PREFERRED
RELIABILITY
PRACTICES

DESIGN PRACTICE TO CONTROL INTERFERENCE FROM ELECTROSTATIC DISCHARGE (ESD)

Practice:

Minimize the adverse effects of electrostatic discharge (ESD) on spacecraft by implementing the following three design practices:

1. Make all external surfaces of the spacecraft electrically conductive and grounded to the main structure.

2. Provide all internal metallic elements and other conductive elements with an "ESD conductive" path to the main structure.

3. Enclose all sensitive circuitry in an electrically conductive enclosure-- a "Faraday cage".

Benefit:

The first two practices should dissipate most electric charges before a difference in potential can become high enough to cause an ESD. If a discharge occurs, the third practice lowers the coupling to sensitive circuits, reducing the probability or severity of the interference.

Programs That Certified Usage:

Voyager, Magellan, Galileo, and Ocean Topographic Experiment (TOPEX).

Center to Contact for Information:

Jet Propulsion Laboratory (JPL)

Implementation Method:

All external dielectric surfaces such as windows, radomes and solar panels are coated to make them slightly conductive without destroying their transparency to optical/IR/RF radiation. Cost and performance trade-offs must be made in order to select suitable materials for each application. The conductive layer should be less than 10^9 ohms per square and connected to structural ground.

All internal metallic elements, greater than 3 cm^2 in area or 25 cm in length, including unused wires in cables, connectors, circuit board traces, spot shields, and other conductive elements, have a conductive path to ground with a resistance less than 100 MΩ. Small metallic objects (< 3 cm^2) may be ungrounded if grounding is not practical.

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Each metallic layer of thermal blankets is grounded to the main structure.

All external metallic components are electrically connected to the common ground of the main structure.

All electronics are enclosed in a Faraday cage shielded enclosure. External cabling outside of the Faraday cage are shielded by means of overshields with 360 degree backshells at the Faraday cage entry. Sensitive circuits should use independent, balanced wiring with each lead and its return twisted together.

Filter all circuits coming into the Faraday cage; low-pass filters and transient suppressors are typical, but digital logic discriminators have also been used. Avoid the possibility of high differential voltages between components by connecting all conductive materials to a common ground.

In the case of large structures, such as Space Station, surface charging can be controlled by use of an external ionizing plasma source.

Since it is impractical to duplicate the space plasma environment, testing for ESD resorts to resistance measurement on one hand and circuit immunity to artificial discharges on the other hand. The requirements for each of these conditions depend on the spacecraft charging conditions anticipated for the particular orbit that the spacecraft will occupy.

Technical Rationale:

All spacecraft designers must consider space charging in the spacecraft design. Space charging arises when materials are immersed in an energetic space plasma. Different materials with different surface resistivities produce voltage gradients which can build up until the voltage breakdown limit is exceeded. When this occurs, a discharge is produced which causes transients in electrical circuitry and degradation or redeposition of material.

Impact of Non-Practice:

ESD events can cause transient voltage spikes on sensitive circuits which can corrupt data, produce false commands, or cause system failure. Degradation of surface material can result from arcing or redeposition of material on other surfaces if precautions are not observed.

Related Practices:

1. *Surface Charging / ESD Analysis*, Practice No. PD-AP-1301

2. *Thick Dielectric Charging / Internal Electrostatic Discharge (IESD)* (Draft), Guideline No. (to be assigned)

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References:

1. Purvis, C., Garrett, H., Whittlesey, A., Stevens, N. (1984), "Design Guidelines for Assessing and Controlling Spacecraft Charging Effects," NASA Technical Paper 2361. (This paper has an extensive bibliography.)