IEC TS 62686-1

Edition 3.0 2020-04
REDLINE VERSION

TECHNICAL SPECIFICATION

colour inside

Process management for avionics – Electronic components for aerospace, defence and high performance (ADHP) applications –
Part 1: General requirements for high reliability integrated circuits and discrete semiconductors

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Process management for avionics – Electronic components for aerospace, defence and high performance (ADHP) applications – Part 1: General requirements for high reliability integrated circuits and discrete semiconductors

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PROCESS MANAGEMENT FOR AVIONICS – ELECTRONIC COMPONENTS FOR AEROSPACE, DEFENCE AND HIGH PERFORMANCE (ADHP) APPLICATIONS –

Part 1: General requirements for high reliability integrated circuits and discrete semiconductors

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62686-1, which is a Technical Specification, has been prepared by IEC technical committee 107: Process management for avionics.

This third edition cancels and replaces the second edition, published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) update related to obsolescence of STACK Specification S/0001 revision 14 notice 3;
b) addition of alternative automotive methods of compliance and revision of Annex B initially related to cross-reference to STACK Specification S/0001;
c) addition of an Annex C to include a requirement matrix for IEC TS 62686-1 verification.

The text of this Technical Specificationis based on the following documents:

Draft TS	Report on voting
107/349/DTS	107/361A/RVDTS 107/361/RVDTS

Full information on the voting for the approval of this Technical Specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62686 series, published under the general title *Process management for avionics – Electronic components for aerospace, defence and high performance (ADHP) applications*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 62686 includes all the requirements of the now obsolete STACK Specification S/0001 revision 14 notice 3 and also contains revisions for alternative ~~IEC~~ strategies using for example automotive standards together with the option of using various qualification test methods and additional test information.

This document complements IEC TS 62564-1 which is used for ADHP applications when additional manufacturers' data is required beyond the publicly available ~~manufacturer~~ original component manufacturers' published data sheets (for example when additional thermal performance data is required for thermally challenging applications or when additional verification data ~~are~~ is needed, for example to comply with the requirements of RTCA DO-254/EUROCAE ED-80 for complex components for flight critical applications, etc.).

This document can also be used to comply with the typical qualification requirements of IEC TS 62564-1. Further guidance is given in IEC ~~TS~~ 62239-1.

NOTE ~~With the adoption of the STACK Specification S/0001 revision 14 notice 3 it will be possible for all~~ Existing STACK certified manufacturers ~~to~~ can be audited by IECQ under the new STACK-IECQ joint venture or alternatively to the new IECQ automotive scheme.

PROCESS MANAGEMENT FOR AVIONICS – ELECTRONIC COMPONENTS FOR AEROSPACE, DEFENCE AND HIGH PERFORMANCE (ADHP) APPLICATIONS –

Part 1: General requirements for high reliability integrated circuits and discrete semiconductors

1 Scope

This part of IEC 62686, which is a Technical Specification, defines the minimum requirements for general purpose "off the shelf" COTS (commercial off-the-shelf) integrated circuits and discrete semiconductors for ADHP (aerospace, defence and high performance) applications.

This document applies to all components that can be operated in ADHP applications within the manufacturers' publicly available data sheet limits in conjunction with IEC ~~TS~~ 62239-1. It ~~may~~ can be used by other high performance and high reliability industries, at their discretion.

ADHP application requirements ~~may~~ are not necessarily ~~be~~ fulfilled by this document alone. ADHP OEMs (original equipment manufacturers) ~~may~~ might need to consider redesigning their products or conducting further testing to verify suitability in ADHP applications using their IEC ~~TS~~ 62239-1 ECMP procedures. Alternatively, a component in accordance with IEC TS 62564-1 ~~may~~ can be more suitable.

NOTE Component qualification and outgoing quality discussed herein do not addres component atmospheric radations SEE effects per IEC 62396-1.

2 Normative references

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

~~ISO 9001, *Quality management systems – Requirements*~~

~~ISO TS 16949, *Quality management systems – Particular requirements for the application of ISO 9001:2008 for automotive production and relevant service part organizations*~~

ANSI/EIA-556, *Outer Shipping Container Bar Code Label Standard*

ANSI/ESD S541, *Packaging Materials Standards for ESD Sensitive Items*

~~AS/EN/JISQ 9100, *Aerospace series – Quality management systems – Requirements for aviation, space and defense organisations*~~

~~IPC/JEDEC J-STD-020, *Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices*~~

~~IPC/JEDEC J-STD-033, *Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices*~~

IPC/JEDEC J-STD-609, *Marking and Labeling of Components, PCBs and PCBAs to Identify Lead (Pb), Lead-Free (Pb-Free) and Other Attributes*

JEDEC/IPC/ECIA J-STD-048, *Notification Standard for Product Discontinuance*

JEP130, *Guidelines for Packing and Labeling of Integrated Circuits in Unit Container Packing*

JESD471, *Symbol and Label for Electrostatic Sensitive Devices*

~~TL 9000, *Quality management system*[1]~~

~~JESD46~~ J-STD-046, *Customer Notification of Product/Process Changes by Solid-State Suppliers*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms, definitions and abbreviated terms apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
calendar days, pl.
continuous days, including week-ends and holidays

3.1.2
container
outer shipping container consisting of one or more inner containers

3.1.3
customer
user
original equipment manufacturer (OEM) which purchases electronic components, including integrated circuits and/or semiconductor devices compliant to this document and uses them to design, produce, and maintain systems

3.1.4
data sheet
document prepared by the manufacturer that describes the electrical, mechanical, and environmental characteristics of the component

3.1.5
deviation
user agreement to allow the delivery of a shipping lot which does not fully meet the requirements of this document

Note 1 to entry: Considered equivalent to concession for the purposes of this document.

3.1.6
device specification
document written by a user and agreed by the supplier or OCM

[1] ~~For the telecommunications industry.~~

3.1.7
form
shape, arrangement of parts, visible aspect, mode in which a part exists or manifests itself, and material an item is constructed from

3.1.8
fit
fitability of an item to physically interface or interconnect with or become an integral part of another item or assembly

Note 1 to entry: Size and scale are examples of considered characteristics.

3.1.9
function
work that an item is designed to do without degrading reliability

3.1.10
incoming lot
one or more shipments of a device, grouped together for the purpose of incoming inspection

3.1.11
inner container
box or bag containing devices, either in magazines or bulk packaged

3.1.12
magazine
shipping container that feeds into automatic placement machines

Note 1 to entry: Sticks, tubes, matrix trays, tape/reel, etc., are examples of magazine.

3.1.13
microcircuit
component
device
electrical or electronic device that is not subject to disassembly without destruction or impairment of design use and is a small circuit having a high equivalent circuit element density

Note 1 to entry: It is considered as a single part composed of interconnected elements on or within a single substrate to perform an electronic circuit function.

Note 2 to entry: This excludes printed wiring boards/printed circuit boards, circuit card assemblies and modules composed exclusively of discrete electronic components.

3.1.14
moisture sensitivity level
MSL
rating indicating a component's susceptibility to damage due to absorbed moisture when subjected to reflow soldering

3.1.15
original component manufacturer
OCM
company specifying and manufacturing the electronic component

3.1.16
room temperature
temperature identified at 25 °C ± 5 °C in a room

3.1.17
semiconductor device
electronic devices in which the characteristic distinguishing electronic conduction takes place with a semiconductor

Note 1 to entry: Semiconductor diodes are examples of semiconductor devices having two terminals and exhibiting a nonlinear voltage-current characteristic.

Note 2 to entry: Transistors are examples of active semiconductor devices capable of providing power amplification and having three or more terminals.

3.1.18
shipping lot
single lot of one or more containers received by a user

3.1.19
supplier
company which provides to another an electronic component which is identified by the logo or name marked on the device

Note 1 to entry: A supplier can be the OCM, a franchised distributor or agent, a non-franchised distributor, broker, reseller, OEM, CEM and EMS etc.

3.1.20
termination
element of a component that connects it electrically and mechanically to the next level of assembly

3.1.21
triboelectric charge
electrical charge generated by frictional movement or separation of two surfaces

3.2 Abbreviated terms

AC	alternating current
ADHP	aerospace, defence and high performance
AEC	Automotive Electronics Council
AOQ	average outgoing quality
AQEC	aerospace qualified electronic component
AQL	acceptable quality level
ASIC	application specific integrated circuit
ATC	autoclave
BGA	ball grid array
BPSG	borophosphosilicate glass
BS	bond strength
BST	ball shear test
CB	certification body
CEM	contract electronic manufacturer
CFC	chlorofluorocarbon
COTS	commercial off-the-shelf
CMOS	complementary metal oxide semiconductor
D	semiconductor device
DC	direct current
DFMEA	design failure modes and effect analysis

DLA	Defense Logistics Agency (see http://www.dscc.dla.mil/)
DPM	defects per million
DRAM	dynamic random access memory
DS	die shear
DVP&R	design verification plan and report
ECMP	electronic component management plan
ED	electrical distribution
EHS	environmental health and safety
EM	electromigtration
EMAS	Eco-Management and Audit Scheme (established by the European Union)
EMS	electronic manufacturing services
ESD	electrostatic sensitive damage
ET	electrical test
FFF	form, fit and function
FIT	failures in time
FL	flamability
GR&R	gage repeatability and reproducibility analysis
h	hour
HAST	highly accelerated stress test
HCI	hot carrier injection
HE	hermeticity
HTB	high temperature bake
HTBB	high temperature blocking bias
HTGB	high temperature gate bias
HTOL	high temperature operating life
HTRB	high temperature reverse bias
IECQ	International Electrotechnical Commission Quality Assessment System for Electronic Components
IATF	International Automotive Task Force
IC	integrated circuit
I/O	input and output
IR	infra-red
LI	lead integrity
LT	lid torgue
LTB	last time buy
LTPD	lot tolerance percent defective
LU	latchup
min	minute
MOSFET	metal-oxide-semiconductor field-effect transistor
MP	marking permenancy
MS	mechanical sequence
MSA	measurements system analysis
MSL	moisture sensitivity level

NBTI	negative bias temperature Instability
NMOS	n-type metal oxide-semiconductor (refers to field effect transistors (MOSFETs))
NVL	non-volatile memory operating life
OCM	original component manufacturer
OEM	original equipment manufacturer
OI	oxide integrity
PC	preconditioning
PCB	printed circuit board
PCM	process control monitor
PCN	product or process change notification
PD	package dimension
PFMEA	process failure modes and effects analysis
PGA	pin grid array
Pkg	package
PPAP	production part approval process
PTC	power cycling
QA	quality assurance
RSH	resistance to solder heat
SD	solderability
SDRAM	synchronous dynamic random access memory
SEE	single event effect
SEFI	single event functional interrupt
SEL	single event latchup
SEU	single event upset
SER	soft error rate
SMD	surface mount device
SPC	statistical process control
SRAM	static random access memory
SS	sample size
SSOL	solid-state operating life
T_{amb}	ambient temperature
TC	test code
THB	temperature humidity bias
THM	through hole mount
THRB	temperature humidity reverse bias
TPC	temperature cycling
TR	thermal resistance
TS	terminal strength
T_{opmin}	minimum operating temperature
T_{opmax}	maximum operating temperature
UCL	upper control limit
VI	visual inspection
VPR	vapour

WV water vapour

XR X-ray

4 Technical requirements

4.1 General

4.1.1 Overview

The supplier, preferably the original component manufacturer (OCM) or the franchised distributor, as defined in 3.1.19 and 3.1.15 respectively, shall ~~be Third Party ISO 9001 certified~~ have an appropriate quality management system and shall provide the following minimum technical requirements. The supplier or the OCM ~~may~~ can use the test methods and methodologies specified herein which are based on IEC semiconductor test methods or any other equivalent test method, for example JEDEC test methods (see 4.9.2.3 and Annex A) or the automotive alternative process, see 4.1.2. Proposed equivalent test methods, rationale and supporting data shall be reviewed and shall achieve the same end objectives as specified herein. Use of such equivalent tests shall not be considered to be deviations or waivers to the requirements of this document.

NOTE 1 ISO 9001 or AS/EN/JISQ 9100 can assist with compliance to Clause 4.

NOTE 2 In case the COTS integrated circuits and discrete semiconductors cannot be procured directly from the OCM (for example if the quantity is too small), the franchised distribution network is usually privileged with regard to potential risks (for example lack of traceability and counterfeiting).

Informative annexes are provided at the end of this document and their content is subject to change. Users of this document are encouraged to review the latest data available whenever referencing the content of these annexes as well as the Bibliography:

- Annex A: test code information which summarises all semiconductor test methods discussed herein;
- ~~Annex B: cross-reference to STACK Specification S/0001 revision 14 notice 3;~~
- Annex B:typical automotive component requirements;
- Annex C: requirement matrix for IEC TS 62686-1 verification;
- Bibliography.

4.1.2 Automotive components

Automotive components, which are typically manufactured on IATF 16949 certified manufacturing lines and qualified to AEC-Q100 for temperature grades 0 and 1, with the outgoing quality requirements typically included in a production part approval process (PPAP) process and with the obsolescence and product change notification as specified herein, can meet the requirements of this document; see Annex B for guidance.

NOTE 1 The IECQ automotive qualification programme can be expanded to cover this category of automotive component.

NOTE 2 The VDA 6 series assessment, particularly VDA 6.3, can be used for the PPAP element of the IECQ assessment process.

4.2 Procedures

4.2.1 General

The OCM shall have the following procedures:

- product discontinuance (4.2.2);
- ESD protection during manufacture (4.2.3);
- specification control (4.2.4);

- traceability including anti-counterfeit measures (4.2.5).

4.2.2 Product discontinuance

Notification shall be in accordance with JEDEC/IPC/ECIA J-STD-048 or equivalent, with the exception of timing as described in a) and b) below:

a) the OCM shall provide the user with a notice of last order dates:
   – a minimum of 12 months before these dates for single-source devices, and
   – 6 months before these dates for multi-sourced devices;
b) the OCM may give less than the specified notice period provided a mutually acceptable extension (up to the specification limit) is negotiated with any user needing a different period;
c) for custom ASIC devices, the normal procedure is to include discontinuation notice in the purchase contract.

4.2.3 ESD protection during manufacture

All integrated circuits and discrete semiconductors are considered to be static sensitive and shall be protected through the OCM's manufacturing operation. The OCM shall ensure that devices are not exposed to static damage and are not degraded or damaged due to static discharge. IEC 61340-3-1, IEC 61340-5-1 and JESD625 or AEC-Q100-002 are examples of suitable standards for ESD precautions in wafer fabrication and probe. ~~The OCM holding current IECQ certification for compliance with IEC 61340-5-1 shall be deemed to have satisfied this requirement.~~

4.2.4 Specification control

The OCM shall:

a) when applicable, have a central or local record of the user's part number and specification, against the product to be delivered;

   NOTE 1 This applies to direct sales and not to parts sold through distribution.

b) ensure the specifications on the purchase documents have been reviewed and accepted by personnel authorized to do so.

   NOTE 2 This applies to custom and special orders only.

4.2.5 Traceability including anti-counterfeit measures

Traceability shall be managed as follows:

a) the OCM shall have traceability for any device in a shipping lot through a route code, lot code or other marking on the device or magazine or inner container to identify the manufacturing route, for example groups of wafer lots, wafer fabrication location, assembly location, test location, date code and/or lot code;
b) the information needed to interpret the code shall be available;
c) the procedure shall be available for inspection during audit.

The OCMs shall use anti-counterfeit measures to protect their intellectual property, such as use of registered trademarks, logos, patents, etc. The OCM shall also assist the user in determining if the product is genuine when requested and in identifying the franchised distributors.

4.3 Product or process change notification (PCN)

4.3.1 General

The OCM shall provide the following:

- notification (4.3.2);
- notification details (4.3.3); and
- notifiable changes (4.3.4).

4.3.2 Notification

In the event of the OCM proposing or making a change to a device, then:

a) the OCM shall give at least 90 calendar days' written notice prior to shipping the changed product. The user will respond to confirm the date on which changed product shipments can begin (it could be less than 90 calendar days), advise that the changed product is not acceptable, or request further information;

b) for custom ASIC devices, change notification periods are normally specified in the purchase contract;

c) in an event beyond the control of the OCM where 90 calendar days' notice cannot be given, the OCM shall reach a mutually agreed lesser notice period with any user affected by the change ~~or the IECQ CB that issued IECQ certification~~.

4.3.3 Notification details

The PCN shall include the following items:

a) title of change;

b) the OCM's type number(s) affected;

c) the OCM's notification identification number;

d) estimated last order and shipment dates for unchanged devices to be supplied on request;

e) estimated earliest shipment date of changed devices;

f) manufacturing location and product line affected;

g) a thorough description of the proposed change;

h) the means of distinguishing changed devices from unchanged devices. This may be a date code, lot code, date code range or a distinguishing marking or feature that is visible to the user at point of receipt of shipment;

i) sufficient engineering and/or qualification test data, including details of any qualification test vehicle used and its applicability to the product change, shall be available on request to demonstrate that the change will not adversely affect device form, fit, function, quality or reliability, and that the changed product will continue to meet the specified requirements;

j) user part number of the affected device (preferred item but not mandatory).

4.3.4 Notifiable changes

~~JESD46~~ J-STD-046 shall be used as a guide to changes requiring notification.

4.4 Shipment controls

4.4.1 General

The OCM shall have the following shipment controls:

- shipping container and date code marking (4.4.2);
- date code remarking (4.4.3);
- inner container formation (4.4.4);
- date code age on delivery (4.4.5);
- ESD marking (4.4.6);
- MSL (4.4.7);

- lead-free marking (4.4.8); and
- labels (4.4.9).

4.4.2 Shipping container and date code marking

The shipping container and date code marking shall be in accordance with JEP130 or an equivalent standard. The OCM's name, logo and/or trademark shall be marked on the shipping container where it is practical to do so.

4.4.3 Date code remarking

If the date of assembly and test are both marked, the test date can be remarked if the device is re-tested at a later date. If only one date is marked to represent the manufacturing date and initial electrical test it shall not be changed unless it is necessary to correct poor quality marking or incorrect information, and provided that the time delta between the original mark and the remark is less than 6 weeks.

4.4.4 Inner container formation

It is preferred that the inner container contains only devices of the same die revision/stepping level.

It is preferred that devices also come from the same:

– wafer fabrication location;
– assembly site;
– outgoing QA electrical inspection site.

4.4.5 Date code age on delivery

Date code age on delivery ~~shall~~ should be as follows:

a) the date codes of devices ~~shall~~ should not be older than 24 months upon users' receipt date;
b) for custom ASIC devices, the date code age limits will normally be defined in the purchase contract.
~~c) if the OCM wishes to ship devices outside the specified limit, the deviation procedure should be used.~~

4.4.6 ESD marking

The symbols used and labelling shall be in accordance with JESD471 or an equivalent standard.

4.4.7 MSL

The labelling and shipping container shall be in accordance with IEC 61760-4 or IPC/JEDEC J-STD-033 or an equivalent standard.

4.4.8 Lead-free marking

The shipping container and date code marking shall be in accordance with IPC/JEDEC J-STD-609 or an equivalent standard.

4.4.9 Labels

In general, labels shall include the requirements mentioned in Table 1 and exhibit:

a) human readable content: the content shown for each label in 4.4.9 shall be available in human readable form on the outside of the relevant package;

a) machine readable content: bar codes for those items specified shall be included in 3 of 9 codes (bar code 39) as per ANSI/EIA-556 or equivalent compatible standard;

b) warning notice: any necessary warning notices or symbols to ensure the safety of the contents shall be included as appropriate.

Table 1 – Label requirements

Dry pack label:	**Bar code**
Date of sealing and sealed life or expiration date.	
Time and storage condition limits after opening.	
Bake conditions if usage conditions after opening are violated.	
Moisture sensitivity classification per IEC 61760-4 or IPC/JEDEC J-STD-020 or per the OCM's own classification provided a cross reference is provided at registration.	
Container label: this label is typically implemented as a shipping note or packing list attached to the outer container.	
Delivery address.	
Purchase order number.	*
User part number.	*
OCM's device type number [a].	*
OCM's name [a].	
Export control certification number and controlling authority [b].	*
Quantities enclosed of each device type [a].	*
Inner container label:	
OCM's device type number.	*
User part number [b].	*
Purchase order number [b].	*
Quantity of devices.	*
Date code.	*
Lot number.	*
Assembly location [b].	
Test location [b].	
[a] For security reasons can be omitted with the agreement of the user.	
[b] Preferred but not mandatory.	

4.5 Electrical

4.5.1 General

Operating conditions shall be as defined in the device specification or data sheet, as explained in 4.5.2 to 4.5.7.

4.5.2 Electrical test

All shipped packaged devices shall have passed a production electrical test program, or in the case of user-specific devices, a test program approved by the user. Tested wafer or die products shall have an effective equivalent wafer probe test. Untested wafer and die products shall have met the OCM's minimum process control monitor (PCM) requirements. JEDEC test methods shall be used wherever possible.

4.5.3 Electrical parameter assessment

Test methods for assessing the electrical parameter distributions (AC, DC, functional and timing) of devices should be in accordance with JESD86.

4.5.4 SDRAM memories

SDRAM memories should be designed and tested in accordance with the JESD79 series.

4.5.5 Logic families

Logic families should be designed and tested in accordance with JESD36, JESD52, JESD76 or JESD80.

4.5.6 Power MOSFETs

Power metal-oxide-semiconductor field-effect transistors (MOSFETs) should be tested in accordance with JESD24.

4.5.7 Silicon rectifier diodes

Silicon rectified diodes should be tested in accordance with JESD282, MIL-PRF-19500 or an equivalent standard.

4.6 Mechanical

4.6.1 General

Integrated circuits or discrete semiconductor package dimensions, specified in industry standard outlines (e.g. JEDEC outlines), will be met as specified, if the package is stated as compliant with that outline.

4.6.2 Device marking

4.6.2.1 General

All the specified markings on the device or shipping container shall be clearly legible.

4.6.2.2 Top surface

All of the following required markings shall be marked on the top side, except where otherwise indicated below:

a) pin 1, identifiable either by a mark or by reference to a physical feature of the device;

b) the OCM's name or logo;

c) the OCM's part number or individual user part number as required;

d) the date code of assembly or test. Formats YYWW, or YWW or YM are acceptable (Y = year numeral, W = week numeral, M = month character). If both assembly and test date codes are marked, the assembly code may be bottom marked;

e) a manufacturing route trace code. The top surface is preferred, but the device bottom surface may be used;

f) if both assembly and manufacturing route trace codes are marked on the bottom surface, the manufacturing route trace code shall be marked below the assembly code.

4.6.3 Small packages

If the marking area available on the device is too small to do so, then the unit container is to include all the required marking.

4.6.4 Moisture sensitivity

The moisture sensitivity of all non-hermetic surface mount components shall be tested and classified according to IEC 61760-4 or IPC/JEDEC J-STD-020. The MSL classification shall be available.

4.6.5 Robustness of hermetic seals

The seal shall not be compromised by any normal handling, testing or manufacturing processes.

4.6.6 Termination finishes

The OCMs should make available on their web pages or data sheets (or otherwise) information pertaining to the leaded (Pb) and lead-free termination finish qualification testing, termination material, finish alloy composition, and (if used) heat treatment process of the parts used relative to the RoHS directive. In addition, the following requirements shall be met:

a) thickness limits shall be met over 95 % of the termination surface. The OCM shall select appropriate measurement locations;

b) plating composition and thickness limits shall be available;

c) it is not necessary for solder dipping, where used to improve the solderability of the termination, to cover the entire termination. The area covered should be appropriate to the type of package, for example J-bend packages (area below base plane), or gull wing packages (center of bottom radius to trimmed edge of termination);

d) tin electroplate finishes shall be matt, dense, homogenous, free of co-deposited organic material and suitably treated to inhibit whisker growth. When applicable an appropriate tin whisker plan or process should be in place (for example accelerated tin whisker testing to JESD201 Class 2 limits or JESD22-A121 or IEC 62483) and be demonstrable. Documented results should be made available to the user upon request;

e) providing notification of changes, via the PCN process, to termination finish materials, thickness, or to plating process chemistry.

4.7 Audit capability

4.7.1 General

The OCM shall be able to carry out the following:

- internal quality audits (4.7.2); and
- subcontract manufacturing (4.7.3).

4.7.2 Internal quality audits

The OCM shall periodically audit each internal location, to assess compliance with internal standards for the following areas listed below. ~~Minimum Third Party certification shall be to ISO 9001. Avionics certification AS/EN/JISQ 9100 is preferred to the automotive ISO TS 16949 certification.~~ The following areas defined in Table 2 shall be addressed:

Table 2 – Internal quality audit requirements

Quality system	Calibration	Failure analysis
Shipment and container	Stores and dispatch	ESD control
Contract review	Customer service	Production test
Design management	Process control	Subcontract controls
Purchasing	Incoming materials	Wafer fabrication and probe
OCM audits	Documentation control	Assembly
Training	Product qualification	Reliability monitor

The results of these audits and the audit acceptance criteria shall be available for onsite inspection during an audit. The internal quality audit documentation shall be available upon request.

NOTE ISO 9001, AS/EN/JISQ 9100 and IATF 16949 can assist with the requirements of 4.7.2.

4.7.3 Subcontract manufacturing

The OCM shall qualify and periodically audit all subcontracted operations to a standard equivalent to the OCM internal operations.

4.8 Quality assurance

4.8.1 General

The OCM shall have the following quality assurance systems:

- quality system (4.8.2);
- sampling plans (4.8.3);
- failure analysis support (4.8.4); and
- outgoing quality (4.8.5).

4.8.2 Quality system

The OCM quality system shall meet the following requirements:

a) ~~the OCM shall have~~ satisfy an appropriate quality management system registration, for example one (or more) of ISO 9001~~, TL 9000~~, AS/EN/JISQ 9100,~~ ISO/TS~~ IATF 16949, etc.;

b) ~~the system shall~~ ensure that the requirements of this specification are met;

c) ~~the system shall~~ provide for the prevention and ready detection of discrepancies and for timely and positive corrective action.

4.8.3 Sampling plans

Appropriate and statistically valid sampling plans shall be used and documented. The target for reliability qualification of microelectronics by accelerated ageing is an LTPD better than 3 %. This ~~may~~ can be achieved by overstress testing of sample sizes exceeding 76 devices from the specific device population, with no failures permitted, or by invoking structural similarity and accumulating samples from other device types at the level of the build being tested. For example, thermal cycling is intended to evaluate die and wire bonding and back-end assembly, and the desired LTPD ~~may~~ can be achieved from structurally similar builds of similar metallization, die size and attachment, wire-bond material diameter, process, and loops.

