



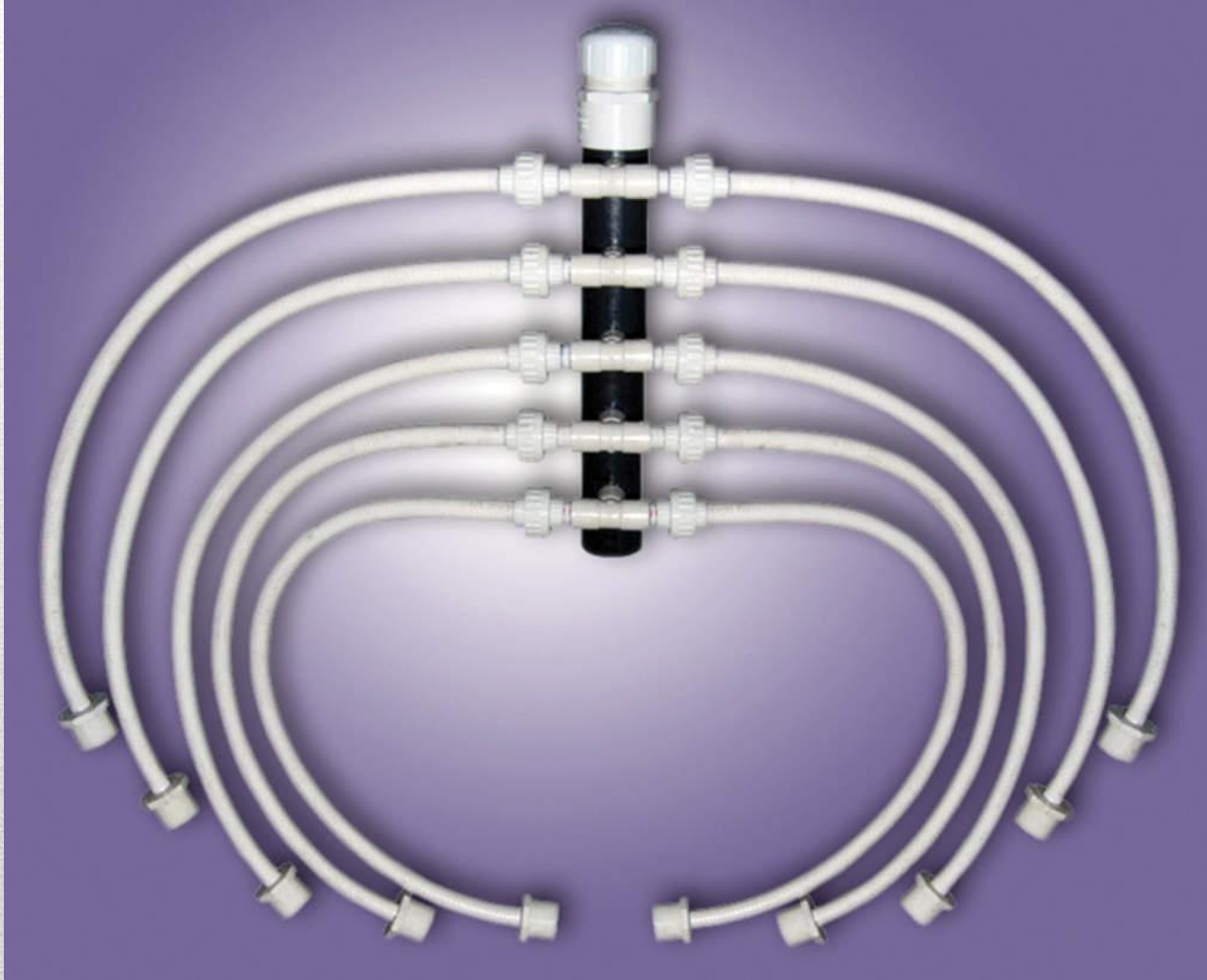
Section 2: Pressure Manifold



SHOW YOUR WORK ON THE TEST!

**Partial credit is possible if you
show work**

Pressure Manifold



Pressure Manifold

Orifice Disk must be sized according to the specification found in the permit. Accurate drill size is important when the manifold is used with uneven length lines.



Pressure Manifold



WHY?

Calculations tell us which pump will work. And which ones will **NOT!**

Final answer will include:

1. Flow rate (GPM)
2. Total Dynamic Head (TDH in feet)
 - a) Elevation: difference in pump outlet and absorption field
 - b) Force Main: friction loss in pipe
 - c) Residual: ensures enough pressure to clean orifices

Total Dynamic Head			
Flow	Elevation	Force Main	Residual
X	X	X	X

Orifice Sizing

Orifice Discharge Rate Chart (gpm)							
Orifice size (in)							
	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Head (ft)							
3	0.335	0.754	1.34	2.094	3.015	4.104	5.361
4	0.387	0.871	1.548	2.418	3.482	4.739	6.19
5	0.4326	0.973	1.73	2.703	3.893	5.299	6.921
6	0.474	1.066	1.895	2.961	4.264	5.804	7.581
7	0.512	1.152	2.047	3.199	4.606	6.27	8.189
8	0.547	1.231	2.189	3.42	4.924	6.702	8.754
9	0.58	1.306	2.321	3.627	5.223	7.109	9.285
10	0.612	1.376	2.447	3.823	5.505	7.493	9.787

Orifice Sizing

Q. What is the total flow per minute in a system with one ½” orifice, three ¼” orifice, and two ⅜ with 5 feet of head?

Step 1: Locate the orifice sizes on the chart.

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5	0.4326	0.973	1.73	2.703	3.893	5.299	6.921

Orifice Sizing

Q. What is the total flow per minute in a system with one 1/2" orifice, three 1/4" orifice, and two 3/8 with 5 feet of head?

Step 2:

1/4" @ 5' head → 1.73 gpm	X	3 orifices = 5.19 gpm	
		+	
3/8" @ 5' head → 3.893 gpm	X	2 orifices = 7.786 gpm	
		+	
1/2" @ 5' head → 6.921 gpm	X	1 orifice = 6.921 gpm	

			19.897 gpm ← total flow

Orifice Sizing

1. What is the total flow of a manifold with three 7/16", one 5/16", and two 3/8" orifices with 5 feet of head?

$$(3 \times 5.299 \text{ gpm}) + (1 \times 2.703 \text{ gpm}) + (2 \times 3.893 \text{ gpm}) =$$

26.386 gpm

2. What is the total flow of a manifold with six 3/8" orifices with 5 feet of head?

$$(6 \times 3.893 \text{ gpm}) =$$

23.358 gpm

Orifice sizing is important!!!

System Details

Estimated daily flow – 370 GPD

Dose volume – 25% of daily flow

Orifice Diameter 7/16”

5 lines @ 80’ long

Residual head - 5’

Pump “off” elevation – 48.3’

Manifold elevation – 64.1’

Distance to be pumped - 175’

Force main specs - 2” Sch 40

Calculating TDH

Total Dynamic Head			
Flow	Elevation	Force Main	Residual
26.5 gpm			5'

Q. What is the minimum flow rate for this system?

(flow per orifice X # of orifices) = total flow

(5.299 gpm X 5) = flow

Minimum flow = 26.495 or 26.5 gpm

Calculating TDH

Total Dynamic Head			
Flow	Elevation	Force Main	Residual
26.5 gpm	15.8'		5'

Q. What is the elevation difference in pump out and manifold?

Manifold elevation – 64.1'

Pump off elevation - 48.3'

$$64.1' - 48.3' = 15.8'$$

Calculating TDH

Total Dynamic Head			
Flow	Elevation	Force Main	Residual
26.5 gpm	15.8'	4.2'	5'

