Design Problem
CE 6628 - Pipeline Hydraulics
SALINAS DAM PIPELINE INFORMATION

Water is supplied from Salinas dam to the city of San Luis Obispo through a 24-inch pipeline (23.25-inch I.D.). Sufficient pressure is available to supply the required flows only at the higher reservoir elevations. For low reservoir conditions, two pumps, located at the dam can be used. Water is transmitted to a 2-million gallon reservoir at a booster pump station. Three pumps are available at the booster station to lift the water over a mountain into the city. We will analyze this system.

1. There are three pumps at the booster station (BS),
   capacity =
   9.2 mgd (3 pumps),
   6.3 mgd (2 pumps)
   3.6 mgd (1pump).

2. Maximum Reservoir = 1320 ft

3. Reservoir Elevation at the downstream booster station = 1150 ft

4. The nominal pump capacity at the reservoir pump station (PS) is = 3000 gpm per pump @ about 40-feet head (There are two pumps.). Assume the following data define the pump curve for each PS pump.

Qgpm	H-ft
0	55
1500	50
3000	40

5. Ignore Losses at PS when Pumps are not operating.

6. Pipe elevation at PS = 1226 ft, L = 200-feet from dam to PS and CV

7. The surge tank is located 20 ft downstream of the CV and has a top elevation =1281ft.

8. The pipe length is 47,520 ft between the CV and the BS reservoir, D = 23.25 inches (ID), e = 0.004 inches (roughness)

9. Elevation of high point of pipe = 1250 ft, located 4500 feet downstream from the control valve. There is a vacuum breaker valve at that location.

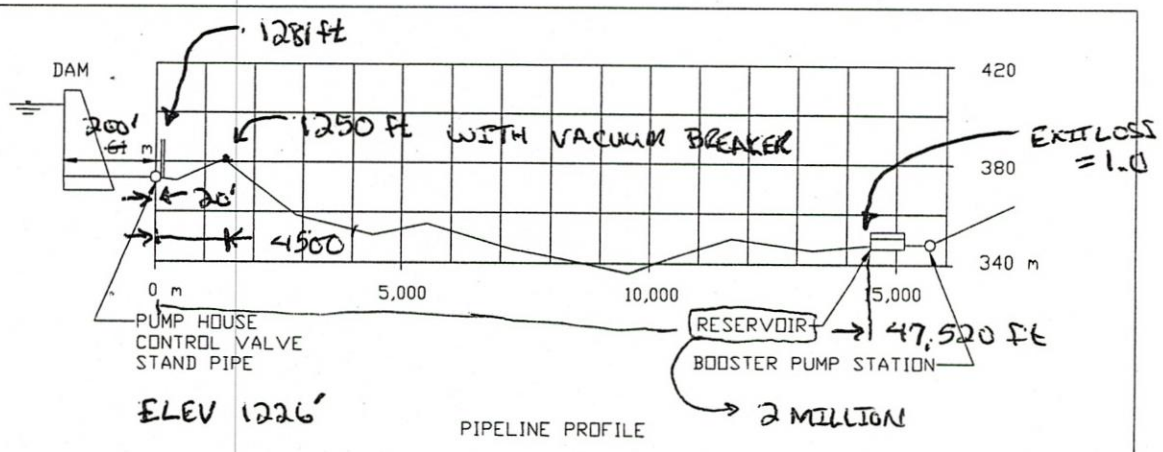
10. The water temperature is 60 degrees F and the barometric pressure should be calculated at the valve elevations.

11. The control valve (CV) is a butterfly valve.

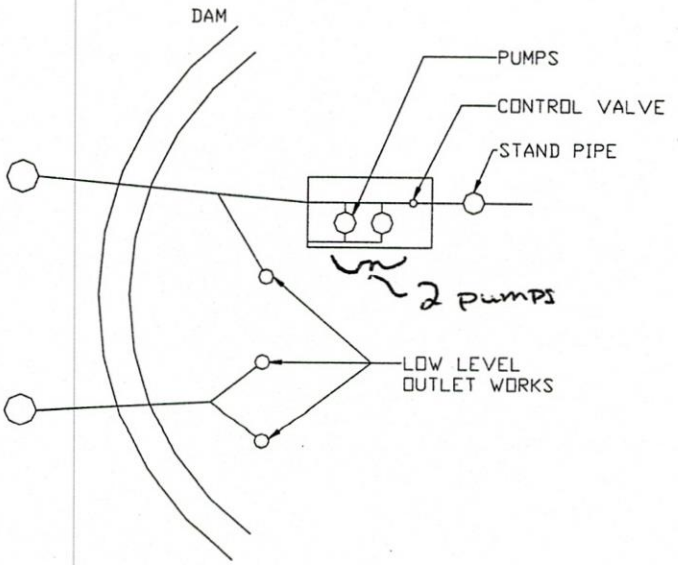
12. Minor loss coefficients:
    inlet = 0.9
    between reservoir and CV = 1.0
    exit = 1.0

Additional Comments

a) Hand calculations must be provided to get a score
b) Identify method used to calculate friction factor
c) Add a column in spreadsheet for "f"
d) Print out functions
e) Use reference cells for program rather than inserting constants into program.
f) Use appropriate fluid property values based on temperature and elevation
g) Assume a value of 32.2 ft/sec^2 for gravity.



