Extravehicular Activity Technology Development – Thermal Subsystem

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The thermal subsystem provides temperature control for an astronaut. In current Constellation Program (CxP) Portable Life Support System (PLSS) concepts, the thermal subsystem consists of a single-phase water loop that contains a pump, an evaporative cooling device, an avionics cold plate, a water bladder that serves as an accumulator, and the liquid cooling and ventilation garment that the astronaut wears. The extravehicular activity (EVA) technology development team is developing critical thermal subsystem components to support the CxP lunar spacesuit. Development of suit water membrane evaporators (SWMEs) addresses PLSS heat rejection, and an advanced pump development addresses heat transport.

Sheet membrane suit water membrane evaporator

The sheet membrane SWME (figures 1 and 2) provides cooling to the spacesuit water loop by evaporating some of the water across a membrane into the vacuum of space. As the water turns to vapor, it takes the energy needed to cause the phase change with it as the vapor is vented into space. The sheet membrane SWME uses six concentric cylindrical membranes to create water passages separated by a vented space. A back pressure control valve is used to control the pressure within the evaporator assembly, which controls the amount of water that is evaporated; it therefore controls the amount of cooling the crew member experiences.

Fig. 1. *Sheet membrane SWME.*

A critical aspect of the SWME is its ability to maintain acceptable performance throughout the entire 6-month mission of a spacesuit on the lunar surface. Another critical aspect of this membrane-based device is its sensitivity to contamination. In addition to performance testing, the sheet membrane SWME will be subjected to life testing and challenge testing in which different contaminants are present in the water.

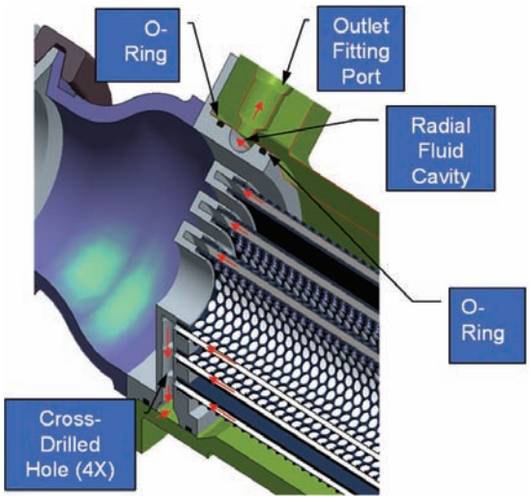

Fig. 2. *Detail of sheet membrane SWME.*

Hollow-fiber suit water membrane evaporator

The hollow-fiber SWME operates on the same principles as the sheet membrane SWME. Instead of using sheet membranes arranged in concentric cylinders, the hollow-fiber SWME uses a bundle of hollow tubes made from a hydrophobic material. Scientists compared three commercial off-the-shelf (COTS) hollow-fiber units through an accelerated life test (figure 3). A Membrana (Wuppertal, Germany)-made unit was the clear winner because it showed no performance degradation over a series of tests that simulated 100 EVAs. Once this specific technology was selected, additional tests provided sizing data to demonstrate the controllability of the unit by using a back pressure control valve. Other evaluations showed how the unit would handle bubbles in the water. Data taken from these tests were used to design a full-

sized engineering unit that will be submitted to the same series of tests as the sheet membrane SWME (figure 4).

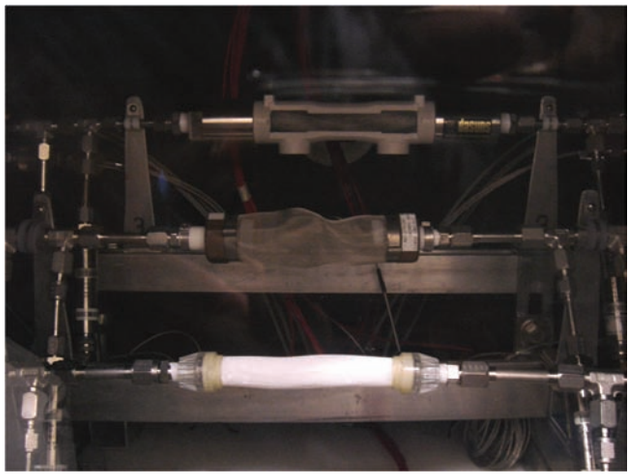

Fig. 3. *COTS hollow-fiber evaluations.*

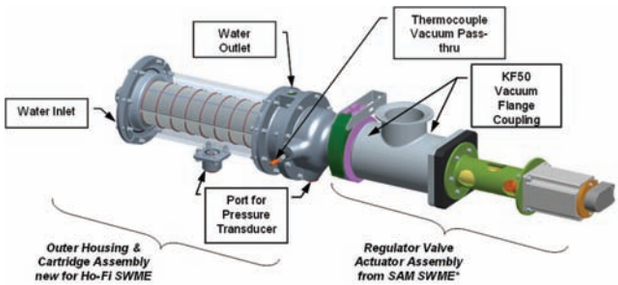

Fig. 4. *Hollow-fiber SWME design.*

Water pump

The shuttle spacesuit water pump had two on-orbit failures caused by water-quality issues. Due to the long duration of Constellation (Cx) missions and a drive to increase the robustness of the spacesuit, missions designers pursed water pump development. In addition to increasing robustness, the Cx spacesuit water pump must be able to deliver a wider range of pressure head than the shuttle unit. This led to the evaluation of several COTS positive displacement pumps, an aerospace heritage gear pump, and a custom gerotor pump (figure 5). Not only did we compare the performance of these pumps, we also subjected the pumps to a series of life tests and water quality challenge tests to evaluate their robustness.

Fig. 5. *Gerotor pump head.*

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