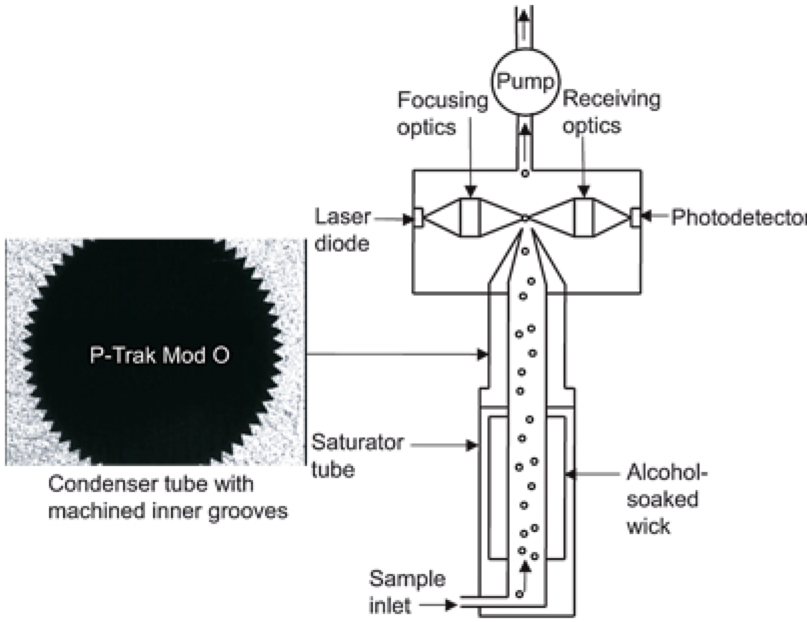
Fundamental Research Applied To Enable Hardware Performance in Microgravity

NASA sponsors microgravity research to generate knowledge in physical sciences. In some cases, that knowledge must be applied to enable future research. This article describes one such example. The Dust and Aerosol measurement Feasibility Test (DAFT) is a risk-mitigation experiment developed at the NASA Glenn Research Center by NASA and ZIN Technologies, Inc., in support of the Smoke Aerosol Measurement Experiment (SAME). SAME is an investigation that is being designed for operation in the Microgravity Science Glovebox aboard the International Space Station (ISS). The purpose of DAFT is to evaluate the performance of P-Trak (TSI Incorporated, Shoreview, MN)--a commercially available condensation nuclei counter and a key SAME diagnostic--in long-duration microgravity because of concerns about its ability to operate properly in that environment. If its microgravity performance is proven, this device will advance the state of the art in particle measurement capabilities for space vehicles and facilities, such as aboard the ISS.

The P-Trak, a hand-held instrument, can count individual particles as small as 20 nm in diameter in an aerosol stream. Particles are drawn into the device by a built-in suction pump. Upon entering the instrument, these particles pass through a saturator tube where they mix with an alcohol vapor (see the following figure). This mixture then flows through a cooled condenser tube where some of the alcohol condenses onto the sample particles, and the droplets grow in a controlled fashion until they are large enough to be counted. These larger droplets pass through an internal nozzle and past a focused laser beam, producing flashes of light that are sensed by a photodetector and then counted to determine particle number concentration. The operation of the instrument depends on the proper internal flow and recycling of isopropyl alcohol in both the vapor and liquid phases.



P-Trak internal components and flow.

Long description of figure. Internal components and airflow for the P-Trak, showing pump, focusing optics, laser diode, photodetector, saturator tube, alcohol-soaked wick, and sample inlet. Also shows a cross-sectional view of the inner wall of the modified condenser. The precisely machined grooves are visible.

As the instrument was originally designed, alcohol that condenses on the inner wall of the condenser drains back down the saturator tube by gravity. The condenser in the unit was modified to promote the capillary flow of liquid alcohol back toward the saturator without depending on gravitational forces. This was accomplished through a series of 60 precisely machined grooves, each 0.009 in. deep, which promote the wicking of the liquid alcohol in the proper direction along the condenser's inner wall. This design was developed by fluids physics researchers at Glenn following an analysis to measure the contact angle of isopropyl alcohol on the aluminum surfaces of the condenser. The technique for this analysis is based on the results of fundamental research conducted at Glenn that investigated the wetting properties of liquids on surfaces (ref. 1).

For the DAFT experiment, both a modified and an unmodified version of the P-Trak will be tested in the long-duration microgravity conditions aboard the ISS. In addition to the P-Traks, another commercial instrument, the TSI DustTrak, will be utilized with the experiment. The DustTrak measures particle concentrations and is not sensitive to gravity. For experiment operations, DAFT will be secured to the front of an Expedite the Processing of Experiments to Space Station (EXPRESS) Rack and gaseous nitrogen provided by the rack will be used to fill 15-liter sample bags. These bags also will be loaded with a small quantity of a characterized source of particulates made up of Arizona road dust. One of the P-Traks and the DustTrak will then simultaneously draw samples from these bags while recording measurements of particle counts and mass concentrations, respectively. Prior to the particulate/nitrogen sample entering the instruments, the smallest particles will be removed from the flow stream by a device called the DAFT Impactor, which was designed with the guidance of scientists at the National Institute of Standards and Technology. The EXPRESS laptop computer will be used to download the recorded measurements from the instruments and downlink them to the ground. There, they will be compared to quantitatively assess the operation of the P-Trak: that is, whether or not the readings of the P-Trak properly correlate to the readings of the DustTrak. These instruments also will take data from samples of the ISS cabin air. Environmental Control and Life Support Systems personnel at the NASA Johnson Space Center and NASA Marshall Space Flight Center have expressed a strong interest in these measurements since they will provide valuable information regarding particulate loading in the ISS cabin atmosphere. The DAFT hardware has been formally turned over to Johnson and awaits shipment to the launch site.

Reference

1. Allen, J.S.: An Analytical Solution for Determination of Small Contact Angles From Sessile Drops of Arbitrary Size. J. Colloid Interface Sci., vol. 261, 2003, pp. 481–489.

Find out more about this research
http://microgravity.grc.nasa.gov/combustion/daft/daft_index.htm

Glenn contacts: William A. Sheredy, 216–433–3685, William.A.Sheredy@nasa.gov; Dr. David L. Urban, 216–433–2835, David.L.Urban@nasa.gov; and Dr. Gary A. Ruff, 216–433–5697, Gary.A.Ruff@nasa.gov
Author: William A. Sheredy

Headquarters program office: Exploration Systems
Programs/Projects: Life Support & Habitation