Q. What is the head loss in force main (add 20% for fittings)?

Force main specs - 175' of 2" Sch 40

(From chart): 2.0' of loss in 100' of 2" Sch 40 @ 30 gpm

$2.0 \times 1.75 = 3.5$ ← Add 20% for fittings

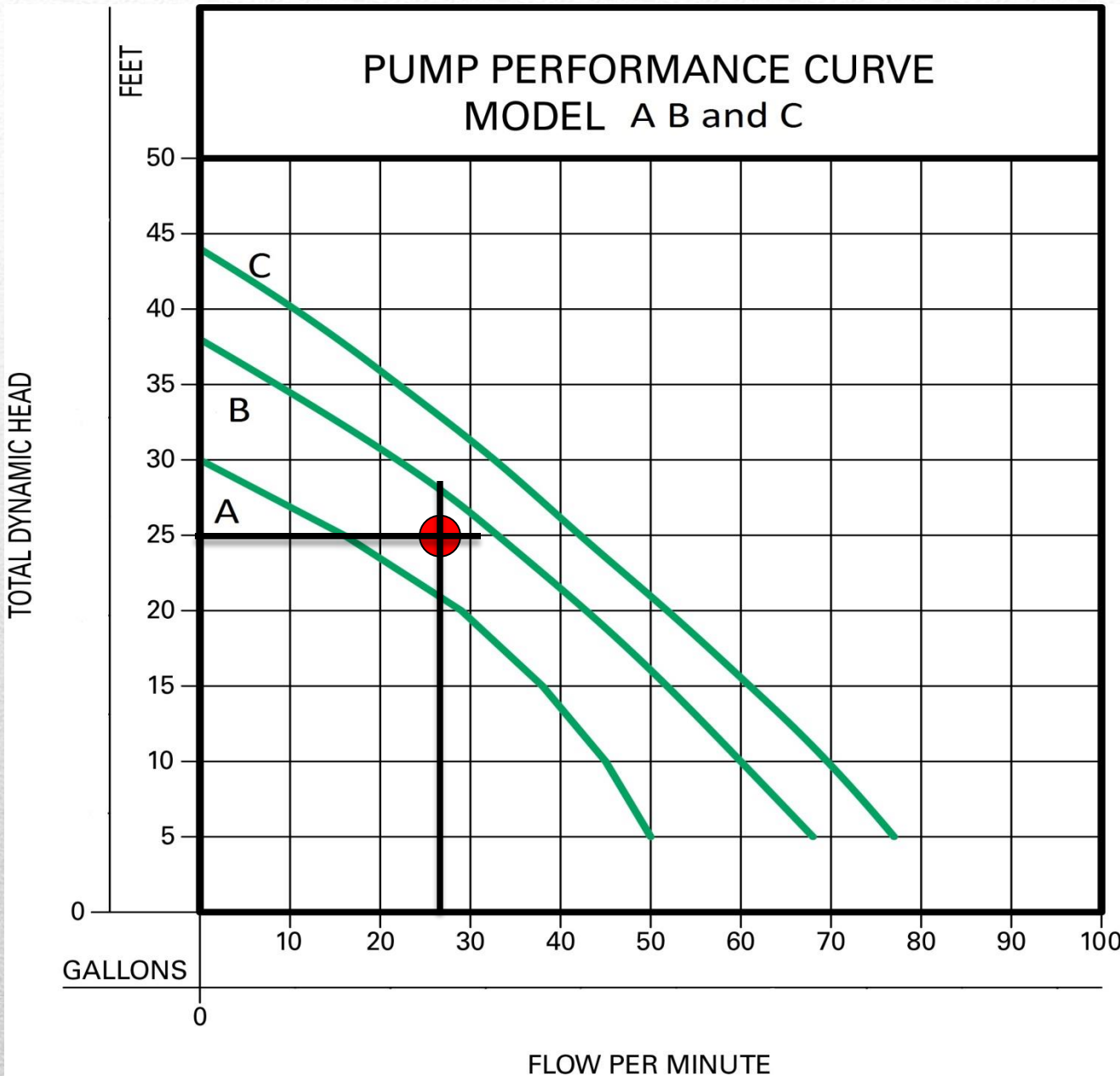
$3.5 \times 1.2 = 4.2'$

Calculating TDH

Total Dynamic Head			
Flow	Elevation	Friction	Residual
26.5 gpm	15.8'	4.2'	5'

Total Dynamic Head:

$$15.8' + 4.2' + 5' = 25'$$



26.5 GPM
@ 25' TDH

Which
pumps will
work?

Calculating Operating Point

Original →

Total Dynamic Head			
Flow	Elevation	Friction	Residual
26.5 gpm	15.8'	4.2'	5'

New Point →

Total Dynamic Head			
Flow	Elevation	Friction	Residual
	15.8'		10'

Calculating Operating Point

Total Dynamic Head			
Flow	Elevation	Friction	Residual
New Point → 37.5 GPM	15.8'		10'

Still 7/16" orifices, but now we have 10' residual head/squirt height.

Orifice Discharge Rate Chart (gpm)							
Orifice size (in)							
	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Head (ft)							
10	0.612	1.376	2.447	3.823	5.505	7.493	9.787

7.493 X 5 orifices = 37.465 GPM or 37.5 GPM

Calculating Operating Point

Total Dynamic Head			
Flow	Elevation	Friction	Residual
New Point → 37.5 GPM	15.8'	7.2'	10'

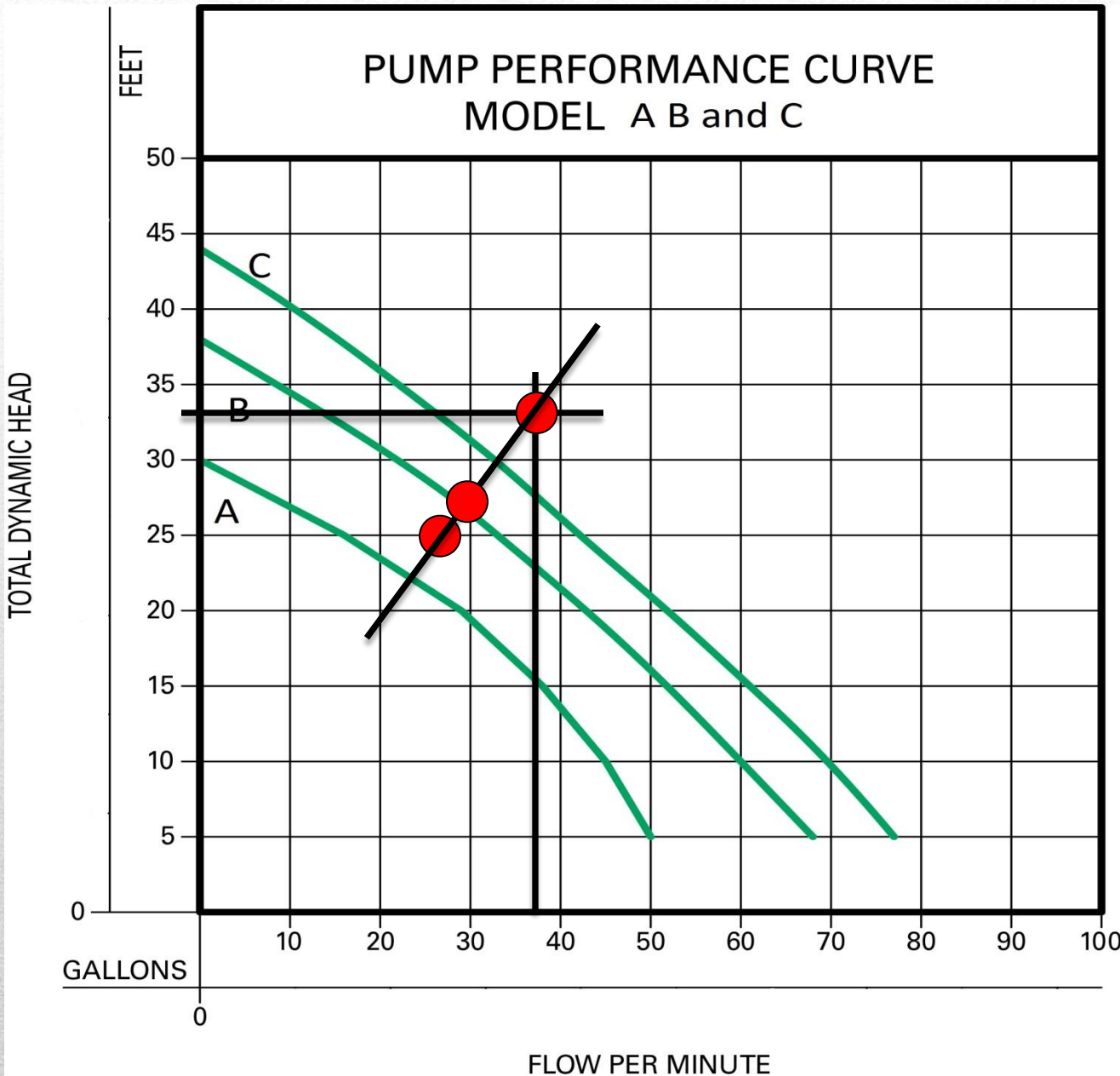
Still 175' of 2" SCH 40, but now at a higher flow.

(From chart): 3.4' of loss in 100' of 2" Sch 40 @ 40 gpm

$3.4 \times 1.75 = 5.95'$ OR 6' ← Add in for fittings – 20%

$6 \times 1.2 = 7.2'$

$TDH = 15.8' + 7.2' + 10' = 33'$



37.5 GPM
@ 33' TDH

Our pump will
operate at:
30 GPM

Calculating Dose Time

Estimated daily flow – 370 GPD

Dose volume – 25% of daily flow

Calculating Dose Volume:

$$370 \text{ GPD} \times .25 = 92.5 \text{ gallons}$$

Calculating Dose Time:

$$92.5 \text{ gallons per dose} \div 30 \text{ GPM (from pump)} = 3.083 \text{ minutes or } 185 \text{ seconds}$$

Calculating Dose Time

Estimated daily flow – 370 GPD

Dose volume – 25% of daily flow

How many times a day will our pump kick on?

$$4 \quad 100\% \div 25\% =$$

24 hours X 60 minutes per hour = 1440 minutes in a day

$$1440 \div 4 \text{ doses} = 360 \text{ minutes}$$

How long will our pump be off between doses?

$$360 \text{ min.} - 3.08 \text{ min. (pump run time)} = 357 \text{ minutes}$$

pump off time

Other Changes to System

What if the force main had been reduced to 1 ½” SCH 40 PVC? Would our pump work?

