

Purpose:

Design the pipeline system by taking the coolant from the railroad tank to the storage tank.

## 1 Fluid Properties

- Coolant: water + soluble oil solution
- Specific Gravity (SG): 0.94

Water at 60°F

- $\gamma$ : 62.4 lb/ft<sup>3</sup>
- $\rho$ : 1.94 slugs/ft<sup>3</sup>  $\rightarrow 0.94 \times (1.94 \times 32.2) \approx 58.7 \text{ lb/ft}^3$
- $\mu$ :  $2.35 \times 10^{-5} \frac{\text{lb-s}}{\text{ft}^2} \rightarrow 1.5 \times (2.35 \times 10^{-5}) \approx 3.53 \times 10^{-5} \text{ lb-s/ft}^2$
- $\nu$ :  $1.21 \times 10^{-5} \text{ ft}^2/\text{s}$

## 2. loss factors

- Pipe friction ( $f_f$ ): 0.020
- Entrance loss ( $K$ ): 0.5 Square edged inlet
- Exit loss ( $K$ ): 1.0 Pipe to static reservoir
- Valve loss ( $K$ ):  $8f_f$  (Gate valve)
- Elbow loss ( $K$ ): 30  $f_f$  (90° standard elbow)

$$Q = \frac{15,000 \text{ gal}}{6 \text{ hr}} = 2500 \text{ GPH} = 41.67 \text{ GPM}$$

$$\text{SG}: 0.94$$

Pipe: 2" Schedule 40 steel pipe

- inner D: 2.067 in  $\approx 0.1722 \text{ ft}$
- A: 0.0233 ft<sup>2</sup>

## 2) velocity Calculation

$$V = \frac{Q}{A} = \frac{41.7 \text{ GPM} \times 0.002228 \text{ ft}^3/\text{s per GPM}}{0.0233 \text{ ft}^2} = 3.99 \text{ ft/s}$$

3) Total Pipe length  $L$ : 700 ft (horizontal) + 32 ft (vertical rise) = 732 ft

• minor losses ( $\sum K$ ): Assume 9 elbows ( $5 \times 0.9$ ), 2 gate valves ( $2 \times 0.2$ ), entrance / exit losses (1.0)  $\sum K = 5.9$

• Friction head  $h_f$   $f = 0.02$

$$h_f = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g} = 0.02 \cdot \left( \frac{732}{0.1722} \right) \cdot \left( \frac{3.99^2}{64.4} \right) = 21.0 \text{ ft}$$

• Minor Head loss  $h_m$

$$h_m = \sum K \cdot \left( \frac{V^2}{2g} \right) = 5.9 \left( \frac{3.99^2}{64.4} \right) = 1.46 \text{ ft}$$

• TDH =  $H_{\text{static}} + h_f + h_m = 32 \text{ ft} + 21.0 \text{ ft} + 1.46 \text{ ft} = 54.46 \text{ ft}$

4. Pump Power Sulzer OHH 1.5 x 3 ft

$$P_p = \frac{Q \cdot \rho \cdot D_H \cdot C_G}{3960 \cdot \eta} = \frac{41.7 \cdot 54.46 \cdot 0.99}{3960 \cdot 0.55} = 0.99 \text{ HP}$$

Electrical Motor Power:-

$$P_{\text{motor}} = 1.10 \cdot P_p = 1.10 \cdot 0.99 \text{ HP} = 1.08 \text{ HP}$$

