SOLAR ROCKS

Concentration and Storage of Energy in Mining Facilities

TEAM MEMBERS

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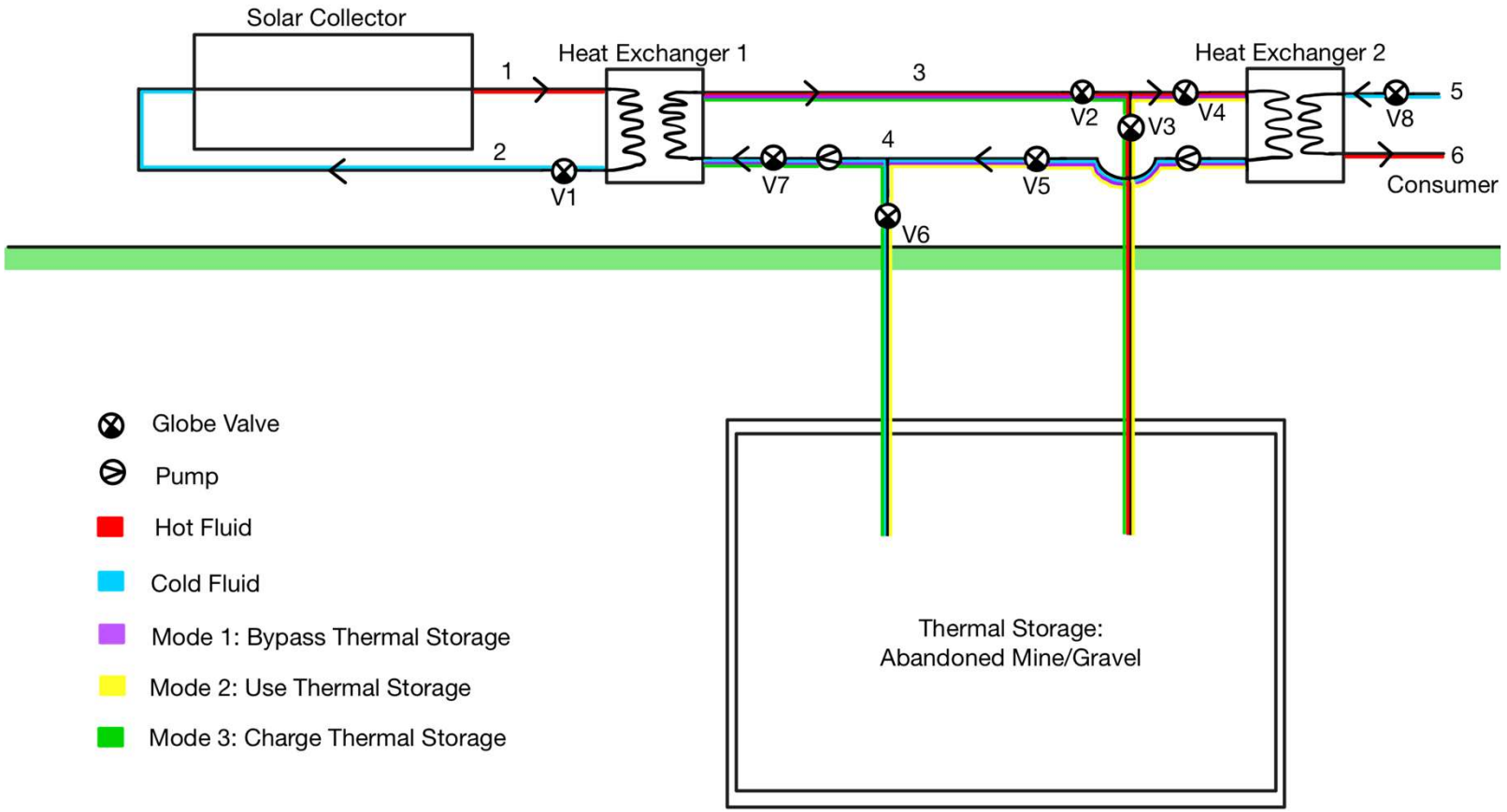
BACKGROUND-
AFTER THE MINES CLOSE

