Sandia23: Thermal Conductivity Measurements in Porous Materials

Alexander Karam-Shilts, Helen Hu, Fayleon Lin, Jack Rao

Background

Insulation is key in many applications. Sandia National Laboratories requires measurements of thermal conductivity of insulation under various conditions. Currently they lack the technology to accurately do so.

Requirements

Measure effective thermal conductivity of insulation under conditions:
1. Temperature range: 20 – 250°C
2. Compressive loads: 0 – 200 psi
3. Gas: single & multi gas mixtures
4. Gas Pressure: 0.01 atm – 1 atm
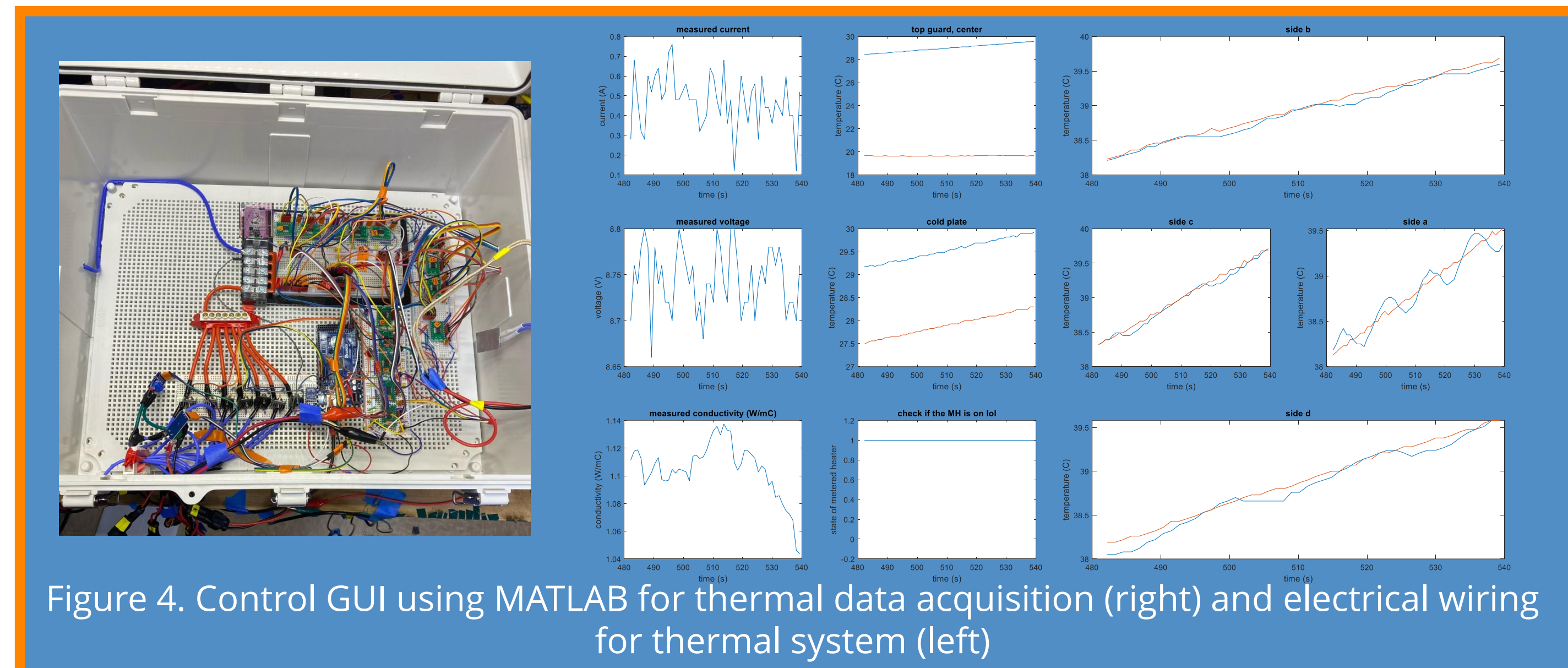
Acknowledgements

Our Solution

Figure 4. Control GUI using MATLAB for thermal data acquisition (right) and electrical wiring for thermal system (left)

