Retrocommissioning Workshop Series III

Parallel Pumps and Pump Power

Facility Dynamics Engineering

Presented By:
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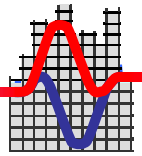
Facility Dynamics Engineering

The Issue

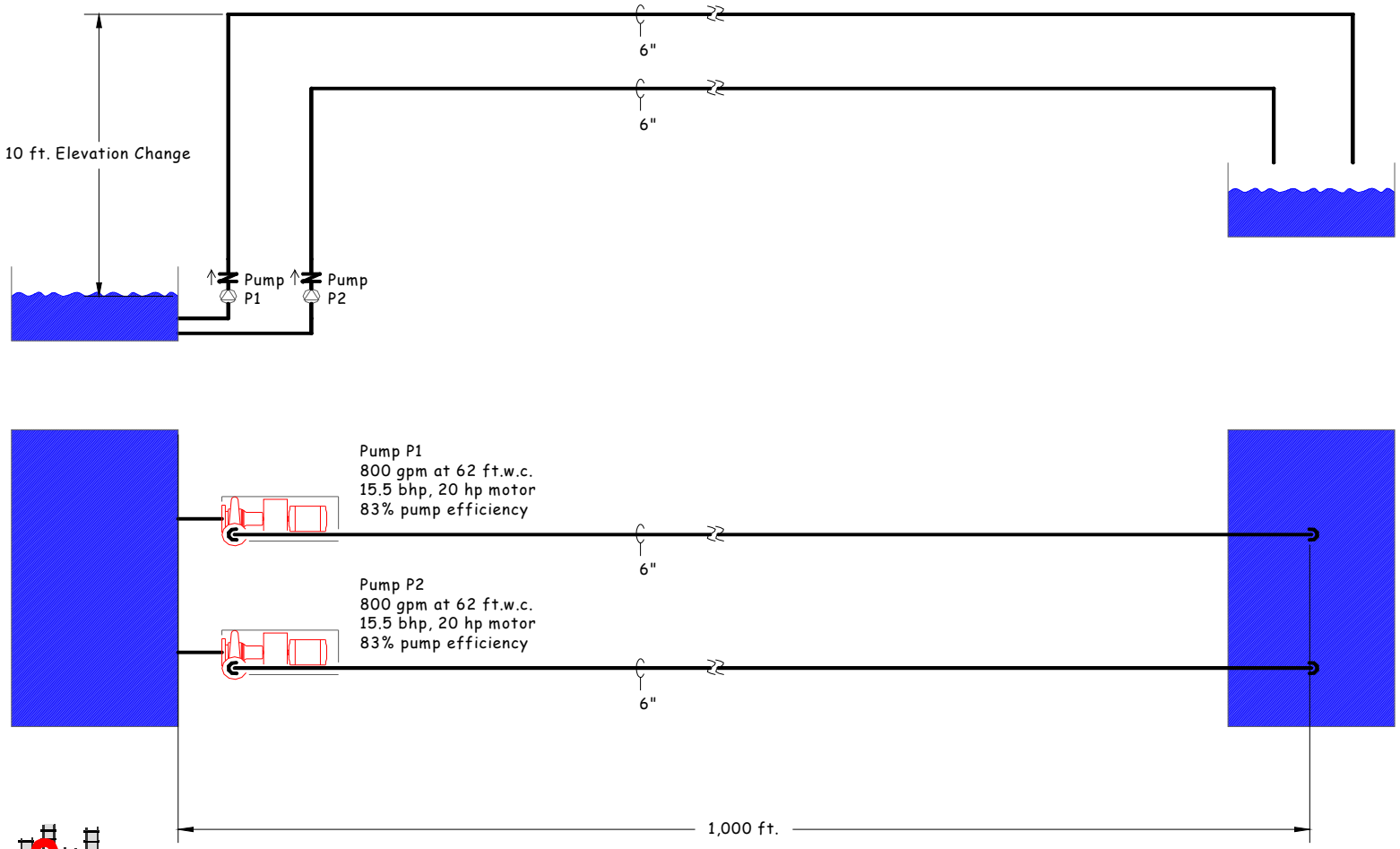
- The pump affinity laws say that horse power varies as the cube of the flow rate.

