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Space systems — Space solar cells — Electron and proton irradiation test methods

Systèmes spatiaux — Cellules solaires spatiales — Méthodes d'essai d'irradiation d'électrons et de protons

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Foreword

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This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

This second edition cancels and replaces the first edition (ISO 23038:2006), which has been technically revised. The main changes compared to the previous edition are as follows:

— radiation environment models were updated from AE8/AP8 to AE9/AP9;

— threshold energies for atomic displacement for silicon and GaAs were deleted;

— a statement was added that, whatever the method, the duration or intensity level of the electron and proton irradiation test is considered a “destructive test”.

Space systems — Space solar cells — Electron and proton irradiation test methods

1 Scope

This document specifies the requirements for electron and proton irradiation test methods of space solar cells. It addresses only test methods for performing electron and proton irradiation of space solar cells and not the method for data analysis.

2 Normative references

There are no normative references in this document.

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

NOTE Physical constants are given to four significant figures only and reflect current knowledge.

3.1
differential energy spectrum
spread of energies of some specific group

Note 1 to entry: In this document, this refers to the number of particles possessing an energy value that lies in the infinitesimal range E, $E + \mathrm{d}E$ divided by the size of the range ($\mathrm{d}E$). Integration of the differential particle spectrum over all particle energies yields the total number of particles. This quantity is given in units of particles per unit area per unit energy.

3.2
electron
e^-
elementary particle of rest mass m = 9,109 kg × 10^{-31} kg, having a negative charge of 1,602 C × 10^{-19} C

3.3
flux
number of particles passing through a given area in a specified time

Note 1 to entry: Flux may also be specified in terms of the number of particles per unit time passing through a unit area from source directions occupying a unit solid angle. Typical units are particles per cm^2 per second per steradian (sr) (1 sr is the solid angle subtended at the centre of a unit sphere by a unit area of the surface of the sphere).

3.4
fluence
total number of particles in any given time period given in units of particles per unit area

Note 1 to entry: Fluence is also known as time-integrated flux.

3.5
integral energy spectrum
total number of particles in a specified group that possess energies greater than, or equal to, a specified value, given in units of particles per unit area

3.6
irradiation
exposure of a substance to energetic particles that penetrate the material and have the potential to transfer energy to the material

3.7
omnidirectional flux
number of particles of a particular type which have an isotropic distribution over 4π steradians and that would traverse a test sphere of 1 cm^2 cross-sectional area in 1 s

Note 1 to entry: Expressed in units of particles per cm^2 per second.

3.8
proton
p^+
positively charged particle of mass number one, having a mass of 1,672 kg × 10^{-27} kg and a charge equal in magnitude but of opposite sign to the electron

Note 1 to entry: A proton is the nucleus of a hydrogen atom.

4 Symbols and abbreviated terms

eV electronvolt

NIEL nonionizing energy loss

NOTE 1 eV, is a unit of energy commonly used for ions, electrons, elementary particles, etc. (1 eV ≈ 1,602 J × 10^{-19} J.)

NOTE 2 The rate at which the incident particle transfers energy to the crystal lattice through nonionizing events is referred to as the nonionizing energy loss (NIEL), typical unit is MeV · cm^2 · g^{-1}.

5 Space radiation environments

5.1 Space radiation

Primarily, electrons and protons with a wide range of energies characterize the space radiation environment (see References [1] and [2]). Gamma rays can be used as a substitute for electron irradiation with the proper transformation. Some reasonable electron and proton fluence limits usually attained in typical earth orbit conditions are given below. For 1 MeV electrons and 10 MeV protons, these typical but not inclusive fluence limits are 10^{15} and 10^{13} particles per cm^2, respectively. Alpha particles and other charged particles are usually of negligible quantity as far as solar cell damage is concerned. The particles come from the solar wind and are trapped by Earth's magnetic field to form radiation belts with widely varying intensities. Solar wind is usually associated with particles of low energy (typically below 100 keV), while particles of concern for solar cells are generally of higher energies. The inner portion of the belts consists mainly of protons and of an inner electron belt, while the outer portion consists primarily of electrons. Outside of these radiation belts, there is a likelihood of sudden bursts of protons and electrons originating from coronal mass ejections from the Sun, referred to generally as solar flares. Thus, the differential spectrum of electrons and protons for any given mission is dependent on the specific mission orbit. Due to the large variability of the involved phenomena, the prediction of the particle spectrum for a given mission is affected by a significant uncertainty. Widely accepted tools for its calculation include the AP9 (protons) and AE9 (electrons) codes for the trapped particles, while the solar proton events are modelled with other tools such as the JPL 91 code. Note that there is also

