Aluminum Cratering Relations for In-Situ Detection of Micrometeoroid and Orbital Debris Particle Diameters

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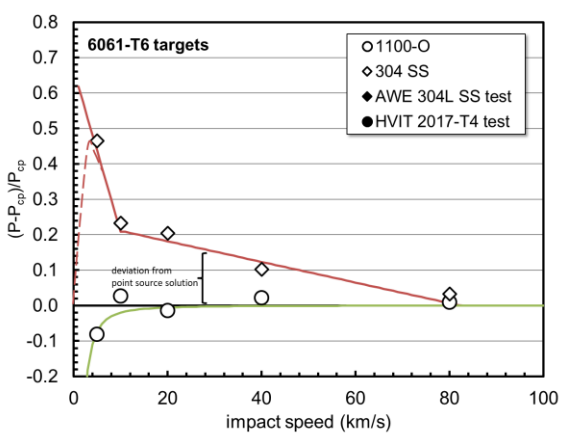
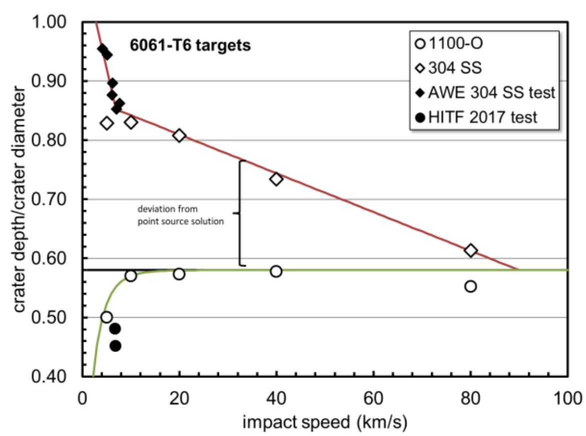
ABSTRACT

Researchers have used crater counts from a number of returned aluminum surfaces for quantifying the micrometeoroid and orbital debris environment. For example, the Solar Max thermal control louvers, the LDEF thermal control panels and the ISS Multipurpose Logistics Module MMOD shields. Inferring the size particle that produced the crater from the crater dimensions is dependent on a reliable crater dimension scaling relation.

The developer of the cratering relation typically used today developed it for Apollo in 1968 and biased the derivation towards meteoroid impact speeds and not underestimating the crater dimensions. For these reasons, it may not be the best relation to use for inferring the dimensions of orbital debris particles from their crater dimensions. In order to address this question, the author developed a new empirical aluminum cratering relation based on the contemporary understanding of the cratering process and crater dimension scaling. He performed two-dimensional CTH finite difference hydrocode calculations with three projectile materials, two aluminum alloy target materials and impact speeds ranging from 5 to 80 km/s. The figures below are plots of the scaled depths, P, and depth to diameter ratios as deviations from the high speed coupling parameter (CP, or point source) scaling relation. (Also plotted are two hypervelocity impact-test data sets.)





The author will use the above crater dimension scaling relations to perform a sensitivity study of the number of craters produced by the medium-density and the high-density populations of the ORDEM 3 orbital debris environment model and the number of craters produced by the MEM release 2 micrometeoroid environment model. The author will compare the results with the Apollo crater dimension scaling relation and draw conclusions about the suitability of the Apollo relation when inferring the particle diameter from in-situ crater dimensions.