

## **Characterization of Carbon Dioxide Washout Measurement Techniques in the Mark-III Space Suit**

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It is essential to provide adequate carbon dioxide (CO<sub>2</sub>) washout in a space suit to reduce the risks associated with manned operations in space suits. Symptoms of elevated CO<sub>2</sub> levels range from reduced cognitive performance and headache to unconsciousness and death at high levels of CO<sub>2</sub>. Because of this, NASA imposes limits on inspired CO<sub>2</sub> levels for space suits when they are used in space and for ground testing.

Testing and/or analysis must be performed to verify that a space suit meets CO<sub>2</sub> washout requirements. Testing for developmental space suits has traditionally used an oronasal mask that collects CO<sub>2</sub> samples at the left and right sides of the mouth. Testing with this mask resulted in artificially elevated CO<sub>2</sub> concentration measurements, which is most likely due to the dead space volume at the front of the mask. The mask also extends outward and into the supply gas stream, which may disrupt the washout effect of the suit supply gas. To mitigate these problems, a nasal cannula was investigated as a method for measuring inspired CO<sub>2</sub> based on the assumptions that it is low profile and would not interfere with the designed suit gas flow path, and it has reduced dead space.

This test series compared the performance of a nasal cannula to the oronasal mask in the Mark III space suit. Inspired CO<sub>2</sub> levels were measured with subjects at rest and at metabolic workloads of 1000, 2000, and 3000 BTU/hr. Workloads were achieved by use of an arm ergometer or treadmill. Test points were conducted at air flow rates of 2, 4, and 6 actual cubic feet per minute, with a suit pressure of 4.3 psid.

Results from this test series will evaluate the accuracy and repeatability across subjects of the nasal cannula collection method, which will provide rationale for using a nasal cannula as the new method for measuring inspired CO<sub>2</sub> in a space suit. Proper characterization of sampling methods and of suit CO<sub>2</sub> washout capability will better inform requirements definition and verification techniques for future CO<sub>2</sub> washout limits in space suits.