QUALIFICATION TESTING OF 3D-PRINTED LOOP HEAT PIPE WITH DEPLOYABLE RADIATOR

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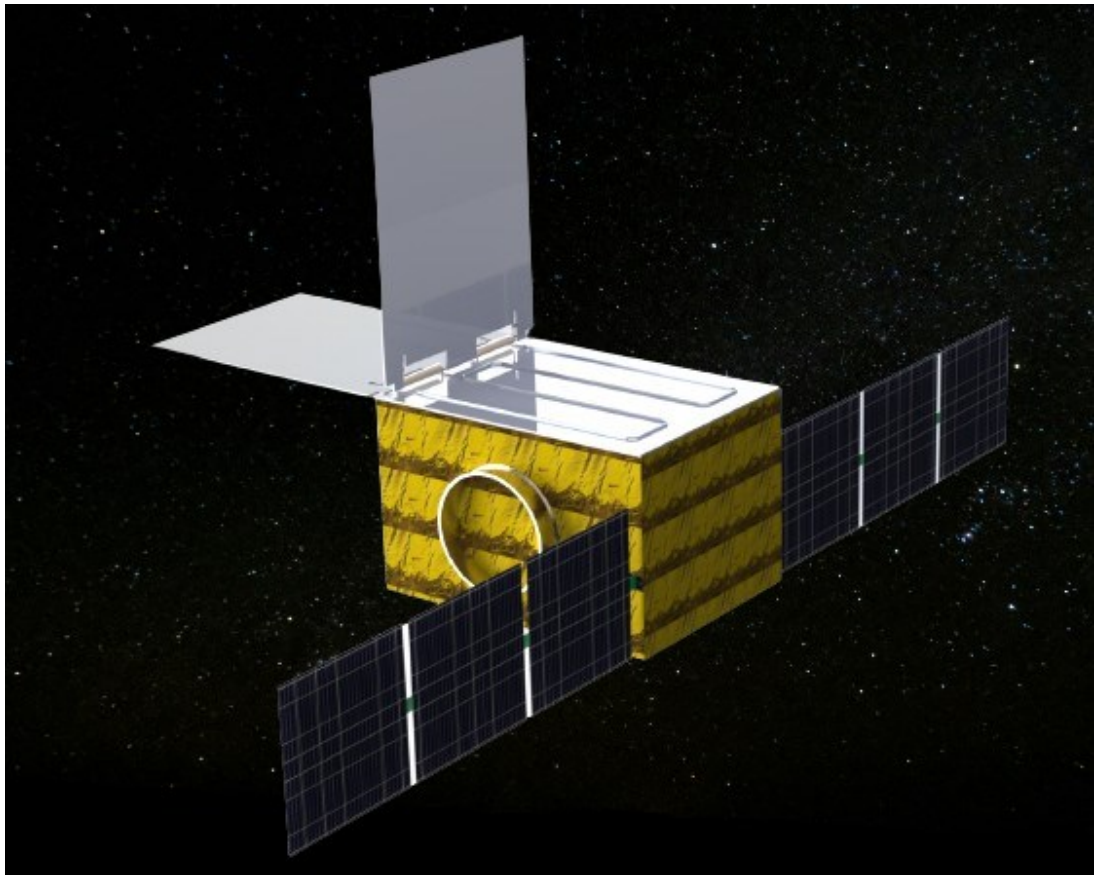
Agenda

- Motivation
- 3DP LHP and DRP Construction
- Laboratory Testing
- Vacuum Chamber Testing
- Next Steps

Motivation

- The AFRL is interested in increasing the heat rejection capabilities for SmallSats
- Rejecting more heat requires a deployable radiator panel (DRP), but current solutions have a high thermal resistance
- The 3DP Loop Heat Pipe (LHP) is ideal for this application because of its lower cost and reduced lead time

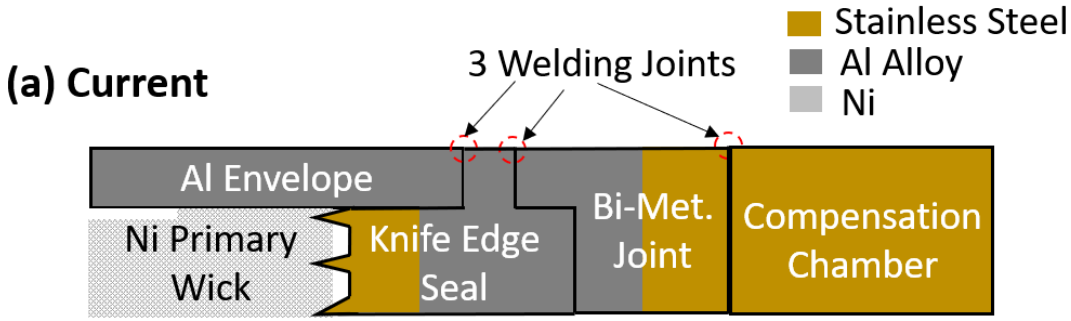


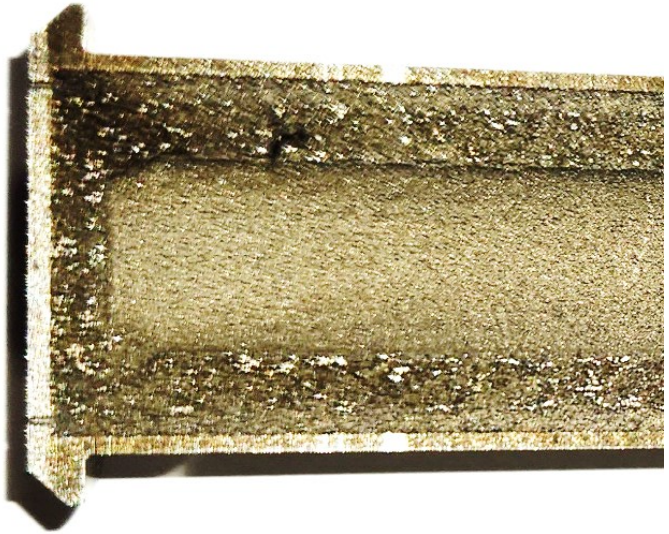
System Design Requirements

- 250W of additional heat rejection from a deployable radiator panel (DRP)
- 3DP Loop Heat Pipe (LHP)
- ESPA sized DRP
- High system conductance
- Small volume

