NASA Facts

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Md. 20771
(301) 286-8955

FS-1998-09-025-GSFC

Cryogenic Thermal Storage Unit Flight Experiment (CRYOTSU)

The Cryogenic Thermal Storage Unit Flight Experiment payload aboard the STS-95 mission will house four thermal control components that will be tested in space to solve complex spacecraft thermal design problems. They are: the 60 K Thermal Storage Unit, the Cryogenic Capillary Pumped Loop, the Cryogenic Thermal Switch and the Phase Change Upper End Plate.

In certain types of spacecraft, such as those used in Earth-observing applications, infrared detectors and optics need to be very cold, and these components must co-exist with other much warmer components. The Cryogenic Thermal Storage Unit Flight Experiment mission is designed to demonstrate the functional abilities of four spacecraft thermal control devices in the weightless environment of space. Three of the devices operate at very low (“cryogenic”) temperatures while the fourth operates at just above room temperature.

The first experiment, the 60 K Thermal Storage Unit functions as a supplement to a cryocooler, which is a small refrigerator designed to cool infrared instruments to low operating temperatures. This particular storage unit operates passively and requires no input power, which also lessens power consumption of the entire payload system.

The second experiment, the Cryogenic Capillary Pumped Loop is a lightweight, miniaturized device that provides the thermal link between an infrared or electrical component and a cryocooler. The fluids used in Cryogenic Capillary Pumped Loops are gases at room temperature, but once they have cooled sufficiently, they become liquid. The working fluid used in this device is Nitrogen. The Cryogenic Capillary Pumped Loop has no moving parts and operates using a two-phase fluid loop similar to that found in a residential heat pump. It is constructed using very small diameter tubing that can be routed around mechanisms and components in tight areas. Cryogenic Capillary Pumped Loops are lightweight and useful in a variety of situations including those where cryocooler mounting space is limited, where the cryocooler creates excessive vibration, or where cooling must be transported across a flexible joint. Besides their weight savings, one other important advantage of Cryogenic Capillary Pumped Loops is the fact that they can be turned ON or OFF.

The third experiment, the Cryogenic Thermal Switch is also a device that enables the thermal link between two components to be turned ON or OFF. The Cryogenic Thermal Switch is necessary when very low-temperature infrared sensors need to be cooled by at least two cryocoolers because of reliability concerns. The primary cooler is normally ON and the back-up cooler is normally OFF. These very low-temperature cryocoolers require a substantial amount of input power to produce just a small amount of cooling. By using two Cryogenic Thermal Switches in parallel (one for each cryocooler), the flow of heat from the backup (OFF) cryocooler can be minimized and the cooling capability of the primary (ON) cryocooler can be maximized. If the primary cryocooler fails, its Cryogenic Thermal Switch can be turned OFF, and the backup cryocooler, along with its Cryogenic Thermal Switch, can be turned ON.

The fourth experiment, the Phase Change Upper End Plate, like the 60 K Thermal Storage Unit, stores energy and also provides a thermal load-leveling function that smoothes out variable heating loads. The operating temperature of the Phase Change Upper End Plate is 113 degrees Fahrenheit. The primary use for the Phase Change Upper End Plate is to maintain the thermal stability of high power components that need to be turned on and off at different intervals. The working fluid of the Phase Change Upper End Plate is Docosane, a wax-like substance. When the high power component is turned ON, the Docosane melts and the component temperature stays relatively constant. When the high power component is turned OFF, the Docosane freezes and the component temperature, again, remains relatively constant. The Phase Change Upper End Plate is an integral part of the overall thermal control system for the payload. With five cryocoolers, the total power distribution exceeds the capability of the Hitchhiker-GetAway Special Canister to disperse the heat without overheating. Thus, under normal conditions, the operating time is limited. The Phase Change Upper allows the cryocoolers to operate longer without overheating, extending the time that the payload has to gather valuable performance data in space.

The Goddard Space Flight Center (Greenbelt, MD) Hitchhiker program provided mission support for the CRYOTSU payload. Goddard's Neal Barthelme is the mission manager. The program manager for the Cryogenic Thermal Storage Unit experiment is Lieutenant M. Rich of the Air Force Research Laboratory, Kirtland AFB, NM. Theodore Swanson at Goddard is the program manager for the Cryogenic Capillary Pumped Loop experiment. Lieutenant B.J. Tomlinson of the Air Force Research Laboratory is the program manager for both the Cryogenic Thermal Switch and Phase Change Upper End Plate experiments.

The Hitchhiker program is managed by the Shuttle Small Payloads Project Office at Goddard. Find more information on the Hitchhiker Program at http://sspp.gsfc.nasa.gov/hh/hh.html .