

Free Breeze Brothers Free Cooling System

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Problem Statement

- The design and implementation of a free cooling system to chill water for the UI campus, during the winter months, is the main goal of this project.
- By considering system economics, environmental impact, and overall optimization, among other factors, the designed system will provide an efficient, cost-saving method of cooling water through the use of cold ambient air.

Background

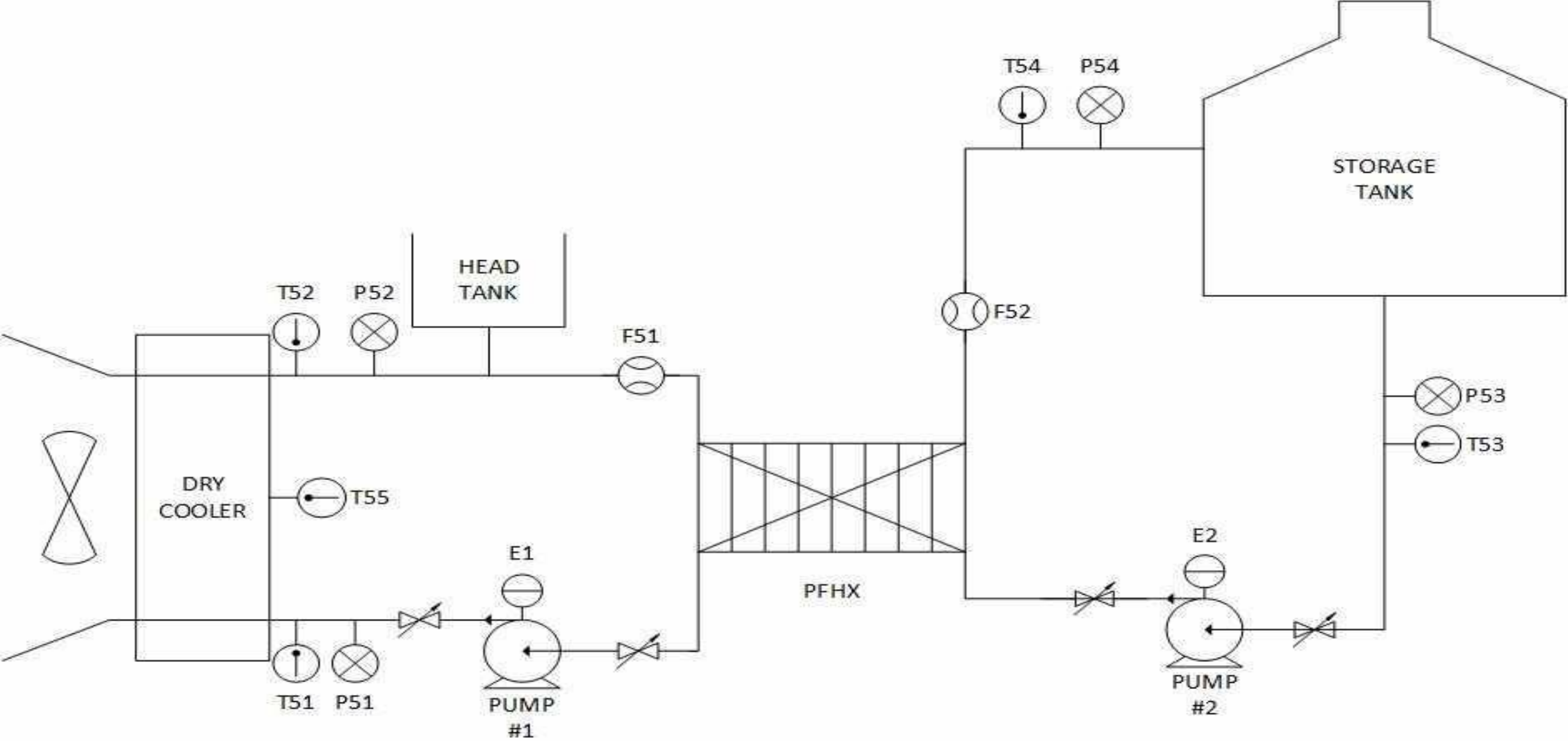
- The server rooms on campus require constant cooling all year round.
- During the Summer season the cooling load is handled by chillers which are connected to water towers.
- During the Winter Season these water towers are shut off due to risk of freezing.
- Currently the free cooling system located in the McClure building handles the cooling load
- But this system experiences issues with fan freeze up.
- Our goal is to implement a new free cooling system that will solve these problems and avoid any possible freezing issues.

