Two Phase Titanium Water Heat Pipe for Space Rated Stirling Power Conversion

Ninth International Conference on Two-Phase Systems for Ground and Space Applications
Baltimore, MD Sept. 22-26, 2014

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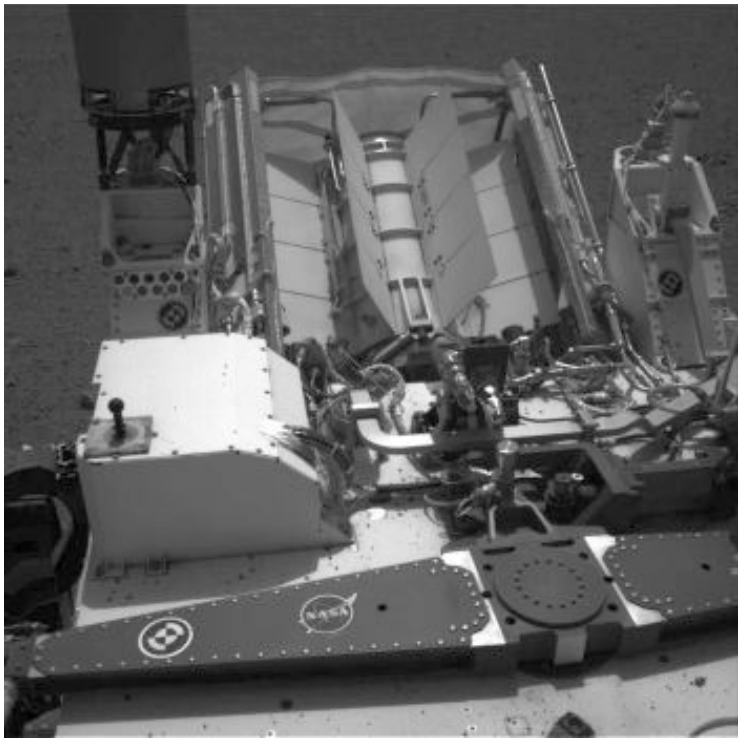
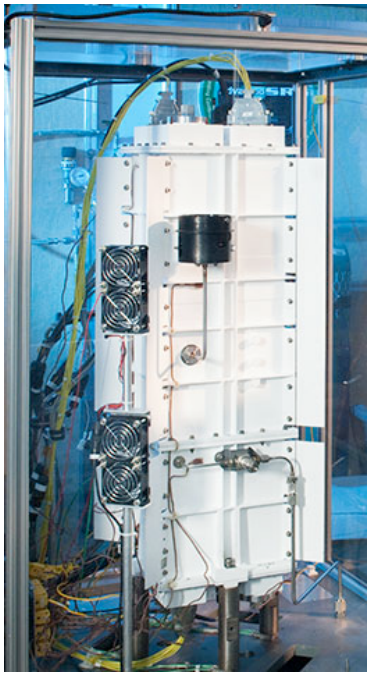
Background

- Radioisotope Power System (RPS) options that yse Pu238 General Purpose Heat Sources (GPHS):
  - Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)
  - Advanced Stirling Radioisotope Generator (ASRG)



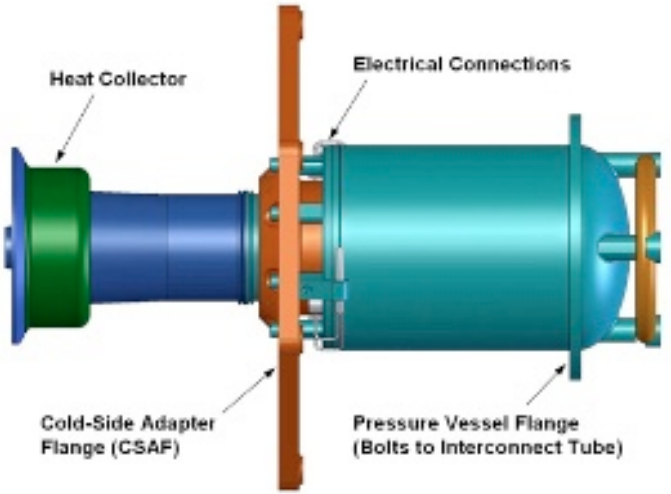
MMRTG (8 GPHS)

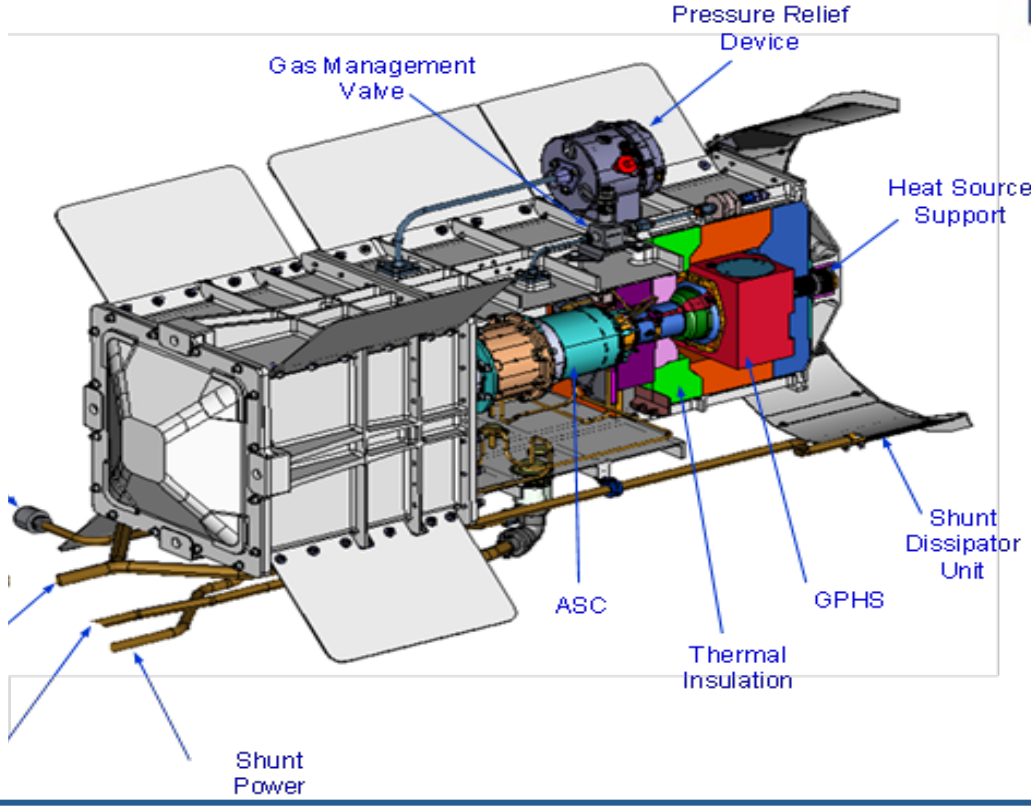
ASRTG (2 GPHS)

