Equation sheet

Chapter 2

$P(vacuum) = P_a - P$

⇒ P: اذا نزلنا تكون موجب

اذا طلعنا ، سالب

$P = \rho g \Delta z$

مركز الجاذبية مش مركز الضغط

from Top to G

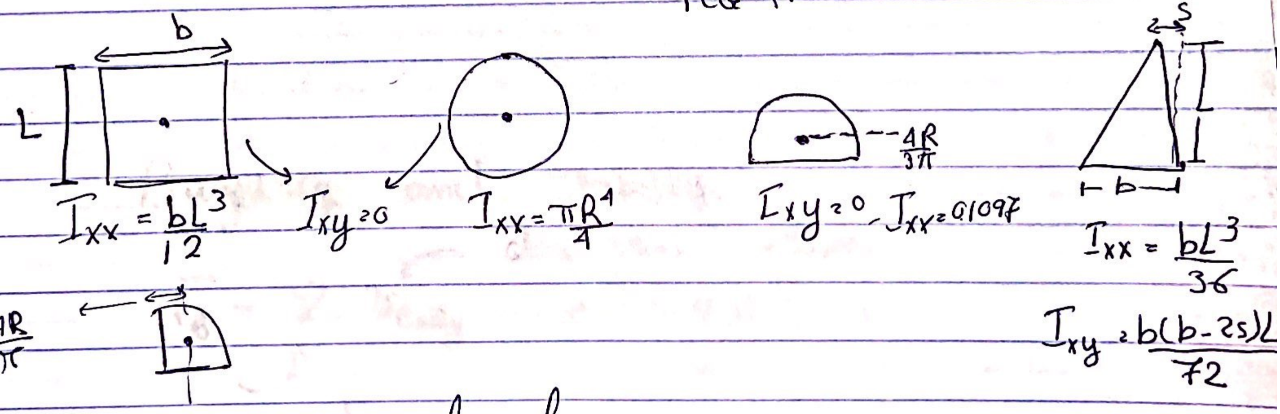
In Gates: $F = \Sigma P \rho g h$

Between surfaces and Body

مش ذراع الـ CG بالضبط رح تكون على الـ flat

$$y_{cp} = \frac{-\gamma \sin\theta \, I_{xx}}{P_{CG} A}$$

$$x_{cp} = \frac{-\gamma \sin\theta \, I_{xy}}{P_{CG} A}$$



$I_{xx} = \frac{bL^3}{12}$ $I_{xy} = 0$ $I_{xx} = \frac{\pi R^4}{4}$ $I_{xy} = 0$, $I_{xx} = 0.1097$ $I_{xx} = \frac{bL^3}{36}$

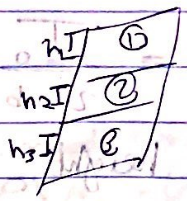
$I_{xy} = \frac{b(b-2s)L}{72}$

Use moment for equilibrium

Layered fluid

γ the unit $kN/m^3 = \rho g$

$P_{CG_1} = (h_1)(\gamma)$



$P_{CG_2} = (2h_1)(\gamma_1) + (h_2)(\gamma_2)$

$P_{CG_3} = (2h_1)(\gamma_1) + (2h_2)(\gamma_2) + (h_3)(\gamma_3)$

$F_1 = (P_{CG_1})A_1$

y_{cp} for each Area $\xrightarrow{\text{using}}$ $y_{cp_1} = \frac{\rho \sin\theta I_{xx}}{F_1}$

z_{cp} " " " $\longrightarrow h_{CG} + y_{cp_1}$

$\rightarrow$ moment $F_1 z_{cp_1} + F_2 z_{cp_2} = (F_1 + F_2) z_{cpR}$

($F_1 z_{cp_1}$ ↑ with sign)

Bayancy and Stability

$F_B = \gamma \, v_{Body} = W_{fluid}$

(v_{Body} ← displaced volume)

(γ ← average weight ~~density~~ for fluid)