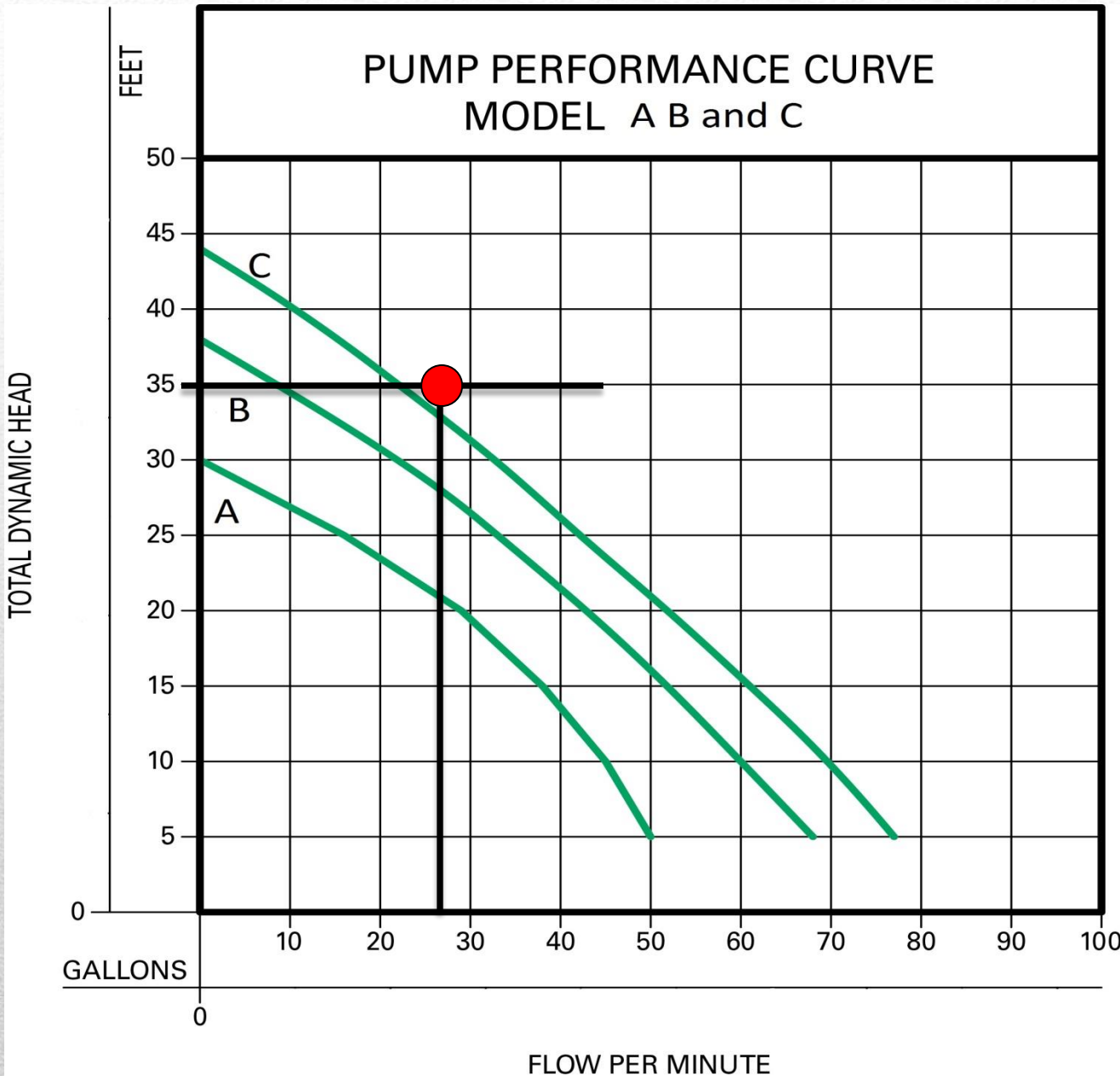
Total Dynamic Head			
Flow	Elevation	Friction	Residual
26.5 GPM	15.8'	42' 14'	5'

Elevation and Residual will stay the same, only friction is changed.

$$6.7 \times 1.75 = 11.725' \leftarrow \text{Add 20\% for fittings}$$

$$11.725' \times 1.2 = 14'$$

Our new TDH is about 35'.



26.5 GPM
@ 35' TDH

Will our
pump work?
Any pump?

System Details

Estimated daily flow – 370 GPD

Dose volume – 25% of daily flow

Orifice Diameter 1/2”

4 lines @ 75’ long

Residual head - 5’

Pump “off” elevation – 1.0’

Manifold elevation – 6.5’

Distance to be pumped - 90’

Force main specs - 1 ½ ” Sch 40

Calculating TDH

Total Dynamic Head			
Flow	Elevation	Force Main	Residual
27.7 gpm			5'

Q. What is the minimum flow rate for this system?

(flow per orifice X # of orifices) = total flow

(6.921 gpm X 4) = flow

Minimum flow = 27.684 or 27.7 gpm

Calculating TDH

Total Dynamic Head			
Flow	Elevation	Force Main	Residual
27.7 gpm	5.5'		5'

Q. What is the elevation difference in pump out and manifold?

Manifold elevation – 6.5'

Pump off elevation - 1.0'

$$6.5' - 1.0' = 5.5'$$

Calculating TDH

Total Dynamic Head			
Flow	Elevation	Force Main	Residual
27.7 gpm	5.5'	7.2'	5'

Q. What is the head loss in force main (add 20% for fittings)?

Force main specs - 90' of 1 ½" Sch 40

$6.7 \times 0.9 = 6.03$ ← Add 20% for fittings

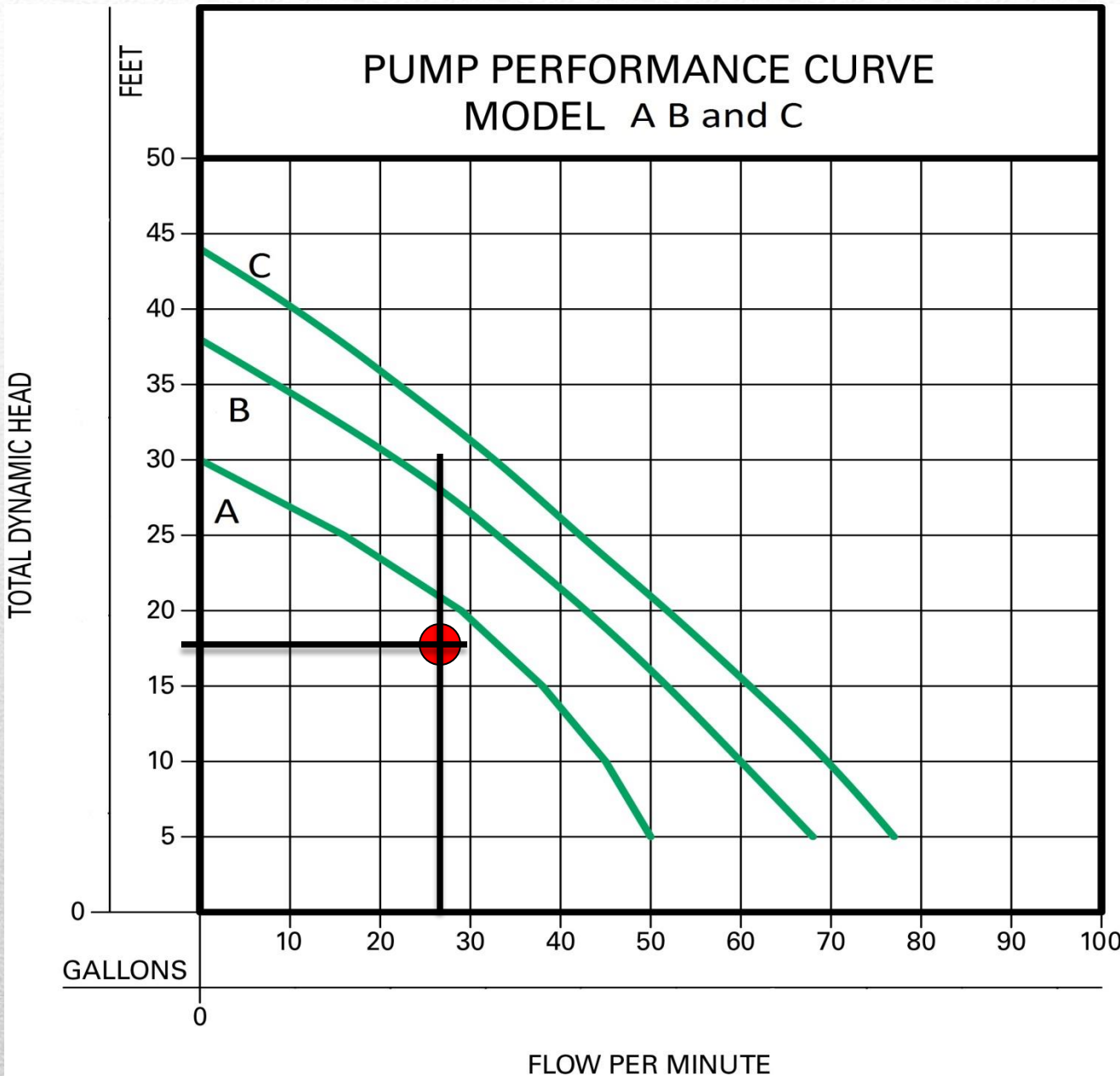
$6.03 \times 1.2 = 7.236'$

Calculating TDH

Total Dynamic Head			
Flow	Elevation	Friction	Residual
27.7 gpm	5.5'	7.2'	5'

Total Dynamic Head:

$$5.5' + 7.2' + 5' = 17.7'$$



27.7 GPM
@ 17.7' TDH

Which
pumps will
work?

