Toxic Gas and Particle Emissions from Combustion of Spacecraft Materials

Bjoern Bingham[1,2], Salix Bair[1,2], Matthew Claassen[1,2], Alita Regi[2], Xiaoliang Wang[1,2], Judith C. Chow[2], John G. Watson[2], W. P. Arnott[1], Marit E. Myer[3], and Claire Fortenberry[4]

[1]University of Nevada, Reno, NV
[2]Desert Research Institute, Reno, NV
[3]NASA Glenn Research Center, Cleveland, OH
[4]Universities Space Research Association, Cleveland, OH

- Contact information:

  Bjoern Bingham (M.S. student): bjoernb@nevada.unr.edu, (707) 362-0940
  Xiaoliang Wang (thesis advisor): xiaoliang.wang@dri.edu, (775) 674-7177

- Statement of proposition/hypothesis: Combustion of spacecraft materials generates a wide range of air toxins.

Abstract:

Fires are catastrophic to space activities. In the confined space of a spacecraft, toxic gases, and particles can increase to dangerous concentrations much faster than in most terrestrial situations, and as missions increase in length, the risk of fire increases. Therefore, the characterization of toxic emissions from spacecraft fires is critical for the design of smoke detectors, respirators, fire extinguishers, and post-fire clean-up. The goal of this project is to better understand gas and particulate emissions from the burning of modern spacecraft materials. Specific objectives are to 1) evaluate the reproducibility of a NASA smoke generator and test procedure to standardize smoke generation for spacecraft fire research; 2) characterize toxic gas emissions from burning of spacecraft materials; 3) study transient smoke particle emissions and transformations during and after fires.

Four types of materials were tested in DRI's combustion laboratory, including Kapton, Teflon (PTFE), Teflon-Kapton wire insulation (TKT), and Velcro. These materials are commonly used in modern spacecraft, relating to the construction of facilities and spacesuits or assisting in day-to-day operations. A small amount of material (~0.5 g) was heated in a quartz furnace smoke generator developed by NASA’s White Sands Test Facility (WSTF). This generator will be used in this study following the proposed NASA test protocol as an independent evaluation of its reproducibility. The heating protocol used in this study includes a 30-minute linear ramp from 22 °C up to 640 °C, then holding the temperature constant for an additional 30 minutes. The smoke was carried out of the smoke generator into the combustion chamber by a pump. A suite of instrumentation monitored concentrations of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur dioxide (SO_2). In addition, a Fourier-transform infrared spectroscopy (FTIR) gas analyzer monitored up to 50 gaseous species, including volatile organic compounds to identify toxic gases that were emitted from the pyrolysis of these materials. The particle number concentration, mass concentration, size and charge distributions were monitored by a condensation particle counter (CPC), DustTrak DRX, and Electrical Low-Pressure Impactor (ELPI), respectively. Particle and acidic gas samples were also collected on filters backed by sodium hydroxide (NaOH) impregnated quartz filters.

The experimental data are being analyzed. The results will include emission factors (in grams of air pollutant per kilogram fuel burned) of gas species and particles, size distributions of smoke particles and their evolution during the heating process, charge distributions of smoke

particles, the chemical composition of smoke particles, and reproducibility of the WSTF smoke generator. These results will provide useful information for smoke modeling, fire detection and suppression, and post-fire cleanup.