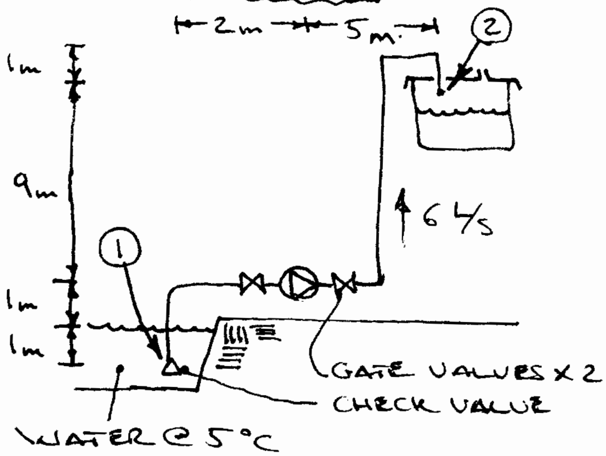
PUMP & PIPE EXAMPLE.

THE SYSTEM



NOTE: $6 \text{ L/s} = 0.006 \text{ m}^3/\text{s}$

$= 95.1$ US GPM

PROBLEM: MAKE IT WORK

① ROUGH LAYOUT ✓

② PIPE SIZE

$$\dot{Q} = VA \, , \quad A = \frac{\pi D^2}{4} \rightarrow D = \sqrt{\frac{4A}{\pi}}$$

$V \rightarrow$ RECOMMENDED.

WE CHOOSE $V = 3 \text{ m/s}$ (DESIGN).

SO ... $A = \frac{Q}{V} = \frac{0.006 \text{ m}^3/\text{s}}{3 \text{ m/s}} = 0.002 \text{ m}^2$

$\therefore \quad D = \sqrt{\frac{(4)(0.002)}{\pi}} = 0.0505 \text{ m}$

$= 50.463 \text{ mm}$

CHOOSE A CLOSE REAL SIZE.

SCH. 40 ... ID = 52.501 mm

THAT'S FOR 2" SCH 40 PIPE.

$A_{FLOW} = 21.648 \times 10^{-4} \text{ m}^2$

③ SUCTION LINE SIZE.

CHOOSE 2½" SCH. 40

SO I.D. = 62.713 mm

$A_{FLOW} = 30.889 \times 10^{-4} \text{ m}^2$

④ ACTUAL FLOW VELOCITIES

$$V_{DISCHARGE} = \frac{Q}{A} = \frac{0.006 \frac{\text{m}^3}{\text{s}}}{21.648 \times 10^{-4} \text{ m}^2}$$

$= 2.77 \text{ m/s}.$

$$V_{SUCTION} = \frac{0.006}{30.889 \times 10^{-4}}$$

$= 1.94 \text{ m/s}.$

⑤ $N_R = \frac{VD\rho}{\mu}$

AT 5°C ...

$\rho = 999.9 \text{ kg/m}^3$

$\mu = 1.519 \times 10^{-3} \text{ kg/m·s}$

5 CONTINUED

$$\text{DISCHARGE } N_R = \frac{(2.77)(52.501 \times 10^{-3})(999.9)}{1.519 \times 10^{-3}}$$

$= 95729.6$

$= 9.6 \times 10^4$

$$\text{SUCTION } N_R = \frac{(1.94)(62.713)(999.9)}{1.519 \times 10^{-3}}$$

$= 8.0 \times 10^4$

⑥ PIPE MATERIAL: COMMERCIAL STEEL

$\varepsilon = 0.045 \text{ mm}$

⑦ RELATIVE ROUGHNESS

$$\text{DISCHARGE } \frac{\varepsilon}{D} = \frac{0.045}{52.501} = 0.00086$$

$$\text{SUCTION } \frac{\varepsilon}{D} = \frac{0.045}{62.713} = 0.00072$$

(8) FRICTION FACTOR

FROM MOODY DIAGRAM

$f \simeq 0.0217$ (DISCHARGE & SUCTION)

(9) PIPE LENGTH

DISCHARGE : $9+1+1+5 = 16\ m$

SUCTION : $1+1+2 = 4\ m$

(10) HEAD LOSS : PIPE

DISCHARGE : $h_L = f\left(\frac{L}{D}\right)\frac{V^2}{2g}$

$$h_{L_D} = (0.0217)\left(\frac{16}{52.501\times10^{-3}}\right)\frac{2.77^2}{(2)(9.81)}$$

$= 2.59\ m$

SUCTION :

$$h_{L_S} = (0.0217)\left(\frac{4}{62.713\times10^{-3}}\right)\left(\frac{1.94^2}{(2)(9.81)}\right)$$

$= 0.266\ m$

(11) MINOR LOSSES

DISCHARGE :

