Extravehicular Activity Technology Development—Thermal Subsystem

Grant Bue, *Johnson Space Center*
Colin Campbell, *Johnson Space Center*
Gregg Weaver, *Jacobs Technology*

The thermal subsystem provides temperature control of an astronaut and associated equipment. In the latest advanced Portable Life Support System (PLSS) schematic, the thermal subsystem consists of a single-phase liquid water loop containing a pump, an evaporative cooling device, an avionics coldplate, a water bladder that serves as an accumulator, and the liquid cooling and ventilation garment that the astronaut wears. The Extravehicular Activity Technology Development Team, which is within the NASA Johnson Space Center Crew and Thermal Systems Division, is developing critical thermal subsystem components to support the development of the next-generation spacesuit. Development of suit water membrane evaporators (SWMEs) addresses PLSS heat rejection, and an advanced pump development addresses heat transport. These technologies are targeted for possible lunar, Martian, or asteroid missions that involve a human presence.

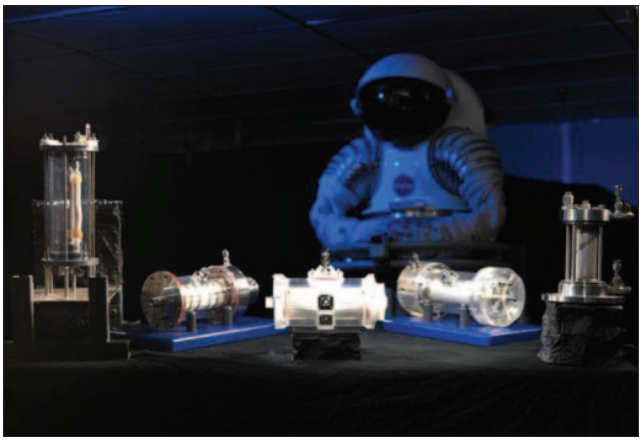

Fig. 1. *Several generations of suit water membrane evaporator test articles.*

Suit Water Membrane Evaporator

An SWME provides cooling to the spacesuit water loop by evaporating some of the water across a membrane into the vacuum of space (figure 1). As the water turns to vapor and is vented into space, it takes the energy needed to cause the phase change with it. A back-pressure control valve is used to control pressure within the evaporator assembly, which, in turn, controls the amount of water that is evaporated and, therefore, the amount of cooling that the crew member experiences. A critical aspect of the SWME is its ability to maintain acceptable performance through an entire 6-month mission of a spacesuit, as would be required on the lunar surface. Another critical aspect of this membrane-based device is its sensitivity to contamination.

