Amber Samm (1)
MET330
Final Test

Purpose: Specify layout of piping system. Specify materials (type + quantity). Explain why kinetic radial pump is needed. Demonstrate that pump will not suffer cavitation. Prepare a list of materials.

Data

$sg_{coolant} = 0.94$ $\rho = 58.7\ lb/ft^3$
Freezing point $= 0°$
$V = 1.5\times$ that of water (temp?)
Operation:
2 shifts/day
7 days/wk > relevant?
Reservoir dump - wkly
Coolant pickup - mnthly

Coolant Storage: 15,000 gal
Reservoir: 1000 gal
Dirty coolant: 1000 gal/wk
· pick up 1/month
· 4(1000) + 1000 (emergency)
= 5,000 gal
Frost Line: 30"
Time constraint ≥ 6 hours

Pipe Lengths: Rail Tank → Storage: 700'
Storage → Reservoir → 110' Reservoir to machine: 3.28' × (2)
Reservoir → Dirty coolant: 400' Dirty coolant → Truck: 10'

Procedure: critical velocity $3\ m/s = 9.843\ ft/s = 0.0928\ ft^3/s$

$Q = \frac{V}{t} = \frac{1500\ gal}{360} = 41.67\ gpm$ or $5.571\ ft^3/min$

(1) Select pipe material/size

$Q = V \times A$
$0.0928\ ft^3/s = 9.843\ ft/s \times A$
$A = 0.009428\ ft^2 = 1.358\ in^2$

$d = \sqrt{\frac{4(1.358)}{\pi}} = 1.3149\ in$

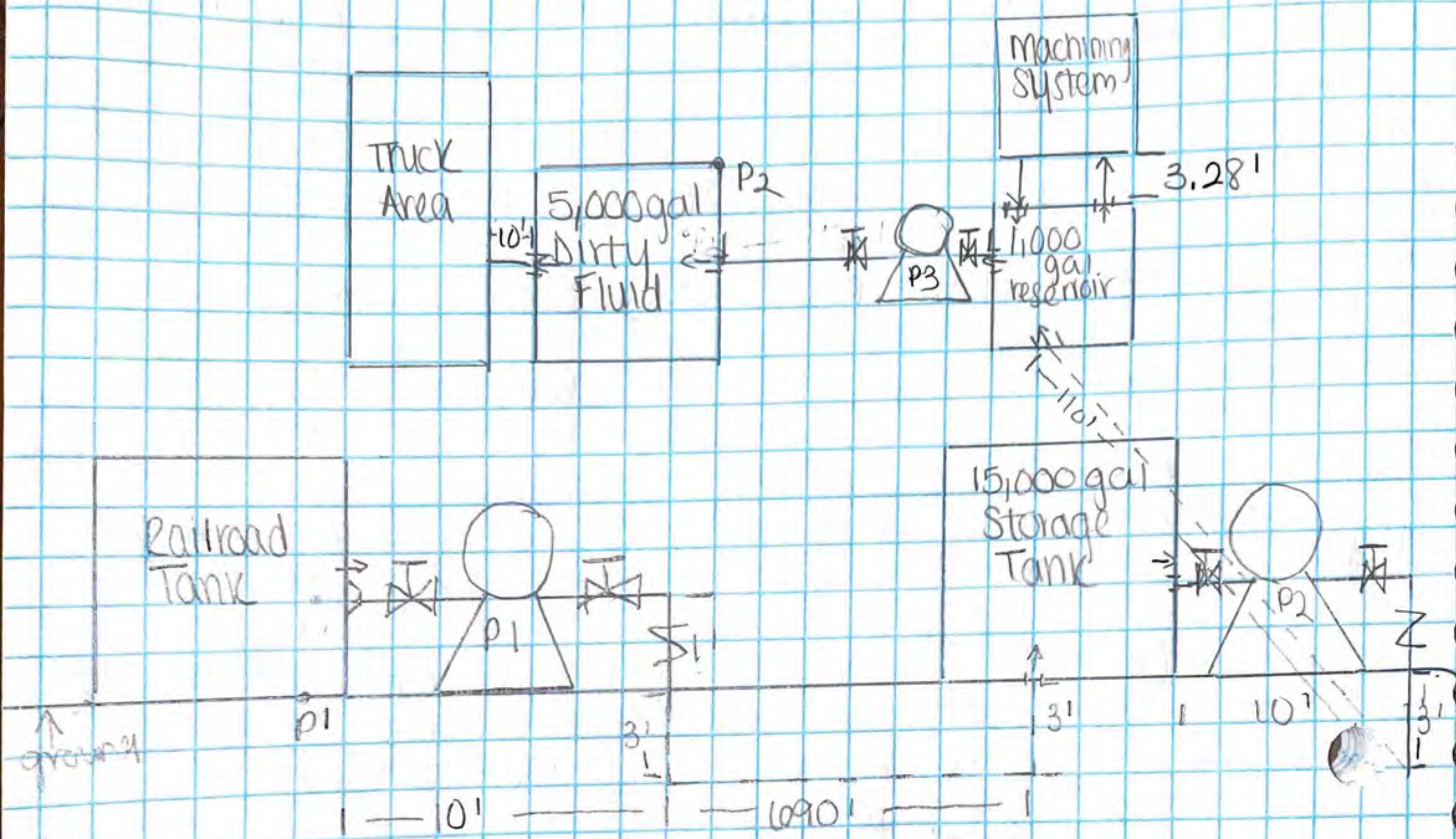
Choice: 2" schedule 40 steel
$d_i = 2.067$, $d_o = 2.375\ in$
$A_p = 0.02333\ ft^2$

