* 3. product specific training that focuses on the hazards related to the specific system element.		

6.2.9.2 Product specific training

ECSS-Q-ST-40_044053	5.9.2a	A
a. The Supplier shall identify the need for product specific safety training and implement the corresponding safety training programme for all relevant parties.		

6.2.9.3 General awareness briefings

ECSS-Q-ST-40_044056	5.9.3a	A
a. All personnel accessing the area where the product is processed shall participate previously in the general safety awareness briefing.		

6.2.9.4 Basic technical training

ECSS-Q-ST-40_044057	5.9.4a	A
a. The Supplier shall provide basic technical training to all project engineering and safety personnel working with hazardous products.		

6.2.9.5 Training records

ECSS-Q-ST-40_044058	5.9.5a	A
a. The Supplier shall maintain records of personnel having received safety training in accordance with ECSS-Q-ST-20.		

6.2.10 ACCIDENT-INCIDENT REPORTING AND INVESTIGATION

ECSS-Q-ST-40_044059	5.10a	A
a. The Supplier shall report to the end customer all accidents and incidents occurred during project activities under the control of the Supplier or his lower tier Suppliers that affect the system element.		

ECSS-Q-ST-40_044060	5.10b	A
b. The Supplier shall support - at request - project related accident and incident investigations that occur outside of the Supplier's control or facility.		

ECSS-Q-ST-40_044061	5.10c	A
c. The Supplier shall coordinate the investigation activities in cooperation with other Supplier functional departments and lower tier Suppliers.		

ECSS-Q-ST-40_044062	5.10d	A
d. The accident or incident investigation report shall be formally closed by the Supplier upon approval by the end customer.		

ECSS-Q-ST-40_044063	5.10e	A
e. If the conclusion of the assessment is that the accident-incident has had an effect on the project, i.e. the safety of the product or its operation, the organisations safety representative shall be informed.		

ECSS-Q-ST-40_044064	5.10f	A
f. In case of 5.10e, the accident-incident report shall become part of the project's safety data and is documented in the safety data package.		

6.2.11 SAFETY DOCUMENTATION

6.2.11.1 General

ECSS-Q-ST-40_044065	5.11.1a	A
a. The Supplier shall maintain, as part of the project documentation, all safety-related data to support reviews and safety compliance demonstration.		

ECSS-Q-ST-40_044066	5.11.1b	A
b. End customer shall be given access to this data on request during audits, safety reviews and meetings held at the Supplier's premises in accordance with ECSS-M-ST-40.		

6.2.11.2 Safety data package

ECSS-Q-ST-40_044067	5.11.2a	A
a. The Supplier shall submit a Safety Data Package (SDP) to support reviews.		

NOTE This can be a stand-alone package or be integrated into the overall data package if the safety review is part of an overall project review.

ECSS-Q-ST-40_044068	5.11.2b	A
b. The safety data package shall contain at least the following safety related documentation: 1. Safety analysis report (in accordance with ECSS-Q-ST-40 / Annex D); 2. Supporting analysis (if applicable); 3. Safety risk assessment (if applicable); 4. Hazardous ground operations list and procedures; 5. Safety verification tracking log (SVTL, in accordance with ECSS-Q-ST-40 / Annex C).		

ECSS-Q-ST-40_044069	5.11.2c	A
c. The contents of the safety data packages for the planned safety reviews of a project or programme shall be specified by the Safety Approval Authority to assure they support the objectives of the safety reviews for which they are delivered (in conformance with clause 5.7.2).		

ECSS-Q-ST-40_044070	5.11.2d	A
d. The Supplier shall use the actual configuration baseline, as defined by ECSS-M-ST-40, as the design and operational baseline that is the subject of the safety data package.		

ECSS-Q-ST-40_044071	5.11.2e	A
e. The supplier shall integrate safety data related to the various subsystems or equipment that makes up the system into the safety data package that is presented at the review.		

ECSS-Q-ST-40_044072	5.11.2f	A
f. All safety data shall be traceable from the safety data package and available for review.		

6.2.11.3 Safety deviations and waivers

6.2.11.3.1 Request for deviation or waiver

ECSS-Q-ST-40_044073	5.11.3.1a	A
a. Safety requirements that cannot be met shall be identified as specified in ECSS-M-ST-40.		

ECSS-Q-ST-40_044074	5.11.3.1b	A
b. A request for deviation or waiver shall be generated and tracked according to the requirements of ECSS-M-ST-40.		

6.2.11.3.2 Assessment of deviation or waiver

ECSS-Q-ST-40_044075	5.11.3.2a	A
a. All RFD/RFW shall be assessed in order to identify those which impact safety.		

ECSS-Q-ST-40_044076	5.11.3.2b	A
b. The accumulated deviations and waivers that affect safety shall be assessed to ensure that the effects of individual deviations do not invalidate the rationale used for the acceptance of other deviations.		

6.2.11.3.3 Acceptance by the safety approval authority

ECSS-Q-ST-40_044077	5.11.3.3a	A
a. Safety deviations and waivers shall be subject to safety approval authority acceptance.		

6.2.11.3.4 Review and disposition

ECSS-Q-ST-40_044078	5.11.3.4a	A
a. Deviations and waivers that affect project safety requirements or safety-critical functions which the Supplier considers acceptable shall be subject of review and disposition by end customer S and the safety approval authority.		

6.2.11.4 Safety lessons learned

ECSS-Q-ST-40_044079	5.11.4a	A
a. Safety lessons learned shall be collected during the project and used during the project, as far as they are relevant.		

NOTE Safety lessons learned should consider as a minimum:

- *the impact of newly imposed requirements;*
- *assessment of all malfunctions, accidents, anomalies, deviations and waivers;*
- *effectiveness of safety strategies of the project;*
- *new safety tools and methods that have been developed or demonstrated;*
- *effective versus ineffective verifications that have been performed;*
- *changes proposed to safety policy, strategy or technical requirements with rationale.*

ECSS-Q-ST-40_044080	5.11.4b	A
b. The safety lessons learned information shall be made available to end customer and Suppliers, particularly to project and safety managers as well as design and safety engineers upon request for use on other projects.		

6.2.11.5 Documentation of safety critical items

ECSS-Q-ST-40_044081	5.11.5a	A
a. The safety critical items identified by the safety analysis shall be documented in accordance with ECSS-Q-ST-10-04.		

6.3 SAFETY ENGINEERING

6.3.1 OVERVIEW

Safety is an integral part of all project product assurance and engineering activities. It is not a stand-alone activity. The quality of all safety engineering related work is based on assurance that the system is designed, qualified, manufactured, and operated in accordance with the ECSS product assurance requirements.

Safety engineering consists of safety analysis, management of hazard and risk reduction processes, hazard and risk potential assessment, design assurance, and hazard and risk control activities.

Safety engineering makes use of lessons learned throughout the programme.

6.3.2 SAFETY REQUIREMENTS IDENTIFICATION AND TRACEABILITY

ECSS-Q-ST-40_044082	6.2a	A
a. Safety requirements shall be identified and traced from the system level into the design and then allocated to the lower levels.		

ECSS-Q-ST-40_044083	6.2b	A
b. When specified by the project, the identified safety requirements shall be justified in the design and presented in an appropriate document.		

6.3.3 SAFETY DESIGN OBJECTIVES

6.3.3.1 Safety policy and principles

The order of priority with respect to safety, which is part of ECSS policy, is presented in clause 6.1 "Safety Principles".

6.3.3.2 Design selection

ECSS-Q-ST-40_044084	6.3.2a	A
a. Appropriate design features shall be selected to ensure inherent safety.		

NOTE Such features are fail safe design solutions, damage control, containment and isolation of potential hazards.

6.3.3.3 Hazard reduction precedence

6.3.3.3.1 General

ECSS-Q-ST-40_044085	6.3.3.1a	A
a. The following sequence of activities shall be applied to identified hazards, hazardous conditions, and functions whose failures have hazardous consequences: 1. Hazard elimination 2. Hazard minimization 3. Hazard control.		

6.3.3.3.2 Hazard elimination

ECSS-Q-ST-40_044086	6.3.3.2a	A
a. Hazards and hazardous conditions shall, consistent with the project constraints and mission objectives, be eliminated from the design and operational concepts by the selection of design technology, architecture and operational characteristics.		

6.3.3.3.3 Hazard minimization

ECSS-Q-ST-40_044087	6.3.3.3a	A
a. Where hazards and hazardous conditions are not eliminated, the severity of the associated hazardous events and consequences shall, consistent with the project constraints and mission objectives, be reduced to an accepted level through the change of the design architecture, technologies, and operational characteristics allowing the substitution of those hazards by other hazards with lower potential threat.		

6.3.3.3.4 Hazard control

6.3.3.3.4.1 General

ECSS-Q-ST-40_044088	6.3.3.4.1a	A
a. Hazards that have not been eliminated and have been subjected to hazard minimization (as defined in 6.3.3.3a) shall be controlled through preventative or mitigation measures, associated to hazard scenarios, which are introduced into the system design and operation to avoid the events or to interrupt their propagation to consequences.		

ECSS-Q-ST-40_044089	6.3.3.4.1b	A
b. The following measures shall be applied in order of precedence: 1. Design selection 2. Automatic safety devices 3. Warning devices 4. Special procedures.		

6.3.3.3.4.2 Design selection - Failure tolerance design

ECSS-Q-ST-40_044090	6.3.3.4.2a	A
a. Failure tolerance is the basic safety requirement that shall be used to control most hazards.		

ECSS-Q-ST-40_044091	6.3.3.4.2b	A
b. The design shall tolerate a minimum number of credible failures and/or operator errors determined by the hazard consequence.		

ECSS-Q-ST-40_044092	6.3.3.4.2c	A
c. The Supplier shall establish the list of failures to be considered as "non credible" for end customer approval as early as possible in development.		

6.3.3.3.4.3 Design selection - Design for minimum risk

ECSS-Q-ST-40_044093	6.3.3.4.3a	A
a. Hazard which cannot be controlled by compliance to failure tolerance shall be reduced to an accepted level by compliance with specific safety related properties and characteristics of the design.		

NOTE Examples are: structures, pressures vessels, mechanisms, material compatibility, flammability.

6.3.3.3.4.4 Automatic safety devices

ECSS-Q-ST-40_044094	6.3.3.4.4a	A
a. Hazards that are not eliminated through design selection shall be reduced and made controllable through the use of automatic safety devices as part of the system, subsystem or equipment.		

ECSS-Q-ST-40_044095	6.3.3.4.4b	A
b. The safety devices, specified in 6.3.3.4.4a, shall not be dependant on human performance.		

ECSS-Q-ST-40_044096	6.3.3.4.4c	A
c. Use of software in automatic safety devices should be avoided.		

ECSS-Q-ST-40_044097	6.3.3.4.4d	A
d. If software is used in automatic safety devices, justification shall be provided.		

6.3.3.3.4.5 Warning devices

ECSS-Q-ST-40_044098	6.3.3.4.5a	A
a. When it is not practical to preclude the existence or occurrence of known hazards or to use automatic safety devices, devices shall be used for the timely detection of the condition and the generation of a warning signal.		

ECSS-Q-ST-40_044099	6.3.3.4.5b	A
b. This shall be coupled with emergency controls of corrective action for operators to safe or shut down the affected subsystem.		

6.3.3.3.4.6 Special procedures

ECSS-Q-ST-40_044100	6.3.3.4.6a	A
a. When it is not possible to reduce the magnitude of a hazard through the design, the use of safety devices or the use of warning devices, special procedures shall be developed to control the hazardous conditions for the enhancement of safety.		

ECSS-Q-ST-40_044101	6.3.3.4.6b	A
b. Special procedures shall be verified by test and appropriate training be provided for personnel.		

ECSS-Q-ST-40_044102	6.3.3.4.6c	A
c. Hazard detection shall be implemented if alternative means cannot be used.		

ECSS-Q-ST-40_044103	6.3.3.4.6d	A
d. To permit the use of real time monitoring, hazard detection and safing systems for hazard control, the availability of sufficient response time shall be verified and corresponding safing procedures be developed and verified and the personnel trained.		

NOTE Special procedures are the least effective of the hazard control and risk reduction measures available. They can include emergency and contingency procedures, procedural constraints, or the application of a controlled maintenance programme.

6.3.3.4 Environmental compatibility

ECSS-Q-ST-40_044104	6.3.4a	A
a. The system design shall meet the safety requirements under the worst-case natural and induced environments defined for the project.		

ECSS-Q-ST-40_044105	6.3.4b	A
b. Design and performance margins shall be established and applied for worst-case combinations of induced and natural environments and operating characteristics.		

6.3.3.5 External services

ECSS-Q-ST-40_044106	6.3.5a	A
a. Loss, malfunctioning, and sudden restoration of external services shall be defined as an input to the development phase.		

ECSS-Q-ST-40_044107	6.3.5b	A
b. The system design shall be defined so that catastrophic or critical consequences are not induced by loss, malfunctioning, and sudden restoration of external services.		

6.3.3.6 Space debris mitigation

ECSS-Q-ST-40_044124	6.3.7a	A
a. The design and the operational characteristics of the space system shall be such that the generation of space debris is minimized consistent with the project constraints and mission objectives.		

6.3.3.7 Access

ECSS-Q-ST-40_044137	6.3.11a	M – End customer
a. System shall be designed such that any required access to system elements during ground operations can be accomplished with an accepted level of risk to personnel.		

6.3.4 SAFETY RISK REDUCTION AND CONTROL

6.3.4.1 Severity of hazardous event

ECSS-Q-ST-40_044138	6.4.1a	M – End customer
a. The severity of potential consequences of identified hazardous events shall be categorized as shown in table 6-1 hereafter		

Severity	Level	Consequences
Catastrophic	1	• Loss of life or life-threatening • Permanently disabling injury or occupational illness • Loss of launcher and or launch site facilities • Loss of public or private property • Severe detrimental environmental effects
Critical	2	• Temporary disabling but no-life-threatening injury, or temporary occupational illness • Major damage to private or public property, or ground facilities • Major detrimental environment effects

ECSS-Q-ST-40_044139	6.4.1b	M – End customer
b. An understanding of the criteria defined in requirement **ECSS-Q-ST-30_MOS-001** of chapter 5.2.3.2 shall be agreed between end customer and Supplier.		

6.3.4.2 Failure tolerance requirements

6.3.4.2.1 Basic requirements

ECSS-Q-ST-40_044146	6.4.2.1a	A
a. Failure tolerance shall be the basic safety requirement used to control hazards.		

ECSS-Q-ST-40_044147	6.4.2.1b	A
b. No single system failure or single operator error shall have critical or catastrophic consequences.		

ECSS-Q-ST-40_044148	6.4.2.1c	A
c. No combination of two independent system failures or operator errors shall have catastrophic consequences.		

ECSS-Q-ST-40_044149	6.4.2.1d	A
d. Safety inhibits shall be independent, verifiable, stable and stay in a safe position even in case of energy failure.		

ECSS-Q-ST-40_044150	6.4.2.1e	A
e. Multiple failures, which result from common-cause or common-mode failure mechanisms, shall be analysed as single failures for determining failure tolerance.		

6.3.4.2.2 Failure propagation

ECSS-Q-ST-40_044154	6.4.2.3a	A
a. Hardware failures or software errors shall not cause additional failures with hazardous effects or propagate to cause the hazardous operation of interfacing hardware.		

6.3.4.3 Design for minimum risk

6.3.4.3.1 General

ECSS-Q-ST-40_044155	6.4.3.1a	A
a. Technical requirements for areas of design for minimum risk shall be identified and approved by the relevant safety approval authorities		

NOTE “Design for minimum risk” is a safety requirement used to control hazards by specifying safety-related properties and characteristics of the design.

6.3.4.3.2 Safety factors

ECSS-Q-ST-40_044156	6.4.3.2a	A
a. Structural safety factors shall be defined and applied in accordance with ECSS-E-ST-32-10 or higher safety factor where applicable.		

ECSS-Q-ST-40_044157	6.4.3.2b	A
b. Safety margins shall be based on worst credible combinations of environmental conditions.		

6.3.4.3.3 Fracture control

ECSS-Q-ST-40_044159	6.4.3.3b	A
a. For unmanned systems, only pressure vessels shall be designed in accordance with ECSS-E-ST-32-01, when required by launch site safety authority.		

6.3.4.3.4 Materials

ECSS-Q-ST-40_044160	6.4.3.4a	A
a. Materials shall be selected and controlled in accordance with ECSS-Q-ST-70.		

ECSS-Q-ST-40_044161	6.4.3.4b	A
b. Material selection shall assure that hazards associated with material characteristics are either eliminated or controlled.		

NOTE Examples of these material properties to be characterized are: toxicity, flammability, resistance to stress corrosion, outgassing, offgassing, resistance to radiation, resistance to thermal cycling, arc tracking, thermal degradation, resistance to cleaning fluid and microbiological growth.

ECSS-Q-ST-40_044162	6.4.3.4c	A
c. If requirement 6.4.3.4b. is not feasible, the system design shall include the necessary provisions to control hazardous events associated with material characteristics in accordance with the requirements of this Standard.		

NOTE An example of provisions to be included by the system design is containment of hazardous substances.

6.3.5 IDENTIFICATION AND CONTROL OF SAFETY-CRITICAL FUNCTIONS

6.3.5.1 Identification

ECSS-Q-ST-40_044165	6.5.1a	A
a. A safety critical function that, if lost or degraded, or through incorrect or inadvertent operation, can result in a catastrophic or critical hazardous consequence, shall be identified as a safety-critical function.		

NOTE: As an example, a series of operational events that can result in a hazard if they occur inadvertently or are operated out of order.

ECSS-Q-ST-40_044166	6.5.1b	A
b. Identification shall be done without taking into account hazards controls to be or already implemented.		

6.3.5.2 Inadvertent operation

ECSS-Q-ST-40_044167	6.5.2a	A
a. Inadvertent operation of a safety-critical function shall be prevented by 1. two independent inhibits, if it induces critical consequences, or 2. three independent inhibits, if it induces catastrophic consequences.		

6.3.5.3 Electronic, electrical, electromechanical components

ECSS-Q-ST-40_044171	6.5.5a	A
a. Electronic, electrical, electromechanical (EEE) components used to support safety-critical functions in flight standard hardware shall be selected and procured in accordance with the applicable programme requirements of ECSS-Q-ST-60.		

6.3.5.4 Software functions

6.3.5.4.1 Software criticality

ECSS-Q-ST-40_044172	6.5.6.1a	A
a. Safety aspects associated with the software function shall be an integral part of the overall system safety efforts and not be assessed in isolation.		

ECSS-Q-ST-40_044173	6.5.6.1b	A
b. A software component shall be considered safety-critical if the loss or degradation of its function, or its incorrect or inadvertent operation, can result in catastrophic or critical consequences.		

6.3.5.4.2 Analysis of safety-critical software

ECSS-Q-ST-40_044174	6.5.6.2a	A
a. During the project life cycle, safety analysis shall be carried out to: 1. identify the criticality of software components in accordance with the severity of the consequences as defined in Table 6-1, 2. determine where and under what conditions the system can trigger hazardous events caused by the software, 3. define verification methods for hazard controls involving software, 4. provide verification evidence of hazard control implementation.		

6.3.5.4.3 Evaluation of software criticality

ECSS-Q-ST-40_044175	6.5.6.3a	A
a. The criticality of a software component shall be evaluated taking into account the overall system design which can provide for, e.g. back-up or emergency procedures, hardware inhibits and certain time to effect.		

6.3.5.4.4 Software development

ECSS-Q-ST-40_044176	6.5.6.4a	A
a. A safety-critical software component shall be designed, implemented, verified and operated according to the engineering and product assurance requirements defined in ECSS-E-ST-40 and ECSS-Q-ST-80.		

ECSS-Q-ST-40_044177	6.5.6.4b	A
b. Safety-critical software shall be analysed for the identification and verification of adequate software controls and inhibits and validated accordingly.		

ECSS-Q-ST-40_044178	6.5.6.4c	A
c. The level of required software product assurance effort shall be determined in accordance with the criticality of the software component.		

6.3.6 OPERATIONAL SAFETY

6.3.6.1 Flight operations and mission control

6.3.6.1.1 Hazardous commanding control

ECSS-Q-ST-40_044190	6.6.2.4c	A
a. Hazardous commanding control shall ensure that the system design provides protection to avoid the erroneous acceptance of commands that can result in catastrophic or critical consequences.		

ECSS-Q-ST-40_044191	6.6.2.4d	A
b. .Hazardous commanding control shall ensure that commands, which can result in catastrophic or critical hazardous consequences, are not performed until they are authorized and verified.		

6.3.6.2 Ground operations

6.3.6.2.1 Applicability

ECSS-Q-ST-40_044200	6.6.3.1a	A
a. Safety requirements of the clause shall be applied during the following ground operations: 1. development, qualification or acceptance testing; 2. assembly, integration or test operations; 3. launch site operations; 4. servicing or turn-around operations; and 5. transportation or handling operations.		

6.3.6.2.2 Review and inspection

ECSS-Q-ST-40_044202	6.6.3.3a	A
a. To verify conformance to safety requirements, readiness reviews and inspections shall include safety review and assessment of facilities, equipment (incl. GSE), test articles, operating, test and contingency procedures, access controls, and personnel capabilities to comply with the safety requirements.		

6.3.6.2.3 Hazardous operations

ECSS-Q-ST-40_044203	6.6.3.4a	A
a. Hazardous operations shall be monitored for conforming to safety requirements and procedures, and for the possible development of unforeseen hazardous situations.		

ECSS-Q-ST-40_044204	6.6.3.4b	A
b. Where necessary, contingency and emergency plans or procedures shall be established and verified prior to the commencement of the operation.		

ECSS-Q-ST-40_044205	6.6.3.4c	A
c. The safety manager or safety relevant authority shall have the authority to stop any operation that does not conform to safety requirements.		

6.3.6.2.4 Ground support equipment

ECSS-Q-ST-40_044208	6.6.3.6a	A
a. All Ground support equipment (GSE) shall be subjected to hazard analysis.		

ECSS-Q-ST-40_044209	6.6.3.6b	A
b. All GSE shall conform to the 'Essential Health & Safety Requirements' of all applicable EU 'New Approach directives'.		

ECSS-Q-ST-40_044210	6.6.3.6c	M – End customer
c. Conformance to relevant EU legislation shall be shown by the addition of the 'CE' mark to the product and the issuing of a 'Declaration of Conformity'.		

ECSS-Q-ST-40_044211	6.6.3.6d	A
d. Conformance to any other product related directives shall be demonstrated.		

NOTE Further guidance is given in ECSS-Q-ST-40 / Annex F.

6.4 SAFETY ANALYSIS REQUIREMENTS AND TECHNIQUES

6.4.1 OVERVIEW

Safety risks are the result of the hazardous characteristics associated with the:

- *design, including the technology selected, the physical arrangement of elements, subsystems and equipment, and software functions;*
- *operating modes;*
- *potential for operator error;*
- *operating environment;*
- *hazardous effects that result from the failure of functions (including software).*

6.4.2 GENERAL

ECSS-Q-ST-40_044212	7.2a	A
a. Safety analysis shall be performed in a systematic manner as a basis for all applicable phases and to ensure that hazards are identified, eliminated or minimized and controlled and safety risks are assessed and reduced.		

ECSS-Q-ST-40_044213	7.2b	A
b. Safety analyses shall be initiated early in the design process and provide concurrent support to project engineering in the selection of the least hazardous design and operational options that are compatible with the project mission and programme constraints and conform to the requirements.		

ECSS-Q-ST-40_044214	7.2c	A
c. The results of safety analyses shall also be used to support project management in the assessment of the overall risks, verification of risk reduction, ranking of risk sources, support to project resource allocation, monitoring of risk trends, and residual risk acceptance.		

ECSS-Q-ST-40_044215	7.2d	A
d. Analysis shall always be made with reference to a defined configuration baseline as defined by ECSS-M-ST-40.		

6.4.3 ASSESSMENT AND ALLOCATION OF REQUIREMENTS

6.4.3.1 Safety requirements

ECSS-Q-ST-40_044216	7.3.1a	A
a. The Supplier shall respond to and comply with the applicable safety requirements for the project.		

6.4.3.2 Additional safety requirements

ECSS-Q-ST-40_044217	7.3.2a	A
a. The Supplier shall identify additional safety requirements, where applicable, through the use of lessons learned from previous projects and the safety analyses performed during the project.		

6.4.3.3 Define safety requirements - functions

ECSS-Q-ST-40_044218	7.3.3a	A
a. The Supplier shall define the safety requirements for the various functions of the system.		

6.4.3.4 Define safety requirements - subsystems

ECSS-Q-ST-40_044219	7.3.4a	A
a. The Supplier shall define the safety requirements associated with the various subsystems and lower levels.		

6.4.3.5 Justification

ECSS-Q-ST-40_044220	7.3.5a	A
a. The Supplier shall justify to end customer the proposed allocation of safety requirements at the latest at the end of the detailed definition phase.		

6.4.3.6 Functional and subsystem specification

ECSS-Q-ST-40_044221	7.3.6a	A
a. The Supplier shall ensure that the function and subsystem safety requirements are included in the relevant functional and subsystem specification.		

6.4.4 SAFETY ANALYSES DURING THE PROJECT LIFE CYCLE

ECSS-Q-ST-40_044222	7.4a	A
a. Safety analysis shall be refined and updated in an iterative manner as the design process proceeds, to ensure that hazards and hazardous events are assessed, and that the relevant detailed design and operational requirements, hazard controls, and verification activities are defined and implemented.		

NOTE Refer to 5.2.7 for detailed safety programme tasks in the different project phases

6.4.5 SAFETY ANALYSES

6.4.5.1 General

ECSS-Q-ST-40_044223	7.5.1a	A
a. The safety analysis report shall be established in conformance with the DRD in ECSS-Q-ST-40 / Annex D in order to gather results of safety analyses, which use deterministic and probabilistic methods which are described in the clauses 7.5.2 to 7.5.4.		

ECSS-Q-ST-40_REQ-005	-	N – End customer
b. If the Supplier judges that providing of a safety analysis report is not justified (no risk exists) then a Hazard Identification Document shall be submitted, at least two months before PDR, to the system level (Prime) for approval. Normative content of the Hazard Identification Document is detailed in ECSS-Q-ST-40 / Annex G.		

Note: *For hazards classified less than critical and as some hazard consequences may only be evaluated at system level the decision for not performing a safety analysis remains under the upper and/or system level decision. After review of this Hazard Identification Document by the system level (Prime) the safety analysis may not be required to the Supplier.*

ECSS-Q-ST-40_REQ-006	-	N – End customer
c. If hazards with catastrophic or critical consequences have been found in this Hazard Identification Document, a safety analysis report shall be provided.		

ECSS-Q-ST-40_REQ-007	-	D
Deleted		

6.4.5.2 Hazard analysis

ECSS-Q-ST-40_044224	7.5.2a	A
a. Hazard analysis shall be performed in a systematic manner, beginning in the concept phase and continuing through the operational phase, including end-of-life and disposal.		

ECSS-Q-ST-40_044225	7.5.2b	A
b. Hazard analysis shall support the hazard reduction process.		

ECSS-Q-ST-40_044226	7.5.2c	M – End customer
c. Hazard analysis shall identify and evaluate: 1. hazards associated with system design, its operation (on ground) and the operation environment; 2. the hazardous effects resulting from the physical and functional propagation of initiator events; 3. the hazardous events resulting from the failure of system functions and functional components; 4. time critical situations.		

ECSS-Q-ST-40_044227	7.5.2d	A
d. The following potential initiator events shall be considered: 1. hardware failure (random or time dependent); 2. latent software error; 3. operator error; 4. design inadequacies, including: (a) inadequate margins; (b) unintended operating modes caused by sneak-circuits; (c) material inadequacies and incompatibilities; (d) hardware-software interactions; 5. natural and induced environmental effects; 6. procedural deficiencies.		

ECSS-Q-ST-40_044228	7.5.2e	A
e. Hazard analysis includes a systematic analysis of the “system” operations and operating procedures that shall be performed in the detailed design and operational stages of a project.		

NOTE This analysis evaluates the capability of the system to be operated safely, to determine the safest operating modes, and to evaluate the acceptability of the operating procedures.

ECSS-Q-ST-40_044229	7.5.2f	A
f. The systematic analysis of system operation and operating procedures shall be repeated as the design and operational detail evolves, including the system’s operational modes and man-machine interfaces.		

ECSS-Q-ST-40_REQ-008	-	N – End customer
g. The safety analysis shall be performed for ground operations and for flight operations up to the separation from the launcher.		

6.4.5.3 Supporting assessment analysis

Section not applicable to satellite, as per ECSS Q-ST-40 applicability matrix given in annex F of the ECSS.

6.5 SAFETY VERIFICATION

6.5.1 GENERAL

ECSS-Q-ST-40_044254	8.1a	A
a. A system shall be in place that tracks all hazards and related risks, to relate all verifications of the corresponding hazard uniquely to unambiguous causes and controls.		

ECSS-Q-ST-40_044255	8.1b	A
b. For common techniques for verification of design features used to control hazards, the requirements of ECSS-E-ST-10 shall apply.		

ECSS-Q-ST-40_044256	8.1c	A
c. To successfully complete the safety process, positive feedback shall be provided on completion results for all verification items associated with a given hazard.		

6.5.2 HAZARD REPORTING AND REVIEW

6.5.2.1 Hazard reporting system

ECSS-Q-ST-40_044257	8.2.1a	M – End customer
a. The Supplier shall establish a hazard reporting system for tracking the status of all identified category catastrophic and critical hazards.		

ECSS-Q-ST-40_044259	8.2.1c	A
c. The Supplier shall report, and provide evidence, that 1. controls are defined and agreed; 2. verification methods are defined and agreed; 3. verification is completed.		

ECSS-Q-ST-40_044260	8.2.1d	A
d. If verification cannot be completed, the Supplier shall establish a Safety Verification Tracking Log (SVTL) (refer to clause 8.5.1a.).		

ECSS-Q-ST-40_REQ-009	-	N – End customer
e. If the hazard causes (and the associated controls) are not under the Supplier control, they shall be documented in the safety analyses for being taken into account at the next upper level.		

6.5.2.2 Safety status review

ECSS-Q-ST-40_044261	8.2.2a	A
a. Status of hazard control and risk reduction activities shall be reviewed at safety progress meetings and project safety reviews for compliance with decisions taken and achievement of intended results.		

6.5.2.3 Documentation

ECSS-Q-ST-40_044262	8.2.3a	A
a. All hazard documentation shall be formally issued for each safety review and major project review, as specified in clause 5.11).		

6.5.3 SAFETY VERIFICATION METHODS

6.5.3.1 Verification engineering and planning

ECSS-Q-ST-40_044263	8.3.1a	A
a. Verification engineering shall select the verification methods consistent: 1. with the verification requirements documented in the hazard report, 2. with the launch base safety rules.		

ECSS-Q-ST-40_044264	8.3.1b	A
b. Verification planning shall commence in an integrated manner upon selection of the control method.		

6.5.3.2 Methods and reports

ECSS-Q-ST-40_044265	8.3.2a	A
a. Safety verification methods shall include alternatively or in combination review of design, analysis, inspection and test.		

ECSS-Q-ST-40_044266	8.3.2b	A
b. For all safety verifications traceability shall be provided.		

6.5.3.3 Analysis

ECSS-Q-ST-40_044267	8.3.3a	A
a. All relevant technical safety and engineering analyses performed or updated with analysis in respect to the as-built configuration shall be used for verification.		

ECSS-Q-ST-40_044268	8.3.3b	A
b. When similarity analysis is provided, for tracking purposes it shall contain a copy of (or a unique reference to) the referenced previous verification, verification procedure and requirement valid at the time of the first verification.		

6.5.3.4 Inspections

6.5.3.4.1 General

ECSS-Q-ST-40_044269	8.3.4.1a	A
a. Inspections which are considered as necessary in order to meet safety requirements of the system shall be identified and included in user manuals and procedures.		

6.5.3.4.2 Preflight inspections

ECSS-Q-ST-40_044270	8.3.4.2a	A
a. All preflight safety inspections shall be assessed for inclusion in the MIP list.		

ECSS-Q-ST-40_044271	8.3.4.2b	A
b. Launch preparation inspections shall be entered into the launch base procedure.		

ECSS-Q-ST-40_044272	8.3.4.2c	A
c. The closeout shall be given by the approved launch authority procedure.		

ECSS-Q-ST-40_044273	8.3.4.2d	A
d. Late access procedures shall be the subject of training and be performed by qualified personnel.		

ECSS-Q-ST-40_044275	8.3.4.2f	A
e. Close-out shall be by safety-approved procedure, documented training session and simulations.		

6.5.3.5 Verification and approval

ECSS-Q-ST-40_044277	8.3.5a	A
a. The Supplier shall select, and propose to the safety approval authority, the safety verification methods to be used in conformance to the applicable safety requirements.		

ECSS-Q-ST-40_044278	8.3.5b	A
b. The results of safety verification shall be submitted for approval to the relevant safety approval authority.		

6.5.4 VERIFICATION OF SAFETY-CRITICAL FUNCTIONS

6.5.4.1 Validation

ECSS-Q-ST-40_044279	8.4.1a	A
a. Safety-critical functions shall be verified by testing which include application of the operating procedures, the “man-in-the-loop”, and the verification of the effectiveness of applicable failure tolerance requirements.		

ECSS-Q-ST-40_044280	8.4.1b	A
b. The tests shall include the demonstration of nominal, contingency and emergency operational modes.		

6.5.4.2 Qualification

ECSS-Q-ST-40_044281	8.4.2a	A
a. The safety-critical characteristics of all safety-critical functions shall be qualified by test.		

ECSS-Q-ST-40_044282	8.4.2b	A
b. Safety-critical function qualification testing shall include the determination of performance margins considering worst case combinations of induced and natural environments and operating conditions.		

ECSS-Q-ST-40_044283	8.4.2c	A
c. Qualification “by similarity” shall not be applied except after customer approval on a case-by-case basis.		

6.5.4.3 Failure tests

ECSS-Q-ST-40_044284	8.4.3a	A
a. Induced failure tests shall be performed when required by safety analysis for evaluating failure effects, and for demonstrating failure tolerance conformance in safety-critical functions.		

6.5.4.4 Verification of design or operational characteristics

ECSS-Q-ST-40_044285	8.4.4a	A
a. Verification of unique safety required design or operational characteristics shall form part of the development, qualification or acceptance testing programmes as appropriate.		

6.5.4.5 Safety verification testing

ECSS-Q-ST-40_044286	8.4.5a	A
a. Where full-scale testing is not performed, equivalent safety verification method based on technically representative hardware or models shall be justified, approved and performed.		

ECSS-Q-ST-40_044287	8.4.5b	A
b. For the verification of hazard controls in catastrophic hazards where non-flight equipment replaces part of the flight equipment to test a flight function the verification shall be performed independently by a third party which was not involved in the design and qualification of the flight model (FM).		

6.5.5 HAZARD CLOSE-OUT

6.5.5.1 Safety assurance verification

ECSS-Q-ST-40_044288	8.5.1a	A
a. A safety verification tracking log (SVTL) shall be established, in conformance with the DRD in Annex C, to collect all the open verification items of the different hazard reports from the safety analysis.		

ECSS-Q-ST-40_044289	8.5.1b	A
b. In time for acceptance by the customer, and in preparation of transfer to the next stage of system integration, the safety manager shall verify that: 1. hazard close-outs performed so far by the responsible engineer are still valid; 2 the verifications reflect the as-built or as-modified status of the hardware; 3. all open verifications at this time are acceptable for transfer to the next stage of system integration; 4. all open verifications are entered into the verification tracking log (SVTL); 5. the verification tracking log is maintained to reflect the current status.x		

ECSS-Q-ST-40_044290	8.5.1c	A
c. If the safety verification constrains any ground operations, the safety manager shall give notification to the safety review panel.		

6.5.5.2 Hazard close-out verification

ECSS-Q-ST-40_044291	8.5.2a	A
a. The safety manager shall assure that each hazard considered for closure has the approval by the safety approval authority, verifying that 1. hazards not eliminated are controlled in accordance with the applicable requirements and associated verification activities are successfully completed, or, when applicable, 2. deviations from, or waivers of requirements, are granted by the safety approval authority.		

6.5.6 DECLARATION OF CONFORMITY OF GROUND EQUIPMENT

ECSS-Q-ST-40_044292	8.6a	A
a. All ground equipment that falls into the scope of an applicable ‘New Approach directive’ shall be ‘CE’ marked and supplied with a supporting ‘Declaration of Conformity’ and User Manual detailing all safety warnings."		

NOTE Additional information is provided in Informative ECSS-Q-ST-40 / Annex G.

6.6 PRODUCT REGULATORY COMPLIANCE REQUIREMENTS

ECSS-Q-ST-40_REQ-010	-	N – End customer
a. In addition to safety analyses, the Supplier shall address specifically the requirements issued by the European Union in terms of product regulatory compliance and related directives.		

ECSS-Q-ST-40_REQ-011	-	N – End customer
b. The regulatory compliance requirements shall apply to every product (flight product and ground support equipment) under the responsibility of the Supplier.		

ECSS-Q-ST-40_REQ-012	-	N – End customer
c. The Supplier shall identify for each product under his responsibility the applicability of the EU directives.		

NOTE A non exhaustive list of directives to be considered is given hereunder for information:

Reference	Title
1985/374/EEC	Product Liability
1999/5/EEC	Radio equipment and telecommunications terminal Equipment
2006/95/EC	Low voltage
2006/42/EC	Machinery
2004/108/EC	Electromagnetic compatibility (EMC)
1997/23/EEC	Pressure equipment
1993/15/EEC	Explosives for civil use
1994/9/EEC	Equipment and protective systems intended for use in explosive atmospheres
1990/270/EEC	Display screen equipment
2006/66/EC	Batteries and accumulators

ECSS-Q-ST-40_REQ-013	-	N – End customer
d. Where applicable, the Supplier shall perform the related certification towards the EU directives.		

ECSS-Q-ST-40_REQ-014	-	N – End customer
e. After compliance assessment the Supplier shall deliver when appropriate a formal Declaration of Conformity mentioning the legal data asserted by the EU directives.		

ECSS-Q-ST-40_REQ-015	-	N – End customer
f. Each product, where appropriate, shall be "CE" marked and in accordance with European Legislation. The "CE" marking shall include the name of the Supplier company.		

ECSS-Q-ST-40_REQ-016	-	N – End customer
g. The user's manual of each product, where appropriate, shall address the product safety issues and the related procedures.		

7 EEE COMPONENTS REQUIREMENTS (Q-ST-60)

This standard defines the requirements for selection, control, procurement and usage of EEE components for **class 1** space projects.

The objective of the EEE component selection, control, procurement and use requirements is to ensure that EEE components used in a space project enables the project to meet its mission requirements. Important elements of EEE component requirements include:

- component programme management,
- component selection, evaluation and approval,
- procurement,
- handling and storage,
- component quality assurance,
- specific components, and
- documentation.

The main tools which can be used to reach the objective are:

- concurrent engineering,
- standardization of component types,
- characterization of components,
- assessment of component manufacturers including declared competencies and processes,
- testing, screening, lot acceptance and periodic testing,
- procurement specifications,
- control and inspection,
- control of nonconforming materials,
- assessment and use of existing component data,
- application of specific control to mitigate risk for components with limited data or confidence, and
- information management.

ECSS-Q-ST-60_REQ-001	-	N – End customer
a. The requirements of this document shall apply to all parties involved at all levels in the integration of EEE components into space segment hardware.		

ECSS-Q-ST-60_REQ-002	-	N – End customer
b. Components for engineering models, when used for qualification purpose (EQM), shall be from the same design type (form, fit, function) and manufacturer as the ones intended to be used on flight standard models.		

7.1 COMPONENT PROGRAMME MANAGEMENT

7.1.1 GENERAL

ECSS-Q-ST-60_048001	4.1.1a	A
a. The supplier shall establish and implement throughout the duration of the business agreement a component programme which ensures that the requirements of the project as defined by end customer and the supplier in the related business agreement are in compliance with this standard.		

ECSS-Q-ST-60_MOS-001	4.1.1b	N - esa
b. Only Class 1 components shall be used within the MetOp-SG System.		

7.1.2 COMPONENTS CONTROL PROGRAMME

7.1.2.1 Organization

ECSS-Q-ST-60_048002	4.1.2.1a	A
a. The Supplier shall identify the organization responsible for the management of the component programme, and describe the organization's approaches (including the procurement system and its rationale) and capability to efficiently implement, manage, and control the component requirements.		

ECSS-Q-ST-60_048003	4.1.2.1b	A
b. The Supplier's organization shall comply with all the requirements of ECSS-M-ST-10.		

7.1.2.2 Component Control Plan

ECSS-Q-ST-60_048004	4.1.2.2a	M - esa
a. The Supplier shall prepare a Component Control Plan (CCP) in conformance with its DRD in Annex A of ECSS-Q-ST-60C Rev.2 as part of the PA Plan as per DRD {sat-PA-01}.		

ECSS-Q-ST-60_048006	4.1.2.2c	M - End customer
c. The supplier shall submit the CCP to end customer and ESA forapproval.		

7.1.3 PARTS CONTROL BOARD

ECSS-Q-ST-60_048007	4.1.3a	M – End customer
a. The approval of the selection and usage of EEE parts shall be implemented through Parts Control Boards (PCBs) held between end customer and the supplier (or lower tier subcontractor).		

ECSS-Q-ST-60_048008	4.1.3b	M – End customer
b. At Supplier's level, the Parts Control Board (PCB) shall be composed as follows: 1. chaired by a member of the supplier's PA team with designated responsibility for components management, 2. include, as a minimum, in addition the suppliers' parts engineer, the end customer and ESA representative and the lower tier subcontractor parts engineers.		

	4.1.3c	M - Airbus DS
c. Other pertinent experts from end customer or suppliers may also participate, on request.		

ECSS-Q-ST-60_048010	4.1.3d	A
d. Depending on the progress of the program, the main PCB activities shall be: 1. Review and approval of the Supplier's EEE component control plan and any associated documents, 2. Parts type reduction and standardization, 3. Parts approval including evaluation activities, 4. Problem assessment (e.g. alerts, non-conformances, RFD, RFW and delivery delays), 5. Assessment activities (by sampling) including: (a) conformity of procurement conditions, (b) conformity of procurement data, (c) post-procurement data, and (d) application of alerts recommendations.		

NOTE For 5(a) to 5(c), assessment is made by comparison of procurement documentation versus approval document.

7.1.4 DECLARED COMPONENTS LIST

ECSS-Q-ST-60_048011	4.1.4a	A
a. For each equipment, its supplier shall issue a DCL in an editable and sortable electronic format, as a minimum compatible with CSV, identifying all component types needed.		

NOTE CSV is a common file format that can be used to transfer data between database or spreadsheet tables (a spreadsheet program is for example Excel®).

ECSS-Q-ST-60_048012	4.1.4b	A
b. This list specified in 4.1.4a shall be kept under configuration control (issue and identification of changes).		

ECSS-Q-ST-60_048013	4.1.4c	A
c. The DCL shall be issued as a minimum at PDR and CDR (as designed) and before TRR (as built).		

ECSS-Q-ST-60_048014	4.1.4d	M – End customer
d. After equipment CDR, all modifications affecting the PAD information shall be implemented, in the "as design" DCL, through the CN / CR process and submitted to end customer and ESA for approval.		

NOTE For PAD generation, see clause 4.2.4d.

ECSS-Q-ST-60_048015	4.1.4e	M – End customer
e. The “as design” DCL shall be sent to end customer S and ESA for approval.		

ECSS-Q-ST-60_048016	4.1.4f	M – End customer
f. Any change of parts during equipment manufacturing (e.g. type and manufacturer) shall be handled through RFWs submitted to end customer and ESA for approval before mounting.		

ECSS-Q-ST-60_048017	4.1.4g	A
g. The “as built” DCL reflecting the actual EEE parts assembled into the flight hardware and their date code shall be provided to end customer for review before TRR.		

ECSS-Q-ST-60_048018	4.1.4h	M – End customer

h. The content of the DCL shall be in conformance with the following list of items:
- Component number (commercial equivalent designation)
- Family (ESCC group code)
- Package
- Value or range of values with tolerance for non qualified parts
- Component manufacturer (name, country)
- Generic procurement specification
- Detail procurement specification (with issue & revision for non qualified parts)
- Specification amendment (including issue and revision)
- Name of the procurement agent (CPPA, supplier, distributor)
- Quality level and lot test (ESCC LAT or LVT, MIL TCI or QCI or CI)
- Space qualified status (yes or no)
- RVT (yes or no)
- Reference of the PAD or the Justification Document, where required
- Approval status of the part
- Change identification between each DCL issue
- Date-code (only for “as built” DCL)

ECSS-Q-ST-60_REQ-003	-	N – End customer

i. For wires and cables listed in DCL, the four following parameters shall be given in the field “comments” :
- External material
- RML (Recovered Mass Loss)
- CVCM (Collected Volatile Condensable Materials)
- Mass code

NOTE If these data are included in the PAD or the detail specification, it is not necessary to give them in DCL.

ECSS-Q-ST-60_MOS-002	4.1.4i	N - esa

j. In addition to the information requested in Annex B of ECSS-Q-ST-60C Rev2, the DCL shall also detail the following information:
- Procurement inspection references by the receiving organisation, or their representatives/agent (pre-cap inspection, etc.), if any;
- Radiation Analysis and Test Report Reference (where applicable);
- Up-screening report reference (where applicable)
- In case of procurement from stock, reference to the re-life report, (where applicable).

NOTE This information is used to assist the component data review process

ECSS-Q-ST-60_MOS-003	4.1.4j	N - esa

k. The Supplier shall consolidate Declared Components Lists from their lower tier suppliers in to a Unit / Equipment / Instrument Level DCL in an editable and sortable format, as a minimum compatible with CSV, and also be provided in an unlocked pdf format (i.e. searchable), identifying all component types needed.

7.1.5 ELECTRICAL AND MECHANICAL GSE

ECSS-Q-ST-60_048019	4.1.5a	A

a. EEE components used in GSE, which are physically and directly interfacing to flight hardware, shall be :
1. Fit Form and Function compatible,
2. manufactured from materials identical to the flight opposite part, and
3. ensured to be visibly clean before each connection to flight hardware.

ECSS-Q-ST-60_048020	4.1.5b	A
b. Flight hardware connector interfaces to GSE shall interface to a flight compatible connector, as per 4.1.5a.		

NOTE This connector can be installed on the test harness or can be a saver.

7.2 COMPONENT SELECTION, EVALUATION AND APPROVAL

7.2.1 GENERAL

ECSS-Q-ST-60_048021	4.2.1a	A
a. The Supplier shall ensure that the following requirements are met during his selection process: 1. Project requirements (e.g. quality levels, component policy, manufacturing and delivery schedules and budgets, quantities), 2. Design requirements (e.g. component type, case, dimensions, materials), 3. Production requirements (e.g. packaging, thermal and storage constraints, component mounting process), 4. Operational requirements (e.g. electrical, mechanical, radiation, reliability, assembly, and lifetime).		

NOTE The Supplier of each product is responsible for the selection of components, which enable the performance, lifetime, environmental, material, safety, quality and reliability requirements of the product of which they form a part, to be satisfied in all respects.

ECSS-Q-ST-60_048446	4.2.1b	A
b. The selection, evaluation and approval of commercial EEE components for class 1programmes shall be performed in conformance with clause 4.2 from ECSS-Q-ST-60-13.		

ECSS-Q-ST-60_MOS-004	4.2.1c	N - esa
c. The procurement of components and/or units subject to stringent export licence regulations such as ITAR shall be avoided where possible.		

ECSS-Q-ST-60_MOS-005	4.2.1d	N - esa
d. The procurement of components from non European/Canadian sources shall be minimised.		

ECSS-Q-ST-60_MOS-006	4.2.1e	N - esa
e. If non-European/Canadian sourced parts are retained, such procurements shall be supported by a Justification File, submitted by the relevant Design Authority (unit, equipment, instrument, sub-system etc.) to, and approved by, end customer and ESA.		

NOTE Justification Files are used to support to PAD process and so shall be submitted before, or with, the PADs.

7.2.2 MANUFACTURER AND COMPONENT SELECTION

7.2.2.1 General rules

ECSS-Q-ST-60_048022	4.2.2.1a	A
a. The Supplier shall establish and maintain in his own facility, and ensure that his Suppliers also establish and maintain, procedures for selecting and controlling all components intended for use in deliverable products.		

ECSS-Q-ST-60_048023	4.2.2.1b	A
b. Components shall be selected on the basis of proven qualification, characterization, and previous space experience and data, relevant with regard to the requirements for the programme, from manufacturers or sources (preferably European) employing effective Product Assurance Programmes in manufacturing and test.		

ECSS-Q-ST-60_048024	4.2.2.1c	A
c. Preference shall be given to components which necessitate the least evaluation or qualification effort.		

ECSS-Q-ST-60_048025	4.2.2.1d	A
d. Starting with the design phase of the project the Supplier shall ensure maximum use of preferred (see clause 4.2.2.3) and qualified components to achieve an effective component reduction and standardization.		

ECSS-Q-ST-60_048026	4.2.2.1e	A
e. When selecting items, the Supplier shall check the current data, applicability of the basis of qualification, problem notifications and alerts, and adequacy of specifications.		

ECSS-Q-ST-60_048027	4.2.2.1f	A
f. The Supplier shall implement a type reduction activity.		

7.2.2.2 Parts and material restriction

ECSS-Q-ST-60_048028	4.2.2.2a	A
a. The Supplier shall ensure that non-hermetically sealed materials of components meet the requirements of ECSS-Q-ST-70 regarding off-gassing, out-gassing, flammability, toxicity and any other criteria specified for the intended use.		

ECSS-Q-ST-60_048029	4.2.2.2b	A
b. The Supplier shall evaluate the robustness of selected EEE components against the stresses induced by the assembly techniques to be employed.		

ECSS-Q-ST-60_048030	4.2.2.2c	A
c. With respect to health and safety, beryllium oxide (except if identified in the procurement specification), cadmium, lithium, magnesium, mercury, zinc, radioactive material and all material which can cause safety hazards shall not be used.		

ECSS-Q-ST-60_048031	4.2.2.2d	M – End customer

d. For limited life duration, known instability, safety hazards or reliability risk reasons, the EEE components listed below shall not be used:

1. EEE components with pure tin (less than 3% Pb in case of SnPb alloy) used as a finish on the leads, terminations and external surfaces of components and packages,
2. Hollow core resistors,
3. Potentiometers (except for mechanism position monitoring),
4. Non-metallurgically bonded diodes,
5. Semiconductor dice with unglassivated active area,
6. Wet slug tantalum capacitors other than capacitor construction using double seals and a tantalum case,
7. Any component whose internal construction uses metallurgic bonding with a melting temperature not compatible with the end-application mounting conditions,
8. Wire link fuses < 5A,
9. TO5 relays without double welding of the mechanism to the header or with any type of integrated diodes inside,
10. RNC90 > 100kohms.
11. Wires and cables with less than 2 microns silver coating on copper strands.

ECSS-Q-ST-60_048032	4.2.2.2e	M – End customer

e. For limited life duration, known instability, safety hazards or reliability risk reasons, EEE components listed below shall not be used for new designs:

1. Deleted
2. TO3 and DO4/DO5 packages.

ECSS-Q-ST-60_048033	4.2.2.2f	A

f. The use of pure tin in internal cavities may be authorized, on a case-by-case basis, based on the demonstration that there is no alternative product and there is no risk (supported by a technical justification).

ECSS-Q-ST-60_048034	4.2.2.2g	M – End customer

g. As per clause 4.2.2.2f, the justification of the use of pure tin shall be presented during a PCB to end and ESA for approval.

ECSS-Q-ST-60_048035	4.2.2.2h	M – End customer

h. The use of pure tin (inside or outside the part) shall be declared in the PAD or in the Justification Document.

7.2.2.3 Preferred sources

ECSS-Q-ST-60_048036	4.2.2.3a	M – End customer

a. Parts will be preferably chosen from the EPPL part I.

ECSS-Q-ST-60_048037	4.2.2.3b	M - esa

b. For parts not selected from the EPPL part I, the following sources shall be considered in the following order of precedence:

1. ESCC QPL and QML,
2. EPPL part II (when compatible with the project requirements)
3. NPSL level 1 (with disposition of the associated application notes) ,
4. MIL QPL's and QML's.

ECSS-Q-ST-60_048038	4.2.2.3c	M – End customer
c. Parts subject to Export Regulation shall not be preferred		

7.2.2.4 Radiation hardness

ECSS-Q-ST-60_048039	4.2.2.4a	A
a. The radiation requirements for EEE components are project specific.		

ECSS-Q-ST-60_048040	4.2.2.4b	A
b. The Supplier who is responsible for the design of the piece of hardware shall demonstrate the compliance of its components selection with the radiation constraints of the project.		

ECSS-Q-ST-60_048041	4.2.2.4c	A
c. For this demonstration, the Supplier shall consider all types of radiation including cosmic (Heavy Ions), electromagnetic, trapped (charged particles - electrons, protons - in radiation belts) and solar (flares).		

ECSS-Q-ST-60_048042	4.2.2.4d	A
d. Due consideration shall be given to the mission orbit and trajectory, the duration, the associated spatial and temporal variations of the radiation environment as well as all protective factors such as shielding.		

ECSS-Q-ST-60_048043	4.2.2.4e	A
e. The Supplier shall assess the actual radiation tolerance of the selected components for compliance with the radiation requirements in term of total dose, displacement damage and Single Events Effects (SEE).		

ECSS-Q-ST-60_048044	4.2.2.4f	A
f. The Supplier shall identify components which are not compliant with the radiation requirements as critical radiation sensitive components.		

ECSS-Q-ST-60_048045	4.2.2.4g	M – End customer
g. The supplier shall implement a Radiation Hardness Assurance Programme, in conformance with the requirements of ECSS-Q-ST-60-15C, complemented with the requirements of chapter 8, documented by a plan to be approved by end customer and ESA, for radiation sensitive components, covering the collection of all relevant information and specifying the necessary actions in terms of evaluation and procurement testing, planning and control.		

ECSS-Q-ST-60_048046	4.2.2.4h	A
h. The Supplier shall issue an Equipment Radiation Analysis document identifying all sensitive components w.r.t. the relevant radiation effects, possibly their impact and giving an adequate engineering solution (e.g. local shielding, design solution, specific test, and RVT) for the relevant equipment.		

ECSS-Q-ST-60_048047	4.2.2.4i	M – end customer
i. The Equipment Radiation Analysis document shall be submitted to Aend customer and ESA for approval.		

NOTE More detailed information about the above requirements is given in ECSS-E-ST-10-12and ECSS-Q-ST-60-15.

ECSS-Q-ST-60_MOS-007	4.2.2.4j	N - esa
j. The planning for the coverage of the requirements of ECSS-Q-ST-60-15C, Radiation Hardness Assurance, complemented with the requirements of chapter 8, shall be part of the overall PA plan as per DRD {sat-PA-01}.		

7.2.2.5 Derating

ECSS-Q-ST-60_048048	4.2.2.5a	M - esa
a. The Supplier shall implement derating rules for components used in his design in accordance with the requirements of ECSS-Q-ST-30-11C Rev.1.		

ECSS-Q-ST-60_048049	4.2.2.5b	A
b. For wire link fuses, the current derating factor shall be 50 % with an additional derating of 0,2 %/°C for an increase in the temperature of fuse body above 25 °C.		

7.2.3 COMPONENT EVALUATION

7.2.3.1 General

ECSS-Q-ST-60_048050	4.2.3.1a	A
a. The Supplier shall perform a component evaluation in absence of an approved demonstration that a component has the ability to conform to the requirements for functional performance, quality, dependability, and environmental resistance as required for the project.		

ECSS-Q-ST-60_048051	4.2.3.1b	A
b. The Supplier shall plan and carry out the evaluation.		

ECSS-Q-ST-60_048052	4.2.3.1c	A
c. The scope and planning of the component evaluation shall be derived from the results of an assessment of the design and intended application of the component.		

ECSS-Q-ST-60_048053	4.2.3.1d	M – End customer
d. An evaluation plan shall be sent to end customer and ESA for approval, and include the following elements: 2. Constructional Analysis (as per clause 4.2.3.3), 3. Evaluation Testing (as per clause 4.2.3.4), 4. Radiation Hardness (as per clause 4.2.3.4b.5).		

ECSS-Q-ST-60_048054	4.2.3.1e	A
e. In the definition of the evaluation programme any information including pertinent reliability, analysis and test data from the manufacturer of the component and previous use in comparable applications shall be considered.		

ECSS-Q-ST-60_048055	4.2.3.1f	A
f. Omission of any of these elements, or the introduction of alternative activities, shall be justified.		

ECSS-Q-ST-60_048056	4.2.3.1g	A
g. All tests and inspections shall be carried out on representative samples of the component type from the current production of the manufacturer selected for the component procurement for the flight hardware.		

ECSS-Q-ST-60_048057	4.2.3.1h	A
h. For programmable devices, the representativeness shall include the programming hardware tools and the compatibility of the software.		

ECSS-Q-ST-60_048058	4.2.3.1i	A
i. The Supplier shall review the evaluation results to determine their impact on the content of the procurement specification which shall be amended as necessary.		

ECSS-Q-ST-60_048059	4.2.3.1j	M – End customer
j. The supplier shall summarize the evaluation results in the evaluation report and send it to end customer and ESA for approval.		

NOTE For guidance for the assessment of the space environmental aspects refer to ECSS-E-ST-10-04 and ECSS-E-ST-10-12.

7.2.3.2 Component manufacturer assessment

7.2.3.2.1 Purpose

The purpose of the manufacturer assessment is to determine its capability, to ensure the adequacy of its organization, plant and facilities, and to ascertain its fitness to supply components to the appropriate specifications for space application.

7.2.3.2.2 Requirements

ECSS-Q-ST-60_048060	4.2.3.2.2a	A
a. The Supplier shall perform an evaluation against the ESCC basic specification no. 20200 and the ancillary specifications for dedicated component families and shall include, but not necessarily be limited to, a survey of: 1. The overall manufacturing facility and its organization and management, 2. The manufacturer's system for inspection and manufacturing control including all relevant specifications, procedures, and internal documents, 3. The production line used for the component.		

ECSS-Q-ST-60_048061	4.2.3.2.2b	A
b. The complete manufacturer assessment, including the survey report and the associated corrective actions, shall be part of the evaluation report.		

7.2.3.3 Constructional analysis

ECSS-Q-ST-60_048062	4.2.3.3a	A
a. Constructional analysis shall be carried out on representative components.		

NOTE The primary aim is to provide an early indication of a component's constructional suitability for meeting the specified performances of the space project application.

ECSS-Q-ST-60_048063	4.2.3.3b	A
b. The Constructional Analysis shall comprise destructive and non-destructive inspections, analyses, and testing, to identify: 1. Design and construction technology, 2. Materials used, 3. Inherent reliability aspects, 4. Quality of workmanship, 5. Potential hazards.		

ECSS-Q-ST-60_048064	4.2.3.3c	A
c. The findings of the analysis shall be contained within a Constructional Analysis Report and shall be included in the Evaluation Report.		

7.2.3.4 Evaluation testing

ECSS-Q-ST-60_048065	4.2.3.4a	A
a. The evaluation shall determine which inspections or tests are required to provide the confidence that the component type under evaluation, when assembled and tested in accordance with the procurement specification, successfully meets the project requirements.		

ECSS-Q-ST-60_048066	4.2.3.4b	A
b. The Supplier shall review the already existing data in order to adapt and minimize the content of the evaluation testing while ensuring that there are inputs and pertinent results covering the following topics: 1. Endurance test (operating at elevated temperature and electrical stress), 2. Mechanical stress (shock, vibration, constant acceleration), 3. Environmental stress (thermal shock, temperature cycling, high and low temperature storage, humidity), 4. Assembly capability testing, 5. Radiation testing, for total dose and single event effects sensitivity.		

NOTE For guidance refer to ESCC basic specification no. 22600 and the ancillary specifications for dedicated component families.

7.2.4 PARTS APPROVAL

ECSS-Q-ST-60_048067	4.2.4a	A
a. The Supplier shall document the procedure for approval of each component type intended for use in flight products.		

ECSS-Q-ST-60_048068	4.2.4b	A
b. The approval of components shall be based on consideration of all pertinent data including both the electrical and environmental performance as well as the established quality and the dependability assurance requirements.		

ECSS-Q-ST-60_048069	4.2.4c	A
c. The Supplier shall maintain a system of traceability of the acceptance and approval of each component used in flight products.		

ECSS-Q-ST-60_048070	4.2.4d	M – End customer

d. Prior to procurement of components (or before equipment CDR, at the latest), the approval process by end customer and ESA shall be organized as follows:

1. A PAD in conformance with **Annex B** of this document (or information included in DCL) is required for space qualified parts when:
   a) additional controls are required (e.g. precap, buy-off, LAT or LVT, RVT, DPA),
   b) used outside the specified limits,
   c) specific tests are required during procurement as per **Annex A** of this document,
   d) pure tin is used inside or outside the part.
2. All other space qualified parts listed in the DCL are approved through the DCL review,
3. For any other part a PAD, in conformance with **Annex B** of this document is required,
4. For any commercial part, a Justification Document, as per ECSS-Q-ST-60-13 (clause 4.2.4), is required, instead of PAD.

ECSS-Q-ST-60_MOS-008	4.2.4d5	N - esa

d5. All PADs shall be approved by the end customer and ESA prior to the relevant equipment/ unit/ instrument/ sub-system/ system CDR closeout.

NOTE 1 The CDR closeout shall be conditional on the approval status of the PADs.

NOTE 2 The Supplier shall ensure PADs are submitted to the Customer in good time to allow a full review & discussion of the PADs prior to the CDR i.e. submitting PADs at the same time as the CDR data pack is considered insufficient.

ECSS-Q-ST-60_048071	4.2.4e	M – End customer

e. In case the evaluation results are changing the procurement conditions documented in the PAD or the Justification document (as per clause 4.2.3.1), a new revision of PAD or the Justification document shall be submitted to the end customer and ESA for approval.

ECSS-Q-ST-60_MOS-009	4.2.4f	N - esa

f. PADs approved on another space programme may be used as supporting evidence for submitting a MetOp-SG specific PAD.

NOTE An approved PAD from another space programme does not automatically guarantee approval for MetOp-SG. The end customer and ESA project teams must approve all PADs for MetOp-SG.

7.2.5 OFF-THE-SHELF (OTS) UNITS

ECSS-Q-ST-60_MOS-010	4.2.6a	N - esa

a. The EEE requirements defined herein shall apply to Off-The-Shelf (OTS) equipment and/or units.

ECSS-Q-ST-60_MOS-011	4.2.6b	N - esa

b. The Radiation Hardness Assurance requirements defined herein shall apply to Off-The-Shelf equipment and/or units.

7.3 COMPONENT PROCUREMENT

7.3.1 GENERAL

ECSS-Q-ST-60_048072	4.3.1a	A

a. The Supplier shall ensure that all procured components meet the programme requirements with respect to inspection, screening and tests.

ECSS-Q-ST-60_048073	4.3.1b	M – End customer
b. Class 1 components shall meet the quality levels and supplementary conditions specified in **Annex A** of this document.		

ECSS-Q-ST-60_048074	4.3.1c	A
c. The Supplier shall be responsible for manufacturer surveillance and control throughout the procurement programme.		

ECSS-Q-ST-60_048075	4.3.1d	A
d. For non qualified parts, the Supplier shall put in place a configuration control system to ensure that any change of the product (e.g. mask, manufacturing and assembly process) affecting evaluation, performance, quality, reliability and interchangeability is communicated to him by the manufacturer (e.g. PCN).		

ECSS-Q-ST-60_048076	4.3.1e	A
e. The Supplier shall ensure the compatibility of the change with its application.		

ECSS-Q-ST-60_048077	4.3.1f	M – End customer
f. The change shall be submitted to end customer and ESA for approval.		

ECSS-Q-ST-60_REQ-004	-	N – End customer
g. During procurement or incoming (if not done during procurement) of EEE parts susceptible to ESD of less than 500V (HBM), they shall be clearly labelled as such to ensure the next user of the part/assembly can ensure correct ESD precautions have been implemented.		

ECSS-Q-ST-60_048078	4.3.1g	A
h. To reduce the risk of procuring counterfeit components, when parts are not directly procured from the manufacturer, the Supplier shall procure parts only from distributors duly franchised by the parts manufacturer.		

ECSS-Q-ST-60_048447	4.3.1h	A
i. The procurements of the commercial EEE components for class 1 programs shall be performed in conformance with the requirements of clause 4.3 of ECSS-Q-ST-60-13.		

ECSS-Q-ST-60_MOS-012	4.3.1h	N - esa
j. The Supplier shall define attrition rules to be applied for end customer and ESA approval.		

7.3.2 PROCUREMENT SPECIFICATION

ECSS-Q-ST-60_048079	4.3.2a	A
a. The Supplier shall procure EEE components according to controlled specifications.		

ECSS-Q-ST-60_048080	4.3.2b	A
b. International specifications systems, recognized as suitable for space applications (e.g. ESCC, MIL), shall be used by the Supplier.		

ECSS-Q-ST-60_048081	4.3.2c	A
c. Any new specification shall be prepared and designed by the Supplier as per existing international specification systems (ESCC, MIL). Preference shall be given to ESCC format when agreed by the manufacturer.		

ECSS-Q-ST-60_048082	4.3.2d	M – End customer
d. The content of any new specification shall include the following items: • Absolute maximum ratings • Electrical and mechanical parameters and limits • Screening, burn-in, and acceptance requirements • Package material and lead finish • Documentation/data requirements • Delta limits when applicable • Criteria for percent defective allowable • LAT or LVT, QCI or TCI • Marking • Storage requirements • Requirements for lot homogeneity • Serialization (when applicable) • Protective packaging and handling requirements • Radiation Verification Testing requirements, when applicable.		

ECSS-Q-ST-60_048083	4.3.2e	M – End customer
e. The use of any new specification shall be submitted to the end customer and ESA for approval through the PAD process (see clause 4.2.4).		

ECSS-Q-ST-60_048084	4.3.2f	A
f. Upon request, any new procurement specification prepared in the frame of the project, shall be delivered to the end customer.		

ECSS-Q-ST-60_048085	4.3.2g	A
g. The Supplier shall keep each procurement specification under configuration control.		

7.3.3 SCREENING REQUIREMENTS

ECSS-Q-ST-60_048086	4.3.3a	A
a. All components to be incorporated into flight standard hardware shall be subjected to screening.		

ECSS-Q-ST-60_048087	4.3.3b	A
b. The screening test requirements shall be defined such that accumulated stress does not jeopardize component reliability.		

ECSS-Q-ST-60_048088	4.3.3c	A
c. All screening tests shall be performed at the component manufacturer's premises or at a facility approved either by the qualification approval authority, where applicable (e.g. ESCC), or otherwise by the Supplier.		

ECSS-Q-ST-60_048089	4.3.3d	M – End customer
d. The quality levels defined in **Annex A** of this document shall apply.		

ECSS-Q-ST-60_048090	4.3.3e	M – End customer
e. For active parts (transistors, diodes) packaged in TO3, DO4 or DO5, the PIND test method shall be submitted to end customer and ESA approval.		

NOTE See also clause 4.2.2.2e.2.

ECSS-Q-ST-60_048448	4.3.3f	A
f. When a component is available in a qualified version according to quality level specified in **Annex A** of this document, it shall be selected.		

ECSS-Q-ST-60_048449	4.3.3g	A
g. In case a component is not available in a qualified version according to quality level specified in **Annex A** of this document, the screening of the component shall meet the screening flow defined by the generic specifications listed in **Annex A** of this document.		

ECSS-Q-ST-60_048450	4.3.3h	A
h. In case of X-rays inspection, the total dose deposited shall be less than 1/10 of the product acceptable dose.		

ECSS-Q-ST-60_MOS-013	4.3.3i	N - esa
i. For non-hermetically sealed millimetre wave and sub-millimeter wave mixer diodes, multiplier diodes and detector diodes mounted in a waveguide and/or on a substrate, the screening test requirements shall be based on Chart II(a), Chart II(b) and Chart III(a) Testing Level B of the ESCC Generic Specification No 5010.		

ECSS-Q-ST-60_MOS-014	4.3.3j	N - esa
j. For non-hermetically sealed millimetre wave and sub-millimeter wave Low Noise Amplifiers (LNAs) and Power Amplifiers (PAs) mounted in a waveguide and/or on a substrate, the screening test requirements shall be based on Chart II(a), Chart II(b) and Chart III(b) Testing Level B of the ESCC Generic Specification No 9010.		

7.3.4 INITIAL CUSTOMER SOURCE INSPECTION (PRECAP)

ECSS-Q-ST-60_048091	4.3.4a	A
a. The procurement entity shall carry out, at the manufacturer's premises, a Customer precap inspection for non-space qualified parts listed below: 1. Capacitors (ceramic, mica and plastic film) 2. Crystals 3. Oscillators 4. Discrete semiconductors (including diodes and transistors) 5. Filters 6. Fuses (cermet) 7. Inductors, coils and transformers (not applicable to in-house products) 8. Monolithic microcircuits (including MMICs) 9. Hybrid circuits 10. Relays 11. Resistors (high precision, fixed, metal foil - RNC90) 12. Switches (including mechanical and thermal) 13. Optoelectronic devices (e.g. opto-couplers, LEDs, CCDs and sensors).		

ECSS-Q-ST-60_048092	4.3.4b	A
b. The procurement entity shall carry out, at the manufacturer's premises, a Customer precap inspection on critical space qualified parts , including as a minimum relays, crystals, oscillators and hybrids.		

ECSS-Q-ST-60_048093	4.3.4c	A
c. When not covered by MIL or ESCC specifications, methods and accept/reject criteria for Customer's precap inspection shall be documented by a procedure to be presented to the end customer, on request, for review.		

7.3.5 LOT ACCEPTANCE

ECSS-Q-ST-60_048094	4.3.5a	M – End customer
a. The Supplier shall ensure that any lot/datecode of EEE parts is submitted to a lot acceptance procedure (in line with applied normative systems) according to the following rules: 1. Space qualified parts: (a) ESCC: user's lot acceptance on the procured lot/datecode is not required due to periodic lot validation testing performed by the manufacturer. (b) MIL: QCI or TCI performed by the manufacturer is in accordance with the quality level of the MIL specification. 2. Non-space qualified parts: (a) The content of the lot acceptance is ESCC level LAT1 or level LAT2 or LVT (subgroups 1, 2 and 3) or comparable QCI. (b) The lot acceptance may be replaced by the review of available data less than 2 years old and provided there have been no changes to the manufacturing process and no changes to the part design and construction. (c) In case of partial available data, any complementary lot acceptance content is defined by the Supplier, subject to PCB agreement. (d) The PCB documents and justifies any reduced lot acceptance based on available data, submitted to end customer and ESA for approval.		

NOTE LAT1 is required unless reliability data are available on the same package from the same manufacturer.

ECSS-Q-ST-60_MOS-015	4.3.5a.2e	N - esa

a.2e. For non-hermetically sealed millimetre wave and sub-millimeter wave mixer diodes, multiplier diodes and detector diodes mounted in a waveguide and/or on a substrate, the lot acceptance test shall be based on the ESCC No 5010, LAT 1: Endurance Subgroup and Environmental/Mechanical Subgroup.

