

Department of Mechanical Engineering, IUPUI
ME 414 Thermal-Fluid Systems Design
Fall 2004

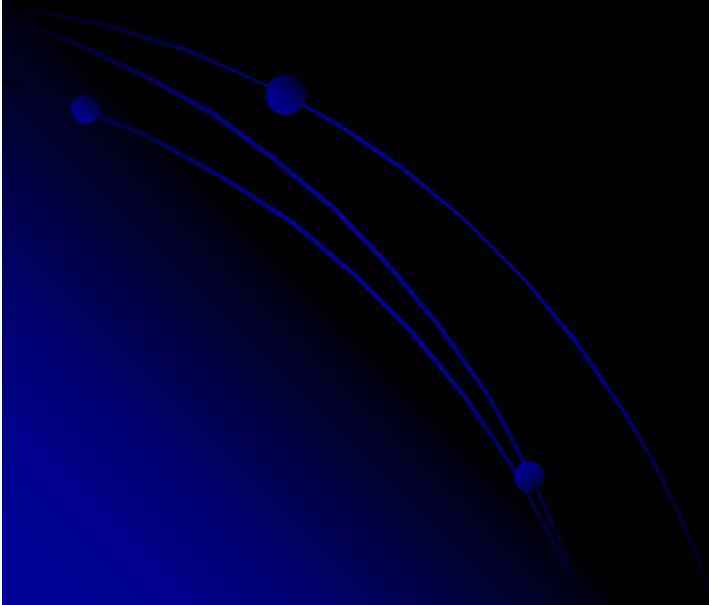
Project 1: Heating System Design

Team 3



Design Objectives

- Design Model with AFT Fathom
- Provide Lowest Flow Rate Variation
- Determine Appropriate Pump Needed
- Calculate Total Cost for System

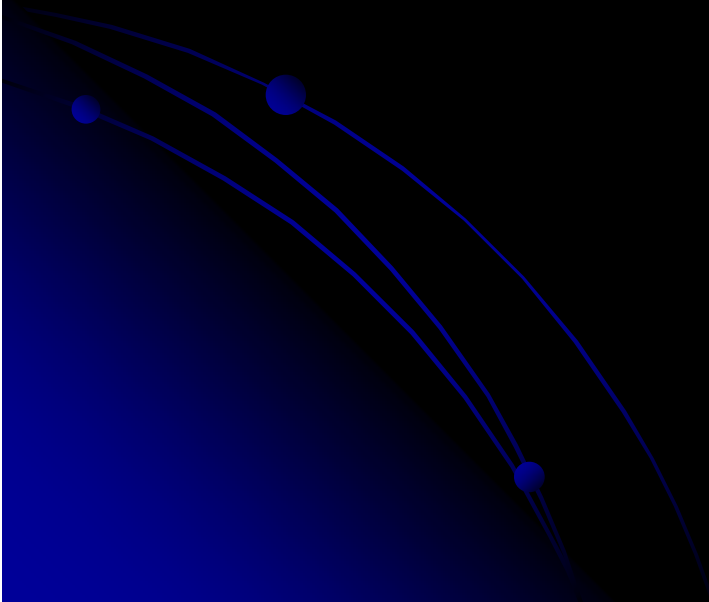


Executive Summary

- Total cost of oxygen supply was reduced by \$2,655,132.06 by using an alternative oxygen source
- Calculated the heat losses for each room
- Selected a pump suitable for our design
- Created a working model of the system using AFT Fathom

