Aerogel Experimental Chamber

Team – P08405

Members: Matt Wavrek, Rich Arlotta, Forrest Svingala, Kushal Kapoor

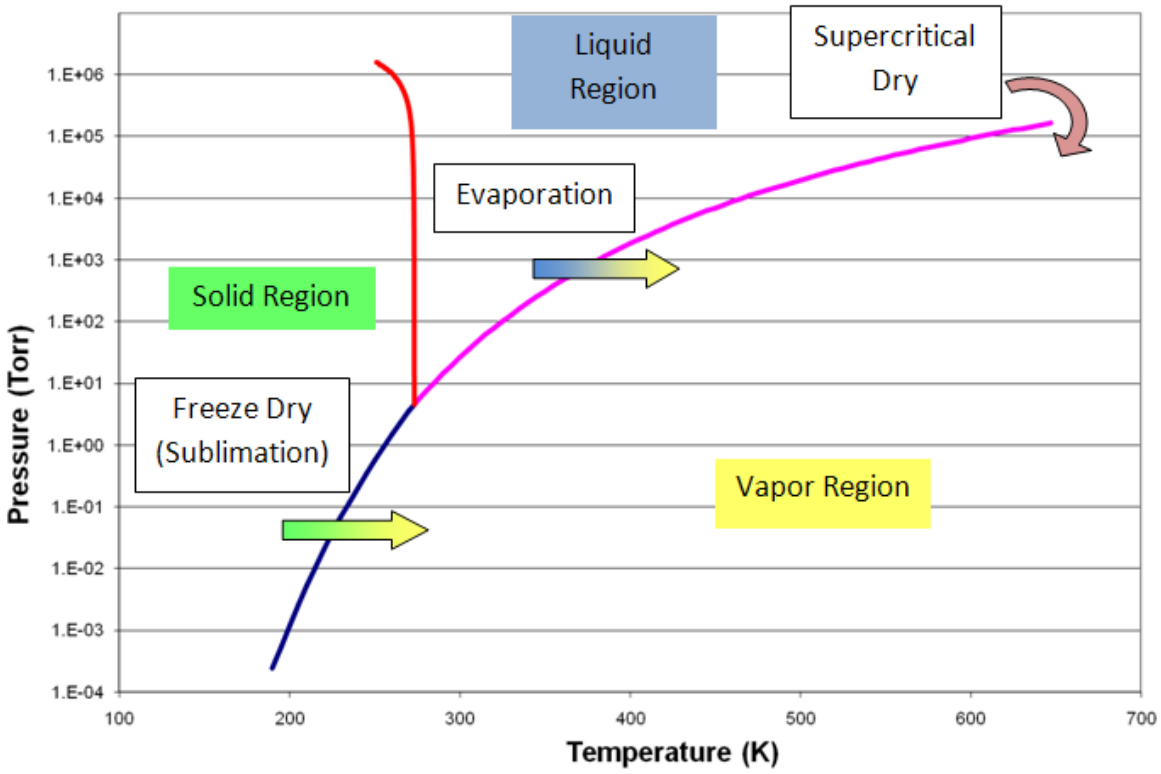
Main Customer/Faculty Guide: Dr. Ben Varela,
Main Users: Dr. Ben Varela, Forrest Svingala

Agenda

- Project Overview
- Financials
- State of Design
- System Architectures
- Final Design and Build Information
- Testing and Evaluation
- Compliance with Needs and Specs

Project Description

- Aerogel System
  - Minimal requirements:
    - Pressure < 4.58 Torr
    - Temperature < 0.01°C



http://upload.wikimedia.org/wikipedia/commons/d/dc/Phase-diag.png

User Requirements

Metric	Units	Marginal Value	Ideal Value	Attained Value
Minimum Chamber Temperature	Degrees Celsius	0	<-30	-25
Vacuum Quality	Torr	<4 Torr	<1 Torr	0.009 Torr
Mobility	Subjective	Moderate	High	High
Corrosion Resistance	Subjective	Moderate	High	High
Chamber Size	in^3	130-200	200+	470
Chamber Pressure accuracy	Torr	.x	.xxx	.xxx
Sample capacity	Number of Samples	1	3+	3
Temperature Monitoring Accuracy	Degrees Celsius	x	.xx	.x
Cooling System Life Cycle	Number of uses	one time use	Reusable	Reusable
Compliance with Budget Requirements	Percent of Budget Used	<100	75%-85%	63.31%
System Voltage Requirement	Supply Voltage, Quantity	120Vx2/ 240x1	120Vx1	120Vx1

