# Advanced Thermal Technology Development

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Active Thermal Controls Systems (ATCSs) are required to control vehicle temperatures and cabin humidity. The Advanced Thermal Team, within the Crew and Thermal Systems Division, develops advanced ATCS technologies to support NASA's Exploration Mission.

## Propylene-Glycol Heat Transport Fluid

A team of engineers coordinated numerous evaluations of propylene-glycol and water mixtures. These mixtures were evaluated for use as a heat transport fluid for future ATCSs. Evaluations included thermal performance, toxicity, flammability, materials compatibility, low-temperature performance, susceptibility to microbial growth, and compatibility with other life support systems. This use of this fluid was desirable because it could be used both inside the crew cabin of the vehicle and in radiators, thus enabling a single-loop ATCS. A single-loop system provides significant mass and power savings over the state-of-the-art dual-loop systems that currently fly on the space shuttle and the International Space Station. Figure 1 shows a long-duration test stand in which chemical and microbial stability of the fluid is evaluated. Lockheed Martin selected this fluid and a single-loop ATCS architecture for the Orion vehicle – the crew exploration vehicle for the space station and the Moon.

## Vapor Compression Heat Pump

Heat pump technology may enable missions to lunar locations where warm environments (up to 250°F/121°C) exist. The vapor compression heat pump was designed for a 15-kW thermal load and a 50°C temperature lift. This system was designed for use in both microgravity and lunar gravity environments. To do so, the evaporator, condenser, and compressor were all carefully evaluated and selected. Vapor compression heat pump is a collaborative effort between Johnson Space Center (JSC) and Glenn Research Center (GRC).

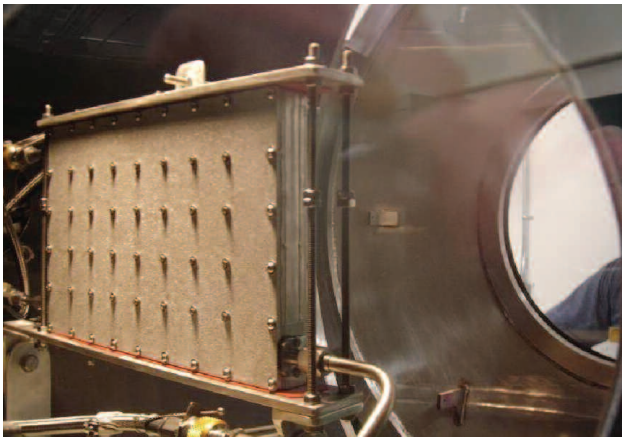

***Fig. 1. Thermal control research and development contaminant insensitive sublimator.***

## Contaminant Insensitive Sublimator

This sublimator was originally designed, fabricated, and tested as part of the another advanced vehicle program (X-38). The primary benefit of this design over state-of-the-art sublimators that are in use in the extravehicular mobility unit and were used on the lunar excursion module is that the design was developed to increase the life of this evaporative heat exchanger. The mass of the X-38 unit was successfully cut in half, while maintaining the same thermal performance. Oceaneering fabricated the engineering unit shown in figure 2. The Engineering Directorate maintains the Building 361 vacuum chamber facility where the unit was tested.

## Multi-Fluid Evaporator

Designed and built by Hamilton Sunstrand (with oversight by JSC), the multi-fluid evaporator is a flow-boiling heat exchanger that can use water as an evaporant while in vacuum and as a secondary fluid, such as R134a, in Earth ambient pressure. This device could be used on a vehicle, such as the Orion vehicle, for cooling during ascent, space, and entry mission phases. The engineering unit shown in figure 3 was designed, built, and tested within the past few years.

## Radiator Developments

Several research and development tasks were performed for the development of space radiators. These efforts included work at JSC, GRC, Jet Propulsion Laboratory (JPL), Goddard Space Flight Center, and Kennedy Space Center. Coating evaluations were performed to generate end-of-life optical properties for several coatings, both new and well used. These evaluations were performed in environments anticipated for the Orion vehicle, and the coatings were applied to both aluminum and composite substrates. Tests were also performed at GRC to evaluate different methods of bonding tubes to composite panels. High-velocity particle impact tests were performed on composite panels at JPL to begin to characterize the durability of composite radiators to micrometeoroids and orbital debris. Lastly, an Apollo-style (1970s lunar landing) selective stagnation radiator was designed, built and tested at JSC. A thermal desktop model of this radiator successfully correlated to the test data. Lockheed Martin Company chose to build composite radiators for the Orion vehicle, and the selection of propylene-glycol and water for a working fluid also made fluid stagnation in the radiator panels a key design challenge.

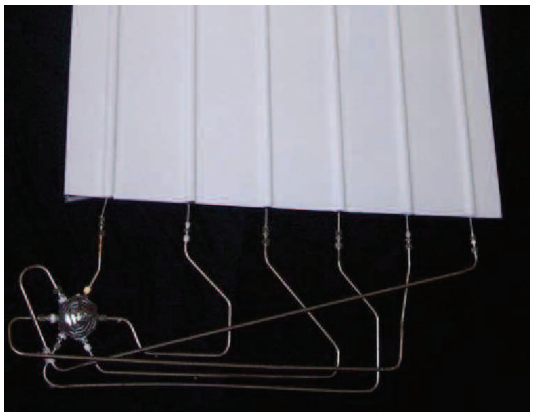

*Fig. 3. Stagnation radiator manifold.*

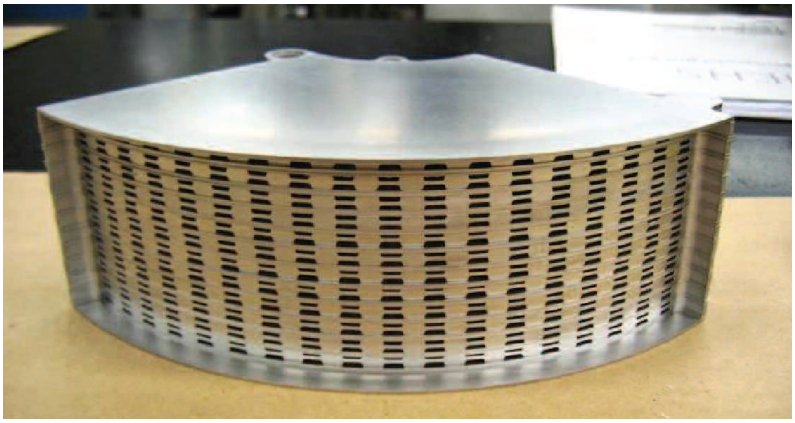

*Fig. 2. Multi-fluid evaporator.*