Design Considerations

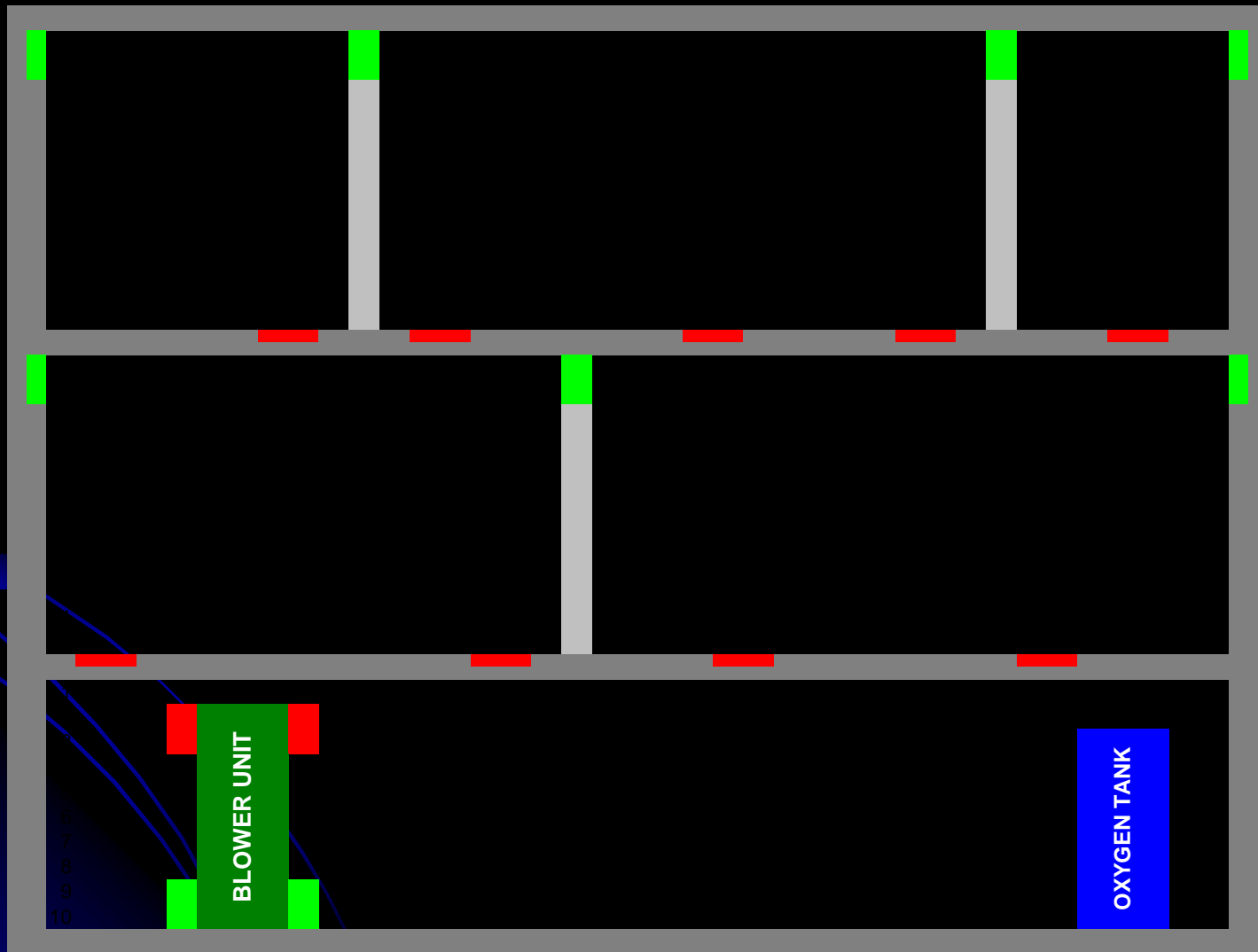
- Overall Change in Pressure
- Total Cost
- Flow Rates
- Overall Heat Loss



Requirements

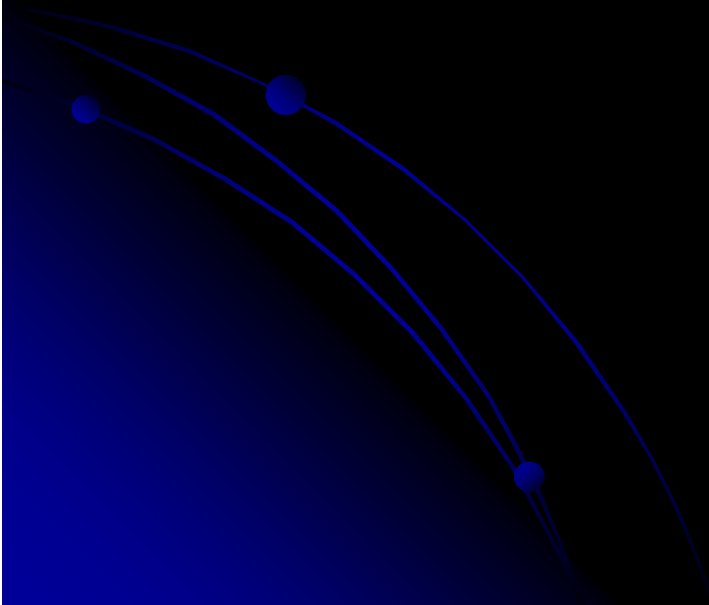
- Design Heating System for North Pole Housing
 - Inside Temperature of 25 °C
 - Outside Temperature of -40 °C
 - Least Operating, Material, Labor and Blower Costs
- Least Flow Rate Variation Between Registers

