https://ntrs.nasa.gov/search.jsp?R=20070010765 2019-08-30T00:38:57+00:00Z

Thermal Performance of High Temperature Titanium – Water Heat Pipes by Multiple Heat Pipe Manufacturers

Abstract. Titanium - water heat pipes are being investigated for use in heat rejection systems for lunar and Mars fission surface power systems. Heat pipes provide an efficient and reliable means to transfer heat to a radiator heat rejection system. NASA Glenn Research Center requisitioned nine titanium water heat pipes from three vendors. Each vendor supplied three heat pipes 1.25 cm diameter by 1.1 meter long with each vendor selecting a different wick design. Each of the three heat pipes is slightly different in construction. Additional specifications for the heat pipes included 500 K nominal operating temperature, light weight, and freeze tolerance. The heat pipes were performance tested gravity-aided, in the horizontal position and at elevations against gravity at 450 K and 500 K. Performance of the three heat pipes is compared. The heat pipe data will be used to verify models of heat pipe radiators that will be used in future space exploration missions.

Sest, Inc.

Thermal Performance of High Temperature Titanium – Water Heat Pipes by Multiple Heat Pipe Manufacturers

Presented at the
2007 Space Technology and International Forum
February 2007
Albuquerque, NM

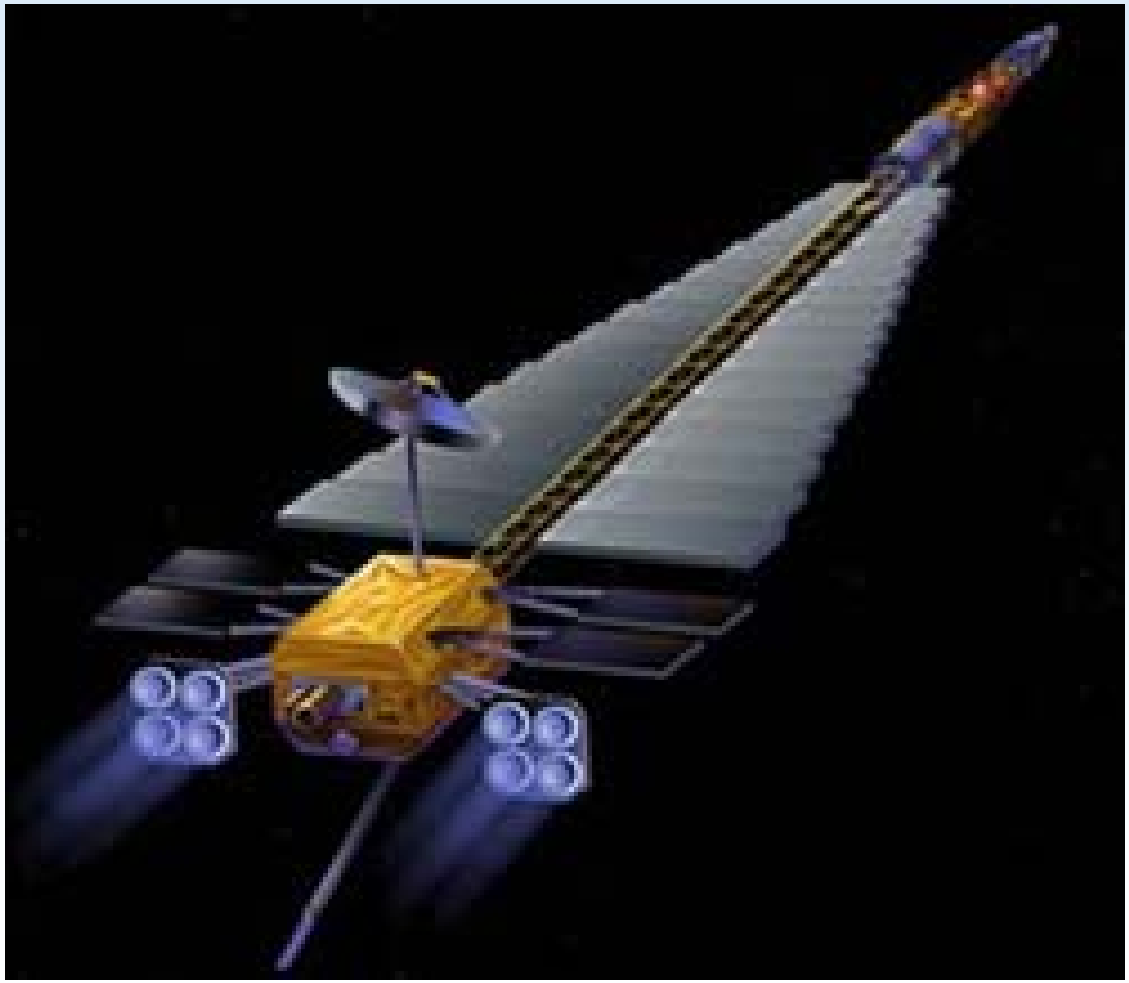
James Sanzi

Sest, Inc.

