

## **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 identical 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 and any and all speeds.

#### **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**

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 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 maintenance schedule may take that chiller out of service, the bypass needs to be sized for the minimum flow of the largest chiller.
- 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 pay-back 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 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 total out-of-pocket expenses are minimized. 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 that 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  $\Delta P$  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.**

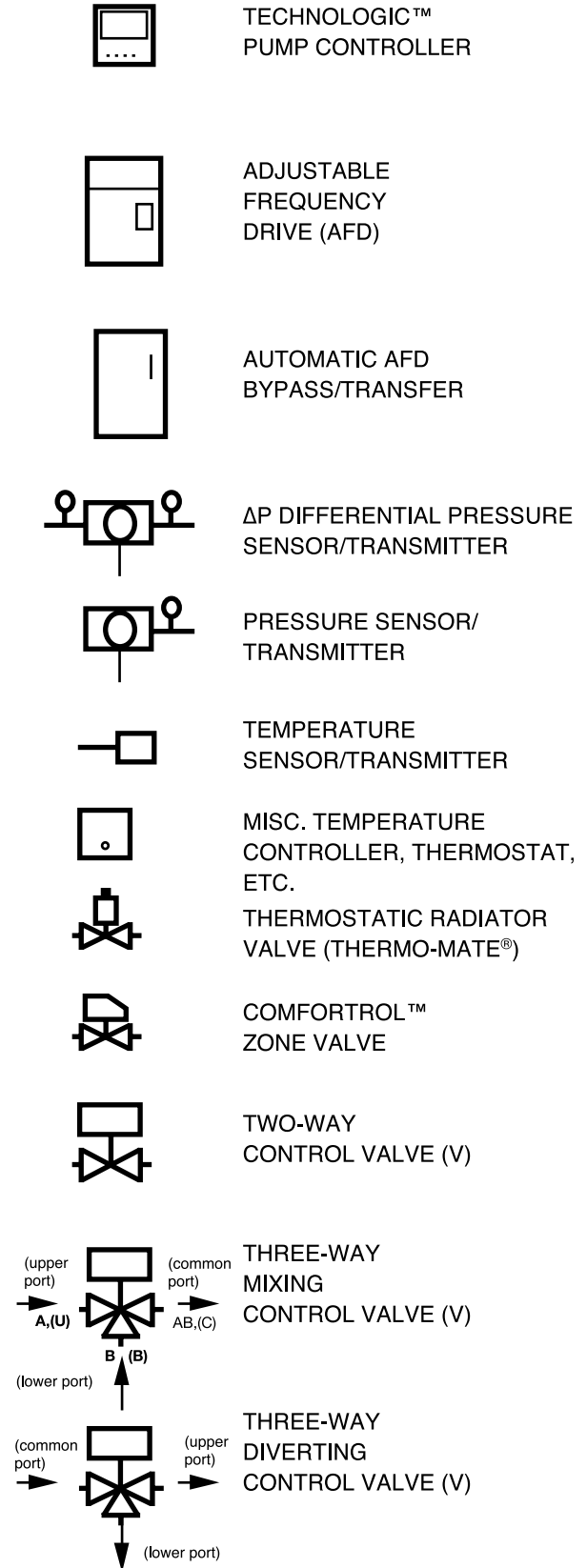
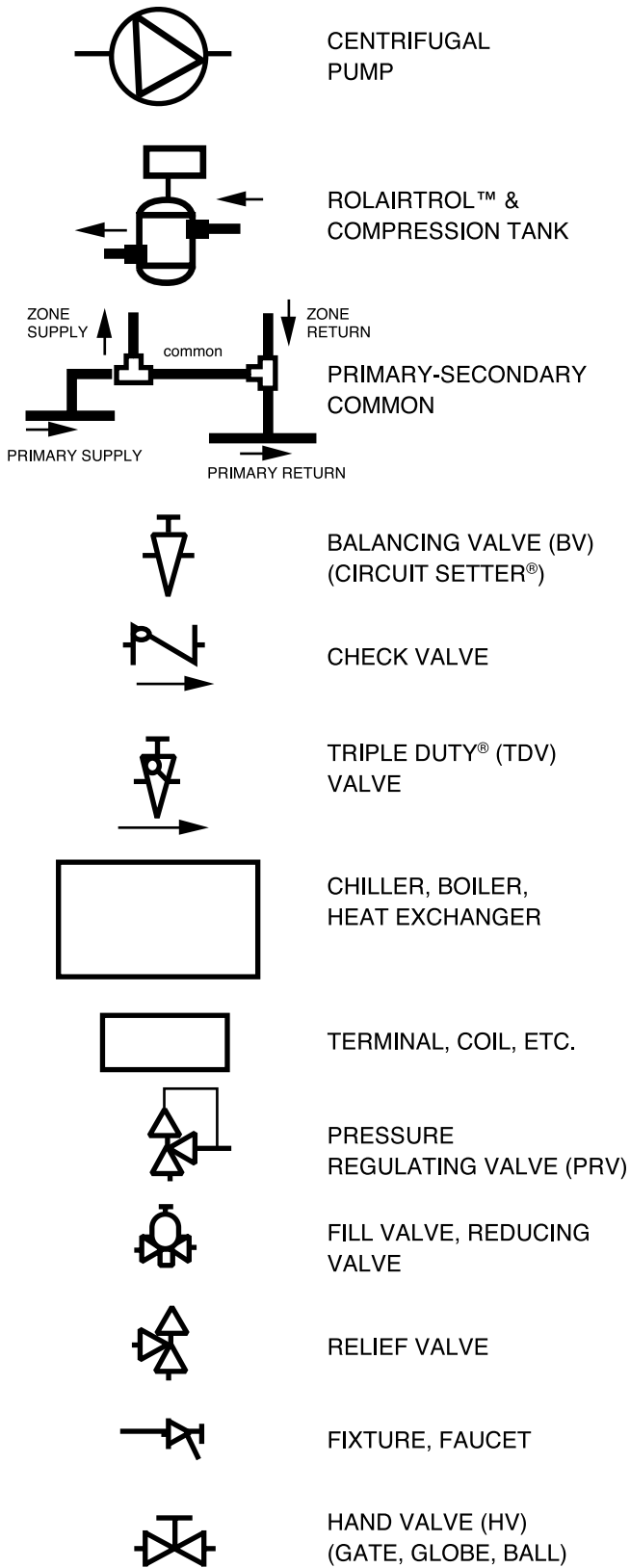
For redundancy, similar in parts, and maintenance issues, chillers are chosen to be equal in size. This redundancy is compromised when chillers of different sizes or types are utilized. Unequally sized chillers present flow concerns. Individual pumps per chiller need to be replaced with headered pumps, See pages 5 and 6 drawings. 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.