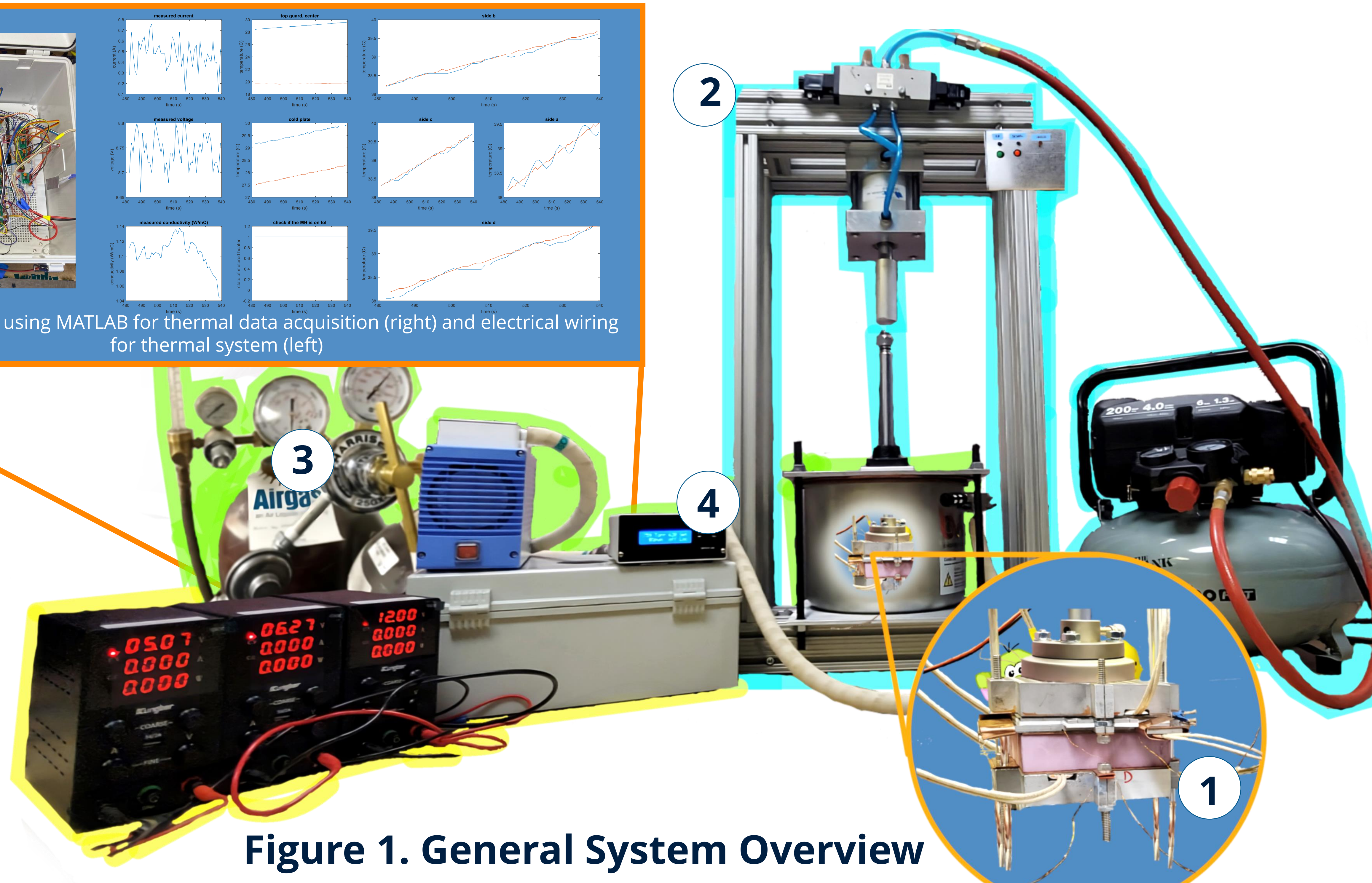**Figure 1. General System Overview**

Evaluation

1. Guarded Hot Plate (GHP)
Evaluation of the system involves verifying:
- The maximum testing temperature
- Accuracy of RTD, voltage, and current sensors
- Effect of heat loss, by using a heat flux sensor
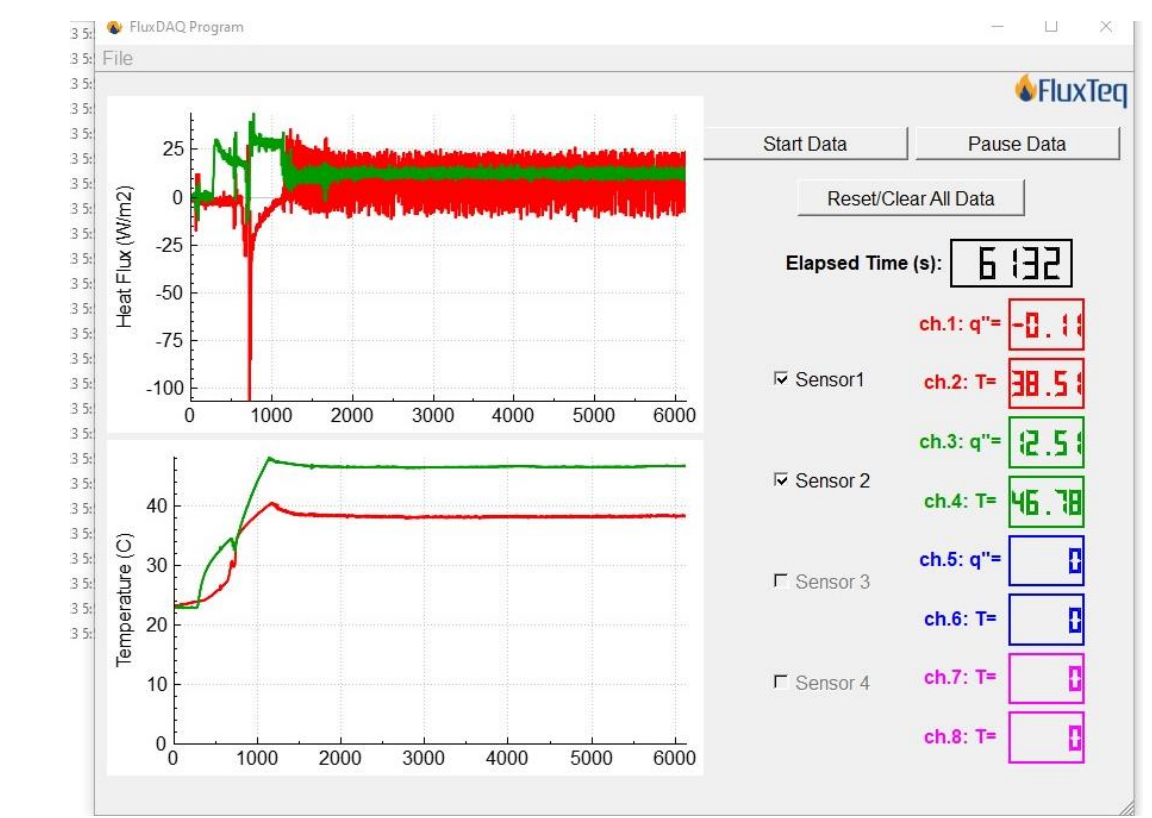- Calibration with sample of known thermal conductivity

Figure 10. Testing the discrepancy of heat flux at the top (green) with the bottom (red)

2. Compression
Compression system testing involves calibrating pneumatic cylinder to reach up to 200 psi.

$y = 16.032x + 6.32$
$R^2 = 0.9993$

Figure 11. Compression testing results

3 + 4. Gas/Vacuum
The system was able to achieve 0.01 atm and flow argon using the vacuum controller.

