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FIRE SAFETY IN HUMAN SPACE FLIGHT – RESEARCH FOR IMPROVED STANDARDS

Abstract

A fire onboard a manned spacecraft is one of the major risks. It accounts for present missions like on the ISS and the more for future exploration missions where an escape or mission abortion and return are even more impractical and the atmosphere onboard future exploration vehicles with 540 mbar and 34% oxygen will be augmenting the fire hazard. Present material qualification tests regarding its flammability like the NASA-STD 6001 B or ECSS-Q-ST-70-21-C tests are performed in a ground laboratory under 1g conditions and are simply qualifying the materials to “pass” or “fail”. These tests foresee flat material samples that are vertically mounted in a large chamber filled with a quiescent atmosphere of a constitution as on the intended mission. The sample with its vertical long edges protected against inflammation becomes appropriately ignited at the lower end must extinguish within 150 mm upward and concurrent to buoyant convection propagation length and may not expel burning debris. Materials that do not pass this test may be used anyway if no substitute material can be selected and if special countermeasures regarding potential ignition sources are taken. Results of recent experiments onboard the ISS, the CYGNUS spacecraft and a sounding rocket mission on polymethyl-metacrylate (PMMA) revealed, that the combustion behavior is substantially different in microgravity and under the forced convection of the air conditioning systems than in 1g and under natural convective conditions. Furthermore, extensive experiments on PMMA samples with structured and machined surfaces on ground displayed that the actual standard tests may not represent realistic or worst-case conditions. In contrast, it turned out, that almost any deviation from the defined standard conditions lead to an increase of the flame spread rate.

The paper presents the results from systematic 1g-experiments on structured PMMA-samples and compares it to results from g-experiments on comparable samples. An empirical model is presented that can serve to predict the burning behavior of arbitrary shaped samples referencing only the tested behavior of a flat sample of the same material. This research is an integral part of an international collaboration that aims for the definition of a new knowledge based qualification method.