$$HP_{New} = HP_{Old} \times (Flow_{New}/Flow_{Old})^3$$

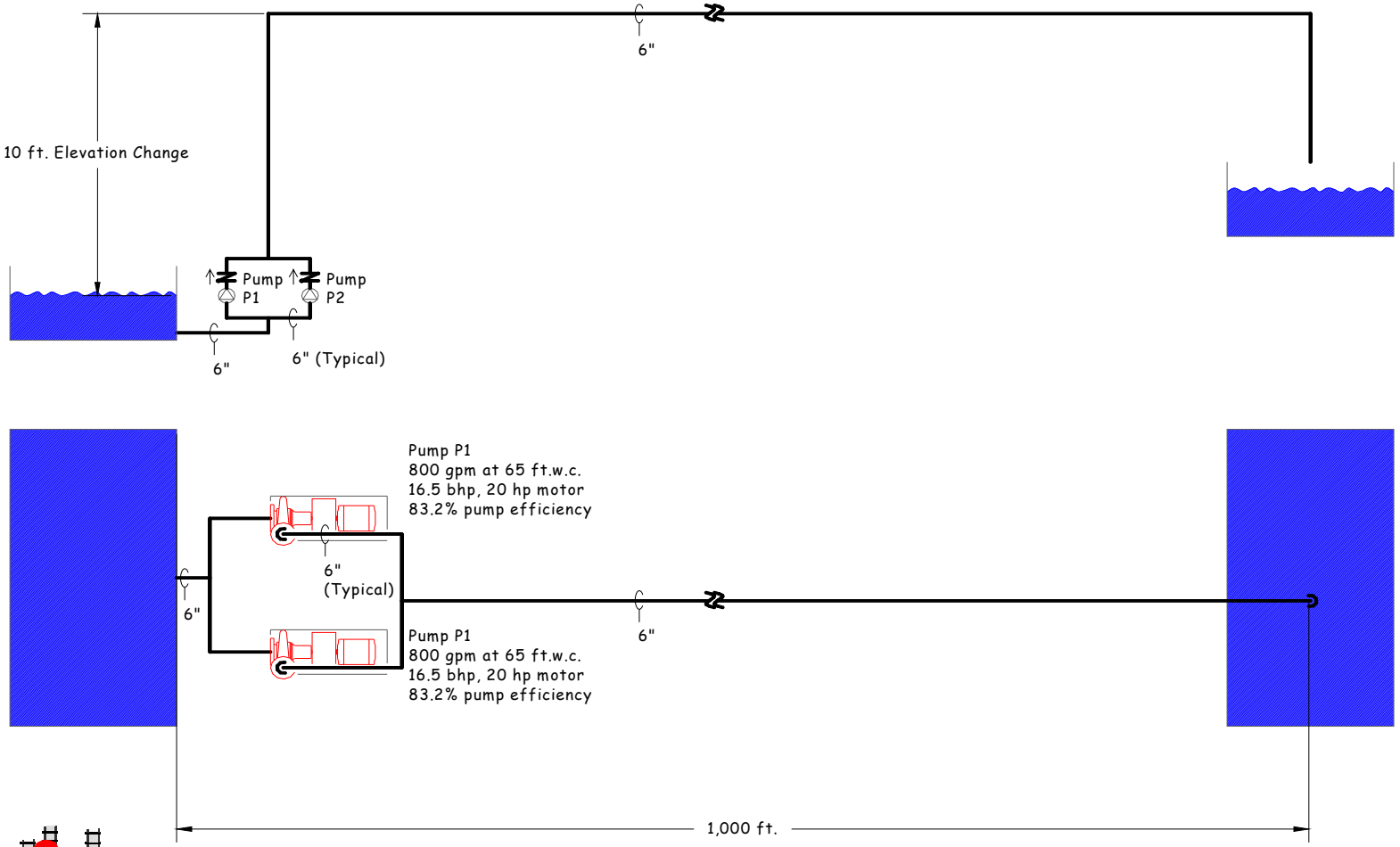
- Does this mean that if I have two pumps in parallel, each capable of moving the design flow, then if I run both of the pumps moving half of the required flow rate each, will the power required be $1/8^{th}$ (1/2 x 1/2 x 1/2) of what was required when I ran one pump alone to provide the required flow rate?