1 Guarded Hot Plate (GHP)

- Central metered heater: Heats up central area of sample with a known heat input
- Four side guard and top guard heaters: Maintain temperature profile near center linear and minimize heat loss effect
- Cold plate: Provides temperature gradient across sample
- 11 Resistance temperature detectors (RTD)
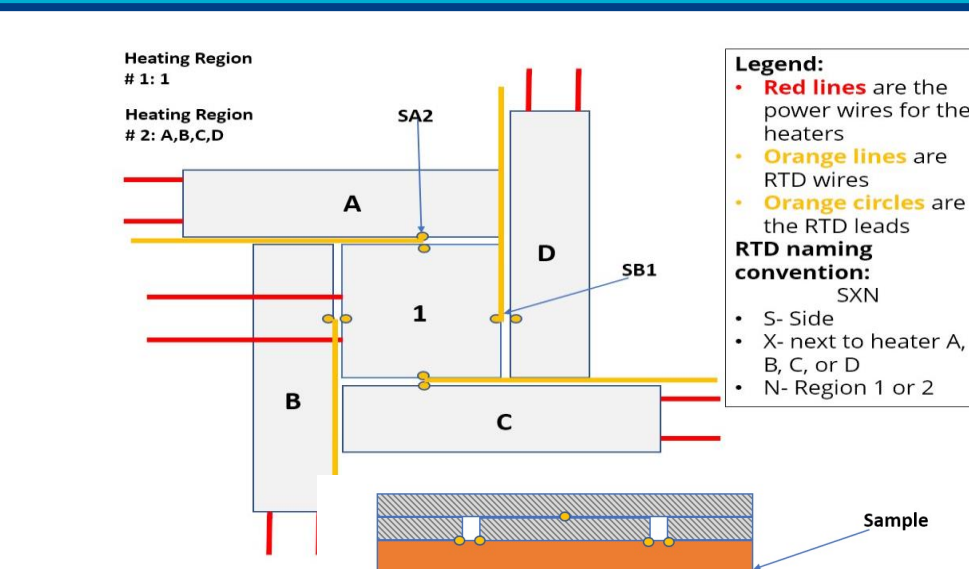- PID control maintains desired temperature at each region

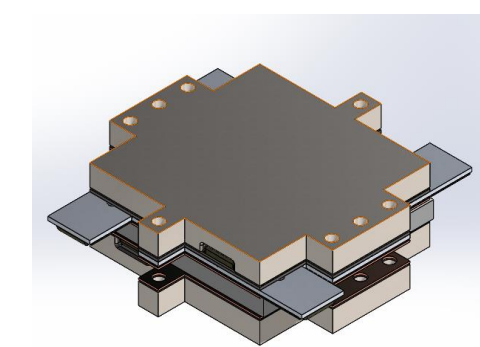Figure 2. Heater and RTD, Top-down view (top), side view (bottom)