PIPELINE PROFILE



PLAN VIEW OF INTAKES, OUTLETS, AND CONTROL STRUCTURE

Figure 1 Salinas Dam Project Overview

Pipeline Project

Part A

1. Set up a spreadsheet to calculate the flow at valve opening increments of every **5 degrees**. Determine the maximum flow rate that can be supplied to the downstream storage reservoir via the pipeline with the upstream reservoir at maximum reservoir elevation (El 1320ft). What controls the maximum allowable flow rate and what is the corresponding valve opening?

   a) Use the Swamee-Jain equation to calculate f. Use the appropriate friction factor for each flow condition.

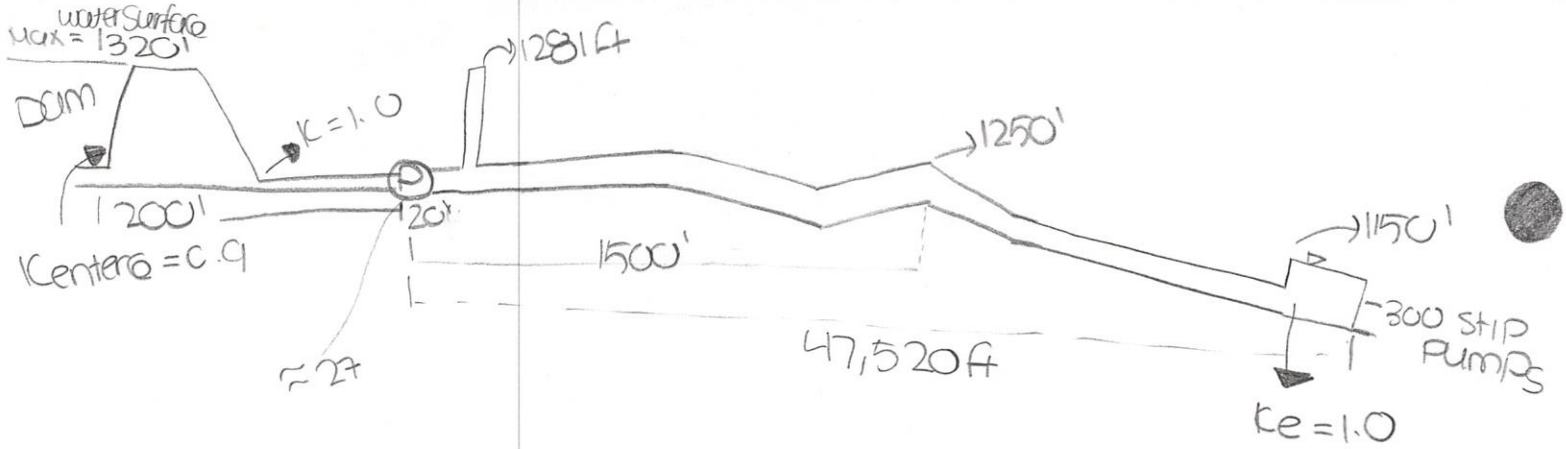
$$f = \frac{1.325}{\left(Log_e\left[\frac{5.74}{\mathrm{Re}^{0.9}} + \frac{e}{3.7D}\right]\right)^2}$$

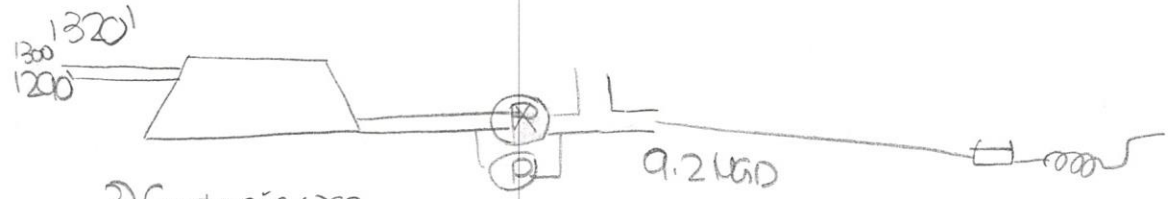
   b) Use minor loss coefficients as given in the system data.

