SUBCOURSE
QM5201

EDITION
A

PUMP GRAPHS

READINESS/
PROFESSIONALISM
THRU
GROWTH

THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM

PUMP GRAPHS

Subcourse Number QM5201

EDITION A

United States Army Combined Arms Support Command
Training Directorate
Fort Lee, Virginia 23801-1809

3 Credit Hours

Edition Date: September 1998

SUBCOURSE OVERVIEW

This subcourse is designed to teach the skills necessary for performing task related to using pump graphs.

There are no prerequisites for this subcourse.

This subcourse reflects the doctrine which was current at the time it was prepared. In your own work situation, always refer to the latest official publication.

Unless otherwise stated, the masculine gender of singular pronouns is used to refer to both men and women.

TERMINAL LEARNING OBJECTIVE

ACTION: You will use pump graphs and also determine flow rate, feet of head, PSI available, and pump size for pump stations.

CONDITION: You are a petroleum management officer. You are given information on how to use pump graphs. You must be able to read pump graphs to ensure maximum efficiency of pumps available to you and to supervise your personnel.

STANDARD: To demonstrate competency of this task, you must achieve a minimum of 70 percent on the subcourse examination.

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LESSON

PUMP GRAPHS

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OVERVIEW

LESSON DESCRIPTION:

In this lesson, you will learn how to read and use pump graphs.

TERMINAL LEARNING OBJECTIVE

ACTION: You will use the pump graphs to determine the flow rate, feet of head, PSI available, and pump size for pump stations.

CONDITION: You are a petroleum management officer. You are given information on how to use pump graphs. You are given pump graphs for all military pumps used on a petroleum pipeline. You must be able to read pump graphs to ensure maximum efficiency of pumps available to you and to supervise your personnel.

STANDARD: You will identify on pump graphs the setting of a petroleum pipeline operation to obtain maximum efficiency of available pumps.

REFERENCES: The materials contained in this lesson were derived from the following publications: FM 10-67-1 and FM 5-482.

INTRODUCTION

As a future petroleum officer, you may find yourself planning and managing petroleum pipelines and pump stations. To get the most efficient performance from the system, you must be familiar with the operating characteristics of the pump stations. An easy way to determine these characteristics is through the use of pump graphs. By using the pump graphs you will be able to obtain maximum efficiency of the available pumps.

Pumping unit operation graphs (performance curves) graphically display the interrelationship between pressure (in feet of head and/or PSI), pump speed, and throughput. From these graphs, you can estimate the pumping unit's operating speeds, the volume of fuel throughput, or the operating head as long as you know two of the three factors. Pump graphs are an integral part of pump stations, pipeline, and terminal operations.

Pump stations are combinations of two or more pump units with connecting manifolds installed where needed along a pipeline to move products through the line to storage or to dispensing facilities. Pump stations are engineer facilities constructed of standard line pipe or IPDS-coupled pipeline with couplings, nipples, valves, fittings, strainers, scraper-receiver assembly, sandtraps, and the required number of pumps. Pipeline pump stations are installed on the main line to keep the product moving at the desired flow rate.

Petroleum pipeline systems vary in complexity depending on the size of the theater of operations. The systems can range from a single product line with one terminal to a series of multiproduct lines with several terminals. Pipelines are used as far forward as tactically feasible. To operate any pipeline successfully, all personnel must understand their responsibilities in controlling the operations. Control of the pipeline operations begins at the operating headquarters with the chief dispatcher and ends with the terminal operating platoon.

1. Hydraulic System Terms. The following terms are presented to aid in the understanding of petroleum terminology. Definitions of these terms will add to the understanding of the terminology used in this lesson.

a. Brake horsepower: The amount of measurable horsepower after deduction for friction loss.

b. Efficiency (%): The efficiency expressed in the percent at which a pump operates at a specific RPM.

c. Emergency head capacity: Pressure in FTH which a pumping unit produces at the maximum rate of discharge.

d. Feeder (flood) pumps: Pumps generally installed to supply the required suction pressure between tank farm installations and main line (trunk) pump stations or to feed fuel through short branch lines to dispensing tankage installations.

e. Head: An expression of pressure, usually stated in terms of inches or feet.

f. Dynamic head: A measure of pressure in liquids in motion.

g. Feet of head: The measure of pressure in terms of the height in feet of a column of liquid of a given fuel.

h. Static head: A measure of pressure in liquids at rest; pressure produced with a column of liquid because of weight alone.

i. Impeller: A device, which impels or pushes forward, such as the rotor of a centrifugal pump or air compressor.

j. Incremental pressure: The difference between the suction and discharge pressure of a pump or of a multipump pumping station.

k. Parallel connection: The arrangement of two or more pumps to discharge their cumulative output at the discharge pressure of one pump.

l. Series connection: The arrangement of two or more pumps to discharge the output of one pump at the cumulative discharge pressure of all pumps.

m. Stage: Grade, level, or step, as in the case of liquid passing through an impeller of a pumping unit with more than one impeller.

n. Throughput: Capacity, quantity transported per unit of time, BPD, GPM/GPH.

2. Operating Characteristics of Pumps. Pumping mechanisms can be broken into two major categories: positive displacement pumps and kinetic pumps. The positive displacement of fluids is the principle behind positive displacement pumps. The most common types of positive displacement pumps are reciprocating and rotary pumps.

a. Reciprocating pumps are similar in theory to reciprocating engines. A piston is used to move fluid into a cylinder on the downstroke then move the fluid out of the cylinder on the upstroke. Reciprocating pumps provide high suction lift and high pressure for small quantities of flow as the pistons move up and down.

b. Rotary pumps use a screw-type device to trap fluids in the cylinder and force it out of the chamber. This type of pump is used with gasoline or other low viscosity fuels when high suction lift is required. The rotary pump provides a smooth, even flow.

c. The most common type of kinetic pump is the centrifugal pump. Centrifugal pumps depend on centrifugal force for their operation. Centrifugal force acts on the body moving in a circular path, tending to force it farther away from the axis or center point of the circle described by the path of the rotating body.