- If evaluation test results for the components are provided and approved by ESA, and if there is evidence that there have been no changes to the manufacturing process and no changes to the part design and construction, the endurance subgroup of LAT1 shall contain as a minimum: Storage Test at one high temperature, DC Forward Biasing Life Test at one High Temperature, DC Reverse Biasing Life test at one High Temperature and RF Life tests at Room Temperature. If no evaluation test results can be provided for the components, and/or if there is evidence that there have been changes to the manufacturing process and/or changes to the part design and construction, the endurance subgroup of LAT1 shall contain, as a minimum: Storage Test at two high temperatures, DC Forward Biasing Life Tests at two High Temperatures, DC Reverse Biasing Life tests at two High Temperatures and RF Life tests at Room Temperature. The duration of each endurance test shall be proposed by the Supplier and approved by ESA.
- The Environmental/Mechanical subgroup shall contain, in addition to the tests mentioned in Chart V of ESCC No 5010, 2 additional tests: Humidity tests without biasing and Humidity tests with biasing to be performed according to the Standard EIA/JEDEC, Test Method A101-B. The duration of Environmental, Mechanical and Humidity tests shall be proposed by the Supplier and approved by ESA.
- The minimum quantity of millimetre wave and sub-millimetre wave mixer diodes, multiplier diodes and detector diodes per type/frequency band to be tested during the different tests of the LAT listed above is 4 components per wafer when a single wafer can cover all procurements.
- In case the total number of samples, dedicated to the Lot Acceptance Tests and to the flight standard hardware, can only be collected from several different wafers, 3 components per wafer shall be tested.
- Except for the storage tests and the DC life tests of the endurance subgroup indicated above, all Lot Acceptance tests shall be performed on mixer diodes, multiplier diodes and detector diodes mounted in a waveguide.
- Similarity may be considered to reduce the sample size for Lot Acceptance Test and shall be submitted to ESA for approval. Similarity has to be understood at waveguide and diode level as follows:
  - two waveguide blocks are similar if they use similar materials, similar chips and identical assembly techniques;
  - two diodes (mixer diodes, multiplier diodes or detector diodes) are similar if they use the same epitaxial material, the same manufacturing process and the same diode geometry/size).

ECSS-Q-ST-60_MOS-016	4.3.5a.2f	N - esa

a.2f. For non-hermetically sealed millimetre wave and sub-millimeter wave Low Noise Amplifiers (LNAs) and Power Amplifiers (PAs) mounted in a waveguide and/or on a substrate, the lot acceptance test shall be based on the ESCC No 9010, LAT 1: Endurance Subgroup and Environmental/Mechanical Subgroup.

- If evaluation test results for the components are provided and approved by ESA, and if there is evidence that there have been no changes to the manufacturing process and no changes to the part design and construction, the endurance subgroup of LAT1 shall contain as a minimum: Storage Test at one high temperature, DC Life Test at one High Temperature and RF Life tests at Room Temperature. If no evaluation test results can be provided for the components, and/or if there is evidence that there have been changes to the manufacturing process and/or changes to the part design and construction, the endurance subgroup of LAT1 shall contain, as a minimum: Storage Test at two high temperatures, DC Life Tests at two High Temperatures and RF Life tests at Room Temperature. The duration of each endurance tests shall be proposed by the Supplier and approved by ESA.
- The Environmental/Mechanical subgroup shall contain, in addition to the tests mentioned in Chart V of ESCC No 9010, 2 additional tests: Humidity tests without biasing and Humidity tests with biasing to be performed according to the Standard EIA/JEDEC, Test Method A101-B. The duration of the Environmental, Mechanical and Humidity tests shall be proposed by the Supplier and approved by ESA.
- The minimum quantity of millimetre wave and sub-millimetre wave LNAs and PAs per type/frequency band to be tested during the different tests of the Lot Acceptance Tests indicated above is 4 components per wafer when a single wafer can cover all procurements.
- In case the total number of samples, dedicated to the Lot Acceptance Test and to the flight standard hardware, can only be collected from several different wafers, 3 components per wafer shall be tested.
- All Lot Acceptance tests shall be performed on LNAs and PAs mounted in a waveguide.
- Similarity may be considered to reduce the sample size for Lot Acceptance Test and shall be submitted to ESA for approval. Similarity has to be understood at waveguide and MMIC level as follows:
  - two waveguide blocks are similar if they use similar waveguide materials, similar chips and identical assembly techniques;
  - two MMICs (LNAs or PAs) are similar if they use the same epitaxial material, the same manufacturing process and the same technology.

ECSS-Q-ST-60_048095	4.3.5b	M – End customer

b. The sample size for lot acceptance which may be reduced in some cases, shall be submitted to end customer and ESA for approval through the PAD process (see clause 4.2.4).

7.3.6 FINAL CUSTOMER SOURCE INSPECTION (BUY-OFF)

ECSS-Q-ST-60_048096	4.3.6a	A

a. The procurement entity shall carry out, at the manufacturer's premises, a final Customer source inspection for non-space qualified parts, based on inspections, tests and review activities to verify that the requirements of the purchase order are met prior to shipment of the flight parts.

ECSS-Q-ST-60_048097	4.3.6b	A

b. The buy-off shall include:

1. External visual inspection,
2. Witnessing electrical measurements,
3. Verifying mechanical dimensions,
4. Review and verification of the data-package.

ECSS-Q-ST-60_048098	4.3.6c	A

c. The buy-off may be replaced by an incoming inspection at the procurement entity's facilities

ECSS-Q-ST-60_048099	4.3.6d	M – End customer
d. If the buy-off is replaced by an incoming inspection at the procurement entity's facilities, it shall be declared in the PAD submitted to end customer and ESA for approval.		

7.3.7 INCOMING INSPECTIONS

ECSS-Q-ST-60_048100	4.3.7a	A
a. The procurement entity shall perform incoming inspection at his premises on all components to verify conformance with the purchase order requirements.		

ECSS-Q-ST-60_048101	4.3.7b	A

b. The incoming inspection shall include the following items:

1. For any part :
   (a) Marking control,
   (b) Quantity verification,
   (c) Packing checking,
   (d) Review of the manufacturer delivered documentation,
   (e) Additional tests based on the type of component, criticality and heritage with the manufacturer (e.g. solderability tests, electrical tests),
   (f) In case of not golden termination finish, check the lead finish as per ESCC 25500 basic specification.
2. For the non-space qualified parts, when the final customer source inspection has not been performed, the following additional items:
   (a) External visual inspection by sampling (AQL 0,65% level II or 20 parts min),
   (b) Electrical measurements at room temperature on 20 parts or 100% (if lot size < 20 parts), or a datapackage review.

NOTE The electrical measurements may be replaced by a datapackage review.

ECSS-Q-ST-60_048102	4.3.7c	A
c. The incoming inspection shall be documented by a procedure to be presented, on request, to end customer for review.		

ECSS-Q-ST-60_048103	4.3.7d	A
d. If the parts have passed successfully a final CSI (or buy-off), the incoming inspection may be reduced to the following minimum: 1. Verification of the manufacturer's CoC 2. Packing checking, 3. Quantity verification.		

ECSS-Q-ST-60_048104	4.3.7e	A
e. In case the incoming inspection has been performed by a procurement agent, the incoming inspection performed by the end-user, may be reduced to the following minimum: 1. Packing checking, 2. Quantity verification.		

7.3.8 RADIATION VERIFICATION TESTING

ECSS-Q-ST-60_048105	4.3.8a	A
a. Radiation sensitive components, as defined in clause 4.2.2.4, and for which applicable existing test data is insufficient shall be subjected to RVT.		

ECSS-Q-ST-60_048106	4.3.8b	M - esa
b. RVT shall be performed in accordance with internationally recognized standards, such as ESCC Basic Specifications No. 22900, No. 25100 for example		

NOTE Additional information on test methods is given in MIL-STD-750 Test Method 1019, MIL-STD-883 Test Method 1019.

ECSS-Q-ST-60_048107	4.3.8c	A
c. In such a case, a PAD in conformance with **Annex B** of this document shall be issued and processed as per clause 4.2.4.		

ECSS-Q-ST-60_048108	4.3.8d	A
d. The results of RVT shall be documented by a report.		

ECSS-Q-ST-60_048109	4.3.8e	M – End customer
e. When RVT is performed in the frame of the project, the Supplier shall send the related report to the end customer for information.		

7.3.9 DESTRUCTIVE PHYSICAL ANALYSIS

DPA comprises a series of inspections, tests and analyses performed on a sample of components to verify that the material, design and workmanship used for its construction, as well as the construction itself, meet the requirements of the relevant specification and are suitable for the intended application.

ECSS-Q-ST-60_048110	4.3.9a	A
a. The DPA shall be performed on 3 samples per lot/datecode for non-space qualified parts belonging to the following categories: 1. Capacitors (glass, ceramic, tantalum and variable) 2. Crystals 3. Oscillators 4. Discrete semiconductors (including diodes and transistors) 5. Filters 6. Monolithic microcircuits (including MMICs) 7. Hybrid circuits 8. Relays 9. Switches (including mechanical and thermal) 10. Optoelectronic devices (e.g. opto-couplers, LED's, CCD's and sensors) 11. Passive microwave devices (e.g. mixers, couplers, isolators and switches).		

ECSS-Q-ST-60_048111	4.3.9b	M - esa
b. The DPA shall be performed on 3 samples per lot/datecode on critical space qualified parts, including as a minimum relays, oscillators, thermal switches, and off-The-Shelf hybrids. For other space qualified parts families, DPA is not required.		

ECSS-Q-ST-60_048113	4.3.9d	M – End customer
c. The DPA sample size may be reduced in some cases which shall be submitted to end customer and ESA for approval through the PAD process.		

ECSS-Q-ST-60_048114	4.3.9e	M – End customer
d. The DPA process shall be documented by a procedure to be sent, on request, to end customer for review.		

ECSS-Q-ST-60_048115	4.3.9f	A
e. The Supplier shall verify that the outcome of the DPA is satisfactory prior to the installation of the components into flight hardware.		

	4.3.9g	M – End customer
f. Independent laboratories may perform DPA when approved by the end customer.		

ECSS-Q-ST-60_048117	4.3.9h	A
g. DPA may be performed by the manufacturer if witnessed by the Supplier (or approved representative).		

ECSS-Q-ST-60_048118	4.3.9i	A
h. For health and safety reasons, any test producing beryllium oxide dust shall be omitted.		

ECSS-Q-ST-60_048119	4.3.9j	M – End customer
i. The results of DPA shall be documented by a report sent to the end customer, on request, for information.		

7.3.10 RELIFING

ECSS-Q-ST-60_048451	4.3.10a	A
a. When components from a Supplier's or parts procurement agent's stock are used, the following criteria shall be met: 1. The parts are stored according to the minimum conditions given in clause 4.4, 2. The minimum overall requirements (including screening) are in accordance with the project requirements, 3. The lot/datecode homogeneity and traceability can be demonstrated, 4. The EEE parts documentation is available and the content is acceptable in accordance with the project requirements (including radiation data, if necessary), 5. There are no open NCR's and no unresolved alerts with respect to their date code.		

ECSS-Q-ST-60_048121	4.3.10b	M – End customer
b. For components meeting the above criteria, and which have a lot / date code exceeding the period defined in the **Annex D** of this document, the relifing procedure described in the **Annex D** shall apply.		

7.3.11 MANUFACTURER'S DATA DOCUMENTATION DELIVERIES

ECSS-Q-ST-60_048122	4.3.11a	A
a. The manufacturer's CoC shall be delivered to the parts procurer.		

ECSS-Q-ST-60_048123	4.3.11b	A
b. Any other data (i.e. LAT or LVT, QCI or TCI), defined in the applicable procurement documents, shall be available at the manufacturer's facilities or delivered to the parts' procurer in line with the purchase order, as a minimum compatible with CSV.		

NOTE CSV is a common file format that can be used to transfer data between database or spreadsheet tables (a spreadsheet program is for example Excel®).

ECSS-Q-ST-60_048124	4.3.11c	A
c. For non-qualified parts, the documentation minimum storage period shall be 10 years after delivery of components by the manufacturer.		

NOTE For qualified parts, the documentation storage period is under the responsibility of the manufacturer and the qualifying authority.

7.4 HANDLING AND STORAGE

ECSS-Q-ST-60_048125	4.4a	A
a. The Supplier shall establish and implement procedures for handling and storage of components in order to prevent possible degradation.		

ECSS-Q-ST-60_048126	4.4b	A
b. The procedures shall be applicable at any facility dealing with components for flight application.		

ECSS-Q-ST-60_048127	4.4c	A
c. On request, handling and storage procedures shall be sent to end customer for review.		

ECSS-Q-ST-60_048128	4.4d	A
d. As a minimum, the following areas shall be covered: 1. Control of the environment in accordance with ESCC Basic Specification No. 24900. 2. Measures and facilities to segregate and protect components during receiving inspection, storage, and delivery to manufacturing. 3. Control measures to ensure that electrostatic discharge susceptible components are identified and handled only by trained personnel using anti static packaging and tools.		

7.5 COMPONENT QUALITY ASSURANCE

7.5.1 GENERAL

ECSS-Q-ST-60_048129	4.5.1a	A
a. The Supplier shall establish and implement the requirements of this document including methods, organizations and documents used to control the selection and procurement of components in accordance with the requirements of ECSS-Q-ST-20.		

7.5.2 NON-CONFORMANCES OR FAILURES

ECSS-Q-ST-60_048130	4.5.2a	A
a. The Supplier shall establish and maintain a non-conformance control system in accordance with the general requirements in ECSS-Q-ST-10-09.		

ECSS-Q-ST-60_048131	4.5.2b	A
b. Any observed deviation of EEE components from requirements as laid down in applicable specifications, procedures and drawings shall be controlled by the non-conformance control system.		

NOTE This includes failures, malfunctions, deficiencies and defects.

ECSS-Q-ST-60_048132	4.5.2c	A
c. The non-conformance control system shall handle all non-conformances occurring on EEE components during: 1. Manufacture (if available), screening and acceptance tests, 2. Incoming inspection, 3. Integration and test of equipment, 4. Storage and handling.		

ECSS-Q-ST-60_048133	4.5.2d	A
d. For ESCC qualified components the Supplier shall apply the ESCC basic specification no 22800.		

7.5.3 ALERTS

ECSS-Q-ST-60_048134	4.5.3a	A
a. The Supplier shall take into account all received alerts from international alert systems, from manufacturers or sent by the end customer and shall validate that there are no alerts on the proposed parts with respect to the batch information (including date-code).		

ECSS-Q-ST-60_048135	4.5.3b	M - Airbus DS
b. If alerts become available at a later stage, the supplier shall analyse the alerts, analyse the project risk and propose an action plan for approval by end customer and ESA.		

ECSS-Q-ST-60_048136	4.5.3c	A
c. The Supplier shall initiate and distribute within the project notifications for all major problems arising on EEE parts during procurement, incoming inspection or during all levels of equipment manufacturing or testing, which are of general concern.		

7.5.4 TRACEABILITY

ECSS-Q-ST-60_048137	4.5.4a	A
a. The traceability of individual components during manufacturing and testing shall be maintained as required by the procurement specifications.		

ECSS-Q-ST-60_048138	4.5.4b	A
b. The traceability shall be maintained through incoming, storage, and installation at the procurer and user of the component in accordance with programme PA requirements.		

ECSS-Q-ST-60_048139	4.5.4c	A
c. In any case, the traceability requirements imposed by the Supplier on the EEE parts manufacturer or distributor shall allow managing the adequacy of the tests performed by the Supplier (i.e. evaluation, lot validation, any additional test or inspection).		

ECSS-Q-ST-60_048140	4.5.4d	A
d. The traceability of EEE parts during installation in equipment, shall be ensured by the Supplier through maintaining the traceability to the manufacturer's lot/datecode number of the EEE parts actually mounted.		

ECSS-Q-ST-60_048141	4.5.4e	A
e. If the as built DCL has not yet been delivered, the Supplier shall be able to provide this information (part type actually installed with its relevant lot/datecode number) within one week.		

7.5.5 LOT HOMOGENEITY FOR SAMPLING TEST

ECSS-Q-ST-60_048142	4.5.5a	A
a. If tests are performed by sampling, the sampled parts shall be selected so that they are representative of the lot/datecode distribution.		

ECSS-Q-ST-60_048143	4.5.5b	A
b. For radiation tests, the set of test samples used shall be in accordance with ECSS-Q-ST-60-15.		

7.6 SPECIFIC COMPONENTS

ECSS-Q-ST-60_MOS-017	4.6a	N - esa
a. The end customer and ESA reserve the right to participate in any and all reviews pertaining to the design, development, manufacture and test of custom ASICs, FPGAs, One time programmable devices and Microwave monolithic integrated circuits for the MetOp-SG programme at any contractual level.		

ECSS-Q-ST-60_MOS-018	4.6b	N - esa
b. The end customer and ESA reserve the right of complete visibility to all design, development, manufacturing and test documentation of ASICs, FPGAs, One time programmable devices and Microwave monolithic integrated circuits procured for the MetOp-SG programme at any contractual level.		

7.6.1 ASICS

ECSS-Q-ST-60_048145	4.6.2a	M – End customer
a. ECSS-Q-ST-60-02 shall apply, complemented by the end customers specific PA requirements in **Annex E** of this document.		

NOTE The end customers requirements for ASIC design and validation are provided in MetOp-SG GDIR [AD13a/b/c].

7.6.2 HYBRIDS

ECSS-Q-ST-60_048146	4.6.3a	A
a. Selection and validation of the hybrids manufacturers shall conform to clauses 5 and 6 of ECSS-Q-ST-60-05.		

ECSS-Q-ST-60_048452	4.6.3b	A
b. Design of hybrids shall conform to clause 7 of ECSS-Q-ST-60-05.		

ECSS-Q-ST-60_048453	4.6.3c	M – End customer
c. The hybrids shall be procured in accordance with the specifications listed in **Annex A** of this document.		

7.6.3 ONE TIME PROGRAMMABLE DEVICES

ECSS-Q-ST-60_048147	4.6.4a	M – End customer
a. For FPGA, ECSS-Q-ST-60-02 shall apply for the design and development complemented by the end customers specific PA requirements in **Annex E** of this document.		

NOTE The end customers requirements for FPGA design, validation and production are provided in MetOp-SG GDIR [AD13 a/b/c].

ECSS-Q-ST-60_048148	4.6.4b	A
b. The PAD shall allow traceability to the information related to the procurement of blank parts, the programming process and the acceptance of the programmed parts.		

NOTE The programming process and the acceptance of the programmed parts are under the authority of the PCB if not otherwise determined in the PAD.

ECSS-Q-ST-60_048150	4.6.4d	A
d. One time programmable components shall be submitted to a post-programming sequence.		

ECSS-Q-ST-60_048151	4.6.4e	M – End customer
e. For FPGA type without a clear and defined heritage, a post-programming burn-in (PPBI) shall be applied in conformance with the following requirements **ECSS-Q-ST-60_REQ-005**, **006** and **007**.		

NOTE 1 FPGA types with defined heritage are documented in the report ESCC REP 010 SCSB Decisions Regarding OTP FPGA PPBI, available on https://escies.org.

NOTE 2 The following FPGA types have been assessed to have accrued sufficient PPBI test data and space application heritage to renounce the requirement for PPBI as part of the post programming screening sequence. These types meet the criteria of "clear and defined heritage".

Manufacturer : Microsemi Corp. (USA)

- *A1280XL*
- *RT1020*
- *RT1280A*
- *RT1425A*
- *RT1460A*
- *RT14100A*
- *A54SX32A on 0.22um UMC fab technology*
- *A54SX72A on 0.22um UMC fab technology*
- *RTSX32SU*
- *RTSX72SU*
- *RTAX250S*
- *RTAX1000S*
- *RTAX2000S*
- *RTAX4000S*
- *RTAX2000D*
- *RTAX4000D*

NOTE 3 The criteria of "clear and defined heritage" is no longer fulfilled in the event of any major change according to MIL-PRF-38535 table A-I :

- *change type D (Mask changes affecting die size or active element, Wafer diameter, Final die thickness),*
- *change type F (Metallization changes),*
- *change type O (Fab move)*
- *change type W (Modification of programming algorithms)*

ECSS-Q-ST-60_REQ-005	-	N – End customer
When required as per 7.6.3d, the post-programming burn-in shall be performed at part level, according to test method 1015 of the MIL-STD-883 (with 168h min).		

ECSS-Q-ST-60_REQ-006	-	N – End customer

The post-programming screening associated with the PPBI, performed at programmed part level, shall be based on the following procedure or tests:

- The pre-BI tests :
  - Record of pre-BI parametric tests at -55°C, +25°C, +125°C.
  - Electrical measurements and criteria shall be in accordance with the SMD table I. It shall include at least all stand-by currents and leakage currents in high impedance mode (IOZL & IOZH)
  - Generic functional test that activate the generic functions of the FPGA independent with the programmed design. (silicon signature reading, binning circuit for example)
- Dynamic Burn with the following conditions :
  - Duration : 168 hours
  - Ambient temperature : 125°C
  - The junction temperature shall be compliant with the specification of the part.
  - Power supply voltage shall be at the max recommended operating voltage of the SMD.
  - All used clocks driven at a defined speed. The frequency of clocks shall be greater than 1MHz.
- The post-BI tests :
  - Same tests as the pre-BI tests
  - Record of post- burn-in parametric values at -55°C, +25°C, +125°C.
- Drift calculation shall be calculated at 25°C. Criteria shall be in accordance with SMD table IIB
- Functional tests
  - The functional tests may be performed at part level to reduce the industrial risk (late disclosure of defects) or system level.
  - Functional tests shall be performed at three temperatures (cold, ambient, hot) in the range used for the acceptance of the system.

ECSS-Q-ST-60_REQ-007	-	N – End customer

d3. The thermal and electrical test setups (burn-in board and burn-in test vectors used during burn-in, test board and test vectors used for the pre-BI tests and post-BI tests) shall be designed and validated with the same rules than the rules applied to the design of the flight boards

ECSS-Q-ST-60_048152	4.6.4f	A

e. The supplier shall prepare a post-programming procedure for end customer and ESA approval, depending on part types (including when necessary electrical tests, programming conditions and equipment, programming software version qualified by the supplier, burn-in conditions, additional screening tests and specific marking after programming) as applicable per 4.6.4d.

ECSS-Q-ST-60_REQ-008	-	N – End customer

f. The Post-programming procedure shall be provided in the PAD.

ECSS-Q-ST-60_REQ-009	-	N – End customer

g. The supplier shall propose a method for the functional verification of the programmed parts, including the following :

- the level of activation of the part during this verification shall be presented,
- the functional tests shall be performed at three temperatures (cold, ambient, hot) in the range used for the acceptance of the system,

Note : the verification may be done either by test at part level before mounting or by the functional test at board or unit level after mounting.

ECSS-Q-ST-60_048153	4.6.4g	A

h. The lot acceptance procedure, as defined in clause 4.3.5, shall be performed on devices coming from the flight lot/datecode and programmed using on the same kind of the hardware tools and compatible software.

ECSS-Q-ST-60_048154	4.6.4h	A
i. In case of several designs based on the same lot of blank parts, the lot acceptance procedure, as defined in clause 4.3.5, may be limited to one representative flight programmed design.		

7.6.4 MICROWAVE MONOLITHIC INTEGRATED CIRCUITS

ECSS-Q-ST-60_048155	4.6.5a	A
a. Design, selection, procurement and use of the microwave monolithic integrated circuits shall be performed in conformance with the requirements from ECSS-Q-ST-60-12.		

7.6.5 CONNECTORS

ECSS-Q-ST-60_REQ-010	-	N – End customer
a. Contacts shall be procured from the same manufacturer as the connector in which they are mounted.		

7.7 LONG TERM STORAGE

ECSS-Q-ST-60_REQ-012	-	N – End customer
a. The supplier shall evaluate the obsolescence risk of EEE parts throughout its supply chain, establish any such risks and present in the Risk Register, and inform the project on technical or programmatic implications, and mitigation actions put in place (strategic stock,..)		

ECSS-Q-ST-60_REQ-013	-	N – End customer
b. The supplier shall identify and evaluate the EEE parts considered as long term storage sensitive and report in the frame of the PCB process, and the critical items list.		

ECSS-Q-ST-60_REQ-014	-	N – End customer
c. If components are stored unassembled (attritions, spare kits,..), the supplier shall take care of the maximum period of 10 years defined in annex D (relifing procedure) after one relifing, and take all necessary dispositions to fit with the long storage period on ground as defined in programme applicable documents.		

7.8 DOCUMENTATION

ECSS-Q-ST-60_048156	4.7a	A
a. Any result from inspection or control shall be documented (including, precap, lot acceptance, buy-off, incoming, relifing and complementary tests).		

ECSS-Q-ST-60_REQ-011	-	N – End customer
b. The following table summarises the list of documents to be provided by the Supplier.		

DOCUMENT	SUBCLAUSE	End Customer	ESA
Component control plan	7.1.2.2	Approval	Review
"as design" DCL	7.1.3	Approval	Approval
RFW during equipment manufacturing *(after "as design" DCL and before "as built" DCL)*	7.1.3	Approval	Approval
"as built" DCL	7.1.33	Review	-
Technical note for parts having pure tin in internal cavities	7.2.2.2	Approval	Approval
Radiation hardness assurance plan	7.2.2.4	Approval	Review
Equipment radiation analysis document	7.2.2.4	Approval	Approval
Evaluation plans	7.2.3.1	Approval	Approval
Evaluation reports	7.2.3.1	Approval	Review
PAD's	7.2.4	Approval	Approval
Justification Documents (applicable to commercial components)	7.2.4	Approval	Approval
Change on EEE parts (e.g. PCN)	7.3.1	Approval	Review
Procurement specifications prepared in the frame of the project	7.3.2	Approval	Approval
PIND test method for DO4, DO5 & TO3 packages	7.3.3	Approval	Information
Procedure for customer precap (when not covered by ESCC or MIL specifications)	7.3.4	Review (on request)	-
Procedure for incoming	7.3.7	Review (on request)	-
RVT reports when RVT is performed in the frame of the project	7.3.8	Information	-
Procedure for DPA	7.3.9	Review (on request)	-
DPA reports	7.3.9	Information(on request)	-
Procedure for handling and storage of EEE parts	7.4	Review (on request)	-
Action plan for alerts	7.5.3	Approval	Approval
Procedure for post-programming sequence	7.6.2	Approval	Approval

Table 7-7: Document requirements list for Class 1 components

8 RADIATION HARDNESS ASSURANCE – EEE COMPONENTS

ECSS-Q-ST-60-15_MOS-001	-	N - esa
a. The requirements of ECSS-Q-ST-60-15C shall apply with the modifications listed of this chapter 8.		

ECSS-Q-ST-60-15_MOS-002	5.1e	M - esa
b. Each EEE part belonging to families & sub-families listed in Table 8-1 (herein) shall be assessed for sensitivity to TID effects to the level specified in Table 8-1 (herein).		

NOTE Hybrids shall also be treated as an electronic box; in this case, RHA requirements, as listed in these PA Requirements, are applicable to every die used in the hybrid.

ECSS-Q-ST-60-15_MOS-003	5.1j	M – esa
c. Component type TIDS shall be statistically calculated as the total dose level at which the one sided tolerance limit, as defined in MIL-HDBK-814, exceeds its limits as defined in requirement 5.1i. The statistical approach shall guarantee a probability of survival Ps (refer to 3.2.5 of ECSS-Q-ST-60-15C) of at least 90% with a confidence level of at least 90%. Alternatively, the Supplier may use of the “worst case” approach which shall be justified on a case-by-case basis and submitted to the Customer for approval; it shall be the total dose level at which the worst case part of the worse case lot exceeds its limits as defined in requirement 5.1i.		

ECSS-Q-ST-60-15_REQ-001	-	N – End customer
d. If the NOVICE (ADJOINT) code is used, histories number shall be > 2000 and TIDL results should have an uncertainty less than 10%. Sector based analysis calculation shall be implemented as follows: 1. calculating the dose at the center (called the detector in the following) of a sphere; The 4π spherical surface surrounding the detector shall then be sectored into N elementary solid angles, considering that: - The total number of elementary solid angles shall be greater than 2000 sectors; they shall be equally distributed over the full space solid angle (4π steradian). Or, 2. calculating the dose at the center (called the detector in the following) of a parallelepiped: Ray tracing calculations shall then follow the procedure described here under: - Each face is meshed N1 x N2 (20 ≤ Ni), - M rays (M ≥ 20) are launched from the detector within each mesh.		

ECSS-Q-ST-60-15_MOS-004	5.1l	M - esa
e. The minimum Radiation Design Margin (RDM) for TID shall be 2 with the exceptions noted in requirement 5.1y below.		

ECSS-Q-ST-60-15_MOS-005	5.1s	M - esa
f. ECSS-Q-ST-60-15 requirement 5.1s is Not Applicable.		

ECSS-Q-ST-60-15_MOS-006	5.1t	M - esa
g. ECSS-Q-ST-60-15 requirement 5.1t is Not Applicable.		

ECSS-Q-ST-60-15_MOS-007	5.1u	M - esa
h. Total Ionising Dose (TID) Radiation Verification Test (RVT) or RADLAT on flight lots shall be performed in accordance with Table 8-1.		

NOTE It is part of Radiation Hardness Assurance to perform RVT on flight lots based on the age of available test data, part type & technology, and RDM.

ECSS-Q-ST-60-15_REQ-002	5.1x	M – End customer
i. All radiation test reports, including RVT reports, shall be available on site for customer review.		

ECSS-Q-ST-60-15_MOS-008	5.1y	M - esa
j. The minimum RDM for TID shall be 4 for the following: • Silicon Monolithic bipolar or BiCMOS Integrated Circuits; .		

ECSS-Q-ST-60-15_MOS-009	5.1z	N - esa
k. For actual flight lots tested and used for the MetOp-SG system, a demonstrated RDM of 1.2 times the TID is acceptable with the exceptions noted in requirement 5.1aa below.		

ECSS-Q-ST-60-15_MOS-010	5.1aa	M – End customer
l. For actual flight lots tested and used for the MetOp-SG system, a demonstrated RDM of 1.5 times the TID is acceptable for the following: • Silicon Monolithic bipolar or BiCMOS Integrated Circuits CCD, CMOS APS, Photodiodes, LED, Phototransistors, Opto-Couplers or Opto-Discrete Devices.		

ECSS-Q-ST-60-15_MOS-011	5.2e	M - esa
m. Each EEE part belonging to families & sub-families listed in Table 8-2 (herein) shall be assessed for sensitivity to TNID effects to the level specified in Table 8-2 (herein).		

NOTE Guidelines & NIEL rates for calculating mono-energetic equivalent proton fluence are provided in ECSS-E-HB-10-12, section 7.5.

ECSS-Q-ST-60-15_MOS-012	5.2l	M - esa
n. Component type TNIDS shall be statistically calculated as the total dose level at which the one sided tolerance limit, as defined in MIL-HDBK-814, exceeds its limits as defined in requirement 5.2k. The statistical approach shall guarantee a probability of survival Ps (refer to 3.2.5 of ECSS-Q-ST-60-15C) of at least 90% with a confidence level of at least 90%. Alternatively, the Supplier may use of the “worst case” approach which shall be justified on a case-by-case basis and submitted to the Customer for approval; it shall be the total non-ionising dose level at which the worst case part of the worse case lot exceeds its limits as defined in requirement 5.2k.		

ECSS-Q-ST-60-15_REQ-003	-	N – End customer
o. If the NOVICE (ADJOINT) code is used, histories number shall be > 2000 and TNIDL/DDEF results should have an uncertainty less than 10%. Sector based analysis calculation shall be implemented as follows: 1. calculating the dose at the center (called the detector in the following) of a sphere; The 4π spherical surface surrounding the detector shall then be sectored into N elementary solid angles, considering that: - The total number of elementary solid angles shall be greater than 2000 sectors; they shall be equally distributed over the full space solid angle (4π steradian). Or, 2. calculating the dose at the center (called the detector in the following) of a parallelepiped: Ray tracing calculations shall then follow the procedure described here under: - Each face is meshed N1 x N2 (20 ≤ Ni), - M rays (M ≥ 20) are launched from the detector within each mesh.		

ECSS-Q-ST-60-15_MOS-013	5.2n	M - esa
p. The minimum Radiation Design Margin (RDM) for TNID shall be 2.		

ECSS-Q-ST-60-15_MOS-014	5.2w	M - esa
q. ECSS-Q-ST-60-15 requirement 5.2w is Not Applicable.		

ECSS-Q-ST-60-15_MOS-015	5.2x	M - esa
r. ECSS-Q-ST-60-15 requirement 5.2x is Not Applicable.		

ECSS-Q-ST-60-15_MOS-016	5.2y	M - esa
s. Total Non-Ionising Dose (TNID) Radiation Verification Test (RVT) or RADLAT on flight lots shall be performed in accordance with Table 8-2.		

NOTE It is part of Radiation Hardness Assurance to perform RVT on flight lots based on the age of available test data, part type & technology, and RDM.

ECSS-Q-ST-60-15_REQ-004	5.2bb	M – End customer
t. All radiation test reports, including RVT reports, shall be available on site for customer review.		

ECSS-Q-ST-60-15_MOS-017	5.2cc	N - esa
u. For actual flight lots tested and used for the MetOp-SG system, a demonstrated RDM of 1.2 times the TNID is acceptable.		

ECSS-Q-ST-60-15_REQ-005	5.3t	M – End customer
v. One of the following two power MOSFET SEB/SEGR assessment methods shall be applied: 1. SEB/SEGR failure rates based on SEB/SEGR cross-section versus equivalent LET curves; the methodology used for such a calculation shall be provided to end customer project team for review and approval before use. 2. VDSmax, VGSoff max derating based on VDS versus VGS SOA.		

NOTE Power MOSFET have a deep sensitive volume. Therefore, LET can vary significantly along ion path in sensitive volume.

ECSS-Q-ST-60-15_REQ-006	5.3u	M – End customer
w. The SEB/SEGR sensitivity assessment of power MOSFET shall comply with the following requirements: 1. The SEB/SEGR test data are acceptable only if evaluation data enclose cross section measurement up to a minimum LET of 38 MeV.cm2/mg, with particles range >> device sensitive depth at ambient temperature. Furthermore, the following information shall be provided: • Worst case VGS used in the application • Case temperature range used in the application 2. In case of acceptable test data (according to 5.3u.1) the following derating shall be applied on VDS for static OFF conditions and worst case temperature: • VDS ≤ 0.8 x VDSth(WC), with |VGS| < |VGSmax| used during testing for VDSth(WC) estimate and, • Ttest < Tcase where Ttest is the case temperature used during testing, for VDSth(WC) estimate.		

NOTE For old parts from Fairchild (Harris, Intersil) heritage products still available and from International Rectifier generation 3 and 4 device types, with BVDSS < 200V, following derating rules on bias conditions (VDS, VGS) can be used in order to prevent SEB and SEGR permanent damage:

- *VDS < 0.5 x BVDSS*
- *N Channel : VGS > 0V*
- *P Channel : VGS < 0V*

P-Channel MOSFETs are intrinsically insensitive to SEB.

ECSS-Q-ST-60-15_REQ-007	5.3gg	M – End customer
x. All radiation test reports shall be available on site for customer review.		

ECSS-Q-ST-60-15_REQ-008	-	N – End customer
y. The approval of the Radiation Hardness Assurance programme and results shall be performed through Equipment Radiation Control Board (ERCB) meetings held between end customer and the supplier according to equipment review schedule as mentioned here below : • "as designed" ERCB: at time of PDR in the case of new or modified equipment design and not later than CDR in case of change of EEE parts between PDR and CDR ; at EQSR time frame in the case of fully recurring or recurring equipment with limited changes. • "as built" ERCB: at time of MRR and not later than TRR, as soon as "as built" DCL is available.		

ECSS-Q-ST-60-15_REQ-009	-	N – End customer
z. The following items shall be reviewed during "as designed" ERCB (non-exhaustive list) : • Applicable and reference documents used in Equipment Supplier Radiation documentation, • Radiation (TID, DD, SEE) test reports applicable to devices used in equipment under review, in order to validate the supplier radiation database, • Identification of all relevant parameter for TIDL and TNIDL/DDEF calculation: radiation environment, used software, methodology, used shielding… • For each relevant and predictable SEE, type-by-type on all active devices, the SEE group and error rate with method used and SEE data review. • Maximum rating used for devices potentially sensitive to SEB and SEGR. • Preliminary SET analysis (EEE part and equipment level). • Preliminary circuit design analysis, focusing on SEE aspects (SET, SEB…) ; Its main objective is to validate the robustness of the design towards radiation, meaning data and schematics shall be validated as "radiation proven", • Part types that shall be submitted to a characterization and/or a RVT (RADLAT), selected parameters to be measured and radiation test plan for such parts, • Part types that shall be submitted to SEE testing, and radiation test plan for such parts. • Assessment on displacement damage, if significant. • Packaging design approach (to achieve maximum inherent shielding), • Preliminary shielding/ray tracing analysis.		

ECSS-Q-ST-60-15_REQ-010	-	N – End customer

aa. The following items will be reviewed during “as built” ERCB (non-exhaustive list):

- List of active parts (extracted from the “as built” issue of the DCL) used in the equipment with identification of manufacturer and date code, and cross check with list of active parts used at “as designed” stage,
- Type by type on all active devices, TIDL, part hardness (TIDS) and dose group; FM lot acceptance status and TID data review.
- Type by type on opto-electronic devices, TNIDL/DDEF to be received, part hardness (TNIDS/DDSF) and displacement damage group, FM lot acceptance status and TNID data review.
- For each relevant and predictable SEE, type-by-type on all active devices, the SEE group and error rate with method used and SEE data review.
- Maximum rating used for devices potentially sensitive to SEB and SEGR.
- Detailed SET analysis (EEE part and equipment level).
- Identification and description of radiation countermeasure used by the supplier, if any.
- Worst case analysis and reliability analysis demonstrating that equipment performance and reliability will be fulfilled considering dose, displacement damage and SEE effects. If not provided in Radiation Analysis, review of the adequate document(s) (ex: FMECA).
- Validation of the consistency between the radiation information given in the PADs and the ones provided in the Equipment Radiation analysis.
- Identification of RFD/RFW connected to radiation issues.
- Closure of radiation RIDs / open action from "as designed" ERCB.

Family	Sub-Family	TIDL	RDM	RVT Requirement
Diodes	Zener, Voltage Reference	All	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years.
	Switching, Rectifier, Schottky	>300 krad-Si eq.	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years. Note: if TIDL <300 krad-SI eq., these devices are considered insensitive and no testing is required
	Microwave	>300 krad-Si eq.	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years. Note: if TIDL <300 krad-SI eq., these devices are considered insensitive and no testing is required
Integrated Circuits	All	All	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years.
	Silicon Monolithic Bipolar or BiCMOS	All	≥4	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years.
		All	<4	RVT Required.
	GaAs	>300 krad-Si eq.	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years. Note: if TIDL <300 krad-SI eq., these devices are considered insensitive and no testing is required
Transistors	MOS	All	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years.
	Bipolar, BiCMOS, NPN or PNP	All	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years.
			<2	RVT Required.
	FET P Channel FET N Channel	All	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years.
	GaAs	>300 krad-Si eq.	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years. Note: if TIDL <300 krad-SI eq., these devices are considered insensitive and no testing is required
Oscillators (Hybrids)		All	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years.
Hybrids containing active parts		All	≥2	RVT if flight diffusion lot number different

			from data diffusion lot and date code older than 4 years.
CCD, CMOS APS, Photodiodes, LED, Phototransistors, Opto-Couplers, Opto-Discrete Devices	All	-	RVT Required.

Table 8-1: Total Ionising Dose RVT Criteria – Class 1 Components

Family	Sub-Family	TNIDL	RDM	RVT Requirement
Diode	Zener, Low Leakage Voltage Reference	$>2\times10^{11}$ p/cm2 50MeV equivalent proton fluence	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years. Note: if TNIDL < $2x10^{11}$ p/cm² 50 MeV equivalent proton fluence, these devices are considered insensitive to displacement damage and no testing is required
Integrated Circuits	Silicon Monolithic Bipolar or BiCMOS	$>2\times10^{11}$ p/cm2 50MeV equivalent proton fluence	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years. Note: if TNIDL < $2x10^{11}$ p/cm² 50 MeV equivalent proton fluence, these devices are considered insensitive to displacement damage and no testing is required
Transistors	NPN or PNP	$>2\times10^{11}$ p/cm2 50MeV equivalent proton fluence	≥2	RVT if flight diffusion lot number different from data diffusion lot and date code older than 4 years. Note: if TNIDL < $2x10^{11}$ p/cm² 50 MeV equivalent proton fluence, these devices are considered insensitive to displacement damage and no testing is required
CCD, CMOS APS, Photodiodes, LED, Phototransistors, Opto-Couplers, Opto-Discrete Devices		All	-	RVT Required.

Table 8-2: Total Non-Ionising Dose RVT Criteria – Class 1 Components

ANNEX A: QUALITY LEVELS FOR CLASS 1

EEE PART FAMILY	QUALITY LEVEL			SUPPLEMENTARY CONDITIONS
	ESCC	MIL	other	
Capacitors, chip, ceramic	ESCC 3009 level C	MIL-PRF-55681 EFR level R min MIL-PRF-123		For ceramic capacitors procured through ESCC or MIL specifications but in an extended, non qualified, range of values or not belonging to ESCC QPL or MIL QML/QPL,the humidity, steady state, low voltage test (cf ESCC 3009, § 5.2.2) is mandatory if U rated <50V and C > 1µF.
Capacitors, molded, ceramic	ESCC 3001 level C	MIL-PRF-39014 EFR level R min MIL-PRF-20 EFR level R min MIL-PRF-123 MIL-PRF-49470 EFR level T		For ceramic capacitors procured through ESCC or MIL specifications but in an extended, non qualified, range of values or not belonging to ESCC QPL or MIL QML/QPL, the humidity, steady state, low voltage test (cf ESCC 3009, § 5.2.2) is mandatory if U rated < 50V and C > 1µF.
Capacitors, glass (CYR type)	-	MIL-PRF-23269 EFR level R min		Lifetest 1000h / 125°C / 1,5Ur on each lot/datecode. Not recommended for new designs
Capacitors, mica	ESCC 3007 level C	MIL-PRF-39001 EFR level R min		
Capacitors, chip, solid tantalum (e.g. TAJ, T495, CWR11)	ESCC 3011 level C ESCC 3012 level C	MIL-PRF-55365 WFR level C min		All capacitors shall be surge current tested.
Capacitors, non-solid tantalum, electrolytic (CLR79)	ESCC 3003 level C	MIL-PRF-39006 EFR level R min		39006 / 22, 25, 30, 31 and "H" dash number designated devices are recommended.

EEE PART FAMILY	QUALITY LEVEL			SUPPLEMENTARY CONDITIONS
	ESCC	MIL	other	
Capacitors, solid tantalum, electrolytic (CSR type)	ESCC 3002 level C	MIL-PRF-39003 WFR level C min		Surge current test mandatory on low ESR capacitors (CSR21 and CSR33)
Capacitors, super metallized plastic film, (CRH type)	ESCC 3006 level C	MIL-PRF-83421 EFR level R min		
Capacitors, metallized film, (HT86PS, KM94S, PM94S, PM90SR2, MKT, …)	ESCC 3006 level C	-		
Capacitors, variable	ESCC 3010 level C	-		
Connectors, non filtered, D-sub rectangular	ESCC 3401 level B			
Connectors, filtered, D-sub rectangular	ESCC 3405 level B			Lifetest 1000h / 125°C / 1,5Ur on each tubular ceramic lot. By default, assured for ESCC products.
Connectors, printed circuit board	ESCC 3401 level B			
Connectors, RF coaxial	ESCC 3402 level B			M39012 connectors cat.B are not preferred. Only SMA connectors are recommended for low earth orbits. N & TNC connectors are not recommended.
Connectors, microminiature rectangular (MDM type)	ESCC 3401 level B	-		
Connectors, non filtered, circular	ESCC 3401 level B			

EEE PART FAMILY	QUALITY LEVEL			SUPPLEMENTARY CONDITIONS
	ESCC	MIL	other	
Connectors, filtered, circular	ESCC 3405 level B	-		Lifetest 1000h / 125°C / 1,5Ur on each tubular ceramic lot. By default, assured for ESCC products.
Crystals	ESCC 3501 level B	-		
Diodes	ESCC 5000	MIL-PRF-19500 JANS		PIND test (see note).
Diodes microwave	ESCC 5010 level B	MIL-PRF-19500 JANS		PIND test (see note).
Filters	ESCC 3008 level B	MIL-PRF-28861 acc. to class S		28861/6 filters not recommended. For M28861 filters not “class S” qualified, group B is required on every lot / datecode.
Fuses (wire link ≥ 5A)	ESCC 4008	MIL-PRF-23419		Burn-in (168h – 85°C – 50% rated current) is mandatory on each lot / datecode.
Fuses (CERMET)	ESCC 4008	MIL-PRF-23419		
Heaters flexible	ESCC 4009 level C	-		
Inductors, coils, (molded)	ESCC 3201 level C	MIL-STD-981 class S		
Inductors, coils (non molded)	ESCC 3201 level C	MIL-STD-981 class S		
Integrated circuits	ESCC 9000	MIL-PRF-38535 class V		PIND test (see note)

EEE PART FAMILY	QUALITY LEVEL			SUPPLEMENTARY CONDITIONS
	ESCC	MIL	other	
Integrated circuits microwave (MMIC)	ESCC 9010 level B	MIL-PRF-38535 class V		PIND test (see note)
Microwave passive parts (circulators , isolators)	ESCC 3202 level B	MIL-DTL-28791 (isolators)		
Microwave passive parts (coupler, power dividers)	ESCC 3404 level B	MIL-DTL-15370 (couplers) MIL-DTL-23971 (dividers) "space flight"		
Microwave passive parts (attenuators, loads)	ESCC 3403	MIL-DTL-39030 (loads) S letter (screened parts) MIL-DTL-3933 (attenuators) S letter (screened parts)		
Microwaves switches		MIL-DTL-3928		
Oscillators (hybrids)	ECSS-Q-ST-60-05 level 1	MIL-PRF-55310 (class 2) level S		
Relays, electromagnetic, latching and non-latching	ESCC 3601 level B ESCC 3602 level B	-		
Resistors, fixed, film, (RNC, MB x xxxx type, except RNC90)	ESCC 4001 level C	MIL-PRF-55182 EFR level R min MIL-PRF-39017 EFR level R min		
Resistors, high precision, fixed, metal foil (RNC90)	ESCC 4001 level C	MIL-PRF-55182/9 EFR level R min		100 Kohms max allowed
Resistors, network, thick film	ESCC 4005 level C	-		
Resistors, current sensing (RLV type)	-	MIL-PRF-49465		
Resistors, power, fixed, wirewound (RWR type)	ESCC 4002 level C	MIL-PRF-39007EFR level R min		

EEE PART FAMILY	QUALITY LEVEL			SUPPLEMENTARY CONDITIONS
	ESCC	MIL	other	
Resistors, power, fixed, wirewound, chassis mounted (RER type)	ESCC 4003 level C	MIL-PRF-39009 EFR level R min		
Resistors, precision, fixed, wirewound (RBR type)	-	MIL-PRF-39005 EFR level R min		Diameter of wire shall be greater than 0,03 mm.
Resistors, fixed, film,high voltage (RHV type)	ESCC 4001 level C	-		
Resistors, fixed, thick and thin film chip	ESCC 4001 level C ESCC 4001 EFR level R min	MIL-PRF-55342 EFR level R min		
Resistors, chip, fixed film, zero ohm	-	MIL-PRF-32159 level T		
Switches, electromechanical	ESCC 3701 level B	MIL-PRF-8805		
Switches, thermostatic	ESCC 3702 level B	MIL-PRF-24236 (b)		(b) Product based on MIL-PRF-24236 are allowed with ESCC screening : Run-in (500 cycles 60/100mA) Elect. Test par ESCC table 2 External visual insp. 100%
Thermistors	ESCC 4006 level C	-		
Transformers	ESCC 3201 level C	MIL-STD-981 class S		
Transistors	ESCC 5000	MIL-PRF-19500 JANS		PIND test (see note)
Transistors microwave	ESCC 5010 level B	MIL-PRF-19500 JANS		PIND test (see note)

EEE PART FAMILY	QUALITY LEVEL			SUPPLEMENTARY CONDITIONS
	ESCC	MIL	other	
Cables & wires, low frequency	ESCC 3901 level B	MIL-DTL-16878		
Cables, coaxial, radio frequency	ESCC 3902 level B	MIL-DTL-17		Only SMA connectors are recommended for flight with MIL-DTL-17 cable for low earth orbits.
Hybrids	ECSS-Q-ST-60-05 level 1	MIL-PRF-38534 class K		
Surface Acoustic Waves (SAW)	ESCC 3502 level B	MIL-PRF-38534 class K		
Charge coupled devices (CCD)	ESCC 9020 level B	-		
Opto discrete devices Photodiodes, LED Phototransistors Opto-couplers	ESCC 5000	MIL-PRF-19500 JANS		PIND test (see note)

NOTE 1 : Particle Inducted Noise Detection (PIND) test is applicable to all cavity packages of active components.

NOTE 2 : By default, PIND test is assured for ESCC products.

NOTE 3 : For semiconductor devices the JANS criteria is applicable per MIL-PRF-19500. The lot / datecode is submitted to 100% PIND testing according to test condition A (per test method 2052 of MIL-STD-750).

NOTE 4 : For integrated circuits the Class V criteria is applicable per MIL-PRF-38535. The lot / datecode is submitted to 100 % PIND testing according to test condition A (per test method 2020 of MIL-STD-883).

NOTE 5: for wires and cables, they shall be procured with 2 microns silver coating, as per ESCC 3901 and 3902 level B

ANNEX B: FORMAT FOR PAD

PROJECT:……………. Doc n°:………………. Prepared by : …………….
Issue:………………….. Date:………………..

Approval requested by:…………………………..
Family:……………….. Fcode [ ] Group:……………… Gcode [ ]
Component Number:……………………………………..
Commer cial Equivalent Designation:………………….
Manufacturer/ Country:……………………………
Technology/Characteristics (value or range of values with tolerance, voltage, package etc): ……………………………..
Pure t in fr ee (Y/N) [ ]
Generic specification:………………...
Detail specification:……………..……. Issue:….. Rev.:….. variant :…….
Specification amendment:…………. Issue:….. Rev.:….. variant :…….
Quality level:…………………….. Procurement by :………………………..

APPROVAL STATUS
EPPL Par t 1/2 listed (1/2/N) [ ]
ESCC QPL or EQML listed. (Y/N) [ ]
MI L QPL or QML listed (Y/N) [ ] If yes: QPL/QML Reference:…………………………..
Other approvals/former usage …………………………………………
Evaluation programme required (Y/N) [ ]
I f yes r efer ence of the Evaluati on Pr ogr amme :…………………………

PROCUREM ENT I NSPECTI ONS and TESTS
Precap (Y/N) [ ]
Lot acceptance :
ESCC LAT/LVT level or subgroup [ ]
MI L QCI/TCI group [ ]
Buy-off (Y/N) [ ]
DPA (Y/N) [ ] i f yes : sample size …………………………

Complementary tests …………………………………………

RADI ATI ON H ARDNESS DATA
Radiation Hardness Assurance Plan applicable (Y/N) [ ]
Doc. Ref.: ....

Tot al Dose Effects :
Evaluati on Test Data (r epor t) r efer ence : ...……………..

Single Event Effects : SEL/SEU/SET/SEFI /SEB/SEGR/others : *(cross out when non applicable)*
Evaluation Test Data (report) reference : ...……………..

RVT required (Y/N)[ ]

REM ARKS

Approval customer .... Date ....

Approval first-level supplier .... Date ....

GUIDANCE NOTE FOR COMPLETION OF PART APPROVAL DOCUMENT

with justification a single PAD may be generic to cover different ranges of parts

Doc No:	Unique sequential number
Issue:	Issue of document
Date:	Date of issue
Project:	Name of project using the component
Prepared by	Name of the person submitting the PAD
Approval requested by:	Name of the company submitting the PAD
Family:	Capacitor, resistor, etc. (Refer ECSS Family Code)
Group:	Ceramic, tantalum, etc. (Refer ECSS Group Code)
Component Number:	In accordance with the procurement specification May be generic to cover different range of parts (with justification) : e.g. range of resistors or capacitors or variants for connectors & accessories
Commercial Equivalent Designation	Self explanatory
Technology/Characteristics:	Additional details of the components covered by the PAD
Pure tin free (Y/N)	When tin ≥ 97% (inside the component and terminations)
Generic specification:	Relevant specification
Detail specification:	Relevant specification with issue and revisions only required for non qualified parts
Specification Amendment	Relevant specification with issue and revisions
Quality level:	As defined in Annex A
Procurement by:	Identify the name of the company procuring the part. E.g. This can be self, CPPA, distributor, manufacturer or a combination thereof.
Manufacturer/Country:	Self-explanatory.
Approval status:	Information about known approvals (EPPL, ESCC, ESCC/QML, MIL, MIL/QML or other approvals/former usage.)
Evaluation programme required:	Y/N as applicable
Procurement inspections and test :	Y/N as applicable
DPA sample size:	Number
Complementary tests	Testing/Inspection in addition to that defined in the procurement specification shall be identified, e.g. PIND, upscreening, …
Lot Acceptance:	Identify level and subgroups
Radiation Hardness Data	Self-explanatory
SEL/SEU/SET/SEFI/SEB/SEGR/others : Evaluation Test Data (report) reference	Reference of the test report for SingleEvent Latchup/ SingleEvent Upset/ Single Event Transient/Single Event Functional Interrupt/Single Event Burn out/Single Event Gate Rupture
RVT	Radiation Verification Test Y/N as applicable
REMARKS	Any additional information
Approval customer:	Signature signifies acceptance
Approval first-level supplier:	Signature signifies acceptance

9 MATERIALS, MECHANICAL PARTS AND PROCESSES REQUIREMENTS (Q-ST-70)

9.1 GENERAL REQUIREMENTS

9.1.1 MMPP MANAGEMENT REQUIREMENTS

9.1.1.1 Overview

The general MMPP activity within the framework of a project is summarized in Figure 9-1.

9.1.1.2 MMPP plan

ECSS-Q-ST-70_049001	4.1.2a	A
a. The Supplier shall prepare, maintain and implement a MMPP plan, as part of the overall PA plan in conformance to ECSS-Q-ST-10 and ECSS-Q-ST-70C or as a separate document.		

ECSS-Q-ST-70_049002	4.1.2b	A
b. The MMPP plan shall be submitted to end customer for approval. Figure 9-1 (Part 1): Materials, mechanical parts and processes flow chart Figure 9-1 (Part 2): Materials, mechanical parts and processes flow chart (Continued) Table 9-1: Steps to be taken to get approval for materials, mechanical parts and processes (MMPP)		

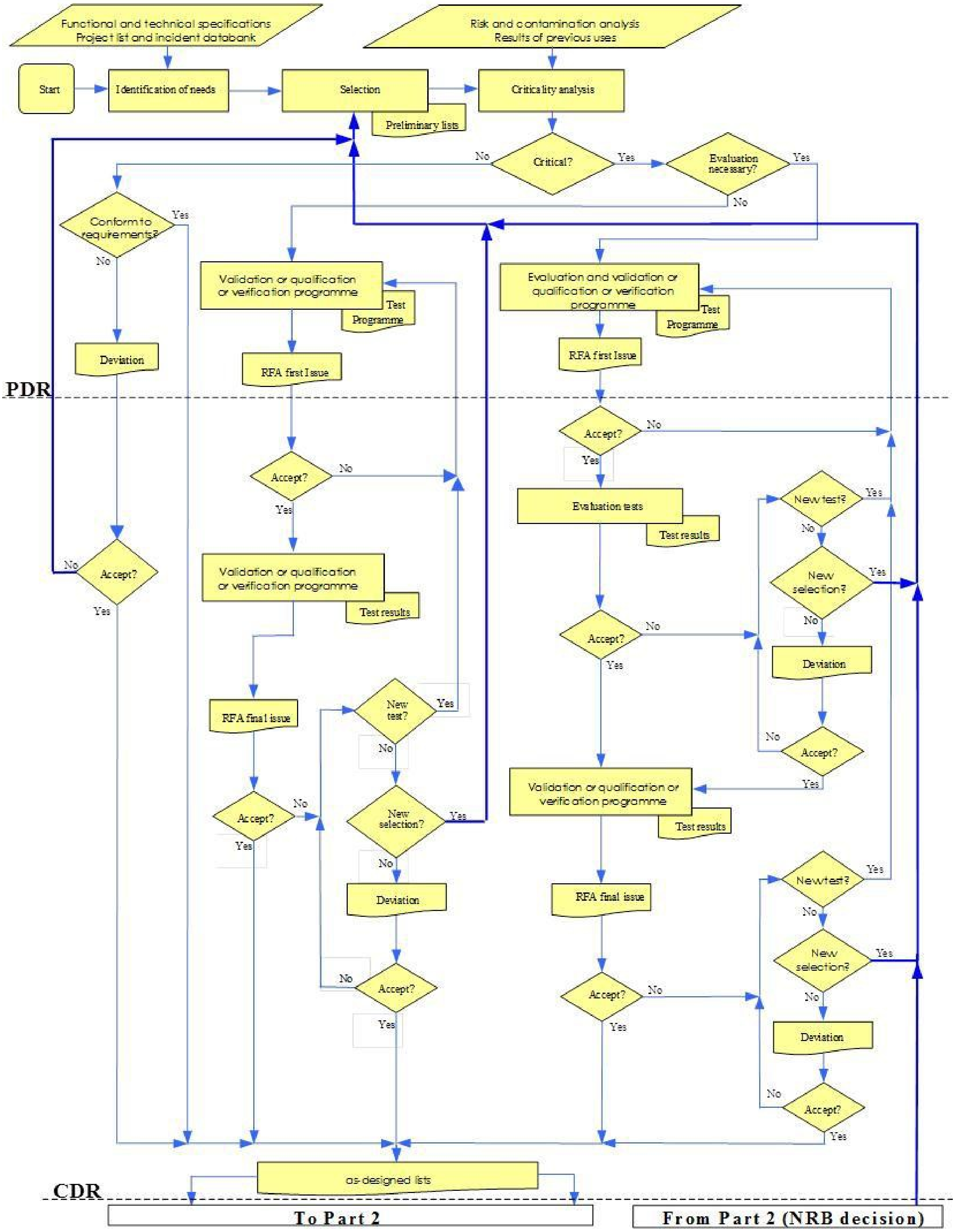


Figure 9-1: Materials, mechanical parts and processes flow chart

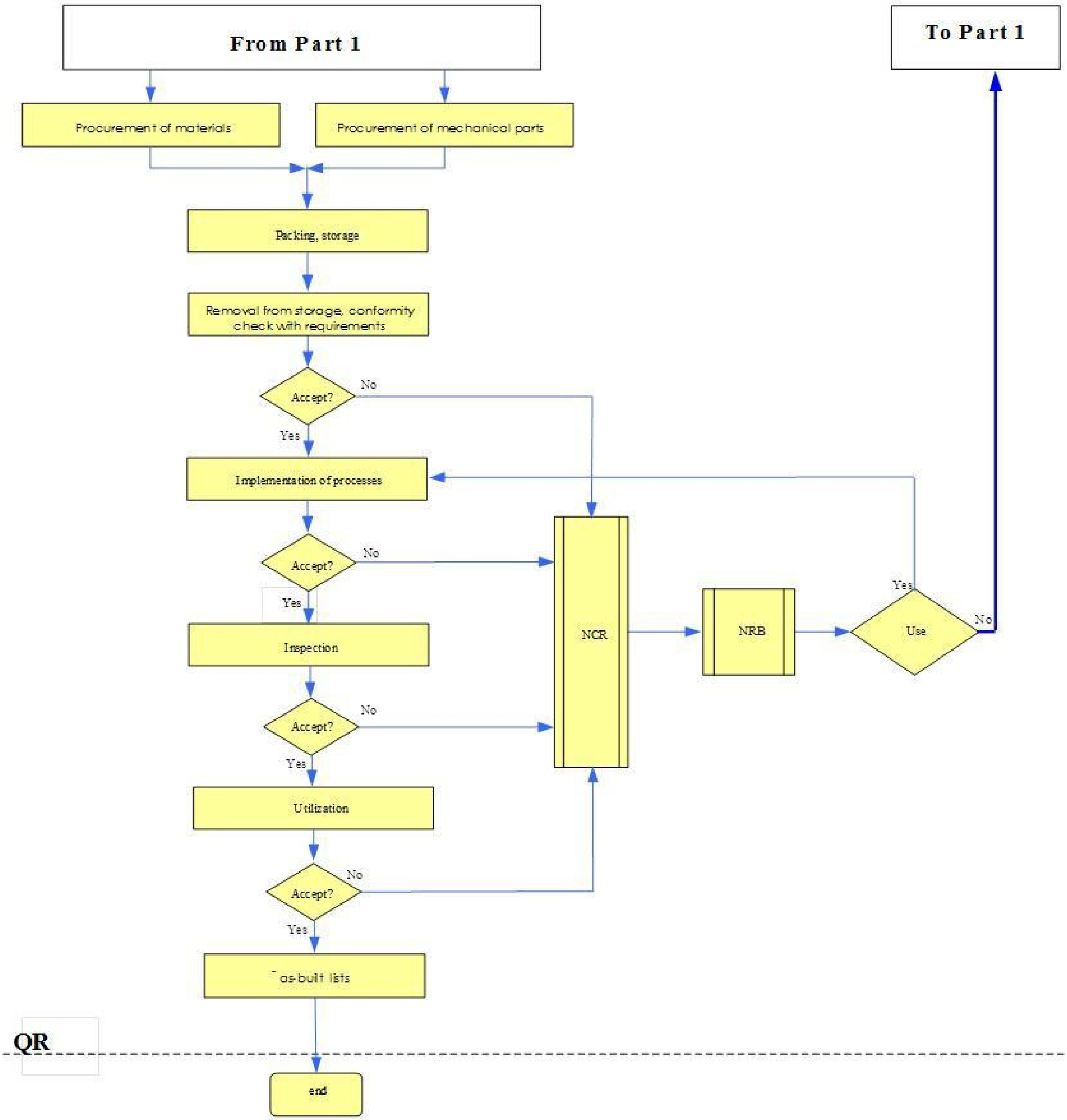


Figure 9-1: Materials, mechanical parts and processes flow chart (Continued)

Phase	Materials		Mechanical parts		Processes	
	Step	Comments	Step	Comments	Step	Comments
Critical Analysis	1		1		1	
Evaluation (usually by test methods defined by ECSS standards)	2	Critical materials are tested, e.g. outgassing, SCC, flammability.	2	Mechanical parts are tested by, for example, vibration, thermal analysis, off-gassing and life test.	2	Critical processes are evaluated by testing "technology samples" including all, for example, electrical interconnection processes and painting, adhesive bonding.
Verification	Not applicable		Not applicable		3	Verification tests usually defined in ECSS standards
Validation	3		Not applicable		Not applicable	
Qualification	Not applicable		3		Not applicable	
Approval		By RFA (Annex D) or DML		By RFA (Annex D) or DMPL/DPL		By RFA (Annex D) or DPL
Note	NOTE 1 Project approval is always by means of the request for approval (RFA) form and the projects' declared materials list (DML), declared mechanical parts list (DMPL) and declared processes list (DPL).					
Note	NOTE 2 The details for approvals of MMPP lists are contained in this Standard.					
Note	NOTE 3 To summarize: Materials are validated. Mechanical parts are qualified. Processes are verified. In addition: Skills training schools are ESA-certified whenever formal personnel certification is requested. Outside test or evaluation laboratories are certified by agency or company audits. Operators and inspectors for special and critical processes are trained, certified and monitored.					

Table 9-1: Steps to be taken to get approval for materials, mechanical parts and processes (MMPP)

9.1.1.3 Customer reviews

ECSS-Q-ST-70_049003	4.1.3a	A
a. To obtain the validation status for materials and qualification status for parts and verification status for processes, the MMPP manager shall present to the end customer those activities which were performed in order to comply with this Standard together with results obtained.		

ECSS-Q-ST-70_049004	4.1.3b	M - esa
b. The Supplier shall appoint a Materials, Mechanical Parts & Processes (MMPP) Engineer/Manager with appropriate competence and adequate experience within the field of MMPP. The MMPP Engineer/Manager shall organise and undertake MMPP Technical Reviews with the suppliers at all levels within the MetOp-SG programme, i.e. Materials, Mechanical Parts and Processes Control Board (MPCB).		

9.1.2 MANAGEMENT AND CONSOLIDATION OF THE ACTIVITIES

9.1.2.1 Overview

The relationship between materials and processes activities and programme phases is shown in ECSS-Q-ST-70 / Annex E.

9.1.2.2 Establishing and processing of lists

ECSS-Q-ST-70_049005	4.2.2a	A
a. Each Supplier and sub-supplier shall establish, collect, review and deliver the declared materials, mechanical parts and processes lists including all the items intended for use in the flight equipment.		

ECSS-Q-ST-70_049006	4.2.2b	A
b. The lists shall reflect the current design at the time of issue.		

ECSS-Q-ST-70_049007	4.2.2c	M – End customer
c. These lists DML,DMPL and DPL shall contain the materials, mechanical parts and processes used in the current design in order to: 1. demonstrate compliance with all requirements of the programme; 2. verify the results of equipment Supplier activities; 3. control and monitor the status of materials, mechanical parts and processes in accordance with programme milestones.		

NOTE See ECSS-Q-ST-70 / Annex F.

ECSS-Q-ST-70_REQ-040	4.2.2d	M – End customer
d. The following constraints shall apply: 1. maximum use of the materials and processes described in approved data sources and items already approved on similar projects; *NOTE: For approved data sources see for example ECSS-Q-70-71.* 2. use of project related preferred lists, if available.		

ECSS-Q-ST-70_049009	4.2.2e	A
e. The following constraints shall be taken into account: 1. requirements originating from the initial technical specification; 2. programmatic project requirements and conditions.		

ECSS-Q-ST-70_049010	4.2.2f	A
f. An analysis of the criticality of these preliminary lists shall, after checking the conformity of the materials, mechanical parts and processes, against all the project requirements, allow them to be classified into three categories: 1. Critical items, subject to evaluation, validation, qualification, or verification programmes. 2. Items that are not critical but which do not conform to one or more project requirements (a justified deviation request should be drafted for this category). 3. Non-critical items.		

ECSS-Q-ST-70_049011	4.2.2g	A
g. For critical items a request for approval shall be submitted in conformance with ECSS-Q-ST-70 / Annex D.		

9.1.2.3 Management of the lists

ECSS-Q-ST-70_049012	4.2.3a	A
a. The Supplier shall document all materials in the Declared materials list in conformance with ECSS-Q-ST-70 / Annex A.		

ECSS-Q-ST-70_049013	4.2.3b	A
b. The Supplier shall document all mechanical parts in the Declared mechanical parts list in conformance with ECSS-Q-ST-70 / Annex B.		

ECSS-Q-ST-70_049014	4.2.3c	A
c. The Supplier shall document all processes in the Declared process list in conformance with ECSS-Q-ST-70 / Annex C.		

ECSS-Q-ST-70_REQ-001	-	N – End customer
d. The supplier shall establish & provide the DML, DMPL and DPL documents in electronic format.		

ECSS-Q-ST-70_REQ-002	-	N – End customer
e. The supplier shall use the ESA DMPL Tool OR an Excel based template provided by Airbus DS in order to establish the DML, DMPL and DPL documents.		

ECSS-Q-ST-70_REQ-003	-	N – End customer
f. The supplier shall transmit the DML, DMPL & DPL documents in 2 types of format: paper & electronic ones. These lists shall be transmitted at the same time in two forms: a signed pdf file and a ESA tool or Excel format file.		

ECSS-Q-ST-70_049016	4.2.3e	A
g. These lists shall be updated during the course of the project.		

ECSS-Q-ST-70_049017	4.2.3f	A
h. The preliminary lists shall include the items from Suppliers' preliminary needs.		

NOTE They are used to identify critical items (available for the PDR).

ECSS-Q-ST-70_049018	4.2.3g	A
i. The as-designed lists shall include the items from the baselines various design files (available for the CDR).		

ECSS-Q-ST-70_049019	4.2.3h	M – End customer
j. Any change to DML, DMPL,DPL post CDR shall be notified to the end customer in accordance with Figure 9-1 (Part 2).		

NOTE 1 The MMPP manager is responsible within the programme to ensure that all the information needed is given and that the approval status is consistent with technical and scheduling objectives and data is exchangeable.

NOTE 2 Where no project requirements exist for a separate DMPL, the mechanical parts can be entered into a separate section of the DML.

NOTE 3 The materials of, for example, screws and nuts that are made up of a few materials can be listed in the DMPL. The materials (metals and plastics) of complex parts can be listed in the DML with, for example, outgassing, toxicity, flammability, corrosion and stress corrosion values and reference to the DMPL item.

9.1.2.4 Supplier role and responsibilities

ECSS-Q-ST-70_049020	4.2.4a	M – End customer
a. The Supplier shall perform the following tasks: 1. obtaining & approving the correct and complete lists from lower level Suppliers; 2. submitting the project declared lists for approval prior to initiation of the hardware phase.		

ECSS-Q-ST-70_MOS-001	4.2.4a4	N - esa
a4. The Supplier shall consolidate all lower level Declared Lists (DML, DPL & DMPL) at unit / equipment / instrument Level (including their own Declared Lists), which shall be electronically editable and sortable, as a minimum compatible with CSV, and also be provided in an unlocked '.pdf' format (i.e. searchable).		

ECSS-Q-ST-70_049021	4.2.4b	M – End customer
b. The lists established by the Suppliers shall include all the information described in this section.		

ECSS-Q-ST-70_049022	4.2.4c	A
c. Amendments to the lists shall be implemented only through established change procedures.		

ECSS-Q-ST-70_049023	4.2.4d	M – End customer
d. The following documentation shall be made available to Airbus DS upon request: 1. RFA (reference and issue) (deliverable); 2. material, mechanical parts or processes justification files (available for review on site); 3. evaluation reports (available for review on site); 4. deviation requests (deliverable).		

ECSS-Q-ST-70_049024	4.2.4e	A
e. The material, mechanical parts or process justification files shall be made available to end customer upon request either on the Supplier site, or by any other process agreed by both parties.		

NOTE For example, by non-disclosure agreement.

ECSS-Q-ST-70_REQ-004	-	N- End customer
f. The supplier is responsible to provide the evidence of mechanical parts & materials conformity to REACH regulation and to produce the list of restricted substances with corresponding mass and authorizations when relevant.		

9.1.3 TECHNICAL CONSTRAINTS

ECSS-Q-ST-70_049025	4.3a	A
a. Parts and materials shall satisfy the mission's functional constraints.		

ECSS-Q-ST-70_049026	4.3b	A
b. Parts and materials shall satisfy both ground environment constraints and flight constraints.		

NOTE Examples are:

- *Ground environment constraints: manufacture, tests, storage, maintenance, transport and integration*
- *Flight constraints: launch and orbit.*

ECSS-Q-ST-70_049027	4.3c	A
c. The technical criteria from clause 5.1 shall be taken into account, according to the mission.		

ECSS-Q-ST-70_049028	4.3d	A
d. The estimated availability of the parts and products obtained from materials and processes used shall be compatible with the final system's life cycle (tests, storage and mission).		

9.1.4 CLEANLINESS AND CONTAMINATION CONTROL

ECSS-Q-ST-70_049029	4.4a	A
a. The Supplier shall establish and maintain a contamination and cleanliness control programme including, as a minimum: 1. cleaning procedures, and 2. cleanliness monitoring procedures or methods.		

ECSS-Q-ST-70_049030	4.4b	M – End customer
b. The risks of molecular or particle pollution generated by parts, materials or processes used shall be identified and reduced in accordance with mission requirements (cleanliness or contamination analysis).		

ECSS-Q-ST-70_049031	4.4c	M – End customer
c. For cleanliness or contamination critical applications, a requirement specification (molecular and particle) and a specific cleanliness control plan and shall be established in conformance with Annex A (CRS DRD) and Annex B (CCCP DRD) of ECSS-Q-ST-70-01.		

ECSS-Q-ST-70_MOS-002	4.4d	N - esa
d. The maximum acceptable level of contamination (particulate and molecular) for sensitive items (e.g. optical surfaces, materials in close proximity to optical surfaces etc.) shall be defined in accordance with MetOp-SG prime Cleanliness Requirements Specification document [AD14e], to assure EOL performance; this shall be verified by appropriate outgassing characterisation.		

