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**Title**

# ESD sensitivity analysis of thermites for satellite demise


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## Abstract

Within the ESA design-for-demise guidelines, one aspect under current investigation consists of the introduction of localized exothermic reactions in satellites during the reentry. Few papers and patents have already considered the use of thermites for this scope. Among few others, the SPADEXO project represents an example of running activity.
A thermite is a pyrotechnic material made by a powder mixture of a metal-oxide and a metal performing an oxygen exchange with strong enthalpy release. Composition and material features drive both the energy budget of the reaction and its reactivity. A typical example is characterized by a micrometric mixture of iron oxide and aluminum which turn into aluminum oxide and metallic iron after their reaction. The reaction is possible only when the Gibbs free energy spontaneity criterion is verified.
The use of some classes of thermites in satellite demise can be of interest because of their relatively high ignition temperature, when compared to other pyrotechnics. If properly formulated, this energetic material can result insensitive to the thermal environment during satellite lifetime, while the exothermic reaction may be triggered by the natural satellite heating, during the reentry maneuver. If the efficacy is proven, this technique may give a new perspective to on-ground casualty risk management for massive object reentry.
Electrostatic discharges (ESD) represent one of the most important hazards when handling pyrotechnics. Accumulation of charges may occur in machines, operators, and material itself. When a discharge occurs, the generation of a spark may ignite a flammable material and, therefore, it is crucial to grant an adequate dispersion of charges to avoid potential accidents. For this reason, it is important to acquire the knowledge about the response of the material to different stimulus levels, thus obtaining fundamental parameters like the minimum ignition energy (MIE) or the 50 % probability of reaction (E50).
The ESD sensitivity can be characterized with multiple methodologies, models, and experimental procedures. In one of the simplest embodiments, the apparatus is made by a high voltage circuit and a pin electrode which touches the material, transferring the charge. The operator records the occurrence of an ignition event and builds up progressively the knowledge on either the MIE or the E50, following specific protocols (e.g. fixed-sample designs, Up-and-Down designs). The value obtained depends on several factors including material type, size, and compaction level [1].
The present paper discusses about thermites in light of their ESD sensitivity hazard. The paper describes the procedure under implementation at the Space Propulsion Laboratory of Politecnico di Milano for the description of thermite ESD

safety levels. A high-voltage system is analyzed, and its design is discussed, based on uncertainty. Moreover, a statistical method used to produce the cumulative ignition curves is also presented and critically analyzed using data stemming from the analysis of some activated thermites.

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## References

[1] Weir C. et al. Electrostatic discharge sensitivity and electrical conductivity of composite energetic materials Journal of Electrostatics. 2013;71: 77-83.