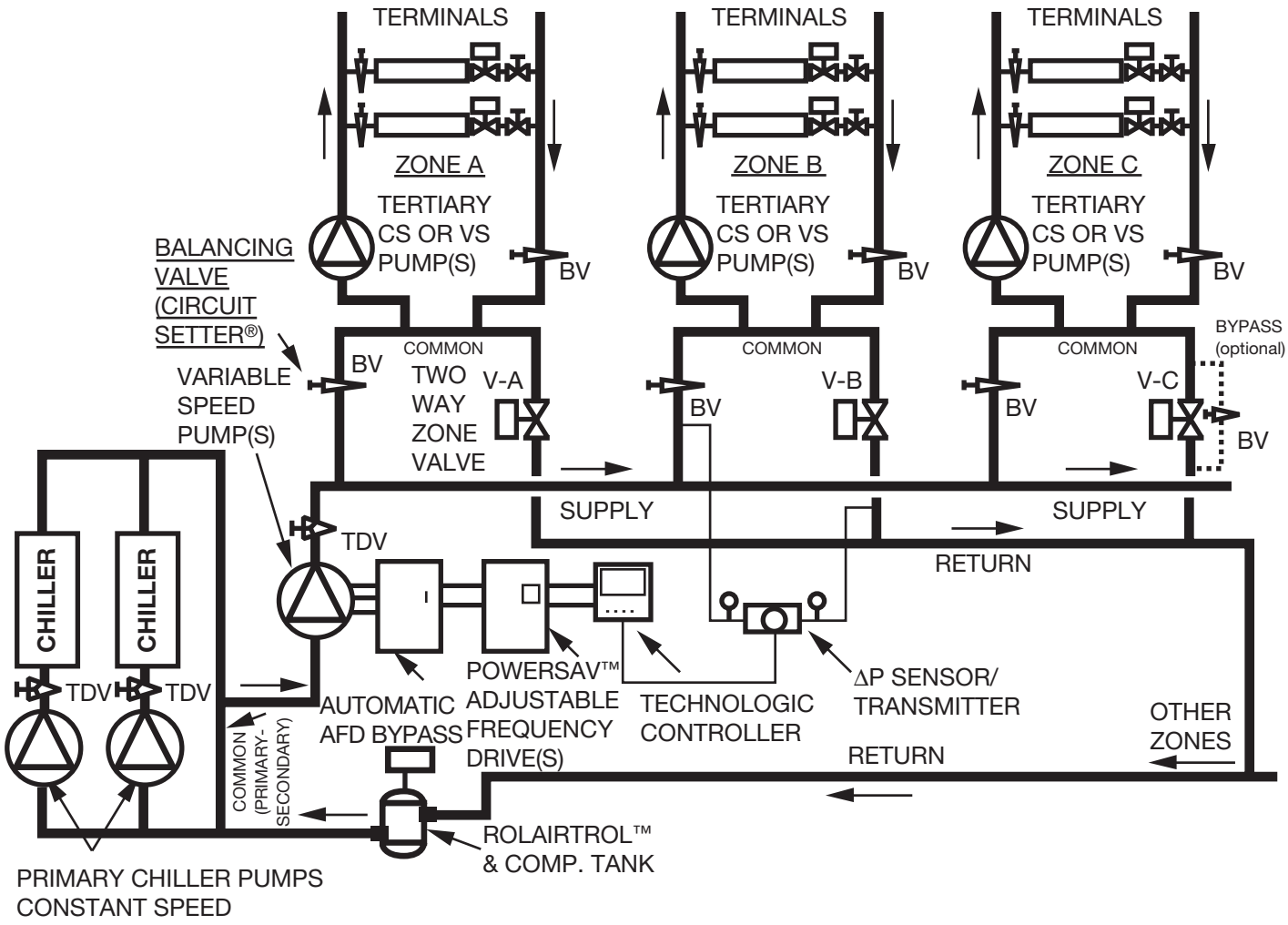
POWERSAV®

Bulletin D-120C

REPLACES BULLETIN D-120B

VARIABLE VOLUME / VARIABLE SPEED PUMPING SYSTEMS APPLICATIONS



UNIT RESPONSIBILITY

WITH

POWERSAV®

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Packaged Systems Group

Bell & Gossett®

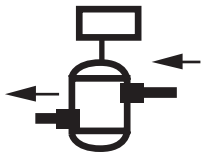
ITT Industries
Engineered for life

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

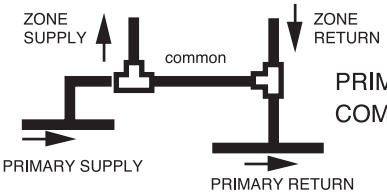
INDEX-VARIABLE SPEED PUMPING SYSTEMS

VARIABLE SPEED / VARIABLE VOLUME PUMPING SCHEMATIC APPLICATION DRAWING SYMBOLS

CENTRIFUGAL PUMP



ROLAIRTROL™ & COMPRESSION TANK



PRIMARY-SECONDARY COMMON

BALANCING VALVE (BV) (CIRCUIT SETTER®)

CHECK VALVE

TRIPLE DUTY® (TDV) VALVE

CHILLER, BOILER, HEAT EXCHANGER

TERMINAL, COIL, ETC.

PRESSURE REGULATING VALVE (PRV)

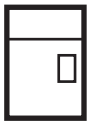
FILL VALVE, REDUCING VALVE

RELIEF VALVE

FIXTURE, FAUCET

HAND VALVE (HV) (GATE, GLOBE, BALL)

TECHNOLOGIC™ PUMP CONTROLLER



ADJUSTABLE FREQUENCY DRIVE (AFD)

AUTOMATIC AFD BYPASS/TRANSFER

ΔP DIFFERENTIAL PRESSURE SENSOR/TRANSMITTER

PRESSURE SENSOR/ TRANSMITTER

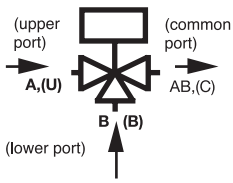
TEMPERATURE SENSOR/TRANSMITTER

MISC. TEMPERATURE CONTROLLER, THERMOSTAT, ETC.

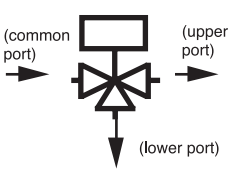
THERMOSTATIC RADIATOR VALVE (THERMO-MATE®)

COMFORTROL™ ZONE VALVE

TWO-WAY CONTROL VALVE (V)



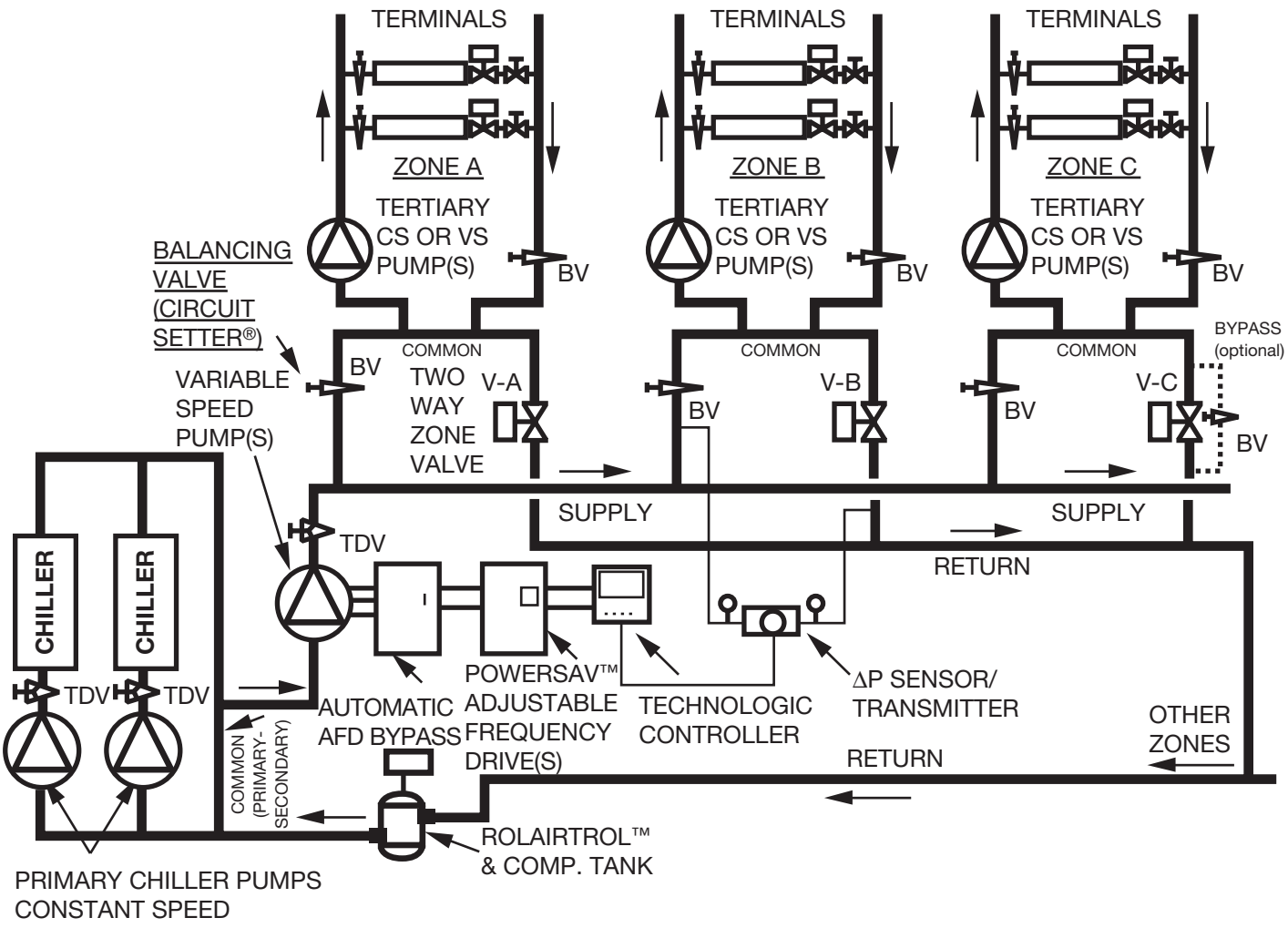
THREE-WAY MIXING CONTROL VALVE (V)



THREE-WAY DIVERTING CONTROL VALVE (V)

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED CHILLED WATER PUMP CONTROL PRIMARY-SECONDARY-TERTIARY SYSTEM WITH REVERSE SECONDARY DISTRIBUTION



VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED CHILLED WATER PUMP CONTROL PRIMARY-SECONDARY-TERTIARY SYSTEM WITH REVERSE SECONDARY DISTRIBUTION

DESCRIPTION:
The volume of water supplied to the system is varied in response to the cooling load by the two-way zone valves. The basis of Variable Speed Pumping is to save pumping cost by optimizing the pump motor horsepower input. The pump produces only the flow and head required at any time. This is performed by regulation of the pump speed by an Adjustable Frequency Drive and Technologic™ Pump Controller. The controller regulates the pump speed in response to the system load conditions.

DESIGN PHILOSOPHY:
The concept of Variable Volume-Variable Speed pumping offers several advantages:

The ability to supply the cooling required to meet the demand.
The two-way control valve properly sized and selected assures the zone control system with the flow required at all loads. The Chillers are sequenced by their control system to maintain their temperature.

