Structural Integrity of Experiment Container for Reduced Gravity Flight Testing

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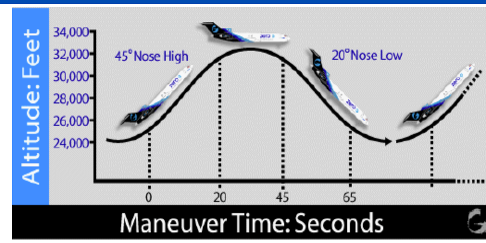
Abstract

An experiment container was designed, analyzed, fabricated and used for conducting a chemical experiment (calcium oxalate production) under reduced gravity conditions aboard a NASA-operated aircraft. The container was constructed of a welded and gusseted aluminum square-tubing frame and walled with polycarbonate panels that were lined in silicone and bolted to remain in-place while reinforced with square u-shaped side-wall supports. For evaluation purposes, separate design loads resulting from 9-g's forward, 3-g's aft, 6-g's down, 2-g's lateral, and 2-g's up were imposed on the container. Analytical, numerical (FEA) and experimental methods were used to validate the structural integrity of the experiment container.

Introduction

A microgravity experiment was proposed with the main objective to determine whether gravity affects the quantity and crystal structure formation of calcium oxalate. The ultimate outcome of the experiment was to establish whether calcium oxalate-producing plants can produce more calcium oxalate in reduced gravity conditions. Through this research, the aim was to answer the following questions: Will the change in ionic concentration of secondary metabolite formation interfere with normal metabolic metabolism? Will a change in the amount of calcium oxalate change the structure of plant cells? Will the excess or deficiency of calcium oxalate increase or decrease the deterring capabilities of plants? If plants are more deterrent toward predators, will they ultimately exclude the possibility of sustaining life of herbivores in deep space?

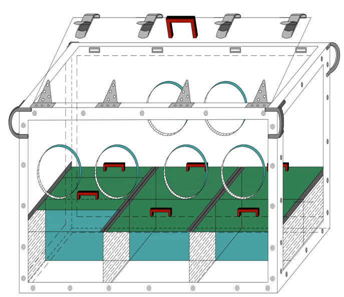
The experiment was designed to be self-contained in an experiment container that was strapped to the cargo floor in a NASA reduced-gravity aircraft (a Boeing 737-200 nicknamed the "weightless wonder" or "vomit comet").

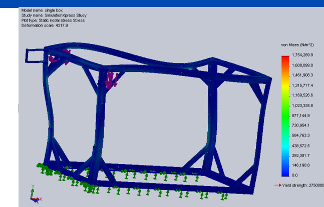


The aircraft flies prescribed parabolic flight maneuvers so as to produce microgravity, lunar gravity and Martian gravity conditions. After an iterartive design process, a user-friendly experiment container was designed that would securely hold the hazardous materials. The structural material and design configuration were finally selected that would not only secure our test specimens but also withstand the potential experimental stresses and forces as prescribed by NASA.

Experiment Container

The design of the experiment container had to meet NASA's guidelines and specifications, including: i) dimensions of 588 mm x 1470 mm x 1470 mm (24" x 60" x 60") and ii) weigh no more than 135 kg (300 lb.). These guidelines led to a container that is strong, resistant to deformation, mobile, multifunctionable, and reusable.





The basic experiment container was a welded frame reinforced by doublers and gussets comprised of 6061-T6 aluminum. The side walls were polycarbonate. The larger front and rear panels were cut to allow for the attachment and insertion of blast cabinet gloves that were fastened into the appropriate holes using mounting bolts and hardware. All doors were fixed with spring hinges, preventing any pre-mature opening. Sliding doors were held in the closed position using magnets. Syringe apparati were stored and utilized within this container.

Summary/Conclusion

Upon finalizing the design of the experiment container and conducting analytical, numerical, and experimental analyses, NASA's engineers deemed the box structurally sound and ready for flight. The angled aluminum welds and polycarbonate polymer enhanced the overall strength of the box and provided an effective safety barrier between the hazardous materials and the experimenters. Welds were capable of withstanding maximum loading of 18 g's. Validation of the design occured when the experiment container successfully flew on a microgravity mission onboard a NASA-operated aircraft in July 2011.