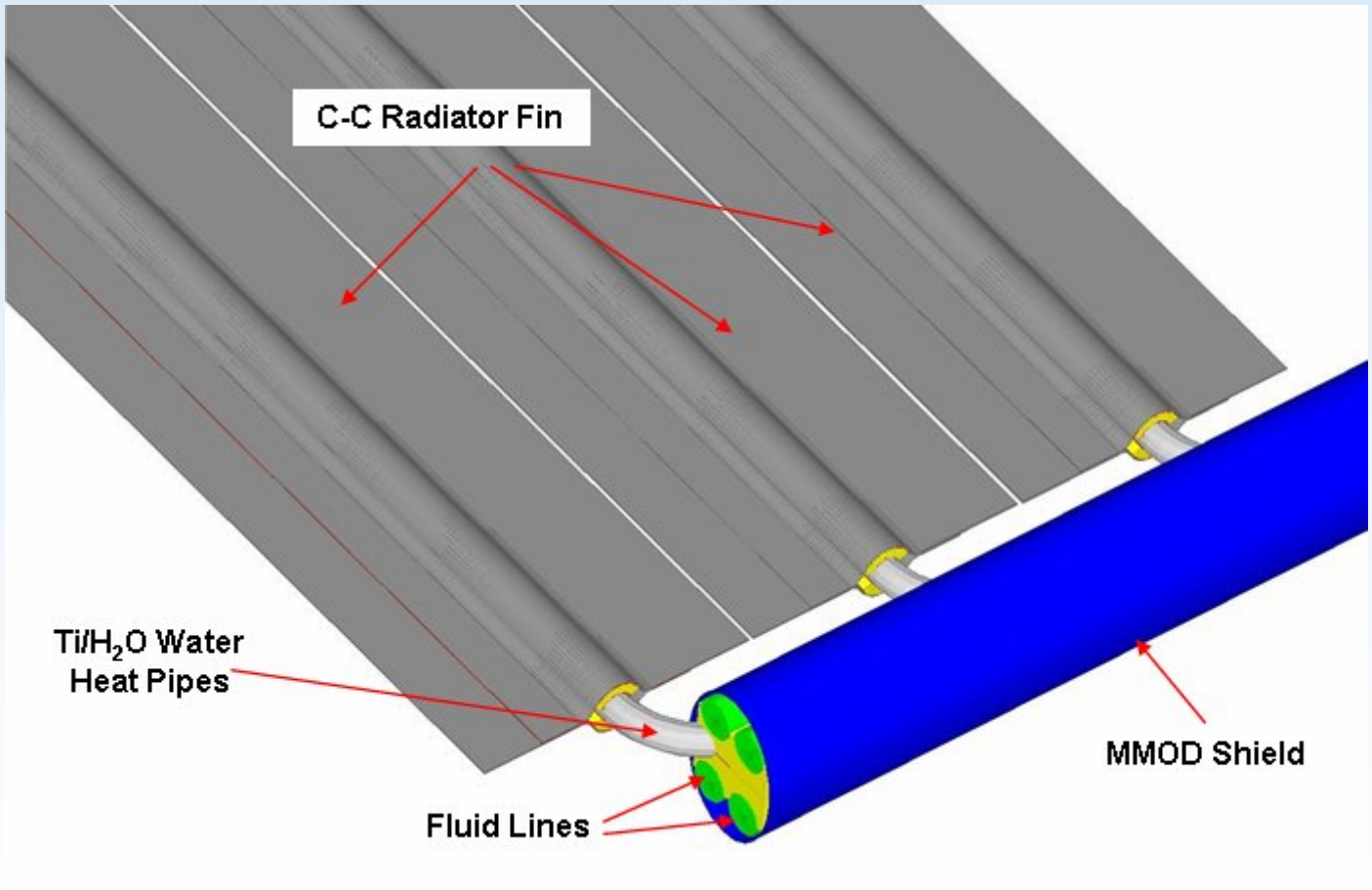
Middleburg Heights, OH

Sest, Inc.

- **Titanium - water heat pipes are being investigated for use in heat rejection systems for lunar and Mars fission surface power systems.**
- **NASA Glenn Research Center requisitioned nine titanium water heat pipes from three vendors.**
- **The heat pipes were performance tested gravity aided, in the horizontal position and at elevations against gravity at 450 K and 500 K.**



Jupiter Icy Moon Orbiter (JIMO) Concept



Heat Pipes Integrated in Heat Rejection Radiator Panel

What is a Heat Pipe?

Sest, Inc.

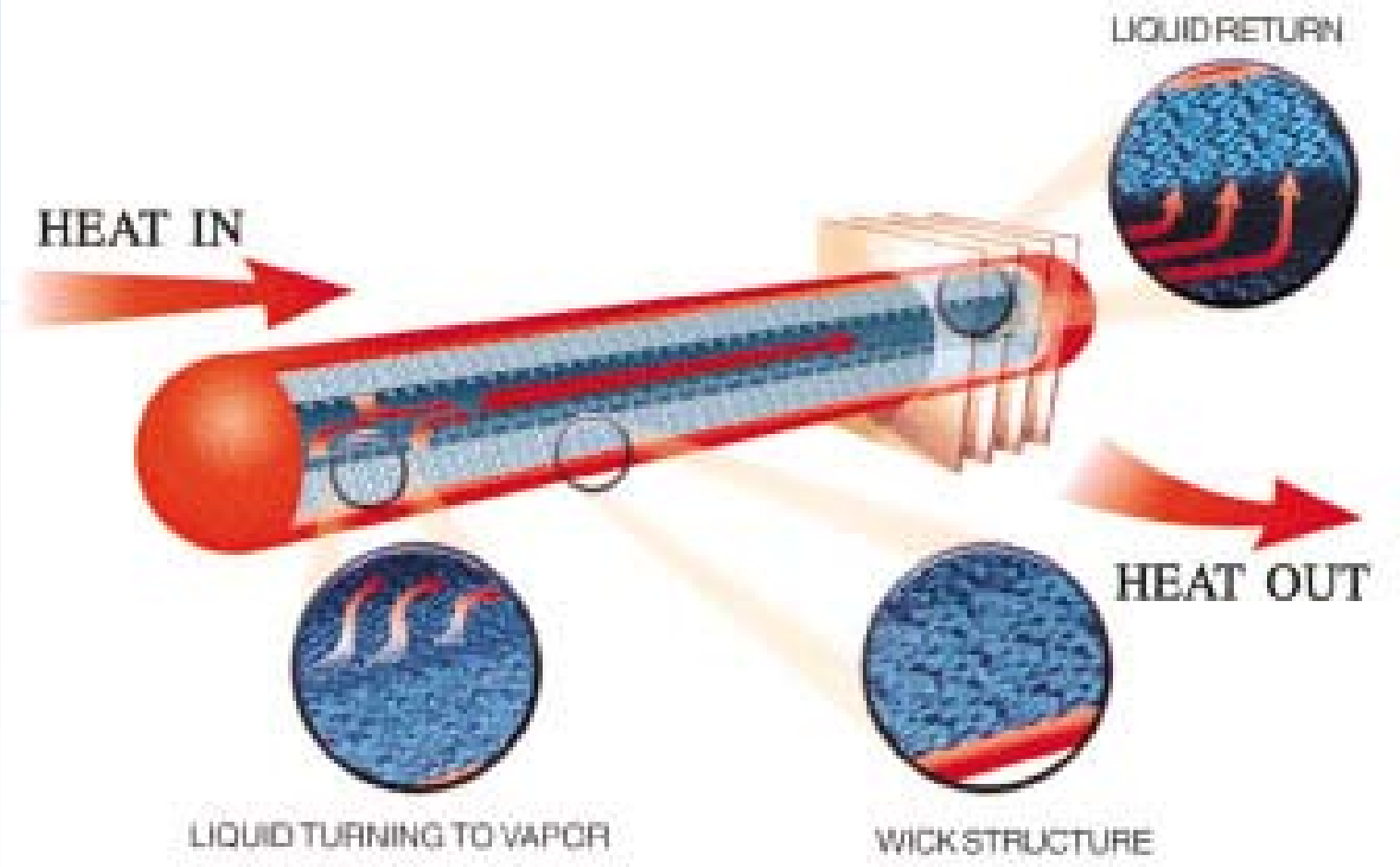


Illustration of a Capillary Two-Phase Heat Transfer Device- a Heat Pipe

What is a Heat Pipe?

Sest, Inc.