System 1:
Two Independent Fully Redundant Circuits

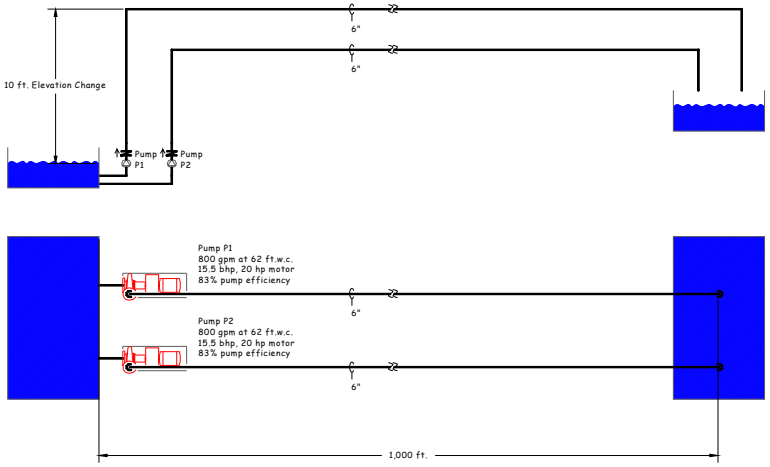


System 2:
Shared Circuit, Redundant Pumps



System 1: Head Loss Calculation

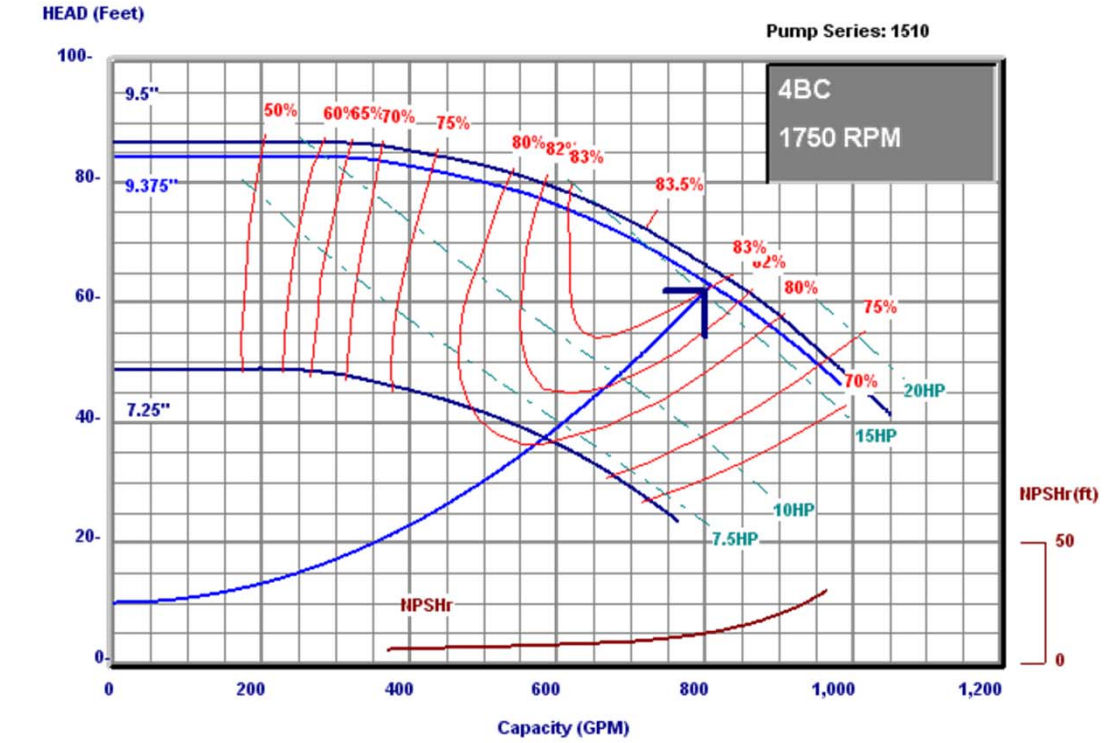
One Pump Provides All Flow



- One circuit has loss as calculated
- One circuit is inactive

Item	Flow, gpm	Quantity	Equivalent feet	Friction Rate, ft.w.c./100 ft.	Loss, ft.w.c.	Comment
Pipe	800	1,010	1,010.00	4.03	41	System sizer for friction rate
Elbows	800	2	17.40	4.03	1	ASHRAE Fundamentals
Globe style check valve	800	1	208.80	4.03	8	ASHRAE Fundamentals
Lift	800	1	N/A	N/A	10	Eleveation change
Inlet loss	800	1	N/A	N/A	1	Estimate
Exit loss	800	1	N/A	N/A	1	Estimate
Total					62	

Option 1:
Operating Mode A – One pump runs full speed



Suction Size = 5 "
Discharge Size = 4 "

Min Imp Dia = 7.25 "
Max Imp Dia = 9.5 "
Cut Dia = 9.375 "

Design Capacity =800.0 GPM
Design Head =62.0 Feet
Motor Size =20 HP

- Two redundant piping circuits
  - Significant first cost penalty
  - Most immune to failure of any component

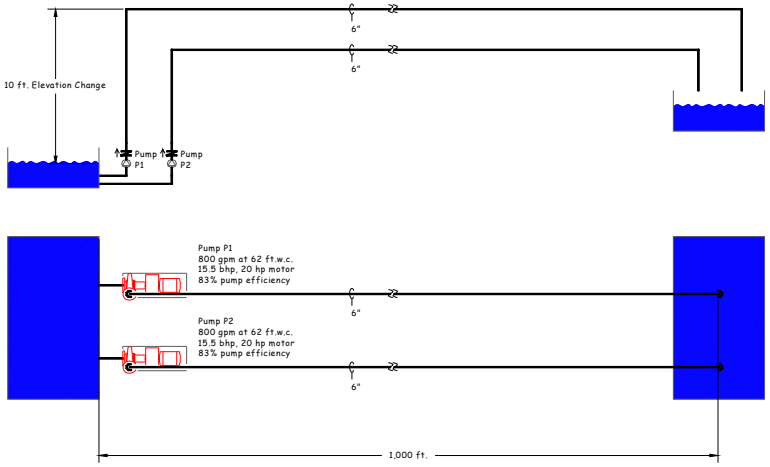
Bell & Gossett
ITT Industries

Summary

Mode	Pump Selection, Bell and Gossett Basis	Number of Pumps Running	Flow, gpm		Head, ft.w.c.	Efficiency	Motor Horse Power	Brake Horse Power	
			Total	Per Pump				Per Pump	Total
One pump at full speed the other off	4BC, 1,750 rpm, 9.375" impeller	1	800	800	62	83.0%	20	15.5	15.5

System 1: Head Loss Calculation

Each Pump Provides 50% of Flow

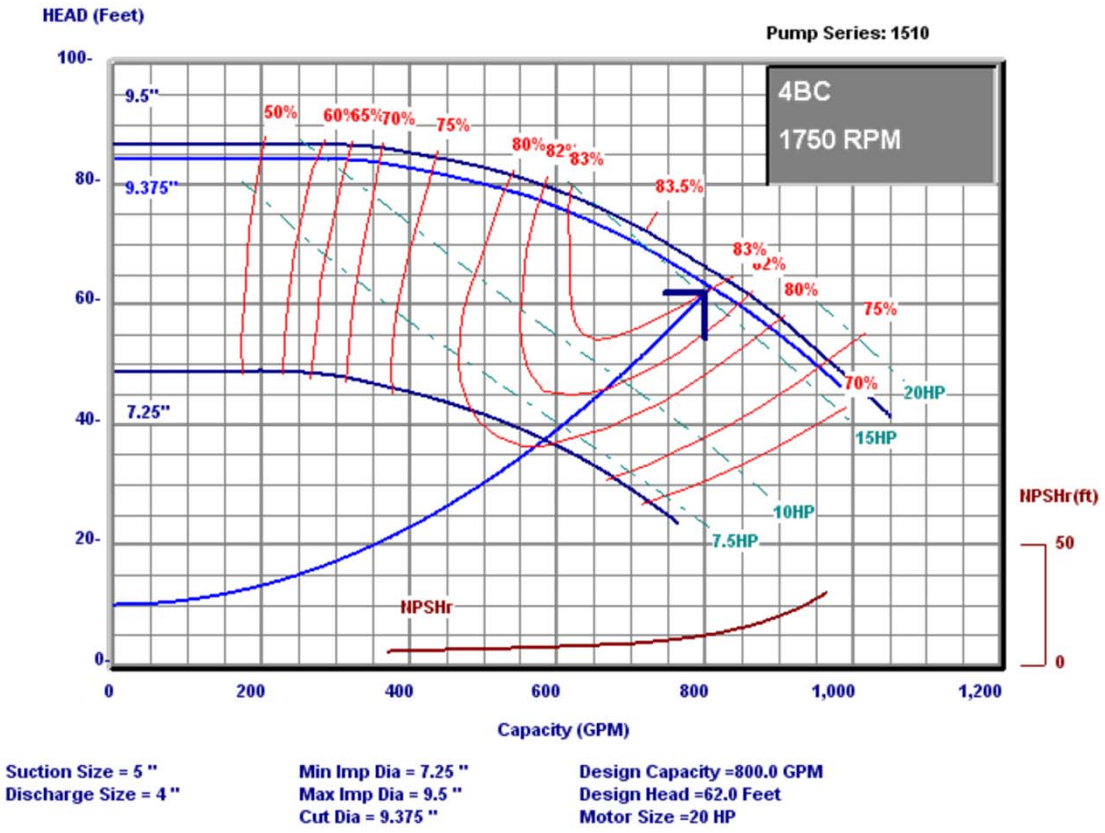


- Both circuits have losses as calculated
- Both circuits are active
- Losses follow square law
- Lift (elevation change) does not vary with flow rate

