# SPACE COPPER-WATER HEAT PIPES

## Overview

With trusted expertise in engineering and manufacturing spacecraft thermal control systems, ACT consistently delivers innovative solutions to meet the most demanding performance requirements. Our aerospace products group offers high-performance heat pipe products that meet critical space requirements such as long life and low mass.

Industry demand for higher heat flux electronics is creating localized cooling challenges at the component, board and box level of satellite payloads. Avionics designers are unable to transfer heat efficiently; primarily limited by thermal conductivity (k) of the heat spreader. Space Copper-Water Heat Pipes (SCWHPs) provide more efficient heat transport compared to traditional conduction solutions with more geometric flexibility, ground testability and heat flux capability compared to other two-phase solutions.

*Figure 1: Photo courtesy of BAE systems, showing ACT SCWHP embedded in a BAE RAD5545™ Space VPX board*

**SCWHP are the next generation thermal technology for electronics cooling at the board and box level.**

## TECHNICAL BENEFITS & PERFORMANCE

- **High Heat Flux Capability:**
  Up to 50 W/cm2
- **Low Temperature Gradient:**
  2-5°C ΔT
- **Wicking Capability:**
  Up to 10” against gravity
- **Geometry / Routing:**
  3x OD Bend Radius
- **Integration:**
  Aluminum (or other metals)
  Evaporator and Condenser Blocks
  Fully or Partially Embedded
  Copper or Aluminum

Advanced Cooling Technologies, Inc. | 1046 New Holland Avenue, Lancaster, PA 17601, USA
Phone: 717.295.6061 | Fax: 717.295.6064 | ISO 9001 & AS9100 Certified | ITAR Registered

## SPACE HERITAGE AND ADOPTION

ACT flew its first SCWHPs in 2017 together with NASA Marshall Space Flight Center and NASA Johnson Space Center, under the Advanced Passive Thermal experiment (APTx) project. The SCWHPs were embedded in aluminum HiK™ plates for validation testing on the International Space Station (ISS). The objective of testing the hardware on the ISS was to demonstrate the operation and flight-worthiness of the SCWHP-embedded HiK™ plate. The program was successful and provided SCWHPs with TRL 8. Since then, SCWHPs have been delivered for numerous spaceflight missions. ACT continues to work with industry leaders and has delivered hundreds of SCWHPs that have passed severe qualification and acceptance testing protocols.

## TESTING CONSIDERATIONS

**On-orbit, freeze/thaw events can occur in three primary modes of operation:**

- Unpowered freeze/thaw
- Frozen start-up (cold start)
- Powered freeze/thaw

SCWHPs must be carefully designed and verified to ensure the design is tolerant of these types of freeze/thaw cycles. Careful selection of heat pipe geometry, wick structure, and fluid charge is necessary to assure a freeze-tolerant SCWHP solution.

The Venn-diagram shows the representative region of acceptable fluid charge required to simultaneously meet thermal performance requirements and achieve freeze/thaw cycling tolerance. The area of overlap between these regions results in a heat pipe that meets both thermal performance and freeze/thaw requirements and can be influenced by the diameter of heat pipe selected.

## SO WHAT'S THE DIFFERENCE?

The two primary differences between SCWHPs and terrestrial copper-water heat pipes are the manufacturing protocols required to survive in deep space. The vacuum environment, operational profiles and temperature extremes SCWHPs will encounter during space flight result in extreme qualification programs to verify long term performance. SCWHPs have alternative design methodology, wick insertion, precision fluid processing, and sealing techniques compared to terrestrial copper-water pipes to ensure a high quality, flight worthy pipes are provided to our customer.

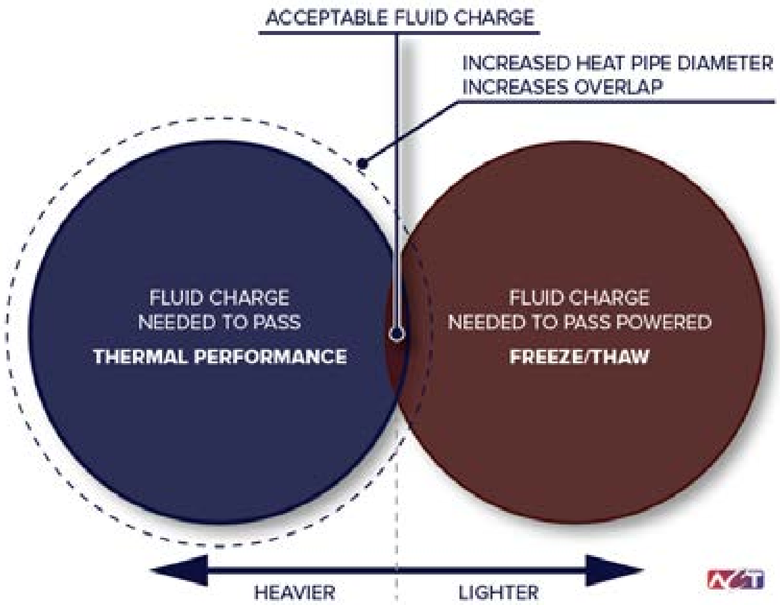
## OTHER TECHNOLOGIES

**PROVEN- HIGH TRL I SPACE HERITAGE**

- CCHPs, VCHPs, SCWHPs, and LHPS

**EMERGING- LOW TO MID TRL I SPECIFIC APPLICATIONS**

- Intermediate temperature heat pipes (250 to 500°C)
- Pressure Controlled Heat Pipes for Milli-Kelvin Thermal Control
- High temperature VCHPs for radioisotope Stirling cooling
- Oxygen production from Lunar regolith (850 to 1050°C)
- Phase change material (PCM) heat sinks

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