House Layout Design

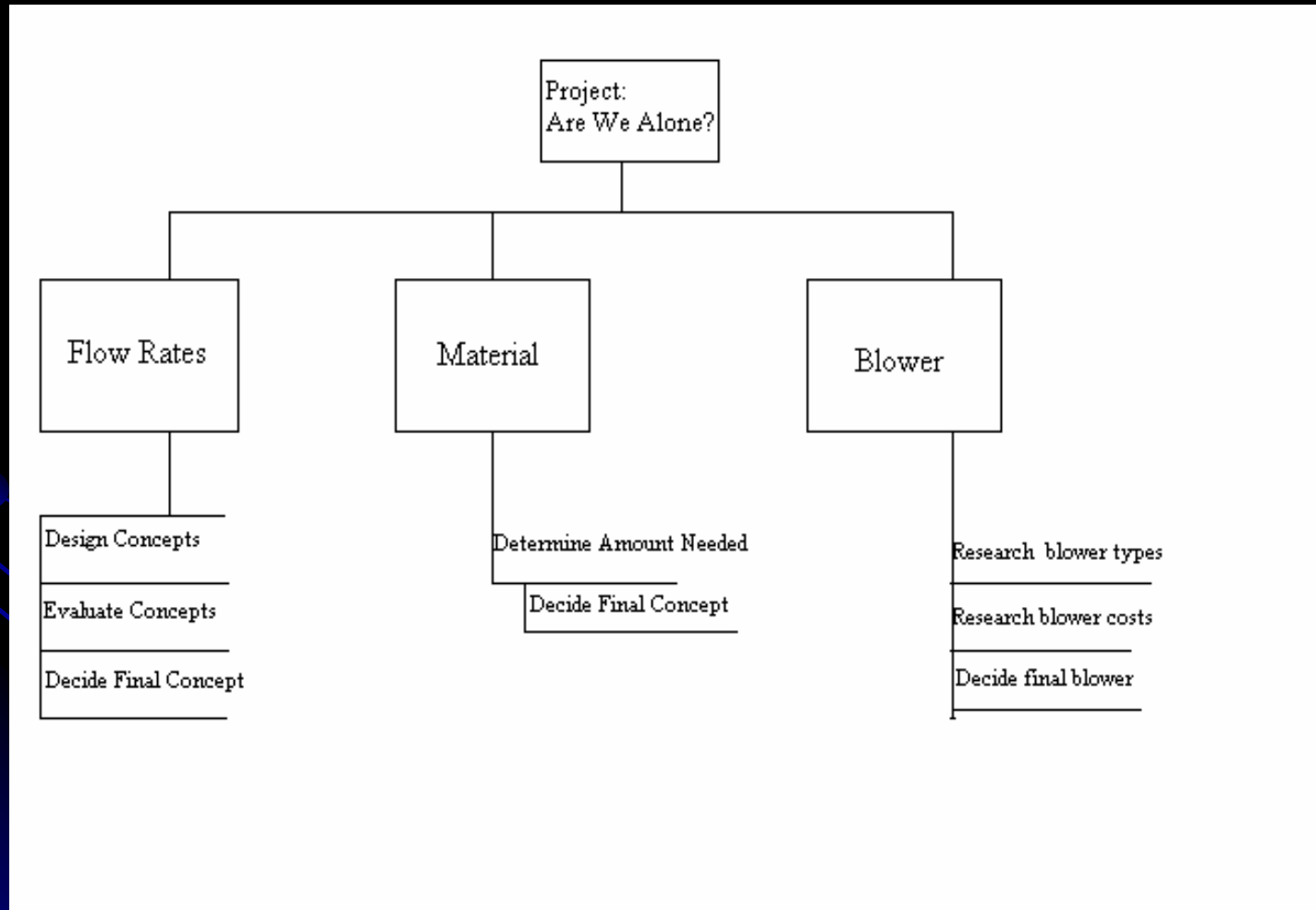


Project Management Tools

- Statement of Work
- Work Breakdown Structure
- Gantt Chart
- Responsibility Matrix



