HAYS

ASHRAE Connecticut Chapter

10/9/2024

Agenda

- Why Do We Balance?
- Balancing Options
  - Reverse Return
  - Balancing Valves
    - Manual vs. Automatic (Different Technologies)
- System Costs
  - Initial vs. Long-term
    - Material Costs & T&B (Initial)
    - System Efficiencies (Long-term)
- Auto-Balancing & Modulation

Why Balance?

- Reduced water flow reduces heat transfer
- Terminals furthest from the pump in unbalanced systems receive less flow resulting in reduced heat transfer
- Excessive flow
  - Increases pressure drop and pump energy
  - Increases pump wear and noise
  - Increasing water flow to 200% of coil design
    - only increases heat transfer by 6% but, increases pressure drop by 400%

Balancing Options

Reverse Return Piping

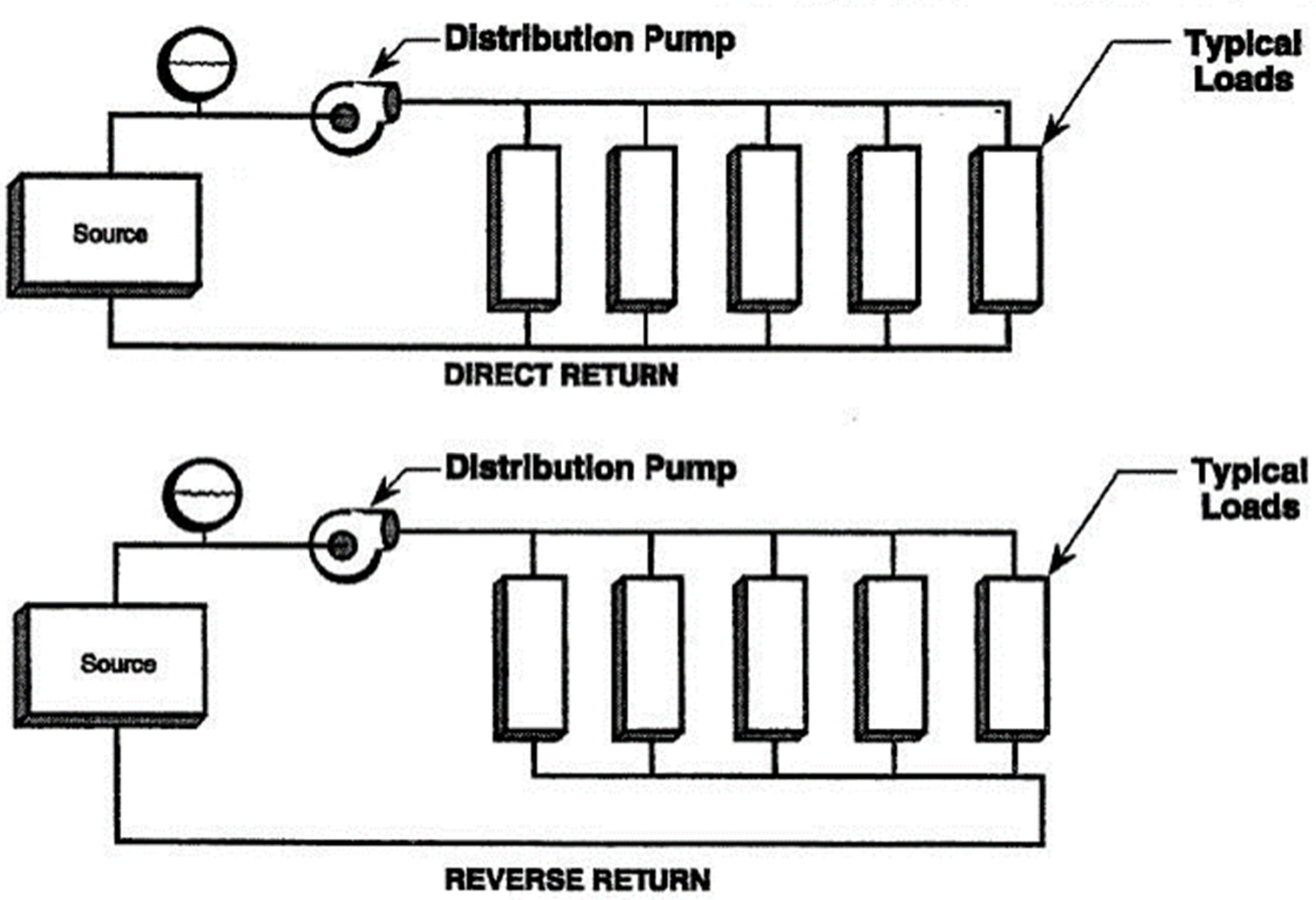
Manual Balancing

Automatic Flow Control Valves

Unconventional Methods

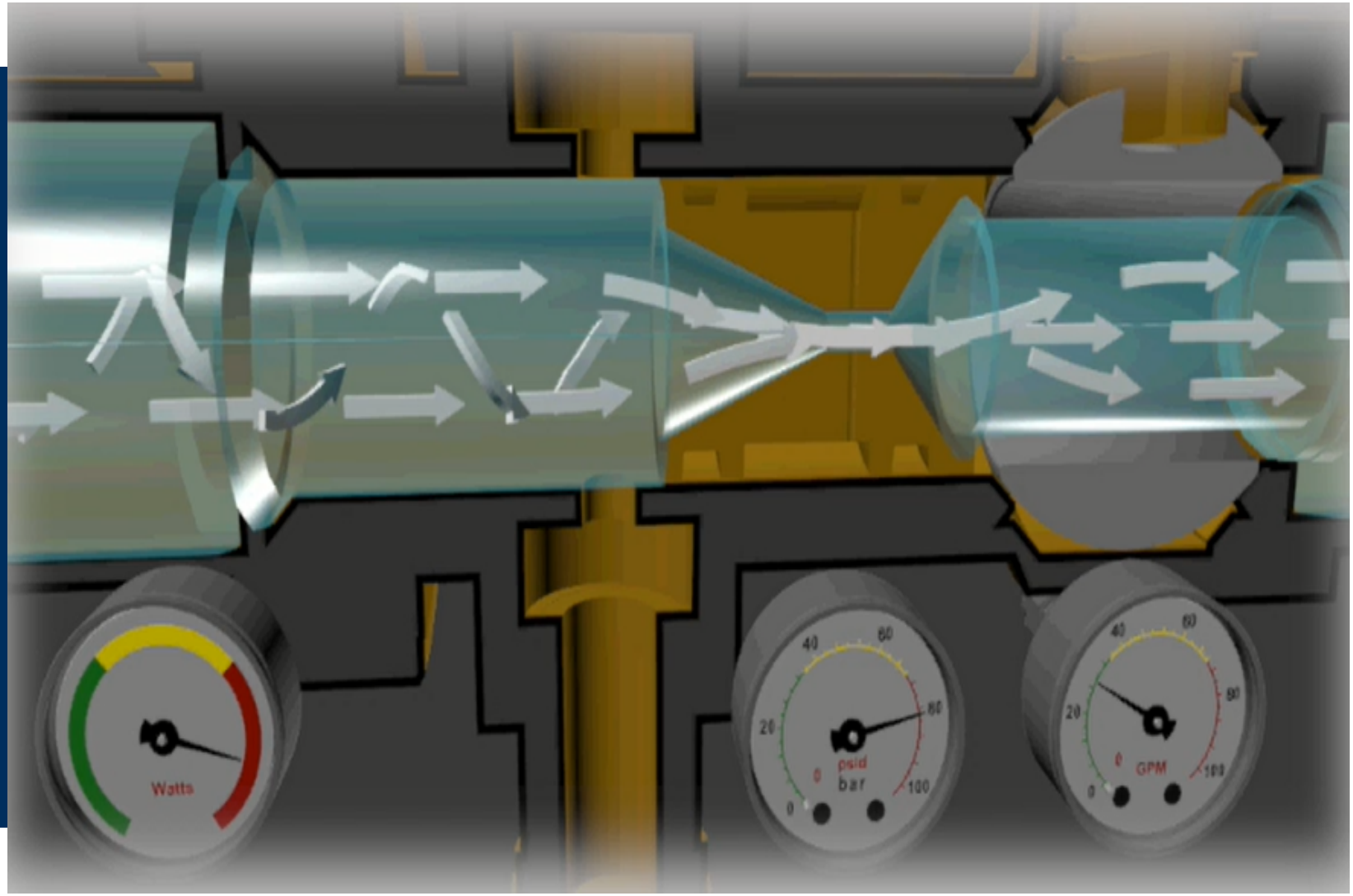
- Circulating Pumps at Each Unit

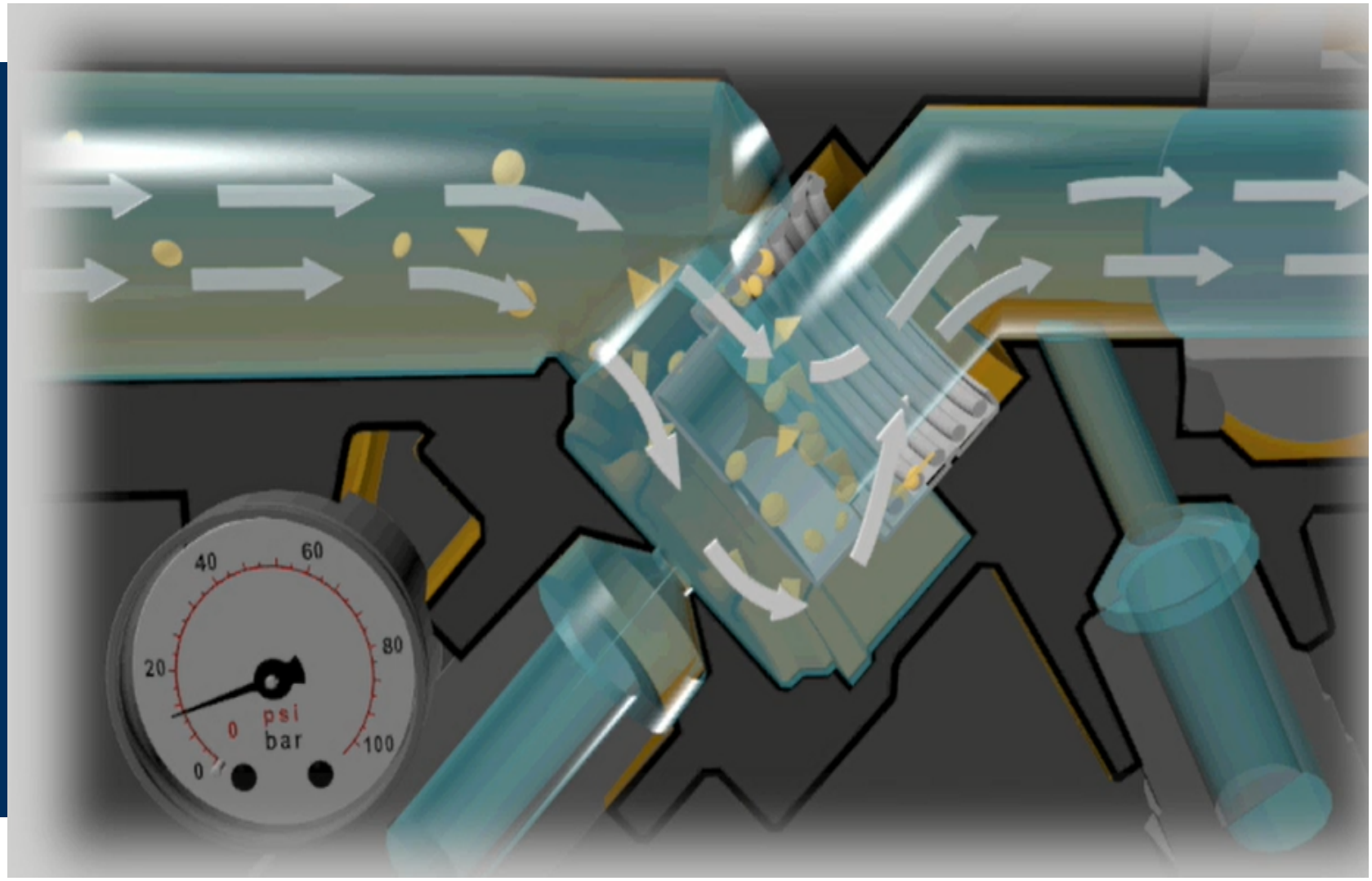
Reverse Return

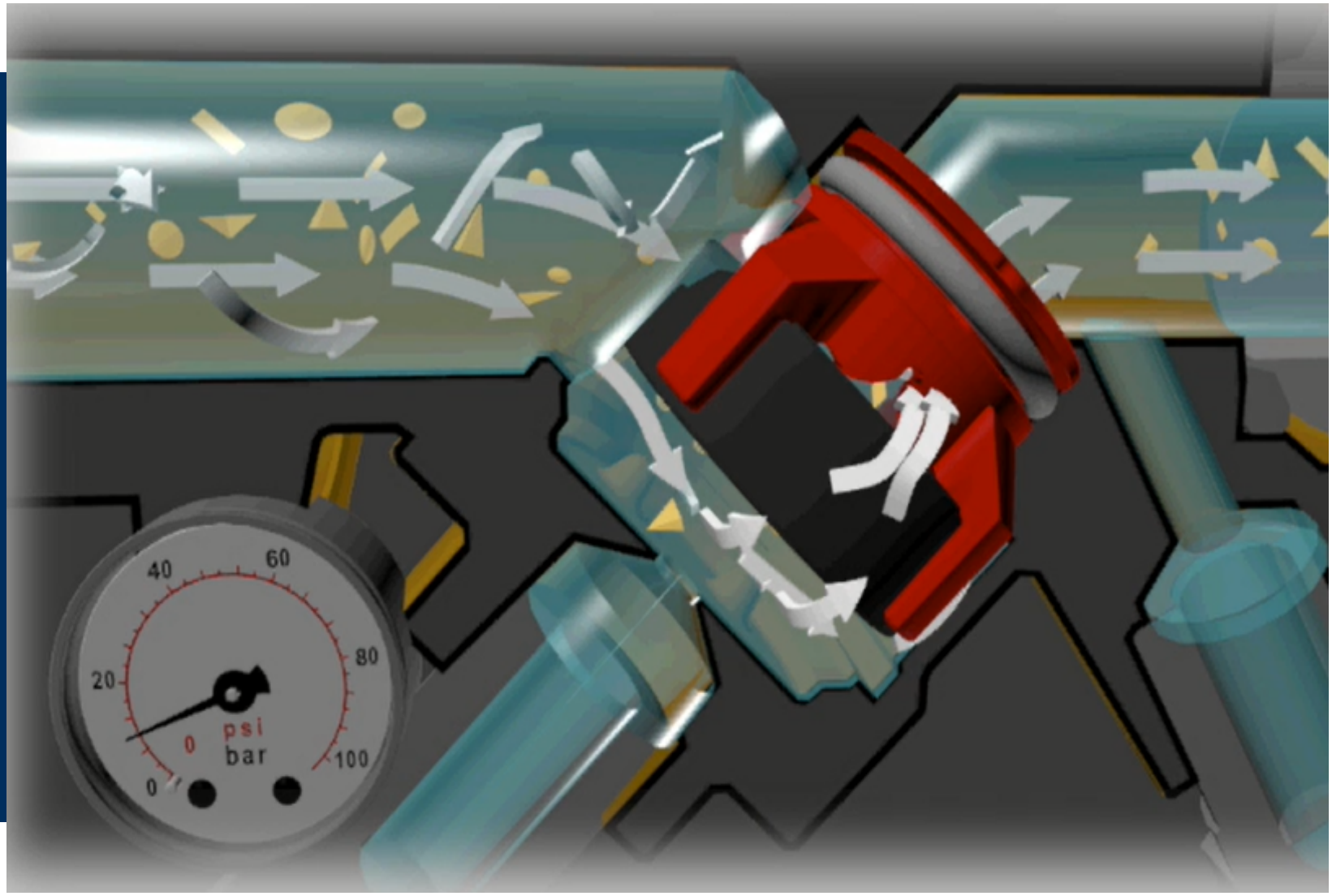


What Is A Balancing Valve?

- Balancing Valves
  - provide proper distribution of water flow to terminal units in the system to ensure maximum comfort with minimal energy consumption.
- Improves performance of
  - HVAC Systems
  - Domestic Water Systems

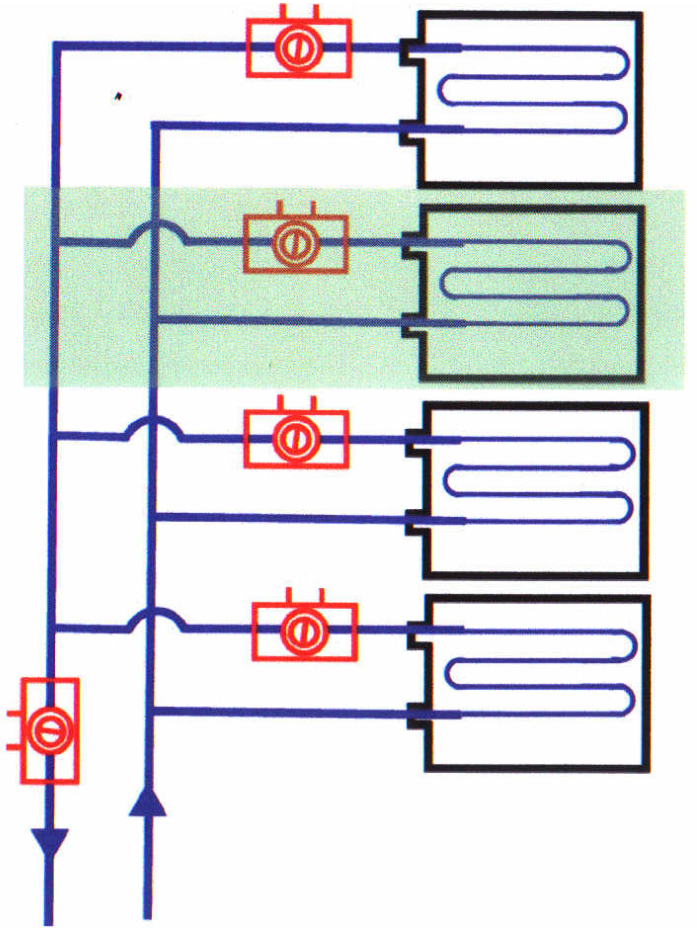

Watts
psid
bar
GPM