- A heat pipe in its simplest form is a passive two-phase heat transfer device in a sealed tube.
- The evaporator region of the heat pipe is in thermal contact with a heat source.
- The envelope of the heat pipe is typically made of a high conductivity material and transports the heat to the liquid inside.
- The only fluid inside the heat pipe is the working fluid in thermodynamic equilibrium with its own vapor.
- Liquid in the evaporator region evaporates to vapor and is transported to the other end of the tube where the vapor condenses to release the latent heat to the tube wall.
- The condensed fluid is transported back to the evaporator region by the capillary action of a wick that lines the inner wall of the tube, hence the device is passive.

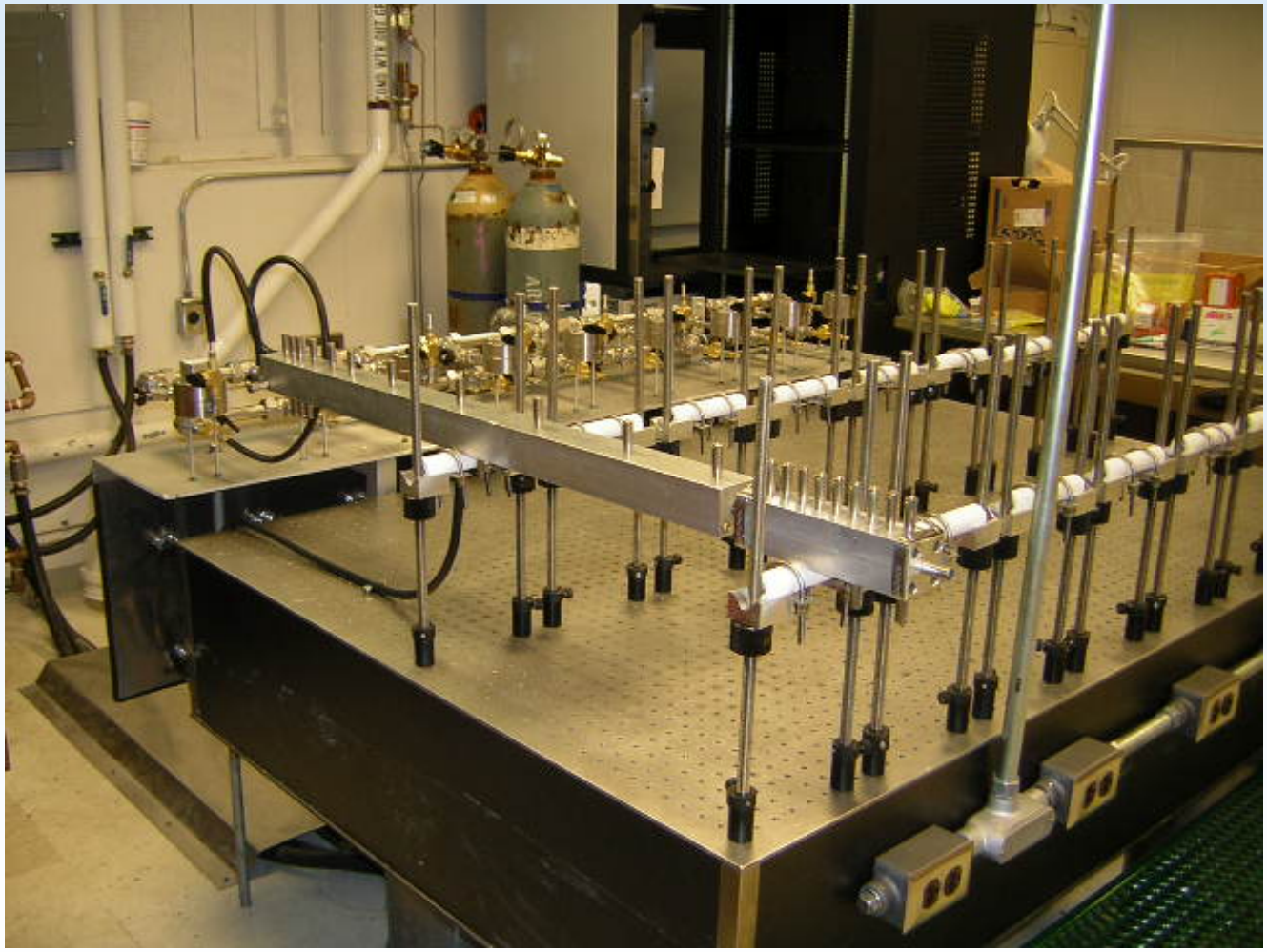
Heat Pipe Specifications

Sest, Inc.

Nominal Operating Temperature (K)	500
Operating Temperature Range (K)	310 to 550
Heat Pipe Heat Transfer Capability (K)	Maximize Power at 500
Heat Pipe Outer Diameter (cm)	1.27
Wall Thickness	Meet ASME Section VIII Boiler and Pressure Vessel Code
Heat Pipe Evaporator Length (cm)	25
Heat Pipe Adiabatic Length (cm)	0
Heat Pipe Condenser Length (cm)	90
Heat Pipe Mass	Minimize
Wick Structure	To Be Specified by Vendor
Heat Pipe Closure	Titanium Valve
Heat Pipe Material and Construction	Titanium Grade 2
Proof Pressure Test	Design Calculations and Validation

Heat Pipe Test Setup

Sest, Inc.