$V = \frac{Q}{A} = \frac{5.571\ ft^3/min}{0.02333\ ft^2} = 3.98\ ft/s$ ✓

(2) Decide Route: 10' of pipe from RR Tank to elbow, 1' down to ground, 3' below ground, 690' to storage, 3' to meet tank, 10' from storage to elbow, 1' down to ground, 3' underground, 110' underground to reservoir, 6.56' from reservoir to machine and back, 400' from reservoir to dirty tank, 10' to truck area.

Underground total: 809' Above ground total: 438.56'
Total pipe length: 1247.56'

(2) Drawing: Proposed pipe / pump system



Materials: (3) pumps: (1) 1.5x3-8 (6" impeller), (2) 1x2-7.5 (5" impeller)

Pipelength: 1247.56', 2" sch. 40 pipe
(6) gate valves $\frac{L_e}{D}=8$ = 48
(2) check valves $\frac{L_e}{D}=50$ = 100
(5) elbow (90°) $\frac{L_e}{D}=30$ = 150
(5) sharp edged outlets, K = 1.0 = 5.0
(4) sharp edged inlets, K = 0.5 = 2.0

$\Delta z = 4.92'$

(3) Compute H using Bernoulli's; $h_L = \left(f\frac{\Sigma L_{eq}}{D}+\Sigma F\right)\frac{v^2}{2g}$

(A) RR Tank to Storage Tank:

$V_1 = \frac{0.1114\ ft^3/s}{0.0233\ ft^2} = 4.78\ ft/s$ $\quad \frac{(4.78\ ft/s)^2}{(2\times 32.2)} = 0.355\ ft$

$Re = \frac{VD}{\nu} = \frac{4.78\times 0.17225}{1.62\times 10^{-5}} = 50,820$ (turbulent) $f = 0.023$

③ cont.