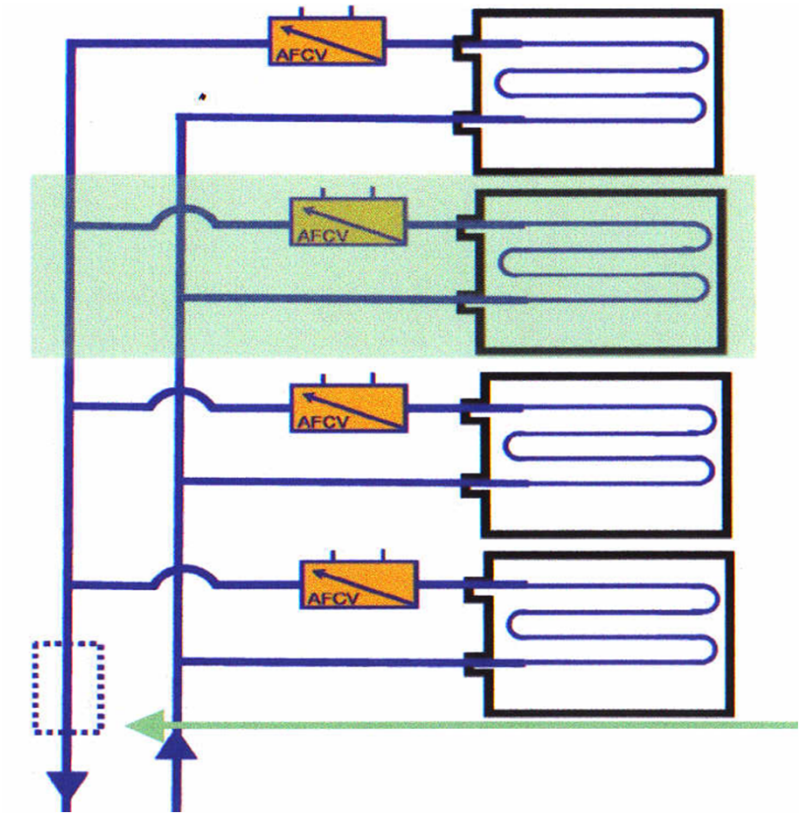

40
60
20
80
0
psi
bar
100
0


40
60
20
80
0
psi
bar
100
0

Cost of a System - Manually Balanced

- Circuit Balance Valves required at all terminal units
- System needs to be rebalanced when new terminal unit(s) added
- Manual Balance = No Balancing
  - Balanced at 100% Design Flow
  - Unbalanced at ALL Other Flows





Cost of a System - Automatically Balanced

- Automatic Flow Control Valves only required at terminal units
- No system rebalancing needed when new terminal unit(s) brought on line.
- No AFCV required on riser
- AFCV dynamically adjust to maintain flow

For Your Consideration…

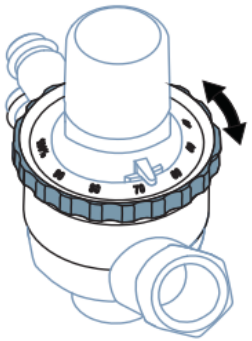
Automatic Flow Control Balance Valves

- (1) Verify that each installed automatic flow control device matches the GPM indicated on the drawings/schedule/unit submittal.
- (2) Verify that the actual pressure differential at each automatic flow control device is within the pressure differential operating range specified by the valve manufacturer for that valve type, inserts, size, and flow rate.

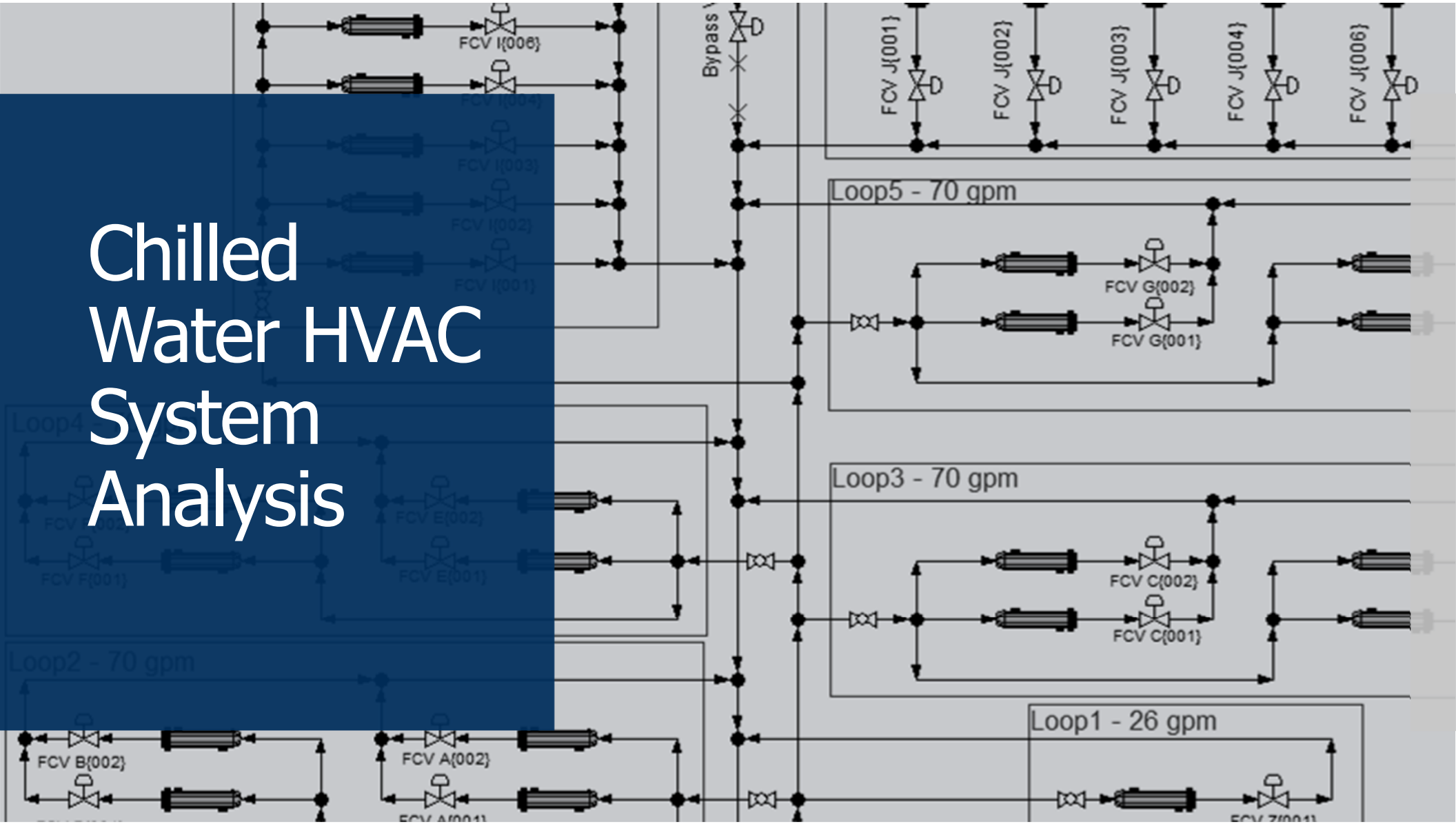
Balancing PICVs

Pressure Independent Control Valves

- While Cv rate selection isn't required, the TAB process must set Max Flow by a dial adjustment on site
- The TAB contractor must also confirm operating range
- Varies by manufacturer – confirm the process upon submittal review



