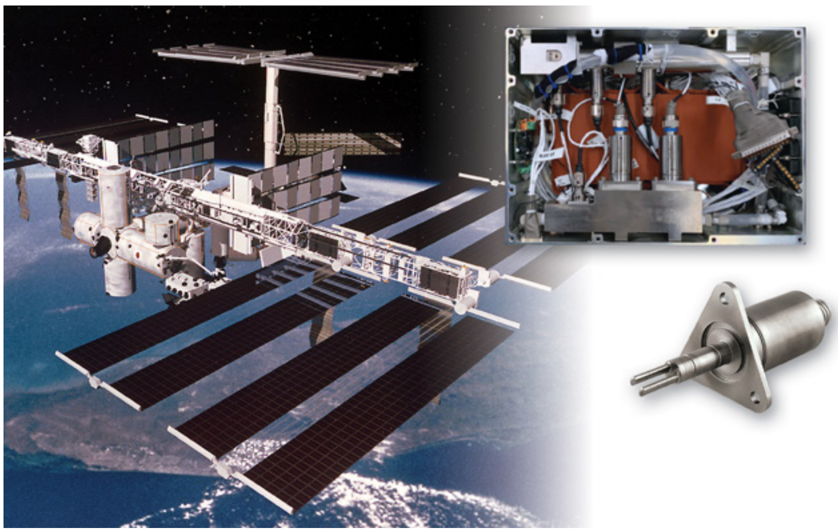
FCI Aerospace Case Study



FCI Flow Switch Embarks on Out of This World Mission for Spacesuit Experiment aboard International Space Station

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The U.S. National Aeronautics and Space Administration (NASA) is developing the next generation of spacesuit technologies that will enable deep space exploration. By incorporating advancements such as re-generable carbon dioxide removal systems and improved water evaporation systems, these future spacesuits will more efficiently provide crew members with the core necessities: breathable air and body temperature regulation.

Mobility and fit of the pressurized spacesuits are important in keeping the astronauts productive on space walks. NASA is focusing on the new spacesuit design to help its crews work more safely and efficiently. Building on previous successes and learning from the development of the Extravehicular Mobility Unit (xEMU) operational spacesuit currently in use on the International Space Station (ISS), the next-gen xEMU engineering team is developing a new thermal control loop (TCL) design to be demonstrated as an experiment now aboard the ISS U.S. Lab *(Figure 1)*.

The Spacesuit Water Membrane Evaporator (SWME) – Spacesuit Evaporation Rejection Flight Experiment (SERFE) *(Figure 2)* was installed in November, 2020, on the ISS by Astronaut Kate Rubins. NASA will run 25 extra-vehicular activity (EVA) spacewalk simulations with the exploration extravehicular mobility unit's (xEMU).

Figure 1: International Space Station (NASA)

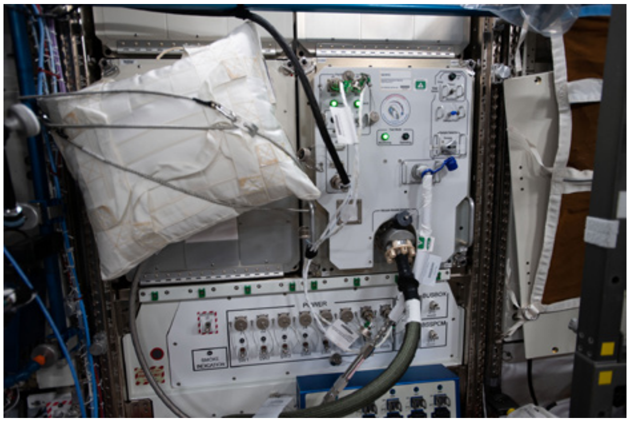

Figure 2: SERFE hardware (NASA)

The Problem

For the new TCL testing protocol to be done with the SERFE, NASA required two liquid flow switches. They are providing the safety low level cut-offs for the SERFE heater performing the metabolic heat injection to test the system. The two thermal liquid flow switches are used in the heater box to safeguard the heater from a loss of water or flow.

This experiment will gather key data on the long-term performance of water quality and effectiveness of biocides in microgravity while demonstrating the operational life cycle for pumps, valves, fitters and evaporators. To mitigate the potential failure of the hardware that results in loss of flow or loss of fluid, two highly reliable, thermal, liquid Flow Switches from FCI Aerospace have been installed to enable safe shutdown of the system.