The flexibility to expand the system easily–
The primary-secondary-tertiary system shown has ultimate capabilities with little modifications required. Additional chillers can be added in parallel along with expansion of distribution pumps to meet the new load conditions.

Accurate comfort control–
By maintaining the system control at the design temperature drops, the complete system operates at its design conditions and comfort levels.

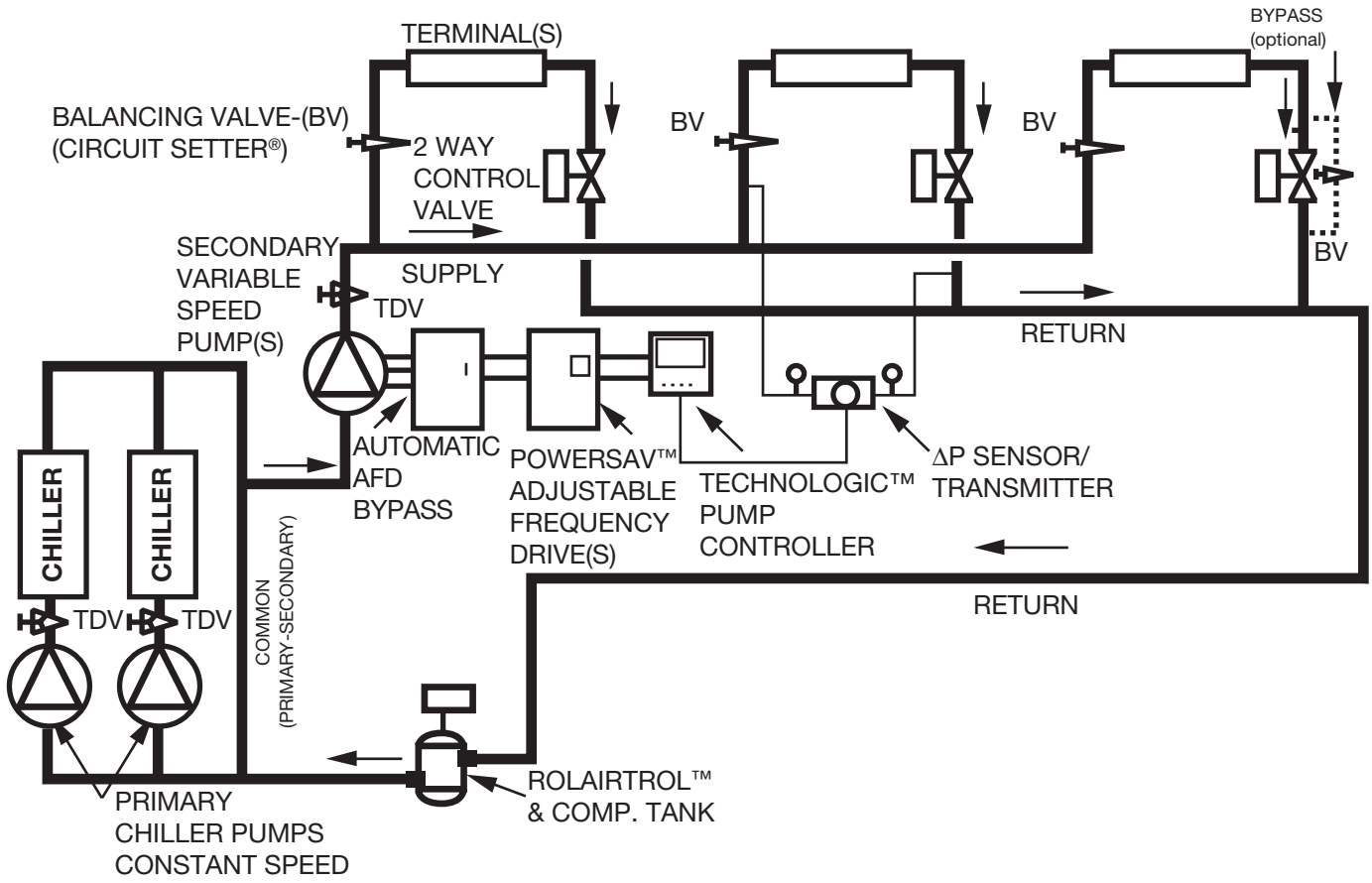
Minimum energy consumption–
Utilizing the Variable Volume system (two-way terminal control valves), the pumping energy can be reduced by more than two-thirds that of a constant speed pumping system riding its pump curve. In addition the primary-secondary design decouples the chiller pumps from the distribution pumps enabling them to be cycled, staged and/or loaded to meet the load requirements as they occur.

APPLICATION COMMENTS:

- The Chillers are placed in a primary-secondary relationship with the distribution load allowing constant speed pumping for the chillers which are sized for the chiller pressure drop and the chiller related piping. The parallel chiller arrangement provides more efficient staging by chiller efficiency and its design permits future expansion.
- When reverse return distribution piping is employed, the piping pressure drop differential from zone to zone is minimized however it must be proportionally balanced to maintain correct distribution and the ΔP sensor/transmitter should be placed centrally as shown; for direct return systems the importance of proportional balancing is essential and the ΔP sensor/transmitter should be located near or across the last zone's risers.
- Improperly located ΔP sensor/transmitters may greatly diminish, or even negate, the savings potential of the Variable Speed Pumping System. Conversely, proper location and a practical number of ΔP sensor/transmitters will maximize the savings by optimizing the system operation.
- A primary-secondary-tertiary should be considered when:
  - applied to a large system (large cooling or heating loads or long piping runs)
  - high diversity requirements
  - high system loss on only 1 or 2 zones (out of many)
  - variable pressure drops (ΔP) on different zones if any of the above conditions are present the tertiary Variable Speed pumping concept will save significant operating cost over primary-secondary. The Bell & Gossett ESP PLUS™ computer program should be consulted for a detailed load analysis.
- Where there are multiple significant loads that have peaks at different times, multiple sensor/transmitters locations should be considered. The Technologic Pump Controller will automatically monitor all sensors with reference to each set point and control to the largest deviation from set point, thus satisfying all loads.
- Where extended loads are light or where a system has week-end shut-downs a small bypass with a balancing valve set for low flow around the zone two-way valve might be a design consideration to reduce thermal stratification and allows a quicker start-up after the shut-down period.
- A good understanding of set point is required to optimize the operation of the variable speed pumping system. If it is set too high, the pumping system will not slow down and the predicted savings in power will not be realized.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED CHILLED WATER PUMPING CONTROL TWO-WAY VALVE REVERSE RETURN PIPING SYSTEM

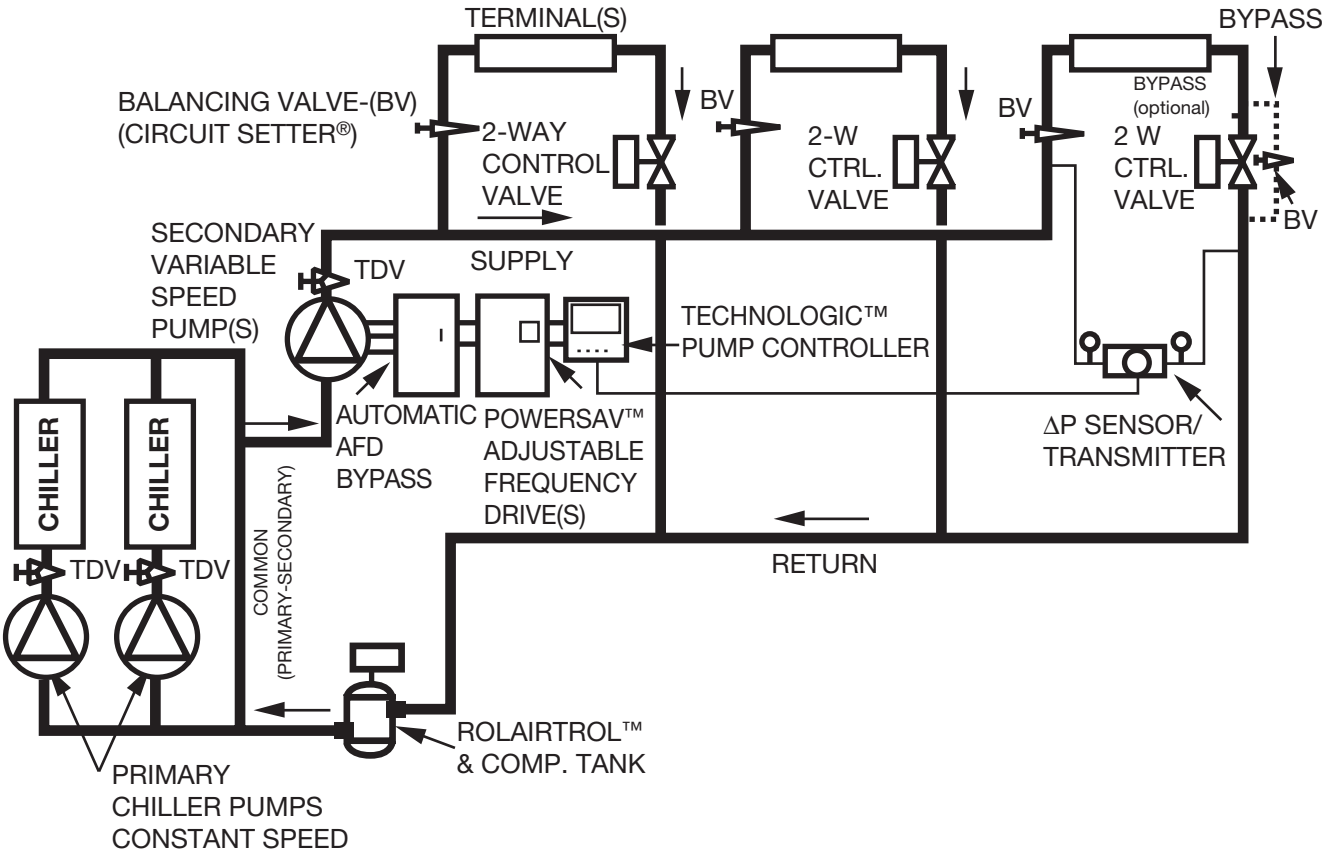


APPLICATION COMMENTS:

- Primary-Secondary pump system for maximum energy savings and control. For further information see Design Philosophy #1 (Drawing D120-102).
- The Variable Speed secondary system responds to a differential pressure sensor/transmitter which is sensing across typical supply-return branch or terminal and two-way control valve. This allows for energy savings as the terminals respond to a lighter load and the two-way valves control at a lower flow position. This increased pressure drop signals the controller to operate the pump(s) at a lower speed to maintain its set point.
- In a system where there are major load differences from one riser to another, multiple ΔP sensor/transmitters can be applied to each major load with unique set points for each load. The controller will control the pump(s) speed for the worst condition, providing even greater energy savings.
- Single ΔP sensor/transmitters should be placed centrally in a reverse return piping system to provide an average indication of load for the entire system.
- Reverse return piping design is usually selected to minimize pressure drop from zone to zone. However, it must be proportionally balanced to maintain uniform distribution.
- The greater the system head loss (terminal coils, piping, fittings) the greater the potential for pumping energy savings.
- An optional bypass with a 2-3% maximum flow setting may be considered for zones with week-end shut down for even pick-up and for more stability for light load conditions. In lieu of bypass on last zone, a 3-way valve may be employed with balancing valve in its bypass.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED CHILLED WATER PUMPING CONTROL TWO-WAY VALVE DIRECT RETURN PIPING SYSTEM