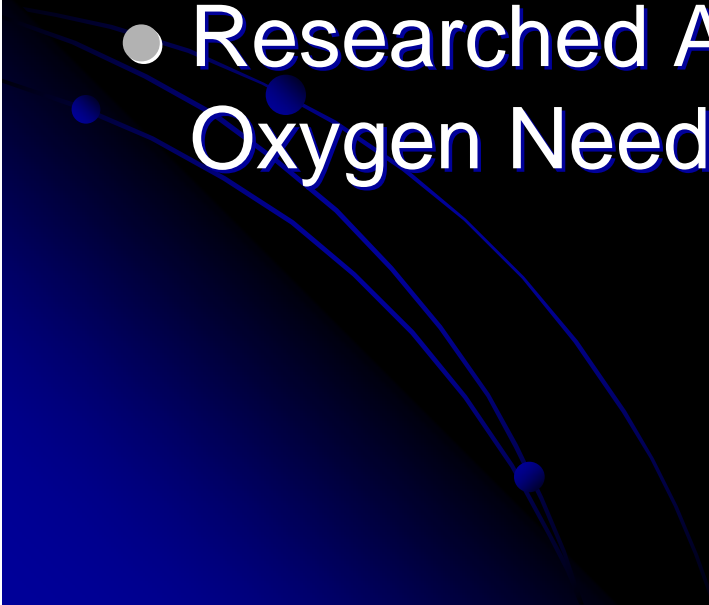
Work Breakdown Structure



RACI Chart

RACI Chart					Responsibilities				
Duration	Start	Finish	Task	Steve Leybourn	Molly Meeks	Jina Miller	Samir Yassine	John Toksoy	
3 days	11/10/04	11/12/04	Generate Concepts	I	A	C	I	R	
4 days	11/12/04	11/15/04	Evaluate Concepts	A	I	I	C	R	
1 day	11/15/04	11/15/04	Make Concept Decisions	A	C	I	I	R	
3 days	11/15/04	11/17/04	Document Decisions	I	C	A	I	R	
1 day	11/17/04	11/17/04	Refine Plan	I	A	C	I	R	
3 days	11/17/04	11/19/04	Generate Product	I	C	I	A	R	
1 day	11/19/04	11/19/04	Evaluate Performance	A	I	I	C	R	
3 days	11/19/04	11/21/04	Evaluate for Cost	I	C	I	A	R	
4 days	11/21/04	11/24/04	Make Product Decisions	C	I	A	I	I	
4 days	11/29/04	12/2/04	Bill of Materials (BOM)	C	I	C	A	I	
5 days	12/4/04	12/9/04	Final Report	C	C	A	I	C	
1 day	12/19/04	12/19/04	Final Presentation	I	A	C	I	C	

Design Steps

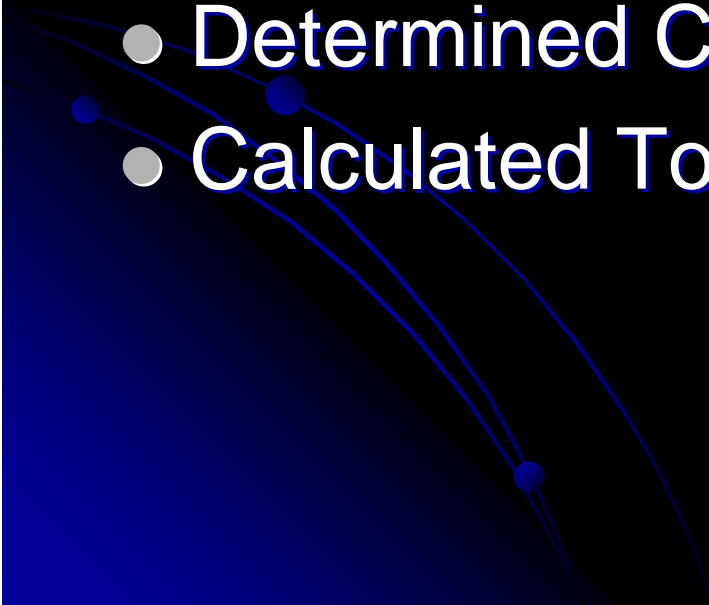
- Calculated Heat Loss
 - Designed Flow System Using AFT Fathom
 - Determined Flow Rates and Pressure Drops
 - Researched Amount of Material and Oxygen Needed
- 

