NASA SBIR 2016 Phase I Solicitation

H4.02 Trace Contaminant Control for Advanced Spacesuit Applications

Lead Center: JSC

Participating Center(s): MSFC

This subtopic is in search of a trace contaminant control (TCC) technology to remove trace contaminants in an advanced spacesuit atmosphere, specifically considering power, size, and removal capability. The advanced spacesuit portable life support system (PLSS) performs the functions required to keep an astronaut alive during an extravehicular activity (EVA) including maintaining thermal control, providing a pressurized oxygen (O_2) environment, and removing carbon dioxide (CO_2). The PLSS ventilation subsystem performs the transport and provides the conditioned O_2 to the suit for pressurization and astronaut breathing. It circulates O_2 through the ventilation loop using a fan and recycles the ventilation gas, removing CO_2 and providing humidity control. The ventilation subsystem is also responsible for removing trace contaminants from the spacesuit atmosphere. The International Space Station extravehicular mobility unit uses an activated charcoal bed inside the CO_2 removal bed (lithium hydroxide (LiOH) and metal oxide (MetOx) canisters). The charcoal in the MetOx canisters can be regenerated on-orbit. The selection of the rapid cycle amine (RCA) swingbed for CO_2 removal in the baseline advanced spacesuit PLSS has added a risk for removing trace contaminants. The trace contaminants in the PLSS ventilation subsystem and their predicted concentrations (mg/m^3) at the end of an 8-hour EVA without suit leakage include the following: acetaldehyde (0.181), acetone (0.301), ammonia (564), n-Butanol (1.13), carbon monoxide (74.4), ethyl alcohol (9.03), formaldehyde (0.902), furan (0.676), hydrogen (113), methyl alcohol (3.16), methane (1352), and Toulene (1.36). The predictions are based on EVA-specific generation rates.1 Based on these predictions ammonia and formaldehyde are the two contaminants most likely to exceed Spacecraft Maximum Allowable Concentration levels if no TCC device is in the PLSS ventilation loop. It would be beneficial for the technology to be regenerable such as vacuum swing regeneration. In particular, a vacuum-regenerable TCC device that can be regenerated in real time on the suit using a vacuum swing with 1 to 3 min of exposure would be optimum. Additional items for optimization include: reduction in expendables and incorporation into integrated CO_2 removal/reduction system. The desire is for the TCC system to be an immediate knock-down of inlet contaminants such as aldehydes which react irreversibly with the RCA sorbent. This will decrease the likelihood of losing capacity over the life of the system to these types of reactions.

Research done in Phase I of these efforts should focus on technical feasibility with an emphasis on hardware development that can be further expanded in a future Phase II award cycle. Phase II products must include a demonstration unit suitable for testing by NASA. Prototyping should be tailored to applications to ongoing HEO Mission Directorate missions and possible collaborative use in both the governmental and commercial manned spaceflight disciplines. Minimum deliverables at the end of Phase I are analysis and/or test reports, with priority given to functional hardware prototypes for further evaluation. Technical maturation plans should be submitted with Phase I submittals, as well as any expected commercial applications both internal and external to the manned spaceflight enterprise.

References:

- Paul, H., Jennings, M., and Waguespack, G., “Requirements and Sizing Investigation for Constellation Space Suit Portable Life Support System Trace Contaminant Control”, 40th International Conference on Environmental Systems, Barcelona, Spain, July 2010.(http://sbir.gsfc.nasa.gov/SBIR/solicitations/2016/AIAA-2010-6065_TCC_CES_Paper_Paul-Jennings-Waguespack.pdf)

- James, J., “Spacecraft Maximum Allowable Concentrations for Airborne Contaminants,” JSC-20584, Houston: NASA/Johnson Space Center, November 2008.(http://sbir.gsfc.nasa.gov/SBIR/solicitations/2016/Spacecraft_Maximum_Allowable_Concentrations_SMAC_JSC-20584.pdf)