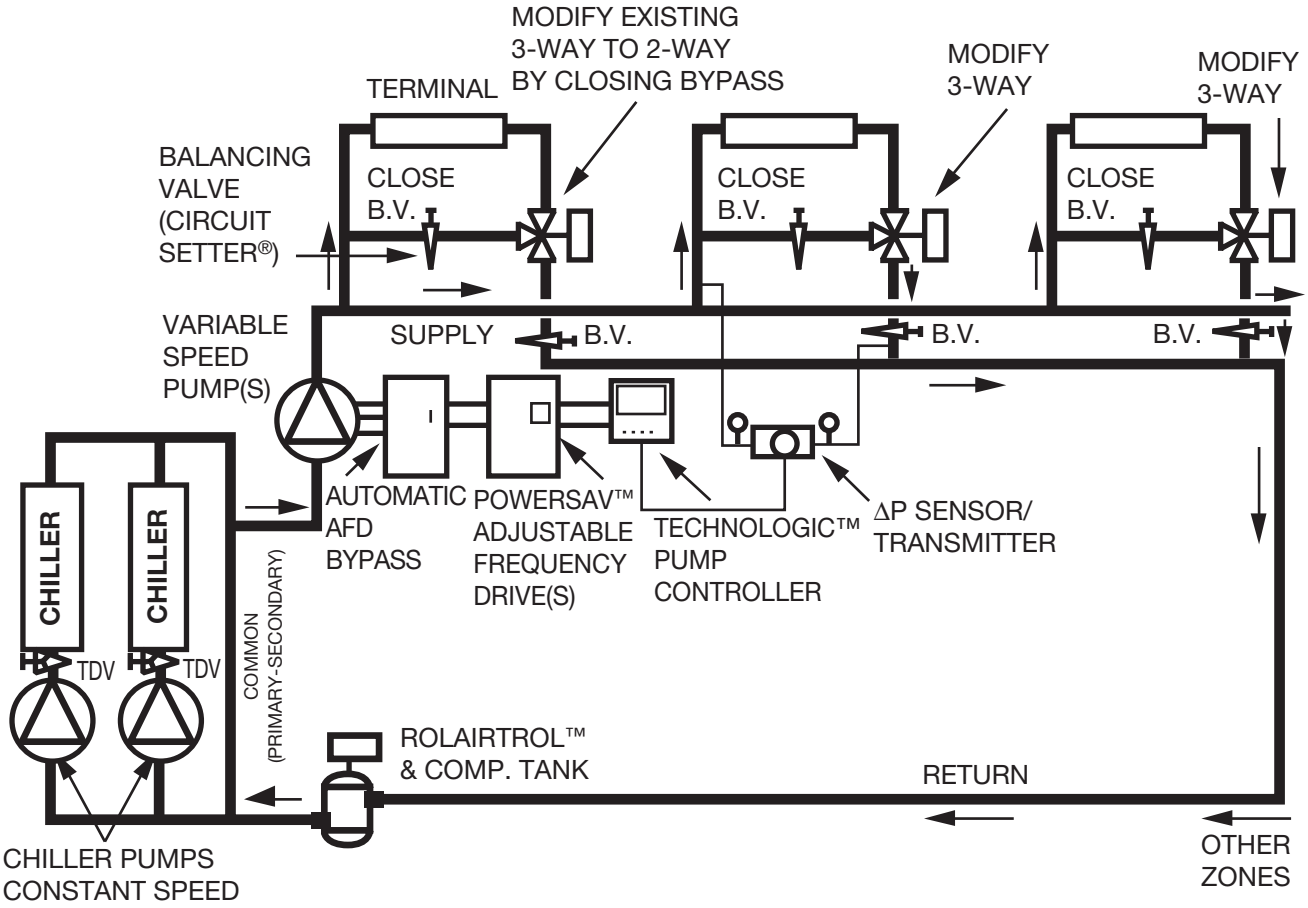


APPLICATION COMMENTS:

- Primary-Secondary pump system for maximum energy savings and control. For further information see Design Philosophy #1 (Drawing D120-102).
- The Variable Speed secondary system responds to a differential pressure sensor/transmitter which is sensing across typical supply-return branch or terminal and two-way control valve. This allows for energy savings as the terminals respond to a lighter load and the two-way valves control at a lower flow position. This increased pressure drop signals the controller to operate the pump(s) at a lower speed to maintain its set point.
- In a system where there are major load differences from one riser to another, multiple ΔP sensor/transmitters can be applied to each major load with unique set points for each load. The controller will control the pump(s) speed for the worst condition, providing even greater energy savings.
- Single ΔP sensor/transmitters should be placed across the farthest and most resistant load in a direct return piping system to provide a signal for the entire system.
- Direct return piping design is usually selected as a lower first cost alternative. However, balancing is more difficult since the pressure drop across the first zones will be much greater and proportional balancing will be required to prevent overflow conditions.
- The greater the system head loss (terminal coils, piping, fittings) the greater the potential for pumping energy savings.
- An optional bypass with a 2-3% maximum flow setting may be considered for zones with week-end shut down for even pick-up and for more stability for light load conditions. In lieu of bypass on last zone, a 3-way valve may be employed with balancing valve in

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

CONVERSION OF CONSTANT SPEED PUMPING & 3-WAY VALVES TO VARIABLE SPEED CHILLED WATER PUMP CONTROL

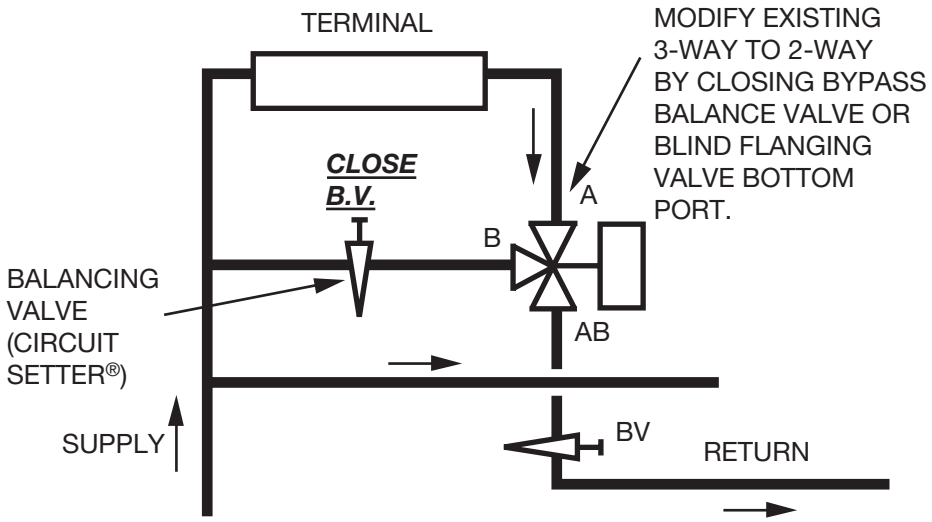


APPLICATION COMMENTS:

- Primary-Secondary pump system for maximum energy savings and control. For further information see Design Philosophy #1 (Drawing D120-102).
- Convert 3-Way valves to Two-way operation to provide variable terminal flow in relation to load and maximize potential pump energy savings by only circulating what is actually required. Check the valve operator for adequate closing power since it will now operate in a two-way mode and must be able to close against the highest expected differential pressure or that determined by the pump variable speed controller ΔP setting.
- Primary-secondary pump chillers are needed because of variable system flow in secondary.
- The balancing valve (BV) in the return line should be re-balanced to proportionally set the design flow to this terminal in proportion to the other valves in this zone.
- ΔP sensor/transmitter taps to be located at end of direct-return main, or centrally for reverse return main.
- For multi-distribution mains, suggest ΔP sensor/transmitter for end of each direct/return main with unique set points and one Technologic Pump Controller.
- The valve size and plug characteristic should also be checked for two-way operation. Valve size should be based upon the terminal design flow (gpm) at an adequate pressure drop. Calculate its Cv factor and compare against the existing valve's value. (Note: $Cv=GPM/\sqrt{\Delta P}$). If more than 25% oversize is found then a smaller valve should be installed. (See drawing D120-105-1.)

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

CONVERSION OF CONSTANT VOLUME PUMPING WITH 3-WAY VALVES TO VARIABLE SPEED-VARIABLE VOLUME PUMPING SYSTEM

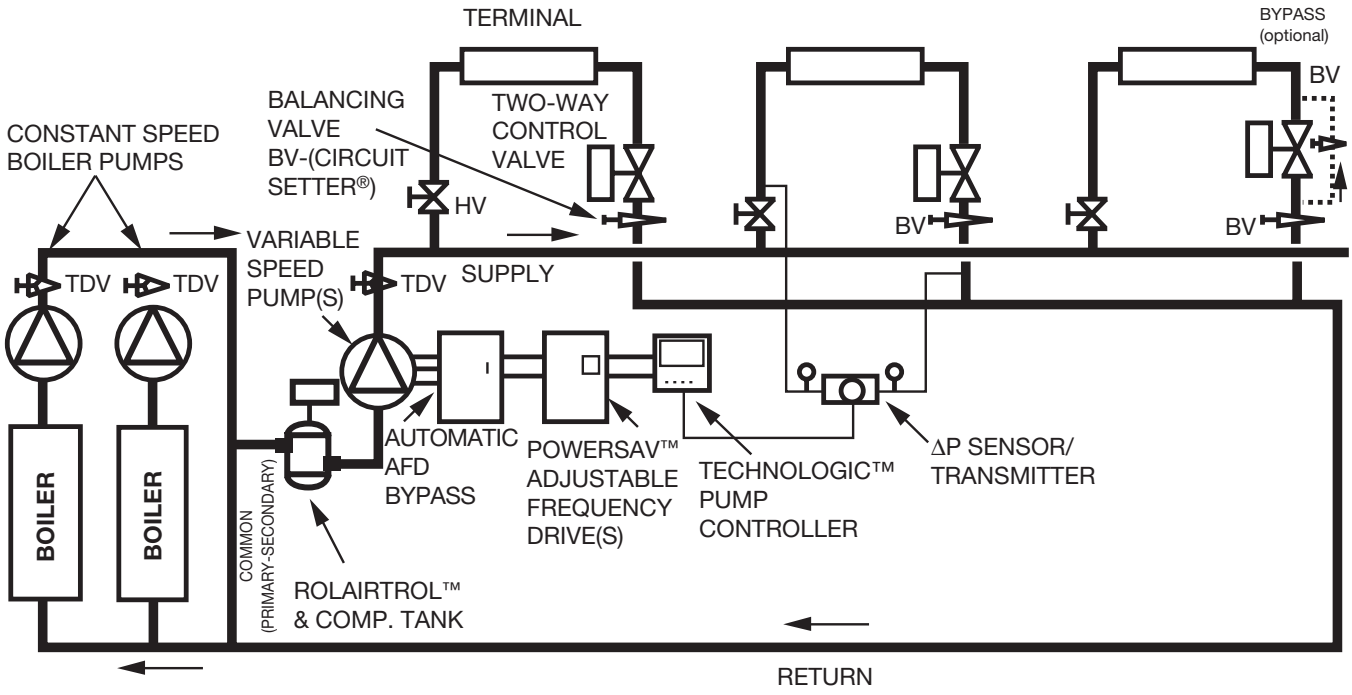


APPLICATION COMMENTS:

- Convert 3-Way valves to Two-way operation to provide variable terminal flow in relation to load and maximize potential pump energy savings by only circulating what is actually required. Check the valve operator for adequate closing power since it will now operate in a two-way mode and must be able to close against the highest expected differential pressure or that determined by the pump variable speed controller ΔP setting.
- The valve size and plug characteristic should also be checked for two-way operation. Valve size should be based upon the terminal design flow (gpm) at an adequate pressure drop. Calculate its Cv factor and compare against the existing valve's value. (Note: $Cv=GPM/\sqrt{\Delta P}$). If more than 25% oversize is found then a smaller valve should be installed. The valve plug characteristic should also be checked. For proportional operation of a hydronic coil consider an equal-percentage valve plug shape to provide a modifying effect to the non-linear hydronic coil relationship so that the ratio of heat transfer versus valve position gives a linear change with the valve control signal.
- The balancing valve (BV) in the return line should be re-balanced to proportionally set the design flow to this terminal in proportion to the other valves in this zone.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED HOT WATER HEATING PUMP CONTROL TWO-WAY VALVE REVERSE RETURN PIPING SYSTEM

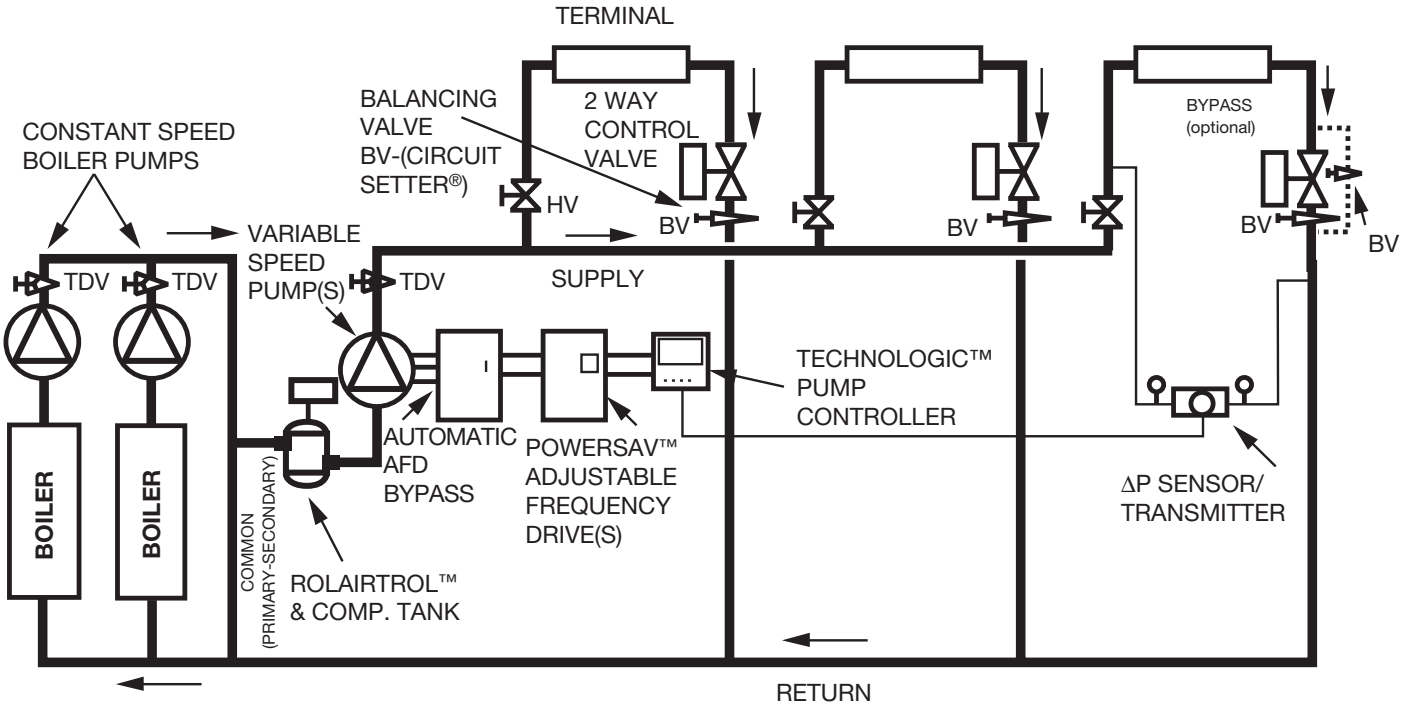


APPLICATION COMMENTS:

- Primary-Secondary pump system for maximum energy savings and control. For further information see Design Philosophy #1 (Drawing D120-102).
- The Variable Speed secondary system responds to a differential pressure sensor/transmitter which is sensing across typical supply-return branch or terminal and two-way control valve. This allows for energy savings as the terminals respond to a lighter load and the two-way valves control at a lower flow position. This increased pressure drop signals the controller to operate the pump(s) at a lower speed to maintain its set point.
- In a system where there are major load differences from one riser to another, multiple ΔP sensor/transmitters can be applied to each major load with unique set points for each load. The controller will control the pump(s) speed for the worst condition, providing even greater energy savings.
- Single ΔP sensor/transmitters on reverse return system shown should be placed across typical terminal supply-return in middle of piping run to provide an average signal for the entire system.
- Primary-secondary pumped boilers recommended because of variable system flow in secondary. Pumps placed on discharge side of boilers to reduce boiler pressure requirements. Air separator on hot water supply, downstream of common, to maximize air removal.
- Each terminal should be proportionally balanced with a balancing valve. Terminal two-way control valve to be equal-percentage characteristic to linearize heat output versus flow of terminal to minimize control hunting.
- For multi-distribution mains, suggest ΔP sensor/transmitter for each main with unique set points for each on the Technologic Pump Controller.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED HOT WATER PUMP CONTROL TWO-WAY VALVE DIRECT RETURN PIPING SYSTEM

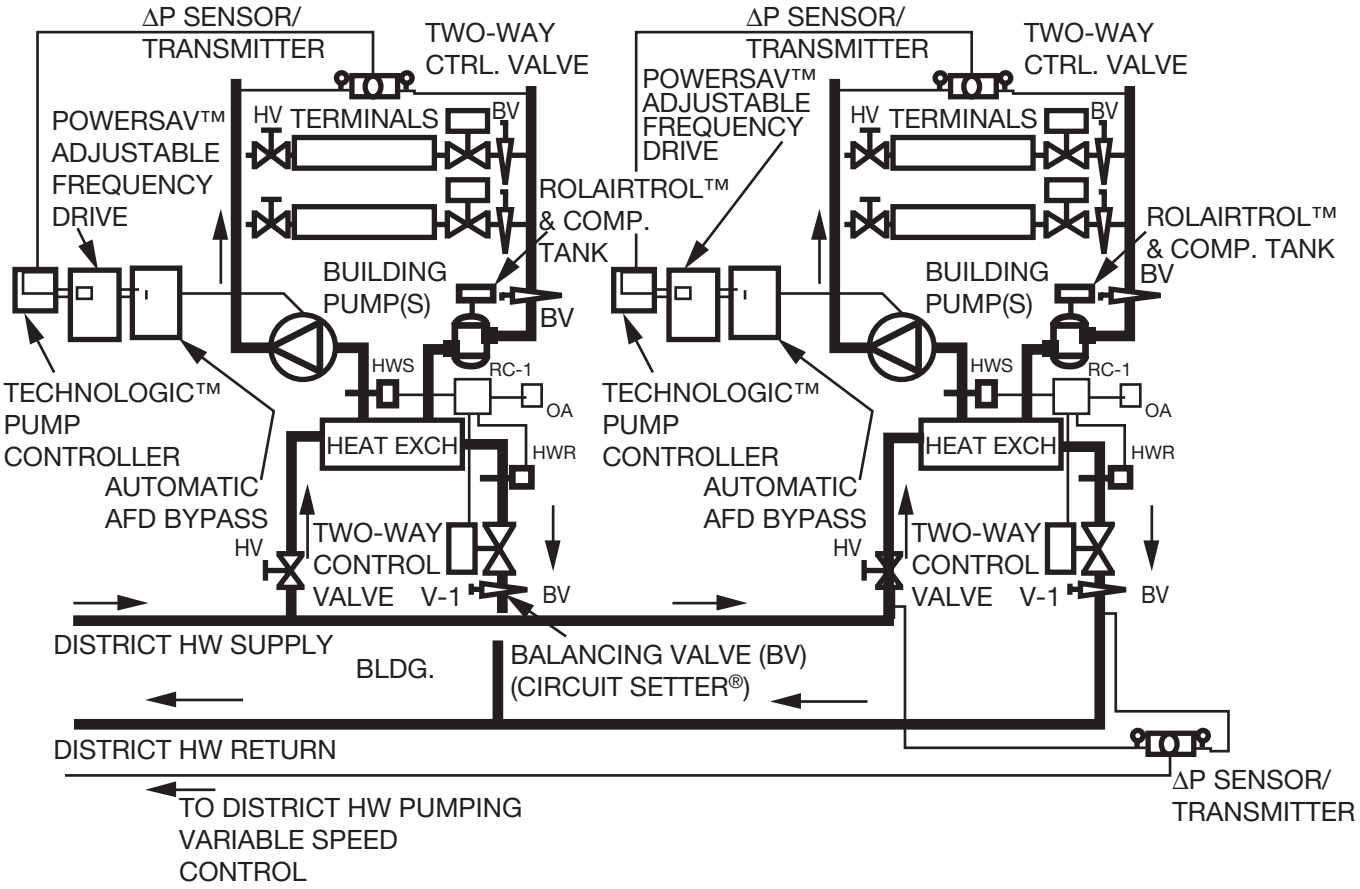


APPLICATION COMMENTS:

- Primary-Secondary pump system for maximum energy savings and control. For further information see Design Philosophy #1 (Drawing D120-102).
- The Variable Speed secondary system responds to a differential pressure sensor/transmitter which is sensing across typical supply-return branch or terminal and two-way control valve. This allows for energy savings as the terminals respond to a lighter load and the two-way valves control at a lower flow position. This increased pressure drop signals the controller to operate the pump(s) at a lower speed to maintain its set point.
- In a system where there are major load differences from one riser to another, multiple ΔP sensor/transmitters can be applied to each major load with unique set points for each load. The controller will control the pump(s) speed for the worst condition, providing even greater energy savings.
- Single ΔP sensor/transmitters should be placed across the farthest and most resistant load in a direct return piping system to provide a signal for the entire system. For multi-distribution mains suggest ΔP sensor/transmitter for each main with unique set point for each on the Technologic Pump Controller.
- Direct return piping design is usually selected as a lower first cost alternative. However, balancing is more difficult since the pressure drop across the first zones will be much greater and proportional balancing will be required to prevent overflow conditions.
- Primary-secondary pumped boilers are recommended because of variable speed flow in secondary. Pumps placed in discharge side of boilers to reduce boiler pressure requirements. Air separator on hot water supply to maximize air removal.
- Each terminal should be proportionally balanced with a balancing valve. Terminal two-way control valve to be equal-percentage characteristic to linearize heat output versus flow of terminal to minimize control hunting.
- The greater the system head loss (terminal coils, piping, fittings) the greater the potential for pumping energy savings.
- An optional bypass with a 2-3% maximum flow setting may be considered for zones with week-end shut down for even pick-up and for more stability for light load conditions. In lieu of bypass on last zone, a 3-way valve may be employed with balancing valve in its bypass.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED BUILDING PUMP CONTROL FOR DISTRICT HEATING SYSTEM-DIRECT RETURN PIPING