ECSS-Q-ST-70_REQ-005	-	N – End customer
e. Silicone based and aromatic based materials shall be avoided and shall only be used with prior agreement of end customer.		

ECSS-Q-ST-70_REQ-006	-	N – End custtomer
f. The supplier shall provide demonstration that silicone containment areas are used to avoid contamination.		

9.1.5 SAFETY HAZARDOUS PARTS AND MATERIALS

ECSS-Q-ST-70_049032	4.5a	A
a. Parts and materials with hazardous characteristics shall be identified, managed and processed in conformance with ECSS-Q-ST-40.		

9.1.6 OPTICAL, MECHANICAL OR ELECTRICAL GSE HARDWARE

ECSS-Q-ST-70_049033	4.6a	A
a. When optical, mechanical or electrical GSE materials are used in thermal vacuum or interfacing with flight hardware, possible degradation shall be taken into account.		

NOTE For example, contamination, surface degradation, electro-mechanical and chemical effects.

9.2 MATERIALS CONTROL

9.2.1 TECHNICAL CRITERIA FOR SELECTION OF MATERIALS

9.2.1.1 Overview

The following requirements apply when the environmental conditions of the mission require their application. The specific requirements, test methods and accept or reject criteria are presented in the ECSS-Q-ST-70 series of documents.

9.2.1.2 Temperature

ECSS-Q-ST-70_049034	5.1.2a	A
a. Material properties shall be compatible with the thermal environment to which they are exposed.		

9.2.1.3 Thermal cycling

ECSS-Q-ST-70_049035	5.1.3a	M - esa
a. Materials subject to thermal cycling shall be assessed for their ability to withstand induced thermal stress.		

NOTE This may also be applied to non-flight hardware required within a thermal environment for Qualification & Acceptance Testing.

ECSS-Q-ST-70_049036	5.1.3b	A
b. The following materials shall be tested in conformance with ECSS-Q-ST-70-04: 1. Materials susceptible to thermal vacuum effect. *NOTE For a non-exhaustive list of such materials, see ECSS-Q-ST-70-04 Clause 1.* 2. Materials of unknown characteristics in respect to thermal vacuum.		

ECSS-Q-ST-70_049037	5.1.3c	A
c. Materials subject to thermal cycling other than those covered by 5.1.3b, shall be tested in accordance with a procedure approved by end customer.		

ECSS-Q-ST-70_REQ-007	-	• N – End customer
d. When thermal shock test is used instead of thermal cycling test to simulate thermal cycling effects, the equivalence shall be demonstrated by the supplier and approved by end customer.		

9.2.1.4 Vacuum

ECSS-Q-ST-70_049038	5.1.4a	A
a. Materials selection shall be made in conformance with ECSS-Q-70-71.		

ECSS-Q-ST-70_049039	5.1.4b	M – End customer
b. Outgassing tests shall be carried out in conformance with ECSS-Q-ST-70-02C or ASTM.E.595.		

NOTE Outgassing performance of materials shall be considered as acceptable based on the environment it is predicted to encounter during the MetOp-SG mission (i.e. temperature, vacuum level and duration) and shall be agreed with end customer.

ECSS-Q-ST-70_MOS-003	5.1.4c	N - esa
c. When relevant out-gassing data is not available, obsolete (defined as a test conducted = ten (10) years ago), or unacceptable (i.e. missing information such as original report reference or insufficient materials/processes description), out-gassing test shall be conducted on the material.		

ECSS-Q-ST-70_REQ-008	-	N – End customer
d. If the material is declared as critical in terms of outgassing, then in addition to ECSS-Q-ST-70 requirements, the exact quantity of material shall be provided in the DML.		

9.2.1.5 Offgassing and toxicity

ECSS-Q-ST-70_049040	5.1.5a	A
a. Spacecraft and associated equipment shall be manufactured from materials and by processes that do not cause a hazard to personnel or hardware, whether on the ground or in space.		

9.2.1.6 Radiation

ECSS-Q-ST-70_049043	5.1.7a	M – End customer
a. Materials used on the spacecraft external surfaces shall be assessed in conformance with ECSS-Q-ST-70-06, completed by the **Annex F** of this document**,** in order to determine their resistance to the radiation dosage expected during the mission.		

ECSS-Q-ST-70_MOS-004	5.1.7b	N - esa
b. Materials shall be able to withstand the total radiation dose level expected for the entire mission without unacceptable degradation of their properties under conditions representative of the mission environment.		

ECSS-Q-ST-70_REQ-010	-	N – End customer
c. A Material Radiation Approval Document (MRAD) containing the exhaustive list of materials affected by Radiations and the justification of approval shall be provided before the MPCB. This document shall contain as a minimum the material name, the localization in the equipment, the cumulative dose, the calculation method and the justification for approval.		

9.2.1.7 Electrical charge and discharge

ECSS-Q-ST-70_049044	5.1.8a	M – End customer
a. External surfaces of the spacecraft shall be sufficiently conductive, interconnected and grounded to the spacecraft structure to avoid the build-up of differential charges in conformance with ECSS-E-ST-20-06.		

*NOTE Materials sensitive to ESD listed in **Annex C** of this document can be used only with the associated restrictions.*

ECSS-Q-ST-70_REQ-011	-	N – End customer
b. Metallic and uncoated floating parts are forbidden.		

9.2.1.8 Corrosion

ECSS-Q-ST-70_049045	5.1.9a	A
a. For all materials that come into contact with atmospheric gases, cleaning fluids or other chemicals, it shall be demonstrated that the degradation of properties during their anticipated service-life is acceptable in terms of the performance and integrity requirements.		

9.2.1.9 Stress-corrosion

ECSS-Q-ST-70_049046	5.1.10a	M – End customer
a. Materials used for structural and load-bearing applications (i.e.: subject to tensile stress) shall be selected in preference from table 5-1 of ECSS-Q-ST-70-36; if it is not available in Table 5-1, use Table 5-2 or Table 5-3 as per clause 5-2 of ECSS-Q-ST-70-36.		

ECSS-Q-ST-70_049047	5.1.10b	A
b. Any material not covered by standard ECSS-Q-ST-70-36 shall be tested in conformance with ECSS-Q-ST-70-37.		

9.2.1.10 Fluid compatibility

ECSS-Q-ST-70_049048	5.1.11a	A
a. Materials within the system exposed to liquid oxygen (LOX), gaseous oxygen (GOX) or other reactive fluids, both directly and as a result of single point failure when failure propagation effects causes hazardous operation of interfacing hardware, shall be compatible with that fluid in their application.		

ECSS-Q-ST-70_049049	5.1.11b	A
b. The possibility of hydrogen embrittlement occurring during component manufacture or use shall be assessed, and an material evaluation be undertaken, including the assessment of adequate protection and control.		

9.2.1.11 Galvanic compatibility

ECSS-Q-ST-70_049050	5.1.12a	M – End customer
a. When bimetallic contacts are used, the choice of the pair of metallic materials used shall be in conformance with table 1 of ECSS-Q-70-71. For non defined configurations, maximum allowed couples is 0.5V in controlled environments and 0.25V in other environments (no temperature or humidity control).		

NOTE This also includes metal-to-conductive fibre-reinforced materials contacts.

ECSS-Q-ST-70_049051	5.1.12b	A
b. Galvanic compatibilities shall be selected in conformance with Table 9-2.		

ECSS-Q-ST-70_049052	5.1.12c	A
c. Materials not listed in Table 9-2 shall be evaluated in a flight-simulated configuration using an accelerated environment to be agreed by end customer.		

ECSS-Q-ST-70_REQ-012	-	N – End customer
d. For materials not listed in the Table 9-2, the maximum allowed couple is 0,5V in controlled environments and 0,25V in uncontrolled environments (no temperature or humidity controls).		

9.2.1.12 Atomic oxygen

ECSS-Q-ST-70_049053	5.1.13a	A
a. All materials considered for use on the external surfaces of spacecraft intended for use in Low Earth Orbit (LEO) altitudes (between 200 km and 700 km) shall be evaluated for their resistance to atomic oxygen (ATOX).		

ECSS-Q-ST-70_049054	5.1.13b	A
b. Test procedures shall be subject to the approval of end customer.		

9.2.1.13 Micrometeoroids and debris

ECSS-Q-ST-70_049055	5.1.14a	A
a. The effect of impacts by micrometeoroids and debris on materials shall 1. be reviewed and assessed on a case by case basis, and 2. their use comply with safety evaluation and assessment results concerning design and application criteria or details.		

9.2.1.14 Moisture absorption and desorption

ECSS-Q-ST-70_049056	5.1.15a	A
a. Precautions shall be taken to avoid moisture absorption during manufacture and storage of CFRP-type materials in conformance with ECSS-Q-ST-70-01 and ECSS-Q-ST-70-22.		

Pure metals and alloys in alphabetical order (including carbon)	Aluminium-Copper alloys	Al (pure), Al-Zinc alloys	Cadmium	Cast iron (austenic)	Chromium	Copper, Brasses	Cupro-Nickel, Al-bronzes, Si-bronzes	Gold, Platinum, Carbon, Rhodium	Gun-metal (CuZn10 alloy), P-bronzes, Sn-bronzes	Magnesium	Nickel, Monel, Inconel, Nickel/Molybdenum-alloys	Silver	Sn-Pb alloys (all), Tin, Lead	Stainless steel 18/8 (300 series)	Stainless steel 13Cr (400 series)	Steel (carbon, low alloy), Cast iron	Titanium and Ti-alloys	Zinc, Beryllium
Aluminium-Copper alloys	■	1	1	3	3	3	3	3	3	2	2	3	1	2	2	3	2	2
Al (pure) Al-Zinc alloys		■	1	3	3	3	3	3	3	2	3	3	2	3	3	3	3	2
Cadmium			■	2	2	2	2	2	2	1	2	2	0	1	1	2	2	2
Cast iron (austenic)				■	1	1	1	2	1	3	1	2	1	1	1	2	1	3
Chromium					■	1	0	0	1	3	1	0	2	0	0	2	0	3
Copper, Brasses						■	0	2	0	3	1	1	2	1	1	3	0	3
Cupro-Nickel Al-bronzes Si-bronzes							■	2	0	3	1	1	2	2	1	3	0	3
Gold Platinum, Carbon Rhodium								■	2	3	2	0	3	0	1	3	0	3
Gun-metal(CuZn10 alloy) P-bronzes Sn-bronzes									■	3	1	1	1	0	0	3	0	3
Magnesium										■	3	3	2	3	3	3	3	3
Nickel Monel Inconel Nickel/Molybdenum-alloys											■	2	2	1	0	2	1	3
Silver												■	3	0	0	3	0	3
Sn-Pb alloys (all) Tin, Lead													■	1	1	1	3	1
Stainless steel 18/8 (300 series)														■	1	3	0	3
Stainless steel 13Cr (400 series)															■	3	0	3
Steel (carbon, low alloy) Cast iron																■	0	3
Titanium and Ti-alloys																	■	3
Zinc Beryllium																		■

Key:

0 - Can be used without restriction.

1 - Can be used in a non-controlled environment (e.g. assembly area and general non-clean room environment).

2 - Can be used in a clean room environment.

3 - Needs specific measures to avoid galvanic corrosion when these combinations are selected.

Table 9-2: Compatible couples for bimetallic contacts

9.2.1.15 Mechanical contact surface effects (cold welding, fretting, wear)

ECSS-Q-ST-70_049057	5.1.16a	A
a. For all solid surfaces in moving contact with other solid surfaces, it shall be demonstrated that the degradation of surface properties over the complete mission is acceptable from a performance point of view.		

ECSS-Q-ST-70_REQ-013	-	N – End customer
b. In case of dynamic electrical contacts, the demonstration shall be made using in addition to the other environment an electrical current representative of the operational flight conditions.		

9.2.1.16 Life

ECSS-Q-ST-70_049058	5.1.17a	A
a. Materials shall be selected to ensure sufficient life with respect to the intended application.		

NOTE Accelerated life tests conditions representative of the mission duration shall be demonstrated and approved by end customer.

9.2.1.17 Safety

ECSS-Q-ST-70_MOS-005	5.1.18g	N - esa
a. Materials that may constitute a Safety Hazard are prohibited from being used without prior approval by end customer via a Request for Approval (RFA).		

NOTE It should be noted that approval may also require that of the Launch Authority and the justification for use shall be included in the Launch Authority Safety Submissions.

9.2.2 SELECTION

9.2.2.1 General

ECSS-Q-ST-70_REQ-014	-	N – End customer
a. Selection of materials shall comply with legal European directives applicable at the date of procurement, including REACH directive.		

ECSS-Q-ST-70_049059	5.2.1a	A
b. Materials shall be chosen giving preference to the following: 1. those successfully used for an identical application in other space programmes similar with respect to environment constraints and lifetime to the proposed application; 2. those for which satisfactory evaluation results are obtained on samples representative of the application with a sufficient margin as regards conditions of use; 3. those included in approved data sources.		

NOTE For example: ECSS-Q-70-71, ESA and NASA data banks.

ECSS-Q-ST-70_049060	5.2.1b	A
c. Whether the materials are already validated or remain to be validated, their selection shall take into account the following criteria: 1. continuity of supply; 2. reproducibility of characteristics.		

ECSS-Q-ST-70_MOS-006	5.2.1c	N - esa
d. The Supplier shall obtain the Customer and ESA approval for the usage of equivalent standards from MIL system or NASA.		

9.2.2.2 Constraints

ECSS-Q-ST-70_049061	5.2.2a	M – End customer
a. Pure tin and lead-Free (Pb-Free) tin alloy surface finishes or under-layers are forbidden even if encapsulated, coated or not exposed. Only Tin alloys containing at least 3% Pb by weight are acceptable as surface finishes or under-layers.		

*NOTE 1 For PCB manufacturing, the here above requirement is superseded by requirements from the **Annex H** of this document.*

NOTE 2 Pb-free alloys used for solder attach and assemblies are not prohibited but require customer approval prior to use. E.g.: Tin-silver (Sn96/Ag4) and tin-antimony (Sn95/Sb5) standard solders.

ECSS-Q-ST-70_REQ-015	-	N – End customer
b. The following not-exhaustive list of materials shall not be used without prior approval from the customer: 1. Beryllium (for structures), 2. Beryllium oxide, 3. Mercury, 4. Polyvinyl chloride (PVC), 5. Radioactive materials, 6. Alkyd, 7. Polysulphide, 8. Cellulose and acetate, 9. Polyvinyl acetate, 10. Polyvinyl butyrate.		

NOTE 1 This applies also to any support equipment used in a vacuum chamber

NOTE 2 This requirement encompasses new requirement 5.2.2a from MOS-RS-ESA-SYS-0495 iss. 1.0.

ECSS-Q-ST-70_049062	5.2.2b	A
c. The incoming inspection of each component batch shall include the verification of the termination composition (to avoid assembly of pure tin finish).		

ECSS-Q-ST-70_REQ-016	-	N –End customer
d. Materials from the restricted materials list given in **Annex C** of this document (not exhaustive), could be used only if the restrictions are strictly respected.		

ECSS-Q-ST-70_REQ-017	-	N – End customer
e. The supplier shall provide in the DML a statement that no prohibited material is used on the supplied product.		

ECSS-Q-ST-70_REQ-018	-	N – End customer
f. Materials prone to shedding, flaking or any other mechanism liable to create particulate debris shall not be used.		

9.2.3 DECLARED MATERIALS LIST (DML)

ECSS-Q-ST-70_049063	5.3a	A
a. The Supplier shall establish and maintain a declared materials list in conformance with ECSS-Q-ST-70 / Annex A.		

9.2.4 CRITICALITY ANALYSIS

9.2.4.1 Overview

To conform to mission requirements, the objective of the analysis is to identify whether further data are required.

9.2.4.2 Requirements

ECSS-Q-ST-70_049064	5.4.2a	A
a. The Supplier shall analyse all the materials contained in his preliminary lists with respect to criticality and in correlation with the risk analysis performed.		

ECSS-Q-ST-70_049065	5.4.2b	M - End customer
b. Any material not meeting the project requirements shall be subject to a RFD to be submitted to end customer.		

ECSS-Q-ST-70_049066	5.4.2c	M – End customer
c. Any critical material shall be subject to a RFA (in conformance with ECSS-Q-ST-70 / Annex D) to be submitted to end customer.		

9.2.5 EVALUATION AND VALIDATION PHASES

9.2.5.1 General

ECSS-Q-ST-70_049068	5.5.1a	A
a. Depending on the results of the criticality analysis, the Supplier shall perform an evaluation phase before the validation phase for all critical materials with unknown characteristics (new materials) or with major changes in the use or in the configuration		

ECSS-Q-ST-70_049069	5.5.1b	A
b. In case of an extension of an existing application, the evaluation indicated in Clause 5.5.1a need not be performed if so agreed with end customer.		

ECSS-Q-ST-70_049070	5.5.1c	A
c. Guaranteed characteristics of materials and material Supplier inspection methods, together with associated documents, shall be available for review at the Supplier's premises before the start of evaluation or qualification phases.		

9.2.5.2 Evaluation phase

ECSS-Q-ST-70_049071	5.5.2a	M – End customer
a. The evaluation shall consider the following as a minimum: 1. the limits of use; 2. the materials physical, chemical or functional characteristics along with their values and tolerances; 3. behavioural tendencies and degradation processes depending on environmental parameters (including ground and in-orbit ageing, contamination and cleanliness); 4. acceptance criteria.		

ECSS-Q-ST-70_049072	5.5.2b	A
b. When evaluation is performed, an evaluation programme (available at PDR, according to Figure 9-1) shall be drawn up, implemented and an evaluation report (available before CDR, according to Figure 9-1 and Table 9-1) shall be drawn up.		

9.2.5.3 Validation phase

ECSS-Q-ST-70_049073	5.5.3a	A
a. For all critical materials, a validation programme (available at PDR) shall be drawn up by the Supplier and then implemented to check or confirm that the materials satisfy the mission requirements with appropriate margins as necessary to obtain validation status.		

ECSS-Q-ST-70_049074	5.5.3b	A
b. Validation status shall depend on the results obtained (validation report) and the review of corresponding documentation (available at CDR).		

ECSS-Q-ST-70_MOS-007	5.5.3c	N - esa
c. The end customer reserves the right to request and receive from the Supplier, or any lower contractual level, samples of raw and / or processed materials for evaluation and testing in the end customer or ESA selected laboratories.		

9.2.5.4 Approval phase

ECSS-Q-ST-70_049075	5.5.4a	A
a. The material shall not receive an approval identification in the declared material list for the project unless the requirements in Clauses 5.5.2 and 5.5.3 are satisfied.		

ECSS-Q-ST-70_049076	5.5.4b	A
b. If approval is not granted, the Supplier in charge of the item shall either: 1. select another material, or 2. propose a modified evaluation programme and resubmit for approval, or 3. if actions 5.5.4b.1 and 5.5.4b.2 fail to achieve positive results, initiate a deviation procedure.		

9.2.5.5 Deviation request

ECSS-Q-ST-70_049077	5.5.5a	M – End customer
a. For materials not conforming to project requirements, whether at the end of criticality analysis or of evaluation and validation tests, the Supplier shall submit a request for deviation.		

9.2.6 PROCUREMENT OF MATERIALS

9.2.6.1 Procurement specifications

ECSS-Q-ST-70_049078	5.6.1a	A
a. All materials shall be procured to an internationally or nationally recognized specification or an in-house fully configured procurement specification which defines the materials properties, the materials requirements, the test methods, the acceptance criteria for the specific applications, source inspection (if any) and material Supplier inspection.		

ECSS-Q-ST-70_049079	5.6.1b	M – End customer
b. When procurement is by means of a datasheet the supplier shall introduce internal, in-house receipt inspection to ensure that the validation status of the material is maintained during the subsequent procurements.		

ECSS-Q-ST-70_049080	5.6.1c	A
c. Materials with long lead times or long procurement delays (versus the project schedule) shall be identified before the formal subsystem PDR.		

ECSS-Q-ST-70_049081	5.6.1d	A
d. Procurement shall be thoroughly planned, documented and implemented in a timely manner to obtain reliable product assurance provision at CDR.		

ECSS-Q-ST-70_049082	5.6.1e	A
e. Back-up plans shall be prepared and initiated whenever there is evidence of delays or technical problems.		

ECSS-Q-ST-70_049083	5.6.1f	A
f. The material requirements shall be explicitly accepted by the material Supplier or manufacturer.		

9.2.6.2 Incoming inspection procedure

ECSS-Q-ST-70_049084	5.6.2a	A
a. All materials shall be submitted to an incoming inspection.		

ECSS-Q-ST-70_049085	5.6.2b	A
b. An incoming inspection procedure shall define the inspections and tests to be carried out, particularly for materials that are known to be variable in their final properties.		

ECSS-Q-ST-70_REQ-019	-	N – End customer
c. Trend analysis on pertinent parameter(s) shall be used to track and anticipate any characteristic / performance drifting.		

9.2.7 USE OF MATERIALS

9.2.7.1 Validation status of materials

ECSS-Q-ST-70_049086	5.7.1a	A
a. The Supplier shall verify that all critical materials are validated before being used in the manufacture of qualification or flight products.		

ECSS-Q-ST-70_049087	5.7.1b	A
b. Any modification, change of condition or configuration of application shall lead to a re-evaluation in conformance with the process shown in Figure 9-1.		

9.2.7.2 Traceability of materials

ECSS-Q-ST-70_049088	5.7.2a	A
a. The Supplier shall apply the traceability rules defined in ECSS-Q-ST-20 to all materials.		

ECSS-Q-ST-70_049089	5.7.2b	A
b. Materials should be identified by a unique reference number, code or a lot number to provide traceability should there be an incident or non-conformance, or a need for a technical investigation following failure or damage, to reconstruct the materials history, either individually (individual traceability) or by the manufacturing lot of which it was a part (lot traceability).		

9.2.7.3 Packaging, storage, removal from storage

ECSS-Q-ST-70_049090	5.7.3a	A
a. The Supplier shall define provisions for packaging, storage and removal from storage for materials.		

ECSS-Q-ST-70_049091	5.7.3b	A
b. Measurements and inspections used to guarantee the material integrity and monitoring during storage and removal from storage shall be identified.		

9.2.7.4 Limited-life materials before implementation

ECSS-Q-ST-70_049092	5.7.4a	A
a. The Supplier shall ensure that all materials which have limited-life characteristics have their date of manufacture (when available, otherwise date of delivery) and shelf-life expiry date accurately identified and clearly marked on each lot or batch.		

ECSS-Q-ST-70_049093	5.7.4b	A
b. Materials which have exceeded their shelf-life expiry date may be re-certified only after the physical and chemical characteristics are inspected and the parameters, subject to deterioration, are evaluated for continued acceptability according to the accept and reject criteria in conformance with ECSS-Q-ST-70-22.		

9.2.7.5 Limited-life materials after implementation

ECSS-Q-ST-70_049094	5.7.5a	A
a. Materials with limited- life after implementation (such as propellant) shall be identified and controlled in conformance with ECSS-Q-ST-10-04.		

NOTE Storage and mission life are criteria for the assessment and control of those materials.

9.2.7.6 Materials non-conformances and alerts

ECSS-Q-ST-70_049095	5.7.6a	A
a. Non-conformances and alerts shall be managed in conformance with ECSS-Q-ST-10.		

9.2.7.7 Health and safety

ECSS-Q-ST-70_049096	5.7.7a	A
a. Material safety data sheet or equivalent shall be available for all materials.		

9.3 MECHANICAL PARTS CONTROL

9.3.1 SELECTION OF MECHANICAL PARTS

ECSS-Q-ST-70_049097	6.1a	A
a. The Supplier shall verify that all materials and processes used in the manufacture of parts satisfy the mission technical requirements.		

9.3.2 SELECTION

ECSS-Q-ST-70_049098	6.2a	A
a. Parts shall be chosen from those successfully used for an identical application in other space programmes similar with respect to environment constraints and lifetime whenever those parts exist.		

ECSS-Q-ST-70_049099	6.2b	A
b. Type reduction actions shall be implemented at all levels of the programme.		

ECSS-Q-ST-70_049100	6.2c	A
c. Whether the parts are already qualified or remain to be qualified, their selection shall take into account the following criteria: 1. durability of supply; 2. reproducibility of characteristics.		

9.3.3 DECLARED MECHANICAL PARTS LIST (DMPL)

ECSS-Q-ST-70_049101	6.3a	A
a. The Supplier shall establish and maintain a declared mechanical parts list in conformance with ECSS-Q-ST-70 / Annex B.		

9.3.4 CRITICALITY ANALYSIS

9.3.4.1 Overview

To conform to mission requirements, the objective of the analysis is to identify whether further data are required.

9.3.4.2 Requirements

ECSS-Q-ST-70_049102	6.4.2a	A
a. The Supplier shall analyse all the parts contained in their preliminary lists with respect to criticality and in correlation with the risk analyses performed in conformance with ECSS-Q-ST-10-04.		

ECSS-Q-ST-70_049103	6.4.2b	A
b. Critical parts shall be identified in the DMPL and included in the critical items list.		

ECSS-Q-ST-70_049104	6.4.2c	A
c. Any critical part shall be the subject of a RFA.		

9.3.5 EVALUATION AND QUALIFICATION PHASES

9.3.5.1 General

ECSS-Q-ST-70_049105	6.5.1a	A
a. Depending on the results of the criticality analysis, the Supplier shall perform an evaluation phase before the validation phase for all critical parts with unknown characteristics or with major changes in the use or in the configuration.		

ECSS-Q-ST-70_049106	6.5.1b	A
b. In case of an extension of an existing application, the evaluation indicated in 6.5.1a need not be performed if so agreed with end customer.		

ECSS-Q-ST-70_049107	6.5.1c	A
c. Guaranteed characteristics of materials and material Supplier inspection methods, together with associated documents, shall be available for review at the Suppliers premises before the start of evaluation or qualification phases.		

NOTE Refer to Table 9-1 for an explanation of the steps involved.

9.3.5.2 Evaluation phase

ECSS-Q-ST-70_049108	6.5.2a	A
a. The evaluation shall consider the following, as a minimum, for each critical part: 1. the limits of use, 2. the part's physical or functional characteristics, along with its values and tolerances, 3. behavioural tendencies and degradation processes depending on environment parameters (including sensitivity to pollution), and 4. acceptance criteria.		

ECSS-Q-ST-70_049109	6.5.2b	A
b. When an evaluation is performed an evaluation programme (available at PDR) shall be drawn up, implemented, and an evaluation report (available before CDR) shall be drawn up.		

ECSS-Q-ST-70_049110	6.5.2c	A
c. The behaviour of the parameters to be monitored which were also recorded during the evaluation programme tests, shall serve as a reference for the analysis of qualification test results.		

NOTE Example of such behaviour is variation and change over time.

9.3.5.3 Qualification phase

ECSS-Q-ST-70_049111	6.5.3a	A
a. For each critical part a qualification programme shall be drawn up by the Supplier (of the equipment using the critical part) and then implemented to check or confirm whether the parts satisfy mission requirements with appropriate margins.		

ECSS-Q-ST-70_049112	6.5.3b	A
b. Qualification status shall depend on the results obtained (qualification report) and the reviews of corresponding documentation (available at CDR).		

9.3.5.4 Approval phase

ECSS-Q-ST-70_049113	6.5.4a	A
a. The mechanical parts shall not receive an approval identification in the declared mechanical parts list for the project unless the requirements in 6.5.2 and 6.5.3 are satisfied.		

ECSS-Q-ST-70_049114	6.5.4b	A
b. If approval is not granted, the Supplier in charge of the item shall either: 1. select another mechanical part, or 2. propose a modified evaluation programme and resubmit for approval, or 3. if actions 6.5.4b.1 and 6.5.4b.2 fail to achieve positive results, initiate a deviation procedure.		

9.3.5.5 Deviation request

ECSS-Q-ST-70_049115	6.5.5a	A
a. For parts not conforming to project requirements, whether at the end of criticality analysis or of evaluation and qualification tests, the Supplier shall submit a request for deviation in conformance with ECSS-Q-ST-10-09.		

9.3.6 PROCUREMENT OF MECHANICAL PARTS

9.3.6.1 General

ECSS-Q-ST-70_049116	6.6.1a	A
a. Mechanical parts with long lead times or procurement delays (versus the project schedule) shall be identified before the subsystem PDR.		

ECSS-Q-ST-70_049117	6.6.1b	A
b. Procurement shall be planned, documented and implemented in a timely manner to obtain reliable product assurance provision at CDR.		

ECSS-Q-ST-70_049118	6.6.1c	A
c. Back-up plans shall be prepared and initiated whenever there is evidence of possible delays or technical problems.		

9.3.6.2 Procurement specification

ECSS-Q-ST-70_049119	6.6.2a	A
a. Each part shall be covered by a procurement specification or a standard.		

ECSS-Q-ST-70_049120	6.6.2b	A
b. The procurement specifications shall define the part characteristics, requirements, tests methods, acceptance criteria, lot acceptance testing, source inspection (if any) and material Supplier inspection.		

ECSS-Q-ST-70_049121	6.6.2c	A
c. The procurement specifications shall be explicitly accepted by the part Supplier or manufacturer.		

9.3.6.3 Source inspection

ECSS-Q-ST-70_049122	6.6.3a	A
a. For complex parts related to a specific project development, each Supplier shall define the nature and frequency of their own source inspection points.		

ECSS-Q-ST-70_049123	6.6.3b	A
b. Source inspection shall be carried out by end customer on the premises of the Supplier (part manufacturer) in conformance with ECSS-Q-ST-20.		

9.3.6.4 Incoming inspection procedure

ECSS-Q-ST-70_049124	6.6.4a	A
a. Each part or batch of parts shall be submitted to an incoming inspection.		

ECSS-Q-ST-70_049125	6.6.4b	A
b. An incoming inspection procedure shall be established defining the inspections and tests to be carried out.		

ECSS-Q-ST-70_REQ-020	-	N – End customer
c. Trend analysis on pertinent parameter(s) shall be used to track and anticipate any characteristic / performance drifting.		

9.3.7 USE OF MECHANICAL PARTS

9.3.7.1 Qualification status of parts

ECSS-Q-ST-70_049126	6.7.1a	A
a. The Supplier shall ensure that all critical parts are qualified before being used in the manufacture of qualification or flight products.		

ECSS-Q-ST-70_049127	6.7.1b	A
b. Any modification, change in condition or configuration of application shall lead to a re-evaluation in conformance with the process shown in Figure 9-1.		

9.3.7.2 Traceability of parts

ECSS-Q-ST-70_049128	6.7.2a	A
a. The Supplier shall apply the traceability rules defined in ECSS-Q-ST-20 to his parts.		

ECSS-Q-ST-70_049129	6.7.2b	A
b. Parts should be identified by a unique reference number or code and a lot number to provide traceability - where there is an incident or non-conformance, or for the purposes of technical investigations following failure or damage - to reconstruct the parts history, either individually (individual traceability) or by the manufacturing lot it was part of (lot traceability).		

9.3.7.3 Packaging, storage, removal from storage

ECSS-Q-ST-70_049130	6.7.3a	A
a. The Supplier shall define provisions for packaging, storage and removal from storage for parts.		

ECSS-Q-ST-70_049131	6.7.3b	A
b. Measurements and inspections used to guarantee the part integrity and monitoring during storage and removal from storage shall be identified.		

9.3.7.4 Limited-life parts or parts subject to wearout

ECSS-Q-ST-70_049132	6.7.4a	A
a. Limited-life parts after implementation or subject to wear out shall be identified and controlled, taking into account storage and mission life.		

NOTE Examples of such parts are mechanisms, pyro initiators and O-rings.

ECSS-Q-ST-70_049133	6.7.4b	A
b. Limited-life parts shall be assessed as candidates to the critical items list in conformance with ECSS-Q-ST-10-04.		

9.3.7.5 Parts non-conformance and alerts

ECSS-Q-ST-70_049134	6.7.5a	A
a. Management of non-conformances and alerts shall be in conformance with ECSS-Q-ST-10.		

9.3.7.6 Specific requirements for pyrotechnic devices

ECSS-Q-ST-70_REQ-021	-	N – End customer
a. All devices must be qualified against the mission requirements in accordance with ECSS-E-ST-33-11. This shall also include demonstration by test prior to launch.		

ECSS-Q-ST-70_REQ-022	-	N – End customer
b. All devices shall be subject to lot acceptance testing upon receipt.		

ECSS-Q-ST-70_REQ-023	-	N – End customer
c. Prime and redundant devices shall not be taken and installed from the same lot. Both lots must be subject to acceptance testing.		

9.4 PROCESS CONTROL

9.4.1 SPECIFICATIONS OR PROCEDURES

ECSS-Q-ST-70_049135	7.1a	A
a. Each process to be used in the manufacturing or assembly of a product shall be identified by a specification or procedure.		

ECSS-Q-ST-70_049136	7.1b	A
b. Reference shall be made to accept and reject criteria.		

9.4.2 ASSOCIATED MATERIALS AND MECHANICAL PARTS

ECSS-Q-ST-70_049137	7.2a	A
a. The Supplier shall verify that the materials and the mechanical parts used during the implementation of processes satisfy the requirements of this Standard.		

9.4.3 SELECTION

ECSS-Q-ST-70_049138	7.3a	A
a. Processes shall be chosen from those already verified according to the following order of preference and priority: 1. those covered by space agencies or other governmental organization certification for identical conditions of use; 2. those for which satisfactory evaluation and verification results are obtained on samples representative of the application with a sufficient margin as regards conditions of use; 3. those already successfully used by the same Supplier for other space programmes in the same conditions of use.		

ECSS-Q-ST-70_049139	7.3b	A
b. Whether the processes are already verified or remain to be verified, their selection shall take into account the following criteria: 1. reliability; 2. inspectability; 3. re-workability of the process item; 4. reproducibility.		

9.4.4 TECHNICAL CRITERIA

9.4.4.1 Electrical connections

ECSS-Q-ST-70_REQ-024	-	N – End customer
a. ECSS-Q-ST-70-08 shall be applicable for manual soldering of high-reliability electrical connections.		

ECSS-Q-ST-70_REQ-025	-	N – End customer
b. ECSS-Q-ST-70-07 shall apply for verification and acceptance of automatic machine wave soldering.		

ECSS-Q-ST-70_REQ-026	-	N – End customer
c. ECSS-Q-ST-70-38, completed by **Annex G** of this document, shall apply for the high reliability soldering for surface mount and mixed technology.		

ECSS-Q-ST-70_REQ-027	-	N – End customer
d. ECSS-Q-ST-70-18 shall apply for the preparation, assembly and mounting of RF coaxial cables.		

ECSS-Q-ST-70_REQ-028	-	N – End customer
e. ECSS-Q-ST-70-26 shall apply for the crimping of high-reliability electrical connections.		

ECSS-Q-ST-70_REQ-029	-	N – End customer
f. ECSS-Q-ST-70-28 shall apply for the repair and modifications of printed circuit boards assemblies for space use.		

9.4.4.2 Printed Circuit Board

ECSS-Q-ST-70_REQ-030	-	N – End customer
a. ECSS-Q-ST-70-10 shall apply for qualification of printed circuit boards.		

ECSS-Q-ST-70_REQ-031	-	N – End customer
b. ECSS-Q-ST-70-11 completed by **Annex H** of this document shall apply for procurement of printed circuit boards.		

ECSS-Q-ST-70_REQ-032	-	N – End
c. To prevent electrical failures due to high voltages or high electrical fields, requirements for double insulation shall be applied and verified.		

ECSS-Q-ST-70_REQ-042	-	N - Airbus DS
d. ECSS-Q-ST-70-12 shall be applied for PCB design, as called by **Annex H**		

Note: It is anticipated that off the shelf units might not be compliant to the new ECSS-Q-ST-70-12C PCB design requirements. Deviation will be accepted for Off The Shelf units with qualification, flight history (TRL 8, 9). A request for deviation with justificatives for previous successful history is to be submitted to End Customer/ESA for formalisation.

9.4.4.3 Conformal Coating

ECSS-Q-ST-70_REQ-033	-	N – End customer
a. Conformal coating shall be used on PCB assemblies according to NASA-STD-8739.1		

9.4.4.4 In house manufactured hybrids

ECSS-Q-ST-70_REQ-034	-	N – End customer
a. In house hybrids shall be manufactured and validated according to ECSS-Q-ST-60-05.		

9.4.4.5 In house manufactured magnetic parts (coils and transformers)

ECSS-Q-ST-70_REQ-035	-	N – End customer
a. In house magnetic parts shall be designed and screened using MIL-STD-981 as a guideline		

9.4.4.6 Black anodising

ECSS-Q-ST-70_REQ-036	-	N – End customer
a. Black anodising on Aluminium series 2000 and 7000 shall be forbidden, unless demonstration is given to end customer that no other solution meets the thermo-optical requirements. In that case, specific qualification plans and reports, including adherence tests after thermal vacuum to be agreed with end customer, shall be delivered for end customer acceptance.		

9.4.4.7 Paints and coatings

ECSS-Q-ST-70_REQ-037	-	N – End customer
a. Application of paints and coatings on space hardware shall be performed according to ECSS-Q-ST-70-31.		

9.4.4.8 Fusion welding

ECSS-Q-ST-70_REQ-038	-	N – End customer
a. Requirements of **Annex I** of this document shall be applied for fusion welding of metals for aerospace materials used in space flight hardware.		

9.4.5 DECLARED PROCESSES LIST (DPL)

ECSS-Q-ST-70_049140	7.4a	A
a. The Supplier shall establish and maintain a declared processes list in conformance with ECSS-Q-ST-70 / Annex C.		

ECSS-Q-ST-70_REQ-039	-	N – End customer
b. The Supplier shall establish cross reference between DPL and DML/DMPL.		

9.4.6 CRITICALITY ANALYSIS

9.4.6.1 Overview

To conform to mission requirements, the objective of the analysis is to identify whether further data is required.

9.4.6.2 Requirements

ECSS-Q-ST-70_049141	7.5.2a	A
a. The Supplier shall analyse all the processes contained in their preliminary lists with respect to criticality and in correlation with the risk analyses performed.		

ECSS-Q-ST-70_049142	7.5.2b	A
b. Critical processes shall be identified in the DPL and included in the list of critical items.		

ECSS-Q-ST-70_049143	7.5.2c	A
c. Any critical process shall be the subject of an RFA.		

ECSS-Q-ST-70_049144	7.5.2d	A
d. Special processes shall be identified and controlled.		

ECSS-Q-ST-70_049145	7.5.2e	A
e. Process control shall be ensured by means of procedures or personnel certification or inline process control.		

ECSS-Q-ST-70_049146	7.5.2f	A
f. Whenever feasible a statistical process may be carried out.		

9.4.7 EVALUATION AND VERIFICATION PHASE

9.4.7.1 General

ECSS-Q-ST-70_049147	7.6.1a	A
a. Depending on the results of the criticality analysis, the Supplier shall perform an evaluation phase before the validation phase for all critical processes which are new or with major changes in the use or in the configuration.		

ECSS-Q-ST-70_049148	7.6.1b	A
b. In case of an extension of an existing application, the evaluation indicated in 7.6.1a need not be performed if so agreed with end customer.		

ECSS-Q-ST-70_049149	7.6.1c	A
c. For confidential processes, the Supplier shall prove that the process has been verified.		

NOTE 1 For example, by presenting a verification certificate from space agencies or other governmental organization responsible to check the applicability of this verification.

NOTE 2 Refer to Table 9-1 for an explanation of the steps involved.

9.4.7.2 Evaluation phase

ECSS-Q-ST-70_049150	7.6.2a	A
a. The evaluation shall consider the following as a minimum for each critical process: 1. the limits of use, 2. the values, determined by test samples or technology samples, of relevant parameters and their tolerances, and 3. acceptance criteria.		

ECSS-Q-ST-70_049151	7.6.2b	A
b. When an evaluation is performed, the Supplier shall provide 1. an evaluation plan at PDR and 2. an evaluation report before CDR.		

9.4.7.3 Verification phase

ECSS-Q-ST-70_049152	7.6.3a	A
a. For each critical process, the Supplier shall implement a verification programme.		

ECSS-Q-ST-70_049153	7.6.3b	A
b. The verification programme shall be defined in conformance with existing ECSS or national agency standards of verification.		

ECSS-Q-ST-70_049154	7.6.3c	A
c. The Supplier shall ensure that the processes satisfy the mission requirements and that the parameters needed for the product design are defined so as to obtain verification status.		

ECSS-Q-ST-70_049155	7.6.3d	A
d. Verification status shall depend on the results obtained (verification report) and the review of corresponding documentation (available at CDR).		

ECSS-Q-ST-70_MOS-008	7.6.3d	N - esa
e. Process procedures shall be supplied or made available to end customer and ESA upon request for review,		

NOTE All parties shall respect proprietary Rights.

9.4.7.4 Approval phase

ECSS-Q-ST-70_049156	7.6.4a	A
a. The processes shall not receive an approval identification in the declared processes list unless requirements in 7.6.2 and 7.6.3 are satisfied. If approval is not granted, the Supplier in charge of the item shall either 1. select other processes, or 2. propose a modified evaluation programme and resubmit for approval, or 3. if actions 7.6.4a.1 and 7.6.4a.2 fail to achieve positive results, initiate a deviation procedure.		

9.4.7.5 Deviation request

ECSS-Q-ST-70_049157	7.6.5a	A
a. For processes not conforming to project requirements, whether at the end of criticality analysis or of evaluation and verification tests, the Supplier shall submit a request for deviation in conformance with ECSS-Q-ST-10-09.		

9.4.8 USE OF A PROCESS

9.4.8.1 Verification status of a process

ECSS-Q-ST-70_049158	7.7.1a	A
a. The Supplier shall confirm that all critical processes have been verified before being used in the manufacture of qualification or flight products.		

ECSS-Q-ST-70_049159	7.7.1b	A
b. Any modification, change of condition or configuration of application shall lead to a re-evaluation in conformance with the process shown in Figure 9-1.		

9.4.8.2 Re-verification of a process

ECSS-Q-ST-70_049160	7.7.2a	A
a. When a process needs to be re-verified, a request for approval (RFA) shall be established and a re-verification programme shall be implemented.		

NOTE Any prolonged stoppage in manufacturing, any major change of the facilities or procedures or any transfer of production to another entity can invalidate partially or completely the initial verification of a process

9.4.8.3 Implementation of a process

ECSS-Q-ST-70_049161	7.7.3a	A
a. Before implementation of a process, the Supplier shall ensure that personnel are trained and that environment, means and documentation are adequate.		

ECSS-Q-ST-70_049162	7.7.3b	A
b. This verification shall ensure that: 1. manufacturing and quality control tools associated with the process are adequate, calibrated and properly maintained are used under appropriate environmental and cleanliness conditions, see clause 4.4, 2. personnel are properly trained and certified, and 3. the processes specifications, manufacturing and inspection procedures and workmanship standards including clear definition of manufacturing operations and clear acceptance criteria exist.		

NOTE 1 Photographically documented if possible for visual acceptance criteria at the appropriate work and inspection stations.

NOTE 2 For planning of manufacturing, assembly and integration operation and inspection see ECSS-Q-ST-20.

9.4.8.4 Traceability of processes

ECSS-Q-ST-70_049163	7.7.4a	A
a. Traceability of processes shall be ensured in conformance with ECSS-Q-ST-20.		

9.4.8.5 Process non-conformances and alerts

ECSS-Q-ST-70_049164	7.7.5a	A
a. Non-conformances and alerts shall be processed in conformance with ECSS-Q-ST-10.		

9.4.8.6 Mandatory inspection points (MIP)

ECSS-Q-ST-70_049165	7.7.6a	A
a. MIPs shall be defined in conformance with ECSS-Q-ST-20.		

9.4.8.7 Packaging, storage, removal from storage

ECSS-Q-ST-70_049166	7.7.7a	A
a. The Supplier shall define provisions for packaging, storage, and removal from storage for products or semi-finished products before and after implementation of processes.		

9.5 LONG TERM STORAGE

ECSS-Q-ST-70_MOS-009	8.1	N - esa
a. The supplier shall evaluate the obsolescence risk of materials and processes (e.g. by REACH, RoHS) throughout its supply chain, establish any such risks and present in the Risk Register, and inform the project on technical or programmatic implications. Obsolescence related issues shall be communicated via the MPCB process and reported (e. g. in the DMPL Tool).		

ECSS-Q-ST-70_REQ-041	-	N – End customer
b. The supplier shall identify and evaluate the materials, mechanical parts and processes considered as long term storage sensitive in the frame of the MPCB process.		

ECSS-Q-ST-70_MOS-010	8.2	N - esa
c. The Long Term Storage Plan shall address material performance during the storage period and identify mechanisms to predict and/or verify material or process or mechanical part performance throughout the storage period until de-storage and launch campaign activities.		

NOTE For example this can include adhesive samples stored with the flight adhesives they represent (i.e. under the same storage conditions), tested at intervals throughout the storage period and evaluated against initial results and control samples; laminated materials (e.g. magnetics) samples stored under the same storage conditions, checked for corrosion/delamination during the storage period and compared to control samples; material samples in a flight representative configuration that may be prone to Creep during the storage period (e.g. resin/plastic washers) and checked throughout the storage period for the presence of Creep.

ANNEX A: QUALITY LEVELS FOR CLASS 1

Note: this annex has been transferred at the end of EEE parts section

ANNEX B: FORMAT FOR PAD

Note: annex B has been transferred at the end of EEE parts section

ANNEX C: RESTRICTED MATERIALS LIST

RESTRICTION	MATERIAL	RESTRICTED (x)		
		External non protected	External protected	Internal
Copper is restricted in LEO when exposed to ATOX	Copper	X		
Copper coatings is forbidden in LEO when exposed to ATOX	Copper coatings	Forbidden		
Brass terminals are forbidden unless they are correctly plated with a 3 to 10 microns barrier layer of copper or nickel.	Copper/zinc alloys (Brass)	X **Forbidden in LEO**	X	X
Forbidden if not used as an alloying agent. Authorized within a solder	Lead	X	X	X
Authorised as an alloying constituent up to 4% by weight	Beryllium	X	X	X
Forbidden for structure and where fluid or moisture entrapment is possible, authorised in areas where minimal exposure to corrosive environments can be ensured and protection systems can be maintained with ease and reliability	Magnesium Alloys	**Forbidden**	X	X
Forbidden as coating when exposed to ATOX	Osmium	X in LEO		
Forbidden as coating or paint when exposed to ATOX	Silver	X in LEO		
Forbidden in high precision equipment except as plain windows or light pipes	Organic glasses	X	X	X
Forbidden in confined areas (E;g.: large bond areas between non porous substrates) because the curing cannot be achieved	Moisture curable adhesives	X	X	X
Only specific grades are authorised when exposed to space environments (must present a very low vapour pressure	Oils & greases (general)	X	X	X
Forbidden when used alone under vacuum. Authorized as a lubricant when used in combination with other lubricating materials such as silver or MoS_2. Graphite is not a lubricant under vacuum but an abrasive	Graphite	X	X	X
Use with aluminium or magnesium is forbidden if shear stresses can be imposed	Lubricants containing Chloro-fluoro compositions	X	X	X
Authorized when removed from super alloys prior to heat treatment or high temperature service	Oils and grease containing sulphur	X	X	X

RESTRICTION	MATERIAL	RESTRICTED (x)		
		External non protected	External protected	Internal
Forbidden for some sequences temperature / preload (sensitive to creep stress)	Nuflon N (PTFE)	X	X	X
Forbidden in open cell structures	Non-metallic foams	X	X	X
Forbidden when containing styrene	Polyester	X	X	X
Forbidden for electronic composite laminates (PCB) as reinforcing materials	Cotton	X	X	X
Forbidden for electronic composite laminates (PCB) as reinforcing materials	Paper	X	X	X
For the most common rubbers, forbidden if the ionizing radiation is more than a few Mrad	Rubbers & elastomers	**Forbidden in GEO**	**Forbidden in GEO**	X Authorised in LEO
For the most common rubbers, forbidden if the ionizing radiation is more than a few Mrad - Forbidden in pressurized systems requiring low gas permeability	Silicone rubbers	X **Forbidden in GEO**	X **Forbidden in GEO**	X
Forbidden if the radiation dose is more than 10 Mrad	Polyurethanes rubbers	X **Forbidden in GEO**	X **Forbidden in GEO**	X Authorised in LEO
Forbidden if the radiation dose is more than 10 Mrad	Fluorinated rubbers	X **Forbidden in GEO**	X **Forbidden in GEO**	X Authorised in LEO
Forbidden if the radiation dose is more than 1 Mrad. Forbidden for surface higher than 5cm² (ESD)	PTFE (Poly Tetra Fluoro Ethylene) E.g.: Teflon	X **Forbidden in GEO**	**Forbidden in GEO** Authorised in LEO	X Authorised in LEO
Perforated or standard aluminized / silverized Teflon (SSM) forbidden. General products forbidden for surface higher than 5cm² (ESD)	FEP (Fluorinated Ethylrne Propylene) E.g.: Teflon	X Authorised in LEO	X Authorised in LEO	X Authorised in LEO
Perforated or standard aluminized / silverized Teflon (SSM) forbidden. General products forbidden for surface higher than 5cm² (ESD)	PFA (Per Fluoro Alcoxy polymer) E.g.: Teflon	X Authorised in LEO	X Authorised in LEO	X Authorised in LEO
Forbidden where the total electron dose is likely to exceed 1 Mrad	Polyacetal or Poly Oxy Methylene (POM) E.g.: Delrin	**Forbidden**	**Forbidden in GEO** Authorised in LEO	X Authorised in LEO
Forbidden for wires longer than 0,5m length (ESD). Forbidden for surface higher than 5cm² (ESD)	Modified ETFE (Ethylene Tetra Fluoro Ethylene) E.g.: Tefzel	X Authorised in LEO	X Authorised in LEO	X Authorised in LEO
Forbidden as ARACON & AMBERSTRAND metallised braids used without thermal protection sleeve (ESD fuse risks + contamination)	Polyamide	X	X	X
Electrical properties restricted (Electrical strength decrease)	Polyethylene	X	X	X

RESTRICTION	MATERIAL	RESTRICTED (x)		
		External non protected	External protected	Internal
Kapton is forbidden for thickness higher than 25µm. For Solar Array intercell, Kapton is forbidden for thickness higher than 50µm (ESD)	Polyimide (E.g.: Kapton	X Authorised in LEO	X Authorised in LEO	Authorised

"X" in the table means: could be used with the described restrictions

"Forbidden" in the table means: shall never be used

"Authorised" in the table means: can be used without restriction

"X" associated with a comment means: partially restricted (E;g.: "X" + Authorised in LEO means that the restriction apply to GEO)

External means exposed to space (outside the satellite body and not protected by shielding nor MLI)

ANNEX D: RELIFING PROCEDURE FOR EEE COMPONENTS

ANNEX D Table of contents

1 DOCUMENT SCOPE AND APPLICABILITY

1.1 SCOPE

This standard specifies the requirements, also known as “relifing requirements”, for the planned, intentional storage, control, and removal from storage of electronic, electrical and electromechanical parts which are intended to be used for class 1 space applications.

The relifing process is a lot quality control activity. The inspections and tests defined do not constitute an up-screening or up-grading of components to a higher level of quality than procured to.

Text in blue identifies the additions to the ECSS-Q-ST-60-14C.

Test in green identifies text moved (without change) between this standard and ECSS-Q-ST-60-14C.

For clarity purpose, the text removed from ECSS-Q-ST-60-14C is not tracked.

1.2 APPLICABILITY

This standard is applicable to all EEE parts covered by ECSS-Q-ST-60 and used in class 1 space programs.

This standard is not applicable to naked dice.

This standard covers the relifing of commercial parts (including those encapsulated in plastic package) provided that the requirements defined in clauses 423b, 612b and 612c are fulfilled.

2 REFERENCES

2.1 RELATED DOCUMENTS

The following documents are referred to in the current procedure and shall be applied for the implementation of the processes described herein (if no version is indicated, latest versions shall be used) :

Applicable documents :

[AD 1]	**ECSS-S-ST-001**	**ECSS - Glossary of terms**
[AD 2]	**ECSS-Q-ST-10-09**	**Space Product Assurance – Non-conformance control system**
[AD 3]	**ECSS-Q-ST-60**	**Electrical, Electronic and Electromechanical (EEE) Components**
[AD 4]	**ECSS-Q-ST-60-14C**	**Space Product Assurance – Relifing procedure – EEE components**
[AD 5]	**ECSS-Q-ST-70-01**	**Space Product Assurance – Contamination and cleanliness control**
[AD 6]	**IPC/JEDEC J-STD-033**	**Standard for Handling, Packing, Shipping and Use of Moisture/reflow Sensitive Surface Mount Devices**
[AD 7]	**ESCC 20600**	**Preservation, Packaging and dispatch of SCC Electronic Components**
[AD 8]	**ESCC 24900**	**Minimum Requirements for Controlling Environmental Contamination of Components**

2.2 BACKGROUND DOCUMENTS

The following documents contain background information relating to the subjects addressed and facilitate the implementation of the principles and processes here detailed (if no version is indicated, latest versions shall be used) :

[1]	**MIL-HDBK-263**	**Electrostatic Discharge Control Handbook for protection of Electronic Parts, Assemblies and Equipment (excluding Electrically Initiated Explosive Devices)**

3 DEFINITIONS AND ABBREVIATIONS

3.1 TERMS FROM OTHER STANDARDS

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 and ECSS-Q-ST-60 apply.

For the purposed of this Standard the following terms from ECSS-Q-ST-70-01 apply:

- clean area
- clean room

3.2 TERMS AND DEFINITIONS SPECIFIC TO THE PRESENT STANDARD

Antistatic material

Material that minimizes the generation of static charges.

Note 1: This term refers to the reduction of triboelectric charge generation.

Note 2: This property is not dependent upon material resistivity.

Conductive material

"ESD protection" material with the following characteristics:

surface conductive type: materials with a surface resistivity less than 10^5 Ω/< .

volume conductive type: materials with a volume resistivity less than 10^4 < -cm.

Contaminant

Unwanted molecular or particulate matter (including microbiological matter) on the surface or in the environment of interest that can affect or degrade the relevant performance or life time

Container

Receptacle which holds, restrains or encloses an item

(Original) Date code

Code used by the EEE part manufacturer at assembly step that indicates the production date.

Note 1: Generally four-figure codes; two for the year and two for the week.

Note 2: Special lot number can also identify the date code.

(Relifing) Date code

Code indicating the date an item is submitted to relifing.

Note: Four-figure code, two for the year and two for the week.

Dissipative material

"ESD protection" material with the following characteristics:

surface conductive type: materials with a surface resistivity equal to or greater than 10^5 Ω/☐ but less than 10^{12} Ω/☐

volume conductive type: materials with a volume resistivity equal to or greater than 10^4 Ω-cm but less than 10^{11} Ω-cm

Electrostatic charge

Negative or positive electrical charge present on the material or item surface, at rest.

Electrostatic Discharge (ESD)

Transfer of electrostatic charge between objects at different potentials caused by direct contact or induced by an electrostatic field.

Electrostatic Discharge Sensitive (ESDS)

Tendency of the performance of EEE parts to be affected or damaged by an ESD event.

ESD protected area

Area which is constructed and equipped with the necessary ESD protective materials, equipment, and procedures, to limit ESD voltages below the sensitivity level of ESDS items handled therein.

ESD protective material

Material with one or more of the following properties: limits the generation of electrostatic charge, dissipates electrostatic charge, and provides shielding from electric fields.

ESD protective packaging

Packaging with ESD protective materials to prevent ESD damage to ESD items.

Electrostatic shield

Barrier or enclosure that prevents or attenuates the penetration of an electric field.

Handled or Handling

Actions during which items are hand manipulated or machine processed.

Identification

Application of appropriate markings to ensure that the identity of an item is unfailingly indicated after preservation and each stage of packing.

Isolating material

“ESD protection” material not defined as conductive or dissipative are considered to be isolating.

Package

Support used for enveloping, protecting or containing materials.

Note: Different types of packages are normally used: Primary, intermediate and final packages.

(Primary) package

Container, envelope or wrap holding an individual item.

(Intermediate) package

Container holding 2 or more primary packages.

(Final) package

Container holding one or more intermediate packages, used for transportation of supplies to the orderer.

Packaging

Operations consisting in the preparation of supplies for transit and delivery.

Note: The term includes preservation, identification and packing

Packing

Operation by which supplies are placed in container or wrapped and placed in containers.

Particles

Unit of matter with observable length, width and thickness.

Note: A particle can be object of solid or liquid composition, or both, and generally between 0,001 µm and 1000 µm in size.

Preservation

Cleaning of an item and the application of a suitable temporary protective, where necessary, to maintain the item in prime condition.

Relifing procedures

Set of tests performed on an item previously stored to verify that its initial quality and reliability have not been affected by time.

Storage area

Area in the storage site where EEE parts are stored and which contains one or more storage zones.

Storage Long Duration

Storage for which duration exceeds 3 years.

Storage site

Geographical location where EEE parts are stored for a short, medium and long term period.

Note: For this site, the requirements given in this standard apply: EEE parts manufacturer's premises, procurement Agency, EEE part user.

Storage zone

A defined space in which EEE parts are stored and which is equipped for the monitoring and the control of storage conditions.

Timing parameters

One of the following parameters.

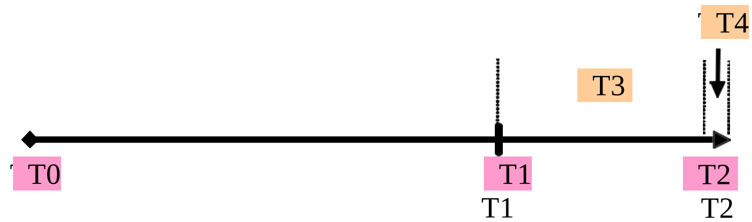
T0 Original date code.

T1 Maximum allowed storage period from T0 with no relifing control.

T2 Maximum duration between the original date code of part and its mounting.

T3 Maximum allowed storage period after a relifing control.

T4 Availability period from the EEE part delivery by a procurement agency to mounting. This is a guarantee for the users to have a sufficient margin for mounting their parts without any relifing consideration during this duration.



Triboelectric effect

The generation of electrostatic charge on an object by rubbing or other type of contact.

3.3 ABBREVIATIONS

The following abbreviations are used in this document.

ASIC	**Application Specific Integrated Circuit**
CCD	**Charge Coupled Device**
CDM	**Charge Device Model**
DPA	**Destructive Physical Analysis**
DSP	**Digital Signal Processor**
ECSS	**European Cooperation for Space Standardization**
EEE	**Electronic, Electrical and Electromechanical**
ESCC	**European Space Components Coordination**
ESD	**Electrostatic Discharge**
FPGA	**Field Programmable Gate Arrays**
HBM	**Human Body Model**
JEDEC	**Joint Electronic Devices Engineering Council**
MM	**Machine Model**
MMIC	**Microwave Monolithic Integrated Circuit**
NA	**Not Applicable**
NCR	**Non Conformance Report**
RH	**Relative Humidity**
VLSI	**Very Large Scale Integration**

3.4 SYMBOLS

Ω	**Ohm**
Ω/☐	**Ohm per square**
Ω-cm	**Ohm centimeter**
µm	**Micrometer**
V	**Volt**

4 ENVIRONMENTAL PARAMETERS FOR STORAGE

4.1 GENERAL RULES AND REQUIREMENTS

4.1.1 Introduction

This clause defines the rules for storing EEE parts to be used on space programs. Those rules are in line with the requirements defined in ESCC Basic Specification 24900.

4.1.2 Procedures

412	*The following domains shall be covered and documented by procedures sent to Airbus DS for information, on request:* • *Storage area and storage zone* • *Cleanliness* • *ESD protection* • *Packing and Packaging* • *Handling* • *Quality assurance*

4.1.3 Storage area and storage zone

413	*It shall be demonstrated that storage areas and storage zones provide such protection against vibration, electromechanical fields, radiation fields and against light so that possible degradation of organic packaging material is prevented.*

4.1.4 Cleanliness

414a	*Rules for cleanliness efficiency shall be implemented.*

414b	*The working areas and the contained equipment shall be maintained as visually clean with no loose material.*

414c	*Access rules shall apply for personnel, materials and equipment.*

414d	*Storage areas shall conform to a cleanliness level as defined in ECSS-Q-ST-70-01 clause 5.3.1.4.*

NOTE: This cleanliness level is often called and known as “grey zone”.

4.1.5 ESD protection

415	*The efficiency of ESD protection measures in storage, handling and testing areas shall be demonstrated.*

NOTE: Guidelines in annex B can be used for this demonstration.

4.1.6 Packing – Packaging - Handling

416	*ESCC 20600 or IPC/JEDEC J-STD-033 shall apply for packing, packaging and handling:*

NOTE: Best practice is to pay attention to ESD sensitivity as described in annex B.

4.1.7 Quality Assurance requirements for storage areas

417	*The storage responsible entity shall establish and document the following:* • *Prohibited materials* • *Personnel access rules* • *Prohibited personnel actions* • *Measures and facilities to segregate and protect components during receiving, inspection, storage and delivery* • *Control measures to ensure that electrostatic discharge susceptible components are identified and handled only by trained personnel using anti static packaging and tools*

4.2 STORAGE CONDITIONS

4.2.1 Air

Normal air is used.

4.2.2 Temperature

422	*Temperature in the immediate vicinity of the stored components shall be maintained between a minimum temperature of 17°C and a maximum of 27°C.*

NOTE: This is to avoid chemical reactions catalysis when it is too high or electronic reactions on certain technologies when it is too low.

4.2.3 Relative Humidity (RH)

423a	RH in store cupboards shall be kept in the range defined by ESCC 24900 section 7 except the RH level which shall be 25% min.

NOTE: This is to avoid, when combined with temperature, corrosion phenomenon. The lower is the Relative Humidity the greater is the probability for ESD damage.

423b	*Commercial parts encapsulated in plastic package shall be stored in one of the following conditions:* • *Nitrogen* • *Dry and ionised air (RH shall be kept in a range of 15% to 20%)* • *Dry packs*

4.2.4 Package

424a	*The packages used during storage shall ensure protection against ESD as defined in section 4.1.6 and against any form of corrosion or contamination.*

424b	*Parts shall be stored in packages such that it can be demonstrated that they offer protection against ESD, corrosion and contamination including the contamination induced by the package itself.*

NOTE: Their primary packages can be used as long as they meet this requirement.

424c	*CCDs and opto-electronic sensors shall be stored in dry air or in neutral ambience, to prevent risks of cover glass pollution and moisture ingress.*

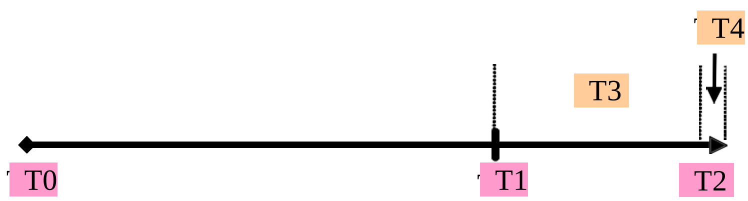
5 TIMING PARAMETERS

5a	*Four timing parameters shall be considered.* *T0 Original date code* *T1 Maximum allowed storage period from T0 with no relifing control* *T2 Maximum duration between the original date code of part and its mounting* *T3 Maximum allowed storage period after a relifing control* *T4 Availability period from the EEE part delivery by a procurement agency to mounting. This is a guarantee for the users to have a sufficient margin for mounting their parts without any relifing consideration during this duration.*

5b	*When used, relifing shall be performed anywhere between T1 and T2 as specified in table 5-1.*

NOTE: For parts not planned to be mounted and to be kept in stock, relifing is not mandatory.

5c	*T4 shall be at least 4 months.*



	T1	T2	T3
All components *(except savers)*	7 years	10 years	3 years
Savers	10 years	NA	NA

Table 5-1 – Timing parameters

6 CONTROL PARAMETERS

6.1 TEST REQUIREMENTS

6.1.1 General requirements per EEE parts family

611a	*For relifing, the following tests, as specified in table 6-1, shall be performed:* • *External Visual Inspection* • *Electrical measurements* • *Seal test* • *Specific test*

611b	*Component families not covered in table 6-1 shall be subject to special procedures to be defined by the program.*

NOTE: The relifing procedure can be applied on a sub-lot containing only the quantity of components immediately needed for production. In this case, the relifing date-code is applicable only to parts actually tested. The time limits specified in table 5-1 remain applicable for the residual sub-lot.

611c	*When sampling is specified in table 6-1, it shall be performed in accordance to the following criteria, with a minimum of 80 parts, calculated with respect to the number of relifed parts.* • *< 80 parts : 100%, with 0 defect allowed* • *81 -> 280 parts : sampling is 80 parts, with 0 defect allowed* • *> 280 parts : sampling is 80 parts, with 1 defect allowed*

611d	*The specifications and methods to be used during relifing shall be those that were in effect for the initial procurement or, if demonstrated that they are not applicable, the most recent updated issues.*

6.1.2 Specific requirements per EEE parts family

612a	*Specific tests indicated as footnotes 612d to 612m after table 6-1 shall be applied to the EEE parts families specified.*

612b	*Commercial parts may be relifed by using the tests defined in table 6-1 provided the availability of humidity test and lifetest results on the flight lot.*

612c	*As part of the relifing process, a DPA on 3 pieces shall be performed for each lot of commercial parts.*

Table 6-1 – Control parameters and detailed application of categories

	VISUAL	ELECTRICAL (10)	SEAL (1)	SPECIFIC TESTS
capacitors, chip, ceramic	sampling	sampling (2)	no	no
capacitors, molded, ceramic	sampling (3)	sampling (2), (3)	no	no
capacitors, glass (CYR, …)	100%	100%	no	no
capacitors, mica (HTxx, …)	100%	100%	no	no
capacitors, chip solid tantalum (TAJ, T495, CWR11, …)	sampling	100%	no	charge/discharge 100% (4)
capacitors, leaded, solid tantalum (CSR, …)	sampling	100%	no	charge/discharge 100% (4)
capacitors, leaded, non solid tantalum (CLR79, ...)	100%	100%	no	charge/discharge 100% (4)
capacitors, film (CRH, CHS, PMxx, MKTS, ...)	sampling	100%	no	DPA on 3p (5)
capacitors, variable	sampling	no	no	no
connectors, non filtered, rectangular	100%	no	100%	no
connectors, filtered, rectangular	100%	100%	100%	no
connectors, non filtered, circular	100%	no	100%	no
connectors, filtered, circular	100%	100%	100%	no
contacts & accessories	no	no	no	no
crystals	100%	100%	100%	no
diodes	100%	sampling	100%	no
diodes, microwave	100%	sampling	100%	no
filters	100%	100%	100%	no
fuses, "cermet"	sampling	sampling	no	no
fuses, wire link	sampling	sampling	no	no
heaters, flexible	100%	100%	no	no
inductors, coils, molded	sampling	sampling	no	no
Inductors, coils, non molded	sampling	sampling	no	no
integrated circuits	100%	sampling (6),(7)	100%	no
integrated circuits, microwave	100%	sampling (7)	100%	no

	VISUAL	ELECTRICAL (10)	SEAL (1)	SPECIFIC TESTS
µwave passive parts (isolators, circulators)	100%	sampling	no	no
µwave passive parts (power dividers, couplers)	100%	sampling	no	no
µwave passive parts (attenuators, loads)	100%	sampling	no	no
oscillators (hybrids)	100%	100%	100%	no
relays, electromagnetic, latching and non-latching	100%	100% (8)	100%	no
resistors, fixed, film (RNC, MBx xxxx, ...) (except RNC90)	sampling	100%	no	no
resistors, high precision, fixed, metal foil (RNC90, ...)	sampling	100%	no	no
resistors, network, thick and thin film	sampling	100%	no	no
resistors, current sensing (RLV, ...)	sampling	100%	no	no
resistors, power, fixed, wirewound (RWR, ...)	sampling	sampling	no	no
resistors, power, fixed, wirewound, chassis mounted (RER, ...)	sampling	sampling	no	no
resistors, precision, fixed, wirewound (RBR, ...)	sampling	100%	no	no
resistors, fixed, film, high voltage (RHV, ...)	sampling	sampling	no	no
resistors, fixed, thick and thin film, chip	sampling	100%	no	no
switches, electromechanical	100%	100%	100%	no
switches, thermostatic	100%	100%	100%	no
thermistors	100%	100%	no	no
transformers	sampling	100%	no	no
transistors	100%	sampling	100%	no
transistors, microwave	100%	sampling	100%	no
wires and cables, low frequency	sampling (9)	no	no	no
cables, coaxial, radio frequency	sampling (9)	no	no	no
hybrids	100%	100% (7)	100%	no
surface acoustic waves	100%	100%	100%	no
charge coupled devices	100%	100% (7)	100%	no
opto discrete devices (photodiodes, LED, phototransistors, optocouplers, …)	100%	100%	100%	no

612d	*(1): Seal test shall be performed when applicable (hermetic cavity package). For instance, this is not applicable to non hermetic connectors or glass diodes.*

612e	*(2): For ceramic chip or moulded capacitors, electrical measurement shall be done after 4 hours of stabilisation at 125°C for type II ceramic.*

612f	*(3): Multi-chips (stacked) capacitors shall be submitted to 100% visual inspection and electrical testing.*

612g	*(4): For all types of Tantalum capacitors (solid and non-solid), the following specific tests shall be performed before the parametrical measurements :* • *Apply 9 discharges and 8 charges with a cycle time of 2 seconds and under nominal voltage* • *Perform a burn-in tests (96 hours, 85°C)* • *Monitor the current during both charge and discharge to detect short circuit*

612h	*(5): For film capacitors using the polycarbonate technology, a DPA test shall be performed on three pieces including:* • *External visual inspection* • *Sealing test after insulate sleeve removal* • *Microsection on two pieces* • *Decaping on 3rd part*

612i	*(6): For programmed parts, the total duration (storage and mission) shall not exceed data retention duration given by the manufacturer (when applicable).*

612j	*(7): For VLSI (ASIC, FPGA, MMIC, DSP, microprocessors, microcontrollers, …), hybrids and CCD, when electrical test is not practicable (availability of test program, product complexity, …), the validation may be transferred to use step (functional test, programming)*

612k	*(8): For electromagnetic relays of latching and non-latching types, 10 switching shall be run before electrical measurements.*

612l	*(9): For low frequency and radio-frequency wires and cables, at least 0.5m shall be inspected and insulating material shall be removed on 0.2m.*

612m	*(10): Electrical test shall be optional for cavity hermetically sealed qualified parts when the qualification level is in line with the quality level defined by the applicable annexes :A-1, A-2 or A-3 of ECSS-Q-ST-60.*

6.1.3 Electrical testing

613	*A subset of DC parameters as given in table 2 of the applicable ESCC detail specification (or equivalent in another specification system) shall be selected for end customer approval and then measured.*

NOTE 1: It is important to pay attention to the test and set up procedures which can have changed since the initial date code.

NOTE 2: Additional burn-in and drift calculation to be performed are only those specified in table 6-1 of this document.

6.1.4 External visual inspection

614a	*In case of doubt or anomaly regarding any surface contamination, one part shall be sampled in order to make a solderability test according to the applicable test method.*

614b	*The solderability test result shall be noted in the relifing report.*

614c	*The part tested for solderability shall be considered destroyed.*

6.1.5 Seal test

615a	*The sealing tests shall be recorded as "pass" where the results meet the requirements of the original procurement specification. Sealing tests include fine leaks or gross leaks or both, depending on the applicable specification.*

615b	*The measurement values of leaks on non-conforming components shall be recorded in the relifing report.*

6.2 NON CONFORMANCE

62a	*ECSS-Q-ST-10-09 shall apply for the handling and processing of non-conformances.*

NOTE: The processing of non-conformances is identical for both relifing and normal procurement procedures.