(1) In a centrifugal pump, the power plant turns an impeller which creates centrifugal force in the pump housing and forces fuel out of the pump. Major advantages to centrifugal pumps are fewer moving parts; smooth, non pulsating flow; and a much higher capacity than positive displacement pumps. One of the disadvantages of centrifugal pumps is that it has a relatively lower head capacity than positive displacement pumps and the head capacity is based on the design of the impeller.

(2) Centrifugal pumps are often classified by their stages. A stage simply refers to the number of impellers on the pump. A one-stage pump has one impeller and a two-stage pump has two impellers. To increase the pressure of the pump, another impeller or stage must be added. Most Army pumps are single stage. Such as the 6-inch, single-stage, 600-and 1,250-GPM self-priming pump (IPDS). The Army's multistage pumps are: the 1,400-GPM pump is a six-inch two-stage pump used as a booster pump and 800-GPM mainline pump for IPDS, which is a three stage pump.

3. Conversion of PSI to FTH. FTH is defined as the measure of pressure in terms of the height in feet of a column of a given fuel. To measure this pressure, we need a standard. This standard has been developed using the one PSI gauge. The measure used as our standard was determined by using a square inch column of water at a constant 60°F. As depicted, 1 PSI is equal to 2.31 feet. We use this measurement as our constant. The gages on pumps are rated in PSI. To determine certain information, we may need to convert PSI into FTH. The formula for converting PSI to FTH is:

$$FTH = \frac{2.31 \times PSI}{SG}$$

$$FTH = \frac{2.31 \times 165\ PSI}{0.725\ SG} = 526 \text{ feet of head}$$

or

$$FTH = \frac{PSI}{0.433 \times SG}$$

$$FTH = \frac{165\ PSI}{0.433 \times 0.725\ SG} = 526 \text{ feet of head}$$

To convert feet of head to PSI, the equation is:

$$PSI = \frac{FTH \times SG}{2.31} \qquad PSI = \frac{526 \times 0.725}{2.31} = 165\ PSI$$

or

$$PSI = 0.433 \times FTH \times SG \qquad 0.433 \times 526 \times 0.725 = 165\ PSI$$

4. Characteristics of Pump Graphs: A pump graph is constructed to show feet of head. It also shows the flow rate in gallons per minute, and barrels per hour. Pumps are equipped with gauges that register the suction and discharge pressure in PSI. Therefore, the operator must be able to convert PSI to feet of head to determine the flow rate and efficiency of the pump.

a. Data on pumping capacity, operating characteristics, operation, and maintenance procedures are in the manufacturer's manual which is packaged with each pump. Presently petroleum pipeline operations consist of the IPDS. In this system, there are three different sizes of pumps, the 6-inch single-stage, 600-GPM self-priming pump; the 6-inch, single-stage, 1,250-GPM self-priming pump; and the 6-inch, three-stage, 800-GPM mainline pump (IPDS).

b. See Figure 1. It is a uniform scale; that is, there is an equal space between all units on the graph in both directions. Rate of flow is plotted along the horizontal axis, increasing from left to right in GPM (cubic meters per hour) on the bottom. The remaining variables are plotted along vertical axis, increasing from bottom to top. Each of the RPM curves represents the other variables at a specific engine operating speed. Engine speed is shown in 100 RPM increments from 2,000 RPM to 2,400 RPM (maximum governed speed). Along the left side of the scale, discharge pressures are shown in PSI and FTH for 1.00, 0.72, and 0.85 specific gravity liquids.

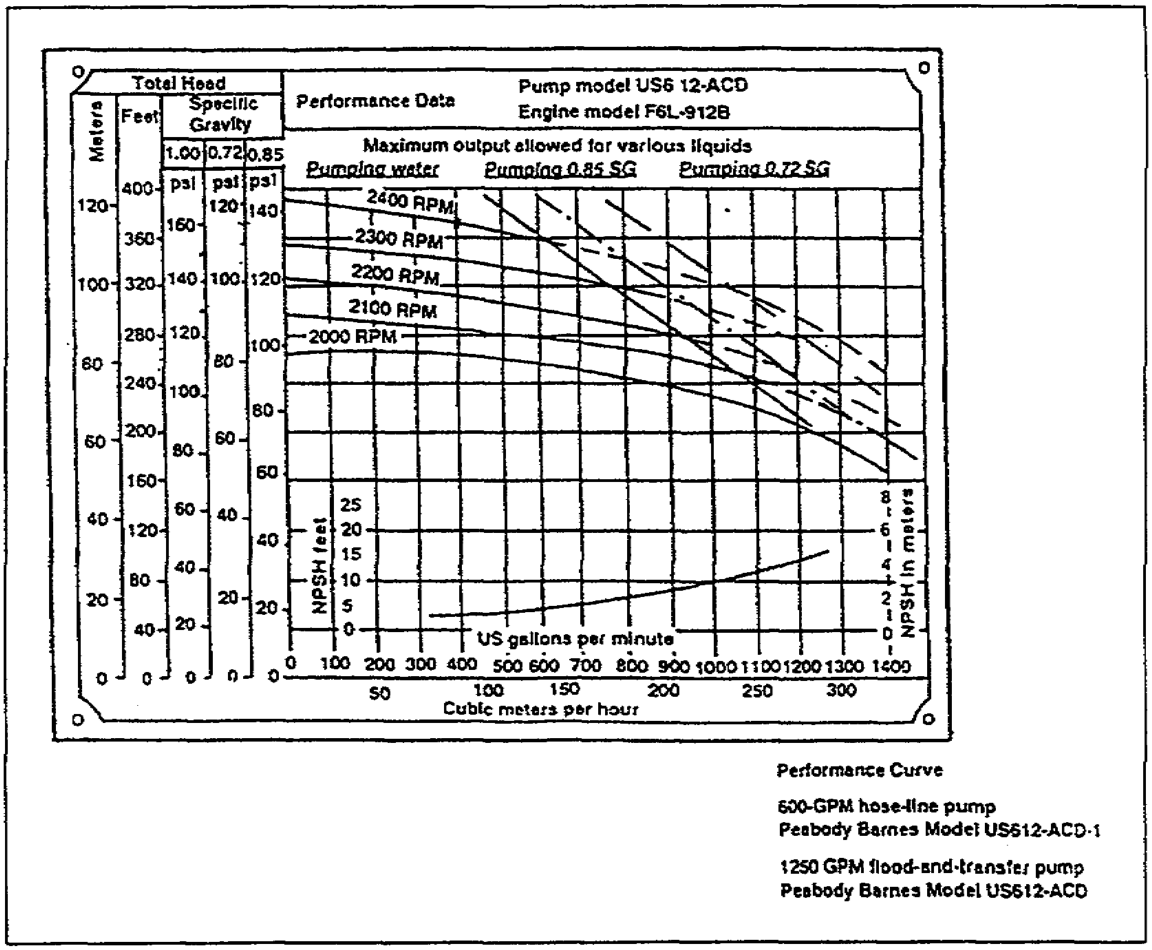


Figure 1. Pump performance: 6-inch, single-stage, 600- and 1,250-GPM self-priming pump