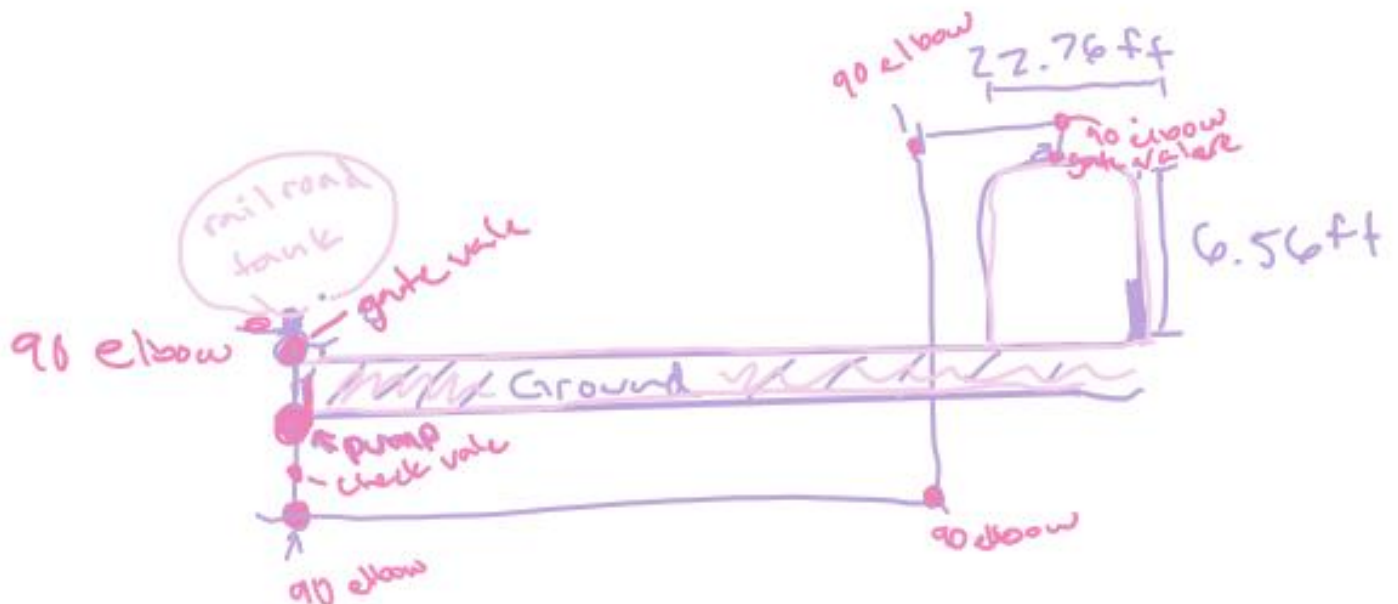
Final choice 1.5 HP Motor

5. Cavitation check (NPSH)

$$NPSH_a = \left( \frac{P_{\text{atm}} - P_{\text{vapor}}}{\rho g} \right) - h_{\text{suction}} - h_{f, \text{suction}}$$

$$= 34 - 6 = 28 \text{ ft}$$

Conclusion: Since  $NPSH_a$  (28 ft)  $>$   $NPSH_{\text{required}}$  (typically 5-8 ft on OHH 1.5 x 3-8 pump) will not cavitate.



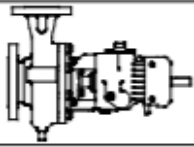
Task 1-4:

- Refer to the work provided above.

Task 5:

- Kinetic vs. PD: Kinetic (centrifugal) is required for pulsation-free, high-volume flow and inherent pressure-blocking safety. Radial vs. Axial: Radial flow is required to provide the pressure energy (Head) necessary to overcome 32ft of static lift, which axial pumps cannot achieve

Task 6:

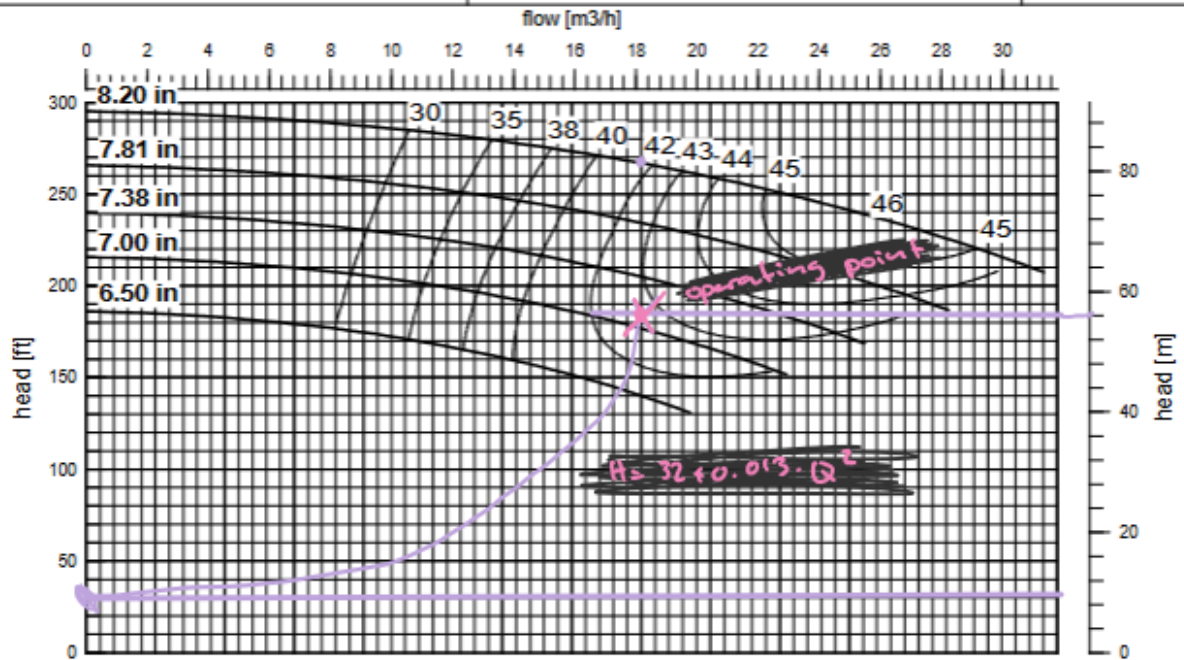


# 1.5 x 3 x 8 -1 OHH

**SULZER**

Series 2.00 / 60Hz E011

|                  |                     |          |                          |                             |
|------------------|---------------------|----------|--------------------------|-----------------------------|
| Curve No         | OHH 70-1-1-03       | NSS      | 9300 (181)               | Speed<br><b>3520</b><br>rpm |
| Efficiency Basis | API Std. clearances | NS       | 600 (12)                 |                             |
| Max Solid        | .24 in (6 mm)       | Rotation | CCW viewed from coupling |                             |



$$\frac{H_1}{H_2} = \left( \frac{D_1}{D_2} \right)^2$$

$$\frac{60}{54.5} = \left( \frac{8.0}{D_{req}} \right)^2$$

$$D_{req} = \frac{8.0}{1.049} = 7.63 \text{ in}$$

Task 7:

- Refer to the work provided above.

- Required Output Power: Select the next standard motor size, which is 1.5 HP.
- Electrical Service: 460V / 3-Phase / 60 Hz (Standard for industrial pump motors in the US).
- Enclosure: TEFC (Totally Enclosed Fan Cooled) to protect against the environment.
- Speed: 3550 RPM (To match the 2-pole induction motor speed for 60 Hz operation).

Task 8:

- Refer to the work provided above.

Task 9:

- Pipe fittings
  - o Pipe: 2-inch Schedule 40 Steel Pipe. This material was selected based on the requirement to handle the calculated flow velocity of approximately 3.99 ft/s while minimizing friction losses.
  - o Elbows: 90° Standard Elbows. Used for directing the flow from the horizontal run to the vertical riser.
  - o Valves: Gate Valves. Included for system isolation and maintenance, with a specified K value factor.
  - o Inlet/Exit: Square-edged inlet and a standard pipe-to-static reservoir exit configuration, accounting for minor entrance and exit losses.
- Pumping Equipment
  - o Pump: SULZER OHH Series 1.5x3-8. This pump was chosen because its performance curve (specifically the 60 Hz E011 curve) matches your system's operating point of 41.7 GPM at 54.5 ft of total dynamic head.
  - o Impeller: 7.63 inches (calculated trim)
  - o Motor: 1.5 HP, 3550 RPM, TEFC (Total Enclosed Fan Cooled).
- Fluid Coolant: Water and soluble oil solution. The system design is based on the properties of this fluid, specifically a Specific Gravity (SG) of 0.94.

