Scroll Pump Dust Tolerance Test for Martian Atmospheric Acquisition

Juan H. Agui and Justin P. Elchert
NASA Glenn Research Center

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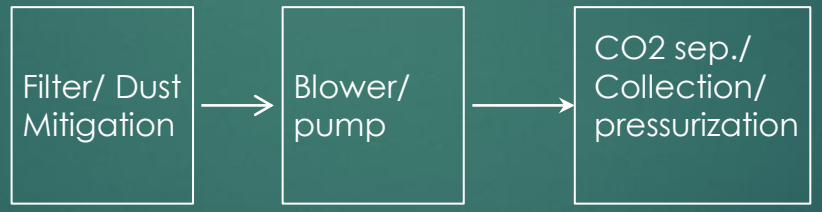
Intro/Motivation

- Oxygen generation technology will be essential to establishing a human presence on Mars.
- Martian atmospheric dust can affect atmospheric acquisition and processing systems where flow generating devices such as pumps, compressors, and blowers may be affected.
- The concern with the reliability of the system and its ability to continue to perform nominally when Martian dust, if it bypasses the inlet filter, enters into the system is a mission risk.

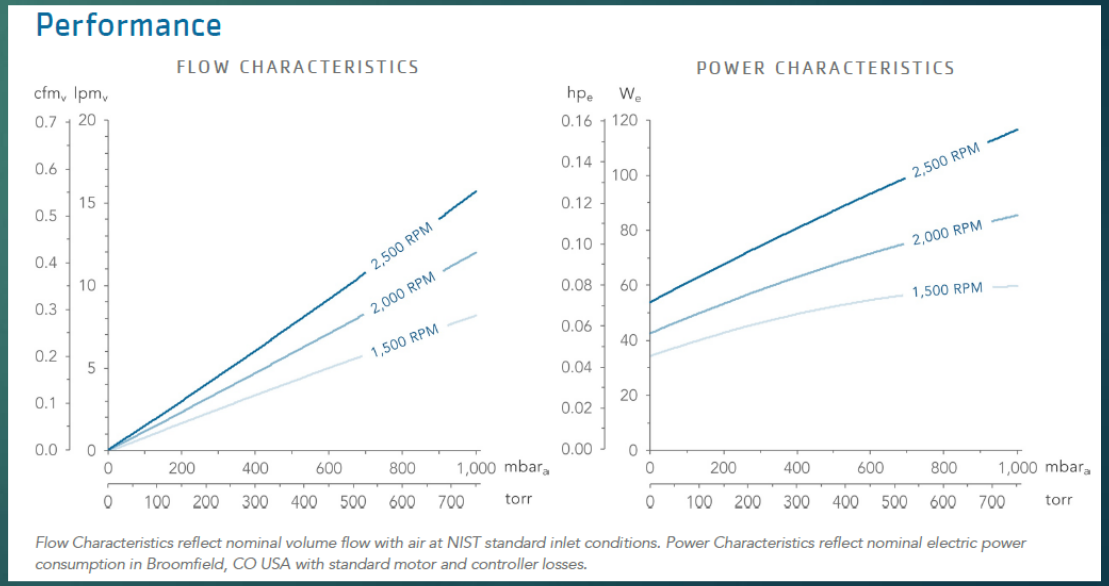
Resource Utilization and Atmospheric Acquisition

- NASA Technology Roadmap Area 7.1
  - Resource Acquisition to collect and pre-process the 'raw' resources, both naturally occurring and discarded, or un-needed components brought from Earth;
  - Processing and Production to convert the raw resources into consumables for propulsion, power, and life support



Scroll Pump Description

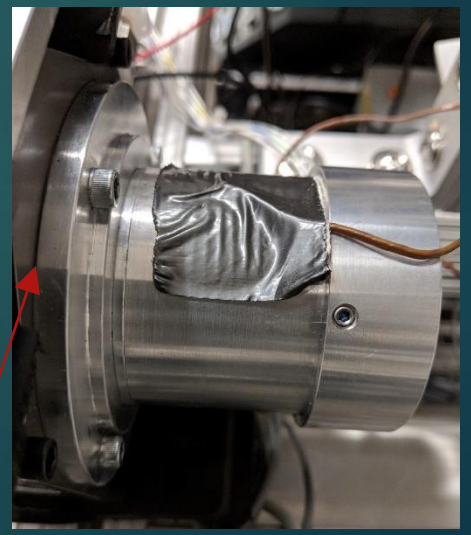
- Same pump initially used by the MOXIE team
- Two-stage scroll vacuum pump
- 100% Oil Free
- Vacuum down to 0.1 Torr
- Volume ratio 7.8
- Operating temperature: -20 ºC to 40 ºC
- Power requirement: less than 25 Watts



