



NASA SBIR 2017 Phase I Solicitation

H4.02 Small, Accurate Oxygen Compatible Gas Flow Meter for Suit Operations

Lead Center: JSC

Technology Area: TA6 Human Health, Life Support and Habitation Systems

The current state of the art for flow measurement on the current ISS Extravehicular Mobility Unit (EMU) space suit is a flapper valve tied to a microswitch. The current EMU flapper valve technology only supports microgravity EVAs (single flow rate requirement) with a sufficient versus non-sufficient flow measurement capability. With the multi-mission goals of the advanced space suit, variable flow rates are required. Therefore, the goals for the required flow meter include accurate measurement of 2-8 acfm \pm 1% with a pressure drop requirement of less than 0.68 in-H₂O in a pure oxygen (O₂) environment. This flow meter needs to also fit within a volume/shape factor of approximately 2.5 in x 1.5in x 3in or less. An innovation is required since currently available flow meters do not meet these specifications.

The Portable Life Support System (PLSS) capable of supporting planned exploration missions is capable of adapting between varied Space Suit Assembly (SSA) architectures that are optimized for micro-gravity Extra-Vehicular Activities (EVAs) from vehicles such as the International Space Station (ISS) to rear-entry walking suits suitable for operation on the lunar and Martian surfaces. The varied suit designs and associated crewmember exertion within the suits under micro-gravity to partial gravity require the ability to vary the suit ventilation flow rate and also to vary the monitoring/alarming for the selected ventilation flow rates. This limits the application of existing flapper-microswitch style low pressure drop flow switches and requires application of technologies such as flow/pressure drop measurements or thermal mass flow measurements. One of the most constraining requirements is the low permissible pressure drop as the flow measurement has been integrated as a measured pressure drop across the ventilation loop heat exchanger 0.68 +/- 0.07 in-H₂O with ventilation gas flow at 6 acfm (170 lpm) and suit pressure of 4.3 psia and 60°F and 100% O₂ (traces of NH₃, H₂O, CO₂); the allocation of differential pressure (DP) will be ~0.5 in-H₂O should the measurement not be acquired across an existing pressure drop in the system. Evaluation of commercial off-the-shelf (COTS) DP sensors has yielded units that are either too large or orientation/vibration sensitive as this hardware needs to operate and tolerate up to 2 grms Grms vibration during operation and >9 grms Grms while stowed.

Volume/shape factor is approximately 2.5 in x 1.5 in x 3 in or less including fluid ports and electrical connectors; if added as an in-line flow, 1 in inlet/outlet porting will be necessary. The absolute pressure range with 100% oxygen is up to 25 psia; the optimal choices would include materials not considered flammable in this environment to reduce compatibility issues with things such as kindling chain ignitions of human generated debris. A thermal mass flow measurement would also seek to minimize the energy input and operating temperature above the core stream temperature to further improve oxygen compatibility. The measurement range for the sensor is 2-8 acfm +/- 1% with 100% O₂, suit pressure from 3.5-25 psia, temperature from 50-90°F, RH 0-50%, and CO₂ from 0-15mmHg.

The sensor must also tolerate low dose rate to 30 krad as well as high energy particles to 75 MeV-cm²/mg without destructive Single Event Effects (SEE) such as latchup, gate rupture, burnout, etc. The ambient operating environment will range from sea level conditions to vacuum with ambient thermal sink ~50°F. Operating life will need to be 8 years without calibration and 5000 hrs of powered operation.

