
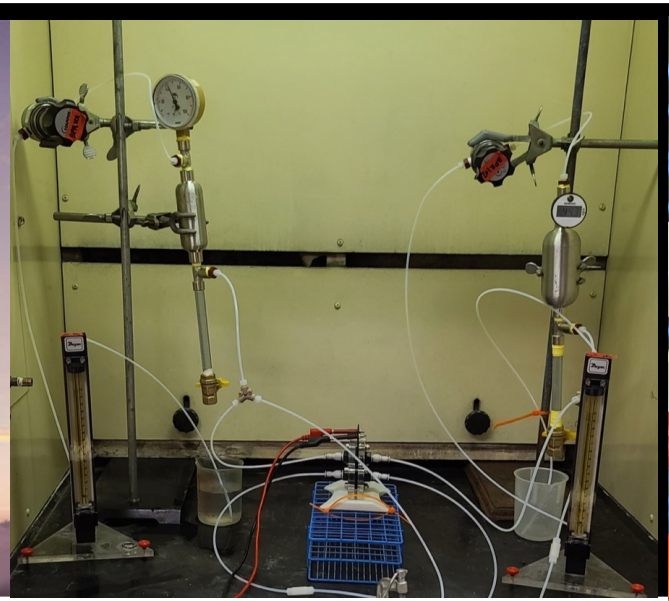
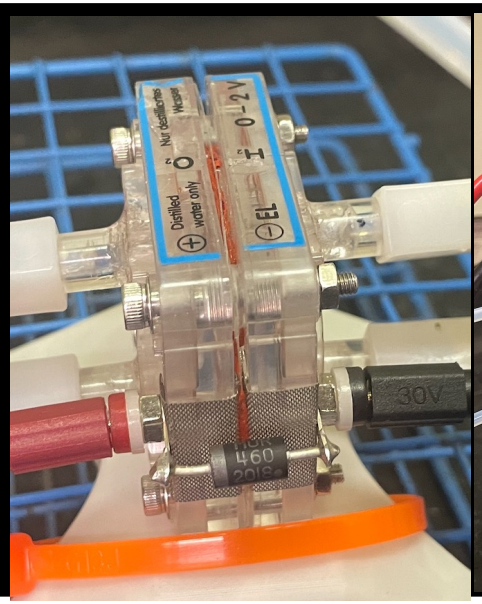

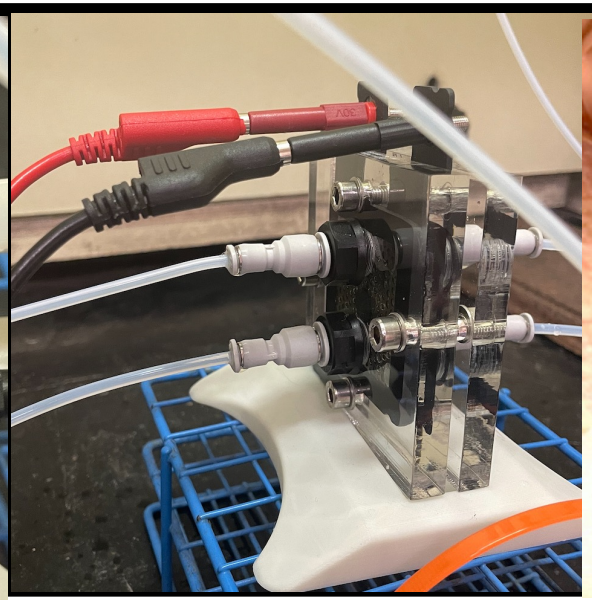
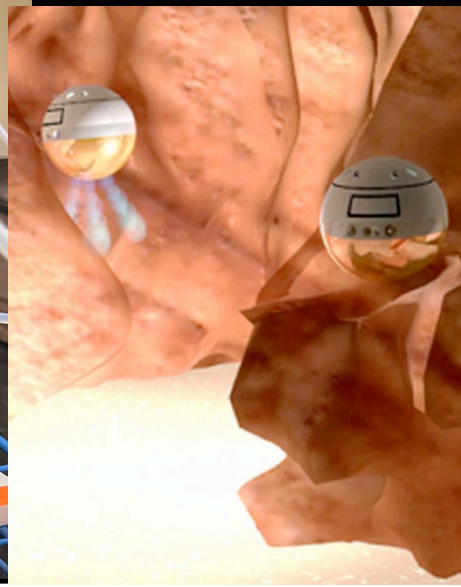

