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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electronic components – Long-term storage of electronic semiconductor devices – Part 9: Special cases

Composants électroniques – Stockage de longue durée des dispositifs électroniques à semiconducteurs – Partie 9: Cas particuliers

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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The text of this International Standard is based on the following documents:

DRAFT	Report on voting
47/2700/FDIS	47/2716/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 62435 series, published under the general title *Electronic components – Long-term storage of electronic semiconductor devices*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This document applies to the long-term storage of electronic components in special cases of configuration. The custom-client relationship for storage of all cases is also included.

This document deals with the long-term storage (LTS) of electronic devices drawing on the best long-term storage practices currently known. For the purposes of this document, LTS is defined as any device storage whose duration can be more than 12 months for product scheduled for long duration storage. While intended to address the storage of unpackaged semiconductors and packaged electronic devices, nothing in this document precludes the storage of other items under the storage levels defined herein.

Although it has always existed to some extent, obsolescence of electronic components and particularly of integrated circuits, has become increasingly intense over the last few years.

Indeed, with the existing technological boom, the commercial life of a component has become very short compared with the life of industrial equipment such as that encountered in the aeronautical field, the railway industry or the energy sector.

The many solutions enabling obsolescence to be resolved are now identified. However, selecting one of these solutions should be preceded by a case-by-case technical and economic feasibility study, depending on whether storage is envisaged for field service or production, for example:

- remedial storage as soon as components are no longer marketed;
- preventive storage anticipating declaration of obsolescence.

Taking into account the expected life of some installations, sometimes covering several decades, the qualification times, and the unavailability costs, which can also be very high, the solution to be adopted to resolve obsolescence should often be rapidly implemented. This is why the solution retained in most cases consists in systematically storing components which are in the process of becoming obsolescent.

The technical risks of this solution are, a priori, fairly low. However, it requires perfect mastery of the implemented process and especially of the storage environment, although this mastery becomes critical when it comes to long-term storage. All handling, protection, storage and test operations are recommended to be performed according to the state of the art.

The application of the approach proposed in this document in no way guarantees that the stored components are in perfect operating condition at the end of this storage. It only comprises a means of minimizing potential and probable degradation factors.

Some electronic device users have the need to store electronic devices for long periods of time. Lifetime buys are commonly made to support production runs of assemblies that well exceed the production timeframe of its individual parts. This puts the user in a situation requiring careful and adequate storage of such parts to maintain the as-received solderability and minimize any degradation effects to the part over time. Major degradation concerns are moisture, electrostatic fields, ultra-violet light, large variations in temperature, air-borne contaminants, and outgassing.

Warranties and sparing also present a challenge for the user or repair agency as some systems have been designated to be used for long periods of time, in some cases for up to 40 years or more. Some of the devices needed for repair of these systems will not be available from the original supplier for the lifetime of the system or the spare assembly may be built with the original production run but then require long-term storage. This document was developed to provide a standard for storing electronic devices for long periods of time.

The storage of devices that are moisture sensitive but that do not need to be stored for long periods of time is dealt with in IEC TR 62258-3.

Long-term storage assumes that the device is going to be placed in uninterrupted storage for a number of years. It is essential that it be useable after storage. It is important that storage media, the local environment and the associated part data be considered together.

Local environments for long term storage can be unique to the application or to the type of subassembly being stored for further assembly. Different device types that are integrated into a single package or module can have different storage requirements that should be considered during long term storage. A product can contain a single die or multiple dice (example: a CMOS processor, a GaN radio, sensors and a new type of memory). Each device technology can impose storage requirements. For example: the memory can be removed from x-ray or high magnetic field sources and the sensors can be stored in a dark environment or low-pressure environment.

Such practice requires good communication interactions and agreements for storage that should account for the possibility and complexity of intermediate assembly of heterogeneous devices. Successful customer supplier interaction involves clear expectations for device provenance, traceability and identification.

These guidelines do not imply any warranty of product or guarantee of operation beyond the storage time given by the manufacturer.

The IEC 62435 series is intended to ensure that adequate reliability is achieved for devices in user applications after long-term storage. Users are encouraged to request data from suppliers to applicable specifications to demonstrate a successful storage life as requested by the user. These standards are not intended to address built-in failure mechanisms that would take place regardless of storage conditions.