62b	*Any components not satisfying at least one of the requirements included in this standard shall be considered as not conform.*

62c	*When sampling test (as per table 6-1), any batch of components failing the sampling rule defined in clause 611c shall be considered as not conform.*

62d	*In the case specified in 62c, the test shall be performed on a 100% basis on the whole lot and the causes of the non-conformance investigated and recorded in the relifing report.*

62e	*In case of 100% test (as per table 6-1), any batch of components shall be declared as not conform when failing the following requirement:* • *lot size < 100 parts : 0 defect allowed* • *lot size > 100 parts : 1 defect allowed*

6.3 RELIFING DATECODE

63a	*The relifing date code shall correspond to the week code of the first test performed on the lot.*

63b	*This date code shall be assigned independent of the report conclusions.*

63c	*The relifing date code shall not be marked on the component and no other additional marking added.*

6.4 RELIFING REPORT

64	*When relifing a component, a relifing report shall be established in conformance with the annex A and sent, on request, to end customer for information.*

6.5 CERTIFICATE OF CONFORMITY

65a	*Once a batch is accepted, supported by relifing report giving an "acceptable" decision or as a result of NCR processing, the original Certificate of Conformity (if available), shall be annotated with the relifing date code.*

65b	*The Certificate of Conformity shall be attached with the components during their delivery.*

65c	*The relifing NCR (if any), signed and dated by the supplier, shall be attached with the components during their delivery.*

65d	*Discarded batches shall be processed internally by the relevant reject system of the supplier.*

ANNEX A (normative)

RELIFING REPORT

A.1 PURPOSE AND OBJECTIVE

The purpose of this document is:

- to give the detailed references of the lot tested
- to describe the relifing tests performed
- to give the results obtained
- to give the date of tests

A.2 EXPECTED RESPONSE

A.2.1 SCOPE AND CONTENT

A21a	*The relifing report shall give the following generic information :* • *part style* • *detailed specification (with issue and variant)* • *item identification by the supplier* • *quantity stored* • *original datecode* • *date of storage*

A21b	*For each test, the relifing report shall indicate :* • *operator* • *date of test* • *quantity tested* • *quantity rejected* • *comments*

A21c	*The relifing report shall include a conclusion (accepted / rejected).*

A21d	*The relifing report shall indicate the new datecode (after relife).*

A.2.2 SPECIAL REMARKS

The table below shows a proposed template to be used for the relifing report.

Part Style:	
Detailed specification: Issue: Var:	
Item identification at User:	
Quantity Stored: Date code: Date of Storage:	
TESTS	**RELIFING**
1. External visual	
Operator	
Date	
Quantity tested	
Quantity rejected	
Comments	
2. Electrical tests	
Operator	
Date	
Quantity tested	
Quantity rejected	
Comments	
3. Hermeticity	
Operator	
Date	
Quantity tested	
Quantity rejected	
Comments	
4. DPA (if any)	
Operator	
Date	
Quantity tested	
Results	
DPA Report number	
5. Other tests	
Conclusion Accepted / Not accepted	
New date code	

Table A-2-1 : Example of a relifing traveller sheet

ANNEX B (informative)

ESD

B.1 GENERALITIES AND NATURE OF STATIC ELECTRICITY

Static electricity is electrical charges at rest.

The electrical charges can be created by two events, which are:

- The transfer of electrons within a body resulting in polarization and a net overall charge of zero. The polarization is caused by induction, that is the body enters an electrostatic field or lines of force around another charged body but without contacting the charged body.
- The transfer of electrons from one body to another resulting in conductive charging and in net positive or negative charge. Triboelectric effects cause the conductive charging

B.2 ESD CONTROL PROGRAM

- Scope of ESD control program
- Tasks, activities and procedures necessary to protect ESDS items
- Identification of organizations responsible for the tasks and activities
- Listings of directive or guidance documents in the ESD control program
- Description of ESD control requirements imposed on subcontractors and suppliers
- Listing of the specific ESD protection tools materials and equipment

B.3 ESD PROTECTIONS

B.3.1 PROTECTIVE AREAS

ESD protective areas are required when handling ESDS parts, assemblies and equipment outside of their ESD protective covering or packaging.

Dispositions shall be taken to limit static voltage levels below the damage threshold of the most sensitive ESDS part.

Implementation of protective areas shall lead to requirements for adequate grounding procedures, personnel electrical safety, Tools materials and equipment specification, operating procedures and development of handling procedures.

The following document may be used as guideline : MIL HDBK 263 appendix F.

B.3.2 PROTECTIVE COVERING AND PACKAGING MATERIALS

Personnel	: Wearing of ESD protective smocks or clothing, footwear (list not exhaustive) when handling ESDS items.
Work areas, protected areas	: Use of conductive materials or dissipative materials.

EEE parts packaging : Use and control of antistatic materials for primary packages like dry-packs, plastic rails or tubes.

Use of dissipative materials for trays, wheels.

The following document can be used as guideline : MIL HDBK 263 appendix I.

Materials are normally classified as conductive, dissipative and isolative. The classification depends upon the material resistivity. Isolative materials are not ESD protective and special attention is recommended.

Surface treated isolative material is used as antistatic materials if their resistivity is compliant to the definition of chapter 0.

Warning: Antistatic materials loose their antistatic properties after a certain time due to the fact that only the surface is impregnated with charges. So special attention is recommended to control it.

B.3.3 HANDLING

The following document can be used as a guideline : MIL HDBK 263 appendix H.

B.4 EEE PARTS SENSITIVITY TO ESD CLASSIFICATION

Parts are classified function of their sensitivity to ESD and 3 main models: HBM model, MM model and CDM model (table B-4)

HBM : The principal source of ESD damage is the human body

MM : The prime source of damage for the MM is a charge machine or device

CDM : The prime source of damage for the CDM is the rapid discharge of a charged part

ESD MODEL	ESD CLASS: sensitivity (S) vs voltage range	
HBM	1	0 V < S < 1999 V
	2	2000 V < S < 3999 V
	3	4000 V < S < 15999 V
MM	1	0 V < S < 100 V
	2	101 V < S < 200 V
	3	201 V < S < 400 V
	4	401 V < S < 800 V
	5	800 V < S
CDM	1	0 V < S < 124 V
	2	125 V < S < 249 V
	3	250 V < S < 499 V
	4	500 V < S < 999 V

Table B-4 : ESD classes

ANNEX E: PRODUCT ASSURANCE REQUIREMENTS FOR ASIC AND FPGA DESIGN MODEL DEVELOPMENT AND VALIDATION

ANNEX E Table of contents

1 SCOPE

This document defines the standard Product Assurance Requirements for digital ASIC and FPGA design model development, verification and validation, to be applied for the procurement of ASIC and FPGA for our end customers programmes.

It contains a set of complementary requirements with respect to the ECSS document entitled “Space product assurance – ASIC and FPGA development” [AD1], therefore it is applicable together with this ECSS document.

This document is only applicable to the design model, implemented by the HDL model: refer to the definition of this term in [AD1] §3.1 Terms and definitions. All activities relative to the hardware devices themselves (ASIC of FPGA) are out of the scope of this document.

2 APPLICABILITY

This document is applicable to the development of digital ASIC and FPGA subcontracted by the end customer for a particular project and has to be applied by both external and internal subcontractors.

The requirements included in the in hand document can be introduced in the project PA requirements for subcontractors. If necessary, these requirements can be tailored by the project team.

3 REFERENCES

3.1 APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. Unless an issue is quoted for a document, the current issue is deemed to apply. When an issue is quoted, that issue and no other must be used.

AD1 ECSS, Space product assurance – ASIC and FPGA development
[ECSS-Q-ST-60-02]

3.2 REFERENCE DOCUMENTS

The publications listed below were used in the preparation of this document, and contain background information relating to the subjects addressed.

RD1 Astrium SAS, Plan d'assurance qualité ASIC
[CDSQ.BA.058.INF ed.03]

RD2 ECSS, Space engineering — Verification
[ECSS-E-ST-10-02C]

3.3 TERMINOLOGY

Abbreviations used in the current document are as follows :

ACP	ASIC and FPGA Control Plan
AD	Applicable Document
ADP	ASIC and FPGA Development Plan
ADRF	ASIC/FPGA Design Reuse suitability File
A/F	ASIC/FPGA
AQSR	ASIC/FPGA Qualification Status Review
ASIC	Application Specific Integrated Circuit
CDR	Critical Design Review
Design model	Set of external schematics, HDL source codes including IP, synthesis scripts, simulation patterns
ECSS	European Committee for Standardisation in Space
FPGA	Field Programmable Gate Array
HDL	Hardware Description Language, Term used in general for the various “hardware description languages” which are applied for coding during design phase, such as VHDL and Verilog
ICD	Interface Control Document
NRB	Non-Conformance Review Board

OTS	Off-The-Shelf
PDR	Preliminary Design Review
PM	Progress Meeting
PR	Progress Report
QR/AR	Qualification and Acceptance Review
RD	Reference Document
RCF	Release Configuration File
SRR	System Requirements Review
Supplier	Organisation or Person that provides a product compliant to the following requirements
VHDL	Very high speed integrated circuit Hardware Description Language
VP	Verification Plan

4 REQUIREMENT PRESENTATION

The requirements are numbered and presented as below:

Identifier	*Applicability*	*Review*	*Document*
Requirement text			

With:

Identifier: Requirement numbering

Applicability: Design Model type concerned by the requirement (ASIC / FPGA)

Review: Name of the first A/F review where the requirement can be verified

Document: Document where the requirement should be implemented

Requirement text: Description of the requirement

5 REQUIREMENTS

5.1 PROJECT MANAGEMENT

PM-010			
Deleted			

PM-020	ASIC + FPGA	SRR	ACP
Trained personnel shall be assigned to the various Product Assurance activities related to the ASIC/FPGA design model development and validation.			

PM-040	ASIC + FPGA	SRR	ACP
The Supplier shall prepare and implement an ASIC/FPGA design model Product Assurance Programme to be approved by the customer. This plan might be provided in the frame of the ACP or in the frame of an overall Product Assurance Plan.			

PM-050	ASIC + FPGA	SRR	ACP
The Supplier shall provide with his A/F Product Assurance Programme a compliance matrix documenting his compliance to the project A/F product assurance requirements applicable for the project/contract.			

Note: in the case where A/F PA requirements specified in the current document are included in the project PA requirements, it is not necessary to include PM-050 in project PA requirements (compliance will be provided as part of the compliance matrix to project PA requirements).

PM-060	ASIC + FPGA	SRR	ACP
The ASIC/FPGA design model Product Assurance Programme shall specify or reference the following items: • quality objectives, expressed in measurable terms whenever possible, • types of verification and validation activities (including tests) to be carried out, • specific responsibilities for quality activities such as reviews and tests, configuration management and change control, non-conformance control and corrective actions, • methods and rules to be applied.			

Note: the ASIC/FPGA design model development life cycle, the related milestones and the input and output criteria for each development phase shall be defined in the ASIC and FPGA Development Plan, as required in [AD1].

PM-070	ASIC + FPGA	PM	PR
The Supplier shall periodically prepare and submit to the Customer a report on the status and progress of the Product Assurance programme related to ASIC/FPGA design model, as part of the overall PA reporting.			

PM-080	ASIC + FPGA	PM	PR
The report shall include a summary of the quality activities performed, an assessment of the current quality of the process and the product, based on measured properties and verification of the actual implementation of the project plans, and the list of the problems detected and problems resolved.			

PM-090	ASIC + FPGA	SRR	ADP
The Supplier shall establish and maintain a non-conformance control system or use the equipment non-conformance control system to register ASIC and FPGA Non Conformances.			

PM-100	ASIC + FPGA	SRR	ADP
The used non-conformance control system shall provide the recording, reporting, review, disposition and analysis of non-conformances, and the definition and implementation records of corrective actions.			

PM-110	ASIC + FPGA	NRB	NRB MoM
ASIC and FPGA non-conformances shall be reviewed and managed by a formal Non-conformance Review Board (NRB).			

5.2 CONFIGURATION MANAGEMENT

CM-010	ASIC + FPGA	SRR	ADP
A configuration management system shall be used to manage ASIC/FPGA design model items such as simulation patterns, schematics, HDL source code files, test scripts and synthesis scripts. This system shall provide a version control mechanism (revision of each item and overall version),			

Note: usage of a computer-based configuration management tool is recommended.

CM-020	ASIC + FPGA	CDR	RCF
An ASIC or FPGA Design Model Release Configuration File shall be provided for each review in the scope of which a new A/F design is frozen and shall include: • product version identification, based on design model configuration management system, • applicable baseline for this version (specifications, ICD, Change request), • deviations to the baseline (Non conformances, Request for waiver), • list of product documents related to this version, • list of design model versioned items (product files and all tools used to generate the product), • configuration status of test environment (platform description, test procedures, post-processing tools...) used for validating this version.			

Note: this file can be incorporated in another existing document at ASIC/FPGA or equipment level.

5.3 TRACEABILITY MANAGEMENT

TM-010	ASIC + FPGA	SRR	Traceability Matrices
Bidirectional traceability shall be provided (in two traceability matrixes) between higher level technical requirements specified in ASIC/FPGA requirements baseline (part of A/F applicable documentation) and ASIC/FPGA technical requirements (specified in ASIC/FPGA requirements specification).			

TM-015	ASIC + FPGA	PDR	Traceability Matrices
Traceability shall be provided between A/F technical requirements and A/F verification and validation cases (covering tests performed in simulation, tests performed on breadboard and analyses).			

TM-020	ASIC + FPGA	PDR	Traceability Matrices
The traceability matrices shall provide the coverage of 100% of the technical requirements by verification and validation cases (covering tests performed in simulation, tests performed on breadboard and analyses).			

5.4 DESIGN MODEL STANDARDS

DS-010			
Deleted			

DS-020			
Deleted			

DS-030	ASIC + FPGA	PDR	VP
Adherence to applicable design standards and rules shall be verified.			

DS-040	ASIC + FPGA	SRR	ADP
Mandatory and advisory coding standards shall be defined and applied.			

DS-050	ASIC + FPGA	SRR	ADP
The HDL coding standards shall address the following subjects: ► general HDL coding rules, ► specific coding languages, such as VHDL or Verilog, ► consistent naming conventions, ► adequate commentary rules.			

DS-060	ASIC + FPGA	PDR	VP
Adherence to coding standards shall be verified.			

5.5 DESIGN MODEL VERIFICATION

DV-010	ASIC + FPGA	SRR	VP
The supplier shall design, for each interface parameter (as far as possible), boundary tests cases, to check the behaviour of the design model at the lower and upper bounds of this parameter.			

DV-020	ASIC + FPGA	SRR	VP
The statement coverage of HDL code, achieved by various types of tests, shall be 100%, with any exceptions being identified and justified.			

5.6 REVIEW PROCESS

RP-010	ASIC + FPGA	SRR	ADP
The customer shall be invited to the following A/F reviews: SRR, PDR, CDR, QR/AR.			

RP-020	ASIC + FPGA	SRR	ADP
Phasing of A/F reviews with equipment reviews shall be described in the A/F development plan including foreseen synchronisation of A/F reviews with equipment reviews (e.g. SRR or PDR may be part of equipment PDR, QR/AR may be part of equipment CDR).			

5.7 REUSE OF EXISTING ASIC /FPGA DESIGNS

5.7.1 Definition

Reused A/F design is any design developed outside the contract to which this document is applicable.

5.7.2 Requirements

RF-001	ASIC + FPGA	AQSR or SRR	ADRF or ACP
In case of reuse of an existing A/F design, the supplier shall identify the reused A/F design and classify the ASIC/FPGA item in one of following categories (similar to those defined for OTS products in ECSS-Q-ST-10-02C/Table5-1): **Category A**: **Description**: A/F design reused without modifications and • subjected to a qualification test programme at least as severe as that imposed by the actual project specifications including the environment applicable to the design (e.g. radiation, operating frequency, ...) • produced by the same manufacturer or supplier and using the same tools and manufacturing processes and procedures **Associated Requirements and Qualification Programme**: all requirements RF-XX included in this section are applicable and their outputs could justify the decision that no additional A/F qualification programme is required for the ASIC/FPGA design. **Category B**: **Description**: A/F design reused without modifications. However it has been subjected to a qualification programme less severe or different to that imposed by the actual project specifications (including the environment applicable to the design, e.g. radiation, operating frequency, ...). **Associated Requirements and Qualification Programme**: all requirements RF-XX included in this section are applicable and their outputs shall include the definition of a delta qualification programme. **Category C:** **Description:** A/F design reused with modifications. **Associated Requirements and qualification programme:** all requirements applicable to new ASIC/FPGA designs are applicable; requirements RF-XX included in this section are not applicable except RF-001 and RF-070. The ECSS A/F reviews shall be held; However, in case of small modifications, some of them could be merged. A/F documentation shall be generated accordingly.			

RF-010	ASIC + FPGA	AQSR	ADRF
In case of reuse of an existing ASIC/FPGA design, the supplier shall establish an ASIC/FPGA design reuse suitability file.			

Note: The ASIC/FPGA design reuse suitability file shall be submitted to the contractor and the customer in a preliminary issue during the ASIC/FPGA design reuse process (i.e. prior to the selection of the corresponding subcontractors).

RF-020	ASIC + FPGA	AQSR	ADRF
The existing ASIC/FPGA design shall be assessed with regards to the applicable functional, performance and quality requirements.			

RF-030	ASIC + FPGA	AQSR	ADRF
The quality of the existing ASIC/FPGA design shall be analysed with respect to the applicable project requirements, taking into account the following aspects: 1. ASIC/FPGA requirements documentation; 2. ASIC/FPGA architectural and detailed design documentation; 3. ASIC/FPGA verification and validation documentation (plans and reports) and coverage metrics (code coverage, requirements coverage); 4. Residual Non Conformances and Waivers.			

RF-040	ASIC + FPGA	AQSR	ADRF
For each case of reuse of an existing A/F design, a dedicated ASIC/FPGA Qualification Status Review (AQSR) shall be held to determine • the category of the ASIC/FPGA item with respect to categories defined in RF-01 and • the necessary (delta) qualification approach within the project.			

Note: If the unit including the ASIC/FPGA is an OTS, AQSR to be held can be part of EQSR to be held for the OTS item.

RF-044	ASIC + FPGA	AQSR	ADRF
This ASIC/FPGA Qualification Status Review (AQSR) shall take place not later than the PDR for the next higher assembly level.			

RF-050	ASIC + FPGA	AQSR	ADRF
Each ASIC/FPGA Suitability File shall contain at least: • The project technical specification identifying the project requirements for the ASIC or FPGA; • All results of the existing ASIC/FPGA design analysis (resulting from RF-020 and RF-030); • Justification File clearly identifying any non compliance between the applicable functional, performance and quality requirements and the actual characteristics/performances of the ASIC or FPGA; • Delta Activities Programme describing all necessary tasks to be performed to verify the fulfilment of the project requirements, if any; • ASIC/FPGA Suitability Report presenting the results of the Delta Activities and demonstrating the full suitability of the reused ASIC/FPGA design; • All results of the AQSR of the ASIC/FPGA.			

RF-060	ASIC + FPGA	AQSR	ADRF
The Delta qualification Activities Program as defined during the AQSR shall be completed prior to the qualification review of the next higher assembly level.			

RF-070	ASIC + FPGA	AQSR or SRR	ADRF or ACP
The supplier shall describe the overall approach for reuse within the ADRF or ACP.			

ANNEX F: RADIATION HARDNESS ASSURANCE REQUIREMENTS FOR MATERIALS USED ON SPACE PROGRAM

ANNEX F Table of contents

1 SCOPE

The purpose of this document is to provide Space Radiation Hardness Assurance (RHA) Requirements applicable to materials used on spacecraft system. These are to be followed during program in order to prove that the space system will continue to perform its function throughout project mission duration.

These RHA requirements apply to all space systems contractors and equipment providers. Specifically, this document

- Discusses methods to calculate the ionizing radiation and UV environment at sensitive material level, and the resulting effects,
- Provides materials test and analysis requirements to be used by suppliers to ensure completeness and consistency in reporting and analyzing material radiation response and qualification.

2 APPLICABILITY

This specification is applicable to all external materials used on flight hardware and flight spares used on platform and payload. For other materials, the applicability of this document shall be considered on case by case.

This document is applicable to all contractors and parties working on the end customers programs.

3 REFERENCES

3.1 APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. Unless an issue is quoted for a document, the current issue is deemed to apply. When an issue is quoted, that issue and no other must be used.

- [AD1] Project related Radiation Environment Specification
- [AD2] Project related equipment specification

3.2 REFERENCE DOCUMENTS

The publications listed below were used in the preparation of this document, and contain background information relating to the subjects addressed.

- [RD 1] “The particle and ultraviolet (UV) radiation testing of space materials”, ESA PSS.01.706, issue 1, 03/1983.
- [RD 2] "Space product assurance – Data for selection of space materials and processes", ESAECSS Q-70-71, 11/2003.

- [RD 3] “Standard practice for combined, simulated space environment testing of thermal control materials with electromagnetic and particulate radiation”, ASTM E-512-94 (reapproved 1999).
- [RD 4] “Standard Solar Constant and Zero Air Mass Solar Spectral Irradiance Tables”, ASTM E-490
- [RD 5] "Space environmental effects on Spacecraft : LEO materials selection guide", NASA contractor report 4461 part 1 and part 2, 08/1995.
- [RD 6] "Radiation Environment for Materials. Radiation Effects Description", EADS ASTRIUM SAS report ref. EUR3.DDD.07118.DP.T.ASTR issue 1, 03/2003.

3.3 ABBREVIATIONS

Abbrev.	Meaning
FM	Flight Model
GEO	GEOsynchronous / GEOstationary
LEO	Low Earth Orbit
MPCB	Materials and Process Control Board
PDR	Preliminary Design Review
PMP	Parts, Materials and Processes
RFD	Request For Deviation
RFW	Request For Waiver
RHA	Radiation Hardness Assurance
TIC	Technology Identification Card
UV	Ultra Violet
WC	Worst Case

4 INTRODUCTION

Radiation hardness is a critical issue for materials used in long duration space flight. The Space radiation environment can lead to extremely harsh operating conditions for the materials, especially if they are located on external surfaces. Radiation accelerates the ageing of the material by long term effects and can lead to a degradation of its physical properties (optical, electrical and/or mechanical). Such damage at material level can in turn induce damage or functional failure at equipment and/or system levels.

The radiation sensitivity of materials is mainly due absorbed dose. The **Absorbed Dose** is the amount of energy imparted by ionizing radiation per unit mass of irradiated matter. The nature of the species created by ionizing radiation is the same whatever the type of radiation (electrons, protons, ions or energetic photons). The ionization process leads to the liberation of an electron which is either thermalised and absorbed by the ion or leaves the site of primary interaction to excite or ionize other atoms or molecules along its trajectory. As an example, for GEO orbit, particles responsible of ionizing dose damage mainly come from the ones trapped in the Radiation belts (Van Allen belts) and from particles directly received from the sun.

In addition to ionization effects, degradation linked to solar exposition, particularly in the **UV range**, has to be considered ; UV exposition leads to potential excitation of atoms, since, except for far UV, UV photons do not have enough energy to ionise them.

In addition to both effects, heavy particles (like protons) can also cause **Displacement Damage**. This type of degradation appears mainly in crystalline materials, so it is marginal for most of materials used on spacecraft and it should be considered only in very particular cases. As an energetic particle collides with an atom, the atom will recoil from its lattice site. If the energy transferred to the atom is high enough, the atom can be knocked free from its lattice site to an interstitial site. As the atom is displaced from its original position it leaves behind a vacancy. If the displaced atom has sufficient energy, it can in turn displace other atoms. Thus, for very high energy recoils a defect cascade can be created with large defect clusters.

5 RADIATION ENVIRONMENT DEFINITION

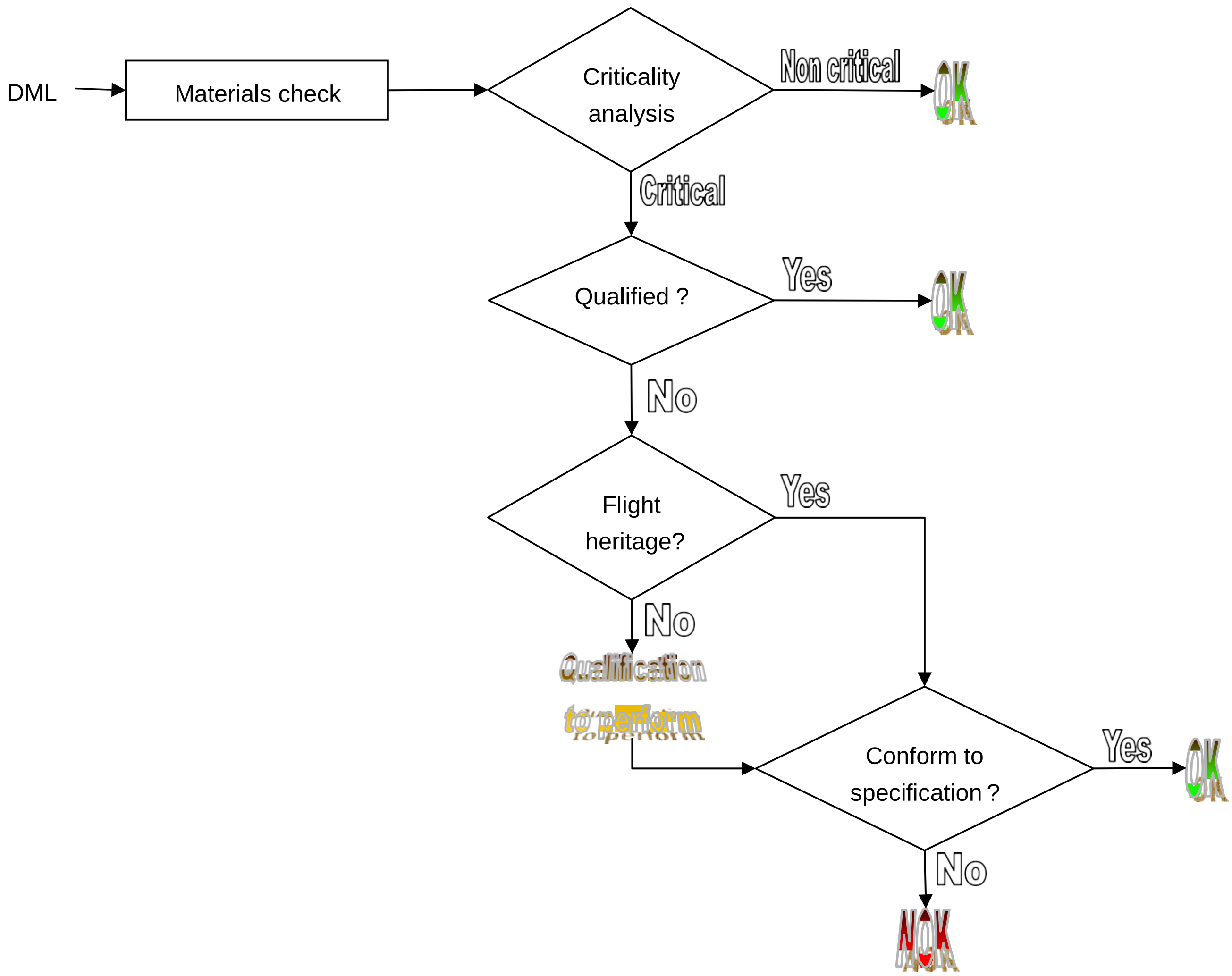
Mission specific requirements are given in satellite and in equipment environment specification, as well as in project related radiation environment specification.

The radiation environment specifically applicable to space program is defined in [AD 1] and should include charged particle environment as well as solar electromagnetic (including UV) aspects.

6 QUALIFICATION STATUS OF MATERIALS

6.1 GENERAL OVERVIEW OF THE QUALIFICATION POLICY

The evaluation of the qualification status of materials and processes versus radiation should be performed through a criticality analysis. Next graph presents the general policy to follow in order to insure Radiation Hardness of materials and processes.



6.2 CRITICALITY ANALYSIS

REQ QSM01 : A criticality analysis shall be conducted at the beginning of the project on all PMP in order to define critical materials or processes related to radiation aspects. This analysis will determine complementary data to acquire to answer to project mission requirements.

A **Critical Material** is a Material which is deemed to be a hazardous for the intended mission. Criteria to be considered for radiation aspects are :

- New Material or not qualified for application.
- Material which has caused problems during previous application.
- No ageing (degradation of material properties versus thermal cycling, radiation, mechanical constraints…) law exists on the material (based on formal physical laws, flight heritage or experimental data)
- Material needing particular additional follow up due to reliability analysis conclusions.

Critical material types to be addressed are at least (non exhaustive list) :

- Composites,
- Rubbers and elastomers,
- Thermoplastics, dielectric materials,
- Optical glasses, OSR, optical coatings,…

A **Critical Process** is defined according to the following criteria :

- New Process or not fully validated in a similar application.
- Anomalies were detected in previous use.
- Repeatability of the Process is intrinsically difficult to achieve and implies criticalities on functional performances.
- Process depending on the operator.

For instance, a lack of repeatability on the manufacturing of an optical coating can induce a risk on the radiation hardness of the coating, whereas the material itself is known as stable in space environment. Therefore, the process has a direct influence on the radiation hardness of the material.

REQ QSM02 : The criticality analysis of all critical PMP and the associated evaluation and qualification programme will be submitted to the MPCB approval before authorisation to proceed with the design using this critical item.

6.3 QUALIFIED MATERIAL

A **qualified material** is a material which has been successfully qualified versus the specified radiation environment (see § 5) by laboratory tests (see § 7 for the method to apply in order to qualify a material).

6.4 FLIGHT HERITAGE

It is impossible to reproduce exactly the space environment with ground testing of space system elements, because of the variety and complexity of the environment and effects on materials. Then, flight heritage may be a useful tool to determine whether a particular material is able to withstand the space environment of a given mission, furthermore considering that flight data will as well consider potential synergistic effects that are particularly difficult to reproduce at ground level.

However, use of flight heritage has to be conducted with cautious in order to guarantee that :

- Material previously exposed to space environment is of same nature as the one forecasted to be used in space program,
- Used flight data have been obtained in space radiation environment conditions that are worst case or at least representative of the ones of space mission.

REQ QSM03 : Use of flight heritage for radiation qualification purpose of a given material is allowed in the frame of space program once it is established that :

- Used flight data concern rigorously the same material than the one to be used in the frame of space program (or any technology changes is proven not to alter material radiation hardness),
- Used flight data concern the same location in the spacecraft and the same geometry,
- Used flight data have been obtained in space radiation environment conditions worst case, or at least equivalent to the one of space mission, as described in [AD1].

Such demonstration has to be submitted to space project for review and approval.

7 EVALUATION OF MATERIAL RADIATION HARDNESS

REQ MRH01 :. Materials on the external surface of a spacecraft (e.g. thermal blankets, thermal insulation systems, thermal paints, transparencies and windows, harness), shall be evaluated to determine that any degradation of properties due to absorbed dose and/or UV does not affect the specified material performance throughout the entire mission.

Such assessment will rely either on tests performed according either to [RD1] or [RD3] or on flight heritage (as described in § 6.4).

7.1 APPLICABLE METHODOLOGY FOR GROUND TESTING OF MATERIALS

REQ MRH02 : The following methodology shall be applied for the validation of critical PMP versus radiation :

1. Select the space environment factors influencing the selected properties that are critical for performance and reliability of the material to be tested
2. Consider the induced environment factors (*) that can influence the effects that are under investigation (outgassing, contamination…)
3. Determine the environment acceptable acceleration rates that will not adversely affect the results.
4. Select the environments to be simulated for on-ground tests.
5. Select the radiation sources for ground simulation.
6. Determine the energies and fluences for the radiation sources to closely simulate the expected space constraints (depth dose profile, UV illumination,…).

(*) induced environment factors: the environmental factors that result from interactions of the space system with the natural space environment or the factors that are produced by the space system. They include thermocycling, ambient atmosphere, electrical charging, etc.

7.2 MATERIAL PROPERTIES SENSITIVITY DETERMINATION

REQ MRH03 : Properties that are critical for performance and reliability of materials used on spacecraft, as defined in § 6.2, especially on external surfaces shall be assessed.

Main macroscopic properties that can be affected are :

- Mechanical properties : primary effects are generally deformation, brittleness and discoloration, which impacts the mechanical integrity and the thermal equilibrium of the material
- Optical and thermo-optical properties : the macroscopic effect of the degradation of optical glasses, white paints or some polymers is a darkening ("yellowing") of the material, which traduces a change in the absorption properties of the material,
- Electrical properties : electrical conductivity modification.

REQ MRH04 : The evaluation of materials sensitivity to radiation (absorbed dose and/or UV) shall comply with the following rules :

- Test performed in accordance with **REQ MRH02**,

and,

- Tested material is manufactured with technology identical to the technology to be used for FM material (except if technology changes are proven not to alter radiation hardness),

and,

- Test conditions worst or equivalent to the application.

REQ MRH05 : In case of non-compliance to these requirements, a Request For Deviation (RFD) or a Request For Waiver (RFW) shall be issued towards space project team, where subcontractor establishes that test result (and especially the overall test accuracy) will provide the information required for material acceptance status.

7.3 ABSORBED DOSE EVALUATION

Absorbed Dose Level to be received by materials shall be calculated whenever the material of concern is potentially sensitive to absorbed dose induced degradation.

REQ MRH06 : Depth dose profile applied to the tested material shall be calculated thanks to appropriate calculation tools agreed by space project before use. The user shall identify the calculation tool, nature and method used for these absorbed dose calculations.

REQ MRH07 : When a mathematical software (ray-tracing or Monte Carlo) is used, rays or histories number shall be high enough to ensure the Absorbed Dose Level convergence with an uncertainty less than 10%.

REQ MRH08 : Absorbed Dose curves for space environment and test environment shall be calculated using the same mathematical code and taking into account the geometries of particle incidence for both the space and simulated space radiation environments.

7.4 UV DOSE EVALUATION

REQ MRH09 : The evaluation of ultraviolet (UV) radiation hardness shall only apply on external materials directly exposed to sun illumination.

In the case of UV radiations, it is estimated that the degradation is a function of the solar illumination in the UV range (wavelength lower than 0.4 μm), expressed in $W.m^{-2}$ (see [RD 4]). The integrated irradiance is approximately 118 $W.m^{-2}$ for this part of the spectrum.

The degradation is estimated by considering the number of equivalent sun hours (esh), which is equal to the integrated irradiance over 1 hour and corresponds to the density of energy absorbed by the material. This degradation will depend on the orientation of the material, as the sun illumination is different on each wall (see Figure 7-1)

Figure 7-1 : Orientation of the walls and sun illumination

As an example, during one year in GEO environment, the solar irradiation is :

- 1110 esh on North/South (-Y/+Y) side of the spacecraft
- 2555 esh on –Z side of the spacecraft, facing the sun.

REQ MRH10 : The solar irradiation, expressed in esh (equivalent sun hours), applied to the exposed material shall be calculated for all external materials directly exposed to sun illumination, taking into account the orientation of the materials.

REQ MRH11 : If no existing acceptable data allows to determine material hardness to UV, as per **REQ MRH01**, UV induced effects evaluation program to be implemented, according to **REQ MRH02**, shall be submitted to space project approval.

7.5 ACCEPTANCE CRITERIA

REQ MRH12 : Acceptance criteria rely on the material specification for the considered application and shall be agreed by space project.

REQ MRH13 : Depending on the criticality of the PMP evaluated for radiation hardness, a minimum margin of 20 % shall be applied on absorbed dose simulation or acceptance criteria to demonstrate that performance can be achieved in worst case conditions and for the required life time.

7.6 NEED FOR A SCREENING TEST

In very specific cases, where a high criticality level has been identified on PMP (see **REQ QA01**), a screening test on FM material samples shall be done in addition to qualification tests in order to guarantee the good functionality of PMP for space program.

As an example, a screening test is necessary if :

- Process is operator-dependent
- Radiation hardness of the material can depend on lot production.

REQ MRH14 : A screening test shall be done on highly critical materials, for which radiation hardness is dependent on manufacturing parameters.

The screening test shall comply with the following rules :

- Test performed in accordance with **REQ MRH02**,

and,

- Test performed on FM material samples : lot testing if different manufacturing lots are used

and,

- Test conditions worst or equivalent to the application.

8 QUALITY ASSURANCE

REQ QA01 : Radiation aspects for PMP shall be assessed during MPCB, at Preliminary Design Review time frame (PDR, EQSR, ...) in order to address the following points:

- To review qualification test reports, in order to validate the subcontractor radiation database.
- To validate criticality analysis performed on PMP for radiation aspects.
- To determine material types that shall be submitted to a complementary characterization test, selected parameters to be measured and to review radiation test plan for such materials.
- To review preliminary radiation calculation hypothesis, methodology and results.

REQ QA02 : For each relevant subsystem, a Material Radiation Analysis is required. The required minimum information to be included in the Material Radiation Analysis Document (MRAD) are listed here below. For the detailed required content, the reader will refer to the previous sections.

MRAD content :

1. Identification of all applicable and reference documents used in MRAD.
2. Identification of all relevant parameter for calculation : radiation environment, used software, methodology, used shielding…
3. List of materials (extracted from the DML) used in the subsystem with identification of manufacturer (and lot identification if relevant).
4. Absorbed Dose level received on all relevant materials during the entire mission duration.
5. Criticality analysis on all relevant materials with justification of criticality level.
6. Type by type on all relevant materials, identification of the relevant property to be checked and the material sensitivity to absorbed dose and UV (see 7.2).
7. Identification and description of qualification test data. If no qualification data are available, flight data might be used (according to 6.4).
8. Type by type on all relevant materials, acceptance status regarding all radiation (ionizing radiation and UV) degradation mechanisms.
9. Identification and description of radiation test used by the subcontractor, if any, including all test parameters (type of particles, energies, vacuum…).
10. Worst case analysis and reliability analysis demonstrating that equipment performance and reliability will be fulfilled considering absorbed dose and UV effects. If not provided in MRAD, reference of the adequate document(s).

ANNEX G: HIGH RELIABILITY SOLDERING FOR SURFACE MOUNT AND MIXED TECHNOLOGY REQUIREMENTS

ANNEX G Table of contents

INTRODUCTION

The document is a tailoring of the ECSS-Q-STQ70-38C in accordance with the ECSS management plan in order to be more effective with regards to reliability for soldering a variety of SMT components. In order to follow the Management Plan, the text can fall under one of four sections.

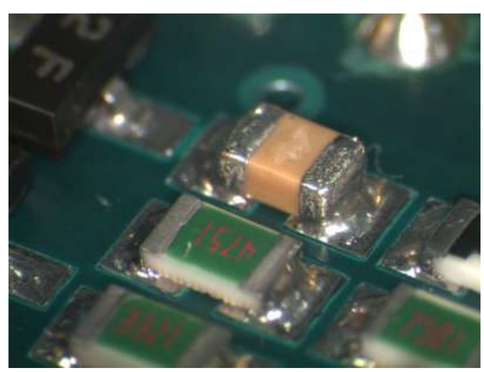
- **ACCEPTED** text shall be **BLACK**, and has been extracted directly from ECSS-Q-ST-70-38C
- **NEW** text that is not within the ECSS-Q-ST-70-38C is coloured **BLUE** with a box surrounding that section of text.
- **MODIFIED** text is where small changes such as change of wording have taken place. This will appear as **BLUE** text.
- **DELETED** text shall be **RED**.

Through discussion, it is crucial that the difference between VERIFICATION and QUALIFICATION are explained. ESA defines these as:

Verification: A process which demonstrates through the provision of objective evidence that the product is designed and produced according to its specifications and the agreed deviations and waivers, and is free of defects.

Qualification: that part of **verification** which demonstrates that the **product** meets specified **qualification margins**

This Standard prescribes requirements for electrical connections of leadless and leaded surface mounted devices (SMD) on spacecraft and associated equipment, utilising a range of substrate assemblies and employing solder as the interconnection media. The principal types of SMDs can be gathered in the following families:

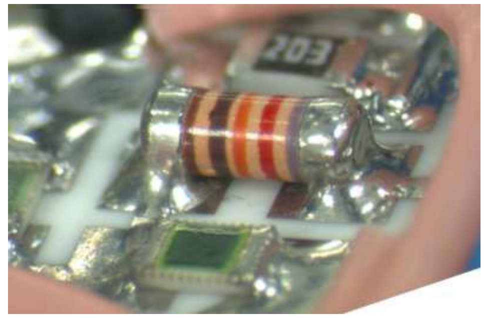
Rectangular and square end-capped or end-metallized device with rectangular body e.g. end capped chip resistors and end capped chip capacitors.	

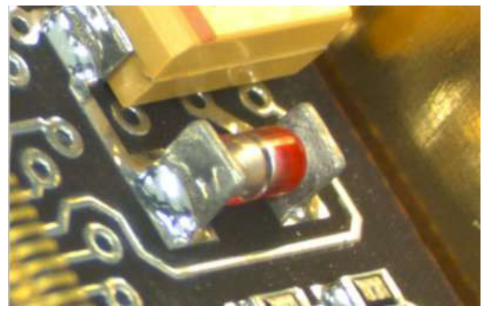
Cylindrical or square end--capped devices with cylindricalbody

Top image shows a Cylindrical capped device with a cylindrical body e.g. DIODE DO213

Second image shows a cylindrical bodied device, capped with square ends.

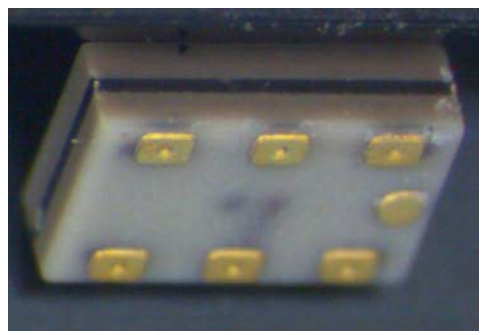
e.g. MELF.





Bottom terminated chip device

This type of device has metallised terminations on the bottom side only.

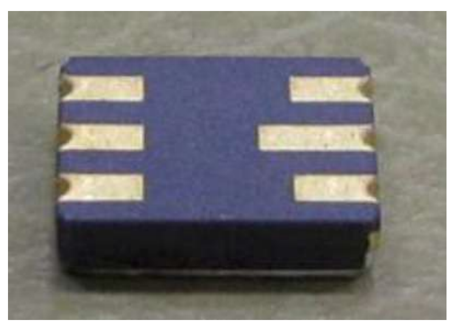


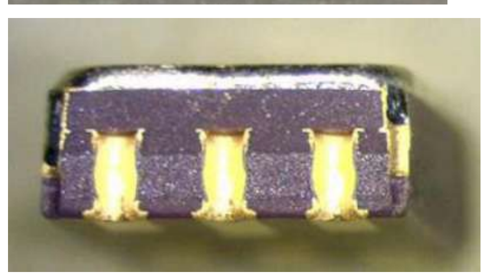
Castellated chip carrier device

The main component of this type is leadless ceramic chip carrier (LCCC).

The top image shows the underside of the component, with terminals being soldered to the designated pads upon the substrate.

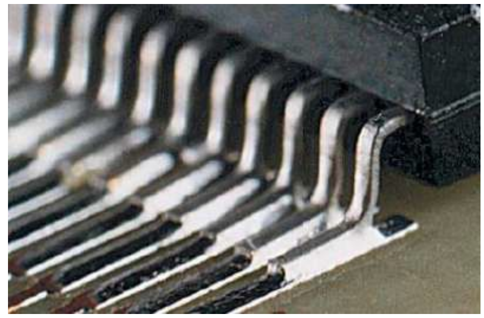
The bottom image shows where the wetting of the device is expected to create the solder joint.





Device with round, flattened, ribbon “L” and gull-wingleads

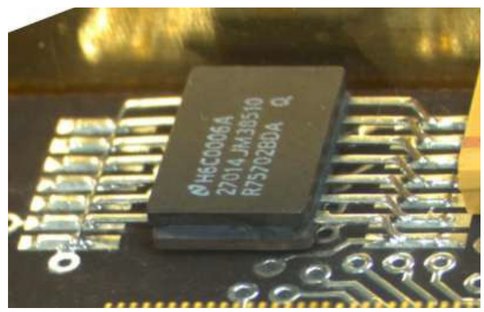
e.g. Flat Pack (FP) Quad Flat Pack (QFP) Small Outline Transistor (SOT)



Flat Pack (FP)

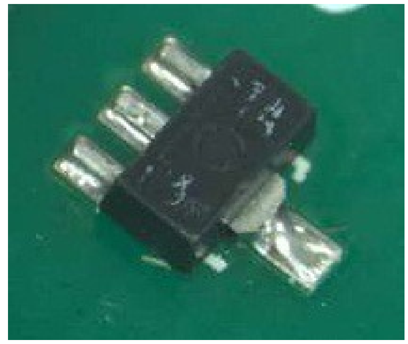
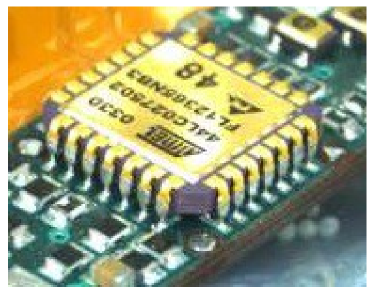
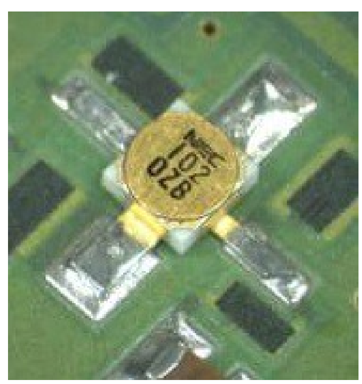
The basic form is a flat rectangular or square body with leads at two or four sides but with numerous variations in the design. These differ usually only in lead number, pitch (nominal, fine pitch, small-outline), dimensions, and materials used (e.g. body may be ceramic, metallic, plastic)….usually to improve thermal characteristics.

The package shown has leads at two opposite sides but with numerous variations in the design.



Quad Flat Pack (QFP)

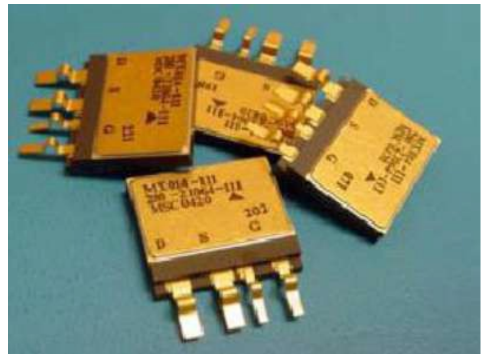
This is a package similar to the Flat Pack (FP) device but with leads on all four sides. Again, the design has a number of variations such as lead number, pitch (nominal, fine pitch, small-outline…), dimensions, and materials used (e.g. body may be ceramic, metallic, plastic).

SOT, … This device is a Small Outline Transistor.	
"J" leaded device **A "J" leaded component is a device which has its contacts soldered to the PCB via the curl when the lead is formed to the shape of a "J".**e.g. ceramic leaded chip carriers (CLCC) and plastic leaded chip carriers (PLCC).	
Device with Inward formed L--shaped leads A Device with Inward formed "L" shaped leads is a component which has it's two contacts 'hugging' the underside and each side of the device. This means that once the Device is soldered, the bottom of the component should not be flush with the PCB, but in fact be slightly elevated due to the solder. e.g. moulded tantalum chip capacitors.	
Device with flat lug leads This package has flat leads extending from the sides.	

Leaded device with thermal plane termination

e.g. Diode Package (DPAK).

Although the SMD02 device is regarded as a leadless device with thermal plane termination, it can be attached to a carrier and become a leaded device.



Leadless device with thermal plane termination

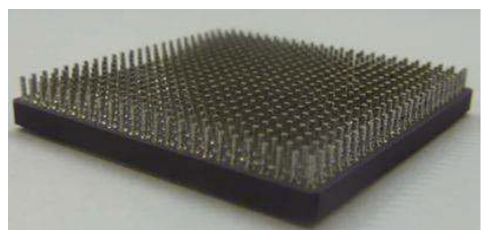
This SMD01 (0.625" x 0.450") package consists of three terminal pads, ceramic housing, and lid brazed together to form a hermetic semiconductor die carrier. SMD022 (0.220" x 0.150") and SMD05 (0.400" x 0.300") devices are of a similar design, but are smaller in size.

Similarly, SMD02 is a larger sized component than the SMD01.

Area Array Devices

These are devices that are leadless, but have interconnections between the solder pads on the devices and solder pads on the PCB consists entirely of solder. In addition, a copper spiral, wound to the columns, can be utilised to maintain electrical continuity.

There are two categories of Area array devices; either Ball Grid Array BGA or Column Grid Array (CGA), shown right. BGA has solder balls and CGA has columns applied to pads prior to mounting on the PCB. Area array devices are available in a vast number of variations for numerous purposes.



1 SCOPE

This Standard defines the technical requirements and quality assurance provisions for the manufacture and verification of high-reliability electronic circuits based on surface mounted device (SMD) and mixed technology.

The Standard defines acceptance and rejection criteria for high-reliability manufacture of surface-mount and mixed-technology circuit assemblies intended to withstand normal terrestrial conditions and the vibrational g-loads and environment imposed by space flight.

The proper tools, correct materials, design and workmanship are covered by this document. Workmanship standards are included to permit discrimination between proper and improper work.

The assembly of leaded devices to through-hole terminations and general soldering principles are covered in ECSS-Q-ST-Q-70-08.

Requirements related to printed circuit boards are contained in **ANNEX H** of MetOp-SG document MOS.SP.ASF.SYS.00401. The substrates covered by this document are divided into five classes in accordance with their average X and Y coefficient of thermal expansion (CTE).

The mounting and supporting of components, terminals and conductors prescribed herein applies to assemblies designed to operate within the temperature limits of -55 °C to +85 °C.

For temperatures outside this normal range, special design and verification testing is performed to ensure the necessary environmental survival capability.

Special thermal heat sinks are applied to devices having high thermal dissipation (e.g. junction temperatures of 110 °C, power transistors) in order to ensure that solder joints do not exceed 85 °C.

Verification of SMD assembly processes is made on test vehicles (surface mount Verification samples). Temperature cycling ensures the operational lifetime for spacecraft. However, mechanical testing only indicates SMD reliability as it is unlikely that the test vehicle represents every flight configuration.

Examples of the method for achieving SMD Verification approval and guidelines for the soldering of area array devices are given in the Annexes.

This Standard does not cover the verification and acceptance of the EQM and FM equipment with surface-mount and mixed-technology.

The verification and acceptance tests of equipment manufactured in accordance with this Standard are covered by ECSS-E-ST-10-03.

This standard may be tailored for the specific characteristics and constraints of a space project, in accordance with ECSS-S-ST-00.

2 NORMATIVE REFERENCES

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

ECSS-S-ST-00-01	ECSS system — Glossary of terms
ECSS-M-ST-40	Space project management — Configuration and information management
ECSS-Q-ST-10-09	Space product assurance — Non-conformance control system
ECSS-Q-ST-20	Space product assurance — Quality assurance
ECSS-Q-ST-60	Space product assurance — Electrical, electronic and electromechanical (EEE) components
ECSS-Q-ST-60-05	Space product assurance — Generic requirements for hybrids
ECSS-Q-ST-70	Space product assurance — Materials, mechanical parts and processes
ECSS-Q-ST-70-01	Space product assurance — Cleanliness and contamination control
ECSS-Q-ST-70-02	Space product assurance — Thermal vacuum outgassing test for the screening of space materials
ECSS-Q-ST-70-08	Space product assurance — Manual soldering of high–reliability electrical connections
ANNEX H of MetOp-SG document MOS.SP.ASF.SYS.00401	End Customer Procured Equipment's - Printed Circuit Boards Requirements
ECSS-Q-ST-70-71	Space product assurance — Data for selection of space materials
MIL-STD-883 Method 2009.8	Test Method Standard, Microcircuits
ECSS-Q-ST-70-38C	High-reliability soldering for surface mount and mixed technology

3 TERMS, DEFINITIONS AND ABBREVIATED TERMS

3.1 TERMS FROM OTHER STANDARDS

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01C apply.

3.2 TERMS SPECIFIC TO THE PRESENT STANDARD

3.2.1 Approval authority

The end customer entity that reviews and accepts the verification programme, evaluating the test results and grants the final approval. The end csutomer with agreement of the supplier could delegate this responsibility to a third party

3.2.2 Co-planarity

Maximum distance between lowest and highest termination when device rests on flat surface

3.2.3 Electrical clearance

Spacing between non-common electrical conductors on external layers of a printed circuit board assembly

NOTE The distance between conductors depends on the design voltage and DC or AC peaks. Any violation of minimum electrical clearance as a result of a non-conformance is a defect condition.

3.2.4 Scavenging (leaching)

Basis metal or metallization partly or wholly dissolved in melted solder during a soldering operation

3.2.5 Selective plating

Tin-lead plated solder pads connected to gold plated copper tracks

NOTE It is usually related to RF circuits.

3.2.6 Solder balling (solder balls)

Numerous spheres of solder having not melted in with the joint form and being scattered around the joint area normally attached by flux residues

NOTE Can be caused by incorrect preheating or poor quality solder.

3.2.7 Tombstoning

Chip components lifting off one of their two terminal pads causing the chip to stand up like a tombstone

NOTE Normally caused by :

- bad design where one pad reaches solder reflow temperature before the other;

- different quantities of solder paste on each pad;
- Different solderability of one pad or one termination with respect to the other.

3.2.8 Underfill

Encapsulant material deposited between a device and substrate used to reduce the mechanical stress resulting from a mismatch in the coefficient of thermal expansion (CTE) between the device and the substrate

3.2.9 Dynamic wave soldering machine

System that achieves wave soldering and which consists of stations for fluxing, preheating, and soldering by means of a conveyer

3.2.10 Critical Devices

Devices having shown cracks during previous verification programmes also if the cracks were considered acceptable. Critical device lists shall be maintained by the supplier and agreed with the Approval Authority. Critical devices, as defined by ESA, are set out in the table below.

NOTE This table is included to give a bench mark for critical devices and whilst correct at the date of issue, it is subject to continual improvement. Therefore, it should not be considered definitive. As such, it is the responsibility of the supplier to check the validity of this table against the most current ESA list.

Component	Package Type	Type of Failure	Recommendations and/or notes
Chip Resistors	R1206, R2010, R2512	Cracks in the solder joint	- To increase the stand off. Such corrective action may not be sufficient.
Chip Capacitors	Any	Crack in the ceramic initiated at the end termination	- To follow component manufacturer recommendations (preheating of the board, device and limited temperature). - Rework of such capacitors shall not be performed. In case of rework needed, replacement of the device is recommended.
	LCCs	Crack in the solder joint	- Degolding and preheating temperature used to be compliant to component manufacturer datasheet. - To increase the stand off - To solder the device upside down and add gull wing terminations (need of verification in compliance with ECSS). Change of footprint is

			required. - To solder upside down and have long wiring implemented. - Not to consider any verification by similarity for such package.
Tantalum Capacitors	CWR06	Crack in the device. Crack in the epoxy between the tantalum and the terminal	- Use of TAJ/CWR package which the temperature is not directly spread to the package.
	SMDs (SMD0.5, SMD1, SMD2, SMD5C)	Crack in the ceramic	- Procurement of package with terminations when possible which require a change of design of the solder footprint. - Assembly upside down using thermal adhesive and addition of wires or ribbons. This configuration may not be adapted for high thermal dissipation need.
Oscillator	JLCC4 with bottom brazed terminals	Crack in the solder joint	- Failure due to stiffness of the terminals combined with missing stress relief.
Stacked Devices	SOP from 3D+	- Crack in the solder joint - Unacceptable, per ECSS-Q-ST-70-38C, solder height at heel when hand soldering - No possible visual inspection possible due to the shape of the terminals -Restrictive soldering	- Procurement of devices with shortened leads (around 3mm instead of 5mm)
Stacked Capacitors	CNCXX	- Poor wetting due to finish type 10 (Ag 98%) - Poor co-planarity of the leads	- To pre-tin the device
Photo Transistor	Pill from micropac	- Cracks in the solder joint of the two small	- To degold and pre-tin at the temperature compliant to the component manufacturer

		terminals	recommendations. - Not to solder the bottom part of the PCB but to make a wiring connection.
Inductor	Coilcraft Inductor - AE235 type	Poor wetting of the terminals.	- To request coilcraft for the additional cleaning of the terminal to remove the contamination from the enamel present on the terminal.
	Enamel Wire	Short due to damaged enamel	- Recommendation to add an insulation (Kapton, brady label, filled varnish…) to avoid contact with metallic traces.

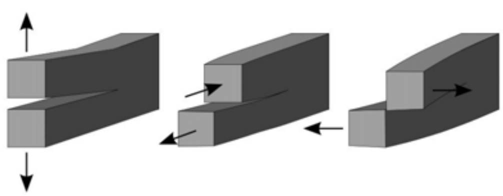
Table 1-1: List of identified critical devices for the assembly as per ECSS-Q-ST-70-38C on PCB laminates

3.2.11 Crack

A local separation of an object or material into two or more pieces under the action of stress. Two types of failure are noted for solder joints.

Brittle fracture – No apparent plastic deformation occurs before failure

Ductile fracture – Extensive plastic deformation takes place before fracture. The terms rupture or ductile rupture describe the ultimate failure of tough ductile materials loaded in tension



Mode I Mode II Mode III

Opening In-Plane Shear Out-Plane Shear

Detailed micro sectional analysis shall be performed with a metallographic microscope and not using stereomicroscope. SEM surface analysis can be used to support further investigations. Such further investigations might be needed, for example, to conclude if the line observed is a stress line, a crack or is enlarged grain boundaries.

It is recommended that Micro sectional analysis should be performed within 24 hours of the finalisation of the micro-section to avoid the creation of stress lines due to stress relaxation of the micro-section. In the case of stress lines induced by stress relaxation, with further polishing of the micro-section the stress lines disappears.

3.2.12 Stand Off

The depth of solder between the underside of the device termination and the surface of the PCB pad.

3.3 ABBREVIATED TERMS

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	**Meaning**
BGA	ball grid array
CBGA	ceramic ball grid array
CGA	column grid array
CCGA	ceramic column grid array
CLCC	ceramic leaded chip carrier
CTE	coefficient of thermal expansion
JEDEC	Joint Electron Device Engineering Council
LCCC	leadless ceramic chip carrier
MELF	metal electrode face bonded
	NOTE: Also known as minimelf or micromelf
MCGA	multichip column grid array
PCB	printed circuit board
PLCC	plastic leaded chip carrier
PID	process identification document
QFP	quad flat pack
r.m.s.	root-mean-square
SMD	surface mounted device
SMT	surface-mount technology
SO	small outline
SOD	small outline device
SOT	small outline transistor
TO	transistor outline

4 PRINCIPLES OF RELIABLE SOLDERED CONNECTIONS

The following are the general principles to ensure reliable soldered connections:

- Reliable soldered connections are the result of proper design, control of tools, materials, processes and work environments, and workmanship performed in accordance to verified and approved procedures, inspection control and precautions.
- The basic design concepts to ensure reliable connections and to avoid solder joint failure are as follows:
  - Stress relief is an inherent part of the design, which reduces detrimental thermal and mechanical stresses on the solder connections.
  - Where adequate stress relief is not possible materials are so selected that the mismatch of thermal expansion coefficients is a minimum at the constraint points in the device mounting configuration.
- The assembled substrates are designed to allow easy inspection.
- Since only the outer row of solder joints to area array packages can be visually inspected, inner rows are inspected using X-ray techniques. To facilitate X-ray inspection of the solder joints to BGAs, the solder pads have a teardrop design.
- Circuit designs for area array devices, (e.g. BGA, CGA) have clearance around the perimeter of these packages to ensure that reflow nozzles can perform rework or repair operations (see ECSS-Q-ST-70-28 [12]). The clearance depends on the equipment used for reworking and the height of adjacent components.

  NOTE Unpopulated areas on the underside of the substrate assist indirect heating for removal of these packages. See also Annex C.3.
- Soldering to gold using tin-lead alloy can cause failure.

5 PROCESS IDENTIFICATION DOCUMENT (PID)

5.1 GENERAL

5.1.1 Purpose

The purpose of the PID is to ensure that a precise reference is established for the assembly processes approved in accordance with this Standard.

The PID provides a standard reference against which any anomalies occurring after the approval can be examined and resolved.

5.1.2 Document preparation

a. The supplier shall prepare the PID in conformance with clause 5.1.3.

5.1.3 Content

a. The PID shall comprise

1. the assembly design configuration;
2. materials and components used in manufacture;
3. all manufacturing assembly processes and production controls;
4. all inspection steps with associated methods.

   NOTE This ensures that all future assemblies supplied by the manufacturer are manufactured in conformance with procedures that are identical to those for which approval was granted.

5. Facility room layout

b. All processes and procedures shall be verified and approved.

5.1.4 Approval

a. The PID shall be submitted to the approval authority

b. The Approval authority shall approve the PID.

c. The approval authority shall be given visibility of the supporting verification reports

5.2 PRODUCTION CONTROL

a. The PID shall contain a production flow chart which identifies all individual processes, inspections and a summary table that compiles all verified surface mount components and materials

NOTE See Annex B for examples.

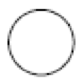
b. The points of application of quality controls shall be identified.

c. The flow chart shall present the processes, inspections and quality controls schematically in their correct sequence and, for each operation, make reference to the corresponding documents.

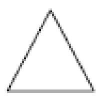
d. The issue number and date of documents applicable at the time of preparation of the flow chart shall be stated.

e. The following symbols shall be used to prepare the chart:

for process and assembly operations



for inspection and test operations



for quality control operations

5.3 PROCESS IDENTIFICATION DOCUMENT UPDATING

a. The PID shall be managed in accordance with ECSS-ST-M-40.

b. A PID shall represent the current verified manufacturing processes and production controls.

c. Any proposed changes to the PID shall be agreed by the Approval authority

d. The supplier shall identify the need for additional testing to be approved by the Approval authority.

e. The PID, the summary table and the relevant applicable documents shall be re-issued and agreed by the approval authority

6 PREPARATORY CONDITIONS

6.1 CALIBRATION

a. Records of tool calibration and validation shall be maintained.

6.2 FACILITY CLEANLINESS

a. ECSS-Q-ST-70-08 shall apply for "Facility cleanliness".

6.3 ENVIRONMENTAL CONDITIONS

a. ECSS-Q-ST-70-01 shall apply for "Environmental conditions".

b. Humidity Conditions shall be controlled within the limit 55 (-15 + 10)% RH

6.4 PRECAUTIONS AGAINST STATIC CHARGES

a. ECSS-Q-ST-70-08 shall apply for "Precautions against static charges".

6.5 LIGHTING REQUIREMENTS

a. ECSS-Q-ST-70-08 shall apply for "Lighting requirements".

6.6 EQUIPMENT AND TOOLS

6.6.1 Brushes

a. ECSS-Q-ST-70-08 shall apply for "Brushes".

6.6.2 Pliers

a. ECSS-Q-ST-70-08, shall apply for "Pliers".

6.6.3 Bending tools

a. ECSS-Q-ST-70-08 shall apply for "Bending tools".

6.6.4 Clinching tools

a. ECSS-Q-ST-70-08 shall apply "Clinching tools".

6.6.5 Insulation strippers

a. ECSS-Q-ST-70-08 shall apply for "Insulation strippers".

6.6.6 Soldering tools

a. ECSS-Q-ST-70-08 shall apply for "Soldering tools".

6.6.7 Soldering irons and resistance soldering equipment

a. ECSS-Q-ST-70-08 shall apply for “Soldering irons and resistance soldering equipment”.

b. For normal soldering of surfaced mounted devices, a soldering-bit temperature of 280°C is recommended, but it shall not exceed 340°C.

NOTE: Based on the component manufacturer’s recommendations, solder iron can be substituted by applying, for instance, hot air in order to avoid thermal shock.

NOTE: On a case by case scenario, a higher temperature than 340 can be used as agreed with the approval authority.

6.6.8 Non-contact heat sources

a. ECSS-Q-ST-70-08 shall apply for "Non-contact heat sources".

6.6.9 Solder pots and baths

a. ECSS-Q-ST-70-08 shall apply for "Solder pots and baths".

6.7 SOLDERING MACHINES AND EQUIPMENT

6.7.1 General

a. Machines and equipment used to solder surface mount devices :

1. leadless and leaded devices specifically designed for surface mounting,
2. components initially designed for insertion mounting,

shall either be a type incorporating dynamic single or dual solder wave, or be of the solder reflow type.

b. The soldering machine shall be grounded in order to avoid electrostatic discharge.

c. The supplier shall ensure that the soldering conditions do not exceed the values given by the individual component data sheets (e.g. maximum temperature to avoid internal melting, removal of marking ink, degradation of encapsulating plastic).

d. Temperature and time profiles for assembly shall be identified by the supplier and approved by the approval authority.

6.7.2 Dynamic wave-solder machines

a. Dynamic soldering machines shall be of automatic type and of a design offering the following:

1. Controllable preheating to drive off volatile solvents and to avoid thermal shock damage to the PCB and component packages.
2. The capacity to maintain the solder temperature at the printed circuit board assembly to within 5 °C of the established bath temperature throughout the duration of any continuous soldering run when measured 3,0 mm below the surface of the wave.
3. A wave system that limits shadowing and allows solder fillet formation.
4. Carriers made from a material that cannot contaminate, degrade or damage the printed circuit board or substrate nor transmit vibrations or shock stress from the conveyors to a degree permitting physical, functional or electrostatic damage to devices, board or substrate during transport through preheating, soldering and cooling stages.
5. An extraction system, either integral or separate, conforming to the requirements of clauses 6.2a and 6.3a.

6.7.3 Condensation (vapour phase) reflow machines

a. Condensation reflow machines shall conform to the following requirements:

1. Not transmit a movement or vibration into the assemblies being soldered that result in misalignment of parts or disturbed solder joints.
2. Be capable of preheating an assembly with solder paste to the temperature recommended by the solder paste manufacturer prior to soldering.
3. Use a reflow fluid whose boiling point is a minimum of 12 °C above the melting point of the solder being used.
4. Maintain the preselected temperature to within 5 °C in the reflow zone during soldering.
5. Include an extraction system that conforms to clauses 6.2a and 6.3a.

6.7.4 Hot gas reflow machines

a. Hot gas reflow machines shall conform to the following requirements :

1. Does not transmit movement or vibration to the assemblies being soldered which result in misalignment of parts or disturbed solder joints.
2. Preheats an assembly with solder paste to the temperature recommended by the solder paste manufacturer prior to soldering.
3. Heats the area of the assembly to be soldered to a preselected temperature between 220 °C and 250 °C as measured on the substrate surface.
4. Prevents the reflow of adjacent components.
5. Maintains the preselected reflow temperature within 5 °C as measured at the substrate surface.

6.7.5 Shorted bar and parallel gap resistance reflow machines

a. Resistance reflow machines shall be of a design such that the system meets the following requirements :

1. Does not impart mechanical damage to the component leads.
2. Provides "time at temperature" control type of power supply.
3. Maintains the shorted bar or component lead to a preselected temperature that is a minimum of 12 °C above the melting point of the solder being used.
4. Maintains the dwell time at temperature to within 5 % of the pre-set value.
5. Provides a repeatable down force to within 15 % of the pre-set value.
6. Provides a system (e.g. an optical feature) to ensure that the shorted bar or electrode alignment with the component lead foot is within 20 % of the nominal lead foot length.

6.7.6 Convection and radiation reflow systems

a. Convection and radiation reflow machines shall be of design such that the system meets the following requirements:

1. Provides a controlled temperature profile and does not transmit movement or vibration into the assembly being soldered.
2. Preheats an assembly with solder paste to the temperature recommended by the solder paste manufacturer prior to soldering.
3. Heats the area of the assembly to be soldered using focused or unfocussed energy, to a preselected temperature that is a minimum of 12 °C above the melting point of the solder being used as measured at laminate or substrate surface.
4. Maintains the preselected temperature to within 6 °C in the reflow zone during soldering.

6.7.7 Other equipment for reflow soldering

a. Other solder reflow systems can be approved for use by the Approval authority. This approval shall be subject to compliance with clauses 6.7.1 to 6.7.6a.

6.8 ANCILLARY EQUIPMENT

6.8.1 General

a. Equipment shall not generate, induce or transmit electrostatic charges to devices being placed.

6.8.2 Solder deposition equipment

a. Equipment used to deposit solder pastes shall be of a screening, stencilling, dispensing, roller coating or dotting type.

b. Equipment shall apply pastes of a viscosity and quantity such that the positioned device is retained on the board before and during soldering operations, ensuring self-centring and solder fillet formation.

c. Equipment used to apply solder preforms shall ensure alignment of the preform with the land or device lead and termination.

6.8.3 Automatic device placement equipment

a. Automatic or computer controlled equipment used for device placement shall be of the coordinate-driven pick-and-place type or of the robotic type.

b. The placement equipment used shall be of a type that :

1. prevents device or board damages
2. indexes devices with respect to the circuit
3. aligns the device leads or castellations with the board terminal areas.

6.8.4 Cleaning equipment and systems

a. ECSS-Q-ST-70-08 requirements on “Cleaning of PCB assemblies – General” and “Cleaning of PCB assemblies – Ultrasonic cleaning” shall apply.

6.8.5 Cleanliness testing equipment

a. ECSS-Q-ST-70-08 shall apply for “Cleanliness testing”.

6.8.6 Magnification aids

a. Clause 13.1 shall apply.

6.8.7 X-ray inspection equipment

a. X-ray inspection shall not damage the components.

b. X-ray equipment shall be calibrated in order to evaluate the total dose received by the components during the inspection.

NOTE In order to minimize the dose given to the component, it is good practice to :

- Record the total dose received.
- Use off-line image analysis as much as possible.
- Use filters, optimizing the direction of the X-ray beam and masking sensitive areas.

c. The resolution of the X-ray equipment shall be able to detect solder balls having a diameter of 0,03 mm.

d. The sensitivity shall be demonstrated by means of actual 0,03 mm diameter solder balls, stuck to adhesive tape, attached to the multilayer board assembly being inspected.

NOTE For guidelines, see C.4.3 and E.1 for X-ray inspection.

6.8.8 Metallographic equipment

a. The metallographic equipment shall enable mounting, cross-sectioning and polishing of the solder interconnections.

7 MATERIAL SELECTION

7.1 GENERAL

a. Material selection shall be performed in accordance with ECSS-Q-ST-70-71.

7.2 SOLDER

7.2.1 Form

a. Solder paste, ribbon, wire and preforms shall be used provided that the alloy and flux meet the requirements in clause 7.2.2.

b. Alloy for use in solder baths shall be supplied as ingots (without flux).

7.2.2 Composition

a. The solder alloy shall have a composition specified in Table7-1, unless approved by the Approval authority.

NOTE 1 See ISO 9453 [13] for further details.

NOTE 2 The solder alloy used depends upon the application. See Annex E.2 for Guide for choice of solder type.

7.2.3 Solder paste

a. Solder paste shall conform to the requirements of clause 7.2.1.

NOTE The solder ball size and flux percentage are selected depending on the process employed, i.e. screen, stencil or needle application.

b. The alloy authorised is the one used for verification.

c. The metal purity shall be as specified in table 7-1.

Table 7-1: Chemical composition of spacecraft solders

ESA designation	Sn min % - max %	Pb max %	In min % – max %	Sb max %	Ag min % – max %	Bi max %	Cu max %	Fe max %	Zn max %	Al max %	As max %	Cd max %	Other max %
63 tin solder	62,5-63,5	remain	-	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
62 tin silver loaded	61,5-62,5	remain	-	0,05	1,8-2,2	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
60 tin solder	59,5-61,5	remain	-	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
96 tin solder	remain	0,10	-	0,05	3,5-4,0	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
75 indium lead	max 0,25	remain	74,0-76,0	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
70 indium lead	0,00-0,10	remain	69,3-70,7	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
50 indium lead	0,00-0,10	remain	49,5-50,5	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08
10 tin lead	9,0-10,5	remain	-	0,05	-	0,10	0,05	0,02	0,001	0,001	0,03	0,002	0,08

7.2.4 Maintenance of paste purity

a. When purchased premixed or mixed in house, the purity of solder paste shall be maintained.

b. Manufacturers' instructions shall be applied for the handling and storage of containers of solder paste purchased premixed.

c. Refrigerated solder paste shall reach room temperature before opening the container.

d. Neither paste purchased premixed nor paste mixed in-house shall be used if the use-by date or shelf life recommended by the manufacturer of the paste or paste constituents has expired.

e. When the solder paste's shelf life has expired (see ECSS-Q-ST-70-22 [11]), it shall not be used unless :

- relifing is performed
- tests that include visual inspection and viscosity measurements (according to the manufacturer's recommendations) are passed successfully.

f. When relifing is performed, and the material passes the specified tests, the new shelf life shall be half the initial shelf life.

g. Tools used for removing solder paste from the container shall not contaminate the paste dispensed or that remaining within.

