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INTERNATIONAL STANDARD

colour inside

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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IEC 62396-1 has been prepared by IEC technical committee 107: Process management for avionics.

IEC 62396-1 cancels and replaces IEC/TS 62396-1 published in 2006.

This International Standard includes the following technical changes with respect to the Technical Specification:

a) Guidance has been provided on the environment for altitudes above 60 000 feet (18,3 km) and the effects on electronics are documented in Annex E and F;

b) Annex G has been added to provide late news as of 2011 on SEE cross-sections applicable to the atmospheric neutron environment.

The text of this international standard is based on the following documents:

FDIS	Report on voting
107/176/FDIS	107/182/RVD

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

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

A list of all the parts in the IEC 62396 series, published under the general title *Process management for avionics – Atmospheric radiation effects*, 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 web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

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 industry-wide technical specification informs avionics systems designers, electronic equipment, component manufacturers and their customers of the kind of ionising radiation environment that their devices will be subjected to in aircraft, the potential effects this radiation environment can have on those devices, and some general approaches for dealing with these effects.

The same atmospheric radiation (neutrons and protons) that is responsible for the radiation exposure that crew and passengers acquire while flying is also responsible for causing the single event effects (SEE) in the avionics electronic equipment. There has been much work carried out over the last few years related to the radiation exposure of aircraft passengers and crew. A standardised industry approach on the effect of the atmospheric neutrons on electronics should be viewed as consistent with and an extension of the on-going activities related to the radiation exposure of aircraft passengers and crew.

Atmospheric radiation effects are one factor that could contribute to equipment hard and soft fault rates. From a system safety perspective, using derived fault rate values, the existing methodology described in ARP4754 (accommodation of hard and soft fault rates in general) will also accommodate atmospheric radiation effect rates.

In addition, this International Standard refers to the JEDEC Standard JESD89A, which relates to soft errors in electronics by atmospheric radiation at ground level (at altitudes less than 10 000 feet (3 040 m)).

PROCESS MANAGEMENT FOR AVIONICS – ATMOSPHERIC RADIATION EFFECTS –

Part 1: Accommodation of atmospheric radiation effects via single event effects within avionics electronic equipment

1 Scope

This part of IEC 62396 is intended to provide guidance on atmospheric radiation effects on avionics electronics used in aircraft operating at altitudes up to 60 000 feet (18,3 km). It defines the radiation environment, the effects of that environment on electronics and provides design considerations for the accommodation of those effects within avionics systems.

This International Standard is intended to help aerospace equipment manufacturers and designers to standardise their approach to single event effects in avionics by providing guidance, leading to a standard methodology.

Details of the radiation environment are provided together with identification of potential problems caused as a result of the atmospheric radiation received. Appropriate methods are given for quantifying single event effect (SEE) rates in electronic components. The overall system safety methodology should be expanded to accommodate the single event effects rates and to demonstrate the suitability of the electronics for the application at the component and system level.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC/TS 62239:2008, *Process management for avionics – Preparation of an electronic components management plan*

NOTE IEC/TS 62239-1, *Process management for avionics – Management plan – Part 1: Preparation and maintenance of an electronic components management plan* is under study and will supersede IEC/TS 62239.

IEC/TS 62396-2:2008, *Process management for avionics – Atmospheric radiation effects – Part 2: Guidelines for single event effects testing for avionics systems*

IEC/TS 62396-3, *Process management for avionics – Atmospheric radiation effects – Part 3: Optimising system design to accommodate the single event effects (SEE) of atmospheric radiation*

IEC/TS 62396-4:2008, *Process management for avionics – Atmospheric radiation effects – Part 4: Guidelines for designing with high voltage aircraft electronics and potential single event effects*

IEC/TS 62396-5, *Process management for avionics – Atmospheric radiation effects – Part 5: Guidelines for assessing thermal neutron fluxes and effects in avionics systems*

3 Terms and definitions

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

NOTE Users of this international standard may use alternative definitions consistent with convention within their companies.

