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Process management for avionics - Aerospace qualified electronic components (AQEC) -
Part 1: Integrated circuits and discrete semiconductors

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Process management for avionics - Aerospace qualified electronic components (AQEC) - Part 1: Integrated circuits and discrete semiconductors

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC TS 62564-1:2016. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC TS 62564-1, which is a technical specification, has been prepared by IEC technical committee 107: Process management for avionics. It is a Technical Specification.

This fourth edition cancels and replaces the third edition published in 2016. This edition constitutes a technical revision.

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

a) addition of optional ADHP PPAP;

b) revision to Annex B; addition of Annex C and Annex D;

c) removal of STACK;

d) general update to referenced standards throughout.

GEIA-STD-0002-001 (June 2006), *Aerospace Qualified Electronic Component (AQEC) Requirements, Volume 1 - Integrated Circuits and Semiconductors*, has served as a basis for the elaboration of the first edition (2009) of this technical specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
107/442/DTS	107/443/RVDTS

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 Technical Specification 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/publications.

A list of all parts in the IEC 62564 series, under the general title *Process management for avionics - Aerospace qualified electronic components (AQEC)*, 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, or

– revised.

INTRODUCTION

Aerospace qualified electronic components (AQEC) plans are developed by manufacturers in order to document compliance with AQEC requirements for aerospace, defence and high performance (ADHP) users. For AQEC designated components, the intention is to

a) provide AQEC users access to information and data from the AQEC manufacturers that is necessary for using commercial-off-the-shelf (COTS) products, particularly in the context of aerospace certification process where complex electronic components are involved;

b) better enable AQEC users to assess whether these parts are capable of operating reliably in their applications;

c) minimize deviations from the AQEC manufacturers' COTS ~~products~~ electronic components;

d) have minimal impact on the AQEC manufacturers' standard operating or business procedures;

e) promote communication between the AQEC manufacturers and users.

This document only addresses integrated circuits and discrete semiconductors manufactured using silicon based technology and excludes silicon carbide and gallium nitride technologies.

1 Scope

This part of IEC 62564, which is a Technical Specification, defines the minimum requirements for integrated circuits and semiconductors which are designated as an "aerospace qualified electronic component (AQEC)". It applies to integrated circuits and semiconductors exhibiting the following attributes:

a) a minimum set of responses to requirements, ~~or~~ information and data including physical hardware data, provided by the part manufacturer, which will allow a standard COTS electronic component to be designated AQEC by the manufacturer;

b) as a minimum, each COTS electronic component (designated AQEC) will have been designed, fabricated, assembled, and tested in accordance with the component manufacturer's requirements for standard data book components with additional enhancements as considered appropriate;

c) qualification of, and quality systems for, the COTS electronic components to be designated as AQEC ~~should~~ will include the manufacturer's standards, operating procedures, and technical specifications. This information ~~should~~ will be available when requested;

d) electronic components manufactured before the manufacturer has addressed AQEC requirements, but utilizing the same processes, are also considered AQEC compliant, providing sufficient data is made available;

e) additional desired attributes of a device designated AQEC (that will support AQEC users) are found in Annex B of this document.

This document contributes by the above attributes to the aerospace certification process which include particularly complex COTS electronic components.

NOTE 1 Parts qualified to military specifications such as JAN, JANTX, JANTXV transistors and diodes, MIL-PRF-38535 or MIL-PRF-5962-XX microcircuits, CECC (CENELEC Electronics Component Committee) specified components, etc. (except those identified as being for "logistic support" purposes only) are considered AQEC; the remainder of this document only addresses non-military specification parts.

NOTE 2 Adding a TX to JAN prefix means that the part was not only made to MIL-PRF-19500 but it was also tested to Mil spec. Adding a V to the TX means that the part was verified during testing before the package was completed.

NOTE 3 Electronic components classified by original component manufacturers (OCMs) as being 'enhanced' components only become AQEC components when they meet the requirements of this document.