Calculated Q Values

Calculated Q Values By Room

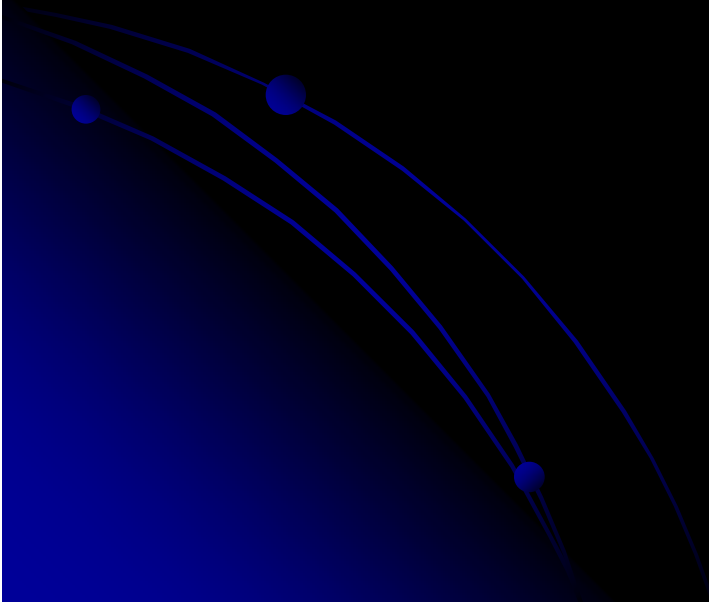
	Front	Back	Side 1	Side 2	Top	Bottom	Total q
Room 1	1,901.90	1,901.90	3,804.10	0.00	3,169.99	0.00	10,777.89
Room 2	3,804.10	3,804.10	0.00	0.00	6,339.80	0.00	13,948.00
Room 3	1,331.40	1,331.40	0.00	3,804.10	2,218.87	0.00	8,685.77
Room 4	3,233.30	3,233.30	3,804.10	0.00	0.00	0.00	10,270.70
Room 5	3,994.20	3,994.20	0.00	3,804.10	0.00	0.00	11,792.50