7.3 FLUX

7.3.1 Rosin based flux

a. ECSS-Q-ST-70-08 shall apply for "Rosin based flux".

7.3.2 Corrosive acid flux

a. ECSS-Q-ST-70-08 shall apply for "INH1 Corrosive acid flux".

7.3.3 Flux controls for wave-soldering equipment

a. A controlled method shall be established and implemented for wave-soldering machines such that the flux is not contaminated with remaining residues from previous non-space works.

7.4 SOLVENTS

a. ECSS-Q-ST-70-08 shall apply for "Solvents".

NOTE The compatibility of solvents, in particular those used in proprietary cleaning equipment shall be considered

7.5 FLEXIBLE INSULATION MATERIALS

a. ECSS-Q-ST-70-08 shall apply for "Flexible insulation materials".

7.6 TERMINALS

a. ECSS-Q-ST-70-08 shall apply for "Terminals".

7.7 WIRES

a. ECSS-Q-ST-70-08 shall apply for "Wires".

7.8 PRINTED CIRCUIT SUBSTRATES

7.8.1 Selection

a. Printed circuit boards and substrates shall be selected from the classes given in Table 7-2.

b. The class of board selected shall have a CTE characteristic compatible with the CTE of the devices.

NOTE 1 The objective is that the impact of stresses from the environment is minimized.

NOTE 2 The warp and twist of multilayer boards can affect the geometry of the solder joints.

c. The warp and twist of the printed circuit multilayer board shall be in accordance with **ANNEX H** of MetOp-SG document MOS.SP.ASF.SYS.00401.

NOTE Symmetrical board design reduces warp and twist of the printed circuit board.

Table 7-2: Guide for choice of printed circuit boards and substrates

Class	Description	CTE (10^{-6}/°C)
1	Non-compensated printed board	14 – 17
2	Ceramic	5 –7
3	Compensated printed board	11 – 13
4	Compensated printed board	9 – 11
5	Compensated printed board	5 – 9

7.8.2 Class 1 - Non-compensated printed circuit board

a. Boards shall be made of materials manufactured and procured in conformance with the requirements of **ANNEX H** of MetOp-SG document MOS.SP.ASF.SYS.00401.

NOTE Typical substrates are epoxy-woven glass and polyimide-woven glass.

7.8.3 Class 2 - Ceramic substrates

a. Hybrid microcircuits shall meet the requirements of ECSS-Q-ST-60-05.

NOTE Typical PCB ceramic substrates are alumina and aluminium nitride.

7.8.4 Class 3 - Compensated printed circuit board

a. Boards shall be made of materials manufactured and procured in conformance with the requirements of **ANNEX H** of MetOp-SG document MOS.SP.ASF.SYS.00401.

NOTE These boards can be reinforced with low CTE fibres such as aramid, quartz or carbon.

7.8.5 Class 4 - Compensated printed circuit board

a. Boards shall be made of materials manufactured and procured in conformance with the requirements **ANNEX H** of MetOp-SG document MOS.SP.ASF.SYS.00401.

NOTE CTE compensated boards use standard construction and are compensated with materials such as a distributed plane consisting of a low CTE material.

7.8.6 Class 5 - Compensated printed circuit board

a. Boards shall be made of materials manufactured and procured in conformance with the requirements of **ANNEX H** of MetOp-SG document MOS.SP.ASF.SYS.00401.

NOTE CTE compensated boards use a standard construction with compensated materials such as low CTE substrate or cores. Typical cores are copper-plated invar and copper- plated molybdenum.

7.9 COMPONENTS

7.9.1 General

a. Components and their finishes shall be selected from those approved in conformance with ECSS-Q-ST-60, for "manufacturer and component evaluation" and "Procurement control".

b. Device leads and terminations shall be solder coated with a tin/lead alloy in accordance with Table E-1.

NOTE It is good practice to select the device with solder finish applied over sintered metal on ceramic terminations having a diffusion barrier (nickel or equivalent diffusion layer) layer between the metallization and the solder finish.

c. Solder may be applied to the leads by hot dipping or by plating from a solution.

d. Plated solder terminations shall be subjected to a post plating reflow operation to fuse the solder.

e. The incoming inspection of each component batch shall include the validation of the termination composition (to avoid assembly of pure tin finish).

f. Pure tin finish with more than 97 % purity shall not be used.

NOTE This is due to the possibility of whisker growth and transformation to grey tin powder at low temperatures.

g. Where condensation reflow (vapour phase) is used for assembly, devices shall be capable of withstanding three cycles through the reflow system at its operating temperature (e.g. 215 °C), each cycle consisting of a minimum of 60 seconds of exposure.

h. Where wave soldering is used for surface-mount soldering, devices shall be capable of withstanding a minimum of 10 seconds immersion in molten solder at 260 °C.

i. Devices shall be capable of withstanding cleaning processes currently used in space projects.

j. The body of the devices shall not be cracked, scored, chipped, broken or otherwise damaged, to an extent greater than the applicable part procurement specification.

7.9.2 Active components

a. Active leadless devices (e.g. transistors, thyristors, diodes, and integrated circuit devices) shall be of a configuration incorporating sintered metal-on-ceramic terminations, solid-reflow termination pads integrated to the device body.

b. Axial leads, wire or ribbon non-axial leads shall be hermetically sealed.

c. Castellated chip carrier components shall have no discontinuities in the metallized terminal areas on the mounting pattern of the device.

7.9.3 Moisture sensitive components

a. Moisture sensitive components shall be stored and handled in conformance with the component manufacturer's recommendations. See also clause 8.5b.

NOTE Many types of plastic encapsulated components, particularly some plastic BGAs, are moisture sensitive.

b. When moisture sensitive components are used, bakeout shall be performed in accordance with clause 8.5b.

7.9.4 Passive components

a. If passive components initially designed for insertion-mount application are used for surface mounting, they shall be of a style that can be surface-mount adapted to provide conformance with the requirements of clause 7.9.1.

b. The adaptation as in a shall not functionally or physically degrade the component or the substrate to which the adapted component is to be attached.

c. End-capped and end-metalized devices shall have no discontinuities in the terminal areas.

d. Connectors shall be of a configuration incorporating either male or female quick-disconnect contacts and stress relief provision for the soldered connection of each individual contact when such connections are completed.

7.10 ADHESIVES (STAKING COMPOUNDS AND HEAT SINKING), ENCAPSULANTS AND CONFORMAL COATINGS

a. Adhesives shall be dispensable, non-stringing, and shall have a reproducible dot profile after application.

b. Adhesives, encapsulant and conformal coating shall be non-corrosive to devices and substrates.

c. The uncured strength shall be capable of holding devices during handling prior to curing.

d. Adhesives, encapsulants and conformal coatings shall conform to the outgassing requirements of ECSS-Q-ST-70-02.

e. Adhesives, encapsulants and conformal coatings shall have no adverse effects upon materials used on the substrate, or devices attached thereon.

NOTE The effects of some conformal coatings on the reliability of mounted SMDs are described in ESA SP-1173 [3].

f. Adhesives, encapsulants and conformal coatings shall be selected based on their thermal conductivity and dielectric properties (see ESA STM 265 [2]).

NOTE Some thermally conductive adhesives used to dissipate Joule heating are listed in ESA STM-265 “Evaluation of Thermally Conductive Adhesives as Staking Compounds during the Assembly of Spacecraft Electronics” [2].

g. The capability of the adhesives to meet their requirements shall be demonstrated by means of a verification test programme in conformance with clause 14.

h. Stress relief of device leads shall not be negated by the encapsulants or conformal coatings.

NOTE 1 This is particularly important at low service temperatures.

NOTE 2 The coefficient of expansion, glass transition temperature and modulus of adhesives used under devices for thermal reasons, for achieving stand-off heights or mechanical support during vibration, can be considered to ensure that the additional stress put on the solder joints does not degrade the solder joint reliability.

i. When bonding (mechanical or thermal) is needed the adhesive shall not be applied on fused tin lead. The use of gold finish pads dedicated for bonding may be used.

NOTE Adhesion to fused tin/lead finishes is poor (see also ECSS-Q-ST-70-28).

8 PREPARATION FOR SOLDERING

8.1 PREPARATION OF DEVICES AND TERMINALS

8.1.1 Preparation of wires and terminals

a. ECSS-Q-ST-70-08, clause "Preparation of conductors, terminals and solder cups" shall apply.

8.1.2 Preparation of surfaces to be soldered

a.

8.1.3 Degolding and pretinning of conductors

a. ECSS-Q-ST-70-08 shall apply for "Degolding and pretinning of conductors".

b. LCC's & castellated devices in general shall be fully "degolded" prior to fitting with tin solders.

8.1.4 Alloying of pure tin finish

a. Tin finish with more than 97 % tin purity shall not be used.

NOTE 1 This is due to the possibility of whisker growth and transformation to grey tin powder at low temperature.

NOTE 2 Pure tin terminations can be dipped into liquid solder as described in ECSS-Q-ST-70-08, clause 7.2.6 in order to replace the tin with tin-lead alloy.

8.2 PREPARATION OF SOLDER BIT

a. ECSS-Q-ST-70-08 shall apply for "Preparation of solder bit".

8.3 HANDLING

a. ECSS-Q-ST-70-08 shall apply for "Handling".

8.4 STORAGE

a. ECSS-Q-ST-70-08 shall apply for "Storage".

8.5 BAKING OF PCBS AND MOISTURE SENSITIVE COMPONENTS

a. ECSS-Q-ST-70-08, clause "Baking of PCB's", shall apply for PCBs, partially assembled PCBs and assemblies going through reworking.

b. Baking of moisture sensitive devices before an assembly process shall be implemented.

NOTE This is to counteract the "popcorn" effect in soldering using oven or vapour phase reflow techniques.

c. Baking times and temperatures shall be documented.

NOTE 1 Typical baking conditions are from 6 h to 24 h at 125 °C depending on the JEDEC classification, except for components delivered in reels for which a lower temperature and longer time are used.

NOTE 2 It is good practice to store components under nitrogen, dry air (20 % RH maximum) or partial vacuum.

NOTE 3 Baking of unpopulated PCB shall be made as a minimum of 8 hours at 120 degree C. Baking of populated PCB shall be performed when the PCB has been stored for more than 72 hours in environment greater than 20%RH. Baking of populated PCB shall be made for time/temperature which does not degrade the devices.

NOTE 4 To limit the bake out operation, which could induce later failure the PCB may be stored in dry environment after the baking.

NOTE 5 Alternative bake out at lower temperature under vacuum can be considered.

9 MOUNTING OF DEVICES PRIOR TO SOLDERING

9.1 GENERAL REQUIREMENTS

a. ECSS-Q-ST-70-08, "Mounting of components – General" shall apply.

9.2 LEAD BENDING AND CUTTING REQUIREMENTS

a. ECSS-Q-ST-70-08, clause "Lead bending requirements" shall apply.

9.3 MOUNTING OF TERMINALS TO PCBS

a. ECSS-Q-ST-70-08 shall apply for "Mounting of terminals to PCBs".

9.4 LEAD ATTACHMENT TO THROUGH HOLES

a. ECSS-Q-ST-70-08 shall apply for "Lead attachment to through holes".

9.5 MOUNTING OF COMPONENTS TO TERMINALS

a. ECSS-Q-ST-70-08 shall apply for "Mounting of components to terminals".

9.6 MOUNTING OF CONNECTORS TO PCBS

a. ECSS-Q-ST-70-08 shall apply for "Mounting of connectors to PCBs".

9.7 SURFACE MOUNT REQUIREMENTS

9.7.1 General

a. Devices to be mounted shall be designed for, and be capable of withstanding the soldering temperatures of the particular process being used for fabrication of the assembly.

b. Surface mounted devices may be mounted on either one side or both sides of a printed circuit assembly.

c. Devices incapable of withstanding machine soldering temperatures shall be hand soldered in a subsequent operation.

d. The supplier shall ensure that "degolding", pre-tinning and soldering conditions do not exceed the values given in the individual component data sheets and/or technical notes.

NOTE: soldering conditions are, for example, temperature, time, ESD protection…

9.7.2 Stress relief

a. When Class 1 boards are employed (i.e. glass fibre epoxy or glass fibre polyimide resins with no CTE compensation), the supplier shall accommodate CTE mismatch by the mounting technology.

NOTE 1 Pure eutectic tin-lead solder or indium-lead solder provide better stress relief (due to their ductility) than those with additional elements, e.g. antimony, gold.

NOTE 2 Leadless devices with e.g. end-cap terminations, metallizations, can have some stress relief (such as additional foil or wire leads, possibly attached by welding or high melting point solder).

NOTE 3 A solder stand-off (see Figure 11-1, dimension “X”) can assist stress relief; in this situation, the CTE mismatch strain is taken up by the ductile solder.

NOTE 4 CTE compensated substrates or laminates of Classes 2 - 5 (listed in clause 7.8) can be selected to match the CTE of large leadless packages.

9.7.3 Registration of devices and pads

a. Devices shall be mounted on their associated terminal pads (lands).

b. The spacing between conductive elements shall not be reduced below the minimum electrical spacing specified in **ANNEX H** of MetOp-SG document MOS.SP.ASF.SYS.00401.

NOTE: Some surface mounted components that are not bonded to the PCB can self- align during the soldering process. It is the registration after soldering that is important.

9.7.4 Lead forming

a. The leads of leaded surface mount devices shall be formed to their final configuration prior to mounting.

b. Forming shall not degrade the solderability or cause loss of plating adhesion to the leads.

c. Forming shall not cause mechanical damage to the leads or attachment seals.

d. Leads of dual-in-line and gull-wing packages, flat-packs and other multileaded devices shall be dressed (mechanically re-aligned) to ensure co-planarity.

e. Each change of lead forming for same package shall require a new verification unless no impact is demonstrated and agreed by the Approval Authority.

9.7.5 Mounting devices in solder paste

a. Both leaded and leadless surface mounted devices shall be mounted in solder paste prior to reflow soldering.

NOTE It is good practice to optimize the pick and place mounting force on the device lead, ball or column.

b. The solder paste deposited on each solder land shall be visually inspected for registration and coverage by the operator prior to mounting the devices.

NOTE After device mounting, the solder paste can extend beyond the edge of the pad by up to 40 % of the conductor separation.

9.7.6 Leadless devices

a. Devices shall not be stacked.

b. Devices shall not bridge the spacing between other parts or components such as terminals or other properly mounted devices.

c. Except for RF applications, devices with electrical elements deposited on an external surface (such as resistors) shall be mounted with that surface facing away from the printed circuit board or substrate.

c. See Figure 9-1 for details.

d. Devices that are bonded to the PCB prior to wave- or reflow-soldering shall be placed so that the requirements after soldering given in clause 11 are met.

e. The adhesive shall not extend onto the solder pads.

f. Artificial stand-off (e.g. elevation as seen in clause 11.5.5) may be achieved by removable spacers or other techniques in conformance with fully documented procedures.

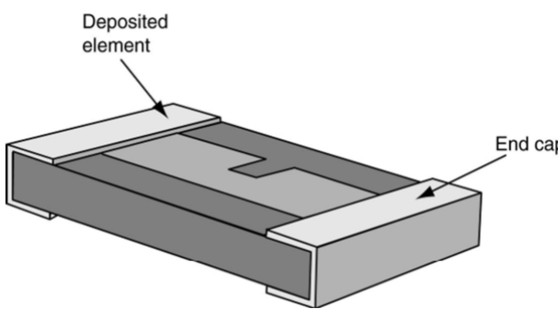


Figure 9-1: Exposed element

9.7.7 Leaded devices

a. Surface mounting of leaded (round or flattened cross section) devices shall be parallel to the board surface.

9.7.8 Area array devices

a. There shall be no more than three reflow operations on a single device.

NOTE Any reworking constitutes one reflow operation

9.7.9 Any reworking constitutes one reflow operation Staking of heavy devices

a. Staking compounds shall be selected in conformance with clause 7.10.

b. Contamination shall be removed prior to staking.

NOTE Some surfaces can be prepared to enhance the adhesion (e.g. by mechanical abrasion).

c. Staking compounds shall be mixed and cured in accordance with the manufacturer's procedures.

d. The process of applying the staking compound shall be controlled by a written procedure which defines the location of the staking compound, the volume and the spread area (between device bottom surface and substrate upper surface).

e. The staking compound shall not negate the stress relief of the device, nor come into contact with surrounding devices.

f. All devices except area arrays weighing more than 5 g shall be staked.

NOTE 1 This is to minimize shock and vibration loading on the leads

NOTE 2 The staking compound can be applied either before or after soldering in conformance with the supplier's process identification document.

9.7.10 Conformal coat under components

a. Conformal coating shall not fill the gap between the body and the PCB when this has not been verification tested. Once verification tests in compliance with the this standard have been completed, and are considered successful, the amount of conformal coating shall not be modified otherwise the approval status will no longer be valid.

10 ATTACHMENT OF CONDUCTORS TO TERMINALS, SOLDER CUPS AND CABLES

a. ECSS-Q-ST-70-08 shall apply for “Attachment of conductors to terminals, solder cups and cables”.

11 SOLDERING TO TERMINALS AND PRINTED CIRCUIT BOARDS

11.1 GENERAL

a. ECSS-Q-ST-70-08, clause "Soldering to terminals and printed circuit boards – General" shall apply.

11.2 SOLDER APPLICATION TO TERMINALS

a. ECSS-Q-ST-70-08 shall apply for "Solder application to terminals".

11.3 SOLDER APPLICATIONS TO PCBS

a. ECSS-Q-ST-70-08 shall apply for "Solder applications to PCBs".

11.4 WICKING

a. ECSS-Q-ST-70-08 shall apply for "Wicking".

11.5 SOLDERING OF SMDS

11.5.1 General requirements

a. Devices shall not be mounted on flexible substrates (flexible copper-clad polyimide film). Soldering to gold with tin/lead alloys shall not be performed (see also clause 8.1.3).

b. Devices shall not be stacked nor bridge the space between other parts or components (e.g. as terminals or other properly mounted devices).

c. Mispositioning of devices shall not reduce the specified minimum electrical clearance to adjacent tracks or other metallized elements.

d. Non-axial-leaded devices (e.g. small outline, flat-packs and similar devices) shall be mounted with all leads seated on a terminal area to ensure mechanical strength.

e. Solder shall cover and wet the solderable surfaces as specified in clause 13.2.

11.5.2 End-capped and end-metallized devices

a. There shall be no discernible discontinuities in the solder coverage of the terminal areas of devices.

b. Solder shall not encase any non-metallized portion of the body of the device following reflow.

c. The solder joints to these devices shall meet the dimensional and solder fillet requirements of

Table 11-1 and Figure 11-1.

NOTE End-capped and end-metallized devices having terminations of a square or rectangular configuration (such as chip resistors, chip capacitors, MELFs and similar leadless discrete components) can have three or five face terminations, as shown in “a” and “b” in Figure 11-1.

Table 11-1: Dimensional and solder fillet requirements for rectangular and square end capped devices

Parameter	Dimension	Dimensionlimits
Maximum side overhang	A	0,1 × W
End overhang	B	Not permitted
Minimum lap contact	L	0,13 mm
Minimum fillet height	M	X + 0,3 × H or X + 0,5 mm whichever is less
Stand-off (elevation)	X	Present up to 0,4 mm
Maximum tilt limit	C	10°
Minimum solder coverage of edges on terminal pad	-	75 % (see Annex E.1)

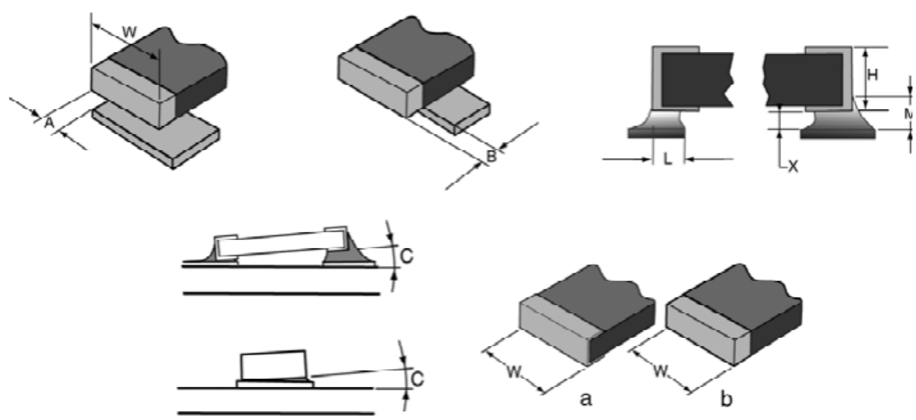


Figure 11-1: Mounting of rectangular and square end-capped and end-metallized devices

11.5.3 Bottom terminated chip devices

a. Devices having metallized terminations on the bottom side only shall meet the dimensional and solder fillet requirements of

Table 11-2 and Figure 11-2.

Table 11-2: Dimensional and solder fillet requirements for bottom terminated chip devices

Parameter	Dimension	Dimensionlimits
Maximum side overhang	A	0,1 × W
End overhang	B	Not permitted
Minimum lap contact	L	0,75 × W
Stand-off (elevation)	X	0,1 mm to 0,4 mm

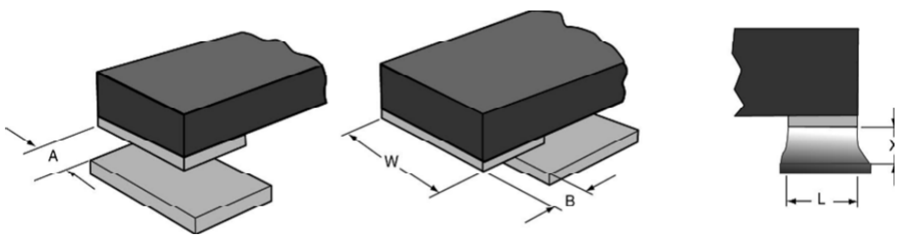


Figure 11-2: Mounting of bottom terminated chip devices

11.5.4 Cylindricalend-cappeddevices

a. Solder joints to components having cylindrical terminations (such as MELF and SOD components) shall meet the dimensional and solder fillet requirements of Table 11-3 and Figure 11-3.

Table 11-3: Dimensional and solder fillet requirements for cylindrical end-capped devices

Parameter	Dimension	Dimensionlimits
Maximum side overhang	A	0,25 × D
End overhang	B	Not permitted
Minimum fillet width	E	0,5 × D
Minimum fillet height	M	X + 0,3 × D or X + 1,0 mm whichever is less
Minimum side fillet length	L	0,5 × T
Stand-off (elevation)	X	Present up to 0,75 mm

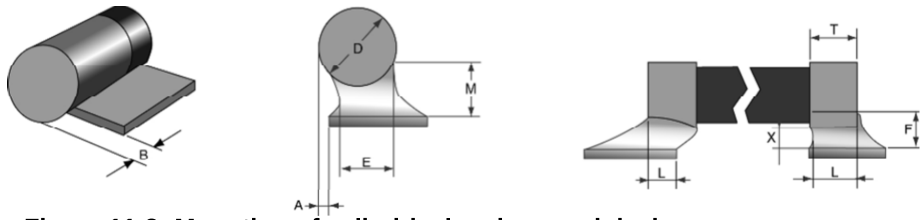


Figure 11-3: Mounting of cylindrical end-capped devices

11.5.5 Castellated chip carrier devices

a. Joints to castellated device terminations shall meet the dimensional and solder fillet requirements of Table 11-4 and Figure 11-4.

NOTE 1 The stand-off enables adequate cleaning beneath the assembled LCCC and also to enhance solder fatigue life (see also clause f)

NOTE 2 Devices bigger than LCCC 16 are not expected to be used for space applications when mounted on Class 1 substrates.

Table 11-4: Dimensional and solder fillet requirements for castellated chip carrier devices

Parameter	Dimension	Dimensionlimits
Maximum side overhang	A	Zero
Maximum fillet length	E	P
Minimum fillet height	M	0,25 × H
Stand-off (elevation)	X	0,1 mm to 0,4 mm

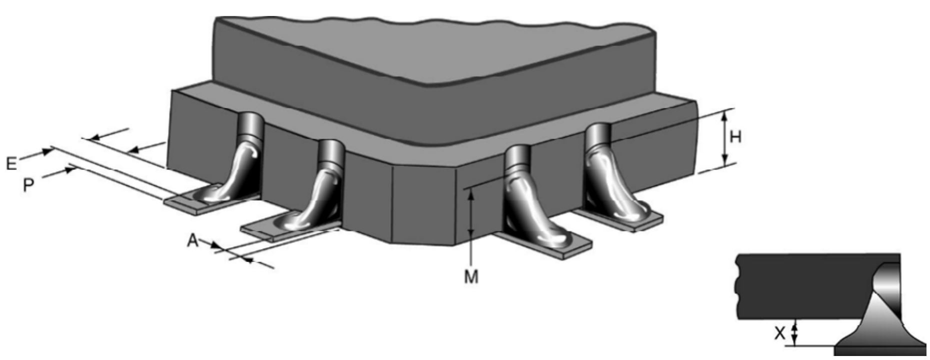


Figure 11-4: Mounting of castellated chip carrier devices

11.5.6 Devices with round, flattened, ribbon, "L" (Inward and Outward) and gull-wing leads

a. Solder joints formed to round, flattened, ribbon, "L" (inward and outward) and gull-wing shaped leads shall meet the dimensional and solder fillet requirements of

Table 11-5 and Figure 11-5.

Table 11-5: Dimensional and solder fillet requirements for devices with round, flattened, ribbon, "L" (inward and outward) and gull-wing leads

Parameter	Dimension	Dimensionlimits
Maximum side overhang	A	0,1 × W
Minimum distance to pad edge at toe	B	0,20 mm
Minimum distance to pad edge at heel	L	0,5 × W
Minimum side joint length	D	3,5 × W
Standoff elevation	X	Present to 0.75 mm
Minimum heel fillet height	E	X + T

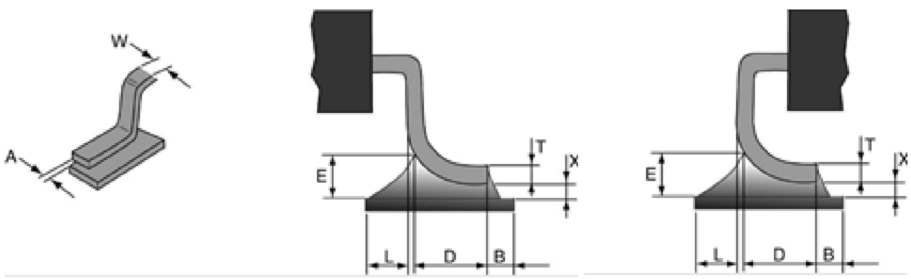


Figure 11-5: Mounting of devices with round, flattened, ribbon, "L" (inward and outward) and gull-wing leads

Note Devices with flat lug leads eg microwave transistors dimensions A,B,D, & X Applies.

11.5.7 Devices with "J" leads

a. Solder joints formed to "J" and "V" shaped leads shall meet the dimensional and solder fillet requirements of

Table 11-6 and Figure 11-6.

Table 11-6: Dimensional and solder fillet requirements for devices with “J” leads

Parameter	Dimension	Dimensionlimits
Maximum side overhang	A	0,1 × W
Minimum side joint length	L	1,5 × W
Minimum heel fillet height	M	X + T
Maximum stand-off	X	0,75 mm

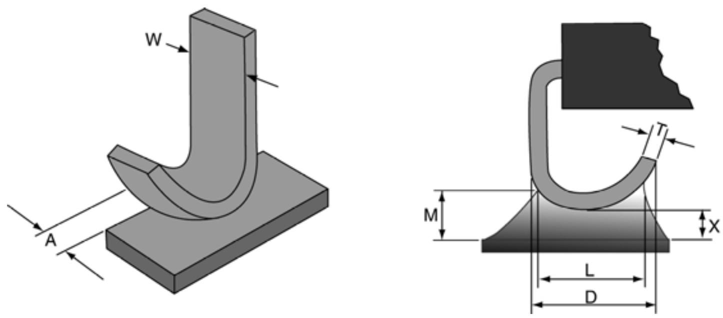


Figure 11-6: Mounting of devices with “J” leads

11.5.8 Area array devices

a. The outer row of solder joints to area array devices shall be visually inspected by looking from the side in accordance with the requirements in 11.5.1 and

Table 11-7 and with the rejection criteria specified in 13.3 and 13.4.

b. Inner rows of solder joints shall be inspected using X-ray techniques in accordance with clause 11.5.8 and

Table 11-7.

NOTE 1 Annex C, clause C.4.3 and the workmanship standard shown in clauses 16.2 and 0 can be used as guidelines for such an inspection.

NOTE 2 As it is impossible to visually inspect solder joints to area array devices, reliability of these devices cannot be assured by inspection and rework. Even using X-ray techniques, some types of defect are difficult to detect. Therefore, reliability of these solder joints can only be assured by robust process control. Quality assurance guidance for these types of devices is given in Annex C.

NOTE 3 Examples of typical area array devices are shown in Figure 11-7, Figure 11-8 and Figure 11-9.

Table 11-7: Dimensional and solder fillet requirements for area array devices

Parameter	Dimensionlimits
Misplacement	0,15 × D (for outer edge)
BGA ball	Collapse of BGA ball spacing does not violate minimum electrical clearance or become less than 0,10 mm.
Maximum component height	Overall height of component does not exceed maximum specified.
Soldered connection	a. BGA balls contact and wet to the land forming a continuous elliptical connection consistent with the tear drop. b. CGA solder columns contact and wet to the land forming a continuous connection
Voids in the solder region (see C.2.2)	Voids to the solder-to-package interface or solder-to-PCB interface: a. max. 25 % of the BGA ball cross section. b. max. 25 % of the column cross section diameter, by X - ray or microsection or alternative technique.
Solder balls	Any solder ball having a diameter greater than 0,1 mm shall be rejected. The total number of solder balls having a diameter greater than 0,03 mm shall not exceed 10 per device.
Maximum CGA column tilt	5 degrees
D = pad diameter (not including any teardrop extension)	

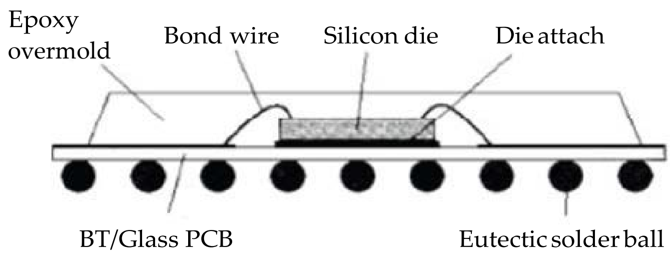


Figure 11-7: Typical plastic ball grid array (PBGA)

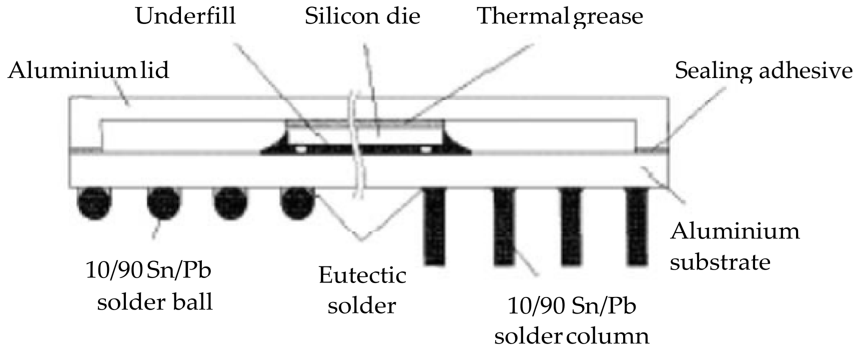


Figure 11-8: Typical ceramic area array showing ball grid array configuration on left and column grid array on right (CBGA & CCGA)

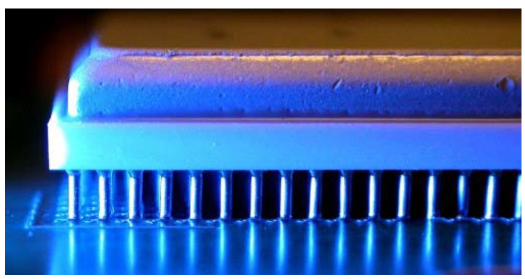


Figure 11-9: Typical assembled CCGA device

11.6 TALL PROFILE DEVICES

a. Tall profile components having bottom only terminations, as illustrated in Figure 11-10, shall not be used if the height (V) is greater than the width or breadth (T).

b. Devices taller than 12 mm in height shall be bonded or secured to the board without reducing the existing lead stress relief.

NOTE This is to minimize shock and vibration loading on the part leads

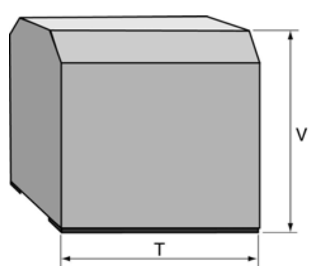


Figure 11-10: Dimensions of tall profile components

11.7 STAKING OF SOLDER ASSEMBLY

a. When devices, except area arrays, weighing more than 5 g are not staked or secured to the board prior to soldering, they shall be staked or secured after soldering in conformance with clause 9.7.9.

11.8 UNDERFILL

a. Underfill beneath area arrays may be applied if it does not restrict the possibility of device removal.

NOTE 1 For power dissipation thermal adhesive can be used provided that it does not contravene the requirement of this standard (see ESA STM-265 for suitable silicone product) [2].

NOTE 2 Underfill has been observed to promote thermal fatigue of soldered connections during thermal cycling (see ESA STM-266 [4]).

12 CLEANING OF PCB ASSEMBLIES

12.1 GENERAL

a. ECSS-Q-ST-70-08, clause "Cleaning of PCB assemblies – General" shall apply.

12.2 ULTRASONICCLEANING

a. ECSS-Q-ST-70-08 shall apply for "Ultrasonic cleaning".

12.3 MONITORINGFORCLEANLINESS

a. ECSS-Q-ST-70-08 shall apply for "Monitoring for cleanliness".

12.4 CLEANING MACHINE

a. The cleaning machine shall be inserted in verification tests.

13 FINAL INSPECTION

13.1 GENERAL

a. Each soldered connection shall be visually inspected in accordance with the criteria specified in the clauses below.

b. Inspection shall be aided by magnification appropriate to the size of the connections between 4× and 25×. General inspection of the board: x4 minimum; Inspection of leadless devices: minimumx15 Inspection of leaded devices: min: x15 , except for fine-pitches where x25 is required

c. Additional magnification shall be used to resolve suspected anomalies or defects.

d. Parts and conductors shall not be physically moved to aid inspection.

e. The substrate, components and component position, as well as the fasteners and the mounting hardware, shall be inspected in accordance with the requirements in clause 11.5.

NOTE Clause 16 includes examples of acceptable and unacceptable workmanship.

13.2 ACCEPTANCE CRITERIA

a. Acceptable solder connections shall be characterised by:

1. clean, smooth, satin to bright undisturbed surface,
2. solder fillets between conductor and termination areas as described and illustrated in clause 16,
3. visible contour of wires and leads such that their presence, direction of bend and termination end can be determined,
4. complete wetting as evidenced by a low contact angle between the solder and the joined surfaces,
5. acceptable amount and distribution of solder in accordance with clause 11.5,
6. absence of any of the defects mentioned in clauses 13.3 and 13.4.

13.3 VISUAL REJECTION CRITERIA

a. The following are some characteristics of unsatisfactory conditions, any of which shall be cause for rejection:

1. charred, burned or melted insulation of parts,
2. conductor pattern separation from circuit board,
3. burns on base materials,
4. continuous discolouration between two conductor patterns (e.g. measling, delamination, halo effect),
5. excessive solder (including peaks, icicles and bridging), see clause 16,
6. flux residue, solder splatter, solder balls, or other foreign matter on circuitry, beneath components or on adjacent areas,

7. dewetting,
8. insufficient solder, see clause 16,
9. pits, holes or voids, or exposed base metal (excluding the ends of cut leads) in the soldered connection.

NOTE: Flying probe marks in solder joints.
During the validation of PCB's flying probing may be used to validate conformity of components. This process leaves small probe marks and inspection is required to confirm that solder joint have not been impaired. The mark created by the flying probe tester shall be confined to the pad and should be no further than 25% of the solder joint from the wetted point. Dimension X on Figure 13-1. This process if utilised shall be included in any verification activity.

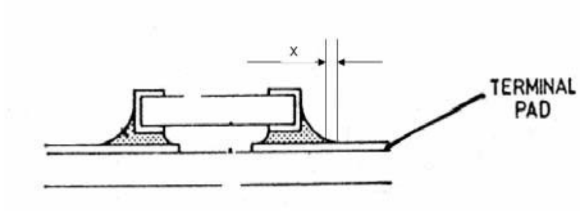


Figure 13-1- Flying Probe Tester Criteria

10. granular or disturbed solder joints,
11. fractured or cracked solder connection,
12. cut, nicked, gouged or scraped conductors or conductor pattern,
13. incorrect conductor length,
14. incorrect direction of clinch or lap termination on a PCB
15. damaged conductor pattern,
16. bare copper or base metal, excluding the ends of cut wire or leads or sides of tracks and soldering pads on substrate,
17. soldered joints made directly to gold-plated terminals or gold-plated conductors using tin-lead solders,
18. cold solderjoints,
19. component body embedded within solder fillet,
20. open solder joints (e.g. tombstoning),
21. probe marks present on the metallization of chip devices caused by electrical testing after assembly.
22. Glass seal does not conform to MIL-STD-883 Method 2009.8.

28. Adhesive shall not compromise the stress relief of the leads. -Adhesive shall not be encased between the body of the device and the pcb when the verification has not been performed

    Note: The adhesive may flow on surrounding devices.

29. Bonding on glass with epoxy shall be not acceptable, unless verified. Note: It is recommended to add an insulation sleeve in between

13.4 X-RAY REJECTION CRITERIA

13.4.1 Area Array Devices

a. The following are some characteristics of not acceptable conditions from X-ray inspection, utilizing equipment defined in clause 6.8.7, any of which shall be cause for rejection:

    1. criteria and dimensions outside the limits given in

Table 11-7,

2. bridges,
3. for BGA: non-wetting of the solder on the teardrop pad.

13.5 WARP AND TWIST OF POPULATED BOARDS

a. Warp and twist exceeding the requirement of **ANNEX H** of MetOp-SG document MOS.SP.ASF.SYS.00401, shall not be reduced after solder operation.

NOTE Shims can be used to accommodate warp and twist during integration, after justification considering relative mechanical, thermal and any other constraints upon the populated board. This is to ensure that the design integrity of the board is not compromised.

13.6 INSPECTION RECORDS

a. The result of the final inspection shall be recorded on the shop traveller.

14 VERIFICATION PROCEDURE

14.1 GENERAL

a. The supplier shall establish a verification programme to be approved by the Approval authority.

NOTE Annex A presents an example of such a programme

b. The supplier shall demonstrate verification for each combination of substrate class, SMD type, soldering technique applied, staking compound and conformal coating as used on flight models.

c. Both, the verification of the assembly by hand and machine soldering shall be made in accordance with this clause 14.

NOTE: The verification sample shall be submitted twice to reflow when the assembly of the flight hardware is made on both sides using machine reflow.

d. The supplier shall design surface mount verification samples (test vehicles) using printed circuit board substrates (e.g. basic materials, number of layers, thickness).

e. The range of surface mounted components and associated materials shall be documented in the verification programme, including:

1. For passive components: nature, types, sizes, termination finishes.
2. For active components: type of package, sizes, number of I/0, pitch, termination finishes.
3. Solder alloy composition, adhesives, conformal coating and printed circuit boards.

f. The verification test boards shall support at least five devices (see 14.3.1 for specific needs of area array devices) of each type and size of component which are assembled in conformance with the PID specified in clause 5.

g. The supplier's repair process including removing and replacing shall support at least three devices of each type and size of component which are assembled in conformance with the PID specified in clause 5 and subjected to qualification.

NOTE: If agreed with Approval authority, a reduced number of parts might be acceptable in case of excessive price or availability of parts. This will be discussed on a case by case basis.

h. The configuration shall be submitted to a verification test programme as specified in clause 14.3.

i. Any mounted package that has been verified on one class of substrate shall be considered verified on another substrate material that belongs to the same class as shown in Table 7-2 and has the same surface finish,

j. Verification by similarity shall not be used for moisture sensitive components.

k. Verification testing of plastic encapsulated components shall be performed for each batch in conformance with this clause.

l. A repair, not included in ECSS-Q-ST-70-28, shall be submitted to a verification test programme.

m. Rework on plastic component shall not be performed.

n. The assembly of the devices shall be made on representative flight pad configuration. When via in pad is used the verification shall have via in pad.

o. Copper thermal and stress distribution on the verification vehicle PCB shall be representative of flight hardware. The number of copper plane layers, total copper and overall thickness shall be taken into account.

p. The supplier shall maintain and make visible to the Approval Authority a list of "critical" components. All critical devices shall be submitted to qualification every three years.

NOTE: Critical devices are as defined by ESA and stated in section 3.2.10.

q. The audit of the assembly line shall be performed as minimum every 5 years by the approval authority.

r. Electrical monitoring instead of micro-sections could be considered acceptable on a case by case as agreed with approval authority. The number of parts and cycles shall be agreed with the approval authority prior to start.

s. The reflow temperature profile used during manufacture shall be demonstrated to be within the same defined range of the verification programme, (This ensures thermal mass is considered in the assembly process control).

14.2 VERIFICATION BY SIMILARITY

a. The assembly of intermediate sizes of SMD, of a same package type, shall be considered approved when the smallest and largest devices pass the environmental test programmes made in accordance with this Standard. For chip components provided the aspect ratio is identical.

b. SMD size is defined by the greatest distance between soldering points, which is the diagonal dimension, usually between corner leads. Chip components with different aspect ratios are not considered the same family.

c. When the weight of the intermediate size of the device is not between the weight of the smallest and biggest device the verification by similarity shall not apply.

d. Packages belonging to the same family shall be constructed from the same materials. The type of ceramic for the chips shall be clearly identified. Verification by similarity shall not apply between type 1 and type 2 ceramic capacitors.

e. The lead pitch and materials composition shall be identical.

f. The coated layers on the termination shall be identical.

g. The metallization of the termination and the barrier layers on leadless devices shall be identical.

h. Different lead forms (e.g. gullwing, J-leads, and LCC) shall be considered as different families.

i. Side-brazed, top-brazed and bottom-brazed packages shall be considered as different families.

j. Dual and quad-side pin arrangements shall be considered as different families.

k. Within a family the bending dimensions and shape shall be identical.

l. Verification by similarity shall not apply to plastic components.

m. The lead bending shall be identical.

n. Verification by similarity of LCCs is not allowed

14.3 VERIFICATION TEST PROGRAMME

a. The verification test programme as shown in Figure 14-1 shall consist of:

1. Visual inspection in conformance with clause 13.
2. Vibration and Shock testing in conformance with clause 14.5.

   NOTE Mechanical testing according to this standard gives an indication of the reliability of the product in actual applications. It is unlikely that the test vehicle represents every flight configuration (size of the board, damping of the board, stiffening of board, number of board layers). The deflections, amplitudes, transmissibilities, radii of curvature experienced by SMDs under shock and vibration are totally dependent on the board to which they are mounted. Because each space project has its own unique shock and vibration requirements it is impossible to determine appropriate test levels without testing actual electronic boxes.

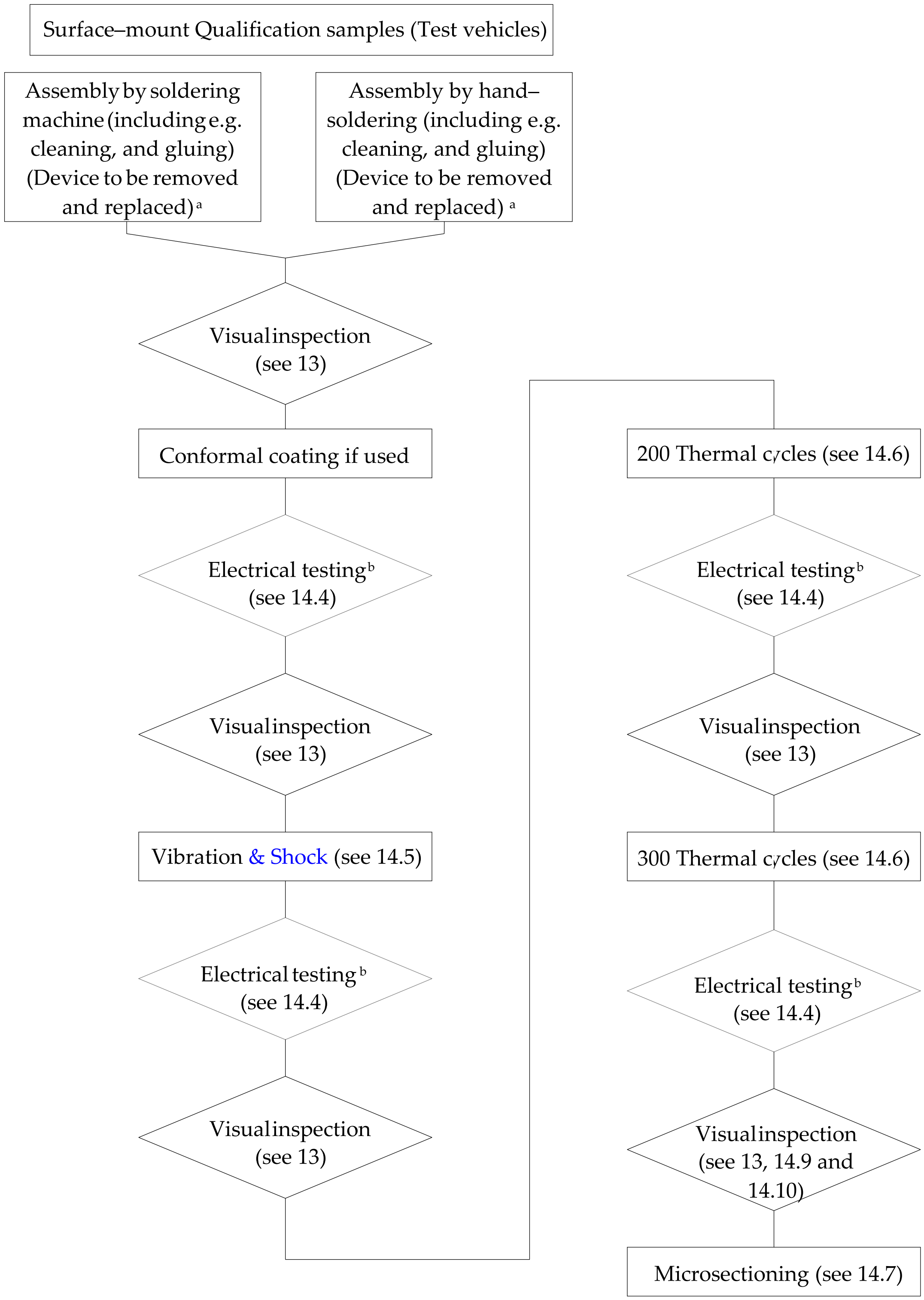
3. Temperature cycling in conformance with clause 14.6 except for area array devices where temperature cycling is in conformance with clause 14.9.2.

   NOTE Temperature cycling is performed to ensure that the SMDs, substrates, solder alloys and associated staking compounds and conformal coatings are suitable for the operational lifetime of the spacecraft.

4. Microsectioning and dye-penetrant testing in conformance with clauses 14.7 and 0.

b. The supplier shall present a verification programme for approval.

   NOTE Owing to the different modes of failure resulting from vibration, shock and temperature cycling, the supplier can use any sequence of environmental testing.



[a] This validates the repair of each type of device removed and replaced.

[b] Electrical testing is recommended. It is good practice to perform the vibration and thermal cycling testing under electrical monitoring

Figure 14-1: Verification programme flow chart

14.3.1 Verification of the assembly of the area array packages

The procedure to achieve the Approval of the assembly of area array device is the following:

a. Manufacture of capability samples

One device shall be assembled by machine reflow

One device shall be assembled by machine reflow – remove and replaced

In total 3 devices are needed for to manufacture the capability sample.

X-Ray and visual inspection shall be performed to ensure the compliance with table 9 of this standard.

These two configurations shall then be submitted to vibration/shock and 500 thermal cycles from -55/+100 degree C.

At the completion of the environmental testing microsection shall be performed to ensure that the PCB has not been damaged.

Defect such as pad lifting, cracks in laminate, cracks in via, cracks of tracks, PCB delamination… shall conclude to the reject of the assembly.

In such case the company shall not start the verification programme prior to demonstrate corrective actions.

The capability samples shall then be remanufactured and re tested.

Once the capability sample has shown acceptable results the verification programme can start.

It is possible also to determine the failure mechanism of the device during the microsectioning. This information is considered as informative.

In case the company assemble and repair using the same soldering station the assembly by machine reflow may be omitted as then the repair configuration will provide sufficient results.

b. Verification programme

In total a minimum of 5 devices are needed.

Four devices shall be assembled. One of these four devices shall be removed and replaced by a new one in order to verify the repair of the assembly.

These 4 assembly samples shall then be submitted to vibration / shock testing and to thermal cycling.

The thermal cycling shall be performed for 1500 cycles or until failure, whichever is first.

The pass criteria shall be no electrical failure before 1500 thermal cycling. In the case of electrical failure before 1500 thermal cycling, then a failure investigation shall be performed.

A1: the end users shall provide their criteria for electrical failure: It should be clearly identified if this is an open circuit or an increase of resistivity. It could be possible to provide a generic fail criterion which could be for example open circuit. In case the application requires a loss in resistivity of less than X% then the fail criteria would be such criteria. This of course could depend on application of a given design.

The assembly/repair shall be performed on representative configuration (conformal coating, underfill, mechanical support…). The PCB shall be made with the same materials and the routing of the device shall be identical to the FM. Indeed the capability sample is made to ensure that the PCB is not degraded by the assembly/repair and in addition that the environmental tests do not create damage of the PCB.

In order to conclude on the verification programme it is required:

-The Daisy chain device is representative of the FM. At EEE part level, the daisy chain shall be submitted to all tests made on the FM.

-The daisy chain shall be reliable. Some electrical failures induced by cracking in the wire bonding due to the lack of stress relief have been reported.

-If a verification programme has already been performed on a device with a different pitch the capability sample may be omitted with the agreement with the Approval Authority.

14.4 ELECTRICAL TESTING OF PASSIVE COMPONENTS

a. When passive components are functionally tested, and when continuity tests on series-connected packages are made using internal wiring of packages (daisy-chain):

1. No signal loss shall be accepted.

   NOTE 1 When performed, electrical testing can best be conducted during the complete thermal cycle.

   NOTE 2 Devices can be interconnected to multilayered circuit boards.

2. A drift of less than 10 % of resistance shall be accepted when the continuity tests are performed at room temperature.

   NOTE Devices having soldered connections that cannot be inspected (due to access, small size or opaque conformal coating) are expected to be monitored during environmental testing by electrical test.

14.5 VIBRATION AND SHOCK

a. ECSS-Q-ST-70-08 shall apply for "Vibration".

b. The supplier shall take account of the shock environment. Shock levels can be modified by the equipmentstructure.

c. The test vehicle shall demonstrate robustness of the assembly.

Note1. Testing at board level is intended as a risk reduction measure that does not negate the need for testing at equipment level.

Note 2. Shock as part of the verification flow reflects the cumulative stresses seen during mission. (Shock, Vibration & thermal cycles)

d. One shock shall be applied in each axis as defined (minimum)

Shock (perpendicular)		Shock (In plane)	
Frequency (Hz)	SRS (g)	Frequency (Hz)	SRS (g)
1000-2000	2000	1000-2000	1500

14.6 TEMPERATURE CYCLING TEST

a. ECSS-Q-ST-70-08, clause "Temperature cycling test" shall apply for the thermal profile.

b. The total number of temperature cycles shall be 500, except for area array devices with conformal coating when clause 14.9.2 is applicable.

c. The monitoring thermocouple shall be attached to the surface of the printed circuit board.

d. Temperature cycling may be performed before the vibration testing. Vibration testing may be performed after any number of temperature cycles.

14.7 MICROSECTION

a. Microsection shall be made after environmental testing on each type of device, size and process (machine assembly and manual soldering).

NOTE Examples of microsections are shown in clause 16.4.

b. The micro section shall be on 3 out of the 5 devices submitted to the verification programme. Note if the supplier chooses for data gathering to submit greater than 5 devices to verification the microsection requirements is limited to the 3 having the worse solder joint appearance. The remaining items to be stored for minimum of 10 years. For repair parts 1 shall be submitted to microsection.

NOTE Microsection requirements are shown in section 16.4 identifying the recommended cut and polish aspects for a range of component types

c. The microsection shall be made even if all similar devices have no indication of surface cracks.

NOTE The reason is that there can be cracks in the interconnection.

d. The Approval authority shall have access to the microsection.

e. The microsections shall be stored for a period of at least 10 years.

NOTE Stored samples can assist the analysis of in-service failures.

f. Magnification to assess the presence of cracks shall be x 200. In case of indication of presence of potential damage, without being able to conclude if there is a damage or not, the magnification shall be increased. Max magnification required x400.

NOTE Insufficient magnification can miss the presence of cracks

NOTE The report shall provide visual evidences (pictures) with the appropriate (i.e. min x200; up to x400) magnification

g. The choice of microsection facility shall be approved, before the microsections are done, by the approval authority.

14.8 DYE PENETRANT TEST

a. At least one BGA or CGA shall be submitted to a dye penetrant test.

NOTE A typical dye penetrant test is described in C.4.5.

b. The dye penetrant test results and samples shall be stored for a period of at least 10 years.

NOTE Stored samples can assist the analysis of in-service failures.

14.9 SPECIAL VERIFICATION TESTING FOR CONFORMALLY COATED AREA ARRAY PACKAGES

14.9.1 Introduction

BGA and CGA packages are generally assembled and then conformally coated. When the conformal coating cannot be removed it prevents the use of dye penetrant testing.

When the device is conformally coated, as no other test can evaluate all the I/O connections after environmental testing, a special programme is developed.

NOTE Conformal coatings and underfills can lead to non-inspectability and difficulties for rework or repair.

14.9.2 Provisions

a. When a device is conformally coated, the supplier shall submit a special programme for approval.

b. The special programme specified in 14.9.2a shall consist of vibration & shock testing in accordance with clause 14.5 and at least 1 500 thermal cycles in accordance with clause 14.6.

c. For devices other than MCGA, a data acquisition system applying 5 V with monitoring current limited to 1 mA shall continuously monitor the electrical continuity of all I/O and for at least 10 cycles every 100 thermal cycles and the results recorded.

d. For MCGA, a data acquisition system applying 0,1 A with monitoring current limited to 1 mA shall continuously monitor the voltage and thus the electrical continuity of all I/O and for at least 10 cycles every 100 thermal cycles and the results recorded.

e. The system shall be capable of detecting open circuit durations exceeding 200 ms.

14.10 FAILURES AFTER VERIFICATION TESTING

a. Any electrical failures during or after testing shall invalidate the SMD verification.

b. In the case of visual failures, an analysis shall be performed to identify the cause: component or soldering process.

c. In the case of cracked joints, microsections shall be made to evaluate their depth and origin.

d. Surface and internal cracks that penetrate less than 25 % of the solder fillet critical zone (as defined in Figure 14-3), ball or column, shall be considered acceptable.

e. Cracks present outside the critical zone shall be considered acceptable.

f. Cracks in the intermetallic layer in solder joints to area array devices shall be considered as not acceptable.

g. After removing the area array device during the dye penetrant test the dye penetrant shall not cover more than 25 % of the ruptured solder joint area.

NOTE 1 See C.4.5 for an example of dye penetrant test.

NOTE 2 For details see also Figure 14-2 to Figure 23-7 in clause 16.

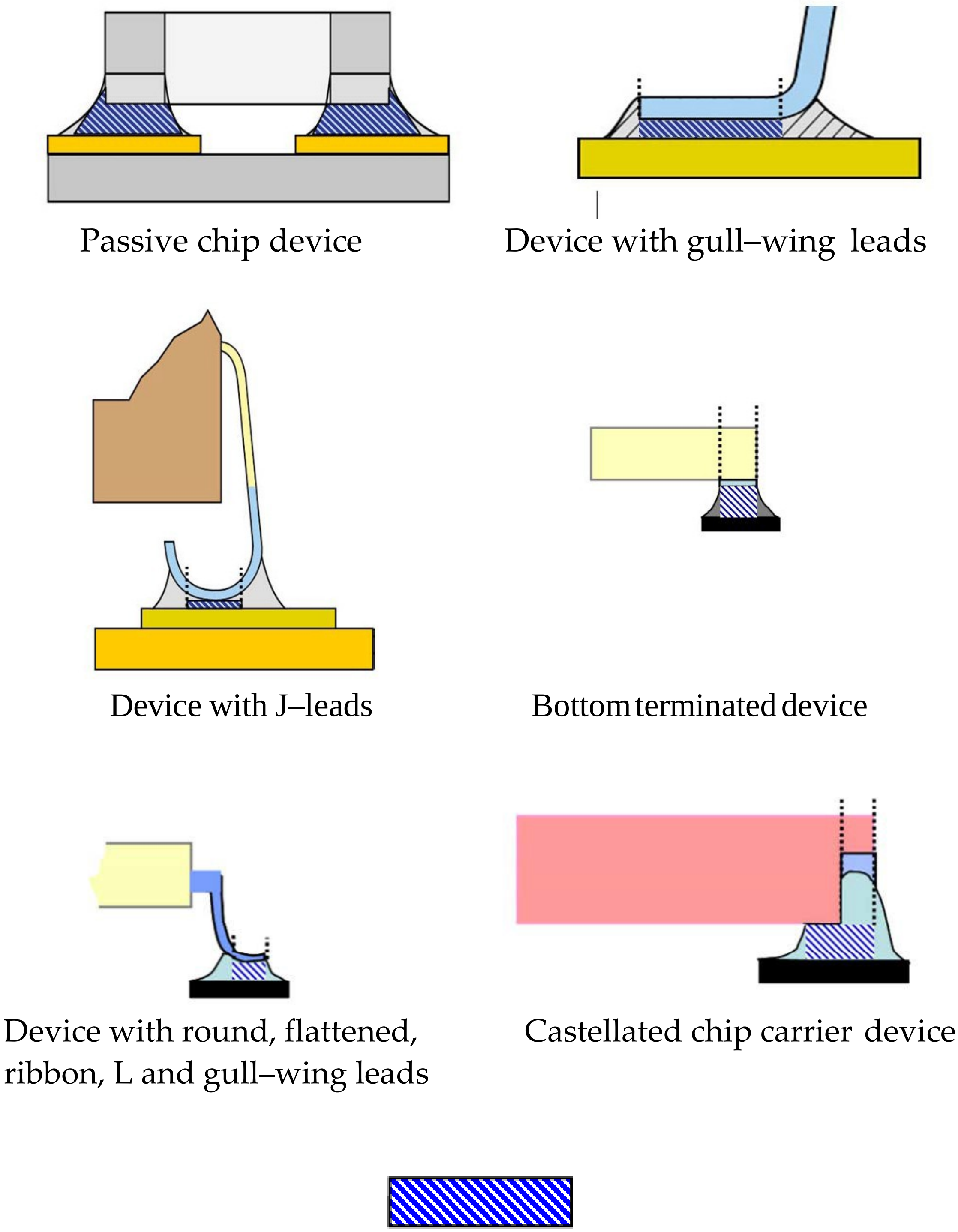
h. Any cracks or delamination in the package, lead or lead package interconnection

i. damage of the pcb. – as defined in **ANNEX H** of MetOp-SG document MOS.SP.ASF.SYS.00401

j. In case of mechanical bonding, presence of cracks in the bonding material at the completion of the vibration and less than 50 thermal cycles.

Note the presence of cracks after 500 thermal cycling shall not be considered as failure criteria. This can be checked by visual inspection, including visual evidences (pictures) in the report, after vibration and 50 or more cycles. To satisfy this requirement the supplier will need to insert addition inspection point after the first 50 cycles

k. In case of thermal bonding or electrical bonding (grounding), presence of cracks in the bonding joint at the completion of the verification tests.



Filled critical zone d

Figure 14-3: Illustrations defining critical zone in solder fillet

14.11 APPROVAL OF VERIFICATION

a. A letter confirming the completion of a successful Verification programme shall be sent to the contact person of the supplier, with the summary table specified in Annex B attached to it.

NOTE 1 The letter and the summary table provide evidence of the verification approval to a third party.

NOTE 2 The approval of verification applies to all space projects from the date of the approval until withdrawn.

b. Every two years the supplier shall submit an updating of the SMT approval status.

c. When the materials used, or component types or processing parameters change, the supplier shall submit for approval to the Approval authority, a delta-verification programme.

d. Reference to the summary table number shall be made on each space project declared processes list in order to assist in achieving project approval.

NOTE See ECSS-Q-ST-70, Table D-3.

14.12 WITHDRAWAL OF APPROVAL STATUS

a. The approval status of the supplier shall be withdrawn when any of the following status justify its withdrawal:

1. Repetitive supply problems and manufacturing defects.
2. Undeclared changes to the PID.
3. Continuous non-compliance with the PID.

15 QUALITY ASSURANCE

15.1 GENERAL

a. ECSS-Q-ST-20 shall apply.

15.2 DATA

a. ECSS-Q-ST-70-08 shall apply for "Data".

15.3 NONCONFORMANCE

b. ECSS-Q-ST-10-09 shall apply.

15.4 CALIBRATION

a. ECSS-Q-ST-70-08 shall apply for "Calibration".

15.5 TRACEABILITY

a. ECSS-Q-ST-70-08 shall apply for "Traceability".

15.6 WORKMANSHIP STANDARDS

a. ECSS-Q-ST-70-08 shall apply for "Workmanship standards".

b. Visual standards consisting of work samples or visual aids that illustrate the quality characteristics of all soldered connections involved shall be prepared and be available to each operator and inspector.

NOTE The illustrations presented in clause 16 of this Standard can be included as part of the examples.

15.7 INSPECTION

a. During all stages of the process, the inspection points defined in the manufacturing flow chart shall be carried out.

b. The inspection shall be performed in conformance with clause 13 of this Standard.

c. The inspection shall also include the substrate, components and component position in accordance with clauses 11.5.1 to 11.5.8.

15.8 OPERATOR AND INSPECTOR TRAINING AND CERTIFICATION

a. ECSS-Q-ST-70-08 shall apply for "Operator and inspector training and certification".

b. A training programme for operators performing machine soldering shall be developed, maintained and implemented by the supplier to provide excellence of workmanship and personal skill in SMTs.

NOTE Records of training, testing and certification status of the soldering operators are maintained for at least 10 years.

c. Operators performing hand soldering of SMDs, and inspectors of SMD and mixed-technology assemblies shall be trained and certified at a school authorised by the final customer.

d. Operators for X-RAY measurement. The operators shall be trained and in house certified to perform and assess X-RAY results.

NOTE The assessment of the X-Ray is mainly done in real time. Some photos are taken to demonstrate to the customer the compliance. The photos are not sufficient to assess the acceptance. The operator certification is also needed.

15.9 QUALITY RECORDS

The quality records shall be made of, as a minimum, the following:

a. PID (including the summary tables and workmanship standards).

b. Audit report established by the approval authority.

c. verification report, as output of the Verification test programme.