Susceptibility to dust

- Contact between rotating and stationary spiral scroll elements
- Internal channel turns/corners
- Fittings
- Bearings (mechanically sealed)

Scroll spiral elements



Picture of sealed bearing

Scroll compressor life test concept

- Goals
  - Determine the performance, efficiency, and susceptibility to a simulated dusty Mars atmosphere of the V10T016A two-stage scroll compressor (manufactured by Air Squared).
- System Level Performance Question
  - How do we expect dust to affect the downstream components (specifically the CO2 acquisition subsystem)? How are these important parameters different for the different CO2 acquisition methods? What are the expected critical failure mechanisms (due to dust) for each CO2 acquisition method?
- Top level design characteristics
  - Conducted in Mars Flow loop at Mars pressures (5 to 7 Torr)
  - Two test phase configurations: (1) pump attached to Mars Flow Loop but placed outside, (2) pump inside flow loop and venting out.
  - Pump controls: current and speed
  - Mass flow controller regulates Mars Flow Loop pressure, even though it's being evacuated
  - Instrumentation: pump speed, flow rate, motor temperature, motor current, MAFL pressure

CO_2 processing requirements

- Pressure
  - Inlet: Mars pressure ~ 5 -7 Torr
  - Outlet pressure: 1 atm. (to Cryocooler or RCAP)

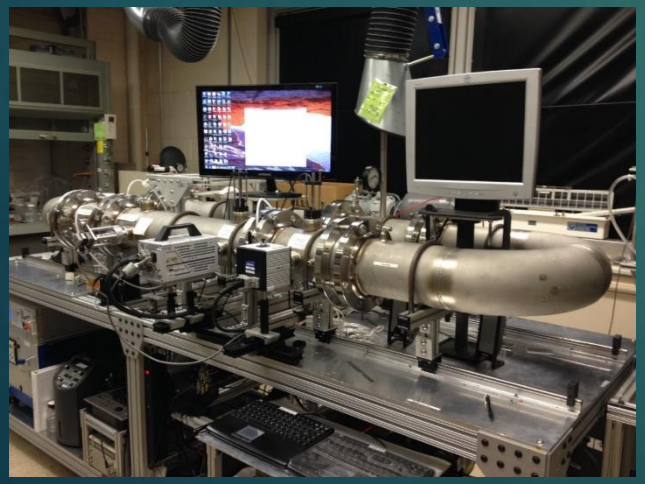
- Flow rate
  - 1.1 kg/h CO_2 (T. Muscatello, email communication)
  - 966 lpm (actual), 8.44 (slpm) (Martian density 0.02 kg/m^3)