Item	Flow, gpm	Quantity	Equivalent feet	Friction Rate, ft.w.c./100 ft.	Loss, ft.w.c.	Comment	
Pipe	400	1,010	1,010.00	1.08	11	System sizer for friction rate	
Elbows	400	2	17.40	1.08	0	ASHRAE Fundamentals	
Globe style check valve	400	1	208.80	1.08	2	ASHRAE Fundamentals	Was 8 ft.w.c. at 800 gpm
Lift	400	1	N/A	N/A	10	Eleveation change	
Inlet loss	400	1	N/A	N/A	0	Estimate	
Exit loss	400	1	N/A	N/A	0	Estimate	
Total					24		

Option 1:

Operating Mode B – Two pumps run at 50% speed



- Two redundant piping circuits
  - Significant first cost penalty
  - Most immune to failure of any component
  - Approaches the "cube rule" but not quite due to the constant head associated with lift

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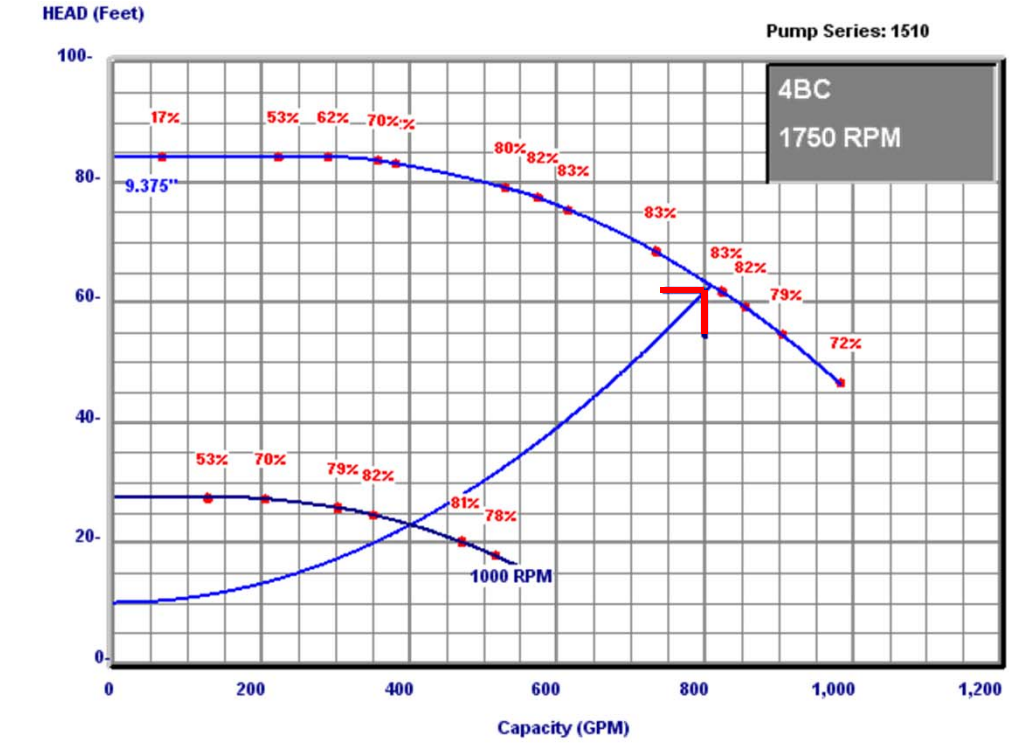
Option 1:

Operating Mode B – Two pumps run at reduced speed



Suction Size = 5 "
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Min Imp Dia = 7.25 "
Max Imp Dia = 9.5 "
Cut Dia = 9.375 "

Design Capacity =800.0 GPM
Design Head =62.0 Feet
Motor Size =20 HP

The Power and Eff. curves shown are for the cut dia. impeller.

- Two redundant piping circuits
  - Significant first cost penalty
  - Most immune to failure of any component
  - Approaches the "cube rule" but not quite due to the constant head associated with lift