Design and Testing of Polymer Electrolyte Membrane (PEM) Hydrolysis System for Producing Hydrogen and Oxygen Propellants for CubeSat Applications

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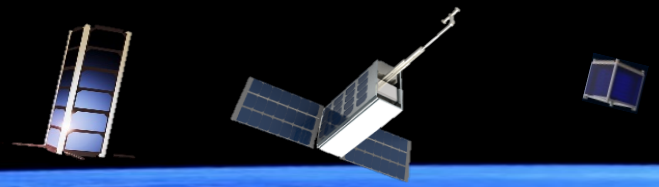
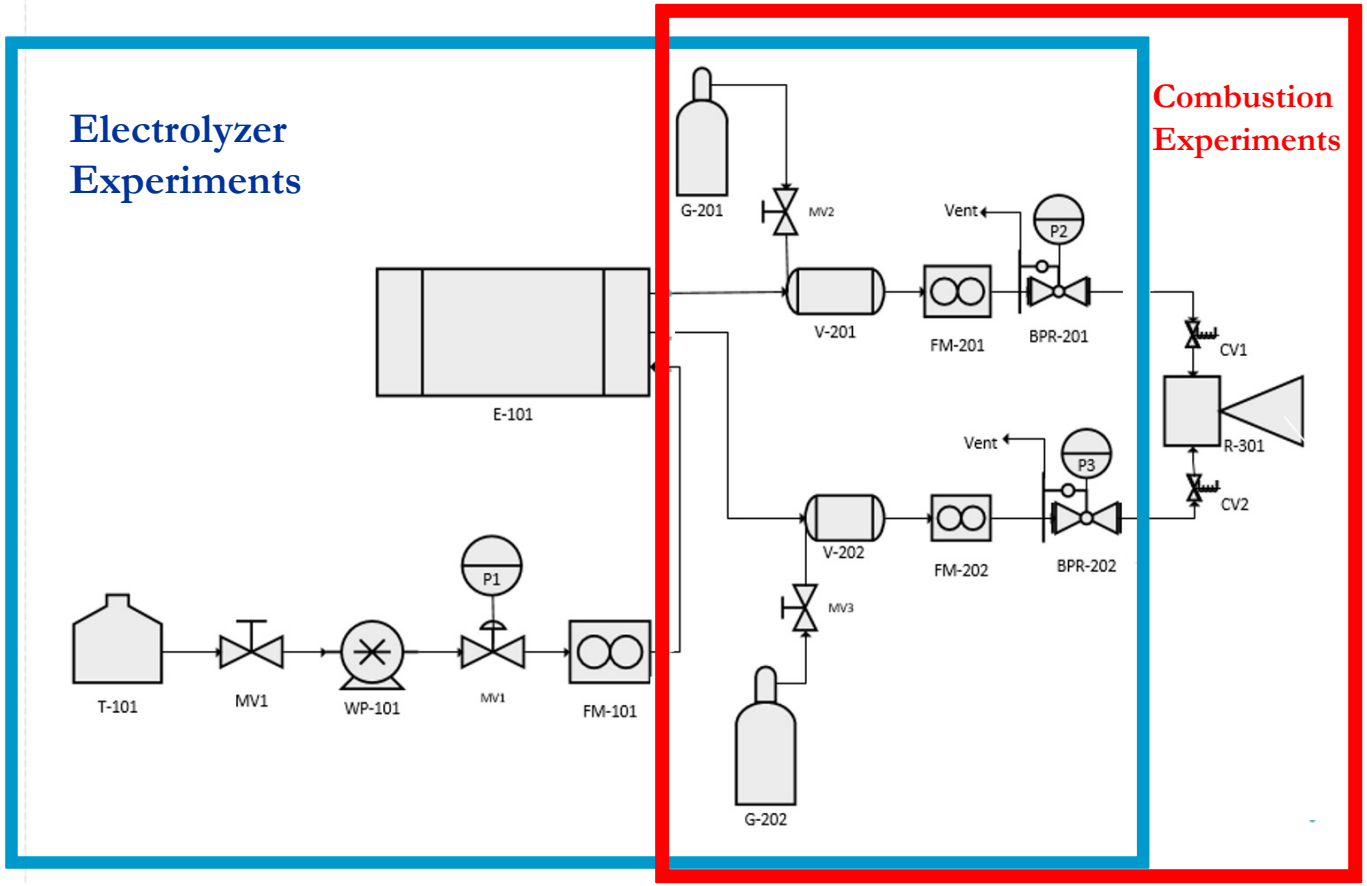