These standards are intended to give practical guide to methods of long-duration storage of electronic components where this is intentional or planned storage of product for a number of years. Storage regimes for work-in-progress production are managed according to company internal process requirements and are not detailed in IEC 62435 (all parts).

The overall standard is split into a number of parts. Parts 1 to 4 apply to any long-term storage and contain general requirements and guidance, whereas Parts 5 to 9 are specific to the type of product being stored.

The structure of the IEC 62435 series consists of the following:

– Part 1: General
– Part 2: Deterioration mechanisms
– Part 3: Data
– Part 4: Storage
– Part 5: Die and wafer devices
– Part 6: Packaged or finished devices
– Part 7: MEMS
– Part 8: Passive electronic devices
– Part 9: Special cases

ELECTRONIC COMPONENTS – LONG-TERM STORAGE OF ELECTRONIC SEMICONDUCTOR DEVICES –

Part 9: Special cases

1 Scope

This part of IEC 62435 specifies storage practices encompassing silicon and semiconductor device building blocks of all types that are integrated together to into products in the form of either packages or boards that can be stored as fully assembled units or partial assemblies. Special attention is given to memories as components and assemblies although methods also apply to heterogeneous components. Guidelines and requirements for customer-supplier interaction are provided to manage the complexity.

NOTE In IEC 62435 (all parts), the term "components" is used interchangeably with dice, wafers, passives and packaged devices.

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.

IEC 60050-192, *International electrotechnical vocabulary – Part 192: Dependability*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
failure modes effects analysis
FMEA
quantitative method of analysis that involves the study of possible failure modes and faults in sub items, and their effects at various indenture levels

[SOURCE: IEC 60050-192:2015, 192-11-05, modified – The deprecated terms have been removed, "qualitative" has been changed to "quantitative" because formal methods call for quantitative ranking of defined risks and the note has been removed.]

3.2
magnetoresistive random access memory
MRAM
non-volatile memory technology that uses electron spin domains to store information

3.3
resistive random access memory
ReRAM
non-volatile memory technology that uses changes in the resistance of a solid-state dielectric material to store information

Note 1 to entry: Resistive random access memory is often referred to as a "memristor".

3.4
ferroelectric random access memory
FeRAM
non-volatile memory technology that uses changes in the ferroelectric resistance of a solid-state dielectric material to store information

Note 1 to entry: Ferroelectric random access memory is often referred to as a "memristor".

3.5
erasable programmable read-only
EPROMS
type of memory that stores and retains information when the device power supply is switched off characterized as a non-volatile characteristic

3.6
flash memory storage
type of EEPROM memory that can be cleared only on blocks of memory or on a memory array

3.7
micro-electromechanical system
MEMS
system composed of one or more integrated microsized components, such as sensors, actuators, transducers, resonators, oscillators, mechanical components, or electric circuits

Note 1 to entry: In the definition, "microsized" is used to mean a size of less than a few millimetres.

Note 2 to entry: Technologies relating to MEMS are extremely diverse and include fundamental technologies (such as design, material, processing, functional element, system control, energy supply, bonding and assembly, electric circuit, and evaluation), basic sciences (such as micro-science and engineering) as well as thermodynamics on a micro-scale and microtribology.

Note 3 to entry: "MEMS" is the acronym of "micro-electromechanical systems", but was used in the past for "micro-electromechanical device". The singular and plural forms of the term "MEMS" are identical.

[SOURCE: IEC 62047-1:2016, 2.1.1, modified – The preferred term "micro-electromechanical device" has been replaced by "micro-electromechanical system" to reflect current usage. Note 1 to entry has been revised for clarity, and the second sentence has been transferred to Note 2 to entry.]

3.8
2,5 dimensional packaging
2.5D
silicon devices that are stacked upon each other or using package as part of the stacking scheme

3.9
3 dimensional packaging
3D
silicon devices stacked upon one another and connected via through silicon vias

4 Component storage cases

Semiconductor storage encompasses a number of different types of devices in many forms that challenge customer-supplier interactions. Silicon and semiconductor device building blocks of all types are integrated together to into products in the form of either packages, modules or boards that can be stored as fully assembled units or partial assemblies. The devices in a 2.5D or 3D product can include, Si logic, semiconductor memory, power devices, radios and MEMs. Storage at intermediate steps is a method to control costs and manage configurations or end product features. Each device or subassembly can be procured from a different foundry or assembly site. The storage risk assessment and mitigations shall consider all elements as finished or in partial assembly.

