# INDEX

## A-7.1 Controlling a Water Pump's Operation

There are several methods by which a water pump may be controlled to operate and several factors could enter into making an appropriate choice. The horse power of a pump's motor will dictate whether a relay, a contactor or a starter must be used to operate a pump. There is always the option of just using a main disconnect for some pump's operation too (typically pumps which operate all the time). Then, depending upon the controlling method chosen (relay, contactor or starter), you will have to decide what will signal the chosen device in order to start the pump's operation.

The easiest answer to all these issues, is to use a chiller which has a manufacturer's supplied water pump. The manufacturer will have the pump's controlling circuit already installed and wired, and the chiller's typical 24 volt control circuit ( R to Y ) will be the signal to start the pump's operation. Unfortunately, this scenario may not be available all the time and now, you have to design a control system for the pump. I will first discuss the difference between a relay, a contactor and a starter and why one or another of these may need to be used. Then, I will discuss some controlling options (how to signal a relay, contactor, or starter). To do this, I will show some of the layout designs which were shown in chapter 6 and add controlling comments for each one. I sincerely hope this information will be helpful for you.

The main difference between a relay, a contactor or a starter, is the operational amp load which a device has to handle.

**Relay =** Small amp load operating devices (typically 30 amps or less). The normally open contacts (NO) will have a specific amp rating and it is important to choose a relay which has a proper amp rating for the load it will handle. Some relays come with both a NO set of contacts and a normally closed (NC) set of contacts. Most relay sizes and types are capable of being energized by several different voltages (24v, 115v, 208v, 230v, 460v). You must know the voltage of the controlling signal to make a correct choice for a relay's operating coil. This voltage logic for an operating coil, is identical for relays, contactors and starters.

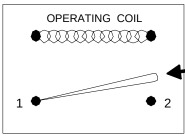
**Contactor =** Large amp load operating devices (typically 20 amps and up). These devices are also available in various sizes based upon the operating amp load. Be sure to choose a proper amp rated contactor for the motor be operated.

**Starter =** A Contactor + an Over-load Protector. Many motors require a separate and independent means of thermal over-load protection. A starter provides for this. Starters are also sized and amp rated for various loads, as with the over-load device. To choose a proper starter, it is always best to consult a good supplier.

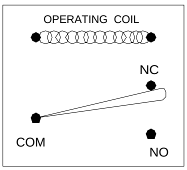
## A-7.2 Relay, Contactor, Starter Designs

While there are many similarities in the design of these items, there are just as many differences. The following drawing shows the typical design of each item and the typical method by which they are labeled for wire connections.

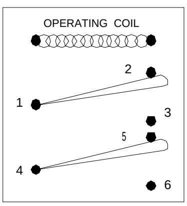
### RELAYS




SINGLE POLE, SINGLE THROW = SPST

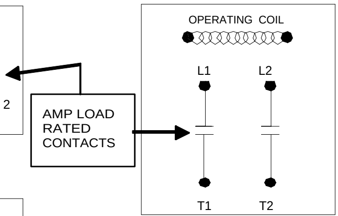



SINGLE POLE, DOUBLE THROW = SPDT

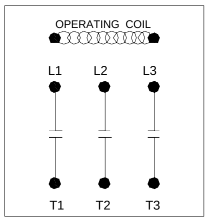



DOUBLE POLE, DOUBLE THROW = DPDT

### CONTACTORS



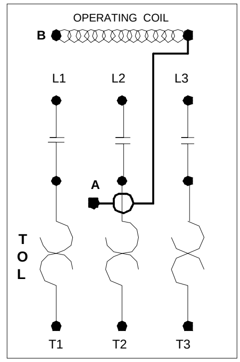

DOUBLE POLE, SINGLE THROW = DPST




3 POLES, SINGLE THROW TYPICALLY USED FOR 3 PHASE ELECTRICAL DEVICES

DPST = SINGLE PHASE OPERATED DEVICES

### STARTER




3 POLES, SINGLE THROW CONTACTOR "WITH" **T**HERMAL **O**VER-**L**OAD PROTECTION ADDED.

TYPICALLY USED FOR 3 PHASE OPERATING DEVICES WHICH DO NOT HAVE OVER-LOAD PROTECTION, OR THEY REQUIRE ADDED PROTECTION.

**TOL's** ARE SIZED PER STARTER BASED ON THE OPERATING AMPS OF THE CONTROLLED DEVICE.

#### TERMINAL CONNECTIONS, RELAYS

Terminals, 1, COM and 1-4 are used for the main power source which the relay will deliver to a device to make it operate.