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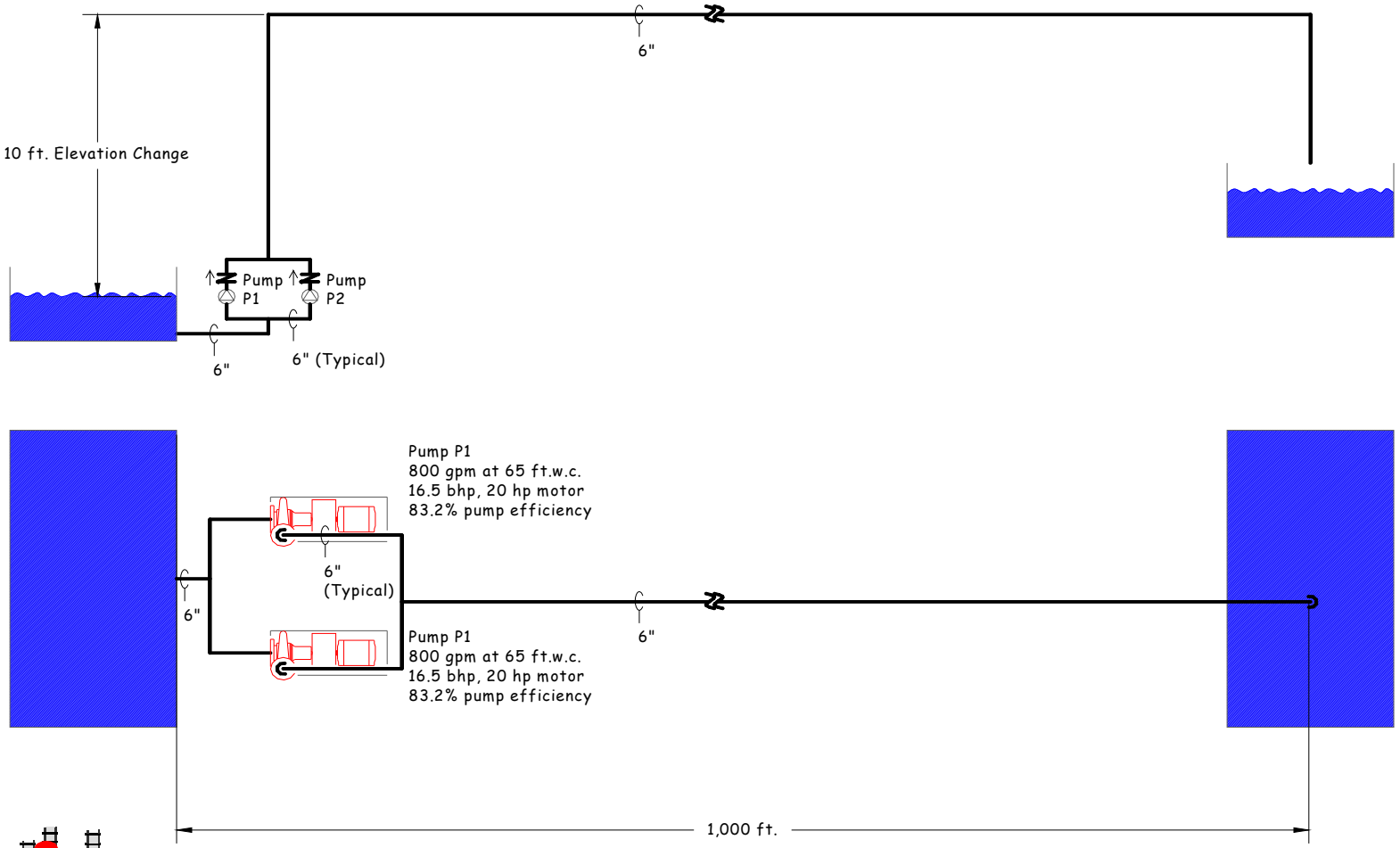
Summary

Mode	Pump Selection, Bell and Gossett Basis	Number of Pumps Running	Flow, gpm		Head, ft.w.c.	Efficiency	Motor Horse Power	Brake Horse Power	
			Total	Per Pump				Per Pump	Total
One pump at full speed the other off	4BC, 1,750 rpm, 9.375" impeller	1	800	800	62	83.0%	20	15.5	15.5
Both pumps run at reduced speed	4BC, 1,000 rpm, 9.375" impeller	2	800	400	24	83.0%	20	2.9	5.8

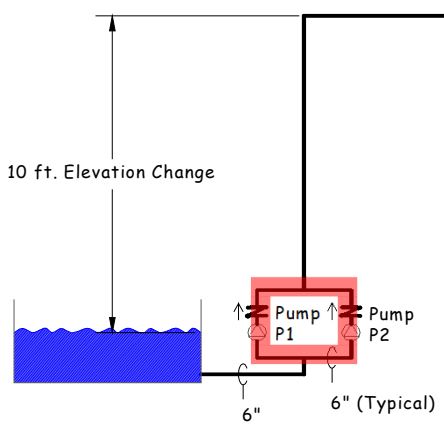
Cube rule predicts 1.9 bhp per pump or 3.8 bhp total

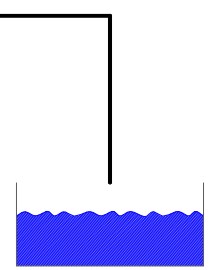
Option 2:
Shared Circuit, Redundant Pumps



