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Process management for avionics — Atmospheric radiation effects

Part 5: Assessment of thermal neutron fluxes and single event effects in avionics systems

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee GEL/107, Process management for avionics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2014

ISBN 978 0 580 84550 5
ICS 03.100.50; 31.020; 49.060

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2014.

Amendments/corrigenda issued since publication

Date	Text affected

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IEC 62396-5

Edition 1.0 2014-08

INTERNATIONAL STANDARD

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Process management for avionics – Atmospheric radiation effects – Part 5: Assessment of thermal neutron fluxes and single event effects in avionics systems

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE S

ICS 03.100.50; 31.020; 49.060

ISBN 978-2-8322-1821-1

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PROCESS MANAGEMENT FOR AVIONICS – ATMOSPHERIC RADIATION EFFECTS –

Part 5: Assessment of thermal neutron fluxes and single event effects in avionics systems

FOREWORD

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International Standard IEC 62396-5 has been prepared by IEC technical committee 107: Process management for avionics.

This first edition cancels and replaces the first edition of IEC/TS 62396-5 published in 2008. This edition constitutes a technical revision.

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

a) Change to title.
b) Updated references and bibliography.
c) Subclause 6.2 expanded to consider smaller geometry devices.

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d) Table 4 neutron cross-sections expanded to add more recent data and the ratio between thermal and high energy neutron cross-section amended to 2,42 from 2,77.

e) Addition of reference section on thermal neutron high voltage burn out.

f) New clause on determination of thermal neutron SEE rates for use in equipment assessments.

g) Document aligned as an IEC standard.

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

FDIS	Report on voting
107/237/FDIS	107/242/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.

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PROCESS MANAGEMENT FOR AVIONICS – ATMOSPHERIC RADIATION EFFECTS –

Part 5: Assessment of thermal neutron fluxes and single event effects in avionics systems

1 Scope

The purpose of this part of IEC 62396 is to provide a more precise definition of the threat that thermal neutrons pose to avionics as a second mechanism for inducing single event upset (SEU) in microelectronics. There are two main points that will be addressed in this part of IEC 62396:

a) a detailed evaluation of the existing literature on measurements of the thermal flux inside of airliners, and

b) an enhanced compilation of the thermal neutron SEU cross-section in currently available SRAM devices (more than 20 different devices).

The net result of the reviews of these two different sets of data will be two ratios that are considered to be very important for leading to the ultimate objective of how large a threat is the SEU rate from thermal neutrons compared to the SEU threat from the high energy neutrons (E >10 MeV). The threat from the high energy neutrons has been dealt with extensively in the literature and has been addressed by two standards (IEC 62396-1 in avionics and JESD89A [1][1] in microelectronics on the ground). Neutrons with E > 1 MeV are considered for parts with geometries below 150 nm.

NOTE Reference is made to IEC 62396-1:2012, 5.3.2, for smaller geometry parts below 150 nm which provides the neutron flux for energies above 1 MeV.

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 62396-1:2012, *Process management for avionics – Atmospheric radiation effects – Part 1: Accommodation of atmospheric radiation effects via single event effects within avionics electronic equipment*

IEC 62396-4, *Process management for avionics – Atmospheric radiation effects – Part 4: Design of high voltage aircraft electronics managing potential single event effects*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62396-1 apply.

4 Overview of thermal neutron single event rate calculation

The two ratios that this part of IEC 62396 considers to be important are:

[1] Numbers in square brackets refer to the Bibliography.

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a) the ratio of the thermal neutron flux inside an airliner relative to the flux of high energy (> 10 MeV) neutrons inside the airliner, and

b) the ratio of the SEU cross-section due to thermal neutrons relative to that due to high energy neutrons.

These ratios are considered to be important because with them, once the SEU rates are defined from the high energy neutrons for an avionics box, a topic which has been dealt with extensively, such as in IEC 62396-1 and [1], then the additional SEU rate due to thermal neutrons can be obtained with these ratios. Thus, given the SEU rate from high energy neutrons, multiplying this by the two ratios gives the SEU rate from the thermal neutrons. The total SEU rate will be the combination of the SEU rates from both the high energy and thermal neutrons.

The process for calculating the SEU rate from the thermal neutrons is shown in the following set of equations, (1) to (5).

SEU rate (Hi E[2], upset/dev·h) $= \Phi_{\text{Hi}}$ (neutron flux = 6 000 n/cm^{2}h) × σ(Hi E, SEU X-Sctn. cm^2/dev) (1)

SEU rate (thermal neutron, upset/dev·h)

$$= \text{SEU rate (Hi E)} \times \frac{\Phi_{\text{therm}}(\text{neutron flux})}{\Phi_{\text{Hi}}(\text{neutron flux})} \times \frac{\sigma(\text{therm SEU X - Sctn.})}{\sigma(\text{Hi E SEU X - Sctn.})} \quad (2)$$

Ratio-1

$$= \frac{\Phi_{\text{thermal}}(\text{neutron flux})}{\Phi_{\text{Hi}}(\text{neutron flux})} \quad (3)$$

Ratio-2

$$= \frac{\sigma(\text{therm SEU X - Sctn.})}{\sigma(\text{Hi E SEU X - Sctn.})} \quad (4)$$

SEU rate (thermal neutron, upset/dev·h) SEU rate (Hi E neutron upset/dev·h) × Ratio-1 × Ratio-2 (5)

The objective of this part of IEC 62396 is to provide the values of Ratio-1, the ratio of the thermal to high energy neutron flux within an airplane, and of Ratio-2, the ratio of the SEU cross-section due to thermal neutrons relative to that due to high energy neutrons. The Ratio-1 should be relatively similar in various types of commercial airliners, but it could vary significantly in other types of aircraft, such as military fighters. However, in the larger type of military aircraft, such as AWACS (Advanced Warning and Command System, E-3, which is based on either a Boeing 707-320-B or 767) and JSTARS (Joint Surveillance Target Attack Radar System, E-8C, which is based on Boeing 707-300 airframe), the ratio should be very similar to that in airliners.

With regard to the ratio of the thermal neutron SEU cross-sections, until recently, not very many such SEU cross-sections were reported in the literature. There were a few, and these were cited in [1]. Due to the data that has recently become available, the number of devices in which the thermal neutron SEU cross-section has been measured has increased significantly. This additional data allows us to have good confidence on the values that have been measured and the resulting average value of the ratio.

[2] Hi E = High Energy.

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