3D Printed Loop Heat Pipe

- The 3DP evaporators eliminate the costly and labor-intensive knife edge seal found on current LHP evaporators
- The evaporator envelope, primary wick, and seal are printed as one piece
- The bottom figure shows the 3DP wick structure





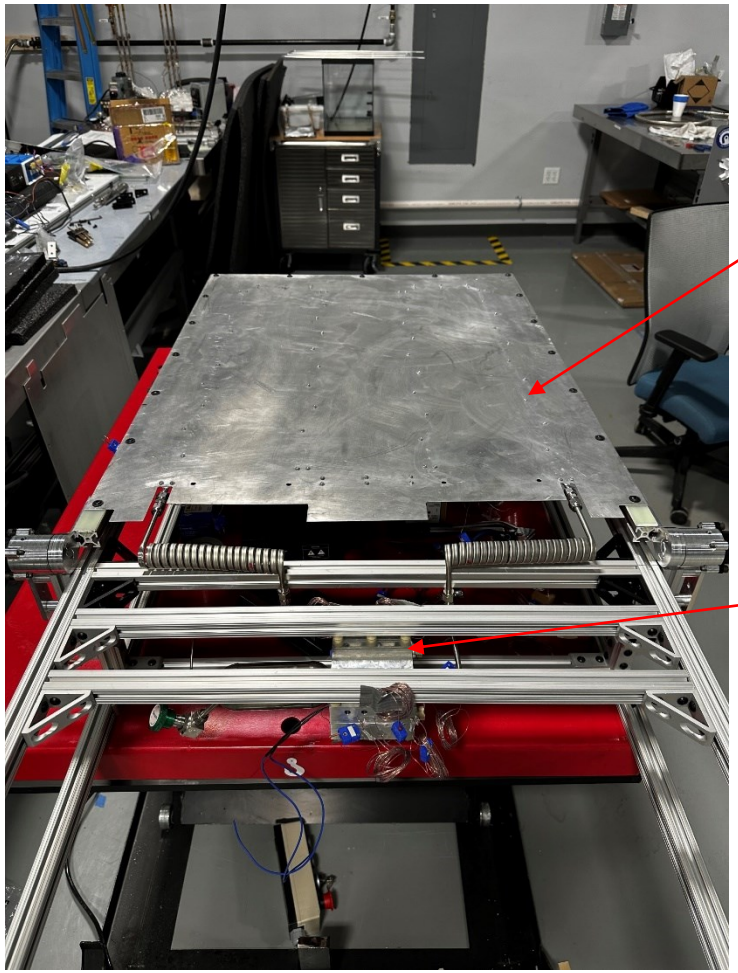
3D Printed LHP Specifications

- 1” in diameter, 4” in length
- 316L SS primary wick and sleeve
- SS compensation chamber and secondary wick
- Manufactured with LPBF
- Single-piece component (Primary wick and sleeve)
- 6-micron pore radius
- Ammonia as the working fluid

Deployable Radiator Panel Specifications

- The panel is a 1/32” sheet of 6061-T6 aluminum
- The condenser line is 6061-T6 aluminum, 0.25” OD
- The bourdon coil hinge is constructed from 316L SS
- The radiative surface is coated in black paint
- Hinges are custom fabricated from 6061-T6 aluminum.
- G-10 is used to isolate the radiator panel from the support structure