(B) Storage Tank to Reservoir

$V_B = \frac{0.0371 ft^3/s}{0.0233 ft^2} = 1.59 ft/s$ $\frac{(1.59 ft/s)^2}{(2 \times 32.2)} = 0.039 ft$

$Re = \frac{1.59 \times 0.17225}{1.62 \times 10^{-5}} = 16{,}910$ (turbulent) $\underline{f = 0.028}$

Ⓐ $\left(\frac{Le}{D}\right) = 2(8) + 50 + 3(30) = 156$

$L_{eq} = 704 + (156 \times 0.17225) = 730.87$

$\Sigma K_A = 0.5 + 1.0 = 1.5$

$h_{LA} = \left(0.2333 \times \frac{730.87}{0.17225} + 1.5\right) \times 0.355 ft = 35.48 ft$

Ⓑ $\Sigma \frac{Le}{D} = 4(8) + 50 + 2(30) = 142$ $L_{eq} = 543.56' + (142 \times 0.17225)$
$= 568.021'$

$\Sigma K_B = 1.5 + 4 = 5.5$

$h_{LB} = \left(0.0278 \times \frac{568.02}{0.17225} + 5.5\right) \times 0.039' = 3.79'$

$h_L total = 35.48 + 3.79 = 39.27 ft + \Delta z (4.92) = \underline{44.19 ft}$

④ Select pumps from catalog: Req. P1 - 50gpm P2/P3 - 16.67 gpm (Q)
1.5×3×8 pumps: 1×2×7.5 (see attached pump map)
P1: 6" impeller P2/3: impeller: 5"
(See attached performance curve)

$\boxed{1.5 HP}$

$BHP_1 = \frac{Q \times H \times SG}{3960 \times \eta_p} = \frac{50 \times 44.19 \times 0.94}{3960 \times} = \frac{0.524 HP}{0.45} = 1.16 \times 1.1 = 1.28$ $\boxed{0.5 HP}$

$BHP_{2/3} = \frac{16.67 \times 44.19 \times 0.94}{3960 \times} = \frac{0.1748}{0.45} = 0.388 \times 1.1 = 0.427$