Calculating Operating Point

Original →

Total Dynamic Head			
Flow	Elevation	Friction	Residual
27.7 gpm	5.5'	7.2'	5'

New Point →

Total Dynamic Head			
Flow	Elevation	Friction	Residual
	5.5'		10'

Calculating Operating Point

Total Dynamic Head			
Flow	Elevation	Friction	Residual
New Point → 39 GPM	5.5'		10'

Still 1/2" orifices, but now we have 10' residual head/squirt height.

Orifice Discharge Rate Chart (gpm)							
Orifice size (in)							
	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Head (ft)							
10	0.612	1.376	2.447	3.823	5.505	7.493	9.787

9.787 X 4 orifices = 39.148 GPM or 39 GPM

Calculating Operating Point

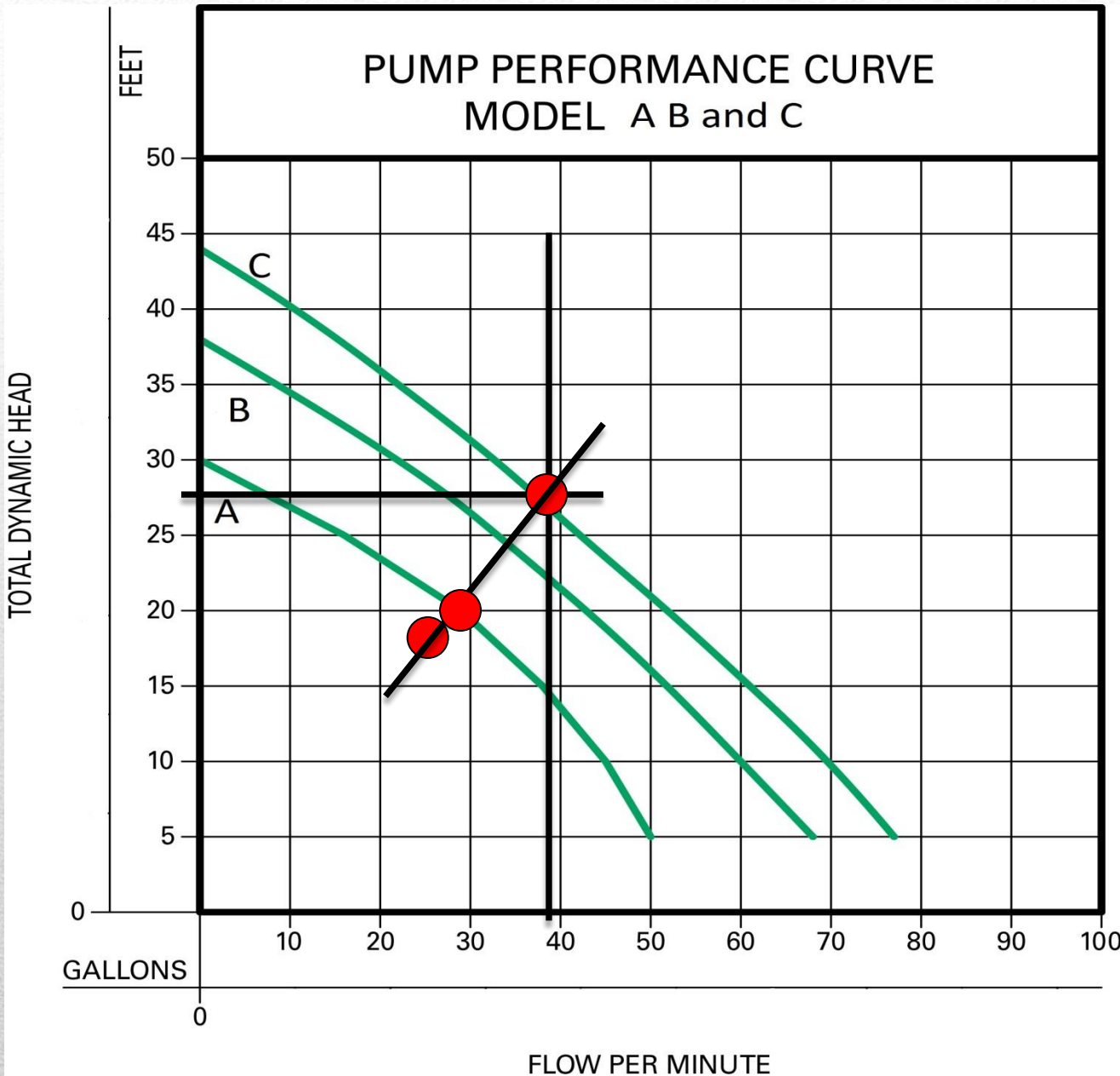
Total Dynamic Head			
Flow	Elevation	Friction	Residual
New Point → 39 GPM	5.5'	12.2'	10'

Still 90' of 1 ½" SCH 40, but now at a higher flow.

$$11.3 \times 0.90 = 10.17' \quad \leftarrow \text{Add in for fittings} - 20\%$$

$$10.17 \times 1.2 = 12.204'$$

$$\text{TDH} = 5.5' + 12.2' + 10' = 27.7'$$



39 GPM @
27.7' TDH

Our pump will
operate at:
30 GPM

Calculating Dose Time

Estimated daily flow – 370 GPD

Dose volume – 25% of daily flow

Calculating Dose Volume:

$$370 \text{ GPD} \times .25 = 92.5 \text{ gallons}$$

Calculating Dose Time:

$$92.5 \text{ gallons per dose} \div 30 \text{ GPM (from pump)} = 3.083 \text{ minutes or } 185 \text{ seconds}$$

Calculating Dose Time

Estimated daily flow – 370 GPD

Dose volume – 25% of daily flow

How many times a day will our pump kick on?

$$4 \quad 100\% \div 25\% =$$

24 hours X 60 minutes per hour = 1440 minutes in a day

$$1440 \div 4 \text{ doses} = 360 \text{ minutes}$$

How long will our pump be off between doses?

$$360 \text{ min.} - 3.08 \text{ min. (pump run time)} = 357 \text{ minutes}$$

pump off time

CALCULATING TANK VOLUME

The inside dimensions of Ernie's rectangular septic tank are:

Length 97 in. Width 48 in. Height 59 in.

Inlet height 52 in. Outlet height 50 in.

What is the volume of this entire septic tank?

CALCULATING TANK VOLUME

$$\text{Volume of Water (gallons)} = \frac{\text{Inside Length} \times \text{Inside Width} \times \text{Liquid Depth}}{231 \text{ inches}^3 / \text{gallon}}$$

$$\text{Volume of Water} = \frac{97 \text{ in.} \times 48 \text{ in.} \times 50 \text{ in.}}{231 \text{ in.}^3 / \text{gallon}} = \frac{232,800 \text{ in.}^3}{231 \text{ in.}^3 / \text{gallon}}$$

$$\frac{232,800 \text{ in.}^3}{231 \text{ in.}^3 / \text{gallon}} = 1007.8 \text{ gallons}$$

DOSE DRAWDOWN CALCULATIONS

(Rectangular tank) – Calculating water volume in 1” depth

Tank dimension (inside): 60 in. (long) X 36 in. (wide) X 44 in. (deep)

$$\text{Volume of Water} = \frac{60 \text{ in.} \times 36 \text{ in.} \times 1 \text{ in.}}{231 \text{ in.}^3 / \text{gallon}} = \frac{2,160 \text{ in.}^3}{231 \text{ in.}^3 / \text{gallon}}$$

One inch of water = 9.35 gallons

If dose volume is 30 gallons, how many inches should drawdown be each dose cycle?

$$30 \text{ gal (dose)} \div 9.4 \text{ gal/in} = \mathbf{3 \text{ inch drawdown}}$$

DOSE DRAWDOWN CALCULATIONS

(Round tank) – Calculating water volume in 1” depth

Tank dimension (inside): 50” in diameter x 44 in. (deep)