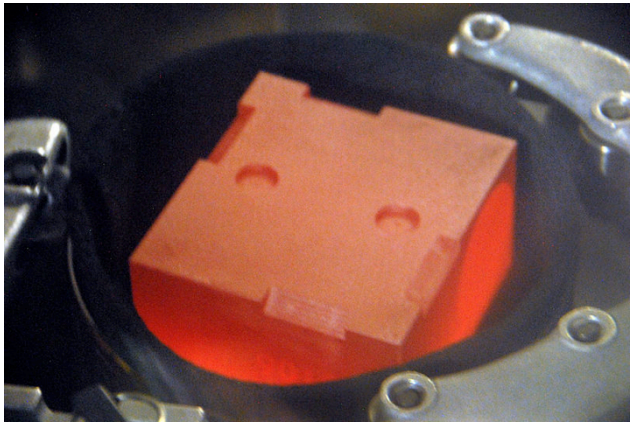


ASRG Thermal Control

- GPHS provides approx. 250Wt
- Convertor Accepts approx. 200Wt
- Conversion of 200Wt to 70We
- Rejects approx. 130Wt from convertor to radiator housing

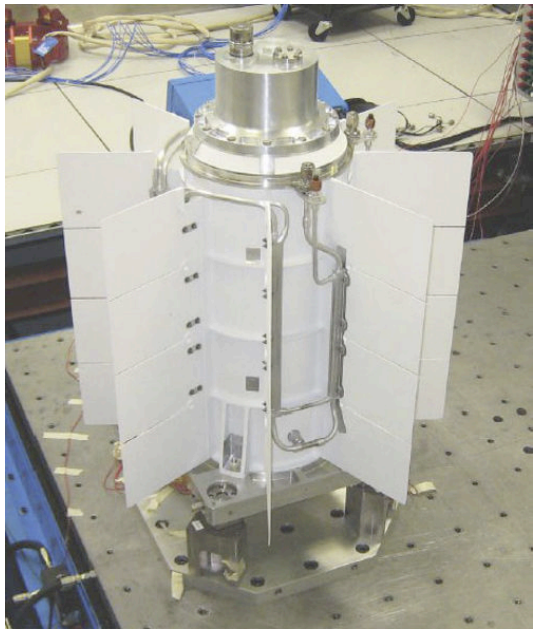




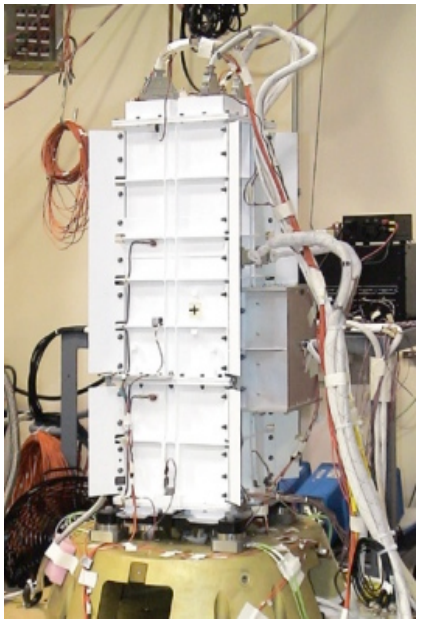


Radioisotope Power Systems

110 We Multi-Mission Radioisotope Thermalelectric Generator (MMRTG)
8 GPHS Plutonium Fuel Modules



140 We Advanced Stirling Radioisotope Generator (ASRG)
2 GPHS Plutonium Fuel Modules

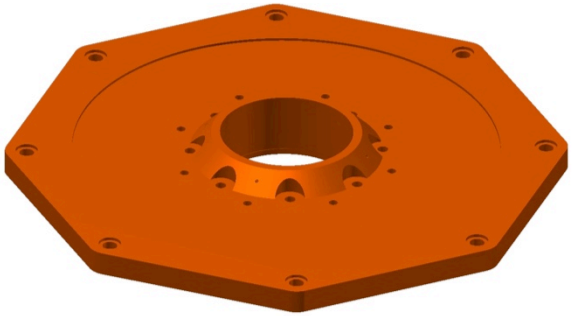


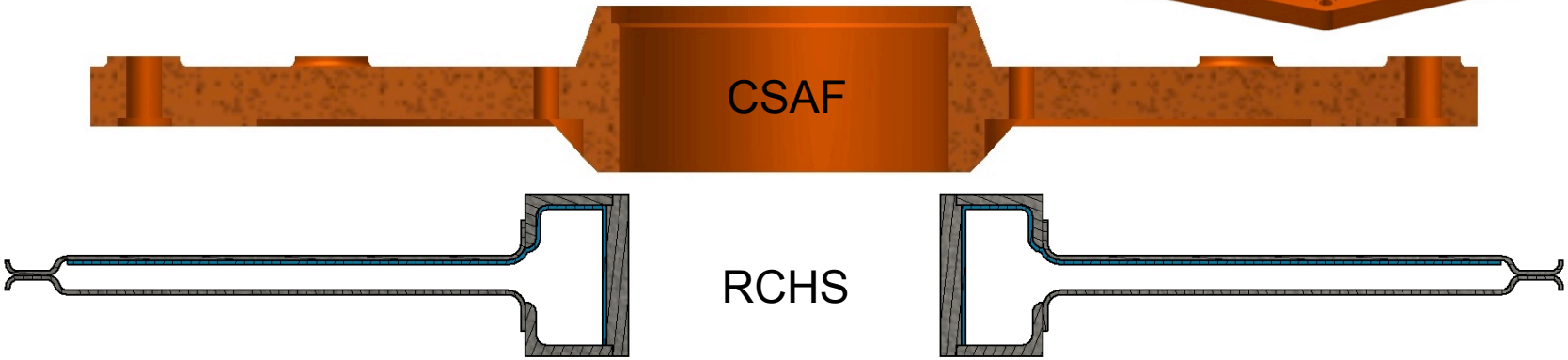
500-1000 We ASRG

?

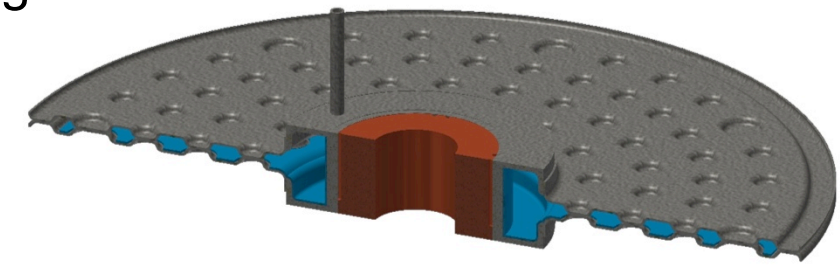
Conduction vs. Two-Phase

- Conduction fins become too heavy as rejection power levels increase