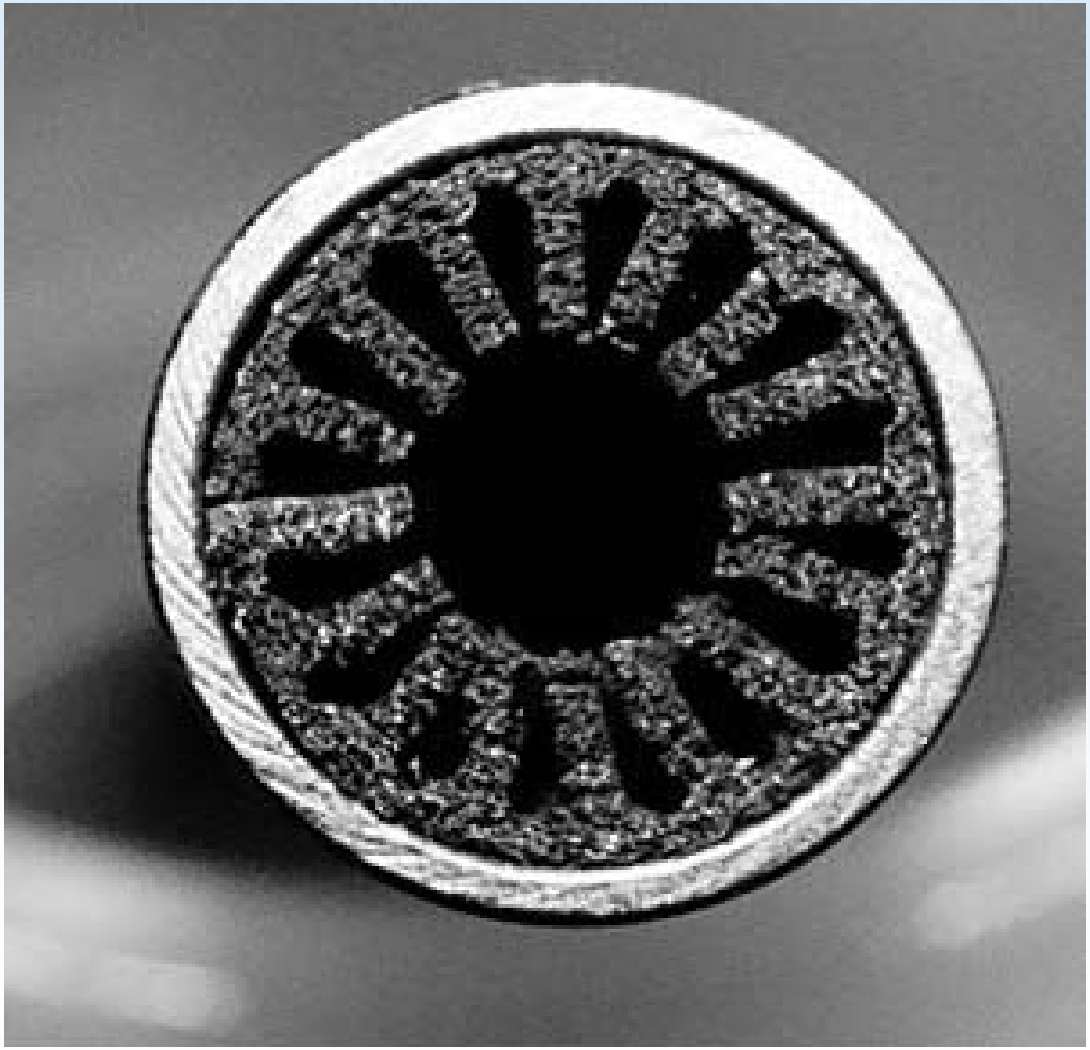


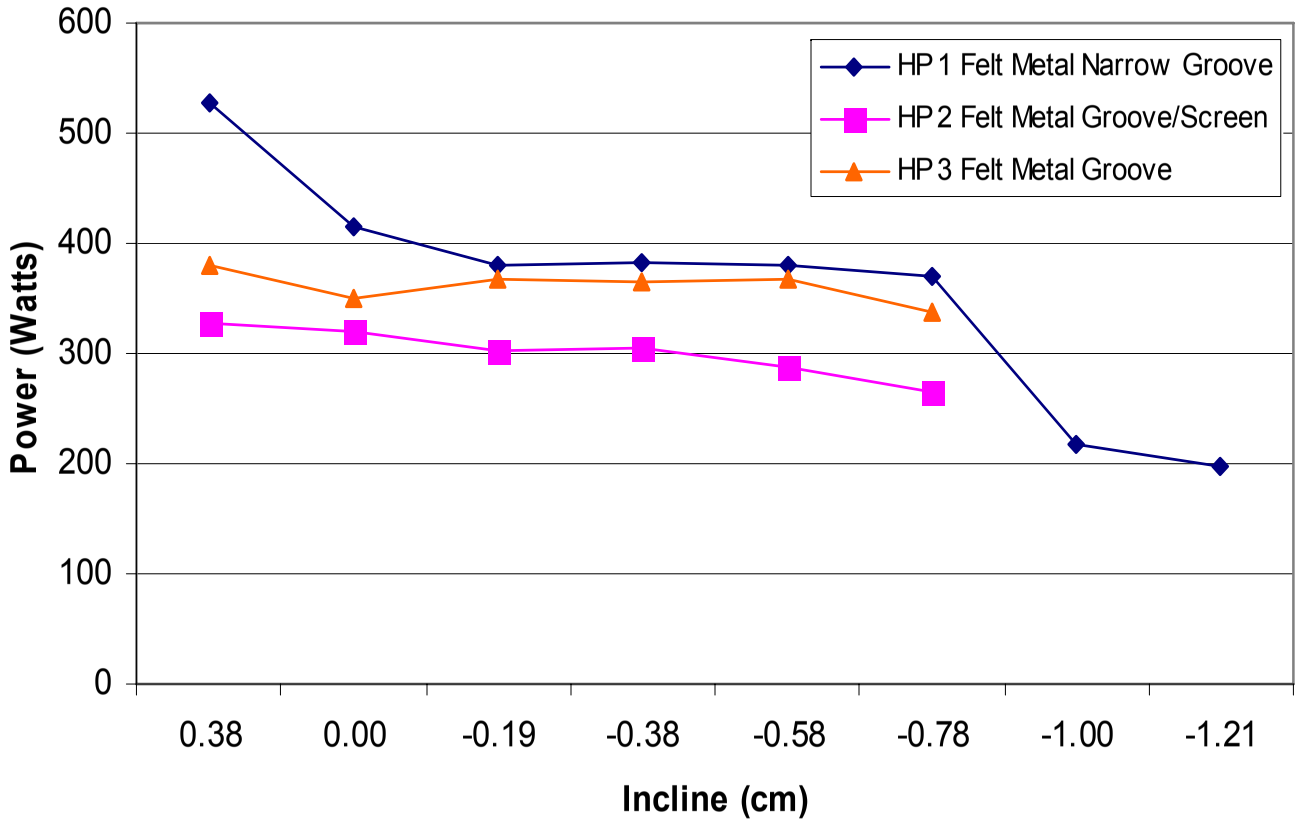
Heat Pipe Test Setup

Sest, Inc.

