Fire Protection Hydraulics and Water Supply Analysis

FPST 2483 Chapter 10

Pump Performance

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Module objective

- Upon completing this module, the student should be able to:
  - Understand the principles of pump operation
  - Use pump performance curve
  - Understand the pump selection
- Reading materials
  - Brock's book, chapter 10

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Acceptable driving

- Electrical motor
  - Vertically mounted split-case
  - Horizontal split-case
  - Vertical-shaft turbine pump
- Diesel engine
- Steam turbine (only available with cheap steam abundant)

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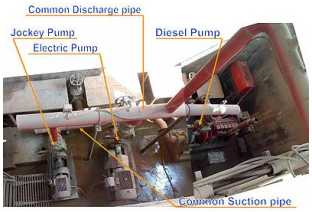
Jockey pump

- A **jockey pump** is a small pump connected to a fire sprinkler system and is intended to maintain pressure in a fire protection piping system to an artificially high level so that the operation of a single fire sprinkler will cause a pressure drop which will be sensed by the fire pump automatic controller, causing the fire pump to start. The jockey pump is essentially a portion of the fire pump's control system.



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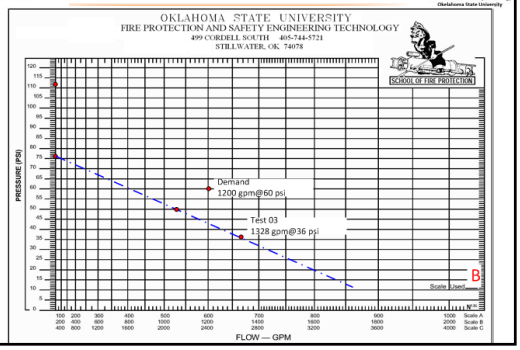
What if the water supply is insufficient?



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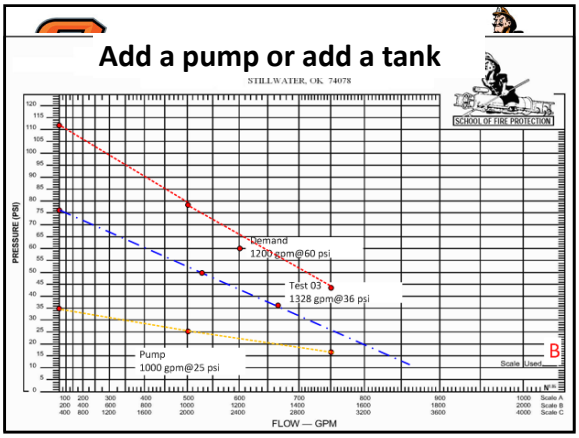
Add a pump or add a tank



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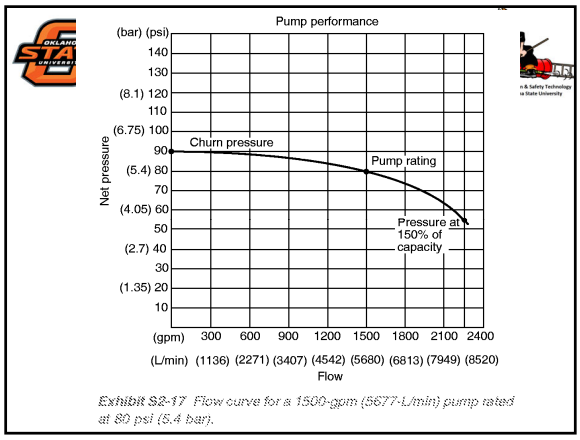

Exhibit 82-17 Flow curve for a 1500-gpm (5677-L/min) pump rated at 80 psi (5.4 bar).

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Combining pump performance with existing water supplies

- Usually only applies to horizontal shaft pumps
  - First plot the supply curve of the existing water supply system from test results.
  - Plot the pump performance curve from test results or from three standard points:
    - ***0gpm@140% rated psi***
    - ***100% rated gpm@100% rated psi***
    - ***65% rated psi@150% rated gpm***
  - After these two curves are plotted add the two curves together by choosing various flows and adding the pressures from each curve at those flows.