4.8.4 Failure analysis support

OCM failure analysis support shall meet the following requirements:

a) the OCM shall maintain an adequate failure analysis capability and provide a timely response to failures returned for failure verification or failure analysis;

b) representative samples of devices returned as failures shall be analysed and a failure analysis report issued to the originating user, typically within 30 calendar days of the receipt by the analytical facility of such returns;

c) for failure returns relating to a critical problem at a user, the failure analysis report shall typically be issued within 7 calendar days of receipt by the analytical facility.

4.8.5 Outgoing quality

4.8.5.1 General

Outgoing quality shall be measured as per 4.8.5.2 to 4.8.5.5.

4.8.5.2 DPM levels

The OCM shall measure average outgoing quality (AOQ) in defects per million from uniform manufacturing processes and the results shall be in accordance with Table 3. The measurement of outgoing quality via in-process measurements is acceptable in principle. The number of defects will include all devices non-conforming to any functional, electrical, visual or mechanical specification requirement of a device.

4.8.5.3 DPM calculation

Measurement may be by any appropriate classification and method, for example individual devices or device families, package type and/or technology family, in-process measurements.

4.8.5.4 Corrective action

If the outgoing quality levels given in Table 3 are not met, the OCM shall take root cause corrective action and issue a closure date for achieving the required DPM.

Table 3 – Outgoing quality

Device family		Maximum DPM
Electrical	Transistor count	
Discrete and integrated circuits	≤ 100 000	50
	< 1 000 000	100
	≥ 1 000 000	150
Programmable logic when supplied, programmed and tested		100
Visual/mechanical		200
NOTE This information can be considered proprietary and confidential.		

4.8.5.5 Data reporting

AOQ data shall be compiled periodically and be available upon request.

4.9 Supplier performance monitoring by the user

4.9.1 General

The user reserves the right to decide upon the following:

- lot acceptance (4.9.2);
- suspension of deliveries (4.9.3);
- loss of approval (4.9.4);
- AQL figures (4.9.5);
- 100 % screening (4.9.6); and
- termination determination (4.9.7).

4.9.2 Lot acceptance

Users reserve the right to perform incoming lot acceptance on every lot received, using any incoming test as shown in Table 4 or the qualification test in Table 5.

Table 4 – Incoming test

Package type	Test per Table 5	Inspection level [a]	AQL %
All	Electrical test	II	0,065
All	External visual inspection	II	0,20
Hermetic only	Hermeticity fine	II	0,40
Hermetic only	Hermeticity gross	II	0,25
All	Dimensions	II	0,10
[a] See ANSI/ASQ Z1.4.			

4.9.3 Suspension of deliveries

The user may bring to the attention of the OCM any failure to meet a qualification or incoming test and to require the OCM to withhold further deliveries to that user until the cause of the failure has been identified and corrected.

4.9.4 Loss of approval

A failure of one or more shipping lots of a specific device to meet the requirements of this specification or the device specification may constitute grounds for loss of approval. The action taken will depend on the nature of the problem found.

4.9.5 AQL figures

The AQL/LTPD figures quoted are for the purpose of individual incoming lot rejection; they do not imply an overall acceptance quality level.

4.9.6 100 % screening

Users reserve the right to perform 100 % screening on individual shipping lots received and to reject any devices from the OCM which do not meet the special requirements specified in the contract.

~~4.9.7 Termination determination~~

~~The following procedures: X-ray fluorescence (XRF) spectroscopy per JESD213 or energy dispersive (X-ray) spectroscopy (EDS) per MIL-STD-1580 may be used for termination verification.~~

4.9 Qualification

4.9.1 General

The OCM shall manage the following:

- methodology (4.9.2);
- test samples (4.9.3);
- qualification categories (4.9.4);
- maintenance of qualification standards (4.9.5);
- in-process test results (4.9.6);
- product monitor results (4.9.7);
- references (4.9.8);
- qualification report (4.9.9);
- archiving (4.9.10);
- qualification by similarity (4.9.11); and
- similarity assessment (4.9.12).

4.9.2 Methodology

4.9.2.1 General

The OCM shall use appropriate methodologies to qualify new technology, new devices and device changes, to demonstrate that the device under qualification is capable of meeting the specified electrical, quality and reliability requirements, using qualification families (as defined in JESD47 or AEC-Q100).

4.9.2.2 Procedures and methods

Stress test qualification procedures and methods ~~are as~~ shall be performed per Table 4.

4.9.2.3 ~~Alternate~~ Alternative procedures

~~Alternate~~ Alternative procedures and methods are acceptable as per 4.1 and are as follows:

a) qualification in conformity with JESD47, for integrated circuits and their generic families, providing the following, additional, items are addressed by the OCM:
   - X-ray,
   - long term FIT-rate calculations,
   - marking permanency,
   - die shear strength,
   - thermal resistance,
   - flammability,

     NOTE 1 Flammability is typically confirmed by the epoxy mould compound manufacturer flammability UL94 test results.

   - internal visual inspection;

b) qualification in conformity with AEC-Q100 for integrated circuits and their generic families providing the OCM addresses the following additional items:

- high temperature operating life (HTOL) test ~~shall be 1 000 h minimum at temperature cycling equal to 125 °C, i.e.~~ for grade 1, or grade 0.
- marking permanency,
- X-ray,
- thermal resistance, a package property
- flammability,
- internal visual inspection; only required for hermetic components,

NOTE 2 Thermal resistance is an integrated circuits or discrete semiconductors package property.

NOTE 3 Flammability is typically confirmed by the epoxy mould compound manufacturer UL94 test results.

c) qualification to AEC-Q101 for discrete semiconductors and their generic families which now has guidance in an appendix on the relationship of robustness validation to SAE J1879/ZVEI and JEP122 compared to AEC-Q101. When using AEC-Q101,the OCM shall also address the following additional items:

- latch-up,
- electromigration; hot carrier injection; time dependent dielectric breakdown; and negative bias temperature instability,
- internal water vapour,
- flammability,
- internal visual inspection,
- X-ray,
- lid torque (for hermetic components only),

NOTE 4 Flammability is typically confirmed by the epoxy mould compound manufacturer UL94 test results.

d) qualification to an application specific scheme should be created as per the methodology and guidance provided in JESD94. An application specific plan should address the subjects of concern contained in the preceding qualification schemes;

e) qualification using JEP148, based on the physics of failure risk and opportunity assessment, addressing the subjects of concern in the preceding qualification scheme which may be more appropriate for new technologies.

~~**4.10.2.4 Risk analysis**~~

~~A risk analysis shall be accomplished to determine the impact on reliability and quality.~~

~~**4.10.2.5 Stress test driven qualification**~~

~~The stress test driven qualification shall be performed and documented in stress test driven qualification plans.~~

4.9.2.4 Use of product similarity data

Perform testing and document the re-using of existing data based on product similarity arguments.

4.9.2.5 Use of reliability models

Perform and document the verified reliability models.

4.9.3 Test samples

4.9.3.1 General

The OCM shall use the test samples described in 4.9.3.2 to 4.9.3.5.

4.9.3.2 Test failures

The general acceptance level for all stress test qualification is zero rejects in the tested sample size.

Test failures attributed to extraneous factors not related to the qualification stress applied shall not be counted against acceptance criteria. If excessive failures from non-qualification test related mechanisms are generated, the test shall be repeated.

If a larger sample size than that specified in Table 4 is used and failures allowed, then the result shall meet an LTPD = 3 % for a specified sample size of 76. The target LTPD requirement is stated in 4.8.3. In Table 4, lower sample quantities are allowed where the particular stress tests are not intended for statistical extrapolation, but for characterization or package evaluation.

4.9.3.3 Additional samples

Users reserve the right to take additional samples for a qualification test result confirmation.

4.9.3.4 Consolidation of lots

Where production volumes of a device are low and the sample sizes specified are not economically feasible from one manufacturing lot, consolidation of lots is permissible. If consolidation of lots is performed, the combining of parts shall follow the similarity rules as per 4.9.12 (similarity assessment).

4.9.3.5 Reduced sample sizes

The OCM's qualification procedures ~~may~~ can allow devices to be released to the market after testing them to a qualification schedule which does not fully meet the requirements herein, in terms of reduced sample size, reduced test time, etc. This is only acceptable providing test data continues to be accumulated as per 4.11 and corrective actions and/or repeat testing is performed as necessary until the qualification level is reached or exceeded in a target of 90 calendar days. ~~Where IECQ certification has been issued for compliance with this specification, the IECQ CB shall decide on the acceptance of any reduced sample size.~~

4.9.4 Qualification categories

The qualification may be conducted on a specific device type. Alternatively, qualification may be accomplished by using generic family qualification data provided similarity rules are followed (see 4.9.11).

4.9.5 Maintenance of qualification standards

Regular quality and reliability test results, which are obtained from a monitor program, but which are not related to any particular customer shipment, are an acceptable method of maintaining the qualification standard of this document. It is desirable that the manufacturer maintains a regime of "maintenance of qualification" in order to ensure that reliability sensitive processes are routinely tracked and sample tested.

4.9.6 In-process test results

In-process test results shall be managed as follows:

a) if any of the inspection or package qualification tests are performed on a regular basis in the manufacturing line, these tests need not be repeated in new device qualification testing;

b) if qualification tests are not performed, manufacturing inspection results showing the current quality level shall be included in the qualification report. Manufacturing package test results shall be available.

Table 4 – Technology/family qualification and device qualification *(1 of 3)*

Test code (TC) information – See Annex A		Product family	Title	Test reference – See 4.10.2 for more details	Number of lots for family qualification	Sample size per lot	Number of lots for device qualification
			ELECTRICAL				
TC6	(ET)	IC, D	Electrical test	JESD86/MIL-STD-883-M3012 or JESD6	3	50	1
TC7	(ED)	IC, D	Electrical distributions	JESD86/MIL-STD-883-M3012 or JESD6	3	30	1
TC16	(LU)	IC, D	Latch-up	JESD78 or IEC 60749-29 or AEC-Q100-004	1	6	1
TC5	(ESD)	IC, D	ESD – human body model	ANSI/ESDA/JEDEC JS-001 or IEC 60749-26	1	3	1
TC28	(SER)	IC	Soft error at sea level	JESD89 or IEC 60749-38 or IEC 60749-17	-	-	-
			PROCESS				
TC22	(OI)	IC, D	Time dependent dielectric breakdown (oxide integrity)	JP001.01 or IEC 62417	-	-	-
TC4	(EM)	IC, D	Electromigration	JP001.01, JEP119, JESD202, JEP154 or IEC 62415	-	-	-
TC9	(HCI)	IC, D	Hot carrier injection	JP001.01 or IEC 62416	-	-	-
TC40	(NBTI)	IC, D	Negative bias temperature instability	JP001.01 or IEC 62374 or IEC 62374-1	-	-	-
			ENDURANCE				
TC24	(PTC)	D	Power cycling	MIL-STD-883-M1037 or IEC 60749-34	3	76	1
TC29	(SSOL)	D	Steady state operating life	JESD22-A108 or IEC 60749-23	3	76	1
TC13	(HTGB)	D	High temperature gate bias	JESD22-A108	3	76	1
TC12	(HTBB)	D	High temperature blocking bias	MIL-STD-750-M1048	3	76	1
TC14	(HTRB)	D	High temperature reverse bias	JESD22-A108	1	76	1
TC15	(HTOL)	IC	High temperature operating life	JESD 22-A108 or IEC 60749-23	3	76	1
TC21	(NVL)	IC	Non-volatile memory operating life	JESD22-A117 or AEC-Q100-005	1	22	1
TC11	(HTB)	IC, D	High temperature bake	JESD22-A103 or IEC 60749-6	3	76	1

Table 4 *(2 of 3)*

Test code (TC) information see Annex A		Product family	Title	Test reference See 4.10.2 for more details	Number of lots for family qualification	Sample size per lot	Number of lots for device qualification
			TEMPERATURE/HUMIDITY				
TC25	(RSH)	D	Resistance to solder heat	JESD22-B106 or IEC 60749-15 or IEC 60749-20	1	30	1
TC31	(THRB)	D	Temperature humidity reverse bias	JESD22-A101	1	76	1
TC30	(~~TC~~ TPC)	IC, D	PC + temperature cycling	JESD22-A104 or IEC 60749-25	1	32	1
TC32	(THB)	IC, D	PC + THB: 85 °C / 85 % RH (or HAST) (plastic only)	JESD22-A101 or IEC 60749-4 or IEC 60749-5	1	76	1
TC32	(HAST)	IC, D	PC + HAST plastic only	JESD22-A110 or IEC 60749-4	1	76	1
TC1	(~~AC~~ ATC)	IC, D	PC + autoclave (plastic only)	JESD22-A102 or IEC 60749-33	1	32	1

Table 4 *(3 of 3)*

Test code (TC) information see Annex A		Product family	Title	Test reference See 4.10.2 for more details	Number of lots for family qualification	Sample size per lot	Number of lots for device qualification
			MECHANICAL				
TC23	(PD)	IC, D	Package dimensions	JESD22-B100	1	5	1
TC27	(SD)	IC, D	Solderability (76 leads / 5 devices minimum)	JESD22-B102 or IEC 60749-21	1	76	1
TC36	(WV)	IC, D	Internal water vapour (hermetic only)	MIL-STD-883-M1018 or IEC 60749-7	1	3	1
TC20	(MP)	IC, D	Marking permanency	JESD22-B107 or IEC 60749-9	1	3	1
TC2	(BS)	IC, D	Bond strength (76 wires / 5 devices minimum)	JESD22-B116 or IEC 60749-22 or AEC-Q100-001	1	76	1
TC3	(DS)	IC, D	Die shear strength	MIL-STD-883-M2019 or IEC 60749-19	1	5	1
TC34	(TR)	IC, D	Thermal resistance	Not specified	1	3	1
TC8	(FL)	IC, D	Flammability (plastic only)	UL94 or IEC 60749-32	-	-	-
TC8	(FL)	IC, D	Alternative flammability (plastic only)	IEC 60695-2-2	1	3	1
TC17	(LI)	IC	Lead integrity (applicable devices)	JESD22-B105 or IEC 60749-14	1	3	1
TC33	(TS)	D	Terminal strength	MIL-STD-750-M2036	1	3	1
TC18	(LT)	IC, D	Lid torque (hermetic only)	MIL-STD-883-M2024	1	5	1
TC19	(MS)	IC	Mechanical sequence (hermetic only)	See test in Clause A.19	1	5	1
TC10	(HE)	IC, D	Hermeticity (hermetic packaging end point test only)	JESD22-A109 or IEC 60749-8	-	-	-
TC38	(MSL)	IC, D	Moisture sensitivity level	IPC/JEDEC J-STD-020 or IEC 60749-20-1	-	-	-
TC39	(BST)	IC, D	Ball shear	JESD22-B117A or AEC-Q100-010	-	-	-
TC41	(TW)	IC,D	Tin whisker	JESD201 or IEC 62483	-	-	-
			INSPECTION				
TC35a	(VI)	IC, D	External visual inspection	JESD22-B101 or IEC 60749-3	1	25	1
TC35b	(VI)	IC, D	Internal visual inspection	MIL-STD-883-M2010	1	5	1
TC37	(XR)	IC, D	X-ray inspection (plastic only)	MIL-STD-883-M2012	1	5	1

4.9.7 Product monitor results

If any inspection or package qualification tests are performed on a regular basis in product monitor testing, these tests need not be repeated in new device qualification testing.

4.9.8 References

References are given for guidance only. Reference shall always be made to the appropriate test code information for full test details.

4.9.9 Qualification report

The qualification report shall be available upon request.

4.9.10 Archiving

The qualification report and the test specification (not the test program) used in the qualification shall be archived for a minimum of ~~3~~ 7 years.

4.9.11 Qualification by similarity

Qualification by similarity can be used as follows:

a) a change shall be qualified if there is a potential effect on performance, quality or reliability, or if there is any degree of uncertainty about the effect of the change;

b) guidance on the qualification tests, which the OCM should consider applying, for the various combinations of die, package and process changes, is shown in JESD47. The OCM shall perform tests defined in the qualification table that are appropriate, or relevant to the change;

c) upon request, the OCM shall provide data for any device transferred to a new process to prove that no design deficiencies (e.g. mechanical, electrical performance, reliability, single event effects, etc.) were introduced by the process transfer.

4.9.12 Similarity assessment

4.9.12.1 General

The principle of similarity may be applied in qualification, qualification of changes and product monitor testing as follows:

- die changes (4.9.12.2);
- process/wafer fabrication changes (4.9.12.3);
- package/assembly changes (4.9.12.4).

4.9.12.2 Die changes

The OCM shall document and operate an appropriate set of die similarity rules or guidelines applied by appropriate engineering review.

4.9.12.3 Process/wafer fabrication changes

Devices to be assigned to a qualification family shall share the same critical processes and material elements.

4.9.12.4 Package/assembly changes

Package/assembly changes shall be managed as follows:

a) package families shall be grouped by configuration and materials of construction, for examples see AEC-Q100. In general, all members of the group that are equal to or smaller in dimensions and lead count can be considered as similar to a qualified package, provided the assembly process technology is identical;

b) packages should be qualified with the worst case configuration (e.g. the largest die) they are designed to carry that is currently in production. For custom ASICs, use of a "qualification die" is acceptable, such that dies larger than the qualification die by +10 % by linear dimension are qualified, provided the package designed maximum die size is not exceeded.

4.10 Reliability

4.10.1 General

The OCM shall ensure the following:

- operating reliability (4.10.2);
- failure criteria (4.10.3);
- corrective action (4.10.4);
- warranty (4.10.5);
- ~~suspension of certification (4.11.6); and~~
- single event effects (SEEs) (4.10.6).

4.10.2 Operating reliability

The OCM shall manage operating reliability as follows:

a) the OCM shall determine the failure rate of devices operating in systems at an ambient temperature of +55 °C using the high temperature operating life (HTOL) test method or an alternative test method suitable to the device technology (i.e. HTRB or HTGB for discrete components). Failure rates shall not exceed the qualification requirements in accordance with Table 5; an approximate maximum of 155 FITs is expected. For mature and/or high volumes a desired target of 50 FITs or less is expected for integrated circuits and 20 FITs or less for discrete semiconductors. The OCM shall, upon request from the user, make available FIT rate data to confirm application specific life expectancy;

b) results observed at a temperature other than +55 °C will be projected to this temperature, with 60 % confidence using an activation energy, appropriate to the failure mechanism observed. Refer to TC15 HTOL for calculation of acceleration factors; projected results shall show the 60 % confidence range. Alternatively, results can be analysed using JESD85 at higher confidence levels;

c) for custom devices the OCM shall on request provide a FIT rate including the confidence range and operating life prediction to the user (based on a demonstrable methodology) for the application and environmental conditions intended;

d) the OCM should provide upon request, for their device feature sizes under 100 nm, any mitigation strategies, tools or data for device lifetime calculations; see TC22, TC4, TC9 and TC40 in Annex A.

NOTE JEP148, IEC TR 62240-2 and SAE ARP 6338 can assist with the understanding of semiconductor wear-out failure mechanisms that the ADHP user is concerned about.

4.10.3 Failure criteria

Failure criteria shall consist of any of the following modes:

a) functional failure;

b) parameter limit failure;

c) intermittent faults due to the package pins, or the interconnect system, from the pins to the die surface, shall be regarded as failures;

d) transitory faults attributable to the device shall be regarded as failures.

4.10.4 Corrective action

If failures are detected in the reliability processes, the OCM shall investigate, determine root cause and take appropriate actions to achieve conformity to this document or the OCM's internal requirements whichever is the most stringent.

4.10.5 Warranty

The reliability requirements in this document apply to the general population of devices supplied. The warranty period and terms and conditions of sale for failure of individual devices within any warranty are not covered by this document.

~~#### 4.11.6 Suspension of certification~~

~~The user reserves the right to apply accelerated life test and to accumulate life test data on any device, starting with the life test performed for qualification. The reliability data accumulated shall show a device meets the specified requirements in 4.11.2 a).~~

4.10.6 Single event effects (SEEs)

Single bit error rate for DRAM and SRAM are shown in Clause A.29 for test TC28 (SER). SEE data shall be made available upon request if available.

4.11 Product monitor

4.11.1 General

The OCM shall ensure the following:

- monitor programme (4.11.2);
- problem notifications (4.11.3);
- data reporting (4.11.4);
- samples (4.11.5);
- ~~production maturity factors (4.12.6);~~
- ~~device dissipation (4.12.7);~~
- corrective action (4.11.6);
- product monitor results (4.11.7); and
- accumulated test data (4.11.8).

4.11.2 Monitor programme

The monitor programme shall be as follows:

a) the OCM shall have a continuous monitor programme to demonstrate that the requirements of this document are met, on an ongoing basis, for each manufacturing operation or product process;

b) statistical process control: the OCM shall control wafer production, assembly process and final test using statistical analysis. When anomalies are observed, parametric and yield data from the probe and final tests shall be analysed against in-line or electrical process control data. The root cause of the deviation shall be determined and the consequent corrective actions implemented;

c) Table 5 shows the minimum test requirements for a conventional stress driven monitor. The use of a failure mechanism driven approach to optimise reliability monitoring is encouraged. On-going qualification test data and accumulated reliability monitor test data may be assessed in a structured way to reduce reliability monitor testing when failure mechanisms

are shown to be eliminated by process controls and to increase testing or introduce new tests when failures are detected.

4.11.3 Problem notification

The OCM shall have a process to notify the users and distributors in cases where failures were detected and where there is the possibility that failed parts may have been shipped or may be in the process of being shipped to the user.

NOTE This is usually part of the PCN system as described in ~~JESD46~~ J-STD-046 as a guide.

4.11.4 Data reporting

Reliability monitor data accumulated over the preceding two full quarters shall be available, at one month's notice.

4.11.5 Samples

Samples shall be selected as follows:

a) appropriate sample sizes shall be selected;

b) samples shall be randomly selected from representative package and process family devices;

c) all package types and all process families, but not necessarily all package/process combinations, shall be monitored;

d) package tests shall use the largest die size the package is designed to carry that is currently in production. Custom ASIC qualification die may be used (see similarity assessment (4.9.12));

e) sample lots will be added to the monitor at intervals appropriate for each test.

4.11.6 Corrective action

Failure to meet the limits in Table 5 or the OCM's internal limits, whichever is the most stringent, shall trigger appropriate corrective action by the OCM.

4.11.7 Product monitor results

Product monitor results shall meet the requirements of Table 5.

4.11.8 Accumulated test data

Accumulated test data can be analysed as follows:

a) failure rates and levels may be a rolling average with a data accumulation period appropriate to the production quantity level;

b) for HTOL test, the minimum total sample size (SS) required over the data accumulation period, may be calculated using:

$$SS = \frac{Chi^2\,(B,c)\times 10^9}{2\times FITS\times A\times t}$$

where

Chi^2 (60 %,0) = 1,83

Chi^2 (60 %,1) = 4,04

Chi^2 (60 %,2) = 6,21

FITS see 4.11.2 a)

c is the number of failures;

B is the upper confidence limit;

A = A_T × A_V (see Clause A.16 for TC15);

t is the time under bias in an oven.

Table 5 – Product monitor tests

Test codes	Title	Maximum failure
HTOL	High temperature operating life long term life	a, b, c
NVL	Non-volatile memory operating life	a
TC	Temperature cycling	~~c~~ a
HE (hermetic packages only)	Hermeticity	d
PC + THB or HAST	Preconditioned 85/85 or HAST (plastic package only)	~~c~~ a

[a] Zero failures with sample size per Table 5.

[b] Failure rate calculated as shown in test HTOL.

[c] HTOL on devices may be substituted by appropriate wafer level reliability, i.e. testing at the wafer level.

[d] Zero failure with a sample size of 5 parts minimum per batch.

4.12 Environmental health and safety (EHS)

4.12.1 General

The OCM shall ensure the following health and safety precautions are in place:

- EHS compliance (4.12.2);
- device handling (4.12.3); and
- device materials (4.12.4).

4.12.2 EHS compliance

The OCM shall be expected to comply with all applicable national, regional, state and local laws and regulations governing environment, health and safety. The OCM registration to industry recognized EHS standards, such as ISO 14001, RC14001 or EMAS, is encouraged, but not mandatory.

4.12.3 Device handling

Devices should not produce any toxic effects for personnel as a result of handling, storage or disposal, or when operated according to the OCM's data sheet.

4.12.4 Device materials

Materials used in the manufacture of devices should be non-flammable, and shall not emit harmful levels of toxic materials as a result of electrical overload or fault within the device.

4.13 Shipping containers

4.13.1 General

Shipping containers shall protect devices and address the following considerations.

4.13.2 ESD requirements

4.13.2.1 General

The OCM shall ensure that all shipping containers ~~should be~~ are static safe (non-generating as a minimum) to safeguard sensitive products occupying the same manufacturing areas. The OCM shall also ensure the following:

- electrostatic properties (4.13.2.2);
- ESD protection (4.13.2.3);
- specification compliance after shipment (4.13.2.4);
- device orientation (4.13.2.5);
- user instructions (4.13.2.6);
- electrostatic shield (4.13.2.7);
- magazine surface resistivity (4.13.2.8);
- inner container surface characteristics (4.13.2.9).

4.13.2.2 Electrostatic properties

The electrostatic properties of the shipping container material shall be as specified after a conditioning of 48 h at 23 °C ± 3 °C and 12 % RH ± 3 %. Any appropriate test method may be used; examples are contained in ANSI/ESD S541. This test requirement may be met by a certificate of conformance from the shipping container material supplier.

4.13.2.3 ESD protection

All devices shall be supplied in suitable electrostatic protective shipping containers with electrostatic properties meeting the requirements of ANSI/ESD S541 unless otherwise specified in 4.13.2.

4.13.2.4 Specification compliance after shipment

The method of packing for land, sea or air transportation shall adequately protect the device from being electrically or mechanically degraded or damaged in any way during transit.

4.13.2.5 Device orientation

Devices shall all have the same orientation within a magazine.

4.13.2.6 User instructions

Any special handling requirements or precautions (e.g. placing of desiccants; resealing of containers; maximum number of 24 h 125 °C bake cycles allowable) which shall be observed for storage or reshipment shall be stated on the packing and, where necessary, supporting documentation shall be supplied with each inner container.

4.13.2.7 Electrostatic shield

The inner container or magazine shall contain an electrostatic shield of surface resistivity less than 10^6 Ω/square.

4.13.2.8 Magazine surface resistivity

Packing material in direct contact with the device pins shall have a surface resistivity less than 10^{12} Ω/square.

4.13.2.9 Inner container surface characteristics

All surfaces of the inner container other than an electrostatic shield shall meet the following:

- surface resistivity: 10^5 Ω/square to 10^{12} Ω/square;
- charge decay in 2 s: 5 kV to less than 100 V;
- triboelectric charge: not to exceed 100 V.