5. Application of the Pump Graph. A common application of a pump graph is its use in determining the rate of flow, efficiency, and brake horsepower, given the total dynamic head in feet and the operating speed of the engine in RPM. Rate of flow is the most commonly desired quantity on the graph, and it can be expressed in GPM or BPH.

a. Figure 1. Shows the Pump performance for a 6-inch, single-stage, 600-and 1,250-GPM self-priming pump. The 600-GPM pump is designed to pump petroleum or potable water at a maximum operational output of 600-GPM at 150 PSI. The 1,250-GPM pump is designed to pump petroleum or potable water at a maximum operational output of 1,250-GPM at 180 FTH or 66.2 PSI. The difference between the two pumps is the 600-GPM pump is designed for use with the tactical hoseline; it operates at higher pressure but lower volume. The 1,250-GPM pump is a flood and transfer pump designed to provide high volume with low pressure to your 800-GPM mainline pump (IPDS). Using the pump graph in Figure 1. Given a 6-inch, single-stage, 600-GPM self-priming pump with a head capacity of 2,100 RPM; 35°F API gravity; and a operating pressure of 103 PSI, determine all other factors. See Figure 1. to determine the rate of flow and feet of head.

(1) First determine type of fuel. Use the following formula: Note both SG and API is at 60°F.

$$SG = \frac{141.5}{API + 131.5}$$

SG = 0.8498 = 0.85 on pump performance graph (diesel)

(2) Enter the graph on the vertical line at 103 PSI for diesel. Follow this line horizontally to the right until it intersects the head capacity cure for 2,100 RPM. At this point, all the answers are determined vertically up or down, and horizontally right or left.

(3) To read the rate of flow in GPM, move down to the horizontal line for GPM and read the answer: 500-GPM.

(4) To determine the FTH read to the left of PSI. To be more accurate or to confirm your reading, go through the formula that was given earlier as follows:

$$H = \frac{2.31 \text{ X } 103}{0.85} = 279.9 \text{ FTH}$$

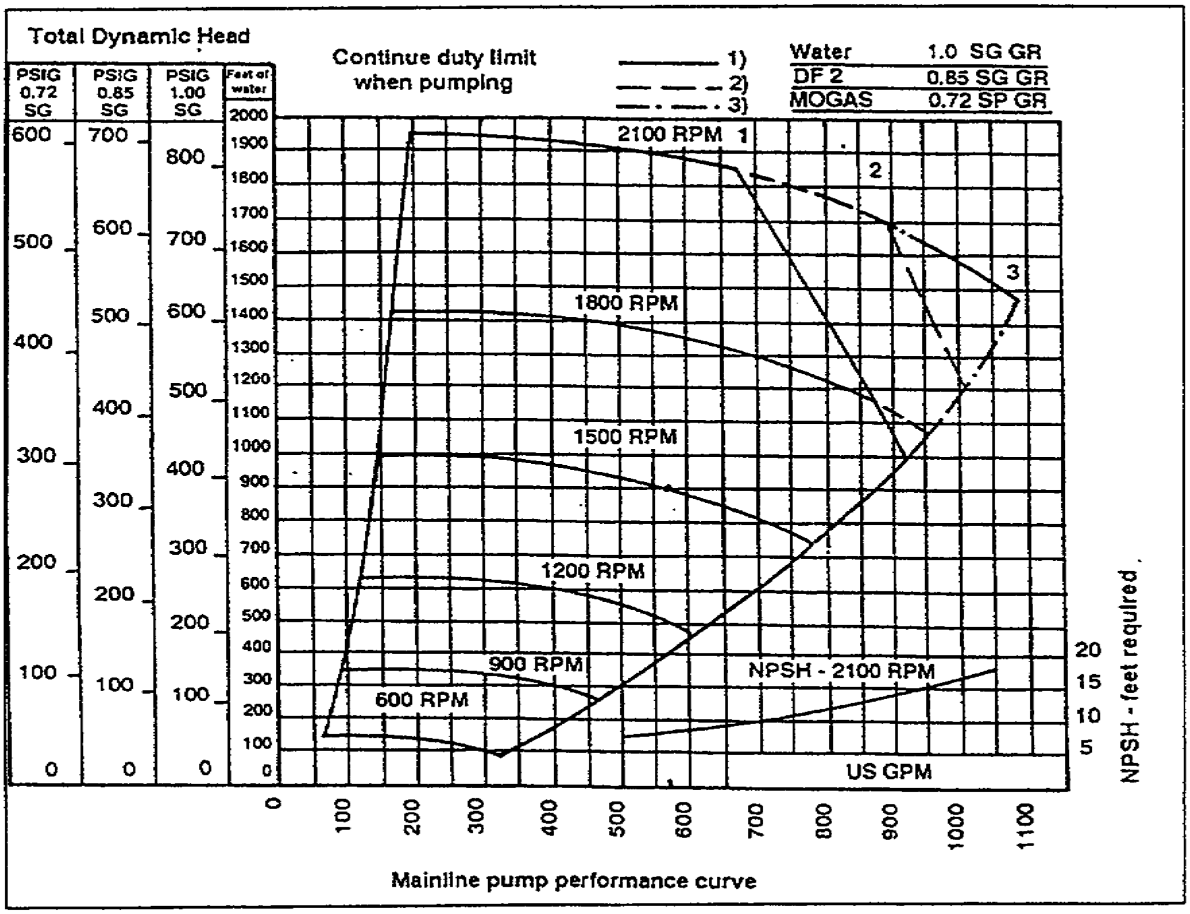


Figure 2. The 6-inch, three-stage, 800-GPM mainline pump (IPDS)

b. Figure 2 shows the pump performance of a 6-inch, three-stage, 800-GPM mainline pump (IPDS), operational output of 800-GPM at 1,800 FTH, at 2,100 RPM, when pumping liquids with specific gravity of 0.85 (diesel). Using the pump graph in Figure 2. Given a 6-inch, three-stage, 800-GPM mainline pump (IPDS) with a head capacity of 1,800 RPM, product diesel, and a operating pressure of 450 PSI, determine all other factors. See Figure 2 to determine the rate of flow and FTH.

