Problem Set Solution – See Handout in Volk Pump Course

1. Total Head Calculation

Total Head = Static Head + Friction Head + Pressure Head + Velocity Head = $H_s + H_f + H_p + H_v$

From this system layout in the handout, Static Head H_s = 109.0 ft.

Based on the design flow of 1000 gpm and the given values for design suction velocity of 5-7 ft/sec and design discharge velocity of 10-12 ft/sec, the following pipe sizes and associated data is chosen from Table 2.1 on page 51 of the Volk book:

Pipe	Size	V (ft/sec)	$V^2/2g$ (ft)	H_f (ft/100 ft)
Suction	8”	6.41	0.64	1.56
Discharge	6”	11.1	1.92	6.17

Friction Head H_f (see calc. on next page) = 65.4 ft.

Pressure Head H_p (see calc. on next page) = 123.7 ft.

Velocity Head H_v = 0, with the liquid levels in the 2 tanks as the reference points (see Volk, p. 58)

Total Head = $H_s + H_f + H_p + H_v$ = 109.0 + 65.4 + 123.7 + 0
= 298.1 ft. (rounded to 300.0 ft for pump selection)

2. $NPSH_a$ Calculation

$NPSH_a = P + H_s - H_f - H_{vp}$
P = 28.8 ft. (see note in Absolute Pressure Head calculation on next page)
H_s = 2.0 ft. (see pump system drawing, suction tank liquid level above pump inlet)
H_f = 2.8 ft. (see note in Suction Pipe Friction Head calculation on next page)
H_{vp} = 8.7 ft. (see Table 2.3, page 80, in Volk book, at 150°F)

$NPSH_a = P + H_s - H_f - H_{vp}$ = 28.8 + 2.0 – 2.8 – 8.7
= 19.3 ft.

3. Pump Selections

Size	RPM	Efficiency	$NPSH_r$	Notes
3x6x12	3560	70%	27 ft.	To right of POR, very short on NPSH
4x6x12	3560	75%	20 ft.	Not enough NPSH margin, need 27 ft.
4x6x9	3560	81%	22 ft.	Not enough NPSH margin, need 29.7 ft., near max. impeller
6x8x11	3560	71%	25 ft.	To left of POR, very short on NPSH
6x8x17	1760	66%	10 ft.	To left of POR, near max. impeller
6x8x21	1760	66%	10 ft.	Only choice that meets all design criteria
8x10x21	1760	58%	8 ft.	Very much to left of POR

Pump Sizing Application Exercises (cont'd) – See Handout in Volk Pump Course Friction and Pressure Head Calculations for Pump Sizing Application Exercises

Friction Head Calculation

(Values of h_f and $V^2/2g$ come from table on preceding page. Values of K come from Volk, p. 55 and 56)

Suction Pipe

H_f (pipe) = h_f x L/100 = 1.56 x 1.5 = 2.34 ft.

H_f (gate valves) = K x $V^2/2g$ x Qty. = .07 x 0.64 x 2 = 0.09 ft.

H_f (suction pipe inlet) = K x $V^2/2g$ = 0.5 x 0.64 = 0.32 ft. (assume square edged inlet)

H_f (Total Suction Pipe) = 2.34 + 0.09 + 0.32 = 2.8 ft.

(Note that this value of 2.8 ft. is also the third term of the $NPSH_a$ calculation.)

Discharge Pipe

H_f (pipe) = h_f x L/100 = 6.17 x 9.0 = 55.5 ft.

H_f (gate valves) = K x $V^2/2g$ x Qty. = .09 x 1.92 x 2 = 0.35 ft.

H_f (check valve) = K x $V^2/2g$ = 2 x 1.92 = 3.84 ft.

H_f (elbows) = K x $V^2/2g$ x Qty. = 0.27 x 1.92 x 2 = 1.0 ft.

H_f (discharge pipe outlet) = K x $V^2/2g$ = 1.0 x 1.92 = 1.92 ft. (sudden enlargement, K=1, see p. 56)

H_f (Total Discharge Pipe) = 55.5 + 0.35 + 3.84 + 1.0 + 1.92 = 62.6 ft.

H_f (Total) = H_f (Total Suction Pipe) + H_f (Total Discharge Pipe) = 2.8 + 62.6 = 65.4 ft.

Pressure Head Calculation

This calculation is done two ways, using gage values and absolute values of vacuum and pressure, and of course will get the same result. To compute H_p (suction), use equation 2.8 from Volk, Vac (ft) = Vac ("Hg) x 1.133/SG, to convert from "Hg to ft. To compute H_p (discharge), use equation 2.7 from the Volk book, Head (ft) = psi x 2.31/SG, to convert from psi to ft.

Gage Pressure Calculation

Suction Tank

H_p (suction) = Vac ("Hg) x 1.133/SG
= 5 x 1.133/0.98
= –5.8 ft. gage

Discharge Tank

H_p (discharge) = psi x 2.31/SG
= 50 x 2.31/0.98
= 117.9 ft. gage

Hp (Total) = H_p (discharge) – H_p (suction)
= 117.9 – (– 5.8)
= 123.7 ft

Absolute Pressure Calculations

Suction Tank

H_p (suction) = Vac ("Hg) x 1.133/SG
= (29.9 – 5) x 1.133/0.98
= 28.8 ft. absolute

(Note that this value of 28.8 ft is also the 1st term of the $NPSH_a$ calculation.)

Discharge Tank

H_p (discharge) = psi x 2.31/SG
= 64.7 x 2.31/0.98
= 152.5 ft. absolute

Hp (Total) = H_p (discharge) – H_p (suction)
= 152.5 – 28.8
= 123.7 ft.