~~Parts qualified to AEC-Q100, grade 0 through to grade 3 are considered AQEC. For those applications where a 0 °C to +70 °C temperature range is appropriate, grade 4 is also considered to be AQEC.~~ Parts qualified to AEC-Q100, grade 0, AEC-Q100 grade 1, and AEC-Q100 grade 2 according to the standard qualification test plan according to Table 2 of AEC-Q100:2023 are considered candidates for AQEC providing they meet the requirements of this document. Parts qualified to AEC-Q100 for a specific mission profile require analysis to determine suitability for AQEC selection. The users should document that the grade category used is compatible with the application in accordance with their IEC ~~TS~~ 62239-1 electronic components management plan (ECMP).

Although developed for the avionics industry, this document can be applied by other industrial sectors at their discretion.

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

~~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 TS 62668-1, *Process management for avionics – Counterfeit prevention – Part 1: Avoiding the use of counterfeit, fraudulent and recycled electronic components*~~

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

J-STD-048, *Notification Standard for Product Discontinuance*

3 Terms, definitions and abbreviated terms

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

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

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

3.1 Terms and definitions

3.1.1
AQEC specification
document prepared by or for the manufacturer to describe an AQEC product

Note 1 to entry: It includes a data sheet and ~~may~~ can include other documents, such as material descriptions, environmental test procedures, quality monitoring processes, etc. It ~~may~~ can be a stand-alone document or a clearly denoted item within a larger documentation system. There ~~may~~ can be additional data associated with specific applications which ~~may~~ can be requested separately.

3.1.2
AQEC plan
instrument prepared by the plan owner (see 3.1.13) that clearly, concisely, and unambiguously documents the processes used by the plan owner to satisfy the requirements of this document

Note 1 to entry: The plan contains auditable content.

3.1.3
assessment
evaluation of a plan owner's AQEC plan to determine if it is compliant with this document

Note 1 to entry: It ~~may~~ can be conducted by IECQ, the customer, the customer's designee, or by a third party designated by the customer community.

3.1.4
microcircuit
integrated circuit
microcircuit (device with a high circuit-element density) in which all or some of the circuit elements are inseparably associated and electrically interconnected (on one or more substrates, in a unique indivisible package) so that the microcircuit is considered to be indivisible for the purpose of construction and commerce

3.1.5
semiconductor
discrete semiconductor device
semiconductor device that is specified to perform an elementary function and that is not divisible into separate components functional in themselves (for example diodes, transistors, optocouplers, LEDs and related products)

3.1.6
certification
process for validation of requirements by a higher authority

Note 1 to entry: Certification of complex components in the avionics industry typically refers to meeting the requirements of AMC 20-152A formerly known as ED80. ED80 was identical to RTCA DO-254. The FAA will be publishing a revision to AC-152 soon which will be identically worded to AMC 20-152A.

3.1.7
component
part
microcircuit, integrated circuit, semiconductor or discrete semiconductor for the purpose of this document

3.1.8
customer
user
designer
original equipment manufacturer (OEM) that procures integrated circuits or semiconductor devices, or both, compliant with this document and uses them to design, produce, and maintain systems

3.1.9
customer community
body of customers that ~~may~~ act together to address issues related to this document

3.1.10
data sheet
document prepared by the manufacturer that describes the electrical, mechanical, and environmental characteristics of the component

3.1.11
enhanced
increased or improved, usually applied to a property or a characteristic value or a quality level or a performance level of an item

Note 1 to entry: In the field of electronic components, enhanced properties for example result in additional requirements which raise the long-term reliability of the item for an ADHP environment.

Note 2 to entry: An enhanced electronic component is a suitable candidate for becoming an AQEC component.

3.1.12
erratum
error or fault

Note 1 to entry: The plural of erratum is errata.

Note 2 to entry: An errata list is a compilation of errors or faults with their corrections and changes.

3.1.13
manufacturer
plan owner
producer of integrated circuits, microcircuits, or other semiconductor devices that ~~may~~ can be designated AQEC

Note 1 to entry: A manufacturer ~~may~~ can produce the components directly or ~~may~~ can oversee subcontracted manufacturing according to their own processes. The manufacturer is also the plan owner.