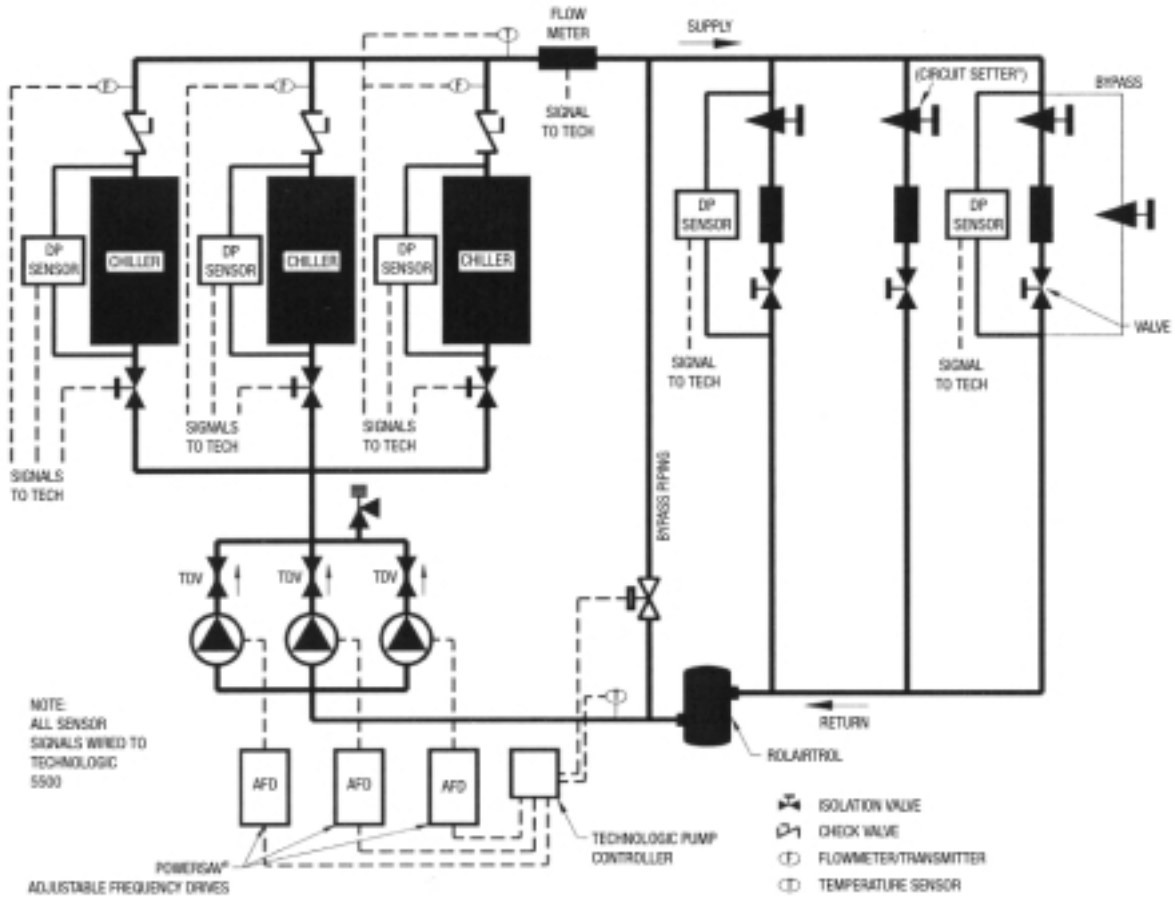
Bell & Gossett

**VARIABLE SPEED / VARIABLE VOLUME PUMPING SCHEMATIC  
APPLICATION DRAWING SYMBOLS**



**VARIABLE VOLUME / VARIABLE SPEED**  
**SYSTEMS APPLICATIONS**