$$\text{Volume} = \pi r^2h$$

$$V = 3.14 \times 25^2 \times 1$$

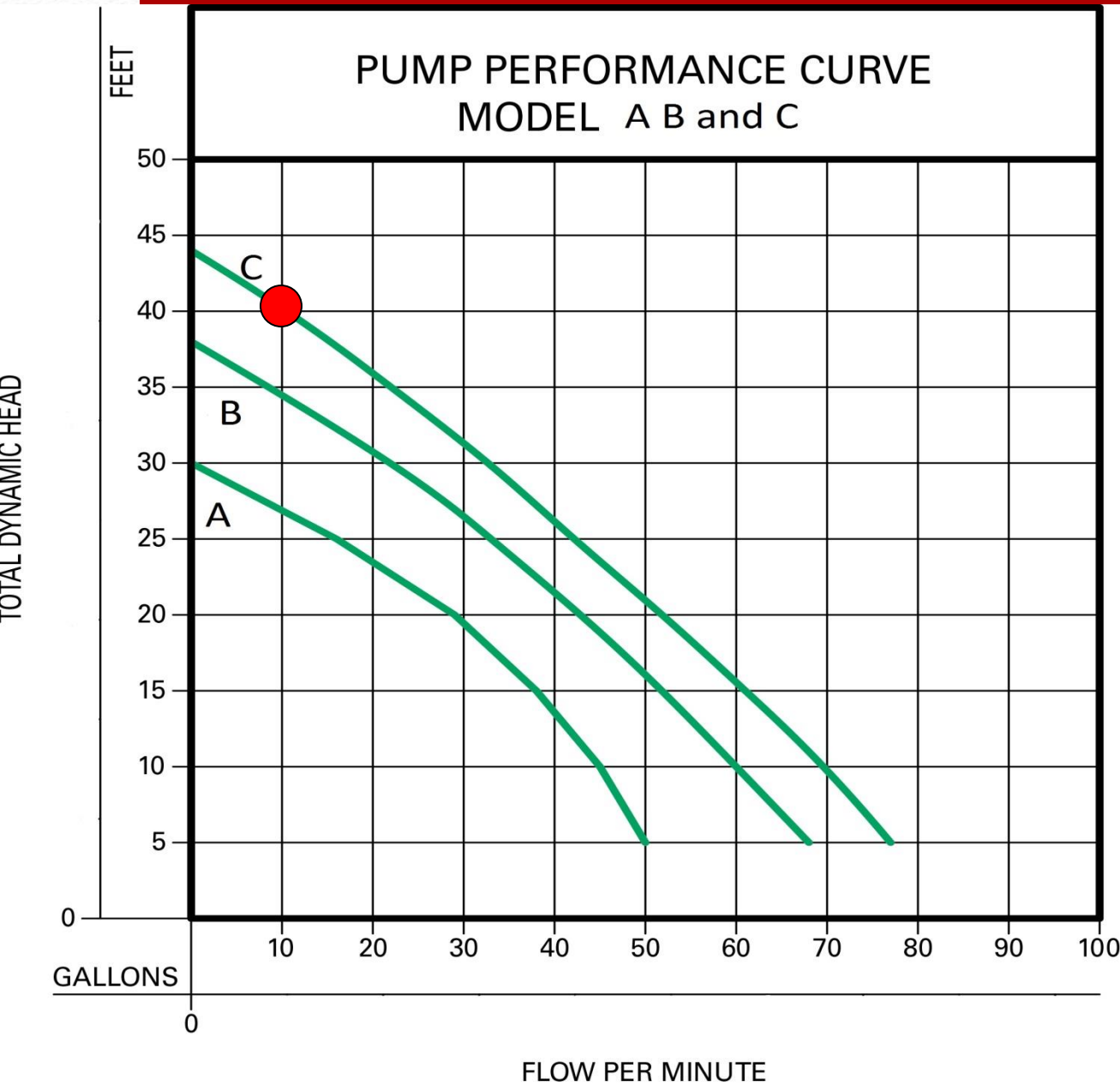
$$V = 3.14 \times 625 \times 1$$

$$V = 1962.5 \text{ in}^3$$

$$V = 1963 \text{ in}^3 \div 231 \text{ in}^3 / \text{gal} = 8.49 \text{ gal} / \text{inch}$$

If dose volume is 30 gallons, how many inches should drawdown be each dose cycle?

$$30 \text{ gal dose} \div 8.5 \text{ g} / \text{in} = \mathbf{3.5 \text{ inch drawdown}}$$



What is the pump run time for Pump C at TDH of 40' if dose volume is 45 gallons?

$$45 \text{ gallons} / 10 \text{ gpm} = 4.5 \text{ minutes}$$



Pressure Manifold Design #2

Pressure Manifold Design

Estimated Daily flow- 370 Gallons

Dose volume- 25% of daily flow

Orifice diameter- 1/2"

4 lines- 75' long

Residual Head- 5'

Pump "off" rod reading- 6.5'

Manifold rod reading- 1.0'

Distance to be pumped- 90'

Force main specs- 1.5" Sch 40 PVC

20% add-on for friction in fittings

Pressure Manifold Design

Step 1—Calculate Dose Volume

Step 2—Calculate Minimum Flow Rate for System

Step 3—Calculate Total Dynamic Head (TDH) @ Minimum Flow Rate

Step 4—Selecting the Pump

Step 5—Calculate Operating Capacity of Selected Pump

Step 6—Setting the Pump Timers

Step 7—Calculate Draw Down for Demand Dosing

Step 1---Calculate Dose volume

Need to Know:

#1—Number of Orifices

- Number of field lines → 4 lines in our example

#2—Dose Volume

- Given or Selected
-

Step 1--Calculations

Common dose rate is 10-25% of the daily flow in gallons (GPD). This is usually a given value.

(a) select dose rate of 25% of the daily flow

(b) $370 \text{ GPD} \times .25 = \underline{92.5 \text{ gal dose}}$

Step 2—Calculate Minimum Flow Rate for the System

Need to Know:

#1--Orifice sizes----1/2 inch

(Given or Selected)

#2--Residual Head (Squirt Height)----5 ft.

(Given or Selected)

Step 2----Calculations

- A 1/2 in. orifice with a 5 ft. squirt height (residual head) has a flow rate of 6.921 gal per orifice. This will be 6.921 gallons per line with one orifice per absorption line.
(Refer to chart provided on next slide)
 - 6.921 gallons per orifice x 4 total orifices = 27.684 gpm (gal per minute). You may round to 27.7 gpm
 - To meet the 5 ft. residual head, the pump must be able to pump 27.7 gpm against the Total Dynamic Head (TDH)
-

Table 1

Orifice Discharge Rate Chart (gpm)

	Drill Size (in)						
	1\8	3\16	1\4	5\16	3\8	7\16	1\2
Head (ft)							
3	0.335	0.754	1.34	2.094	3.015	4.104	5.361
4	0.387	0.871	1.548	2.418	3.482	4.739	6.19
5	0.4326	0.973	1.73	2.703	3.893	5.299	6.921
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7	0.512	1.152	2.047	3.199	4.606	6.27	8.189
8	0.547	1.231	2.189	3.42	4.924	6.702	8.754
9	0.58	1.306	2.321	3.627	5.223	7.109	9.285
10	0.612	1.376	2.447	3.823	5.505	7.493	9.787

Table 2

TABLE II

HEADLOSS IN 100 Feet of SCHEDULE 40 PVC PIPE

FLOW RATE GPM	1"	1¼"	1½"	2"	3"
5	1.3	0.5	0.2	0.1	0.01
10	4.8	1.8	0.9	0.3	0.04
15	10.2	3.9	1.8	0.5	0.08
20	17.3	6.7	3.1	0.9	0.14
25	26.2	10.1	4.7	1.4	0.2
30	36.7	14.1	6.7	2.0	0.3
35	48.8	18.7	8.8	2.6	0.4
40	62.5	24.0	11.3	3.4	0.5
45	77.7	29.9	14.1	4.2	0.6
50	94.4	36.3	17.1	5.1	0.7
55	112.7	43.3	20.4	6.1	0.9
60	132.3	50.9	24.0	7.1	1.0
65		59.0	27.8	8.2	1.2
70		67.7	31.9	9.5	1.4
75		76.9	36.3	10.7	1.6
80		86.7	40.9	12.1	1.8

Step 3---Calculate Total Dynamic Head

Need to Know:

#1-- Minimum Flow Rate (step 2)—27.7 gpm

#2-- Elevation Head—5.5 ft.

(Difference in elevation between the pump off {6.5 ft} and the discharge assembly {1.5 ft} or manifold)

#3-- Friction Head

a. Length of force main---90 ft.

b. Pipe size of force main--- 1.5 in. Sch. 40 PVC

c. Fitting and connections--- 20% of total friction loss

Step 3---Calculations

- 1.5 in. Sch. 40 pvc has a friction loss of 6.7 ft. per 100 ft.

@ 30 gpm (Refer to chart on next slide)

- 90 ft. of pipe $(0.90 \times 6.7) = \underline{6.03 \text{ ft}}$ of head loss for force main

- Fittings loss = $6.03 \text{ ft.} + (20\% \underline{1.21 \text{ ft.}})$

- **Total friction loss = $6.03 + 1.21 = \underline{7.24 \text{ ft.}}$**

Step 3—Total Dynamic Head (TDH)

Total Dynamic Head=

$$\begin{array}{r} \text{Elevation Head} \text{---} 5.5 \text{ ft.} \\ + \text{ Friction Head} \text{---} 7.24 \text{ ft.} \\ + \text{ Residual Head} \text{---} 5 \text{ ft.} \end{array}$$

17.74 ft.