(1) Enter the graph on the vertical line at 450 PSI for diesel. Follow this line horizontally to the right until it intersects the head capacity curve for 1,800 RPM. At this point, all the answers are determined vertically, and horizontally.

(2) To read the rate of flow in GPM, move down to the horizontal line for GM and read the answer 780 GPM.

(3) To determine the FTH, read to the left of PSI. To be more accurate or to confirm your reading, go through the formula that was given earlier as follows:

$$H = \frac{2.31 \times 450}{0.85} = 1{,}222.9 \text{ FTH}$$

6. Series and Parallel Installation of Pumps. Pumps are normally hooked up either in series or in parallel. A pump hydraulic system is very similar to an electrical system. Electrical storage batteries are described in terms of series or parallel hookups. To get 12 volts of electricity, two 6-volt batteries must be connected in series. The same two 6-volt batteries connected in parallel yield 6 volts of electricity, but the current doubles. In other words, head capacity resembles voltage, and flow rate resembles current. Both types of hookups (manifold) have certain advantages. Two pumps connected in series double the head capacity of a single pump, while the flow rate remains the same as for a single pump. Two pumps connected in parallel double the flow rate capability of a single pump, while the head capacity remains the same as for a single pump.

a. Pump station operation in series. Pumps in a mainline pump station are invariably hooked up in series, since the primary consideration is head capacity. Pumps hooked up in series actually pump the fuel more than once. This repeated pumping builds up high pressure, which pushes the fuel through the pipeline for a long distance to the next pump station. The 6-inch, single-stage and the 4-inch, four-stage pumps can be hooked up in series by use of a crossover pipe (Figure 3). The 4-inch, four-stage pump unit is preset to always operate in series.

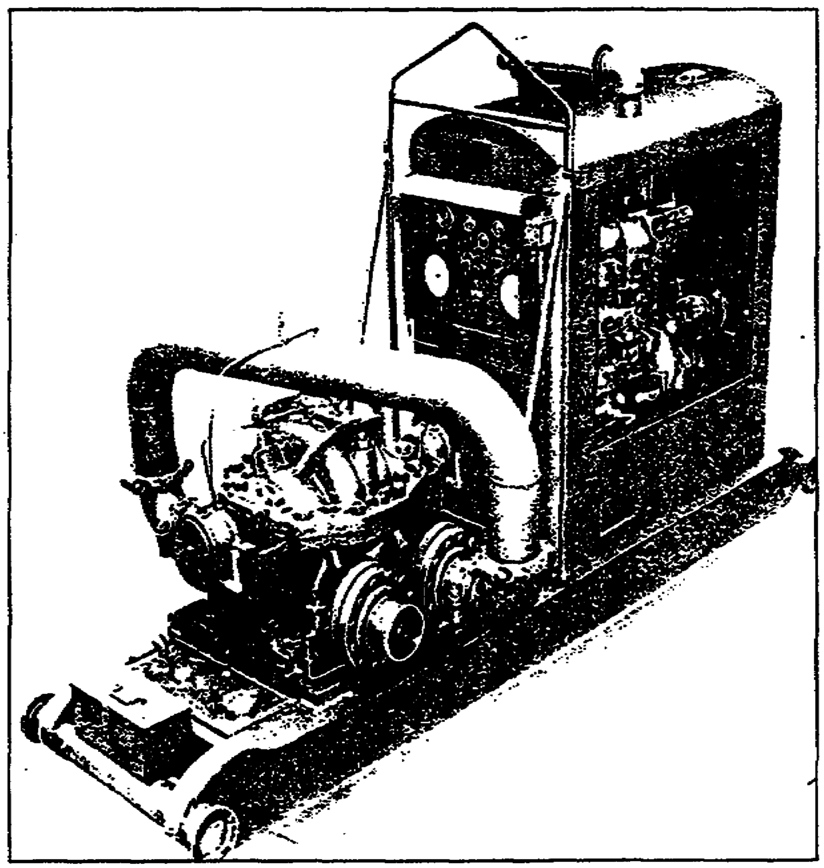


Figure 3. The 6-inch, two-stage pumping unit

b. Pump station operation in parallel. Parallel operation is not normally used on petroleum pipelines but can be found in terminal operations due to the capability to move high volumes of fuel. Parallel installation increases flow rate capability without increasing head capacity. The lower the head capacity, the closer together pump stations must be located; therefore, the more pump stations required for a given length of pipeline. Only the 6-inch, two-stage pump can be placed in parallel operation. Paralleling means that fuel flows through both stages at the same time. This increases the volume and output of the pump. The pump is put into parallel by using Y flanges (Figure 4), which are attached the suction and discharge side of the pump.

