IEC 62435-7

Edition 1.0 2020-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Electronic components – Long-term storage of electronic semiconductor devices –
Part 7: Micro-electromechanical devices**

**Composants électroniques – Stockage de longue durée des dispositifs électroniques à semiconducteurs –
Partie 7: Dispositifs microélectromécaniques**

IEC 62435-7:2020-12(en-fr)

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

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

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

IEC 62435-7

Edition 1.0 2020-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electronic components – Long-term storage of electronic semiconductor devices –
Part 7: Micro-electromechanical devices

Composants électroniques – Stockage de longue durée des dispositifs électroniques à semiconducteurs –
Partie 7: Dispositifs microélectromécaniques

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.020 ISBN 978-2-8322-9147-4

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 7: Micro-electromechanical devices

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62435-7 has been prepared by IEC technical committee 47: Semiconductor devices. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
47/2664/FDIS	47/2669/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 "http://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.

This is a standard for 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 may 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 their 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, ultraviolet 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. For storage of devices that are moisture sensitive but that do not need to be stored for long periods of time, refer to 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 is useable after storage. Particular attention should be paid to storage media surrounding the devices together with the local environment.

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 this series of standards.

The overall standard series 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. It is intended that the product specific part should be read alongside the general requirements of Part 1 to 4.

Electronic components requiring different storage conditions are covered separately starting with Part 5.

The structure of the IEC 62435 series as currently conceived is as follows:

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 – Micro-electromechanical devices – MEMS

Part 8 – Passive electronic devices

Part 9 – Special cases

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

Part 7: Micro-electromechanical devices

1 Scope

This part of IEC 62435 on long-term storage applies to micro-electromechanical devices (MEMS) in long-term storage that can be used as part of obsolescence mitigation strategy. Long-term storage refers to a duration that may be more than 12 months for products scheduled for storage. Philosophy, good working practice, and general means to facilitate the successful long-term storage of electronic components are also addressed.

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 60721-3-1, *Classification of environmental conditions – Part 3-1: Classification of groups of environmental parameters and their severities – Storage*

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 62435-2, *Electronic components – Long-term storage of electronic semiconductor devices – Part 2: Deterioration mechanisms*

IEC 62435-3, Electronic *components – Long-term storage of electronic semiconductor devices – Part 3: Data*

IEC 62435-4, *Electronic components – Long-term storage of electronic semiconductor devices – Part 4: Storage*

IEC 62435-5, *Electronic components – Long-term storage of electronic semiconductor devices – Part 5: Die and wafer devices*

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
storage environment
specially controlled storage area, with particular control of temperature, humidity, atmosphere and any other conditions depending on the product requirements

3.2
critical moisture limit
maximum safe equilibrium moisture content for a specific encapsulated device at reflow assembly or rework

3.3
long-term storage
LTS
planned storage of components to extend the life-cycle for a duration with the intention of supporting future use

Note 1 to entry: Allowable storage durations will vary by product, form factor (e.g., packing materials, shape) and storage conditions. In general, long-term storage is longer than 12 months.

3.4
LTS storeroom
area containing components that have additional packaging for storage to protect from moisture or from mechanical impact or for ease of identification or handling

3.5
moisture-sensitive device
MSD
device that has moisture absorption or moisture retention and whose quality, process ability or reliability is affected by moisture

3.6
electronic device
packaged electrical, electronic, electro-mechanical (EEE) item, or assemblies using such items

3.7
desiccant
hygroscopic substance used to remove moisture from an atmosphere

3.8
moisture barrier bag
MBB
storage bag manufactured with a flexible laminated vapour barrier film that restricts the transmission of water vapour

Note 1 to entry: Refer to IEC 60749-20-1 for packaging of moisture sensitive products.

3.9
humidity indicator card
HIC
card printed with a moisture sensitive chemical that changes from blue to pink (colour) in the presence of water vapour

3.10
water vapour transmission rate
WVTR
measure of permeability of MBBs to water vapour

3.11
dunnage
all the matter stored in a moisture barrier bag that is additional to the packaged electronic component

3.12
electro-static discharge
ESD
transfer of electric charge between bodies of different electrostatic potentials in proximity or through direct contact

[SOURCE: IEC 60050-561:2014, 561-03-06]

4 Storage considerations

4.1 Overview of MEMS applications

MEMS (Micro-electromechanical Systems) are miniaturized mechanical or electromechanical elements that typically vary in size from 1 micron to 1 000 microns that are used to mechanically measure or manipulate matter, light or create electric signals from environmental inputs. Storage of MEMS devices should consider different sensitivities and risks compared to other semiconductor devices due to the mechanical nature of the devices. MEMS may be subject to additional mechanical related performance and failure mechanisms in addition traditional semiconductor performance mechanisms. The storage program should consider the end use and failure mechanisms related to the function of the MEMS device. Typical uses are listed for initial consideration and risk assessment.