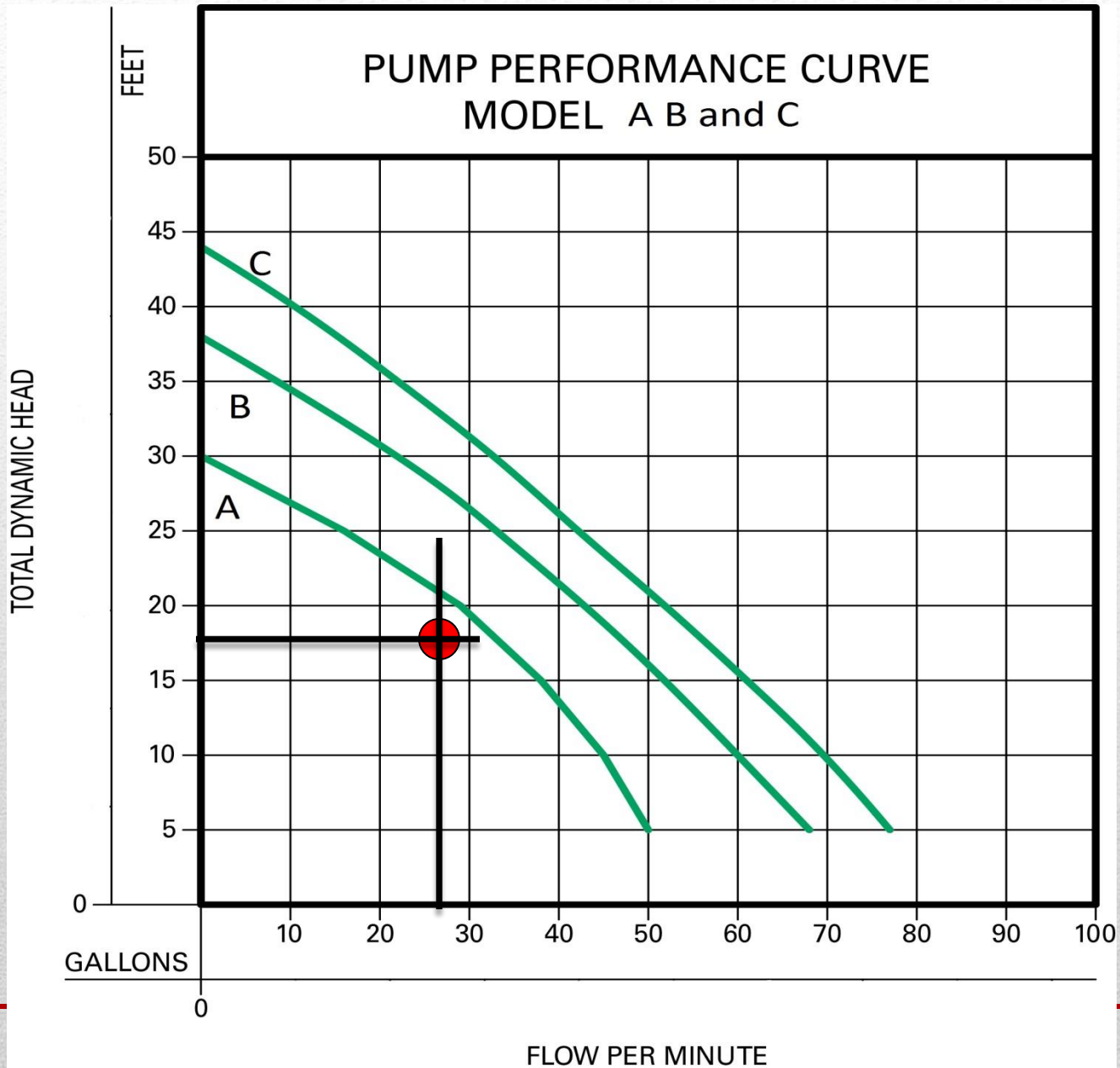
The pump must be able to pump 27.7 gpm at 17.74 ft. of Total Dynamic Head

GPM	H_e	H_f	H_r Chart 1	TDH
27.7	5.5 ft	7.24 ft	5.0 ft	17.74ft

Calculations

Step 4---Selecting the Pump

- #1. Plot the point where 27.7 GPM intersects 17.74 ft. TDH on the pump curve(s) chart
 - #2. The point must be below the pump curve.
 - #3. Select the pump best suited for the job.
-



Step 5---Calculate Operating Point of Selected Pump

- Pump A, B, and C all meet the requirements of the system because the pump curves are above the plotted point of the system.
 - Pump A is best pump to meet the minimum needs of the system.
 - Now that a Pump has been selected, re-calculate the TDH at a flow rate above the pump curve for pump A.
-

Orifice Discharge Rate Chart (gpm)

	Drill Size (in)						
Head (ft)	1/8	3/16	1/4	5/16	3/8	7/16	1/2
3	0.335	0.754	1.34	2.094	3.015	4.104	5.361
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9	0.58	1.306	2.321	3.627	5.223	7.109	9.285
10	0.612	1.376	2.447	3.823	5.505	7.493	9.787

Use a higher residual head to find a new flow rate above the pump curve.

Table 1 states a 1/2" orifice with a residual head of ten feet will have a flow rate of 9.787 gpm

4 orifices at 9.787gpm = 39.148gpm

This is the new flow rate above the pump curve

Step 5---Calculate Operating Point of Selected Pump

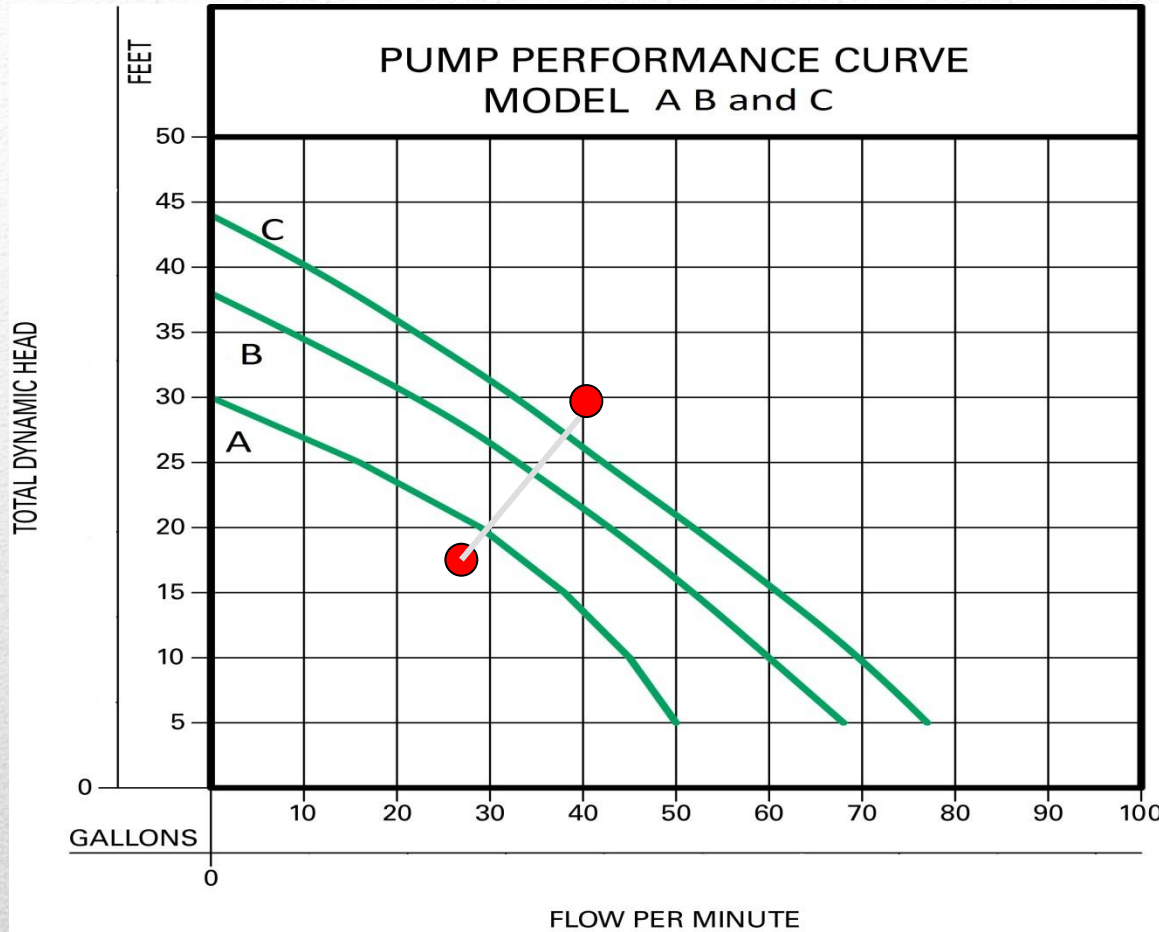
GPM	H _e	H _f	H _r Chart 1	TDH
27.7	5.5 ft	7.24 ft	5.0 ft	17.74ft
39	5.5 ft	$11.3 \times 0.90 = 10.17 + 20\%$ 12.2 ft	10 ft	27.7ft

- Recalculate the friction loss in force main with the new higher flow point above the curve

- *Hint* Elevation will not change

➤ **Step 5---Calculate Operating Point of Selected Pump**

- Plot the points (gpm/tdh) on pump curve A
 - Connect both points with a line to find the system curve
 - Where the system curve intersects the pump curve is the operating point for the pump.
-



System curve crosses pump curve at 30GPM. This will be the pump operating point for Pump A.