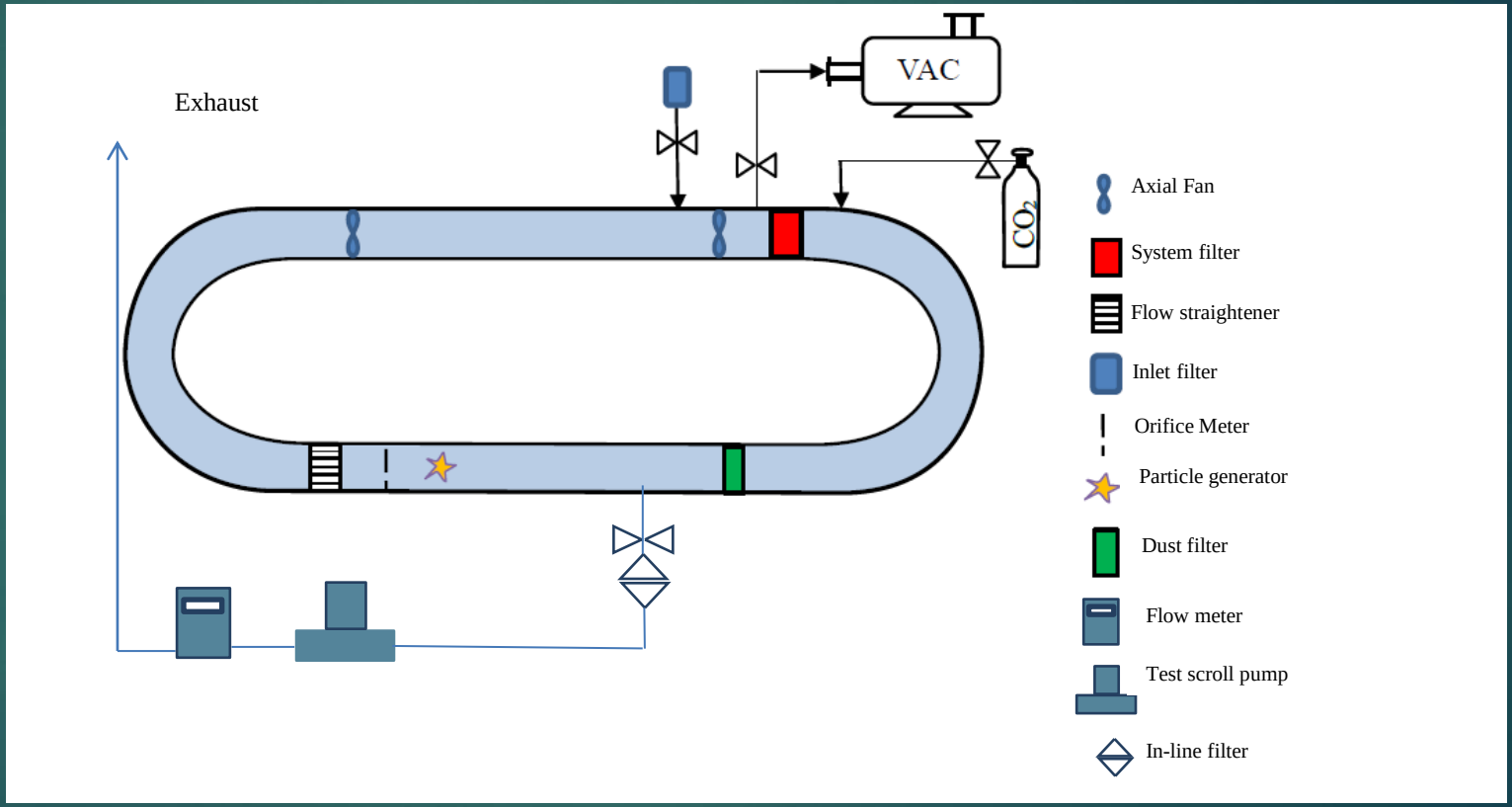
  - Reference, MOXIE: ~1% scale of full ISRU reactor (12 gms/h)