16 VISUAL AND X-RAY WORKMANSHIP STANDARDS

16.1 WORKMANSHIP ILLUSTRATIONS FOR STANDARD SMDS

16.1.1 Chip components

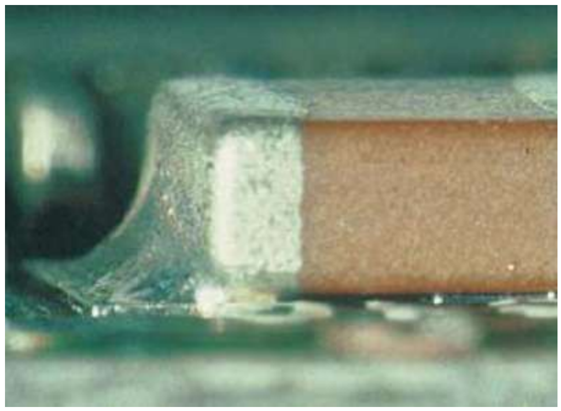


Figure 16-1: Preferred solder (see also

Table 11-1)

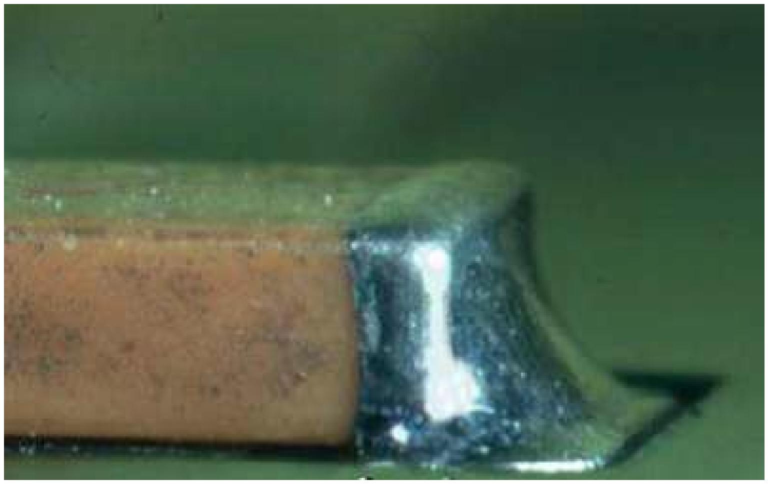


Figure 16-2: Acceptable, maximum solder (see also

Table 11-1)

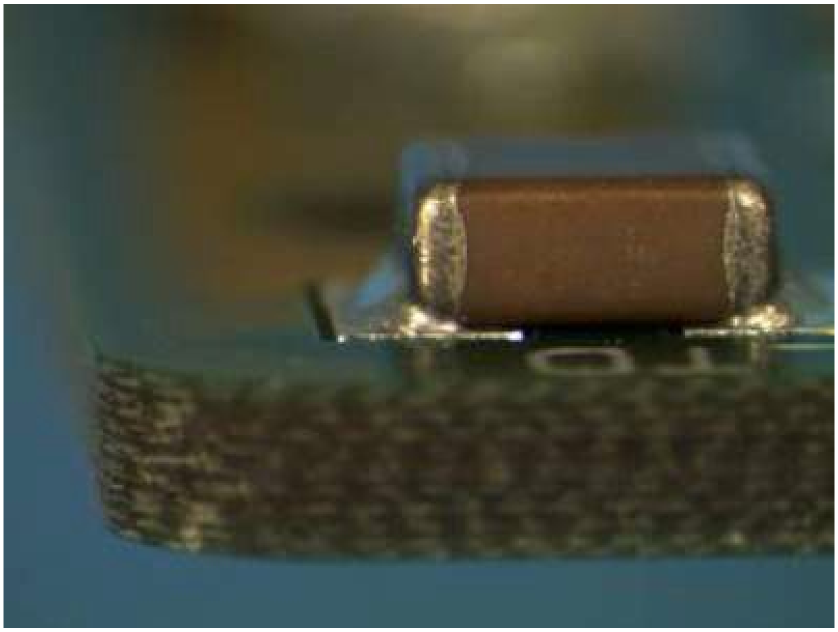


Figure 16-3 Acceptable, minimum Solder (See Table 11-1)

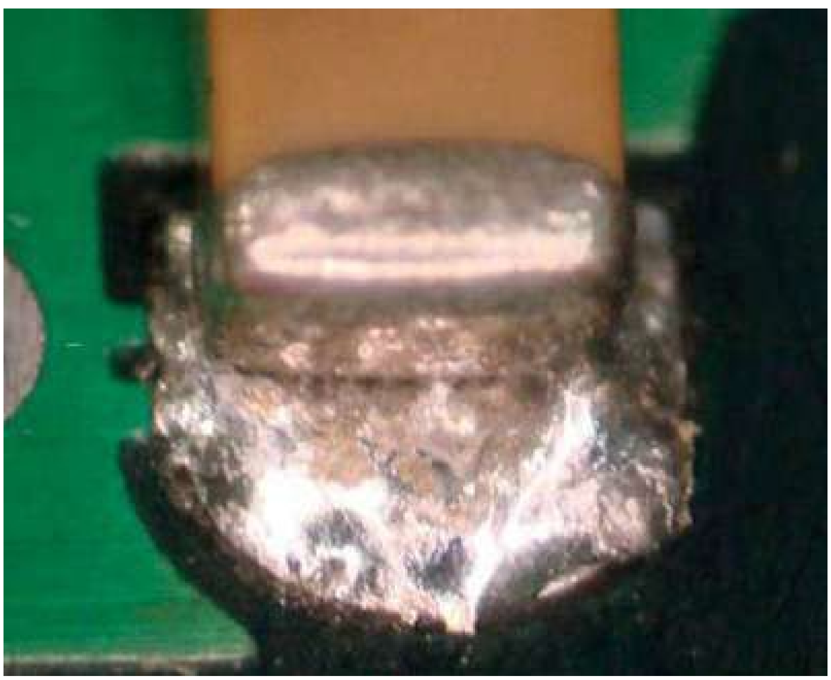


Figure 16-4: Unacceptable, poor wetting (see also

Table 11-1)

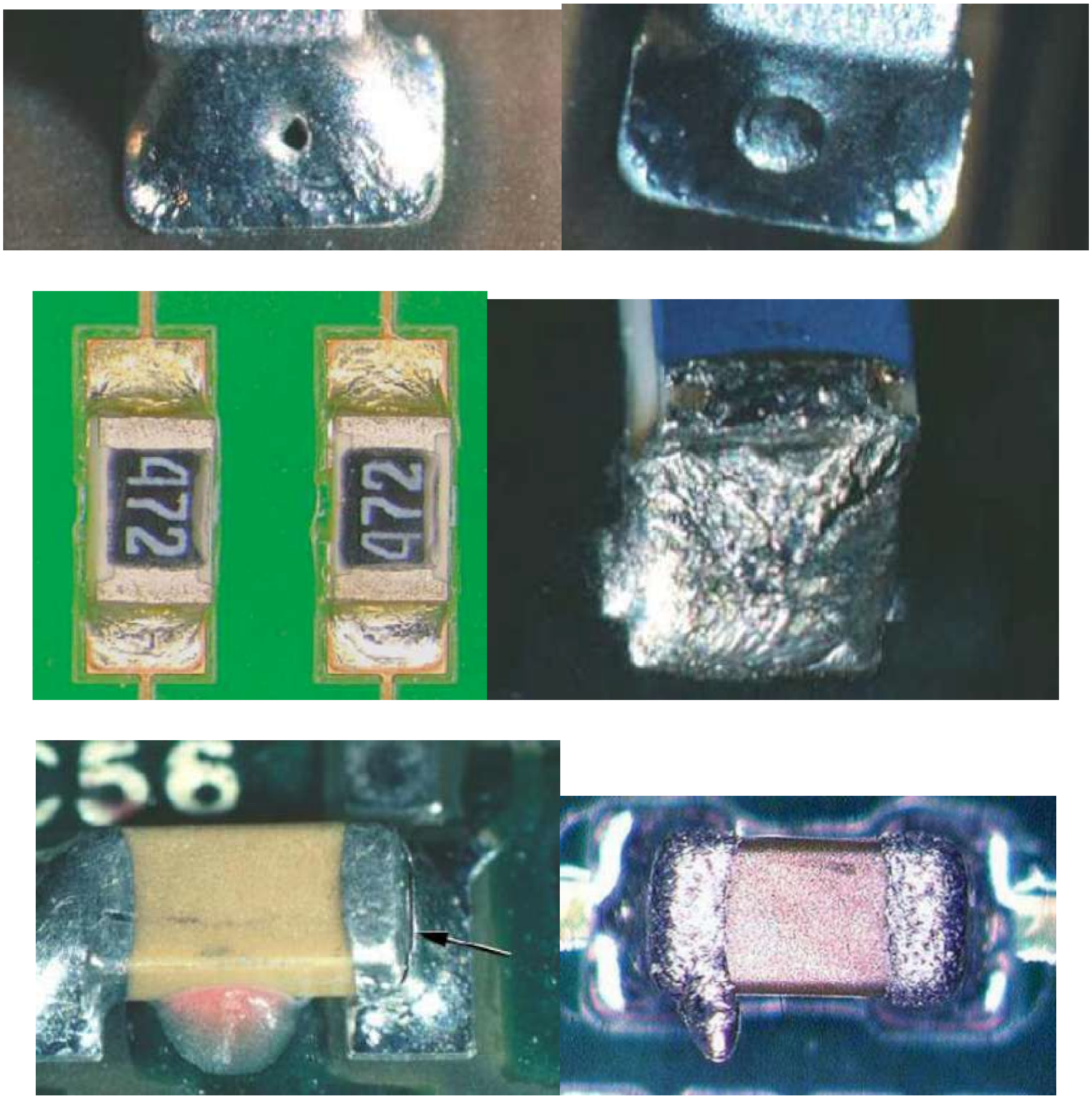


Figure 16-5 Voiding/ disturbed/ fractured/ solder spikes solder fillets Less than 90% wetting of terminal edges

16.1.2 MELF components

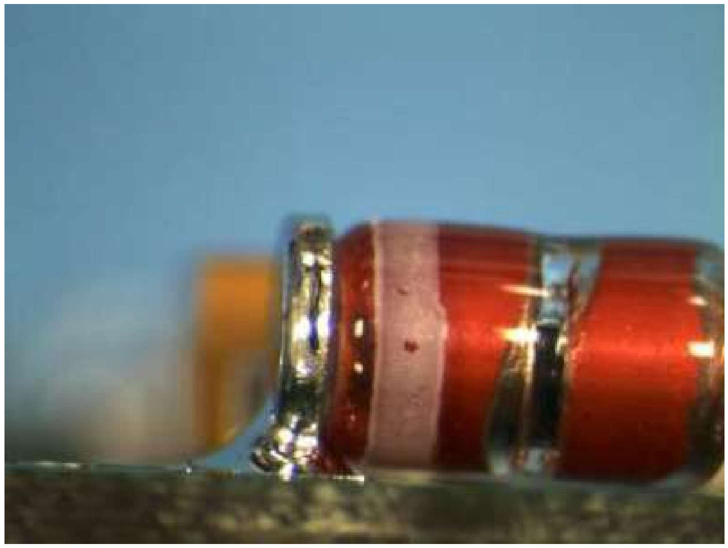


Figure 16-6 Acceptable, minimum solder -- Terminal wetted along end, face and sides (see also

Table 11-1)

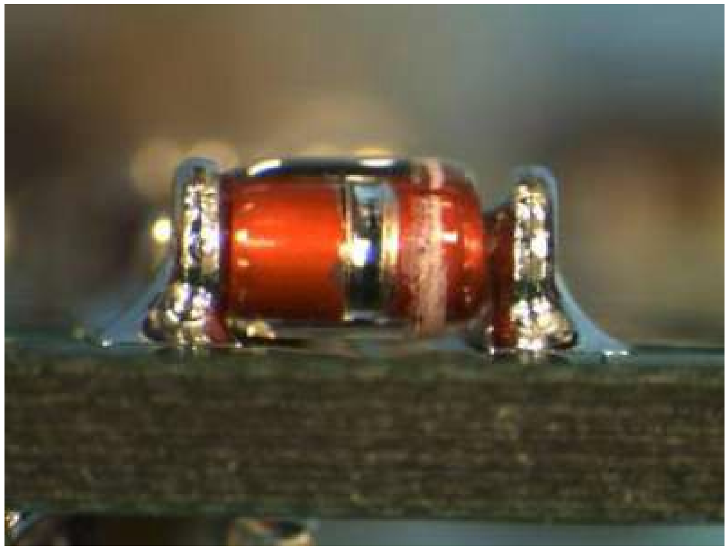
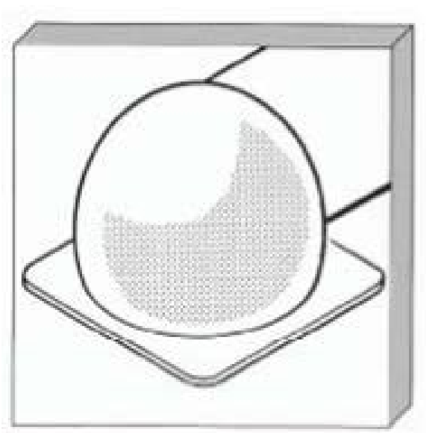


Figure 16-7 Preferred solder (see also **Table 11-3**)



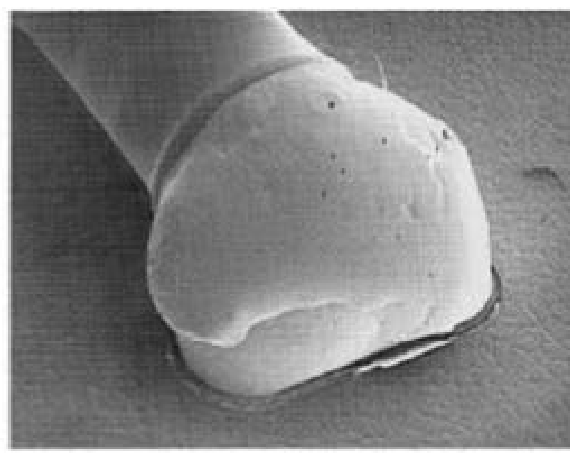


Figure 16-8 Unacceptable -- Excessive solder (see also Table 11-3)

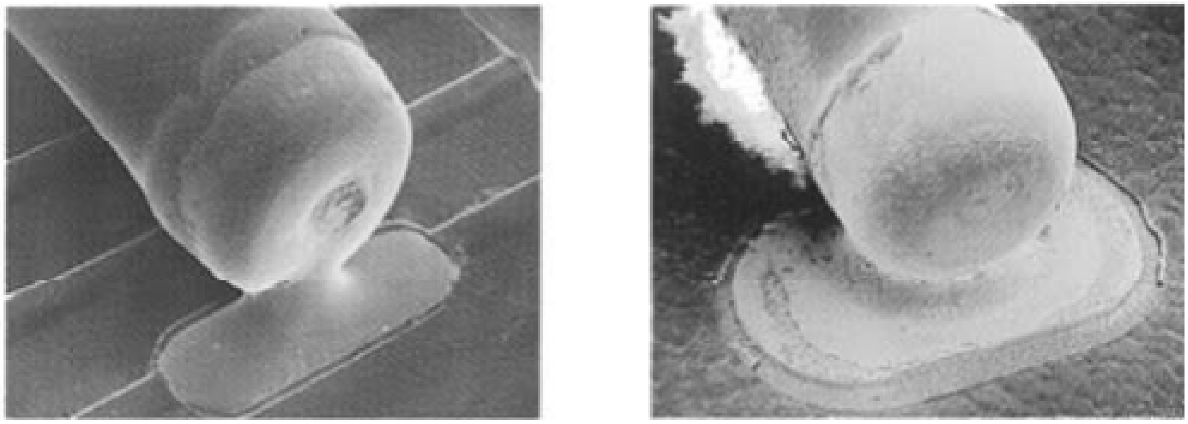


Figure 16-9 Unacceptable -- Insufficient solder (see also **Table 11-3**)

16.1.3 Ribbon, "L" and Gull-wing leaded devices

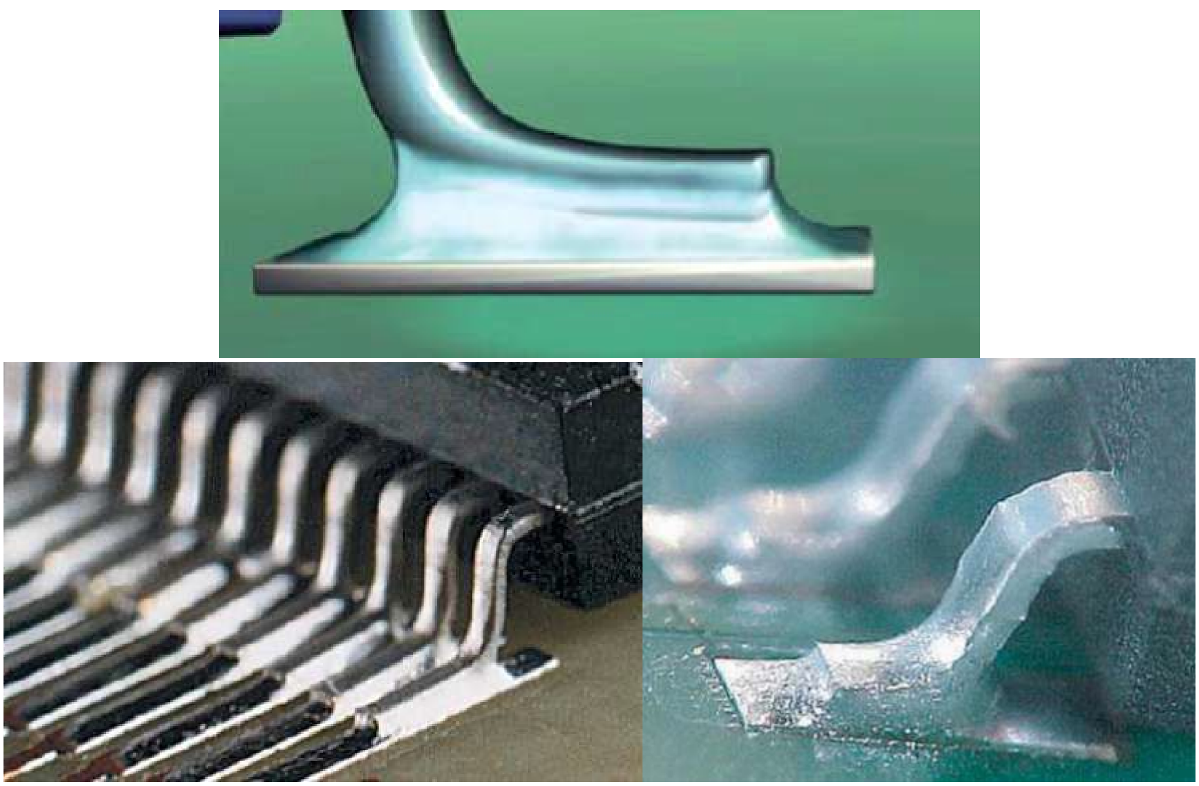


Figure 16-10: Example of flattened leads

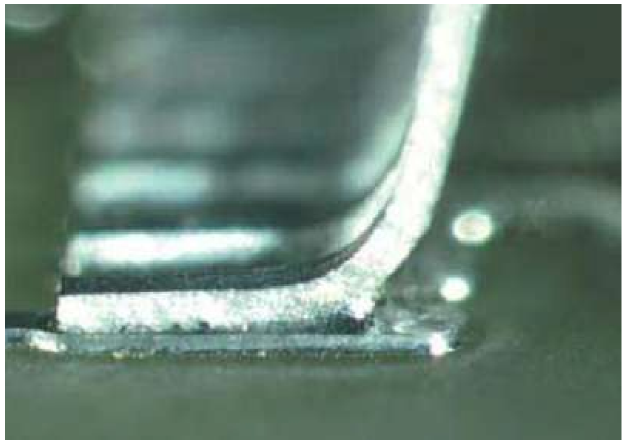


Figure 16-11 Acceptable, minimum solder

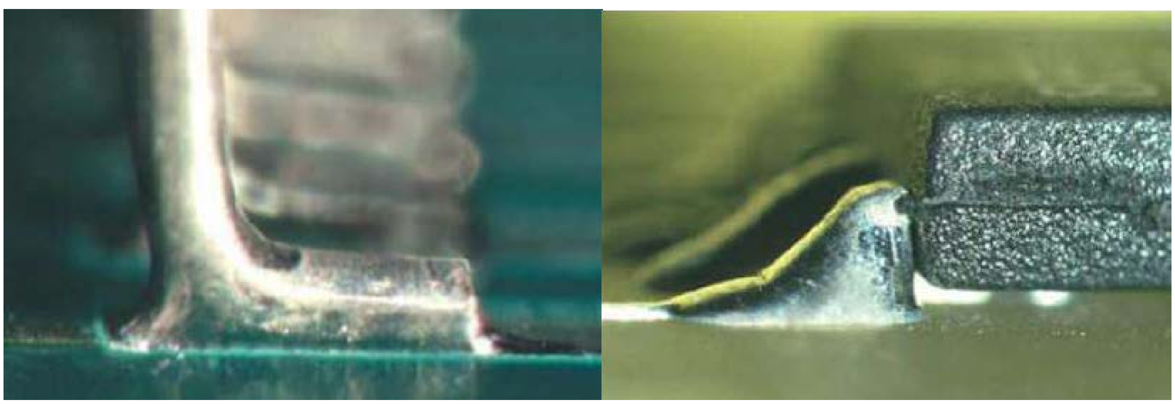


Figure 16-12 Unacceptable -- Excessive solder

16.1.4 “J” leaded devices

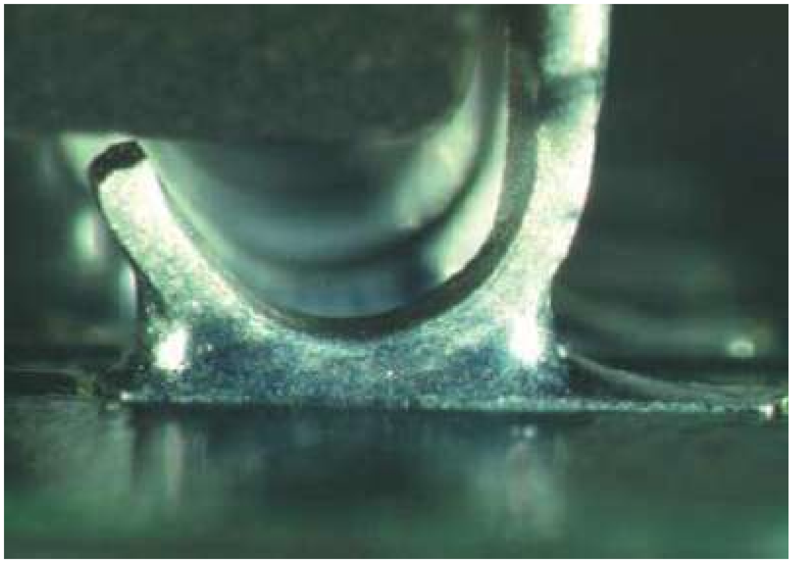


Figure 16-13 Preferred solder joint

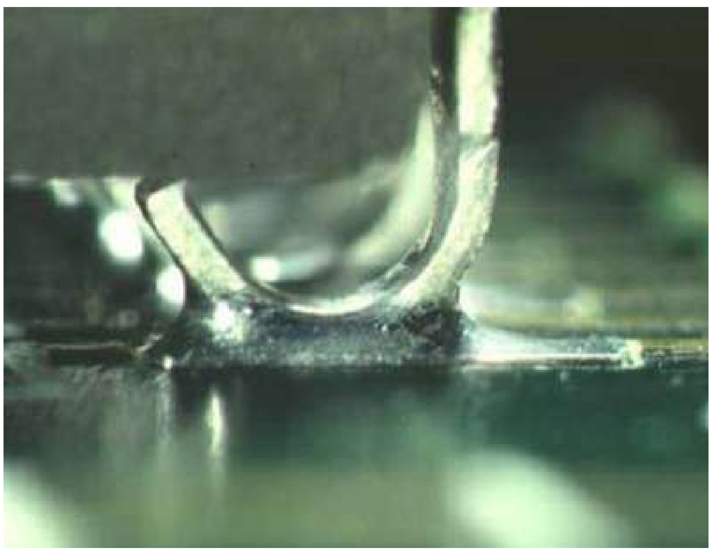


Figure 16-14: Acceptable minimum solder joint

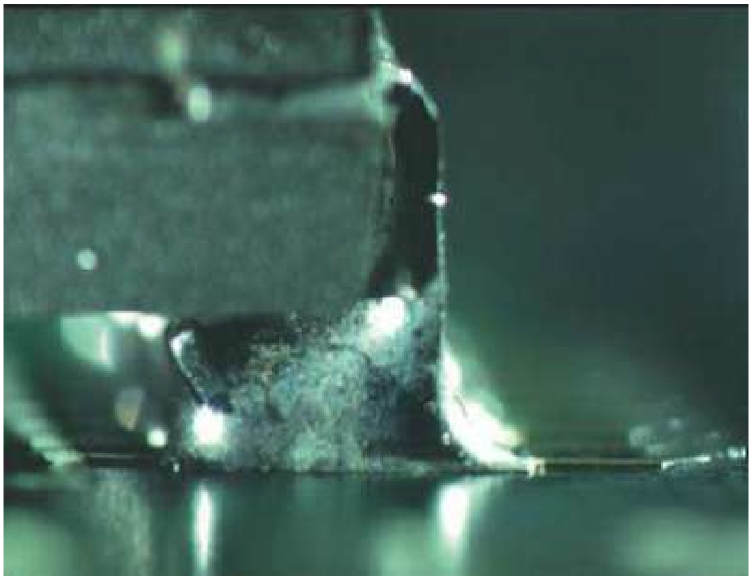


Figure 16-15: Unacceptable, stress relief of J lead compromised

16.1.5 Inward facing “L” Leaded Component

Figure 16-16 Acceptable, preferred solder joint

16.1.6 Miscellaneous soldering defects

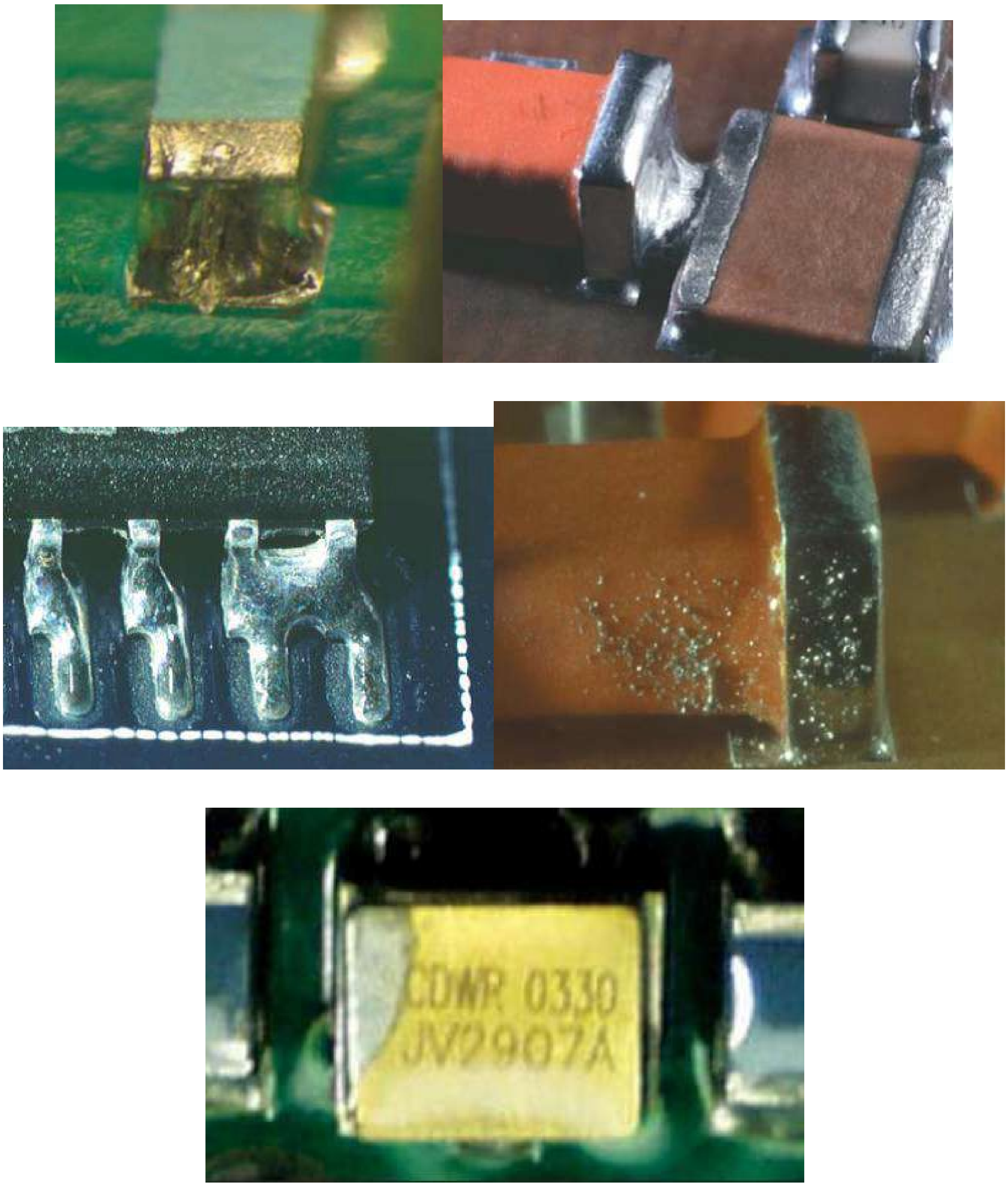


Figure 16-17: Examples of unacceptable soldering

16.2 WORKMANSHIP ILLUSTRATIONS FOR BALL GRID ARRAY DEVICES

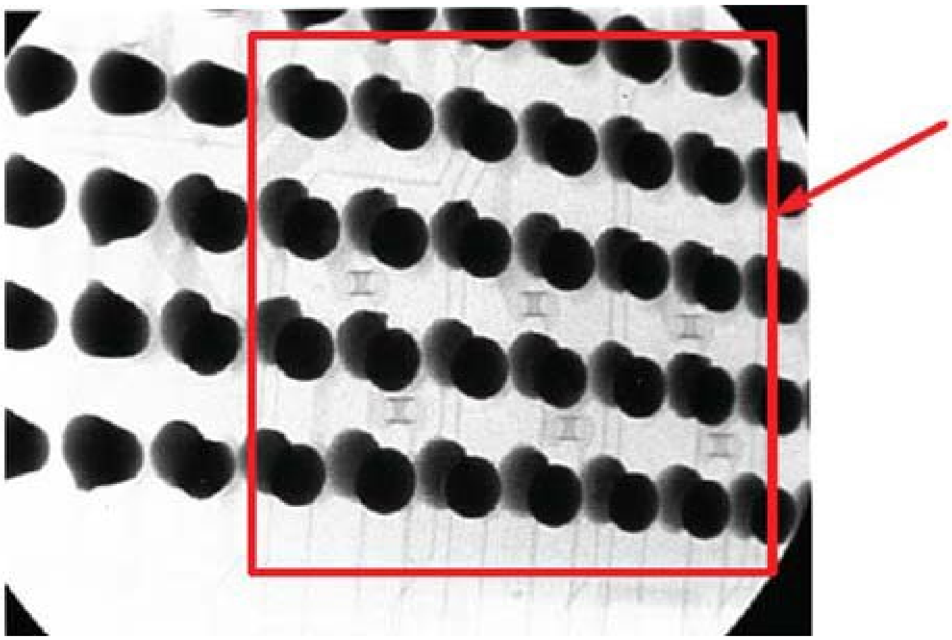
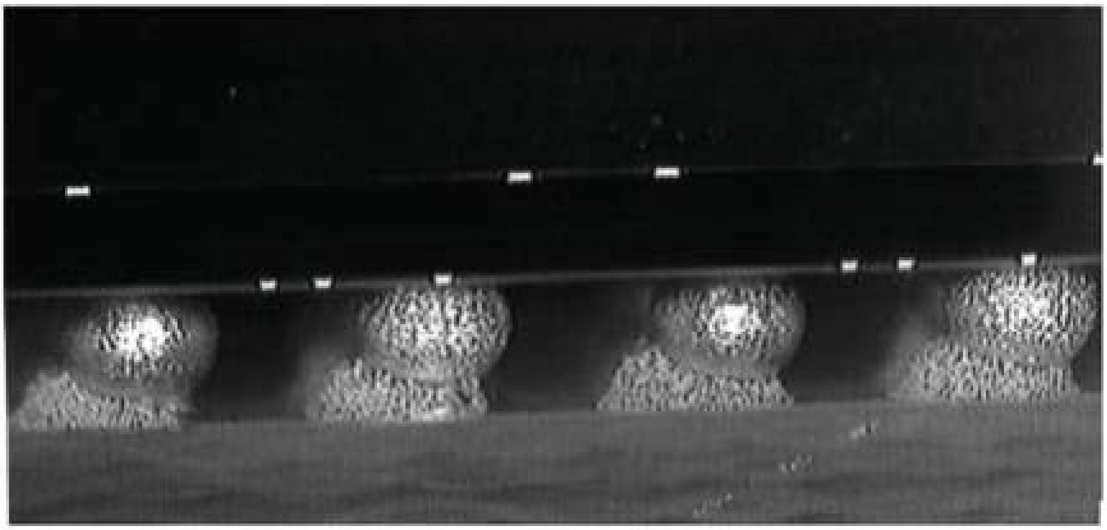


Figure 16-18: Angled-transmission X-radiograph showing solder paste shadow due to partial reflow: Reject

Figure 16-19: BGA – Unacceptable, fractured solder joint



- non-reflow of solder paste: Reject
- maximum misplacement (15 % of pad ∅): Accept

Figure 16-20: Micrograph showing

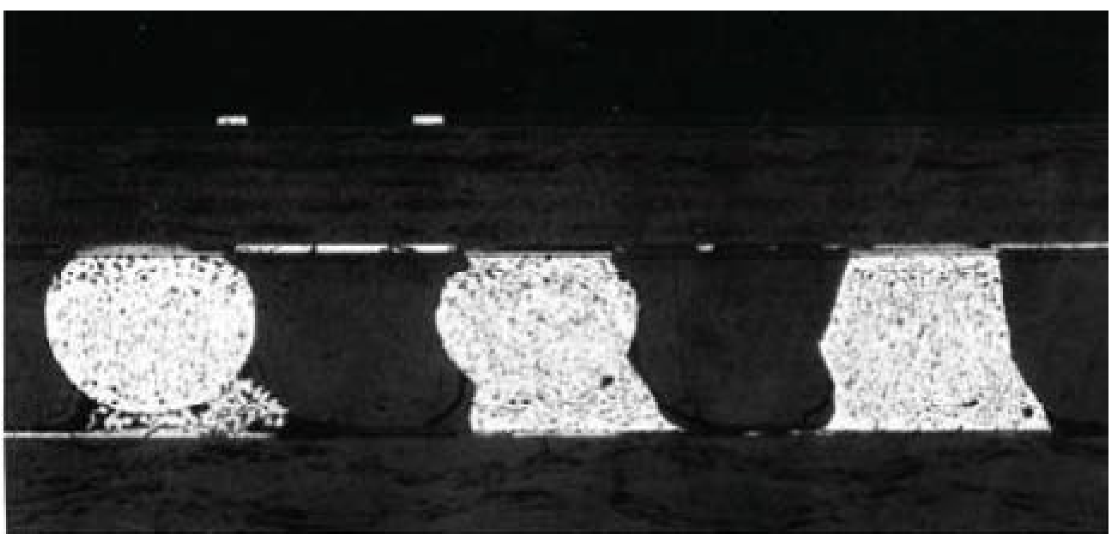
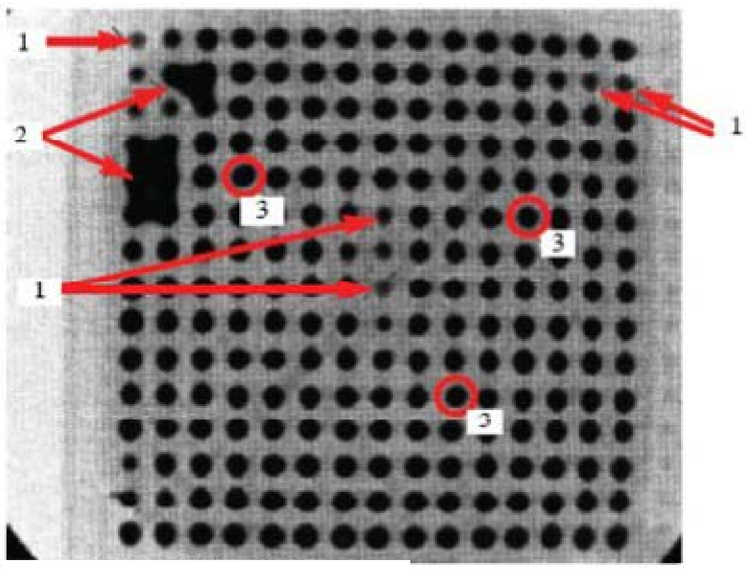
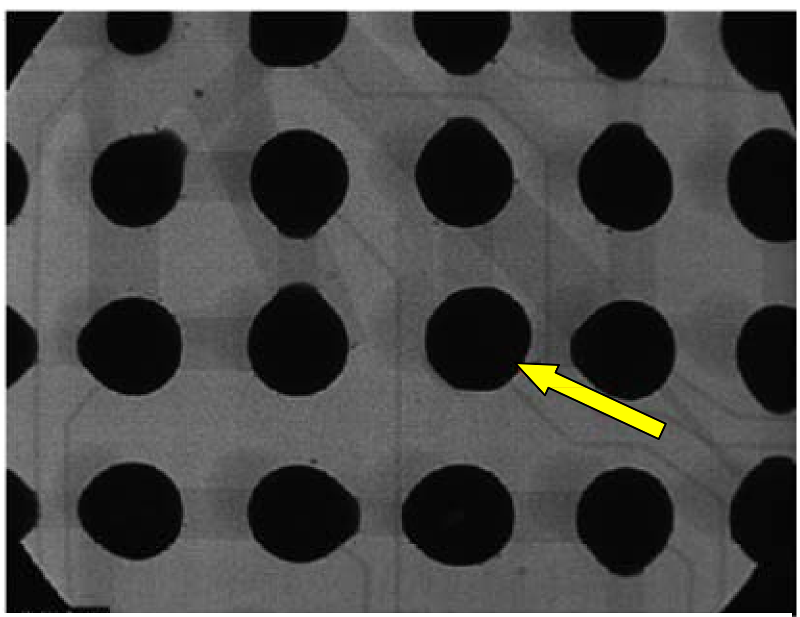


Figure 16-21: Microsection showing partial reflow of solder paste: Reject



1. missing balls: Reject
2. bridges: Reject
3. non-wetted pads: Reject

Figure 16-22: Perpendicular transmission X-radiograph showing unacceptable defects



Solder has not flowed to extent of teardrop pad: Reject

Figure 16-23: Perpendicular transmission X-radiograph showing non-wetted pad

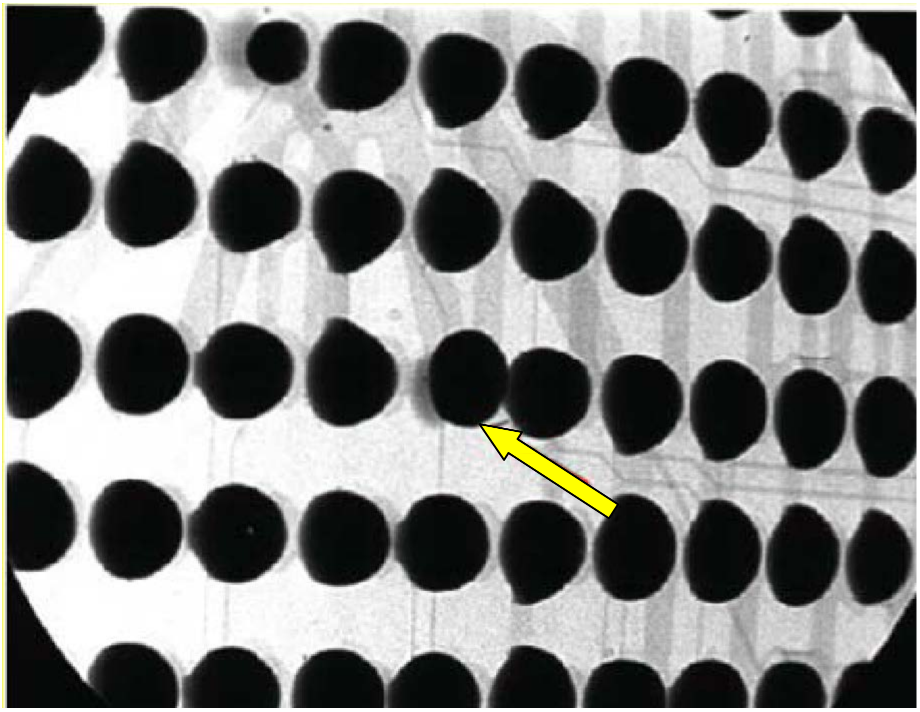


Figure 16-24: Angled transmission X-radiograph showing non-wetted pad: Reject

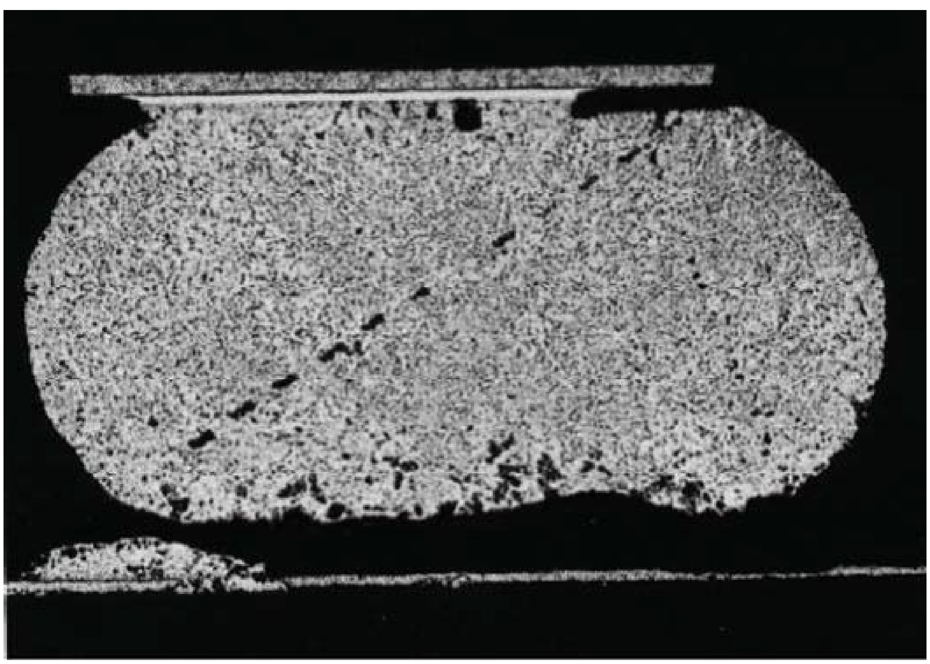


Figure 16-25: Microsection through a ball showing non-wetting of solder to pad: Reject

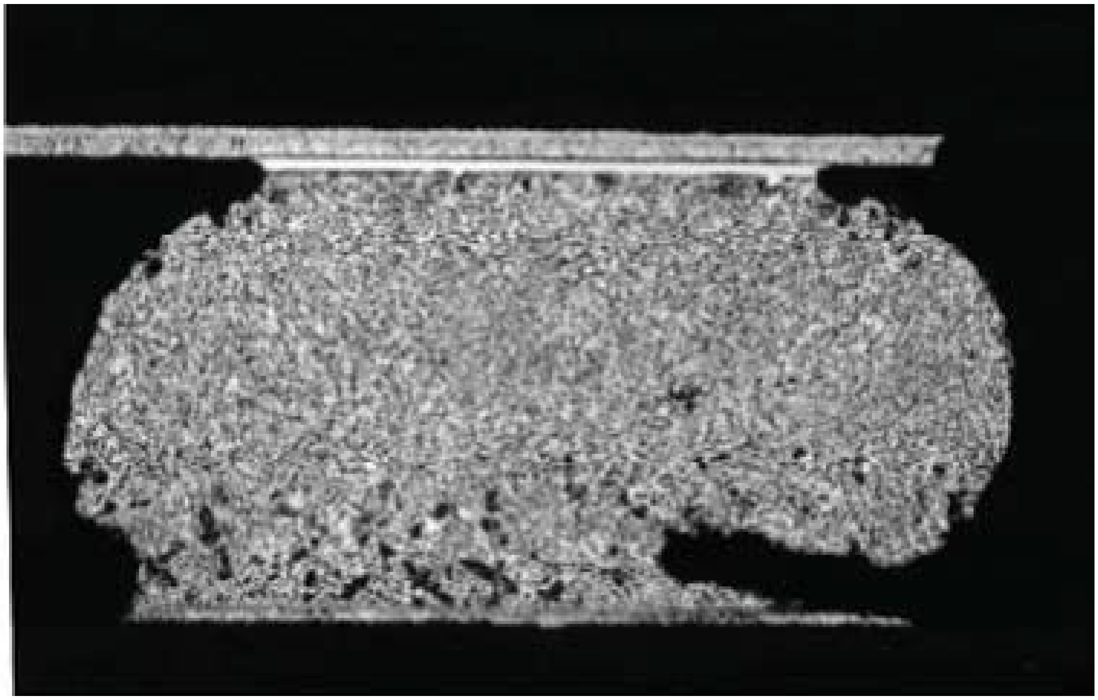


Figure 16-26 Microsection through ball showing partial wetting of solder to pad: Reject

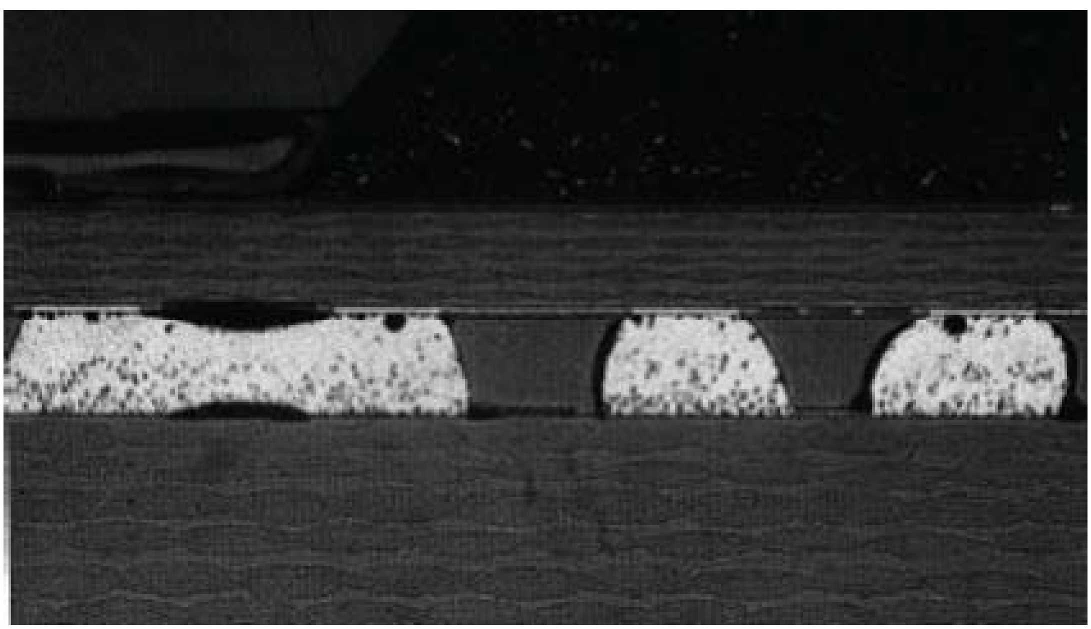
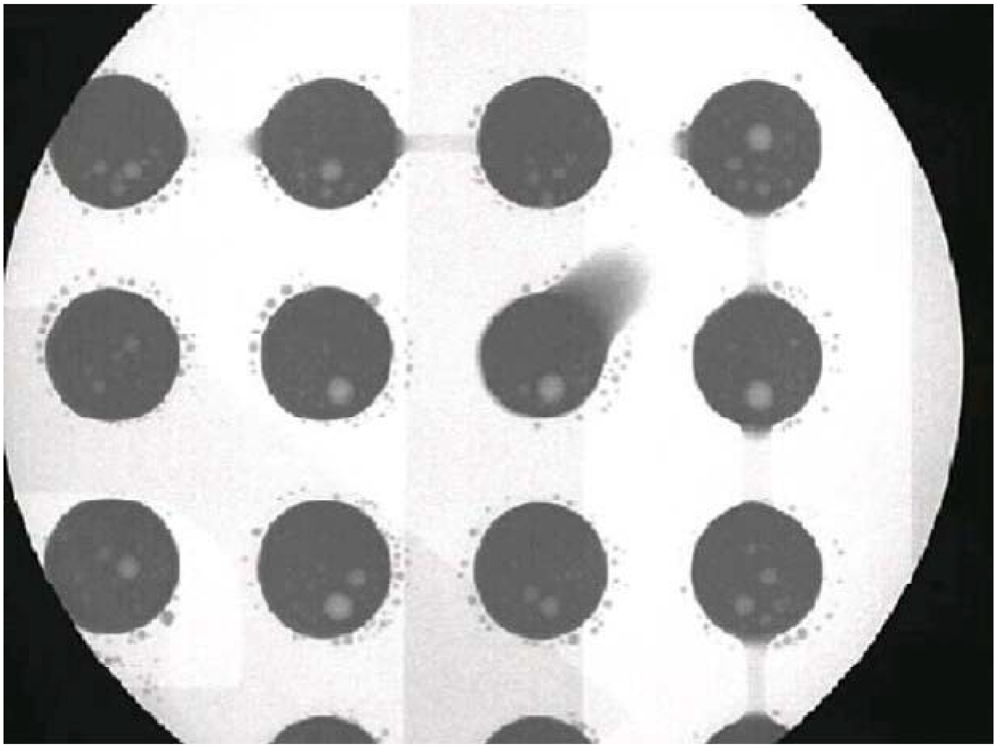


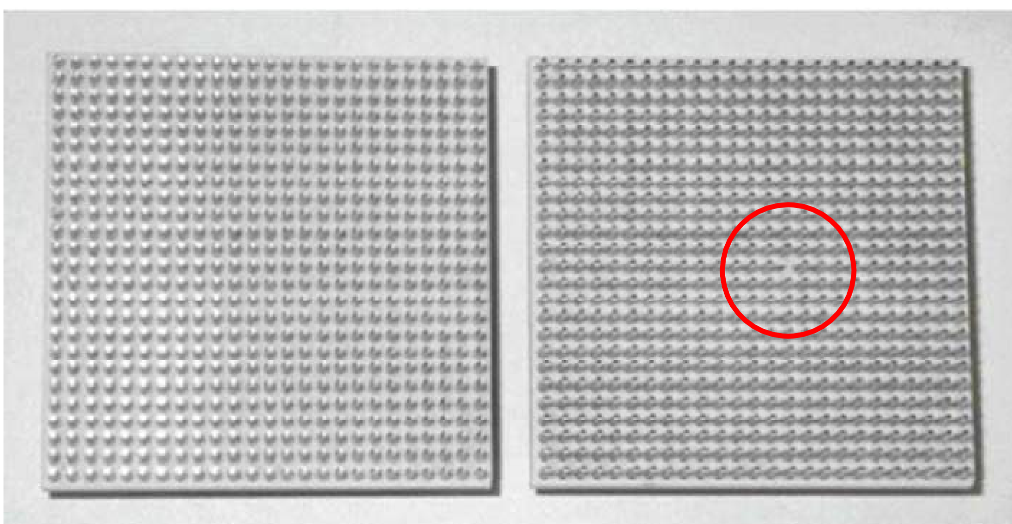
Figure 16-27: Microsection through ball showing solder bridge: Reject



Sum of voids in some BGA balls exceeds 25 % of ball's cross section diameter: Reject

Figure 16-28: X-radiograph showing many small voids and solder balls: Reject

16.3 WORKMANSHIP ILLUSTRATIONS FOR COLUMN GRID ARRAY DEVICES



Good consistency of column alignment: Accept Missing column: Reject.

Figure 16-29: Underside view showing missing column

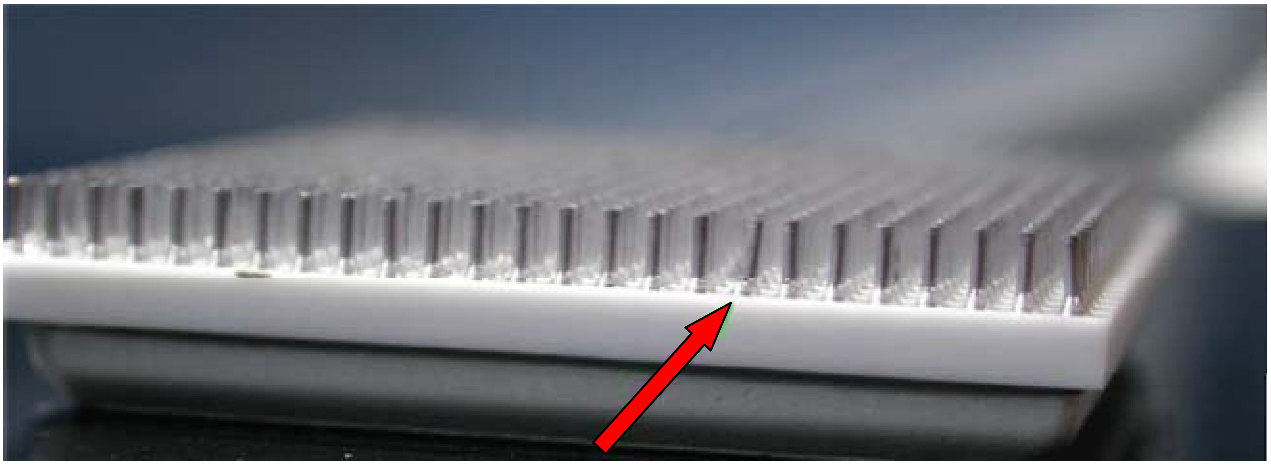


Figure 16-30: Side view showing column; column by more than 5°: Reject

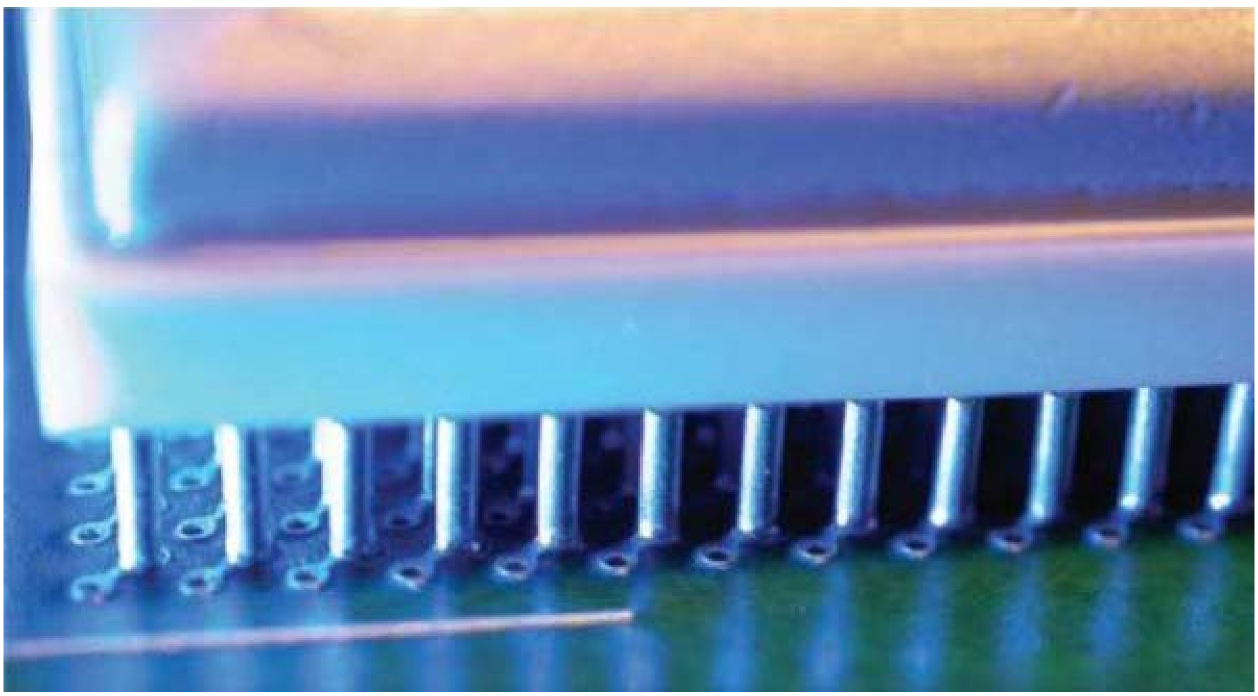
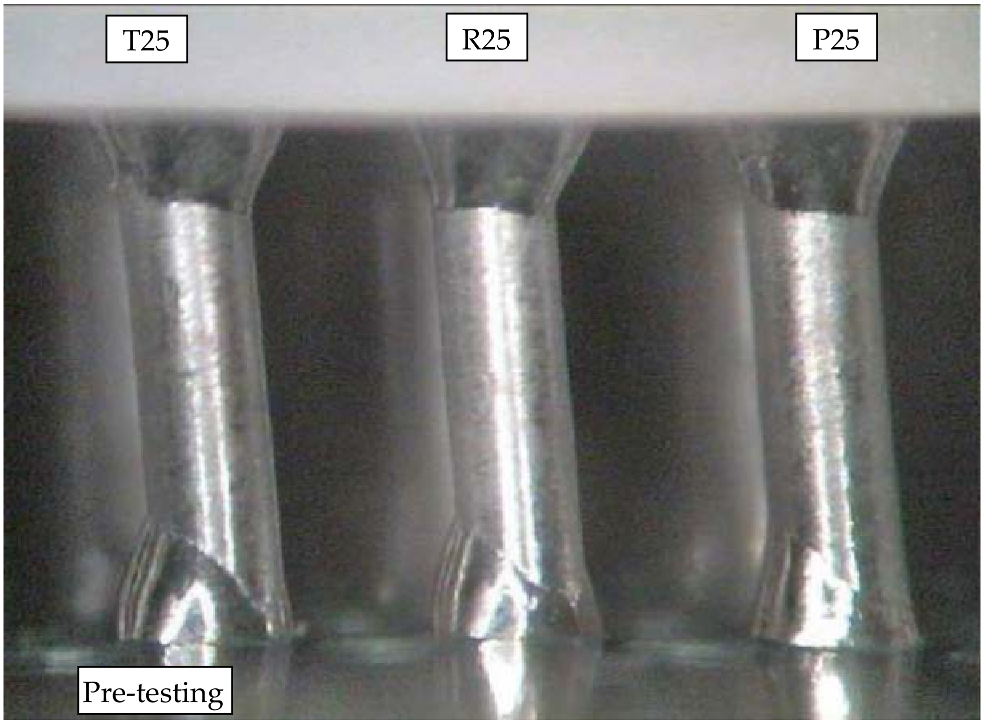
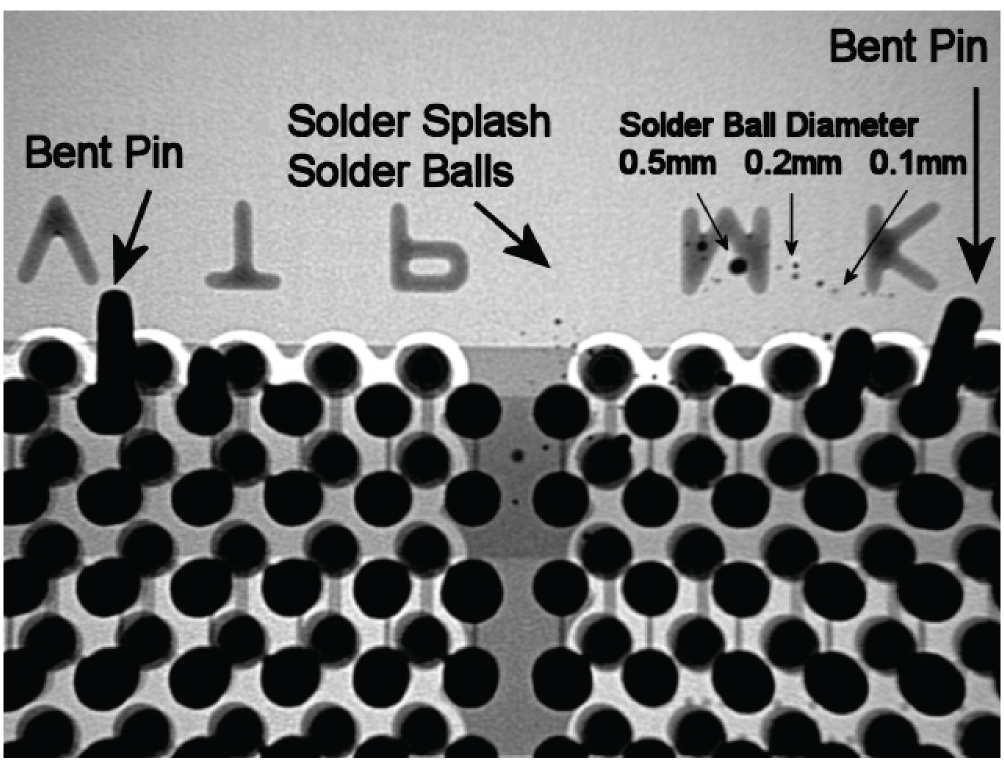


Figure 16-31: CGA mounted on PCB showing perpendicular columns centrally placed on pads: Targetcondition



Note: Asymmetry of solder fillets at PCB is consequence of teardrop pads and is acceptable

Figure 16-32: CGA mounted on PCB showing columns tilted < 5°: Accept



Bent columns (pins): Reject

Solder balls: Reject

Figure 16-33: X-radiograph of CGA mounted on PCB

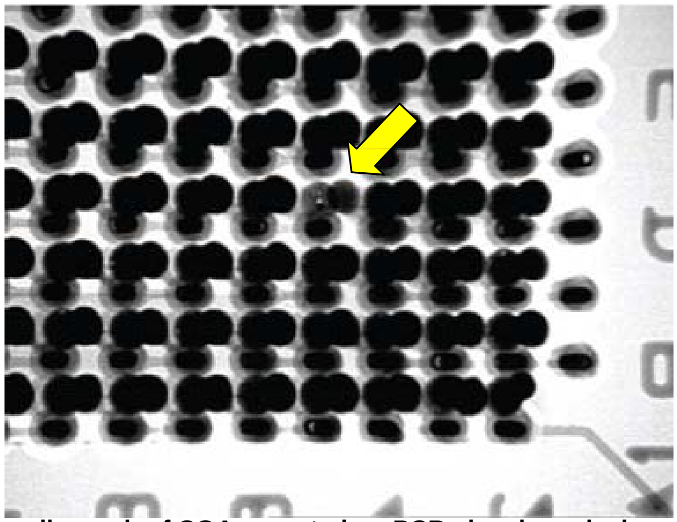


Figure 16-34: X-radiograph of CGA mounted on PCB showing missing column: Reject

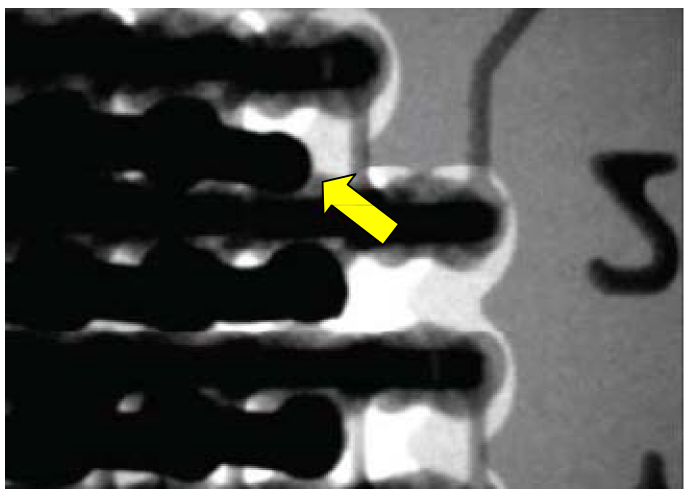


Figure 16-35: X-radiograph of CGA mounted on PCB showing insufficient solder: Reject

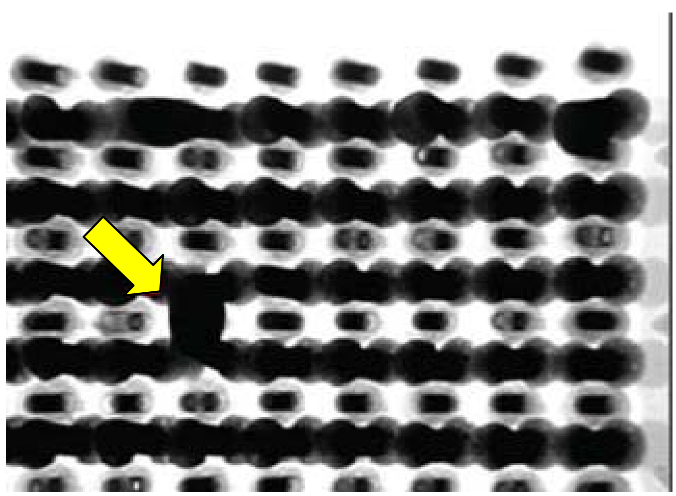


Figure 16-36: X-radiograph of CGA mounted on PCB showing solder bridge: Reject

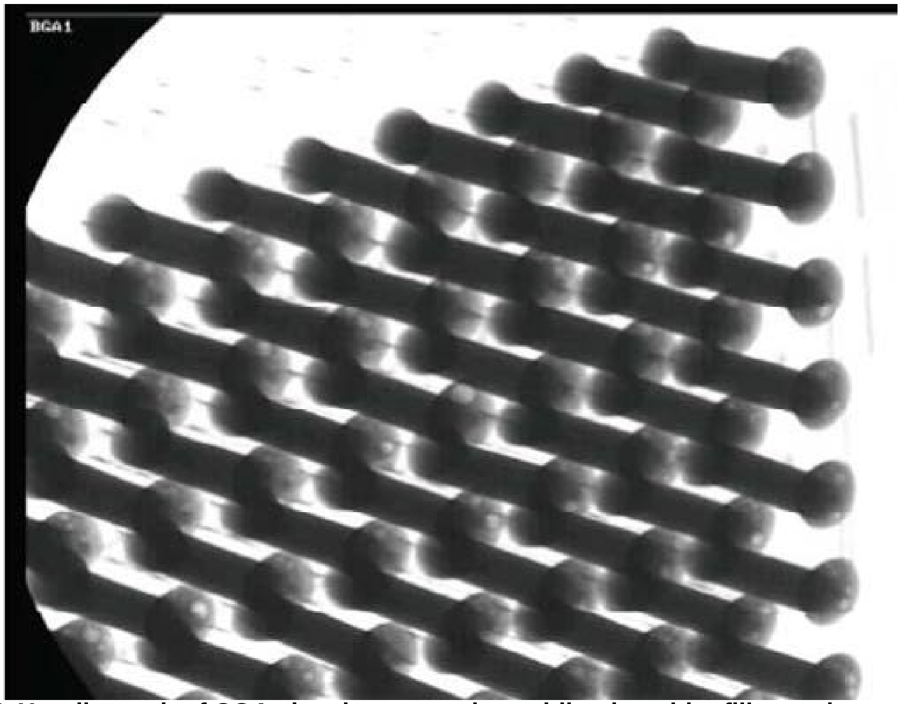
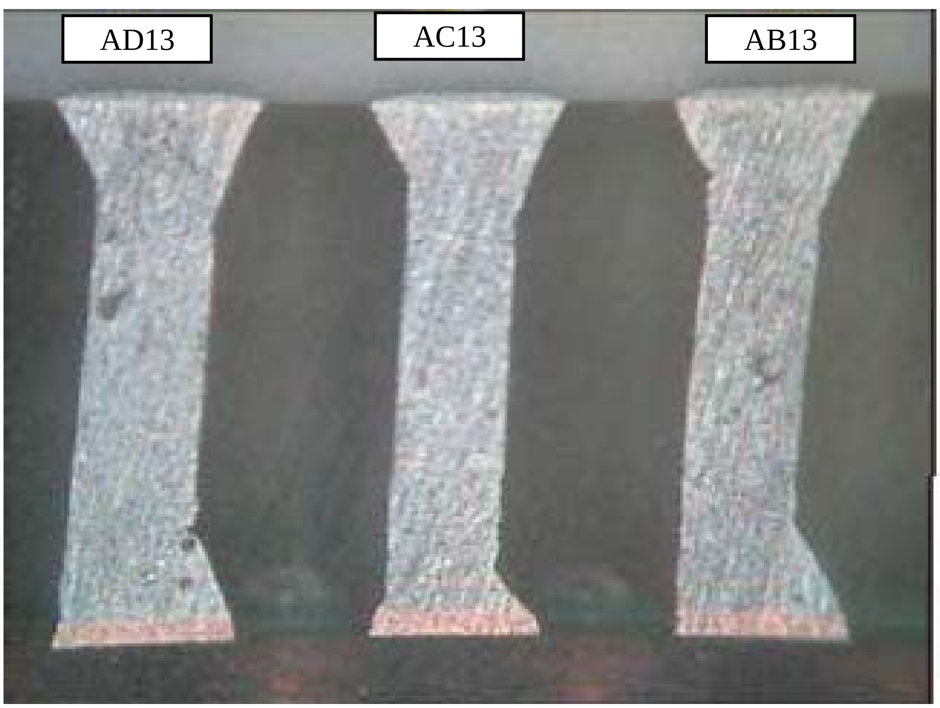


Figure 16-37: X-radiograph of CGA showing excessive voiding in solder fillets at base of columns: Reject



Good solder fillets at PCB: Accept

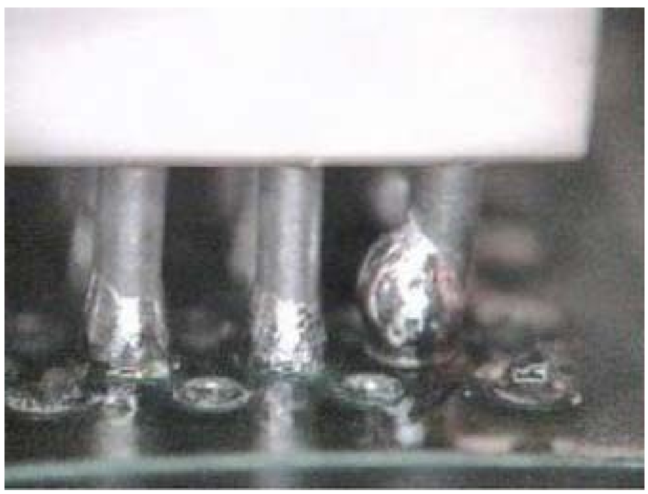
Note: Asymmetry of solder fillets at PCB is consequence of teardrop pads and is acceptable.

Solder fillets at package undisturbed by reflow process: Accept.

Figure 16-38: Microsection of CGA mounted on PCB

Bent column: Reject

Figure 16-39: Micrograph of CGA mounted on PCB



Unsoldered column: Reject.

