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Author: Mr. Ulises Rojas Alva
The University of Edinburgh, United Kingdom

Mr. Cameron Creamer
University of Edinburgh, United Kingdom
Mr. David Hanna
University of Edinburgh, United Kingdom
Prof. Grunde Jomaas
University of Edinburgh, United Kingdom

FIRE BEHAVIOUR OF POLYDIMETHYLSILOXANE MATERIALS FOR SPACECRAFT APPLICATIONS

Abstract

Elastomer materials, such as polydimethylsiloxane, are commonly used for spacecraft applications. Silicone membranes are employed in life-supporting systems, while silicone jackets are used as insulations of wires. Understanding the fire behaviour of these materials is an important task to ensure the fire safety of spacecrafts. Besides combustion gases and products, the silicone-based materials also produce silica ash that has insulating properties. The role of the silica ash during burning becomes significant, and it adds difficulties in predictions of the flammability. Various experiments were conducted to understand the fire behaviour of two silicone-based materials. Silicone membranes of various thicknesses and silicone jackets were used in the experimental study. The thickness of the sample, the size and geometry of sample, the variation of flow (either buoyant or forced), and the mode of flame spread (opposed or concurrent) were part of the experimental matrix. During ignition, the results over the flat samples suggests that there is a minimum critical energy (normalized) to attain flame spread for samples of various thickness, with the exception of the thickest sample (one millimetre). Furthermore, it was found that the size and geometry of the ignitor can deform the sample during heating, influencing the results significantly. An optimized ignitor was found suitable for all sample thickness. Prediction of opposed and concurrent flame spread under buoyant and forced flow conditions was conducted through heat balance estimation and employing scaling analysis. Gas-phase and solid-phase temperatures were measured with thermocouples and with an IR camera. The IR was also employed to quantify the thermal lengths. The kinetic properties of the silicone materials were found using TGA and empirical reverse modelling. An Extended Simplified Theory was used to predict the opposed flame spread. The predictions were found to be in good agreement with the results. The silica ash influence on the fire behaviour was found to be negligible for the thinner samples under opposed forced flow. On the contrary, prediction of flame spread under concurrent forced flow was challenging as the silica ash deposits upstream of the pyrolysis region. Additionally, the emissivity value of the silicone during burning and the silica ash are different which adds uncertainty in predicting the flame spread. The accumulated ash deposit ahead of the pyrolysis front for both sample geometries was quantified and characterized for a range of forced flows by using a SEM. For the concurrent, forced flow, the model still requires further improvements.