Agenda

- Motivation
  - Where we fit in
- Objective
- Challenges
- Method
- Analysis/Results
- Discussion
- Takeaway

Big Picture: Green Propulsion System Development

T-101 Water Tank	**WP-101** Pressurization Pump	**E-101** PEM Electrolyzer	**FM-101** Flow Meter	**G-201** Hydrogen Cylinder	**G-202** Oxygen Cylinder	**V-201** Hydrogen Tank	**V-201** Oxygen Tank	**BPR-201** Hydrogen Back Pressure Regulator	**BPR-202** Oxygen Back Pressure Regulator	**FM-201** Flow Meter	**FM-202** Flow Meter	**R-301** Rocket Engine



Objectives

- **Develop 1U CubeSat Propulsion System using commercial Polymer Electrolyte Membrane (PEM) Electrolyzers**
  - **Water→ propellant storage medium**
  - **Electrolyzers produce hydrogen and oxygen for propulsion**

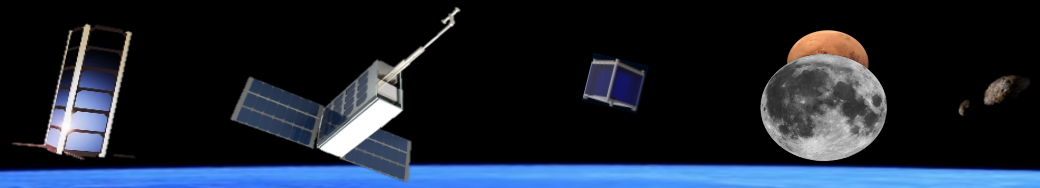
Double Electrolyzer
$100

Single Electrolyzer
$80

Single Rebuildable Electrolyzer
$200

Challenges

- Building the entire experimental apparatus in our lab
  - Pressurizing the system with Hydrogen & Oxygen instead of Nitrogen
  - Leak testing and calculating impact on data accuracy
  - Difficulty with back pressure regulators
  - Testing different Educational Electrolyzers
  - Making and accounting for modifications to various Units
  - Coordinating support for testing



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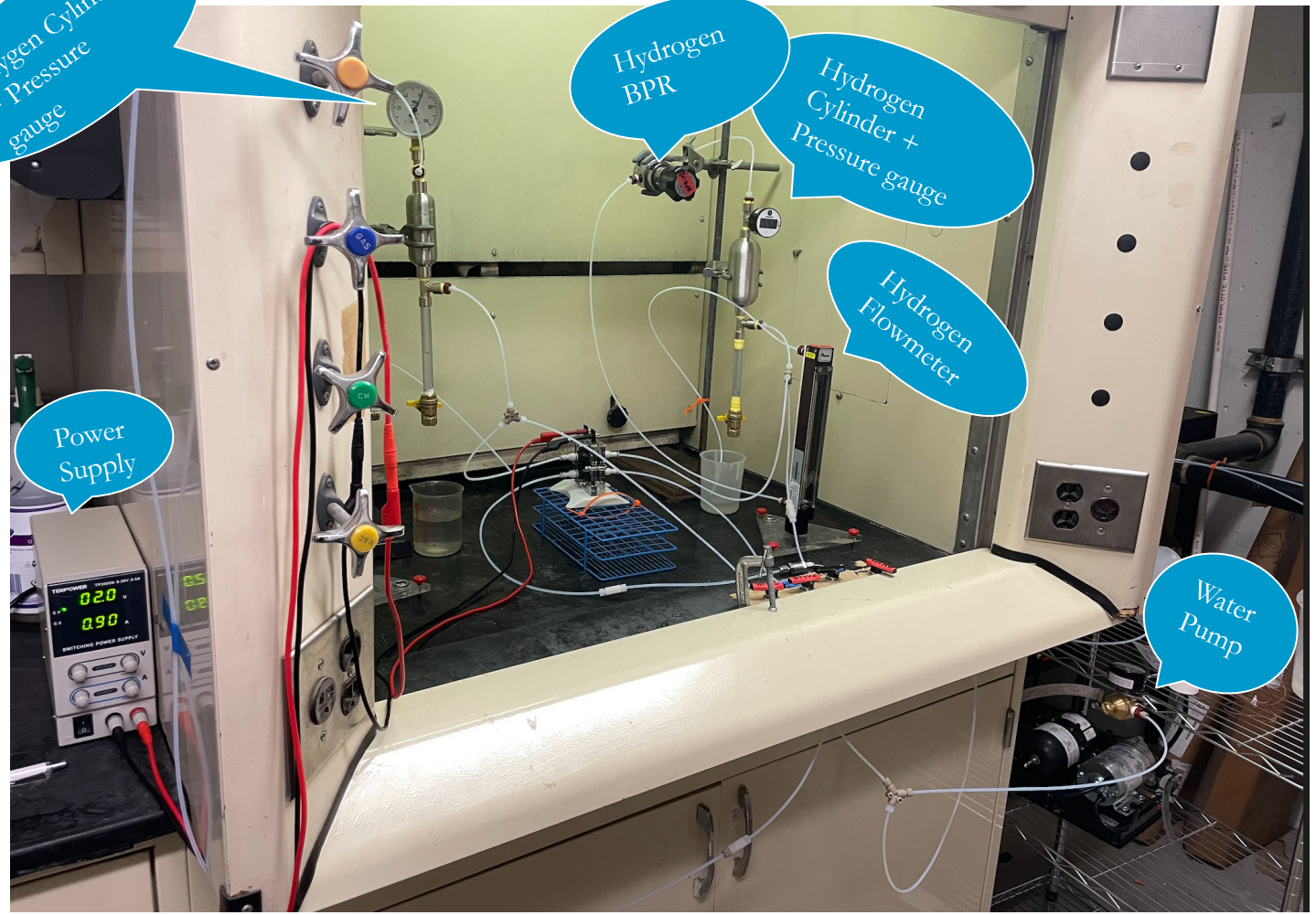
Experimental Plan