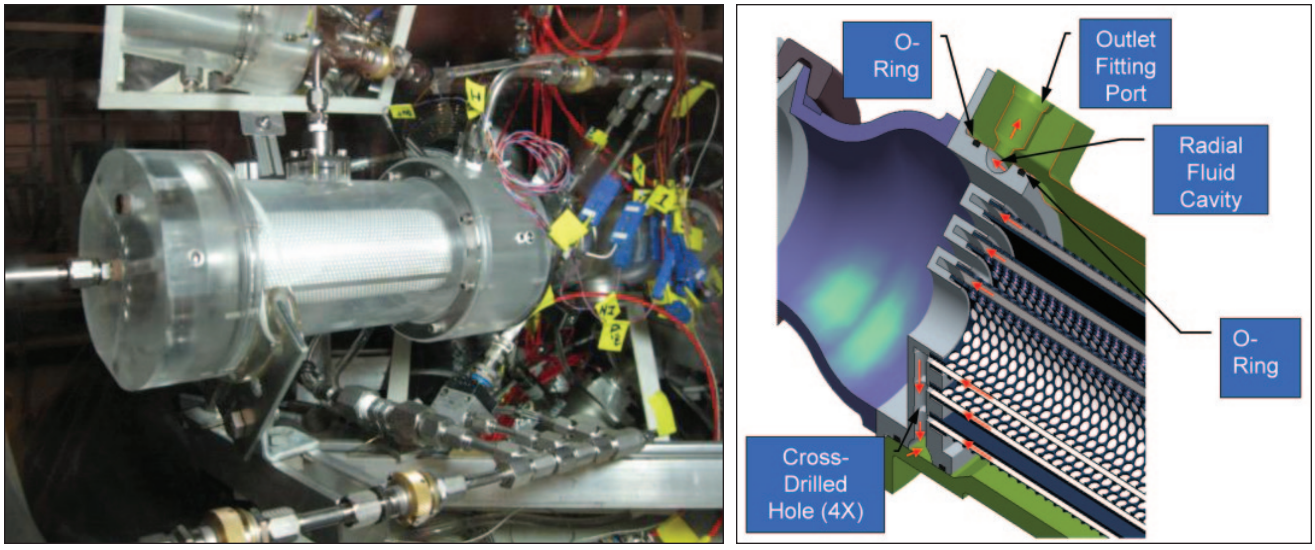

Fig. 2. *Sheet membrane suit water membrane evaporators.*

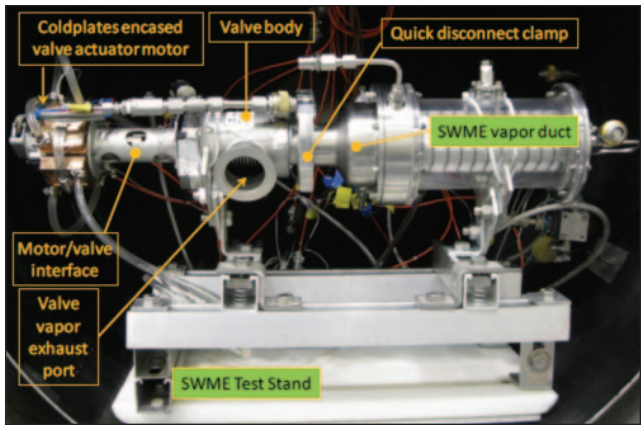

Fig. 3. *Hollow-fiber suit water membrane evaporators design.*

Two types of SWMEs have been developed and tested. The sheet membrane SWME (figure 2) uses six concentric cylindrical, porous, hydrophobic membranes to create alternating coolant water/vacuum passages. In addition to performance testing, the sheet membrane SWME was subjected to life testing and also to challenge testing in which different contaminants were present in the water. Further tests were performed to provide sizing data, demonstrate the controllability of the unit by using a back-pressure control valve, and evaluate how the unit would handle bubbles in the water.

The hollow-fiber (HoFi) SWME (figure 3) operates on the same principles as the sheet membrane SWME. However, instead of using sheet membranes arranged in concentric cylinders, the HoFi SWME uses a bundle of thousands of hollow tubes made from another porous hydrophobic material in which coolant flows through the center of the tubes and vacuum is present on the outside. The HoFi SWME was subjected to the same battery of tests as the sheet membrane SWME. The HoFi "cage" is shown in figure 4.

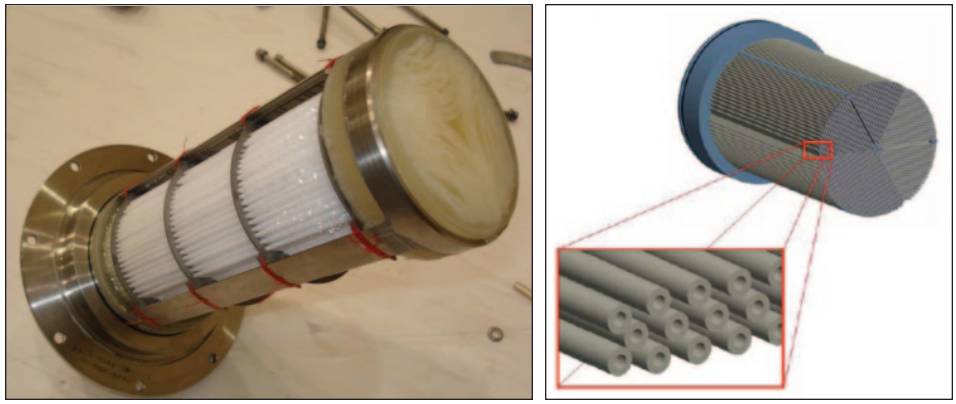

Fig. 4. *Hollow-fiber "cage."*

Following testing of the sheet membrane SWME and HoFi SWME, a down-select was performed and just the HoFi SWME was further developed. Key improvements in the next design focused on reducing mass and volume, and on developing a more flight-like back-pressure valve. This second-generation HoFi SWME (figure 5) underwent a battery of tests similar to those performed on its predecessor, with excellent results.

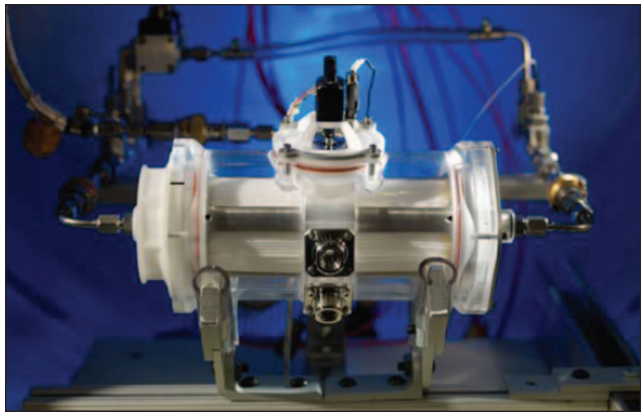

Fig. 5. *Second-generation hollow-fiber suit water membrane evaporators with improved back-pressure valve (on top).*