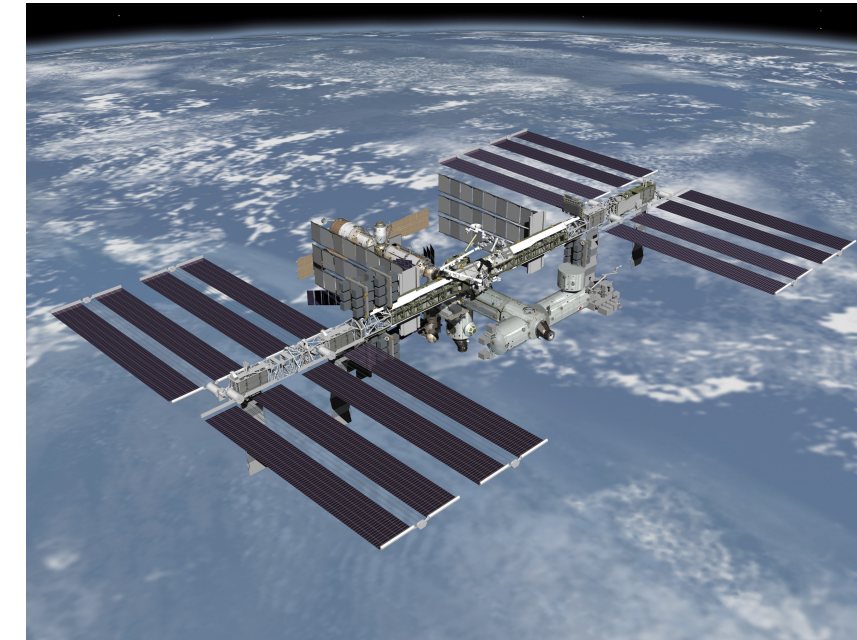


Environmental Cooling on the ISS

Environmental cooling on the International Space Station is a two-fluid, single-phase system. Water is circulated through pipes in conductive contact with the station interior to absorb heat and then brought into conductive contact with anhydrous ammonia circulating in pipes exposed to the external space environment.



A more efficient method of heat transfer makes use of flow boiling in a single liquid two-phase cooling system. In two-phase systems, the coolant has a low enough boiling temperature that when it absorbs ambient heat it begins to boil. The vapors are then cycled outside the station where they condense back into a liquid that can be cycled back into the station for reuse.

Problems with the Single-Phase Cooling System

- The fluid in contact with the external space environment must have its contact time monitored and limited to prevent it from freezing.
- In the case of the liquids presently employed on the station, ammonia has a less than ideal heat capacity and is not ideal for quickly absorbing and radiating heat on station.
- Finally, the use of ammonia poses health risks to crewmembers in the event of leaks.

Goal of the Experiment

Flow boiling heat transfer efficiency is reduced by the presence of dissolved gases in the liquid.

Goal: To effectively remove dissolved gases from FC-72 using membrane filtration in reduced gravity.

Results of this experiment will be used to supplement the Flow Boiling and Condensation Experiment (FBCE), currently being developed at Purdue University and NASA Glenn Research Center. The FBCE is scheduled for deployment on the ISS in 2017.

Technology

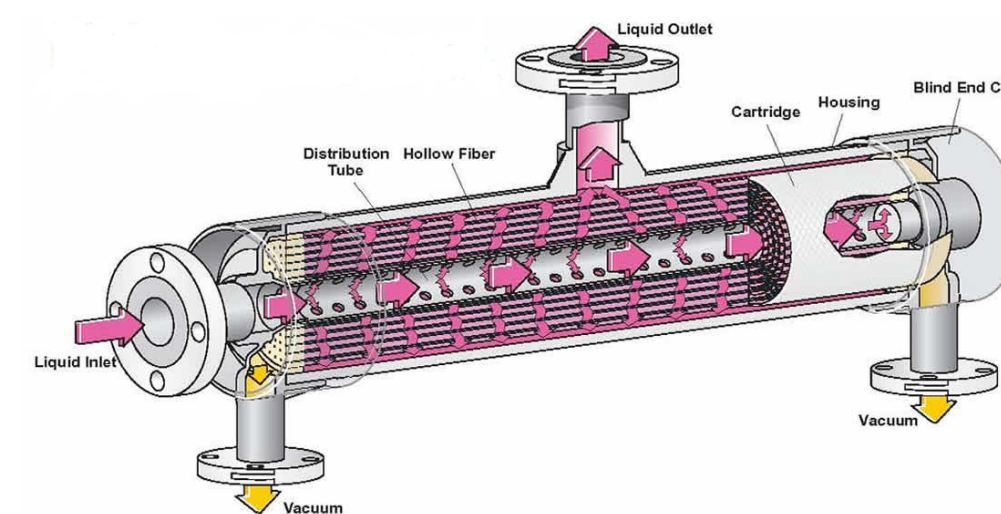


Figure 1: Radial Membrane Contactor (Image Courtesy of Liqui-Cel, Inc.)