Room 6	6,129.80	6,129.80	3,169.80	3,169.80	0.00	12,258.50	30,857.70
Total							86,332.56 Watts 294,578.78 Btu/h

Design Steps

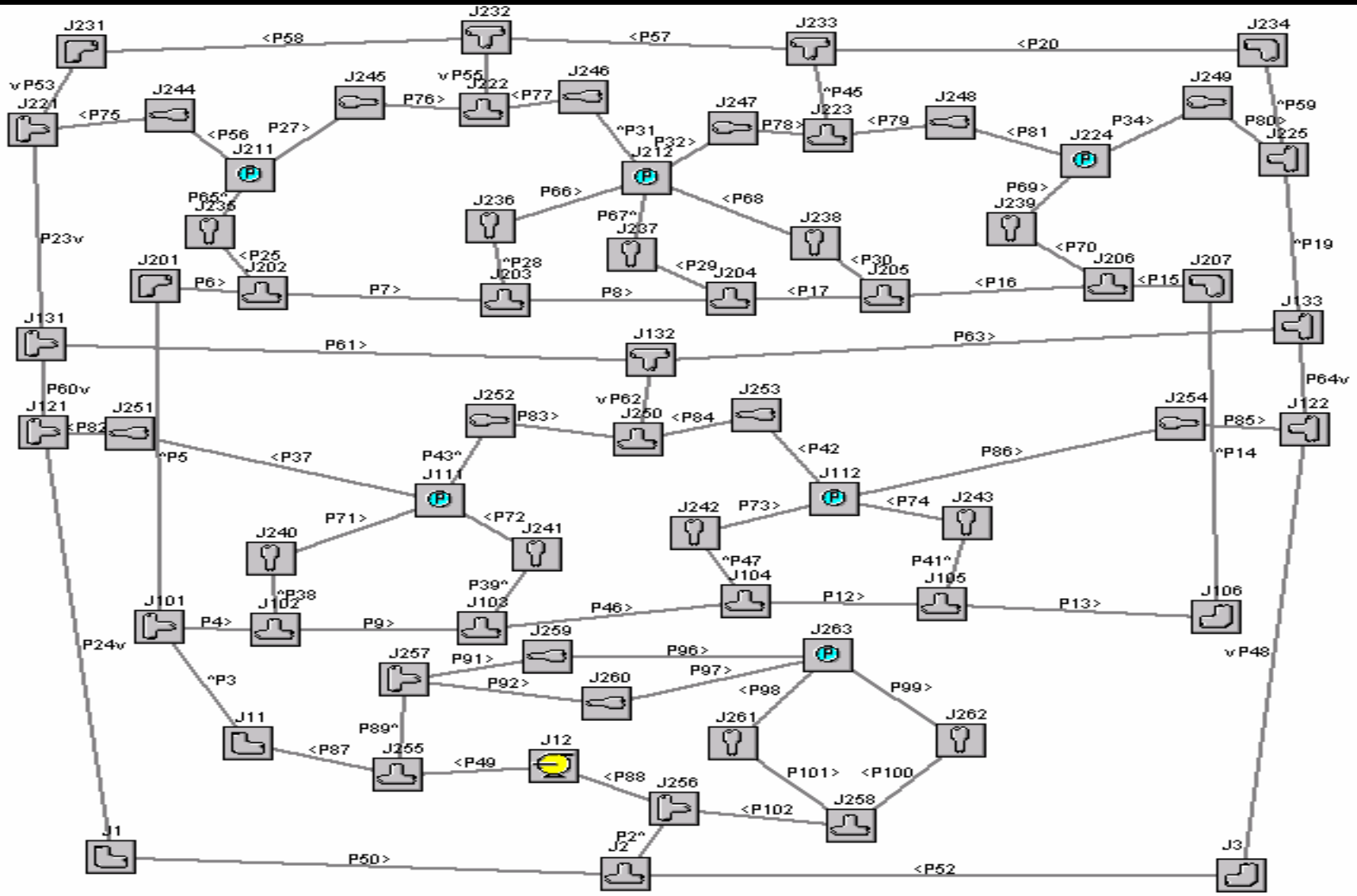
- Calculated Material, Labor and Energy Costs
 - Selected Pump
 - Researched Corn Oxygen Supply
 - Determined Corn Materials Needed
 - Calculated Total Cost
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Design Concepts Considered