Stability related to waterline Area :-

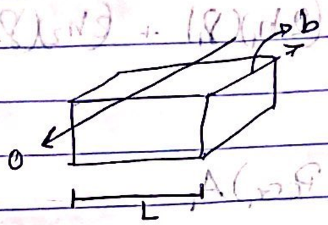
$$\overline{MG} = \frac{I_o}{V_{sub}} - \overline{GB}$$

$\overline{GB}$ → مسافة بين B و G

B → center الـ للمساحة تحت الماء

$\overline{MG}$ → metacentric height

$$I_o = \frac{bL^3}{12}$$



$MG > 0$ stable

$MG < 0$ unstable

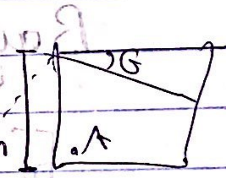
Uniform linear acceleration

$$\theta = \tan^{-1} \frac{a_x}{g + a_z}$$

a_z → مش شرط موجود

معظم الـ تسارع $G = \sqrt{a_x^2 + (g + a_z)^2}$

at a point A ← $P = \rho G \Delta s$ ← $h \cos \theta$



Chapter 6.

$$HGL = \frac{P}{\rho g} + \frac{V^2}{2g} + z$$

$Re < 2300$ lam

$Re > 4000$ Tur

HGL 1 < HGL 2

from 2 → 1

for lam $\frac{L_e}{d} \approx 0.06 Re$

$L_e \approx 138 d$ at critical Re

for Turb. $\frac{L_e}{d} \approx 1.6 Re^{\frac{1}{4}}$

$$h_f = f \frac{L}{d} \frac{V^2}{2g}$$

$$= \frac{4 \tau_w L}{\rho g d}$$

for lam $h_f = \frac{32 \mu L V}{\rho g d^2} = \frac{128 \mu L Q}{\pi \rho g d^4}$

$$f = \frac{64}{Re}$$

for Turb. $\frac{1}{\sqrt{f}} = -1.8 \log\left(\left(\frac{\varepsilon/d}{3.7}\right) + \frac{6.9}{Re}\right)$

Scanned with CamScanner

Problems Types

① Find h_f

$Re \rightarrow \frac{\epsilon}{d} \rightarrow f \rightarrow h_f = f \frac{L}{d} \frac{V^2}{2g}$

② V, Q

$f = h_f \frac{d}{L} \frac{2g}{V^2}$

Start with → fully rough → $\frac{1}{\sqrt{f}} = -2 \log \left(\frac{\epsilon/d}{3.7}\right)$

$f \rightarrow V \rightarrow Re \rightarrow \epsilon/d$ → constant

new $f \rightarrow V \rightarrow$ ---

③ d

$f = \frac{\pi^2}{8} \frac{g h_f d^5}{L Q^2}$ Guess f

$Re = \frac{4Q}{\pi d \nu}$ ← kinematic visc

$\frac{\epsilon}{d}$

Then iterate

④ L

$(h_p) = \frac{P}{\rho g Q} = h_f = f \frac{L V^2}{d 2g}$ if hori & minor losses neg

→ Re → ε/d → f (using eq.)

Hydraulic diameter

$D_H = \frac{4 \times Area}{b \times 4}$

$D_H = 4h$ → distance apart /2

lam

$\tau_w = \frac{3 \mu V}{h}$

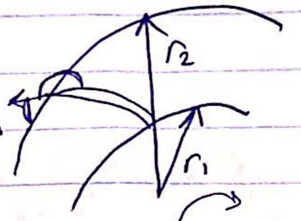
Turb

$D_{eff} = \frac{64}{96} D_h$

Equation sheet

1 mm Hg = 0.133322 KPa
1 L = 0.001 m3

Chapter 11 :