Local environments for long term storage can be unique to the application or to the type of subassembly being stored for further assembly. Different device types that are integrated into a single package or module can have different storage requirements that should be considered during long term storage. A product can contain a single die or multiple dice (example: a CMOS processor, a GaN radio, sensors and a new type of memory). Each device technology can impose storage requirements. For example, the memory can need to be removed from x-ray or high magnetic field sources and the sensors can need storage in a dark environment or low-pressure environment. The storage risk assessment should consider the unique storage requirements of each device and the storage environment.

The customer supplier interactions and agreements for storage should account for the possibility and complexity of intermediate assembly of heterogeneous devices. Successful customer-supplier interaction involves clear expectations for device provenance, traceability and identification.

5 Storage of memory devices

5.1 General

Storage of solid-state memory devices can impose additional considerations to long term storage because of the different sensitivities in the storage environment and the different device types. Another complicating factor to non-volatile memory storage is that components can be stored in long duration with data written for later use after final assembly. The time between read and write can be years. The risks associated with each memory shall be determined using a standardized risk assessment process, e.g. FMEA per IEC 60050-192. Examples of known interactions for different memory types are provided in Table 1 for reference. Similarly, Annex A indicates examples of ownership that should be considered during documentation and business agreements.

5.2 Semiconductor memory device types

A number of different types of memory exist with different sensitivities to the ambient environment. Memories can use different types of substrates or different physical phenomena to store charge or state. Historically memories have been known to have degraded ability to store charge when stored in higher temperature environments. The same memories are also sensitive to x-ray radiation to various degrees. Some memories utilize different mechanisms to store data such as magnetic spin or alterations in resistance and changes in the materials phases. Magnetic memories can be sensitive to high field environments while phase change memories can have a sensitivity to other environmental factors experienced in storage.

For long term storage of semiconductor memories, it is required to perform a failure modes effects analysis to identify potential vulnerabilities during the storage duration. The risk assessment FMEA should consider the storage environment including the proximity to x-ray sources, shielding, magnetic fields and higher temperatures. The ambient storage environments can be different than the standard storage environments given in IEC 60721-3-1 classification 1K21 which are used throughout the IEC 62435 series. Examples of temperature environments are shown in Table 1 below. The storage scheme should be based upon the risk Assessment FMEA with special care to ensure mitigations to mechanism stimuli for failure during or after long term storage.

Table 1 – Example failure mechanisms and stimuli for memory devices

Failure mechanism	Failure mechanism detail	Failure mode	Mechanism stimuli
Popcorn effect	High rate vapour expansion within a package during surface mounting	Open circuit, blistering, package cracks	Temperature increase leading to moisture vapour
Handling damage	Cracking	Open, short, visible crack	Application of force
	Visible scratch/smudge	Open, short, surface mark	Mechanical abrasion
Device data loss/damage	Electro-magnetic current field induced short/open/error	Open, short, data corruption	Electro-magnetic field
	High ionizing radiation induced open, short or error	Open, short, data corruption	High-energy radiation, x-ray
	Soft error resulting from device damage – random event	Open, short or data corruption	Neutron particle hit Alpha particle emission hit
	Charge loss in programmed cell		
Staining residue	Change in surface appearance and specification resulting from unplanned exposure to oxidizing contents	Visible defect, non-conforming appearance and potential of misprocessing	Exposure resulting in aging, oxidation or hardening of residue
Polymer material aging	Polymer embrittlement	Visible cracking, open or shorting	Temperature exposure, residual mechanical stress and bright light
Storage media issues	Tape on reel, tube embrittlement/aging	Misalignment during processing	Temperature exposure, mechanical stressing and bright light
	Tray and tube aging embrittlement	Dropped parts from broken tray media or parts out of formed pocket	Temperature, handling and bright light
	Box aging embrittlement	Dropped parts Opens or shorts from ESD Foreign material	Temperature and bright light
	ESD coating degradations	Opens or shorts from ESD	Triboelectric charging or charge potential difference
	Label aging	Illegible mark	Bright light, temperature
		Missing label	Temperature and bright light
		Brittle flaking – partial label	Temperature and bright light