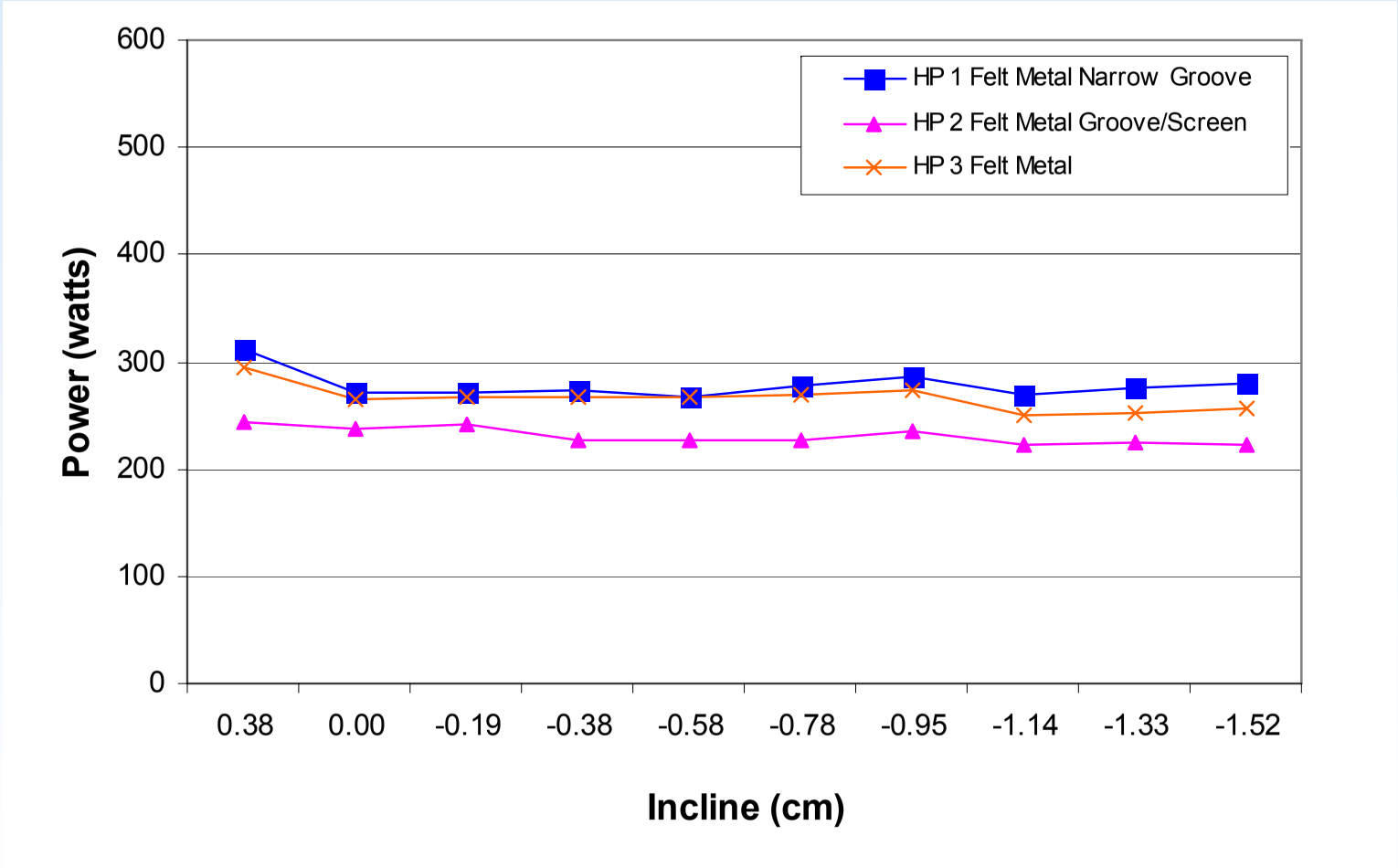
Felt Metal Wick

Sest, Inc.





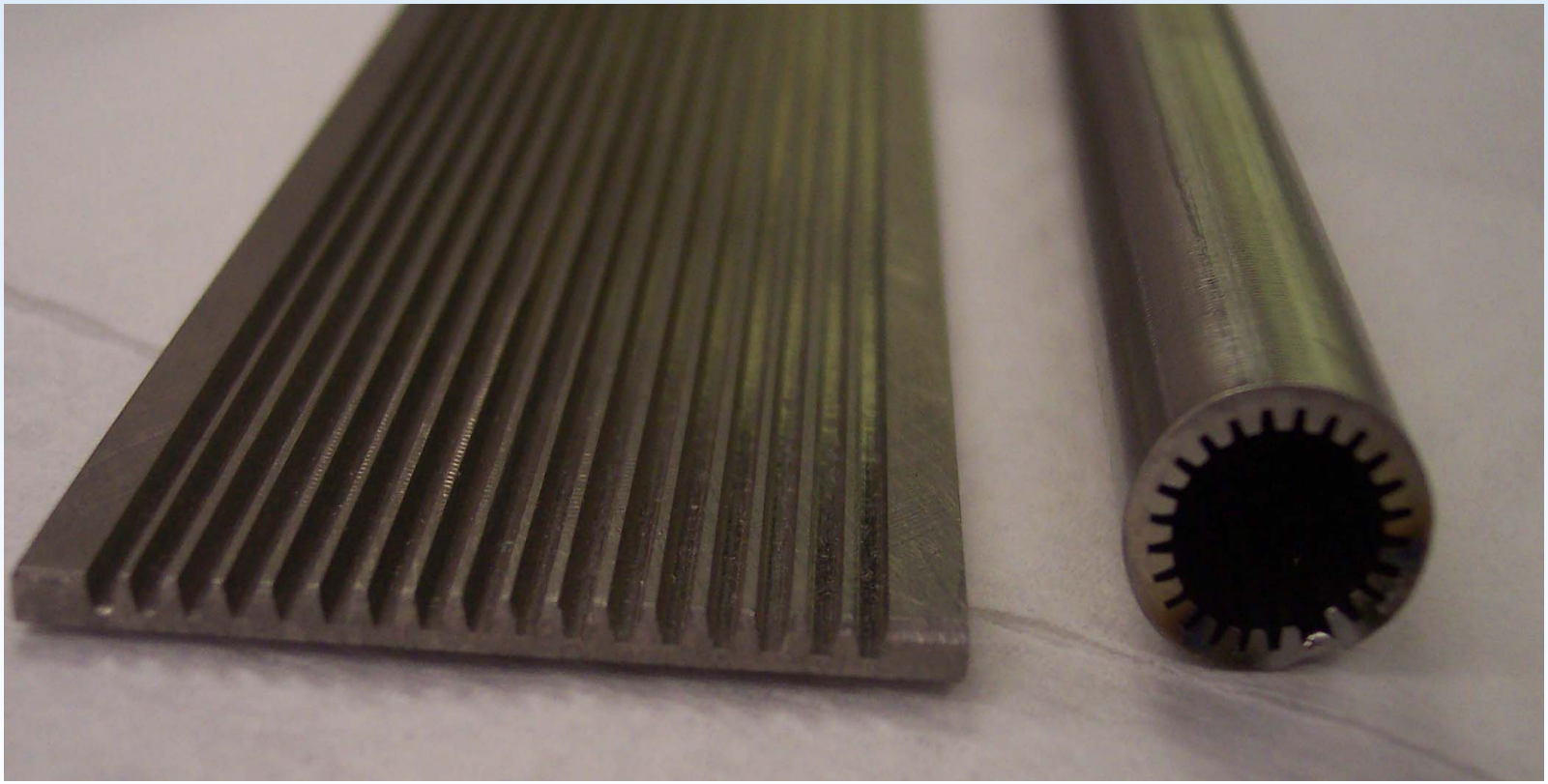
Heat Pipe Performance for Felt Metal Axial Groove at 500 K.



Heat Pipe Performance for Felt Metal Groove Heat Pipes at 450 K.

Machine Groove

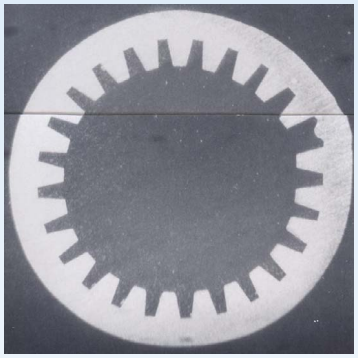
Sest, Inc.