- Two-phase heat pipe uses working fluid vapor to transfer heat
- Hollow design for vapor path creates much lighter design



Technology Derived Design Requirements

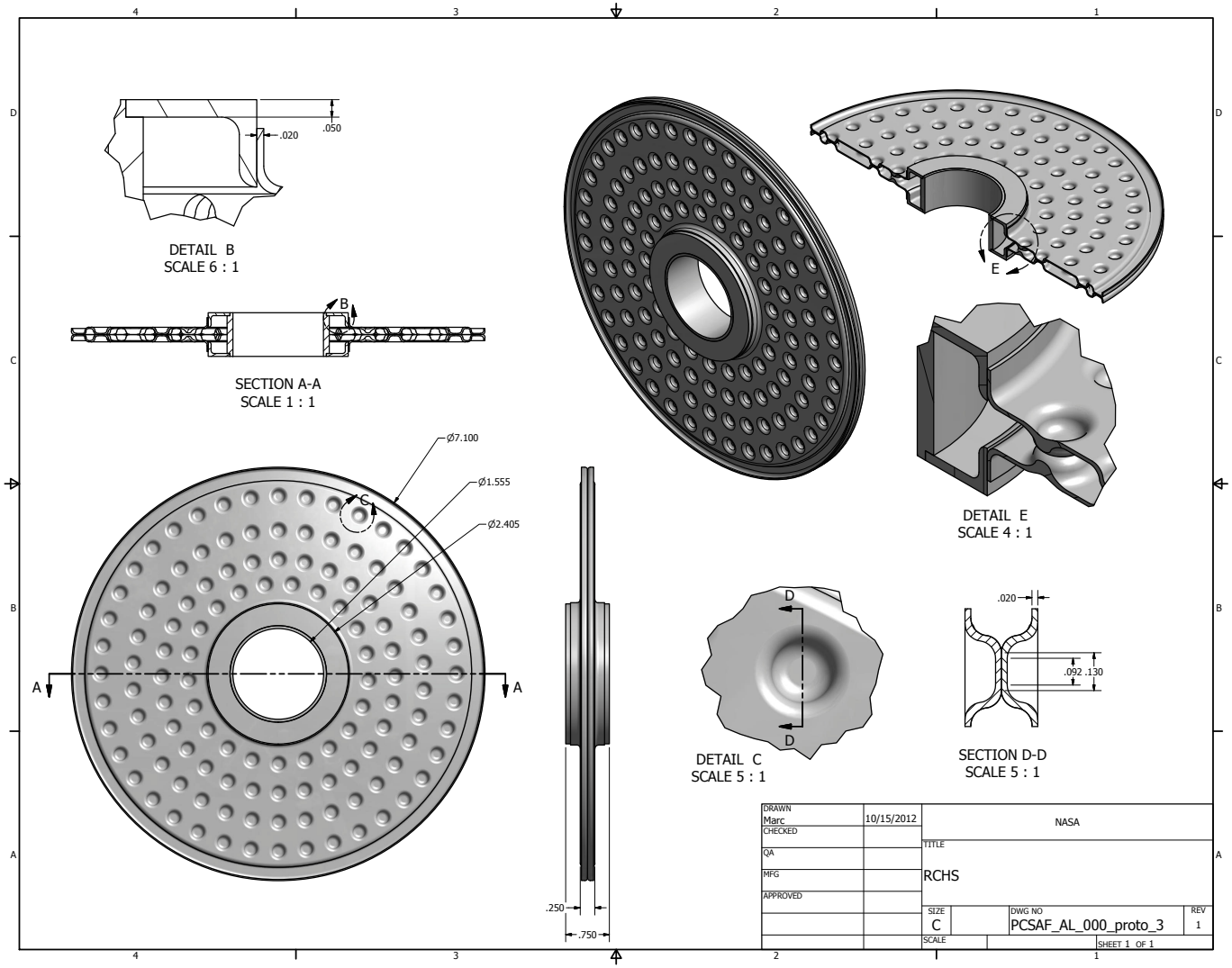
- Thermal
  - Reject 130Wt from Stirling Convertor (RCHS ID) to generator housing (RCHS OD) DURING LAUNCH
  - Operational Temperature Range: 50-150C
  - Temperature Delta <30C
- Environment
  - Assembly Test and Launch
    - Accelerations: Specific to Launch Vehicle (Peregrine)
    - Horizontal and Vertical Orientations: Specific to Spacecraft
  - Atmospheric and Vacuum Environment
    - Atmospheric during ground, launch
    - Vacuum or Atmospheric during transit and science return depending on mission