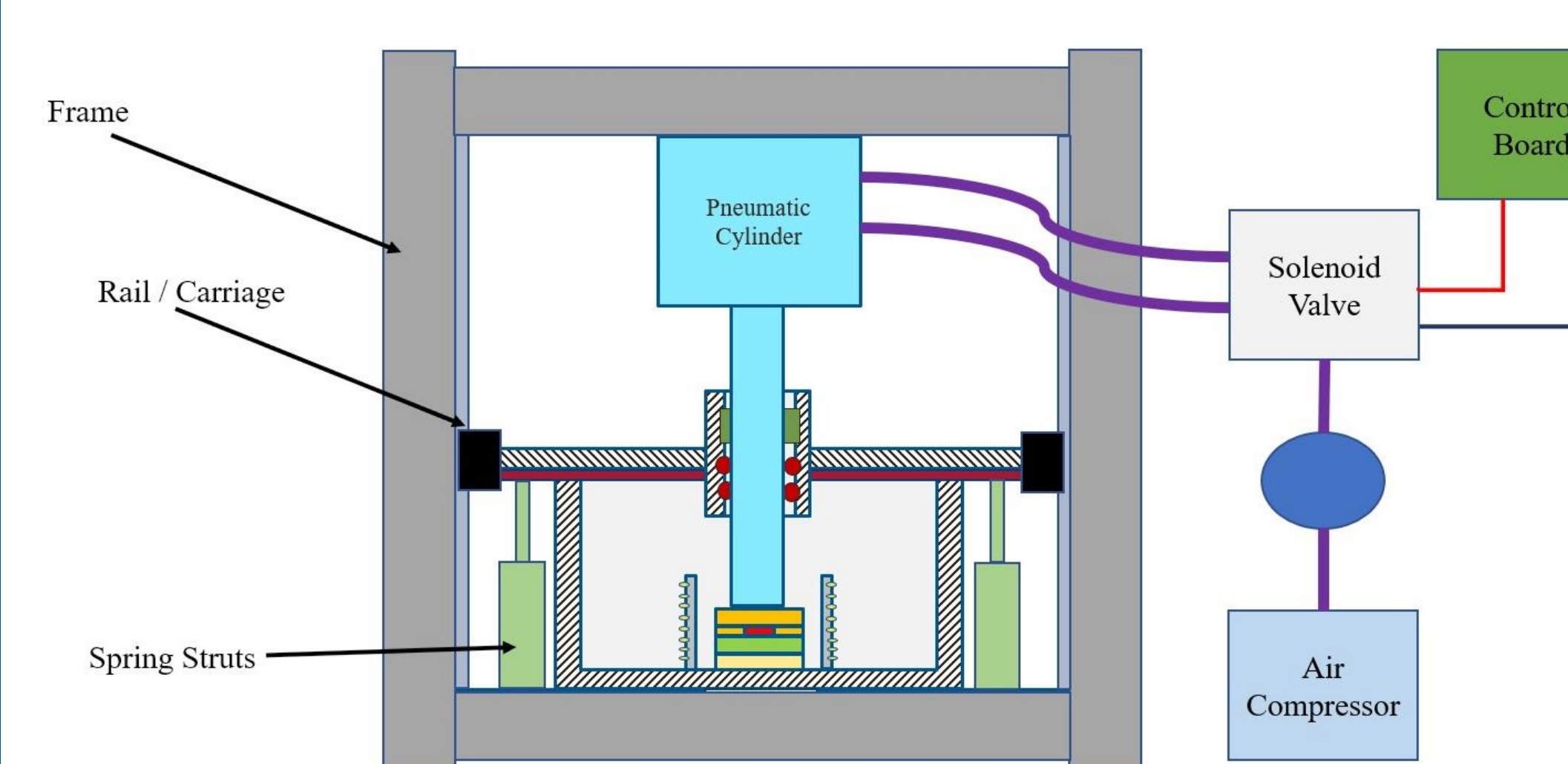Figure 3. Heater casing CAD

2 Compression

Figure 5. Compression system schematic

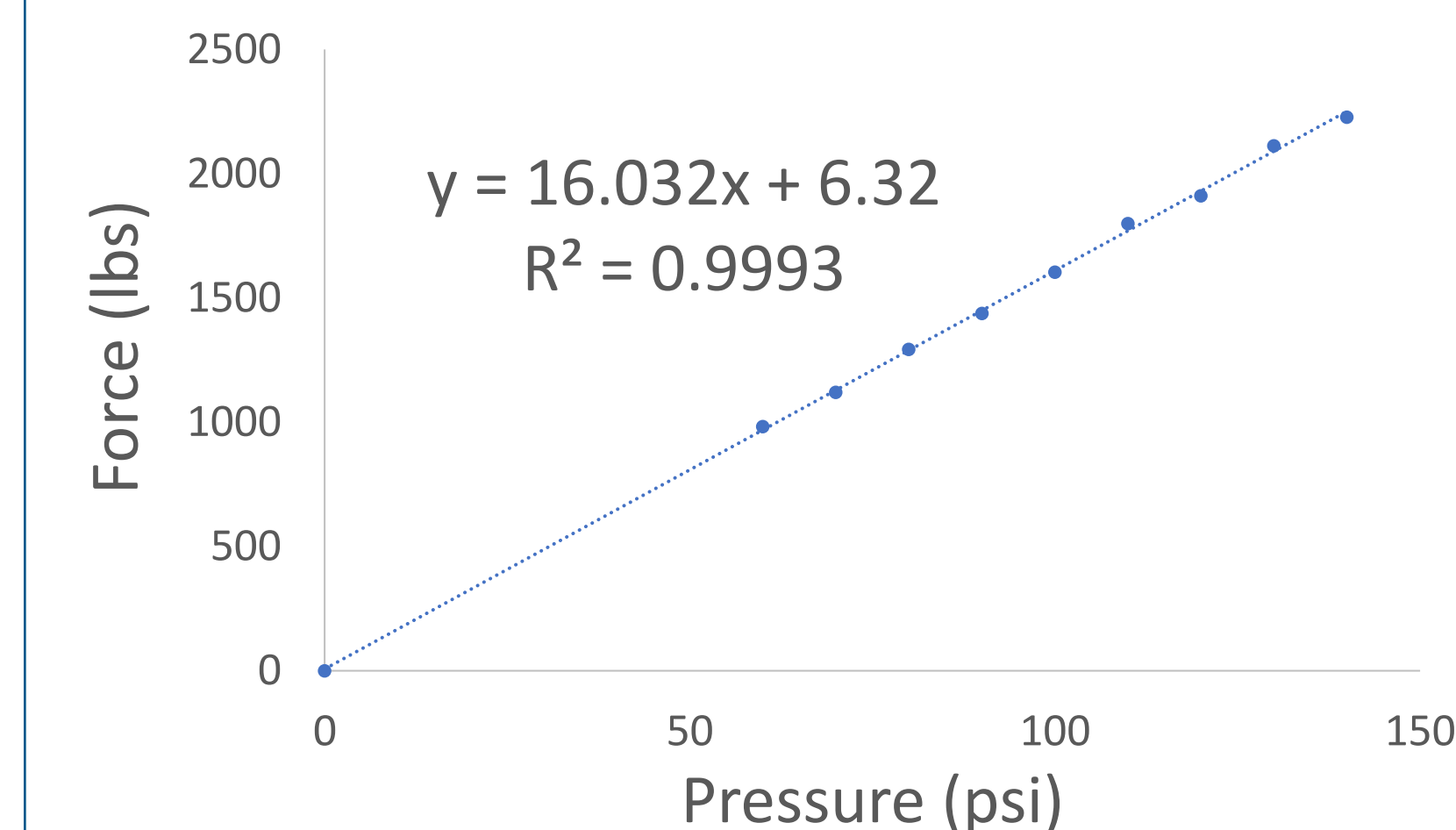- Pneumatic