The core of the experiment is the radial membrane contactor (RMC). The RMC consists of a dense network of capillary tubes through which liquid passes to an outlet. Dissolved gases diffuse through capillary walls due to a pressure difference applied by a vacuum on the outer surface of the capillary tubes. Figure 1 shows the flow of fluid through the radial membrane contactor.

Methods

We carried out experiments in both microgravity and 1-g environments. Microgravity conditions were obtained on parabolic flights aboard a microgravity research aircraft through NASA's System Engineering Educational Discovery (SEED) Program and NASA Glenn Research Center Flight Week.

Experimental Setup

Figure 2 shows a schematic of the flow loop.

- The flow loop consists of a 500ml reservoir, flow pump, vacuum pump, dissolved gas sensor (DGS), pressure and temperature sensor.
- Flow pump circulates the FC-72 constantly through the flow loop at a rate of 1.0 l/min.
- During zero-gravity portions of flight, the FC-72 is circulated through the radial membrane contactor which degasses the liquid.
- A vacuum pump is attached to the radial membrane contactor to remove the dissolved gas in the liquid FC-72.

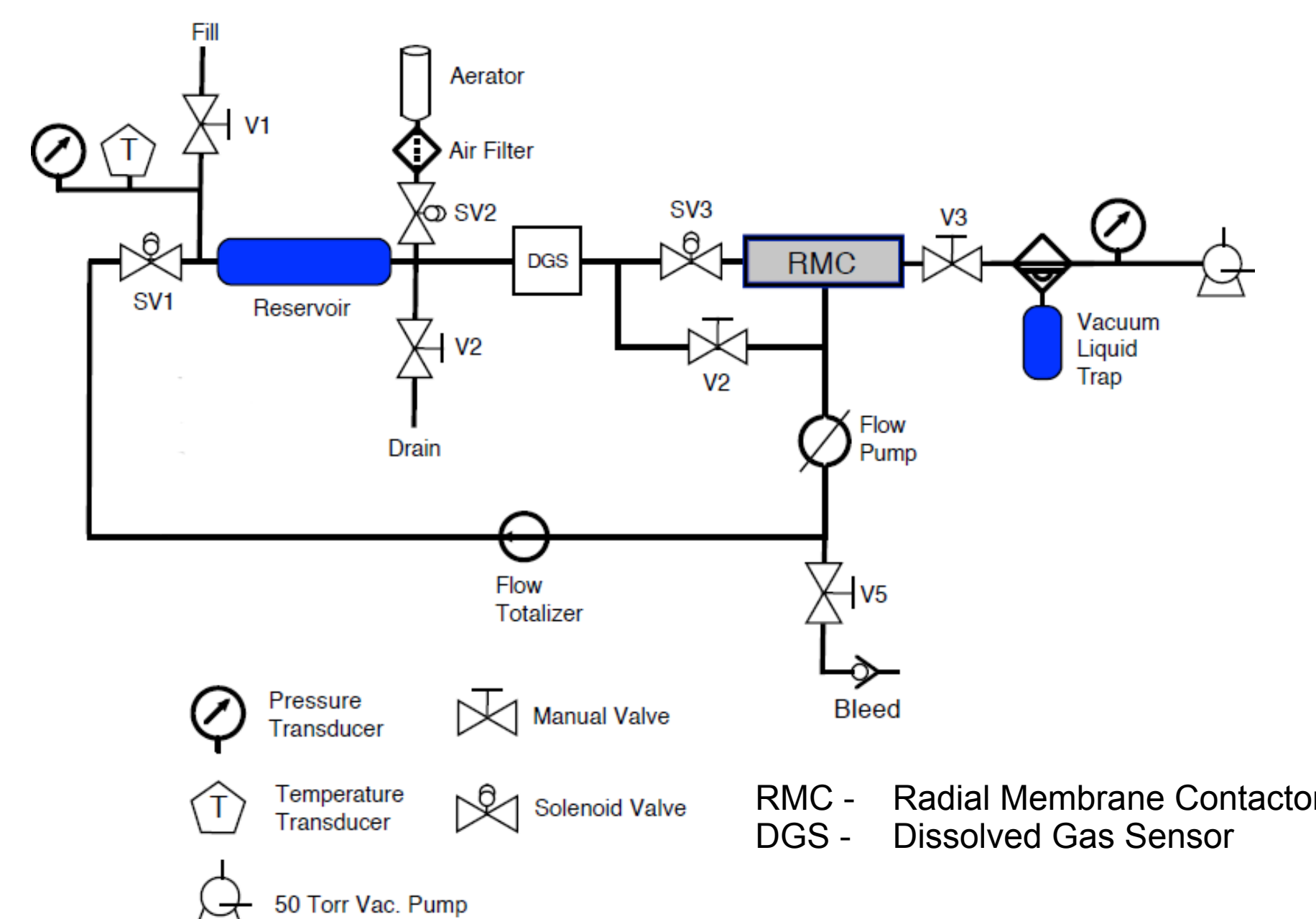


Figure 2: Flow Loop Schematic

Flight Weeks

- 220 parabolas on Zero-G Corp. parabolic aircraft.
- 6 flight days over two flight weeks.
- 73 minutes in zero-gravity.

Pictured during Flight Week #1, Day #1 are Project Mentor Nancy Hall of NASA Glenn Research Center and Danielle Weiland, Carthage College.



Results & Analysis

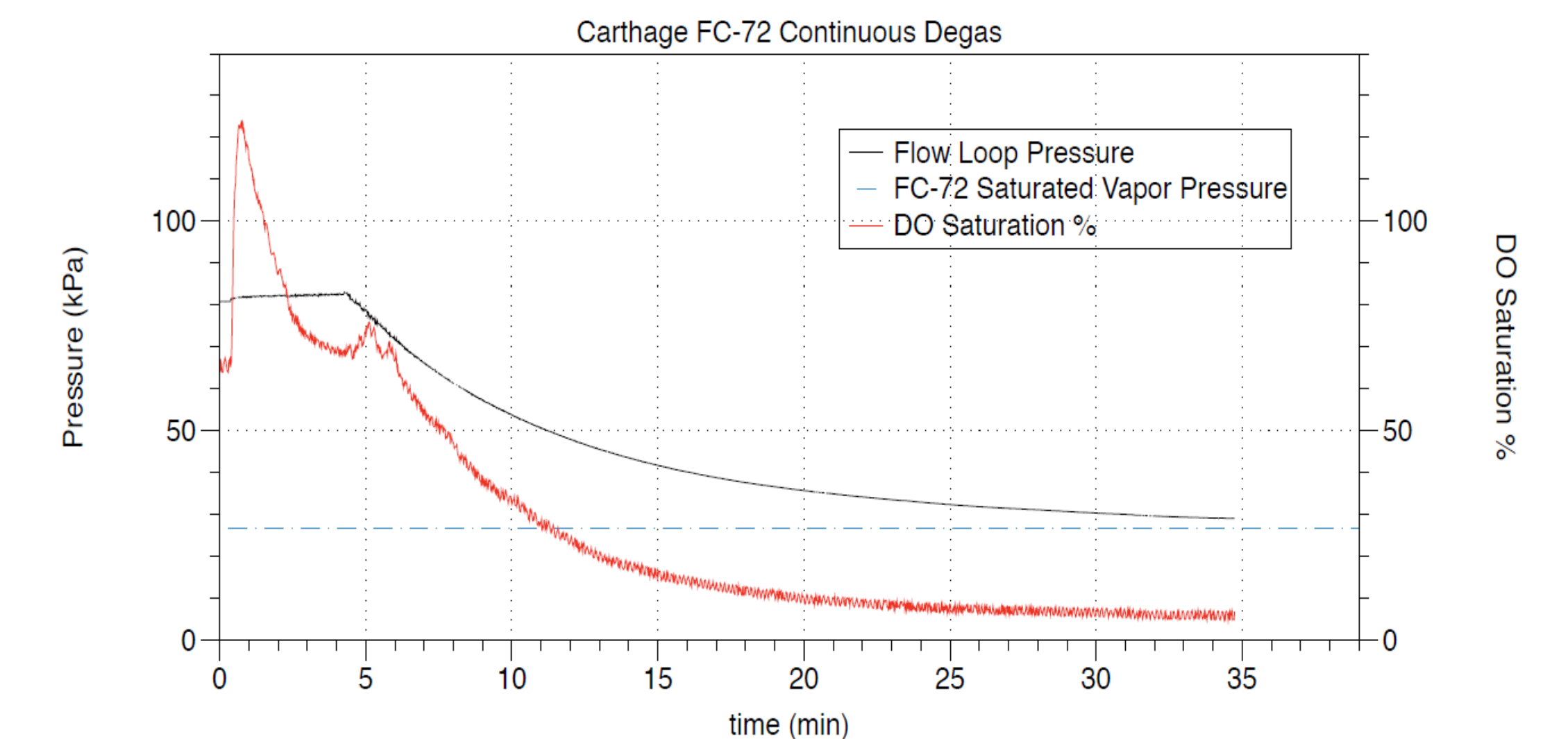


Figure 3: FC-72 Continuous Degas of FC-72 in 1-g (lab) conditions. Shown here are both pressure in the flow loop and Dissolved Oxygen (DO) saturation.