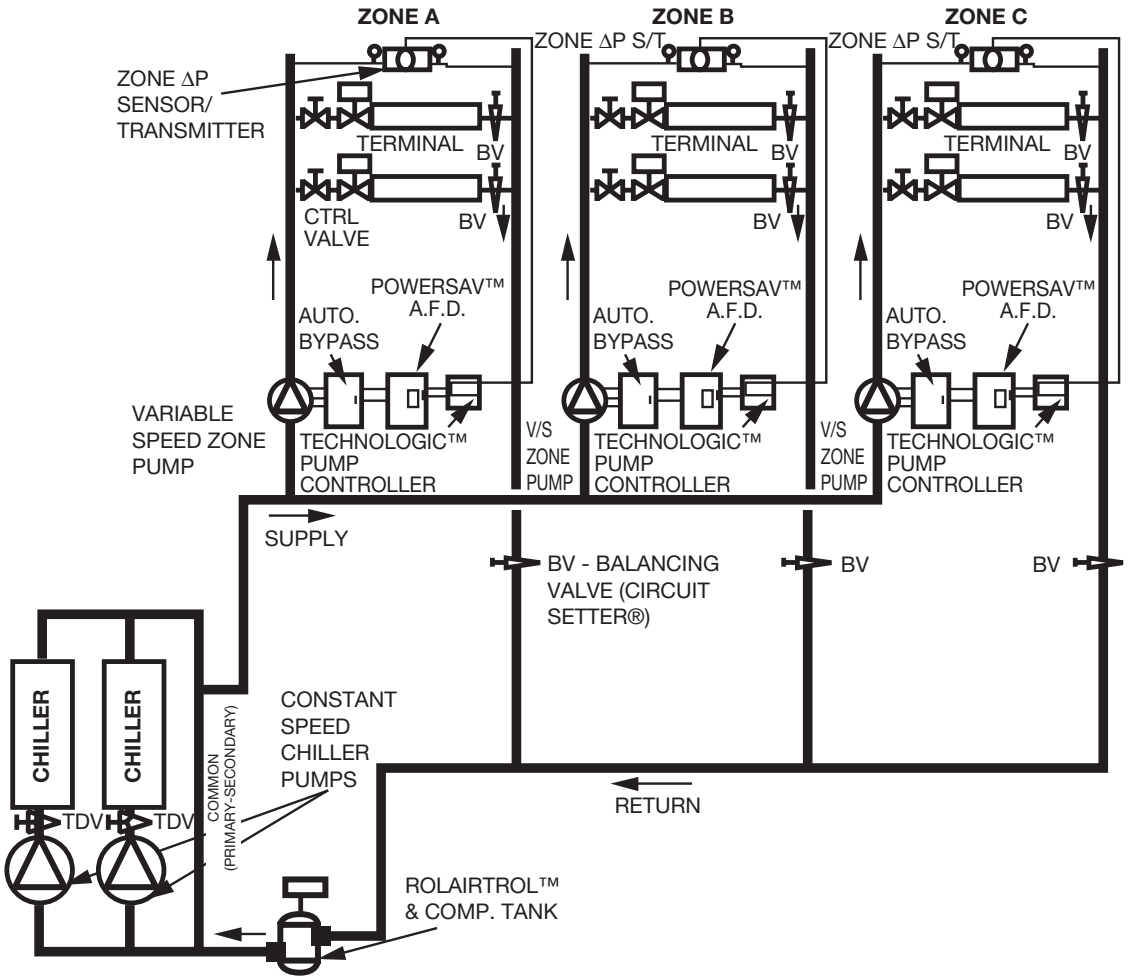


APPLICATION COMMENTS:

- The building variable speed pumping system responds to a differential pressure sensor/transmitter sensing across the end of the supply-return terminal risers. This provides energy savings as the terminals respond to a lighter load and the two-way valves control at a lower flow position. This increased pressure drop signals the controller to operate the pump(s) at a lower speed to maintain its set point. The greater the system head loss (terminal coils, piping, fittings) the greater the potential for pumping energy savings.
- In a building system with multiple risers and there are major load differences from one riser to another, multiple ΔP sensor/transmitters can be applied to each major load with unique set points for each load. The controller will regulate the pump(s) speed for the worst condition, providing even greater energy savings.
- ΔP sensor/transmitters should be placed across the end of each distribution loop in a direct return district piping system to provide an adequate ΔP for each system loop.
- Direct return design is usually selected for the building piping as a lower first cost alternative. However, balancing is more difficult since the pressure drop across the first zones will be much greater and proportional balancing will be required to prevent overflow conditions.
- Reset of each building's hot water supply temperature can be customized with O.A. reset by employing a reset controller positioning the building's heat exchanger two-way control valve. A temperature sensor is also provided in the return water to the district return to insure a required maximum return temperature, if required for the district system.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

ZONED VARIABLE SPEED/VARIABLE VOLUME CHILLED WATER PUMPING CONTROL & TWO-WAY VALVE SYSTEM

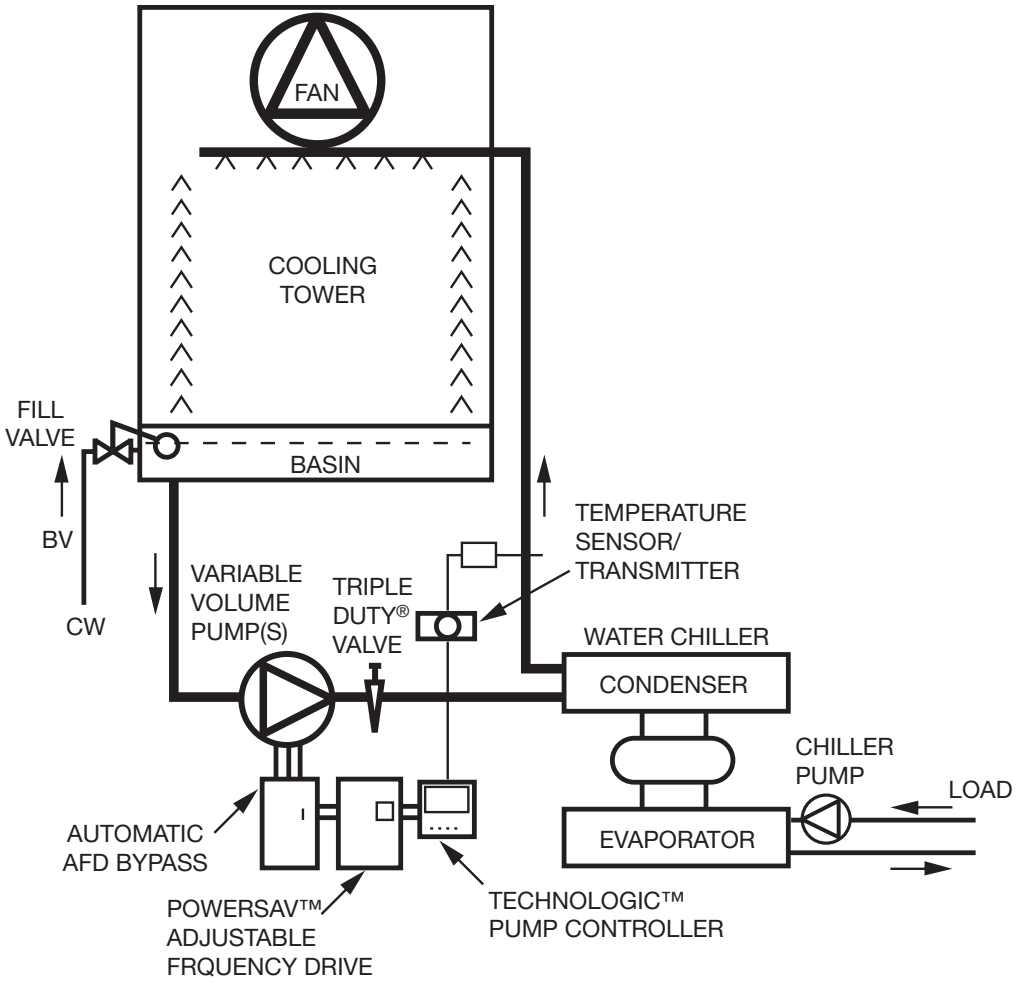


APPLICATION COMMENTS:

- Each zone pump must be carefully sized for the supply-return distribution main in addition to it's zone requirements without overpressuring adjacent zone's return. The zone's variable speed/variable volume pump control automatically compensates for it's load requirements by maintaining a zone differential pressure as the load changes. Two-way valve control permits diversity control within the zone or building.
- Single ΔP sensor/transmitters should be placed across the farthest and most resistant load in a direct return piping system to provide a signal for the zone system. In a system where there are major load differences from one riser to another, multiple ΔP sensor/transmitters can be applied to major loads with unique set points.
- The constant speed chiller pumps are sized to deliver design flow to the system common and it's return.
- Direct return piping design is usually selected as a lower first cost alternative. However, balancing is more difficult since the pressure drop across the initial terminals within a zone/building will be much greater and proportional balancing will be required. Balancing of the zone returns is required to minimize reverse flow and over-pressuring in adjoining zones.
- A primary-secondary variable speed distribution pumping system will show a lower first cost and comparable operating cost with less complexity than the direct zone pumping method shown. In addition, ΔP sensor/transmitters can be located to insure design flows for critical zones.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

COOLING TOWER WITH VARIABLE VOLUME-VARIABLE SPEED CONDENSER PUMP CONTROL

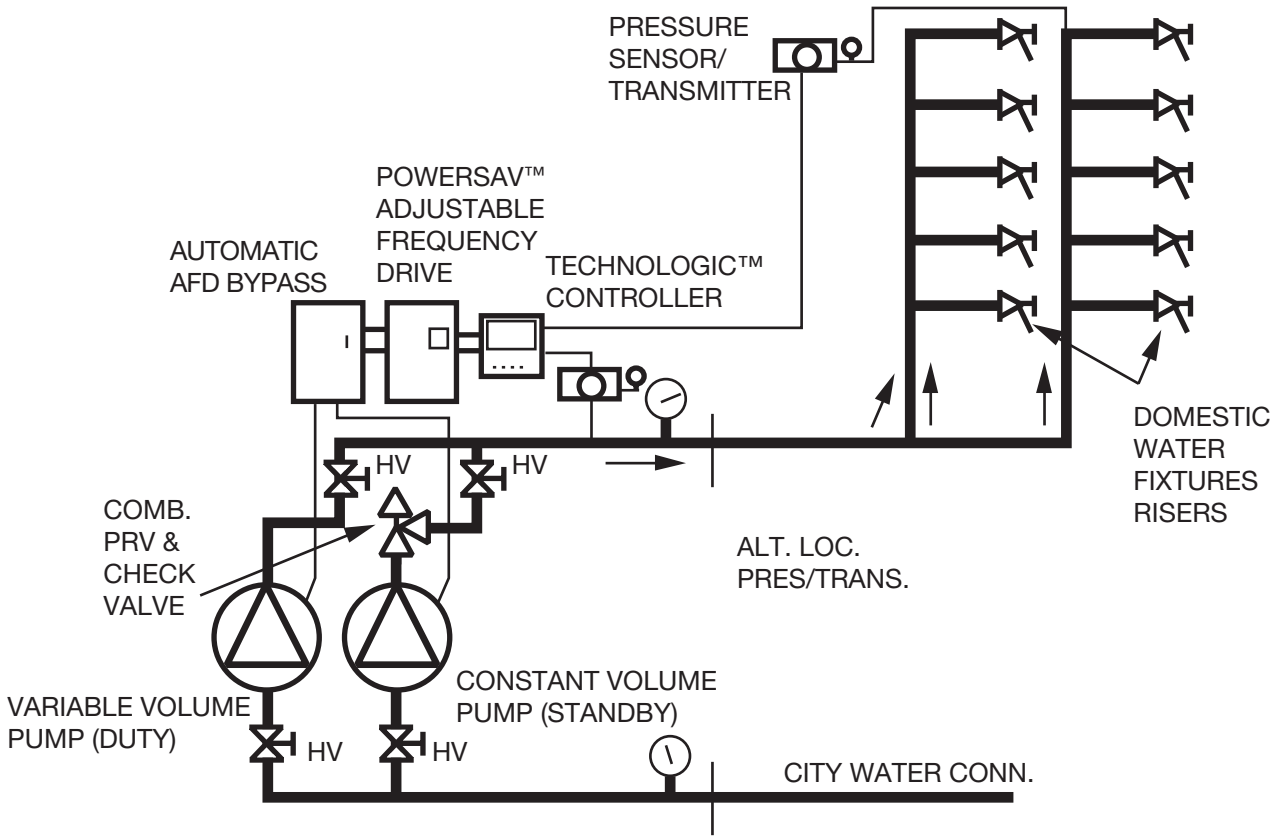


APPLICATION COMMENTS:

- Variable pumping flow rate is controlled by the condenser leaving water temperature which is affected by the refrigeration load.
- An alternate sensor location is to measure differential temperature across the condenser or sense the refrigerant head pressure (care must be exercised to insure against refrigerant leakage).
- Pumping energy is directly influenced by the pressure drop through the condenser tubes and the tower nozzles. Variable pump speed provides operating power saving. Variable speed pump control will automatically maintain flow as the condenser tubes and tower sprays foul due to water conditions.
- Minimum condenser flow is mandatory and is set on the pump control to reduce condenser tubes fouling with extremely low flows and reduce freeze-up with operation near freezing conditions. Differential temperature sensing may be required for minimum flow operation.
- Maximum pump speed may be set on the pump control to prevent over-pressure tower nozzles and reduce misting.
- Tower bypass piping may be required for “free-cooling” or cold weather operation with tower basin installed inside the building and proper freeze-detection controls. Balancing valve in the tower-bypass is set to maintain positive head in the riser to the sprays to prevent air introduction into condenser water from the spray heads due to negative pressure.
- Where variable speed fan control is utilized on the tower, the variable speed pumping system will compliment it. Both will reduce total power consumption for the condensing water system.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

DOMESTIC WATER SUPPLY PRESSURE BOOSTER WITH VARIABLE SPEED PUMPING

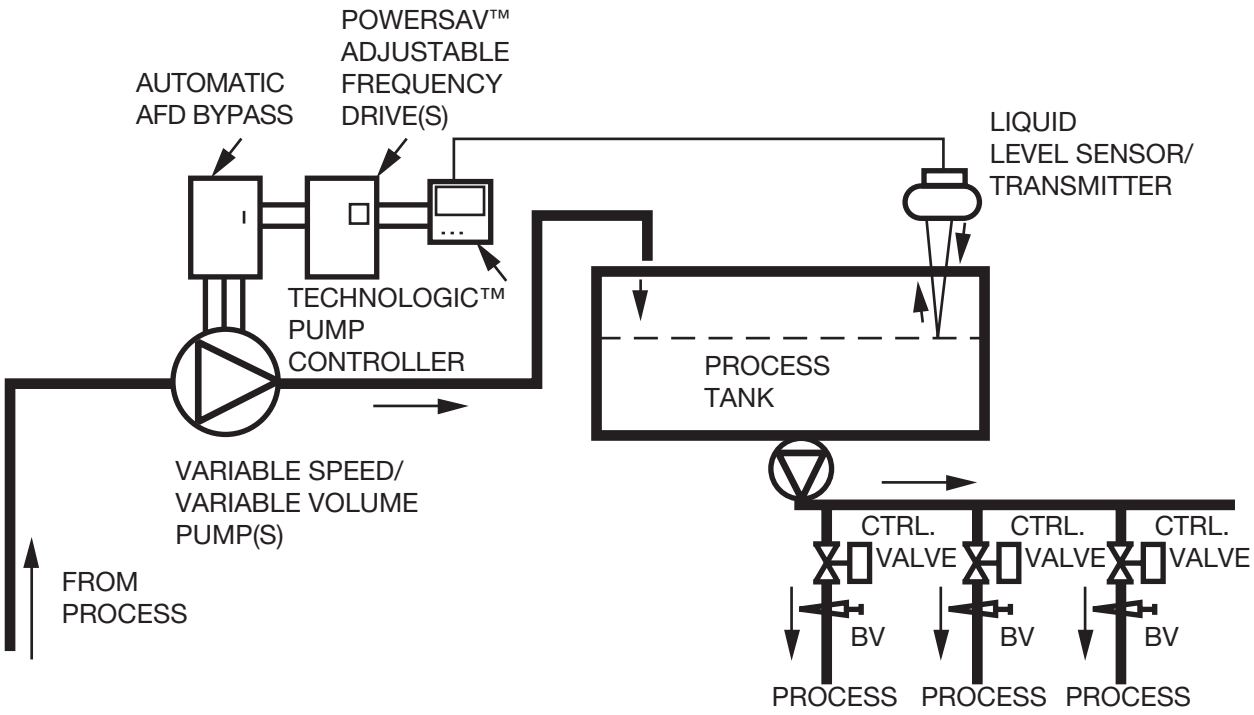


APPLICATION COMMENTS:

- The variable speed/variable volume pump is sized for fixture full load capacity. As the building demand is reduced, the variable speed pump is reduced in speed to meet the load indicated by the pressure at the pressure sensor/transmitter compared to the controller's set point. The Technologic Pump Controller has an adjustable set point and control that automatically regulates the pump speed to meet the load.
- Variable speed pumping is justified on basis of changes of city water pressure (pump suction), load changes and overheaded constant speed pump selection. Overheading is caused by a pump selected for a greater delivery and head than actually required and may also result from a higher city water pressure.
- The constant volume (standby) pump is automatically brought on-line by the Automatic Bypass if a failure occurs at the variable/speed (duty) pump drive, Technologic pump controller, or the pressure sensor/transmitter.
- Down-stream pressure control is essential to protect the system in high head conditions.
- The proper pressure sensor location is very important. It should be away from the immediate pump location so that it will sense "typical" or average fixture supply pressures; usually a location near the top of the farthest riser will provide this. Alternate locations may be dictated by job conditions but care should be exercised so that it's location does not cause short-cycling of the pumps and starvation of farthest loads.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

LIQUID LEVEL CONTROL WITH VARIABLE SPEED PUMPING



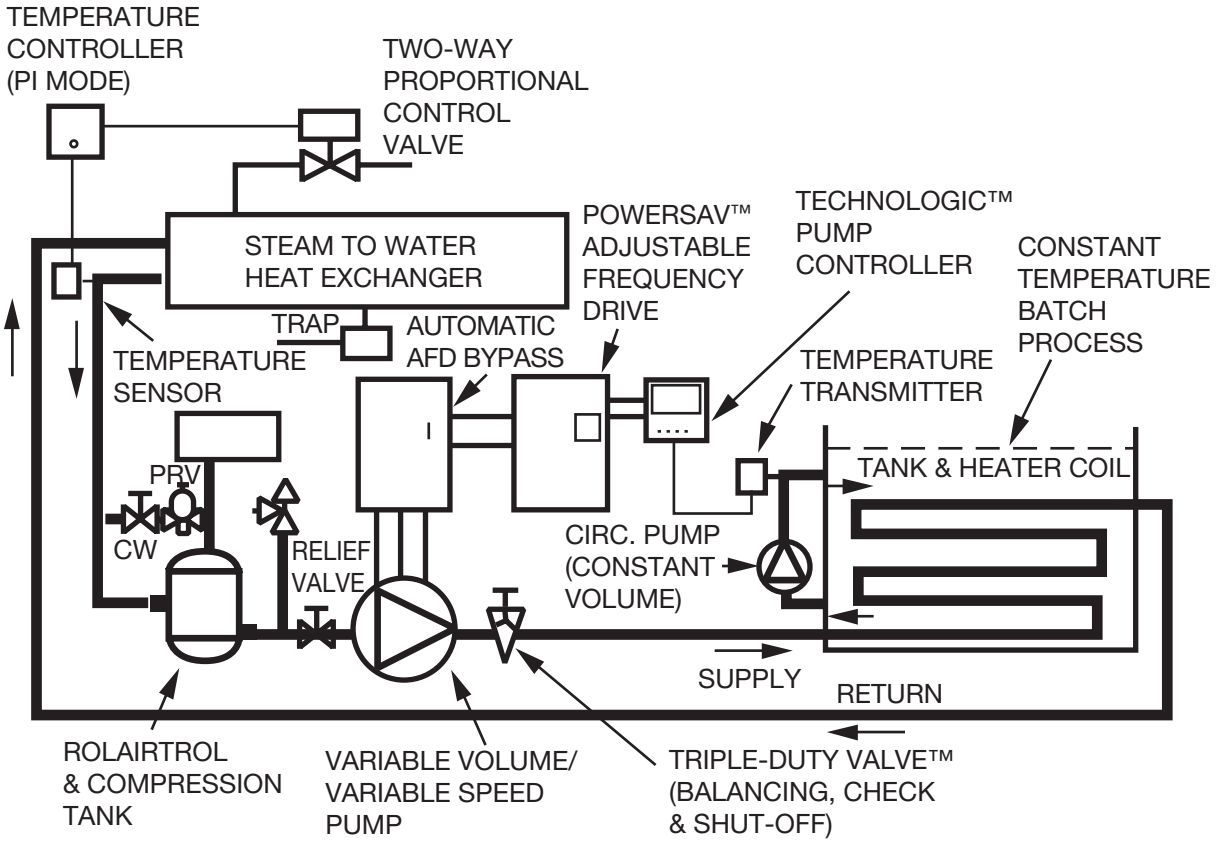
(BV - BALANCING VALVE
CIRCUIT SETTER®)

APPLICATION COMMENTS:

- Variable speed pumping is justified by the resulting process control accuracy; with resulting every savings in large systems having substantial flow variations.
- The liquid level transmitter can be different analog types to suit process, materials, etc., such as float type transmitter, bubbler-pressure transmitter, or non-intrusive types such as ultra-sonic, etc.
- In this application the typical “on-off” cycling of the constant speed pump is eliminated and the pump life will be extended at a lower power consumption.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

BATCH PROCESS HEAT TRANSFER WITH CONSTANT TEMPERATURE CONTROL USING VARIABLE SPEED PUMPING



APPLICATION COMMENTS:

- Variable speed pumping is justified by providing accurate process control and fast response to system load changes by monitoring temperature of batch process resulting in uniform product production. In addition, electrical power reduction via variable speed pumpingh at part load conditions is achieved.
- In this application the two-way or three-way temperature control valve pressure drop on the tank and heater coil is eliminated, resulting in further optimum energy reduction. The small circulation pump promotes effective thermal mixing and expedient response to load changes.
- This is one example of many process control applications showing how variable volume/variable speed pumping and heat transfer equipment can be employed.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED PRIMARY CHILLED WATER PUMP CONTROL WITH TWO WAY VALVE DIRECT RETURN SYSTEM

DESCRIPTION:
The volume of water supplied to the system is varied in response to the cooling load by the two-way zone valves. The basis of variable speed pumping is to save pumping cost by optimizing the pump motor horsepower input. The pump produces only the flow and head required at any time. This is performed by regulation of the pump speed/adjustable frequency drive and modulation of a bypass valve through the use of the Technologic™ Controller. The controller regulates the pump speed and valve position in response to the system load conditions and in order to protect the pumps and chillers.