Bill of Materials

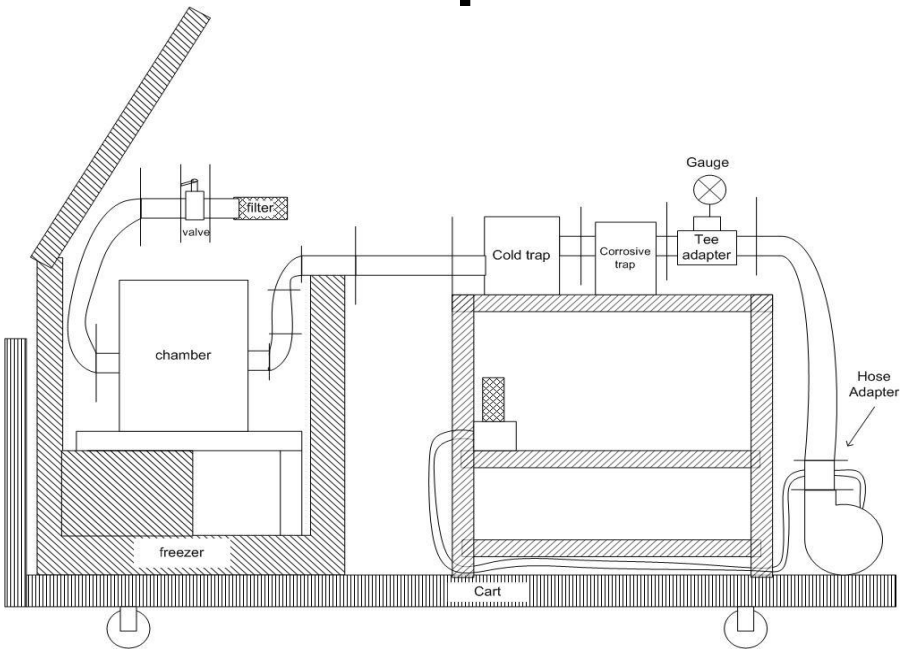
P08405 Condensed Budget

Subsystem	Cost	Percentage of Budget
Cooling System	325.44	3.62
Vacuum System	4,134.90	45.94
Mobility	387.11	4.30
Data Logging	850.16	9.45
	5697.61	**63.31**

Current State of Design

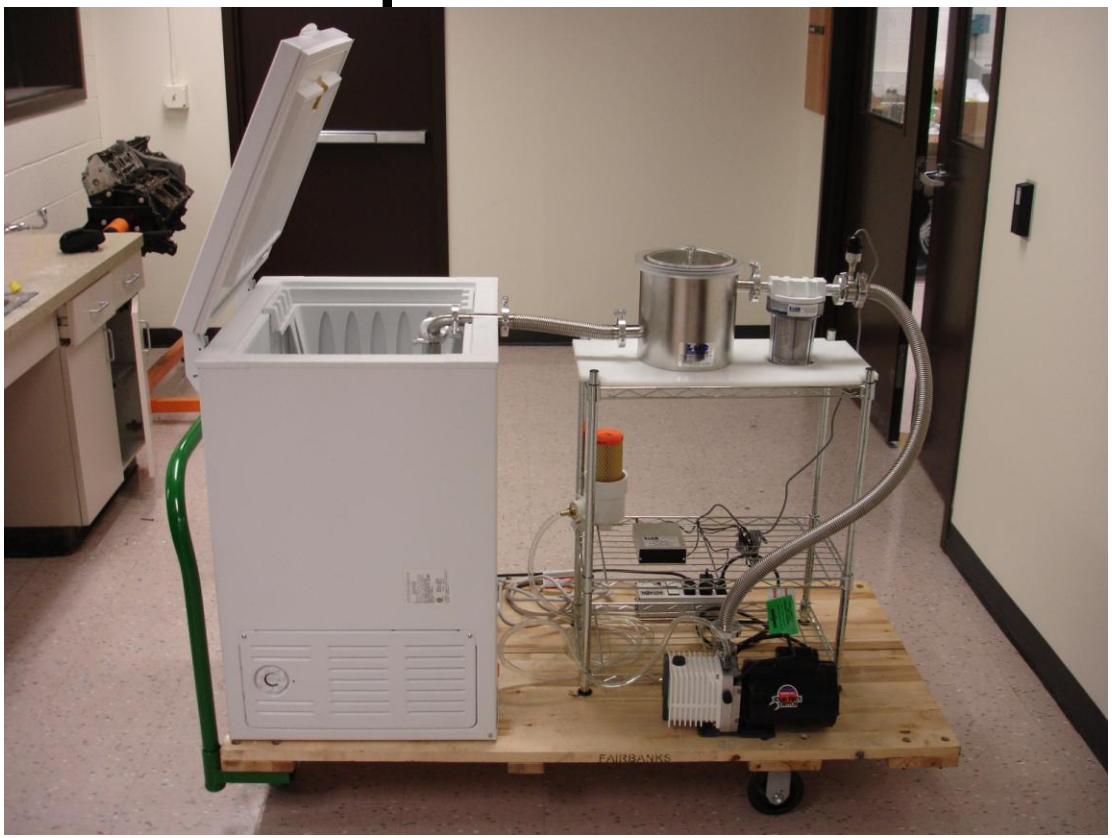
- Mechanical subsystems built and testing is finalized
- All ordered items are presently implemented into the system
- Final testing and integration is completed
- Final qualification testing for Data logging circuitry is incomplete
- Project completed well under initial budget
- Scope Revisions
  - Budget adjusted to redirect Case Western and MSF funding to further research with system by Forrest Svingala and Dr. Ben Varela
  - Pressure logging attained and implemented