Ambient Condition Testing of the LHP and DRP



DRP

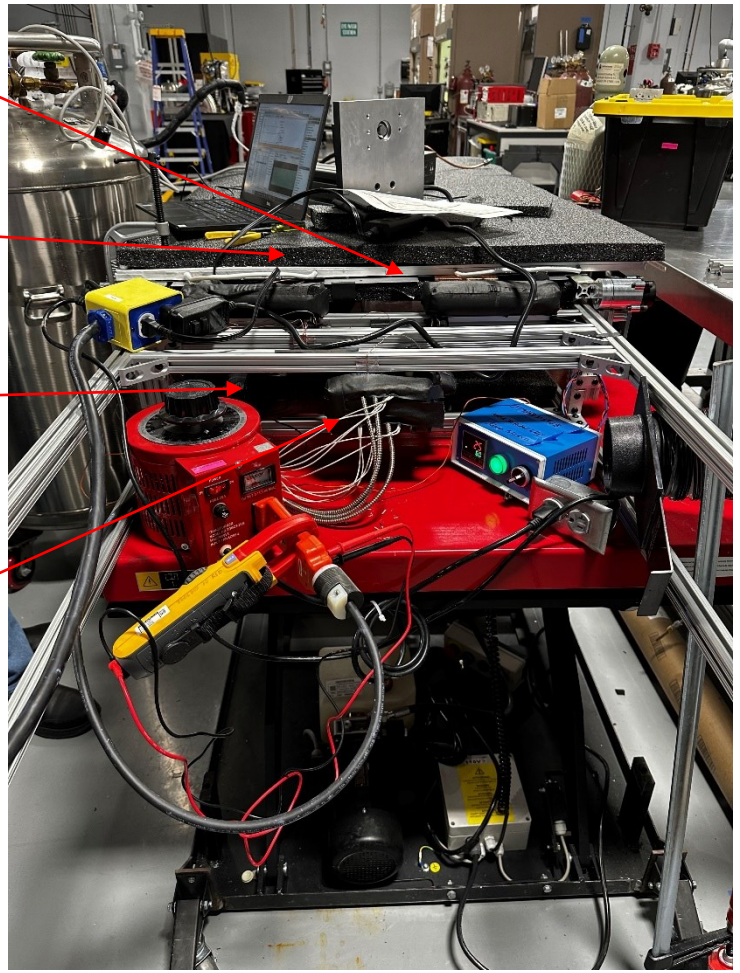
Evaporator Assembly

Cold Plate

Insulation

PLC

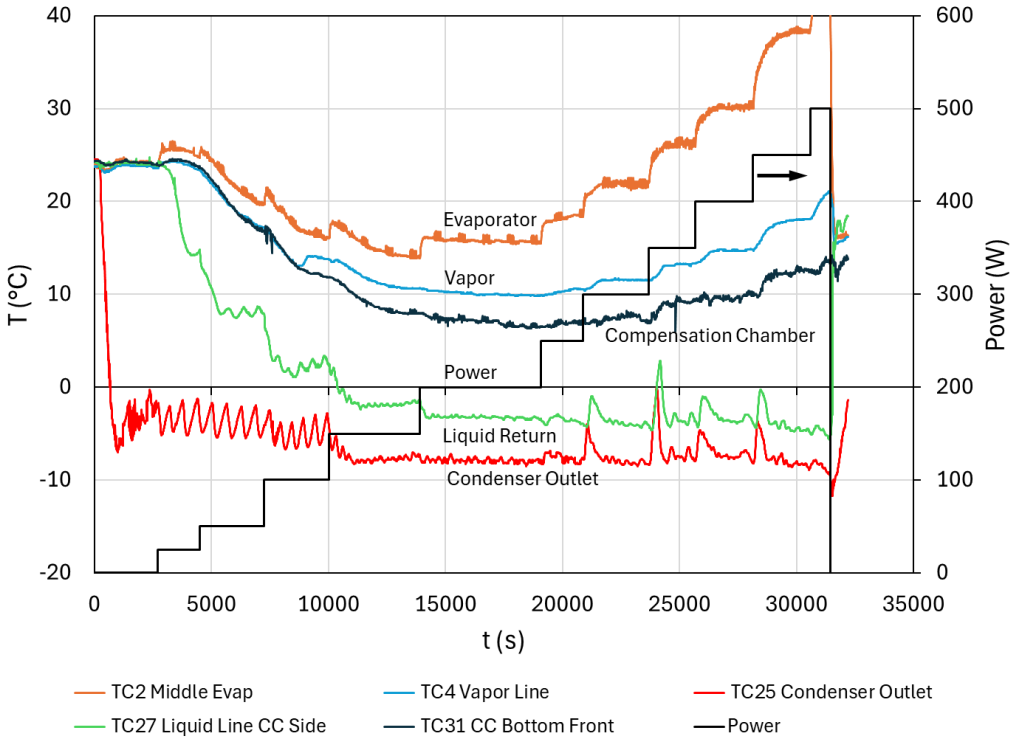
Heaters

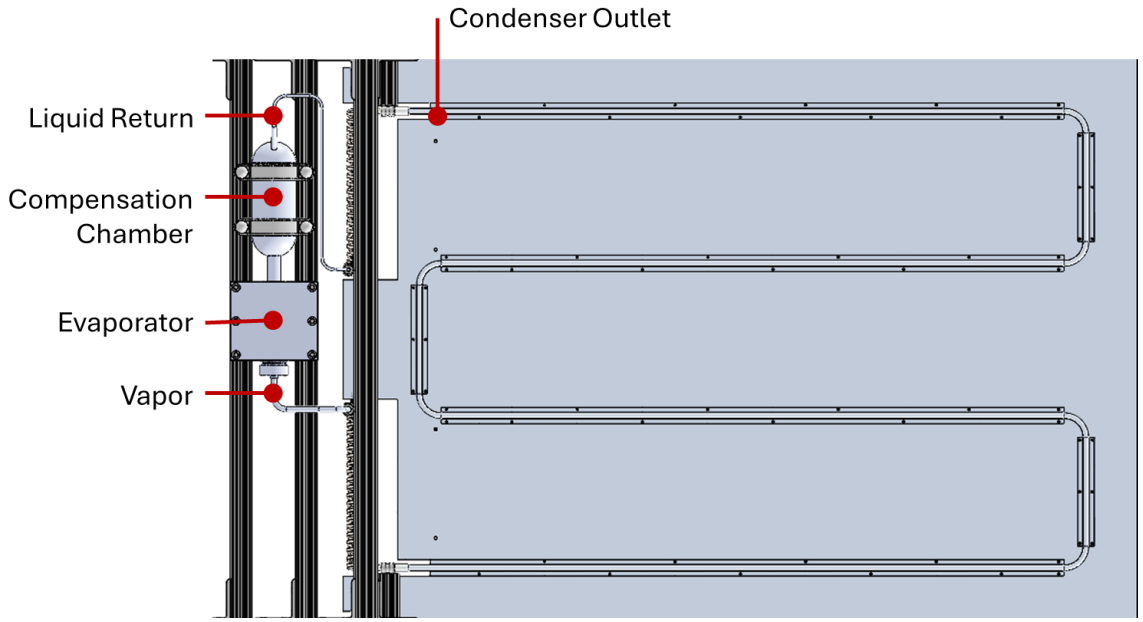


Ambient Testing and Startup

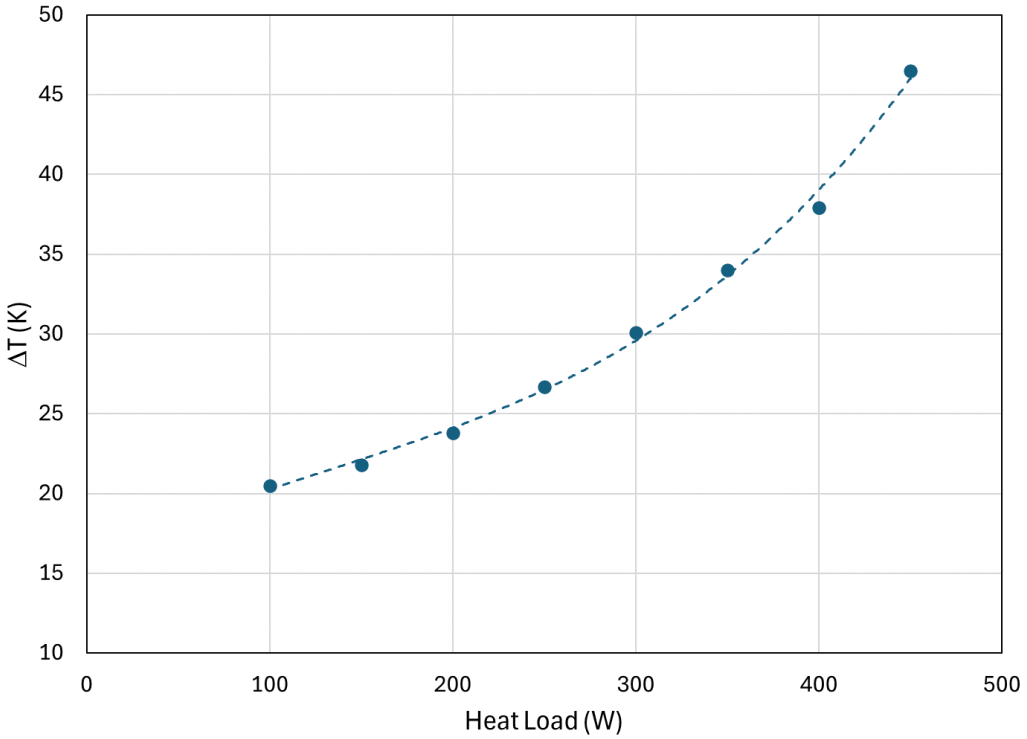
LHP laboratory test results:

- Loop starts at ~ 25 ° C.
- The LHP was tested up to 500 W heat load.
- The loop conductance has a maximum of 10 W/K at a heat load of 300 W.