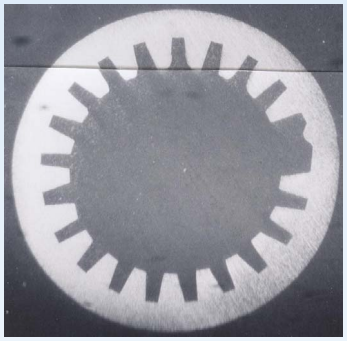
The solid groove heat pipes are fabricated from a flat plate.

Machine Groove

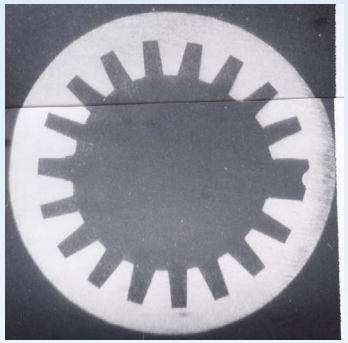
Sest, Inc.



.020” x .040” Groove
23 Grooves

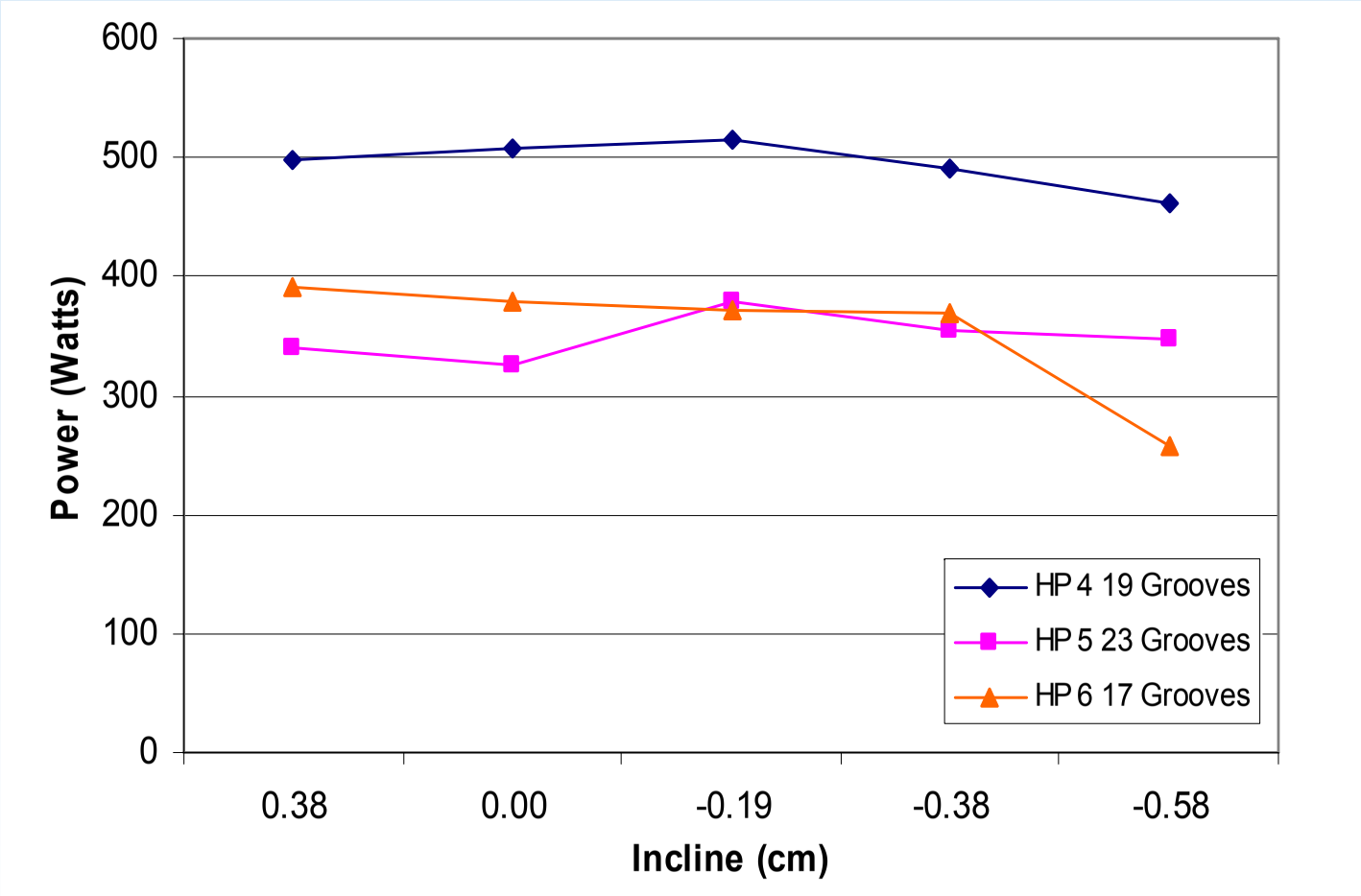


.025” x .050” Groove
19 Grooves

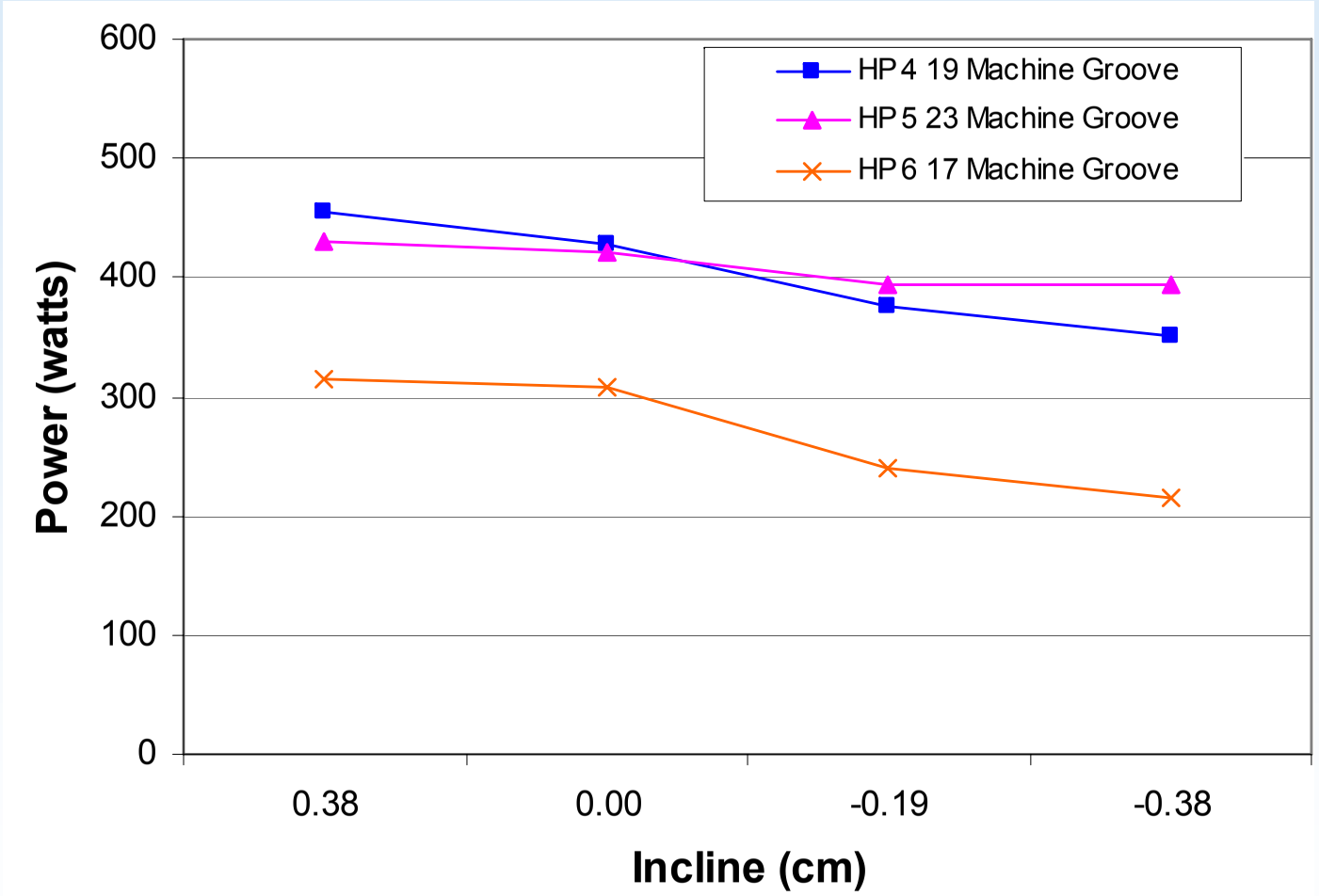


.030” x .060” Groove
17 Grooves