Specifications

Specifications:

- 75-100 Tons of cooling capacity
- Velocity of $4-8 \frac{ft}{s}$
- Chilled water loop can not be exposed to air.
- Inlet chilled water temperature of 65 °F
- Outlet chilled water temperature of 52 °F maximum.
- Ethylene Glycol solution must have a high enough concentration to prevent freezing or slush build up.

P&ID



Initial Design With New Components

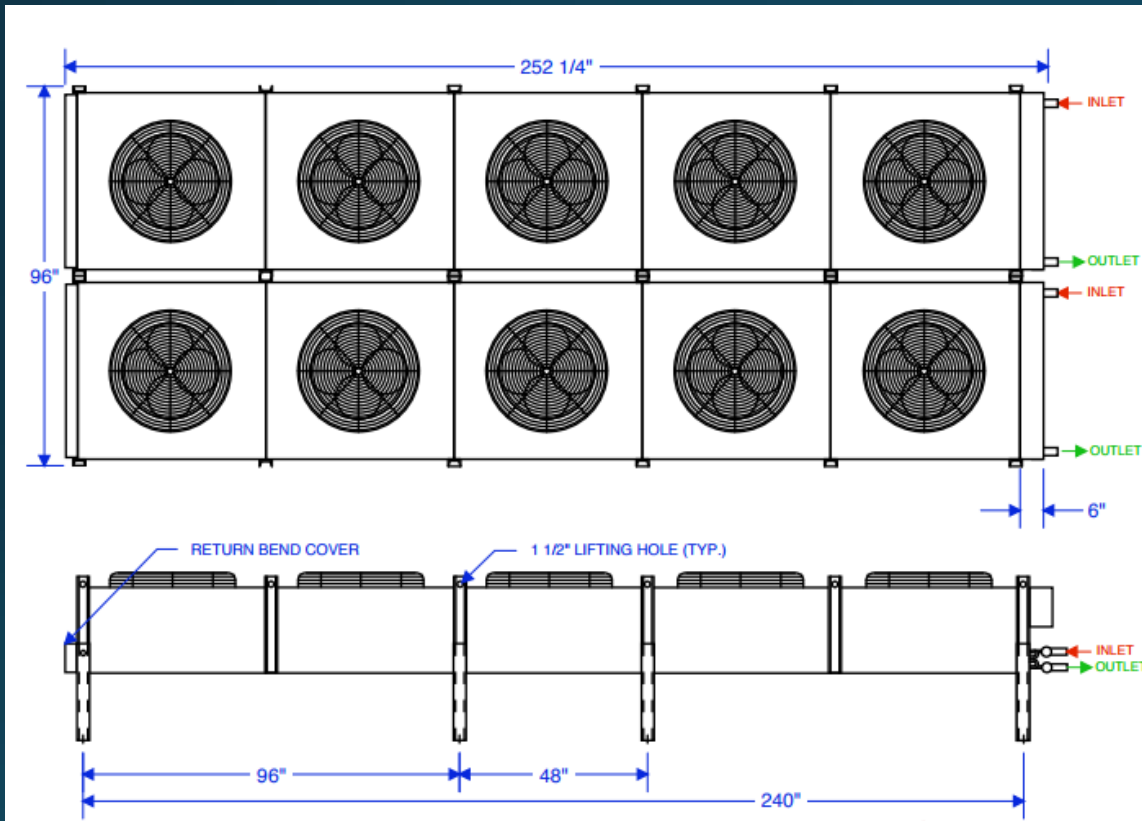
Dry Cooler (AVR-158)

Pros:

- Fluid is not in contact with surrounding air, thus eliminating use of additives.
- VFD fans are available, allowing for variable Air volumetric flow rates at different loads.
- Provides necessary cooling capacity. (>100 Tons)

Cons:

- Cost of initial purchase. (\$25,000)
- Largest fittings available are 3.125".
- Slightly oversized, and yet smaller model does not meet cooling capacity.



