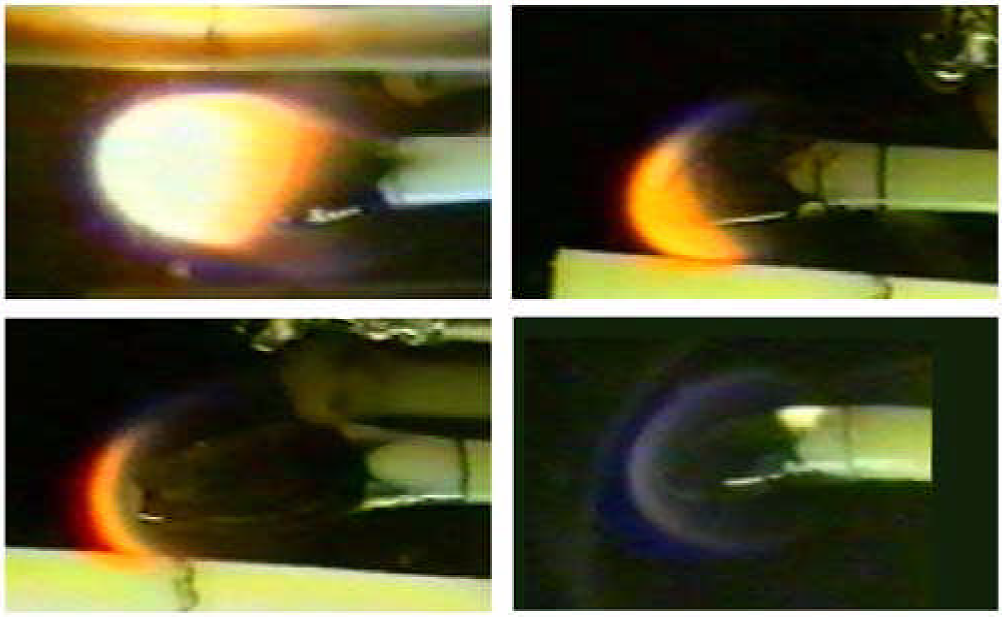
Burning Plastics Investigated in Space for Unique U.S./Russian Cooperative Project

It is well known that fires in the low-gravity environment of Earth-orbiting spacecraft are different from fires on Earth. The flames lack the familiar upward plume, which is the result of gravitational buoyancy. These flames, however, are strongly influenced by minor airflow currents. A recent study conducted in low gravity (microgravity) on the Russian orbital station Mir used burning plastic rods mounted in a small chamber with a controllable fan to expose the flame to airflows of different velocities. In this unique project, a Russian scientific agency, the Keldysh Research Center, furnished the apparatus and directed the Mir tests, while the NASA Glenn Research Center at Lewis Field provided the test materials and the project management. Reference testing and calibrations in ground laboratories were conducted jointly by researchers at Keldysh and at the NASA Johnson Space Center's White Sands Test Facility.

Multiple samples of three different plastics were burned in the tests: Delrin, a common material for valve bodies; PMMA, a plastic "glass"; and polyethylene, a familiar material for containers and films. Each burned with a unique spherical or egg-shaped flame that spread over the rod. The effect of varying the airflow was dramatic. At the highest airflow attainable in the combustion chamber, nearly 10 cm/sec (a typical ventilation breeze), the flames were bright and strong. As airflow velocity decreased, the flames became shorter but wider. In addition, the flames became less bright, and for PMMA and polyethylene, they showed two colors, a bright part decreasing in volume and a nearly invisible remainder (see the photographs). Finally, at a very low velocity, the flames extinguished. For the plastics tested, this minimum velocity was very low, around 0.3 to 0.5 cm/sec. This finding confirms that at least a slight airflow is required to maintain a flame in microgravity for these types of materials.



Changes in flame appearance with airflow velocity for burning polyethylene rods in microgravity. Airflow and flame spread are from left to right in the photographs. Top left: Air velocity, 8.5 cm/sec. Top right: Air velocity, 4.0 cm/sec. Bottom left: Air velocity, 2.0 cm/sec. Bottom right: Air velocity, 1.0 cm/sec.

The results of the project are significant for spacecraft fire safety. Of course, the plastics studied are flammable, and their use is limited on spacecraft. Because they are so common and difficult to replace, however, some quantities of these materials will be present in cabins, even on the International Space Station. The encouraging result is that the practice of shutting off ventilation or cooling airflows upon a fire indication or alarm will very likely extinguish small fires. On the other hand, if the shutoff is slow, fires may persist for some time under the stimulation of low airflows. The Mir tests also showed that the nearly invisible flames observed under low airflows are still hot and, therefore, could ignite nearby objects.

Bibliography

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Glenn contact: Robert Friedman, (216) 433–5697, fax (216) 977–7065, Robert.Friedman@grc.nasa.gov

Author: Robert Friedman

Headquarters program office: OLMSA

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