3.1.14
supplier
distributor of components

Note 1 to entry: A plan for controlling AQEC inventory is in place in order to supply AQECs. A manufacturer can be a supplier in the case where no distributor is involved.

3.1.15
third party
party designated to act on the behalf of the customer community

3.1.16
termination
element of a component that connects it electrically and mechanically to the next level of assembly

Note 1 to entry: A termination includes base materials and coatings (including underplates).

3.1.17
form
shape, size, arrangement of parts, visible aspect, mode in which a part exists or manifests itself, or the material an item is constructed from

3.1.18
fit
qualified and competent

3.1.19
function
work to a specification that an item is designed for without degrading reliability

3.2 Abbreviated terms

ADHP	Aerospace, defence and high performance
AOQL	Average outgoing quality limit
AQEC	Aerospace qualified electronic component
BAG	Bandwidth allocation gap
Bi-CMOS	Bipolar CMOS
BOM	Bill of material
BPSG	Borophosphosilicate glass
~~COTS~~	~~Commercial off the shelf~~
CECC	CENELEC Electronics Component Committee
CMOS	Complementary metal oxide semiconductor
COTS	Commercial off the shelf
DDR	Double data rate
DFMEA	Design failure mode and effects analysis
DLA	Defence logistics agency (USA agency)
DPM	Defects per million
DRAM	Dynamic random access memory
~~DSCC~~	~~Defence supply centre Columbus (see http://www.dscc.dla.mil/)~~
DR&R	Design review and report

DSIAC	Defense systems information analysis center
DVP&R	Design verification plan and report
ECMP	Electronic component management plan
FFF	Form, fit and function
FIT	Failures in time
FMEA	Failure mode and effects analysis which for purposes of this specification includes DFMEA and PFMEA
FPGA	Field programmable gate array
GIDEP	Government industry data exchange program
HAST	Highly accelerated stress test
HCI	Hot carrier injection
HTOL	High temperature operating life
IP	Intellectual property
JAN	Joint army navy
LED	Light emitting diode
LTB	Last time buy
MCU	Multiple cell upset
MRAM	Magnetoresistive random access memory
MSA	Measurement systems analysis
NAND	Negation AND
NBTI	Negative bias temperature Instability
NOR	Negation OR
PFMEA	Process failure mode and effects analysis
PPAP	Production part approval process
PBTI	Positive bias temperature instability
PCN	Product change notification
RoHS	Restriction of hazardous substances in electrical and electronics equipment
SAE	Society of automotive engineers
SDRAM	Synchronous dynamic random access memory
SEE	Single event effect
SEU	Single event upset
SER	Soft error rate
SEL	Single event latch
SEFI	Single event functional interrupt
SPC	Statistical process control
SRAM	Static random access memory
SOS	Silicon on sapphire
TDDB	Time dependant dielectric breakdown
THB	Temperature humidity bias
VID	Vendor item drawing (controlled and released by ~~DSCC~~ DLA)

4 Technical requirements

4.1 AQEC plan

The processes used to ensure compliance with the following requirements shall be documented by the AQEC manufacturer and included in their AQEC plan. These requirements identify the additional processes, documentation and procedures required to supply a manufacturer's COTS part as an AQEC. Components classified by original component manufacturers (OCMs) as being 'enhanced' components only become AQEC components when they meet the requirements of this document. AQEC components can assist, with the physical hardware data, the aerospace certification process which involves complex components. The plan includes, but is not limited to, identifying data sheet parameters ~~and/~~or conditions that are different for the AQEC versus the COTS part. These differences shall be identified and the data made available upon request.

4.2 AQEC documentation

4.2.1 General

For an ~~avionics~~ ADHP customer, the information supplied by the AQEC manufacturer will be normally utilised and retained in accordance with the customer electronic component management plan (see IEC ~~TS~~ 62239-1).