Design Overview

Plate and Frame Heat Exchanger (M6-FD)



Pros:

- Total heat transfer area of 233.821 ft^2 , which is greater than the minimum area requirement. This will provide for the cooling capacity to be reached.
- Easily maintained as opposed to cleaning fouling in a shell and tube heat exchanger.
- Efficient heat exchanger.
- Compact
- Flexible (Plates can be added)

Cons:

- Costly
- Necessity of long gaskets.
- Leaks are possible if gaskets fail.

Repurposed Parts Design



There was a possibility of reusing equipment available on campus. This would lower costs and provide the necessary cooling capacity.

Pros:

- Carrier unit provides 80 tons of cooling.
- Eliminates initial cost of new unit.
- Available on campus, which removes shipping costs. (Note: Transportation costs are still present)

Cons:

- Old machine thus fans are not as efficient.
- Replacement parts may prove difficult to find.

Repurposed Parts Design

This unit was moved from the McClure building.

Pros:

- Plate and Frame heat exchangers are costly, thus this will prevent the need for a new one.
- Is oversized, which will insure that the current cooling load need is met with ease and if a greater capacity is required then it is readily available. (200 ton capacity).

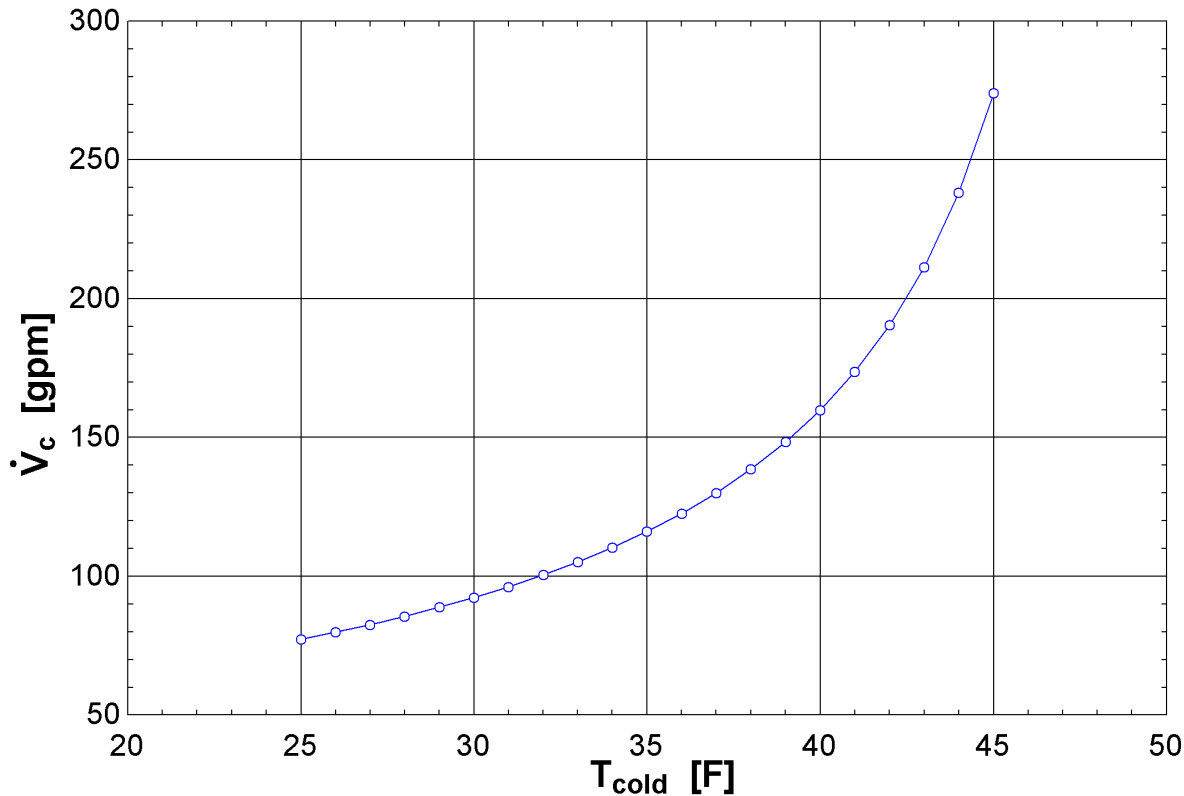
Cons:

- Will need to be inspected and pressure tested.



Alfa Laval M10-BFG

Sizing pumps



Flow rate of Ethylene Glycol required to maintain 100 tons of cooling. Flow rate vs. Ambient air temperature

- 200-250 GPM pump required for EG loop.
- 100-150 GPM pump required for chilled water loop.
- Chilled water flow rate will be set constant at an optimal setting of approximately 120 GPM.

Pumps chosen

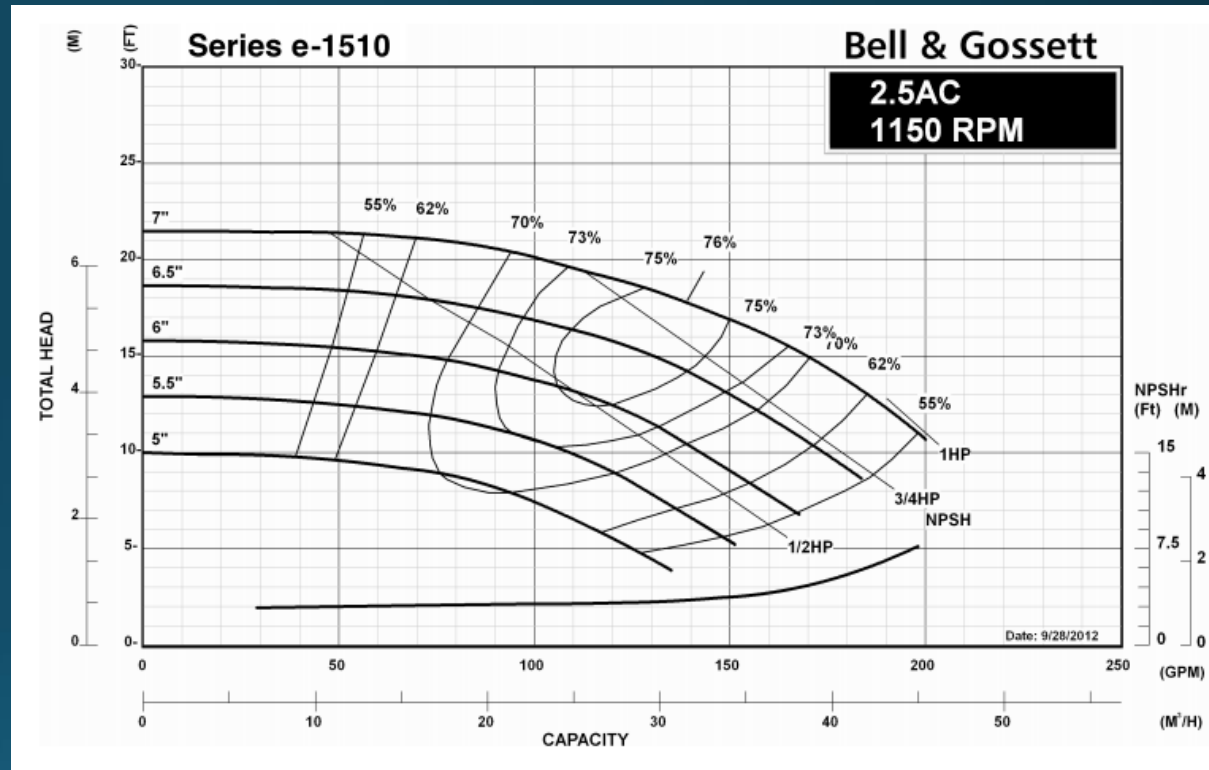
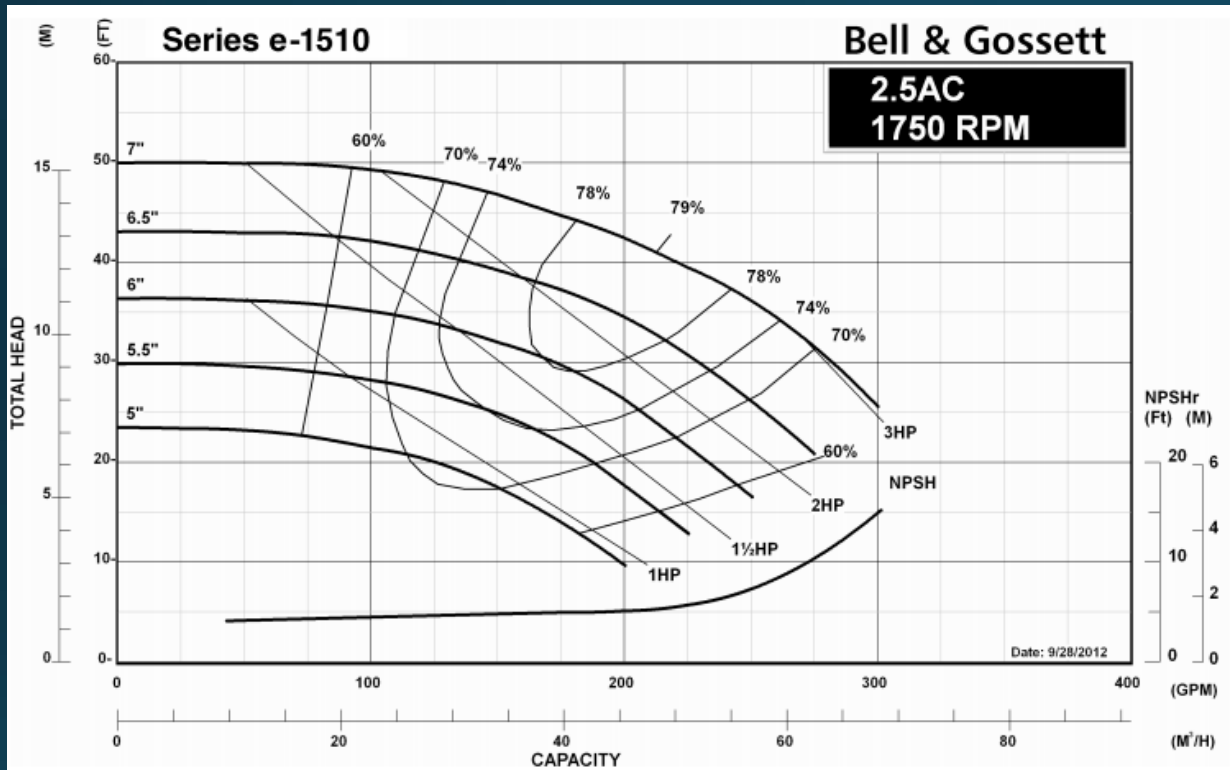
Chilled water loop:

Bell and Gossett e-1510 2AD-es (1HP)

Ethylene Glycol loop:

Bell and Gossett e-1510 2AC-es (3HP)