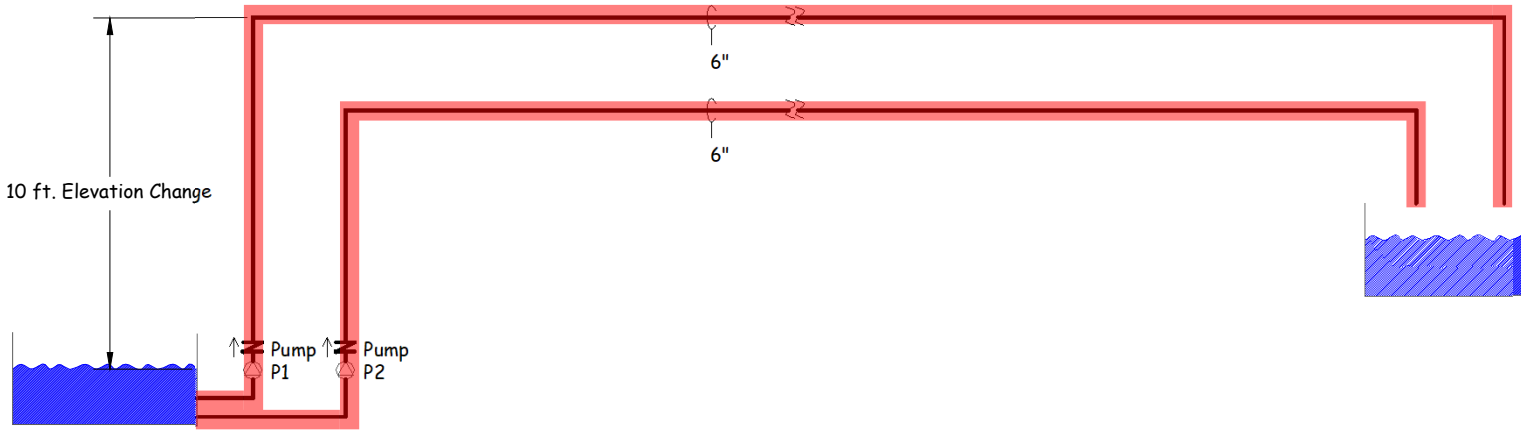
Option 2 versus Option 1

Shared Circuit versus Independent Circuit



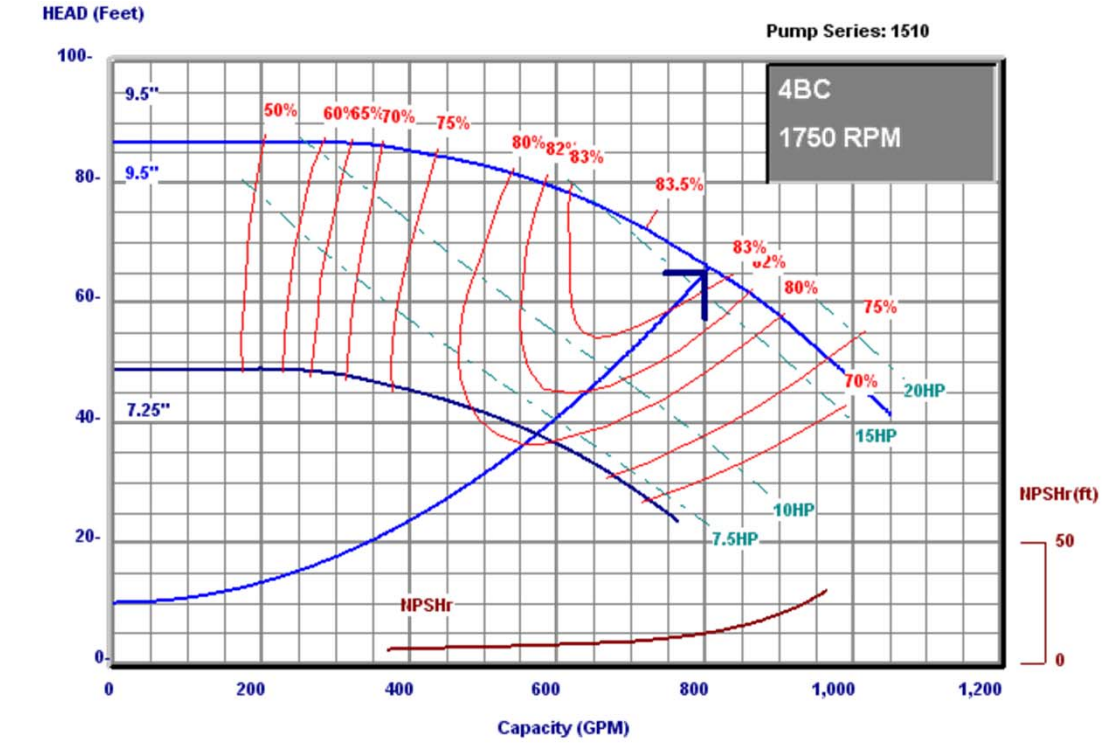


Shaded piping is the piping that sees 400 gpm with two pumps running at 400 gpm and thus sees a reduction in head that is proportional to the square of the reduction in flow



Option 2:

Operating Mode A – One pump runs at full speed



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Design Capacity =800.0 GPM
Design Head =65.0 Feet
Motor Size =20 HP

- One common circuit
  - Minimizes first cost penalty
  - Immune to failure of a pump
  - Not immune to a piping failure

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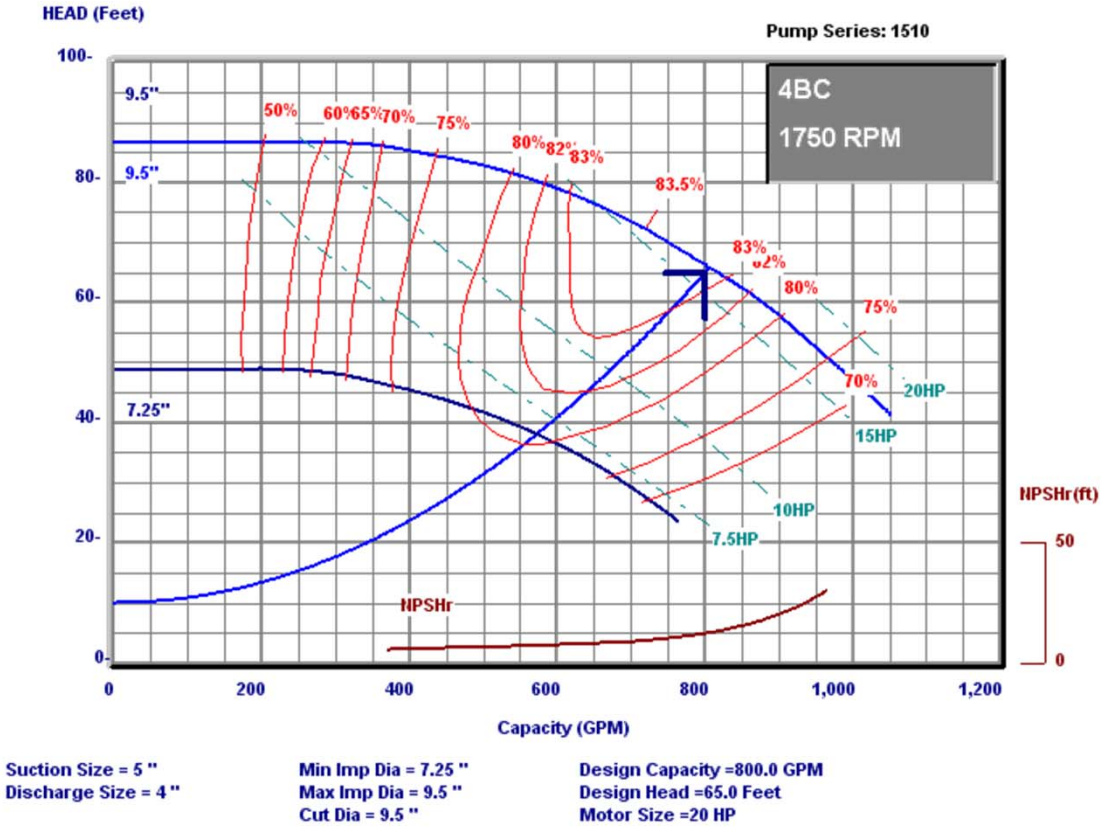
Both pumps run at reduced speed	4BC, 1,000 rpm, 9.375" impeller	2	800	400	24	83.0%	20	2.9	5.8
One pump at full speed the other off	4BC, 1,750 rpm, 9.5" impeller	1	800	800	65	83.1%	20	16.5	16.5