- 2 GATE VALVES : $K = 0.16$ EACH
- 3 ELBOWS (FLANGED) : $K = 0.39$ EACH
- DISCHARGE (FIGURE 6.21) : $K = 1.0$

SUCTION

- 1 CHECK VALVE : $K = 2.0$ EACH
- 1 ELBOW : $K = 0.39$ EACH

DISCHARGE

$$h_{L_D} = \left[(0.16)2 + (0.39)3 + (1.0) + 0\right]\frac{(2.77)^2}{(2)(9.81)}$$

$= 0.974\ m$

SUCTION

$$h_{L_S} = \left[(2.0) + (0.39)\right]\frac{(1.94)^2}{(2)(9.81)}$$

$= 0.458\ m$

(12) $h_A = ?$ (PUMP HEAD).

RE-ORDER

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} + h_A - h_R - h_L = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$

TO ...

$$h_A = \frac{(P_2 - P_1)}{\gamma} + (z_2 - z_1) + \frac{(V_2^2 - V_1^2)}{2g} + h_R + h_L$$

MY LITTLE EXTRA STUDY (SEE "FLOW START/END QUESTION") SHOWS THAT START END SHOULD BE AS PER SHOWN ON THE SYSTEM SCHEMATIC (PAGE 1).

$P_1 = \rho g h = (999.9)(9.81)(1)$

$= 9.81\ kPa$ (GAGE).

$P_2 = 0\ kPa$ (GAGE).

NOTE $\gamma = \rho g = 999.9 \times 9.81 = 9.81\ kN/m^3$

SO

$$h_A = \frac{(0 - 9.81)}{9.81} + ([1+1+9] - 0) + \frac{2.77^2 - 1.94^2}{(2)(9.81)} + 0 + [0.266 + 0.458 + 2.59 + 0.974]$$

$= -1 + 11 + 0.199 + 4.29$

$h_A = 14.49\ m$

(13) PUMP SELECTION (GOULDS)

$\dot{Q} = 6\ L/s = 21.6\ m^3/HR = 95.1$ US GPM

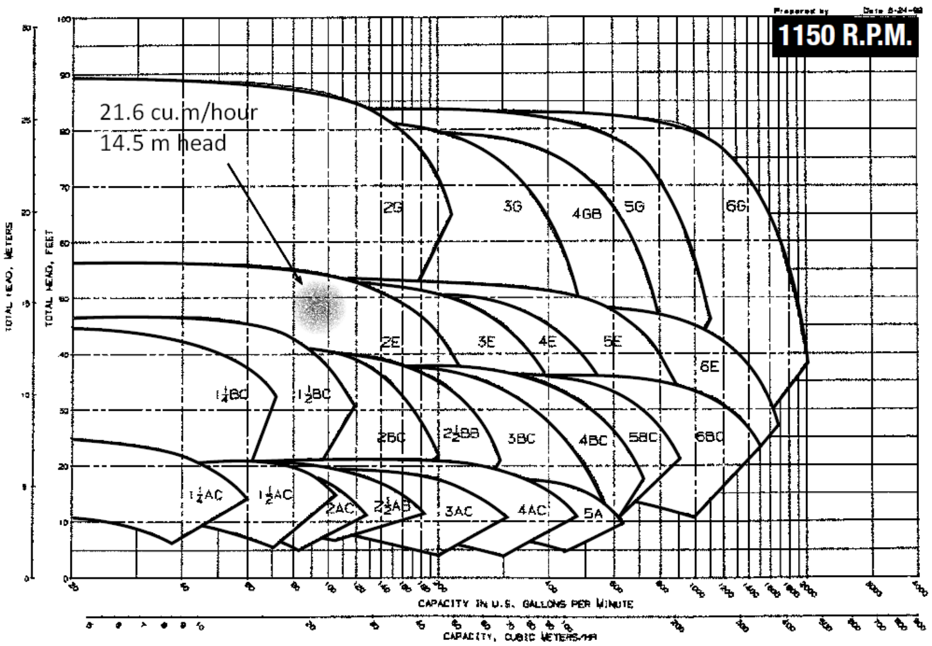
$h_A = 14.49\ m = 47.54$ FEET

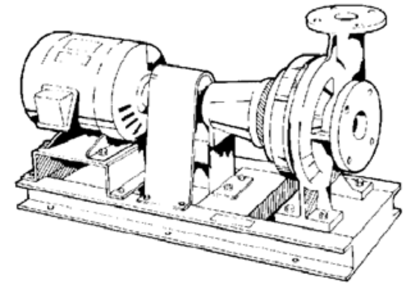
AFTER A LITTLE SEARCHING ...