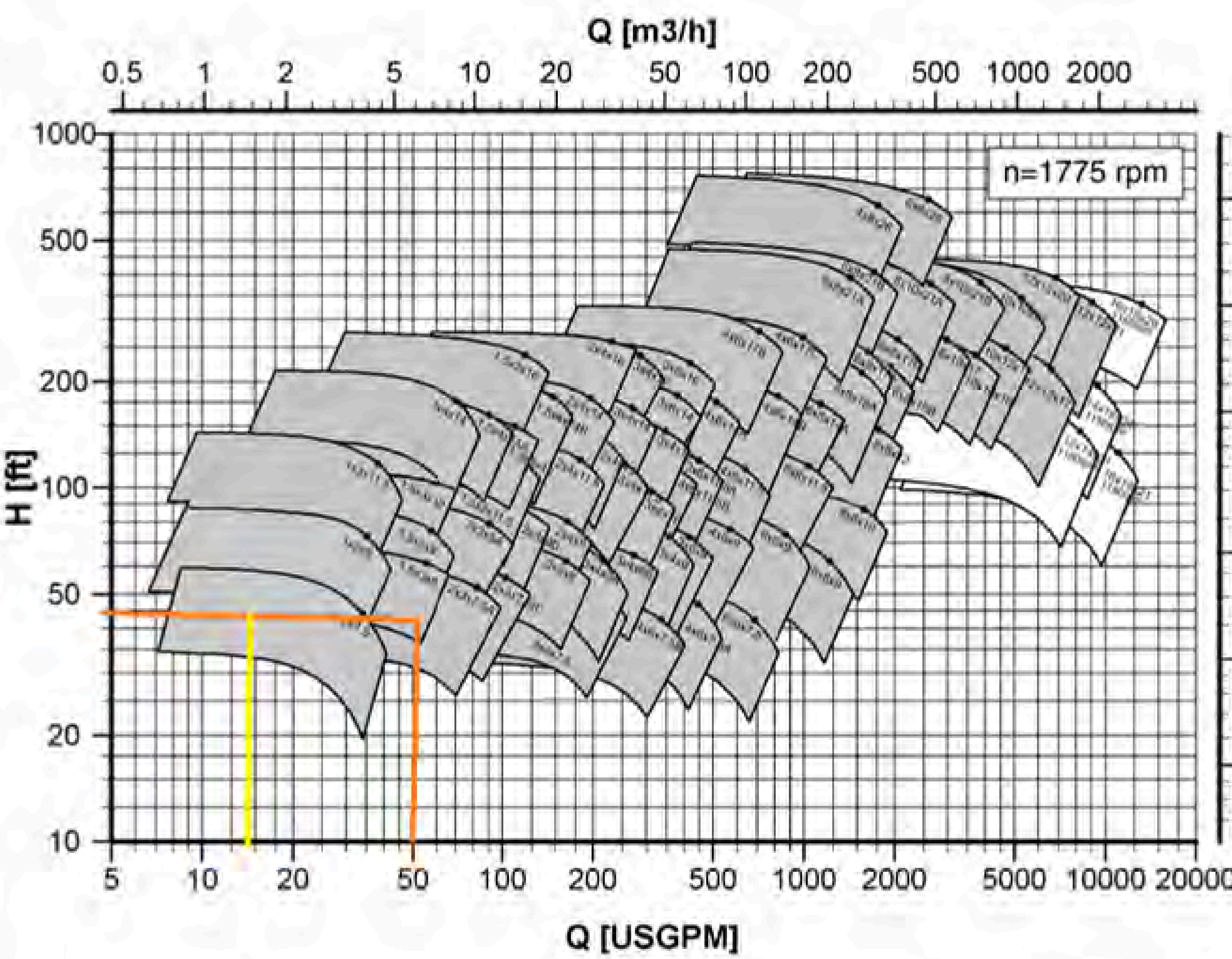
P_1 $NSPH_r = 2.0 ft$ $NPSH = 34.1 ft + 2 - 0.3 - 2.31 ft = 33.5 ft$ $33.5 ft > 2.0 ft$
$P_{2/3}$ $NSPH_r = 1.5 ft$ $NPSH = 33.5 > 1.5$ ✓
The head for exceeds pump requirements.
No cavitation

Kinetic vs. Positive Displacement: Kinetic pumps are best for fluids up to moderate viscosity. Our fluid is 1.5x more viscous than water. The head for the system is high with a low flow rate which is great for kinetic radial pump. Positive displacement pumps are for highly viscous fluids or system with very high pressure.

④

Summary ; Since the head is significatly higher than required head for system there will be no cavitation. The actual flow rate at operating point is 36.10 gpm and roughly 55ft of head. Pump 1 will require 1.5 HP, and 2+3: 0.5 HP. The total lengths of pipes and fittings are as listed under materials.

SULZER



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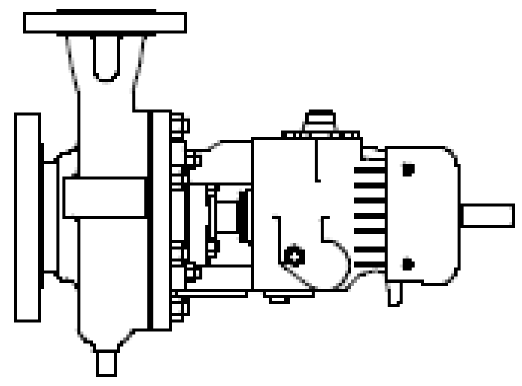
SULZER
CURVES - TYPE OHH
Range of Performances - 60 Hertz

Series 2.00 CURVES 12 February 2002	Page 60Hz E0E



1 x 2 x 7.5 -1 OHH

SULZER

Series 2.00 / 60Hz E001

Curve No	OHH 53-1-1-02	NSS	10190 (197)	Speed
Efficiency Basis	API Std. clearances	NS	560 (11)	3520
Max Solid	.20 in (5 mm)	Rotation	CCW viewed from coupling