Without mining, over 1/3 of residents in Benham KY live in poverty

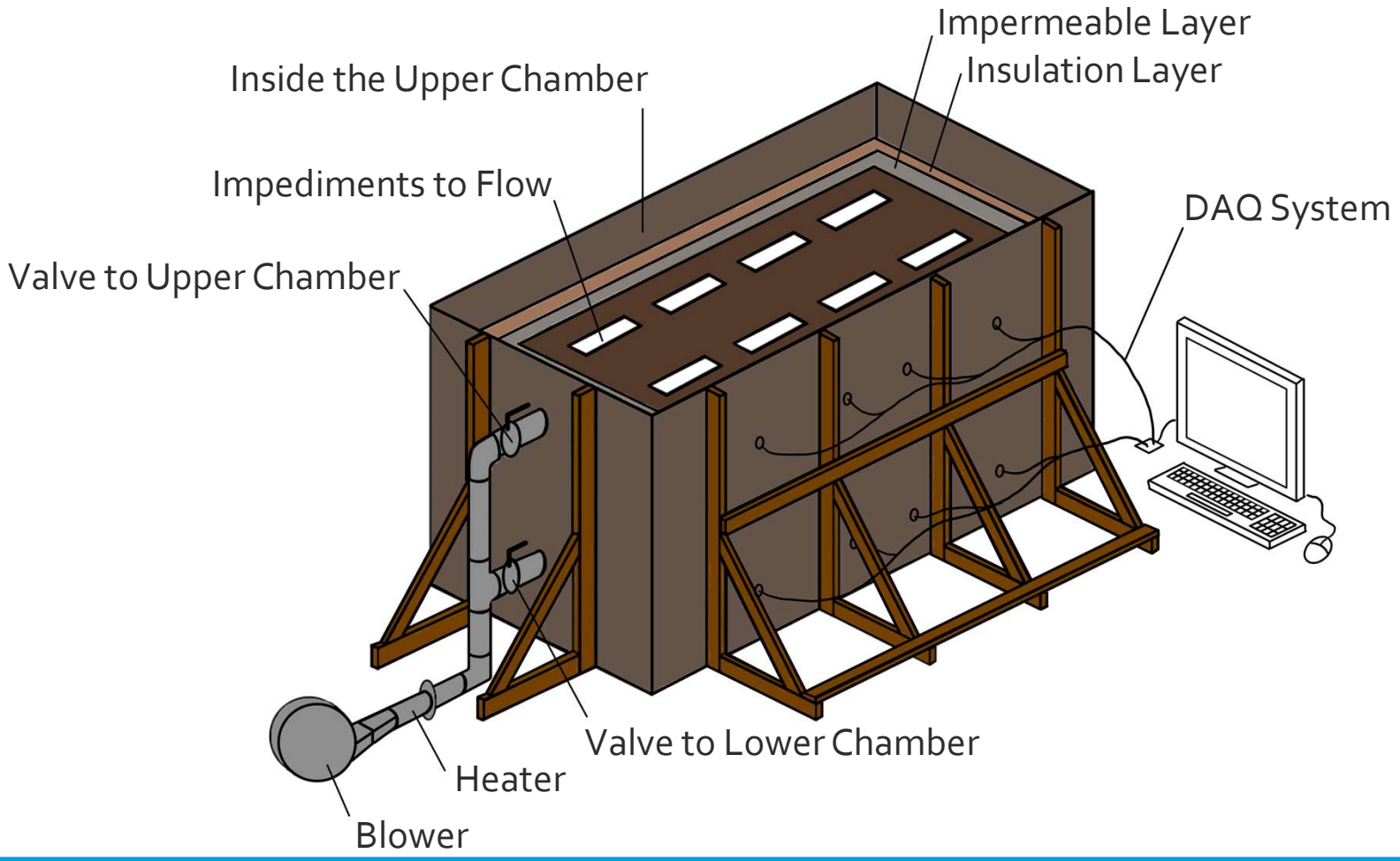
Bingham Canyon mine is 1.2 km deep

Thousands of Canadian Geese died after landing in Berkeley Pit

PROPOSED SOLUTION

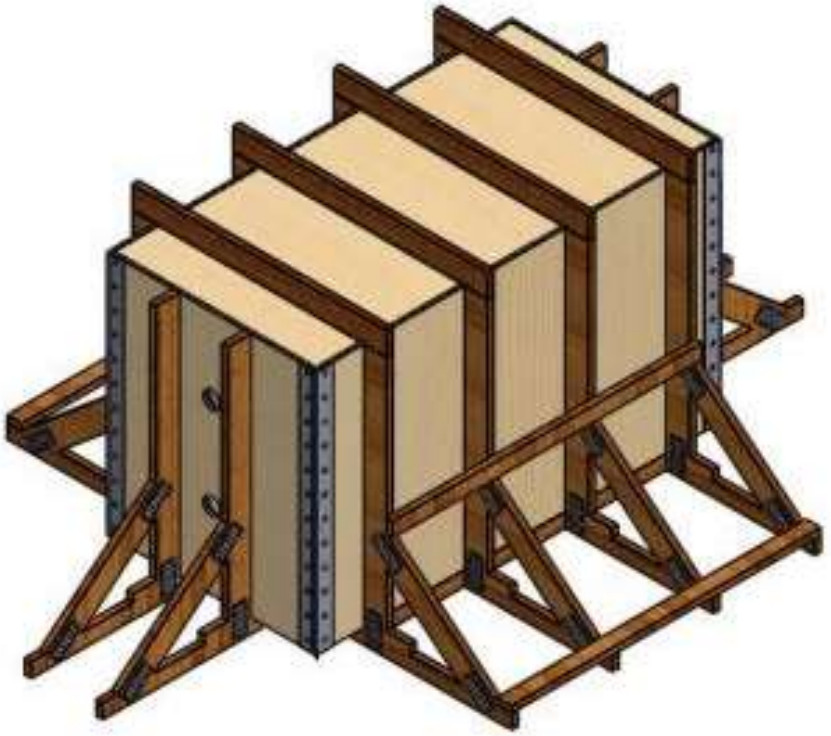


SYSTEM DESIGN



STRUCTURAL DESIGN

- Structure must withstand approximately 20,000 lb_f
- Used ASD/LFRD Manual National design Specification for wood construction.
- Maximum spacing between supports is 24".
- Major Areas of concern
  - Deflection at corners
  - Stress at the center between beams
  - Sheared nails



Chamber Design Drawing

STRUCTURAL TABLES AND EQUATIONS

ASD/LFRD Manual National Design Specification for Wood Construction.

Modified Maximum bending Stress

$F_bS' = F_bS * C_M * C_t * C_s(2.54)(0.85) * \lambda$			M9.3-1	Units
F_bS'	Modified Bending Stress times Section Modulus	8060.27		lbf-in/ft width
F_bS	Bending Stress times Section Modulus	4666.67	M9.2-1	lbf-in/ft width
C_M	Moisture Coefficient	1		
C_t	Temperature Factor	0.8		
C_s	Panel Size Factor	1	9.3.4	
λ	Time Factor	1	9.3.7	
	Resistance Factor	0.85	M9.3-1	
	Format Conversion Factor	2.54	M9.3-1	

Results

Maximum Allowable Stress	1535.288889	psi	(divide FbS' by S)
Modulus of Rupture	5000	psi	
w/ Safety Factor	2000	psi	
Safety Factor	2.5		

