CUSTOMER: CASEY O'CONNOR DATE: PROJECT NO.

TITLE: BY: REFERENCE NO.

DESCRIPTION: CKD:

REV:

PURPOSE

DESIGN COMBINATION LINE SERIES TO DELIVER WATER AT 275 gpm FROM TANK THROUGH HEAT EXCHANGER & BYPASSES.

- REQUIRED PUMP POWER CLOSED AND POWER AT DIFFERENT THROTTLED 1" GATE VALVES.

SOURCES

MOTT, R., UNTENAR JA, "APPLIED FLUID MECHANICS". 7th EDITION, PEARSON Inc (2015)

DESIGN CONSIDERATIONS:

INCOMPRESSIBLE FLUID
ISOTHERMAL 160° F
STEADY STATE
NEWTONIAN FLUID

MATERIALS:

WATER
STEEL SCH 40

CUSTOMER:

TITLE:

DESCRIPTION:

DATE:

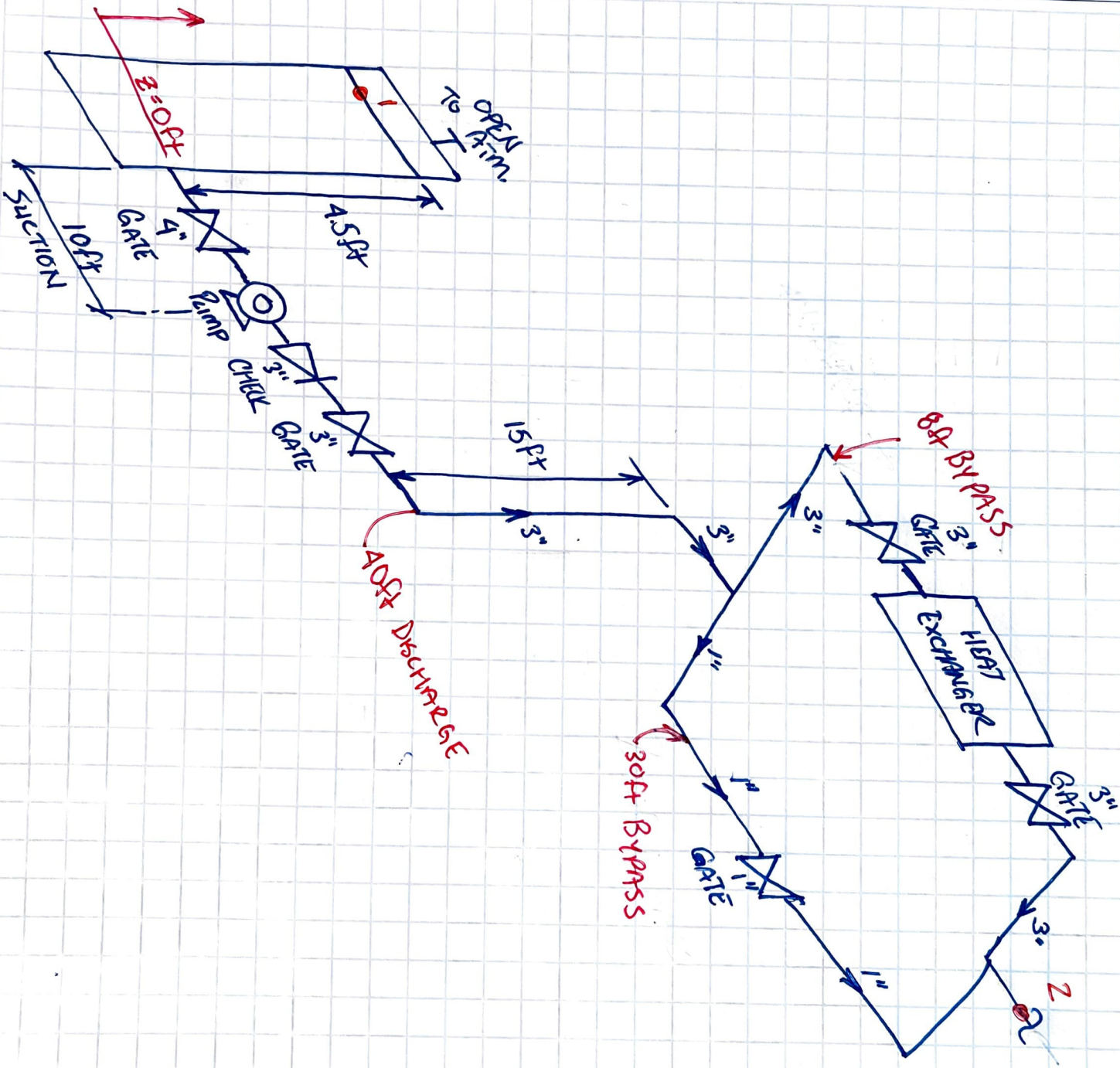
BY:

CKD:

REV:

PROJECT NO.

REFERENCE NO.



CUSTOMER:
TITLE:
DESCRIPTION:

DATE:
BY:
CKD:
REV:

PROJECT NO.
REFERENCE NO.

DATA & VARIABLES

WATER 160°F

γ_w = 61

ρ = 1.9

$\eta = 8.3 \times 10^{-6}$

$\nu = 4.38 \times 10^{-6}$

Q = 275 gpm => .6127 ft^3/s

3"Ø SCH40 => .05132 ft^2, I.D. = .2557 ft

1"Ø SCH40 => .006 ft^2, I.D. = .0874 ft

4"Ø SCH40 => .08840 ft^2, I.D. = .3355 ft

PIPE	ft
4:	.016
3:	.017
1:	.022

4" GATE VLV => K = 8ft 8(.016) = .128

3" GATE VLV => K = 8ft 8(.017) = .136

3" CHECK VLV => K = 100ft 100(.017) = 1.7

3" 90° ELBOW => K = 30ft 30(.017) = .51

PUMP

HEAT EXCHANGER => K = 12ft 12

GATE	
OPEN	8
3/4	35
1/2	160
1/4	900

TEE * SPECIAL FABRICATED => K VALUE - SAME AS BOOK 60ft = 60(.017) = 1.02

SQUARE EDGE INLET - K = .5

1" GATE VLV => K = 8ft

CUSTOMER: DATE: PROJECT NO.

TITLE: BY: REFERENCE NO.

DESCRIPTION: CKD:

REV:

CALCULATIONS: FIND Q IN 4"Ø SUCTION PIPE

$Q = VA \Rightarrow .6127\ ft^3/s = V(.08840\ ft^2) = 6.93\ ft/s$

4" V = 6.93 ft/s

V of 3"Ø

$.6127\ ft^3/s = V(.05132\ ft^2) = 11.9\ ft/s$

V of 1"Ø

$.6127\ ft^3/s = V(.006\ ft^2) = 102.1\ ft/s$

$\frac{V^2}{2g}$ of 4" $\Rightarrow \frac{6.93^2}{2(32.2)} = .746$

$\frac{V^2}{2g}$ of 3" $\Rightarrow \frac{11.9^2}{2(32.2)} = 2.2$

h_L OF 4" $\Rightarrow h_{exit} = .5$

$h_{GATE} = .128$

$h_{PIPE} = .016 \frac{10}{.3355} = .477$

$.5 + .128 + .477(.746) = .82433\ ft$

CUSTOMER:
TITLE:
DESCRIPTION:

DATE:
BY:
CKD:
REV:

PROJECT NO.
REFERENCE NO.

LOSSES IN DISCHARGE, 3"

$\frac{V^2}{2g}$ OF 3" = 2.2 ft/s

3 $h_{GATE} = .136$

$h_{CHECK} = 1.7$

4 $h_{ELL} = .51$

2 $h_{TEE} = 1.02$

$h_{DISCHARGE} = .017 \left(\frac{40}{.2557}\right) = 2.659$

$h_{TEE} = 1.02$

$h_{PIPE} = .017 \left(\frac{8}{.2557}\right) = .5319$

$h_{HE} = 12(.017) = .204$

$h_{OUTLET} = 1(.617) = .017$

ADD $h_{VALVES} = 10.6199 (2.2) = 23.36$ ft

CUSTOMER: DATE: PROJECT NO.