Pump Curves



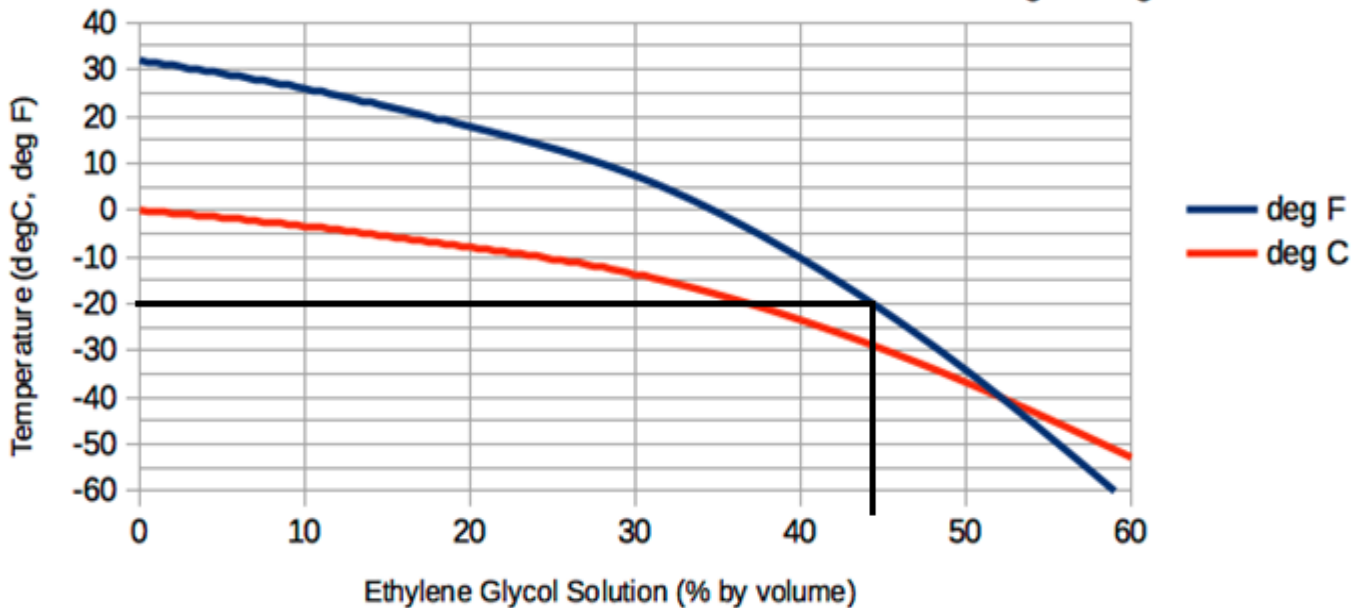
Ethylene Glycol Concentration Selection

Freezing Point								
Ethylene Glycol Solution		0	10	20	30	40	50	60
Temperature	(°F)	32	25.9	17.8	7.3	-10.3	-34.2	-63
	(°C)	0	-3.4	-7.9	-13.7	-23.5	-36.8	-52.8

Water and Ethylene Glycol

Freezing Point

engineeringtoolbox.com



20% EG solution

Q_dot= 108.5 [ton]

t_co=52.38 [F]

T_cold=40 [F]

T_hi=65 [F]

T_ho=48.74 [F]

V_dot_c= 220 [GPM]

V_dot_h= 159.9 [GPM]

30% EG Solution

Q_dot= 103.6 [ton]

t_co=52.46 [F]

T_hi=65 [F]

T_ho=49.47 [F]

V_dot_c= 220 [GPM]

V_dot_h= 159.9 [GPM]

40% EG Solution

Q_dot= 98.13 [ton]

t_co=52.55 [F]

T_cold=40 [F]

T_hi=65 [F]

T_ho=50.29 [F]

V_dot_c= 220 [GPM]

V_dot_h= 159.9 [GPM]

45% EG Solution

Q_dot= 95.25 [ton]

t_co=52.59 [F]