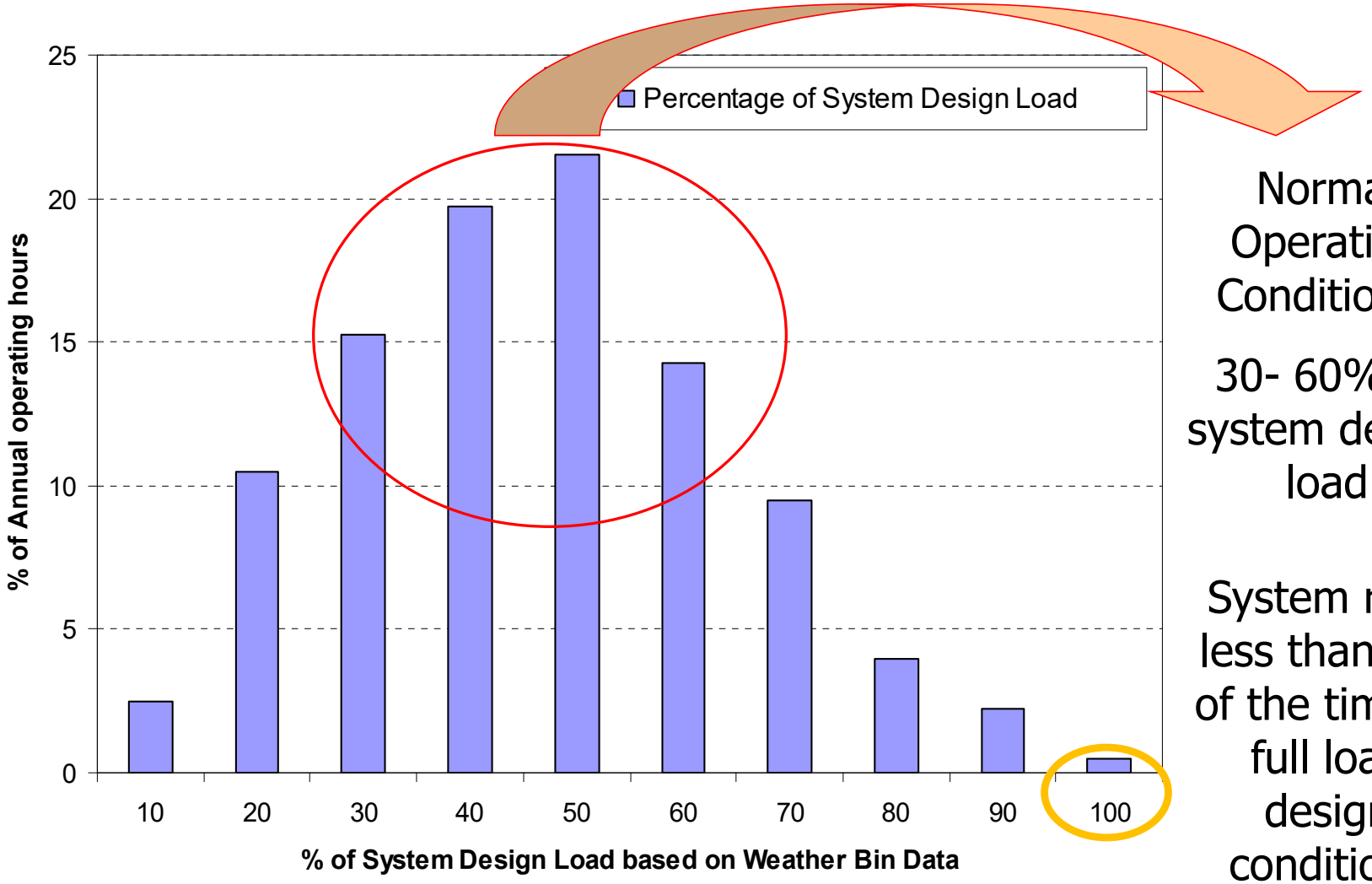
Chilled Water HVAC System Analysis



System Configuration

- Pumps - 2 Primary & 2 Secondary
- Chillers - Inline w/ Primary Pumps
- Designed flow rate – 460 gpm (230 gpm per pump)
- System analyzed under three different balancing options:
  - Fully Open – no balancing
  - Manual balancing
  - Automatic balancing

Annual System Load Profile

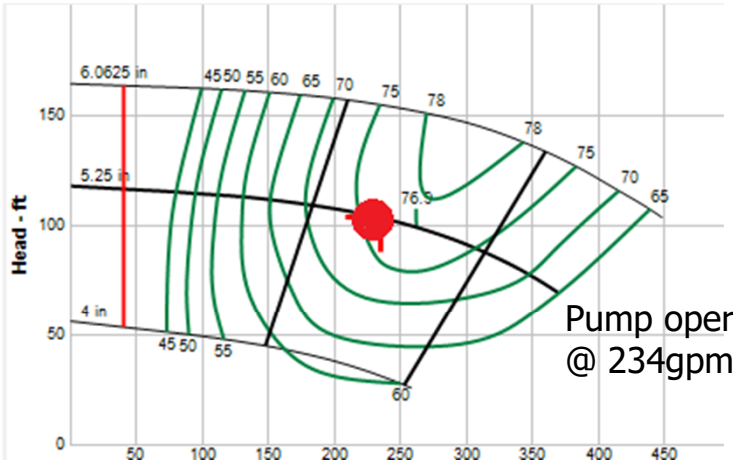


Normal Operating Conditions:

30- 60% of system design load

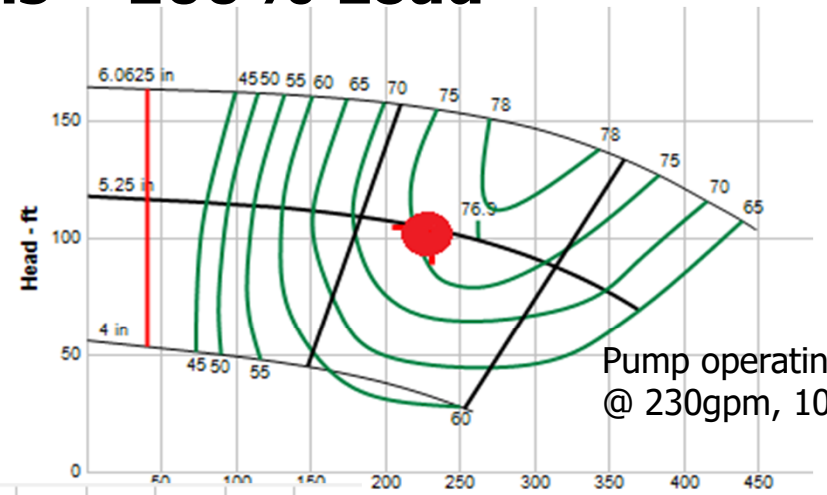
System runs less than 2% of the time at full load design conditions

Design Conditions – 100% Load



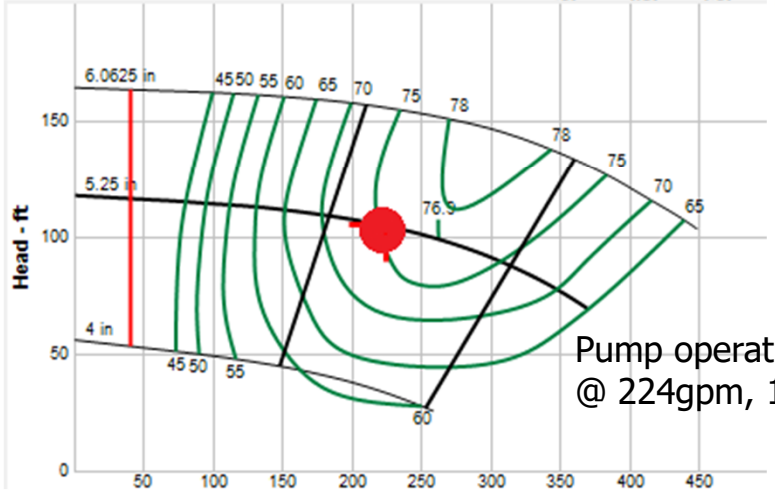
Pump operating
@ 234gpm, 103ft

No Balancing



Pump operating
@ 230gpm, 104ft

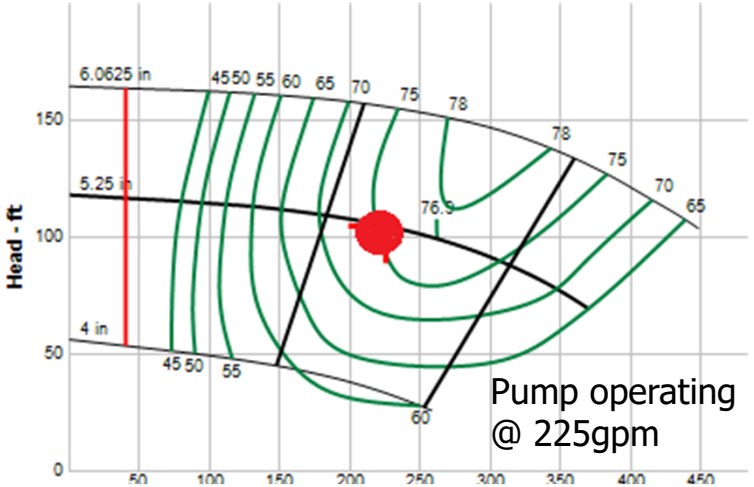
Manual Balancing



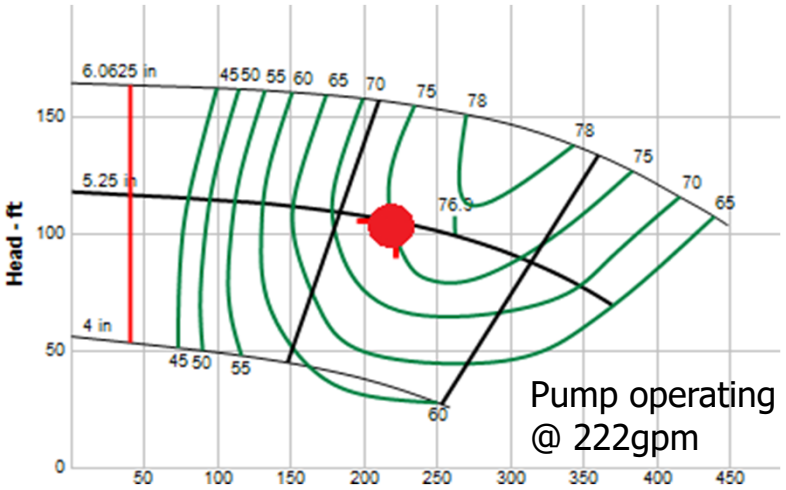
Pump operating
@ 224gpm, 105ft

Automatic Balancing

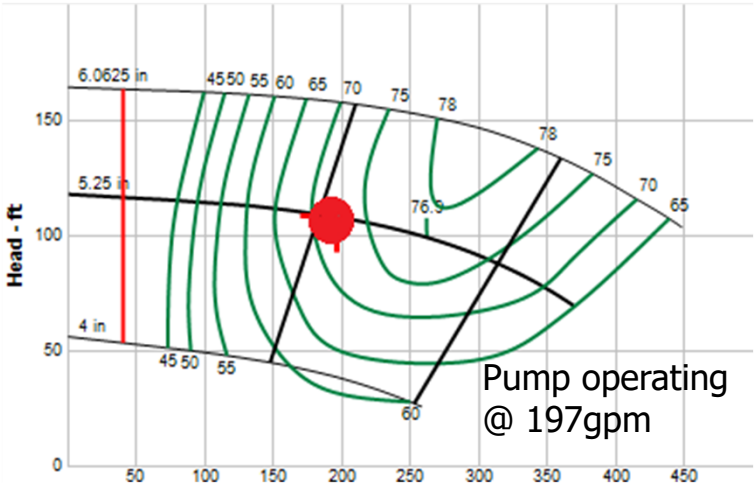
Fixed Speed Pump Curves Comparison: Design Conditions – 90% Load