– Actuator mechanical movement related to electrostatics, thermal changes or piezoelectric effects.
– Physical sensors related to acceleration, vibration, field/flux, force, magnetic field, electro-static, optical stimulus or radiation effects, pressure, temperature.
– Chemisensors related to gas or liquid induced mechanical response changes (may also have requirements for moisture or solvent which also have shelf life).
– Biosensors liquid, mechanical or fluidic induced mechanical response changes (may also have requirements for moisture or solvent which also have shelf life).

4.2 Failure mechanisms

4.2.1 Occurrence of failure and driving force

Failures during long-term storage may be mitigated by control of the stimuli driving given failure modes of interest as defined by risk assessment tools, for example, failure modes and effects analysis (FMEA). Storage related failures are often detected as modes of non-operation, visual quality, reduced life time or other non-conformance. The modes of failure during storage are typically related to a failure mechanism that is driven by a physical stimuli or condition. Example failure stimuli are given in Table 1. Additional examples of deterioration mechanisms are found in IEC 62435-2. Successful long-term storage is accomplished by mitigating failures through control of the stimuli or driving force.

Table 1 – Failure mechanisms in storage and stimuli to mitigate during storage

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, sense signal degradation	Application of force
	Visible scratch/smudge	Open, short, surface mark, sense signal degradation	Mechanical abrasion
	Physical crack in sensing device	Open, short, sense signal degradation	Excessive pressure change
	Mechanical overstress	Sensitivity shift, non-parametric sensitivity, offset shift, stuck at	Sources of mechanical overstress are shock, fatigue, vibration, corrosion or the effects of electrical overstress (EOS) or electrostatic discharge (ESD) that result in structural damage to MEMS transducer parts.
	Fractured spring	Non-parametric sensitivity	MEMS motion transducers typically use a collection of springs to establish mechanical positioning in linear sensitivity and travel limits. When springs are compromised by excessive handling the difference between springs and proof mass is compromised resulting in error by nonlinear sensitivity.
	Fractured finger	Sensitivity shift, offset shift, change of sensor dynamics	Capacitive interdigitated fingers used to sense the proof mass movement are damaged. When a finger fractures, the total capacitance is reduced, resulting in a decrease of sensitivity and offset shift.
	Cavity seal breach	Sensitivity shift, offset shift, change of sensor dynamics	The gap between the fingers provides an aerodynamic dampening due to the sealed gas molecules inside the cavity structure that is proportional to the pressure of the sealed gas. The lower pressure results in an increase of sensitivity and then a change of sensor dynamics or cut-off frequency.
	Fractured diaphragm	Offset shift, stuck-at	Pressure transducers are diaphragms that exert a strain on piezo-resistive elements or change a capacitive gap. When a diaphragm fractures, an offset or a complete loss of sensitivity occurs, resulting in a stuck-at ground fault.
	Fractured anchor	Offset shift, stuck-at	Motion transducers are typically have springs with anchors used to limit travel distance. If the anchor, or travel-limiter fractures, the proof mass becomes misaligned or travels out of range to contact the inner surfaces of the cavity, resulting in a stuck-at fault
Device data loss/damage (currently not typical to MEMs)	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	Open, short or data corruption	Neutron particle hit Alpha particle emission hit

Failure mechanism	Failure mechanism detail	Failure mode	Mechanism stimuli
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 sense signal degradation	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; mechanical malfunction due to particles	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
Indirect material issues	Moisture barrier bag leak	Humidity indicator card trigger, visual non-conformance	Handling abrasion, bending and shock events
	Humidity indicator card inactivated	Incorrect colour or no moisture exposure indicated	Temperature, humidity exposure before use
	Label aging	Illegible mark Missing label Brittle flaking – partial label	Bright light, temperature Temperature and bright light Temperature and bright light
Solderability	Inability to form a good solder joint	Post surface mount electrical open	Temperature, humidity exposure
Corrosion	Electro-chemical reaction leading failure or reduced mechanical functionality	Open, short, visual non-conformance, stiction related sense signal degradation or failure	Temperature, galvanic cell, chemical residue
Stiction	Reduction in mechanical movement due to effects of static friction coating: may result from corrosion, oxidation, foreign material or mechanical wear	Sense signal degradation, shift, non-parametric sensitivity and stuck at	Temperature humidity, use cycling, dynamic stresses-vibration. Capillary or electrostatic forces cause suspended/cantilevered surfaces to become stuck to other moving surfaces or to fixed surfaces due to anomalies of coatings used to prevent such effects
Wear	Degradation of functionality related to use of a mechanical function	Sense signal degradation	Mechanical cycling, dynamic stresses-vibration, and shock