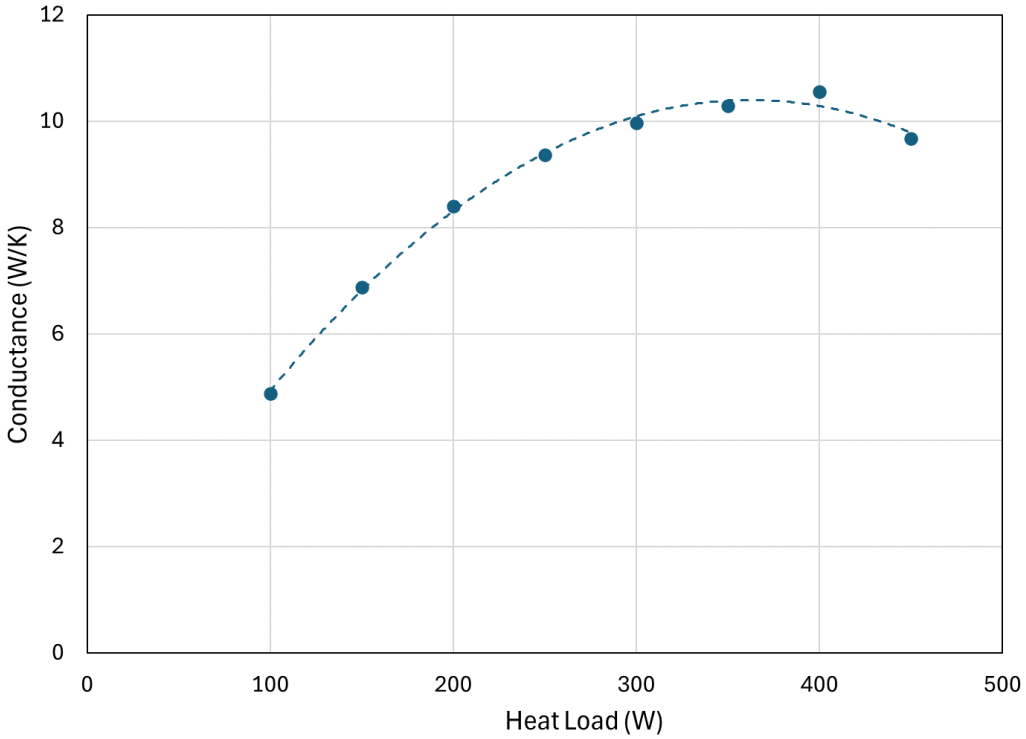




System Conductance

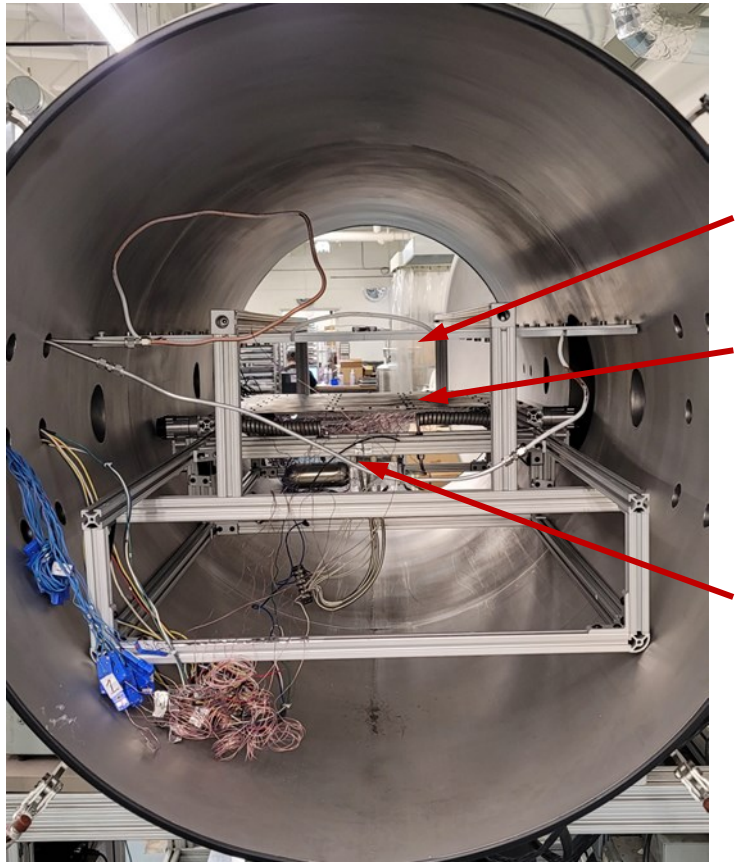


Temperature difference between evaporator surface and condenser outlet.



Heat removed for 1 K difference between evaporator surface and condenser outlet.

