
Space environment (natural and artificial) — Plasma environments for generation of worst case electrical potential differences for spacecraft

Environnement spatial (naturel et artificiel) — Environnements plasmatiques pour la génération de différences de potentiel électrique les plus défavorables pour les véhicules spatiaux





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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*.

Space environment (natural and artificial) — Plasma environments for generation of worst case electrical potential differences for spacecraft

1 Scope

This document specifies space plasma environments that lead to the generation of the worst-case surface potential differences for spacecraft. It also specifies how to estimate worst-case potential differences by using the simulation codes provided.

This document includes plasma energy and density in GEO, PEO, and MEO. This document does not include descriptions of plasma energy and density in LEO because large surface charging in LEO is likely to be due to high-voltage power generation by instrumentation of the spacecraft.

This document deals with external surface charging of spacecraft only.

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>

3.1

double Maxwellian distribution

electron and proton distribution functions in GEO fitted with two temperatures

Note 1 to entry: Maxwellian distribution is as follows^[12]:

$$f(v) = \left(\frac{m}{2\pi}\right)^{3/2} \left[\frac{n_1}{(kT_1)^{3/2}} \exp\left(-\frac{mv^2}{2kT_1}\right) + \frac{n_2}{(kT_2)^{3/2}} \exp\left(-\frac{mv^2}{2kT_2}\right) \right]$$

where

- m is the mass of particle;
- k is the Boltzmann constant $1,380\,648\,52 \times 10^{-23}$ J/K;
- n_1, n_2 are the number density of particle;
- T_1, T_2 are the temperature of particle.

3.2

differential voltage

differential potential

potential difference between any two points in spacecraft, especially the insulator surface and the spacecraft body, during differential charging

3.3

inverted potential gradient

result of differential charging where the insulating surface or dielectric reaches a positive potential with respect to the neighbouring conducting surface or metal: PDNM (positive dielectric negative metal)

3.4

normal potential gradient

result of differential charging where the insulating surface or dielectric reaches a negative potential with respect to the neighbouring conducting surface or metal: NDPM (negative dielectric positive metal)

3.5

surface charging

deposition onto or the removal of electrical charges from external surfaces of the spacecraft

4 Symbols and abbreviated terms

eV	electron volt, where $1 \text{ eV} = 1,602 \times 10^{-19} \text{ J}$
GEO	geosynchronous orbit
LEO	low Earth orbit
MEO	medium Earth orbit
PEO	polar Earth orbit
N_e	electron density
N_i	ion density
T_e	electron temperature
T_i	ion temperature

5 Criteria for worst-case environment

The worst-case environment shall be defined as the space environment measured in space that causes the maximum potential difference between the spacecraft electrical grounding body and external non-conductive surfaces or isolated conductive surfaces. Worst-case conditions shall be realistic.

Combinations of densities and temperatures for a valid worst-case condition shall be subject to all of the following:

- reported in the literature or published databases;
- checked to make sure they are based on valid measurements;
- physically realistic (i.e. do not violate energy density or other physical requirements); and
- verified using good spacecraft charging codes (i.e. COULOMB-2, MUSCAT, SPIS, NASCAP-2k).

This document is a part of spacecraft charging design.

6 Procedures for application to spacecraft design

Spacecraft charging simulation should be carried out at an early stage of spacecraft design. Ideally, this should be before selecting the materials for those spacecraft surfaces that will be exposed to the space environment.