Thermal Energy Storage Flight Experiment in Microgravity

David Namkoong, Principal Investigator
Andrew Szaniszlo, Project Manager / Scientist

NASA Lewis Research Center
Cleveland, Ohio

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October 5-9, 1992
Heat Pipe Performance Experiment

Flight Experiments Technical Interchange Meeting

Sponsored by
Space Technology Interdependency Group
Flight Experiments Committee

October 5-9, 1992
Monterey, CA

George Fleischman
Hughes Aircraft Company
CRYOGENIC HEAT PIPE EXPERIMENT
FY 93 PLANS

- SUPPORT FLIGHT OPERATIONS
- REDUCE FLIGHT DATA AND RESOLVE ANY ANOMALIES
- PERFORM POST FLIGHT TESTS ON EXPERIMENT AND HEAT PIPES
- INCORPORATE RESULTS INTO GROOVE ANALYSIS PROGRAM AND SUBMIT TO COSMIC
- COMPLETE FINAL REPORT
CRYOGENIC HEAT PIPE EXPERIMENT
CURRENT STATUS

- DELIVERED TO KSC AND INSTALLED ON SHUTTLE
- FINAL INTERFACE VERIFICATION TEST COMPLETED
- ALL DOCUMENTATION COMPLETE
- LAUNCH DUE ON NOVEMBER 16, 1992
# CRYOHP Instrumentation

<table>
<thead>
<tr>
<th>Type</th>
<th>Quantity</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Platinum Resistance Thermometers (PRTs)</td>
<td>26</td>
<td>13 each heat pipe system</td>
</tr>
<tr>
<td>Thermistors</td>
<td>24</td>
<td>UEP, EBP, pillars, heat pipe structure, cryo-coolers, electronics</td>
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<tr>
<td>Thermistors</td>
<td>9 (HH)</td>
<td>EBP, Canister, &amp; CECM Mounting Brackets</td>
</tr>
<tr>
<td>Pressure Transducers</td>
<td>1</td>
<td>Canister Internal Pressure</td>
</tr>
<tr>
<td>Current Monitors</td>
<td>13</td>
<td>CECM</td>
</tr>
<tr>
<td>Voltage Monitors</td>
<td>18</td>
<td>1 for bus voltage, 17 for temperature calibration</td>
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<tr>
<td>Heaters (Kapton foil)</td>
<td>11</td>
<td>4 per heat pipe, 3 survival</td>
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<tr>
<td>Thermostats</td>
<td>33</td>
<td>Tri-series circuit for each heater</td>
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</tbody>
</table>
HAC HEAT PIPE TRANSIENT COOLDOWN
TEST DATE: 04-09-92

TEMPERATURE (K)

TIME (HOURS)
HEAT PIPE - CONCEPT
SCHEMATIC -- CRYOHP OPERATION

Cryocoolers
Heat Out

Thermal Shunt

Kapton Foil Heaters
Heat In

Heat Pipe
CRYOHP OPERATIONS SCENARIO

ASCENT
- Vent to 2 PSIA
- Hitchhiker Avionics On
- Survival Heaters On
- Vent to $10^{-4}$ Torr or Less
- CRYOHP On
- Cooldown TRW Heat Pipe
- Cooldown Start Up
- Cooldown Transport/Recovery
- Cooldown Hughes Heat Pipe
- Cooldown Transport/Recovery/Minimum Temperature

Descent
CRYOHP DESCRIPTION (cont.)

- Heat Pipes
  - Two Independent Designs
  - Axially Grooved Aluminum Extrusion
    - TRW
    - Hughes

- Cryo-Coolers
  - Five Split Stirling Cycle Coolers
    - Hughes Model No. 7044H
      - 3.5 Watts Each @ 80K
      - Mounted to HH Canister UEP
      - Helium at 450 Psia Maximum
      - 95 W Power, 7.5 Amp Startup for 100 Millisecond Max.
CRYOHP DESCRIPTION

- Shuttle/HH Carrier Flight Experiment (Minus Avionics) Less Than 345 lbs

- HH Canister
  - Modified Upper End Plate (UEP)
    - Thermal Mass
    - Radiator
    - Flown on CPL/GAS and CPL/HH-1

- Uninsulated Top Plus Sides

- Vented Can (Valves in Lower End Plate (LEP))
  - 16 Psia Prior to Launch
  - 2 Psia Differential Pressure Relief Valves on Ascent
  - Solenoid and Butterfly Valves Provide Flight Vacuum

- HH Avionics
  - Provides Power, Signal, Command, and Data
  - 3 HH Ports Required
CRYOGENIC HEAT PIPE EXPERIMENT

OBJECTIVE

CONDUCT A SHUTTLE EXPERIMENT TO DEMONSTRATE THE RELIABLE OPERATION OF TWO OXYGEN HEATPIPES IN MICROGRAVITY.

1. DEMONSTRATE STARTUP OF THE PIPES FROM THE SUPERCRITICAL STATE.

2. MEASURE THE HEAT TRANSPORT CAPACITY OF THE PIPES

3. MEASURE EVAPORATOR AND CONDENSER FILM COEFFICIENTS

4. WORK SHUTTLE SAFETY ISSUES

APPROACH

✓ FLY TWO AXIALLY GROOVED OXYGEN HEAT PIPES ATTACHED TO MECHANICAL STIRLING CYCLE TACTICAL COOLERS

✓ INTEGRATE EXPERIMENT IN HITCHHIKER CANISTER

✓ FLY ON SHUTTLE AND CONTROL FROM GROUND
CRYOGENIC HEAT PIPE EXPERIMENT

BACKGROUND

- No micro-gravity data available for oxygen or nitrogen heat pipes
- Poor wicking and low transport make 0-G extrapolation difficult
- Reliable start up from super critical temperature needs to be demonstrated
- Micro-gravity information on cryo (<100 K) heat pipes identified as critical technology need by NASA and the Air Force - 1988 Thermal Fluids in Space Workshop and INSTEP 88 Workshop
- Oxygen and nitrogen pipes built and evaluated
## TES Flight Schedule

<table>
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<tr>
<th>ACTIVITIES</th>
<th>FY 1990</th>
<th>91</th>
<th>92</th>
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<td>MAJOR MILESTONES</td>
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<tr>
<td>Flight Experiment Review</td>
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<tr>
<td>Preliminary Design Review</td>
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<tr>
<td>Launch</td>
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*NASA Lewis Research Center*