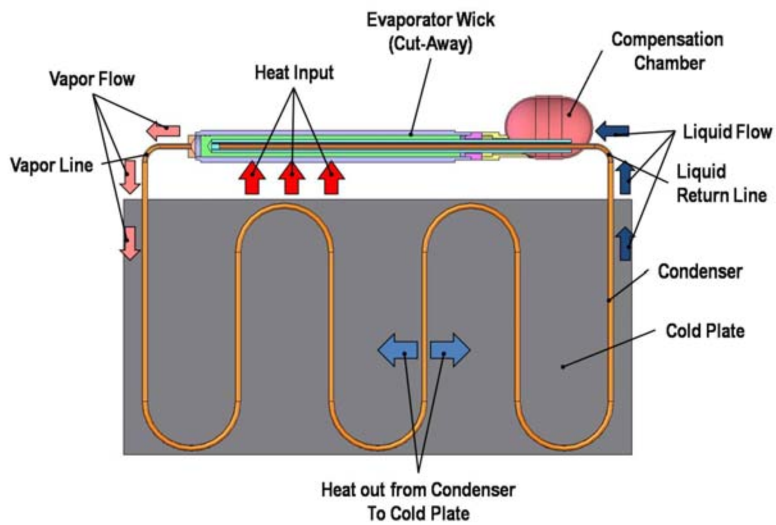
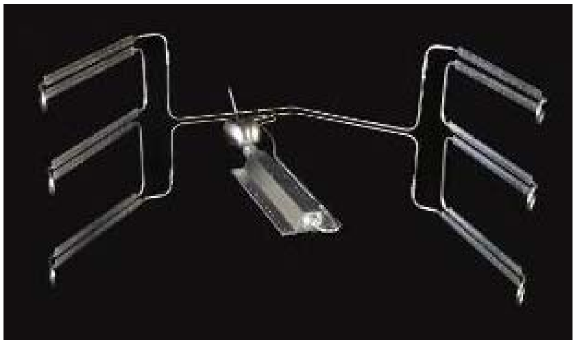
LOOP HEAT PIPES

Loop Heat Pipes (LHPs) are passive heat transfer devices that are capable of transferring large amounts of heat over long distances. The technology was invented in the former Soviet Union in the 1980s for spacecraft thermal control, and transferred to the U.S. in the 1990s.

A schematic of a LHP is shown below. Heat enters the evaporator and vaporizes the working fluid at the outer surface of the wick. The vapor flows down a system of grooves and headers in the evaporator and the vapor line toward the condenser, where it condenses as heat is removed by the cold plate (or radiator). The compensation chamber (or reservoir) at the end of the evaporator is designed to operate at a lower temperature than the evaporator and condenser. The lower saturation pressure in the reservoir draws the condensate through the condenser and liquid return line. The liquid then flows into a central pipe where it feeds the wick. A secondary wick hydraulically links the reservoir and the evaporator primary wick.



Below are two photos of LHP radiators designed and built by ACT for military satellites.

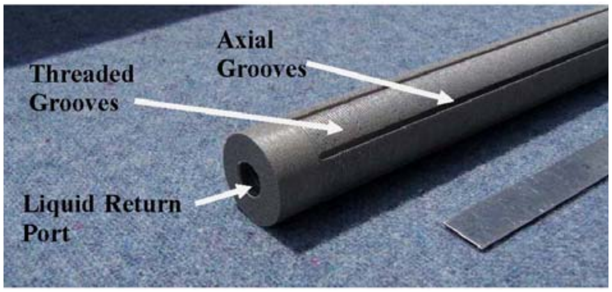


Left: a 3-LHP radiator for a high power satellite; Right: a dual condenser LHP for a micro-satellite

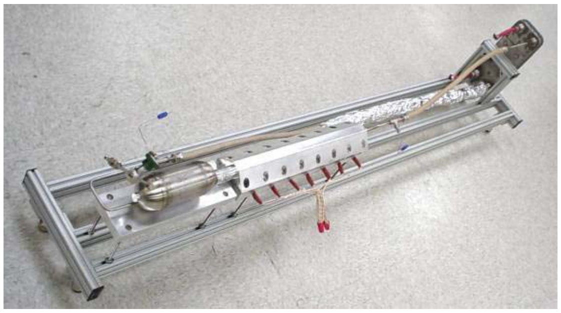
Applications:

- Payload Thermal Management
- Heat Transport
- Radiator Panel Enhancement
- Avionics Cooling and Aircraft Anti-Icing

The LHPs use wicks having very fine pores (effective pore radius on the order of 1µm) to generate large capillary pumping capabilities. These wicks are sintered powder metal structures with circumferential and axial grooves machined into the outer surfaces. These grooves are designed to remove the vapor generated in the evaporator. The machined wick structure is subsequently inserted into the evaporator body. To date, ACT has manufactured Nickel, Stainless Steel, Titanium and Monel wicks with effective pore radii as small as 0.85µm and porosity as great as 72%.



ACT has the complete facility in house to manufacture and characterize LHP primary and secondary wicks. ACT has also established a LHP evaporator/reservoir characterization apparatus (shown right) for quickly and accurately assessing the performance of an evaporator/reservoir assembly prior to assembly into the overall transport line and radiator panel.



ACT's LHP design code is capable of analyzing steady-state LHP behaviors. Other advanced features of the code include variable sub-cooled liquid lengths in the condenser, the ability to add heat leaks/gains (non-adiabatic conditions) to the transport lines, and secondary wick performance prediction.

ACT manufactures LHPs to exact customer requirements under its AS 9100-B certified quality system. The materials used for manufacturing are certified and qualified to meet the demanding level of aerospace quality. Each evaporator block, vapor and liquid lines, and aluminum extrusions are fully characterized to determine thermal and pressure containment capabilities as functions of operating temperature and fluid charge. The welding processes are performed by welders certified to AWS 17.1 Specification for Fusion Welding for Aerospace Applications.

ACT's LHP manufacturing and testing equipment is state-of-the-art, including: multi stage cleaning baths for chemically cleaning raw extrusions, triple distillation apparatus for purifying ammonia and other fluids, helium mass spectrometer leak detector, dedicated charging, processing and non-condensable gas venting stations, specialized test setups for testing and characterization at temperatures from -120 to +100°C, and a 3 foot diameter by 8 foot thermal-vacuum test chamber. During fabrication, LHP parts are continually checked to verify that they meet the performance requirements. Once the LHP is completed, it is subject to multiple performance acceptance tests including start-up, transient power, high power, shut down, and unbalanced condenser heat removal (in case of multiple condensers). Additional tests are performed per customer requirements.