- Dust Environment
  - ~ 6 particles/cm^3
  - 1.6 µm mean particle diameter

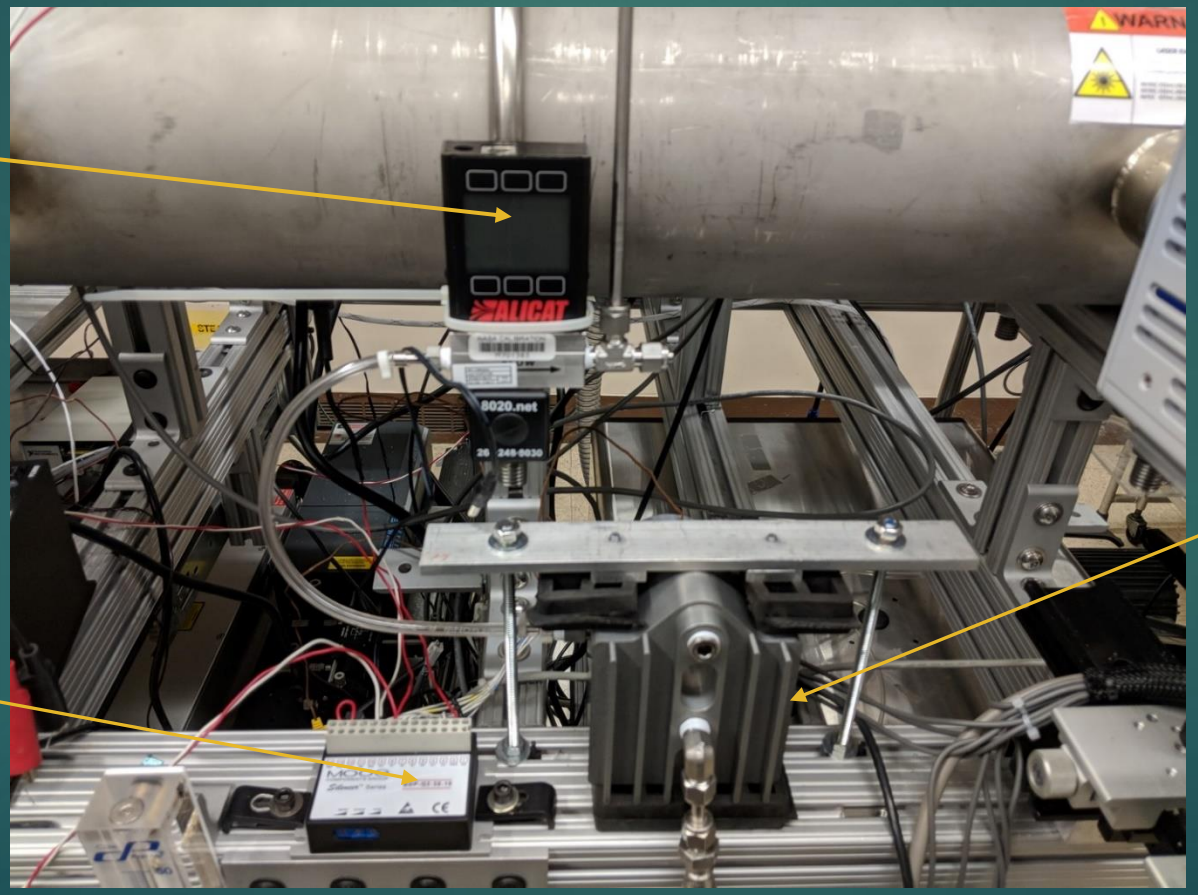
Experimental Setup in the GRC Filtration Flow loop