Name: Kim Nguyen

MET 330 Fluid Mechanics  
Dr. Orlando Ayala  
FINAL Test

Take home – Due before midnight on the date shown in CANVAS.

## READ FIRST

1. RELAX!!!! DO NOT OVERTHINK THE PROBLEM!!!! There is nothing hidden. The test was designed for you to pass and get the maximum number of points, while learning at the same time. HINT: THINK BEFORE TRYING TO USE/FIND EQUATIONS (OR EVEN FIND SIMILAR PROBLEMS)
2. I will allow you to work on this test with someone else from the class. Only one of you will turn in the solution. Please, make sure you indicate the name of both.
3. The total points on this test are one hundred (90). The other 10 points will come from the HW assignments.
4. There is only one problem and I will divide the 100 points among the different tasks.
5. PLEASE READ CAREFULLY THE TASKS AND INFORMATION BEFORE THE TASKS. Take notes while you read. You will NOT need everything stated on the project description section.
6. The test is open book, open notes. You cannot use online sources (only ODU related ones).
7. What you turn in should be only your work. You cannot discuss the exam with anyone else, except me. For those off campus, call me if you need help (302-397-4981).
8. I do not read minds. You should be explicit and organized in your answers. Use drawings/figures. If you make a mistake, do not erase it. Rather use that opportunity to explain why you think it is a mistake and show the way to correct the problem.
9. Cheating is completely wrong. The ODU Student Honor Pledge reads: "I pledge to support the honor system of Old Dominion University. I will refrain from any form of academic dishonesty or deception, such as cheating or plagiarism." By attending Old Dominion University you have accepted the responsibility to abide by this code. This is an institutional policy approved by the Board of Visitors. It is important to remind you the following part of the Honor Code:

### IX. PROHIBITED CONDUCT

#### A. Academic Integrity violations, including:

1. *Cheating*: Using unauthorized assistance, materials, study aids, or other information in any academic exercise (Examples of cheating include, but are not limited to, the following: using unapproved resources or assistance to complete an assignment, paper, project, quiz or exam; collaborating in violation of a faculty member's instructions; and submitting the same, or substantially the same, paper to more than one course for academic credit without first obtaining the approval of faculty).

**With that said, you are NOT authorized to use any online source of any type, even if it is ODU related.**

## HONOR CODE

I pledge to follow the Honor Code and to obey all rules for taking exams and performing homework assignments as specified by the course instructor.

I understand that when asked to follow the Honor Code on exams or homework assignments I must follow the rules below.

1. When following the Honor Code a student must work entirely alone on exams.
2. When following the Honor Code a student may not share information about any aspect of the exam with other members of the class, other faculty members, or other people who has not already taken the exam this year, or its equivalent in future years.
3. When following the Honor Code a student must direct all questions concerning the exam or homework assignment to the course instructor or teaching assistant.
4. When following the Honor Code it is the student's responsibility to obtain clarification from the instructor if there are questions concerning the requirements of the Honor Code.
5. When following the Honor Code a student can only access websites related to ODU (such as Blackboard, etc.) while taking the test.
6. When following the Honor Code a student cannot access, neither ask for help, from websites such as coursehero, chegg, and any other similar website, while taking the test.

I understand that failure to follow this Honor Code imply that the professor will immediately report my case for academic dishonesty to the ODU Office of Student Conduct & Academic Integrity.

Student Name: Kim T. Nguyen

Student Signature: Kim Nguyen

Date: 7-12-26