A Super Cooled, Non-toxic, Non-flammable Phase Change Material Thermal Pack for Portable Life Support Systems

Paragon Space Development Corporation

Technical Abstract

The continuation of concept development and test of a water-based, advanced Phase Change Material (PCM) heat sink is proposed. Utilizing a novel material choice for both an expansion diaphragm and the PCM case itself, the PCM can accommodate both the expansion of the freezing water-based material and very low temperature of approximately -250F. The water-based PCM itself would be non-toxic and non-flammable, but additives will be included to preclude deterioration of wither the PCM container or the diaphragm material. The use of a water-based PCM gives the highest heat capacity for the mass. This is highly limited due to the needs for portability as required for an Extra-Vehicular Activity (EVA). The total heat capacity of an operational unit would be for 4 hour duration EVA use. Through a logical progression of tasks including concept of operation formulation, requirements formulation, concept design reviews and detail design reviews that include design and thermal analysis using Thermal Desktop^{TM} models, this effort can progress from the TRL 3 achieved in Phase I to TRL 4-5. The team will continue development by designing a Variable Conductance Interface (VCI) for protecting water in the Liquid Cooling Garment (LCG) from freezing due to the temperature of the heat sink used by the PCM. The team will also develop system improvements identified during Phase I testing. The PCM will be tested to confirm heat input/temperature performance and cycling capability. The test bed will allow for accurate heat input knowledge, temperature monitoring and cycling capability. The results will be compared to the thermal model to ensure accurate prediction capability for the next phase unit and system implementation. The design description and test results would form the basis of the final report.

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2007 Phase II
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Advanced, Long-Life Cryocooler Technology for Zero-Boil-Off Cryogen Storage

Creare, Inc.

Technical Abstract

Long-life, high-capacity cryocoolers are a critical need for future space systems utilizing stored cryogens. The cooling requirements for planetary and extraterrestrial exploration missions, Crew Exploration Vehicles, extended-life orbital transfer vehicles, and space depots will range from 10 to 50 W at temperatures between 20 and 120 K. Turbo-Brayton cryocoolers are ideal for these systems because they are lightweight, compact and very efficient at high cooling loads, in addition to their inherent attributes of high reliability; negligible vibration; long, maintenance-free lifetimes; and flexibility in integrating with spacecraft systems and payloads. To date, space-borne turbo-Brayton technology has been developed for modest cooling loads. During the proposed program, Creare will develop an advanced, high efficiency turbine optimized for a high-capacity cryocooler. The advanced turbine will enable a landmark reduction in cryocooler input power and overall cooling system mass. In Phase I, we defined the cryocooler requirements for a particular mission class, developed the conceptual design of a multistage cryocooler to meet the requirements, developed the preliminary design of the advanced turbine and successfully performed proof-of-concept tests on the turbine. During Phase II, we will fabricate the turbine optimized to provide 5-20 W of net refrigeration at 20 K and demonstrate its performance at prototypical operating conditions.

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