Phase 2 Project Summary

Firm: Creare Incorporated
Contract Number: NNJ08JA52C
Project Title: Lightweight, Flexible, and Freezable Heat Pump Radiator for EVA Suits

Identification and Significance of Innovation:

Future space exploration missions may include establishment of lunar or planetary outposts suitable for extended human presence and/or construction of advanced space telescopes. Crew members may need to spend extensive time in extravehicular activity, and the portable life support systems (PLSSs) for their EVA suits will require advanced technology to control temperature inside the suit. Future cooling technology should vent no water, both to conserve a valuable resource and to avoid contaminating the environment. To meet these needs, we have developed an innovative thermal control system based on a LiCl/water heat pump. The system has two parts: (1) a heat pump/radiator assembled from rugged, flexible, lightweight materials that conforms to the shape of the PLSS, and (2) a flexible evaporator/cooling garment that simplifies the overall cooling system and integrates easily with the absorber/radiator. The flexible heat pump/radiator will control temperature inside exploration EVA suits and radiate heat directly to the environment. The system will surpass the state of the art: It will be compact, low mass, freeze-tolerant, and will be flexible and conformable to the PLSS package, and will reduce logistical burden by venting zero consumables.

Technical Objectives and Work Plan:

The overall objective was to develop EVA technology that will help NASA meet requirements for future manned exploration missions. The approach was to develop a flexible heat pump/radiator with high cooling power and high cooling capacity in challenging EVA environments, integrates easily with a PLSS, vents zero water during normal operation, and is lightweight and rugged. The specific technical objectives for the system are as follows:

Lightweight: The overall cooling mass density should approach 130 W-hr/kg.
Effective: The absorber/radiator should maintain the cooling garment temperature at 19°C.
Simple: The flexible radiator should integrate easily with the PLSS. The cooling garment should simplify the system by eliminating components needed for existing EVA suits.
Rugged: The absorber/radiator should be rugged and easy to repair
Freeze-tolerant: The system must be able to start up from a frozen state.
Versatile: Multiple modes of operation should be available to accommodate a wide range of planned and unplanned EVA situations.
Non-venting: Normal operation of the system should vent zero water.

Technical Accomplishments:

Components of the flexible absorber/radiator can be fabricated from low-cost materials using inexpensive methods. Each 12 in. x 17 in. x 1.1 in. absorber/radiator module could radiate heat at a rate of 33 W/ft² at a temperature of 50°C to a 250 K environment while absorbing water from an evaporator maintained at 19°C. The absorber/radiator operates between 50 and 90% LiCl with an overall heat capacity of 123 W-hr/kg (including water). Each absorber module can withstand internal and external pressures of 10 psi without damage or permanent deformation. The flexible evaporator could absorb heat at a flux of 65 W/ft² while maintaining a cooling temperature of 19°C.

These results show that a space suit can be cooled by a flexible absorber/radiator. The absorber maintains evaporation at temperatures low enough for crew comfort while rejecting heat at temperatures high enough to enable a compact radiator that is simple to integrate with EVA suit backpacks. Overall heat absorbing capacity is high enough to provide effective cooling for long EVA missions. The system's

operational flexibility allows for effective cooling in off-design and emergency situations. Materials are lightweight and rugged and can be repaired in situ if necessary. The flexible evaporator can absorb heat at fluxes high enough to enable an evaporation-cooled garment.

NASA Application(s):

NASA's main application for the absorber/radiator will be environmental control for future space suits. The basic technology can also be used for non-venting environmental control for small spacecraft such as manned rovers and ascent/descent vehicles.

Non-NASA Commercial Application(s):

Variations of the absorber/radiator that we demonstrated in Phase II can be used in personal, microclimate cooling systems for defense and commercial applications.

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