Extravehicular Activity Technology Development—Oxygen Subsystem

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The Extravehicular Activity (EVA) Technology Development Team—within the Crew and Thermal Systems Division of NASA Johnson Space Center (JSC)—is developing critical oxygen subsystem components to support the next-generation spacesuit. The oxygen subsystem of the Portable Life Support System of a spacesuit provides a crew member with gaseous oxygen for metabolic consumption, a pressurized environment, and the ability to supply open-loop purge flows for carbon dioxide washout or supplemental cooling. Primary components of the oxygen subsystem are tanks and regulators. Additional components include quick disconnects, purge valves, and relief valves.

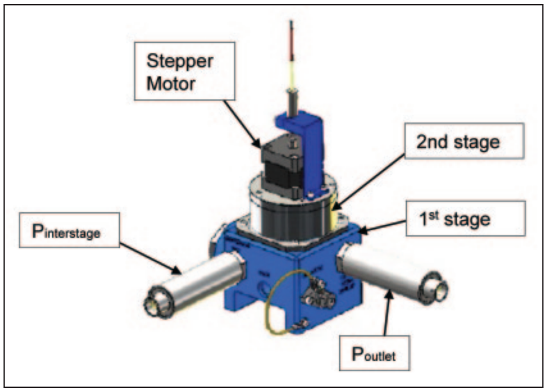

Fig. 1. *Primary variable regulator.*

Primary Variable Regulator

The space shuttle and International Space Station extravehicular mobility units have oxygen regulators with only two mechanically fixed set points. However, having a variable-pressure regulator in the spacesuit architecture allows for greater functionality (figure 1). The team performed work to develop a regulator to meet requirements, which stated that the regulator must decrease pressure from 20,684 kilopascals (kPa) (3000 psia) in the oxygen tank to a nominal suit pressure of approximately 33.1 kPa (4.8 psia). Making the regulator capable of varying the pressure setting provides added functionality because it can be used to regulate suit pressure to: match different vehicle pressures; perform procedures to prevent or treat decompression sickness; or minimize prebreathe durations prior to performing an EVA. An electronically driven regulator has been developed with a minimum of five set points and a goal of making the regulator continuously variable. Carleton Technologies Inc. (Orchard Park, New York), a subsidiary of Cobham plc (Wimborne, Dorset, UK), built this regulator by using a stepper motor to adjust the compression of a spring that then mechanically sets the regulator. This development effort not only includes the mechanical operations of the regulator, but also the electronics that drive both the regulator and the control logic. This regulator is being tested at JSC on a test stand (figure 2) that has been designed and built to evaluate candidate regulators for future spacesuit development.

Fig. 2. *Regulator test stand.*

Variable Electronic Regulator

The variable electronic regulator (figure 3) is an alternative concept to implement a variable-pressure regulator. The variable electronic regulator is one of the approaches currently being examined to meet improved requirements by using electronically controlled solenoid valves that are connected to high- and low-pressure supplies. The valves are controlled based on a pressure feedback to set the regulation pressure of the regulator. Key features of the variable electronic regulator include precise pressure control without droop or hysteresis.