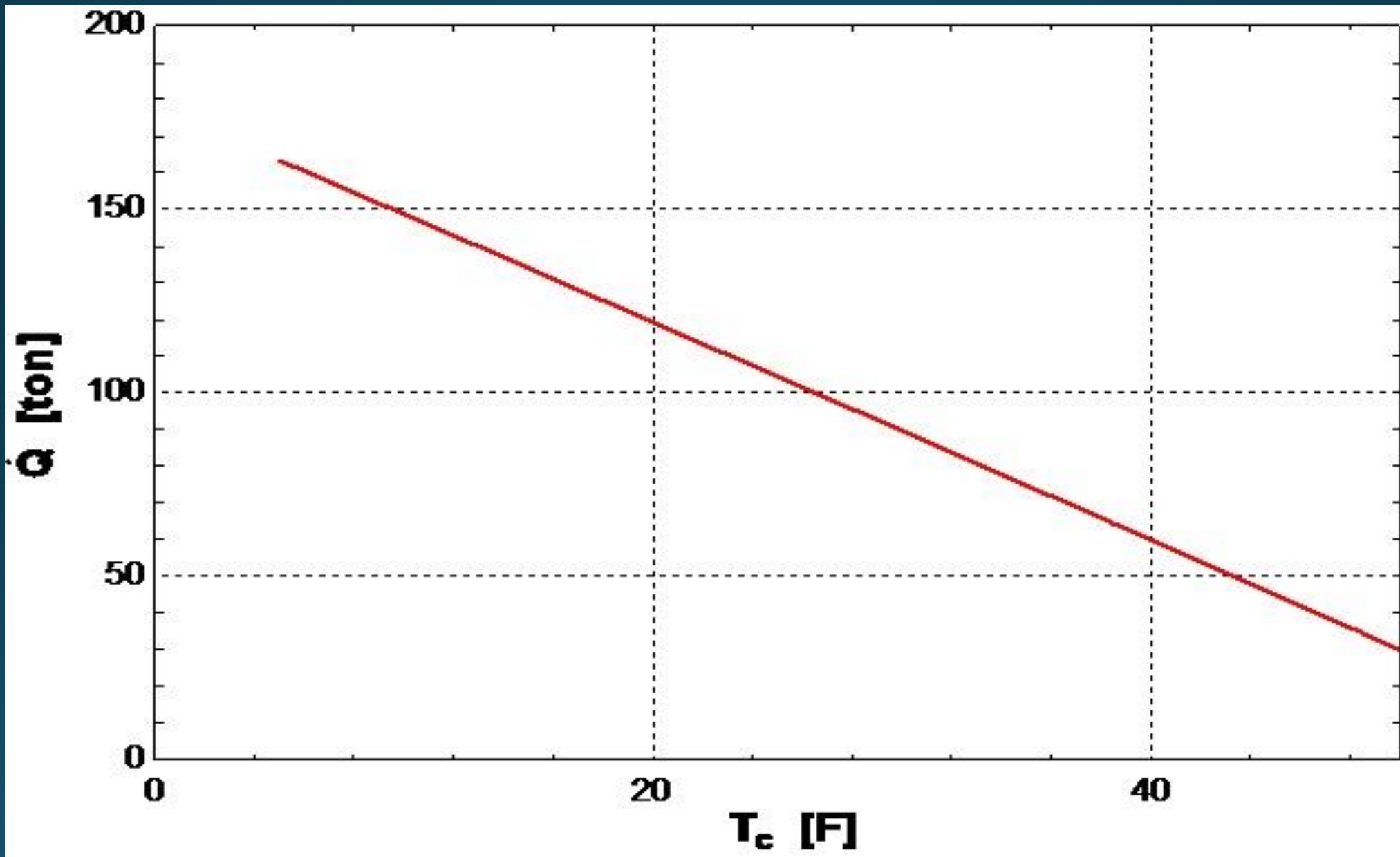
T_hi=65 [F]

T_ho=50.72 [F]

V_dot_c= 220 [GPM]

V_dot_h= 159.9 [GPM]