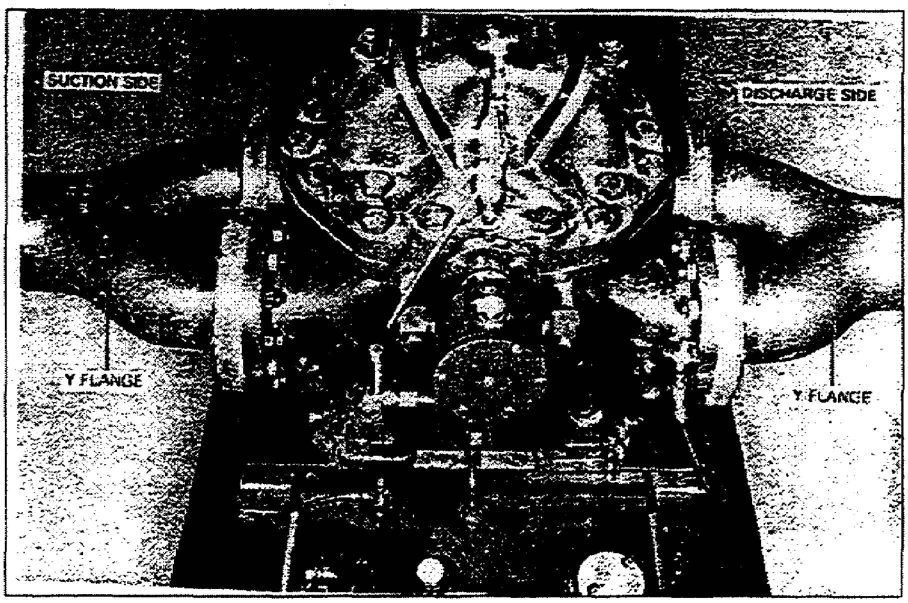


Figure 4. The 6-inch, two-stage pump with stages in parallel

7. <u>Effect of Pump Station Operations on Head Capacity and Flow Rate</u>. The normal head capacity of a pump station is the total head against which it will pump at the most efficient operating point. In other words, the design speed (RPM) of the pumping units must be considered together with the required head and desired throughput (GPM or BPH) to establish maximum efficiency in design. Optimum standard military pipeline head capacities of pipeline pump units are shown in Figure 5. It also shows these emergency capacities. Maximum head capacities are for emergency operations only and are never used as the basis for design. Pump stations should not be operated at maximum head capacity except during emergencies, and then for no longer than 24 hours. Normal capacities are used for pipeline designing.

Size of Line Nominal (in)	Pump Units per Station		Normal Design Capacity							Emergency Capacity						
	Number	Type	Number of pumps operating	Net available head (ft)	Net available pressure (psi)	Barrels per hour	Barrels per day (24-hour operation)	Engine speed (rpm)	Hydraulic horse-power	Number of pumps operating	Net available head (ft)	Net available pressure (psi)	Barrels per hour	Barrels per day (24-hour operation)	Engine speed (rpm)	Hydraulic horse-power
4	2	A	2	1,072	336	355	8,520	1,800	48.7	2	1,321	614	393	9,432	2,000	66.4
6	4	A	3	1,342	427	785	18,840	1,800	136.8	4	2,233	700	1,000	24,000	2,000	285.7
6*	2	C	1	1,800	565	857	20,570	2,000	197.7	1	1,800	565	1,143	27,429	2,100	263.3
8	4	B	3	973	305	1,355	35,520	1,850	168.7	4	1,522	477	1,730	41,520	2,100	336.8
8	2	B	2	313	98	2,860	68,640	1,850	114.4	2	354	111	3,570	85,680	2,100	161.7
12	4	B	4	201	63	7,150	171,600	1,850	183.8	4	217	68	11,400	273,600	2,100	316.4

[1]Based on fuel of 0.725 specific gravity and normal operating conditions
A - 4-inch, 4-stage
B - 6-inch, 2-stage
C - 6-inch, 3-stage
*6-inch aluminum pipe based on 0.85 specific gravity fuel

Figure 5. Operating characteristics of a standard pipeline pumping station

8. Determining of Pump Speed.

There should be only enough pumps on line (operating) at any station to produce the required pressure (FTH) and throughput (GPM or BPH). Further regulate pressure by adjusting pump speeds between minimum and maximum speeds permitted. Determining pump speeds is largely based on experience. Pump speeds are highly variable, influenced by line diameter, number of pumps on line, specific gravity and viscosity of products, and other hydraulic characteristics of the particular pipeline and pump station in operation. Pump station pump speeds may also be determined using Figure 6. These graphs are for three or four pumps in series.