No Balancing



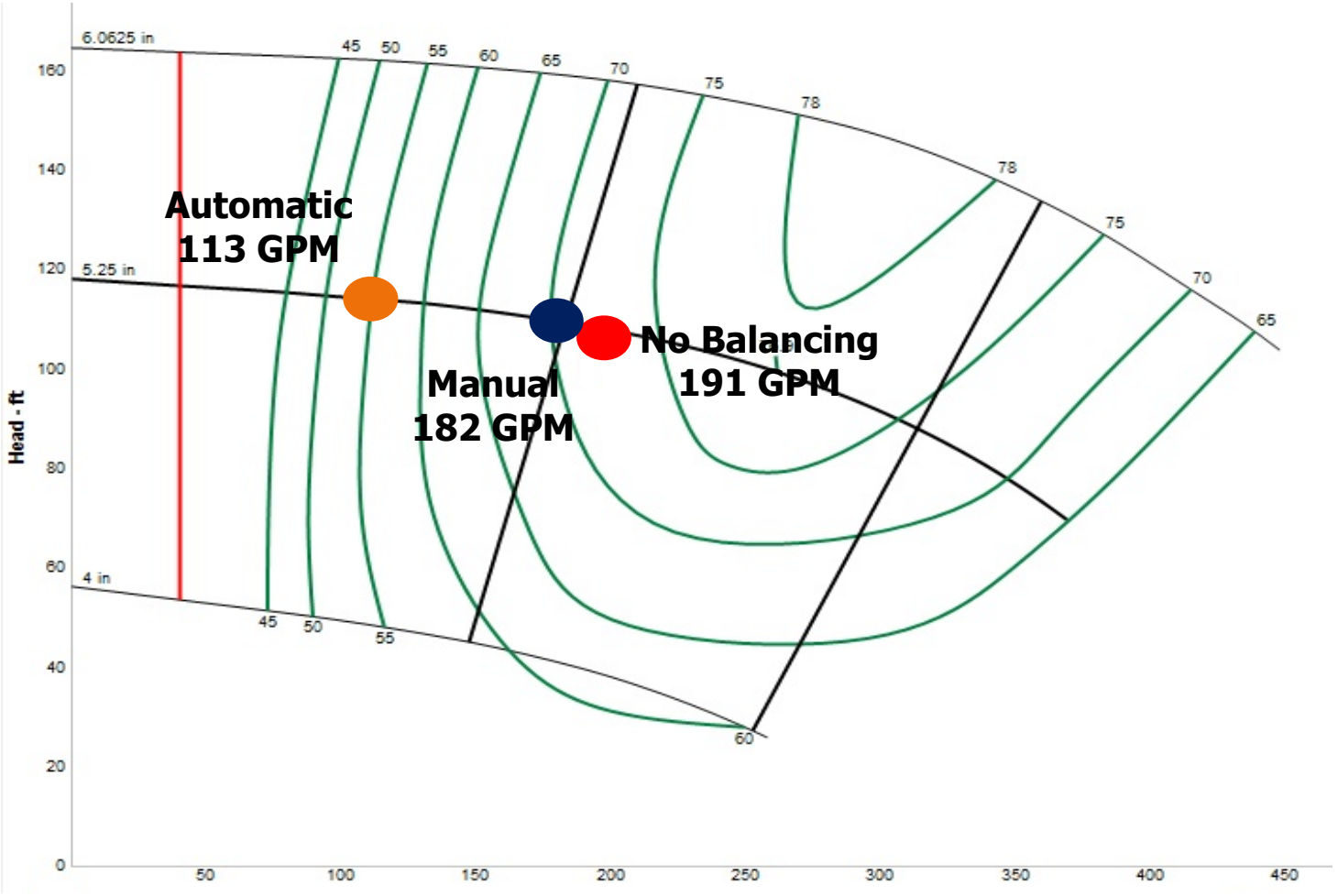
Manual Balancing



Automatic Balancing

Pump Operating point moving to the left on pump curve =
ENERGY SAVINGS

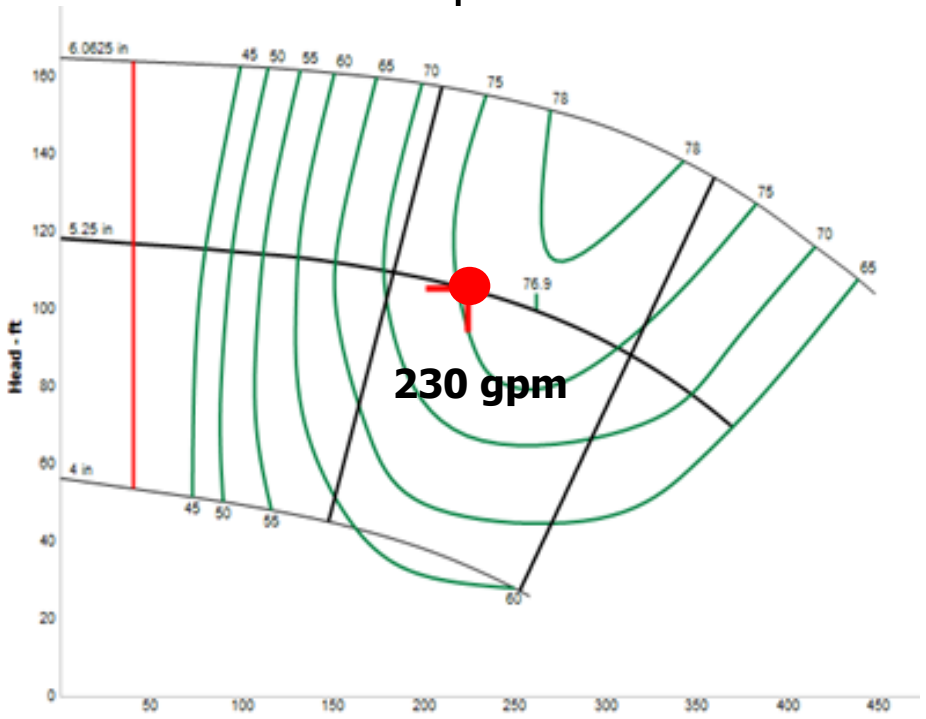
Fixed Speed Pump Curves Comparison: Design Conditions – 50% Load



100% Design Flow Condition

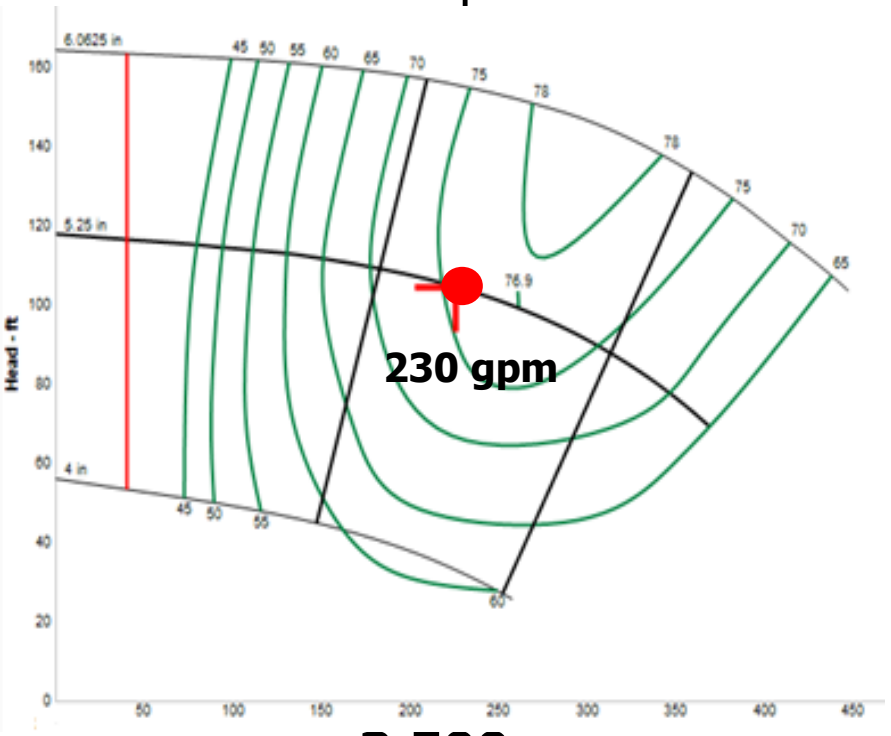
(Manual Balancing)

