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The Purdue University Get Away Special II (PUGAS II)

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Abstract

The Purdue University Get Away Special Project is a student-run organization dedicated to preparing payloads for flight on NASA's space shuttle. The first such payload (PUGAS I) flew on Challenger in 1983. The second payload (PUGAS II) should be ready by the end of this year. Three experiments will be included. The first experiment will involve the production of tin metal foam under microgravity conditions. The second experiment will focus on the desorption of water from carbon-epoxy composite materials. The third experiment will use a solid polymeric material to detect radiation in space.

Introduction

This project was made possible through the continuing Small Self Contained Payload (SSCP) program of the National Aeronautics and Space Administration (NASA). The intent of this program is to generate new activities unique to space by providing numerous, frequent opportunities for small industrial users and educational institutions to fly payloads on the shuttle. Because of its low cost, the SSCP program is commonly referred to as the "Get Away Special " or GAS program. NASA hopes that this program will encourage greater use of the shuttle for education, commerce and research.

History of PUGAS I

The Purdue University Get Away Special (PUGAS) project began in 1978. A Purdue alumnus, Dr. Harold W. Ritchey, donated an SSCP reservation to provide students "hands-on" design experience. The students were expected to manage the project themselves, from the initial concepts through to the post-flight analysis of the collected data.

Three experiments were developed for the first payload. The Geotropism Experiment was designed to investigate the effects of gravity on the germination and initial growth of sunflower seeds. "Geotropism" refers to the process by which sprouts orient themselves in a gravitational field. A centrifuge is commonly used to study this effect; the centrifugal force acts as an additional body force on the sprout. However, gravity on the at the earth's surface introduces a bias that complicates interpretation of experimental results—hence the interest in working under microgravity conditions. In this experiment, 200 sunflower seeds were distributed at various radii in a centrifuge wheel, where they would be subjected to different levels of acceleration. Once in orbit, the seeds were to be sprayed with water, thus initiating germination; after 72 hours, the sprouts were to be sprayed with a fixer/preservative (glutaraldehyde).

The Zero-Gravity Fluid Dynamics experiment was designed to investigate the motion of a fluid in a microgravity environment. A drop of mercury was placed in a cell containing approximately 10 cubic centimeters of a perfluorinated hydrocarbon liquid. A motion picture camera was aimed through a window in the cell to record the response of the mercury drop to shuttle maneuvers.

The Nuclear Particle Detector was designed to record the passage of nuclear particles (such as cosmic rays) through the GAS canister. The detector comprised 75 thin sheets of a sensitive polycarbonate plastic, stacked together in an aluminum box. When an energetic charged particle passes through the polycarbonate, it disrupts the polymer structure along its path. This makes the polymer locally more susceptible to chemical attack. A caustic solution will etch a pit in the polycarbonate, thereby marking the track of the particle.

The PUGAS I payload took some four years to develop, at a cost of about $25,000. Nearly a hundred students, almost all of them undergraduates, worked on the project at various times over that period. The payload flew aboard STS-7 (Orbiter Challenger) 18-24 June 1983. Unfortunately, the geotropism and fluid experiments failed to operate because of a short in the power system. In contrast, the nuclear particle detector was a complete success; a detailed report was published by Weber and Weber (1984). Additional information on the PUGAS I project can be found in the paper by Perez (1984).

PUGAS II

The current space shuttle project, known as PUGAS II, began in 1984. Reservations were made for a 2.5-cubic-foot GAS cannister having a 100-pound capacity. Two dozen students are involved in PUGAS II. The work is divided among five engineering design groups (Microprocessor Control, Structures, Power, Thermal Control, and Safety) and three experimental groups (Materials Processing, Nuclear Particle Detection, and Moisture Desorption).

This paper will concentrate on the work of the experimental groups. The PUGAS II microcontroller was previously described by Weber and Deckard (1986). The construction of the lightweight composite structure was described by Spencer (1986). The thermal control system for PUGAS II will be similar to that used for PUGAS I, which was described by Stark (1985).

Materials Processing

This experiment is designed to investigate the feasibilty of producing foamed-metal materials in space. A foamed metal is one in which a significant fraction of the material's volume is occupied by gas bubbles. Such materials are light and strong, and may prove useful for constructing structures in space. On earth, foamed metals can be produced by bubbling gas through a molten metal, but buoyancy and convection tend to distribute the gas bubbles unevenly. It is hoped that a uniform distribution of bubbles might be achieved under microgravity conditions in orbit.

In the Purdue experiment, a small quantity of zinc carbonate is mixed with powdered tin. This mixture is pressed to form cylindrical rod, approximately 2.5 cm in diameter and 2.5 cm long, which is placed inside a stainless steel cylinder. The end of steel cylinder is then closed by the insertion of a movable piston. Nichrome heating elements are wrapped around the cylinder, and the entire assembly is placed in an insulated steel containment vessel in the GAS canister.

Once in orbit, the microcontroller will activate the experiment by supplying battery power to the heating elements, raising the temperature of the sample to about 600 K. Tin melts at 505 K; zinc carbonate decomposes into zinc oxide and carbon dioxide above 575 K. Thus, bubbles of carbon dioxide gas will form throughout the molten tin, causing the sample to expand against the piston. On command from the microcontroller, the power to the heating elements will be cut, and the sample will be allowed to cool. As the tin solidifies, it will trap the carbon dioxide bubbles.

After the flight, the sample will be removed from the cylinder and subjected to various mechanical tests (for hardness, tensile strength, etc.) The material will then be sectioned and examined by electron microscopy.

Moisture Desorption

In this experiment, carbon-epoxy materials will be exposed to the vacuum of space to determine what changes in tensile strength may result from the loss of volatile substances such as water. Because of their impressive strength and low density, carbon-epoxy materials are finding widespread use in aerospace applications. Obviously, anything that changes the physical properties of these composites will be of interest to the designer.

The experiment itself is fairly straightforward. Samples of the carbon-epoxy composite will be fabricated at the Purdue Department of Aeronautical and Astronautical Engineering. These will be weighed and placed inside a gastight aluminum chamber in the GAS canister. In orbit, a valve on the chamber will be opened, and will remain open until just before the shuttle is to return to earth. The valve will then be closed, sealing the chamber under vacuum. On the ground, the chamber will be transferred to a glove box containing a dry, inert atmosphere. The carbon-epoxy samples will be weighed, then tested to determine their tensile strength.

Nuclear Particle Detection

The present particle detector is similar to the detector that flew on PUGAS I. The principle of the experiment remains the same: interactions with energetic charged particles weaken the polymer structure, resulting in the formation of pits when the sample is subsequently exposed to a chemical etchant. The number and energies of the particles can be inferred from an examination of the pits. Colorless allyl diglycol polycarbonate sheets (sold as "CR-39" by Pittsburgh Plate Glass) will be used, as in the original experiment. Forty sheets, 10 cm by 10 cm by 0.32 cm thick, are stacked together between two aluminum end plates. Cutouts in the aluminum allow direct access to the polymer surface. The assembly is secured to the inside of the GAS canister by four bolts.

A second detector is being constructed using red polycarbonate sheets ("LRI-115"). The red material reacts to the charged particles and the caustic etchant in much the same as the colorless material. The difference is that the tracks should be more readily visible in the red material when it is examined under under contrasting green light.

An improved standard was made for the current experiment. Polycarbonate was exposed to a 14.9 MeV proton beam from the Purdue Particle Accelerator, then etched with a sodium hydroxide solution in the usual manner. This provides a reproducible standard with which the exposed polycarbonate sheets from the space shuttle can be compared.

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