Solution

FCI worked closely with NASA to help solve this instrumentation application that will fly for several years. NASA's team of portable life support system engineers responsible for the next-gen spacesuit design project specified that the chosen liquid flow switches would require wetted materials to resist the highly corrosive environment of the testing protocol and that they be galvanically compatible with the spacesuit water loop materials. The flow switch's electronics enclosure also needed to be hermetically sealed (including the connectors).

The flow switches that NASA required would act as a solid state open collector, which would indicate "closed" when sufficient water flow is present and "open" if the liquid flow is too low or in a no-flow condition. The test system is powered by typical aircraft power, 28 VDC nominal per MIL-STD-704. The NASA engineers explained their greatest challenge was to find an existing liquid flow switch, which was already flight-proven, highly qualified and one that also was a commercial off the shelf (COTS) aerospace product.

To meet all of these requirements, FCI agreed to make minor modifications to the material of its existing, COTS-listed thermal AS-FS flow switch design and to support improved sealing reliability for the SERFE test hardware application to be placed aboard the ISS U.S. Lab. To make this possible, FCI's design engineering team agreed to change the switch's standard wetted materials and add a second O-ring seal to its already fully-qualified, proven mature design. The installed FCI AS-FS flow switches *(Figure 3)* are functioning as a safety switch; one which NASA hopes never to have to read during SERFE test procedures.

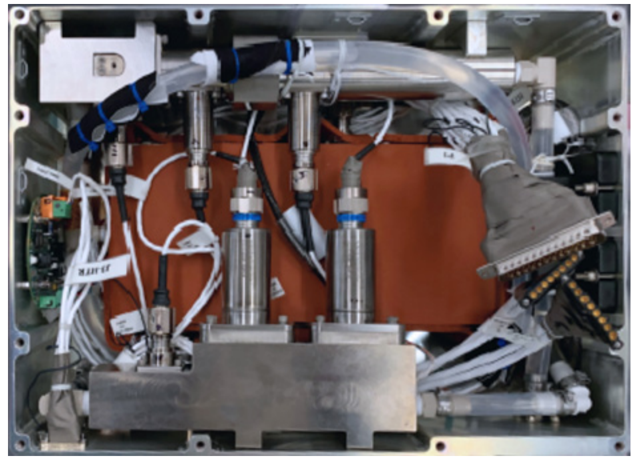

Figure 3: Installed AS-FS liquid flow switches (NASA)

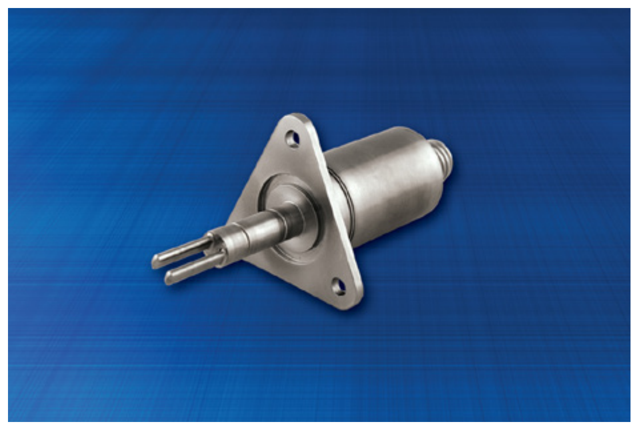

Figure 4: Model AS-FS liquid flow switch

FCI AS-FS Flow Switches

The AS-FS flow switch *(Figure 4)* operates over a wide set-point range in liquids of 0.01 SFPS to 10 SFPS [0,003 MPS to 3 MPS] or in air from 0.25 SFPS to 1,000 SFPS [0,07 MPS to 305 MPS], which is factory set to the user's specification. FCI's thermal mass flow switches monitor mass flow directly, and do not require pressure and temperature corrections necessary with volumetric type flow sensors.

Developed from FCI's proven, high performance aircraft qualified flow switch designs, the Model AS-FS provides a COTS-listed liquid flow switch for faster delivery lead-times at reduced cost. Highly reliable, this flow switch features repeatability of ±2 percent over the full signal range. Response time is 5 to 15 seconds (typical), depending on the user's desired switch point.

Designed for rugged aerospace environments, the Model AS-FS flow switch's standard operation pressure is up to 2000 psig [138 bar(g)], with higher pressure ranges available upon request. The flow element is designed for freezing to frying conditions: -65 °F to 350 °F [-54 °C to 175 °C] to meet the demands of deep space exploration.

