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Title: CO_2 Washout Testing of the REI and EM-ACES Space Suits

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Requirements for using a space suit during ground testing include providing adequate carbon dioxide (CO_2) washout for the suited subject. Acute CO_2 exposure can lead to symptoms including headache, dyspnea, lethargy and eventually unconsciousness or even death. Symptoms depend on several factors including partial pressure of CO_2 ($ppCO_2$), duration of exposure, metabolic rate of the subject and physiological differences between subjects. The objective of this test was to characterize inspired oronasal $ppCO_2$ in the Rear Entry I-Suit (REI) and the Enhanced Mobility Advanced Crew Escape Suit (EM-ACES) across a range of workloads and flow rates for which ground testing is nominally performed.

Three subjects were tested in each suit. In all but one case, each subject performed the test twice to allow for comparison between tests. Suit pressure was maintained at 4.3 psid. Subjects wore the suit while resting, performing arm ergometry, and walking on a treadmill to generate metabolic workloads of approximately 500 to 3000 BTU/hr. Supply airflow was varied at 6, 5 and 4 actual cubic feet per minute (ACFM) at each workload. Subjects wore an oronasal mask with an open port in front of the mouth and were allowed to breathe freely. Oronasal $ppCO_2$ was monitored real-time via gas analyzers with sampling tubes connected to the oronasal mask. Metabolic rate was calculated from the total CO_2 production measured by an additional gas analyzer at the air outlet from the suit. Real-time metabolic rate was used to adjust the arm ergometer or treadmill workload to meet target metabolic rates.

In both suits, inspired CO_2 was primarily affected by the metabolic rate of the subject, with increased metabolic rate resulting in increased inspired $ppCO_2$. Suit flow rate also affected inspired $ppCO_2$, with decreased flow causing small increases in inspired $ppCO_2$. The effect of flow was more evident at metabolic rates ≥ 2000 BTU/hr. Results were consistent between suits, with the EM-ACES demonstrating slightly better CO_2 washout than the REI suit, but not statistically significant. Regression equations were developed for each suit to predict the mean inspired $ppCO_2$ as a function of metabolic rate and suit flow rate.

This paper provides detailed descriptions of the test hardware, methodology and results, as well as implications for future ground testing in the REI and EM-ACES.