DESIGN PHILOSOPHY:
The concept of variable speed primary pumping offers several advantages:

The ability to supply the cooling required to meet the demand.
The two-way control valve properly sized and selected assures the zone control system with the flow required at all loads. Two-way valve control permits diversity control within the zone or building. The Technologic™ provides optimal chiller/pump sequencing commands.

The flexibility to expand the system easily.
Additional chillers and pumps can be added in parallel to meet the new load conditions.

Reduce energy consumption.
Utilizing the variable volume system (two-way terminal control valves), the pumping energy can be reduced by more than two-thirds that of a constant speed pumping system riding its pump curve.

Protection features built into B&G algorithms.
B&G developed and fully tested software eliminates nuisance chiller trips due to lack of flow and prevents operation of chiller beyond maximum flow. End of curve protection ensures that pumps do not run off their operating curve at any speed.

SYSTEM CONTROL:
Pump and system controls should utilize dynamic sequencing that provides most efficient, energy-savings control while furnishing appropriate protection of chillers and pumps.

Priority #1 Energy Savings
The variable speed system responds to a differential pressure sensor/transmitter, which is sensing across a terminal and two-way valve. This allows for energy savings as the terminal responds to a lighter load and the two-way valves control at a lower flow position. This increased pressure drop signals the controller to operate the pump(s) at a lower speed to maintain its set point.

Priority #2 Minimize Tube Fouling & Prevent Freeze Up
The variable speed system responds to ensure minimum flow requirements are being met for all running chillers. When necessary, the minimum speed and the valve position shall be adjusted in order to meet the operating chillers' flow requirements. Maintaining minimum chiller flow is mandatory and is set on the pump controller to reduce chiller tube fouling and prevent chiller freeze up with extremely low flows.

Priority #3 Prevent Premature Tube Erosion
The third priority is to monitor system flow rate to prevent operation above the maximum flow for the chillers and the pumps. Additional chiller(s) and pump(s) shall be signaled to run upon detection of a high flow condition in order to avoid pump operation beyond end of curve and to protect chiller from high velocity/tube erosion conditions. Maximum flow must be constantly monitored independent of drive speed to guarantee that at any speed, these damaging conditions do not occur.

APPLICATION COMMENTS:

- Single differential pressure sensor/transmitters should be placed across the appropriate load in a direct return piping system to provide a signal for the zone system. In a system where there are major load differences from one riser to another, multiple differential pressure sensor/transmitters can be applied to major loads with unique set points. The Technologic™ Pump Controller will automatically monitor all sensors with reference to each set point and control to the largest deviation from set point, thus satisfying all loads.
- A good understanding of set point is required to optimize the operation of the variable speed pumping system. If it is set too high, the pumping system will not slow down and the predicted savings in power will not be realized.
- Constant monitoring of chiller flow is essential in order to protect both the chillers and the pumps. This can be accomplished by utilizing either differential pressure sensors or flow sensors piped across each chiller. If differential pressure is used, size the differential pressure sensor for minimum chiller flow.
- Theoretically, the bypass should be sized for the smallest chiller, but since that chiller could be out of service for any reason, the bypass needs to be sized for the minimum flow of the largest chiller.
- When the bypass is located near the pumps, size the bypass valve for the differential pressure from pump suction to chiller discharge at minimum flow. When the bypass is at the end of the loop, size the bypass modulating valve for zone differential pressure.
- Chiller isolation valve control, linked to each chiller, is needed to guarantee most efficient operation and to only allow flow through operating equipment.
- In the event that no chiller is running, the bypass valve control will function to protect the pumps from operating at deadhead pressures in the event all of the zone control valves are closed.
- Locate the air separator in the return piping prior to the bypass pipe to maximize air removal due to the relatively higher temperature of the water.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED PRIMARY CHILLED WATER PUMP CONTROL WITH TWO WAY VALVE DIRECT RETURN SYSTEM (cont.)

SYSTEMS EXHIBITING ALL OF THESE CHARACTERISTICS ARE MOST LIKELY TO RESULT IN SUCCESSFUL APPLICATION OF VARIABLE SPEED PRIMARY PUMPING

System flow can be reduced by 30%.
If system flow can be reduced by 30% from design, the potential for energy savings and reasonable payback period is likely. Systems whose load does not vary significantly will not reap the benefits of this sophisticated control scheme.

System can tolerate modest change in water temperature.
As with primary-secondary piping arrangement, systems that can tolerate moderate changes in water temperature are better candidates for variable primary pumping. Allowing temperature to rise before staging on another chiller could result in greater cost savings.

Operators are well trained.
If the operator is not familiar with the equipment and the control scheme, he is unlikely to operate it as designed thus the system will not operate efficiently. Initial periodic training is mandatory.

Demonstrates a greater cost savings.
First costs are straightforward to determine, since these are comprised of equipment and installation costs at the time of design or bid. Operating costs can be more difficult to determine. Software is available. (ESP-Plus) Life cycle cost should be the cost methodology used to ensure that the building owner's return on investment is maximized. Comparison between variable primary pumping and primary-secondary designs is the most common assessment to investigate during the design phase. Keep in mind that variable primary systems require one set of larger variable speed pumps as compared to secondary variable speed pumps. Primary-secondary does require two sets of pumps, but the cost of larger primary pump adjustable frequency drives may offset the cost of starters, with an added benefit of reduced system complexity to benefit the untrained owner.

High % of hours is at part load or low return water temperature.
Applications that operate for a high percentage of time at part load will utilize the variable speed, energy savings potential of variable primary systems by lowering speed, thus consuming less energy during lighter loads. Those that operate at full load but with lower than design return water temperature benefit in a similar manner by slowing down the pumps to an adequate rate, thus maintaining optimal return temperature, allowing the chiller(s) to operate more efficiently.

AVOID THE USE OF VARIABLE SPEED PRIMARY PUMPING IN THESE APPLICATIONS

Supply temperature is critical.
Depending upon the volume of the system and the rate of change, the supply water temperature may vary. If temperature is critical, primary-secondary piping will allow for more evenly maintained temperature. Only those systems that can tolerate variable supply water temperatures should be considered.

System volume.
Constant volume results in little energy savings. The amount of fluid contained in the system can dictate the rate of change of temperature through the chiller. Without adequate system volume, the temperature of the return fluid can be too low creating a low temperature trip in the chiller or a freeze up condition.

Existing controls are old or inaccurate.
If existing controls are old or inaccurate, system will be difficult to control. Variable speed primary pumping requires additional controls for the chillers and the pumps. The system relies on these controls for proper regulation. Pumps will operate based on flow and temperature, and ΔP requirements. Sensors must be maintained and periodically calibrated to ensure that the sequencing that utilizes the sensor inputs is accurate.

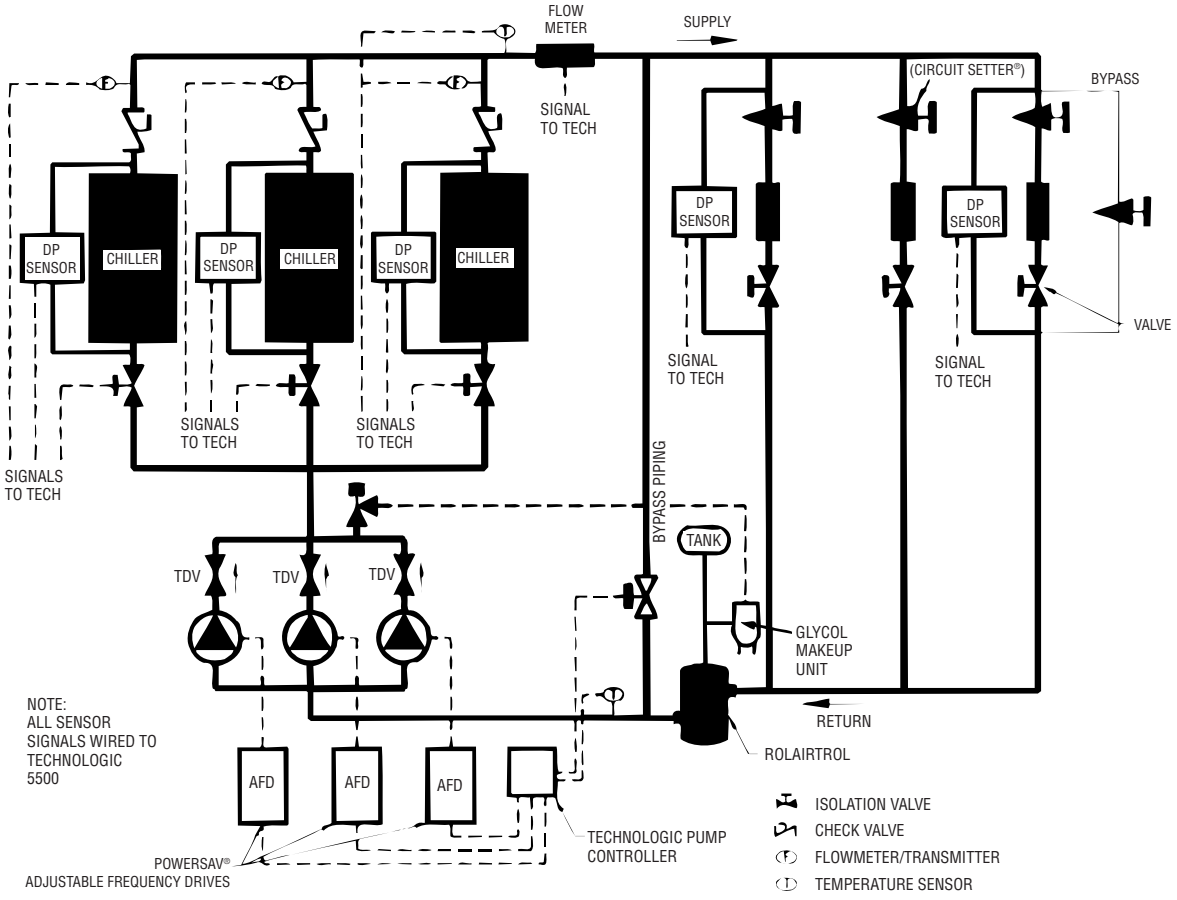
Limited operator knowledge.
Care must be taken to keep the complexity of the system within the operator's ability. If the operator does not understand the control sequencing and complexity, he is unlikely to operate the system as designed. Systems too complex for the operator are often turned to manual, bypassing the energy saving functionality of the control system.

Unequal sized chillers.
For redundancy, similar in parts, and maintenance issues, chillers are chosen to be equal in size. This redundancy is compromised when chillers of different sizes or types are utilized. Unequally sized chillers present flow concerns. Individual pumps per chiller need to be replaced with headered pumps, See pages D120-116 and 117. In addition, flow meters or differential pressure sensors along with two position control valves need to be provided for each chiller. The control valves should be sized per chiller manufacturer's recommendation. The control algorithm must compensate for the minimum flow for each chiller as well as the proportion of flow for each chiller when the system is flowing at less than full chiller capacity.