Vacuum Chamber Testing



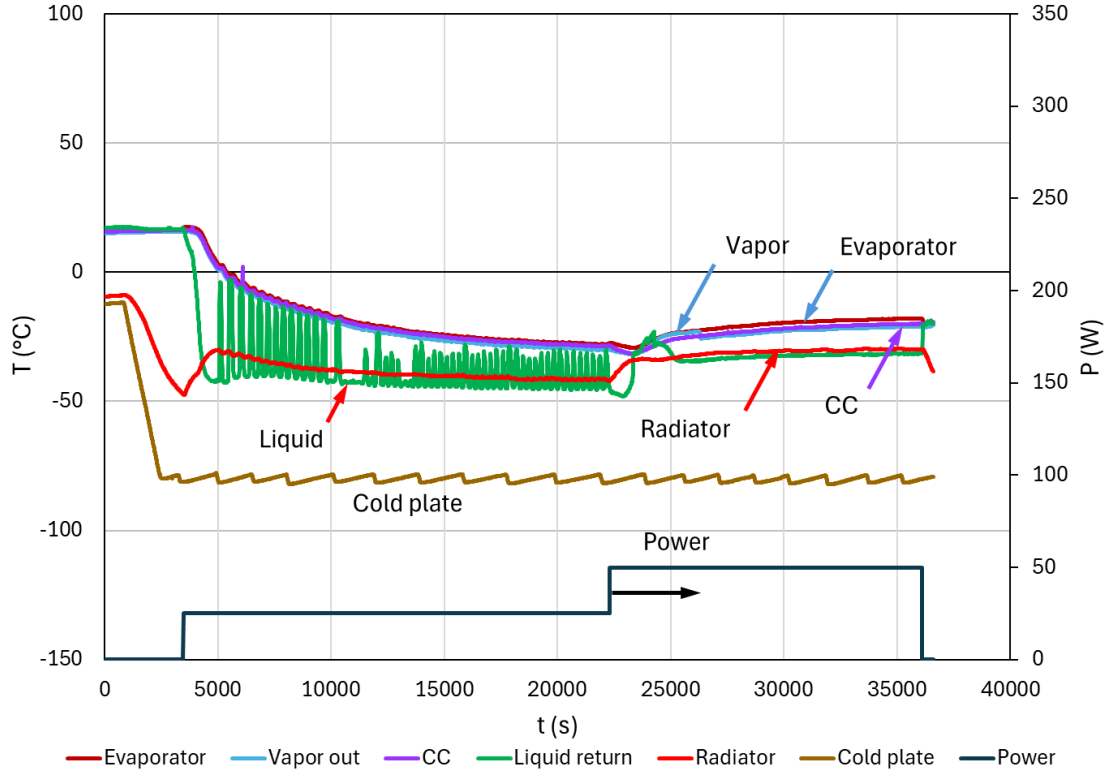
Cold plate

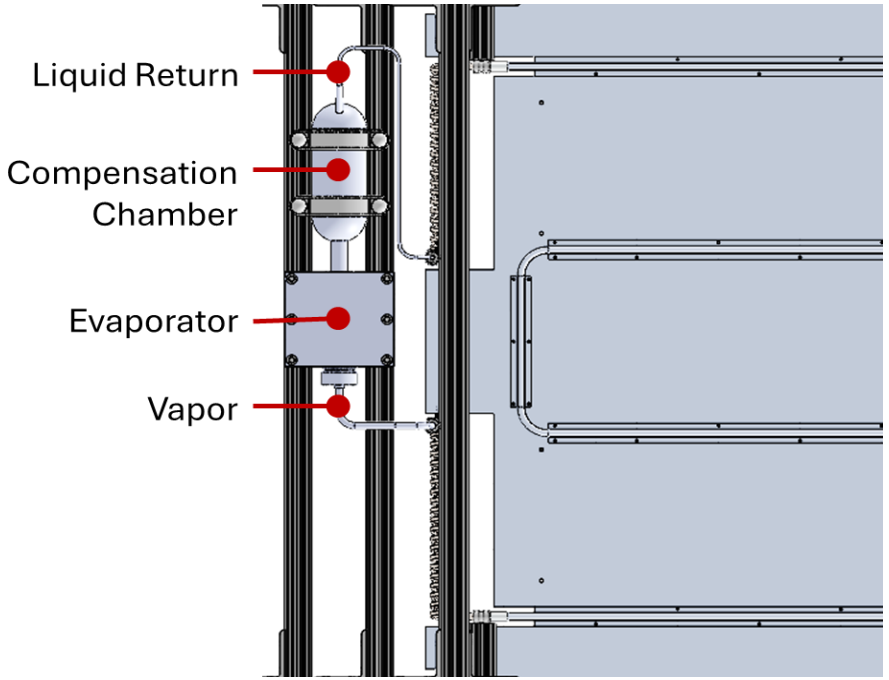
Radiator

Compensation chamber and evaporator

Start Up

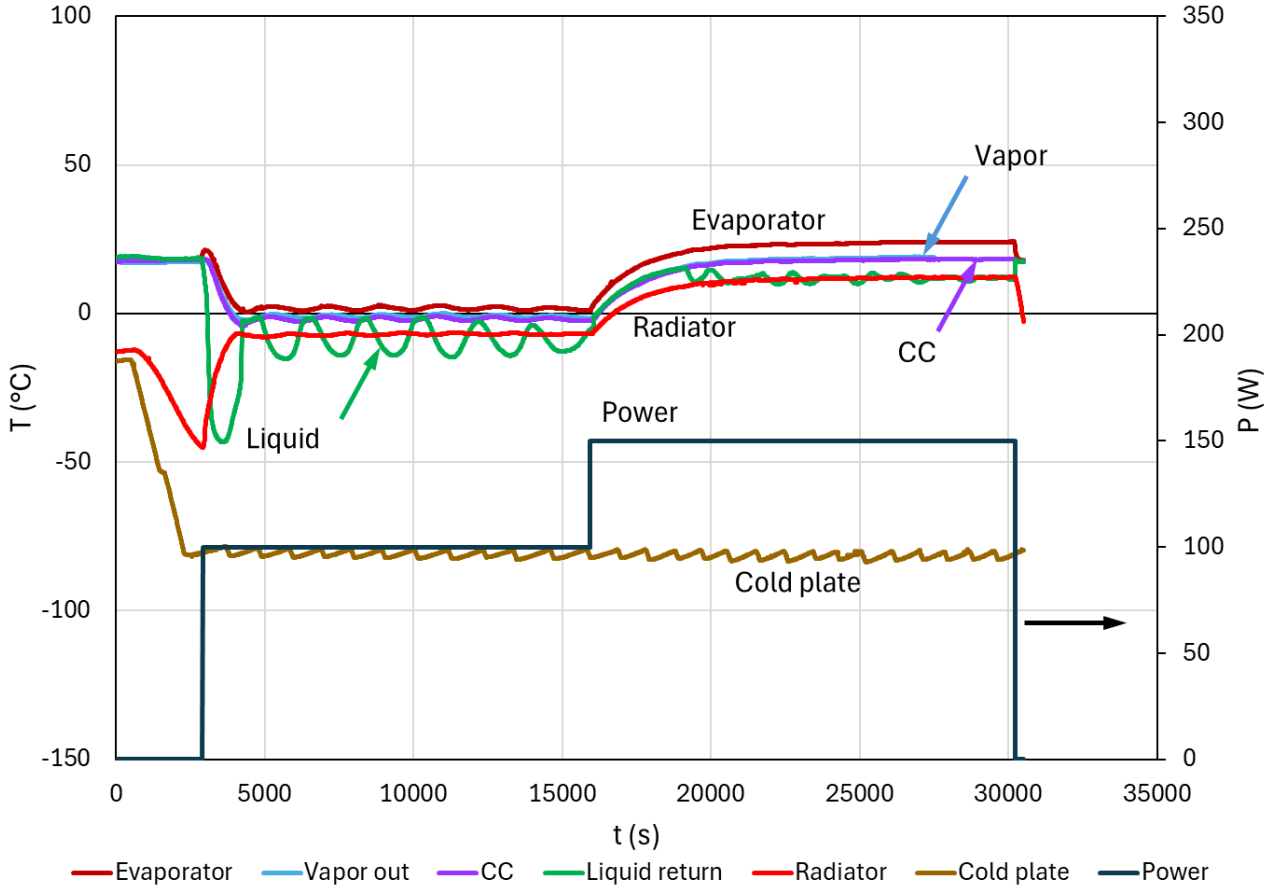
- The cold plate is held at -80 Celsius.
- Start up occurs at 25W

