Extravehicular Activity Technology Development—Ventilation Subsystem

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The ventilation subsystem provides oxygen circulation, carbon dioxide (CO_2) removal, trace contaminant removal, and humidity control. The Extravehicular Activity (EVA) Technology Development Team, which is within the Crew and Thermal Systems Division at NASA Johnson Space Center (JSC), is developing critical ventilation subsystem components to support future NASA missions.

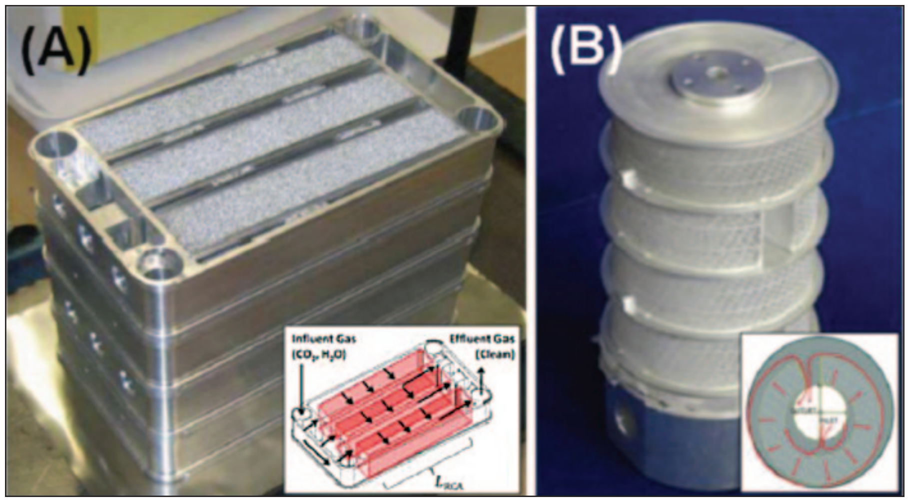

Fig. 1. *Rectangular rapid cycle amine unit (A) and cylindrical rapid cycle amine unit (B).*

Rapid Cycle Amine Swing Bed

A principal concern for EVA spacesuits is the ability to control CO_2 and water vapor (H_2O) for the suited crew member. The release of CO_2 into a confined or an unventilated area is dangerous for human health and could lead to asphyxiation. As water vapor also must be controlled to maintain crew comfort, CO_2 and H_2O control are leading factors in the design and development of advanced spacesuits. Hamilton Sundstrand (Windsor Locks, Connecticut) (HSWL) developed an amine-based CO_2 and H_2O vapor sorbent for use in pressure-swing regenerable beds. The application of solid-amine materials with vacuum-swing adsorption technology has demonstrated the capacity to manage CO_2 and H_2O levels concurrently through a regenerative cycle that eliminates mission constraints imposed by non-regenerative technologies. Two prototype solid amine-based systems (rectangular and cylindrical), known as rapid cycle amine swing beds, were designed and tested (figure 1).HSWL designed the rectangular unit (A), which is a full-scale, linear flow unit. Jacobs Technology designed the cylindrical unit (B) as an alternative rapid cycle amine design. This unit is a subscale radial flow unit. Each prototype solid amine-based system was designed to continuously remove CO_2 and H_2O from a constantly flowing ventilation stream through the use of a two-bed, amine-based, vacuum-swing adsorption system. While one set of sorbent layers was exposed to the ventilation stream to remove both CO_2 and H_2O (adsorb), the other set of beds was regenerated by exposure to vacuum (desorb). Testing was performed in a sea-level pressure environment and a reduced-pressure environment with simulated human metabolic loads in a closed-loop configuration. Both the full-scale and subscale test articles were tested. Test

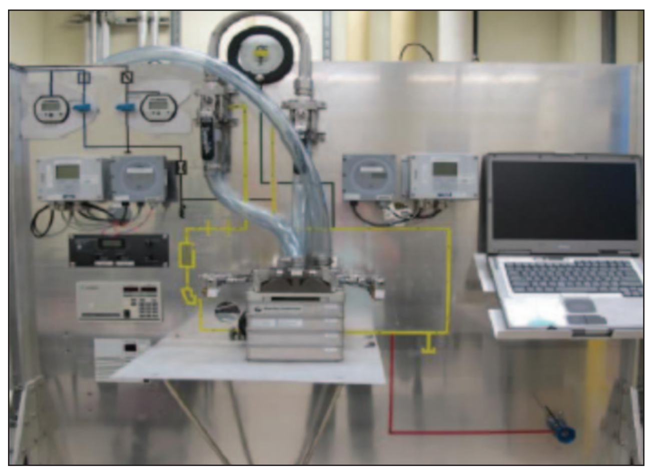
Fig. 2. *Portable Life Support System ventilation subsystem test loop with the rectangular rapid cycle amine unit.*

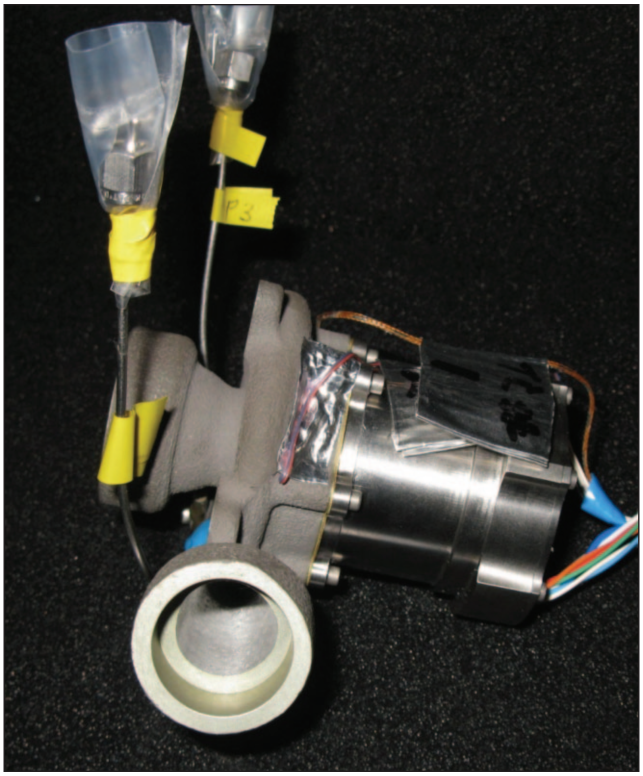

Fig. 3. *Photograph of fan assembly.*

points simulated a range of crew member metabolic rates. Experimental results demonstrated the ability of each rapid cycle amine unit to remove sufficient CO_2 and H_2O from both a closed-loop and a sub-ambient atmosphere.

Ventilation Fan

The team developed and tested a centrifugal fan to meet the expected requirements for ventilation flow modes in the next-generation Portable Life Support System (figure 2). Performance testing and life cycle testing (at atmospheric and sub-atmospheric pressures) were conducted at JSC. An oxygen compatibility assessment evaluation was also conducted at the NASA White Sands Test Facility. Fan development for the ventilation subsystem has focused on minimizing mass and power while providing adequate flow over a wider range of flow rates and pressure drops than are found in heritage spacesuit fans. A photograph of the fan assembly is shown in figure 3.