Hand Calculations – Force on Top

Our Structure- Forces on the Side

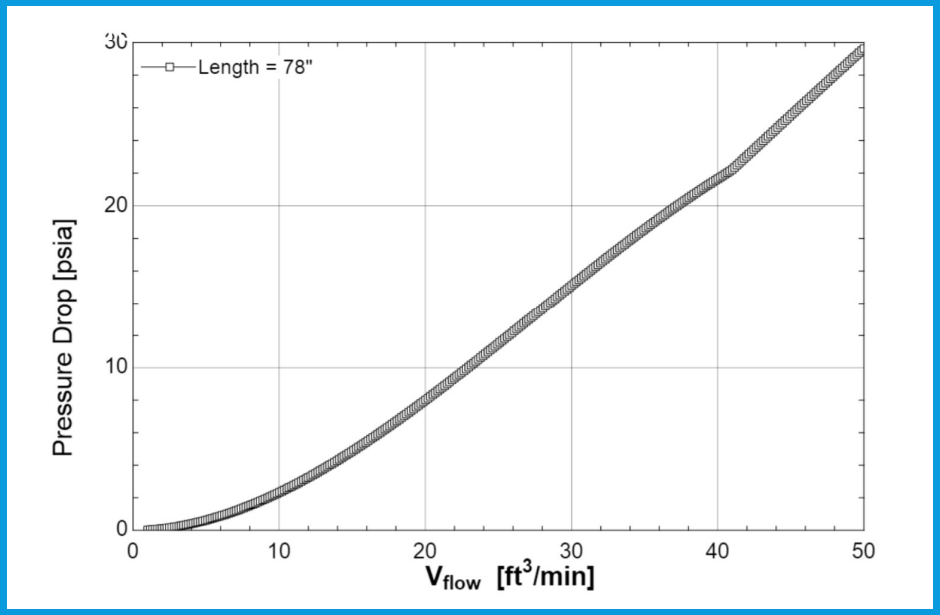
Equivalent Force	$F = \gamma * h^2/2 * w$		
F	Force	2733.965	lbf
γ	Specific Weight	0.07265	lbf/in^3
h	Height	56	in
w	width	24	in
M	Maximum Moment	8201.894	in-lb
S	Section Modulus	5.25	in^3
Stress	$F_b = M/S$		
F_b	Bending Stress	1562.266	psi

Hand Calculations – Force on Bottom

Equivalent Force	$F = \gamma * h^2 * w$		
F	Force	2733.965	lbf
γ	Specific Weight	0.07265	lbf/in^3
h	Height	56	in
w	width	12	in
M	Maximum Moment	8201.894	in-lb
S	Section Modulus	5.25	in^3
Stress	$F_b = M/S$		
F_b	Bending Stress	1562.266	psi

BLOWER REQUIREMENTS

Pressure Drop Through the Thermal Chamber
- Computed with EES and the Packed Spheres



Dayton 7C447 Blower
- Single phase 240 volt
- 10 9/16" Wheel
- 1 HP

AIR HEATER REQUIREMENTS

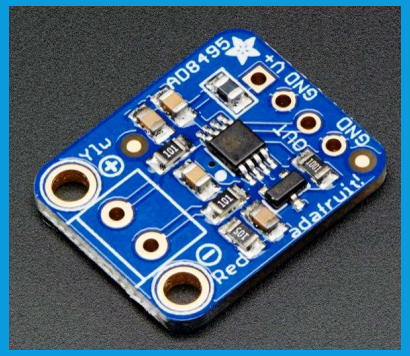
OMEGA AHF Air Heater

- Can supply 500 to 2000 Watts of energy to the airflow.
- Can heat air to a maximum temperature of 600 °F.
- Can operate at a maximum flow rate of 200 CFM.
- Runs on either 110 or 220 Volt power.
- Currently controlled via dimmer switch on a 110 volt power supply

