Coolant Delivery System

MET 330
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Coolant System- Continental AG

Bernoulli's Principle

Theory - Equation

$$P_1 + \frac{1}{2}\rho V_1{}^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2{}^2 + \rho g h_2$$

Design considerations:
Fast fill times to ensure no delay in coolant delivery.

Reduced energy losses that allow for smaller pumps and lower energy costs.

Materials selected with corrosion resistance and safety in mind.

Modern technology used to verify that calculations are correct and that design specifications are met.

Custom designed differential pressure manometers and flow nozzles.

NPSH requirements met to ensure proper pump operation.

Initial Design

The initial design was created with efficiency and cost in mind. Galvanized steel was chosen to be used for the pipes and tanks to resist corrosion and fatigue.

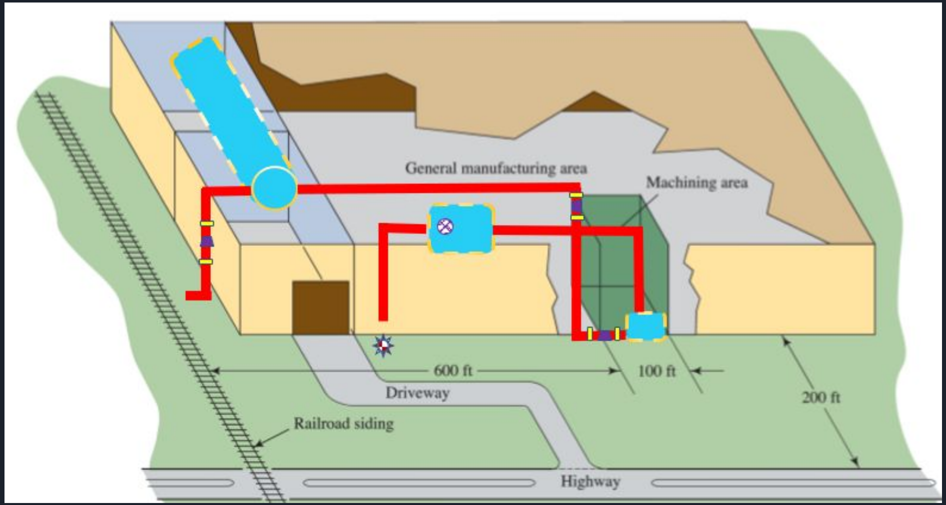
Delivery of the coolant will be by train which means that coolant will have to be routed from the tracks across the building. We chose to mount the pipes along the roof to save room.

We chose to fill the tanks quickly enough that production will not be inhibited, but not so fast that the system is too costly to make.

Being that the coolant is oil-based it can separate if left sitting for too long. We chose a pipe that will give us a turbulent flow so that the liquid would be mixed up on its way to the machines.

Initial Design Continued

Fluid will be run from the track , up the side of the building, and across the roof to the main storage tank. It will then run across the roof and then down through the building to the reservoir beneath the machines. Finally, the fluid will be routed back up to the roof and across the building to the trash tank.



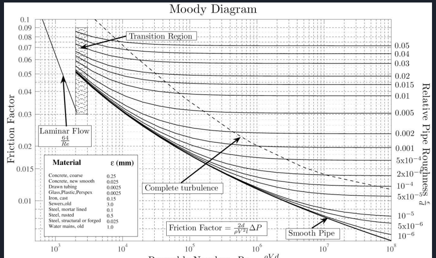
Energy Losses- Valves

In all fluid systems, there are energy losses that exist from the fluid coming in contact with the walls of the pipes, valves, and tanks.

These losses create the need for bigger pumps and more power to move the fluid . The system was analyzed and software was utilized to limit these losses.

While losses are increased by the addition of components such as valves and elbows, these are necessary for maintenance and flow manipulation.

Gate valves were chosen due to how well they work while adding minimal losses.



Energy Losses Continued

Various factors affect the total energy loss of a system including pipe size, flow rate, pipe length, material, fittings, etc.

Our plan in designing the piping system was to minimize the pump head/energy losses by positioning our tanks and pumps in positions that enabled the simplest/most efficient pipe run

The equations below helped us take all energy loss possibilities into account and run a trial and error method until we were satisfied with the efficiency of our layout.