Selected Concept



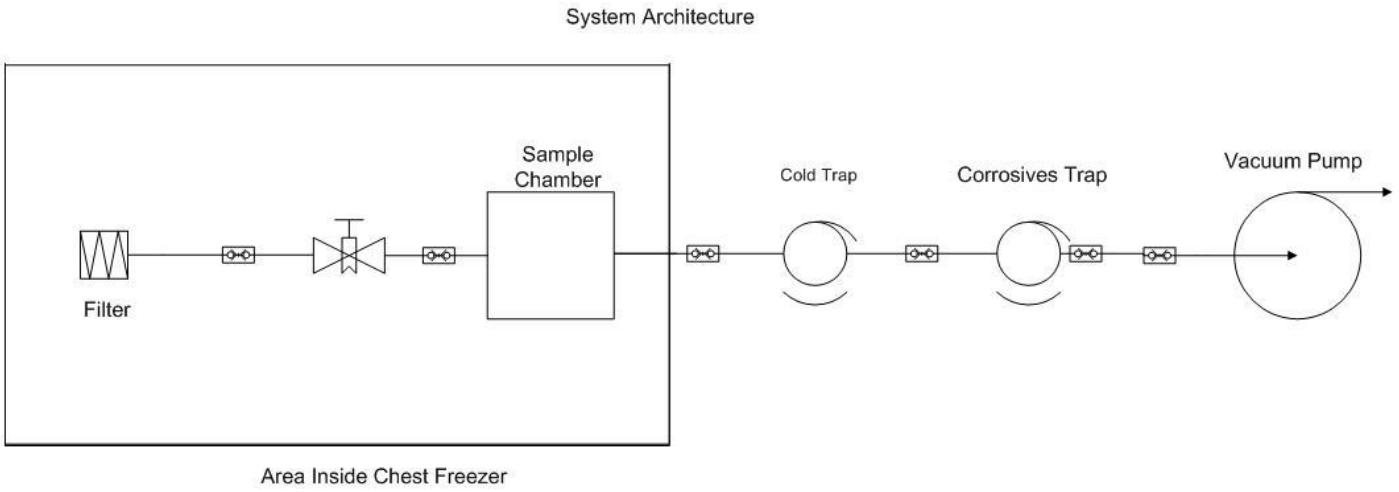
- Cooling System:
  - Consumer Chest Style Freezer
    - Slight modifications to allow for hose/pipe connections, thermocouple mounting, and wiring outlets
- Vacuum System:
  - Adixen 1.4 CFM Vacuum Pump
    - Cold trap, Corrosives Trap, and outlet filter to protect pump.