Structural

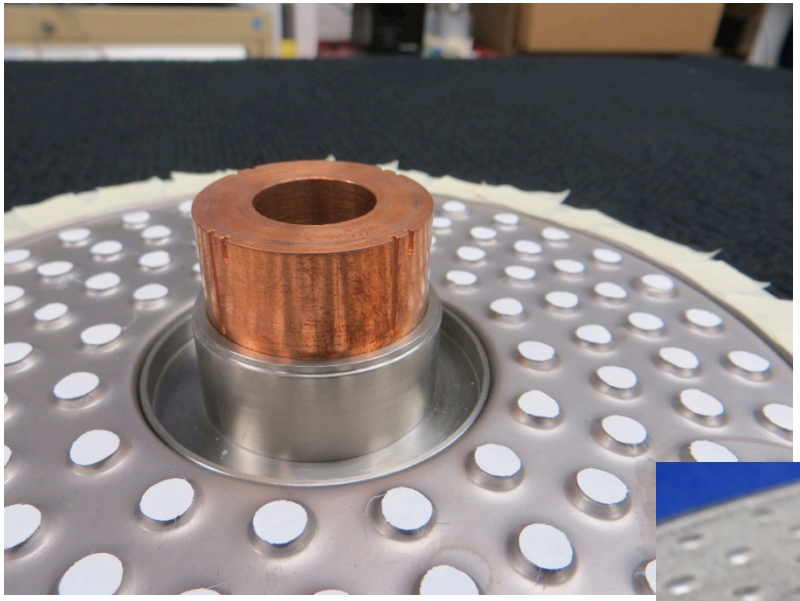
- Survive Thermal and Environmental requirements