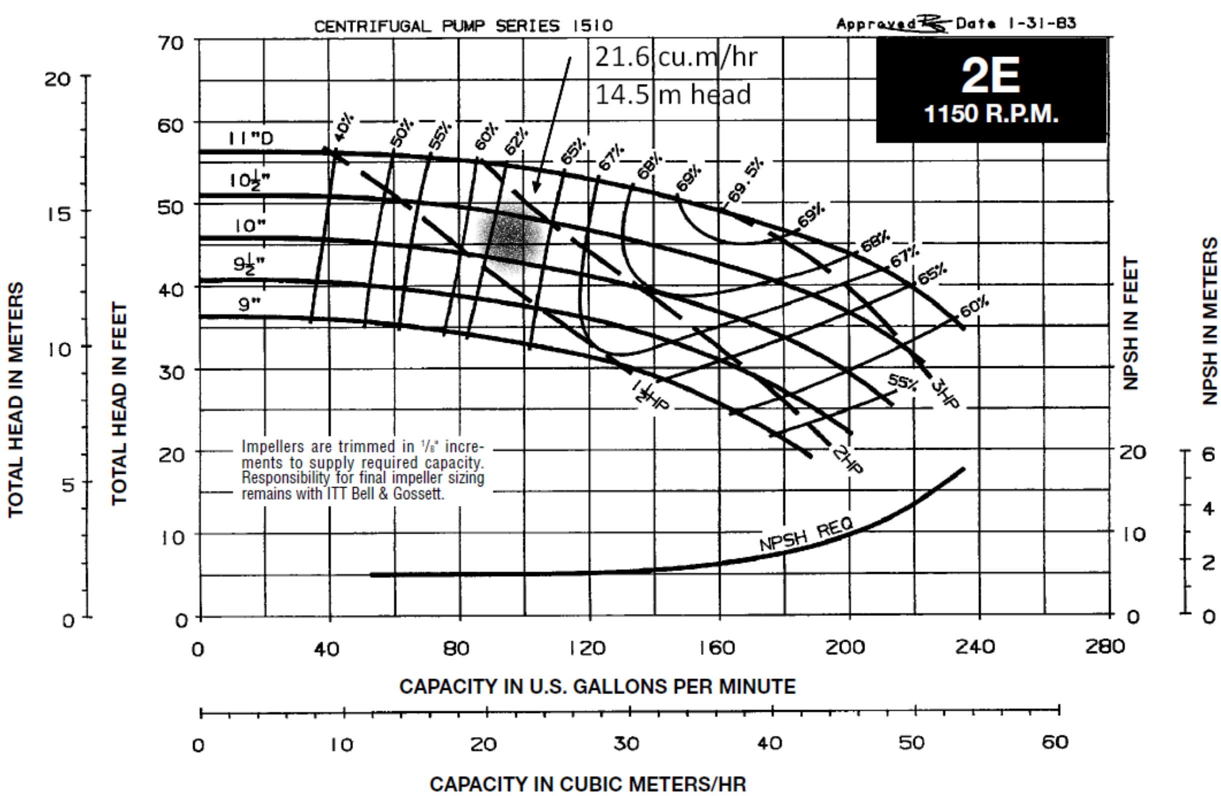
B & G MODEL 1510 - (2E) AT 1150 RPM (CATALOG PAGE 23)

SEE THE PUMP CURVE ON THE NEXT PAGE.

Bell & Gossett







PUMP SPEC:

MAKE : B & G
SERIES : 1510
MODEL : 2E
RPM : 1150
POWER : 2 HP
IMPELLER : $10\frac{1}{2}$" ϕ
$NPSH_R$: 5 FEET = 1.52 m

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(14) CHECK THE SUCTION DESIGN.

NPSH = NET POSITIVE SUCTION HEAD, m

$NPSH_A$ = AVAILABLE NPSH AT THE PUMP'S IMPELLER.

$$= \frac{P_{ATM}}{\gamma} - h_e - h_f - \frac{P_v}{\gamma}$$

- P_v ← FLUID VAPOUR PRESSURE
- h_f — SUCTION LINE HEAD LOSS.
- h_e — LIFT FROM FLUID SURFACE TO PUMP.
- P_{ATM} — ATMOSPHERIC PRESSURE OR ABSOLUTE PRESSURE AT THE FLUID SURFACE.

$$= \frac{101.3\text{ kPa}}{9.81\text{ kN/m}^3} - 1 - [0.266 + 0.458] - \frac{0.9\text{ kPa}}{9.81\frac{\text{kN}}{\text{m}^3}}$$

$$= 10.33 - 1 - 0.724 - 0.0917$$

$$= 8.5 \text{ m}$$

THAT'S HOW MUCH NPSH WE HAVE (AVAILABLE).

THE PUMP NEEDS (REQUIRES) 1.52 m TO BE HAPPY.

$\therefore$ THE PUMP IS HAPPY :-)

$\because$ $NPSH_A > NPSH_R$