Option 2:

Operating Mode B – Two pumps run at 50% speed



- One common circuit
  - Minimizes first cost penalty
  - Immune to failure of a pump
  - Not immune to a piping failure
  - Some, but not all of the piping circuit sees a 50% reduction in flow

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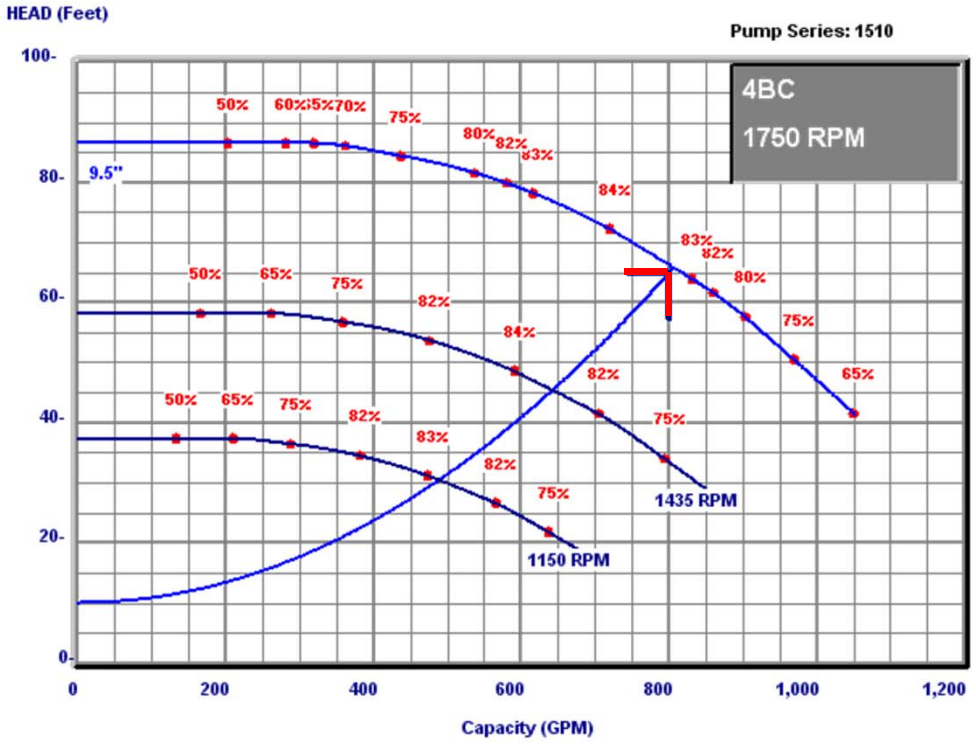
Option 2:

Operating Mode B – Two pumps run at reduced speed



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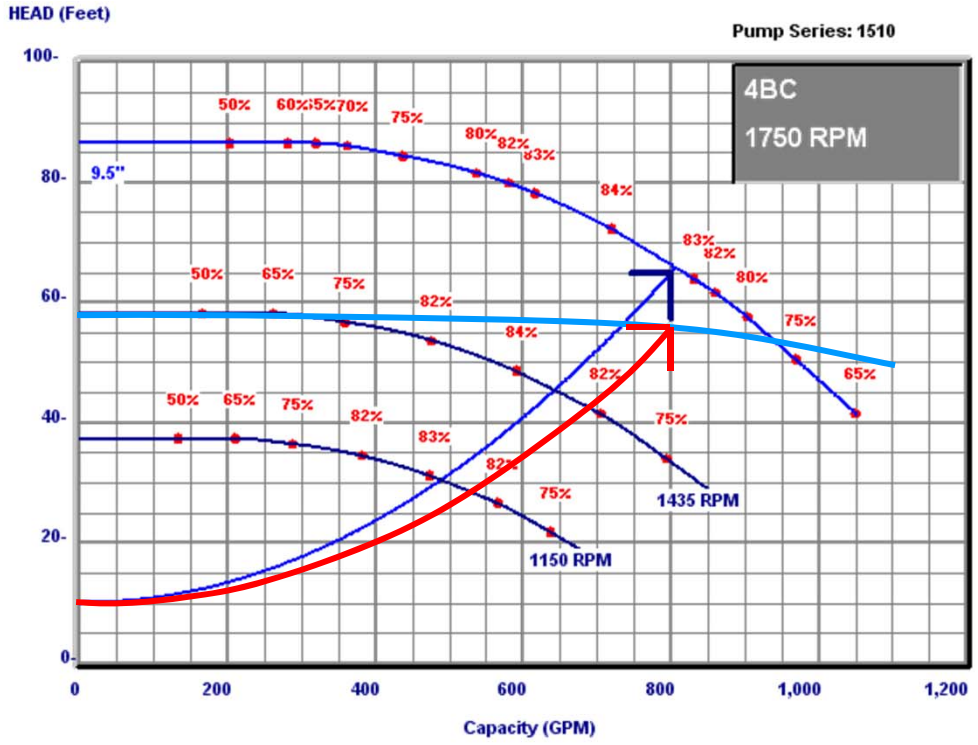