Unequal sized pumps.
Like their chiller counterparts, equally sized pumps are desirable. Operators prefer the simplicity of like components. For pump protection and to ensure the proper flow is passing through each chiller, pumps must be equal in size (flow and head). Dissimilar pumps may result in premature pump failure.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED CHILLED WATER PUMP CONTROL
VARIABLE SPEED PRIMARY SYSTEM WITH BYPASS AT THE CHILLERS

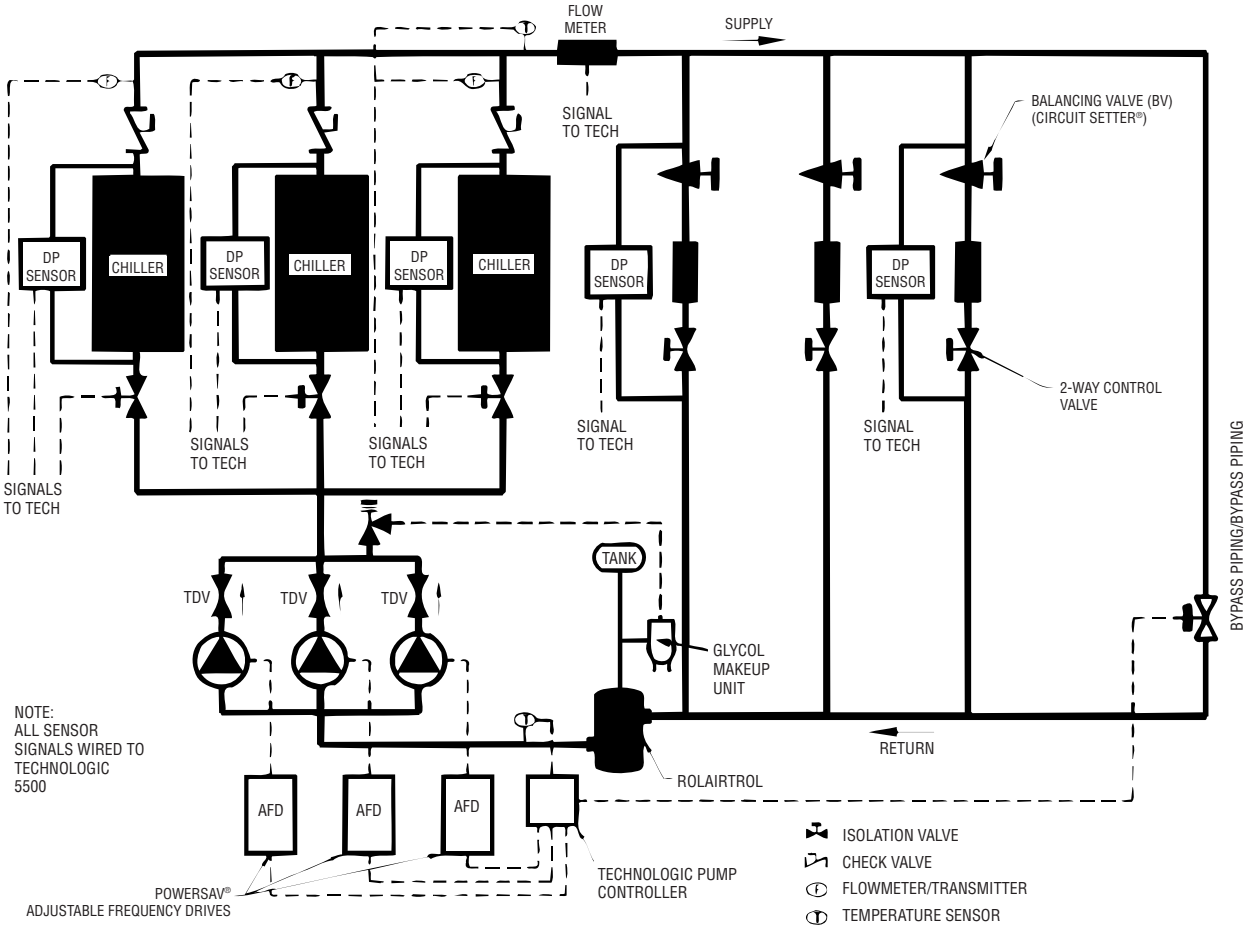


APPLICATION COMMENTS:

- A variable speed primary pumping system allows for energy savings and can reduce the floor space requirement for HVAC equipment in the mechanical room. For further information on design philosophy see page D120-115.
- Where extended loads are light or where a system has weekend shutdowns, a small bypass (2-3% maximum flow setting) with balancing valve set for low flow around the zone two-way valve should be a design consideration to reduce thermal stratification and allow a quicker start-up after shut-down period. In lieu of bypass on last zone, a 3-way valve may be employed with balancing valve in its bypass.
- The pressure relief valve mounted in the pump discharge piping will protect against excessive pressure should all chiller isolation valves be closed.
- The chillers are placed in series with a bank of equally sized (flow and head) parallel pumps to supply chilled water to the two-way terminal control valves. This allows variable speed pumping for the chillers and system in which the variable speed chiller pumps are sized for the pressure drop through the chillers, and the entire network of system piping.
- Recovery of glycol is possible when the system relief valve is piped to a glycol make-up unit.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED CHILLED WATER PUMP CONTROL
VARIABLE SPEED PRIMARY SYSTEM WITH BYPASS AT THE END OF SYSTEM

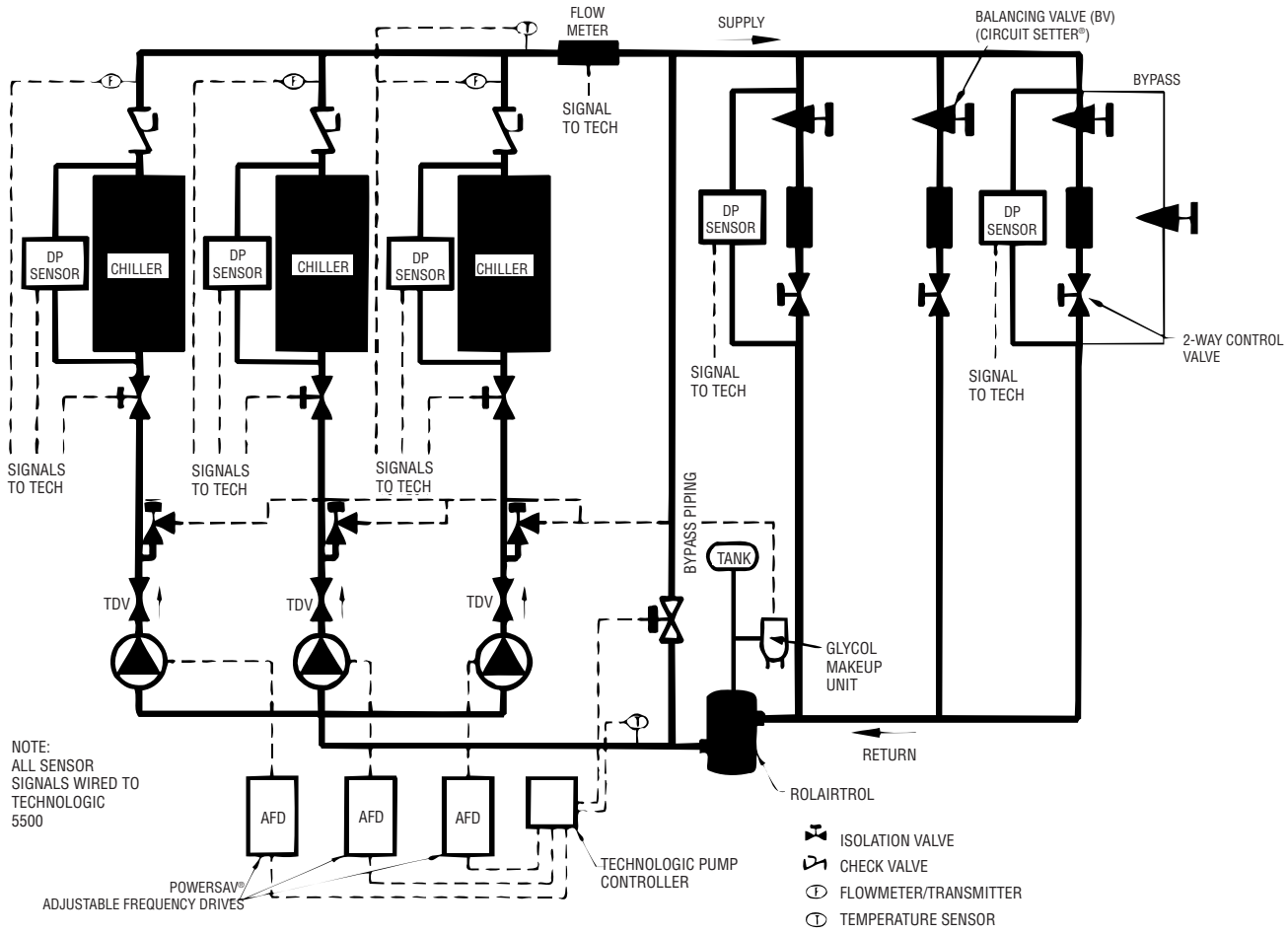


APPLICATION COMMENTS:

- A variable speed primary pumping system allows for energy savings and can reduce the floor space requirement for HVAC equipment in the mechanical room. For further information on design philosophy see page D120-115.
- The parallel chillers are placed in series with a bank of equally sized (flow and head) parallel pumps to supply chilled water to the two-way terminal control valves. This allows variable speed pumping for the chillers and system in which the variable speed chiller pumps are sized for the pressure drop through the chillers, and the entire network of system piping.
- Where extended loads are light, and in the event the lead chiller is off, the bypass valve should not be fully closed. This will prevent stagnation of water at the point of supply. In addition, the flow through the bypass will protect the pumps from operating at deadhead pressures in the event all of the control valves are closed.
- The pressure relief valve mounted in the pump discharge piping will protect against excessive pressure should all chiller isolation valves be closed.
- Recovery of glycol is possible when the system relief valve is piped to a glycol make-up unit.

VARIABLE VOLUME / VARIABLE SPEED SYSTEMS APPLICATIONS

VARIABLE SPEED CHILLED WATER PUMP CONTROL
VARIABLE SPEED PRIMARY PUMP PIPED DIRECLY TO CHILLER, CHILLERS WITH EQUAL RATINGS



APPLICATION COMMENTS:

- A variable speed primary pumping system allows for energy savings and can reduce the floor space requirement for HVAC equipment in the mechanical room. For further information on design philosophy see page D120-115.
- In this application, dedicated chiller pumps may operate at different rates of speed to minimize energy consumption.
- The pressure relief valve mounted in the pump discharge piping will protect against excessive pressure should all chiller isolation valves be closed while pump is running.
- Where extended loads are light or where a system has weekend shutdowns, a small bypass (2-3% maximum flow setting) with balancing valve set for low flow around the zone two-way valve should be a design consideration to reduce thermal stratification and allow a quicker start-up after shut-down period. In lieu of bypass on last zone, a 3-way valve may be employed with balancing valve in its bypass.
- The pressure relief valve mounted in the pump discharge piping will protect against excessive pressure should all chiller isolation valves be closed.
- Recovery of glycol is possible when the system relief valves are piped to a glycol make-up unit.

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