System Cooling Capacity

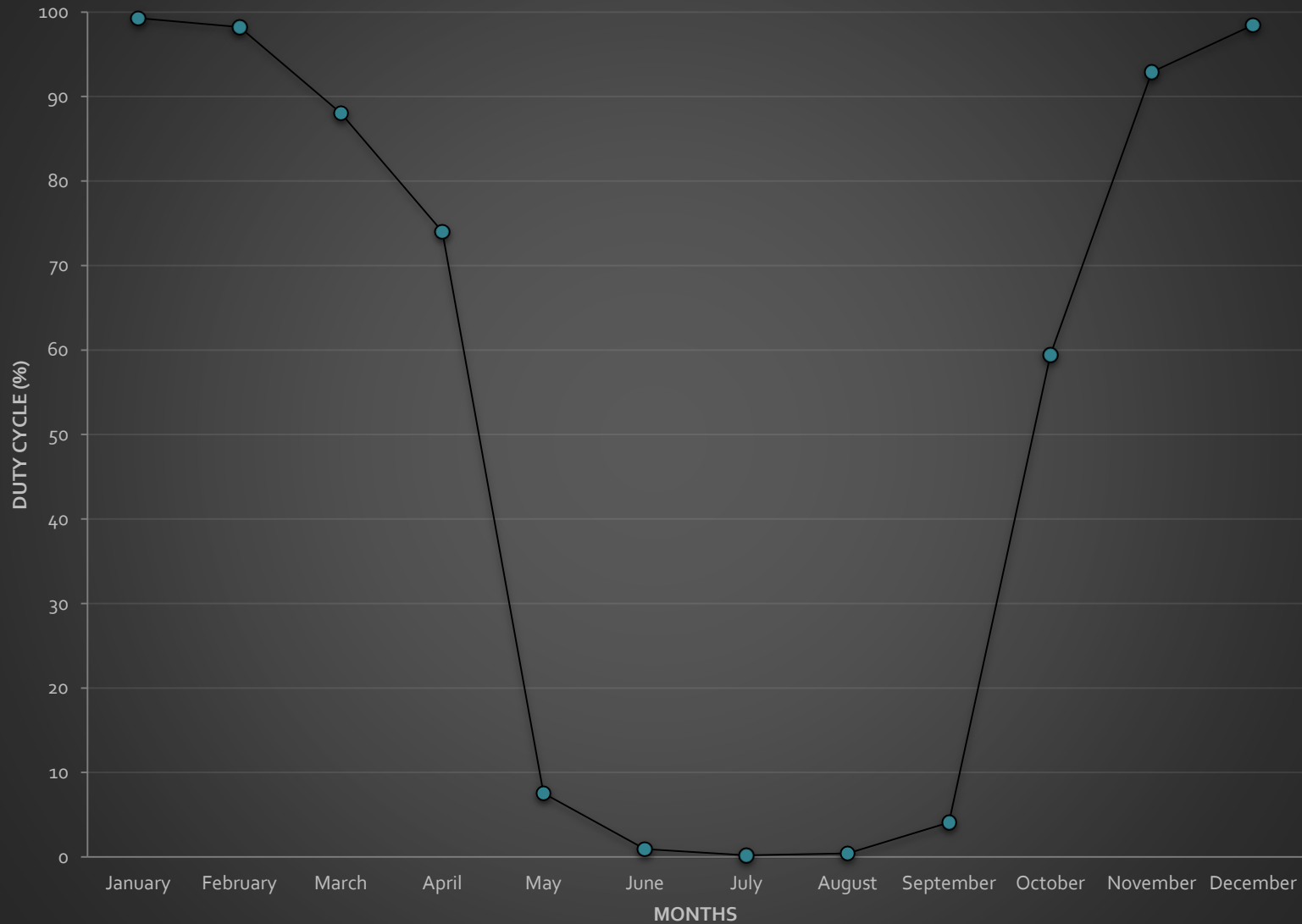


Payback Period

Off the Shelf Design	Initial Cost	Cost of Operation per year	Savings	Payback period (years)
Dry cooler	25000	997.84		5.216962754
PFHX	45000			
Pump 1	2992.70	834.66		
Pump 2	3197.65	563.15		
SUM	76190.35	2395.65	14604.35	
Repurposed Parts Design	Initial Cost	Cost of Operation per year		Payback period (years)
Dry cooler		1573.73		2.282875766
PFHX				
Pump 1	2992.70	731.32		
Pump 2	3197.65	563.15		
SUM	6190.35	2868.20	14131.80	
Current Operation		Cost of Operation per year		
Chillers		17000		

Monthly Duty Cycle

Average Monthly Duty Cycle



- System is shut off when duty cycle is below 50%
- System can operate for 7 possible months
- Machine will be planned to shut off during May-September, where the chillers will resume operation.

Floor Plan

Selected location