   c) Use the following Valve Cd equation with the following coefficients:
   a=-0.01566
   b=0.889
   c=55.61
   d=14.77
   Note: "x" is the valve opening in **degrees**

$$Cd = a + \frac{b}{1 + e^{-(x-c)/d}}$$

   d) Calculate C_d using the above equation, along with C_v, and K_l
   e) Use spreadsheet program format like that given on the handout.
   f) Start calculations with the valve full open then close the valve until you identify the maximum system flow rate that does not result in a spilling surge tank condition. Identify the corresponding valve opening. Calculate the actual valve opening, rather than just the closest 5-degree incremental opening.
   g) What is the required ΔH across the control valve (CV) at the maximum flow rate?
   h) List the equations and assumptions and provide hand calculations for one complete row of data.
   i) Provide a brief write-up (grad students).





2) Find min WSE

3) Full pipeflow

Prob. 1 Part A, (Swamee Jain Equation)

System Data:

DS Pipe Length (L) =	47520	ft	US. Reservior Elevation (RH1)=	1320	ft
US pipe length =	200	ft	DS. Reservoir Elevation (RH2)=	1150	ft
Pipe Diameter (D) =	23.25	in	Elevation of pipe at valve =	1226	ft
Elevation of top surge tank =	1281	ft	Barometric Pressure @ Valve (Elev. 1226 ft)=	14.087	psi
Pipe Roughness (e) =	0.004	in	Absolute vapor pressure (@ 60 deg F)=	0.2556	psi
e/D =	1.72E-04	in	Entrance Loss Coef.=	0.9	
Kinematic Viscosity =	1.217E-05	sq-ft/sec	Minor Loss Coef.=	1	
g =	32.2		Exit Loss Coef.=	1	
water temperature =	60	deg F			
γ =	62.37	ft^2/sec			

Cd eqn coef:

a= -0.01566
b= 0.889
c= 55.61
d= 14.77

$$Cd = a + \frac{b}{1 + e^{-(x-c)/d}}$$

X=degrees Open

Pipe Area(A)= 2.95 sf

Swamee Jain $$f = \frac{1.325}{\left[\log e\left(\frac{K_s}{3.7D} + \frac{5.74}{\mathrm{Re}^{0.9}}\right)\right]^2}$$

Log=LOGe in VB

Valve Open. deg.	Cv	Cd	Kl loss coef	f friction factor	Calc. Flow gpm	Calc. Flow mgd	Pipe Vel fps	Calc. Valve Dp psi	HGL at S-tank feet	Pu valve psi	Pd valve psi	Cond at s-tank
1	2	3	4	5	6	7	8	9	10	11	12	13
90.0	21091	0.794	0.5846	0.01457	7273.0	10.48	5.50	0.12	1317.6	39.82	39.70	Spill
85.0	19241	0.766	0.70	0.01457	7271.8	10.47	5.50	0.14	1317.5	39.82	39.68	Spill

Part B

1. At the maximum reservoir elevation, find the smallest flow and required valve opening that keeps the pipe full. What criteria determine this condition? Set up the spreadsheet to calculate the flow at every 5 degrees.

2. For valve openings (and flows) below the full-pipe flow, calculate the flow rate correctly and find P_d at the valve.

3. Plot the HGL for 3.6mgd flow using Excel or Autocad and **explain** what is going on in the pipe. Include the pipeline profile.

4. At 3.6 mgd and maximum reservoir, what is the ΔP across the valve? What is the downstream pressure? Calculate sigma. Do you think the valve will cavitate? (Look for valve cavitation data in ch.6, include scale effect considerations and incorporate into spreadsheet)

5. Provide a brief write-up and include Part B hand calculations for data not included in Part A.

Part C

1. Find the required valve openings to provide 9.2 mgd at each 10 foot of reservoir elevation from 1320 to the minimum possible.

2. Find the lowest reservoir elevation that can supply 9.2 mgd with the valve full open.

3. What is the lowest reservoir elevation at which the reservoir can operate and maintain a full pipe and what is the corresponding flow rate (control valve will be fully open)?

4. What is the function of a Surge Tank (ST)? Why is there one in this system?

Part D

1. Modify the Spreadsheet to include the two PS pumps.

2. Write the system and pump equations. Determine the pump H-Q equation for one and two pumps in parallel. Modify the Spreadsheet to solve for the flow with two pumps operating.

3. Starting at reservoir elevation 1270ft, find the approximate valve opening that will provide about 9.2mgd with the pumps operating.

4. What is the lowest reservoir elevation that can supply 9.2 mgd with two pumps operating?

5. Turn in hand calculation for Part D.