Pump A operating point

Step 6---Setting the Pump Timers

Need to Know:

#1. Dose Volume (step 1) --- 92.5 gal

#2. Number of Doses per Day--- 4

(Assume 370 gpd for daily flow)

$$370 \text{ gpd} \div 92.5 \text{ gal} = 4 \text{ doses per day}$$

#3. Dose Interval

Calculating Dose Interval

- 60 min. per hour x 24 hrs = 1440 min. per day
 - Dose Interval is Pump On + Pump Off
 - 1440 min. per day ÷ 4 doses per day = 360 minutes between doses (Dose Interval)
 - Pump On = 92.5 gal per dose / 30 gpm (pump operating point from step 5) = 3.08 or 3.08 minutes or 185 seconds
 - Timer is set for the pump to run for 3.1 minutes and be off for **356.9** minutes
-

Down

Need to Know:

#1. Dimensions of Tank

48 in. long

70 in. wide

50 in. to the bottom of the outlet

#2. 1 gallon of water = 231 cubic inches

Step 7---Calculate the Draw Down

$$\text{Volume} = L \times W \times H^*$$

*The height is normally calculated to the outlet flow line since that is the typical working liquid volume level

$$V = 48 \text{ in.} \times 70 \text{ in.} \times 50 \text{ in.} = 168,000 \text{ in}^3$$

$$168,000 \text{ in}^3 \div 231 \text{ in}^3 = 727.3 \text{ gallons}$$

$$727.3 \text{ gallons} \div 50 \text{ inches}^* = 14.5 \text{ gal/in.}$$

92.5 gallons \div 14.5 gal/in = 6.4 inch draw down
for a 92.5 gallon dose

Step 8---Tank Reserve

To set a reserve capacity in the tank to prevent floating and pulling solids off the bottom, select a reserve volume (250 gal)

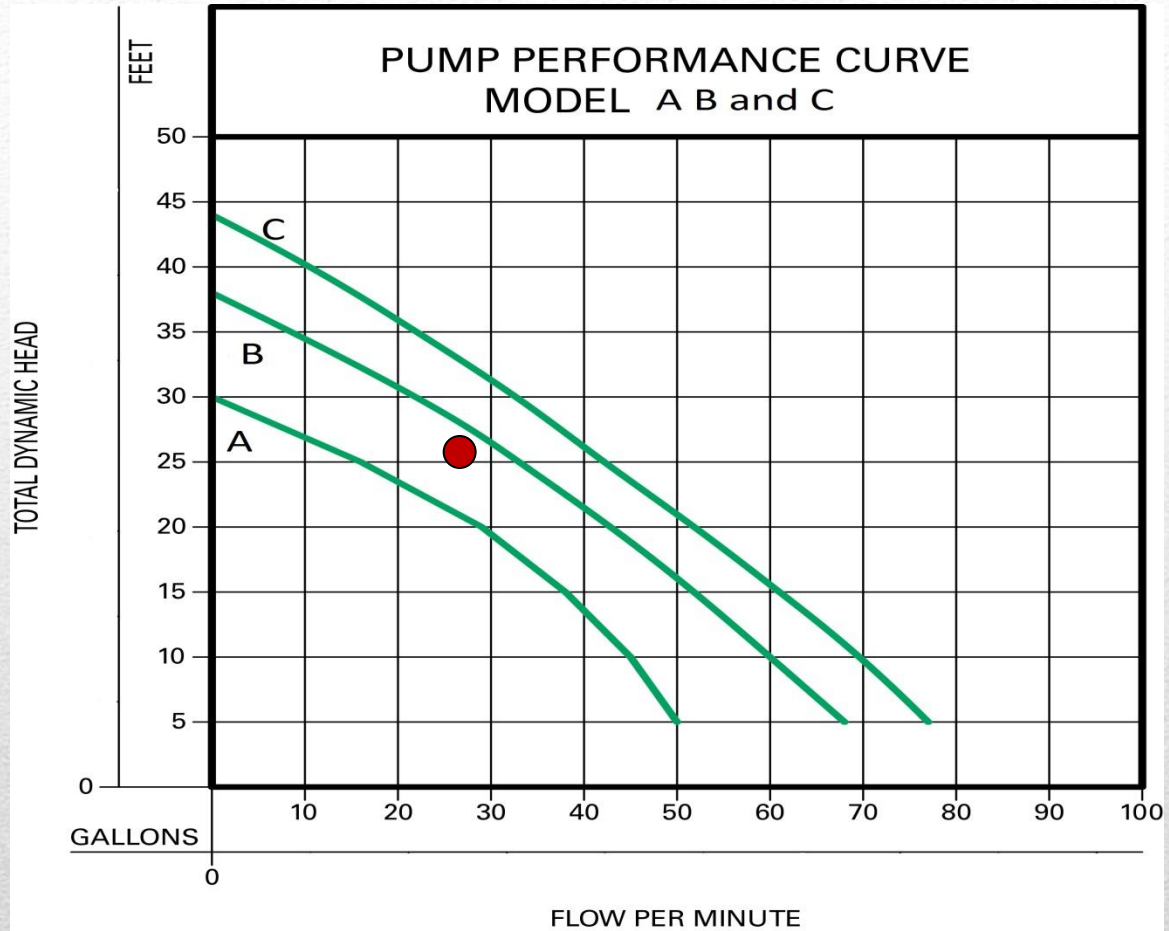
$250 \text{ gal} \div 14.5 \text{ gal/in} = 17.24 \text{ inches}$ of liquid required below the pump shut off.

Questions/pump concepts

- ➔ List all pumps that would meet the needs of the system if the elevation difference between the pump and the manifold was increased to 15.5'.
-

Calculations

GPM	H_e	H_f	H_r Chart 1	TDH
27.7	5.5 ft	7.24 ft	5.0 ft	17.74ft
27.7	15.5	7.24 ft	5.0	27.74ft



New system design point

Questions/pump concepts

- ⇒ List all pumps that would meet the needs of the system if the elevation difference between the pump and the manifold was increased to 15.5’.
 - ⇒ Pumps B and C
-

Questions/pump concepts

- ➔ List all pumps that would meet the needs of the system if the force main was decreased to 1” on the original system with 27.7 gpm?
-

Calculations

GPM	H _e	H _f	H _r Chart 1	TDH
27.7	5.5 ft	7.24 ft	5.0 ft	17.74ft
27.7	5.5 ft	$(36.7 \times 0.90) + 20\%$ 39.6 ft	5.0 ft	50.1 ft

Questions/pump concepts

- ➔ List all pumps that would meet the needs of the system if they force main was decreased to 1” on the original system with 27.7 gpm?
 - ➔ None
-

Questions/pump concepts

Why is it important to maintain the 5' residual head or squirt height?

To keep orifices clean.

Questions/pump concepts

- ➔ List all the pumps that would work if the system had 8 lines instead of 4.
 - ➔ Do we need to do any calculations?
 - ➔ What is $2 \times 27.7\text{gpm}$?
 - ➔ Do we have a pump that can perform at 55.4gpm and a higher TDH than the original?
-

Pressure Manifold Practice Problems

(Be able to work these types of problems for the math section of the exam)

(Answers on the following page)

1. What is the pump run time for Pump A with a TDH of 25' if the dose volume is 60 gallons?

Note: Use Figure 1 below.

2. What is the total flow per minute in a system with two ½" orifice, two ¼" orifice, and one ¾" with 4' of residual head?

Note: Use Figure 2 below

3. List all the pumps capable of meeting the needs for a system running at 30' of TDH and 20 gpm.

Note: Use Figure 1 below.

4. What friction head loss would be expected through 175' feet of 1.5" Sch 40 pipe if the pump is operating at 25 gpm?

Use Figure 2 and add 20% for loss through fittings.

5. What is the liquid volume in gallons of a septic tank with the following **inside** dimensions:

Length – 102"; Width – 57"; Total Height – 66"; Bottom of outlet flow line – 44"

6. If a timed dose system has 12 dosing cycles per day and a pump run time of 6 minutes per dose, how much time should pass between doses?

7. How long will a pump run time be if the total dose volume is 60 gallons and the pump flow is 30 gpm?

Use the following information to answer questions 8-12. This is a pump design with a short pressure manifold with one orifice per line.

Estimated Daily flow- 300 Gallons

Dose volume- 15% of daily flow

Orifice diameter- 3/8"

5 lines- 80' long

Residual Head- 5'

Pump "off" elevation- 89.4'

Manifold elevation- 102.8'

Distance to be pumped- 185'

Force main specs- 2" Sch 40 PVC

20% add-on for friction in fittings

8. What is the minimum total flow rate for this system?

9. What is the dose volume?

10. What is the total dynamic head based on the minimum total flow rate in Question 9?

11. Which pumps would work for this system?

12. If the force main diameter were decreased to 1 ½", list the pumps that could operate in this system.

Note: Elevation and Residual head stay the same.

Answers to Math Work Sheet problems:

1. 4 minutes
2. 18.958 gpm
3. B and C
4. 9.87' of friction head loss
5. 1107.43 gallons
6. 114 minutes
7. 2 minutes
8. 19.465 gpm
9. 45 gallons
10. 20.4'
11. Pumps A, B or C; all will work
12. None

To solve:

Problem 1: At 25' of head, Pump A can flow about 15 gallon per minute.

$$60 \text{ gallons} \div 15 \text{ gallons per minute} = 4 \text{ minutes}$$

Problem 2: Here is the flow per orifice (in gpm) at 4' residual head; add flow from each orifice for total

$\frac{1}{2}$ " – 6.19 x 2 orifices	= 12.38
$\frac{1}{4}$ " – 1.548 x 2 orifices	= 3.096
$\frac{3}{8}$ " – 3.482 x 1 orifice	= 3.482
13.842 + 3.096 + 3.482	= 18.958 gpm

Problem 3: At 30' TDH and 20 GPM, only the pump curves for B and C are above that point. That point is above the Pump A curve so it will not work for this system.