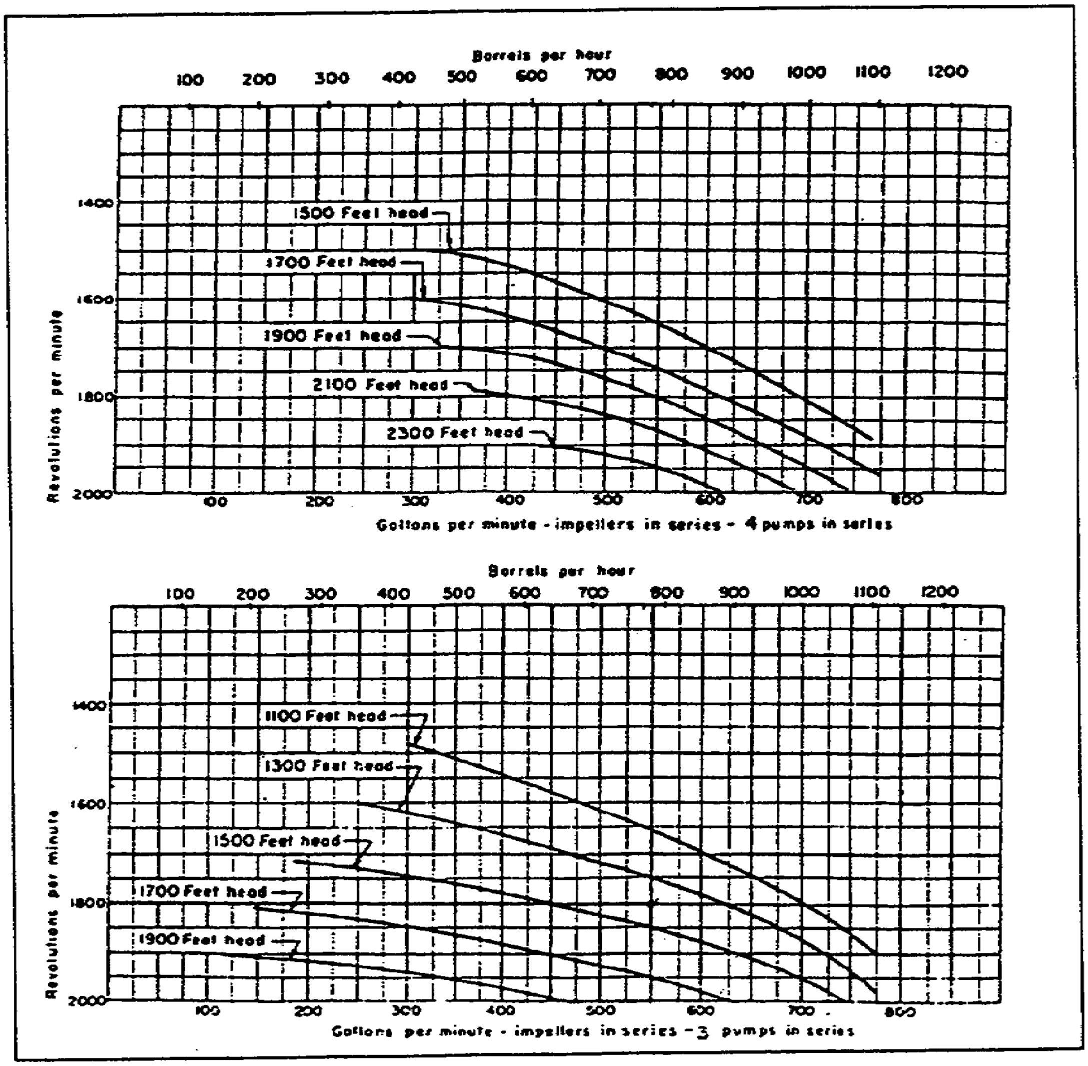


Figure 6. Operating characteristics of a standard pump station for 6-inch pipeline

a. Figures 6 and 7 shows the operating characteristics of pipeline pump station facilities. From these graphs, any one of three factors--the pumping unit operating speeds, the volume of fuel throughput and the operating head--may be estimated provided the other two factors are known. For example, determine the operating speed required for three--pump operation of a station on 6-inch pipeline to deliver 785 BPH (550 GPM) against a head loss to the next station of 1,395 feet.

(1) Enter the bottom chart in Figure 6 at 550 GPM. Follow the vertical line at this point to about midway between the curves labeled "1,300 FTH" and "1,500 FTH."

(2) Follow the intersecting horizontal line to the left side of the chart and read 1,800 RPM. Therefore, the three-pump operation calls for speed for each pump of 1,800 RPM. Similarly, assume that a single 6-inch booster pump is to be used to pump fuel from a marine terminal to a tank farm. Data includes that the pump must overcome 300 FTH loss between the dockside and tank farm.

c. See Figure 7. Assume that a single 6-inch booster pump is to be used to pump fuel from a marine terminal to a tank farm. Data includes that pump must overcome 300 FTH loss between the dockside and the tank farm. Determine the volume of fuel delivered by the pump at 1,800 RPM, assuming the pump stages are connected in series (single discharge). Find the point at which the 1,800-RPM line intersects the curve labeled "300 FTH." This point coincides approximately with the line representing 1,000 GPM. Therefore, the pump throughput is about 1,000 GPM or about 1,429 BPH.

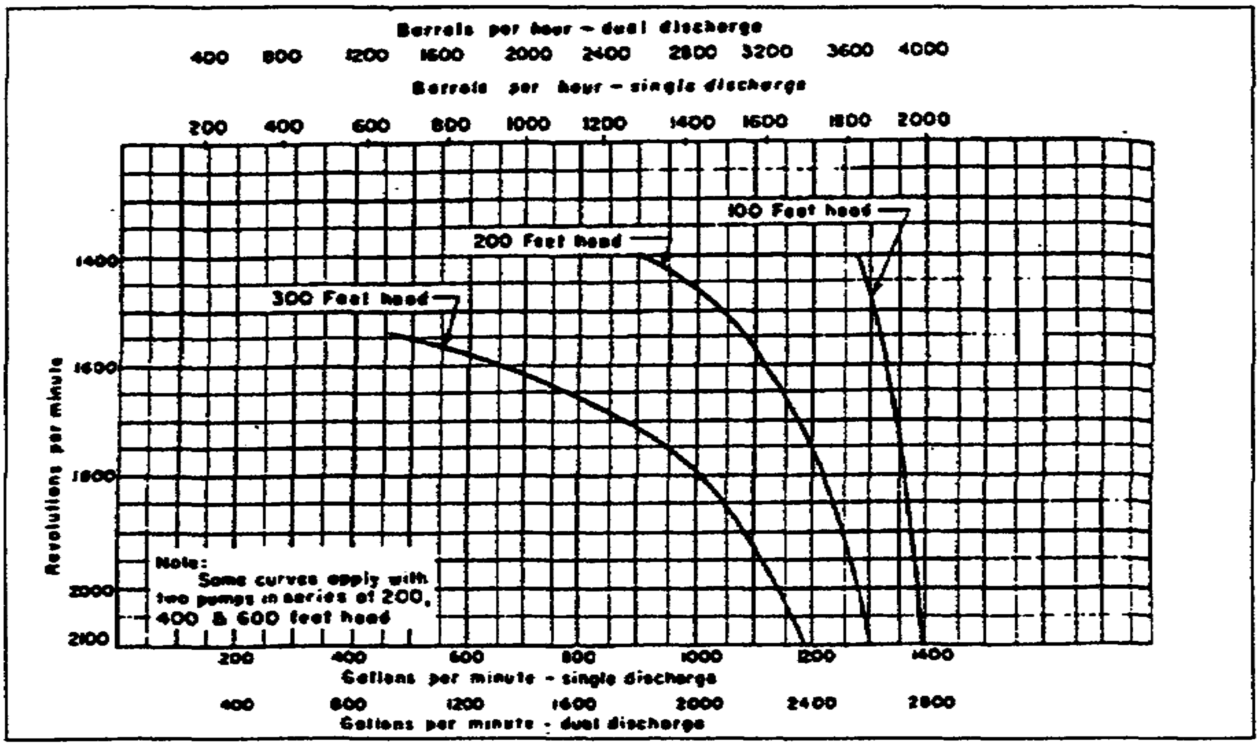


Figure 7. Operating characteristics of 6-inch, two-stage booster pump at constant head conditions

d. Individual pump stations must regulate pump speed (pressure) to keep suction pressures above the minimum at the next pump station downstream. It is desirable that pump station suction pressure be 20 PSI for elevations less than 5,000 feet and for temperatures below 100°F (20 PSI is equivalent to 64 feet of military gasoline (MOGAS) head). If the temperature exceeds 100°F or 5,000 feet elevation, then the minimum suction pressure will be 30 PSI. The minimum suction pressure at a pump station must be 5 PSI because of pump-entrance friction losses and the possibility of vapor lock in the pump (5 PSI is equivalent to 16 feet of MOGAS head). The net discharge pressure of the pump is determined by using the pump graph for the specific rate or an operating pressure is given to you. The total discharge pressure is determined by simply adding the suction pressure and the net discharge pressure.