حسب β
الدوران
اذا ع تحركوا
الصغيرة دا
عكس تحرك الكبيرة

$$Q = 2\pi r_1 b_1 V_{1_n} = 2\pi r_2 b_2 V_{2n}$$

$$V_{t2} = u_2 - \frac{V_{2n}}{\tan\beta_2}$$

$$u_1 = r_1\omega \qquad u_2 = r_2 w$$

$$T = \rho Q\,(r_2 V_{t2} - r_1 V_{t1})$$
$$P_w = \rho Q\,\omega\,(r_2 V_{t2} - r_1 V_{t1})$$

first assumbtion
$V_{n_1} = V_1$
$\alpha_1 = 90$

$$Bhp = \frac{P_w}{n_p}$$

$$H = \frac{u_2 V_{t2} - u_1 V_{t1}}{g}$$

To avoid cavitation:

right - hand side

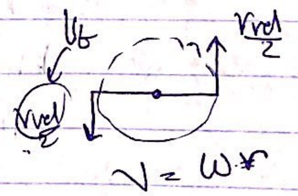
$$NPSH \le \frac{P_a - P_v}{\rho g} - z_i - h_f$$

NPSH from graph

left - hand side $\quad \frac{P_i}{\rho g} + \frac{V_i^2}{2g} - \frac{P_v}{\rho g}$