Terminals 2, NO an 3-6 are normally open connections and when the relay is energized, these contacts will be closed to deliver the power to the device.

Terminals NC and 2-5 are normally closed connections and they will be opened when the relay is energized. Typically used to stop one operation when another operation is started.

e.g. one set of contacts in the dpdt relay can be used to start a device and the other set of contacts can be used to stop a device.

#### TERMINAL CONNECTIONS, CONTACTORS & STARTERS

Terminals L1, L2 and L3 (Line) are used for the main power source which is to be delivered to a device to make it operate.

Terminals T1, T2 and T3 (Load) are used for delivering power to the operating device, when the contactor closes it contacts.

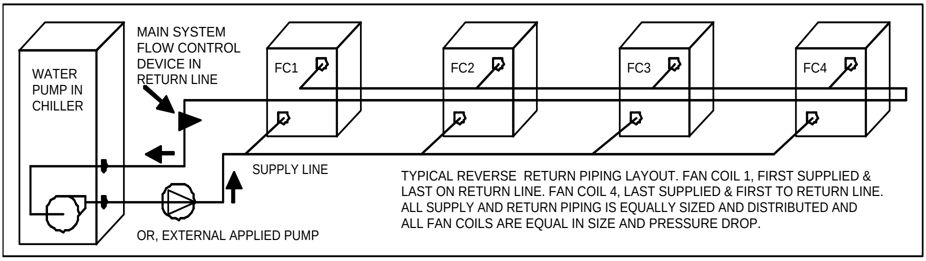
Starter : when operational power is delivered to the device, the thermal over-loads will monitor the amp draw of the device, and should any problem cause a higher than normal operational amp draw, the overloads will shut down the starter. Part of the operating coil's power circuit is controlled through a NC contact in the over-load device. The operating coil's wires will be connected to terminals **A** and **B**.

**OPERATING COILS ( ALL RELAYS, CONTACTORS & STARTERS )**

All of these relays, contactors and the starter, may be purchased with several options for the voltage required to power the operating coil.
Typical coil operating voltages are;
24 volts, 115 volts, 208 volts, 230 volts and 460 volts.

**ELECTRICAL CONTACTS OF ALL RELAYS, CONTACTORS & STARTERS**
Every one of these devices are available in a wide range of amp loads;
1 to 30 amps typical for a relay, 20 to 200 + for contactors and starters.
It is very important to purchase a relay etc. which has an appropriate amp rating for the device it will be operating (e.g. amp rating of device + 25 %).
Overloads may be sized a little different. It is always best to consult a good supplier for all over-load protection devices.

## A-7.3 Single In-Chiller or External Pump



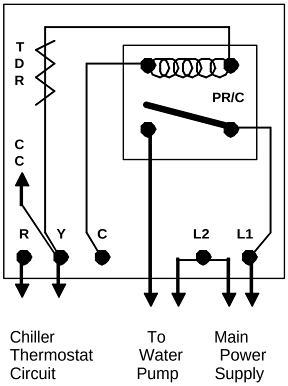

1- IF, a manufacturer provides a chilled water pump in their chiller, your worries are over. The manufacturer will have provided all the controlling options for the pump and all you have to be concerned with is the chiller's R to Y operational circuit. But, IF there is no pump in the chiller, or the chiller's supplied pump is not large enough for the designed system, you now have to use a separately purchased external pump.

2- **NO CHILLER PUMP:** a water pump must be sized properly for the system and the operational amp draw of the pump's motor must be known. You must decide whether to use a relay or contactor (R/C) based on the motor's operating amps. You must also choose a coil voltage for the (R/C). Because the chiller will be controlled to operate by a 24 volt control circuit and if water flow is only required when the chiller is signaled to operate, it would be best to use a 24 volt coil to operate the R/C. This 24 v coil will be interlocked with the chiller's R to Y circuit. ***Note: Always be sure to check a manufacturer's literature regarding any time delayed shut down requirements for a pump.*** Remember, you must provide the operating power supply for the water pump.