Selected Concept



- Chamber
  - LVC0810NW25-VHE High Vacuum Chamber (10^-6 Torr capability)
    - Custom ports to allow for hook-ups to vacuum pump, pressure release valve, and chamber thermocouple
- Mobility/Mounting
  - Modified commercial “platform” style cart to bolt shelf down
- Data Processing and logging
  - Labview Signal Express Interface with a NI USB-6008 DAQ system
  - Pressure logging through serial port connection to computer from sensor DRO

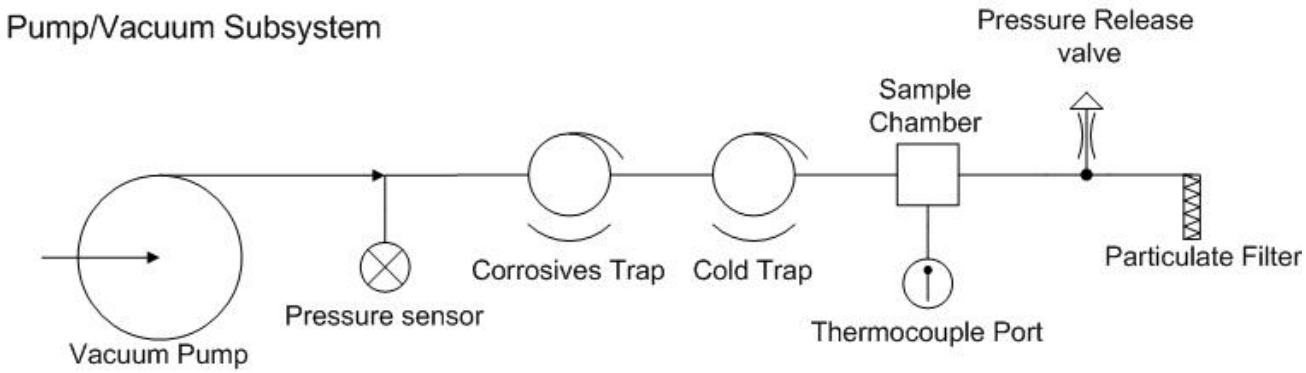
System Architecture

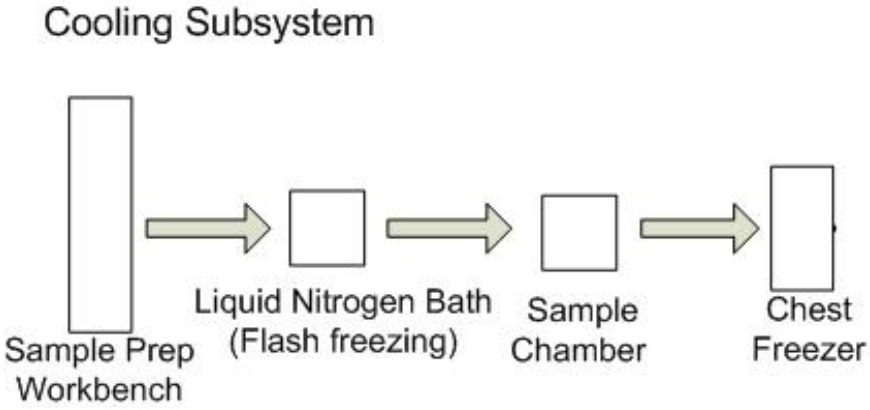


- System component layout diagram
  - Merged cooling and vacuum subsystem architectures
  - NW flange fittings are used to connect all devices, stainless steel is used for all hosing/connections