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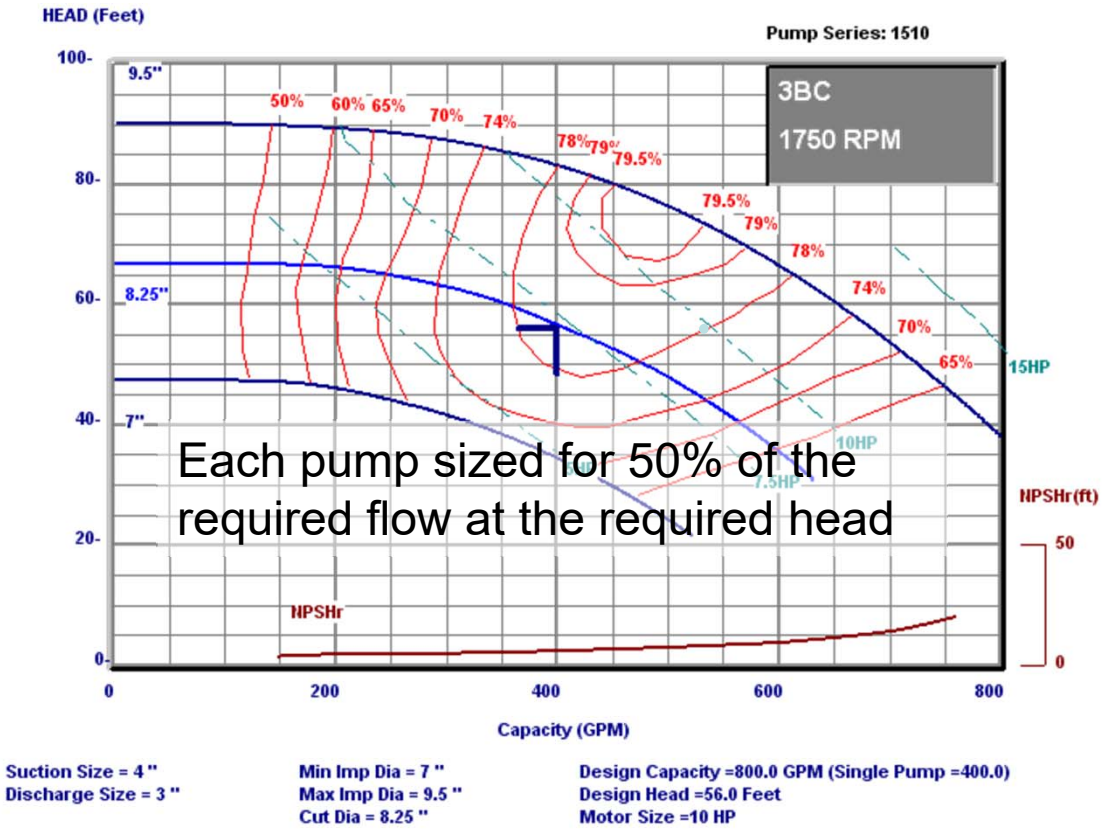
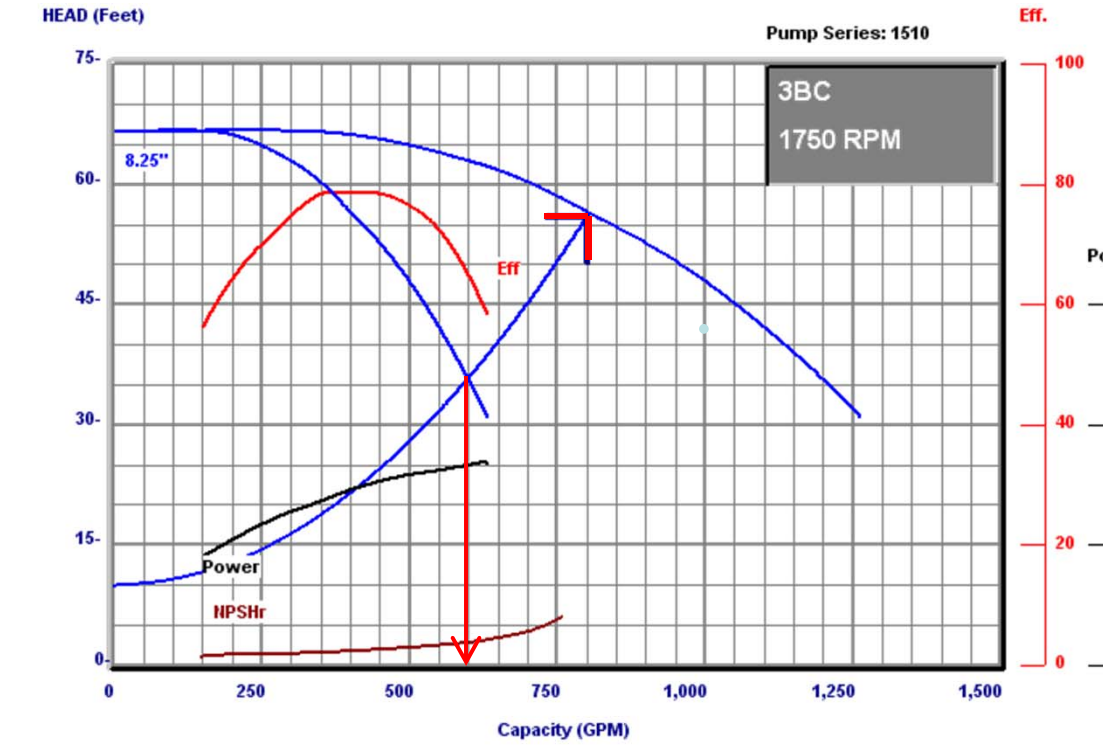
One pump at full speed the other off	4BC, 1,750 rpm, 9.5" impeller	1	800	800	65	83.1%	20	16.5	16.5
Both pumps run at reduced speed	4BC, 1,435 rpm, 9.5" impeller	2	800	400	56	77.5%	20	7.3	14.6

Option 3:
Shared Circuit, Non-redundant pumps



- One common circuit
  - Lowest first cost penalty
    - Smaller pump
    - Smaller motor
    - Smaller electrical service
  - Not immune to pump or piping failure
  - Better than 50% redundant

Option 3:
Shared Circuit, Non-redundant pumps



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One pump at full speed the other off	4BC, 1,750 rpm, 9.5" impeller	1	800	800	65	83.1%	20	16.5	16.5
Both pumps run at reduced speed	4BC, 1,435 rpm, 9.5" impeller	2	800	400	56	77.5%	20	7.3	14.6
Both pumps run at full speed, less than 100% redundancy	3BC, 1,750 rpm, 8.25" impeller	2	800	400	56	78.3%	10	7.2	14.4