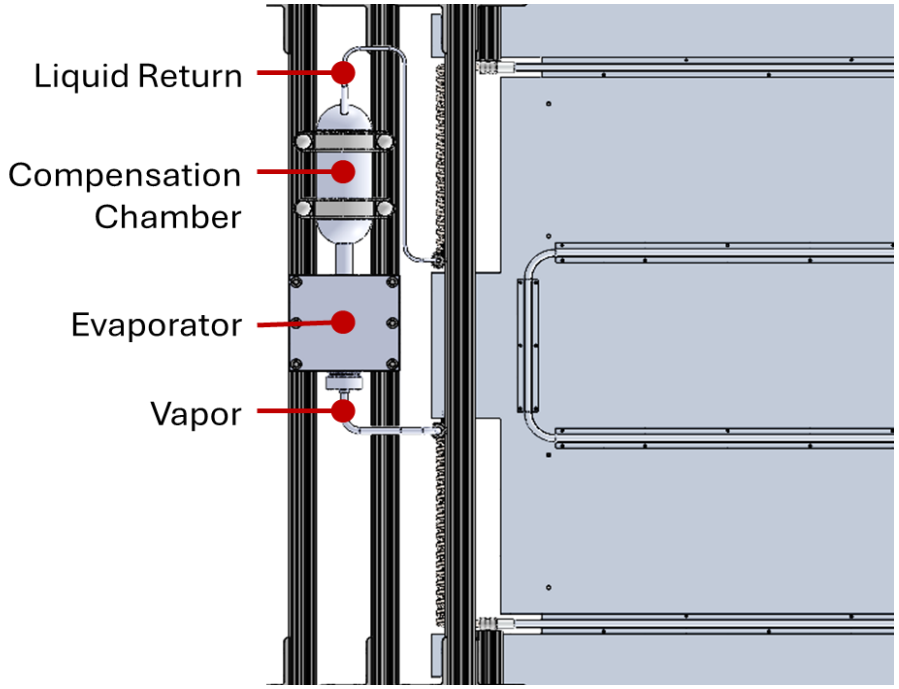




Steady State Operation

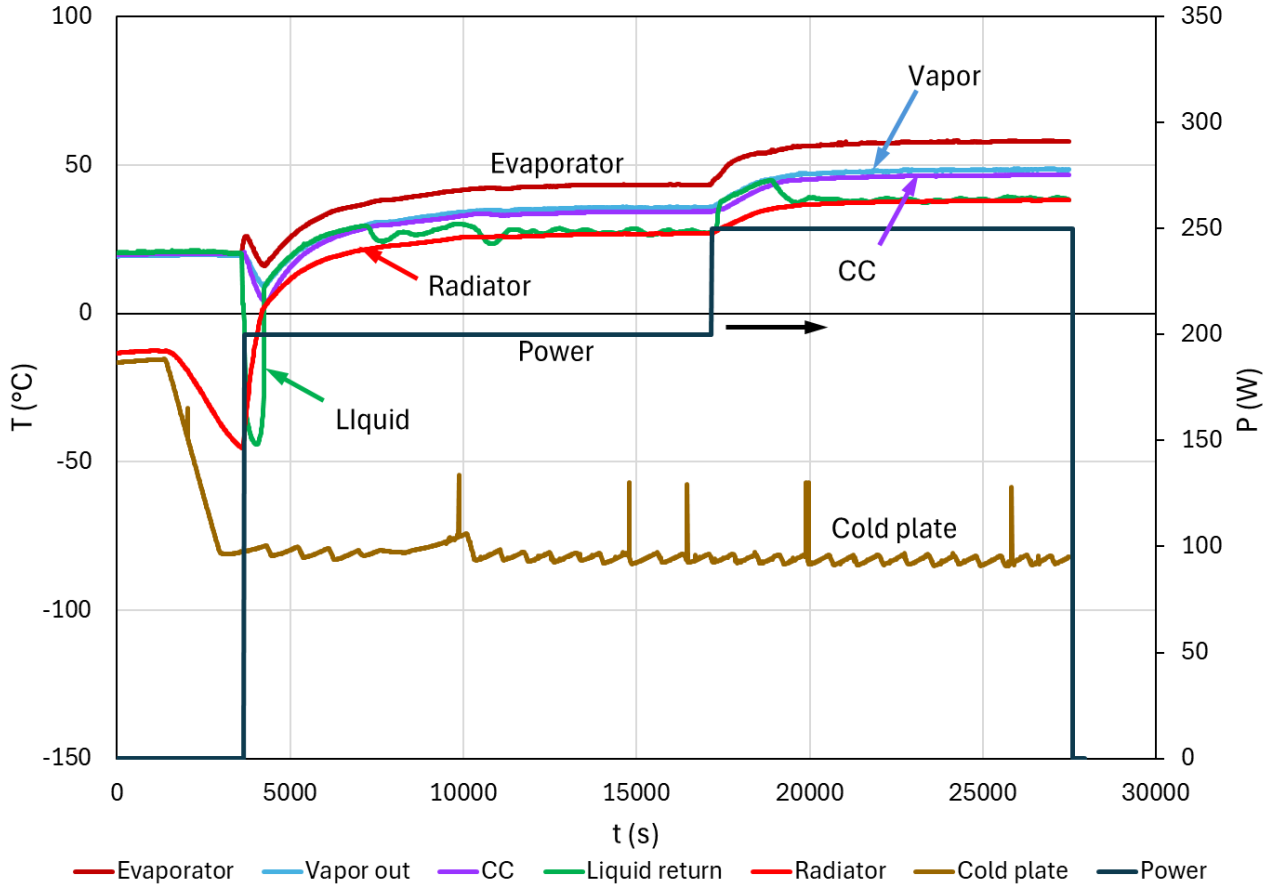
- Testing at 100W and 150W

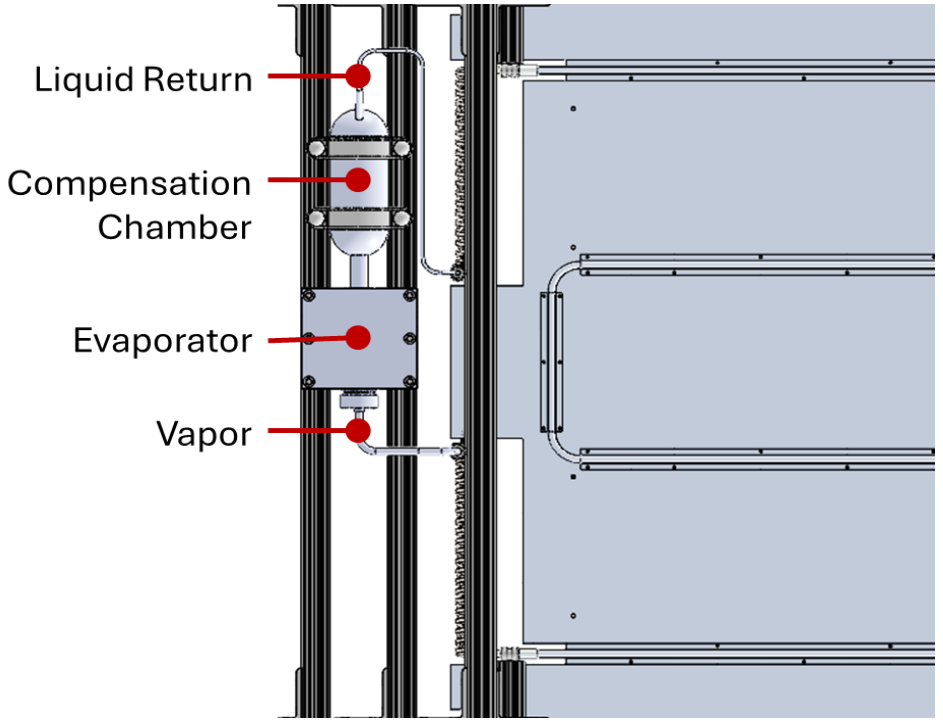




Steady State Operation

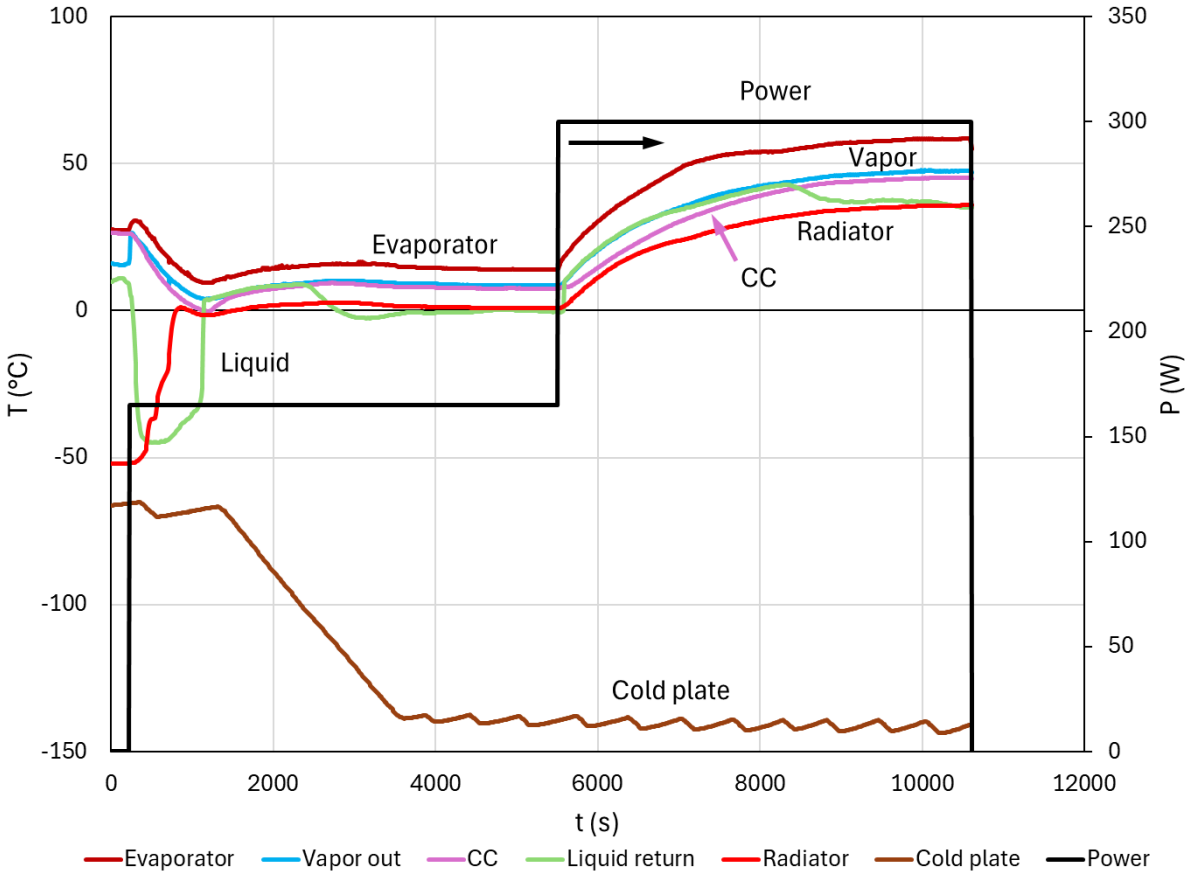
- Testing at 200W and 250W

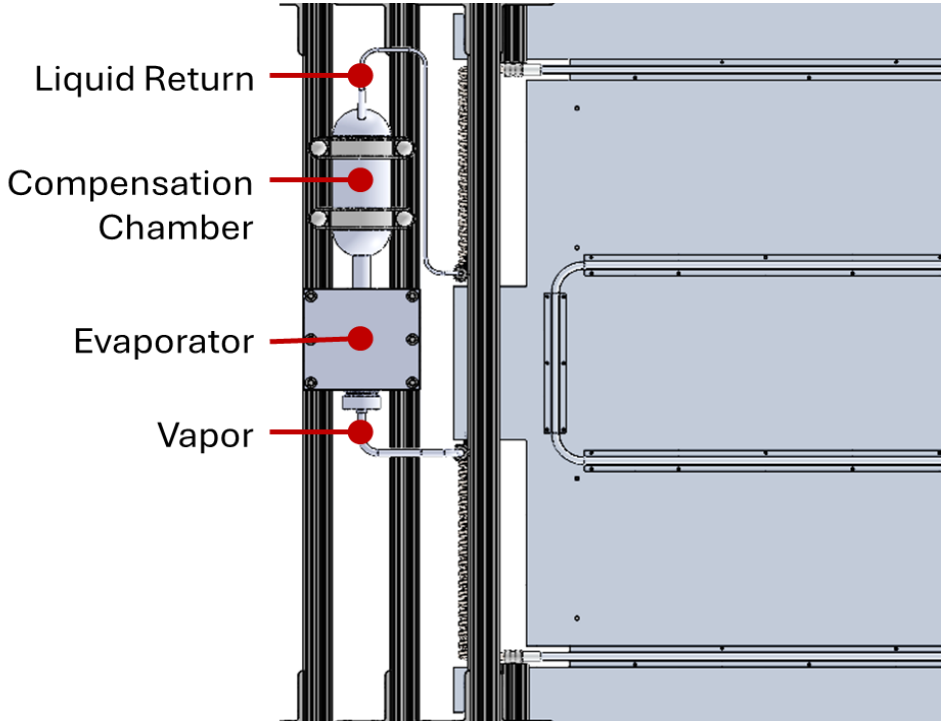




300W of Heat Rejection

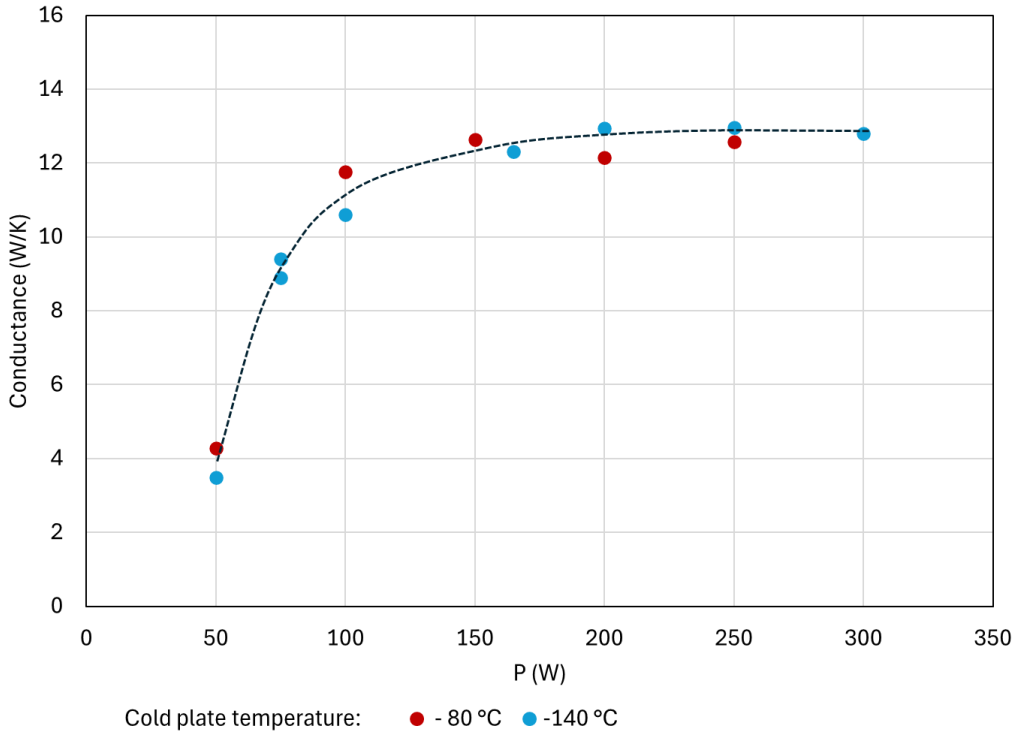