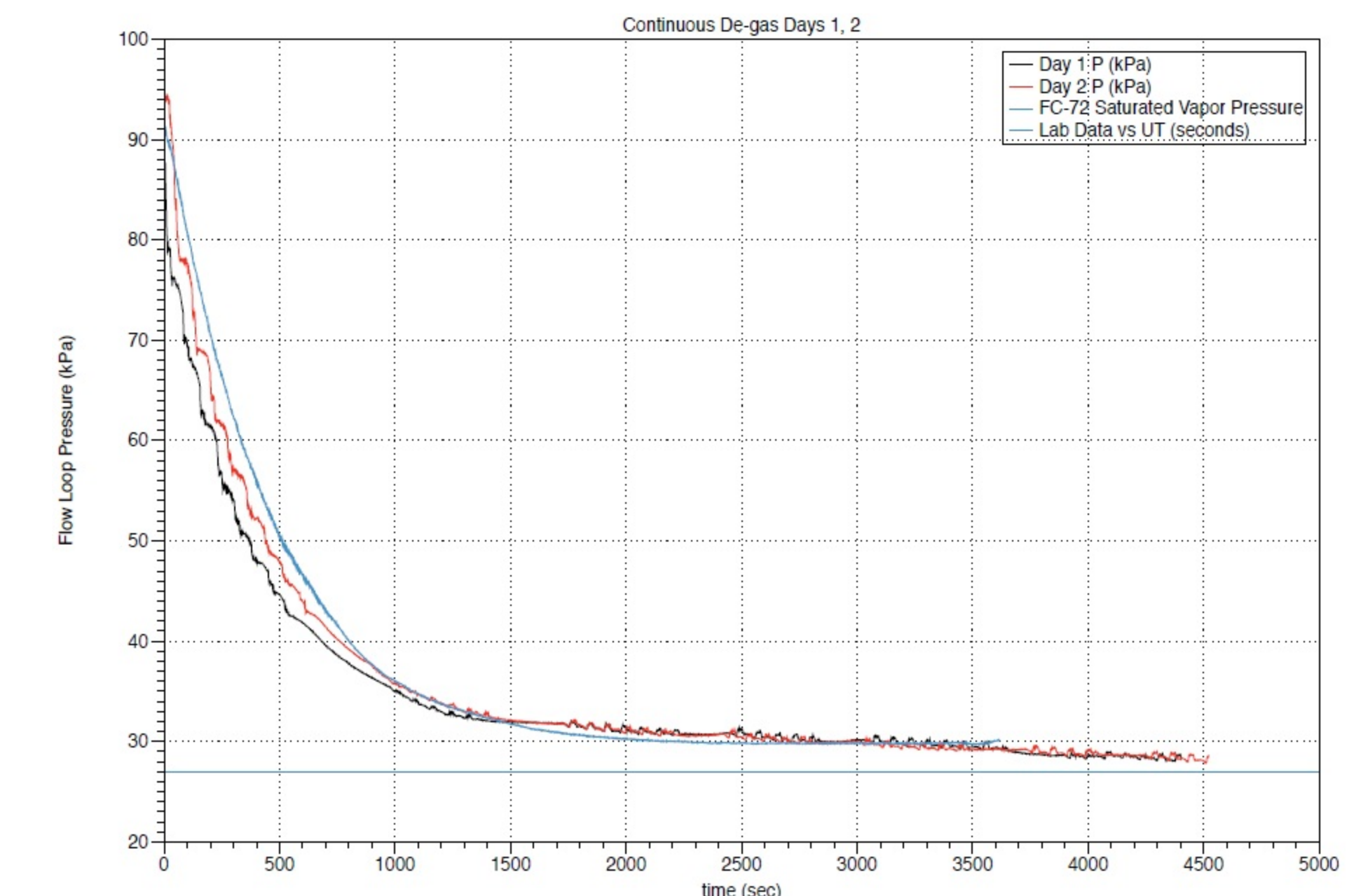


Figure 4: Lab and Flight Week 2 Pressure Data for continuous degas.

Key Results

- **FC-72 O₂ concentration to 7% of saturated value.**
- **FC-72 total dissolved gas partial pressure to within a few kPa of its vapor pressure.**
- **RMC is a cheap, effective, quick way to degas fluid within a flow loop on board the ISS.**

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