cylinder up to 2,385 lbs at 150 psi input gas pressure
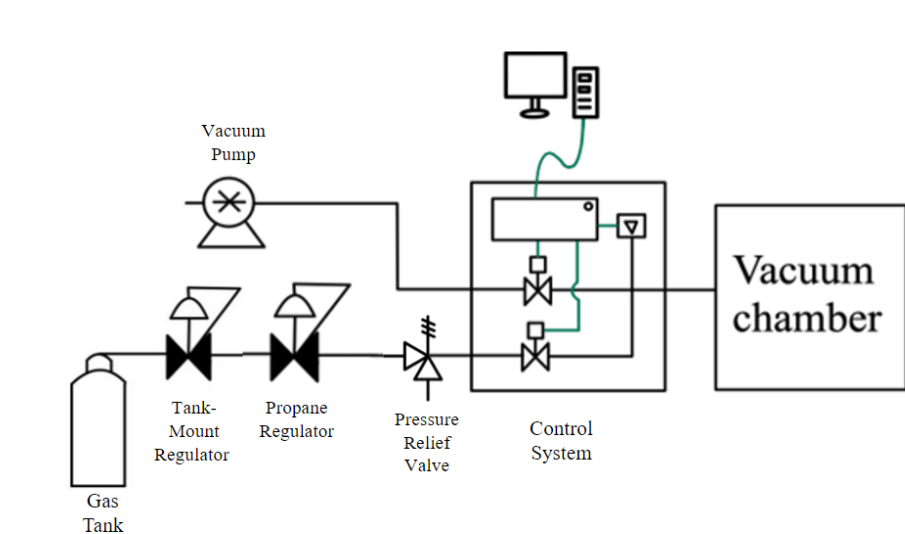- Sample compression up to 136 psi