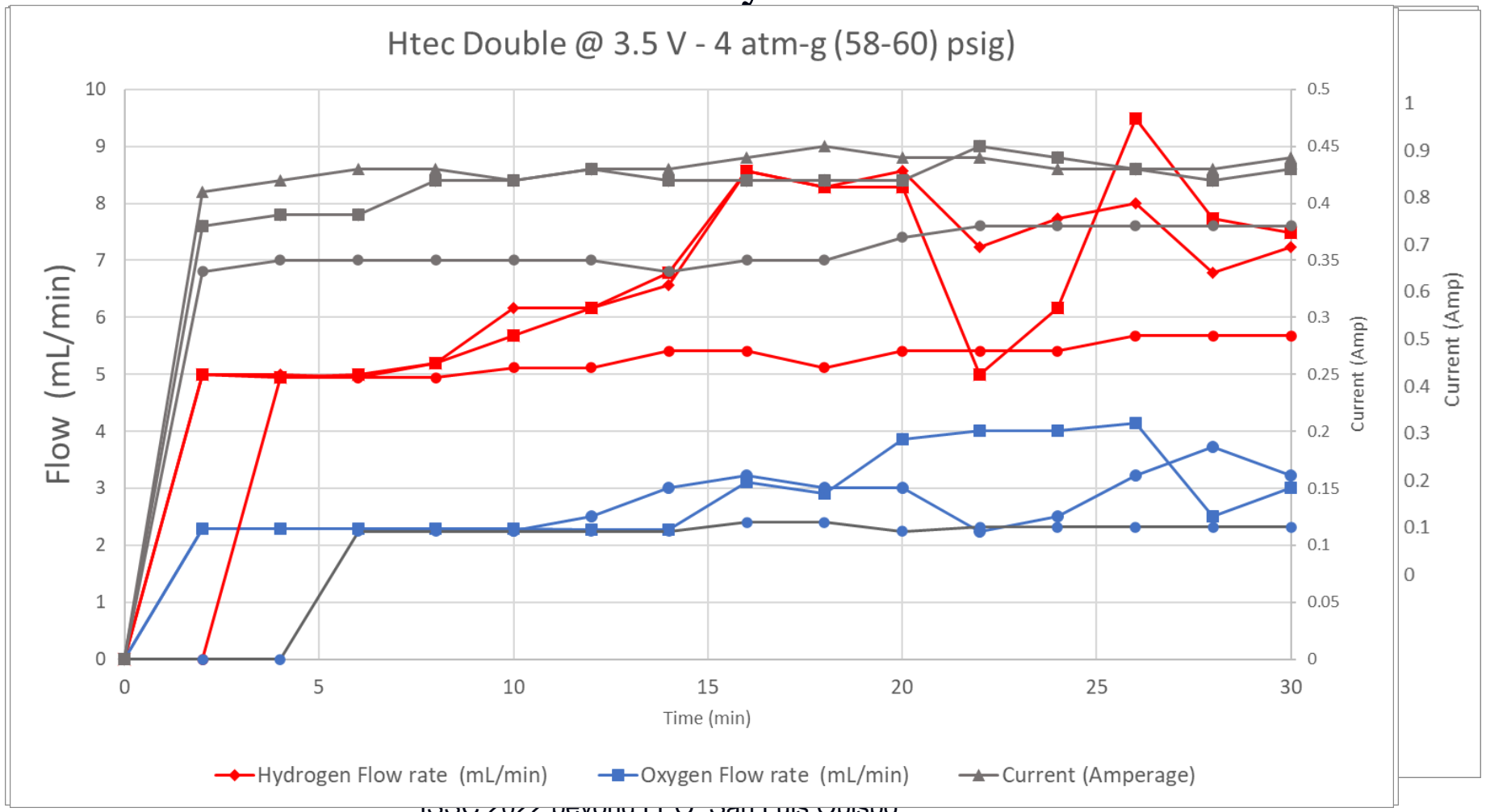
- **Parameters Measured: Hydrogen & Oxygen Flowrates and Current**