Challenge dust was JSC-Mars 1 simulant

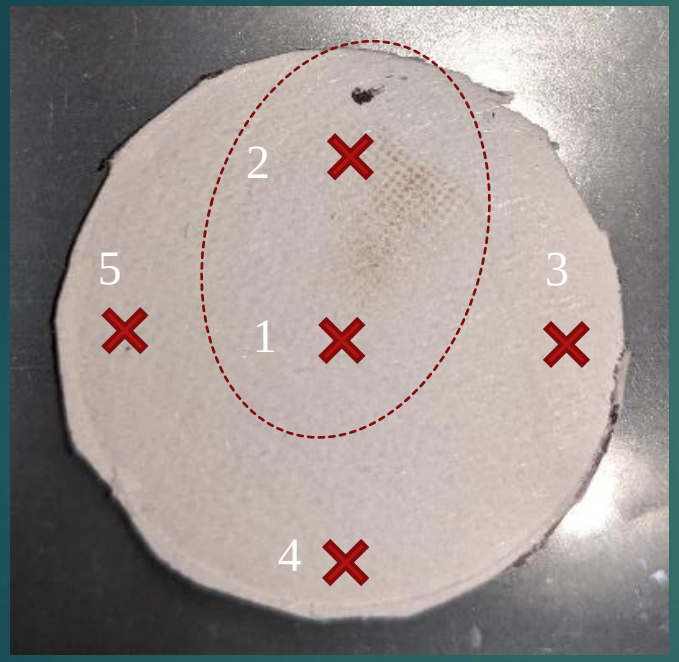




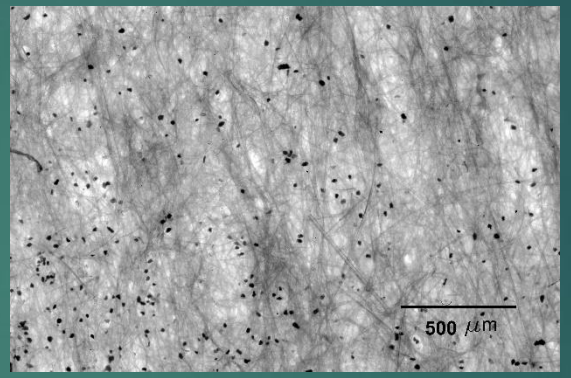
Experimental setup picture



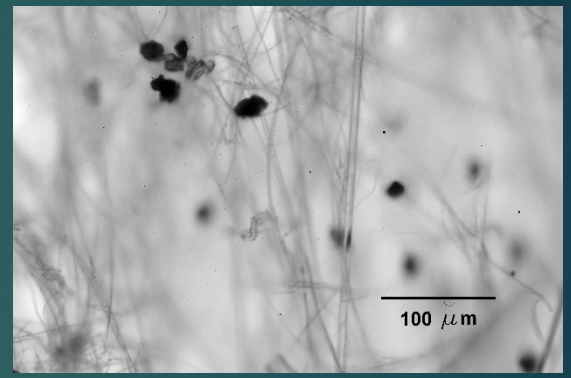
Particle sampling (performed prior to exposure test)



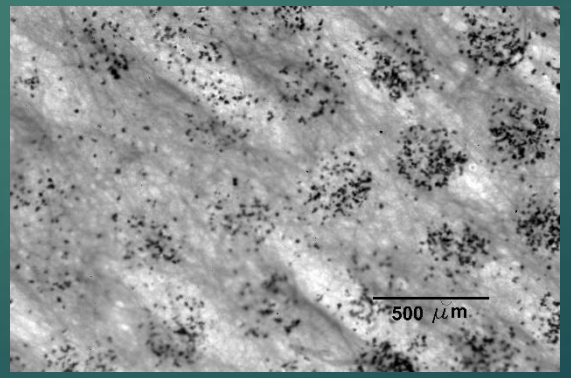
Imaging locations on filter media sample marked by an “x”