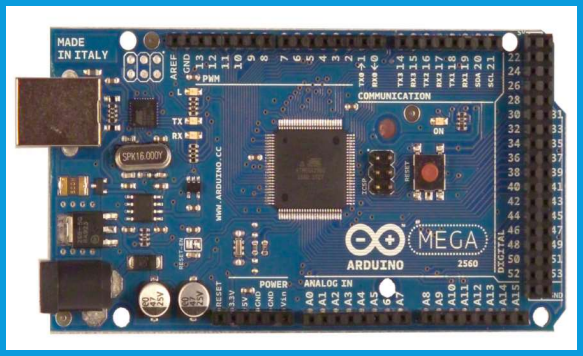
DATA ACQUISITION SYSTEM REQUIREMENTS

The Data Collection system had to perform as follows

- Acquire temperature data at a specified interval.
- Acquire temperature data accurately to one °F.
- Log and store data within the ARDUINO serial monitor to be written to .TXT files.



AD-8495 Op-Amp

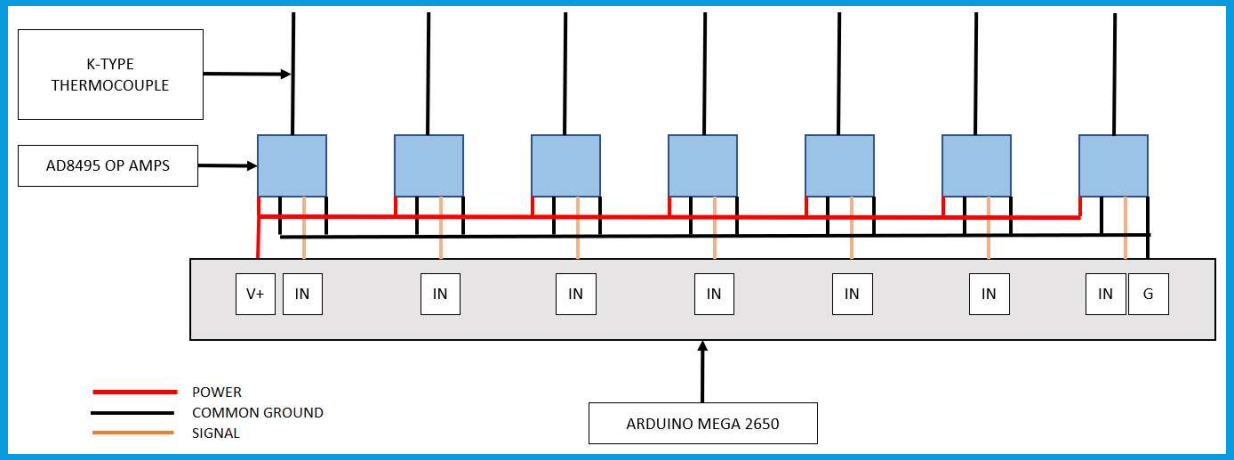


ARDUINO MEGA 2650

K-Type Thermocouple

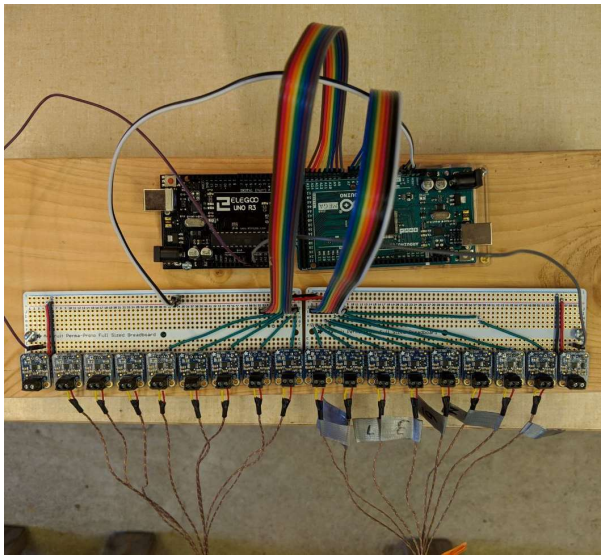
DATA ACQUISITION SYSTEM

- K-Type thermocouples create a voltage difference to measure temperature.
- AD-8495 Op-Amps amplify that signal for data collection.
- ARDUINO MEGA 2650 and ARDUINO UNO read the signal and log the temperature data.
- The temperature data is saved in a .TXT file for processing.