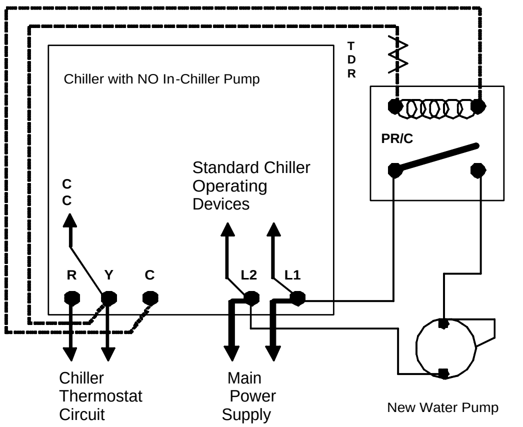
3- **REMOVING IN-CHILLER PUMP:** you must size and purchase the pump and you must know the new pump motor's amp load. Then, check the manufacturer's literature for the chiller. It may be possible, that the new pump can operate through the chiller's existing pump circuit (in-chiller pump's amp draw, verses new pump's amp draw). Or, you can purchase a R/C for the new pump and use the chiller's pump circuit to operate the R/C. This option could create two options; 1- use the chiller's pump R/C to energize your R/C (this will require a operating coil voltage equal to the in-chiller pump's voltage), or 2- replace the in-chiller R/C with your new R/C and use the chiller's control circuit to energize the new R/C (this will typically mean a 24v operated coil). IF, a time delayed pump operation is required, interlocking with a chiller's control system will cover this need. ***Note: depending upon the new pump motor's amp draw, you may have to have a new power supply.***

# A-7.3.1 Wiring Diagrams for A-7.3

Chiller with In-Chiller Pump




CC = Chiller Control Circuit
PR/C = Pump Relay or Contactor
24 volt operating coil
TDR = Time Delay Relay, If
Applicable




NOTE: Main power supply must now be sized for the chiller "and" the amp load of the water pump too.

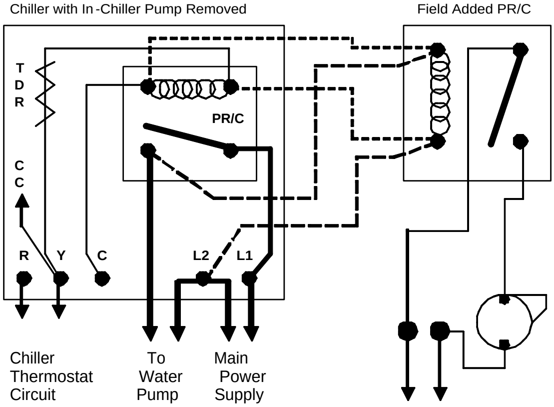
………. = Field installed 24 volt interlocking control wiring for the field added relay or contactor.

PR/C sized for amp load of the new pump.

TDR added to PR/C if needed per manufacturer's literature.

Chiller with In-Chiller Pump Removed

Field Added PR/C




Depending upon the amp load of the new water pump, "and" the amp rating of the chiller's PR/C, you may be able to just increase the water pump's wiring size and the size of the main power supply for the chiller.

Optional:
New independent power supply, sized for the amp load of the new pump.

**NOTE: Please note that the TDR (if required) will still be used for the water pump's controlling circuit, no matter which option is chosen.**

**Controlling Options for Added PR/C**

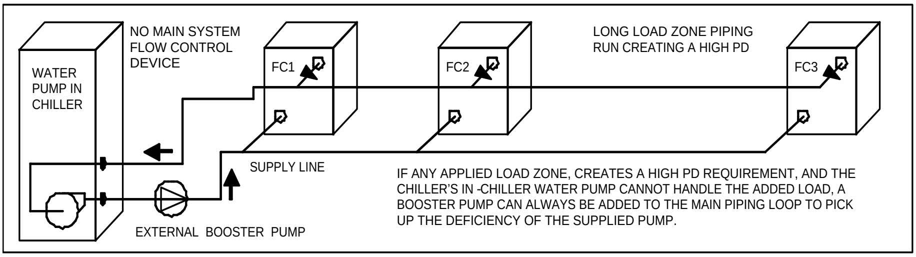
Option 1:
Use the chiller's PR/C high voltage contact circuit to energize the new field added PR/C. This will typically require a 208/230 volt operating coil for the new PR/C. Field wiring indicated by a dashed line.

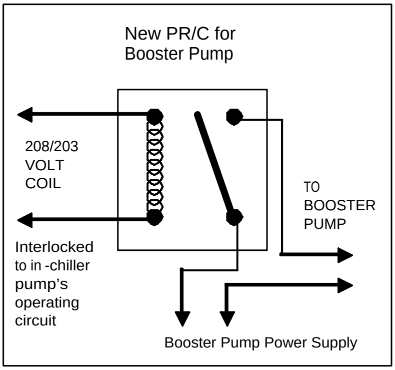
Option 2:
Use the chiller's 24 volt control circuit to energize the new field added PR/C.
The new PR/C may even be able to be located in the chiller's control panel in place of the manufacturer's supplied PR/C. This option requires the new PR/C to have a 24 volt operating coil. Field wiring for this option is indicated by a dotted line.