Parallel Problem:

Given:
- Suction at each pump = 20 PSI
- Total discharge = 150PSI
- Flow at each pump = 160 GPM
- Fuel = DF2

Find:
- Net PSI for each pump
- Net FTH each pump
- Total discharge in FTH
- Flow after pump station

Parallel Problem Solution:

$$150 - 20 = 130 \text{ PSI}$$

$$\frac{2.31 \text{ X } 130}{.8448} = 355 \text{ FT/HD}$$

$$\frac{2.31 \text{ X } 150}{.8448} = 410 \text{ FT/HD}$$

$$160 \text{ GPM X } 3 \text{ pumps} = 480$$

Series Problem:

Given: Suction at Pump Station 1 = 30 PSI
Discharge at Pump Station 1 = 860
Fuel = MOGAS

Find: FTH at suction side of Pump Station 1
Total discharge in FTH of Pump Station
Net discharge FTH of Pump Station
Net FTH generated per pump

Series Problem Solution:

$$\frac{2.31 \text{ X } 30}{.7250} = 95 \text{ FTH}$$

$$\frac{2.31 \text{ X } 860}{.7250} = 2{,}740 \text{ FTH}$$

$$2{,}740 - 95 = 2{,}645 \text{ FTH}$$

$$\frac{2{,}645}{3} = 881.6 \text{ FTH}$$

e. Discharge pressures are kept within safe working limits of pump, pipes, and fittings to produce the desired rate of flow. Products handled in a multiproduct line vary greatly in gravity and viscosity. To maintain an even rate of flow, stations pumping a heavier or more viscous product must develop higher pressure than other stations simultaneously pumping lighter or less viscous product. Therefore, the heaviest product sets the rate of flow.

f. Because gravity and viscosity affect flow, suction and discharge pressure at one station are seldom identical to pressures at an adjacent station. Hydraulic characteristics of sections of pipeline between stations vary; making identical pressures improbable, even when all stations are pumping the same product.

g. Increasing or decreasing pump speed raises or lowers both head capacity and flow rate as shown in Figure 8. When the pumps in the station are in series, all the pumps should be operated at about the same speed, because each pump handles the full stream. None of the pumps should be operated at speeds lower than 1,200 RPM except when idling.

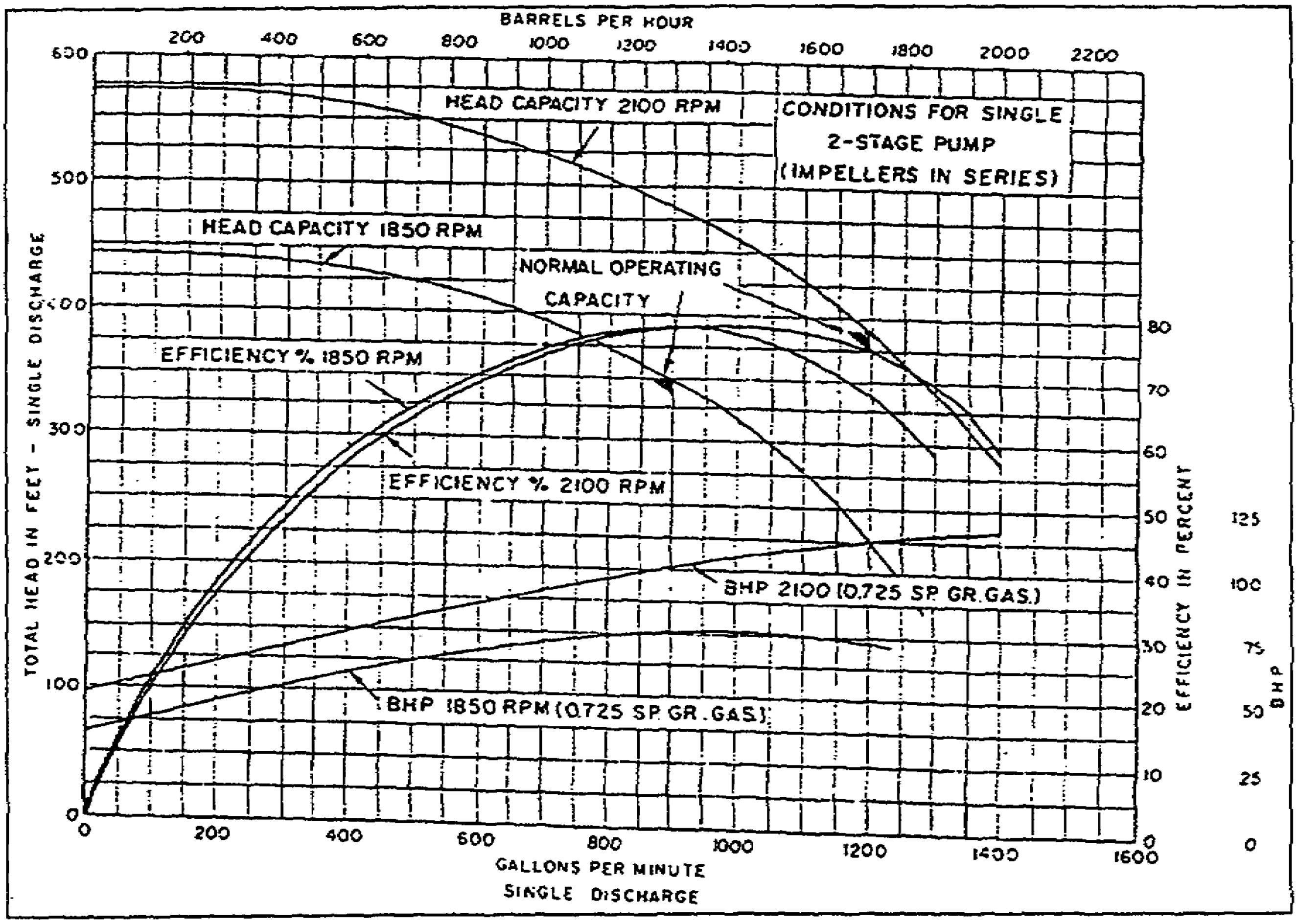


Figure 8. Operating characteristics of 6-inch, two-stage pump: impellers in series

LESSON

PRACTICE EXERCISE

The following items will test your grasp of the material covered in this lesson. There is only one correct answer r each item. When you complete the exercise, check your answer with the answer key that follows. If you answer any item incorrectly, study again that part of the lesson which contains e portion involved.