Fixed Speed Drive



3,500 rpm
Eff: 75.5 %
Power: 8 hp

Variable Speed Drive

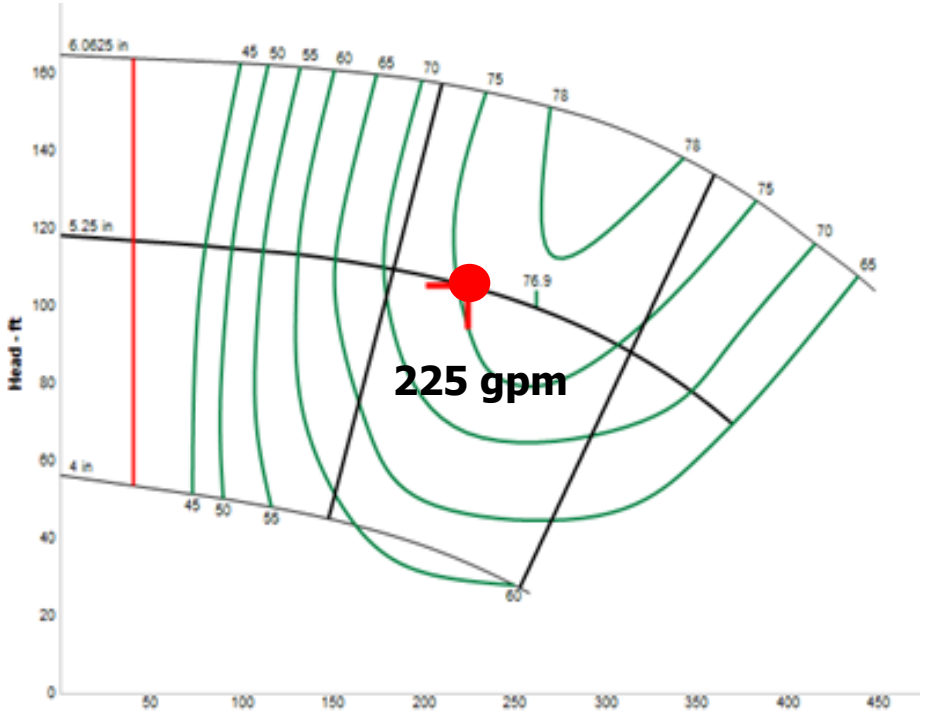


3,500 rpm
Eff: 75.5 %
Power: 8 hp

100% Design Flow Condition

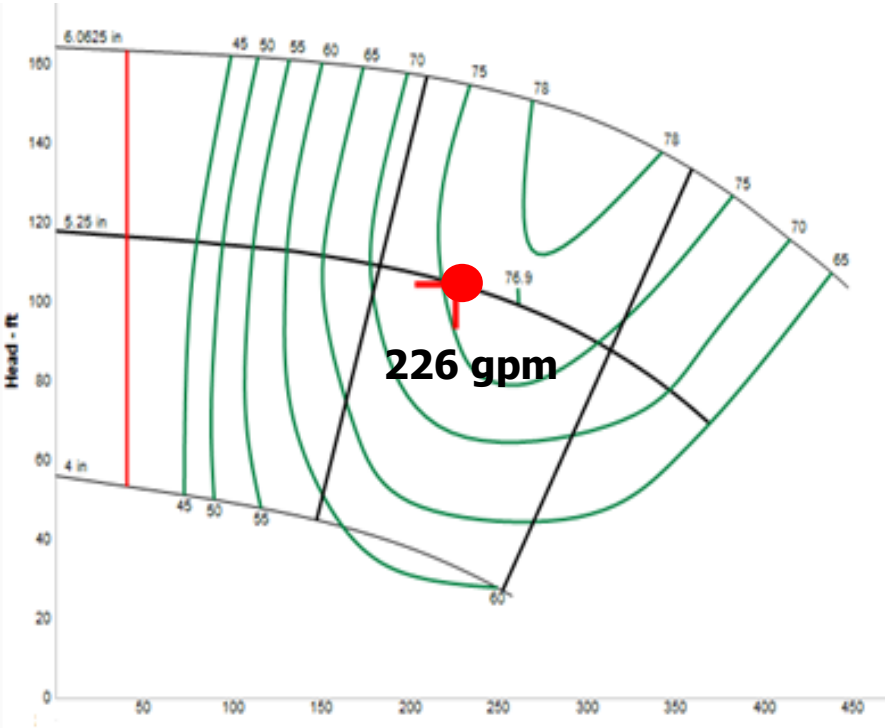
(Automatic Balancing)

Fixed Speed Drive



3,500 rpm
Eff: 75.5 %
Power: 8 hp

Variable Speed Drive

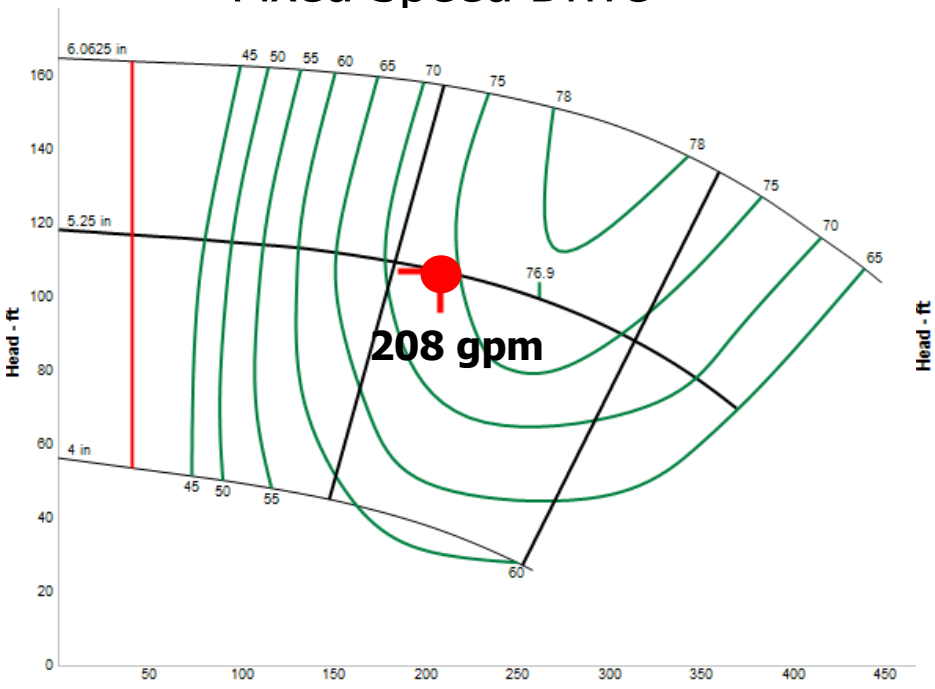


3,500 rpm
Eff: 75.5 %
Power: 8 hp

70 % Design Flow Condition

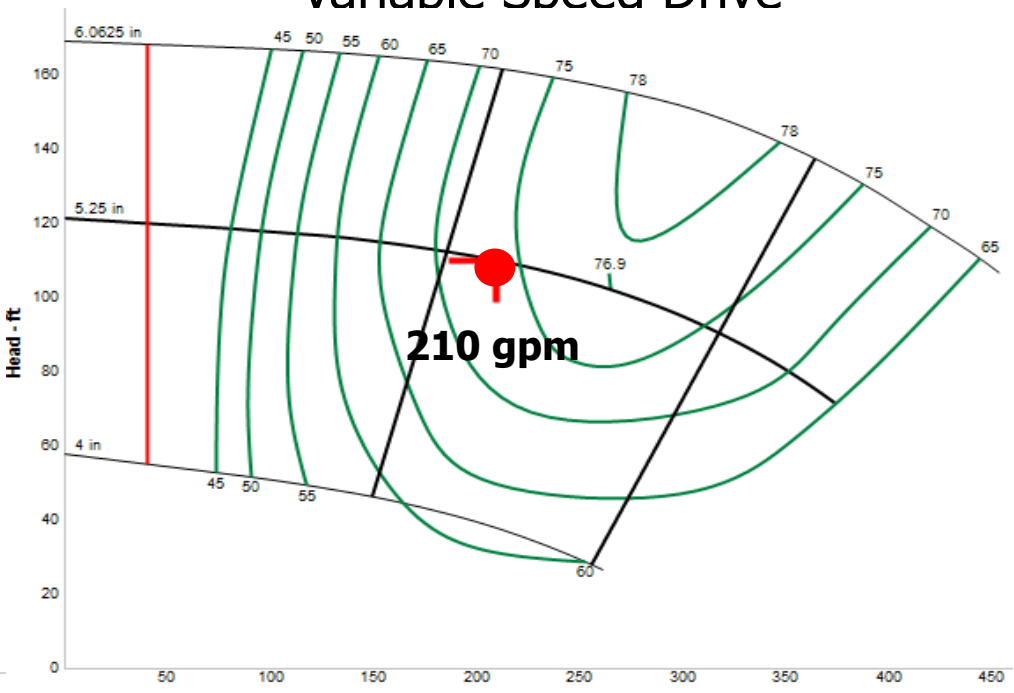
(Manual Balancing)

Fixed Speed Drive



3,500 rpm
Eff: 73.8 %
Power: 7.6 hp

Variable Speed Drive

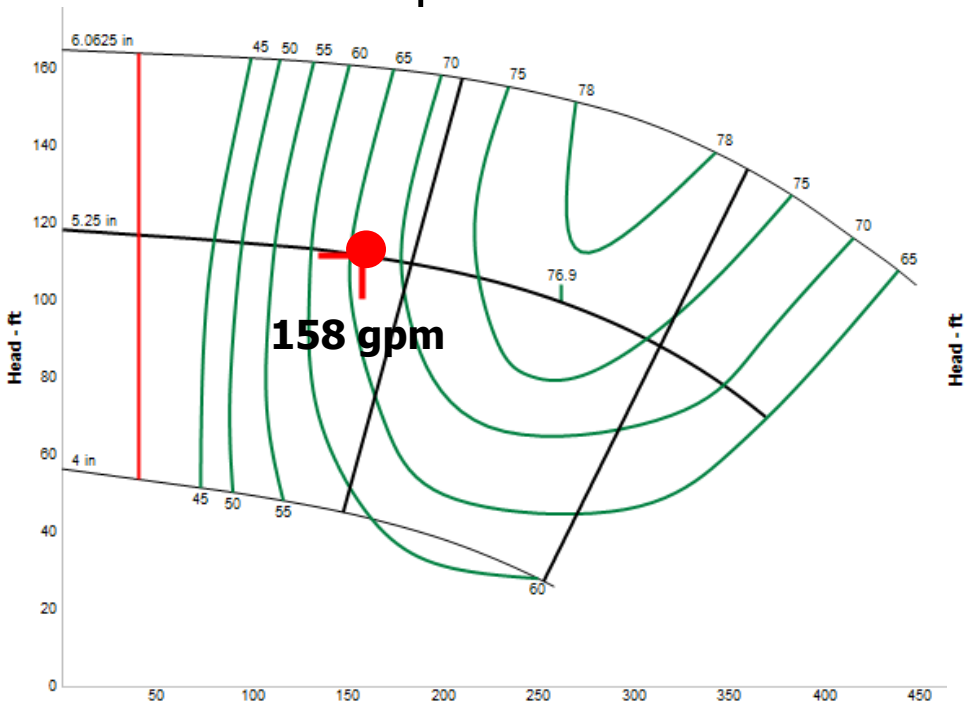


3,545 rpm
Eff: 73.7 %
Power: 7.9 hp

70 % Design Flow Condition

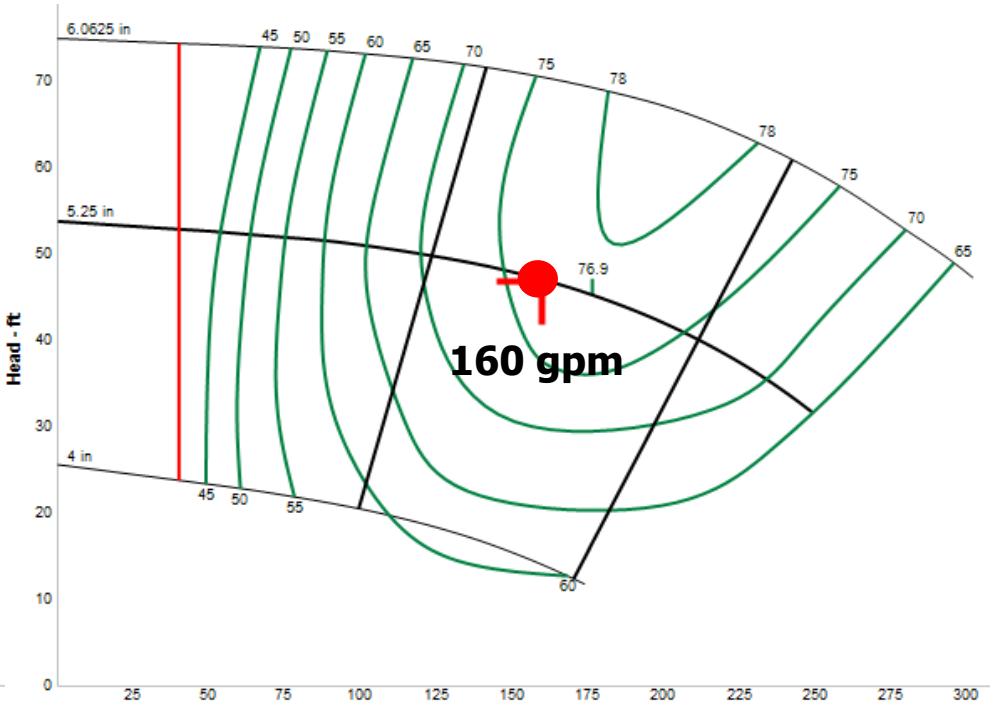
(Automatic Balancing)