3.1
aerospace recommended practice
documents relating to avionics which are published by the Society of Automotive Engineers (SAE)

3.2
analogue single event transient
ASET
spurious signal or voltage produced at the output of an analogue device by the deposition of charge by a single particle

3.3
availability
probability that a system is working at instant *t*, regardless of the number of times it may have previously failed and been repaired

Note 1 to entry: For equipment, the fraction of time the equipment is functional divided by the total time the equipment is expected to be operational, i.e. the time the equipment is functional plus any repair time.

3.4
avionics equipment environment
for aeronautical equipment, the applicable environmental conditions (as described per the equipment specification) that the equipment is able to withstand without loss or degradation in equipment performance during all of its manufacturing cycle and maintenance life

Note 1 to entry: The length of the maintenance life is defined by the equipment manufacturer in conjunction with customers.

3.5
capable
ability of a component to be used successfully in the intended application

3.6
certified
assessment and compliance to an applicable third party standard and maintenance of a certificate and registration (i.e. JAN, IECQ)

3.7
characterisation
process of testing a sample of components to determine the key electrical parameter values that can be expected of all produced components of the type tested

3.8
component application
process that assures that the component meets the design requirements of the equipment in which it is used

3.9
component manufacturer
organisation responsible for the component specification and its production

3.10
critical charge
smallest charge that will cause a SEE if injected or deposited in the sensitive volume

Note 1 to entry: For many devices, the unit applied was the picocoulomb (pC); however, for small geometry devices, this parameter is measured in femtocoulomb (fC).

3.11
cross-section
σ
in radiation terms for proton and neutron interactions, combination of sensitive area and probability of an interaction depositing the critical charge for a SEE

Note 1 to entry: The cross-section may be calculated using the following formula:
σ = number *of errors/particle fluence*

Note 2 to entry: The units for cross-section are cm^2 per device or per bit.

3.12
digital single event transient
DSET
spurious digital signal or voltage, induced by the deposition of charge by a single particle that can propagate through the circuit path during one clock cycle

Note 1 to entry: See 6.2.4 of this document.

3.13
electron
elementary particle having a mass of approximately 1/1 840 atomic mass units, and negative charge of $1{,}602 \times 10^{-19}$ C

3.14
electronic components management plan
ECMP
equipment manufacturer's document that defines the processes and practices for applying components to an equipment or range of equipment

Note 1 to entry: Generally, it addresses all relevant aspects of controlling components during system design, development, production, and post-production support.

3.15
electronic components
electrical or electronic devices that are not subject to disassembly without destruction or impairment of design use

Note 1 to entry: They are sometimes called electronic parts, or piece parts.

EXAMPLE Resistors, capacitors, diodes, integrated circuits, hybrids, application specific integrated circuits, wound components and relays.

3.16
electronic equipment
item produced by the equipment manufacturer, which incorporates electronic components

EXAMPLE End items, sub-assemblies, line-replaceable units and shop-replaceable units.

3.17
electronic flight instrumentation system
EFIS
example of an avionics electronic system requiring system development assurance level A type II and for which the pilot will be within the loop through pilot/system information exchange

3.18
expert
person who has demonstrated competence to apply knowledge and skill to the specific subject

3.19
firm fault
term used at the aircraft function level. It is a failure that cannot be reset other than by rebooting the system or by cycling the power to the relevant functional element

Note 1 to entry: Such a fault could impact the value for the MTBF of the LRU and provide no fault found during subsequent test.

3.20
fly by wire
FBW
example of avionics electronic system requiring system development assurance level A type I and for which the pilot will not be within the aircraft stability control loop

3.21
functional hazard analysis
FHA
assessment of all hazards against a set of defined hazard classes

3.22
giga electron volt
GeV
radiation particle energy giga electron volts (thousand million electron volts)

Note 1 to entry: The SI equivalent energy is 160,2 picojoules.

3.23
gray
Gy
SI unit of ionising radiation dose and the energy deposited as ionization and excitation (J) per unit mass (kg)

Note 1 to entry: Related units are centigray (cGy) and rad. 1 cGy is equal to 1 rad.