1. Which of the following is never used as a basis for the design of a pump station?

   A. Maximum head capacity
   B. Semihead capacity
   C. Optimum head capacity
   D. Normal head capacity

2. What does static head indicate in liquids at rest?

   A. Pressure
   B. Static electricity
   C. Gravitational pull
   D. Discharge suction

3. In what type of connection must two or more pumps be to discharge their cumulative output at the discharge pressure of one pump?

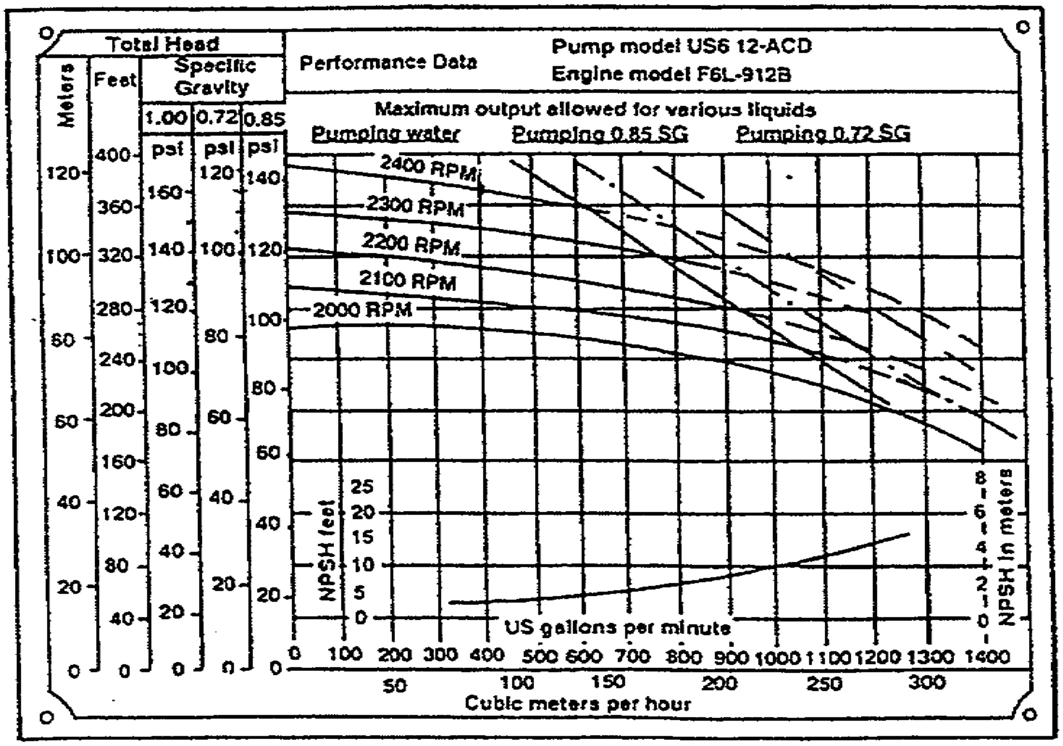
   A. Even
   B. Odd
   C. Parallel
   D. Series

4. What piece of equipment is used to connect the two stages of the 6-inch, two-stage pump in series?

   A. By-pass valve
   B. Crossover pipe
   C. Crossunder pipe
   D. Joint valve

5. Given the feet of head of 489 and a specific gravity of .8442, what would be the PSI?

   A. 158.9
   B. 178.7
   C. 192.7
   D. 197.7



Performance Curve

600-GPM hose-line pump
Peabody Barnes Model US612-ACD-1

1250 GPM flood-and-transfer pump
Peabody Barnes Model US612-ACD

Figure 1. The 6-inch, single-stage, 600 and 1,250-GPM self-priming pump

Situation. (Question 4 and 5) See Figure 1. You are given a 6-inch, single-stage, 600-GPM self-priming pump operating at 2,300 RPM, specific gravity 0.72 with a pi of 105 PSI.

6. What is the total FTH?

   A. 240
   B. 316
   C. 336
   D. 400

7. What is the flow rate?

   A. 360 GPM
   B. 400 GPM
   C. 660 GPM
   D. 720 GPM

8. What is the most common type of kinetic pump?

   A. Positive displacement pump
   B. Centrifugal pump
   C. Rotary pump
   D. Reciprocating pump

9. What is the minimum of a pump station's suction pressure to prevent a possible vapor lock?

   A. 5 PSI
   B. 10 PSI
   C. 15 PSI
   D. 20 PSI

10. Given 180 psi and specific gravity of 0.7762, what is the FTH?

   A. 489
   B. 500
   C. 525
   D. 536

LESSON

PRACTICE EXERCISE

ANSWER KEY AND FEEDBACK

Item	Correct Answer and Feedback	
1.	A.	Maximum head capacity(Page 11, para 7)
2.	A.	Pressure (Page 3, para 1h)
3.	C.	Parallel (Page 3, para 1k)
4.	B.	Crossover pipe (Page 9, para 6a)
5.	B.	178.7 (Page 5)

$$PSI = \frac{489 \times .8442}{2.31} = 178.7 \text{ PSI}$$

6.	C.	336.8 (Page 6, 7, para 5a 1, 2, 3)
7.	B.	400 (Page 6, 7, para 5a, 1, 2, 3)
8.	B.	Centrifugal pump (Page 4, para 2c)
9.	A.	5 PSI (Page 14, para 8d)
10.	D.	536 (Page 5)

$$FTH = \frac{2.31 \times 180}{0.7762} = \frac{415.8}{0.7762} = 535.68 \text{ or } 536$$