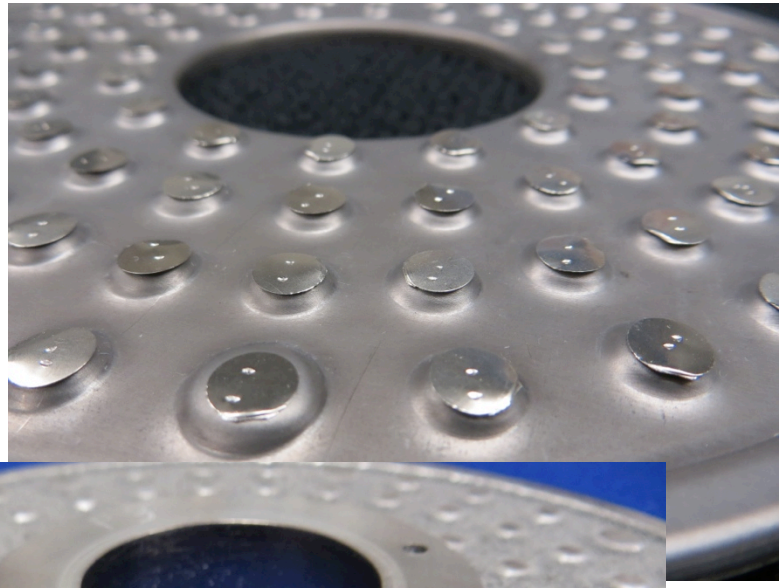
Experiment Description

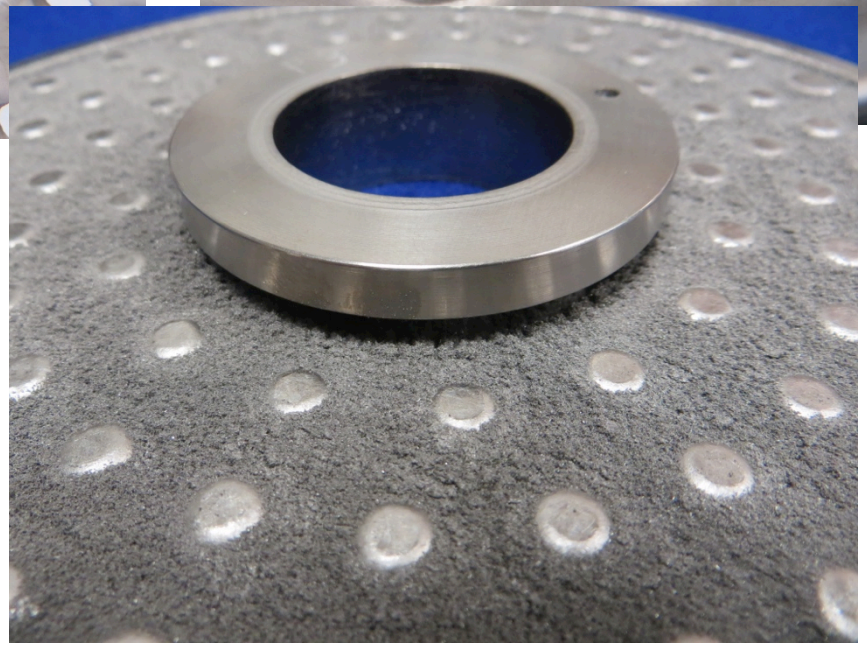
RCHS



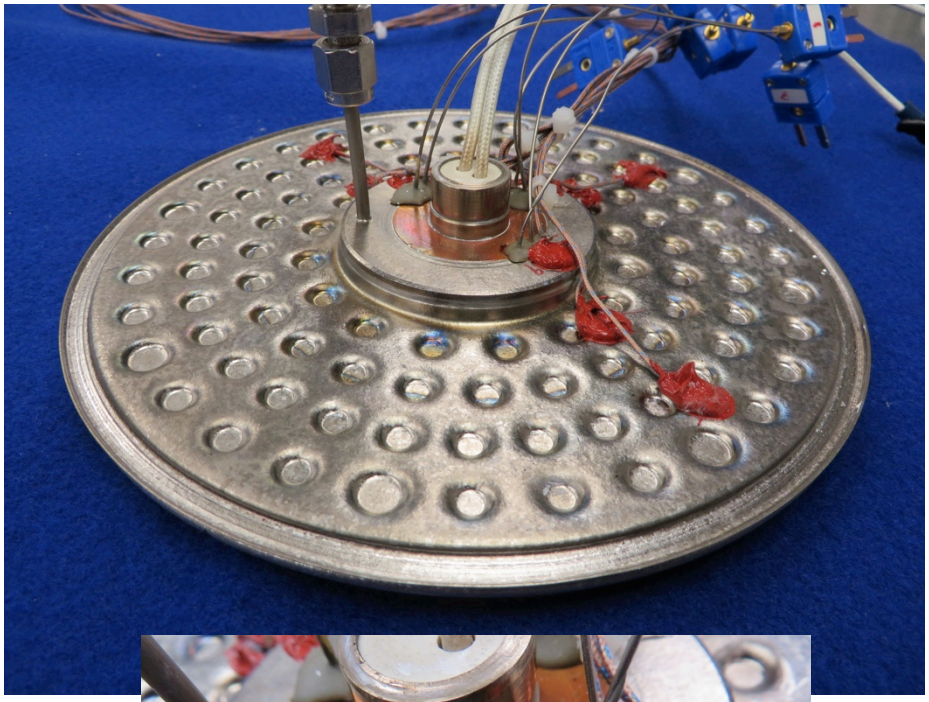
RCHS Design

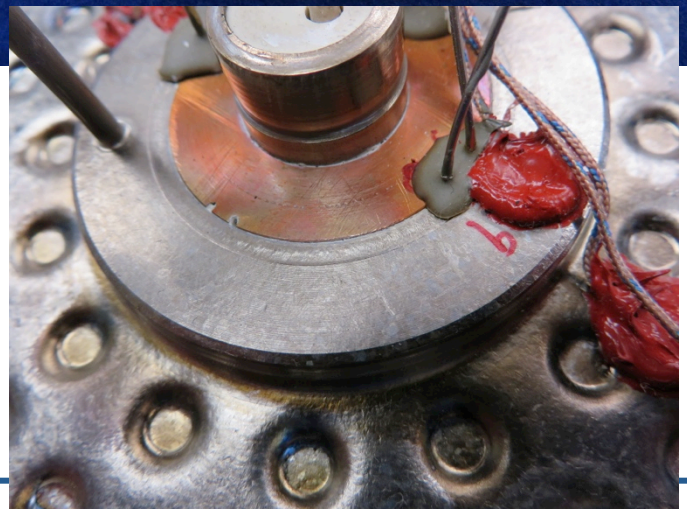






RCHS Design Continued

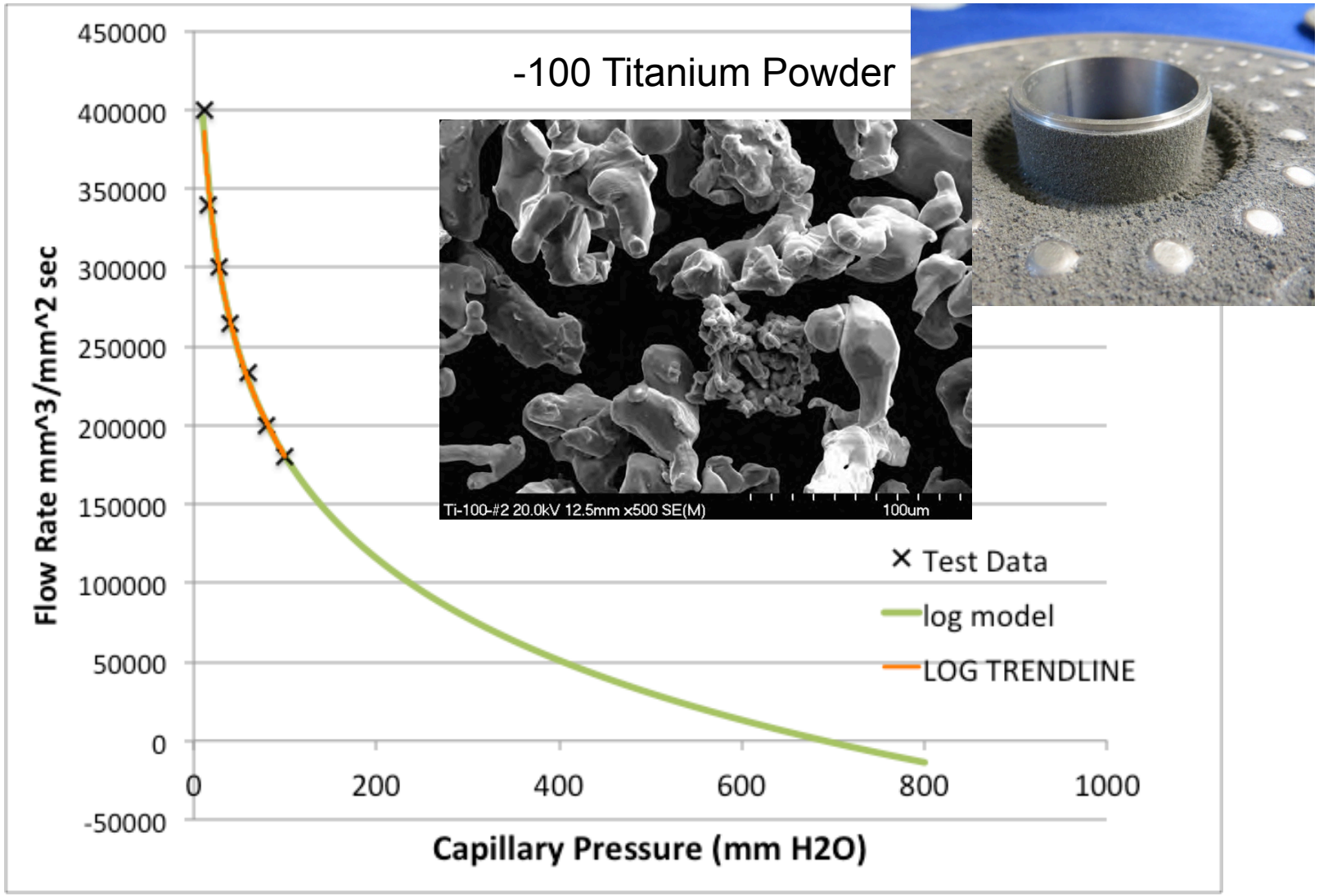