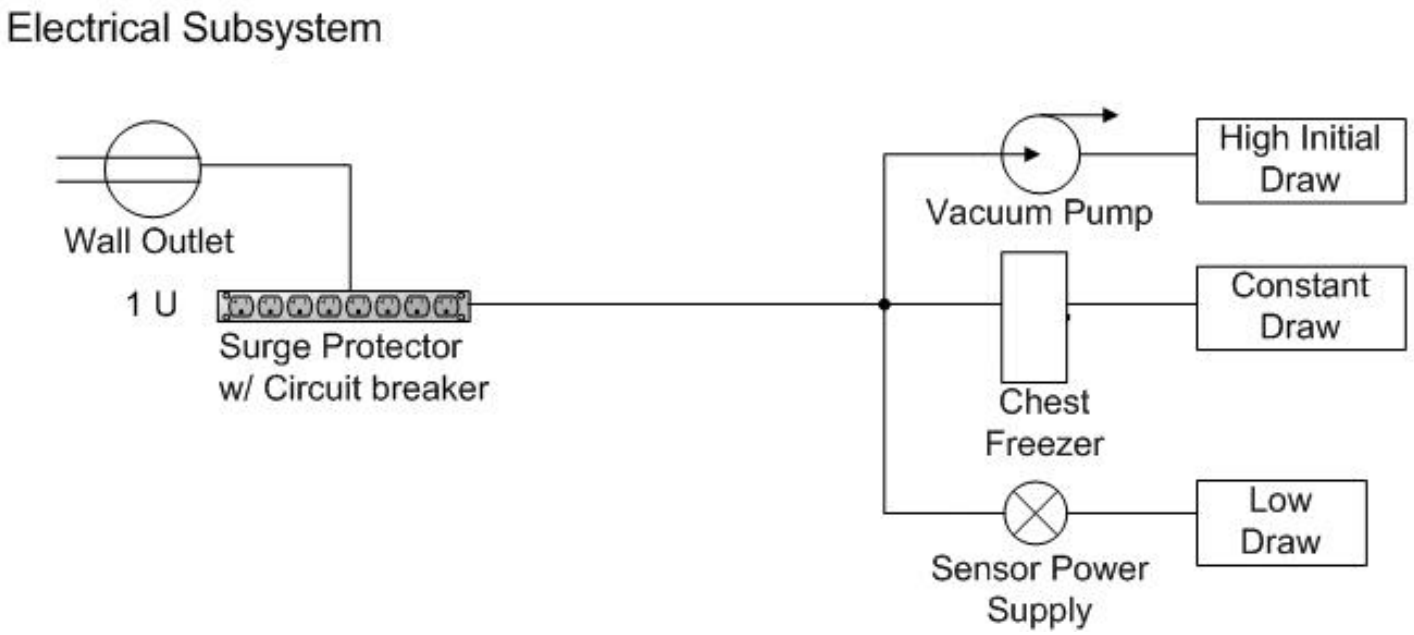
Sample Chamber and Traps

System Architecture

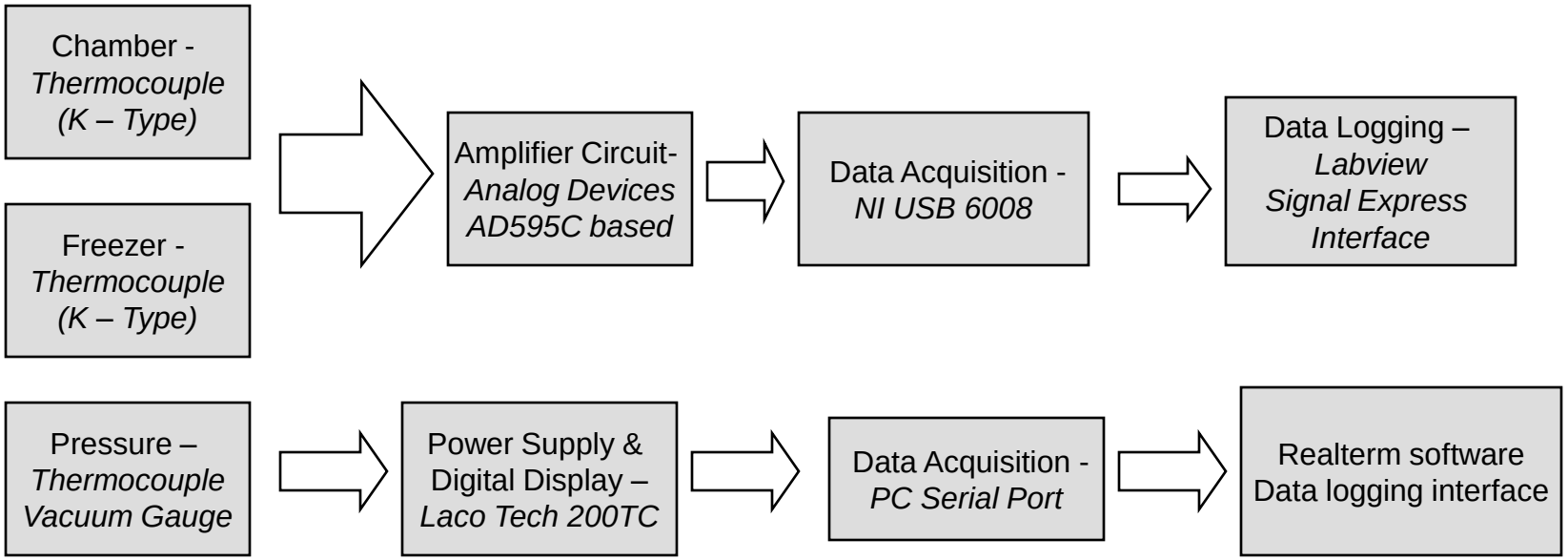




System Architecture

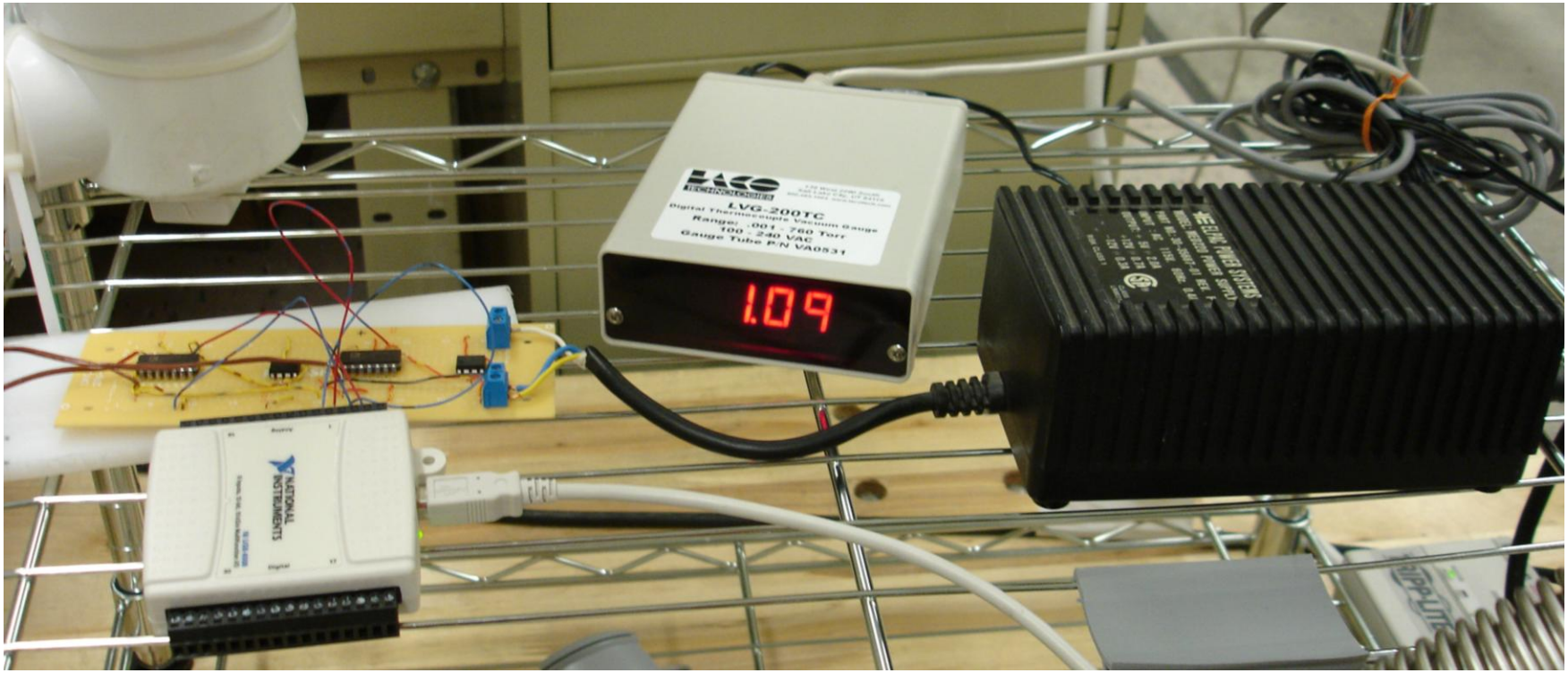


System Sensor Flow



- Temperature System:
  - K type Pipe Plug Probe & K type Quick Disconnect Probe
    - Thermocouple voltage outputs go to amplifier for signal conditioning before data acquisition.
- Pressure System:
  - Thermocouple Vacuum Gauge
    - Self contained unit provides power to sensor and gives digital readout of chamber pressure as well as data logging capability through a serial adapter to the PC

Data Logging Setup



Issues During Build

- **Component Lead Time**
- **Vacuum Pump Protection**
- **Temperature Data Logging**
- **Design/testing of custom signal conditioning circuitry**
- **System level integration**
- **Providing power to system components**

Component-Level Tests

- Chest Freezer
- Thermocouples
- Pressure Gage/Vacuum Pump
- Thermocouple Circuit

Subsystem Test Results

- **Chest Freezer**
- The minimum temperature reached by the freezer was -27 degrees Celsius; Pass.

- **Thermocouples**
- Thermocouple output was correct within +/-3 degrees Celsius in all cases; Pass.