Fixed Speed Drive



3,500 rpm
Eff: 66.3 %
Power: 6.7 hp

Variable Speed Drive

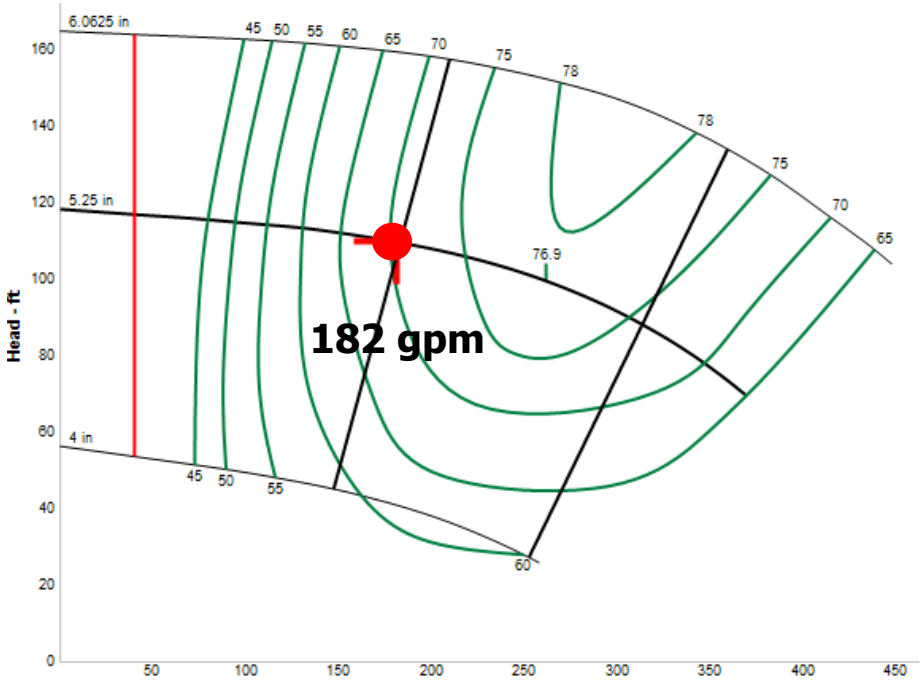


2,360 rpm
Eff: 75.8 %
Power: 2.5 hp

50 % Design Flow Condition

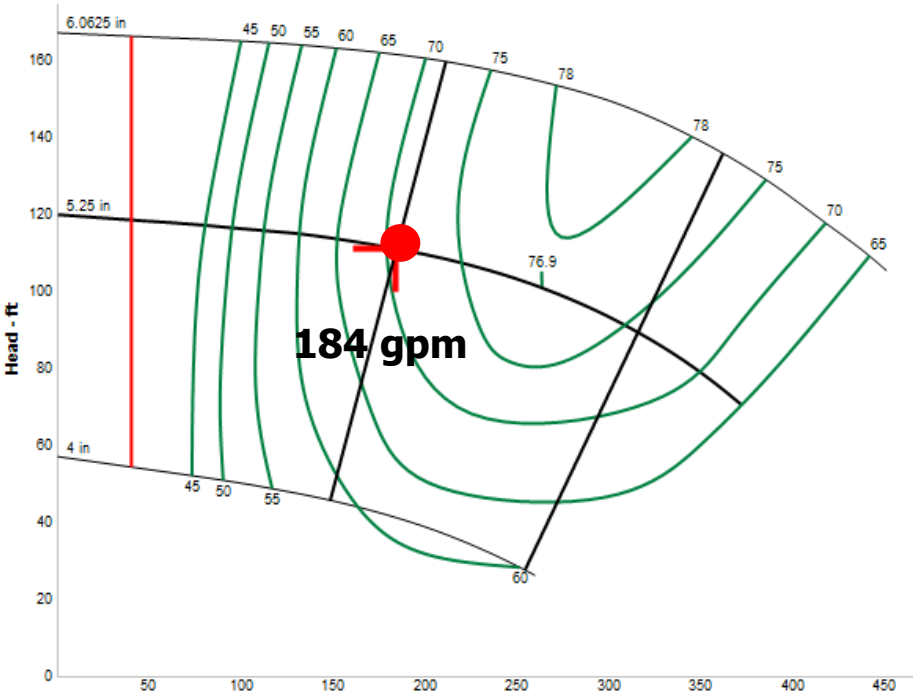
(Manual Balancing)

Fixed Speed Drive



3,500 rpm
Eff: 70.5 %
Power: 7.1 hp

Variable Speed Drive

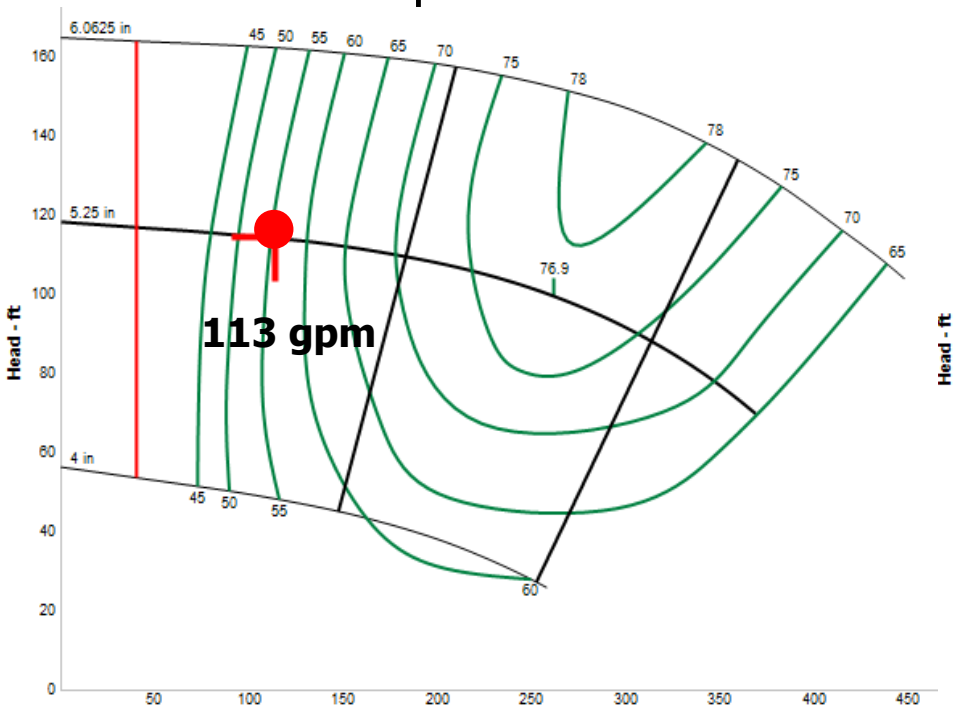


3,525 rpm
Eff: 70.6 %
Power: 7.3 hp

50 % Design Flow Condition

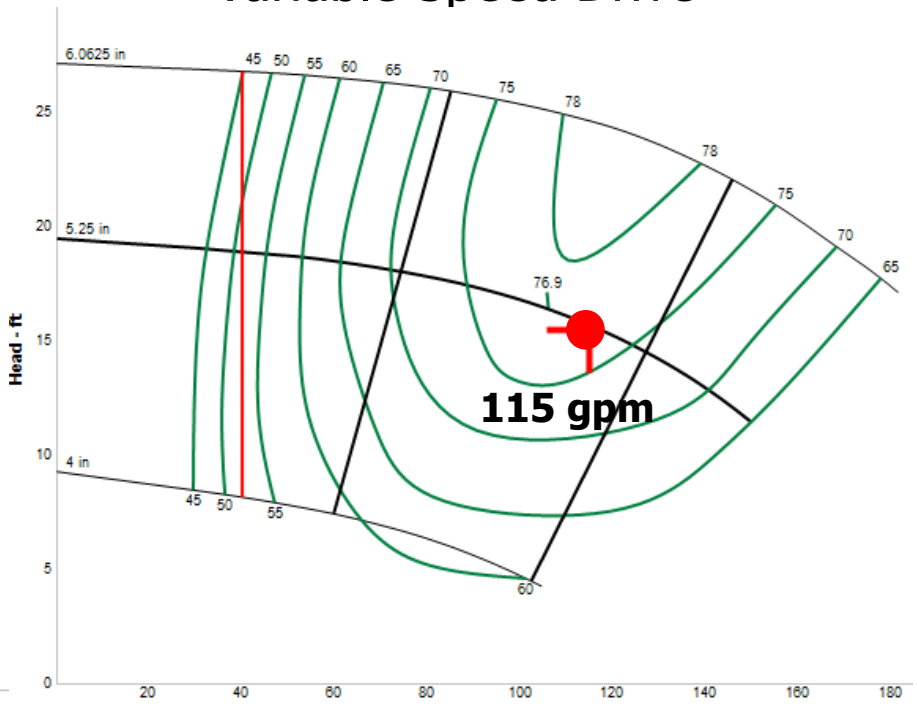
(Automatic Balancing)