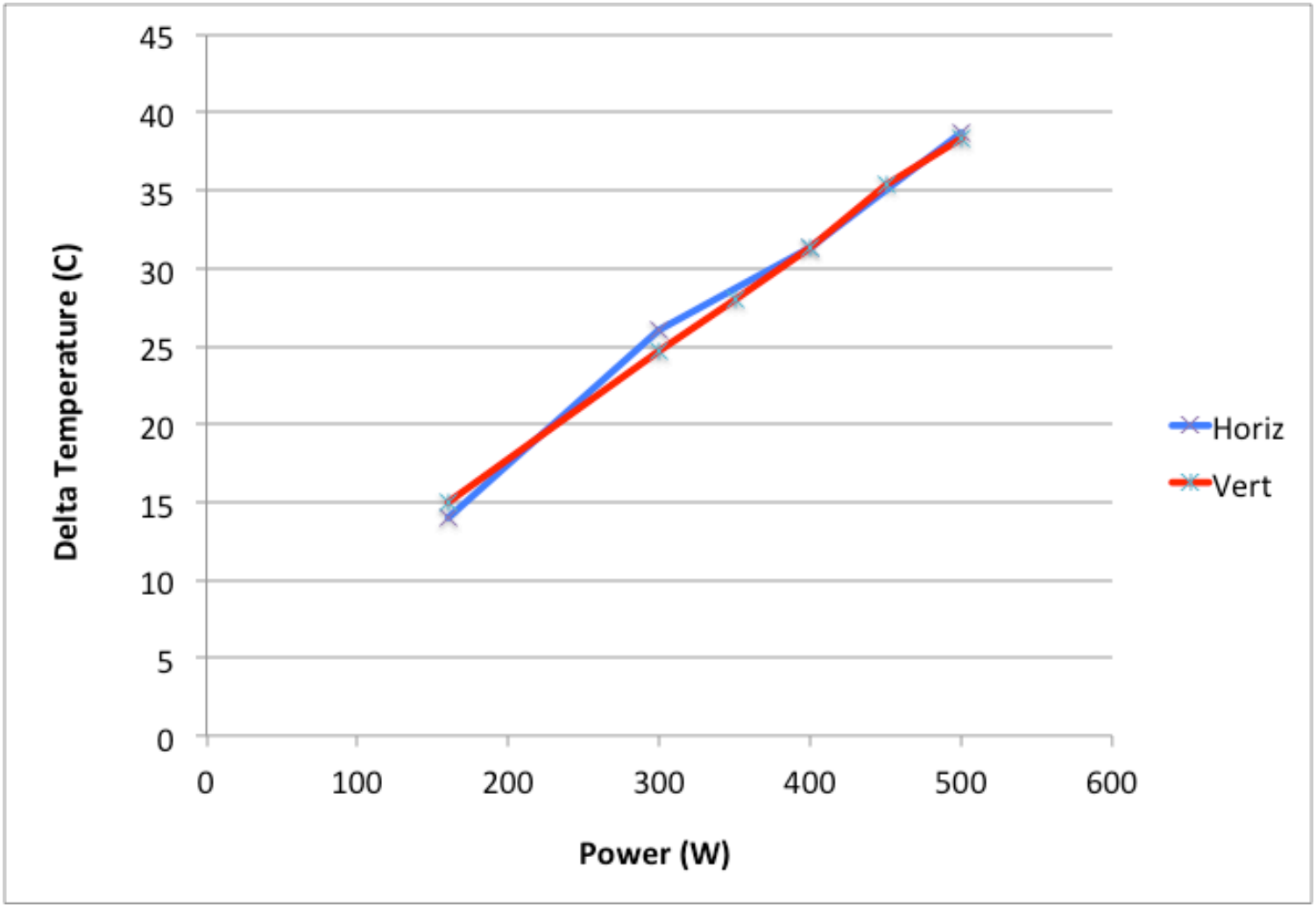
Testing

- Ground
  - 1g Environment
  - Wick Capillary Performance
  - Thermal Vacuum
  - Power Capacity
  - Vibration
- Parabolic
  - 0-2g Gravitational Performance
    - Microgravity, Lunar, and Martian Environments
- Sounding Rocket