Heat pipes were fabricated with three different groove dimensions: 23 grooves, 0.51 mm x 1.02 mm (0.020” x 0.040”), 19 grooves, 0.64 mm x 1.27 mm, and 17 grooves, 0.76 mm x 1.52 mm.



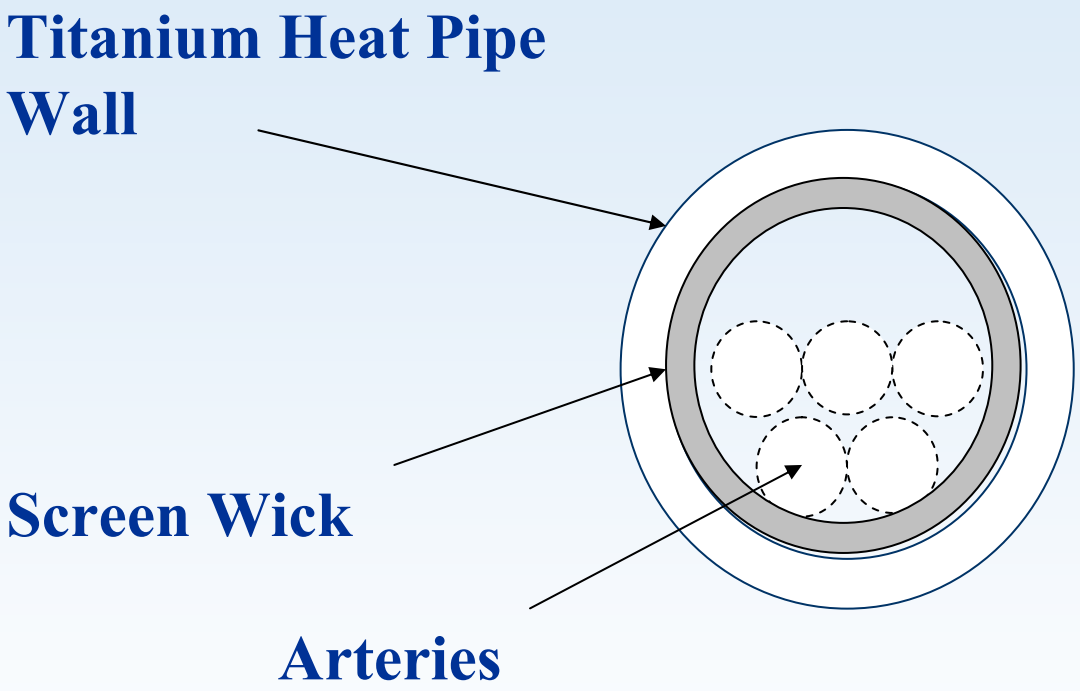
Heat Pipe Performance for Machined Solid Axial Groove at 500 K.



Heat Pipe Performance for Machined Groove Heat Pipes at 450 K.