- To reach 300W of heat rejection, the cold plate temperature had to be lowered to -140 Celsius.





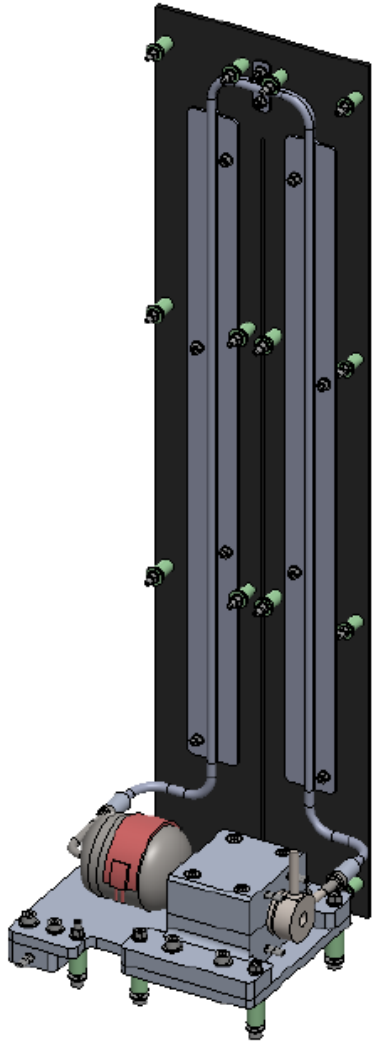
System Conductance

- Conductance was calculated from the measurements as the ratio of power load to evaporator to radiator temperature difference.
- The LHP reached constant conductance at ~150 W.
- The maximum conductance was 12.8 W/K



Next Steps

- ACT is developing new evaporators with a different primary wick and vapor groove structure to increase permeability and reduce dry-out.
- A scaled model is being constructed for a flight technology demonstration, in which the 3DP LHP will reject 15W of heat from a 3U CubeSat. This technology demonstration will occur in 2025.



Acknowledgments

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Questions

Thank you!