3.24
hard error
permanent or semi-permanent damage of a cell by atmospheric radiation that is not recoverable even by cycling the power off and on

3.25
hard fault
term used at the aircraft function level which refers to the permanent failure of a component within an LRU

Note 1 to entry: A hard fault results in the removal of the LRU affected and the replacement of the permanently damaged component before a system/system architecture can be restored to full functionality. Such a fault could impact the value for the MTBF of the LRU repaired.

3.26
heavy ions
positively charged nuclei of the elements heavier than hydrogen and helium

3.27
in-the-loop
test methodology where an LRU is placed within a radiation beam that provides a simulation of the atmospheric neutron environment and where the inputs to the LRU would be from an electronic fixture external to the beam to enable a closed loop system

Note 1 to entry: The electronic fixture would contain a host computer for the aircraft simulation model. The electronic fixture would also contain appropriate signal conditioning for compatibility with the LRU. In the case of an automatic control function, the outputs from the LRU could be, in turn, sent to an actuation means or directly to the host computer. The host computer would automatically close a stability loop (as in the case of a fly-by-wire control system). In the case of a navigation function, the outputs from the LRU could be sent to a display system where the pilot could then close the navigation loop.

3.28
integrated modular avionics
IMA
implementation of aircraft functions in a multitask computing environment where the computations for each specific system implementing a particular function are confined to a partition that is executed by a common computing resource (a single digital electronic circuit)

3.29
latch-up
triggering of a parasitic pnpn circuit in bulk CMOS, resulting in a state where the parasitic latched current exceeds the holding current. This state is maintained while power is applied

3.30
linear energy transfer
LET
energy deposited per unit path length in a semiconductor along the path of the radiation

Note 1 to entry: The units applicable are MeV·cm^2/mg.

3.31
linear energy transfer threshold
LETth
for a given component, the minimum LET to cause an effect at a particle fluence of 1×10^7 ions/cm^2

3.32
line replaceable unit
LRU
piece of avionics electronic equipment that may be replaced during the maintenance cycle of the system

3.33
mega electron volt
MeV
radiation particle energy mega electron volts (million electron volts)

Note 1 to entry: The SI equivalent energy is 160,2 femtojoule.

3.34
mean time between failure
MTBF
measure of reliability requirements and is the mean time between failure of equipment or a system in service

3.35
mean time between unscheduled removals
MTBUR
measure of reliability requirements and is the mean time between unscheduled removal of equipment or a system in service

3.36
multiple bit upset
MBU
the energy deposited in the silicon of an electronic component by a single ionising particle causes upset to more than one bit in the same word

Note 1 to entry: The definition of MBU has been updated due to the introduction of the definition of MCU.

3.37
multiple cell upset
MCU
the energy deposited in the silicon of an electronic component by a single ionising particle induces several bits in an integrated circuit (IC) to upset at one time

3.38
neutron
elementary particle with atomic mass number of one and which carries no charge

Note 1 to entry: It is a constituent of every atomic nucleus except hydrogen.

3.39
particle fluence
for a unidirectional beam of particles, this is the number of particles crossing unit surface area at right angles to the beam

Note 1 to entry: For isotropic flux, this is the number entering sphere of unit cross-sectional area.

Note 2 to entry: The units applicable are particles/cm^2.

3.40
particle flux
fluence rate per unit time

Note 1 to entry: The units applicable are particles/$cm^2 \cdot s$.

3.41
pion or pi-meson
sub-atomic particle

Note 1 to entry: The charge possibilities are (+1, –1, 0) and they are produced by energetic nuclear interactions.

3.42
preliminary system safety assessment
PSSA
systematic evaluation of a proposed system architecture and implementation based on the Functional Hazard Assessment and failure condition classification to determine safety

Note 1 to entry: See section 2.2 ARP4761 [118].

3.43
proton
elementary particle with atomic mass number of one and positive electric charge and which is a constituent of all atomic nuclei