Figure 16-40: Micrograph of CGA mounted on PCB

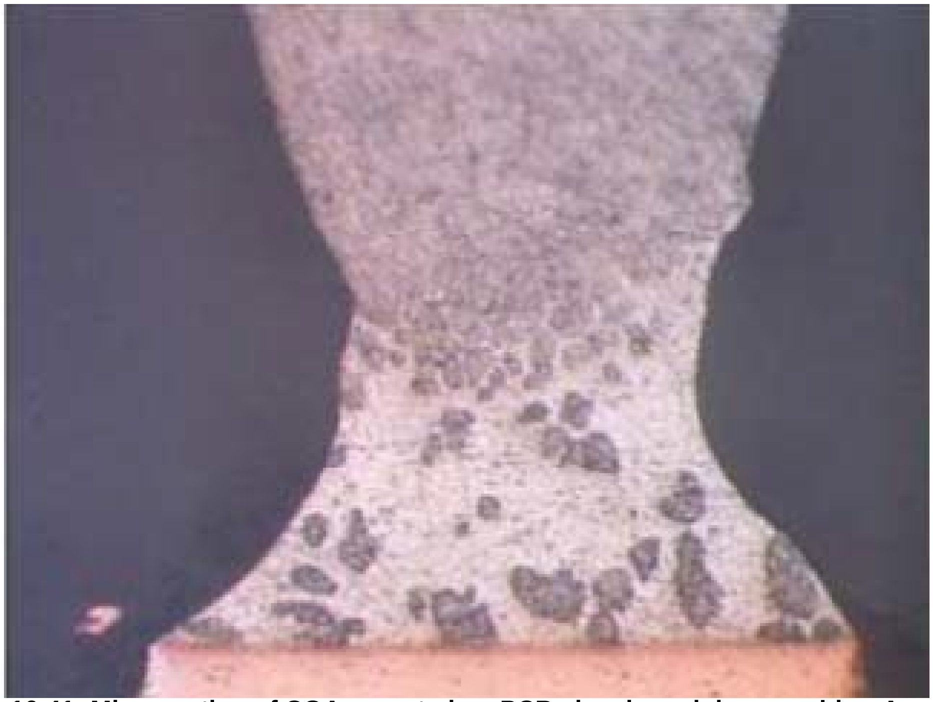


Figure 16-41: Microsection of CGA mounted on PCB showing minimum solder: Acceptable

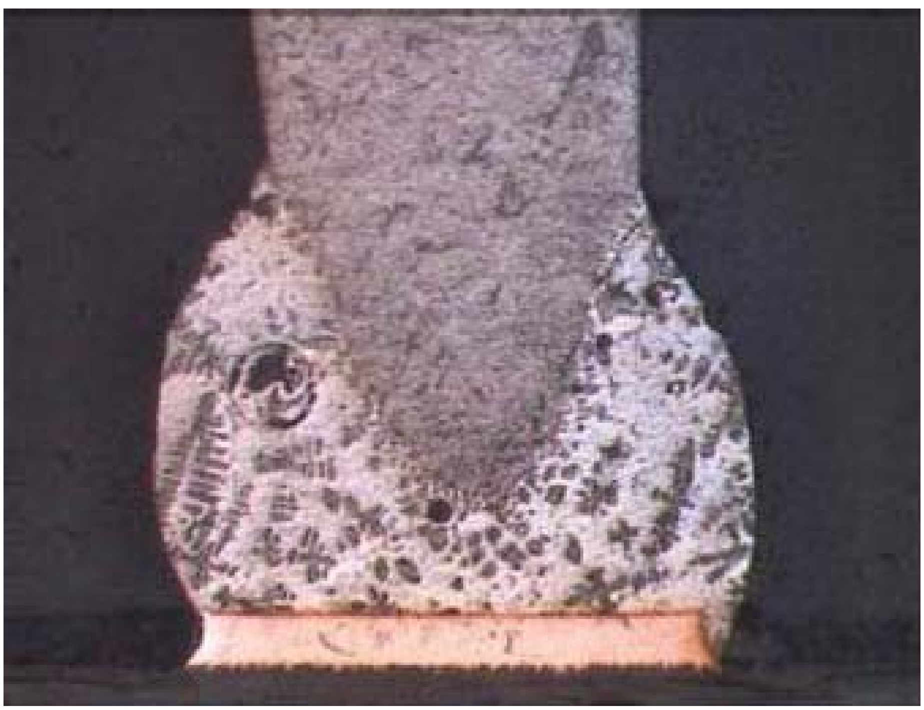
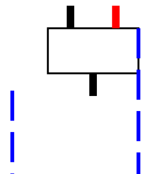
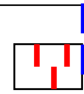
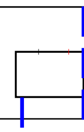
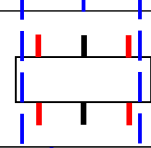
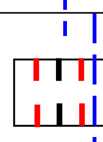
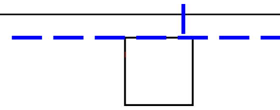
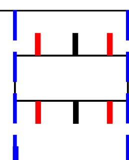
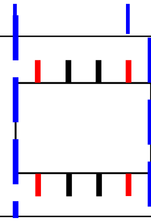
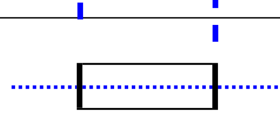
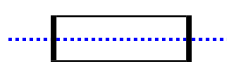
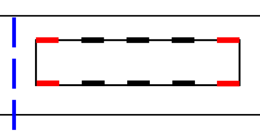
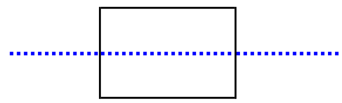
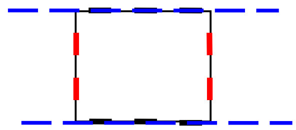
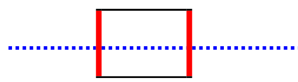
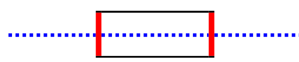
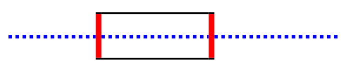
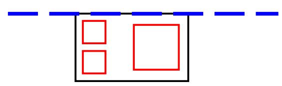
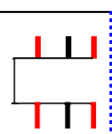
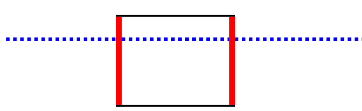
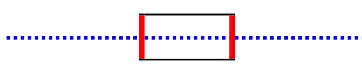
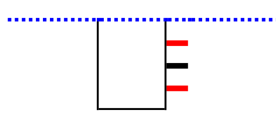
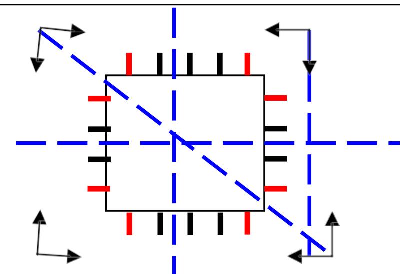
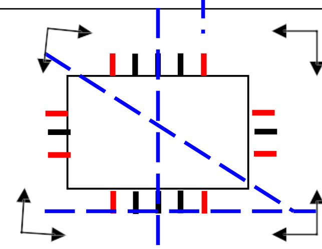


Figure 16-42: Microsection of CGA mounted on PCB showing maximum solder: Acceptable

16.4 MICROSECTION EXAMPLES

SOT23:	
LCC3	
TO252	
SO20	
LCC6	
D2 Pack	
FP	
SESI	
Chip resistor	
MM series resistors	
CRA 12E and array resistors	

CTC	
LCC32 or LCC with terminations on 4 faces	
MPCI	
DO213	
D5-B	
SMD	
SOT223	
PM94-S4	
CWR	
CH51	

CQFP To cut after embedding	
MQFP	

Position of the microsection

Leads to be microsectioned

16.5 ACCEPT AND REJECT CRITERIA AFTER ENVIRONMENTAL TESTING

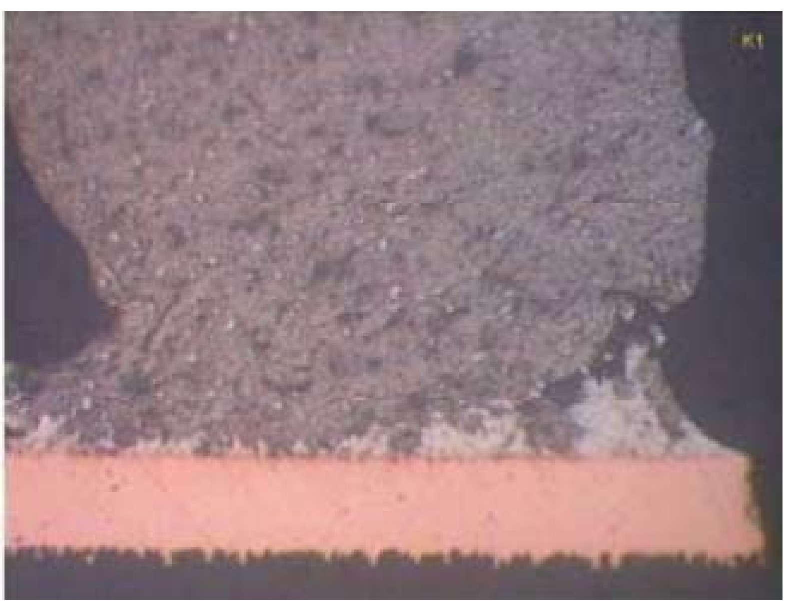
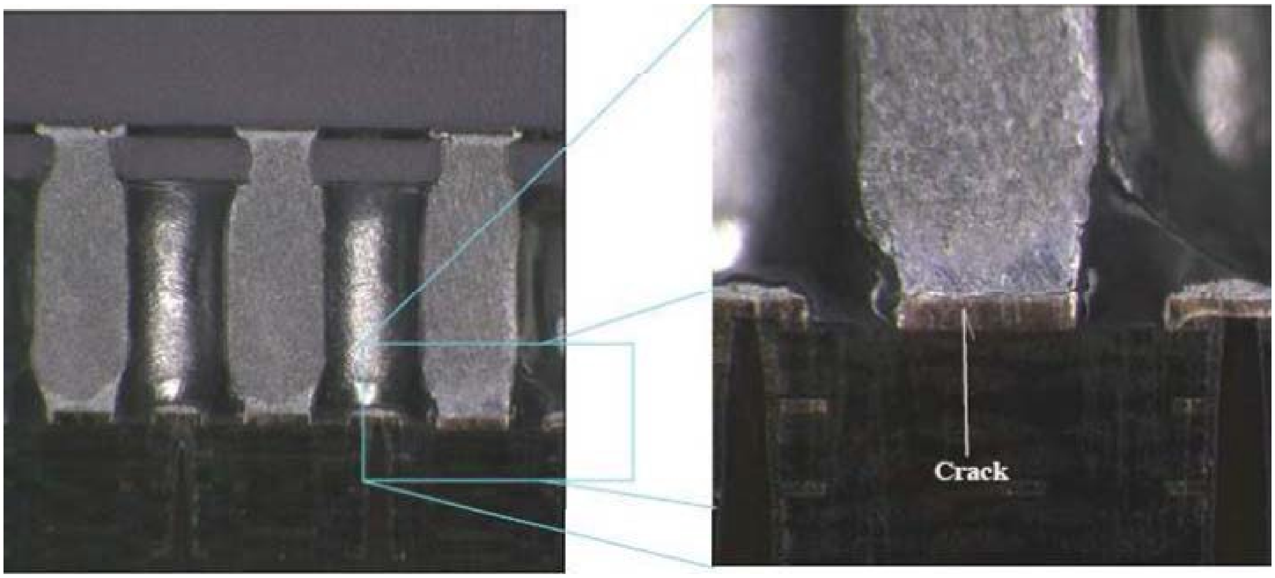
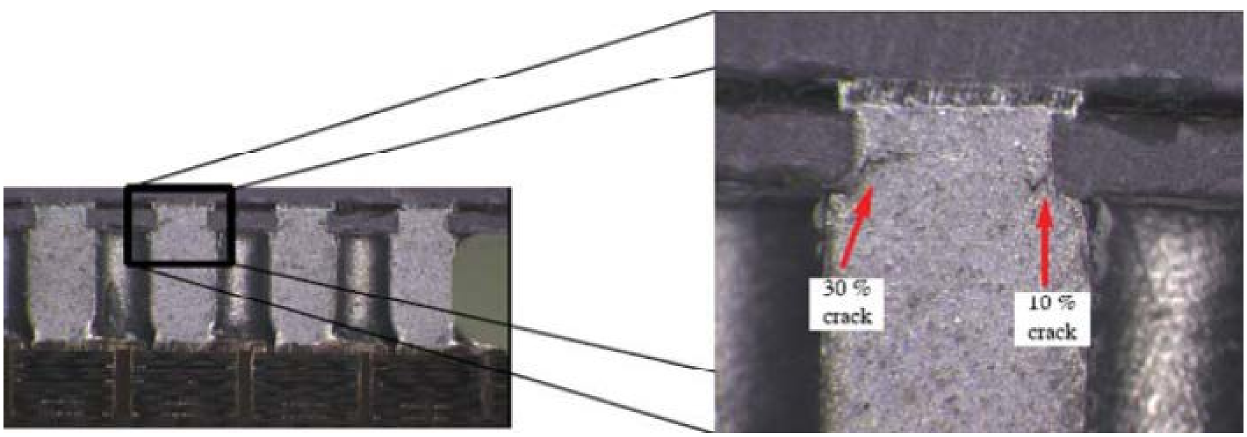


Figure 16-43: Sample after Qualification sample testing: Microsection of CGA mounted on PCB showing crack in the solder fillet



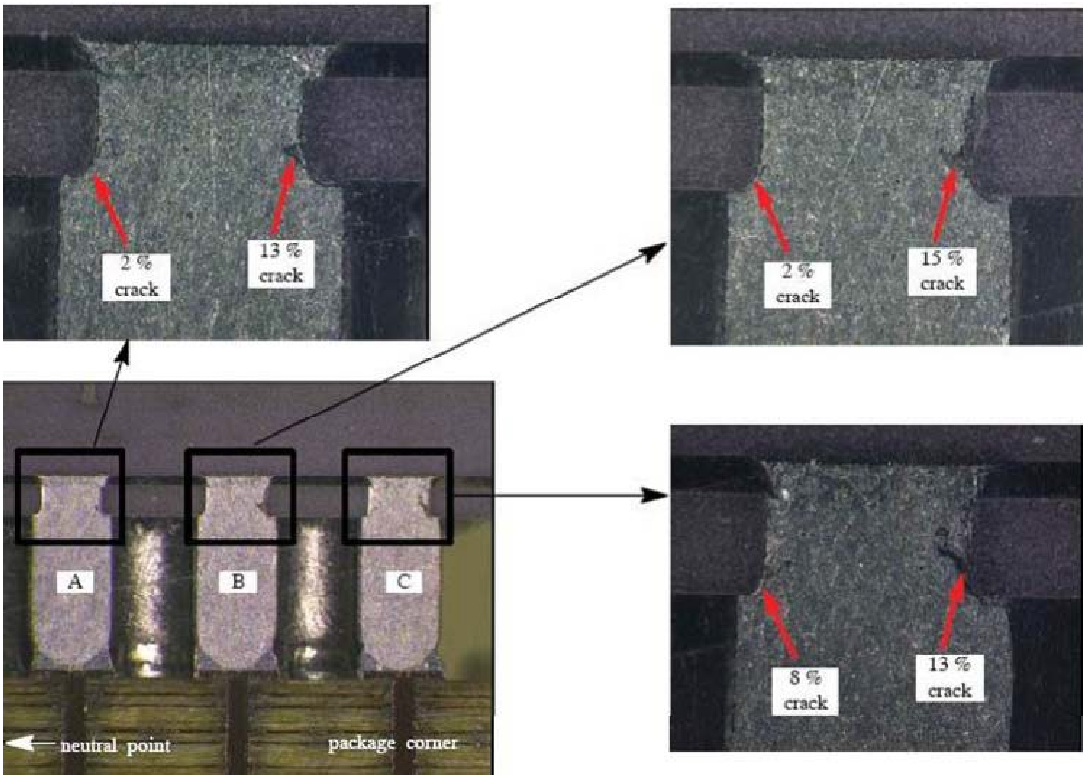
A fatal crack located in the solder joint between the column and the pad. The crack goes through the whole solder joint: Reject

Figure 16-44: Microsection of a CGA showing a crack



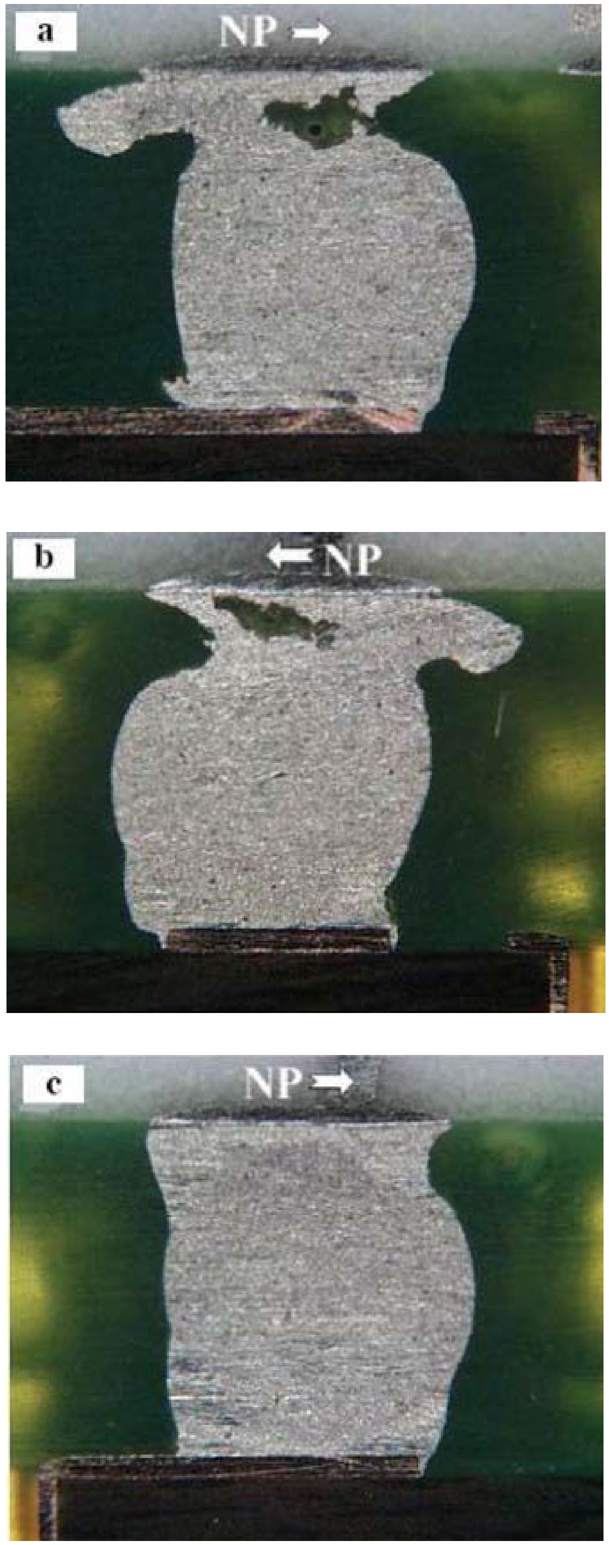
Two micro cracks are located in the column insertion to the cartridge.
The extension of the two micro cracks is estimated at 30 % and 10 % of the column diameter, respectively.
The total length of the micro cracks in the column is 40 % of the column diameter (which is more than the accepted 25 % diametrical crack): Reject

Figure 16-45: Microsection of CGA showing cracks



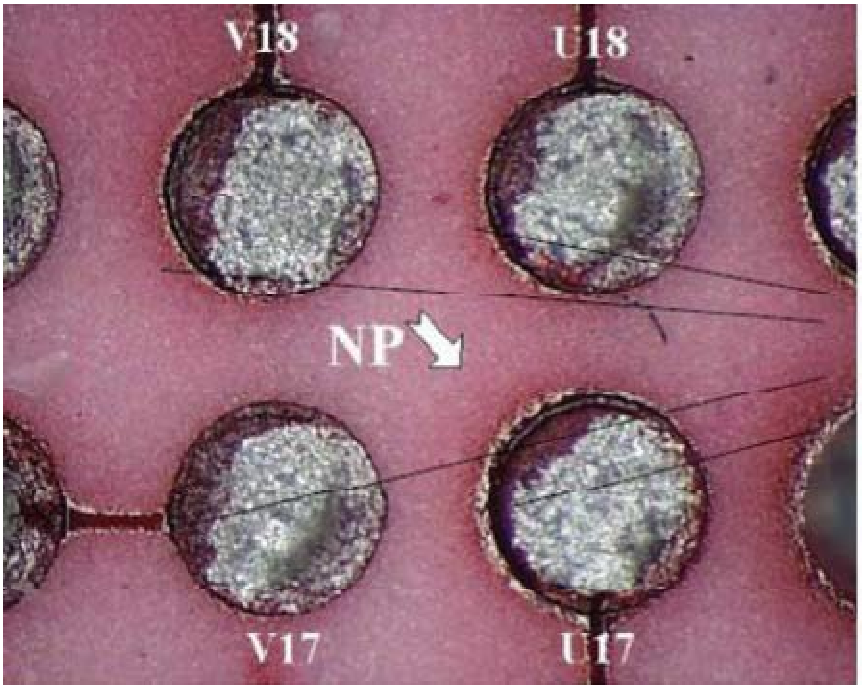
Two micro cracks are located in each column insertion to the cartridge. The extents of the micro cracks are estimated at 15 % of column diameter A, 17 % of column diameter B, and 23 % of column diameter C. The crack extensions are lower than the accepted 25 % diametrical crack.
Column A-C: ACCEPT
Note that the largest cracks are located at the column sides closest to the package corner.

Figure 16-46: Microsection of CGA showing cracks



(a) (b) Micro sections where cracks are located at the solder joint between solder ball and component pad on the package side. The extent of the cracks is above 50% of the ball diameter: REJECT
(c) Micro section after Qualification test without any micro cracks: ACCEPT
(The arrows show the direction to the neutral point at the centre of the CBGA)

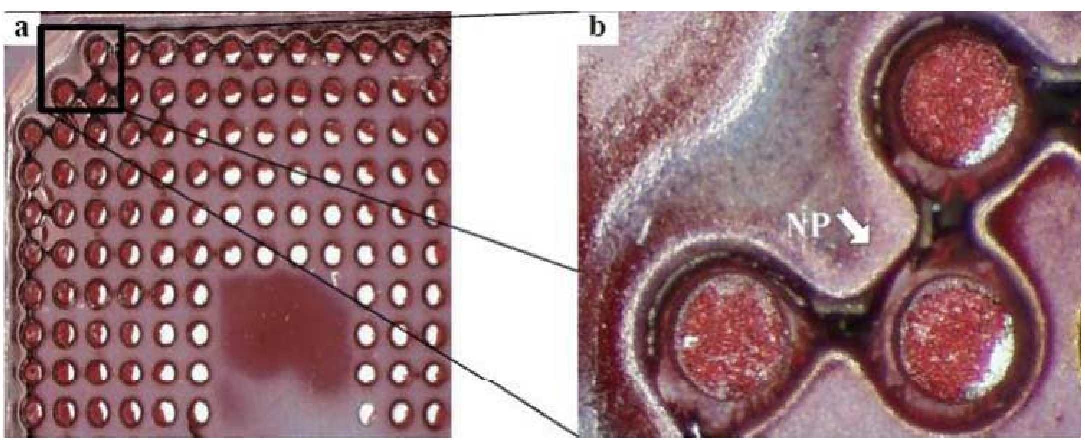
Figure 16-47 Microsection of CGA showing cracks



Area darkened by dye penetrant, i.e. crack

The figure shows dye penetration on the component pads on a CBGA package. The interconnections remain on the PCB. The penetrant dye has darkened the area where cracks have been localised after verification testing.
The darkened area is less than 25 % of the total cross sectional area of the original solder joint area: ACCEPT
(The arrow shows the direction to the neutral point (NP) at the centre of the CBGA)

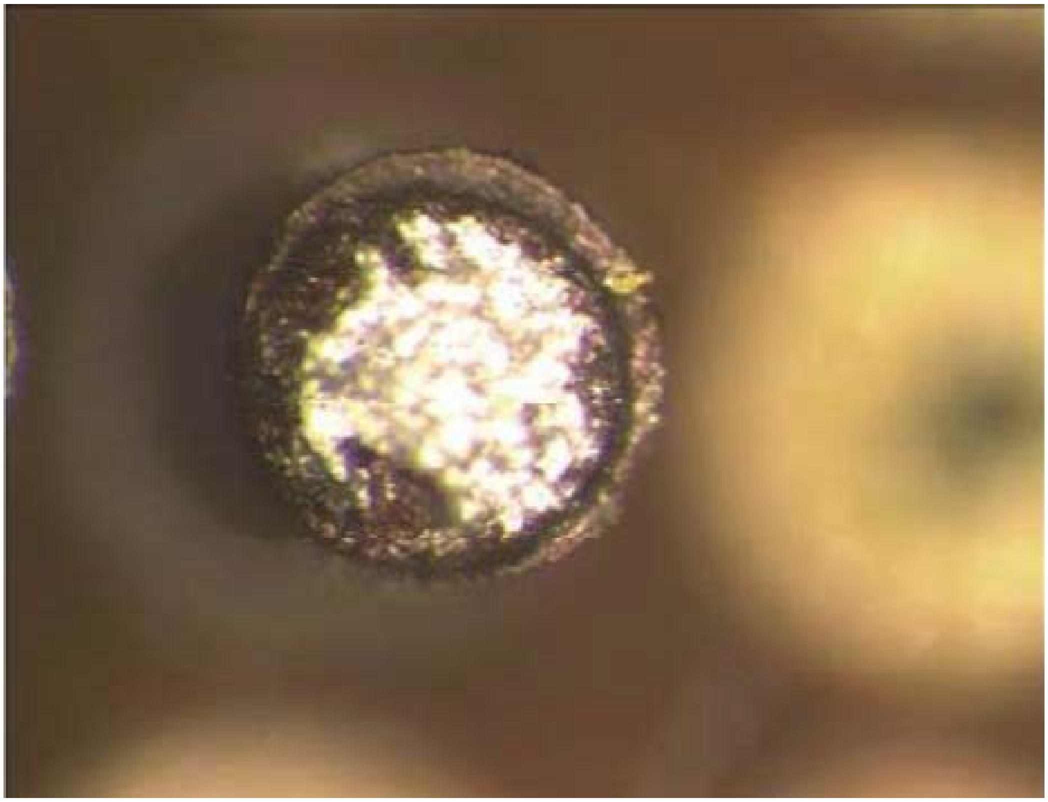
Figure 16-48: Micrography of CBGA after dye penetration testing



(a) The figure shows remaining interconnections on the PCB after the dye penetrant test. The majority of solder joints were severely cracked close to the component pads after the verificationtest.
(b) The close-up figure clearly reveals the cracks, which extend more than 25 % of the solder balls:REJECT

(The arrow shows the direction to the neutral point (NP) at the centre of the CBGA)

Figure 16-49: Micrography of CBGA after dye penetration testing



Dye penetrant on a ruptured column. The rupture of the column is localised in the solder joint between the component pad and the column. The dye penetrant has darkened the area where a crack has been localized after verification test. The darkened area is more than 25% of the total cross section area of the column: REJECT

Figure 16-50: Micrography of a column of CBGA after dye penetration testing

Annex A (informative) Verification approval

A.1 General

a. The final customer makes the final decision to grant verification status to the supplier of surface mount technology on the basis of examination and acceptance of the fully documented verification test report.

b. The verification test results are compiled by the supplier into a test report data package and contains the results for all the tests specified in clause 14.

c. At this point the surface mount manufacturing processes are established and frozen and documented in a process identification document (PID) in accordance with clause 5.

A.2 Methodology of approval

A.2.1 Request for Verification

a. The Verification of any SMT assembly is restricted to those suppliers that have been selected to supply equipment for space projects.

b. Each supplier assigns a contact person to be the single point contact for all SMT matters.

c. The following items are submitted to the approval authority.

1. A letter from the supplier addressed to the approval authority, describing his experience in SMT and making the request for Verification. The letter is signed by the contact person and the quality assurance organization of the supplier.

2. A process identification document and product control record relating to the technology sample.

3. One technology-sample of SMT of the highest possible quality, taken from the assembly line to be verified, not carrying conformal coating (even if the assembly line normally applies conformal coating) is submitted to the approval authority for inspection purposes.

NOTE The reason for not carrying conformal coating is that the sample is inspected.

A.2.2 Technology sample

a. The technology sample is inspected at by the approval authority based on the criteria set out in clause 13.

NOTE For example, visual inspection can determine the cleanliness and workmanship standard. Metallography can be used to evaluate the SMT connections.

A.2.3 Audit of assembly processing

a. The approval authority informs the supplier of the result of this examination and advises either acceptance or rejection with the start of the next stages of the approval process.

b. The audit assembly process is organized during operation of the SMT processes.

c. The contact person submits the following documents to the approval authority, prior to or during the audit:

1. Organigram of the company related to the SMT and the quality control functions.
2. A list of SMT components and connection types, printed circuit board type, staking compounds and conformal coating to be verified.
3. A description of test capabilities, for example for thermal cycling, vibration, cleanliness testing and metallographic inspection.
4. A list of personnel who are trained and certified for SMT soldering processes.

d. The findings of the audit remain confidential to the approval authority, but a summary report may be issued.

NOTE A typical Audit Report questionnaire is shown in Annex D.

A.2.4 Verification programme

a. A Verification programme is submitted to the approval authority for acceptance prior to the start of assembly of the test SMT.

NOTE At the time of the audit specified in A.2.3, details of the Verification programme can be discussed. See also clause 14.

b. The number of devices per SMT configuration is at least 5, of which one or more is a repaired configuration.

c. The devices are assembled to the Surface Mount verification board as specified in clause 14.1.

NOTE The number of test samples per SMT configuration can be reduced if justification exists. Such justification can be, for example, that the supplier demonstrates that certain devices can be verified by similarity (see clause A.2.5).

d. During the environmental test programme, continuous monitoring, by means of an event detector able to detect events of 1 μs (during the last 5 thermal cyclings), of the connections by electrical continuity measurements is preferably applied.

e. After the environmental test programme, analysis of the SMT configurations includes metallography of the worst case connections.

NOTE A.2.4d. and A.2.4e. are due to the fact that some induced cracks and failures in connections are not apparent visually.

f. A comprehensive verification test report is compiled and submitted to the approval authority by the supplier.

g. An SMT summary table is submitted with the report.

NOTE Self explanatory examples are presented in Annex B.

A.2.5 Verification by similarity

Several families of SMDs are produced having a wide variation in outline dimensions. The selection of SMDs that is submitted for assembly to printed circuit boards and later to the environmental testing prescribed in clause 14 of this standard does not mean that every size variant is verification tested.

As a result of the large amount of data obtained during past surface mount technology verification programmes, it is proposed that only the largest and smallest SMDs belonging to individual families be selected for testing. The smallest devices ensure that the processing methods are sufficiently dextrous (i.e. their small size can cause handling or soldering problems). The largest sizes ensure that thermal fatigue and vibration fatigue do not cause failures.

Due to the very high cost of some space qualified SMDs consideration can be given to using commercial quality devices and empty packages (specially with internal “daisy-chained” electrical continuity).

Annex B (informative)
Examples of SMT summary tables

The following Figures present examples of summary tables for different types of components verified against the requirements of this Standard.

Summary Table for SMD Assembly Verified to ADS1136 by "Company Name"

1) Process Identification Document (PID): **TBB-908-IN-E, rev. 8**
2) Board Class for Thermal Environment: **Polyimide**
3) Assembly process (g) : **Vapour Phase**
4) Reference of Equipment used for assembly process: **VP Oven SN1**
5) Conformal coating: **Solithane C 113**
6) Solder type (h) : **Sn62Pb36Ag2**
7) Flux : **n/a**

SMD Class	SMD Type (e) (f)	Package				Terminal						Body fixation (d)	Specifics (i)	Foot print reference	Report Reference
		Max Body Dimensions (mm) (a)	Max Diagonal (mm) (a)	Max Weight (g) (a)	Material (b)		Shape (c)	Width (a)	Thickness	Material (a)	Finish (a)				
Resistor Ceramic	RM1005	2,8 x 1,4	3,1	0,3	Ceramic	n/a	End Capped	-	-	-	Tin Lead	-		ACD-FP-0035	
	RM2512	6,35 x 3,18	7,1	0,5		n/a					Tin Lead			ACD-FP-0042	
Capacitor	CC0805	2,3 x 1,45	2,7	0,3	Ceramic Type I, Type II	n/a	End Capped	-	-	-	Tin Lead	-		ACD-FP-0114	

Ceramic	CC2220	6,2 x 5,5	8,3	0,6	Ceramic type II	n/a	End Capped	-	-	-	Tin Lead			ACD-FP-0128	

Flatpack	FP20 pitch 1,27	13,72 x 7,62	15,7	2,2	Ceramic	n/a	Flat bended as gull wing, bottom brazed	0,38-0,56	0,10-0,23	Kovar	Gold	Side bonding with EC 2216		ACD-FP-0263	M12-APQ42-019

(a) Tolerance on size and weight (increase until 10% on top of the max body mechanical characteristics acc. to datasheet is acceptable)
(b) Package material: For ceramic capacitor, distinguish Ceramic Type I and II
(c) Terminal shape: for FP, distinguish attachment to body location (e.g. middle , top and bottom) and type of connection (e.g. brazed or glass sealed)
(d) Body Fixation: If adhesive bonding: type of adhesive, function (i.e. electrical, mechanical, thermal) and location of adhesive; If body soldering, state characteristics
(e) For components with leads, the pitch, in mm, should be included in the column of the SMD type
(f) Specificities to differentiate components which have otherwise the same characteristics, should be stated in the SMD Type (e.g. for 3D Stack the length of the leads)
(g) The assembly process assumes repairs have been verified. If no repair has been verified, a note should be written.
(h) Solder Type: Alloy composition, Manufacturer…
(i) Specifics: any specificity of the assembly not covered in the other columns (e.g. special stand-off)

Parameters to be traced (and to be available for review), but which don't have to be in the SMT approval letter:

Manufacturer, Batch, Date Code
Bending lead shape
Bending Tool
Process parameters (e.g. for reflow profile, reflow parameter reference (Reflow profile reference/soldering procedure reference…):
PCB characteristics: Stack-up and size
Repairs: detail of process parameters and repair configuration

Annex C (informative)
Soldering of area array devices

C.1 General

Only the outer row of solder joints to area array devices can be visually inspected. Inner rows of solder joints cannot be inspected unless X-ray or X-ray-like techniques are used but, even using such techniques, it can be difficult to assure the quality of the solder joints. Reliability of solder joints to area array devices can only be assured by good process control.

Since it is difficult to rework a single solder joint to an area array device, reworking of solder joints generally necessitates that the whole component is removed.

C.2 Solder joint

C.2.1 General

Requirements in clauses 11.5.1 and 13.2 apply to area array devices.

The rejection criteria specified in 13.3 apply to area array devices.

NOTE The general requirements of solder joints to reflow soldered components specified in clause 11.5.1 and 13.2, and the rejection criteria specified in clause 13.3, also apply to area array devices, although it can be difficult to verify through inspection that the requirements are met.

C.2.2 Voids

Voids are often found to varying extents in solder joints to area array devices. They can be found adjacent to the PCB solder pad and to the device solder pad. For BGAs with eutectic solder balls, they can also be found within the main body of the solder joint. Voids can impact reliability by weakening the solder balls and by reducing the heat transfer and current-carrying capability. However, there are no industry data indicating that voids in the solder joint are a reliability concern unless the voids are very large. In fact, moderately sized voids can cause a slight increase in the solder joint fatigue life. Still, the presence of voids is an indication of the necessity of adjusting the manufacturing parameters.

For voids within the ball refer to

Table 11-7 of clause 11.5.8.

For voids at a solder pad interface refer to

Table 11-7 of clause 11.5.8.

C.2.3 Solder fillets to high temperature balls

Eutectic solder balls to BGAs completely reflow during the soldering process. That is, the solder in the solder paste and the solder in the ball are blended making up the final joint. This is in contrast to high temperature balls, which do not reflow during the soldering process; see Figure C-1. For this reason, solder joints with eutectic balls have a very different structure compared to solder joints with high temperature balls. Whereas the solder paste volume printed on the solder pads on the PCB has little influence on the geometry of the solder joints for eutectic solder balls, as long as proper wetting occurs, it does have a large impact on the geometry of the solder joints for high temperature solder balls. Too much solder paste increases the risk of bridging between the solder joints, whereas too little solder paste results in meagre solder joints having a reduced fillet diameter between the solder pad and the solder ball. Even a slightly reduced fillet diameter can have a large impact on the fatigue life of the solder joint [6].

a. The maximum and minimum solder paste volume to be printed on the solder pads for a BGA device is specified.

b. The volume of solder paste printed on the solder pads is verified before the BGA device is mounted on the PCB.

NOTE This is because it is very difficult to detect meagre solder joints even using X-ray inspection techniques.

Figure C-1: Typical CBGA solder joint (high melting point balls)

C.2.4 Solder fillets to solder columns

a. The solder completely fills under the column and forms a fillet that wets at least 180 degrees of the column circumference.

b. Avoid excess solder paste since it can increase the fillet height and make the column stiffer resulting in a shorter fatigue life.

NOTE The final solder joint to a solder column often has an asymmetrical fillet with the columns aligned to the edge of the solder pads. This also causes the columns to be tilted (Figure C-2), sometimes in different directions. This is normal and acceptable. It occurs even if the columns are centred in the paste prior to the reflow, and it does not affect the reliability of the solder joint.

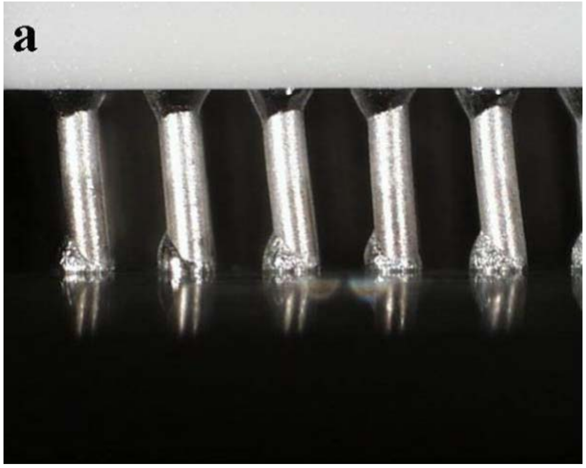


Figure C-2: Tilted columns to a CBGA

C.2.5 Increase of the melting point of solder

During soldering of area array devices with high temperature balls or columns, the eutectic solder used to solder the devices is enriched with lead. This increases the effective melting point of the once eutectic solder. The increased melting point renders reworking more difficult.

It is good practice to have a solder joint peak temperature of 220 °C with a maximum of 235 °C. The duration of the solder temperature higher than 183 °C is limited to 145 seconds.

C.2.6 Cold solder

The reflow profile used for soldering area array devices is:

a. specified, and

b. assures that the solder reaches high enough temperature that it wets the pad surfaces for all solder joints and does not leave any cold solder joint.

C.2.7 Brittle fractures

The solder pads on area array devices often have a plating consisting of either electrolytic nickel or electrolytic gold or electroless nickel or immersion gold (ENIG). In both cases, the gold is completely dissolved in the solder during attachment of the balls or columns to the devices. That is, the solder joint is formed towards a nickel surface. Solder joints to electroless nickel surfaces have been found to be much more susceptible to catastrophic, brittle fractures than solder joints to electrolytic nickel and copper surfaces [5]. Analysis indicates that brittle solder joint fracture occurs under a high level of both applied strain and strain rate. The fracture occurs between the nickel surface and the solder, i.e. in the intermetallic layer. Fractures can occur due to thermal shock (too fast cooling after soldering), bending, mechanical shock or thermal cycling (premature failures). This can be related to the black pad embrittlement.

C.3 Removal and replacement of area array devices

C.3.1 General

Removal and replacement are more complicated for grid array devices than for conventional devices because touch-up of individual joints is not feasible [7], [8].

When removing and replacing area array devices, the whole package is removed and replaced with a new one.

NOTE For this removal, special tooling is used. Most removal and replacement systems are based on a hot-gas reflow tool, although there are also some infrared systems available.

C.3.2 PCB design guidelines for facilitating removal and replacement

a. A clearance of 2 mm to 5 mm for reflow nozzles is left around the perimeter of area array devices to facilitate removal and replacement of the devices.

NOTE The clearance to be left depends on the equipment used for removal and replacement, and the height of adjacent components. The given values are generally used. A large clearance also decreases the risk for reflow of solder joints to adjacent components.

b. If a stencil is used for printing new solder paste, a clearance of 3 mm to 5 mm is used.

c. The assembly is preheated before the hot-gas reflow tool is used.

NOTE 1 This is in order to minimize warpage of the PCB and decrease the stress on the components.

NOTE 2 If a bottom PCB heater is used, it can restrict the type and sizes of components (if any) that can be placed on the corresponding area on the opposite side of the PCB.

d. Capacitors and resistors within the clearance zone are removed and replaced during BGA reworking.

C.3.3 Pre-baking assemblies and devices

a. Assemblies are demoisturized prior to removal and replacement in conformance with ECSS-Q-ST-70-08, clause 7.6.

b. If moisture-sensitive devices are used, these are stored and handled in conformance with clause 8.5.

C.3.4 Device removal

a. Preheating is performed prior to the application of hot gas from the top heater, to a maximum temperature of 10 °C below the T_g for the PCB material.

NOTE This is crucial for minimizing PCB warpage and thermal shock. The higher this temperature is, the better, but without surpassing the limit given in C.3.4a above.

b. Each area array device site to be reworked is individually profiled by monitoring the following points: centre and edge joints of the package, adjacent packages, and the PCB.

NOTE Thermal profiling is essential for package removal. Individual profiling is performed due to variations in adjacent packages and the heat-sinking properties of the PCB internal layers.

c. The hot-gas top heater is used to reflow the solder joints.

d. The joints are profiled to 190 °C minimum (220 °C maximum if the device has high temperature balls or columns) prior to applying the vacuum pick-up force.

NOTE By ensuring that all solder joints are reflowed, lifted PCB pads can be avoided.

e. The temperature of solder joints to adjacent area array devices is limited to less than 150 °C.

f. The flow of hot gas is directed onto to the top of the package.

NOTE Deflection of the gas flow underneath the package tends to create non-uniform solder temperatures across the array pattern.

g. After removal of the package, solder balls remaining on the board and the remaining solder are removed.

NOTE The latter has a high lead content if the devices have high temperature balls or columns and can increase the melting point of new solder paste.

h. It is good practice to limit the growth of copper-tin intermetallics and warping during this process.

NOTE This is the process that presents the greatest risk to the PCB.

C.3.5 Device replacement

For soldering a new package to the board, there are several ways to apply the solder paste, including:

- screen solder paste onto the balls on the area array device,
- screen solder paste onto PCB site,
- solder preforms or decals, and
- dispense solder paste onto PCB site.

The same solder paste volume criteria that apply to initial assembly also apply to replacement processes. For area array devices having eutectic balls, it is possible to just apply a flux to the PCB. However, it is expected to use solder paste, since it increases the stand-off height of the device and thereby also the reliability.

The tooling for reflow soldering of the new package is the same as for package removal. The rework thermal profile has the same limitations as in initial assembly. Too much heat applied causes damage to adjacent packages.

C.4 Inspection techniques

C.4.1 Overview

Inspection methods can be split into non-destructive and destructive methods. Examples of non-destructive methods are visual and X-ray inspections, whereas microsectioning and dye penetrant analysis are examples of destructive methods. Obviously, destructive methods can only be used for qualifying processes, not for quality Qualification of the final product.

C.4.2 Visual inspection

The traditional method for inspecting solder joints is visual inspection using magnification aids (see clause 13.1). Although the solder joints to area array components are located beneath the component, visual inspection is still a useful tool for assessing the quality. Basic process control techniques such as PCB artwork lines around the periphery of the device site indicate accurate placement, and measurement of component height can indicate successful reflow for BGAs with melting balls.

By looking from the side, at least the outer row of solder joints can be inspected. If other components are soldered close to the area array device, it can be necessary to use fibre optics or mirrors (endoscopy) to enable visual inspection of all solder joints in the outer row. Usually, it is possible to see some parts of the solder joints in the rows just inside the outer row and gross defects such as bridges.

C.4.3 X-ray inspection

The most useful non-destructive methods for inspection of solder joints to area array devices are X-ray techniques. X-ray techniques can be split into two main groups: transmission and cross-sectional (laminographic) X-ray techniques. In transmission X-ray, all features in the vertical "line of sight" are viewed concurrently without distinguishing front or back. Differences in material thickness or density result in different transmitted signal attenuations at the detector. With laminography, the X-ray source and the X-ray image plane are moved in a coordinated way with respect to the electronic device being inspected. A clear image of only one layer of the device can thereby be obtained.

Gross defects such as missing solder ball or bridges are easily detected using transmission X-ray techniques. Inadequate reflow of the solder paste and open joints are more difficult to detect, but inspecting the device from an angle can facilitate it. This allows the operator to inspect the shape of the solder connection as it forms onto the pad to verify that the pad is in contact with the solder ball and that the solder is completely wetted to the pad. Inadequate reflow of the solder paste may be seen as a jaggedness around the perimeter of the solder balls.

For BGAs having eutectic solder balls, a tear-drop pad design can improve the identification of open joints or inadequate reflow [9]. If the solder paste is properly reflowed and joined with the solder ball, the solder ball have a distorted shape, which is easily seen in the X-ray image. A tear-drop pad design can be useful also for the inspection of BGAs having high temperature balls and for CGAs, but that has not been verified. Since the balls and columns do not reflow for these components, the distortion of the solder joints can be expected to be less pronounced.

Still, for thick ceramic devices, boards with a very large number of layers and components on both side of the board, it can be impossible to inspect all solder joints using transmission X-ray techniques. Laminography techniques can then be a useful tool.

X-ray analysis is the only available non-destructive method for the inspection and detection of void in solder joints to area array devices. However, it is important to use this technique with caution. Many real time X-ray inspection systems have an X-ray imaging device that exhibits an aberration called "Voltage Blooming" [5]. The result is that the size of a void is affected by the voltage applied to the X-ray source. If the system has this type of aberration, a calibration is done by taking images of solder joints with voids having known sizes.

C.4.4 Microsectioning of solder joints

a. Destructive methods are used to verify the integrity of solder joints to these devices after Qualification testing.

NOTE Cracks in solder joints to area array devices are usually very difficult to detect using visual and X-ray inspection techniques.

b. The sample is moulded in a resin to alleviate chipping or destruction of the sample during microsectioning.

c. The resin has an added fluorescent agent.

NOTE This facilitates the detection of fine cracks in solder joints, but also in the PCB laminate.

C.4.5 Dye penetrant analysis

a. Dye penetrant analysis is used as follows to analyse the integrity of the solder joints after Qualification testing.

1. A low viscosity dye is applied to the sample, which penetrates any cracks or delaminated areas.
2. The dye is dried and the device is then removed, either by prying it away or by applying a pulling force at room temperature or higher.
3. The presence of dye on a solder pad indicates that a crack has been formed prior to the application of the dye. Cracks present in the PCB laminate beneath solder pads are also be coloured with the dye. Thus, coloured surfaces beneath solder pads that are ripped off during the removal of the device indicate the presence of laminate cracks after the Qualification testing.

NOTE For further details, see reference [5].

C.5 Verification testing

Due to the lack of stress relief on area array devices, thermo-mechanical stresses are more effectively transferred into the device and the PCB laminate. This can cause cracking of conductors connecting the solder pads, of the PCB laminate and within the device. Such cracking can be cause for rejection. Cracking of the PCB laminate beneath solder pads improves the fatigue life of the solder joints since it makes the joint more flexible. Therefore, it can lead to an overestimation of the fatigue life. That is, the fatigue life can be shorter under more benign conditions that do not cause cracking of the PCB laminate.

Annex D (Informative)
Example of an SMT audit report

CONFIDENTIAL once completed

SURFACE MOUNT TECHNOLOGY PROCESS AUDIT REPORT

SECTION 1	COMPANY DETAILS				
1. NAME					
2. ADDRESS					
3. TEL					
4. FAX					
5. MANAGING DIRECTOR					
6. QUALITY ORGANIZATION					
7. PRODUCTION ORGANIZATION					
8. SMT CONTACT PERSON					
9. SMT PRODUCT RANGE AND HISTORY (brief summary)					
10. Numbers of SMT operators		Design Engineers		QA	

CONFIDENTIAL once completed

SURFACE MOUNT TECHNOLOGY PROCESS AUDIT REPORT

SECTION 2	QUALITY SYSTEM					
1. QUALITY MANUAL* Reference: Issue: Date:					Viewed:	Y N
2. ORGANISATION OF THE QUALITY DEPARTMENT FOR SMT						
3. INTERNAL QUALITY AUDIT SYSTEM Reference: Date of last audit: Comments:					Viewed:	Y N
4. NON-CONFORMANCE SYSTEM Reference:	No. of NCRs in previous 12 months:		No. open at audit date:		Viewed:	Y N
5. CURRENT QUALITY APPROVALS Date of last assessment						
6 COMMENT ON COMMITMENT TO ADS.E.1136						
7. REFERENCE TO GENERAL ESA AUDIT						
DATE:						

* Note: Request that a copy of the Contents List of the Quality Manual be appended to this report (See Attachment 1).

CONFIDENTIAL once completed

SURFACE MOUNT TECHNOLOGY PROCESS AUDIT REPORT

SECTION 3	PROCESS CONTROL
1. SMT APPROVED (if any) Make reference to an existing list of SMT configurations considered already tested. Identify how the SMT was tested.	

2. Make reference to the procedures that have the following functions and identify current issue and date:	
1. Process instructions	Viewed: Y N
2. Workmanship acceptance/rejection criteria	Viewed: Y N
3. Calibration of SMT tooling	Viewed: Y N
4. Control of limited shelf-life materials	Viewed: Y N
5. Material procurement control with CofC or CofTest	Viewed: Y N

3. TRAINING Make reference to the procedure for operator and inspector training. Identify the number of certificated operators and inspectors.				
	Viewed:	Y N	Certificates viewed:	Y N

CONFIDENTIAL once completed

SURFACE MOUNT TECHNOLOGY PROCESS AUDIT REPORT

CHECK LIST			
1. Components storage and kitting area.		**2.** Solder paste dispensers	
3. Cleanliness in assembly areas		**4.** Hand Soldering iron (280 °C to 340 °C max)	
5. Calibration		**6.** Degolding bath (250 °C - 280 °C) Pretinning (210 °C - 260 °C)	
7. Lighting (min 1080 lux)		**8.** Is the soldering equipment well controlled (temperature-time profile, speed control)	
9. ESD protection and control		**10.** SMT Assembly Traveller (operator activities, inspector stamps)	
11. Humidity and temperature control		**12.** Cleaning Equipment	
13. Magnification aids		**14.** Cleaning Solvent is:	
15. Fume exhaust facilities		**16.** Cleanliness Testing ($< 1,6\ \mu g/cm^2$)	
17. PCB drying ovens and procedure		**18.** Conformal Coating used	
19. Cleanliness in conformal coating facilities		**20.** Staking compounds/ Adhesives used:	
21. Refrigerators: check expiration dates for staking compounds, conformal coatings		**22.** Bending tools	
23. Solder alloys used		**24.** Areas for Nonconforming Items (Quarantine)	
25. Solder fluxes (internal and external) used		**26.** Laboratories exist for: Temperature cycling Vibration Electrical testing Metallography	

END OF SECTION 4

SURFACE MOUNT TECHNOLOGY PROCESS AUDIT REPORT

SECTION 5 see Annex B

CONFIDENTIAL once completed

SURFACE MOUNT TECHNOLOGY PROCESS AUDIT REPORT

SECTION 6 FINAL ASSESSMENT

AN ASSESSMENT OF THE SURFACE MOUNT TECHNOLOGY LINE AT THE FOLLOWING SUPPLIER'S FACILITY HAS BEEN UNDERTAKEN AND THE FOLLOWING CONCLUSIONS MADE:

Supplier:

Address:

THE FACILITIES FOR THE ASSEMBLY OF SURFACE MOUNT TECHNOLOGY (ACCORDING TO ECSS Q-ST-70-38 AT THE ABOVE SUPPLIER'S SITE ARE CONSIDERED:

SUITABLE CONDITIONALLY SUITABLE NOTSUITABLE

SUMMARY OF FINDINGS/CONDITIONS OF APPROVAL/SUMMARY OF CORRECTIVE ACTIONS NECESSARY:

NAME SIGN

PROCESS ASSESSMENT CARRIED OUT BY APROVAL AUTHORITY:

IN PRESENCE OF (SUPPLIER):

DATE:

END OF SECTION 6

Annex E (informative) Additional information

E.1 X-Ray inspection equipment (to 6.8.7)

Various X-ray inspection equipment is available for the non-destructible inspection of SMD joints that are hidden beneath packages. This includes perpendicular transmission, angled transmission and automatic X-ray laminography systems.

X-ray inspection techniques and detectable defects are described in ESA STM-261 [1].

E.2 Melting temperatures and choice

Table E-1: Guide for choice of solder type

Solder type	Melting range (°C)		Uses
	Solidus	Liquidus	
63 tin solder (eutectic)	183	183	Soldering printed circuit boards where temperature limitations are critical and in applications with an extremely short melting range. Preferred solder for surface mount devices.
62 tin silver loaded	179	190	Soldering of terminations having silver and or silver palladium metallization. This solder composition decreases the scavenging of silver surfaces.
60 tin solder	183	188	Soldering electrical wire/cable harnesses or terminal connections and for coating or pretinning metals.
96 tin silver (eutectic)	221	221	Can be used for special applications, such as soldering terminal posts.
75 indium lead	145	162	Special solder used for low temperature soldering process when soldering gold and gold-plated finishes. Can be used for cryogenic applications.
70 indium lead	165	175	For use when soldering gold and gold-plated finishes when impractical to degold.
50 indium lead	184	210	This solder has low gold leaching characteristic.
10 tin lead	268	290	For use in step-soldering operations where the initial solder joint must not be reflowed on making the second joint (e.g. CGA columns, connections internal to devices)

Bibliography

[1] *ESA STM-261*, An Investigation into Ball Grid Array Inspection Techniques.

[2] *ESA STM-265,* Evaluation of Thermally Conductive Staking Compounds during the Assembly of Spacecraft Electronics.

[3] *ESA SP-1173*, Evaluation of Conformal Coating for Future Spacecraft Applications.

[4] *ESA STM-266,* Assessment of the Reliability of Solder Joints to Ball and Column Array Packages for Space Applications

[5] *IPC-7095*, Design and Assembly Process Implementation for BGAs, IPC, August 2000.

[6] *P.-E. Tegehall and B. D. Dunn*, Impact of Cracking Beneath Solder Pads in Printed Board Laminate on Reliability of Solder Joints to Ceramic Ball Grid Array Packages, ESA STM-267, ESA Publications Division, Noordwijk, 2003.

[7] *P.-E. Tegehall And B.D Dunn,* Assessment of the Reliability of Solder Joints to Ball And Column Grid Array Packages for Space Applications, ESA STM-266, ESA Publications Divisions, Noordwijk, 2003.

[8] *P. Wood and H. Rupprecht,* BGA and CSP Rework: What is involved? K. Gilleo (Ed.) Area Array Packaging Handbook, McGraw-Hill, Inc., 2001, Chapter 19.

[9] *M. Wickham, C. Hunt, D.M. Adams and B.D. Dunn,* An Investigation into Ball Grid Array Inspection Techniques, ESA STM-261, ESA Publications Divisions, Noordwijk, 1999.

[10] *ECSS-E-ST-10-03,* Space engineering — Testing.

[11] *ECSS-Q-ST-70-22,* Space product assurance — Control of limited shelf-life materials.

[12] *ECSS-Q-ST-70-28,* Space product assurance — Repair and modification of printed circuit board assemblies for space use.

[13] *ISO 9453,* Soft solder alloys - Chemical compositions and forms

ANNEX H: PRINTED CIRCUIT BOARDS REQUIREMENTS

Note: This annex has been modified at issue 03 of the PA requirements specification to remove the requirements relative to PCB design, and to replace them by applicability of the ECSS-Q-ST-70-12C (NDPA75).

CONTENTS

List of ANNEXES

1 SCOPE

This specification defines the technical, procurement and quality requirements for rigid, flexible, rigid-flex and HDI Printed Circuit Boards for space flight use.

This specification is applicable to suppliers to the end customer that procure non populated PCB's for their own equipments. For populated PCBs or sub lower tiers, these requirements shall be flowed down.

This end customer standard is based on the ECSS-Q-ST-70-10C , ECSS-Q-ST-70-11C and ECSS-Q-ST-70-12C it envelopes and requires additional requirements to the ECSS standards.

In this standard the requirements are specified in table format as follow :

Id	Requirement Text	

This standard may be tailored to the project specific requirements when necessary.

2 TERMS DEFINITIONS AND ABBREVIATED TERMS

2.1 TERMS FROM OTHER STANDARDS

For the purpose of this standard, the terms and definition from ECSS-Q-ST-70-10C apply.

2.2 TERMS SPECIFIC TO THE PRESENT STANDARD

HDI High Density Interconnect

Refers to PCB's that exhibit a greater circuit density than standard (ie defined in ECSS-Q-ST-70-10C), categorised by the inclusion of either or both of the following features:

µ-via – laser or mechanically drilled hole < Ø 150µm with an aspect ratio of 1:1 or less

Fine Line track width and gap sub 100µm

New design

Refers to new PCB routing, new stack-up, new article.

Technical Authority (for PCB's)

PCB Expert

Manufacturer

Entity that manufactures the PCB.

Supplier

Entity in charge of the PCB definition (i.e. equipment supplier)

Customer

End user of the equipment, i.e. spacecraft prime.

Continuity test under thermal cycling

Continuity test under thermal cycling could be, as an example, Interconnect Stress Test (IST) test coupon as defined in IPC TM 650 2.6.26 or similar test coupon.

Abbreviation terms

The following abbreviations are used in this document :

ADS	(End Customer) Space Document System	IEC	International Electro-technical Commission
CNES	Centre National d'Études Spatiales	IPC	Association Connecting Electronics Industries
DML	Declared Materials List	IR	Insulation Resistance
DWV	Dielectric Withstanding Voltage	MRR	(PCB) Manufacturing Readiness Review
ECSS	European Cooperation for Space Standardization	MPCB	Material and Process Control Board
ESA	European Space Agency	PCB	Printed Circuit Board
HDi	High Density Interconnect	PID	Process Identification Document
IAW	In Accordance With	RFD	Request for Deviation
		RFW	Request for Waiver

3 REFERENCES

3.1 RELATED DOCUMENTS

The following publications form a part of this document to the extent specified herein. Unless an issue is quoted for a document, the current issue is deemed to apply. When an issue is quoted, that issue and no other must be used. Throughout the text applicable documents are referred to as AD/(x) applicable document.

The documents hereunder listed are :

A : Fully applicable

E : Applicable except when an equivalent document is identified and has been submitted to Satellite Prime Contractor, for approval. Equivalent standard or internal contractor documents proposed to be applicable shall be mentioned in the compliance matrix to the End Customere & Space PA requirements and all the discrepancies between this document and the applicable one shall be identified by the contractor.

G : Guidelines (reference document). Some ECSS documents when called in draft issue in this document shall be applied in their latest issue when official release is issued.

3.2 APPLICABLE DOCUMENTS

E	**[AD 1]**	**ECSS-Q-ST-70-10C**	**Qualification of Printed circuit boards for space use**
E	**[AD 2]**	**ECSS-Q-ST-70-11C**	**Procurement of Printed circuit boards for space use**
E	**[AD 3]**	**MIL-PRF-55110**	**General Specification for rigid printed wiring boards.**
E	**[AD 4]**	**MIL-PRF-50884**	**Printed Wiring Flexible and Rigid Flex**
E	**[AD 5]**	**MIL-PRF-31032**	**Performance specification Printed Circuit Board Printed / Wiring board**
E	**[AD 6]**	**ECSS-Q-ST-70-12C**	**Design rules for printed circuit boards**

3.3 REFERENCE DOCUMENTS

The following documents contain background information relating to the subjects addressed and facilitate the implementation of the principles and processes here detailed (if no version is indicated, latest versions shall be used) :

Throughout the text reference documents are referred to as RD/(x)

G	**[1]**	**ECSS Q-ST-70-02C**	**Thermal vacuum out-gassing test for the screening of space materials**
G	**[2]**	**ECSS-Q-ST-20C**	**Space product assurance - Quality assurance**
G	**[3]**	**ECSS-Q-ST-10C**	**Space product assurance – product assurance management.**
G	**[4]**	**IEC 60326-2 am 1**	**Printed Boards part 2: Test methods**
G	**[5]**	**IPC-6011**	**Generic Performance Specification for Printed Boards**
G	**[6]**	**IPC-6012**	**Qualification and performance specification for rigid printed boards**
G	**[7]**	**IPC-6013**	**Qualification and Performance Specification for Flexible Printed Boards**
G	**[8]**	**IPC-6016**	**Qualification and Performance Specification for High Density Interconnect (HDI) Layers.**
G	**[9]**	**IPC-A-600**	**Acceptability of Printed Boards**
G	**[10]**	**IPC-2221**	**Generic Standard on Printed Board Design**
G	**[11]**	**IPC-2222**	**Sectional Design for Rigid Organic Printed boards.**
G	**[12]**	**IPC-2223**	**Sectional Design for Flexible Printed Boards.**
G	**[13]**	**IPC-4101**	**Specification for base materials for rigid and multilayer printed boards.**
G	**[14]**	**IPC-4204**	**Flexible Metal Clad Dielectrics for use in Fabrication of Flexible Printed Circuitry.**
G	**[15]**	**IPC TM-650**	**IPC test methods manual.**
G	**[16]**	**prEN9102**	**Aerospace series Quality Systems First Article Inspection**
G	**[17]**	**QT/2013/681/SH**	**High resistance electrical test for PCBs**

4 GENERAL REQUIREMENTS

4a	The requirements of this document apply to all suppliers involved at all levels in the supply of electronic equipment using Printed Circuit Boards for the End Customer.	

5 TECHNICAL REQUIREMENTS

5.1 PRINTED CIRCUIT BOARD TECHNOLOGY

51a	The requirements of this document are applicable to the following technologies (including sequential lamination): - Double sides with plated holes - Multilayer - Rigid Flex - Flexible - HDI	

5.2 MATERIALS

5.2.1 Material reference

521a	The supplier shall provide the commercial reference of all the materials used in the PCB and the material manufacturer name, per requirements of §7.8.2.	

5.2.2 Material definition on drawing

522a	All materials used shall be required to conform to the release levels specified on the engineering drawing by the supplier.	

522b	All materials used shall be required to conform to the standards specified on the engineering drawing by the supplier.	

5.2.3 Material restrictions

523a	Mixing material/resin systems to produce Printed Circuit Board, even if procured from the same supplier, shall be qualified together (separate qualification of each material is not sufficient).	

523b	Neltec 7000-1 shall be forbidden for both PCB cores & pre-preg.	

5.2.4 Number of prepreg

524a	The insulation distance between two conductive layers shall be achieved by a minimum of two plies (layers) of pre-preg (regardless of glass to resin ratio) or a PCB laminate fabricated from two plies or a combination of pre-preg and laminate with at least two plies. A maximum of three pre-preg layers shall be used between each laminate.	

5.3 PCB SURFACE FINISH

5.4

53a	Fused tin lead only shall be used for PCB surface finish. When required by design, PCB surface finish may use locally electroplated hard/soft nickel gold. Any other surface finishes shall be submitted to the End Customer for approval.	

5.4 PCB ELECTRICAL TEST

54a	The PCB’s shall be electrically tested using: - Circuit continuity	

	- Insulation resistance according to RD 17	

5.5 PCB DESIGN DATA

55a	No change are allowed to the design data by the PCB manufacturer without written permission from the equipment supplier, except compensation for manufacturing processes. The equipment supplier shall maintain a configured record of all changes to the design data.	

5.6 QUALIFICATION FOR PCB TECHNOLOGY

5.6.1 Qualification content

561a	The supplier shall perform a qualification for each technology covering as a minimum: - Assembly simulation (material integrity, peel strength, electrical measurements) - Rework simulation IAW assembly process - Material integrity, peel strength, electrical measurements after 3x thermal stress 288°C/10s and after cumulative stress test. Cumulative stress test includes assembly simulation, rework and thermal cycling. - Environmental testing (material integrity, peel strength, electrical measurements after thermal cycling & damp heat) - For complex PCB's (≥ 12 layers, Sequential lamination, rigid flex, HDI), continuity test under thermal cycling on a dedicated test coupon.	

5.6.2 Acceptance for the qualification of PCB's

562a	Acceptance criteria shall be according to ECSS-Q-ST-70-10C.	

562b	For the continuity test under thermal cycling, the change of resistance shall be <10% after 400 cycles minimum @ 170 °C maximum for polyimide base material (150°C for FR4 base material). The test coupon shall be preconditioned using a simulation of both assembly and rework thermal profiles.	

562c	Laminate integrity shall be evaluated according to § 7.11.2c.	

5.6.3 Qualification frequency

563a	The supplier shall define qualification and maintenance of qualification frequency.	

5.7 TEST COUPONS

5.7.1 Test coupon number

571a	All flight PCB's shall be required to be produced with two sets of coupon samples per panel enabling inspection to be performed iaw §7.10.2.a.	

5.7.2 Test coupon design

572a	Test coupons design shall be representative of the PCB. Test coupon location in the manufacturing panel shall be representative of the worst case (for mis-registration, plating thickness and materials dielectric thickness). Planes shall be included on the same layers as the PCB. Non-functional pads shall be removed to the same extent as the PCB. Holes sizes (Plated through holes + vias holes) and their associated pads shall match the PCB. The minimum track width and gap shall be included for each layer. Surface finish shall be representative of the PCB. All plating, drilling, lamination sequences shall be included in the test coupon to ensure evaluation according to the test coupon evaluation flow.	

	The test coupon design patterns shall ensure that the minimum coupon sample requirements of ECSS-Q-ST-70-11C plus other requirements defined in § 7.11.2 are met and exceeded. The coupons shall be defined to allow submission to and submitted to the following tests for the purpose of qualification (§5.6.1.a) and incoming inspection flow (§7.10.2.a): - Rework Simulation - Thermal Stress, Plating Thickness - Thermal stress, inner layer interconnect integrity - Plating Thickness - Peel strength - Moisture and Insulation resistance - Inter-layer dielectric withstanding voltage. - Interconnection resistance, Flexural stress - Continuity test under thermal cycling on a dedicated test coupon	

5.8 PCB DESIGN

58a	ECSS-Q-ST-70-12C shall apply for PCB design rules.	

58b	Exceptions to the rules as defined in ECSS-Q-ST-70-12C shall be reported during MPCB and approved by the End Customer.	

5.8.1 PCB design procedure

5.8.1.1 Component footprint definition

5811a	Component footprints shall be controlled so that they can be traced to a component assembly qualification.	

5.8.1.2 Component footprint definition

5812a	All documentation for manufacture and assembly of the PCB shall be archived, along with the native design files and a non-modifiable version of the artwork for 10 years.	

6 PROCUREMENT REQUIREMENTS

6.1 PROCUREMENT SPECIFICATION

61a	The supplier shall use a procurement specification for the Printed Circuit Board supply.	

6.2 PROCUREMENT SPECIFICATION CONTENT

62a	The procurement specification for the Printed Circuit Board shall cover as a minimum the following requirements: - Materials, including forbidden materials - Technical contract review, MRR and DRB - Change - Rework/repair - Traceability - Labelling of PCB's - Outgassing - PCB and test coupon procurement flow - PCB and test coupon inspection flow - PCB and test coupon acceptance criteria - Test coupon definition - First Article Inspection - PCB handling and storage - PCB packaging - Delivery documentation, Certificate of Conformance content - Retention of records - Shelf life - Qualification and maintenance of qualification	

6.3 DATA SUPPLY

63a	Data to be supplied to the PCB manufacturer by supplier shall as a minimum consist of the procurement specification, article drawing and data files conforming to either Gerber X or ODB++ format.	

7 QUALITY REQUIREMENTS

7.1 TECHNICAL CONTRACT REVIEW

71a	The PCB manufacturer shall perform a technical contract review covering as a minimum: - Full technical risk analysis of the proposed design - An accurate representation of the actual 'stack up' applicable to the PCB design - The PID applicable to the product being procured - A statement of compliance to the PID including notification of all deviations to qualified process	

7.2 MPCB

72a	MPCB shall be performed by the End Customer, including: - Technology review, covering the features described in Appendix A - Approval sheet for Printed Circuit Board review, covering the features described in Appendix B - Qualification report review - Qualification report for HDI technology shall be provided 2 weeks minimum before MPCB - PCB design rules review and RFD to the design rules	

7.3 MANUFACTURING READINESS REVIEW FOR PRINTED CIRCUIT BOARD

73a	The supplier shall perform a Manufacturing Readiness Review for Printed Circuit Board covering as a minimum: - Technical contract review - Traceability of the design modification - Stackup definition - Risk assessment - PID reference and issue - Deviation with respect to PID	

7.4 DELIVERY REVIEW

74a	The supplier can perform a delivery review at the PCB manufacturer premises.	

7.5 PROCESS IDENTIFICATION DOCUMENT (PID)

7.5.1 PCB supplier name

751a	The supplier shall provide the name of the PCB manufacturer.	

7.5.2 PID content

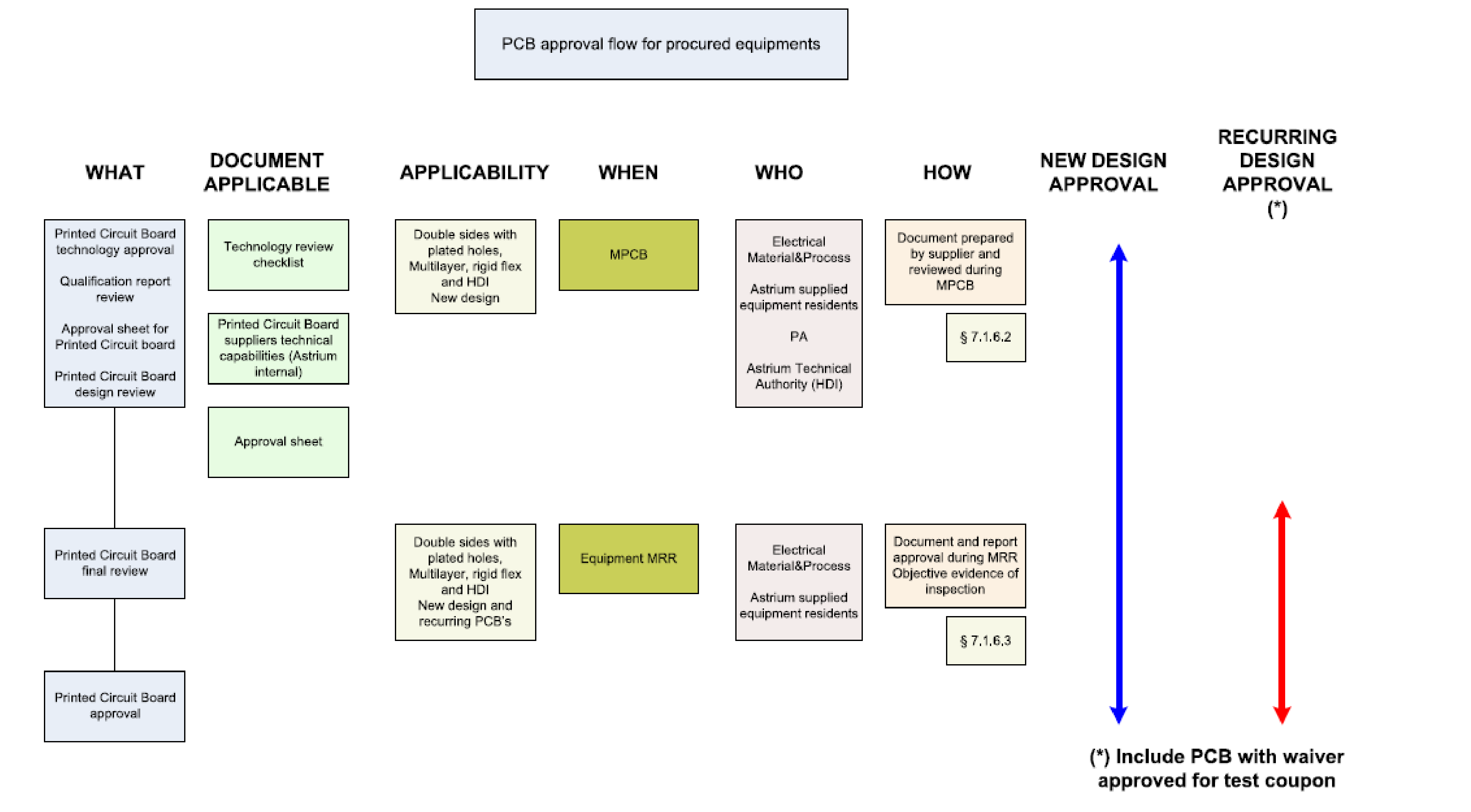
752a	The PID shall comprise of a fully comprehensive list of ALL process and procedures utilised in the production of the PCB, the PID shall include the issue status of all procedures in use and shall contain reference to key processing equipment.	

7.5.3 PID reference and issue

753a	The supplier shall provide reference and the revision of the PID used for the PCB manufacturing.	

7.6 PRINTED CIRCUIT BOARD APPROVAL

7.6.1 Printed Circuit Board Approval flow



7.6.2 Printed Circuit Board Approval during MPCB

762a	The Printed Circuit Board approval shall be done during MPCB using: - The approval sheet for Printed Circuit Board (Appendix B) - The technology review checklist for Printed Circuit Board (Appendix A) The qualification report shall be reviewed during MPCB in order to bring the evidence that the qualification indeed covers the application PCB design. The approval sheet and the technology checklist shall be approved by the supplier and the end customer. The approval sheet and the technology checklist shall be available for the end customer Technical Authority review. The approval is applicable to new design for Double sides with plated holes, Multilayer, Rigid flex and HDI Printed Circuit Board technologies.	

7.6.3 Printed Circuit Board Approval during equipment MRR

763a	The Printed Circuit Board approval shall be done during equipment MRR using: - Printed Circuit Board inspection report - Test coupon inspection report The test coupon sample (microsections) shall be available during MRR. Procurement specification, RFW during manufacturing and change are reviewed during MRR. The approval is applicable to new and recurring design for Double sides with plated holes, Multilayer, Rigid flex and HDI Printed Circuit Board technologies.	

7.7 REWORK AND REPAIR

77a	Rework or repair of any un-populated flight quality level PCB is not permitted.	

7.8 DOCUMENTATION

7.8.1 Declared Material List

781a	The supplier shall issue a DML for each equipment in an editable electronic format identifying all Printed Circuit Boards.	

7.8.2 Declared Material List content

782a	The content of the DML shall be in conformance with the following list of items: - Number - Commercial identification - Chemical nature/type of product - Manufacturer/specification - Summary of processing - Use and location - Environment code - Size code - Outgassing - Justification for approval - Approval sheet for Printed Circuit Board reference	

7.8.3 Documentation review and approval

783a				
DOCUMENT	SUBCLAUSE	SUPPLIER	END CUSTOME	WHEN
Technology qualification report	5.6	Approval	Review	MPCB
HDI technology qualification report	5.6	Approval	End Customer Technical Authority Approval	MPCB
PCB design review	5.8	Approval	Approval	MPCB
PCB visual inspection report	7.10.1	Approval	Approval	Equipment MRR
Test coupon inspection report	7.10.2	Approval	Approval	Equipment MRR
Procurement specification	6.2	Approval	Review	MPCB + Equipment MRR
RFW during manufacturing		Approval	Review	Equipment MRR
Approval sheet for PCB	Appendix B	Approval	Approval	MPCB
Technology review for PCB	Appendix A	Approval	Approval	MPCB
Change		Approval	Review	Equipment MRR
Procedure for incoming inspection	6.2	Approval	Review	MPCB
Procedure for test coupon analysis	6.2	Approval	Information	MPCB
DML	7.8.2	Approval	Approval	MPCB

7.9 TRACEABILITY

7.9.1 PCB's and test coupons

791a	All PCB's and associated Test Coupons shall be identified in such a manner as to give full traceability of each supplied circuit to the individual manufacturing panel, the manufacturing batch and to the material batches utilised. Test coupons shall be suitable for evaluation according to the test coupon inspection requirements.	

7.9.2 Date code and reference

792a	All PCB's (100%) shall be identified and shall contain as a minimum a unique reference and a date code.	

7.10 INCOMING INSPECTION REPORT

7.10.1 PCB visual inspection

7101a	All PCB's shall be visually inspected (magnification x10) by PCB manufacturer and supplier. Inspection results shall be compiled in a report. Inspection results according to acceptance criteria defined in § 7.11 shall be included in the report.	

7.10.2 Test coupons inspection flow

7102a	All test coupons shall be required to be evaluated by PCB manufacturer and supplier for: - Materials integrity (after thermal stress and rework simulation) - Dielectric and copper thickness - For complex PCB's (≥ 12 layers, Sequential lamination, rigid flex, HDI), continuity test under thermal cycling - For rigid flex PCB's, material integrity after bending test Inspection results shall be compiled in a report. Test coupons shall be available for inspection. Inspection results according to acceptance criteria defined in § 7.11 shall be included in the report.	

7.10.3 Test coupon witness

7103a	A full set of test coupon shall be archived for further evaluation if needed. Archive test coupons and microsections shall be stored for 10 years.	

7.11 LOT ACCEPTANCE CRITERIA

7.11.1 Basic requirements for test coupons and PCB's acceptance

7111a	Acceptance criteria shall be according to ECSS-Q-ST-70-11C.	

7111b	In case an acceptance criteria is not covered by ECSS-Q-ST-70-11C, as a generic rule, IPC documents (R/D5 to R/D14) will be used as a reference for acceptance. Level class 3A for rigid and 3 for flex will be used for acceptability.	

7.11.2 Other requirements for test coupons acceptance

7112a	For the test coupons evaluation after thermal stress, the samples shall be submitted to 3 times thermal stress (288°C/10 seconds according to IPC TM 650 method 2.6.8) and not only 1 time like described in ECSS- Q-ST-70-11C.	

7112b	For the continuity test under thermal cycling, the change of resistance shall be <10% after 400 cycles minimum @ 170 °C maximum for polyimide base material (150°C for FR4 base material). The test coupon shall be preconditioned using a simulation of both assembly and rework thermal profiles.	

7112c	Laminate integrity, voids and cracks: Voids that originate in thermal zone and extend outside thermal zone or are entirely outside thermal zone shall not be in excess of 80 µm.	

	The thermal zone extends 80µm beyond the end of the land, either internal or external extending furthest into the laminate area. Multiple voids between two adjacent plated through holes in the same plane shall not have a combined length which exceeds these limits. Laminate cracks up to a maximum of 80µm in thermal zone shall not be evaluated. Cracks between two uncommon conductors in either the horizontal or vertical direction shall not decrease the minimum dielectric spacing beneath that specified by the engineering drawings by the supplier.	