The wetted portion of the probe is hermetically sealed and is made of all welded Hastelloy C-276 parts for NASA that were easily substituted for the standard 316L stainless steel material. The flow element's heavy-duty construction provides superior corrosion resistance in liquid flow applications. It is available with a flanged mounting with a standard O-ring seal and can be provided with a variety of military electrical connectors.

The electronics are hermetically sealed (welded) in an integral enclosure. Power input is 19-32 VDC per MIL-STD-704. Standard outputs include an open collector (sink) and/or a filtered, buffered op-amp (source) (<1VDC [low flow] or >17 VDC [high flow]). Electronic hysteresis is included to prevent undesired switching when flow rates are in the vicinity of the set-point.

This AS-FS meets multiple rigorous environmental and performance industry standard specifications. They include EMI and lightning protection of the electronics to MIL-STD-461 and RTCA/DO-160, as well as full qualification to MIL-STD-810 and RTCA/DO-160.

FCI's thermal mass AS-FS flow switches are suitable for a wide range of aircraft and spacecraft applications. They have proven themselves for decades in environmental cooling systems, air management systems, cooling fan failure alarms, RAM air flow failure alarming, fuel tank inerting systems, and PACK and bleed air systems.

Thermal Sensing Technology

FCI flow sensors have established an unmatched record of superior performance and reliability in the toughest aerospace applications. FCI's unique thermal dispersion technology (TDT) provides exceptional reliability and repeatability for monitoring flow rate in liquids, air and gases.

The sensing element contains two thermowell-protected platinum resistance temperature detectors (RTDs). When the flow element is installed in the pipe or duct, the reference RTD measures the temperature of the surrounding fluid, while the active RTD is heated by an adjacent heater to a temperature that is warmer than the surrounding fluid *(Figure 5)*.

The temperature difference between the two RTDs (highest at no flow) is read. Flow cools the heated RTD and reduces the temperature difference between the active and reference RTDs. Higher flow results in a small temperature difference and low flow produces a larger temperature difference between the RTDs.

The element RTDs are connected to a bridge circuit that senses the changing temperature difference and switches the signal output when a critical flow rate is reached. This provides a repeatable flow switch point in harsh application conditions without moving parts in the switch.

Conclusions

NASA found a unique and differentiated, liquid flow switch supplier for this most significant long-term test hardware requirement when they called on FCI. The required high-quality instruments were completed on time, under a firm fixed-price agreement with low program risk. The U.S. Government's contracting officer noted in a post contract completion review, "Given what I know today about the contractor's ability to perform in accordance with this contract or order's most significant requirements, I would recommend them for similar requirements in the future."

FCI Aerospace is a world leading manufacturer of standard off-the-shelf and custom built-to-specification flow, level, temperature and pressure sensors with designs that meet and exceed specifications for performance, reliability and quality. FCI is in addition ISO 9001 and AS-9100 certified, FCI's quality program and policies are continuously reviewed and audited by all major airframe manufacturers and contractors. ■

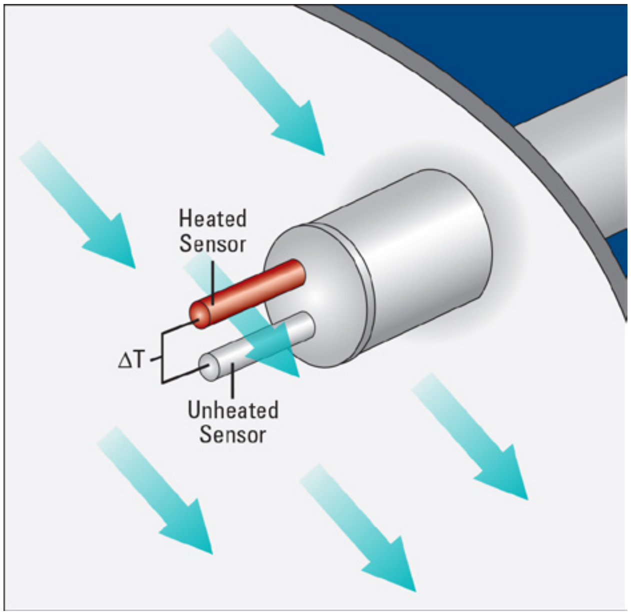

Figure 5: Thermal flow sensing theory of operation