4.13.3 Magazine reuse

Tubes, trays or other magazines, which depend for their electrostatic properties on surface coatings, shall be limited to a defined number of load/unload cycles. The specified surface resistivity shall be met after the defined number of cycles and data shall be available to justify the limit chosen. Coated magazines may be "reset" to zero load cycles by a suitable recycling process, which includes recoating.

Magazines that utilize bulk material properties may be reused.

4.13.4 Tubes

4.13.4.1 General

The OCM shall ensure the following:

- cushioning material (4.13.4.2);
- partial tubes (4.13.4.3);
- marking access (4.13.4.4); and
- opening (4.13.4.5).

4.13.4.2 Cushioning material

Ceramic devices packaged in tubes shall have an adequate amount of cushioning material to ensure that the devices are not damaged as a result of movement within the tubes.

4.13.4.3 Partial tubes

Full tubes shall be shipped with a maximum of one partly-filled tube per inner container.

4.13.4.4 Marking access

The material of the tube shall be transparent or contain a slot to allow inspection of top markings.

4.13.4.5 Opening

Tubes shall be openable at either end unless otherwise specified to meet unique customer applications.

4.13.5 Trays

4.13.5.1 General

The OCM shall ensure the following:

- devices with MSL of 4 or higher (4.13.5.2);
- marking of bake temperature limit (4.13.5.3);
- stacking of trays (4.13.5.4);

- special packaging (4.13.5.5).

4.13.5.2 Devices with MSL of 4 or higher

For devices with a moisture sensitivity classification according to IPC/JEDEC J-STD-020 of level 2 or higher, the tray shall have a bake capability of at least 125 °C.

4.13.5.3 Marking of bake temperature limit

The bake temperature limit shall be marked on the tray, or the tray marked heatproof.

4.13.5.4 Stacking of trays

There shall be no more than 10 full trays to be stacked in height, plus one partial tray with one further tray as a cover.

4.13.5.5 Special packaging

For devices with special leads, balls or columns, appropriate packaging to accommodate these features without damaging them shall be used (e.g. pedestals for extended leads below package base).

4.13.6 Tape and reel

For devices with moisture sensitivity classification according to IPC/JEDEC J-STD-020 of 2 or higher, the tape and reel shall have a bake capability of 40 °C minimum. The bake temperature limit shall be marked on the reel or the reel shall be marked heatproof.

4.14 Compliance with internal standards

This document does not exempt the OCM of its responsibility to meet its own internal company requirements.

Annex A
(informative)

Test code (TC) information

A.1 General

Annex A provides guidance only and summarizes the content of the quoted standards or specifications at the time of the publication of this document. It is necessary that the users consider the latest revision of the standards or specifications to ensure they use the most recent information.

A.2 TC1 – Autoclave (~~AC~~ ATC)

Test method: JESD22-A102, condition C, for plastic packages only or IEC 60749-33 for 96 h. Solder preconditioning for non-hermetic SMD per test TC26 (PC).

NOTE Autoclave, whether biased or unbiased, is sometimes used for testing plastic packaged devices. The test is a valid quality test but is a non-valid reliability test because of no known reliability data. Instead it is better to use HAST, JESD22-A118 condition A, which is non-saturating and non-condensing, and is the proven and preferred method for valid and known acceleration of ageing of electronics in humid environments.

A.3 TC2 – Bond strength, internal (BS)

Test method: Minimum bond strength as specified in JESD22-B116 for ball shear testing or MIL-STD-883 method 2011, test condition D, for wire bond pull testing or IEC 60749-22 or AEC-Q100-001. Recording of failure categories is not required. Plastic packages, for example, can be tested before encapsulation.

NOTE IEC 60749-22 uses metric units and defines methods A to G which cover a wider variety of test conditions than JESD22-B116.

A.4 TC3 – Die shear strength (DS)

Test method: MIL-STD-883 method 2019. Plastic packages, for example, can be tested before encapsulation.

Alternative test methods are:

- MIL-STD-883 method 2027, stud pull test (for integrated circuits (ICs));
- MIL-STD-750 method 2017, die attach integrity test (for discrete components);
- IEC 60749-19.

A.5 TC4 – Electromigration (EM)

Test methods to characterize the metallization system include JP001.01 and/or JEP119, JESD202, JEP154 or IEC 62415 and/or IEC 62418.

Details of the test methods, results and the capability life demonstrated, for < 0,1 % failures at worst case operating temperature, are to be available on request. The requirement to perform electromigration testing is not limited to sub-micron technologies. Larger geometries are subject to electromigration wear out mechanisms. Characterization data could be for the metallization and contact process as a whole, using accelerated current and temperature testing of test structures on the wafer rather than individual device types. Acceleration factors shall be justified by experimental data.

A.6 TC5 – Electrostatic discharge (ESD)

Test method: Human body model.

a) ANSI/ESDA/JEDEC JS-001 or IEC 60749-26;

NOTE ANSI/ESDA/JEDEC JS-001 superseded JESD22-A114 in 2010.

b) ESD withstanding voltage to be determined and be available;

c) ESD classification to be recorded in the qualification report.

Similarity: Sample testing among groups of similar pins is acceptable and, for example, the similarity basis can be stated in the qualification report. Users reserve the right to test any pin-to-pin combination and to reject on failure.

OCMs holding current IECQ certification for compliance with IEC 61340-5-1 are deemed to have satisfied this requirement.

A.7 TC6 – Electrical test (ET)

Test method: JESD86.

Qualification electrical test: The electrical test is performed at the worst still air ambient temperature in the range of T_{opmin} to T_{opmax}. The device shall be stabilized at the test temperature. Where the test is carried out at a temperature which is not the worst case, then full guard banding allowance can be made.

Testing is as follows:

a) DC test to data sheet;

b) AC test to data sheet or correlated DC testing to guarantee the AC parameters;

c) special functional tests where applicable, for example pattern sensitivity, etc.;

d) functional verification;

e) fault coverage target requirements that are stuck at "1" and "0" are typically in excess of 95 %.

Population parameter drift: Where parameter drift assessment is specified in HTOL and HCI tests, a sample of > 10 devices is to pass the electrical test both before and after endurance testing, and the results of the main parameters are to be data-logged:

1) individual devices are not required to be serialized;

2) adequate parameter stability confirmation is required;

3) reporting of statistical measures of population drift is required. The drift of the population mean for any parameter is to be less than 10 % of the initial population mean;

4) functional failures are to be excluded from calculation of mean values.

A.8 TC7 – Electrical distributions (EDs)

Purpose: OCM to verify the data on specified electrical-variables parameters on devices to be qualified per data sheet limits, and assess the device's capability to function within the data sheet limits over time and application environment (e.g. operating temperature range, voltage, input/output levels, etc.) in accordance with JESD86.

Input/output capacitance is one of the parameters evaluated for new process/design qualifications using MIL-STD-883 method 3012 or JESD6. The device bias is at nominal operating voltage. Capacitance measurements are made at all logic levels for digital devices and normal biased condition for analogue devices.

A.9 TC8 – Flammability (FL)

Flammability is only applicable to plastic devices.

Test methods: UL94 or IEC 60749-32 are applicable.

The bulk material test is mandatory but the OCM could meet this test requirement by using material manufacturers' test data. If bulk material is not available, IEC 60695-11-5 needle flame is a suitable method for tests on individual devices.

A.10 TC9 – Hot carrier injection (HCI)

This is applicable to sub-micron MOS technologies where appropriate testing to evaluate long term intrinsic failure mechanisms for device/design related charge injection is carried out.

Test methods: JP001.01 or IEC 62416.

Details of test methods, results and the capability life demonstrated, for < 0,1 % failures, are to be made available. Examples of appropriate methods are found in Table A.1.

Table A.1 – Conditions of the DC over the voltage stress method of JP001.01 or IEC 62416 test

Absolute maximum V_{cc} for DRAM.	Maximum V_{cc} for other devices.
Duration 1 000 h.	
Dynamic operation.	End point: electrical test (ET). Population parameter drift.

A.11 TC10 – Hermeticity (HE)

Not applicable to non-hermetic packages.

Test methods: JESD22-A109 or MIL-STD-883 method 1014 or MIL-STD-750 method 1071 or IEC 60749-8. Note that IEC 60749-8 uses metric units, and has condition E for weight gain gross leak testing and die penetrant gross leak testing.

A.12 TC11 – High temperature bake (HTB)

Test methods: JESD22-A103 or IEC 60749-6 condition B for 1 000 h or JESD22-A103 condition C for 500 h for plastic packages.

JESD22-A103 condition E for 10 h or condition D for 72 h for ceramic packaged devices. Note that IEC 60749-6 does not contain these test conditions

Examines device metal/contact inter-diffusion robustness.

A.13 TC12 – High temperature blocking bias (HTBB)

Test method: MIL-STD-750 method 1048, T_{amb} 150 °C ± 5 °C / 500 h or at 125 °C / 1 000 h at $V_{bias\ max}$ at which DC and AC parameters are guaranteed unless otherwise specified. The critical device blocking junction is reverse biased. Thermal shutdown is not allowed.

A.14 TC13 – High temperature gate bias (HTGB)

Test method: JESD22-A108 examines MOS gate oxide capabilities. T_{amb} 150 °C ± 5 °C for 1 008 h at V_{cc} (maximum) at which DC and AC parameters are guaranteed unless otherwise specified.

A.15 TC14 – High temperature reverse bias (HTRB)

Test method: JESD22-A108 examines junction capabilities. T_{amb} 150 °C ± 5 °C at maximum rated junction temperature specified in the user's/OCM's specification with the device reverse biased to 80 % of maximum breakdown voltage specification or maximum junction temperature to avoid thermal runaway. If T_{amb} is < 145 °C due to device stability, actual T_{amb}, T_j and bias conditions shall be documented. Examination of junction capabilities is done at 504 h (optional) and 1 008 h.

NOTE T_j is the device semiconductor junction temperature, and bias refers to the reverse voltage bias.

A.16 TC15 – High temperature operating life (HTOL)

A.16.1 General

Test method: JESD22-A108 or MIL-STD-883 method 1005 or IEC 60749-23 where a static or dynamic life test which best relates to the device type is applied:

a) devices are cooled to 55 °C or lower prior to the removal of bias;

b) interruption of bias for up to 1 min for the purpose of moving the devices to cool down positions is not considered removal of bias;

c) following bias removal the devices are maintained at less than 30 °C ambient until tested;

d) electrical endpoint testing is normally to be completed within 48 h of removal of bias.

End point measurements: electrical test TC6 (ET) including population parameter drift.

A.16.2 Qualification conditions

The qualification conditions are as follows:

a) 1 000 h at T_{amb} ≥ 125 °C. Higher test temperatures for shorter test times could be used provided the stress is equivalent and anomalous failures do not result from the higher test temperature;

b) maximum operating voltage;

c) if internal power dissipation causes T_j to exceed T_{jmax} or activate a thermal shutdown circuit, the test temperature could be reduced and the test time extended;

d) use the field life simulated by the qualification test derived from using the temperature and voltage acceleration factors defined herein in the qualification report.

A.16.3 Test results assessment

Product monitor results accumulated from periods of accelerated life test could be used to assess early life and long term failure rates, using JESD85 or the following:

$$\text{FIT} = \frac{\text{Chi}^2\left(B,c\right)\times 10^9}{2\times N\times t\times A_\text{T}\times A_\text{V}}$$

where

Chi^2 (60 %,0) = 1,83

Chi^2 (60 %,1) = 4,04

Chi^2 (60 %,2) = 6,21

B is the upper confidence limit;

c is the number of observed defects;

N is the number of devices tested;

A_V is the voltage acceleration factor;

A_T is the temperature acceleration factor;

t is the test duration of up to 168 h for early life calculations or total test duration minus early life period for long term life calculations.

A.16.4 Temperature acceleration factor

Use the activation energy indicated from relevant failure analysis data. Where no relevant data is available, an activation energy of 0,7 eV is to be used, but it shall be recognized that this will not take account of oxide failure mechanisms.

See Table A.2 for examples of temperature acceleration factors which use activation energy of 0,7 eV.

Table A.2 – Examples of temperature acceleration factors

Examples of A_T for E_a = 0,7 eV	T_oven °C	t h	T_{ja} °C	A_T	Field life years
$A_T = e^{\left[\left[\frac{E_\text{a}}{K}\right]\left[\frac{1}{T_{j\text{sys}}}-\frac{1}{T_{j\text{oven}}}\right]\right]}$	125	1 000	0	78	8,9
			15	55	6,3
			30	41	4,7
			45	31	3,6
			60	25	2,8
where	125	2 000	0	78	17,8
E_a is the activation energy;			15	55	12,6
K = 8,617 × 10^{-5} eV/K;			30	41	9,3
$T_{j\text{sys}}$ K = 273 + T_{ja} + T_{sys};			45	31	7,1
$T_{j\text{oven}}$ K = 273 + T_{ja} + T_{oven};			60	25	5,6
T_{sys} = 55 °C system ambient;	150	1 000	0	260	29,7
T_{ja} is the junction temperature rise due to power dissipation.			15	170	19,4
			30	117	1ESD
			45	83	9,5
			60	61	7,0

A.16.5 Supply voltage acceleration factor

The supply voltage acceleration factor is selected as follows:

- if a supply voltage higher than the nominal operating voltage is used, a voltage acceleration factor is to be used in FIT rate calculations;
- relationships are typically of the form shown below but any formula and constant values C can be used for which the OCM has supporting evidence available:

$$A_V = e^{C(V1 - V2)}$$

where

A_V is the voltage acceleration factor;

C is a constant determined by the dielectric integrity data;

$V1$ is the stress voltage;

$V2$ is the operating voltage;

- supply voltage acceleration shall be used with circumspection and justified on a case-by-case basis.

A.17 TC16 – Latch-up (LU)

Latch-up is applicable to CMOS, NMOS, bipolar and all variations and combinations of these technologies.

Test methods: JESD78 (preferred test method) or IEC 60749-29, or AEC-Q100-004 with power supply overvoltage and current injection into the input and output (I/O) pins.

A.18 TC17 – Lead integrity (LI)

This is applicable to through hole mount ICs. It is not applicable to SMD and PGA (pin grid array).

Test methods: JESD22-B105 or MIL-STD-883 method 2004 condition B2 lead fatigue or IEC 60749-14. Note that IEC 60749-14 uses metric units.

The number of leads to be tested is 15 leads from a random sample of a minimum of 3 devices. If package corner pins have reduced width or thickness, then at least 1 corner pin is to be tested on each device such that all corner pins are included in the sample.

Carry out the end point hermeticity test for hermetic packages. This is a destructive test.

A.19 TC18 – Lid torque (LT)

Test method: MIL-STD-883 method 2024.

A.20 TC19 – Mechanical sequence (MS)

A.20.1 General

The same samples are to receive all the tests in the sequence.

This is applicable only to cavity packages and devices with bonds and solder joints not moulded in.

End point tests: External visual inspection TC35 (VI), hermeticity fine and gross TC10 (HE), electrical test TC6 (ET).

A.20.2 Constant acceleration

Test method: MIL-STD-883 method 2001. Apply Y1 axis only. IEC 60749-36.

A test condition appropriate to the package mass, area and perimeter length is to be selected.

The test condition used is to be made available.

A.20.3 Vibration (variable frequency)

Test method:

- JESD22-B103; or
- MIL-STD-883 method 2007 condition A; or
- IEC 60749-12.

Peak acceleration: 20 g.

A.20.4 Mechanical shock

Test method:

- JESD22-B104 condition B; or
- MIL-STD-883 method 2002 condition B; or
- IEC 60749-10, 5 pulses 1 500 g, each pulse 0,5 ms duration.

A.21 TC20 – Marking permanency (MP)

Test methods: JESD22-B107 or MIL-STD-883 method 2015 or IEC 60749-9.

Tests to evaluate the legibility when subjected to the application and removal of labels or the use of solvents and cleaning solutions commonly used during the removal of solder flux residue.

The sample "groups" can each consist of one device. Each group is tested with a different solvent.

A.22 TC21 – Non-volatile memory operating life (NVL)

Test method: JESD22-A117.

Applicable to floating gate technology electrically programmable/erasable non-volatile memory devices including embedded memory. The write/erase and subsequent data retention properties of the device using a combination of write/erase cycling and high temperature bake testing is to be determined. Endurance and retention qualification specifications are specified in JESD47 (requirements are considered destructive) or may be developed using application knowledge based on methods as in JESD94. Appropriate interim bake and electrical test points are selected by the OCM.

The subsequent data retention bake is carried on the same sample devices unless otherwise notified.

Alternative test method: AEC-Q100-005 which is similar to JESD22-A117 but requires different samples for high and low temperature data retention storage as there are some degradation processes which heal with temperature and may not show up in the high temperature flow.

A.23 TC22 – Time dependent dielectric breakdown (oxide integrity) (OI)

Test method: JP001.01 or IEC 62417.

Appropriate testing to evaluate long term intrinsic failure mechanisms in semiconductor gate oxide systems and dielectric isolation material systems is to be carried out.

Details of test methods, results and the capability life demonstrated, for < 0,1 % failures, are to be made available.

A.24 TC23 – Package dimensions (PD)

Test method: JESD22-B100 or MIL-STD-883 method 2016, or IEC 60749-3.

A.25 TC24 – Power cycling (PTC)

Test methods: MIL-STD-883 M1037 (power cycling only), test at T_{amb} = 25 °C. Test duration based upon package size/type. Devices powered to ensure T_j = 100 °C (not to exceed absolute maximum ratings).

JESD22-A122 or IEC 60749-34.

Electrical test before, at midpoint and endpoint.

Examples of conditions:

- Small package (e.g. SMD SOTS, D-pak) duration 15 000 cycles, 2 min on/off.
- Medium package (e.g. TO-220, D2-pak) duration 8 572 cycles, 3,5 min on/off.
- Large package (e.g. TO-3, TO-247) duration 5 000 cycles, 5 min on/off.

If a T_j of 100 °C cannot be achieved, consider JESD22-A105 (power and temperature cycling) as an alternative method. Test is performed only on devices with maximum rated power > 1 W and T_j 40 °C. Apply 1 000 cycles of –40 °C to 125 °C. Thermal shutdown is not allowed.

A.26 TC25 – Resistance to solder heat (RSH)

Test methods:

- JESD22-B106, test before and after RSH. SMD devices are to be fully submerged during test;
- IEC 60749-15; or
- IEC 60749-20.

A.27 TC26 – Solder preconditioning (PC)

This is not applicable to hermetic packages.

Test method: JESD22-A113 or IEC 60749-30:

a) moisture conditioning appropriate to the device moisture sensitivity classification followed by three reflow soldering operations in accordance with IPC/JEDEC J-STD-020;

b) moisture conditioning and soldering operation(s) applied are to be stated in the qualification report;

c) the moisture conditioning requirement is to be as specified or an equivalent moisture weight gain specified;

d) if wave soldering capability is required by a device specification agreed with the OCM, it will be demonstrated by immersing the device in flux followed by immersion in solder at 260 °C for 10 s. This operation could include soldering devices onto a PCB with a preheat ramp rate of up to 10 °C/s. To avoid solder bridging problems on some fine pitch packages oil can be used in place of solder for wave soldering simulation.

A.28 TC27 – Solderability (SD)

Requirement:

Devices stored in the as received condition and shipping container are to retain solderability after delivery for a minimum of 12 months in "standard atmospheric conditions" of ambient temperature and relative humidity in the range 5 °C to 30 °C, 20 % to 70 % RH.

Test method and ageing, see Table A.3: industry standard dip and look test conditions and steam ageing are given below as test references. These methods will not be suitable for all packages, for example fine pitch and chip scale and dry heat ageing can be more suitable for some lead finishes. Any differences in test method and ageing used should be noted during registration.

Table A.3 – Dip and look test references

Test method:	JESD22-B102 or MIL-STD-883-M2003 or IEC 60749-21.
Flux:	Non-activated flux.
Ageing:	8 h steam.
THM (through hole mount):	245 °C for 5 s.
SMD:	215 °C ± 2 °C for 5 s ± 1 s.
Palladium plated SMD:	The OCM can perform the test at 215 °C ± 2 °C for 10 s ± 1 s, but the user reserves the right to perform the test as specified and to reject on failure.
NOTE	IEC 60749-21 uses metric units and defines lead-free solder in more detail than JESD22-B102.

A.29 TC28 – Soft error rate (SER)

Test methods: JESD89 including JESD89-1, JESD89-2 and JESD89-3 or IEC 60749-38 or IEC 60749-17.

This test applies to DRAM and SRAM devices only (not embedded memory). For SRAM references to refresh can be ignored.

Reporting: The number of errors detected, including SEFI and SEL and the following test parameters are to be stated in the qualification report. Appropriate parameter values (see Table A.4), are to be chosen by the OCM:

Table A.4 – Parameter values for consideration

Sample size.	Refresh type, burst, etc.
Test duration (h).	Test temperature.

Sample size/test duration: For qualification (see Table A.5), the number of device-hours shall be adequate to demonstrate that the soft single bit error rate at T_{amb} 55 °C and 90 % UCL does not exceed 20 FIT/Mbit for both DRAM and SRAM.

Table A.5 – Test conditions

Recommended test conditions:	Recommended data pattern:
V_{cc} minimum specified for data retention.	Write and verify checkerboard once, then read/refresh continuously.
Maximum specified refresh interval (period).	Repeat with complementary checkerboard.
Test temperature 55 °C. Cycle time 500 ns.	Test with checkerboard and complementary pattern for approximate equal durations.

Accelerated testing: Accelerated testing using the "hot source" irradiation method is not acceptable as a substitute for system level soft error test.

A.30 TC29 – Steady state operating life (SSOL)

Test method: JESD22-A108 or IEC 60749-23.

Examine device power handling capabilities. T_{amb} for 1 008 h. Device is biased statically to full power at ambient temperatures. Thermal shutdown is not allowed.

A.31 TC30 – Temperature cycling (~~TC~~ TPC)

Test methods:

- solder preconditioning for non-hermetic SMD per test TC26 (PC);
- JESD22-A104 condition C, 500 cycles, −65 °C to +150 °C; or
- JESD22-A104 condition B, 1 000 cycles, −55 °C to +125 °C; or
- MIL-STD-883 method 1010 condition B, 1 000 cycles, −55 °C to +125 °C; or
- IEC 60749-25, 1 000 cycles, −55 °C to +125 °C.

1 min maximum transfer time. 10 min minimum dwell time if using MIL-STD-883 method 1010 or 1 min minimum dwell time if using soak mode 1 of JESD22-A104 or select an appropriate dwell time based upon featuring and mass. Solder preconditioning to be applied for non-hermetic SMD per test code TC26 (PC).

End points: Hermeticity (hermetic devices only) test TC10 (HE).

Qualification electrical test TC6 (ET).

The OCM will apply the specified number of cycles. An alternative number of cycles and temperature extremes with T_{min} ≤ −40 °C is acceptable if the OCM can show the stress level is equivalent.

A.32 TC31 – Temperature humidity reverse bias (THRB)

Test method: JESD22-A101. 1 000 h 85 °C / 85 % RH with device reverse biased at 80 % of rated breakdown voltage up to a maximum of 100 V or limit of chamber. Electrical test before at 500 h and 1 000 h.

A.33 TC32 – Temperature humidity bias (THB or HAST)

See Table A.6 for the test methods.

Solder preconditioning for non-hermetic SMD per test TC26 (PC).

Consider intermittent bias for cases where T_j > 5 °C above ambient.

End point: Qualification electrical test TC6 (ET).

Table A.6 – Test methods

Temperature humidity bias (THB) test	Highly accelerated temperature and humidity stress test HAST is considered to be a destructive test.	
JESD22-A101 or IEC 60749-5	JESD22-A110 or IEC 60749-4	
	Relative humidity:	85 % ± 5 %
	Temperature:	130 °C ± 2 °C
	Duration:	96 h

HAST shall not exceed 130 °C as above this value non-valid results have been known to occur. Other HAST conditions with lower temperatures per JESD22-A110 can be used as an alternative to the 85/85 THB test when the OCM has adequate evidence of correlation using those conditions. The conditions used shall be stated in the qualification report.

A.34 TC33 – Terminal strength (TS)

Test method: MIL-STD-750 method 2036 for diodes and transistors.

A.35 TC34 – Thermal resistance (thermal impedance) (TR)

Use any appropriate test method. Examples of methods are included here but not limited to:

- JESD531 for signal and regulator diodes,
- JESD313-B for conduction cooled power transistors,
- JESD51-1 and JESD51-2 for integrated circuits (natural convection),
- JESD282 for bridge rectifier assemblies, JESD24-4 for bipolar transistors,
- JESD24-3 for power MOSFETs,
- JEP138 for IR thermal imaging determination of die temperature.

The device data shall state the thermal impedance determined (θ_{jc} and θ_{ja}).

NOTE

θ_{jc} is the thermal resistance from the component semiconductor junction to the component case.

θ_{ja} is the thermal resistance from the component semiconductor junction to the surrounding ambient air.

A.36 TC35 – Visual inspection (VI)

A.36.1 TC35a – External visual inspection

Purpose, apparatus and procedure are as specified in:

- JESD22-B101 for plastic encapsulated devices;
- MIL-STD-883 method 2009 for hermetically packaged ICs; and
- MIL-STD-750 method 2071 for hermetically packaged discrete semiconductor devices or test method IEC 60749-3.

NOTE JESD22-B101 inspects from ×3 to ×7 with up to ×30 magnification whereas IEC 60749-3 allows ×3 to ×10 magnification. Also IEC 60749-3 does not include:

a) the external visual report from templates;

b) the maximum criteria of 5 % base material exposure through the final plating.

Plastic package failure criteria: JESD22-B101 with the addition of the following molding defect criteria. Where no measurement criteria are given, the defect is a reject if visible at ×3 magnification as follows:

a) incomplete fill of package form;

b) inner lead exposed;

c) rough surface > 10 % of the total area in any site of package;

d) pin holes;

e) surface blister;

f) blister void (surface blister already broken or can be broken by a needle);

g) blister near a power package mounting tab;

h) ejection pin defects in any direction and in any part of the marking area which are > 0,1 mm in any direction;

i) any crack or gap at interface of metal and resin;

j) flash on lead > 0,5 mm from package body;

k) flash on power package mounting tab hole;

l) cap and frame misalignment > 0,1 mm;

m) broken package;

n) resin mark around ejector hole > 0,1 mm in any direction.

A.36.2 TC35b – Internal visual inspection

Test method:

- MIL-STD-883 method 2010 condition B for microcircuits,
- MIL-STD-750 method 2072.5 for transistors,
- MIL-STD-750 method 2074.2 for discrete semiconductors,
- MIL-STD-750 method 2069 for MOSFETs transistors,
- MIL-STD-750 method 2070 for microwave discrete and multiple transistors.

Only the criteria given which are relevant to the device under inspection need be applied. Normally, OCMs' results prior to encapsulation will be used. If decapsulation is employed, due allowance will be made for damage caused in the decapsulation process.