APPENDIX A **Technology review for Printed Circuit Board (Guideline)**

Technology Review for Printed Circuit Board

Printed Circuit Board summary drawing sheet		
		Actual value - worst case (Filled by supplier)
Number layers/sequence	Rigid	
	Flex	
	Drilling sequence	
	Lamination sequence number	
Thickness/size	PCB Size (mm)	
	PCB Thickness (mm)	
	External min Cu thickness (µm)	
	External max Cu thickness (µm)	
	Internal min Cu thickness (µm)	
	Internal max Cu thickness (µm)	
Material (Commercial reference Manufacturer name)	FR4	
	HTg FR4	
	Polyimide	
	Flexible	
	PTFE	
	Mixed materials	
	Metal core	
Surface finish	Sn/Pb reflow	
	Ni/Au electroplated (Hard/soft)	
	ENIG	
	Tin diffusion layer	
	Soldermask	
Design features (µm)	External trace width	
	External space width	
	Internal trace width	
	Internal space width	
	Min Z insulation thickness	
Min hole size (µm)	PTH	
	Blind	
	Buried	
	Microvia	
Aspect ratio	PTH	
	Blind	
	Buried	
	Microvia	

Design review checklist approval		
Supplier approval	Date	
Astrium approval	Date	

APPENDIX B Approval sheet for Printed Circuit Board

Approval sheet for Printed Circuit Board					
Manufacturer / country					
Backup manufacturer					
Technology	ML				
	Flex				
	HDI				
Pure tin free	(Y/N)				
Generic specification		Issue		Revision	
Detail specification		Issue		Revision	
Quality level	ECSS, MIL, IPC, ADS.E.1029				
Approval status					
QML ECSS-ST-Q-70-10					
PID		Issue		Revision	
QML MIL-PRF-31032					
Other approval:					
Evaluation programme required:	(Y/N)				
If yes, reference of the evaluation programme					
Procurement inspections and tests					
Visual inspection 100%	(Y/N)				
Test coupon DPA	(Y/N)				
Test coupon analysis per production pane	(Y/N)				
Buy off	(Y/N)				
Approval					
Supplier approval		Date			
Astrium approval		Date			

ANNEX I: FUSION WELDING OF METALS

ANNEX I Table of contents

1 SCOPE / APPLICABILITY

This standard establishes the requirements for manual and automatic, fusion welding for space flight applications and special test equipment used for testing flight hardware.

Welding processes are classified critical (see § 6.2 for tests and controls to be done for Qualification). After Qualification, they are considered as requiring special surveillance (see § 6.3 for tests and controls to be done for Serial Production).

APPLICABILITY :

This standard recommends engineering practices for the end customersprograms and projects. It may be cited in contracts and program documents as a technical requirement.

APPLICABLE PROCESSES :

This standard covers all fusion processes used for joining metallic materials. This includes, but is not limited to:

Gas Tungsten Arc Welding (GTAW) / Tungsten Inert Gas (TIG),

Plasma Arc Welding (PAW) / Plasma of Transferred Arc (PTA),

Electron beam welding (EBW),

Laser beam welding (LBW).

PERSONNEL :

This specification requires qualified personnel.

2 CLASSIFICATION

Welding within the scope of this specification is classified in accordance with the following and shall be specified in engineering drawing.

2.1 SAFETY CLASS 1

Class 1 joints are critical and structural. Failure of a Class 1 joint would result in loss of spacecraft, major components or loss of control of the spacecraft. Class 1 joints shall have the highest level of scrutiny in term of acceptance appropriate to criticality of performance including internal and external weld integrity verification.

2.2 SAFETY CLASS 2

Class 2 joints are noncritical but structural and shall be considered fail safe – their failure could reduce the efficiency of the system but not cause the loss of the spacecraft. Class 2 joints shall require weld integrity verification (either external, internal, or both) appropriate for the intended use.

2.3 SAFETY CLASS 3

Class 3 joints are noncritical and non-structural and are contained so that failure will not affect other flight elements. These joints shall require minimal weld integrity verification; the controls are mainly visual.

2.4 SENSITIVITY CLASS (A, B, C)

Specific imperfections have to be tolerated in a welded joint, depending on the material and relevance involved. These differ by their nature and size and are assigned for the purpose of quality inspection to three acceptance levels (A, B or C) according to the compliance with the component requirement. Level A represents the more stringent requirements.

3 REFERENCES

3.1 REFERENCE DOCUMENTS

- ECSS-Q-ST-20 : Quality Assurance
- ECSS-Q-ST-70 : Materials, mechanical parts and processes
- DIN 29595: fusion welded metallic components – requirements

3.2 APPLICABLE DOCUMENTS

- ISO 6506: Metallic materials-Brinell hardness test
- ISO 6507: Metallic materials-Vickers hardness test
- ISO 6508: Metallic materials-Rockwell hardness test
- ASTM E3: standard guide for preparation of metallographic specimens
- ISO 14744-1: welding – acceptance of EBW machines – Part 1: principles and acceptance conditions
- ISO 14744-2: welding – acceptance of EBW machines – Part 2: measurement of accelerating voltage characteristics
- ISO 14744-3: welding – acceptance of EBW machines – Part 3: measurement of beam current characteristics
- ISO 14744-4: welding – acceptance inspection of EBW machines – Part 3: measurement of welding speed
- ISO 14744-5: welding – acceptance of EBW machines – Part 5: measurement of run-out accuracy
- ISO 14744-6: welding – acceptance of EBW machines – Part 6: measurement of stability of spot position
- ISO 22827-1: acceptance of Nd: YAG LBW machines – Part 1: laser assembly
- ISO 22827-2: acceptance of Nd: YAG LBW machines – Part 2: moving mechanism
- ISO 15609-1: specification and qualification of WPS – Part 1: Arc Welding
- ISO 15609-3: specification and qualification of WPS – Part 3: Electron Beam Welding
- ISO 15609-4: specification and qualification of WPS – Part 4: Laser Beam Welding
- ISO 16644-1: clean rooms and associated controlled environments
- ISO 17636: NDT of welds– radiographic examination of fusion welded joints
- ISO 17637: visual examination of fusion welded joints
- ISO 17640: ultrasonic inspection of welded joints
- ASTM E164: standard practice for ultrasonic testing of weldments

- ISO 24394: welding in aerospace – qualification test of welders and welding operators – welding of metallic components
- DIN EN 571-1 / ISO 3452-1: NDT – penetrant testing
- AMS 2644: inspection material, penetrant
- QPL-AMS 2644: qualified product list of products qualified under performance specification AMS 2644
- ISO 4063: welding and allied processes – nomenclature of processes and reference numbers
- ISO 4136: destructive tests on welds in metallic materials – transverse tensile tests
- ISO 6520-1: welding and allied processes – classification of geometric imperfections in metallic materials – Part 1: fusion welding
- ISO 14731: welding coordination – tasks and responsibilities
- DIN EN 4179 / NAS 410 / ISO 9712: certification and qualification of NDT personnel
- ISO 14175: Welding consumables - gases and gas mixtures for fusion welding and allied processes
- ISO 6848: Arc welding and cutting – non-consumable tungsten electrodes
- ISO 23461: non conformance control system

3.3 TERMINOLOGY & ABBREVIATIONS

DML: Declared Material List defined in ECSS-Q-ST-70

FAI: First Article Inspection

Fail-safe: the failure could reduce the efficiency of the system but not cause the loss of the system

Heat-affected zone (HAZ): The portion of the base metal that was not melted during welding, but whose microstructure and mechanical properties were altered by the heat.

Job card: see shop traveller

Machine welding. Welding with equipment that performs the welding operation

Maintenance book: –record of any modification and investigation on equipment

Manual welding. A welding operation performed and controlled completely by hand.

NCR: Non Conformance Report

NC: Non Conformity

Production Run: a welding run corresponding to the same sample coupons, the same material lot and the same post-thermal treatment (if any)

Qualification Test Plan (QTP) / Qualification Test Record (QTR): A document providing the actual welding variables used to produce an acceptable test weld (qualification test plan) and the results of tests conducted on the weld for the purpose of demonstrating process and procedural capability and repeatability (Qualification test report). Demonstration of capability qualifies the welding procedure.

Router: see shop traveller

Shop traveller: document recording the complete weld process, the repairs done on the weld, malfunction of equipments, reference of sample welded, inspections

Welder: a person who performs manual welding

Welding Inspector: A certified individual with the responsibility and ability to judge the quality of the welded specimens in relation to some form of written specification. Welding inspectors shall be entitled by relevant national or federal authority, as for example DIN EN 4179 or equivalent (e.g. NAS 410).

Welding operator: a person who operates welding equipment used to perform mechanized welding

Welding Procedure Specification (WPS): A document providing in detail the required variables for a specific application to ensure repeatability by certified welders and welding operators. The WPS is under the responsibility of the Welding Supervisor. The WPS is documented according to ISO 15609-1 (GTAW / PAW), ISO 15609-3 (EBW) or ISO 15609-4 (LBW).

Weld schedule: Welding Procedure Specification

Welding Supervisor: person in charge of welding coordination and who is responsible of the WPS.

Reweld: an additional weld pass according to a qualified weld procedure to eliminate defects. Traceability shall be insured (e.g. NCR, shop traveller).

Repair weld: any weld is not covered by the basic qualification.

MEOP: Maximum Expected Operating Pressure

RFA: Request For Approval

NDT: Non Destructive Tests

US: Ultrasonic inspection

4 GENERAL REQUIREMENTS

4.1 WELD AND TEST PERSONNEL

In order to ensure proper performance of welding work, the following condition shall be fulfilled :

a) The plant shall appoint a welding supervisor who is responsible for all welding technical aspects. The welding supervisor is responsible to prepare the WPS. Welding Supervisor responsibility shall be in accordance with ISO14731.

For companies which cannot appoint a welding supervisor (e.g. SMEs), the validation of WPS must be done by one the following possibilities:

- The National Welding Institute of the state/country in which is located the welding company,
- A Welding Coordinator who was trained by the National Welding Institute of the state/country in which is located the welding company. The Welding Coordinator must be approved by the end customer.
- Awelding supervisor from the end customer if the previous possibilities are impossible.

b) Only welders and welding operators holding a valid qualification test certificate are allowed to perform welding operations on the equipment. The welders and weld operators shall be assigned and briefed by the responsible welding supervisor. Certification and re-qualification of welders and welding operators shall be established in accordance with ISO 24394. The “welding certificate” is delivered by an external organism (or internal authorized person).

c) NDI/NDT qualified Inspectors shall be qualified per ISO 9712 or equivalent (e.g. NAS 410 or DIN EN 4179).

The personnel for inspection shall be assigned and briefed by the responsible qualified inspector. The Qualification and certification of inspection personnel shall be in accordance with ISO 9712 or equivalent (e.g. NAS 410). Visual, dye penetrant and radiographic testing shall be performed by a welding inspector, in accordance with ISO 9712 or equivalent (e.g. NAS 410 or DIN EN 4179).

All personnel in use shall be experienced with the respective processes and shall have the required abilities to use weld and NDI/NDT equipment.

4.2 EQUIPMENT AND FACILITIES

4.2.1 Welding Equipment

Automatic and semiautomatic welds shall be accomplished using equipment containing calibrated dials, meters, or recorders that quantitatively indicate process parameters.

All joining equipment (including manual) shall be capable of producing joints that meet the requirements specified herein.

General acceptance tests at Welding equipment shall fulfil the following requirements :

- EBW: ISO 14744 (see applicable documents)
- LBW: ISO 22827 (see applicable documents)
- TIG: see Table 1

	VARIATION
Process / Parameters	GTAW and PAW
Max. allowable current change caused by lightning arc length changes	± 3 %
Min. current for direct current (DC)	< 3 A
Min. current for alternating current /AC)	< 10 A
Repeating accuracy for current values > 100 A	± 1 %
Repeating accuracy for current values ≤ 100 A	± 1 A
Max. allowable current change for ± 10% voltage current changes	± 1 %
Current up- slope and down- slope must be linear, time values for both sectors	0- 10 s
Pulse mode, repeating accuracy of time adjustment range	≤ 3 %
DC mode; ripple quality for 10%, 50% and 100% weld current	≤ 5 %
AC mode; stepless adjustment of half wave shift for 10%, 50% and 100% weld current	20- 80%
Ignition capability for DC	< 3 A
Ignition capability for AC	< 10 A

Table 1 : weld settings allowable variation from qualified Arc Welding machines

Note : from experience it is also useful to state a tolerance value of max. 2% for the voltage (regulated value) in the case of automated welding processes.

It is required to calibrate and demonstrate the capability of the equipment according to requirements mentioned in this section.

Re-acceptance of an equipment is necessary under either of the following condition :

- After severe repair operation,
- After relocation of the welding equipment,
- After installation of electrical components which can affect any welding parameter.

It is to be decided by the welding supervisor if a re-acceptance is necessary.

The weld equipment shall be monitored and maintained within 12 month period.

Measuring instruments, meters, gages, or direct reading electrical control circuits to be used for automatic, semiautomatic, and machine joining operations shall be initially calibrated and periodically recalibrated (Max 12 months) to maintain adequate performance or when any maintenance is performed that may have changed calibration.

All maintenance operations have to be documented (e.g. in the Maintenance Book).

4.2.2 Maintenance of welding equipment

A Maintenance Book shall insure the traceability of all maintenance operations. Records shall be located close to the welding machines.

4.2.3 Tooling and fixtures (related to the weld itself)

Tooling and fixtures used in the joining operation shall be constructed of nonmagnetic materials (EBW) that do not affect the welding arc or beam, or that are not detrimental to the weld quality. Tooling and fixtures shall not be a source of contamination to the joint. Magnetic materials, when used, shall be degaussed prior to welding. Degaussing shall be controlled by the Welding Supervisor when necessary for the successful completion of the weld.

Tooling and fixtures shall ensure compliance with dimensions identified in the QTP and shall be identified on the WPS.

Shielding material within 2 cm of the root of the weld shall be from the same alloy as the material being welded. Deviations from this rule must be justified in the qualification plan as well as in the qualification documentation and must be approved during qualification.

4.2.4 Environmental condition

All flight hardware welding shall be performed under following general environmental conditions:

a) Room Temperature : 22 ± 3°C;

b) Relative Humidity : < 65%; for structural Aluminium alloys a relative humidity < 60 % is required

For Critical welds (safety classes 1&2), welding equipment has to be separated to prevent any contamination from other machines (e.g. milling set-up) shop

If cleanliness conditions are changed, the welding supervisor has to check if requalification is necessary.

The welder or welding operator is responsible for the equipment cleanliness.

4.2.5 Clothing requirements

The welders, welding operators and all other personnel involved in the welding process have to wear lint free clothing and lint free gloves for assembly and welding of flight hardware. It has to be insured that no pollution of the weld interface and the relevant piece parts may occur.

4.3 MATERIALS AND CONSUMABLES

Materials used during processing shall conform to the applicable standard or specification, and shall be capable of being used for the purpose for which they are intended.

4.3.1 Base materials and filler metals

Unless otherwise specified or approved by the end customer, base metal alloy and filler metal shall conform to applicable industry specifications for each given alloy group. The base metals and filler metal shall be ordered and provided with lot specific certificates of compliance (versus applicable purchase specifications). The base metal, material condition, and appropriate specification shall be recorded as a part of the WPS. Weld start and runoff tabs, when used, shall be of the same alloy as the material being joined and shall be welded with the same filler metal specified on the drawing or WPS.

It is required to avoid any mixture and degradation during the storage of filler materials. Filler material identification & traceability shall be demonstrated.

4.3.2 Shielding gas

Welding-grade gases conforming to the applicable industry or military specifications shall be used for gas shielding when required. The shield gas type and flow rates shall be recorded as a part of the WPS.

Welding with GTAW, PAW, GMAW and LBW needs generally to use a shielding gas (Argon) both on weld face and weld root to protect welds from oxidation except for Al alloys and steels.

The shielding gases shall be ordered and provided with a lot specific certificate of compliance (versus applicable purchase specifications) and the purities shall be compliant with Table 2.

The minimum purities and dew point required are summarized in the table 2.

	Purity	Moisture
ARGON	Ar: 99.998 % min O: 2 ppm max	H_2O < 3 ppm
HELIUM	He: 99.998 % min O: 2 ppm max	H_2O < 3 ppm
NITROGEN	N2: 99.998 % min O: 2 ppm max	H_2O < 3 ppm

Table 2 : shielding gas purity –gas mixture can be used with the same level of purity

4.3.3 Tungsten electrodes

The electrode diameter, tip shape and alloy composition shall be recorded as a part of the WPS.

4.4 ELECTRON BEAM WELDING (EBW) & LBW ALIGNEMENT

Alignment may have to be determined by establishing index points at both ends of the weld or at intervals not to exceed 1/3 for the length of the weld.

Alignment and position of parts and tooling are verified prior welding and shall be documented for critical application (safety class 1&2); the results are recorded in the shop traveller.

4.5 HANDLING AND PACKAGING

The handling and packaging before welding must guarantee that the weld to be done on the piece part will be representative of the weld done during qualification.

All personnel in use shall be experienced with the respective processes and shall have the required abilities to handle the used weld and test equipment.

For spacecrafts components and raw materials, packaging shall be handled in a manner which prevents damage and contamination even during different manufacturing steps.

Lint free gloves shall be worn whenever parts are to be handled to help prevent contamination.

4.6 MANUFACTURING DOCUMENTS

4.6.1 General

Prior to the start of manufacturing (in sense of this specification) the following documents shall be available and approved by the Welding Supervisor :

a) Complete set of drawings, including released weld stamp;

b) Appropriate manufacturing parameters (WPS).

4.6.2 Drawings

The drawing for welded components shall contain all necessary information regarding materials, processes, weld joint design and inspection requirements.

Essential features for all welds shall be completely described, either on the engineering drawing or in referenced supporting documentation. When necessary, the engineering drawing shall show the profile (cross section) of a complex joint with sufficient detail for the fabricator to determine essential features at any position along the length of the weld.

Every drawing that shows weld seam must contain a weld stamp defining :

1) Base material type and condition at the time of welding (e.g. thermal treatment, stress hardening etc.),
2) Filler metal type, commercial appellation or autogenous weld (without filler),
3) Post weld mechanical and/or thermal treatment,
4) Welding process number per ISO 4063,
5) Welding safety class (1, 2 or 3),
6) Welding sensitivity class (A, B, or C),
7) Additional inspection methods plus acceptance criteria if applicable.

All information mentioned above can be summarized in a weld stamp approved by the Welding Supervisor. An example of suitable stamp is shown in Table 3.

<table>
<tr><td colspan="2">Thermal joining is accordance with</td></tr>
<tr><td rowspan="2">Process n°:
(as per ISO4063)</td><td>Welding safety class</td></tr>
<tr><td>Welding sensitivity class</td></tr>
<tr><td>Base metal</td><td>Filler metal</td></tr>
<tr><td colspan="2">Additional Inspection
-Visual Dimension
- X-ray or US
- Penetrant test
- Other</td></tr>
<tr><td>Post-weld treatment</td><td>Welding Supervisor
Date Signature</td></tr>
<tr><td colspan="2">Further details</td></tr>
</table>

Table 3 : weld stamp (example)

5 WELD PROCEDURE SPECIFICATION (WPS) AND MANUFACTURING

All weld produced to the requirements of this standard shall be completed in accordance with a written welding process specification (WPS).

The Minimum WPS content are defined in ISO 15609.

Variables considered essential shall be identified on the WPS (see terminology definitions)

5.1 PREPARATION

5.1.1 Joint configuration and preparation

Acceptable joint designs are butt, overlap, corner, tee, and edge. All joints shall be documented on a WPS, design drawing, or other suitable document.

Joint design and dimension are specified in engineering drawing.

Surface roughness shall be compatible with process be representative of the qualification.

The joint configuration has to be approved by the Design Authorities.

5.1.2 Cleanliness

It has to be insured that no pollution of the weld interface and the relevant piece parts may occur.

Preweld cleaning of contaminants detrimental to weld quality on filler materials and surfaces to be welded shall be accomplished in an environment which will not degrade the quality of the weld. Contamination of filler materials shall be controlled.

All surfaces adjacent to welds shall be free of foreign material (oxide, paint, grease, oil, dirt, organic residues,…). When solvent cleaning does not remove contaminants, surfaces can be mechanically, abrasively, chemically or electrochemically cleaned as accepted during qualification.

Pre-weld cleaning procedure shall be included in the WPS.

The cleaning procedure shall indicate the maximum time authorized between the final cleaning and welding.

Pre-weld joint fit-up is under design authority responsibility.

5.1.3 Tack welds

Tack weld shall be clean and free of cracks. If filler metal is used, use the same filler metal as specified for the weld.

All discolorations due to tack weld shall be removed prior to welding. For titanium no decolourisations are allowed.

Tack welds shall be totally remelted during welding to be sure that they have no effect on the weld quality.

5.1.4 Pre heat treatment – Post heat treatment

If pre heating and/or post heating is foreseen, this is to be applied also during the qualification of the WPS. Relevant parameters must be fixed either on the drawing or in the WPS.

Pre heating and/or post heating parameters must be approved by the end customer prior qualification.

5.2 INSPECTION OF WELDS BY NON DESTRUCTIVE TESTING

All NDI results are attached to the shop traveller, especially if only one NDI method is used.

5.2.1 Visual and Dimensional Examination

Production weld joints and test joints shall be inspected to ensure that the construction, physical dimensions, identification, and production records conform to the Engineering Drawing and the requirements section 5.4 (Acceptance Criteria).

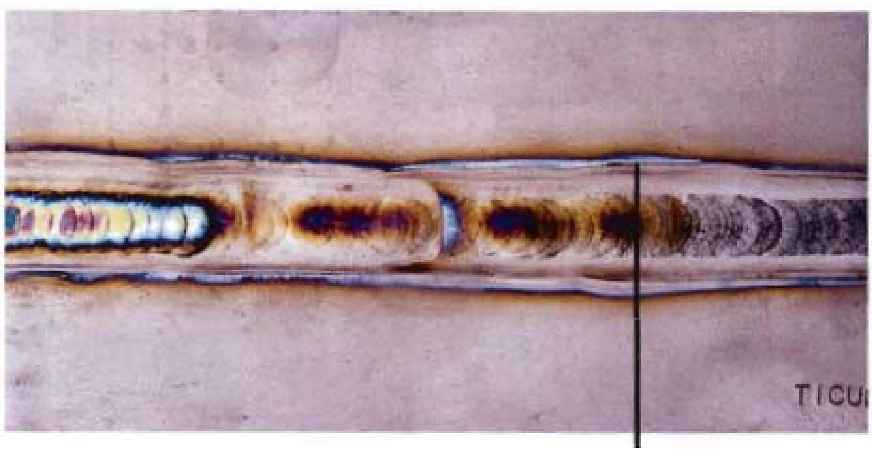
Visual examination shall be performed per ISO 17637 with following exceptions :

1. Using X5 to X10 magnification with twenty power magnification available to examine questionable conditions; it is also possible to use mirrors or endoscopes. A higher magnification can be used if necessary.
2. Criteria of acceptance are defined in section 5.4: Acceptance per DIN 29595.

Particular attention shall be given to the following :

- General appearance & regularity
- Excess weld metal
- Linear & angular misalignment
- Undercuts and shrinkage groove
- Open craters, pores or cracks
- Root concavity
- Excessive penetration
- Incomplete penetration
- Weld width & angle
- Discoloration
- Burn - through
- Weld spatter
- Lack of fusion

Effectiveness of gas coverage and lack of moisture or oxygen in the inert gases used may be evaluated by the surface colour; Titanium & Titanium alloys are especially sensitive to oxygen during welding : criteria of acceptance for Titanium alloys versus weld sensitivity is given in Table 4. Particular attention shall be given to the inside of test joints. If there is evidence of oxidation, corrosion products shall be removed by abrasive or chemical cleaning; removal of at least 25 µm is required as defined in qualification.

<table>
<tr><td colspan="2">Acceptable
Weld and HAZ</td><td colspan="4">Acceptable
HAZ : only for safety classes 2 and 3</td></tr>
<tr><td colspan="2">350 °C
</td><td colspan="2">400 °C
</td><td colspan="2">450 °C
</td></tr>
<tr><td colspan="6">Unacceptable</td></tr>
<tr><td>500 °C
</td><td colspan="2">550 °C
</td><td colspan="2">600 °C
</td><td>650 °C
</td></tr>
<tr><td colspan="6"><u>TIG welding</u>
</td></tr>
<tr><td colspan="4">Unacceptable</td><td colspan="2">Acceptable in weld
Unacceptable in HAZ for Safety class 1</td></tr>
</table>

(1) Discoloration must be removed prior to additional welding

(2) Blue discoloration for other cases but must be removed prior to subsequent processing or overwelding

Table 4 : unacceptable discoloration of titanium alloys welds versus safety classes: by courtesy of DVS (Deutscher Verband für Schweissen und verwandte Verfahren E.V.)

5.2.2 Penetrant inspection

For detecting imperfections such as cracks and pores at the surface, the penetrant inspection as per ISO 3452 or equivalent (e.g. DIN EN 571-1) shall be applied.

Unless other thing is specified by design, sensitivity level 3 or higher is required (defect down to 10 μm); for some welding technologies (TIG - PTA), a sensitivity 2 (defect down to 20 μm) can be used.

Penetrant inspection methodology and associated qualified products are given in AMS 2644 and QPL-AMS 2644 respectively.

Linear indications are not acceptable, the acceptability of non linear indications depends on design requirements. For other defects and unless otherwise is specified by Design, the basic acceptance criteria are given in section 5.4 (Acceptance Criteria per DIN 29595).

5.2.3 Radiographic testing

Radiographic examination shall be performed using methodology described in ISO 17636.

This method is suitable to detect the following imperfections: cracks, internal pores, lack of fusion, penetration or foreign inclusions.

The welds will be inspected in the perpendicular direction.

Unless otherwise is specified by Design, the basic acceptance criteria are given in section 5.4 (Acceptance Criteria per DIN 29595).

5.2.4 Ultrasonic inspection

Ultrasonic inspection in accordance with ISO 17640 shall be applied to detect internal imperfections for materials thicker than 8 mm. For materials thinner than 8 mm, ASTM E164 should be used.

The ultrasonic inspection can be selected to replace radiographic testing depending on the design of the weld and sensitivity required.

Unless otherwise is specified by Design, the basic acceptance criteria are given in section 5.4 (Acceptance Criteria per DIN 29595).

5.2.5 X-Ray tomography inspection (CT Scan)

In order to get a exhaustive cartography of internal defects (non open cracks, internal pores), radiographic or ultrasonic inspection can be not sufficient and additional inspection, such as X-Ray tomography, is suitable: this type of investigation shall be mentioned in the QTP / QTR.

Unless otherwise is specified by Design, the basic acceptance criteria are given in section 5.4 (Acceptance Criteria per DIN 29595).

5.3 INSPECTION OF WELDS BY DESTRUCTIVE TESTING

5.3.1 Metallographic and Hardness measurement

When metallographic examinations are required for cross section examination, samples shall be prepared per ASTM E3. The weld size (depth and with) are measured and compared to the acceptance criteria defined in the QTP.

For qualification, a part (or a representive sample) must be cut for inspection.

For circumferential welds, one cut will be in the over weld area (0° position of the weld seam); the other in the nominal area (180° position of weld seam) of the weld seam. Every cross section will be documented by pictures and show at least weld seam (penetration & depth), heat affected zone (cracks) and parent materials. For flat samples, refer to QTP.

For Qualification and according to section 6, every weld hardness profile will be checked transversely to the direction of the weld seam. A line of measurement points will be laid through the weld seam, covering parent material, heat affected zone and weld metal. Details for this measurement (hardness steps, loads,…) will be given in the QTP.

For serial production, refer to QTP / QTR.

5.3.2 Tensile test

Tensile test shall be performed in accordance with ISO 4136 or equivalent.

As acceptance criteria the values for yield and ultimate strength will reach the specified values from the weakest parent material used for the present sample; the required values shall be indicated in the QTP.

The test results will be documented in the QTR.

5.3.3 Leak & proof pressure test

The weld parts shall fulfil the leak requirement given by the end customer specification (QTP) and will be checked by a proof pressure test to withstand launch specification requirements. The results of leak & proof pressure test will be documented in the QTR.

Generally. the leak requirement of the weld seam must prove to be tight at Maximum Expected Operating Pressure (He pressure) with a value of $< 1 \times 10^{-6}$ scc/s for 5 minutes minimum.

The same sample will be checked by a proof pressure test. As requirement, the weld seam shall prove to be tight by 1.5 to 2 (depending on the customer requirement) x MEOP pressure for 5 minutes minimum.

The results of leak & proof pressure test will be documented in the QTR.

5.3.4 Burst pressure test

The samples that undergo leak & proof pressure test will be pressurised from the inside up to 4 X MEOP. The samples shall not rupture below this level.

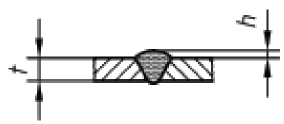
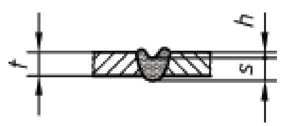
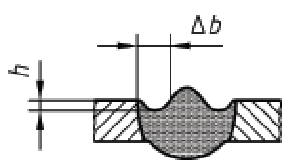
The burst pressure is recorded and documented in the QTR.

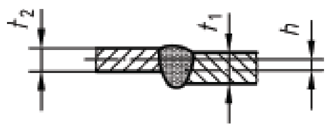
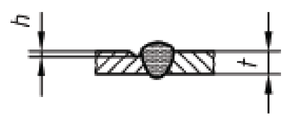
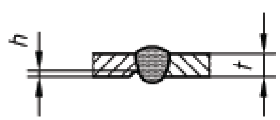
5.4 ACCEPTANCE CRITERIA : DIN 29595

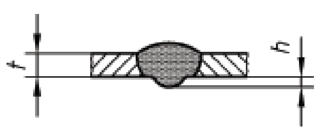
The following criteria is the base line regarding what is acceptable. However, requirements can be enlarged or restricted depending on application. **Any modifications are to be documented by the Design Office and submitted for acceptance to the end customer.**

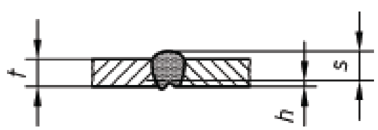
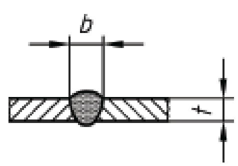
Inspections can be limited due to Design of part: this shall be documented and submitted for acceptance to the end customer.

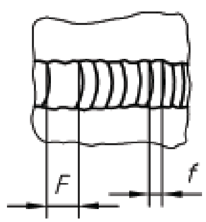
5.4.1 Outer characteristics

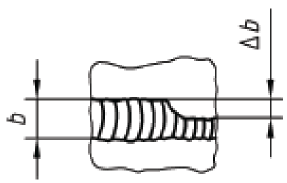
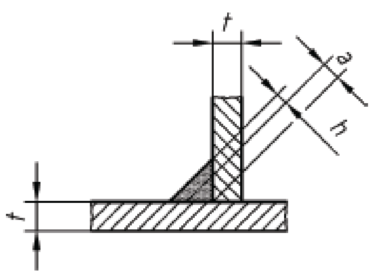
Serial Number	Reference according to ISO 6520-1	Designation and Remarks	Process reference per ISO 4063	Material Group (a)	Limits for imperfections for quality levels		
					A	B	C
1	502	Excess weld metal 	141, 15	A B C	$h \le 0.2t + 1.2$ mm		$h \le 0.2t + 2.0$ mm
				D	$h \le 0.2t + 1.8$ mm		$h \le 0.2t + 2.5$ mm
			511, 52	A B C D	$h \le 0.3t \le 5$ mm		
2	511	Incomplete filled groove 	141, 15, 511, 52	A B C D	Unacceptable		$h \le 0.1t \le 1$ mm $t \le s$
3	511	Incomplete filled groove 	511	A B C D	Unacceptable	$b \ge 4h$	

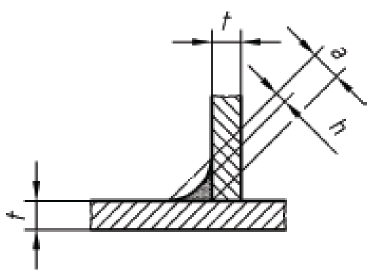
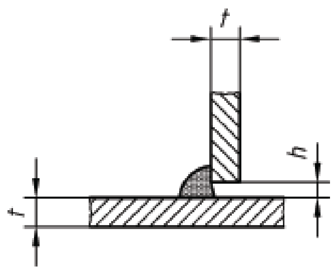
<table>
<tr><th rowspan="2">Serial Number</th><th rowspan="2">Reference according to ISO 6520-1</th><th rowspan="2">Designation and Remarks</th><th rowspan="2">Process reference per ISO 4063</th><th rowspan="2">Material Group (a)</th><th colspan="3">Limits for imperfections for quality levels</th></tr>
<tr><th>A</th><th>B</th><th>C</th></tr>
<tr><td rowspan="2">4</td><td rowspan="2">507</td><td rowspan="2">Linear misalignment
</td><td>141, 15</td><td rowspan="2">A B C D</td><td colspan="2">h ≤ 0.1 (t1+t2)/2 + 0.25 mm for butt joints
h ≤ 0.2 (t1+t2)/2 + 0.3 mm for bent joints</td><td>h ≤ 0.3 (t1+t2)/2 + 0.3 mm</td></tr>
<tr><td>511, 52</td><td colspan="3">h ≤ 0.1 (t1+t2)/2 ≤ 1.0 mm</td></tr>
<tr><td rowspan="2">5</td><td>5011, 5012</td><td>Undercut
</td><td>141, 15</td><td rowspan="2">A B C D</td><td colspan="2" rowspan="2">Unacceptable</td><td>h ≤ 0.1t + 0.1 mm
≤ 0.4 mm</td></tr>
<tr><td>5013</td><td>Shrinkage groove
</td><td>511, 52</td><td>h ≤ 0.05t + 0.1 mm ≤ 0.4 mm</td></tr>
<tr><td>6</td><td></td><td>Flash-over groove</td><td>511</td><td rowspan="2">A B C D</td><td colspan="3" rowspan="2">Unacceptable</td></tr>
<tr><td>7</td><td>5025</td><td>Opened crater</td><td>141, 15</td></tr>
</table>

Serial Number	Reference according to ISO 6520-1	Designation and Remarks	Process reference per ISO 4063	Material Group (a)	Limits for imperfections for quality levels		
					A	B	C
8	2017	Surface pore	141, 15	A B C	Unacceptable		Length ≤ 0.5t Max 10 pores per 50 mm weld length section
			511, 52	D	Unacceptable		
9		Burn	141, 15	A B C D	Unacceptable		
10	601	Arc strike					
11	6021	Spatter					
12	602	Tungsten spatter	141, 15	A B C D	Unacceptable		
13	504	Excessive penetration 	141, 15	A B C	h ≤ 0.2t + 1.2 mm		h ≤ 0.2t + 2.0 mm
				D	h ≤ 0.2t + 1.8 mm		h ≤ 0.2t + 2.5 mm
			511, 52	A B C D	h ≤ 0.3t ≤ 5 mm		

Serial Number	Reference according to ISO 6520-1	Designation and Remarks	Process reference per ISO 4063	Material Group (a)	Limits for imperfections for quality levels A	B	C
14	515	Root concavity 	141, 15	A B D	Unacceptable		
				C	Unacceptable		h ≤ 0.2t
			511, 52	A B C D	Unacceptable		
15	402	Incomplete penetration	141, 15	A B C D	Unacceptable		Overall ≤ 0.03 weld length
			511, 52		Unacceptable		
16	5212	Weld width 	141, 15	A B	b ≤ 2t + 4 mm		b ≤ 2t + 8 mm
			141, 15	C D	b ≤ 2t + 6 mm		
17	100	Cracks	141, 15 511, 52	A B C D	Unacceptable		
18	401	Lack of fusion					
19	510	Burn trough					

Serial Number	Reference according to ISO 6520-1	Designation and Remarks	Process reference per ISO 4063	Material Group (a)	Limits for imperfections for quality levels		
					A	B	C
20	506	Overlap	141, 15	A B C D	Unacceptable	5% max over a weld length of 100 mm	5% max over a weld length of 100 mm
			511, 52		Unacceptable		
21	610	Coloration due to temperature	141, 15, 511, 52	B	To be removed unless otherwise specified by Design		
				C	See section 5.2.1 for permitted Titanium discoloration		
22		Vaporized metal deposition	511, 52	A B C D	Only same type of vaporized metal deposit as base metal is authorized		
23	514	Irregular surface (ripple) 	141, 15	A B C D	F : f ≤ 4:1	F : f ≤ 6:1	No specification

Serial Number	Reference according to ISO 6520-1	Designation and Remarks	Process reference per ISO 4063	Material Group (a)	Limits for imperfections for quality levels		
					A	**B**	**C**
24	513	Irregular weld width 	141, 15	A B C D	Δ b ≤ 0.3b	Δ b ≤ 0.4b	No specification
25	5214	Insufficient throat thickness 	141, 15	A B C D	h ≤ 0.1a + 1 mm (b)		

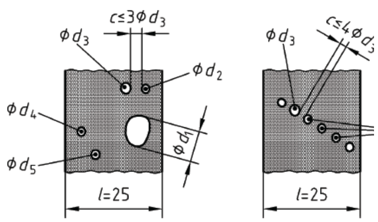
Serial Number	Reference according to ISO 6520-1	Designation and Remarks	Process reference per ISO 4063	Material Group (a)	Limits for imperfections for quality levels		
					A	B	C
26	5213	Excessive throat thickness 	141, 15	A B C D	Unacceptable	h ≤ 0.2a	
27	617	Incorrect root gap 	141, 15	A B C D	h ≤ 0.2 mm	h ≤ 0.4 mm	h ≤ 0.8 mm

(a) A: unalloyed and low-alloy steels, high-alloy ferritic steels; B: high alloy-autenitic steels, nickels alloys, cobalt alloys; C: titanium and titanium alloys; D: aluminium and magnesium alloys (b) a is the nominal fillet weld throat thickness as required by Design. If no indication is given by Design, the following values shall be applied: For materials groups A, B and C: a = 0.4t + 0.8 mm (t is the smaller wall thickness) For materials group D: a = 0.4t + 1.8 mm (t is the smaller wall thickness)

Table 5 : acceptance criteria

5.4.2 Inner characteristics

Serial Number	Reference according to ISO 6520-1	Designation and Remarks	Process reference per ISO 4063	Material Group (a)	Limits for imperfections for quality levels (b)		
					A	B	C
28	100	Cracks	141, 15, 511, 52	A B C D	Unacceptable		No specification
29	300	Solid inclusions sharp edges					
30	401	Lack of fusion					
31	402	Incomplete internal penetration					

<table>
<tr><th rowspan="2">Serial Number</th><th rowspan="2">Reference according to ISO 6520-1</th><th rowspan="2">Designation and Remarks</th><th rowspan="2">Process reference per ISO 4063</th><th rowspan="2">Material Group (a)</th><th colspan="3">Limits for imperfections for quality levels (b)</th></tr>
<tr><th>A</th><th>B</th><th>C</th></tr>
<tr><td rowspan="4">32</td><td rowspan="4">201
2011
2012
2013
2014
300</td><td rowspan="4">Gas cavities
Gas porosities
Uniformly distributed porosities
Clustered porosities
Linear porosities
Solid inclusions


Sketch 1
$\sum f1 = \pi / 4[d_1^2+d_4^2+d_5^2+(d_2+d_3)^2]$
Sketch 2 (linear porosities)
$\sum f2 = \pi / 4.n.d^2$</td><td rowspan="2">511, 52</td><td>A B C</td><td>$d_{max} = 0.1t \geq 0.2$ mm
≤ 1.3 mm
$\sum f1 \leq 0.62[mm]t \leq 8mm^2$
$\sum f2 \leq 0.22[mm]t \leq 4mm^2$</td><td rowspan="2">To be defined separatly</td><td rowspan="4">No specification</td></tr>
<tr><td>D</td><td>$d_{max} = 0.25t \geq 1.6$ mm
$\sum f1 \leq 1.6[mm]t \leq 8mm^2$
$\sum f2 \leq 0.64[mm]t \leq 4mm^2$</td></tr>
<tr><td rowspan="2">141, 15</td><td>A B C</td><td>$d_{max} = 0.3t \geq 1.3$ mm
$\sum f1 \leq 0.62[mm]t \leq 8mm^2$
$\sum f2 \leq 0.22[mm]t \leq 4mm^2$</td><td>$d_{max} = 0.5t \geq 1.5$ mm
$\sum f1 \leq 1.2[mm]t \leq 8mm^2$
$\sum f2 \leq 0.4[mm]t \leq 4mm^2$</td></tr>
<tr><td>D</td><td>$d_{max} = 0.5t \geq 1.6$ mm
$\sum f1 \leq 1.6[mm]t \leq 8mm^2$
$\sum f2 \leq 0.64[mm]t \leq 4mm^2$</td><td>$d_{max} = 0.65t \geq 2.0$ mm
$\sum f1 \leq 2.0[mm]t \leq 8mm^2$
$\sum f2 \leq 0.8[mm]t \leq 4mm^2$</td></tr>
</table>

(a) A=unalloyed and low-alloy steels, high-alloy ferritic steels – B: high-alloy austenitic steels, nickel & cobalt alloys – C: titanium alloys – D: aluminium & magnesium alloys

(b) Inner individual inclusions of $d \leq 0{,}2$ (0,25 if weld thickness $t \geq 6$ mm) may be neglected unless 2012 is concerned. Acceptable imperfections are taken to apply only over a weld length section of l = 25 mm which covers accumulation.

$\sum f1$: inclusion area of irregular distribution. In the case of smaller individual inclusion intervals $c \leq 3d3$ (with $d3 > d2$), then $d2 + d3 \leq dmax$

$\sum f2$: inclusion area with more than 4 inclusions in linear porosity with $c \leq 4d3$ (with $d2 > d3$), then $d2 + d3 \leq dmax$ shall be acceptable

Table 6 : inner characteristics

For numerical values (defects 201, 2011, 2012, 2013, 2014, 300), see next page

Defect reference	511, 52						141, 15											
Sensitivity class	A						A						B					
Material group	A B C			D			A B C			D			A B C			D		
Thickness t (mm)	d_{max} mm	∑f1 mm^2	∑f2 mm^2	d_{max} mm	∑f1 mm^2	∑f2 mm^2	d_{max} mm	∑f1 mm^2	∑f2 mm^2	d_{max} mm	∑f1 mm^2	∑f2 mm^2	d_{max} mm	∑f1 mm^2	∑f2 mm^2	d_{max} mm	∑f1 mm^2	∑f2 mm^2
1	0.2	0.6	0.2	0.3	1.6	0.6	0.3	0.6	0.2	0.5	1.6	0.6	0.5	1.2	0.4	0.7	2	0.8
1.2	0.2	0.7	0.3	0.3	1.9	0.8	0.4	0.7	0.3	0.6	1.9	0.8	0.6	1.4	0.5	0.8	2.4	1
1.5	0.2	0.9	0.3	0.4	2.4	1	0.5	0.9	0.3	0.8	2.4	1	0.8	1.8	0.6	1	3	1.2
1.8	0.2	1.1	0.4	0.5	2.9	1.2	0.5	1.1	0.4	0.9	2.9	1.2	0.9	2.2	0.7	1.2	3.6	1.4
2	0.2	1.2	0.4	0.5	3.2	1.3	0.6	1.2	0.4	1	3.2	1.3	1	2.4	0.8	1.3	4	1.6
2.5	0.3	1.6	0.6	0.6	4	1.6	0.8	1.6	0.6	1.3	4	1.6	1.3	3	1	1.6	5	2
3	0.3	1.9	0.7	0.8	4.8	1.9	0.9	1.9	0.7	1.5	4.8	1.9	1.5	3.6	1.2	2	6	2.4
3.2	0.3	2	0.7	0.8	5.1	2.1	1	2	0.7	1.6	5.1	2.1	1.5	3.8	1.3	2	6.4	2.6
3.5	0.4	2.2	0.8	0.9	5.6	2.2	1.1	2.2	0.8	1.6	5.6	2.2	1.5	4.2	1.4	2	7	2.8
4	0.4	2.5	0.9	1	6.4	2.6	1.2	2.5	0.9	1.6	6.4	2.6	1.5	4.8	1.6	2	8	3.2
5	0.5	3.2	1.2	1.2	8	3.2												
6	0.6	3.8	1.4	1.6	8	3.9												
8	0.8	5	1.8	1.6	8	4												
10	1	6.2	2.2	1.6	8	4												
12	1.2	7.6	2.8	1.6	8	4												
15	1.3	8	3.6	1.6	8	4												
18	1.3	8	4	1.6	8	4												
20	1.3	8	4	1.6	8	4												

5.5 REPAIR WELDING

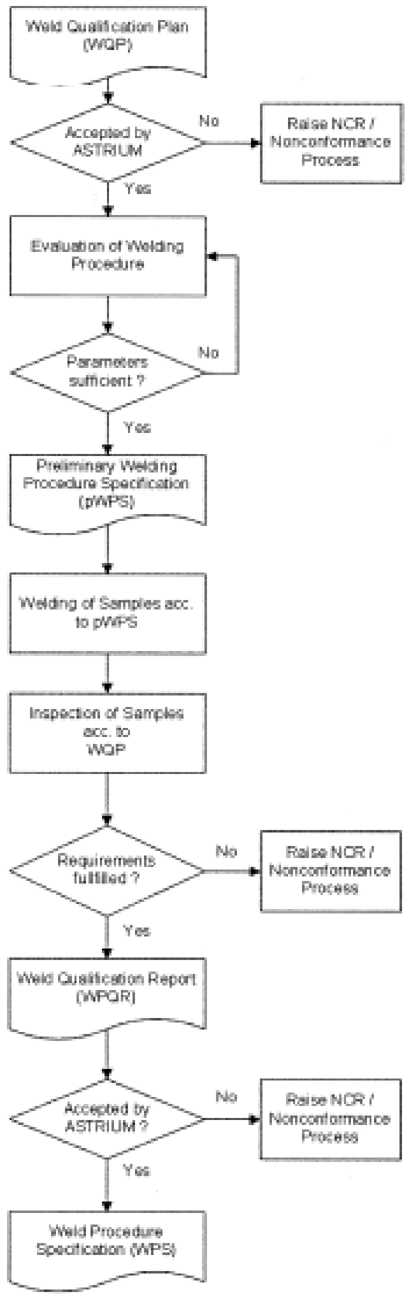
A repair weld is a new weld (meaning re-heat) on the weld to remove internal or external defect and covered by a NCR and recorded (not covered by the basic qualification).

Every repair weld must be qualified: using representative hardware (material, heat treatment,…).

Repaired weld shall meet the acceptance criteria of the original weld and the basic requirements of the flight hardware.

6 WELDING QUALIFICATION & SERIAL PRODUCTION

6.1 FLOW CHART



To complete the flow chart above, percentage of defect during production must fulfil acceptance criteria according § 6.1.1, if not an NCR should be raised.

6.2 WELDING OF QUALIFICATION SAMPLES

6.2.1 Extend of testing

In this section, samples and investigations necessary for Qualification are presented.

Tables 7&8 describe investigations to perform for safety classes 1&2.

For safety class 3, only 2 samples are required which must be visual inspected.

The weld samples will be representative of Flight Hardware. The weld machine, weld head, fixtures, sample material and weld interface will be identical to those used for the flight hardware. Deviations from this rule must be justified in the qualification plan as well as in the qualification documentation and must be approved during qualification.

The weld sequence will corresponds to the sequence defined in the WPS. In order to verify that the weld data set leads to reproducible and acceptable results, all samples are evaluated in accordance with Table 7&8.

Table 7 describes the basic tests to be done for orbital TIG, or PTA qualification.

Table 8 describes the basic tests to be done for EBW and LW qualification.

The rework weld will be qualified on 25% of the samples for full qualification:: letter R in the tables.

The letter D describes the samples to be done for delta-qualification and the letter T, for tolerance and dimensional checks.

The samples must be marked and serialized. All tests & measurements performed on the samples must be compliant with requirements (100% of compliance); if at least one measurement on one sample is non compliant, the Qualification is rejected.

	Sample number							
INSPECTION	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Visual inspection	X	X	X	X	X	X	X	X
Penetrant inspection	X	X	X	X	X	X	X	X
Radiographic testing	X	X	X	X	X	X	X	X
Metallography & hardness	X	X				X		X
Tensile tests			X	X	X			
Complementary tests	Leak, proof, burst, Eddy current, ultrasonic, X-Ray tomography							
Remarks	**D**	**D; R**			**R**	**D**	**D**	**D; T**

D: samples for delta qualification – R: samples for 2 rework weld – T: samples for tolerance and dimensional checks

X-Ray tomography, leak, proof, burst, ultrasonic, eddy current test will be made upon QTP requirements.

Table 7 : Tests to be performed for qualification of orbital TIG, PTA

	Sample number				
INSPECTION	**1**	**2**	**3**	**4**	**5**
Visual inspection	X	X	X	X	X
Penetrant inspection	X	X	X	X	X
Radiographic testing	X	X	X	X	X
Metallography & hardness	X				X
Tensile tests		X	X	X	
Complementary tests	Leak, proof, burst, Eddy current, ultrasonic, X-Ray tomography				
Remarks	**D**	**D**		**R**	**R**

D: samples for delta qualification – R: samples for 2 re-welds – T: samples for tolerance and dimensional checks

X-Ray tomography, leak, proof, burst, ultrasonic, eddy current test will be made upon QTP requirements.

Table 8 : Tests to be performed for qualification of orbital EBW and LBW

For any deviations, they have to be documented and agreed within the QTP/QTR.

6.2.2 Documentation

In the scope of qualifying welds following listed documents have to be established and issued :

- Qualification test plan (QTP) agreed by the customer;
- Qualification test report (QTR) agreed by the customer;
- Standard shop traveller;
- Welding procedure specification WPS (parameter set) for every dimension/material combination.

These documents shall be controlled documents: including date, issue/revision. The changes shall be controlled.

6.3 SERIAL PRODUCTION

6.3.1 Requirements

Any weld on flight model done under WPS parameter shall be done on configuration control. The following requirements will be observed for flight hardware welding :

• The preparation of a shop traveller shall be completed;

• Only qualified weld data sets shall be used for the welding of flight hardware;

• Details for welding can be found in the respective drawing set and the corresponding documents and specifications. These documents shall also be issued and completed;

• During test or final assembly of the piece parts, cleanliness requirements in accordance with 4.3. and 5.1. shall prevail;

• The responsible welding supervisor or the designated representative shall ensure, that the above mentioned requirements are fulfilled prior the start of fight hardware welding;

• For deviations during the weld process, the weld operators shall stop the activities and inform the responsible Welding Supervisor or the designated representative. For deviations classified as major (see 7.2.3), a non conformance report (NCR) shall be raised;

• The facility in which the welding activities take place shall be under the required environmental conditions. This is stated in Chapter 4.2.4 (minimum of one hour prior to the start of flight hardware welding);

• The environmental conditions shall be fulfilled during the flight hardware welding take place;

• Malfunctions of the welding equipment shall be documented in the Logbook.

6.3.2 Extend of testing

As a general rule, the inspection criteria stated in Table 9 shall be performed for serial production. This is in accordance with DIN 29595 and depending on the Safety Class of the weld.

	Visual & dimensional inspection	**Penetrant inspection**	**Radiographic or ultrasonic inspection**
Class 1	100 %	100 %	100 %
Class 2	100 %	100 %	
Class 3	100 %		

Table 9 : Tests to be performed on parts during serial production

At least every 3 months during Production, the yield on the first weld is done. This trend analysis shall be available for Audit or materials reviews.

If welds cannot be penetrant inspected (e.g. tank, heat pipes), alternative methods shall be applied.

For process Control, deviations to Table 9 are possible if it is agreed with the end customer. These deviations depend on the equipment and on the tests done after (e.g. leak test).

Note: Alpha / Beta samples or alternative weld control technique approved & demonstrated during Qualification and agreed by the end customerS can justify deviations to Table 9.

7 QUALITY ASSURANCE

7.1 MAINTENANCE OFWPS

The WPS shall be updated, if required, as a result of jig modifications, parameter changes, etc…

The WPS shall be controlled documents: including date, issue/revision. The changes shall be controlled.

Major modifications to welding parameters shall necessitate the issue of a new weld configuration. The existing welding configuration shall then become obsolete.

Every change shall be communicated to the end customer to determine if a requalification (or delta qualification) is necessary.

7.2 QUALITY CONTROL

7.2.1 Reference Samples

The welding of the reference sample shall be under the same conditions (weld data, weld head, weld machine, weld sequence etc.) as the corresponding flight hardware. The reference welding sample shall be documented.

Reference samples (Alpha and Beta samples) shall be stored in conformance with life duration of the equipment defined during Qualification in the QTP.

7.2.2 Documentation of weld parameters

The used weld data shall be recorded for automatic means. All weld data shall be available for review.

7.2.3 Anomalies

In case of anomalies during the weld process, the weld operators shall stop the activities in a controlled manner and inform the responsible Welding Supervisor or the designated representative.

An anomaly is classified as major according to ISO 23461.

For major anomalies, an NC shall be raised. For Safety Classes 1 & 2, all anomalies are considered major; a NC shall be then raised in any case. For Safety Class 3, an anomaly can be major or minor.

Malfunctions of the welding equipment shall be documented in the maintenance book and the responsible Welding Supervisor or his designated representative informed. A NC shall be raised if a flight part is affected by the equipment malfunction.

All the anomalies (major and minor) shall be recorded and available for the end customer review under request.

7.3 INSPECTION AND TEST METHODS

Inspection shall be performed on welds to ensure the welds are compliant with the requirements of design and drawing for all weld classes as stated in chapters 5.2 and 5.3. An NC shall be recorded and made available to the end customer

7.4 APPROVAL & PROCESS CONTROL

It shall be verified that :

a) The requirements of this standard and any applicable documents are met;

b) All welders are approved to the requirements of paragraph 4.1 and the welding documents to paragraph 4.7.

c) The equipment used is cleaned and serviceable (see § 4.2.);

d) The control working environment requirements are met (see § 4.2.);

e) Pre-treatment and preparation of weld faces are performed to drawing/ welding schedule requirements;

f) The weld complies with requirements of § 5.4 and is free from visible cracks and contamination;

g) All defective welds are traced in shop traveller.

ANNEX J: COMPONENTS FAILURE MODES FOR FMEAs

1 COMPONENTS FAILURE MODES

This standard applies to all components, selected for space applications. These requirements apply to components procured in accordance with approved space specifications (ESCC, NASA, MIL, NSA, customer or manufacturer).

Note: SEP (Single Event Phenomenon: SEU, SET …) are not actual failure modes, but it is reminded that the Effects of SEP which are similar to the effect caused by a failure (reversible or permanent) are to be analysed in the FMEA, based on radiation analysis outputs.

2 CAPACITOR

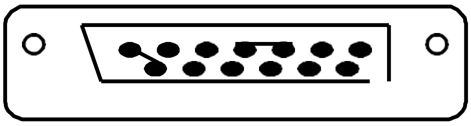
Part Type	Failure Mode	Remark
Capacitor (ceramic & ceramic chip, non solid tantalum, glass, mica, semiconductor)	- Open Circuit - Short Circuit	
Capacitor (solid tantalum)	- Short circuit - Open circuit - Current leakage	- very unlikely - depending on leakage value, final effect can be either short circuit or open circuit (in case of over heating and burst) In particular for CMS tantalum capacitor open circuit condition after short circuit to be considered. Because of explosion risk as a result of low ohmic failure case, redundant solid tantalum capacitors are segregated in such a way that the product resulting from the explosion of the nominal part does not affect the redundant part
Film Capacitor (plastic metallic)	- Open Circuit - Short Circuit	- For self-healing capacitor (typical PM94, PM96, PM90, …) the short circuit shall be considered in the FMEA (for traceability aspects). The minimum self-healing energy shall be indicated in the FMEA.
Feedthrough Capacitor	Open Circuit Short Circuit Short Circuit with Structure	

3 CONNECTOR

Part Type	Failure Mode	Remark
Connector (circular, rectangular, printed circuit board, micro-miniature, rack and panel)	Open Circuit on a pin Short Circuit between adjacent pins (1) Connector Disconnection (2) Short circuit to housing (3)	(1) Subcontractor shall justify the correct implementation of segregation rules of redundant and critical signals * at connector level (free pin not used between them or by using specific connectors). FMEA shall cover short circuit between adjacent pins only when segregation rules are not respected. SPF caused by short circuit of adjacent pins shall be identified.** (2): The number of critical connectors (i.e. the demating of which has critical effects on the mission) shall be minimized by design. A specific analysis shall be performed for identifying critical connectors. Connector disconnection is considered as a not credible failure in flight providing a locking device exists and verification of locking is performed during AIT. An appropriate justification shall be provided. (3) Should be detected at 1rst test sequence. Analyse of the effect of S/C to housing at functional and/or power level is to be performed if there is a risk to damage the equipment and/or to propagate outside the equipment when the equipment is used.

*critical : when failure leads to deviate from the failure tolerance requirement or for safety critical functions

** Example of short-circuits between adjacent pins



4 CRYSTAL / PIEZZO-ELECTRIC DEVICE

Part Type	**Failure Mode**	**Remark**
Crystal Resonator (quartz)	- Open Circuit (no clock signal) - Drift of the frequency	- drift means over the worst case range specified - the worst effect with regard to the device function shall be assessed

5 DIODE

Part Type	**Failure Mode**	**Remark**
Diode (any type)	Open Circuit Short Circuit Short Circuit to ground (1)	(1) for diodes installed directly on structure.

6 RF DIODE

Part Type	**Failure Mode**	**Remark**
RF Diode (microwave schottky Si & GaAs, pin, microwave PIN, microwave GUNN GaAs)	- Open Circuit - Short Circuit	

7 FILTER

Part Type	**Failure Mode**	**Remark**
Feed-through Filter	- Open Circuit - Short Circuit - Short Circuit with Structure	

8 FUSE

Part Type	Failure Mode	Remark
Fuse solid state	- Open Circuit	

9 INDUCTOR

Part Type	Failure Mode	Remark
RF coils Cores Chip	Open Circuit SC between terminals Short Circuit between turns (1) Any single terminal SC to core or structure	(1): SC between terminals or turns to be considered except where specific provisions other than enamel are taken (e.g. specifically insulated wire, kapton layer or specific design rules) It is important to consider SC between terminal and core or structure according to technology for inductors mounted directly on the structure Breaking of the magnetic core is assimilated to SC and is considered except where specific provisions are taken (e.g. potting)

10 TRANSFORMER

Part Type	Failure Mode	Remark
Transformers	- Open Circuit - Short Circuit - SC between windings/turns - Any single terminal SC to core or structure	- Transformer primary/secondary, +/- primary, +/- secondary. Short circuit between windings is analyzed except if insulation (other than enamel) exists between the windings. To be addressed in the analysis SC between terminal and core or structure are considered according to technology for transformers mounted directly on the structure Breaking of the magnetic core is assimilated to SC and is considered except where specific provisions are taken (e.g. potting)

11 MOTOR WINDINGS

Part Type	Failure Mode	Remark
Motor Winding	- Open Circuit - Short Circuit	Main and redundant windings shall be considered as transformer windings (see above). Short circuit between windings shall be analyzed except if double insulation (other than enamel) exists between the windings. To be addressed in the analysis

12 IC - LOGIC

Part Type	Failure Mode	Remark
Integrated circuits (logic) Microprocessor Micro-controller Peripheral Memory SRAM Memory DRAM Programmable logic ASIC technologies (digital, linear, mixed) Logic families MMICs	Output Stuck (1) Input Stuck (2) Loss of Power Supply Short Circuit (3) SEP for sensitive circuits (4) Loss or degradation of all internal sub-functions (including sub-functions interfaces) (5) According to technology: wrong address, wrong bits(s),…	(1): VCC+, VCC-, 0, 1, High Impedance (2): VCC+, VCC-, 0, 1 (3): VCC+/VCC- (4): SEP effect analysis performed in the FMEA shall be based on the output of the radiation analysis. (5): For complex IC's (ASIC, µP,…), the functional FMEA shall be performed taking into account the physical implementation

13 PROM (NON VOLATILE MEMORIES)

Part Type	Failure Mode	Remark
Integrated circuits (non volatile memories) PROM EPROM EEPROM	Output Stuck (1) Input Stuck (2) Loss of Power Supply Short Circuit (3) SEP for sensitive circuits (4) According to technology: wrong address, wrong bits(s),…	(1): VCC+, VCC-, 0, 1, High Impedance (2): VCC+, VCC-, 0, 1 (3): VCC+/VCC-. (4): SEP effect analysis performed in the FMEA shall be based on the output of the radiation analysis.

14 LINEAR

Part Type	Failure Mode	Remark
Integrated circuits (linear) Voltage comparator	Output Stuck (1) Input Stuck (2) Loss of Power Supply Short Circuit (3) Loss or Degradation of the function	(1): VCC+, VCC-, High Impedance (2): VCC+, VCC- (3): VCC+/VCC- SET worst case effect shall be defined when sensibility identified through radiation analysis (generally temporary effect).
Integrated circuits (linear) Voltage regulator Switching regulator	Output Stuck (1) Input Stuck (2) Loss of Power Supply Short Circuit (3) Loss or Degradation of the function	(1): VCC+, VCC-, High Impedance (2): VCC+, VCC- (3): VCC+/VCC- SET worst case effect shall be defined when sensibility identified through radiation analysis (generally temporary effect).
Integrated circuits (linear converters) Analog to digital converter Digital to analog converter	Output Stuck (1) Input Stuck (2) Loss of Power Supply Short Circuit (3) Loss or Degradation of the function	(1) VCC+, VCC-, High Impedance (2) VCC+, VCC- (3) VCC+/VCC- SET worst case effect shall be defined when sensibility identified through radiation analysis (generally temporary effect).

15 RELAY

Part Type	Failure Mode	Remark
Relays and switches	Relay stuck in one position Coil Open Circuit	See details in table hereafter.
	2 open contacts (relay stuck in intermediate position) 2 contacts in opposite position Short Circuit between fix contacts Short Circuit between coil and one contact Short Circuit between contact and structure (epsilon)	Failure modes only applicable to electromechanical devices. For other devices performing same function (e.g. thermally actuated micro-machined relays), alternate possible failure modes must be identified and considered according to the technology of the relay

The following table and figures identifies the failure modes, which shall be analysed for relays:

A: applicable

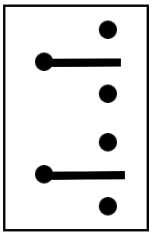
N/A: not applicable

Failure modes	**Mono-stable relays (type J412, T12, GP5 or equivalent)**	**Bi-stable relays (type J422, TL12, GP250 or equivalent)**	**Bi-stable relays (type EL210 or equivalent)**	**Bi-stable relays (type GP3 or equivalent)**
Relay stuck in OFF position:				
coil Open Circuit	A	A	A	A
contact stuck OFF	A	A	A	A
Relay stuck in ON position:				
coil Open Circuit	N/A	A	A	A
contact stuck ON	A	A	A	A
Coil Short Circuit	N/A	N/A	N/A	N/A
2 open contacts (relay stuck in intermediate position)	N/A	A (2)	N/A	A (1)
2 contacts in opposite positions	A (1)	A (1)	N/A	N/A
Short Circuit between fix contacts	A (1)	A (1)	N/A	A (1)
Short Circuit between coil and one contact	A (1)	A (1)	N/A	A (1)

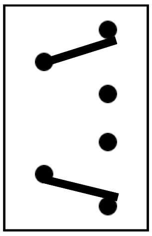
(1): Negligible probability of occurrence. To be considered in the FMEA fro traceability aspects.

(2) : Not applicable for GP250

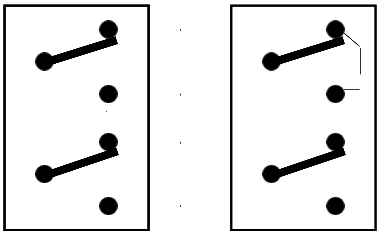
2 open contacts (relay stuck in intermediate position):



2 contacts in opposite positions:



Short Circuit between fix contacts:



16 RF SWITCH

Part Type	Failure Mode	Remark
RF Switches	- Fixed in original position - Failed in intermediate position	 - concerns Wave Guides only

17 RESISTOR

Part Type	Failure Mode	Remark
Resistor (metal film precision [RNC except 90], metal film semi precision [RLR], foil [RNC90], film or foil chips, carbon composition, deposited thick film, microwave load)	- Open Circuit	
Resistor wire wound power [type RWR, RER])	- Open Circuit - Short Circuit	Short circuit only for wire-wound resistors (typical RE, RER, RWR, RB, …); low probability of occurrence
Film network	- Open Circuit	- The open circuit of the common connection must be considered

18 HEATER

Part Type	Failure Mode	Remark
Heaters or flexible heaters	- Open Circuit, - Short Circuit between heater and Structure - Short Circuit between lines (multi-layer heater) - Current leakage between heater and structure (not for flexible heaters)	including heater delamination for thermofoil - Input or output of the heater; depending on device technology - Depending on device technology; low probability of occurrence - Note : Disbonding shall also be analyzed but it is not an internal heater failure mode

19 THERMISTOR

Part Type	Failure Mode	Remark
Thermistors	Open Circuit Short Circuit Erroneous Measurement (drift or blocked)	

20 BIPOLAR TRANSISTOR

Part Type	Failure Mode	Remark
Transistors (bipolar)	Open Circuit (1) Short Circuit (2)	(1), (2): Linear and switching (E/B, E/C, B/C) SC between terminal and structure are considered according to technology for transistors mounted directly on the structure

21 FET TRANSISTOR

Part Type	Failure Mode	Remark
FET Transistor (N channel, P channel)	- Open Circuit - Short Circuit	- Linear and switching (D/S, G/S, G/D) - Linear and switching (D/S, G/S, G/D) - All failures causing over dissipation exceeding rated value must be analysed (thermal risk failure propagation) - SC between terminal and structure are considered according to technology for transistors mounted directly on the structure

22 RF

Part Type	Failure Mode	Remark
RF Bipolar Transistor (RF/microwave PNP low power/low noise, RF/microwave bipolar power, microwave power GaAs, microwave low noise GaAs)	- Open Circuit - Short Circuit	- Linear and switching (E/B, E/C, B/C) - Linear and switching (E/B, E/C, B/C)
RF FET Transistor (RF/microwave FET N & P channel, RF/microwave FET power Si, microwave power GaAs, microwave low noise GaAs)	- Open Circuit - Short Circuit	- Linear and switching (D/S, G/S, G/D) - Linear and switching (D/S, G/S, G/D)

23 WIRES AND CABLES

Part Type	Failure Mode	Remark
Wires and cables	- Open Circuit - Short circuit	- Applicable for the primary power lines only -The effect of the failure on the other redundant line shall be assessed (compliance to the derating requirement in case of permanent effect, compliance to the rating requirement for temporary effect) - Short circuit to be considered only if no double isolation implemented/ If double isolation implemented, failure mode to be mentioned with the following effect: “no effect thanks to double isolation implementation”

24 OPTO-ELECTRONIC

Part Type	Failure Mode	Remark
Opto-Electronics (LED, photo diode/sensor, laser diode)	- Open Circuit - Short Circuit	
Opto-Electronics (photo transistor and opto-coupler)	Diode : - Open Circuit - Short Circuit Transistor : - Open Circuit (C/E) - Short Circuit (C/E) Diode/Transistor : - Short Circuit input/output - CTR decreases - leakage current increase	-To consider according to used technology -To consider radiation/aging effects leading to characteristics modifications (e.g. CTR/gain) and loss of performance

25 FIBER OPTIC

Part Type	Failure Mode	Remark
Fiber Optic (bend radius, cable tension, fiber tension) Connector, isolator, switch	- Open circuit - drift in transmission performance	

26 HYBRIDS

Part Type	Failure Mode	Remark
Hybrid	Each internal discrete part shall be individually analysed and considered as a discrete component with failure modes taken from the present appendix	Physical layout to be taken into account.

27 RF PASSIVE

Part Type	Failure Mode	Remark
RF Passive Components	- Open Circuit of an access or connection - Internal Short Circuit - Detuning	Components : Isolator/Circulator, SMA/RF connector, Waveguide, Filter (this is a non exhaustive list)

28 THERMOSTATS

Part Type	Failure Mode	Remark
Thermostat	- Blocked open - Blocked closed - Drift of commutation thresholds - Short Circuit of input or output with Structure	 - Depending on device technology and when applicable very unlikely

29 BATTERY

Part Type	Failure Mode	Remark
Cells of battery Li-Ion	Short Circuit (1) Open Circuit Cell Rupture Cell Leakage Increase of cell current leakage (2)	(1): short circuit of a LiIon cell electrodes due to a failure within the cell is considered unlikely. However short circuiting the electrodes due to a failure, external to the cell, is possible and to be considered. The protection mechanisms shall be identified by the manufacturer of the battery. (2): due to an internal cell “soft short circuit)

30 SOLAR CELL

Part Type	Failure Mode	Remark
Solar Cell (Si or AsGa)	- Short Circuit - Open Circuit - Short Circuit of input or output with Structure	- Total or partial surface loss; low probability of occurrence - Depending on device technology

31 HEAT PIPE

Part Type	Failure Mode	Remark
Heat Pipe	- Rupture - Leakage - Insufficient thermal transfer	

32 CHEMICAL PROPULSION

Part Type	Failure Mode	Remark
All pressurized element (tank, tubing, welded & screwed connections, filter, valve, regulator, pressure transducer, ...)	- Rupture - External leakage	
Pressure transducer	- Short circuit on all electrical connections - Open circuit on all electrical connections - Drift	
Filter	- Clogging - Insufficient filtering	

Part Type	Failure Mode	Remark
Pyrotechnic valve, Electro valve (isolation)	- Internal leakage - Stuck open / close - Untimely closed / opened	
Bi-propellant thruster valve	- Internal leakage - Stuck open / close - Asymmetric opening	Failure mode to be confirmed by the supplier. The stuck open failure and leakage of both propellants have a very low probability of occurrence
Pressure regulator	- High output pressure - Low output pressure	- Compared to normal pressure - Compared to normal pressure
Non-return valve	- Internal leakage - Stuck open / close	
Fill & Drain valve	- Rupture - External leakage	

33 PYROTECHNICAL DEVICES AND NEAS

Part Type	Failure Mode	Remark
Pyros, NEAs	- Open Circuit - Short Circuit between terminals - Short circuit between any single terminal and structure	Failure modes considered are reported and justified along with a description of the component and of its application

	END CUSTOMER
	Agullo J.M.
	Bayle F.
X	Boué J.
X	Brugnera E.
C	Chinal E.
X	Clochet A.
X	Corradin P.
	Coste P.
	Damilano P.
X	Duquesne J.L.
	Durand C.
X	Etienne C.
X	Gajewski J.F.
X	Gandrieau M.A.
	Giacometto A.
	Gillot B.
X	Goueffon Y.
X	Herbin D.
	Larue N.
	Le Henaff V.
X	Mangeret R.
	Mansour A.S.
	Mechin X.
	Mignard F.
	Mulet Y.
	Orlhac J.C.
	Pawlak D.
	Peltier S.
X	Pendaries M.
X	Peres P.
	Perreau P.
	Redon A.
	Richard X.
X	Rieu J.P.
	Robert F.
	Roques R.
	Rousière M.
	Seronie-Vivien J.
	Tabart C.
	Vlimant P.

	END CUSTOMER
	Braun F.
	Engelke S.
X	Fayard R.
X	Gessler L.
X	Gotsmann M.
	Hashagen V.
	Holzner M.
X	Hug J.
	Koenig W.
	Kraft B.
X	Lau B.
	Lebherz D.
	Leisste T.
	Moore C.
	Müller J.
X	Paul E.
X	Riede M.
	Schmidt H.
	Schull U.
	Schulte H.
	Stephan A.
	Streppel J.
	Timmermann J.
	Wiedermann G.
	Zaglauer A.

	ESA
X	ftp site
X	Adams G.
	Barre H.
	Barsanti I.
	Betto M.
	Bordes Y.
	Capova M.
	Corpaccioli E.
	D'Addio S.
	Erdmann M.
	Garcia Rodriguez A.
	Goodey K.
	Kangas V.
	Klein U.
	Krenzer K.
X	Loiselet M.
	Martin D.
	Mason G.
	Mourra O.
	Oremus R.
	Ostergaard A.
	Perez Albinana A.
	Porciani M.
	Prol Padin E.
	Scolamiero L.

	EUMETSAT
X	ftp site
	Cohen M.
	Fiedler L.
	Wilson J.

Instruments

	Selex ES (3MI)
X	De Vidi R.
	Boldrini F.

	CASA (ICI)
X	Gonzalez R.
	Bergada M.

	RUAG (RO)
X	Liljegren T.
	Christensen J.

	CGS (MWI)
X	Sacchetti A.
	Tominetti F.
	Lupi T.

	End Customer
X	Masterson D.
X	Olivey B.

	SCA

	IASI