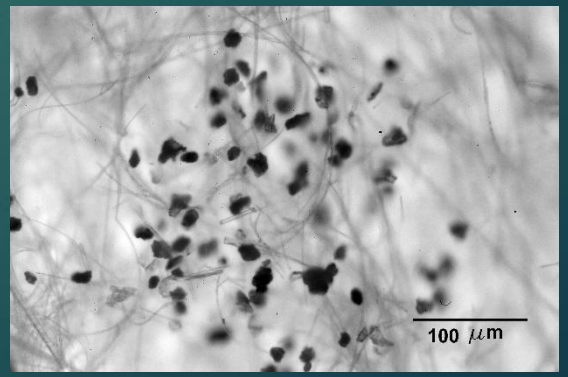
4X @ Position 1



20X @ Position 1



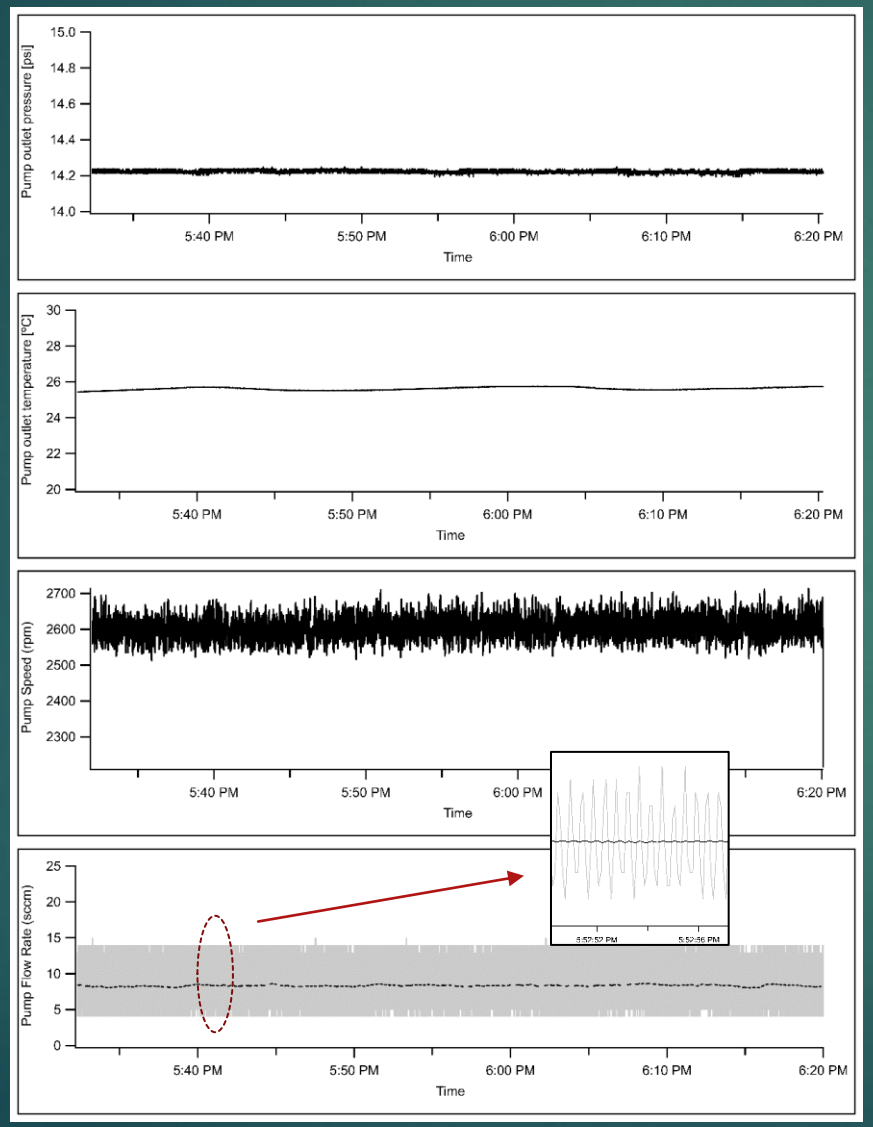
4X @ Position 2

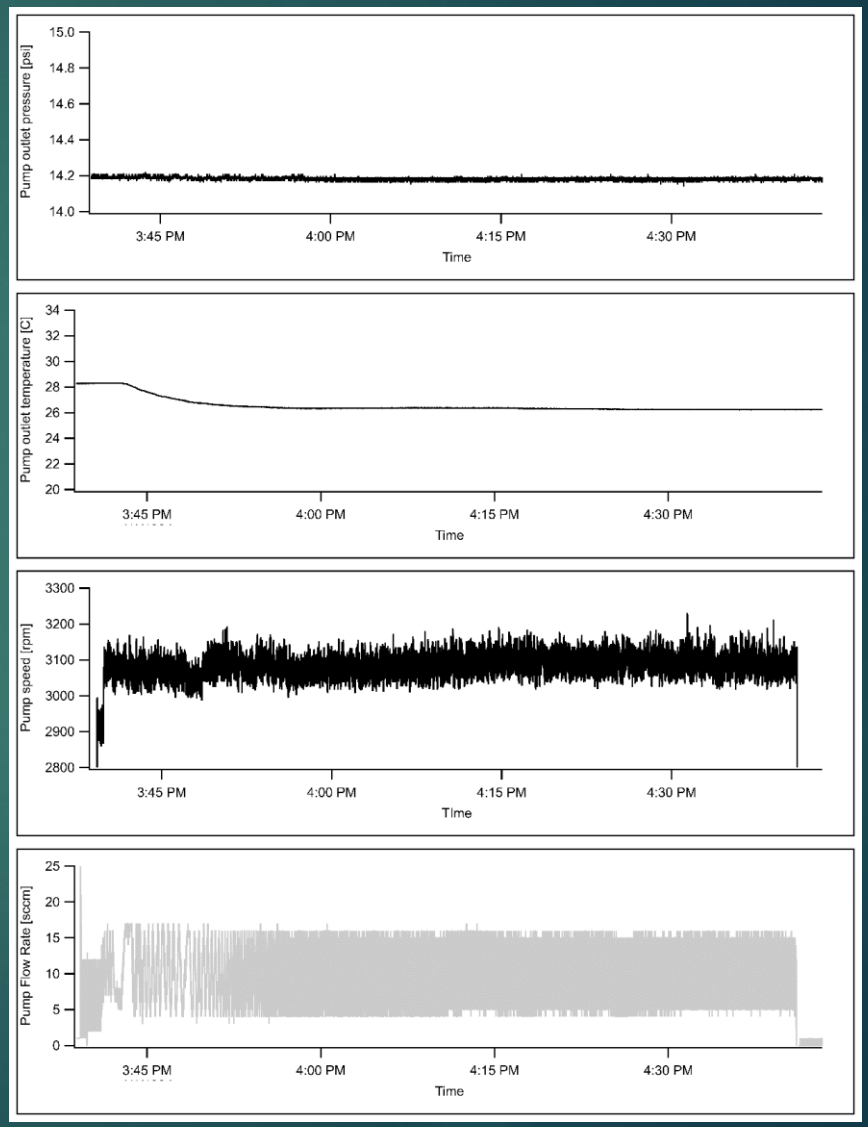


20X @ Position 2

Particle ingestion rate 0.02 mg/min

Test monitoring

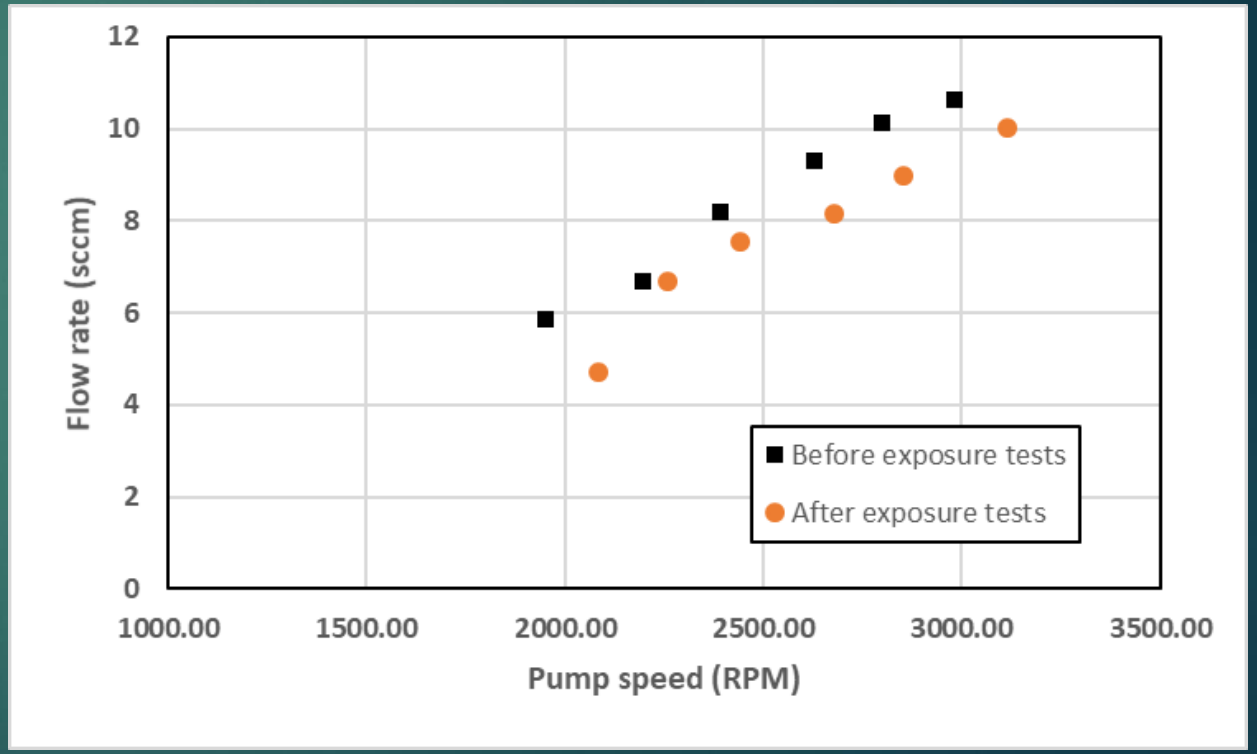




Test Results

- Integrated test

Before Exposure		After Exposure	
pump speed (rpm)	Flow rate (sccm)	pump speed (rpm)	Flow rate (sccm)
1951	5.88	2084	4.71
2198	6.69	2259	6.69
2390	8.19	2442	7.53
2630	9.31	2677	8.14
2797	10.13	2853	8.97
2981	10.63	3112	10.02



Conclusions

- Tests were conducted to simulate the ingestion of Martian dust on a small scroll pump, similar to the one used on the MOXIE payload.
- Two dust exposure tests of an hour duration each and at a dust exposure rate of .02 mg/min were conducted.
- The test results show small, but not insignificant, degradation in pump performance under high dust exposure rates.
- ~~The projected operational time to accumulate this level of exposure, 10^9 hours, is significantly greater than the mission required time of 10^4 hours (11,000 hours) for ISRU surface systems (Kleinhenz and Paz, 2017).~~