A.37 TC36 – Water vapour content, internal (WV)

For hermetic cavity packages only: Test method is 5 000 parts per million maximum water vapour content at 100 °C to MIL-STD-883 method 1018 procedure 1 mass spectrometry or IEC 60749-7.

A.38 TC37 – X-ray inspection (XR)

The construction quality of plastic devices is assessed in relation to the criteria in MIL-STD-883 method 2012. Only the criteria given which are relevant to plastic devices need to be applied.

The number and size of sub surface voids in plastic encapsulation material are assessed by acoustic microscopy to IPC/JEDEC J-STD-035 or IEC 60749-35 components, X-ray or other suitable method. The OCM is to have appropriate acceptance criteria.

A.39 TC38 – Moisture sensitivity level (MSL)

Test method:

a) IPC/JEDEC J-STD-020 or IEC 60749-20 for identification of the MSL rating for non-hermetic, moisture sensitive surface mount components;

b) IPC/JEDEC J-STD-033 or IEC 60749-20-1 for the handling, packaging, shipping and use of MSL sensitive components (preferred).

NOTE IEC 60749-20 and IEC 60749-20-1 both have an extra MSL category for 168 h and label the MSL ratings as MSL = A1 or B1 or B2 or B3 etc. instead of MSL = 1 or 2 or 3 etc.

A.40 TC39 – Ball shear test (BST)

Test method:

- JESD22-B117A; or
- AEC-Q100-010.

A.41 TC40 – Negative bias temperature instability (NBTI)

Test method:

- JP001.01; or
- IEC 62374; or
- IEC 62374-1.

Appropriate testing to evaluate long term intrinsic failure mechanisms due to degradation in threshold voltage as a result of gate bias at high temperature is to be carried out.

Details of test methods, results and the capability life demonstrated, for < 0,1 % failures, are to be made available.

A.42 TC41 – Accelerated tin whisker test

Test method: JESD201 class 2 or JESD22-A121 or IEC 62483 (preferred).

IEC 62483 is the latest most up to date tin whisker accelerated test method.

The ~~supplier~~ OCM is to have an accelerated tin whisker testing and mitigation plan in place. Details of test methods and results are to be available.

Annex B
(informative)

Cross-reference to STACK Specification S/0001 revision 14

STACK Specification S/0001 revision 14 notice 3, paragraph heading title	STACK Specification S/0001 revision 14 notice 3, paragraph number	IEC TS 62686-1 (edition 2.0), clause/subclause, title or paragraph content	IEC TS 62686-1 (edition 2.0), clause/subclause number	Description of reformatting changes in the IEC version
		Introduction	None	Describes relationship to STACK Specification S/0001 revision 14 and IEC TS 62564-1.
Purpose and scope	1.1	Scope	1	IEC scope worded for IEC audience. Warning added about using IEC/TS 62686-1 in avionics environments.
Use of equivalent tests	1.2	General	4.1	Moved to Clause 4 and added that IEC test methods are referenced but alternative methods for example JEDEC are acceptable. Third Party ISO 9001 certification added. Annexes cross-referenced.
Liaison with STACK	1.3	Liaison with STACK	Note in introduction	Removed into a draft IECQ document. Note added to the introduction about adopting the STACK specification.
Translation	1.4	N/A	None	IEC has a process for this – deleted.
Compliance with Internal Standards	1.5	Compliance with internal standards	4.15	
Referenced standards	2	Normative references	2	Added IEC test methods. The Bibliography contains references from Annex A.
Terms and definitions	3	Terms, definitions and abbreviations	3	The individual terms are itemized in IEC format. Abbreviations have been added in 3.2.
Administration	4	N/A	None	Entire section removed into a draft IECQ document.
PROCEDURES	5	Technical requirements	4.1	Change in clause/subclause titles to follow IEC format. The OCM instead of the supplier has been used throughout and removal of italics for the STACK terms and definitions.
		Procedures	4.2	
		General	4.2.1	

STACK Specification S/0001 revision 14 notice 3, paragraph heading title	STACK Specification S/0001 revision 14 notice 3, paragraph number	IEC TS 62686-1 (edition 2.0), clause/subclause, title or paragraph content	IEC TS 62686-1 (edition 2.0), clause/subclause number	Description of reformatting changes in the IEC version
Product discontinuance	5.1	Product discontinuance	4.2.2	No change.
The supplier shall provide the user a minimum of 12 months' notice	5.1.1	The OCM shall provide the user a notice of last order dates: – a minimum of 12 months for single sourced devices – 6 months for multi sourced devices	4.2.2a)	Not a heading so has remained as 4.2.2a).
The supplier may give less notice period	5.1.2	The OCM may give less notice period	4.2.2b)	Not a heading so has remained as 4.2.2b).
Custom ASICS	5.1.3	For custom ASIC devices	4.2.2c)	Not a heading so has remained as 4.2.2c).
ESD protection during manufacture	5.2	ESD protection during manufacture	4.2.3	Refer to latest ESD specification IEC 61340-5-1.
Specification control	5.3	Specification control	4.2.4	Added notes as this applies to custom and special orders.
Traceability	5.4	Traceability	4.2.5	Added an introductory sentence "Traceability shall be managed as follows"; changed "box" to "container" and added date code and/or lot code.
PRODUCT OR PROCESS CHANGE NOTIFICATION (PCN)	6	Product or process change notification (PCN)	4.3	Added subclause title "General" and an introductory sentence: "The OCM shall provide the following".
		General	4.3.1	
Notification	6.1	Notification	4.3.2	Deleted reference to STACK.
Notification details	6.2	Notification details	4.3.3	No change.
Notifiable changes	6.3	Notifiable changes	4.3.4	No change.
SHIPMENT CONTROLS	7	Shipment controls	4.4	Added an introductory sentence "The OCM shall have the following shipment controls".
		General	4.4.1	
Shipping container packaging and date code marking	7.1	Shipping container and date code marking	4.4.2	Modified the heading. Added manufacturer's name, logo and trademark.
Date code remarking	7.2	Date code remarking	4.4.3	No change.
Inner box formation	7.3	Inner container formation	4.4.4	Changed "box" to "container".
Date code age on delivery	7.4	Date code age on delivery	4.4.5	Added an introductory sentence "Date code age on delivery shall be as follows".
ESD marking	7.5	ESD marking	4.4.6	No change.
MSL	7.6	MSL	4.4.7	No change.

STACK Specification S/0001 revision 14 notice 3, paragraph heading title	STACK Specification S/0001 revision 14 notice 3, paragraph number	IEC TS 62686-1 (edition 2.0), clause/subclause, title or paragraph content	IEC TS 62686-1 (edition 2.0), clause/subclause number	Description of reformatting changes in the IEC version
Lead-free marking	7.7	Lead-free marking	4.4.8	New: added lead-free marking requirement
LABELS General	7.8	Labels	4.4.9	Moved to 4.4.9
Label content	7.9		Table 1	
ELECTRICAL	8	Electrical	4.5	No change.
Operating conditions	8.1	General	4.5.1	Modification of subclause title.
Electrical test	8.2	Electrical test	4.5.2	No change.
Electrical parameter assessment	8.2.1	Electrical parameter assessment	4.5.3	No change.
SDRAM memories	8.2.2	SDRAM memories	4.5.4	No change.
Logic families	8.2.3	Logic families	4.5.5	No change.
Power MOSFETs	8.2.4	Power MOSFETs	4.5.6	No change.
Silicon rectifier diodes	8.2.5	Silicon rectifier diodes	4.5.7	Added MIL-PRF-19500 or equivalent.
MECHANICAL	9	Mechanical	4.6	No change.
Package dimensions	9.1	General	4.6.1	Modification of subclause title.
Device or packaging marking	9.2	Device or shipping container marking	4.6.2	Changed title. Changed “packaging” to “container”.
Legibility	9.2.1	General	4.6.2.1	Modification of subclause title.
Top surface	9.2.2	Top surface	4.6.2.2	Added marking can be below assembly code and changed type number to part number.
Small packages	9.2.3	Small packages	4.6.3	No change.
Moisture sensitivity	9.3	Moisture sensitivity	4.6.4	No change.
Robustness of hermetic seals	9.4	Robustness of hermetic seals	4.6.5	No change.
Terminations finishes	9.5	Terminations finishes	4.6.6	Added a tin whisker growth test.
AUDIT CAPABILITY	10	Audit capability	4.7	Added an introductory sentence “The OCM shall be able to carry out the following”.
		General	4.7.1	
Internal quality audits	10.1	Internal quality audits	4.7.2	Added ISO 9001 as a minimum requirement.
Subcontract manufacturing	10.2	Subcontract manufacturing	4.7.3	No change.
QUALITY ASSURANCE	11	Quality assurance	4.8	Added subclause title “General” and the introductory sentence “The OCM shall have the following quality assurance system”.
		General	4.8.1	

STACK Specification S/0001 revision 14 notice 3, paragraph heading title	STACK Specification S/0001 revision 14 notice 3, paragraph number	IEC TS 62686-1 (edition 2.0), clause/subclause, title or paragraph content	IEC TS 62686-1 (edition 2.0), clause/subclause number	Description of reformatting changes in the IEC version
Quality system	11.1	Quality system	4.8.2	Added an introductory sentence "The OCM quality system shall meet the following requirements". Deleted "or an equivalent standard."
Sampling plans	11.2	Sampling plans	4.8.3	No change.
Failure analysis support	11.3	Failure analysis support	4.8.4	Added an introductory sentence "OCM failure analysis support shall meet the following requirements".
Outgoing quality	11.4	Outgoing quality	4.8.5	Added subclause title "General".
		General	4.8.5.1	
DPM levels	11.4.1	DPM levels	4.8.5.2	No change.
DPM calculation	11.4.2	DPM calculation	4.8.5.3	No change.
Corrective action	11.4.3	Corrective action	4.8.5.4	No change.
Data reporting	11.4.4	Data reporting	4.8.5.5	No change.
INCOMING INSPECTION	12	Supplier performance monitoring by the user	4.9	Changed the title. Added subclause title "General" and an introductory sentence "The user reserves the right to decide upon the following".
		General	4.9.1	
Lot acceptance	12.1	Lot acceptance	4.9.2	No change.
Suspension of deliveries	12.2	Suspension of deliveries	4.9.3	No change.
Loss of approval	12.3	Loss of approval	4.9.4	No change.
AQL/LTPD figures	12.4	AQL figures	4.9.5	Modification of subclause title.
100 % screening	12.5	100 % screening	4.9.6	Edited.
		Termination determination	4.9.7	Added new subclause on termination determination.
QUALIFICATION	13	Qualification	4.10	Added an introductory sentence "The OCM shall manage the following".
		General	4.10.1	
Methodology	13.1	Methodology	4.10.2	No change.
		General	4.10.2.1	
Procedures and methods	13.1.1	Procedures and methods	4.10.2.2	No change.
Alternative procedures	13.1.2	Alternate procedures	4.10.2.3	Changed the title.
Accomplish risk analysis	13.1.3	Risk analysis	4.10.2.4	Changed the title.
Perform and document stress test driven	13.1.4	Stress test driven qualification	4.10.2.5	Changed the title to "Stress test driven qualification".

STACK Specification S/0001 revision 14 notice 3, paragraph heading title	STACK Specification S/0001 revision 14 notice 3, paragraph number	IEC TS 62686-1 (edition 2.0), clause/subclause, title or paragraph content	IEC TS 62686-1 (edition 2.0), clause/subclause number	Description of reformatting changes in the IEC version
Perform and document reuse of existing data	13.1.5	Use of product similarity data	4.10.2.6	Changed the title to "Use of product similarity data".
Perform and document verified reliability models	13.1.6	Use of reliability models	4.10.2.7	Changed the title to "Use of reliability models".
Test samples	13.2	Test samples	4.10.3	Added subclause title "General" and an introductory sentence "The OCM shall use the test samples described below".
		General	4.10.3.1	
Test failures	13.2.1	Test failures	4.10.3.2	No change.
Additional samples	13.2.2	Additional samples	4.10.3.3	No change.
Consolidation of lots	13.2.3	Consolidation of lots	4.10.3.4	No change.
Reduced sample sizes	13.2.4	Reduced sample sizes	4.10.3.5	No change.
Qualification categories	13.3	Qualification categories	4.10.4	No change.
Maintenance of qualification standard	13.4	Maintenance of qualification standard	4.10.5	No change.
In process test results	13.5	In-process test results	4.10.6	Added an introductory sentence "In-process test results shall be managed as follows".
Product monitor results	13.6	Product monitor results	4.10.7	No change.
References	13.7	References	4.10.8	No change.
Qualification report	13.8	Qualification report	4.10.9	No change.
Archiving	13.9	Archiving	4.10.10	No change.
Qualification by similarity	13.10	Qualification by similarity	4.10.11	Added an introductory sentence "Qualification by similarity can be used as follows".
Similarity assessment	13.11	Similarity assessment	4.10.12	Added subclause title "General".
		General	4.10.12.1	
Die changes	13.11.1	Die changes	4.10.12.2	No change.
Process/wafer fabrication changes	13.11.2	Process/wafer fabrication changes	4.10.12.3	No change.
Package/assembly changes	13.11.3	Package/assembly changes	4.10.12.4	Added an introductory sentence "Package /assembly changes shall be managed as follows".
RELIABILITY	14	Reliability	4.11	Added subclause title "General" and the introductory sentence "The OCM shall ensure the following".
		General	4.11.1	

STACK Specification S/0001 revision 14 notice 3, paragraph heading title	STACK Specification S/0001 revision 14 notice 3, paragraph number	IEC TS 62686-1 (edition 2.0), clause/subclause, title or paragraph content	IEC TS 62686-1 (edition 2.0), clause/subclause number	Description of reformatting changes in the IEC version
Operating reliability	14.1	Operating reliability	4.11.2	Added an introductory sentence "The OCM shall manage operating reliability as follows". Added reference to JESD85 and new item d) for data on semiconductor wear-out.
Failure criteria	14.2	Failure criteria	4.11.3	No change.
Corrective action	14.3	Corrective action	4.11.4	No change.
Warranty	14.4	Warranty	4.11.5	No change.
Suspension of certification	14.5	Suspension of certification	4.11.6	No change.
Single event effects (SEE)	14.6	Single event effects (SEE)	4.11.7	Deleted "soft" and added "if available".
PRODUCT MONITOR	15	Product monitor	4.12	Added subclause title "General" and an introductory sentence "The OCM shall ensure the following".
		General	4.12.1	
Monitor program	15.1	Monitor programme	4.12.2	Added an introductory sentence "The monitor programme shall be as follows".
Problem notification	15.2	Problem notification	4.12.3	No change.
Data reporting	15.3	Data reporting	4.12.4	No change.
Samples	15.4	Samples	4.12.5	Added an introductory sentence "Samples shall be selected as follows".
Corrective action	15.5	Corrective action	4.12.6	No change.
Suspension of certification	15.6	Product monitor results	4.12.7	No change.
Accumulated test data	15.7	Accumulated test data	4.12.8	No change.
ENVIRONMENTAL HEALTH AND SAFETY (EHS)	16	Environmental health and safety (EHS)	4.13	Added subclause title "General" and an introductory sentence "The OCM shall ensure the following health and safety issues are in place".
		General	4.13.1	
EHS compliance	16.1	EHS compliance	4.13.2	No change.
Device handling	16.2	Device handling	4.13.3	No change.
Device materials	16.3	Device materials	4.13.4	No change.
SHIPMENT PACKAGING	17	Shipping container	4.14	No change.
General	17.1	General	4.14.1	No change.
		ESD requirements	4.14.2	
Electrostatic properties	17.1.1	Electrostatic properties	4.14.2.2	Clarified that the material is the package material.
ESD protection	17.1.2	ESD protection	4.14.2.3	Changed to state all devices.

STACK Specification S/0001 revision 14 notice 3, paragraph heading title	STACK Specification S/0001 revision 14 notice 3, paragraph number	IEC TS 62686-1 (edition 2.0), clause/subclause, title or paragraph content	IEC TS 62686-1 (edition 2.0), clause/subclause number	Description of reformatting changes in the IEC version
Specification compliance after shipment	17.1.3	Specification compliance after shipment	4.14.2.4	Added electrically or mechanically damaged.
Device orientation	17.1.4	Device orientation	4.14.2.5	No change.
User instructions	17.1.5	User instructions	4.14.2.6	Changed 'box' to 'container'.
Electrostatic shield	17.1.6	Electrostatic shield	4.14.2.7	No change.
Magazine surface resistivity	17.1.7	Magazine surface resistivity	4.14.2.8	No change.
Inner box surface characteristics	17.1.8	Inner container surface characteristics	4.14.2.9	Changed 'box' to 'container'.
Magazine reuse	17.2	Magazine reuse	4.14.3	No change.
Tubes	17.3	Tubes	4.14.4	Added an introductory sentence "The OCM shall ensure the following".
		General	4.14.4.1	
Cushioning material	17.3.1	Cushioning material	4.14.4.2	No change.
Partial tubes	17.3.2	Partial tubes	4.14.4.3	Changed 'box' to 'container'.
Marking access	17.3.3	Marking access	4.14.4.4	No change.
Opening	17.3.4	Opening	4.14.4.5	No change.
Trays	17.4	Trays	4.14.5	Added an introductory sentence "The OCM shall ensure the following".
		General	4.14.5.1	
For devices with …	17.4.1	Devices with MSL of 4 or higher	4.14.5.2	Added a new heading 'Devices with MSL of 4 or higher'.
Bake temperature limits…	17.4.2	Marking of bake temperature limit	4.14.5.3	Added a new heading 'Marking of bake temperature limit'.
No more than 10 full trays…	17.4.3	Stacking of trays	4.14.5.4	Added a new heading' Stacking of trays'.
For devices with special leads…	17.4.4	Special packaging	4.14.5.5	No change.
Tape and reel	17.5	Tape and reel	4.14.6	No change.
		Compliance with internal standards	4.15	New: added compliance with internal standards.
TEST CODE INFORMATION FOR REFERENCE ONLY	18	Test code (TC) information	Annex A	All test codes have an annex clause number and heading. IEC test methods have been added.
		Cross-reference to STACK Specification S/0001 revision 14 notice 3, paragraphs	Annex B	New.
		Bibliography	Bibliography	New.

Annex B
(informative)

Typical automotive component requirements

The combination of automotive processes and methods identified in items 1) to 3), are considered to be equivalent to this document:

1) quality management system to IATF 16949
2) component qualification to:
   a) microcircuits: AEC-Q100 and the additional requirements specified in 4.9.2.3 b) for the following grades:
      i) grade 0 (−40 °C to +150 °C)
      ii) grade 1 (−40 °C to +125 °C)
   b) discrete semiconductors: AEC-Q101 with the additional requirements specified in 4.9.2.3 c):

   NOTE 1 VDA 6.5 can assist to comply with some of the component qualification requirements listed in item 2.
3) production part approval process (PPAP) which is typically comprised of 17 elements as follows:
   i) design documentation, containing material composition
   ii) engineering change documentation
   iii) customer engineering approval (for automotive customers)
   iv) design failure mode and effects analysis (DFMEA)
   v) process flow diagram
   vi) process failure modes and effects analysis (PFMEA)
   vii) control plan using the outputs of the PFMEA to include specific steps to ensure the quality issues in the PFMEA will not be present in the final product
   viii) measurement systems analysis (MSA) which includes a gage repeatability and reproducibility (GR&R) analysis
   ix) dimensional results
   x) records of material/performance test report including a design verification plan and report (DVP&R)
   xi) initial process studies including statistical process control (SPC) charts on the critical characteristics
   xii) qualified laboratory documentation for any laboratory involved in completing testing
   xiii) appearance approval report
   xiv) sample production parts (typically only available to the automotive customer, see Note 4)
   xv) master sample used by manufacturer to train operators and acts as a benchmark for comparison purposes
   xvi) checking aids used by production
   xvii) customer specific requirements
4) outgoing quality shall meet the requirements of 4.9.5
5) component operating reliability shall meet the requirement of 4.12.2
6) on-going reliability testing or product monitor testing shall meet the requirements of 4.13

NOTE 2 VDA 6.3 can satisfy most of the PPAP requirements listed in item 3).

NOTE 3 The list in item 3) is not an inclusive list of PPAP requirements as automotive customers vary on the exact requirements.

NOTE 4 OCMs can offer a generic PPAP data package to ADHP customers to avoid non-disclosure issues.

NOTE 5 Official PPAP samples are typically only available to the automotive customer, although other samples are made available to the ADHP customer.

Annex C
(informative)

Requirement matrix for IEC TS 62686-1 verification

Table C.1 provides the requirements matrix for IEC TS 62686-1.

Table C.1 – Requirement matrix

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
None	Introduction		
1	Scope		
2	Normative references		
3	Terms, definitions and abbreviated terms		
4	Technical requirements		
4.1	General		
4.1.1	Overview	The supplier, preferably the original component manufacturer (OCM) or the franchised distributor, as defined in 3.1.19 and 3.1.15 respectively, shall have an appropriate quality management system and shall provide the following minimum technical requirements. Proposed equivalent test methods, rationale and supporting data shall be reviewed and shall achieve the same end objectives as specified herein. Use of such equivalent tests shall not be considered to be deviations or waivers to the requirements of this document.	
4.2	Procedures		
4.2.1	General	The OCM shall have the following procedures: • product discontinuance (4.2.2); • ESD protection during manufacture (4.2.3); • specification control (4.2.4); • traceability including anti-counterfeit measures (4.2.5).	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.2.2	Product discontinuance	Notification shall be in accordance with JEDEC/IPC/ECIA J-STD-048 or equivalent with the exception of timing as described in a) and b) below: a) the OCM shall provide the user with a notice of last order dates: – a minimum of 12 months before these dates for single-source devices, and – 6 months before these dates for multi-sourced devices;	
4.2.3	ESD protection during manufacture	All integrated circuits and discrete semiconductors are considered to be static sensitive and shall be protected through the OCM's manufacturing operation. The OCM shall ensure that devices are not exposed to static damage and are not degraded or damaged due to static discharge.	
4.2.4	Specification control	The OCM shall: a) when applicable, have a central or local record of the user's part number and specification, against the product to be delivered; b) ensure the specifications on the purchase documents have been reviewed and accepted by personnel authorized to do so.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.2.5	Traceability including anti-counterfeit measures	Traceability shall be managed as follows: a) the OCM shall have traceability for any device in a shipping lot through a route code, lot code or other marking on the device or magazine or inner container to identify the manufacturing route, for example groups of wafer lots, wafer fabrication location, assembly location, test location, date code and/or lot code; b) the information needed to interpret the code shall be available; c) the procedure shall be available for inspection during audit. The OCMs shall use anti-counterfeit measures to protect their intellectual property, such as use of registered trademarks, logos, patents, etc. The OCM shall also assist the user in determining if the product is genuine when requested and in identifying the franchised distributors.	
4.3	Product or process change notification (PCN)		
4.3.1	General	The OCM shall provide the following: • notification (4.3.2); • notification details (4.3.3); and • notifiable changes (4.3.4).	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.3.2	Notification	a) the OCM shall give at least 90 calendar days' written notice prior to shipping the changed product. The user will respond to confirm the date on which changed product shipments can begin (it could be less than 90 calendar days), advise that the changed product is not acceptable, or request further information; b) for custom ASIC devices, change notification periods are normally specified in the purchase contract; c) in an event beyond the control of the OCM where 90 calendar days' notice cannot be given, the OCM shall reach a mutually agreed lesser notice period with any user affected by the change	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.3.3	Notification details	The PCN shall include the following items: a) title of change; b) the OCM's type number(s) affected; c) the OCM's notification identification number; d) estimated last order and shipment dates for unchanged devices to be supplied on request; e) estimated earliest shipment date of changed devices; f) manufacturing location and product line affected; g) a thorough description of the proposed change; h) the means of distinguishing changed devices from unchanged devices. This may be a date code, lot code, date code range or a distinguishing marking or feature that is visible to the user at point of receipt of shipment; i) sufficient engineering and/or qualification test data, including details of any qualification test vehicle used and its applicability to the product change, shall be available on request to demonstrate that the change will not adversely affect device form, fit, function, quality or reliability, and that the changed product will continue to meet the specified requirements; j) user part number of the affected device (preferred item but not mandatory).	
4.3.4	Notifiable changes	J-STD-046 shall be used as a guide to changes requiring notification.	
4.4	Shipment controls		

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.4.1	General	The OCM shall have the following shipment controls: • shipping container and date code marking (4.4.2); • date code remarking (4.4.3); • inner container formation (4.4.4); • date code age on delivery (4.4.5); • ESD marking (4.4.6); • MSL (4.4.7); • lead-free marking (4.4.8); and • labels (4.4.9).	
4.4.2	Shipping container and date code marking	The shipping container and date code marking shall be in accordance with JEP130 or an equivalent standard. The OCM's name, logo and/or trademark shall be marked on the shipping container where it is practical to do so.	
4.4.3	Date code remarking	If only one date is marked to represent the manufacturing date and initial electrical test it shall not be changed unless it is necessary to correct poor quality marking or incorrect information, and provided that the time delta between the original mark and the remark is less than 6 weeks.	
4.4.4	Inner container formation		
4.4.5	Date code age on delivery		
4.4.6	ESD marking	The symbols used and labelling shall be in accordance with JESD471 or an equivalent standard.	
4.4.7	MSL	The labelling and shipping container shall be in accordance with IEC 61760-4 or IPC/JEDEC J-STD-033 or an equivalent standard.	
4.4.8	Lead-free marking	The shipping container and date code marking shall be in accordance with IPC/JEDEC J-STD-609 or an equivalent standard.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.4.9	Labels	In general, labels shall include the requirements mentioned in Table 1 and exhibit: a) human readable content: the content shown for each label in 4.4.9 shall be available in human readable form on the outside of the relevant package; a) machine readable content: bar codes for those items specified shall be included in 3 of 9 codes (bar code 39) as per ANSI/EIA-556 or equivalent compatible standard; b) warning notice: any necessary warning notices or symbols to ensure the safety of the contents shall be included as appropriate.	
Table 1		Table 1	
4.5	Electrical		
4.5.1	General	Operating conditions shall be as defined in the device specification or data sheet, as explained in 4.5.2 to 4.5.7.	
4.5.2	Electrical test	All shipped packaged devices shall have passed a production electrical test program, or in the case of user-specific devices, a test program approved by the user. Tested wafer or die products shall have an effective equivalent wafer probe test. Untested wafer and die products shall have met the OCM's minimum process control monitor (PCM) requirements. JEDEC test methods shall be used wherever possible.	
4.5.3	Electrical parameter assessment	Test methods for assessing the electrical parameter distributions (AC, DC, functional and timing) of devices should be in accordance with JESD86.	
4.5.4	SDRAM memories		
4.5.5	Logic families		
4.5.6	Power MOSFETs		
4.5.7	Silicon rectifier diodes		
4.6	Mechanical		
4.6.1	General		
4.6.2	Device marking		