- **Pressure Gage/Vacuum Pump**
- Gage correctly read atmospheric pressure (760 Torr). After activation of pump, system reached equilibrium at 0.02 Torr; Pass.

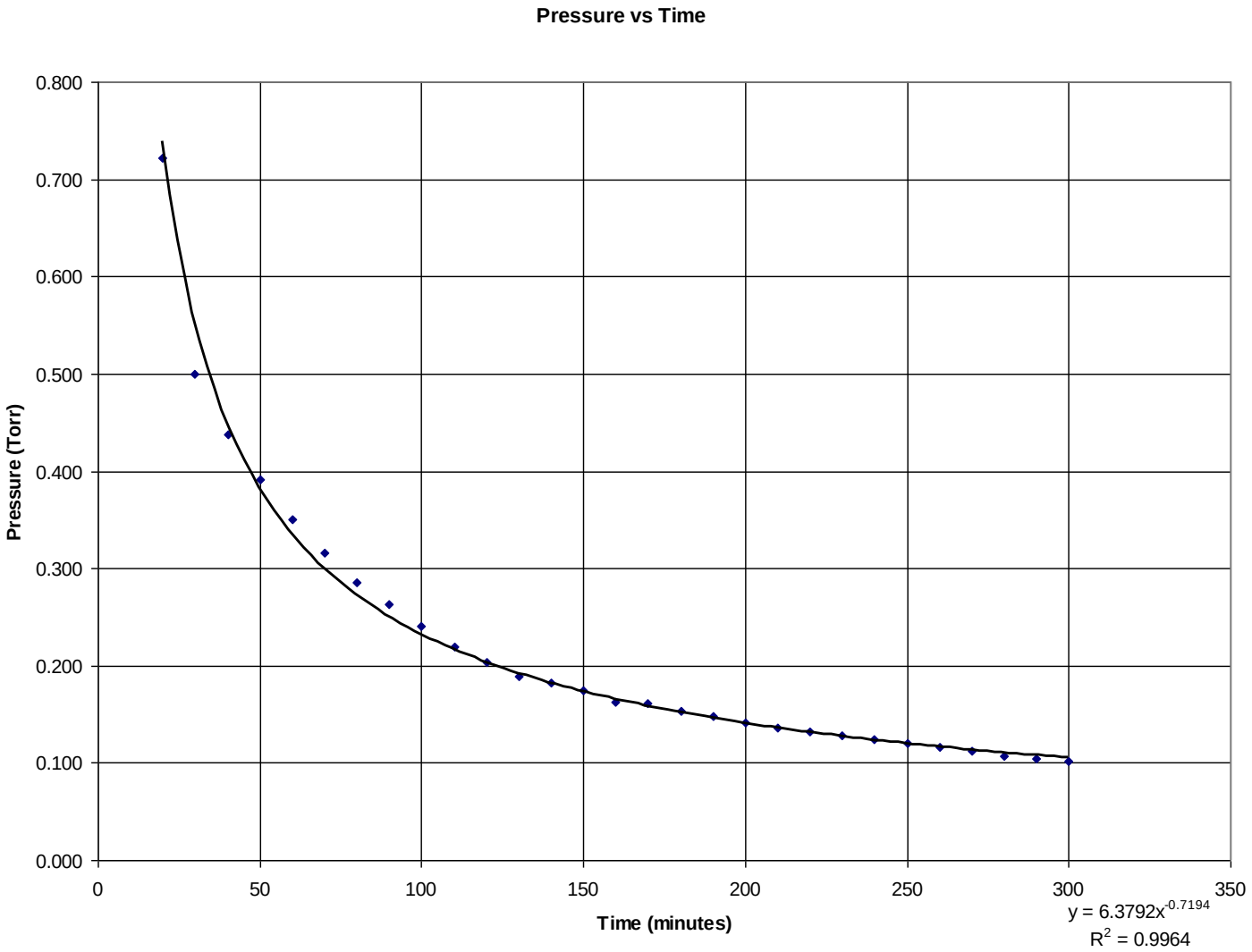
- **Thermocouple Circuit**
- A gain of 238.7 was achieved at room temperature, which is within 5% of expected gain; Pass.