Problem 4: Since we chart is the friction loss per 100 ft of PVC, we have to convert our actually force main length to calculate the total friction loss.

$$175' \text{ (actual pipe length)} \div 100' \text{ (chart unit)} = 1.75$$
$$25 \text{ gpm in } 1 \frac{1}{2}" \text{ SCH 40 PVC is } 4.7' \text{ of head loss per } 100' \text{ of pipe (from chart)}$$
$$4.7 \times 1.75 = 8.225'$$
$$8.225 \times 1.2 \text{ (to add 20\% for fitting)} = 9.87' \text{ of loss}$$

Problem 5: Use Inside Tank Length, Width and Liquid Depth. Liquid Depth is to the bottom of outlet flow line

$$\frac{102" \times 57" \times 44"}{231 \text{ in}^3/\text{gallon}} = \frac{255816 \text{ in}^3}{231 \text{ in}^3/\text{gallon}} = 1107.43 \text{ gallons}$$

Problem 6: A dose cycle has two parts: pump run time and pump off time. The problem gives the pump run time, but we have to calculate pump off time. Start by calculating the total minutes in a day.

$$24 \text{ hours} \times 60 \text{ mins/hr} = 1440 \text{ minutes in a day;}$$
$$\text{If we have 12 dose cycle in a day, then } 1440 \text{ mins} \div 12 \text{ dose cycles} = 120 \text{ minutes per dose cycle}$$
$$\text{If does cycle is } 120 \text{ minutes} = \text{Pump run time} + \text{pump off time, then}$$
$$120 \text{ minutes} - 6 \text{ minutes} = \text{pump off time;}$$
$$114 \text{ minutes} = \text{pump off time.}$$

Pump runs for 6 minutes and is off for 114 minutes, then runs for 6 minutes, off for 114 minutes, etc.

Problem 7: 60 gallons per minutes (dose volume) \div 30 gallons per minute = 2 minutes

Problem 8: Minimum flow rate is calculated by the number of orifices and the flow per orifice.
A 3/8" orifice at 5' residual head puts out 3.893 gallons per minute per orifice;
3.893 gpm x 5 orifices (there are 5 lines) = 19.465 gpm

Problem 9: Problem states the dose volume is 15% of daily flow and that daily flow is 300 gpd;
15% of 300 = 0.15 x 300 = 45 gallons.

Problem 10: There are three parts to total dynamic head: residual head, friction loss and elevation change. Calculate each and add to total.

1. Residual head: Given in the problem as **5'**
2. Friction loss: 185' of 2" SCH40 at 20 gpm:
Friction loss in 20 gpm in 2" SCH40 is 0.9' (per 100 ft) (from chart)
 $185' / 100' \text{ (chart is per 100')} = 1.85$
 $0.9' \text{ per } 100' \times 1.85 = 1.665$ (have to add 20% for fitting loss)
 $1.665' \times 1.2 = \mathbf{2.0' \text{ of friction loss}}$
3. Elevation change: (not rod readings)
Manifold elevation: 102.8
Pump elevation: 89.4
 $102.8' - 89.4' = \mathbf{13.4' \text{ of elevation}}$
TDH = 5' + 2' + 13.4' = 20.4'

Problem 11: At 20.4' of head and 20 gpm, any of the pumps would work since the point is below all of the pump curves. The point is closest to the Pump A curve, so it is best suited.

Problem 12: There are three parts to total dynamic head: residual head, friction loss and elevation change. Calculate each and add to total.

1. Residual head: Given in the problem as **5'** and stays the same.
2. Friction loss: 185' of 1" SCH40 at 20 gpm:
Friction loss in 20 gpm in 1" SCH40 is 17.2' (per 100 ft) (from chart)
 $185' / 100' \text{ (chart is per 100')} = 1.85$
 $17.2' \text{ per } 100' \times 1.85 = 31.82$ (have to add 20% for fitting loss)
 $31.82' \times 1.2 = \mathbf{38.184' \text{ of friction loss}}$
3. Elevation change: (Stays the same)
Manifold elevation: 102.8
Pump elevation: 89.4
 $102.8' - 89.4' = \mathbf{13.4' \text{ of elevation}}$
TDH = 5' + 38.184' + 13.4' = 56.584'

56' of TDH is above what our chart goes to, so none of the pumps can operate at 56' of TDH and 20 gpm. We will need another pump curve.

FIGURE 1: Pump Performance Curves

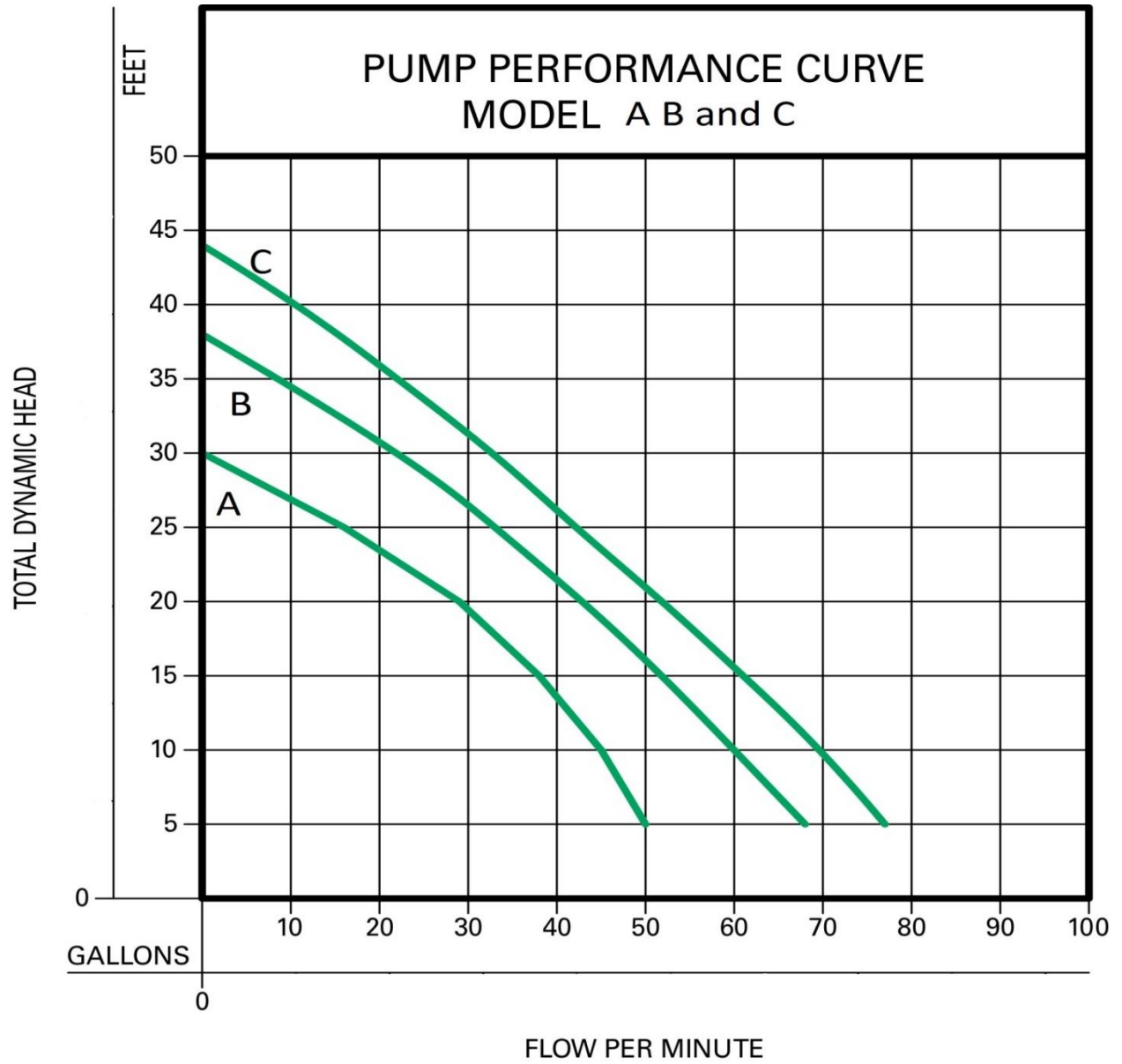


Figure 2: Orifice Discharge Rate Chart

Orifice Discharge Rate Chart (gpm)							
Orifice size (in)							
	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Head (ft)							
3	0.335	0.754	1.34	2.094	3.015	4.104	5.361
4	0.387	0.871	1.548	2.418	3.482	4.739	6.19
5	0.4326	0.973	1.73	2.703	3.893	5.299	6.921
6	0.474	1.066	1.895	2.961	4.264	5.804	7.581
7	0.512	1.152	2.047	3.199	4.606	6.27	8.189
8	0.547	1.231	2.189	3.42	4.924	6.702	8.754
9	0.58	1.306	2.321	3.627	5.223	7.109	9.285
10	0.612	1.376	2.447	3.823	5.505	7.493	9.787

Figure 3: Friction Loss in SCH40 PVC Chart

TABLE II

Friction Head Loss per 100 feet of Schedule 40 PVC Pipe

Flow rate, gpm	Pipe Diameter				
	1"	1 1/4 "	1 1/2"	2"	3"
5	1.3	0.5	0.2	0.1	0.01
10	4.8	1.8	0.9	0.3	0.04
15	10.2	3.9	1.8	0.5	0.08
20	17.2	6.7	3.1	0.9	0.14
25	26.2	10.1	4.7	1.4	0.2
30	36.7	14.1	6.7	2.0	0.3
35	48.8	18.7	8.8	2.6	0.4
40	62.5	24.0	11.3	3.4	0.5
45	77.7	29.9	14.1	4.2	0.6
50	94.4	36.3	17.1	5.1	0.7
55	112.7	43.3	20.4	6.1	0.9
60	132.3	50.9	24.0	7.1	1.0
65		59.0	27.8	8.2	1.2
70		67.7	31.9	9.5	1.4
75		76.9	36.3	10.7	1.6
80		86.7	40.9	12.1	1.8