4.2.2 AQEC data sheet

The AQEC manufacturer shall provide and maintain under revision control a data sheet that includes operating characteristics, as well as physical characteristics. Any known environmental limitations applicable to the application being addressed (see 4.3.1.2) shall be identified. This documentation shall specify the form, fit and function for a given part number. This baseline shall not be changed without proper notification (see 4.7). Use of a unique published or posted AQEC data sheet is encouraged. As a minimum, the AQEC manufacturer shall document, individually or by family,

a) the functional operating temperature range;

b) the defined performance (mechanical and electrical) at the operating temperature range;

c) the maximum storage temperature;

d) the maximum operating junction temperature or operating case temperature;

e) the defined lead material, underplate, and termination finish;

f) a package outline drawing;

g) the designation of applicable COTS data sheet (or AQEC unique data sheet, as applicable) and reference to additional data, if applicable.

NOTE 1 For further guidance, see Annex B.

NOTE 2 A DLA VID drawing typically designated as part of V6/XXXXXX series can satisfy the AQEC data sheet requirement.

4.2.3 Errata list

If errors or faults have been identified and corrected at the electronic component level, including for example the component design and manufacturing or the associated documentation, an errata list shall be made available and clearly identify:

– the data sheet revision or user handbook that it is being collected against;

– the date of publication;

– the component part numbers or families that it impacts.

4.2.4 Material content

For each AQEC covered by this document, the manufacturer shall make available, upon request, information that describes the material content of the part. Annex A describes typical material content for an AQEC. Materials that are considered proprietary by the AQEC manufacturer and are not designated hazardous, ~~may~~ can be excluded from public disclosure.

4.2.5 AQEC visibility

Each data sheet shall either state that the parts meet AQEC requirements (preferred) or optionally, the component manufacturer ~~may~~ can list on its website all the part numbers that are AQEC or include an AQEC reference in a description of another compliant class of parts.

4.2.6 AQEC life expectancy

The AQEC manufacturer shall identify the limiting wear-out failure mechanisms for a given AQEC in a given application environment (see 4.3.1.2) for ~~highly~~ complex silicon based technology components of feature size 90 nm and below including SRAMs, DRAMs (SDRAMSs, DDR series), flash memories (NOR logic gate, NAND logic gate, MRAMS, microprocessors, FPGAs). The AQEC manufacturer shall use acceleration models and failure rate estimating and reporting methods vetted through peer reviewed publications or described in industry standards and publications. This information shall be available on a website, data sheet, alternative database, or provided on an as requested basis.

NOTE 1 Examples of die related reliability wear-out failure mechanisms include electromigration, gate oxide breakdown (TDDB), positive (PBTI) and negative bias temperature instability (NBTI), hot carrier injection (HCI), etc.

NOTE 2 Examples of package reliability wear-out include mechanisms such as delamination, wire bond inter-metallic formation, etc.

NOTE 3 Industry standards and publications which can assist include: IEC TR 62240-2, SAE ARP 6338, SAE J1879, JESD94, JEP122, JP001, JESD47, JESD91, DSIAC (formerly RIAC) publication ("Physics of failure based handbook of microelectronics systems").

The AQEC manufacturer should have reliability models for the lifetime limiting wear-out failure modes that can predict the failure rate of that AQEC for a given end of lifetime frame and use environment.

4.2.7 Device technology

Different technologies (for example bipolar and bi-CMOS; bulk CMOS and CMOS/SOS) shall not be furnished under the same part number.

4.2.8 SEE data

Avionics equipment is subjected to ionising radiation that increases with altitude. At an altitude of 40 000 feet (12,2 km) the radiation flux is approximately 300 times the atmospheric radiation flux at sea level. The principal causes of atmospheric radiation single event effects (SEEs) on devices with geometric feature sizes below a micron are high energy neutrons and thermal neutrons (see IEC 62396-1).

The following information is required, where available, as part of the AQEC data or upon request, for designers to assess the impact of component SEE when using small geometric feature size devices, typically below 1 µm.

a) High energy neutron (> 10 MeV) measured single event upset (SEU) cross section or the terrestrially measured soft error rate (SER).

b) High energy neutron (> 10 MeV) or terrestrially measured multiple cell upset (MCU) cross section.

c) For memory devices, the way in which the bits in an individual word are stored within the device, i.e. contiguously or non-contiguously.

d) The cross sections of any hard SEE, for example single event latch (SEL), single event functional interrupt (SEFI) or stuck bits.

e) Thermal neutron sensitivity and the thermal neutron SEE cross sections. Where the manufacturer uses Borophosphosilicate glass (BPSG) as a passivation and it contains boron 10 or natural boron (20 % boron 10), this is to be declared.