	Electrolyzer/ Pressure	6-8 psig (ambient)	14-16 psig	28-30 psig	42-44 psig	58-60 psig	72-74 psig
Test 1	**Htec double Electrolyzer**	3.5V	3.5V	3.5V	3.5V	3.5V	-
Test 2	**Htec Rebuildable Electrolyzer**	2V	2V	2V	2V	2V	2V
Test 3	**Htec Single Electrolyzer w/ RTV**	2V	2V	2V	-	-	-

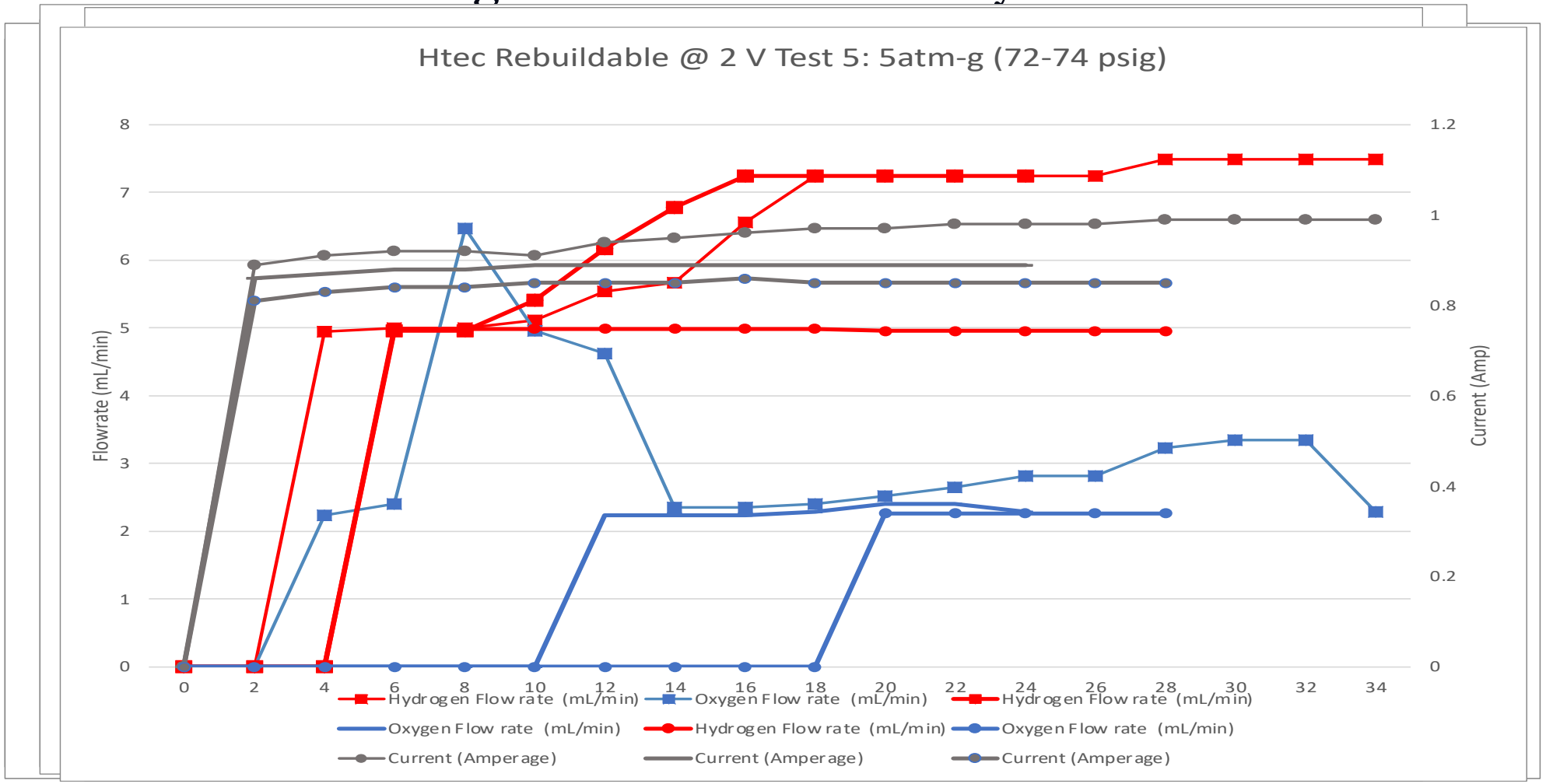
Experimental Apparatus



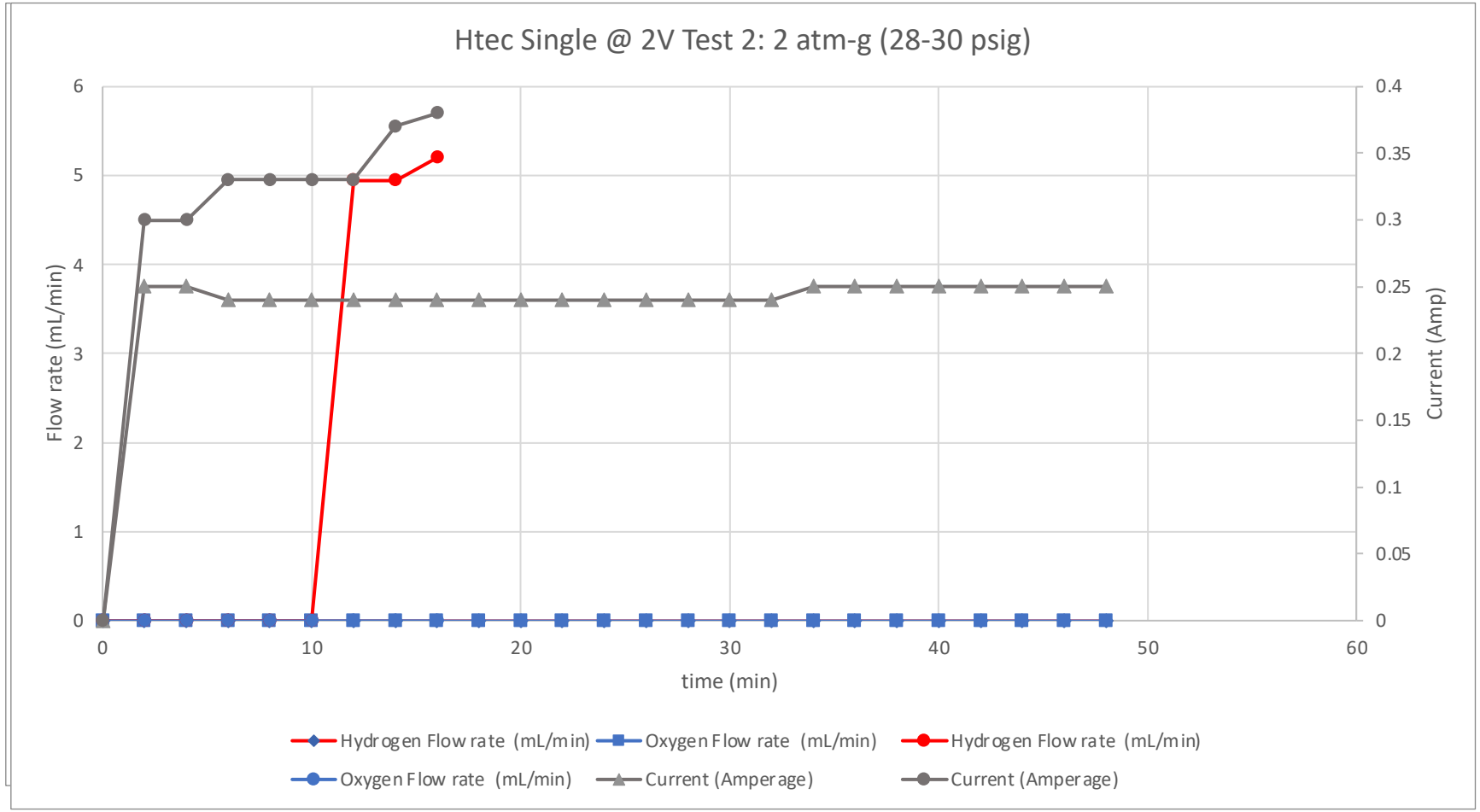
HTec Double Electrolyzer Tested at 3.5V



HTec Single Rebuildable Electrolyzer Tested at 2V



HTec Single Electrolyzer: Tested at 2V

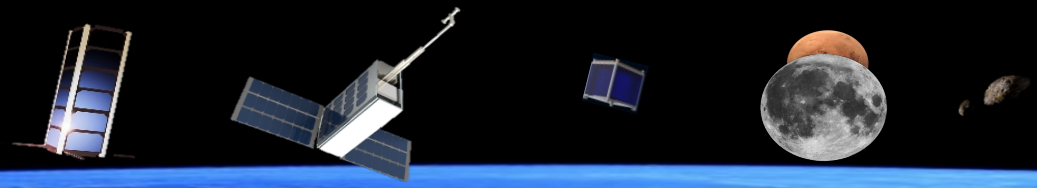


Data

Electrolyzer/ Pressure	Ambient (6-8 psig)	1 atm-g (14-16 psig)	2 atm-g (28-30 psig)	3 atm-g (44-46 psig)	4 atm-g (58-60 psig)	5 atm-g (72-74 psig)