Full System

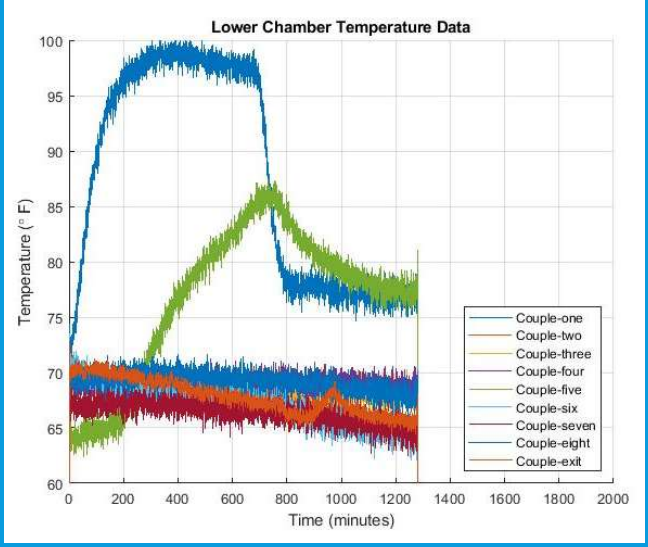
Upper Chamber



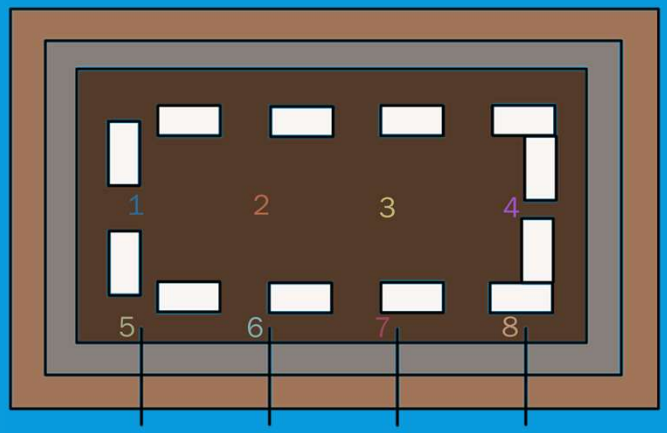
DAQ System

FINAL PRODUCT

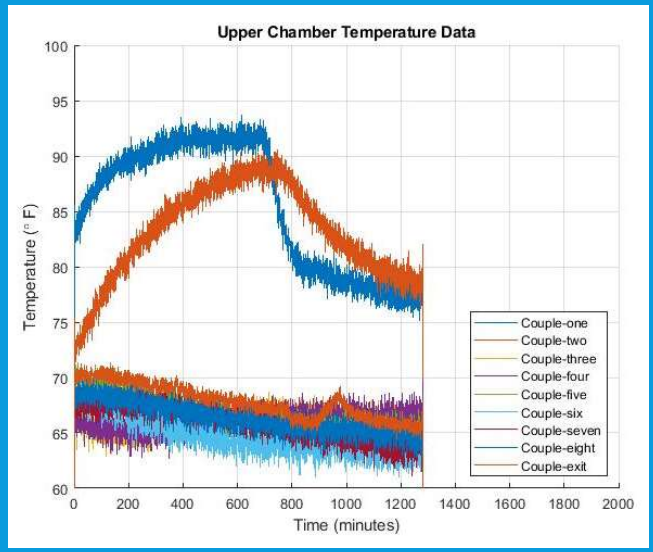
RESULTS



Lower Chamber Results



Location of Thermocouples



Upper Chamber Results

BUDGET

SOLAR ROCKS PROJECT BUDGET

Category	ITEM	UNIT COST	QUANTITY	TOTAL COST	Notes	Acquired?
Materials	Air Blower	$ 571.55	1	$ 571.55	Blower to push the air through the chamber	YES
	Valves	$ 112.63	2	$ 225.26	to control the flow direction of the working fluid	YES
	Piping	$ 260.97	1	$ 260.97	Piping the working fluid will move through	YES
	Chamber Construction	$ 887.56	1	$ 887.56	Total cost of chamber construction	YES
	Mining Rock	$ -	8-TONNES	$ -	The rock to be heated in the cavern frame	DONATED
	Furnace	$ 231.00	1	$ 231.00	Furnace to heat the working fluid	YES
	Data Aquisition Device	$ 38.50	1	$ 38.50	Data collection system	YES
	Pipe Thermocouples	$ 41.30	2	$ 82.60	Thermocouples for entrance and exit temperature	YES
	Chamber Thermocouples	$ 85.08	4	$ 340.32	To collect temperature data from the system	YES
	Pressure Sensors	$ -	2	$ -	To collect pressure data from the system	DONATED
	Circuit board and wire	$ 23.90	1	$ 23.90	To create a single data collection system	YES
	Thermocouple op-amps	$ 10.76	18	$ 193.68	Increases thermocouple reading for DAQ	YES
	Safety Glasses	$ 2.99	1	$ 2.99	Safety glasses for construction	YES
Unavoidable Expenses	University Overhead	$ 300.00	1	$ 300.00	Percentage the university will claim	