- Various AFT Designs
- Shape of Ducting
- Use of House Plants for Oxygen Supply



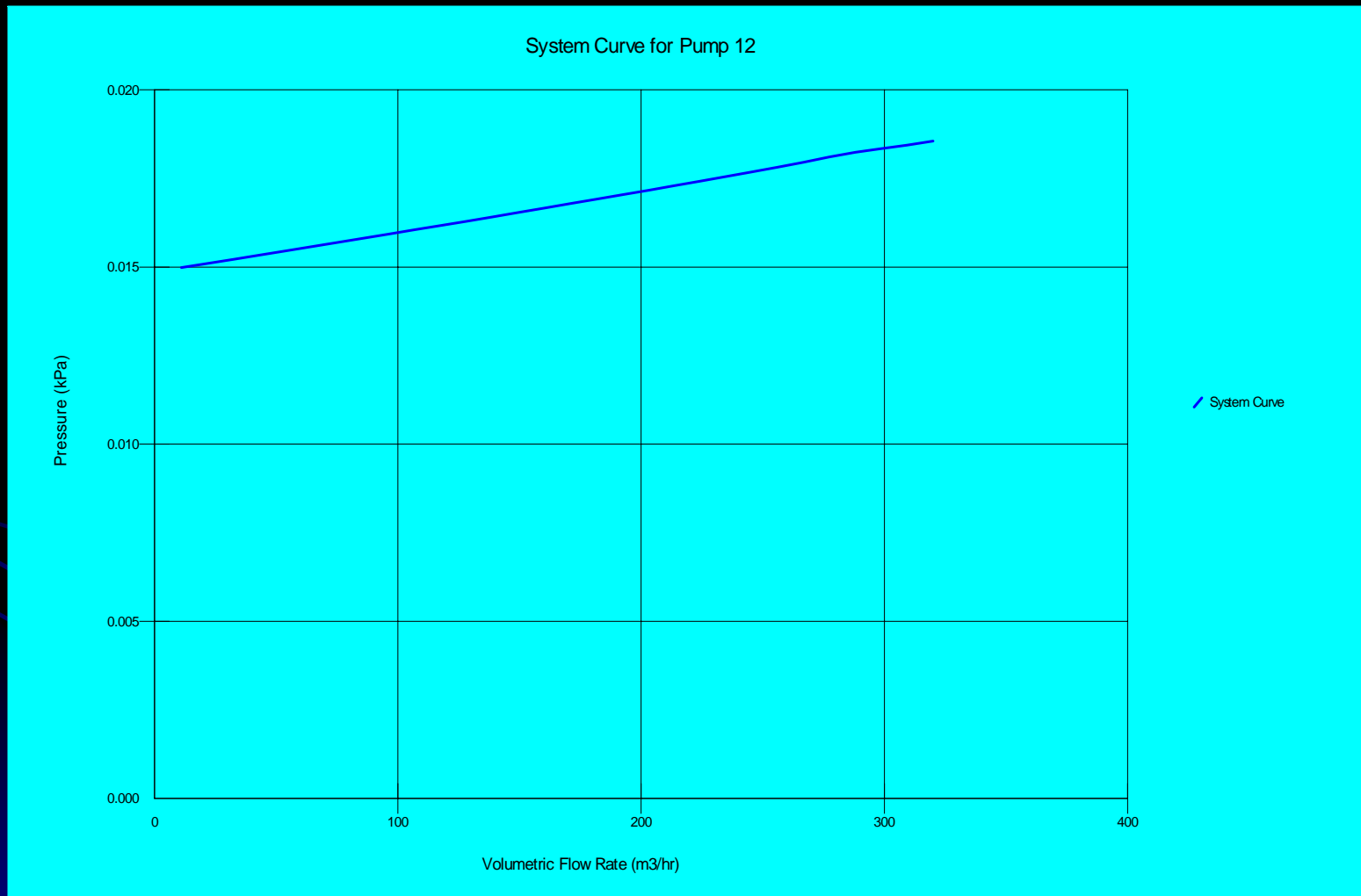
AFT Model



AFT Analysis

Pipe	Vol. Flow (gal/min)	Velocity (feet/sec)	P Static Max (psia)	P Static Min (psia)	dP Gravity (psid)	dH (feet)
2	14819.80	42.04	14.68	14.68	0.00E+00	1.83E+00
3	-6957.20	-19.74	14.70	14.69	5.68E-03	-2.03E+00
5	-4806.90	-13.64	14.69	14.69	6.82E-03	-1.28E+00
50	6526.30	18.51	14.70	14.69	0.00E+00	2.16E+00
55	-3897.70	-24.88	14.68	14.68	-5.68E-04	-5.47E-01
59	-2893.20	-8.21	14.69	14.69	5.68E-04	-3.29E-02
60	17332.60	49.17	14.67	14.67	-5.68E-04	1.25E+00
61	1273.60	8.13	14.69	14.69	0.00E+00	1.03E+00
69	-3893.90	-0.06	14.70	14.70	-2.84E-04	-2.68E-06
70	-3893.90	-13.01	14.69	14.69	2.84E-04	-2.25E-02
75	27131.80	90.67	14.62	14.62	0.00E+00	1.07E+00
80	27172.00	90.81	14.62	14.62	0.00E+00	1.08E+00
83	-4532.80	-15.15	14.69	14.69	0.00E+00	-3.05E-02
85	-17056.70	-57.00	14.66	14.66	0.00E+00	-4.26E-01
89	6173.00	17.51	14.70	14.70	0.00E+00	4.85E-01
91	5689.10	19.01	14.70	14.69	4.55E-03	4.79E-02
96	5689.10	0.06	14.70	14.69	-4.55E-03	1.65E-04
100	-16394.80	-54.79	14.67	14.67	0.00E+00	-3.93E-01
102	-9673.80	-27.44	14.69	14.69	0.00E+00	-1.18E+00