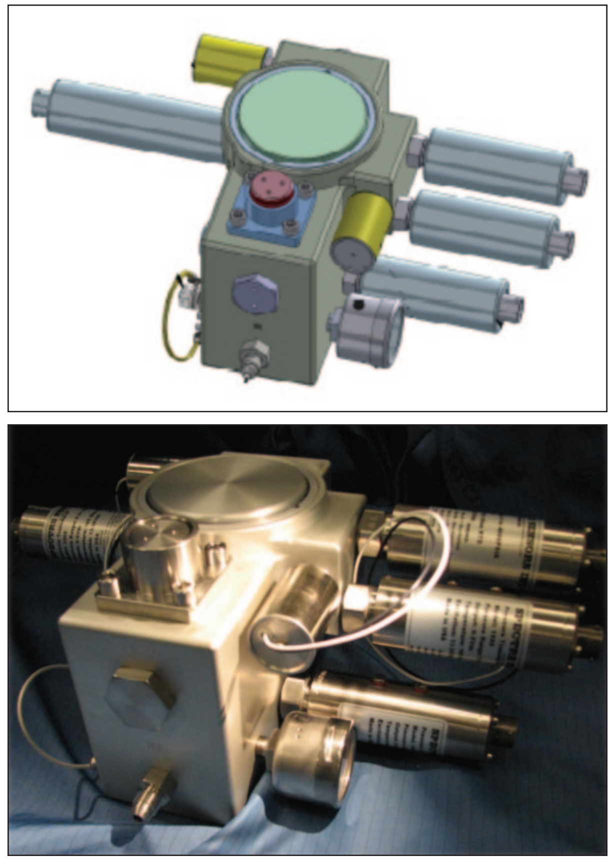

Fig. 3. *Variable electronic regulator.*

Secondary Oxygen Regulator

The secondary oxygen regulator (figure 4) is used to regulate the oxygen supply pressure coming from the secondary tank. The reliability of this regulator and the actuation mechanism that controls it is critical. A secondary oxygen regulator benchtop prototype has been built, delivered to JSC, and tested. The objective of this work is to develop a remotely operated high-pressure oxygen regulator that will function nominally in a lunar dust environment to enable doffing of the Portable Life Support System at vacuum. The space shuttle extravehicular mobility unit has experienced nine secondary oxygen regulator failures due to high actuation forces in a clean environment. The new benchtop prototype of the secondary oxygen regulator is designed for remote actuation in a lunar dust environment. Future work consists of building a functional prototype of the secondary oxygen regulator that has flight-like fluid passages and is compatible with oxygen for dust and vibration testing. Additional work includes development of a controller (modeling and testing of complex electromechanical systems) and research into

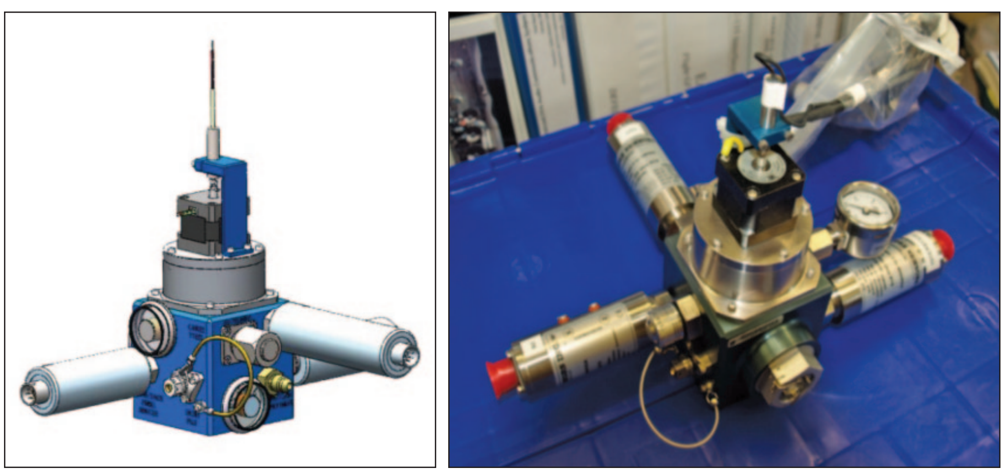

Fig. 4. *Secondary oxygen regulator.*

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oxygen-compatible materials (new lightweight oxygen materials that are safe up to 27,579 kPa [4000 psia]). Development of alternative regulator designs (e.g., a balanced dual-stage regulator that could simplify system design via integral fault tolerance) may also be needed.

Spacesuit Assembly Simulator

NASA designed a spacesuit assembly simulator to provide a transparent, ground-based test bed for studying and validating oxygen flow in a spacesuit during simulated EVA conditions. The team created the spacesuit assembly simulator hardware Pro-E model (figure 5) using two combined laser scans of a Mark III development EVA suit. To obtain these laser scans, the team first pressurized the Mark III suit, and then took one laser scan of the suit exterior to obtain the exterior surface topography. The outermost layers of the Mark III suit were removed, as it was impractical for the interior of the suit to be laser scanned. A scan of the inflated bladder was taken and assumed to be the interior surface of the suit. The team then combined these two laser scans into a single Pro-E model, which became the base spacesuit assembly simulator model.

NASA performed computational fluid dynamics analyses relating to nitrogen purge times and carbon dioxide washout. The interior of the suit model was developed from a scan of a suit and contains typical fabric ripples and folds, thus the spacesuit assembly simulator hardware can be tested to obtain realistic interior airflow data and used to validate the analyses. Having a transparent spacesuit simulator will also help researchers obtain a better visual understanding of ventilation flow paths and their interactions with and around other hardware within the suit.

Fig. 5. *The spacesuit assembly simulator Pro-E model and pressure test arm.*