  - Peregrine Specific Launch Accelerations
  - 6+ minutes of microgravity

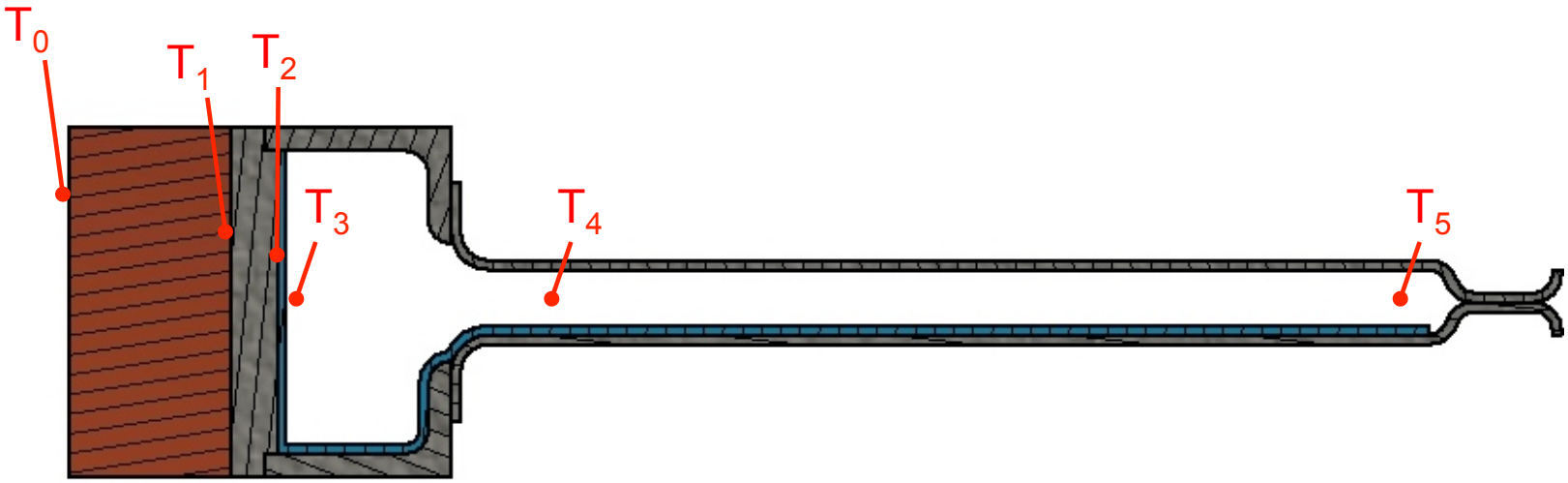
Ground Testing; Wick Performance

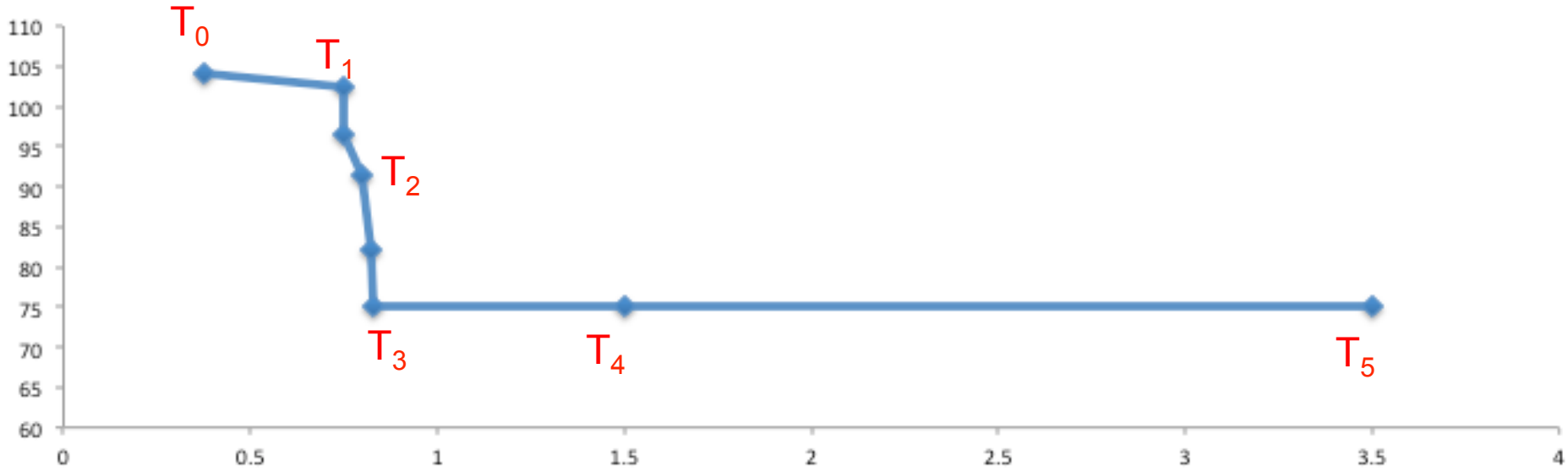


Ground Testing; Thermal Performance



Ground Testing, Thermal Performance Cont.