	Grad Student Overhead	$ 519.00	1	$ 519.00	Grad student expenses	
	Machine Shop Overhead	$ 800.00	1	$ 800.00	Machine shop expenses	
	Shipping		---	$ 48.95	Item shipping expenses (total)	

Total	$ 2,907.28	Total expenses of the project
Initial Value	$ 6,000.00	Value given to the university
Liquid Funds	$ 4,381.00	Available liquid funds for purchases
Remaining	$ 1,473.72	Remaining value in the budget

FUTURE TESTING PLANS

- Test for longer durations.
- Integrating a solar collector into the system (future capstone?).
- Test alterative thermal fluids such as vegetable oil.
- Alter the upper chamber configuration.

THANK YOU

PICTURE REFERENCES FROM RIGHT TO LEFT IN SLIDE 3

- https://www.sierraclub.org/sierra/2019-1-january-february/feature/what-happens-after-mines-close-kentucky-coal
- https://weather.com/science/environment/news/bingham-canyon-mine-worlds-biggest-man-made-hole-ground-20140724#1
- https://mtstandard.com/news/local/here-s-what-happened-after-thousands-of-geese-landed-on/collection_6b453e3c-547e-52e2-99d9-3b69ffa96f5a.html

FASTENER TABLES AND EQUATIONS

Type	Distance type	Value
// to grain-Compression	Distance to end	4D
// to grain- Tension		5D
// to grain	Spacing between Rows	1.5D
Perpendicular to Grain		(5l+10D)/8
Either Direnction	Specing Between Fasteners	4D

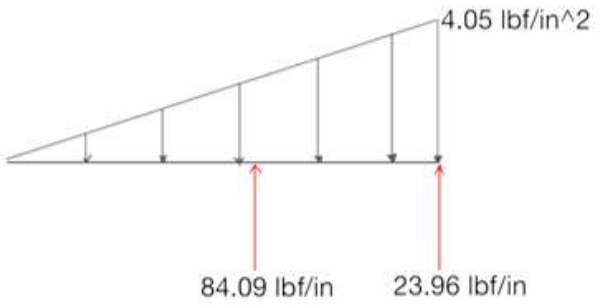


Image 2: Distribution of Force Along Side Beam

Force per inch the beam supports	84.09	lbf/in
Width	24	in
Total Force	2018.16	lbf
Force Nail can withstand	210	lbf
Number of Nails	9.610286	