Fixed Speed Drive

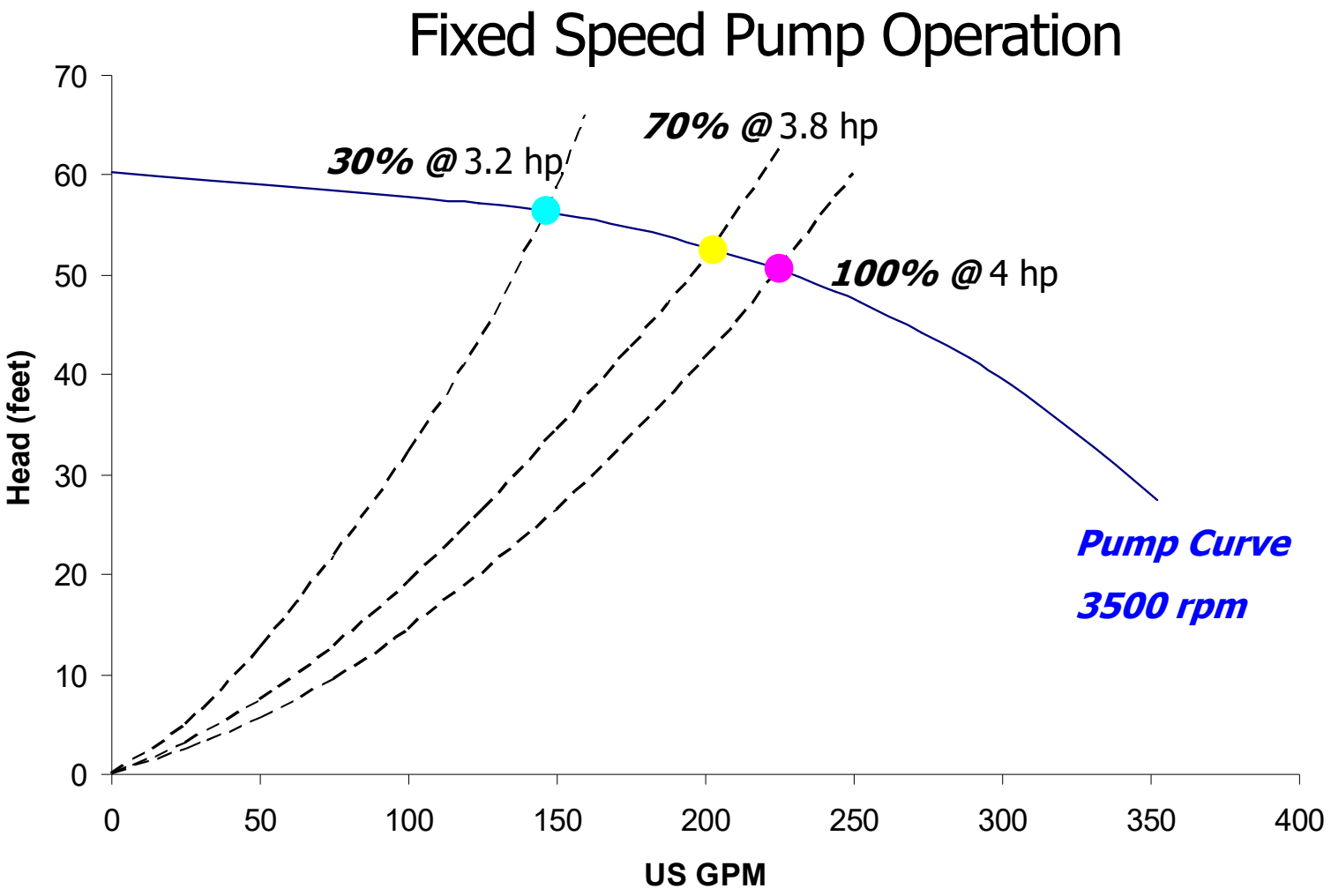


3,500 rpm
Eff: 55.6 %
Power: 5.9 hp

Variable Speed Drive

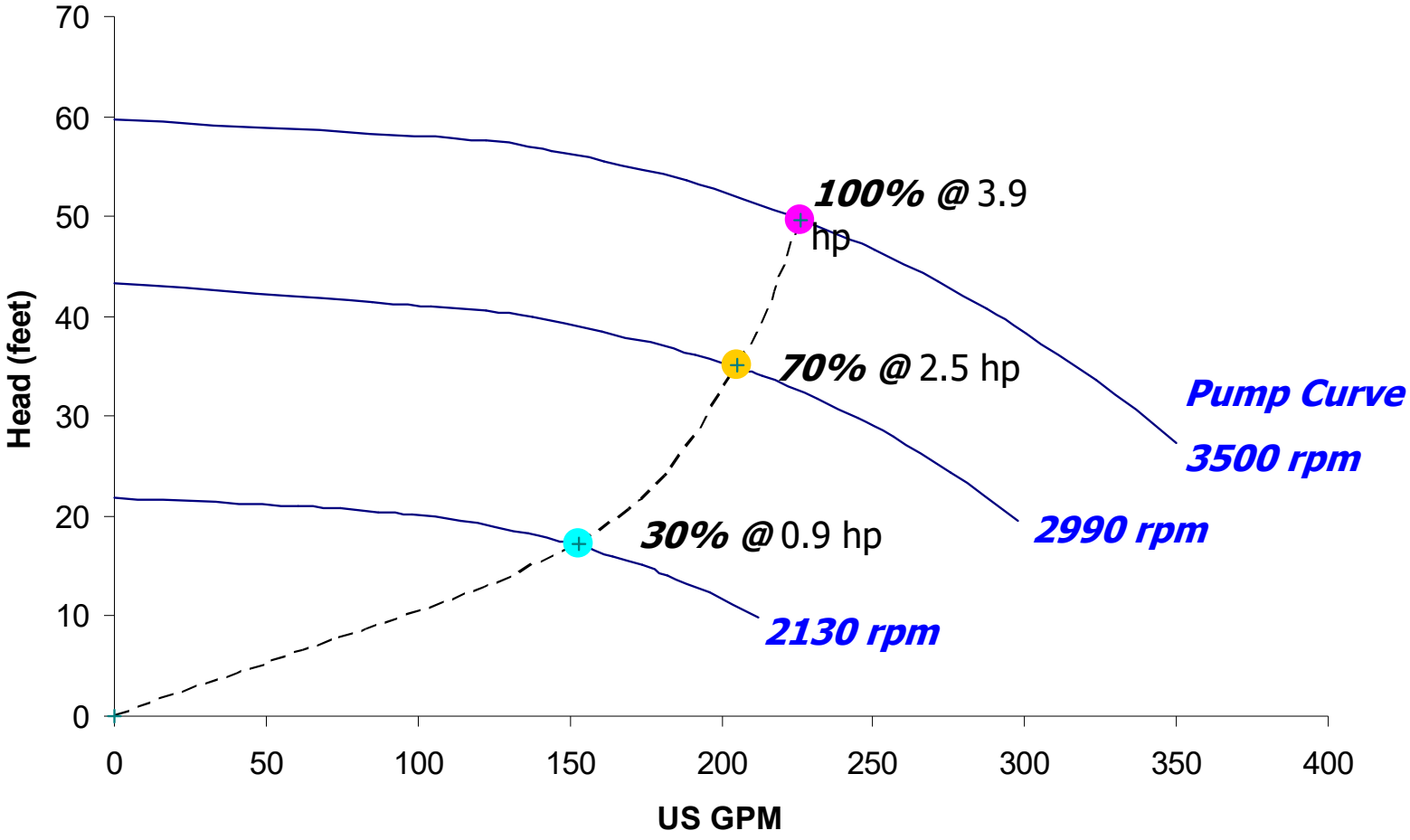


1,420 rpm
Eff: 76 %
Power: 0.6 hp



Automatic
Balancing Valves

Variable Speed Pump Operation



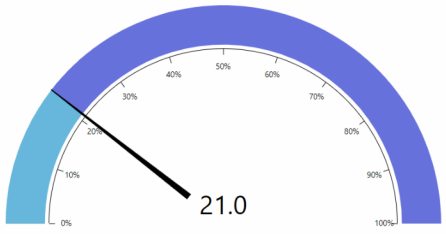
Automatic Balancing Valves

% System Load	% of Operating hours	Operation Cost ($ per % of operating hours)				
		Fully Open No balancing	Manual Balancing		Automatic Balancing	
			Fixed Speed Pumping	Variable Speed Pumping	Fixed Speed Pumping	Variable Speed Pumping
30	**15.25**	2026	1961	2031	1088	1084
40	**19.75**	2834	2744	2828	1961	1810
50	**21.5**	3251	3169	3275	2618	2186
60	**14.25**	2228	2185	2238	1841	1777
70	**9.50**	1521	1497	1545	1307	997
80	**4.00**	652	644	672	586	459
90	**2.25**	372	368	370	350	289
100	**0.50**	83	83	82	82	82
Approx. Annual Pump Running Cost ($/year)		**$12,967**	**$12,650**	**$13,041**	**$9836**	**$8686**

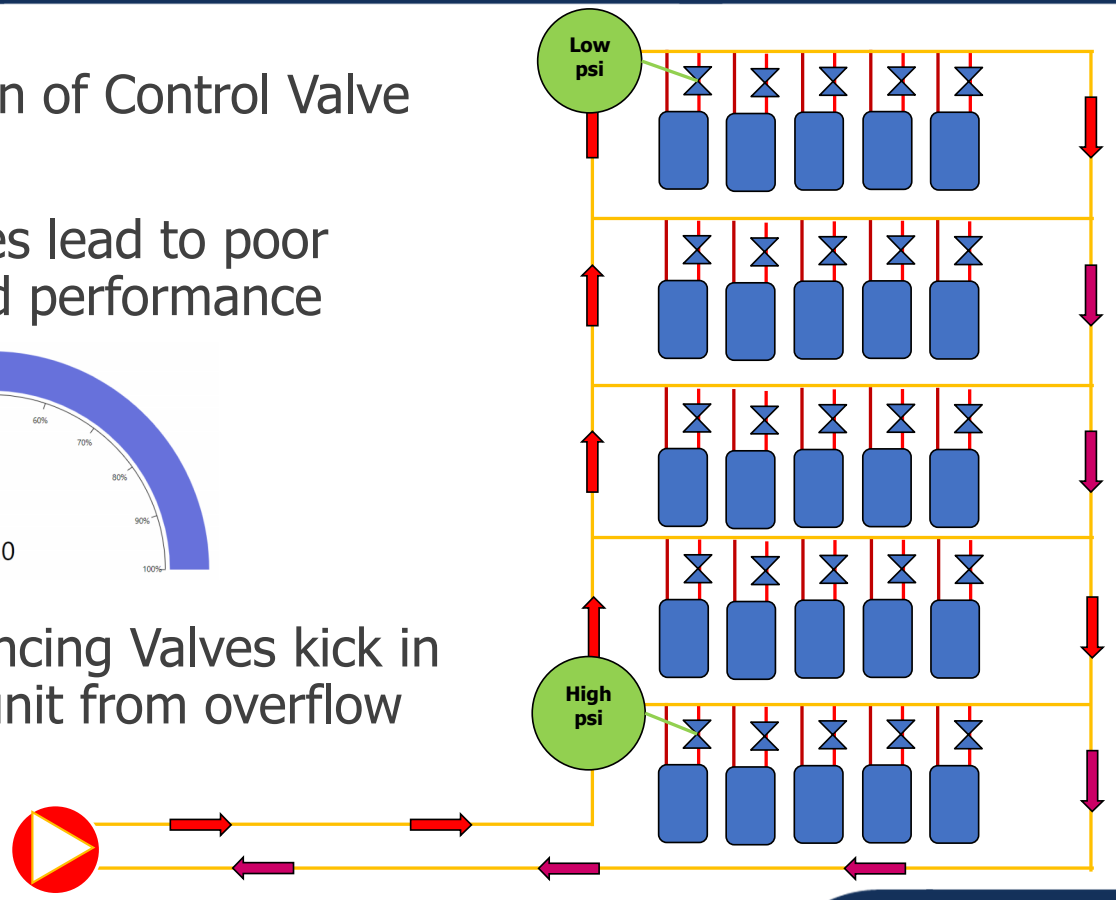
Energy Calculations
(2-Position Control Valves @ $0.10 / kwh)

Cv Rate Selection for Modulation

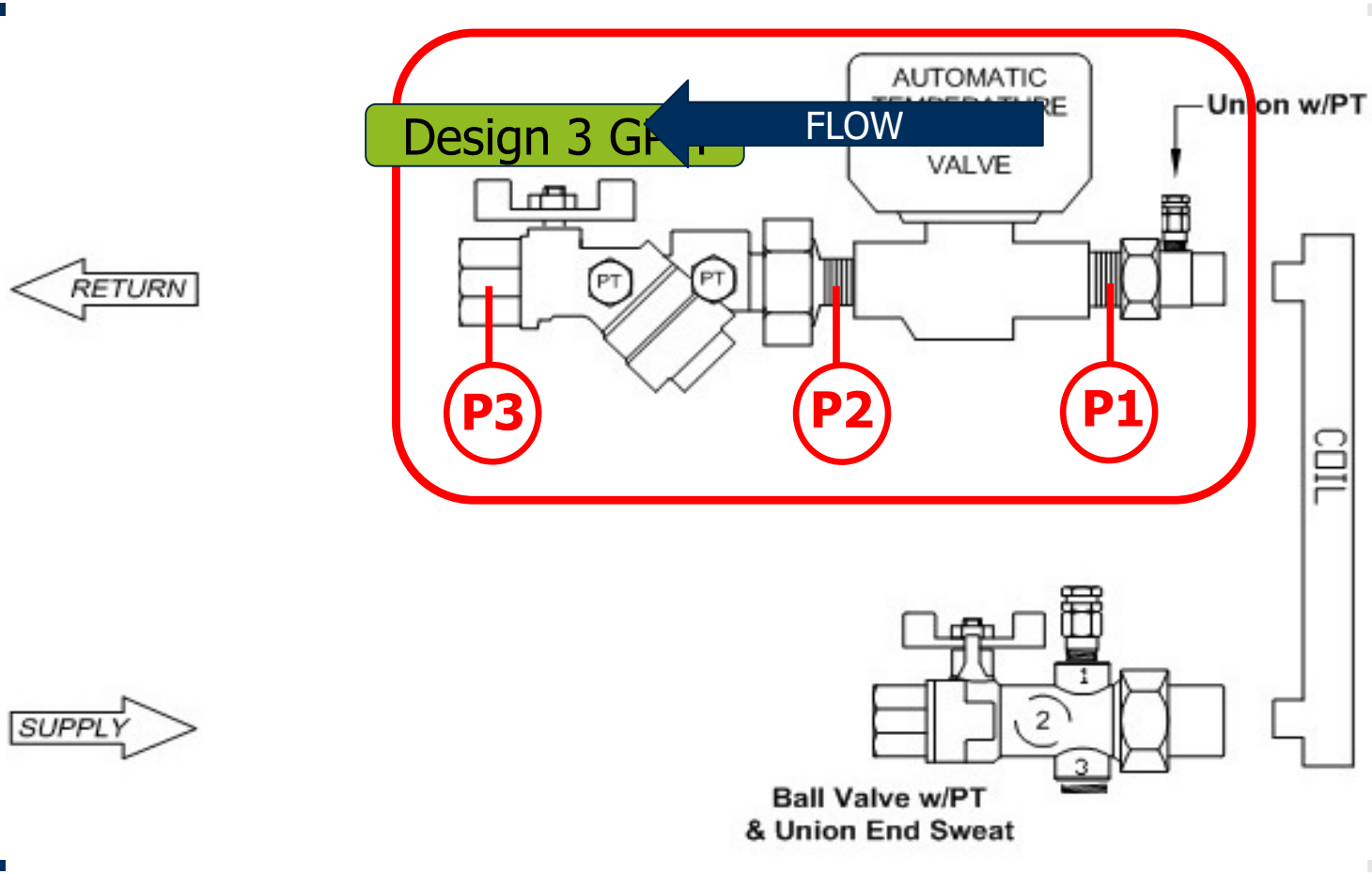
- Cv rate selection of Control Valve body is critical
- Uniform Cv rates lead to poor rangeability and performance