Parabolic Testing

- 200+parabolas 0-2g
- Multiple power levels
- Multiple Orientations

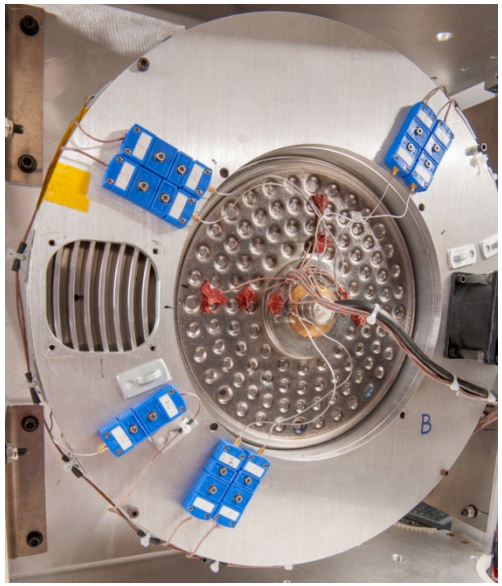
Thermal Performance was unaffected by 0-2g gravity levels!

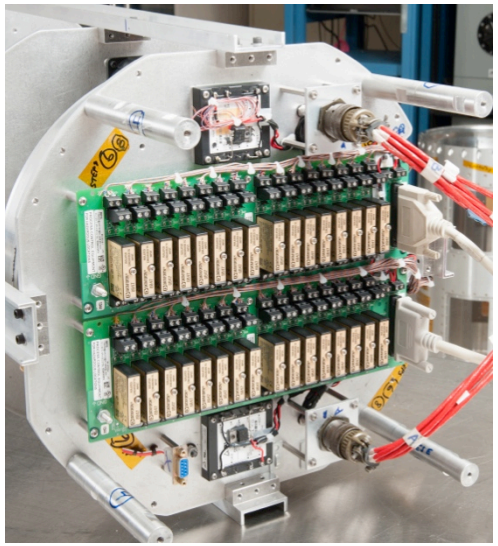
Sounding Rocket Experiment

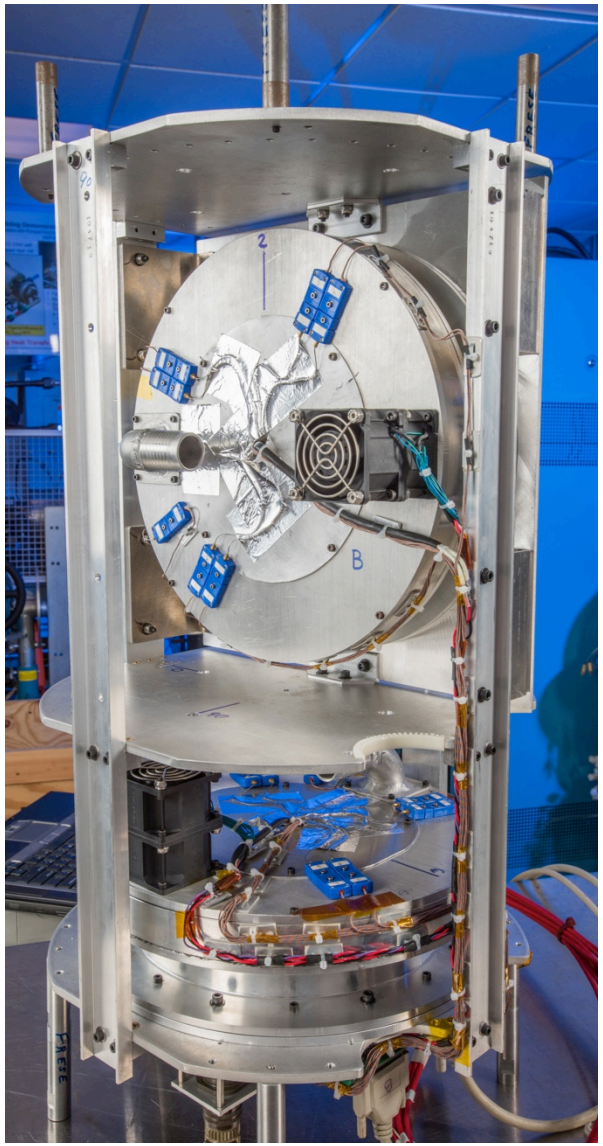
- Radioisotope Power systems are fueled at launch pad and must perform thermal management before, during, and after launch scenarios
- RCHS must be able to:

1. Reject 130Wt from the Stirling convertor to the radiator housing in any spatial configuration during 1g, hyper-gravity, negative gravity, and microgravity. *(For this experiment, the Stirling convertor has been replaced with an electrical heater and the radiator housing with an air/PCM heat exchanger)*

RCHS Experiment







Comparison Data

	RCHS	CSAF
Mass	175g	750g
Delta T @ 130W Heat Rejection	12	10
Max. Thermal Conductance	>1000 W/K	<20 W/K
Temperature Range	50-250C	-200 to 250C

Conclusion

- RCHS heat pipe technology provides a passive thermal control option for current and higher power Radioisotope Stirling Generators
- Current 130W heat rejection application using the RCHS provided a 4:1 decrease in mass over current state of the art with similar thermal performance
- Ground and flight testing of the RCHS has validated the thermal performance over a wide range of environments applicable to TRL5
- Peregrine sounding rocket experiment will validate the RCHS performance through launch and microgravity operations