$P = u^2$ PQ

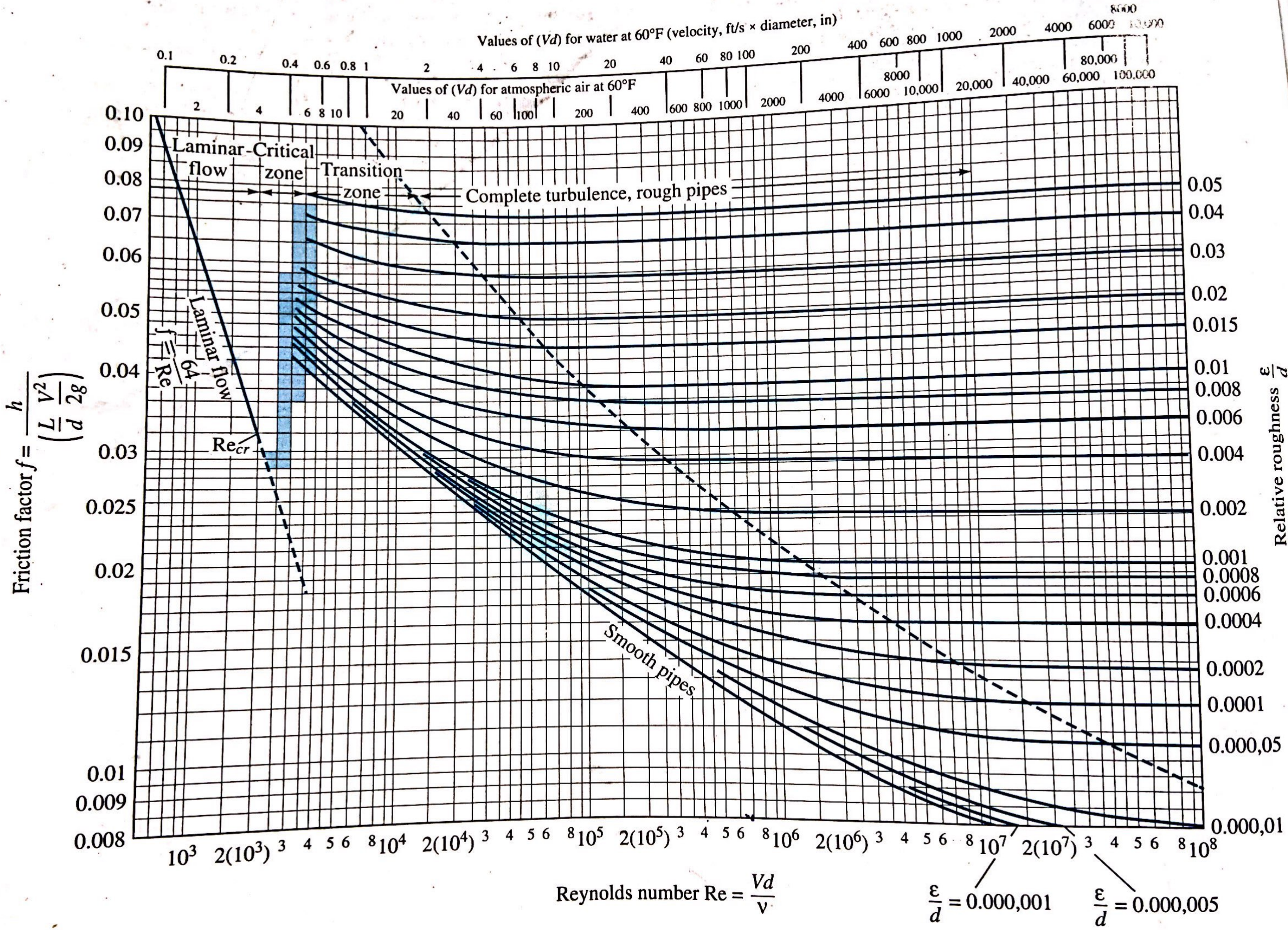
If z is neg → below