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

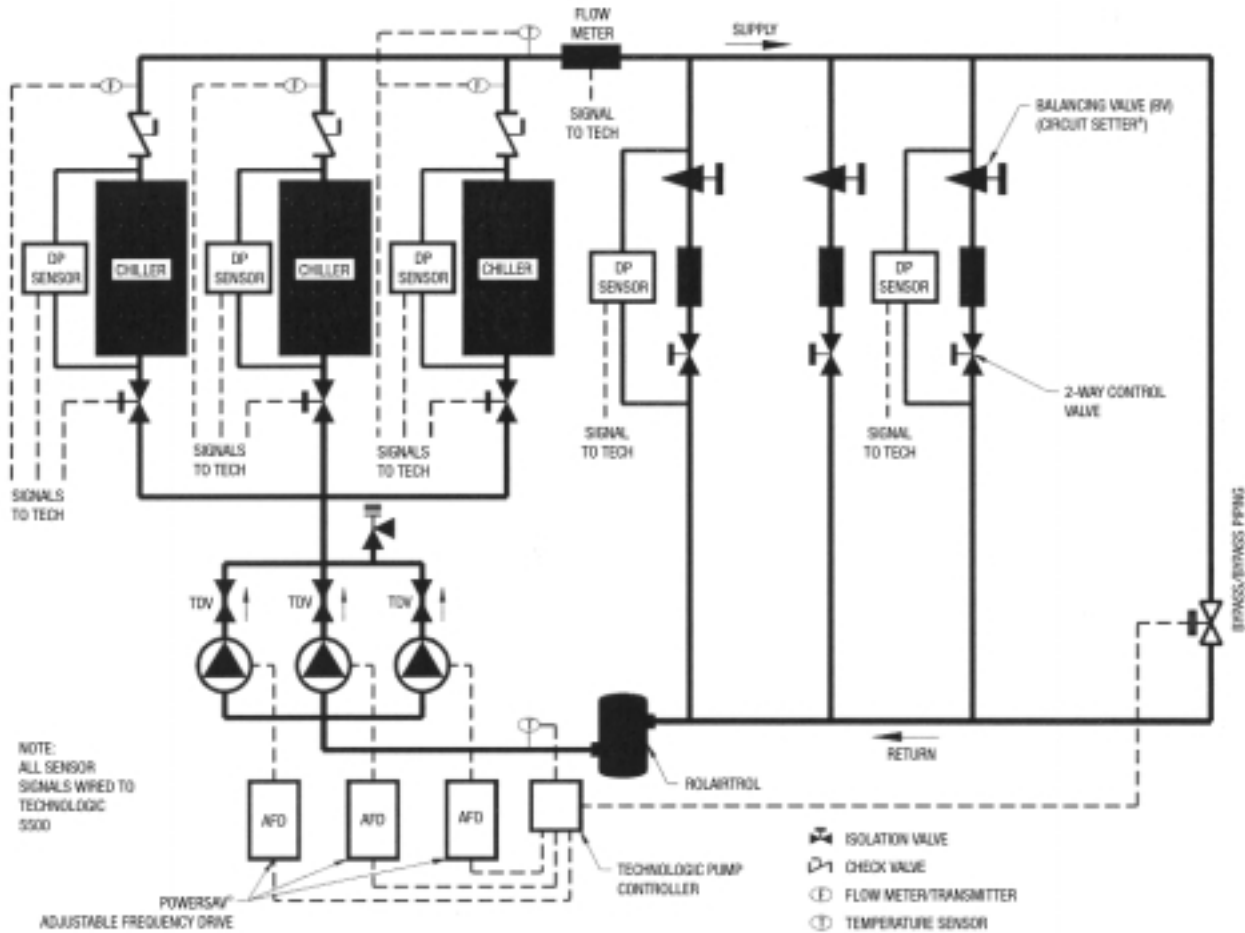


**APPLICATION COMMENTS:**

- 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 1.
- 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.