**SPECIAL NOTE:**
**All wiring and main supply power logic noted on this page is for single phase applied power which uses two hot legs typically notes as L1 and L2.**

**3 Phase wiring and supply power will be noted on another page.**

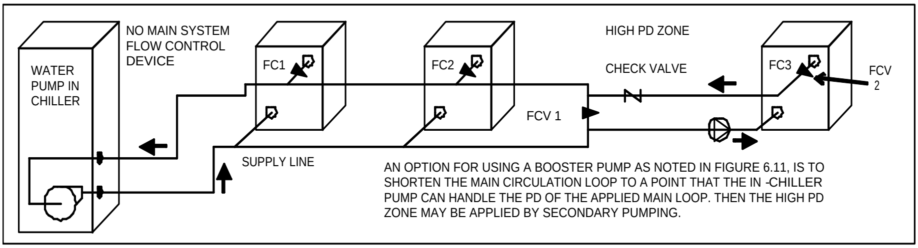
## A-7.4 Booster Pumping



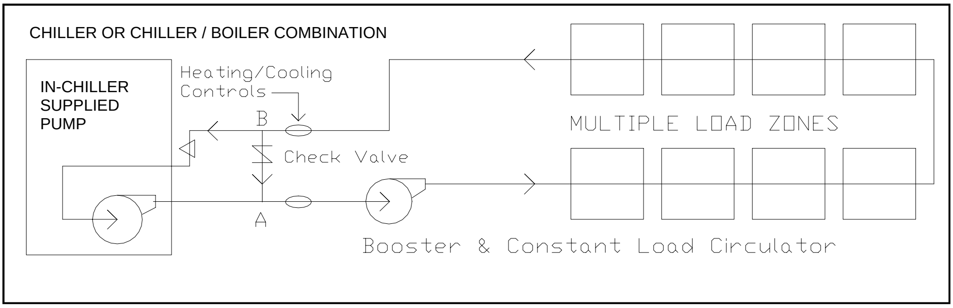

The booster pump, applied as shown above, will be required to operate when the chiller's in-chiller pump is operating. By installing a PR/C for the booster pump and having an operating coil voltage which matches the in-chiller pump's voltage, the new booster PR/C can be energized when the chiller's control circuit signals the in-chiller pump to operate. When the in-chiller PR/C powers the in-chiller pump, it can power the booster's PR/C to start the booster pump's operation too.

Some systems may have a booster pump being applied just for a single zone due to a high PD factor for just the one load zone. This can create a couple of issues; 1- how to energize the booster pump's operation, and 2- how to signal the chiller to ensure it is operating?

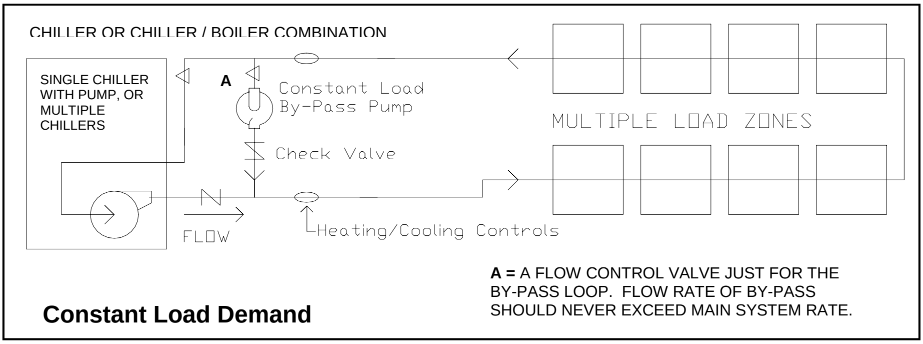


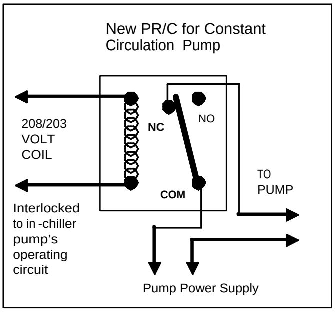

Note; This particular need and logic assumes wild coils at all load zones (no 3-way valves). 1- Use this fan coil's 24 volt circuit to energize a DPDT PR/C. Use one set of contacts for the booster pump's high voltage operating circuit and 2- use the other set of contacts to close the interlocking control circuit for the chiller's operation. "IF" the chiller system's water circuit was controlled to operate constantly (continuous controlled temperature loop) , you would only be concerned with controlling the booster pump's operation (24v coil, SPST PR/C).