Pump System Curve

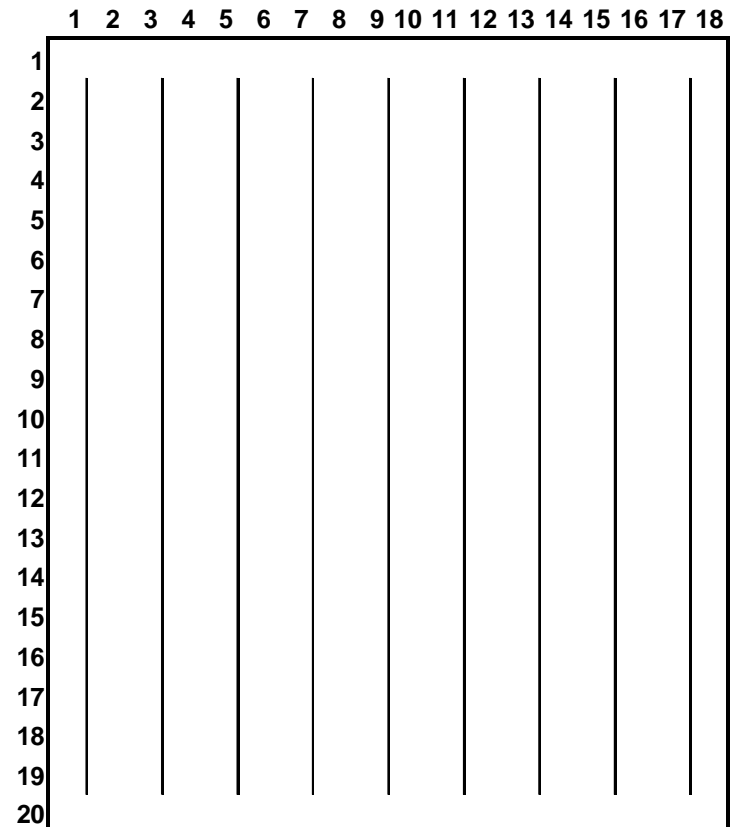


Corn Supply

- Box is 18 x 20 ft.
- Includes a 1 ft. border
- 9 Total Rows
- 2 ft. space between each row

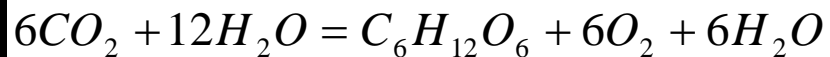
- Corn Seeds
- Potting Soil
- Fill Sand
- Lumber
- Plywood
- Plastic Sheeting
- Sunlight Supply System

Corn Layout



Calculation of O₂ from the Corn

Photosynthesis Chemical Reaction



Ratio of O₂ Production to C₂ biomass Production of Cereal Plants

$$C_2(\text{biomass}) : O_2$$

Biomass Production in terms of C₂

$$363,000 \frac{\text{g of } C_2 \text{ biomass molecules}}{(120 \text{ days})(15m \times 20m)} : 363,000 \frac{\text{g of } O_2 \text{ molecules}}{(120 \text{ days})(15m \times 20m)}$$

$$\rho_{O_2} = 1.429 \frac{\text{g}}{\text{lt.}}, \quad \frac{1}{\rho_{O_2}} = .69979 \frac{\text{lt.}}{\text{g}}$$

Biomass Production in terms of C₂

$$363,000 \left(\frac{\text{g of } O_2 \text{ molecules}}{(120 \text{ days})(10m \times 15m)} \right) \left(\frac{(5.4864m)(6.096m)}{(18 \text{ ft} \times 20 \text{ ft})} \right) \left(.69979 \frac{\text{lt.}}{\text{g}} \right) = 70798.7478 \left(\frac{\text{lt. of } O_2}{(\text{day})(\text{ft}^2)} \right)$$

Cost of O₂ from the Corn Compared to from Tanks

Biomass Production in terms of O₂

$$70798.7478 \left(\frac{\text{lt. of } O_2}{(\text{day})(\text{ft}^2)} \right) \times 123 \left(\frac{\text{days}}{\text{duration}} \right) = 8,708,246 \left(\frac{\text{lt. of } O_2}{(\text{duration})(\text{ft}^2)} \right)$$

At a cost of ...

$$2,042.94 \left(\frac{\$}{\text{duration}} \right) \therefore \frac{2,042.94}{8,708,246} = .000234598 \left(\frac{\$}{\text{lt.}} \right)$$

Calculation of Oxygen Production from Replacement Tanks


$$7,084,800 \left(\frac{\text{lt. of } O_2}{(\text{duration})(\text{ft}^2)} \right)$$

At a cost of ...

$$2,480,100 \left(\frac{\$}{\text{duration}} \right) \therefore \frac{2,480,100}{7,084,800} = .35005928 \left(\frac{\$}{\text{lt.}} \right)$$

$$\therefore \% \Delta = \frac{.000234598 - .35005928}{.000234598} \times 100 = 149,116.44 \% \text{ Increase}$$

Final Costs

- Pump Cost was \$2,333.66
 - Material Cost \$9,146.95
 - Energy Cost \$124,692.00
 - Corn Supply Cost \$2,042.94
 - Total \$138,215.55
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The End