TITLE: BY: REFERENCE NO.

DESCRIPTION: CKD: REV:

BERNOULLI'S EQUATION

$$h_A + \frac{P_1}{\gamma}^{0} + \frac{V_1^2}{2g}^{0} + z_1 = \frac{P_2}{\gamma}^{0} + \frac{V_2^2}{2g} + z_2 + h_{L_{1-2}}$$

$$h_A + 4.5ft = 2.2 + 15ft + 24.124$$

$$h_A = 2.2 + 10.5 + 24.124$$

$$h_A = 36.824\ ft$$

CALC PUMP POWER => $\frac{\gamma Q h_A}{\eta}$

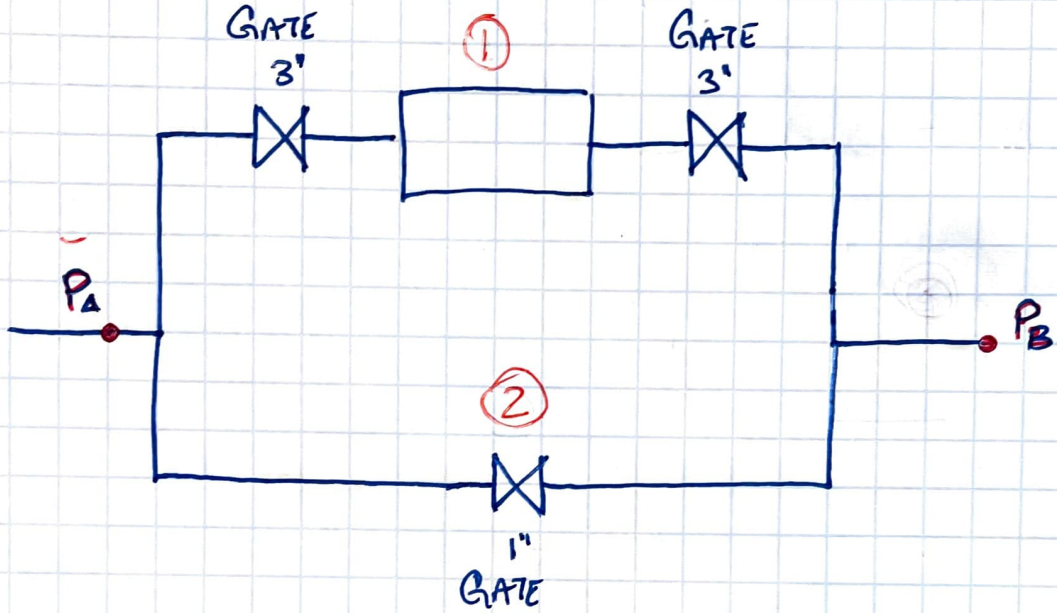
$$= \frac{61\,(.6127\ ft^3/s)\,(36.824)}{.7}$$

$$= 1966.12\ \frac{lb \cdot ft}{s} / 550 = \boxed{3.57\ hp}$$

CUSTOMER:
TITLE:
DESCRIPTION:

DATE:
BY:
CKD:
REV:

PROJECT NO.
REFERENCE NO.



$$\frac{P_A}{\gamma} = h_L \text{ AB}$$

$$\frac{P_A}{61} = 1.02 + 2(.136) + .204 + 1.02 = 2.516 (2.2)$$

$$\frac{P_A}{61} = 5.5352$$

$$P_A = 337.6472$$

CUSTOMER:
TITLE:
DESCRIPTION:

DATE:
BY:
CKD:
REV:

PROJECT NO.
REFERENCE NO.

Summary -

To deliver water from lower tank through higher heat exchanger at a rate of 275 gpm, we will need a pump with 3.57 hp, assuming the pump efficiency is 70%.

The pump power will need increased when the 1" bypass gate valve is open.

Analysis - The procedure in the test is similar to previous exams. Additional concepts from chapter 10 were introduced. Calculating the flow rate for multiple branch systems is a long process that requires significant practice and understanding of the class concepts.