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.6.2.1	General		
4.6.2.2	Top surface	All of the following required markings shall be marked on the top side, except where otherwise indicated below: a) pin 1, identifiable either by a mark or by reference to a physical feature of the device; b) the OCM's name or logo; c) the OCM's part number or individual user part number as required; d) the date code of assembly or test. Formats YYWW, or YWW or YM are acceptable (Y = year numeral, W = week numeral, M = month character). If both assembly and test date codes are marked, the assembly code may be bottom marked; e) a manufacturing route trace code. The top surface is preferred, but the device bottom surface may be used; f) if both assembly and manufacturing route trace codes are marked on the bottom surface, the manufacturing route trace code shall be marked below the assembly code.	
4.6.3	Small packages		
4.6.4	Moisture sensitivity	The moisture sensitivity of all non-hermetic surface mount components shall be tested and classified according to IEC 61760-4 or IPC/JEDEC J-STD-020. The MSL classification shall be available.	
4.6.5	Robustness of hermetic seals	The seal shall not be compromised by any normal handling, testing or manufacturing processes.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.6.6	Terminations finishes	In addition, the following requirements shall be met: a) thickness limits shall be met over 95 % of the termination surface. The OCM shall select appropriate measurement locations; b) plating composition and thickness limits shall be available; c) it is not necessary for solder dipping, where used to improve the solderability of the termination, to cover the entire termination. The area covered should be appropriate to the type of package, for example J-bend packages (area below base plane), or gull wing packages (center of bottom radius to trimmed edge of termination); d) tin electroplate finishes shall be matt, dense, homogenous, free of co-deposited organic material and suitably treated to inhibit whisker growth. When applicable an appropriate tin whisker plan or process should be in place (for example accelerated tin whisker testing to JESD201 Class 2 limits or JESD22-A121 or IEC 62483) and be demonstrable. Documented results should be made available to the user upon request; e) providing notification of changes, via the PCN process, to termination finish materials, thickness, or to plating process chemistry.	
4.7	Audit capability		
4.7.1	General	The OCM shall be able to carry out the following: • internal quality audits (4.7.2); and • subcontract manufacturing (4.7.3).	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.7.2	Internal quality audits	The OCM shall periodically audit each internal location, to assess compliance with internal standards for the following areas listed below. The following areas defined in Table 2 shall be addressed: Table 2 The results of these audits and the audit acceptance criteria shall be available for onsite inspection during an audit. The internal quality audit documentation shall be available upon request.	
4.7.3	Subcontract manufacturing	The OCM shall qualify and periodically audit all subcontracted operations to a standard equivalent to the OCM internal operations.	
4.8	Quality assurance		
4.8.1	General	The OCM shall have the following quality assurance system: • quality system (4.8.2); • sampling plans (4.8.3); • failure analysis support (4.8.4); and • outgoing quality (4.8.5).	
4.8.2	Quality system	The OCM quality system shall meet the following requirements: a) satisfy an appropriate quality management system registration, for example . one (or more) of ISO 9001, AS/EN/JISQ 9100, IATF 16949, etc.; b) ensure that the requirements of this specification are met; c) provide for the prevention and ready detection of discrepancies and for timely and positive corrective action.	
4.8.3	Sampling plans	Appropriate and statistically valid sampling plans shall be used and documented.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.8.4	Failure analysis support	OCM failure analysis support shall meet the following requirements: a) the OCM shall maintain an adequate failure analysis capability and provide a timely response to failures returned for failure verification or failure analysis; b) representative samples of devices returned as failures shall be analysed and a failure analysis report issued to the originating user, typically within 30 calendar days of the receipt by the analytical facility of such returns; c) for failure returns relating to a critical problem at a user, the failure analysis report shall typically be issued within 7 calendar days of receipt by the analytical facility.	
4.8.5	Outgoing quality		
4.8.5.1	General	Outgoing quality shall be measured as per 4.8.5.2 to 4.8.5.5.	
4.8.5.2	DPM levels	The OCM shall measure average outgoing quality (AOQ) in defects per million from uniform manufacturing processes and the results shall be in accordance with Table 3.	
4.8.5.3	DPM calculation		
4.8.5.4	Corrective action	If the outgoing quality levels given in Table 3 are not met, the OCM shall take root cause corrective action and issue a closure date for achieving the required DPM.	
4.8.5.5	Data reporting	AOQ data shall be compiled periodically and be available upon request.	
4.9	Qualification		

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.9.1	General	The OCM shall manage the following: • methodology (4.9.2); • test samples (4.9.3); • qualification categories (4.9.4); • maintenance of qualification standards (4.9.5); • in-process test results (4.9.6); • product monitor results (4.9.7); • references (4.9.8); • qualification report (4.9.9); • archiving (4.9.10); • qualification by similarity (4.9.11); and • similarity assessment (4.9.12)	
4.9.2	Methodology		
4.9.2.1	General	The OCM shall use appropriate methodologies to qualify new technology, new devices and device changes, to demonstrate that the device under qualification is capable of meeting the specified electrical, quality and reliability requirements, using qualification families (as defined in JESD47 or AEC-Q100).	
4.9.2.2	Procedures and methods	Stress test qualification procedures and methods shall be performed per Table 4.	
4.9.2.3	Alternative procedures		
4.9.2.4	Use of product similarity data		
4.9.2.5	Use of reliability models		
4.9.3	Test samples		
4.9.3.1	General	The OCM shall use the test samples described in 4.9.3.2 to 4.9.3.5.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.9.3.2	Test failures	Test failures attributed to extraneous factors not related to the qualification stress applied shall not be counted against acceptance criteria. If excessive failures from non-qualification test related mechanisms are generated, the test shall be repeated. If a larger sample size than specified in Table 4 is used and failures allowed, then the result shall meet an LTPD = 3 % for a specified sample size of 76.	
4.9.3.3	Additional samples		
4.9.3.4	Consolidation of lots	If consolidation of lots is performed, the combining of parts shall follow the similarity rules as per 4.9.12 (similarity assessment).	
4.9.3.5	Reduced sample sizes		
4.9.4	Qualification categories		
4.9.5	Maintenance of qualification standards		
4.9.6	In-process test results	In-process test results shall be managed as follows: a) if any of the inspection or package qualification tests are performed on a regular basis in the manufacturing line, these tests need not be repeated in new device qualification testing; b) if qualification tests are not performed, manufacturing inspection results showing the current quality level shall be included in the qualification report. Manufacturing package test results shall be available.	
4.9.7	Product monitor results		
4.9.8	References	Reference shall always be made to the appropriate test code information for full test details.	
4.9.9	Qualification report	The qualification report shall be available upon request.	
4.9.10	Archiving	The qualification report and the test specification (not the test program) used in the qualification shall be archived for a minimum of 7 years.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.9.11	Qualification by similarity	Qualification by similarity can be used as follows: a) a change shall be qualified if there is a potential effect on performance, quality or reliability, or if there is any degree of uncertainty about the effect of the change; b) guidance on the qualification tests, which the OCM should consider applying, for the various combinations of die, package and process changes, is shown in JESD47. The OCM shall perform tests defined in the qualification table that are appropriate, or relevant to the change; c) upon request, the OCM shall provide data for any device transferred to a new process to prove that no design deficiencies (e.g. mechanical, electrical performance, reliability, single event effects, etc.) were introduced by the process transfer.	
4.9.12	Similarity assessment		
4.9.12.1	General		
4.9.12.2	Die changes	The OCM shall document and operate an appropriate set of die similarity rules or guidelines applied by appropriate engineering review.	
4.9.12.3	Process/wafer fabrication changes	Devices to be assigned to a qualification family shall share the same critical processes and material elements.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.9.12.4	Package/assembly changes	Package/assembly changes shall be managed as follows: a) package families shall be grouped by configuration and materials of construction for examples see AQEC-Q100. In general, all members of the group that are equal to or smaller in dimensions and lead count can be considered as similar to a qualified package, provided the assembly process technology is identical; b) packages should be qualified with the worst case configuration (e.g. the largest die) they are designed to carry that is currently in production. For custom ASICs, use of a "qualification die" is acceptable, such that dies larger than the qualification die by +10 % by linear dimension are qualified, provided the package designed maximum die size is not exceeded.	
4.10	Reliability		
4.10.1	General	The OCM shall ensure the following: • operating reliability (4.10.2); • failure criteria (4.10.3); • corrective action (4.10.4); • warranty (4.10.5); • and single event effects (SEEs) (4.10.6).	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.10.2	Operating reliability	The OCM shall manage operating reliability as follows: a) the OCM shall determine the failure rate of devices operating in systems at an ambient temperature of +55 °C using the high temperature operating life (HTOL) test method or an alternative test method suitable to the device technology (i.e. HTRB or HTGB for discrete components). Failure rates shall not exceed the qualification requirements in accordance with Table 5; an approximate maximum of 155 FITs is expected. For mature and/or high volumes a desired target of 50 FITs or less is expected for integrated circuits and 20 FITs or less for discrete semiconductors. The OCM shall, upon request from the user, make available FIT rate data to confirm application specific life expectancy; b) results observed at a temperature other than +55 °C will be projected to this temperature, with 60 % confidence using an activation energy, appropriate to the failure mechanism observed. Refer to TC15 HTOL for calculation of acceleration factors; projected results shall show the 60 % confidence range. Alternatively, results can be analysed using JESD85 at higher confidence levels;	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
		c) for custom devices the OCM shall on request provide a FIT rate including the confidence range and operating life prediction to the user (based on a demonstrable methodology) for the application and environmental conditions intended; d) the OCM should provide upon request, for their device feature sizes under 100 nm, any mitigation strategies, tools or data for device lifetime calculations; see TC22, TC4, TC9 and TC40 in Annex A.	
4.10.3	Failure criteria	Failure criteria shall consist of any of the following modes: a) functional failure; b) parameter limit failure; c) intermittent faults due to the package pins, or the interconnect system, from the pins to the die surface, shall be regarded as failures; d) transitory faults attributable to the device shall be regarded as failures.	
4.10.4	Corrective action	If failures are detected in the reliability processes, the OCM shall investigate, determine root cause and take appropriate actions to achieve conformity to this document or the OCM's internal requirements whichever is the most stringent.	
4.10.5	Warranty		
4.10.6	Single event effects (SEEs)	SEE data shall be made available upon request if available.	
4.11	Product monitor		

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.11.1	General	The OCM shall ensure the following: • monitor programme (4.11.2); • problem notifications (4.11.3); • data reporting (4.11.4); • samples (4.11.5); • corrective action (4.11.6); • product monitor results (4.11.7); and • accumulated test data (4.11.8).	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.11.2	Monitor programme	The monitor programme shall be as follows: a) the OCM shall have a continuous monitor programme to demonstrate that the requirements of this document are met, on an ongoing basis, for each manufacturing operation or product process; b) statistical process control: the OCM shall control wafer production, assembly process and final test using statistical analysis. When anomalies are observed, parametric and yield data from the probe and final tests shall be analysed against in-line or electrical process control data. The root cause of the deviation shall be determined and the consequent corrective actions implemented; c) Table 5 shows the minimum test requirements for a conventional stress driven monitor. The use of a failure mechanism driven approach to optimise reliability monitoring is encouraged. On-going qualification test data and accumulated reliability monitor test data may be assessed in a structured way to reduce reliability monitor testing when failure mechanisms are shown to be eliminated by process controls and to increase testing or introduce new tests when failures are detected.	
4.11.3	Problem notification	The OCM shall have a process to notify the users and distributors in cases where failures were detected and where there is the possibility that failed parts may have been shipped or may be in the process of being shipped to the user.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.11.4	Data reporting	Reliability monitor data accumulated over the preceding two full quarters shall be available, at one month's notice.	
4.11.5	Samples	Samples shall be selected as follows: a) appropriate sample sizes shall be selected; b) samples shall be randomly selected from representative package and process family devices; c) all package types and all process families, but not necessarily all package/process combinations, shall be monitored; d) package tests shall use the largest die size the package is designed to carry that is currently in production. Custom ASIC qualification die may be used (see similarity assessment (4.9.12); e) sample lots will be added to the monitor at intervals appropriate for each test.	
4.11.6	Corrective action	Failure to meet the limits in Table 5 or the OCM's internal limits, whichever is the most stringent, shall trigger appropriate corrective action by the OCM.	
4.11.7	Product monitor results	Product monitor results shall meet the requirements of Table 5. Table 5	
4.11.8	Accumulated test data		
4.12	Environmental health and safety (EHS)		
4.12.1	General	The OCM shall ensure the following health and safety precautions are in place: • EHS compliance (4.12.2); • device handling (4.12.3); and • device materials (4.12.4).	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.12.2	EHS compliance	The OCM shall be expected to comply with all applicable national, regional, state and local laws and regulations governing environment, health and safety.	
4.12.3	Device handling		
4.12.4	Device materials	Materials used in the manufacture of devices should be non-flammable, and shall not emit harmful levels of toxic materials as a result of electrical overload or fault within the device.	
4.13	Shipping containers		
4.13.1	General	Shipping containers shall protect devices and address the following considerations.	
4.13.2	ESD requirements		
4.13.2.1	General	The OCM shall ensure that all shipping containers are static safe (non-generating as a minimum) to safeguard sensitive products occupying the same manufacturing areas. The OCM shall also ensure the following: • electrostatic properties (4.13.2.2); • ESD protection (4.13.2.3); • specification compliance after shipment (4.13.2.4); • device orientation (4.13.2.5); • user instructions (4.13.2.6); • electrostatic shield (4.13.2.7); • magazine surface resistivity (4.13.2.8); • inner container surface characteristics (4.13.2.9).	
4.13.2.2	Electrostatic properties	The electrostatic properties of the shipping container material shall be as specified after conditioning of 48 h at 23 °C ± 3 °C and 12 % RH ± 3 %.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.13.2.3	ESD protection	All devices shall be supplied in suitable electrostatic protective shipping containers with electrostatic properties meeting the requirements of ANSI/ESD S541 unless otherwise specified in 4.13.2.	
4.13.2.4	Specification compliance after shipment	The method of packing for land, sea or air transportation shall adequately protect the device from being electrically or mechanically degraded or damaged in any way during transit.	
4.13.2.5	Device orientation	Devices shall all have the same orientation within a magazine.	
4.13.2.6	User instructions	Any special handling requirements or precautions (e.g. placing of desiccants; resealing of containers; maximum number of 24 h 125 °C bake cycles allowable) which shall be observed for storage or reshipment shall be stated on the packing and, where necessary, supporting documentation shall be supplied with each inner container	
4.13.2.7	Electrostatic shield	The inner container or magazine shall contain an electrostatic shield of surface resistivity less than 10^6 Ω/square.	
4.13.2.8	Magazine surface resistivity	Packing material in direct contact with the device pins shall have a surface resistivity less than 10^{12} Ω/square.	
4.13.2.9	Inner container surface characteristics	All surfaces of the inner container other than an electrostatic shield shall meet the following: • surface resistivity: 10^5 Ω/square to 10^{12} Ω/square; • charge decay in 2 s: 5 kV to less than 100 V; • triboelectric charge: not to exceed 100 V.	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.13.3	Magazine reuse	Tubes, trays or other magazines, which depend for their electrostatic properties on surface coatings, shall be limited to a defined number of load/unload cycles. The specified surface resistivity shall be met after the defined number of cycles and data shall be available to justify the limit chosen. Coated magazines may be "reset" to zero load cycles by a suitable recycling process, which includes recoating.	
4.13.4	Tubes		
4.13.4.1	General	The OCM shall ensure the following: • cushioning material (4.13.4.2); • partial tubes (4.13.4.3); • marking access (4.13.4.4); and • opening (4.13.4.5).	
4.13.4.2	Cushioning material	Ceramic devices packaged in tubes shall have an adequate amount of cushioning material to ensure that the devices are not damaged as a result of movement within the tubes.	
4.13.4.3	Partial tubes	Full tubes shall be shipped with a maximum of one partly-filled tube per inner container.	
4.13.4.4	Marking access	The material of the tube shall be transparent or contain a slot to allow inspection of top markings.	
4.13.4.5	Opening	Tubes shall be openable at either end unless otherwise specified to meet unique customer applications.	
4.13.5	Trays		
4.13.5.1	General	The OCM shall ensure the following: • devices with MSL of 4 or higher (4.13.5.2); • marking of bake temperature limit (4.13.5.3); • stacking of trays (4.13.5.4); • special packaging (4.13.5.5).	

IEC TS 62686-1 (edition 3.0), clause/subclause number	IEC TS 62686-1 (edition 3.0), clause/subclause, title or paragraph content	Requirements	Demonstrated by (supporting document references and brief descriptions)
4.13.5.2	Devices with MSL of 4 or higher	For devices with a moisture sensitivity classification according to IPC/JEDEC J-STD020 of level 2 or higher, the tray shall have a bake capability of at least 125 °C.	
4.13.5.3	Marking of bake temperature limit	The bake temperature limit shall be marked on the tray, or the tray marked heatproof.	
4.13.5.4	Stacking of trays	There shall be no more than 10 full trays to be stacked in height, plus one partial tray with one further tray as a cover.	
4.13.5.5	Special packaging	For devices with special leads, balls or columns, appropriate packaging to accommodate these features without damaging them shall be used (e.g. pedestals for extended leads below package base).	
4.13.6	Tape and reel	For devices with moisture sensitivity classification according to IPC/JEDEC J-STD-020 of 2 or higher, the tape and reel shall have a bake capability of 40 °C minimum. The bake temperature limit shall be marked on the reel or the reel shall be marked heatproof.	
4.14	Compliance with internal standards		
Annex A	Test code (TC) information		
Annex B	Typical automotive component requirements		
Annex C	Requirement matrix for IEC TS 62686-1 verification		
Bibliography	Bibliography		

Bibliography

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IEC 60749-9, *Semiconductor devices – Mechanical and climatic test methods – Part 9: Permanence of marking*

IEC 60749-10, *Semiconductor devices – Mechanical and climatic test methods – Part 10: Mechanical shock*

IEC 60749-12, *Semiconductor devices – Mechanical and climatic methods – Part 12: Vibration, variable frequency*

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IEC 60749-15, *Semiconductor devices – Mechanical and climatic test methods – Part 15: Resistance to soldering temperature for through-hole mounted devices*

IEC 60749-17, *Semiconductor devices – Mechanical and climatic test methods – Part 17: Neutron irradiation*

IEC 60749-19, *Semiconductor devices – Mechanical and climatic test methods – Part 19: Die shear strength*

IEC 60749-20, *Semiconductor devices – Mechanical and climatic test methods – Part 20: Resistance of plastic encapsulated SMDs to the combined effect of moisture and soldering heat*

IEC 60749-20-1, *Semiconductor devices – Mechanical and climatic test methods – Part 20-1: Handling, packing, labelling and shipping of surface-mount devices sensitive to the combined effect of moisture and soldering heat*

IEC 60749-21, *Semiconductor devices – Mechanical and climatic test methods – Part 21: Solderability*

IEC 60749-22, *Semiconductor devices – Mechanical and climatic test methods – Part 22: Bond strength*

IEC 60749-23, *Semiconductor devices – Mechanical and climatic test methods – Part 23: High temperature operating life*

IEC 60749-25, *Semiconductor devices – Mechanical and climatic test methods – Part 25: Temperature cycling*

IEC 60749-26, *Semiconductor devices – Mechanical and climatic test methods – Part 26: Electrostatic discharge (ESD) sensitivity testing – Human body model (HBM)*

IEC 60749-29, *Semiconductor devices – Mechanical and climatic test methods – Part 29: Latch-up test*

IEC 60749-30, *Semiconductor devices – Mechanical and climatic test methods – Part 30: Preconditioning of non-hermetic surface mount devices prior to reliability testing*

IEC 60749-32, *Semiconductor devices – Mechanical and climatic test methods – Part 32: Flammability of plastic-encapsulated devices (externally induced)*

IEC 60749-33, *Semiconductor devices – Mechanical and climatic test methods – Part 33: Accelerated moisture resistance – Unbiased autoclave*

IEC 60749-34, *Semiconductor devices – Mechanical and climatic test methods – Part 34: Power cycling*

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IEC 60749-38, *Semiconductor devices – Mechanical and climatic test methods – Part 38: Soft error test method for semiconductor devices with memory*

IEC 61340-3-1, *Electrostatics – Part 3-1: Methods for simulation of electrostatic effects – Human body model (HBM) electrostatic discharge test waveforms*

IEC 61340-5-1, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

IEC 61760-4, *Surface mount technology-Part 4: Classification, packaging, labelling and handling of moisture sensitive devices*

IEC ~~TS~~ 62239-1, *Process management for avionics – Management plan – Part 1: Preparation and maintenance of an electronic components management plan*

IEC TR 62240-2, *Process management for avionics – Electronic components capability in operation – Part 2: Semiconductor microcircuit lifetime*

IEC 62374, *Semiconductor devices – Time dependent dielectric breakdown (TDDB) test for gate dielectric films*

IEC 62374-1, *Semiconductor devices – Part 1: Time dependent dielectric breakdown (TDDB) test for inter-metal layers*

IEC 62396-1, *Process management for avionics – Atmospheric radiation effects – Part 1: Accommodation of atmospheric radiation effects via single event effects within avionics electronic equipment*

IEC 62415, *Semiconductor devices – Constant current electromigration test*

IEC 62416, *Semiconductor devices – Hot carrier test on MOS transistors*

IEC 62417, *Semiconductor devices – Mobile ion tests for metal-oxide semiconductor field effect transistors (MOSFETs)*

IEC 62418, *Semiconductor devices – Metallization stress void test*

IEC 62483, *Environmental acceptance requirements for tin whisker susceptibility of tin and tin alloy surface finishes on semiconductor devices*

IEC TS 62564-1, *Process management for avionics – Aerospace qualified electronic components (AQEC) – Part 1: Integrated circuits and semiconductors*

ISO 9001, *Quality management systems – Requirements*

ISO 14001, *Environmental management systems – Requirements with guidance for use*

AEC-Q100, *Stress test qualification for integrated circuits*

AEC-Q100-001, *Wire bond shear test*

AEC-Q100-002, *Human Body Model (HBM) Electrostatic Discharge test*

AEC-Q100-004, *IC latch-up test*

AEC-Q100-005, *Non-volatile memory program-erase endurance data retention and operational life*

AEC-Q100-010, *Solder ball shear test*

AEC-Q101, *Stress test qualification for automotive grade discrete semiconductors*

ANSI/ASQ Z1.4, *Sampling procedures and tables for inspection by attributes*

ANSI/ESDA/JEDEC JS-001, *Electrostatic discharge sensitivity testing – Human body model (HBM) – Component level*

AS/EN/JISQ 9100, *Aerospace series – Quality management systems – Requirements for aviation, space and defense organisations*

IATF16949, *Quality management system requirements for automotive production and relevant service parts organizations*

IPC/JEDEC J-STD-020, *Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices*

IPC/JEDEC J-STD-033, *Handling, Packing, Shipping and Use of Moisture, Reflow and Process Sensitive Devices*

IPC/JEDEC J-STD-035, *Acoustic microscopy for non-hermetic encapsulated electronic components*

JEP119, *A procedure for executing SWEAT*

JEP122, *Failure Mechanisms and Models for Semiconductor Devices*

JEP138, *User guidelines for IR thermal imaging determination of die temperature*

JEP148, *Reliability Qualification of Semiconductor Devices Based on Physics of Failure Risk and Opportunity Assessment*

JEP154, *Guideline for characterizing solder bump electromigration under constant current and temperature stress*

JESD6, *Measurement of small values of transistor capacitance*

JESD22-A101, *Steady State Temperature Humidity Bias Life Test*

JESD22-A102, *Accelerated moisture resistance – Unbiased autoclave*

JESD22-A103, *High temperature storage life*

JESD22-A104, *Temperature cycling*

JESD22-A105, *Power and temperature cycling*

JESD22-A108, *Temperature, Bias and Operating Life*

JESD22-A109, *Hermeticity*

JESD22-A110, *Highly accelerated temperature and humidity stress test (HAST)*

JESD22-A113, *Preconditioning of ~~plastic~~ nonhermetic surface mount devices prior to reliability testing*

JESD22-A114, *Electrostatic discharge sensitivity (ESDS) testing human body model (HBM)*

JESD22-A117, *Electrically erasable programmable ROM (EEPROM) program/erase endurance and data retention stress test*

JESD22-A118, *Accelerated moisture resistance – unbiased HAST*

JESD22-A121, *Measuring whisker growth on tin and tin alloy surface finishes*

JESD22-B100, *Physical Dimensions*

JESD22-B101, *External visual*

JESD22-B102, *Solderability*

JESD22-B103, *Vibration, variable frequency*

JESD22-B104, *Mechanical shock*

JESD22-B105, *Lead integrity*

JESD22-B106, *Resistance to solder shock for through-hole mounted devices*

JESD22-B107, *Marking permanency*

JESD22-B116, *Wire bond shear test*

JESD24, *Power MOSFETS*

JESD24-3, *Addendum No 3 to JESD24 – Thermal impedance measurements for vertical power MOSFETs (delta source-drain voltage method)*

JESD24-4, *Addendum No 4 to JESD24 – Thermal impedance measurements for bipolar transistors (delta base-emitter voltage method)*

JESD36, *Standard description of low-voltage TTL-Compatible, 5 V-Tolerant CMOS logic devices*

JESD47, *Stress test driven qualification of integrated circuits*

JESD51-1, *Integrated circuit thermal measurement method – Electrical test method (Single Semiconductor Device)*

JESD51-2, *Integrated circuit thermal test method environmental conditions – natural convection (still air)*

JESD52, *Description of low voltage TTL-Compatible CMOS logic devices*

JESD625, *Requirements for handling electrostatic discharge sensitive (ESDS) devices*

JESD76, *Description of 1.8 V CMOS logic devices*

JESD76-1, *Standard description of 1.2 V CMOS logic devices (Wide Range Operation)*

JESD76-2, *Standard description of 1.2 V CMOS logic devices (Normal Range Operation)*

JESD76-3, *Standard description of 1.5 V CMOS logic devices*

JESD78, *IC Latchup test*

JESD79, *Double data rate (DDR) SDRAM specification*

JESD79-2, *DDR2 SDRAM specification*

JESD79-3, *DDR3 SDRAM standard*

JESD79-4, *DDR4 SDRAM*

JESD80, *Standard for description of 2.5 V CMOS logic devices*

JESD85, *Methods for calculating failure rates in units of FITS*

JESD86, *Electrical parameters assessment*

JESD89, *Measurement and reporting of alpha particle and terrestrial cosmic ray-induced soft errors in semiconductor devices*

JESD89-1, *Test method for real-time soft error rate*

JESD89-2, *Test method for alpha source accelerated soft error rate*

JESD89-3, *Test method for beam accelerated soft error rate*

JESD94, *Application specific qualification using knowledge based test methodology*