**VARIABLE VOLUME / VARIABLE SPEED**  
**SYSTEMS APPLICATIONS**

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

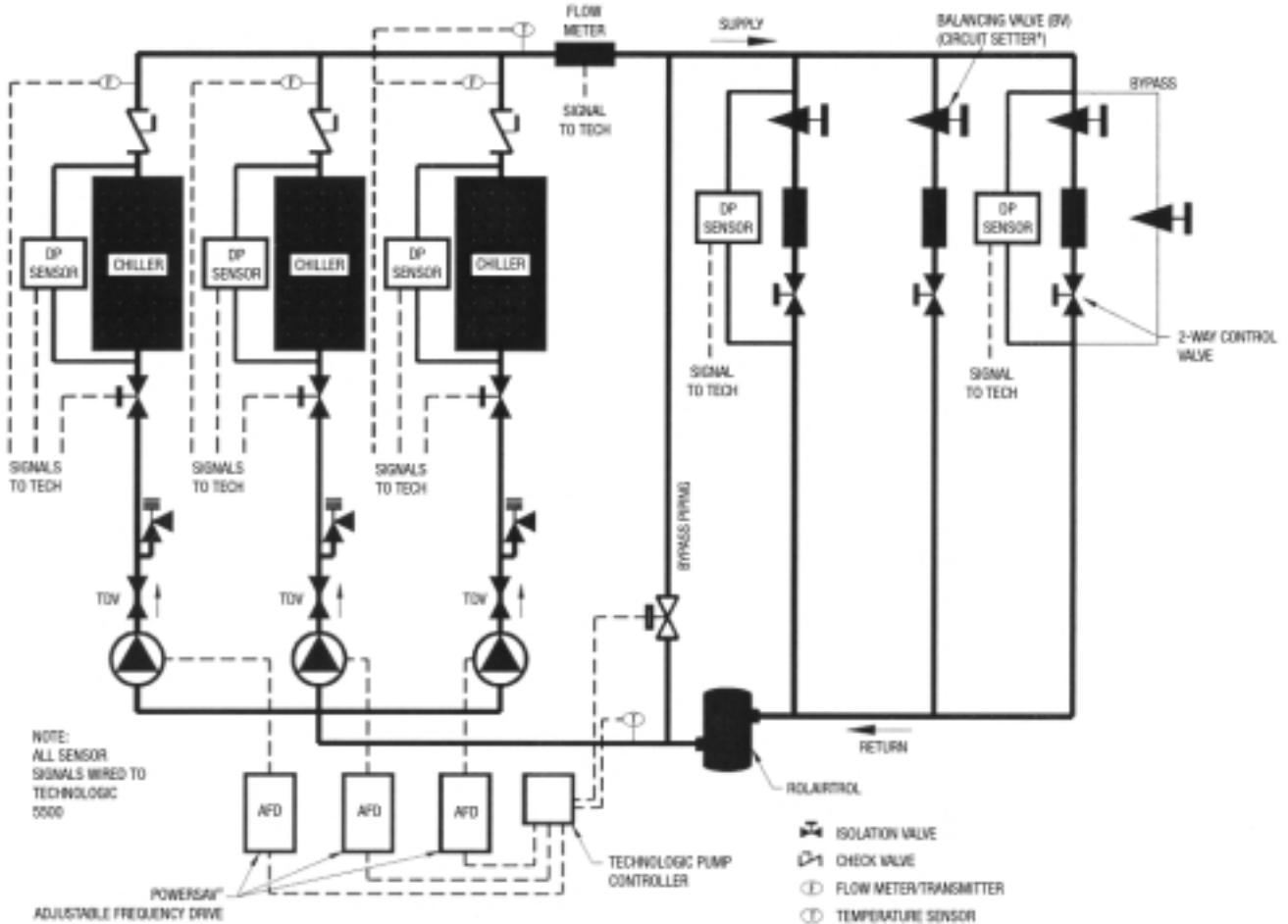


**APPLICATION COMMENTS:**

- 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 1.
- 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.

**VARIABLE VOLUME / VARIABLE SPEED**  
**SYSTEMS APPLICATIONS**

**VARIABLE SPEED CHILLED WATER PUMP CONTROL**  
**VARIABLE SPEED PRIMARY PUMP PIPED DIRECTLY 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 1.
- 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.