4.2.9 Termination finish

Only one type of termination finish ~~may~~ should be furnished on an individual part number supplied as part of the AQEC program. As a minimum, a change to a different single lead finish or ball alloy requires a PCN that includes the date and lot code of implementation. A new assigned part number is preferred.

4.2.10 Third party part numbers

Where applicable, the data sheet shall state the third party part number (for example ~~DSCC~~ DLA VID) for the AQEC manufacturer's part number (preferred). Optionally, the AQEC manufacturer ~~may~~ should list this data on their website or provide a link to the third party information.

4.2.11 ADHP PPAP

The use of the ADHP PPAP is optional but highly recommended. The manufacturer should consider making a version of the automotive PPAP process available for ADHP users, which contains the data in 4.2 and Annex B.

A typical template for this ADHP version of a PPAP is included in Annex C.

4.2.12 Typical physical hardware data related to complex electronic components process

Complex electronic components such as ASICs, microprocessors, microcontrollers, complex interface microcircuits, FPGAs and large memories are typically involved in the aerospace certification process. Additional data explaining how the functionality of these AQEC or component family operates should be made available on request, see Annex D, to assist the certification process.

4.3 AQEC performance

4.3.1 Performance

4.3.1.1 General

The manufacturer shall have documented processes to identify and verify the performance of the given AQEC or component family in all environmental conditions identified in the manufacturer's published data sheet.

4.3.1.2 Additional performance information

The environmental conditions encountered in commercial and military aircraft are sometimes outside the conditions typically addressed by the semiconductor industry. At the same time, the functional requirements of the applications mandate that increasingly high functional performance components be compatible with the application.

NOTE Experience has shown that the part manufacturer often has sufficient information to determine if a specific part being considered for an application has sufficient margin to operate successfully in a proposed application with defined environment and reliability criteria.

~~To minimize the disruption to the manufacturer by continual requests for information, the AQEC program has defined specific multiple operating environments to group AQEC applications into.~~

~~If a specific application does not comply with one of these categories, additional manufacturer information is recommended.~~

~~Environment 1:~~

~~Temperature range: –40 °C to +85 °C case/ambient;~~

~~Failure rate versus time at temperature: 23 °C and 85 °C;~~

~~Atmospheric neutron SEE upset rate: upset rate and basis of information, see 4.2.7;~~

~~Wear-out life expectancy: 23 °C and 85 °C, conditions for which wear-out expectancy is calculated.~~

~~Environment 2:~~

~~Temperature range: –40 °C to +100 °C case/ambient;~~

~~Failure rate versus time at temperature: 23 °C and 100 °C;~~

~~Atmospheric neutron SEE upset rate: upset rate and basis of information, see 4.2.7;~~

~~Wear-out life expectancy: 23 °C and 100 °C, conditions for which wear-out expectancy is calculated.~~

~~Environment 3:~~

~~Temperature range: –55 °C to +125 °C case/ambient;~~

~~Failure rate versus time at temperature: 23 °C and 125 °C;~~

~~Atmospheric neutron SEE upset rate: upset rate and basis of information, see 4.2.7;~~

~~Wear-out life expectancy: 23 °C and 105 °C, conditions for which wear-out expectancy is calculated.~~

~~Environment 4:~~

~~Temperature range: –40 °C to +125 °C case/ambient;~~

~~Failure rate versus time at temperature: 23 °C and 125 °C;~~

~~Atmospheric neutron SEE upset rate: upset rate and basis of information, see 4.2.7;~~

~~Wear-out life expectancy: 23 °C and 125 °C, conditions for which wear-out expectancy is calculated.~~

To minimize the disruption to the parts manufacturer and to guide them to produce COTS parts appropriate for AQEC selection, and thereby minimize requests for information, this document defines specific multiple operating environments to category AQEC applications into, see Table 1. If a specific application does not comply with one of these categories, additional manufacturer information is recommended.