Integrated System Test

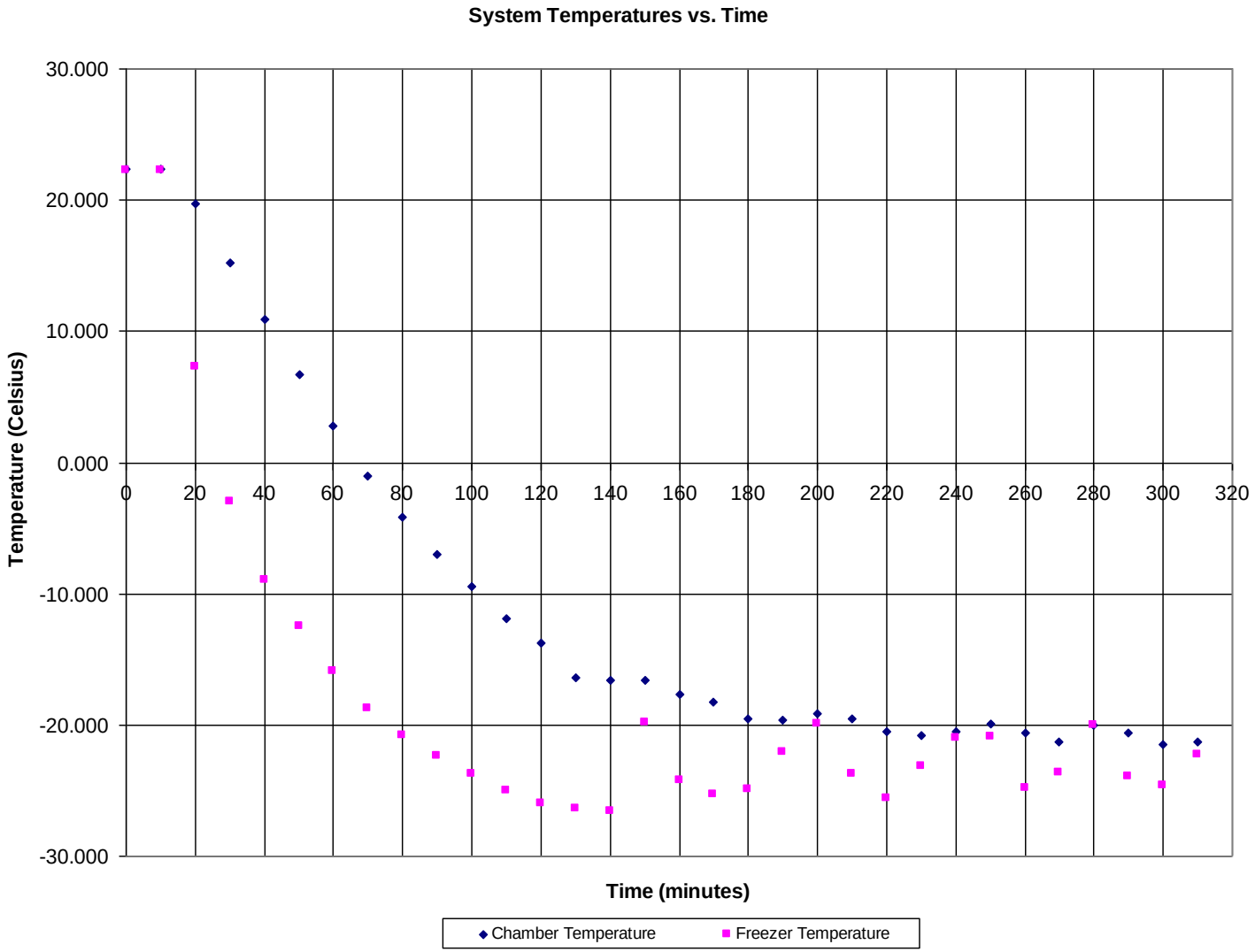
- **Full System**
- After complete assembly of the system, the vacuum pump and freezer will be run for a period of four hours, data will be logged, and ultimate temperature and pressure will be recorded. Pass if temperature is between -10 and -20 degrees Celsius and pressure is below 1 Torr.

- **Desiccation of Sample**
- Once proper operation of the system is verified, the team will use the system to create a sample of clay aerogel. Pass if sample is successfully desiccated.

Pressure Profile of System



Temperature Profile of System



Needs and Specs Met

- As evidenced by the needs/metrics matrix on slide 4, values attained for each metric met or exceeded the ideal values
- System passed all tests it was subjected to and is functioning correctly

Future Uses of System

- System is ready for implementation into testing and research for thesis of Forrest Svingala into aerogel uses and formulations
- Any freeze-drying application research and development of water based substances (only water is used as a solvent)

Questions