

Material Compatibility Assessment of Spacecraft Oxidizer Systems

Recently designed oxidizer systems used in spacecraft propulsion are pushing the limits of materials and operating conditions. As a result, nitrogen tetroxide (NTO) oxidizer systems are exhibiting failures driven by ignition mechanisms similar to oxygen systems. Oxidizer systems (e.g., O_2 , N_2O_4 , N_2O , H_2O_2) have generally been designed and operated within industry experience for material corrosion concerns without a thorough understanding of potential material ignition and burning. To compound the problem, the effects of varying parameters on ignition and the kindling chain have not been studied, and there is a very limited amount of published data to help with the understanding. NASA-sponsored testing is actively researching ignition mechanisms, determining thresholds, and defining operating envelopes to inform the aerospace community.

Applicability

The information in this technical bulletin is applicable to spacecraft oxidizer systems found to be situationally flammable with oxidizers. Titanium was the focus of recent work in the presence of NTO, but other metals such as certain thicknesses of stainless steel and also soft goods may be susceptible as well in the right configuration.

Background

Recent testing found that traditionally acceptable materials of construction (titanium and certain thicknesses of stainless steel) are flammable and ignitable in NTO. Literature searches, flammability testing, and ignition testing confirmed that these materials are sensitive to ignition in much the same way as they are in oxygen systems. Flammability and ignition susceptibility have traditionally not been evaluated for these types of propulsion oxidizer systems other than oxygen.

Discussion

Recent testing has identified the need for compatibility assessments in all oxidizer systems consistent with oxygen systems per NASA-STD-6016A. As a result, NASA-STD-6016A has been updated with this requirement. The recommended oxidizer compatibility evaluation process for NTO and other oxidizers is based on the existing oxygen compatibility assessment process per NASA/TM-2007-213740. Materials evaluation testing is performed per NASA-STD-6001B.

The intent of the oxidizer compatibility assessment process is to identify the likelihood of ignition for flammable materials through system interrogation. High probability ignition sources can be further assessed

through targeted testing at the material, component, or system level. The process also identifies potential hazard controls through material change, system configuration, or operation.

Path Forward

NASA-STD-6016B now requires all spacecraft oxidizer systems to be evaluated per NASA/TM-2007-213740. NASA-sponsored testing is actively researching ignition mechanisms, determining thresholds, and defining operating envelopes to inform the aerospace community.



Successful static fire test with incorporated lessons learned

References

1. NASA-STD-6016B Standard Materials and Processes Requirements for Spacecraft
2. NASA/TM-2007-213740 Guide for Oxygen Compatibility Assessments on Oxygen Components and Systems
3. NASA-STD-6001B Flammability, Offgassing, and Compatibility Requirements and Test Procedures