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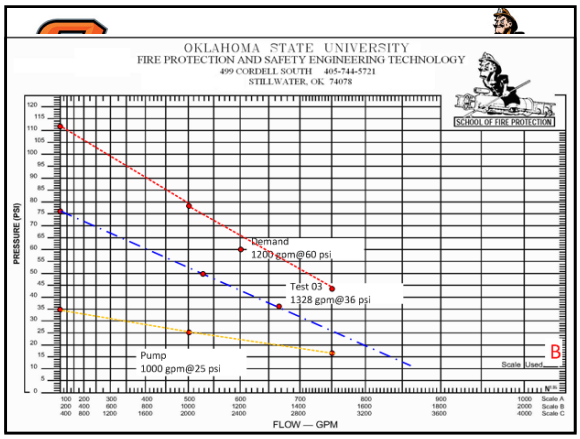

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Another example

- Combine the performance of a horizontal shaft pump rated @ 2000 gpm and 80 psi with the following water supply system
  - Static: 60 psi
  - Residual: 40 psi
  - Flow: 2300 gpm.

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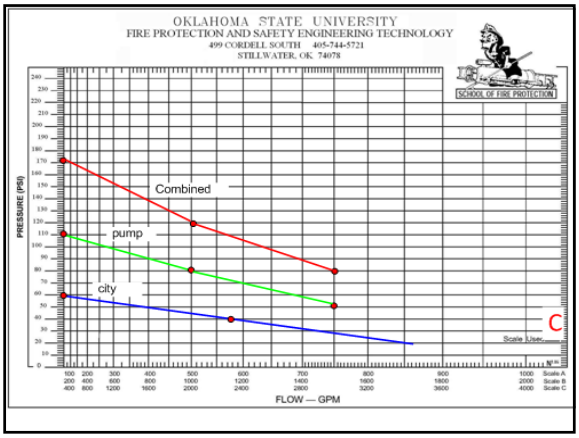

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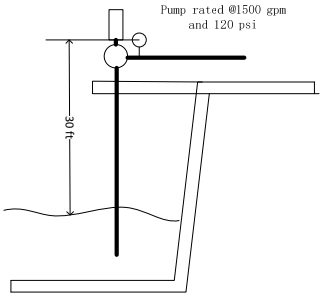
Vertical Pump Example

- For the vertical shaft pump shown below, draw a graph of the predicted flows and pressures at the discharge pressure gauge, and answer the following question:
- What pressure will be available at the pressure gauge at the flow of 1200 gpm?



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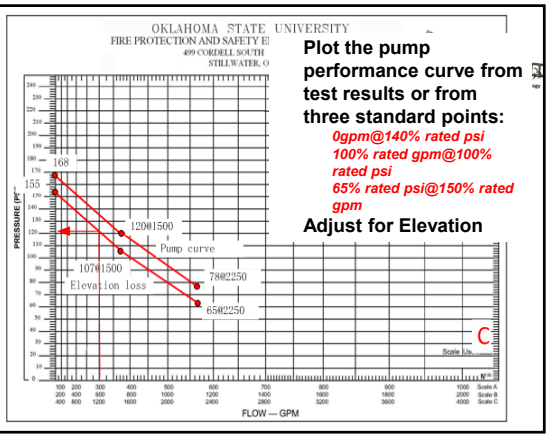

Plot the pump performance curve from test results or from three standard points:

- *0gpm@140% rated psi*
- *100% rated gpm@100% rated psi*
- *65% rated psi@150% rated gpm*