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7\,(D/\varepsilon)} + \frac{5.74}{N_R^{0.9}}\right)\right]^2}$$

$$h_L = f\,\frac{L}{D}\,\frac{V^2}{2g}$$

Open Channel Flow

The new building requires an open channel system in case the trash tank needs to be emptied due to a debris blockage or for general maintenance.

The fluid flows down because of gravity, therefore the channel was designed to be sloping towards the open holding tank.

The rectangular channel is made of a rugged material known as smooth asphalt that can resist the sun and inclement weather. The channel runs in front of the building from the trash tank to the open pool located off to the side of the building for later removal.

Tank Sizes

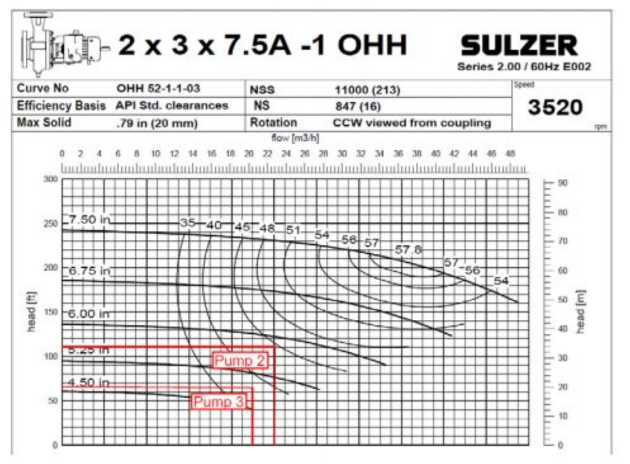
The necessary sizes for the three required tanks had to be determined based on how many gallons each needed to hold. The following table displays the sizes of each tank as well as how each is shaped and oriented.

Tank	Shape/Orientation	Capacity (gal)	Dimensions
Reservoir	Cylindrical/Horizontal	1,000	6 ft diameter x 6 ft long
Used Coolant	Cylindrical/Horizontal	9,000	11 ft diameter x 14.083 ft long
Storage	Cylindrical/Horizontal	60,000	15 ft diameter x 45.5 ft long

Pump Selection

Our pipe system design included 3 Sulzer pumps and 1 gravity fed system. The resourceful pipe layout designed only permitted the need for smaller pumps.

The resultant pump head and the system flow rate had the biggest impact on determining the pump of best fit. These values also pinpointed pump modifications including efficiency rate and impeller size



	Head Requirement	Flow Capacity	Pump Size	Impeller size	Efficiency Rating
Pump 1	53.26 ft	223.25 gpm	3 x 4 x 7.5-1	4.5 in	60%
Pump 2	110.86 ft	99.79 gpm	2 x 3 x 7.5A-1	5.25 in	45%
Pump 3	62.42 ft	89.82 gpm	2 x 3 x 7.5A-1	6.00 in	38%

Drag Forces due to Wind on Outdoor Tanks

Based on the weather conditions in Dayton, OH, the amount of air drag on the tanks needed to be determined so the civil engineering design could be made appropriately.

Dayton has recorded a high speed of 58mph winds (1967) and a temperature range of -20 degrees Fahrenheit to 105 degrees Fahrenheit.

Using the following formula, the maximum air drag was determined:

$$F_D = C_D(½)(\rho)(v^2)(A)$$

The worst case scenario that will result in the maximum drag force will be -20℉ and a maximum wind speed of 60mph or 88 ft/s was used.

The maximum drag force due to wind was found to be 2219.82 lb

Net Positive Suction Head (NPSH)

The system had to be analyzed to determine if it could support the needs of each pump.

The equation to determine NPSH of the system was calculated, and it was checked against charts for each pump. The following equation was used to determine each system's NPSH:

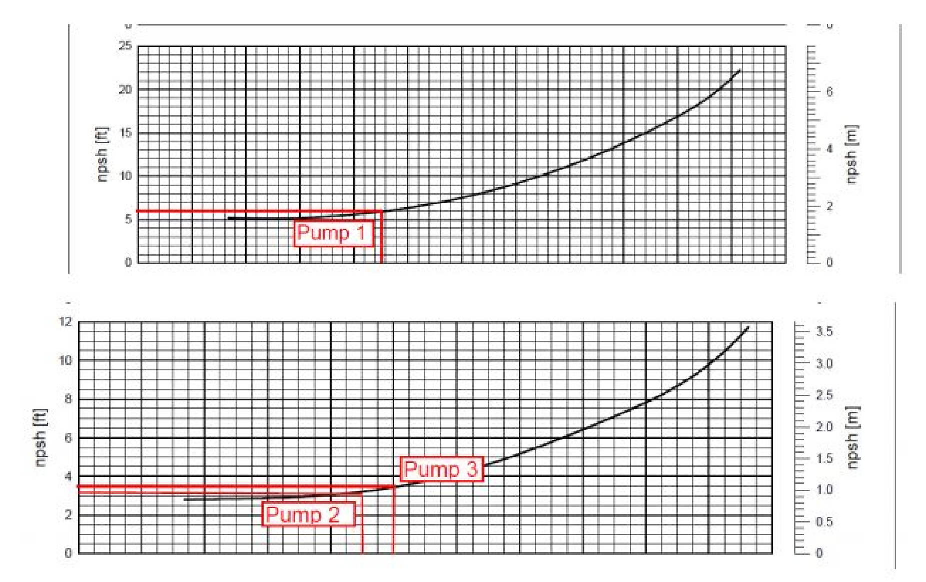
$$(p_{IN}-p_v)/\gamma = (p_1-p_v)/\gamma + \Delta z - h_L$$

The NPSH for the system at Pump 1 is 8.857 ft while the required NPSH for the pump was 6 ft.
The NPSH for the system at Pump 2 is 5.127 ft while the required NPSH for the pump was 3.5 ft.
The NPSH for the system at Pump 3 is 6.352 ft while the required NPSH for the pump was 3.25 ft.

The following slide contains the charts to determine the required NPSH for each pump.

Determining Required NPSH

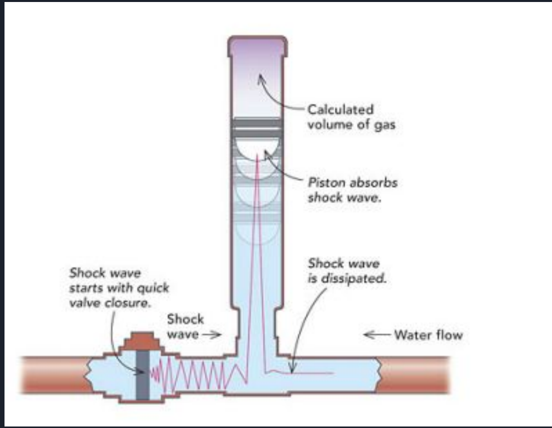
The following charts gave the needed NPSH for each pump chosen for the system.



Water Hammer Arrestor - Overpressurization

The safety of the warehouse/employees was a major focus of our design team. When possible, we tried to limit the amount of pressure on the system line to account for the unknown work environment that would take place by the pipes and pumps.

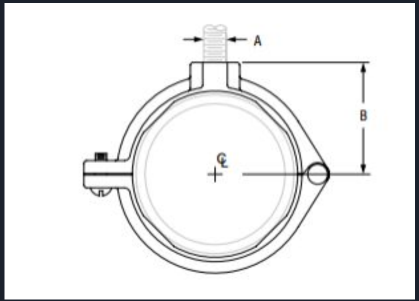
Thorough calculations confirmed that the addition of water hammer arrestors wasn't required due to the normality of the operating pressure



$$C = \frac{\sqrt{\frac{E_o}{\rho}}}{\sqrt{1 + \frac{E_o D}{E\delta}}}$$

T(Thickness required to handle pressure) = [Pmax(D)/2(S)(E)+Pmax(.4)]

Pipe Supports



The fastening/support system is a major emphasis when dealing with heavy equipment/ elevated piping layouts.

In order to maintain the quality control and top performance of the pipe system, we had to maintain a deflection rate of >10% of the pipes diameter

This was confirmed through the solving for the mass, volume, inertia, and density of the pipe and coolant and plugging those values into a manipulated pipe deflection equation.

Support Type	Pipe Diameter(inches)	Distance between Hanger	Force on Hangers	Distance between Hangers Used
Split-ring hanger	4	10.5 feet	167.84 lbf	8 feet
Split-ring hanger	2.5	12.3 feet	82.6 lbf	8 feet
Split-ring hanger	2.5	12.3 feet	82.6 lbf	8 feet
				* Safety Factor and Uniformity

$$y = -\frac{PL^3}{48EI}$$