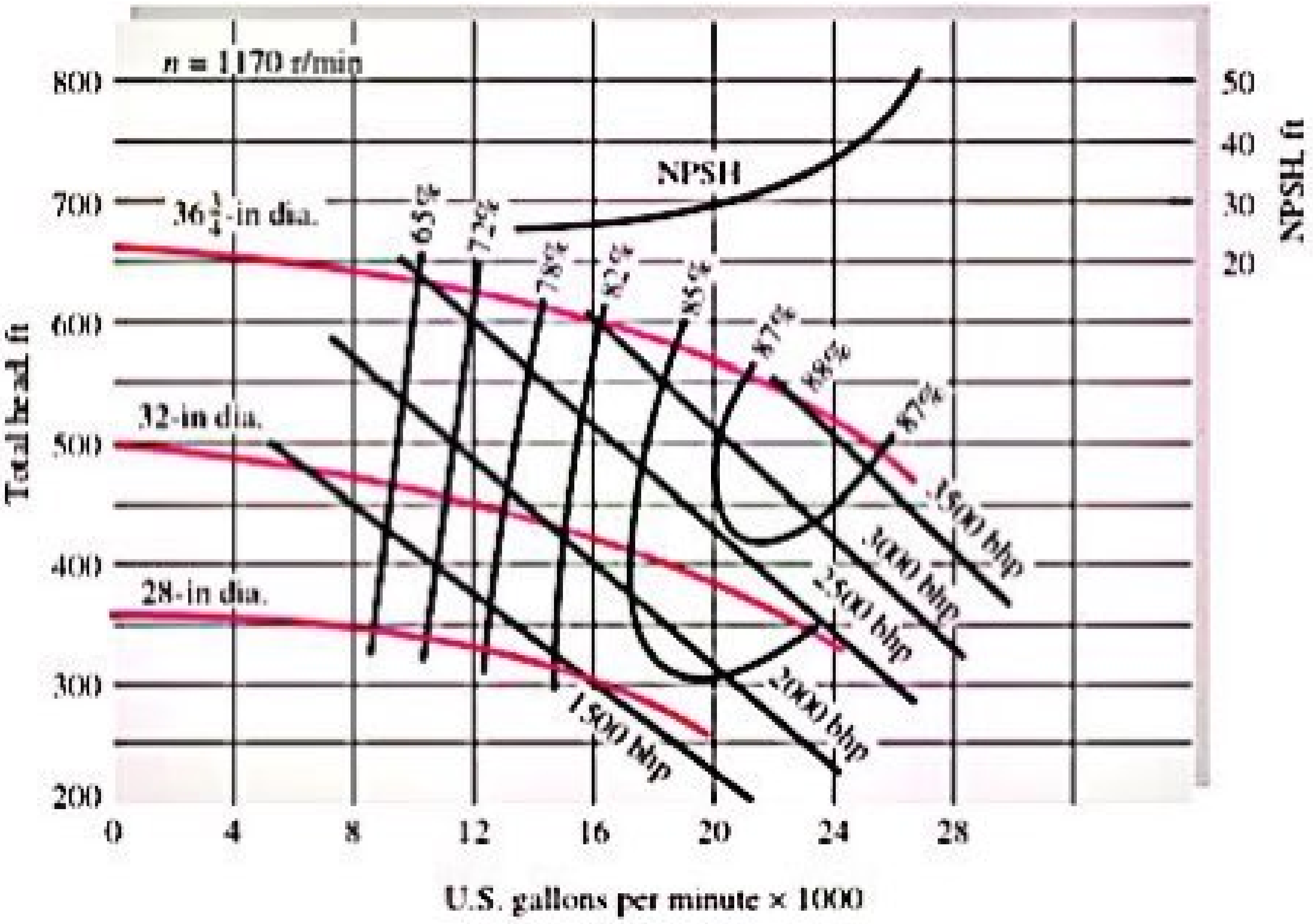
Centrifugal pump :