HTec Double Electrolyzer	H2 : 7.75 mL/min O2 : 3.30 mL/min Current: 0.49 Amps	H2 : 6.91 mL/min O2 : 3.06 mL/min Current: 0.48 Amps	H2 : 5.39 mL/min O2 : 3.11 mL/min Current: 0.46 Amps	H2 : 5.81 mL/min O2 : 2.76 mL/min Current: 0.40 Amps	H2 : 5.67 mL/min O2 : 2.38 mL/min Current: 0.37 Amps	
HTec Rebuildable Single Electrolyzer	H2 : 7.07 mL/min O2 : 4.06 mL/min Current: 0.94 Amps	H2 : 6.75 mL/min O2 : 3.73 mL/min Current: 0.89 Amps	H2 : 6.36 mL/min O2 : 3.89 mL/min Current: 0.94 Amps	H2 : 5.96 mL/min O2 : 2.41 mL/min Current: 0.89 Amps	H2 6.26 mL/min O2 : 2.34 mL/min Current: 0.84 Amps	H2 5.91 mL/min O2 : 1.91 mL/min Current: 0.83 Amps
HTec Single Electrolyzer	H2 : 4.49 mL/min O2 : 2.18 mL/min Current: 0.36 Amps	H2 : 3.79 mL/min O2 : 1.88 mL/min Current: 0.31 Amps	H2 : 0.75 mL/min O2 : 0 mL/min Current: 0.27 Amps			

Data Summary

- HTec Double
  - Survived Pressures up to 4 atm
  - Current and Pressure are inversely proportional
  - Flowrates and Current are directly proportional
- HTec Single Rebuildable
  - Survived Pressures up to 5 atm
  - Current and Pressure are inversely proportional
  - Flowrates and Current are directly proportional
- HTec Single
  - Only worked well under ambient conditions



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Conclusion & Discussion

- 3 commercial electrolyzer units were tested under pressure
  - 2 survived, 1 failed
- As Pressure rises, Current drops, and Flowrates drop
  - Large variability in H_2 flow rates
- Feasibility of using Educational Units determined
- Next steps:
  - Correct flow rates to surface Area
  - Resolve Water pressurization Issue
  - Test other commercial units, different membranes

Questions?