JESD201, *Environmental acceptance requirements for tin whisker susceptibility of tin and tin alloy surface finishes*

JESD202, *Method for characterising the electromigration failure time distribution of interconnects under constant-current and temperature stress*

JESD213, *Standard test method utilizing X-RAY-Fluorescence (XRF) for analyzing component finishes and solder alloys to determine Tin (Sn)-Lead (Pb) content*

JESD282, *Silicon rectifier diodes*

JESD313, *Thermal resistance measurements of conduction cooled power transistors*

JESD531, *Thermal resistance test method for signal and regulator diodes (forward voltage, switching method)*

JP001.01, *Foundry process qualification guidelines (Wafer fabrication manufacturing sites)*

MIL-STD-1580, *Destructive physical analysis (DPA) for electronic, electromagnetic and electromechanical parts*

MIL-PRF-19500, *Performance specification: semiconductor devices, general specification for*

MIL-STD-750, *Test method standards for semiconductor devices*

MIL-STD-883, *Test method standard microcircuits*

RoHS, *Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment of the European Parliament and of the Council, of 27 January 2003*

RC14001, *Responsible Care*

RTCA DO-254/EUROCAE ED-80, *Design assurance guidance for airborne electronic hardware*

SAE ARP 6338, *Process for assessment and mitigation of early wear-out of life limited microcircuits.*

SAE J1879/ZVEI, *Handbook for Robustness Validation of Semiconductor Devices in Automotive Applications*

STACK Specification S/0001 *revision 14 notice 3, General requirements for integrated circuits and discrete semiconductors*

UL94, *Tests for flammability of plastic materials for parts in devices and appliances*

VDA 6.3, *Quality management in the Automotive Industry, Process Audit*

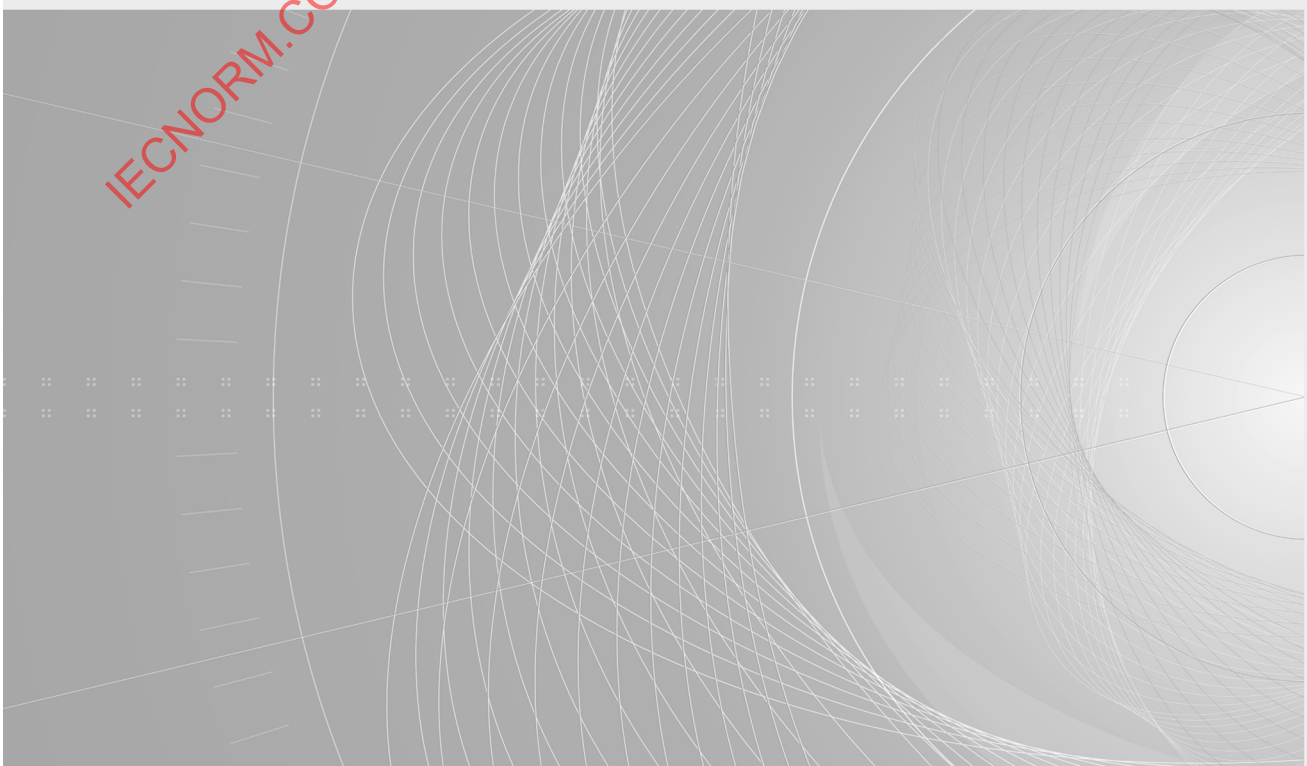
VDA 6.5, *Quality management in the Automotive Industry, Product Audit*

IEC TS 62686-1

Edition 3.0 2020-04

TECHNICAL SPECIFICATION

Process management for avionics – Electronic components for aerospace, defence and high performance (ADHP) applications –
Part 1: General requirements for high reliability integrated circuits and discrete semiconductors



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PROCESS MANAGEMENT FOR AVIONICS – ELECTRONIC COMPONENTS FOR AEROSPACE, DEFENCE AND HIGH PERFORMANCE (ADHP) APPLICATIONS –

Part 1: General requirements for high reliability integrated circuits and discrete semiconductors

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62686-1, which is a Technical Specification, has been prepared by IEC technical committee 107: Process management for avionics.

This third edition cancels and replaces the second edition, published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) update related to obsolescence of STACK Specification S/0001 revision 14 notice 3;
b) addition of alternative automotive methods of compliance and revision of Annex B initially related to cross-reference to STACK Specification S/0001;
c) addition of an Annex C to include a requirement matrix for IEC TS 62686-1 verification.

The text of this Technical Specificationis based on the following documents:

Draft TS	Report on voting
107/349/DTS	107/361A/RVDTS 107/361/RVDTS

Full information on the voting for the approval of this Technical Specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62686 series, published under the general title *Process management for avionics – Electronic components for aerospace, defence and high performance (ADHP) applications,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This part of IEC 62686 includes all the requirements of the now obsolete STACK Specification S/0001 revision 14 notice 3 and also contains revisions for alternative strategies using for example automotive standards together with the option of using various qualification test methods and additional test information.

This document complements IEC TS 62564-1 which is used for ADHP applications when additional manufacturers' data is required beyond the publicly available original component manufacturers' published data sheets (for example when additional thermal performance data is required for thermally challenging applications or when additional verification data is needed, for example to comply with the requirements of RTCA DO-254/EUROCAE ED-80 for complex components for flight critical applications, etc.).

This document can also be used to comply with the typical qualification requirements of IEC TS 62564-1. Further guidance is given in IEC 62239-1.

NOTE Existing STACK certified manufacturers can be audited by IECQ under the new STACK-IECQ joint venture or alternatively to the new IECQ automotive scheme.

PROCESS MANAGEMENT FOR AVIONICS – ELECTRONIC COMPONENTS FOR AEROSPACE, DEFENCE AND HIGH PERFORMANCE (ADHP) APPLICATIONS –

Part 1: General requirements for high reliability integrated circuits and discrete semiconductors

1 Scope

This part of IEC 62686, which is a Technical Specification, defines the minimum requirements for general purpose "off the shelf" COTS (commercial off-the-shelf) integrated circuits and discrete semiconductors for ADHP (aerospace, defence and high performance) applications.

This document applies to all components that can be operated in ADHP applications within the manufacturers' publicly available data sheet limits in conjunction with IEC 62239-1. It can be used by other high performance and high reliability industries, at their discretion.

ADHP application requirements are not necessarily fulfilled by this document alone. ADHP OEMs (original equipment manufacturers) might need to consider redesigning their products or conducting further testing to verify suitability in ADHP applications using their IEC 62239-1 ECMP procedures. Alternatively, a component in accordance with IEC TS 62564-1 can be more suitable.

NOTE Component qualification and outgoing quality discussed herein do not addres component atmospheric radations SEE effects per IEC 62396-1.

2 Normative references

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

ANSI/EIA-556, *Outer Shipping Container Bar Code Label Standard*

ANSI/ESD S541, *Packaging Materials Standards for ESD Sensitive Items*

IPC/JEDEC J-STD-609, *Marking and Labeling of Components, PCBs and PCBAs to Identify Lead (Pb), Lead-Free (Pb-Free) and Other Attributes*

JEDEC/IPC/ECIA J-STD-048, *Notification Standard for Product Discontinuance*

JEP130, *Guidelines for Packing and Labeling of Integrated Circuits in Unit Container Packing*

JESD471, *Symbol and Label for Electrostatic Sensitive Devices*

J-STD-046, *Customer Notification of Product/Process Changes by Solid-State Suppliers*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms, definitions and abbreviated terms apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
calendar days, pl.
continuous days, including week-ends and holidays

3.1.2
container
outer shipping container consisting of one or more inner containers

3.1.3
customer
user
original equipment manufacturer (OEM) which purchases electronic components, including integrated circuits and/or semiconductor devices compliant to this document and uses them to design, produce, and maintain systems

3.1.4
data sheet
document prepared by the manufacturer that describes the electrical, mechanical, and environmental characteristics of the component

3.1.5
deviation
user agreement to allow the delivery of a shipping lot which does not fully meet the requirements of this document

Note 1 to entry: Considered equivalent to concession for the purposes of this document.

3.1.6
device specification
document written by a user and agreed by the supplier or OCM

3.1.7
form
shape, arrangement of parts, visible aspect, mode in which a part exists or manifests itself, and material an item is constructed from

3.1.8
fit
fitability of an item to physically interface or interconnect with or become an integral part of another item or assembly

Note 1 to entry: Size and scale are examples of considered characteristics.

3.1.9
function
work that an item is designed to do without degrading reliability

3.1.10
incoming lot
one or more shipments of a device, grouped together for the purpose of incoming inspection

3.1.11
inner container
box or bag containing devices, either in magazines or bulk packaged

3.1.12
magazine
shipping container that feeds into automatic placement machines

Note 1 to entry: Sticks, tubes, matrix trays, tape/reel, etc., are examples of magazine.

3.1.13
microcircuit
component
device
electrical or electronic device that is not subject to disassembly without destruction or impairment of design use and is a small circuit having a high equivalent circuit element density

Note 1 to entry: It is considered as a single part composed of interconnected elements on or within a single substrate to perform an electronic circuit function.

Note 2 to entry: This excludes printed wiring boards/printed circuit boards, circuit card assemblies and modules composed exclusively of discrete electronic components.

3.1.14
moisture sensitivity level
MSL
rating indicating a component's susceptibility to damage due to absorbed moisture when subjected to reflow soldering

3.1.15
original component manufacturer
OCM
company specifying and manufacturing the electronic component

3.1.16
room temperature
temperature identified at 25 °C ± 5 °C in a room

3.1.17
semiconductor device
electronic devices in which the characteristic distinguishing electronic conduction takes place with a semiconductor

Note 1 to entry: Semiconductor diodes are examples of semiconductor devices having two terminals and exhibiting a nonlinear voltage-current characteristic.

Note 2 to entry: Transistors are examples of active semiconductor devices capable of providing power amplification and having three or more terminals.

3.1.18
shipping lot
single lot of one or more containers received by a user

3.1.19
supplier
company which provides to another an electronic component which is identified by the logo or name marked on the device

Note 1 to entry: A supplier can be the OCM, a franchised distributor or agent, a non-franchised distributor, broker, reseller, OEM, CEM and EMS etc.

3.1.20
termination
element of a component that connects it electrically and mechanically to the next level of assembly

3.1.21
triboelectric charge
electrical charge generated by frictional movement or separation of two surfaces

3.2 Abbreviated terms

AC	alternating current
ADHP	aerospace, defence and high performance
AEC	Automotive Electronics Council
AOQ	average outgoing quality
AQEC	aerospace qualified electronic component
AQL	acceptable quality level
ASIC	application specific integrated circuit
ATC	autoclave
BGA	ball grid array
BPSG	borophosphosilicate glass
BS	bond strength
BST	ball shear test
CB	certification body
CEM	contract electronic manufacturer
CFC	chlorofluorocarbon
COTS	commercial off-the-shelf
CMOS	complementary metal oxide semiconductor
D	semiconductor device
DC	direct current
DFMEA	design failure modes and effect analysis
DLA	Defense Logistics Agency (see http://www.dscc.dla.mil/)
DPM	defects per million
DRAM	dynamic random access memory
DS	die shear
DVP&R	design verification plan and report
ECMP	electronic component management plan
ED	electrical distribution
EHS	environmental health and safety
EM	electromigtration
EMAS	Eco-Management and Audit Scheme (established by the European Union)
EMS	electronic manufacturing services
ESD	electrostatic sensitive damage
ET	electrical test
FFF	form, fit and function

FIT	failures in time
FL	flamability
GR&R	gage repeatability and reproducibility analysis
h	hour
HAST	highly accelerated stress test
HCI	hot carrier injection
HE	hermeticity
HTB	high temperature bake
HTBB	high temperature blocking bias
HTGB	high temperature gate bias
HTOL	high temperature operating life
HTRB	high temperature reverse bias
IECQ	International Electrotechnical Commission Quality Assessment System for Electronic Components
IATF	International Automotive Task Force
IC	integrated circuit
I/O	input and output
IR	infra-red
LI	lead integrity
LT	lid torgue
LTB	last time buy
LTPD	lot tolerance percent defective
LU	latchup
min	minute
MOSFET	metal-oxide-semiconductor field-effect transistor
MP	marking permenancy
MS	mechanical sequence
MSA	measurements system analysis
MSL	moisture sensitivity level
NBTI	negative bias temperature Instability
NMOS	n-type metal oxide-semiconductor (refers to field effect transistors (MOSFETs))
NVL	non-volatile memory operating life
OCM	original component manufacturer
OEM	original equipment manufacturer
OI	oxide integrity
PC	preconditioning
PCB	printed circuit board
PCM	process control monitor
PCN	product or process change notification
PD	package dimension
PFMEA	process failure modes and effects analysis
PGA	pin grid array
Pkg	package

PPAP	production part approval process
PTC	power cycling
QA	quality assurance
RSH	resistance to solder heat
SD	solderability
SDRAM	synchronous dynamic random access memory
SEE	single event effect
SEFI	single event functional interrupt
SEL	single event latchup
SEU	single event upset
SER	soft error rate
SMD	surface mount device
SPC	statistical process control
SRAM	static random access memory
SS	sample size
SSOL	solid state operating life
T_{amb}	ambient temperature
TC	test code
THB	temperature humidity bias
THM	through hole mount
THRB	temperature humidity reverse bias
TPC	temperature cycling
TR	thermal resistance
TS	terminal strength
T_{opmin}	minimum operating temperature
T_{opmax}	maximum operating temperature
UCL	upper control limit
VI	visual inspection
VPR	vapour
WV	water vapour
XR	X-ray

4 Technical requirements

4.1 General

4.1.1 Overview

The supplier, preferably the original component manufacturer (OCM) or the franchised distributor, as defined in 3.1.19 and 3.1.15 respectively, shall have an appropriate quality management system and shall provide the following minimum technical requirements. The supplier or the OCM can use the test methods and methodologies specified herein which are based on IEC semiconductor test methods or any other equivalent test method, for example JEDEC test methods (see 4.9.2.3 and Annex A) or the automotive alternative process, see 4.1.2. Proposed equivalent test methods, rationale and supporting data shall be reviewed and shall achieve the same end objectives as specified herein. Use of such equivalent tests shall not be considered to be deviations or waivers to the requirements of this document.

NOTE 1 ISO 9001 or AS/EN/JISQ 9100 can assist with compliance to Clause 4.

NOTE 2 In case the COTS integrated circuits and discrete semiconductors cannot be procured directly from the OCM (for example if the quantity is too small), the franchised distribution network is usually privileged with regard to potential risks (for example lack of traceability and counterfeiting).

Informative annexes are provided at the end of this document and their content is subject to change. Users of this document are encouraged to review the latest data available whenever referencing the content of these annexes as well as the Bibliography:

- Annex A: test code information which summarises all semiconductor test methods discussed herein;
- Annex B: typical automotive component requirements;
- Annex C: requirement matrix for IEC TS 62686-1 verification;
- Bibliography.

4.1.2 Automotive components

Automotive components, which are typically manufactured on IATF 16949 certified manufacturing lines and qualified to AEC-Q100 for temperature grades 0 and 1, with the outgoing quality requirements typically included in a production part approval process (PPAP) process and with the obsolescence and product change notification as specified herein, can meet the requirements of this document; see Annex B for guidance.

NOTE 1 The IECQ automotive qualification programme can be expanded to cover this category of automotive component.

NOTE 2 The VDA 6 series assessment, particularly VDA 6.3, can be used for the PPAP element of the IECQ assessment process.

4.2 Procedures

4.2.1 General

The OCM shall have the following procedures:

- product discontinuance (4.2.2);
- ESD protection during manufacture (4.2.3);
- specification control (4.2.4);
- traceability including anti-counterfeit measures (4.2.5).

4.2.2 Product discontinuance

Notification shall be in accordance with JEDEC/IPC/ECIA J-STD-048 or equivalent, with the exception of timing as described in a) and b) below:

a) the OCM shall provide the user with a notice of last order dates:
   - a minimum of 12 months before these dates for single-source devices, and
   - 6 months before these dates for multi-sourced devices;

b) the OCM may give less than the specified notice period provided a mutually acceptable extension (up to the specification limit) is negotiated with any user needing a different period;

c) for custom ASIC devices, the normal procedure is to include discontinuation notice in the purchase contract.

4.2.3 ESD protection during manufacture

All integrated circuits and discrete semiconductors are considered to be static sensitive and shall be protected through the OCM's manufacturing operation. The OCM shall ensure that devices are not exposed to static damage and are not degraded or damaged due to static

discharge. IEC 61340-3-1, IEC 61340-5-1 and JESD625 or AEC-Q100-002 are examples of suitable standards for ESD precautions in wafer fabrication and probe.

4.2.4 Specification control

The OCM shall:

a) when applicable, have a central or local record of the user's part number and specification, against the product to be delivered;

NOTE 1 This applies to direct sales and not to parts sold through distribution.

b) ensure the specifications on the purchase documents have been reviewed and accepted by personnel authorized to do so.

NOTE 2 This applies to custom and special orders only.

4.2.5 Traceability including anti-counterfeit measures

Traceability shall be managed as follows:

a) the OCM shall have traceability for any device in a shipping lot through a route code, lot code or other marking on the device or magazine or inner container to identify the manufacturing route, for example groups of wafer lots, wafer fabrication location, assembly location, test location, date code and/or lot code;

b) the information needed to interpret the code shall be available;

c) the procedure shall be available for inspection during audit.

The OCMs shall use anti-counterfeit measures to protect their intellectual property, such as use of registered trademarks, logos, patents, etc. The OCM shall also assist the user in determining if the product is genuine when requested and in identifying the franchised distributors.

4.3 Product or process change notification (PCN)

4.3.1 General

The OCM shall provide the following:

- notification (4.3.2);
- notification details (4.3.3); and
- notifiable changes (4.3.4).

4.3.2 Notification

In the event of the OCM proposing or making a change to a device, then:

a) the OCM shall give at least 90 calendar days' written notice prior to shipping the changed product. The user will respond to confirm the date on which changed product shipments can begin (it could be less than 90 calendar days), advise that the changed product is not acceptable, or request further information;

b) for custom ASIC devices, change notification periods are normally specified in the purchase contract;

c) in an event beyond the control of the OCM where 90 calendar days' notice cannot be given, the OCM shall reach a mutually agreed lesser notice period with any user affected by the change.

4.3.3 Notification details

The PCN shall include the following items:

a) title of change;

b) the OCM's type number(s) affected;

c) the OCM's notification identification number;

d) estimated last order and shipment dates for unchanged devices to be supplied on request;

e) estimated earliest shipment date of changed devices;

f) manufacturing location and product line affected;

g) a thorough description of the proposed change;

h) the means of distinguishing changed devices from unchanged devices. This may be a date code, lot code, date code range or a distinguishing marking or feature that is visible to the user at point of receipt of shipment;

i) sufficient engineering and/or qualification test data, including details of any qualification test vehicle used and its applicability to the product change, shall be available on request to demonstrate that the change will not adversely affect device form, fit, function, quality or reliability, and that the changed product will continue to meet the specified requirements;

j) user part number of the affected device (preferred item but not mandatory).

4.3.4 Notifiable changes

J-STD-046 shall be used as a guide to changes requiring notification.

4.4 Shipment controls

4.4.1 General

The OCM shall have the following shipment controls:

- shipping container and date code marking (4.4.2);
- date code remarking (4.4.3);
- inner container formation (4.4.4);
- date code age on delivery (4.4.5);
- ESD marking (4.4.6);
- MSL (4.4.7);
- lead-free marking (4.4.8); and
- labels (4.4.9).

4.4.2 Shipping container and date code marking

The shipping container and date code marking shall be in accordance with JEP130 or an equivalent standard. The OCM's name, logo and/or trademark shall be marked on the shipping container where it is practical to do so.

4.4.3 Date code remarking

If the date of assembly and test are both marked, the test date can be remarked if the device is re-tested at a later date. If only one date is marked to represent the manufacturing date and initial electrical test it shall not be changed unless it is necessary to correct poor quality marking or incorrect information, and provided that the time delta between the original mark and the remark is less than 6 weeks.

4.4.4 Inner container formation

It is preferred that the inner container contains only devices of the same die revision/stepping level.

It is preferred that devices also come from the same:

– wafer fabrication location;
– assembly site;
– outgoing QA electrical inspection site.

4.4.5 Date code age on delivery

Date code age on delivery should be as follows:

a) the date codes of devices should not be older than 24 months upon users' receipt date;
b) for custom ASIC devices, the date code age limits will normally be defined in the purchase contract.

4.4.6 ESD marking

The symbols used and labelling shall be in accordance with JESD471 or an equivalent standard.

4.4.7 MSL

The labelling and shipping container shall be in accordance with IEC 61760-4 or IPC/JEDEC J-STD-033 or an equivalent standard.

4.4.8 Lead-free marking

The shipping container and date code marking shall be in accordance with IPC/JEDEC J-STD-609 or an equivalent standard.

4.4.9 Labels

In general, labels shall include the requirements mentioned in Table 1 and exhibit:

a) human readable content: the content shown for each label in 4.4.9 shall be available in human readable form on the outside of the relevant package;
b) machine readable content: bar codes for those items specified shall be included in 3 of 9 codes (bar code 39) as per ANSI/EIA-556 or equivalent compatible standard;
c) warning notice: any necessary warning notices or symbols to ensure the safety of the contents shall be included as appropriate.

Table 1 – Label requirements

Dry pack label:	**Bar code**
Date of sealing and sealed life or expiration date.	
Time and storage condition limits after opening.	
Bake conditions if usage conditions after opening are violated.	
Moisture sensitivity classification per IEC 61760-4 or IPC/JEDEC J-STD-020 or per the OCM's own classification provided a cross reference is provided at registration.	
Container label: this label is typically implemented as a shipping note or packing list attached to the outer container.	
Delivery address.	
Purchase order number.	*
User part number.	*
OCM's device type number [a].	*
OCM's name [a].	
Export control certification number and controlling authority [b].	*
Quantities enclosed of each device type [a].	*
Inner container label:	
OCM's device type number.	*
User part number [b].	*
Purchase order number [b].	*
Quantity of devices.	*
Date code.	*
Lot number.	*
Assembly location [b].	
Test location [b].	
[a] For security reasons can be omitted with the agreement of the user.	
[b] Preferred but not mandatory.	

4.5 Electrical

4.5.1 General

Operating conditions shall be as defined in the device specification or data sheet, as explained in 4.5.2 to 4.5.7.

4.5.2 Electrical test

All shipped packaged devices shall have passed a production electrical test program, or in the case of user-specific devices, a test program approved by the user. Tested wafer or die products shall have an effective equivalent wafer probe test. Untested wafer and die products shall have met the OCM's minimum process control monitor (PCM) requirements. JEDEC test methods shall be used wherever possible.

4.5.3 Electrical parameter assessment

Test methods for assessing the electrical parameter distributions (AC, DC, functional and timing) of devices should be in accordance with JESD86.

4.5.4 SDRAM memories

SDRAM memories should be designed and tested in accordance with the JESD79 series.

4.5.5 Logic families

Logic families should be designed and tested in accordance with JESD36, JESD52, JESD76 or JESD80.

4.5.6 Power MOSFETs

Power metal-oxide-semiconductor field-effect transistors (MOSFETs) should be tested in accordance with JESD24.

4.5.7 Silicon rectifier diodes

Silicon rectified diodes should be tested in accordance with JESD282, MIL-PRF-19500 or an equivalent standard.

4.6 Mechanical

4.6.1 General

Integrated circuits or discrete semiconductor package dimensions, specified in industry standard outlines (e.g. JEDEC outlines), will be met as specified, if the package is stated as compliant with that outline.

4.6.2 Device marking

4.6.2.1 General

All the specified markings on the device or shipping container shall be clearly legible.

4.6.2.2 Top surface

All of the following required markings shall be marked on the top side, except where otherwise indicated below:

a) pin 1, identifiable either by a mark or by reference to a physical feature of the device;

b) the OCM's name or logo;

c) the OCM's part number or individual user part number as required;

d) the date code of assembly or test. Formats YYWW, or YWW or YM are acceptable (Y = year numeral, W = week numeral, M = month character). If both assembly and test date codes are marked, the assembly code may be bottom marked;

e) a manufacturing route trace code. The top surface is preferred, but the device bottom surface may be used;

f) if both assembly and manufacturing route trace codes are marked on the bottom surface, the manufacturing route trace code shall be marked below the assembly code.

4.6.3 Small packages

If the marking area available on the device is too small to do so, then the unit container is to include all the required marking.

4.6.4 Moisture sensitivity

The moisture sensitivity of all non-hermetic surface mount components shall be tested and classified according to IEC 61760-4 or IPC/JEDEC J-STD-020. The MSL classification shall be available.

4.6.5 Robustness of hermetic seals

The seal shall not be compromised by any normal handling, testing or manufacturing processes.

