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MICROGRAVITY FLAMMABILITY EXPERIMENTS FOR SPACECRAFT FIRE SAFETY

Abstract

A series of experiments were carried out on different materials to establish their suitability for a forthcoming flight experiment on an ISS resupply vehicle, such as the Automated Transfer Vehicle (ATV) after it leaves the ISS and before it enters the atmosphere. First, experiments were conducted in order to address the significance and validity of the NASA-STD-6001 (Test 1) material flammability acceptance test. Test 1 is a go/no-go test based on upward flammability for the worst case conditions (atmosphere and material thickness) that will be experienced by that material. As implemented, Test 1 does not fully consider the significance of: surface geometry (e.g. grooves and fins); interactions with adjacent surfaces (flow interference or radiative and convective interaction); and the impact of the diffusivity of the metal mounting structure. Second, as the undesired effects of fires are linked to the rate of heat and toxic product release, which is coupled to the oxygen supply through its scaling with the flame propagation rate, the effect of heat transfer at the surface and within the material, as well as the effect of grooving and shaping, had to be established. Further, given the abundance of material assemblies in space comprised of combustible elements with non-combustible, yet heat-conducting, skeletons within, as well as materials in systems with added enthalpy, the effect of such assemblies on ignition and flame propagation was established. Third, in microgravity, the absence of natural convection increases the significance of radiation heat transfer and of the soot production, which is enhanced with increasing residence times. Therefore, the experimental series included measurements of backlighting attenuation through the flame to enable the evaluation of the optical thickness of the flame due to soot, which is a crucial parameter in the estimation of the radiative heat feedback from the flame to the fuel plate. In summary, the cornerstone of fire prevention is the adequate characterization of materials, and the focus in the current study was on isolating relevant physical parameters, establishing their dependency on the test environments, and determining the relationship between them such that future testing results are indicative of safety in the

actual operational environment. As such, the overall goal to be met in the future is to move away from screening and into a method that establishes a targeted assessment of material flammability and intrinsic material properties that can be used in active systems to extrapolate real fire behavior.