Adjust for Elevation

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Net pump pressure

$$P_N = (P_D - P_I) + (P_{DV} - P_{IV}) + 0.433 \cdot H$$

$$P_V = \frac{0.433V^2}{2g}$$

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Velocity pump pressure

$$P_V = \frac{0.433V^2}{2g}$$

Suppose a vertical shaft pump is delivering 2000 gpm into a 6 inch Schedule 40 steel discharge line. The water velocity of 2000 gpm in a 6-inch pipe is

$$V = \frac{2000gpm}{449gpm/ft^3/\sec} \cdot \frac{144in^2/ft^2}{\pi \cdot (3.0325in)^2} = 22.2\,\text{fps}$$

$$P_V = \frac{0.433psi/ft \times (22.2fps)^2}{2 \times 32.2\,\text{ft/sec}^2} = 3.3\,\text{psi}$$

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Pump selection

- The pressure requirement allows the development of a simple equation for calculating the maximum gpm rating of a booster pump used to support an existing water supply system.

$$Q_{max} = \frac{Q_{20}}{1.5}$$

- Q_{20}=the number available at a residual pressure of 20 psi.
- Qmax=the maximum gpm rating of the pump

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Example 2

- What maximum pump gpm rating should be used on a water supply that can deliver 1,230 gpm at a residual pressure of 20 psi?

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Example 2

$$Q_{max} = \frac{Q_{20}}{1.5} = \frac{1230}{1.5} = 820\,\text{gpm}$$

- Since pumps are rated at certain ratings, the closest is 750 gpm pump.

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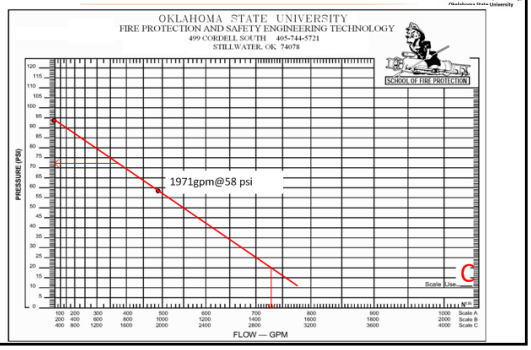
Example 3



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Example 3

- $Q = \frac{2880}{1.5} = 1920$ ➔ select 1500 gpm

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Fire Pumps Outlet

GPM RATING	OUTLET DIAMETER (INCHES)
• 500	• 3, 4, and 5
• 750	• 4 and 5
• 1000	• 5 and 6
• 1500	• 5, 6, and 8
• 2000	• 6 and 8

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Minimum pipe size

Pump rating	Suction pipe (inches)	Discharge Pipe (Inches)
500	5	5
750	6	6
1000	8	6
1250	8	8
1500	8	8
2000	10	10

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Affinity laws

- Pump performance at any pump speed can be corrected to the rated pump speed by affinity laws.

$$\frac{Q_1}{Q_2} = \frac{rpm_1}{rpm_2}$$

$$\frac{P_1}{P_2} = \left(\frac{rpm_1}{rpm_2}\right)^2$$

$$\frac{hp_1}{hp_2} = \left(\frac{rpm_1}{rpm_2}\right)^3$$

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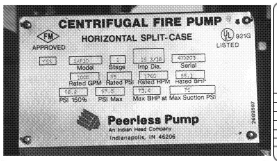
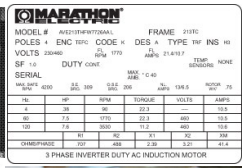
Name plate of a pump





ELECTRIC MOTOR NAMEPLATE					
MODEL 500	SPLIT PHASE		TOTALLY ENCLOSED		
FRAME	TYPE	INS. CLASS	IDENTIFICATION NO.		
145	KC	J	253B9490G298G09		
HP	RPM	VOLTS	AMPS	CYC	S.F.
1½	1725	115/230	15/7.5	60	1.25
DESIGN CODE: B			PHASE	EFF	p.f.
DRIVE END BEARING 8BD 116			1	62%	73%
OPP. END BEARING 8OB 117			DUTY: CONTINUOUS		
AMB. 40 C		NO THERMAL PROTECTION			

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Summary

- We have learned
  - –Pump performance curve
    - •Pump performance curves are useful to modify the water supply curve.
  - –Pump net pressure
  - –Pump selection

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