$$H = h_p - h_f = \frac{P_2 - P_1}{\rho g} + \frac{V_2^2 - V_1^2}{2g} + z_2 - z_1$$

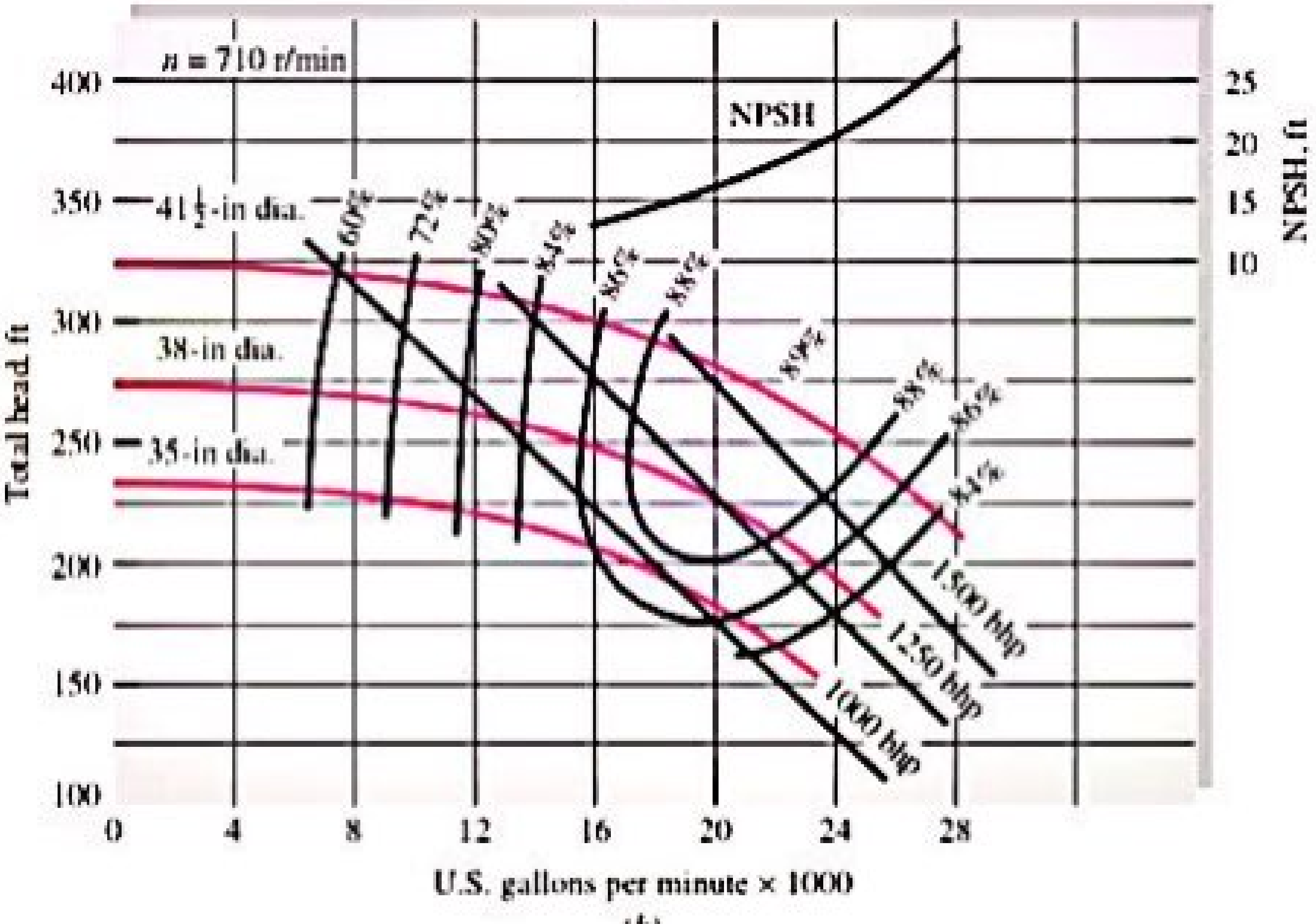
$$Power = \frac{\rho g Q H}{\eta}$$



Values of (Vd) for water at 60°F (velocity, ft/s × diameter, in)
Values of (Vd) for atmospheric air at 60°F
Friction factor $f = \frac{h}{\left(\frac{L}{d}\frac{V^2}{2g}\right)}$
Laminar-Critical
flow
zone
Transition
zone
Complete turbulence, rough pipes
Laminar flow
$f = \frac{64}{Re}$
Re_{cr}
Smooth pipes
Relative roughness $\frac{\varepsilon}{d}$
Reynolds number $Re = \frac{Vd}{\nu}$
$\frac{\varepsilon}{d} = 0.000,001$
$\frac{\varepsilon}{d} = 0.000,005$
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.025
0.02
0.015
0.01
0.009
0.008
0.05
0.04
0.03
0.02
0.015
0.01
0.008
0.006
0.004
0.002
0.001
0.0008
0.0006
0.0004
0.0002
0.0001
0.000,05
0.000,01
10^3 $2(10^3)$ 3 4 5 6 8 10^4 $2(10^4)$ 3 4 5 6 8 10^5 $2(10^5)$ 3 4 5 6 8 10^6 $2(10^6)$ 3 4 5 6 8 10^7 $2(10^7)$ 3 4 5 6 8 10^8


n = 1170 r/min
NPSH
36 3/4-in dia.
32-in dia.
28-in dia.
65%
72%
78%
82%
85%
87%
88%
87%
3500 bhp
3000 bhp
2500 bhp
2000 bhp
1500 bhp
Total head, ft
NPSH, ft
800
700
600
500
400
300
200
50
40
30
20
0
4
8
12
16
20
24
28
U.S. gallons per minute × 1000

(a)


n = 710 r/min
NPSH
41 1/2-in dia.
38-in dia.
35-in dia.
60%
72%
80%
84%
86%
88%
89%
88%
86%
84%
1500 bhp
1250 bhp
1000 bhp
Total head, ft
NPSH, ft
400
350
300
250
200
150
100
25
20
15
10
0
4
8
12
16
20
24
28
U.S. gallons per minute × 1000

(b)

	Nominal diameter, in								
	Screwed				Flanged				
	$\frac{1}{2}$	1	2	4	1	2	4	8	20
Valves (fully open):									
Globe	14	8.2	6.9	5.7	13	8.5	6.0	5.8	5.5
Gate	0.30	0.24	0.16	0.11	0.80	0.35	0.16	0.07	0.03
Swing check	5.1	2.9	2.1	2.0	2.0	2.0	2.0	2.0	2.0
Angle	9.0	4.7	2.0	1.0	4.5	2.4	2.0	2.0	2.0
Elbows:									
45° regular	0.39	0.32	0.30	0.29					
45° long radius					0.21	0.20	0.19	0.16	0.14
90° regular	2.0	1.5	0.95	0.64	0.50	0.39	0.30	0.26	0.21
90° long radius	1.0	0.72	0.41	0.23	0.40	0.30	0.19	0.15	0.10
180° regular	2.0	1.5	0.95	0.64	0.41	0.35	0.30	0.25	0.20
180° long radius					0.40	0.30	0.21	0.15	0.10
Tees:									
Line flow	0.90	0.90	0.90	0.90	0.24	0.19	0.14	0.10	0.07
Branch flow	2.4	1.8	1.4	1.1	1.0	0.80	0.64	0.58	0.41