4.6.6 Termination finishes

The OCMs should make available on their web pages or data sheets (or otherwise) information pertaining to the leaded (Pb) and lead-free termination finish qualification testing, termination material, finish alloy composition, and (if used) heat treatment process of the parts used relative to the RoHS directive. In addition, the following requirements shall be met:

a) thickness limits shall be met over 95 % of the termination surface. The OCM shall select appropriate measurement locations;

b) plating composition and thickness limits shall be available;

c) it is not necessary for solder dipping, where used to improve the solderability of the termination, to cover the entire termination. The area covered should be appropriate to the type of package, for example J-bend packages (area below base plane), or gull wing packages (center of bottom radius to trimmed edge of termination);

d) tin electroplate finishes shall be matt, dense, homogenous, free of co-deposited organic material and suitably treated to inhibit whisker growth. When applicable an appropriate tin whisker plan or process should be in place (for example accelerated tin whisker testing to JESD201 Class 2 limits or JESD22-A121 or IEC 62483) and be demonstrable. Documented results should be made available to the user upon request;

e) providing notification of changes, via the PCN process, to termination finish materials, thickness, or to plating process chemistry.

4.7 Audit capability

4.7.1 General

The OCM shall be able to carry out the following:

- internal quality audits (4.7.2); and
- subcontract manufacturing (4.7.3).

4.7.2 Internal quality audits

The OCM shall periodically audit each internal location, to assess compliance with internal standards for the following areas listed below. The following areas defined in Table 2 shall be addressed:

Table 2 – Internal quality audit requirements

Quality system	Calibration	Failure analysis
Shipment and container	Stores and dispatch	ESD control
Contract review	Customer service	Production test
Design management	Process control	Subcontract controls
Purchasing	Incoming materials	Wafer fabrication and probe
OCM audits	Documentation control	Assembly
Training	Product qualification	Reliability monitor

The results of these audits and the audit acceptance criteria shall be available for onsite inspection during an audit. The internal quality audit documentation shall be available upon request.

NOTE ISO 9001, AS/EN/JISQ 9100 and IATF 16949 can assist with the requirements of 4.7.2.

4.7.3 Subcontract manufacturing

The OCM shall qualify and periodically audit all subcontracted operations to a standard equivalent to the OCM internal operations.

4.8 Quality assurance

4.8.1 General

The OCM shall have the following quality assurance systems:

- quality system (4.8.2);
- sampling plans (4.8.3);
- failure analysis support (4.8.4); and
- outgoing quality (4.8.5).

4.8.2 Quality system

The OCM quality system shall meet the following requirements:

a) satisfy an appropriate quality management system registration, for example one (or more) of ISO 9001, AS/EN/JISQ 9100, IATF 16949, etc.;

b) ensure that the requirements of this specification are met;

c) provide for the prevention and ready detection of discrepancies and for timely and positive corrective action.

4.8.3 Sampling plans

Appropriate and statistically valid sampling plans shall be used and documented. The target for reliability qualification of microelectronics by accelerated ageing is an LTPD better than 3 %. This can be achieved by overstress testing of sample sizes exceeding 76 devices from the specific device population, with no failures permitted, or by invoking structural similarity and accumulating samples from other device types at the level of the build being tested. For example, thermal cycling is intended to evaluate die and wire bonding and back-end assembly, and the desired LTPD can be achieved from structurally similar builds of similar metallization, die size and attachment, wire-bond material diameter, process, and loops.

4.8.4 Failure analysis support

OCM failure analysis support shall meet the following requirements:

a) the OCM shall maintain an adequate failure analysis capability and provide a timely response to failures returned for failure verification or failure analysis;

b) representative samples of devices returned as failures shall be analysed and a failure analysis report issued to the originating user, typically within 30 calendar days of the receipt by the analytical facility of such returns;

c) for failure returns relating to a critical problem at a user, the failure analysis report shall typically be issued within 7 calendar days of receipt by the analytical facility.

4.8.5 Outgoing quality

4.8.5.1 General

Outgoing quality shall be measured as per 4.8.5.2 to 4.8.5.5.

4.8.5.2 DPM levels

The OCM shall measure average outgoing quality (AOQ) in defects per million from uniform manufacturing processes and the results shall be in accordance with Table 3. The measurement of outgoing quality via in-process measurements is acceptable in principle. The number of defects will include all devices non-conforming to any functional, electrical, visual or mechanical specification requirement of a device.

4.8.5.3 DPM calculation

Measurement may be by any appropriate classification and method, for example individual devices or device families, package type and/or technology family, in-process measurements.

4.8.5.4 Corrective action

If the outgoing quality levels given in Table 3 are not met, the OCM shall take root cause corrective action and issue a closure date for achieving the required DPM.

Table 3 – Outgoing quality

Device family		Maximum DPM
Electrical	Transistor count	
Discrete and integrated circuits	≤ 100 000	50
	< 1 000 000	100
	≥ 1 000 000	150
Programmable logic when supplied, programmed and tested		100
Visual/mechanical		200
NOTE This information can be considered proprietary and confidential.		

4.8.5.5 Data reporting

AOQ data shall be compiled periodically and be available upon request.

4.9 Qualification

4.9.1 General

The OCM shall manage the following:

- methodology (4.9.2);
- test samples (4.9.3);
- qualification categories (4.9.4);
- maintenance of qualification standards (4.9.5);
- in-process test results (4.9.6);
- product monitor results (4.9.7);
- references (4.9.8);
- qualification report (4.9.9);
- archiving (4.9.10);

- qualification by similarity (4.9.11); and
- similarity assessment (4.9.12).

4.9.2 Methodology

4.9.2.1 General

The OCM shall use appropriate methodologies to qualify new technology, new devices and device changes, to demonstrate that the device under qualification is capable of meeting the specified electrical, quality and reliability requirements, using qualification families (as defined in JESD47 or AEC-Q100).

4.9.2.2 Procedures and methods

Stress test qualification procedures and methods shall be performed per Table 4.

4.9.2.3 Alternative procedures

Alternative procedures and methods are acceptable as per 4.1 and are as follows:

a) qualification in conformity with JESD47, for integrated circuits and their generic families, providing the following, additional, items are addressed by the OCM:
   - X-ray,
   - long term FIT-rate calculations,
   - marking permanency,
   - die shear strength,
   - thermal resistance,
   - flammability,

     NOTE 1 Flammability is typically confirmed by the epoxy mould compound manufacturer flammability UL94 test results.
   - internal visual inspection;

b) qualification in conformity with AEC-Q100 for integrated circuits and their generic families providing the OCM addresses the following additional items:
   - high temperature operating life (HTOL) test for grade 1, or grade 0.
   - marking permanency,
   - X-ray,
   - thermal resistance, a package property
   - flammability,
   - internal visual inspection; only required for hermetic components,

     NOTE 2 Thermal resistance is an integrated circuits or discrete semiconductors package property.

     NOTE 3 Flammability is typically confirmed by the epoxy mould compound manufacturer UL94 test results.

c) qualification to AEC-Q101 for discrete semiconductors and their generic families which now has guidance in an appendix on the relationship of robustness validation to SAE J1879/ZVEI and JEP122 compared to AEC-Q101. When using AEC-Q101,the OCM shall also address the following additional items:
   - latch-up,
   - electromigration; hot carrier injection; time dependent dielectric breakdown; and negative bias temperature instability,
   - internal water vapour,
   - flammability,

- internal visual inspection,
- X-ray,
- lid torque (for hermetic components only),

NOTE 4 Flammability is typically confirmed by the epoxy mould compound manufacturer UL94 test results.

d) qualification to an application specific scheme should be created as per the methodology and guidance provided in JESD94. An application specific plan should address the subjects of concern contained in the preceding qualification schemes;

e) qualification using JEP148, based on the physics of failure risk and opportunity assessment, addressing the subjects of concern in the preceding qualification scheme which may be more appropriate for new technologies.

4.9.2.4 Use of product similarity data

Perform testing and document the re-using of existing data based on product similarity arguments.

4.9.2.5 Use of reliability models

Perform and document the verified reliability models.

4.9.3 Test samples

4.9.3.1 General

The OCM shall use the test samples described in 4.9.3.2 to 4.9.3.5.

4.9.3.2 Test failures

The general acceptance level for all stress test qualification is zero rejects in the tested sample size.

Test failures attributed to extraneous factors not related to the qualification stress applied shall not be counted against acceptance criteria. If excessive failures from non-qualification test related mechanisms are generated, the test shall be repeated.

If a larger sample size than that specified in Table 4 is used and failures allowed, then the result shall meet an LTPD = 3 % for a specified sample size of 76. The target LTPD requirement is stated in 4.8.3. In Table 4, lower sample quantities are allowed where the particular stress tests are not intended for statistical extrapolation, but for characterization or package evaluation.

4.9.3.3 Additional samples

Users reserve the right to take additional samples for a qualification test result confirmation.

4.9.3.4 Consolidation of lots

Where production volumes of a device are low and the sample sizes specified are not economically feasible from one manufacturing lot, consolidation of lots is permissible. If consolidation of lots is performed, the combining of parts shall follow the similarity rules as per 4.9.12 (similarity assessment).

4.9.3.5 Reduced sample sizes

The OCM's qualification procedures can allow devices to be released to the market after testing them to a qualification schedule which does not fully meet the requirements herein, in terms of reduced sample size, reduced test time, etc. This is only acceptable providing test data continues to be accumulated as per 4.11 and corrective actions and/or repeat testing is performed as necessary until the qualification level is reached or exceeded in a target of 90 calendar days.

4.9.4 Qualification categories

The qualification may be conducted on a specific device type. Alternatively, qualification may be accomplished by using generic family qualification data provided similarity rules are followed (see 4.9.11).

4.9.5 Maintenance of qualification standards

Regular quality and reliability test results, which are obtained from a monitor program, but which are not related to any particular customer shipment, are an acceptable method of maintaining the qualification standard of this document. It is desirable that the manufacturer maintains a regime of "maintenance of qualification" in order to ensure that reliability sensitive processes are routinely tracked and sample tested.

4.9.6 In-process test results

In-process test results shall be managed as follows:

a) if any of the inspection or package qualification tests are performed on a regular basis in the manufacturing line, these tests need not be repeated in new device qualification testing;

b) if qualification tests are not performed, manufacturing inspection results showing the current quality level shall be included in the qualification report. Manufacturing package test results shall be available.

Table 4 – Technology/family qualification and device qualification *(1 of 3)*

Test code (TC) information – See Annex A		Product family	Title	Test reference – See 4.10.2 for more details	Number of lots for family qualification	Sample size per lot	Number of lots for device qualification
			ELECTRICAL				
TC6	(ET)	IC, D	Electrical test	JESD86/MIL-STD-883-M3012 or JESD6	3	50	1
TC7	(ED)	IC, D	Electrical distributions	JESD86/MIL-STD-883-M3012 or JESD6	3	30	1
TC16	(LU)	IC, D	Latch-up	JESD78 or IEC 60749-29 or AEC-Q100-004	1	6	1
TC5	(ESD)	IC, D	ESD – human body model	ANSI/ESDA/JEDEC JS-001 or IEC 60749-26	1	3	1
TC28	(SER)	IC	Soft error at sea level	JESD89 or IEC 60749-38 or IEC 60749-17	-	-	-
			PROCESS				
TC22	(OI)	IC, D	Time dependent dielectric breakdown (oxide integrity)	JP001.01 or IEC 62417	-	-	-
TC4	(EM)	IC, D	Electromigration	JP001.01, JEP119, JESD202, JEP154 or IEC 62415	-	-	-
TC9	(HCI)	IC, D	Hot carrier injection	JP001.01 or IEC 62416	-	-	-
TC40	(NBTI)	IC, D	Negative bias temperature instability	JP001.01 or IEC 62374 or IEC 62374-1	-	-	-
			ENDURANCE				
TC24	(PTC)	D	Power cycling	MIL-STD-883-M1037 or IEC 60749-34	3	76	1
TC29	(SSOL)	D	Steady state operating life	JESD22-A108 or IEC 60749-23	3	76	1
TC13	(HTGB)	D	High temperature gate bias	JESD22-A108	3	76	1
TC12	(HTBB)	D	High temperature blocking bias	MIL-STD-750-M1048	3	76	1
TC14	(HTRB)	D	High temperature reverse bias	JESD22-A108	1	76	1
TC15	(HTOL)	IC	High temperature operating life	JESD 22-A108 or IEC 60749-23	3	76	1
TC21	(NVL)	IC	Non-volatile memory operating life	JESD22-A117 or AEC-Q100-005	1	22	1
TC11	(HTB)	IC, D	High temperature bake	JESD22-A103 or IEC 60749-6	3	76	1

Table 4 *(2 of 3)*

Test code (TC) information see Annex A		Product family	Title	Test reference See 4.10.2 for more details	Number of lots for family qualification	Sample size per lot	Number of lots for device qualification
			TEMPERATURE/HUMIDITY				
TC25	(RSH)	D	Resistance to solder heat	JESD22-B106 or IEC 60749-15 or IEC 60749-20	1	30	1
TC31	(THRB)	D	Temperature humidity reverse bias	JESD22-A101	1	76	1
TC30	(TPC)	IC, D	PC + temperature cycling	JESD22-A104 or IEC 60749-25	1	32	1
TC32	(THB)	IC, D	PC + THB: 85 °C / 85 % RH (or HAST) (plastic only)	JESD22-A101 or IEC 60749-4 or IEC 60749-5	1	76	1
TC32	(HAST)	IC, D	PC + HAST plastic only	JESD22-A110 or IEC 60749-4	1	76	1
TC1	(ATC)	IC, D	PC + autoclave (plastic only)	JESD22-A102 or IEC 60749-33	1	32	1

Table 4 *(3 of 3)*

Test code (TC) information see Annex A		Product family	Title	Test reference See 4.10.2 for more details	Number of lots for family qualification	Sample size per lot	Number of lots for device qualification
			MECHANICAL				
TC23	(PD)	IC, D	Package dimensions	JESD22-B100	1	5	1
TC27	(SD)	IC, D	Solderability (76 leads / 5 devices minimum)	JESD22-B102 or IEC 60749-21	1	76	1
TC36	(WV)	IC, D	Internal water vapour (hermetic only)	MIL-STD-883-M1018 or IEC 60749-7	1	3	1
TC20	(MP)	IC, D	Marking permanency	JESD22-B107 or IEC 60749-9	1	3	1
TC2	(BS)	IC, D	Bond strength (76 wires / 5 devices minimum)	JESD22-B116 or IEC 60749-22 or AEC-Q100-001	1	76	1
TC3	(DS)	IC, D	Die shear strength	MIL-STD-883-M2019 or IEC 60749-19	1	5	1
TC34	(TR)	IC, D	Thermal resistance	Not specified	1	3	1
TC8	(FL)	IC, D	Flammability (plastic only)	UL94 or IEC 60749-32	-	-	-
TC8	(FL)	IC, D	Alternative flammability (plastic only)	IEC 60695-2-2	1	3	1
TC17	(LI)	IC	Lead integrity (applicable devices)	JESD22-B105 or IEC 60749-14	1	3	1
TC33	(TS)	D	Terminal strength	MIL-STD-750-M2036	1	3	1
TC18	(LT)	IC, D	Lid torque (hermetic only)	MIL-STD-883-M2024	1	5	1
TC19	(MS)	IC	Mechanical sequence (hermetic only)	See test in Clause A.19	1	5	1
TC10	(HE)	IC, D	Hermeticity (hermetic packaging end point test only)	JESD22-A109 or IEC 60749-8	-	-	-
TC38	(MSL)	IC, D	Moisture sensitivity level	IPC/JEDEC J-STD-020 or IEC 60749-20-1	-	-	-
TC39	(BST)	IC, D	Ball shear	JESD22-B117A or AEC-Q100-010	-	-	-
TC41	(TW)	IC,D	Tin whisker	JESD201 or IEC 62483	-	-	-
			INSPECTION				
TC35a	(VI)	IC, D	External visual inspection	JESD22-B101 or IEC 60749-3	1	25	1
TC35b	(VI)	IC, D	Internal visual inspection	MIL-STD-883-M2010	1	5	1
TC37	(XR)	IC, D	X-ray inspection (plastic only)	MIL-STD-883-M2012	1	5	1

4.9.7 Product monitor results

If any inspection or package qualification tests are performed on a regular basis in product monitor testing, these tests need not be repeated in new device qualification testing.

4.9.8 References

References are given for guidance only. Reference shall always be made to the appropriate test code information for full test details.

4.9.9 Qualification report

The qualification report shall be available upon request.

4.9.10 Archiving

The qualification report and the test specification (not the test program) used in the qualification shall be archived for a minimum of 7 years.

4.9.11 Qualification by similarity

Qualification by similarity can be used as follows:

a) a change shall be qualified if there is a potential effect on performance, quality or reliability, or if there is any degree of uncertainty about the effect of the change;

b) guidance on the qualification tests, which the OCM should consider applying, for the various combinations of die, package and process changes, is shown in JESD47. The OCM shall perform tests defined in the qualification table that are appropriate, or relevant to the change;

c) upon request, the OCM shall provide data for any device transferred to a new process to prove that no design deficiencies (e.g. mechanical, electrical performance, reliability, single event effects, etc.) were introduced by the process transfer.

4.9.12 Similarity assessment

4.9.12.1 General

The principle of similarity may be applied in qualification, qualification of changes and product monitor testing as follows:

- die changes (4.9.12.2);
- process/wafer fabrication changes (4.9.12.3);
- package/assembly changes (4.9.12.4).

4.9.12.2 Die changes

The OCM shall document and operate an appropriate set of die similarity rules or guidelines applied by appropriate engineering review.

4.9.12.3 Process/wafer fabrication changes

Devices to be assigned to a qualification family shall share the same critical processes and material elements.

4.9.12.4 Package/assembly changes

Package/assembly changes shall be managed as follows:

a) package families shall be grouped by configuration and materials of construction, for examples see AEC-Q100. In general, all members of the group that are equal to or smaller in dimensions and lead count can be considered as similar to a qualified package, provided the assembly process technology is identical;

b) packages should be qualified with the worst case configuration (e.g. the largest die) they are designed to carry that is currently in production. For custom ASICs, use of a "qualification die" is acceptable, such that dies larger than the qualification die by +10 % by linear dimension are qualified, provided the package designed maximum die size is not exceeded.

4.10 Reliability

4.10.1 General

The OCM shall ensure the following:

- operating reliability (4.10.2);
- failure criteria (4.10.3);
- corrective action (4.10.4);
- warranty (4.10.5);
- single event effects (SEEs) (4.10.6).

4.10.2 Operating reliability

The OCM shall manage operating reliability as follows:

a) the OCM shall determine the failure rate of devices operating in systems at an ambient temperature of +55 °C using the high temperature operating life (HTOL) test method or an alternative test method suitable to the device technology (i.e. HTRB or HTGB for discrete components). Failure rates shall not exceed the qualification requirements in accordance with Table 5; an approximate maximum of 155 FITs is expected. For mature and/or high volumes a desired target of 50 FITs or less is expected for integrated circuits and 20 FITs or less for discrete semiconductors. The OCM shall, upon request from the user, make available FIT rate data to confirm application specific life expectancy;

b) results observed at a temperature other than +55 °C will be projected to this temperature, with 60 % confidence using an activation energy, appropriate to the failure mechanism observed. Refer to TC15 HTOL for calculation of acceleration factors; projected results shall show the 60 % confidence range. Alternatively, results can be analysed using JESD85 at higher confidence levels;

c) for custom devices the OCM shall on request provide a FIT rate including the confidence range and operating life prediction to the user (based on a demonstrable methodology) for the application and environmental conditions intended;

d) the OCM should provide upon request, for their device feature sizes under 100 nm, any mitigation strategies, tools or data for device lifetime calculations; see TC22, TC4, TC9 and TC40 in Annex A.

NOTE JEP148, IEC TR 62240-2 and SAE ARP 6338 can assist with the understanding of semiconductor wear-out failure mechanisms that the ADHP user is concerned about.

4.10.3 Failure criteria

Failure criteria shall consist of any of the following modes:

a) functional failure;

b) parameter limit failure;

c) intermittent faults due to the package pins, or the interconnect system, from the pins to the die surface, shall be regarded as failures;

d) transitory faults attributable to the device shall be regarded as failures.

4.10.4 Corrective action

If failures are detected in the reliability processes, the OCM shall investigate, determine root cause and take appropriate actions to achieve conformity to this document or the OCM's internal requirements whichever is the most stringent.

4.10.5 Warranty

The reliability requirements in this document apply to the general population of devices supplied. The warranty period and terms and conditions of sale for failure of individual devices within any warranty are not covered by this document.

4.10.6 Single event effects (SEEs)

Single bit error rate for DRAM and SRAM are shown in Clause A.29 for test TC28 (SER). SEE data shall be made available upon request if available.

4.11 Product monitor

4.11.1 General

The OCM shall ensure the following:

- monitor programme (4.11.2);
- problem notifications (4.11.3);
- data reporting (4.11.4);
- samples (4.11.5);
- corrective action (4.11.6);
- product monitor results (4.11.7); and
- accumulated test data (4.11.8).

4.11.2 Monitor programme

The monitor programme shall be as follows:

a) the OCM shall have a continuous monitor programme to demonstrate that the requirements of this document are met, on an ongoing basis, for each manufacturing operation or product process;

b) statistical process control: the OCM shall control wafer production, assembly process and final test using statistical analysis. When anomalies are observed, parametric and yield data from the probe and final tests shall be analysed against in-line or electrical process control data. The root cause of the deviation shall be determined and the consequent corrective actions implemented;

c) Table 5 shows the minimum test requirements for a conventional stress driven monitor. The use of a failure mechanism driven approach to optimise reliability monitoring is encouraged. On-going qualification test data and accumulated reliability monitor test data may be assessed in a structured way to reduce reliability monitor testing when failure mechanisms are shown to be eliminated by process controls and to increase testing or introduce new tests when failures are detected.

4.11.3 Problem notification

The OCM shall have a process to notify the users and distributors in cases where failures were detected and where there is the possibility that failed parts may have been shipped or may be in the process of being shipped to the user.

NOTE This is usually part of the PCN system as described in J-STD-046 as a guide.

4.11.4 Data reporting

Reliability monitor data accumulated over the preceding two full quarters shall be available, at one month's notice.

4.11.5 Samples

Samples shall be selected as follows:

a) appropriate sample sizes shall be selected;

b) samples shall be randomly selected from representative package and process family devices;

c) all package types and all process families, but not necessarily all package/process combinations, shall be monitored;

d) package tests shall use the largest die size the package is designed to carry that is currently in production. Custom ASIC qualification die may be used (see similarity assessment (4.9.12));

e) sample lots will be added to the monitor at intervals appropriate for each test.

4.11.6 Corrective action

Failure to meet the limits in Table 5 or the OCM's internal limits, whichever is the most stringent, shall trigger appropriate corrective action by the OCM.

4.11.7 Product monitor results

Product monitor results shall meet the requirements of Table 5.

4.11.8 Accumulated test data

Accumulated test data can be analysed as follows:

a) failure rates and levels may be a rolling average with a data accumulation period appropriate to the production quantity level;

b) for HTOL test, the minimum total sample size (SS) required over the data accumulation period, may be calculated using:

$$SS = \frac{Chi^2\left(B,c\right)\times 10^9}{2\times FITS\times A\times t}$$

where

Chi^2 (60 %,0) = 1,83

Chi^2 (60 %,1) = 4,04

Chi^2 (60 %,2) = 6,21

FITS see 4.11.2 a)

c is the number of failures;

B is the upper confidence limit;

A = A_T × A_V (see Clause A.16 for TC15);

t is the time under bias in an oven.

Table 5 – Product monitor tests

Test codes	Title	Maximum failure
HTOL	High temperature operating life long term life	a, b, c
NVL	Non-volatile memory operating life	a
TC	Temperature cycling	a
HE (hermetic packages only)	Hermeticity	d
PC + THB or HAST	Preconditioned 85/85 or HAST (plastic package only)	a

[a] Zero failures with sample size per Table 5.

[b] Failure rate calculated as shown in test HTOL.

[c] HTOL on devices may be substituted by appropriate wafer level reliability, i.e. testing at the wafer level.

[d] Zero failure with a sample size of 5 parts minimum per batch.

4.12 Environmental health and safety (EHS)

4.12.1 General

The OCM shall ensure the following health and safety precautions are in place:

- EHS compliance (4.12.2);
- device handling (4.12.3); and
- device materials (4.12.4).

4.12.2 EHS compliance

The OCM shall be expected to comply with all applicable national, regional, state and local laws and regulations governing environment, health and safety. The OCM registration to industry recognized EHS standards, such as ISO 14001, RC14001 or EMAS, is encouraged, but not mandatory.

4.12.3 Device handling

Devices should not produce any toxic effects for personnel as a result of handling, storage or disposal, or when operated according to the OCM's data sheet.

4.12.4 Device materials

Materials used in the manufacture of devices should be non-flammable, and shall not emit harmful levels of toxic materials as a result of electrical overload or fault within the device.

4.13 Shipping containers

4.13.1 General

Shipping containers shall protect devices and address the following considerations.

4.13.2 ESD requirements

4.13.2.1 General

The OCM shall ensure that all shipping containers are static safe (non-generating as a minimum) to safeguard sensitive products occupying the same manufacturing areas. The OCM shall also ensure the following:

- electrostatic properties (4.13.2.2);

- ESD protection (4.13.2.3);
- specification compliance after shipment (4.13.2.4);
- device orientation (4.13.2.5);
- user instructions (4.13.2.6);
- electrostatic shield (4.13.2.7);
- magazine surface resistivity (4.13.2.8);
- inner container surface characteristics (4.13.2.9).

4.13.2.2 Electrostatic properties

The electrostatic properties of the shipping container material shall be as specified after a conditioning of 48 h at 23 °C ± 3 °C and 12 % RH ± 3 %. Any appropriate test method may be used; examples are contained in ANSI/ESD S541. This test requirement may be met by a certificate of conformance from the shipping container material supplier.

4.13.2.3 ESD protection

All devices shall be supplied in suitable electrostatic protective shipping containers with electrostatic properties meeting the requirements of ANSI/ESD S541 unless otherwise specified in 4.13.2.

4.13.2.4 Specification compliance after shipment

The method of packing for land, sea or air transportation shall adequately protect the device from being electrically or mechanically degraded or damaged in any way during transit.

4.13.2.5 Device orientation

Devices shall all have the same orientation within a magazine.

4.13.2.6 User instructions

Any special handling requirements or precautions (e.g. placing of desiccants; resealing of containers; maximum number of 24 h 125 °C bake cycles allowable) which shall be observed for storage or reshipment shall be stated on the packing and, where necessary, supporting documentation shall be supplied with each inner container.

4.13.2.7 Electrostatic shield

The inner container or magazine shall contain an electrostatic shield of surface resistivity less than 10^6 Ω/square.

4.13.2.8 Magazine surface resistivity

Packing material in direct contact with the device pins shall have a surface resistivity less than 10^{12} Ω/square.

4.13.2.9 Inner container surface characteristics

All surfaces of the inner container other than an electrostatic shield shall meet the following:

- surface resistivity: 10^5 Ω/square to 10^{12} Ω/square;
- charge decay in 2 s: 5 kV to less than 100 V;
- triboelectric charge: not to exceed 100 V.