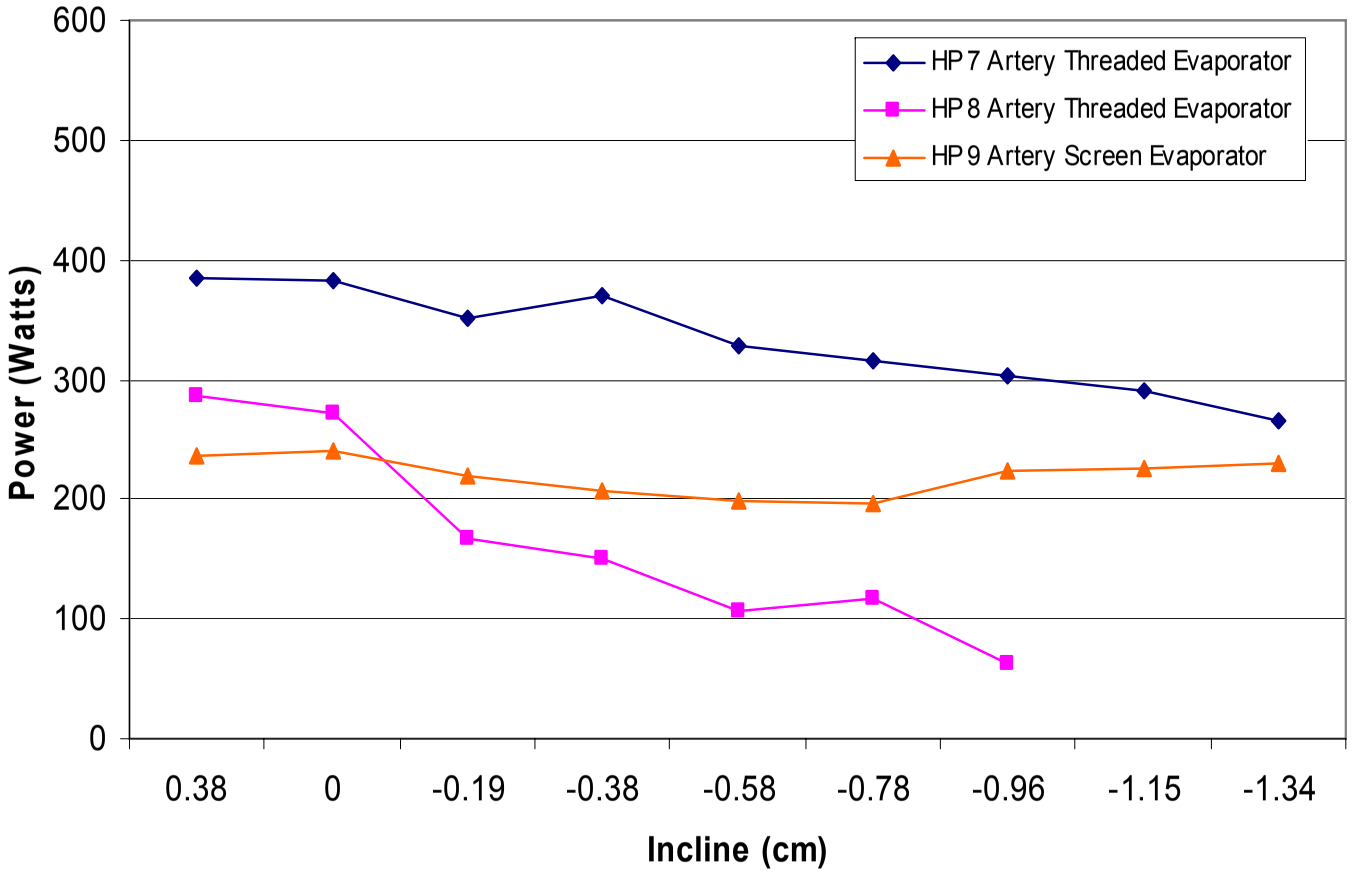
Screen Axial Artery

Sest, Inc.

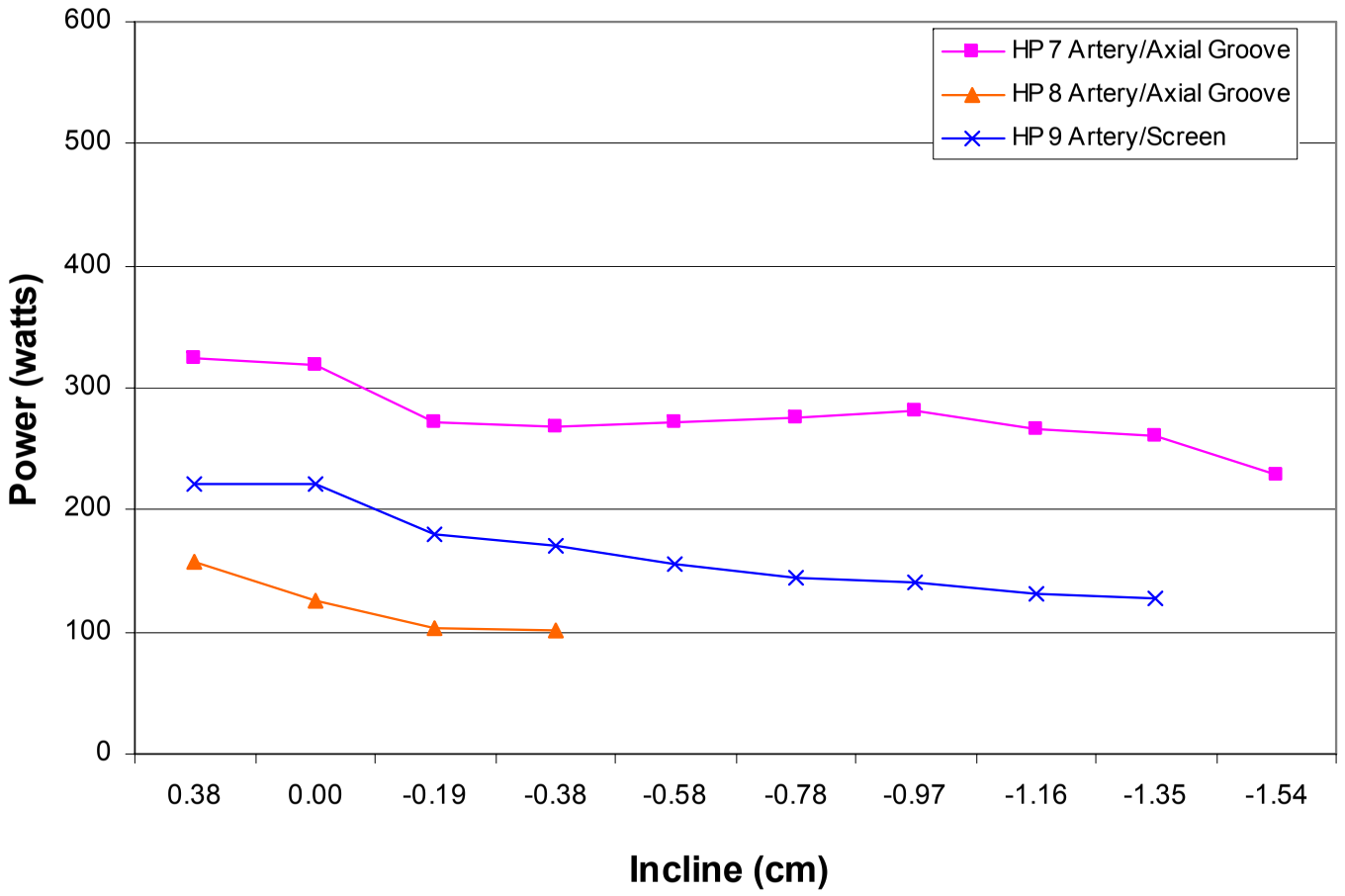


Screen Axial Artery

Sest, Inc.



Heat Pipe Performance for Screen Axial Artery at 500 K



Heat Pipe Performance for Screen Axial Artery at 450 K

Conclusions

Sest, Inc.

- NASA GRC procured nine heat pipes of different designs from three manufacturers.
- Titanium – water provides high temperature heat pipe options for space radiators.
- The heat pipes were tested at 450 K and 500 K at various elevations and inclinations.
- The best heat pipes rejected >500 watts at 500 K operating temperature.

ACKNOWLEDGMENTS

Sest, Inc.

This work was carried out at NASA Glenn Research Center at Lewis field and was supported by Exploration Systems/Prometheus. The opinions expressed in this presentation are those of the author and do not necessarily reflect the views of the National Aeronautics and Space Administration.
Duane Beach provided guidance throughout the development and implementation of the program.

NASA