3 Gas

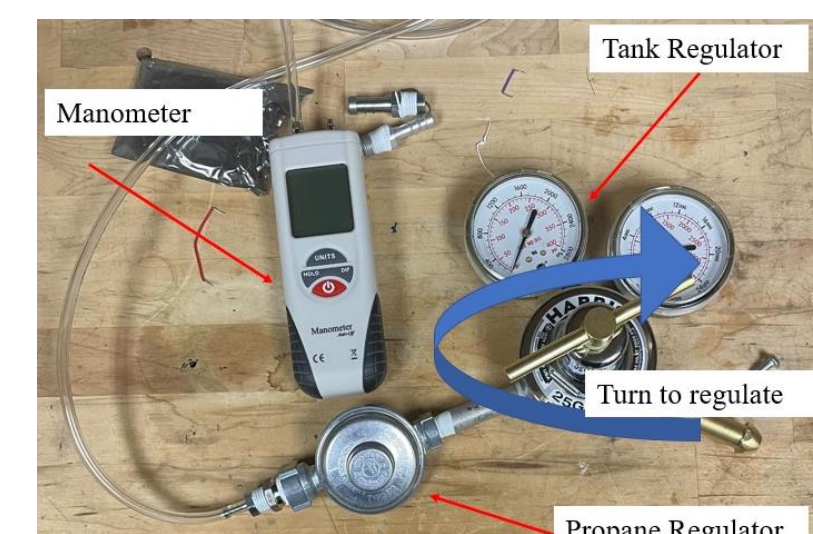Figure 6. Gas and vacuum system schematic

Figure 7: Gas regulators connected to manometer

Figure 8: Vacuum regulator

- 2 Gas regulators to lower pressure
- Gas and vacuum systems controlled by DigiVac Controller
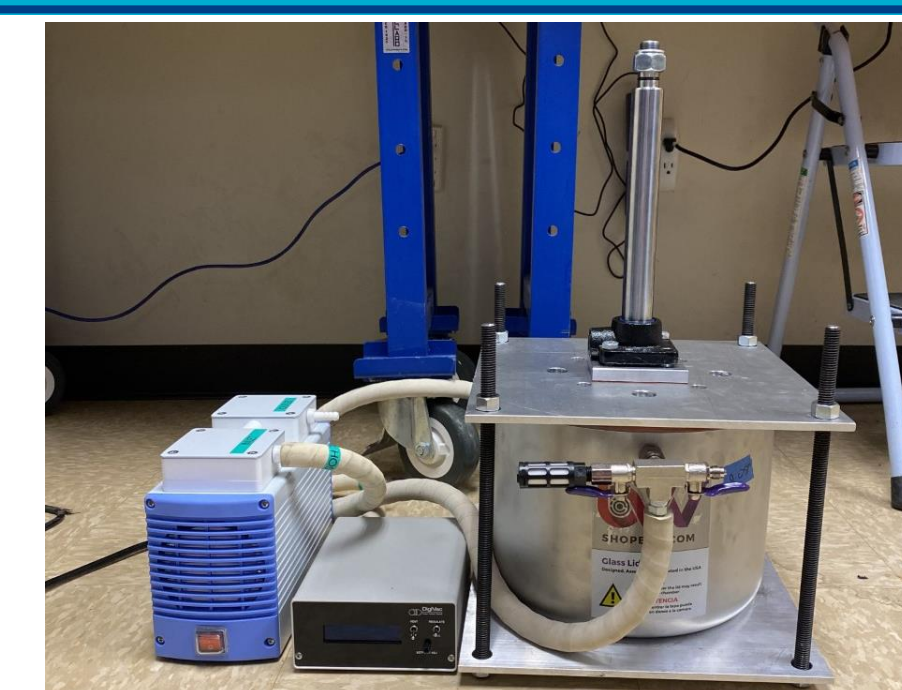
4 Vacuum

Figure 9 Vacuum chamber, pump, & controller

- 10.5" diameter x 8" tall vacuum chamber
- Chemker 410 Diaphragm Pump (reach up to 0.0099 atm vacuum)