4.13.3 Magazine reuse

Tubes, trays or other magazines, which depend for their electrostatic properties on surface coatings, shall be limited to a defined number of load/unload cycles. The specified surface resistivity shall be met after the defined number of cycles and data shall be available to justify the limit chosen. Coated magazines may be "reset" to zero load cycles by a suitable recycling process, which includes recoating.

Magazines that utilize bulk material properties may be reused.

4.13.4 Tubes

4.13.4.1 General

The OCM shall ensure the following:

- cushioning material (4.13.4.2);
- partial tubes (4.13.4.3);
- marking access (4.13.4.4); and
- opening (4.13.4.5).

4.13.4.2 Cushioning material

Ceramic devices packaged in tubes shall have an adequate amount of cushioning material to ensure that the devices are not damaged as a result of movement within the tubes.

4.13.4.3 Partial tubes

Full tubes shall be shipped with a maximum of one partly-filled tube per inner container.

4.13.4.4 Marking access

The material of the tube shall be transparent or contain a slot to allow inspection of top markings.

4.13.4.5 Opening

Tubes shall be openable at either end unless otherwise specified to meet unique customer applications.

4.13.5 Trays

4.13.5.1 General

The OCM shall ensure the following:

- devices with MSL of 4 or higher (4.13.5.2);
- marking of bake temperature limit (4.13.5.3);
- stacking of trays (4.13.5.4);
- special packaging (4.13.5.5).

4.13.5.2 Devices with MSL of 4 or higher

For devices with a moisture sensitivity classification according to IPC/JEDEC J-STD-020 of level 2 or higher, the tray shall have a bake capability of at least 125 °C.

4.13.5.3 Marking of bake temperature limit

The bake temperature limit shall be marked on the tray, or the tray marked heatproof.

4.13.5.4 Stacking of trays

There shall be no more than 10 full trays to be stacked in height, plus one partial tray with one further tray as a cover.

4.13.5.5 Special packaging

For devices with special leads, balls or columns, appropriate packaging to accommodate these features without damaging them shall be used (e.g. pedestals for extended leads below package base).

4.13.6 Tape and reel

For devices with moisture sensitivity classification according to IPC/JEDEC J-STD-020 of 2 or higher, the tape and reel shall have a bake capability of 40 °C minimum. The bake temperature limit shall be marked on the reel or the reel shall be marked heatproof.

4.14 Compliance with internal standards

This document does not exempt the OCM of its responsibility to meet its own internal company requirements.

Annex A
(informative)

Test code (TC) information

A.1 General

Annex A provides guidance only and summarizes the content of the quoted standards or specifications at the time of the publication of this document. It is necessary that the users consider the latest revision of the standards or specifications to ensure they use the most recent information.

A.2 TC1 – Autoclave (ATC)

Test method: JESD22-A102, condition C, for plastic packages only or IEC 60749-33 for 96 h. Solder preconditioning for non-hermetic SMD per test TC26 (PC).

NOTE Autoclave, whether biased or unbiased, is sometimes used for testing plastic packaged devices. The test is a valid quality test but is a non-valid reliability test because of no known reliability data. Instead it is better to use HAST, JESD22-A118 condition A, which is non-saturating and non-condensing, and is the proven and preferred method for valid and known acceleration of ageing of electronics in humid environments.

A.3 TC2 – Bond strength, internal (BS)

Test method: Minimum bond strength as specified in JESD22-B116 for ball shear testing or MIL-STD-883 method 2011, test condition D, for wire bond pull testing or IEC 60749-22 or AEC-Q100-001. Recording of failure categories is not required. Plastic packages, for example, can be tested before encapsulation.

NOTE IEC 60749-22 uses metric units and defines methods A to G which cover a wider variety of test conditions than JESD22-B116.

A.4 TC3 – Die shear strength (DS)

Test method: MIL-STD-883 method 2019. Plastic packages, for example, can be tested before encapsulation.

Alternative test methods are:

- MIL-STD-883 method 2027, stud pull test (for integrated circuits (ICs));
- MIL-STD-750 method 2017, die attach integrity test (for discrete components);
- IEC 60749-19.

A.5 TC4 – Electromigration (EM)

Test methods to characterize the metallization system include JP001.01 and/or JEP119, JESD202, JEP154 or IEC 62415 and/or IEC 62418.

Details of the test methods, results and the capability life demonstrated, for < 0,1 % failures at worst case operating temperature, are to be available on request. The requirement to perform electromigration testing is not limited to sub-micron technologies. Larger geometries are subject to electromigration wear out mechanisms. Characterization data could be for the metallization and contact process as a whole, using accelerated current and temperature testing of test structures on the wafer rather than individual device types. Acceleration factors shall be justified by experimental data.

A.6 TC5 – Electrostatic discharge (ESD)

Test method: Human body model.

a) ANSI/ESDA/JEDEC JS-001 or IEC 60749-26;

NOTE ANSI/ESDA/JEDEC JS-001 superseded JESD22-A114 in 2010.

b) ESD withstanding voltage to be determined and be available;

c) ESD classification to be recorded in the qualification report.

Similarity: Sample testing among groups of similar pins is acceptable and, for example, the similarity basis can be stated in the qualification report. Users reserve the right to test any pin-to-pin combination and to reject on failure.

OCMs holding current IECQ certification for compliance with IEC 61340-5-1 are deemed to have satisfied this requirement.

A.7 TC6 – Electrical test (ET)

Test method: JESD86.

Qualification electrical test: The electrical test is performed at the worst still air ambient temperature in the range of T_{opmin} to T_{opmax}. The device shall be stabilized at the test temperature. Where the test is carried out at a temperature which is not the worst case, then full guard banding allowance can be made.

Testing is as follows:

a) DC test to data sheet;

b) AC test to data sheet or correlated DC testing to guarantee the AC parameters;

c) special functional tests where applicable, for example pattern sensitivity, etc.;

d) functional verification;

e) fault coverage target requirements that are stuck at "1" and "0" are typically in excess of 95 %.

Population parameter drift: Where parameter drift assessment is specified in HTOL and HCI tests, a sample of > 10 devices is to pass the electrical test both before and after endurance testing, and the results of the main parameters are to be data-logged:

1) individual devices are not required to be serialized;

2) adequate parameter stability confirmation is required;

3) reporting of statistical measures of population drift is required. The drift of the population mean for any parameter is to be less than 10 % of the initial population mean;

4) functional failures are to be excluded from calculation of mean values.

A.8 TC7 – Electrical distributions (EDs)

Purpose: OCM to verify the data on specified electrical-variables parameters on devices to be qualified per data sheet limits, and assess the device's capability to function within the data sheet limits over time and application environment (e.g. operating temperature range, voltage, input/output levels, etc.) in accordance with JESD86.

Input/output capacitance is one of the parameters evaluated for new process/design qualifications using MIL-STD-883 method 3012 or JESD6. The device bias is at nominal operating voltage. Capacitance measurements are made at all logic levels for digital devices and normal biased condition for analogue devices.

A.9 TC8 – Flammability (FL)

Flammability is only applicable to plastic devices.

Test methods: UL94 or IEC 60749-32 are applicable.

The bulk material test is mandatory but the OCM could meet this test requirement by using material manufacturers' test data. If bulk material is not available, IEC 60695-11-5 needle flame is a suitable method for tests on individual devices.

A.10 TC9 – Hot carrier injection (HCI)

This is applicable to sub-micron MOS technologies where appropriate testing to evaluate long term intrinsic failure mechanisms for device/design related charge injection is carried out.

Test methods: JP001.01 or IEC 62416.

Details of test methods, results and the capability life demonstrated, for < 0,1 % failures, are to be made available. Examples of appropriate methods are found in Table A.1.

Table A.1 – Conditions of the DC over the voltage stress method of JP001.01 or IEC 62416 test

Absolute maximum V_{cc} for DRAM.	Maximum V_{cc} for other devices.
Duration 1 000 h.	
Dynamic operation.	End point: electrical test (ET). Population parameter drift.

A.11 TC10 – Hermeticity (HE)

Not applicable to non-hermetic packages.

Test methods: JESD22-A109 or MIL-STD-883 method 1014 or MIL-STD-750 method 1071 or IEC 60749-8. Note that IEC 60749-8 uses metric units, and has condition E for weight gain gross leak testing and die penetrant gross leak testing.

A.12 TC11 – High temperature bake (HTB)

Test methods: JESD22-A103 or IEC 60749-6 condition B for 1 000 h or JESD22-A103 condition C for 500 h for plastic packages.

JESD22-A103 condition E for 10 h or condition D for 72 h for ceramic packaged devices. Note that IEC 60749-6 does not contain these test conditions

Examines device metal/contact inter-diffusion robustness.

A.13 TC12 – High temperature blocking bias (HTBB)

Test method: MIL-STD-750 method 1048, T_{amb} 150 °C ± 5 °C / 500 h or at 125 °C / 1 000 h at $V_{bias\ max}$ at which DC and AC parameters are guaranteed unless otherwise specified. The critical device blocking junction is reverse biased. Thermal shutdown is not allowed.

A.14 TC13 – High temperature gate bias (HTGB)

Test method: JESD22-A108 examines MOS gate oxide capabilities. T_{amb} 150 °C ± 5 °C for 1 008 h at V_{cc} (maximum) at which DC and AC parameters are guaranteed unless otherwise specified.

A.15 TC14 – High temperature reverse bias (HTRB)

Test method: JESD22-A108 examines junction capabilities. T_{amb} 150 °C ± 5 °C at maximum rated junction temperature specified in the user's/OCM's specification with the device reverse biased to 80 % of maximum breakdown voltage specification or maximum junction temperature to avoid thermal runaway. If T_{amb} is < 145 °C due to device stability, actual T_{amb}, T_j and bias conditions shall be documented. Examination of junction capabilities is done at 504 h (optional) and 1 008 h.

NOTE T_j is the device semiconductor junction temperature, and bias refers to the reverse voltage bias.

A.16 TC15 – High temperature operating life (HTOL)

A.16.1 General

Test method: JESD22-A108 or MIL-STD-883 method 1005 or IEC 60749-23 where a static or dynamic life test which best relates to the device type is applied:

a) devices are cooled to 55 °C or lower prior to the removal of bias;

b) interruption of bias for up to 1 min for the purpose of moving the devices to cool down positions is not considered removal of bias;

c) following bias removal the devices are maintained at less than 30 °C ambient until tested;

d) electrical endpoint testing is normally to be completed within 48 h of removal of bias.

End point measurements: electrical test TC6 (ET) including population parameter drift.

A.16.2 Qualification conditions

The qualification conditions are as follows:

a) 1 000 h at T_{amb} ≥ 125 °C. Higher test temperatures for shorter test times could be used provided the stress is equivalent and anomalous failures do not result from the higher test temperature;

b) maximum operating voltage;

c) if internal power dissipation causes T_j to exceed T_{jmax} or activate a thermal shutdown circuit, the test temperature could be reduced and the test time extended;

d) use the field life simulated by the qualification test derived from using the temperature and voltage acceleration factors defined herein in the qualification report.

A.16.3 Test results assessment

Product monitor results accumulated from periods of accelerated life test could be used to assess early life and long term failure rates, using JESD85 or the following:

$$\text{FIT} = \frac{\text{Chi}^2\,(B,c)\times 10^9}{2\times N\times t\times A_\text{T}\times A_\text{V}}$$

where

Chi^2 (60 %,0) = 1,83

Chi^2 (60 %,1) = 4,04

Chi^2 (60 %,2) = 6,21

B is the upper confidence limit;

c is the number of observed defects;

N is the number of devices tested;

A_V is the voltage acceleration factor;

A_T is the temperature acceleration factor;

t is the test duration of up to 168 h for early life calculations or total test duration minus early life period for long term life calculations.

A.16.4 Temperature acceleration factor

Use the activation energy indicated from relevant failure analysis data. Where no relevant data is available, an activation energy of 0,7 eV is to be used, but it shall be recognized that this will not take account of oxide failure mechanisms.

See Table A.2 for examples of temperature acceleration factors which use activation energy of 0,7 eV.

Table A.2 – Examples of temperature acceleration factors

Examples of A_T for E_a = 0,7 eV	T_oven °C	t h	T_{ja} °C	A_T	Field life years
$A_T = e^{\left[\frac{E_a}{K}\right]\left[\frac{1}{T_{j\text{sys}}} - \frac{1}{T_{j\text{oven}}}\right]}$	125	1 000	0	78	8,9
			15	55	6,3
			30	41	4,7
			45	31	3,6
			60	25	2,8
where	125	2 000	0	78	17,8
E_a is the activation energy;			15	55	12,6
K = 8,617 × 10^{-5} eV/K;			30	41	9,3
$T_{j\text{sys}}$ K = 273 + T_ja + T_sys;			45	31	7,1
$T_{j\text{oven}}$ K = 273 + T_ja + T_oven;			60	25	5,6
T_sys = 55 °C system ambient;	150	1 000	0	260	29,7
T_ja is the junction temperature rise due to power dissipation.			15	170	19,4
			30	117	1ESD
			45	83	9,5
			60	61	7,0

A.16.5 Supply voltage acceleration factor

The supply voltage acceleration factor is selected as follows:

- if a supply voltage higher than the nominal operating voltage is used, a voltage acceleration factor is to be used in FIT rate calculations;
- relationships are typically of the form shown below but any formula and constant values C can be used for which the OCM has supporting evidence available:

$$A_V = e^{C(V1 - V2)}$$

where

A_V is the voltage acceleration factor;

C is a constant determined by the dielectric integrity data;

$V1$ is the stress voltage;

$V2$ is the operating voltage;

- supply voltage acceleration shall be used with circumspection and justified on a case-by-case basis.

A.17 TC16 – Latch-up (LU)

Latch-up is applicable to CMOS, NMOS, bipolar and all variations and combinations of these technologies.

Test methods: JESD78 (preferred test method) or IEC 60749-29, or AEC-Q100-004 with power supply overvoltage and current injection into the input and output (I/O) pins.

A.18 TC17 – Lead integrity (LI)

This is applicable to through hole mount ICs. It is not applicable to SMD and PGA (pin grid array).

Test methods: JESD22-B105 or MIL-STD-883 method 2004 condition B2 lead fatigue or IEC 60749-14. Note that IEC 60749-14 uses metric units.

The number of leads to be tested is 15 leads from a random sample of a minimum of 3 devices. If package corner pins have reduced width or thickness, then at least 1 corner pin is to be tested on each device such that all corner pins are included in the sample.

Carry out the end point hermeticity test for hermetic packages. This is a destructive test.

A.19 TC18 – Lid torque (LT)

Test method: MIL-STD-883 method 2024.

A.20 TC19 – Mechanical sequence (MS)

A.20.1 General

The same samples are to receive all the tests in the sequence.

This is applicable only to cavity packages and devices with bonds and solder joints not moulded in.

End point tests: External visual inspection TC35 (VI), hermeticity fine and gross TC10 (HE), electrical test TC6 (ET).

A.20.2 Constant acceleration

Test method: MIL-STD-883 method 2001. Apply Y1 axis only. IEC 60749-36.

A test condition appropriate to the package mass, area and perimeter length is to be selected.

The test condition used is to be made available.

A.20.3 Vibration (variable frequency)

Test method:

- JESD22-B103; or
- MIL-STD-883 method 2007 condition A; or
- IEC 60749-12.

Peak acceleration: 20 g.

A.20.4 Mechanical shock

Test method:

- JESD22-B104 condition B; or
- MIL-STD-883 method 2002 condition B; or
- IEC 60749-10, 5 pulses 1 500 g, each pulse 0,5 ms duration.

A.21 TC20 – Marking permanency (MP)

Test methods: JESD22-B107 or MIL-STD-883 method 2015 or IEC 60749-9.

Tests to evaluate the legibility when subjected to the application and removal of labels or the use of solvents and cleaning solutions commonly used during the removal of solder flux residue.

The sample "groups" can each consist of one device. Each group is tested with a different solvent.

A.22 TC21 – Non-volatile memory operating life (NVL)

Test method: JESD22-A117.

Applicable to floating gate technology electrically programmable/erasable non-volatile memory devices including embedded memory. The write/erase and subsequent data retention properties of the device using a combination of write/erase cycling and high temperature bake testing is to be determined. Endurance and retention qualification specifications are specified in JESD47 (requirements are considered destructive) or may be developed using application knowledge based on methods as in JESD94. Appropriate interim bake and electrical test points are selected by the OCM.

The subsequent data retention bake is carried on the same sample devices unless otherwise notified.

Alternative test method: AEC-Q100-005 which is similar to JESD22-A117 but requires different samples for high and low temperature data retention storage as there are some degradation processes which heal with temperature and may not show up in the high temperature flow.

A.23 TC22 – Time dependent dielectric breakdown (oxide integrity) (OI)

Test method: JP001.01 or IEC 62417.

Appropriate testing to evaluate long term intrinsic failure mechanisms in semiconductor gate oxide systems and dielectric isolation material systems is to be carried out.

Details of test methods, results and the capability life demonstrated, for < 0,1 % failures, are to be made available.

A.24 TC23 – Package dimensions (PD)

Test method: JESD22-B100 or MIL-STD-883 method 2016, or IEC 60749-3.

A.25 TC24 – Power cycling (PTC)

Test methods: MIL-STD-883 M1037 (power cycling only), test at T_{amb} = 25 °C. Test duration based upon package size/type. Devices powered to ensure T_j = 100 °C (not to exceed absolute maximum ratings).

JESD22-A122 or IEC 60749-34.

Electrical test before, at midpoint and endpoint.

Examples of conditions:

- Small package (e.g. SMD SOTS, D-pak) duration 15 000 cycles, 2 min on/off.
- Medium package (e.g. TO-220, D2-pak) duration 8 572 cycles, 3,5 min on/off.
- Large package (e.g. TO-3, TO-247) duration 5 000 cycles, 5 min on/off.

If a T_j of 100 °C cannot be achieved, consider JESD22-A105 (power and temperature cycling) as an alternative method. Test is performed only on devices with maximum rated power > 1 W and T_j 40 °C. Apply 1 000 cycles of –40 °C to 125 °C. Thermal shutdown is not allowed.

A.26 TC25 – Resistance to solder heat (RSH)

Test methods:

- JESD22-B106, test before and after RSH. SMD devices are to be fully submerged during test;
- IEC 60749-15; or
- IEC 60749-20.

A.27 TC26 – Solder preconditioning (PC)

This is not applicable to hermetic packages.

Test method: JESD22-A113 or IEC 60749-30:

a) moisture conditioning appropriate to the device moisture sensitivity classification followed by three reflow soldering operations in accordance with IPC/JEDEC J-STD-020;

b) moisture conditioning and soldering operation(s) applied are to be stated in the qualification report;

c) the moisture conditioning requirement is to be as specified or an equivalent moisture weight gain specified;

d) if wave soldering capability is required by a device specification agreed with the OCM, it will be demonstrated by immersing the device in flux followed by immersion in solder at 260 °C for 10 s. This operation could include soldering devices onto a PCB with a preheat ramp rate of up to 10 °C/s. To avoid solder bridging problems on some fine pitch packages oil can be used in place of solder for wave soldering simulation.

A.28 TC27 – Solderability (SD)

Requirement:

Devices stored in the as received condition and shipping container are to retain solderability after delivery for a minimum of 12 months in "standard atmospheric conditions" of ambient temperature and relative humidity in the range 5 °C to 30 °C, 20 % to 70 % RH.

Test method and ageing, see Table A.3: industry standard dip and look test conditions and steam ageing are given below as test references. These methods will not be suitable for all packages, for example fine pitch and chip scale and dry heat ageing can be more suitable for some lead finishes. Any differences in test method and ageing used should be noted during registration.

Table A.3 – Dip and look test references

Test method:	JESD22-B102 or MIL-STD-883-M2003 or IEC 60749-21.
Flux:	Non-activated flux.
Ageing:	8 h steam.
THM (through hole mount):	245 °C for 5 s.
SMD:	215 °C ± 2 °C for 5 s ± 1 s.
Palladium plated SMD:	The OCM can perform the test at 215 °C ± 2 °C for 10 s ± 1 s, but the user reserves the right to perform the test as specified and to reject on failure.
NOTE	IEC 60749-21 uses metric units and defines lead-free solder in more detail than JESD22-B102.

A.29 TC28 – Soft error rate (SER)

Test methods: JESD89 including JESD89-1, JESD89-2 and JESD89-3 or IEC 60749-38 or IEC 60749-17.

This test applies to DRAM and SRAM devices only (not embedded memory). For SRAM references to refresh can be ignored.

Reporting: The number of errors detected, including SEFI and SEL and the following test parameters are to be stated in the qualification report. Appropriate parameter values (see Table A.4), are to be chosen by the OCM:

Table A.4 – Parameter values for consideration

Sample size.	Refresh type, burst, etc.
Test duration (h).	Test temperature.

Sample size/test duration: For qualification (see Table A.5), the number of device-hours shall be adequate to demonstrate that the soft single bit error rate at T_{amb} 55 °C and 90 % UCL does not exceed 20 FIT/Mbit for both DRAM and SRAM.

Table A.5 – Test conditions

Recommended test conditions:	Recommended data pattern:
V_{cc} minimum specified for data retention.	Write and verify checkerboard once, then read/refresh continuously.
Maximum specified refresh interval (period).	Repeat with complementary checkerboard.
Test temperature 55 °C. Cycle time 500 ns.	Test with checkerboard and complementary pattern for approximate equal durations.

Accelerated testing: Accelerated testing using the "hot source" irradiation method is not acceptable as a substitute for system level soft error test.

A.30 TC29 – Steady state operating life (SSOL)

Test method: JESD22-A108 or IEC 60749-23.

Examine device power handling capabilities. T_{amb} for 1 008 h. Device is biased statically to full power at ambient temperatures. Thermal shutdown is not allowed.

A.31 TC30 – Temperature cycling (TPC)

Test methods:

- solder preconditioning for non-hermetic SMD per test TC26 (PC);
- JESD22-A104 condition C, 500 cycles, −65 °C to +150 °C; or
- JESD22-A104 condition B, 1 000 cycles, −55 °C to +125 °C; or
- MIL-STD-883 method 1010 condition B, 1 000 cycles, −55 °C to +125 °C; or
- IEC 60749-25, 1 000 cycles, −55 °C to +125 °C.

1 min maximum transfer time. 10 min minimum dwell time if using MIL-STD-883 method 1010 or 1 min minimum dwell time if using soak mode 1 of JESD22-A104 or select an appropriate dwell time based upon featuring and mass. Solder preconditioning to be applied for non-hermetic SMD per test code TC26 (PC).

End points: Hermeticity (hermetic devices only) test TC10 (HE).

Qualification electrical test TC6 (ET).

The OCM will apply the specified number of cycles. An alternative number of cycles and temperature extremes with T_{min} ≤ −40 °C is acceptable if the OCM can show the stress level is equivalent.

A.32 TC31 – Temperature humidity reverse bias (THRB)

Test method: JESD22-A101. 1 000 h 85 °C / 85 % RH with device reverse biased at 80 % of rated breakdown voltage up to a maximum of 100 V or limit of chamber. Electrical test before at 500 h and 1 000 h.

A.33 TC32 – Temperature humidity bias (THB or HAST)

See Table A.6 for the test methods.

Solder preconditioning for non-hermetic SMD per test TC26 (PC).

Consider intermittent bias for cases where T_j > 5 °C above ambient.

End point: Qualification electrical test TC6 (ET).

Table A.6 – Test methods

Temperature humidity bias (THB) test	Highly accelerated temperature and humidity stress test HAST is considered to be a destructive test.	
JESD22-A101 or IEC 60749-5	JESD22-A110 or IEC 60749-4	
	Relative humidity:	85 % ± 5 %
	Temperature:	130 °C ± 2 °C
	Duration:	96 h

HAST shall not exceed 130 °C as above this value non-valid results have been known to occur. Other HAST conditions with lower temperatures per JESD22-A110 can be used as an alternative to the 85/85 THB test when the OCM has adequate evidence of correlation using those conditions. The conditions used shall be stated in the qualification report.

A.34 TC33 – Terminal strength (TS)

Test method: MIL-STD-750 method 2036 for diodes and transistors.

A.35 TC34 – Thermal resistance (thermal impedance) (TR)

Use any appropriate test method. Examples of methods are included here but not limited to:

- JESD531 for signal and regulator diodes,
- JESD313-B for conduction cooled power transistors,
- JESD51-1 and JESD51-2 for integrated circuits (natural convection),
- JESD282 for bridge rectifier assemblies, JESD24-4 for bipolar transistors,
- JESD24-3 for power MOSFETs,
- JEP138 for IR thermal imaging determination of die temperature.

The device data shall state the thermal impedance determined (θ_{jc} and θ_{ja}).

NOTE

θ_{jc} is the thermal resistance from the component semiconductor junction to the component case.

θ_{ja} is the thermal resistance from the component semiconductor junction to the surrounding ambient air.

A.36 TC35 – Visual inspection (VI)

A.36.1 TC35a – External visual inspection

Purpose, apparatus and procedure are as specified in:

- JESD22-B101 for plastic encapsulated devices;
- MIL-STD-883 method 2009 for hermetically packaged ICs; and
- MIL-STD-750 method 2071 for hermetically packaged discrete semiconductor devices or test method IEC 60749-3.

NOTE JESD22-B101 inspects from ×3 to ×7 with up to ×30 magnification whereas IEC 60749-3 allows ×3 to ×10 magnification. Also IEC 60749-3 does not include:

a) the external visual report from templates;

b) the maximum criteria of 5 % base material exposure through the final plating.

Plastic package failure criteria: JESD22-B101 with the addition of the following molding defect criteria. Where no measurement criteria are given, the defect is a reject if visible at ×3 magnification as follows:

a) incomplete fill of package form;

b) inner lead exposed;

c) rough surface > 10 % of the total area in any site of package;

d) pin holes;

e) surface blister;

f) blister void (surface blister already broken or can be broken by a needle);

g) blister near a power package mounting tab;

h) ejection pin defects in any direction and in any part of the marking area which are > 0,1 mm in any direction;

i) any crack or gap at interface of metal and resin;

j) flash on lead > 0,5 mm from package body;

k) flash on power package mounting tab hole;

l) cap and frame misalignment > 0,1 mm;

m) broken package;

n) resin mark around ejector hole > 0,1 mm in any direction.

A.36.2 TC35b – Internal visual inspection

Test method:

- MIL-STD-883 method 2010 condition B for microcircuits,
- MIL-STD-750 method 2072.5 for transistors,
- MIL-STD-750 method 2074.2 for discrete semiconductors,
- MIL-STD-750 method 2069 for MOSFETs transistors,
- MIL-STD-750 method 2070 for microwave discrete and multiple transistors.