- Automatic Balancing Valves kick in to protect the unit from overflow

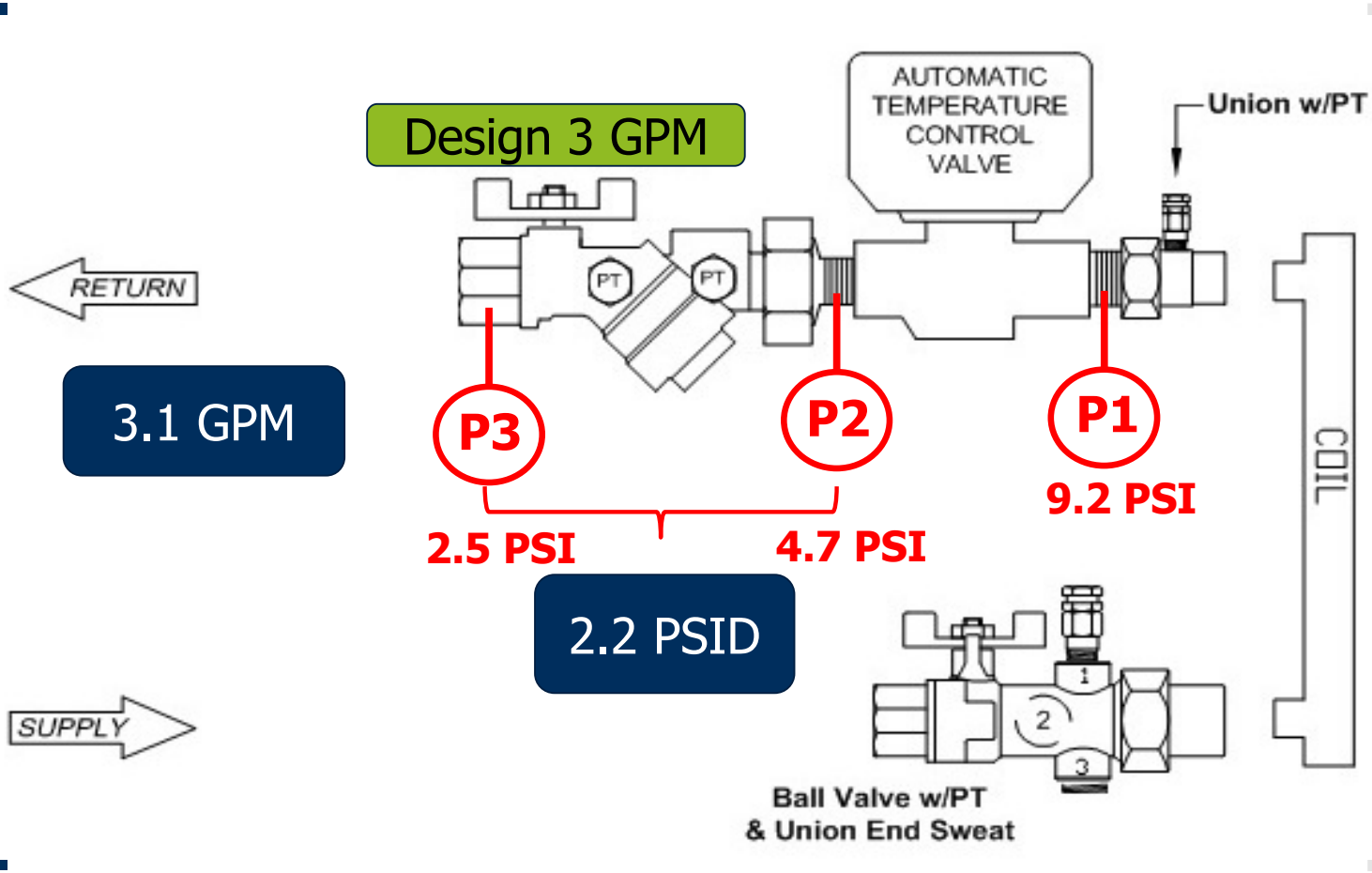


Automatic Balancing Valves & Modulation



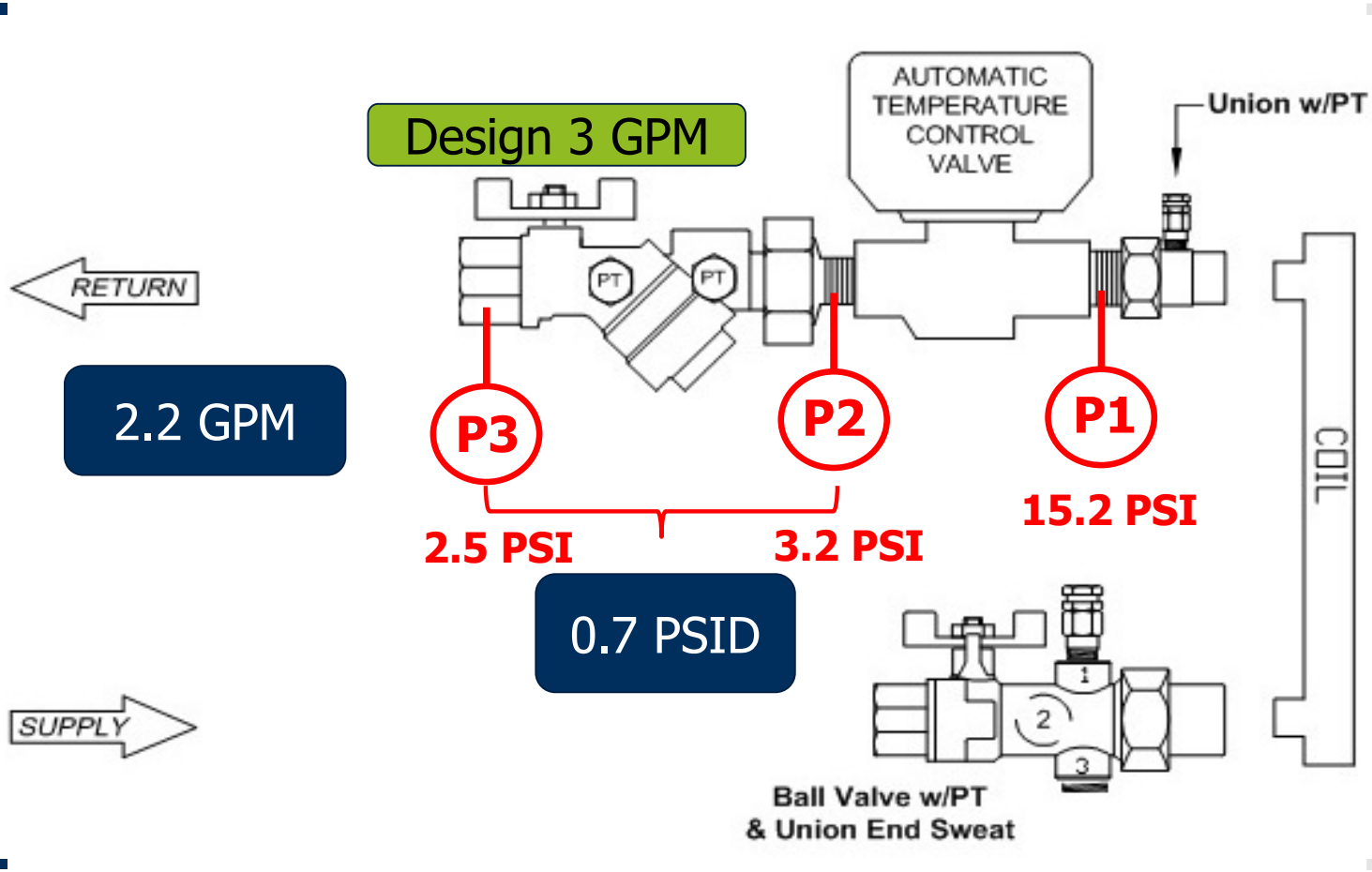
Automatic Balancing Valves & Modulation

(Control Valve = 100% Open)



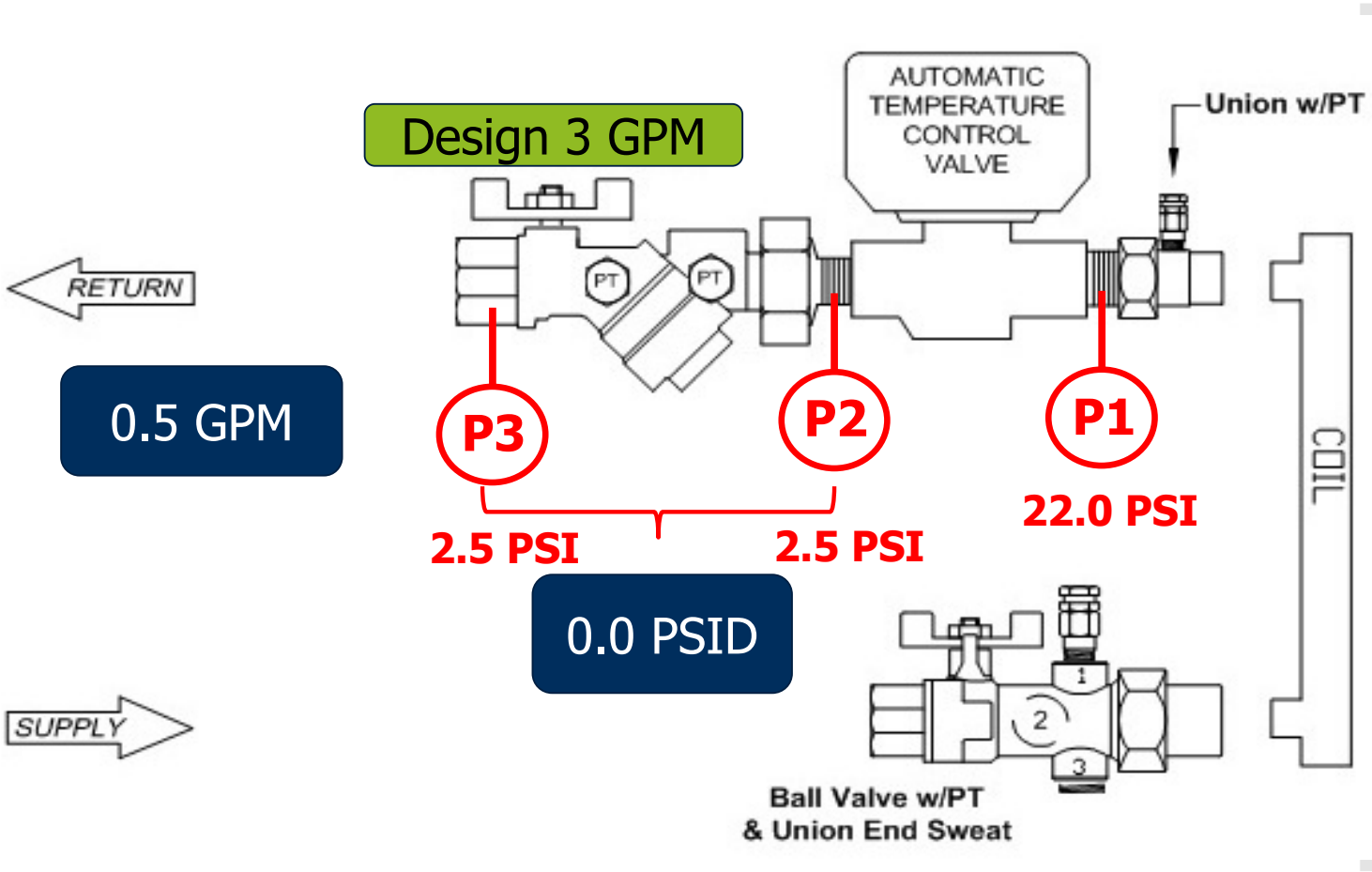
Automatic Balancing Valves & Modulation

(Control Valve = 70% Open)



Automatic Balancing Valves & Modulation

(Control Valve = 20% Open)



Conclusion

- Manual balancing valves are costly to install/balance & are ineffective during the system's lifespan
- *Automatic* balancing valves greatly reduce T&B time/cost, eliminate overflow by reacting to system pressure fluctuations, thereby saving energy & improving comfort

QUESTIONS ?