## A-7.5 Booster Pumping / Constant Circulator




This booster pump's operation performs two functions; 1- It aids the in-chiller pump's operation (increased Ft Hd) and 2- It keep the water system in constant circulation when the in-chiller pump shuts off. This means the booster pump will operate all the time, and this means that NO PR/C will be required. The booster pump will be directly connected to a power switch device (appropriate for amp load of pump). The chiller's operation will be controlled by the field applied Cooling and/or Heating control system. Some applied systems may require a constant circulating water loop, but it does not need to be applied as a booster too.

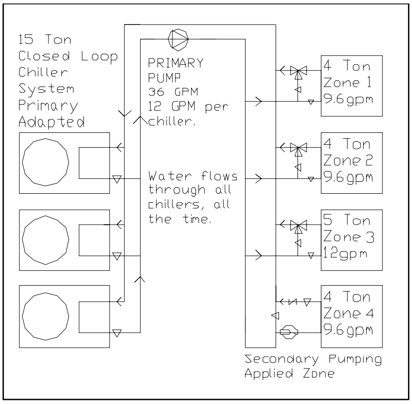



This applied constant circulating pump must be OFF when the in-chiller pump is operating and it must be ON when the in-chiller pump is off. The PR/C chosen must now be a SPDT device which has a normally closed contact option. The constant circulating pump will be wire to operate through this NC circuit and the in-chiller pump's operating circuit will control the new PR/C operating coil. When the in-chiller pump is operating, the PR/C is powered, opening the NC circuit and the circulator shuts off.

When the in-chiller pump shuts off, the PR/C is de-energized and the circulator's operation is started again.

## A-7.6 Multiple Chillers / Multiple Loads




As the number of applied chillers increases, so will the total GPM requirements of the system. As the number of load zones increases, so will the total length of the applied piping system and the total PD of the designed system. This means that any applied water pump will now have a much higher potential for having a fairly large horse power motor. Depending upon the size of the pump's motor, and/or the power requirements of the chillers themselves, this could mean a 3 phase electrical power supply.

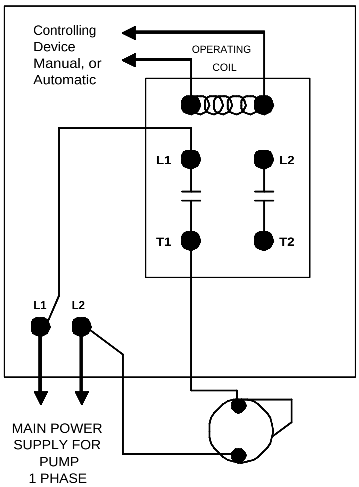
So, the controlling issue for the applied water pump, could now be a single phase operational power requirement, or it could be 3 phase. Larger horse power motors normally require a contactor for On/Off controlling. Also, IF the motor is 3 phase power operated, there is a good chance that it will require a starter due to the need for over-load protection. Last, I have seen some new water pumps on the market which have speed controls built right into the pump's motor (variable speed converter on the side of the motor). These pumps, un-like conventional single speed pumps, cannot operate by using a single controlling hot leg (L1 circuit). The ones I have seen, all required controlling of both hot legs (L1 and L2 being simultaneously energized).

There are several options for this water pump depending upon some variables for the pump motor's; 1- Horse power rating (total amp load). 2- Single phase or 3 phase power. 3- Constant operation or On/Off motor cycling.

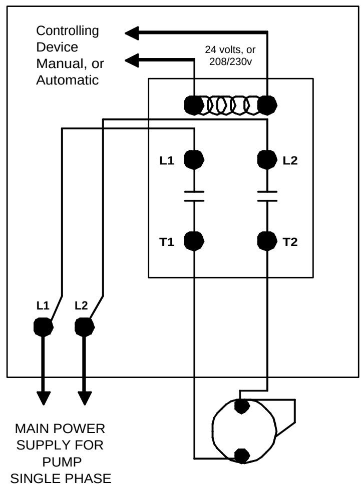
1- Total Amp Load: some motors with small amp loads, may be applied just by using a properly sized disconnect device. But, many motors will require a contactor due to a higher amp load and a control circuit must be used to energize the contactor (constant operation or On/Off cycling of pump).
2- 1 Phase verses 3 Phase: many single phase motors can be properly operated by controlling only one power leg, but others will require controlling of both hot legs. 3 phase motors normally require controlling of all 3 hot legs and over-load protection is normally required.
3- Constant Operation verses On/Off Cycling: any motor can be applied for constant operation or On/Off cycling. A contactor could just have a manual On/Off switch added to the contactor's operating coil, or a automatic controlling circuit would be used. Starters are available with a manual On/Off switch right on their housing assembly, or they can be wired for automatic controlling by an external control system.

# A-7.6.1 Wiring Diagrams for A-7.6

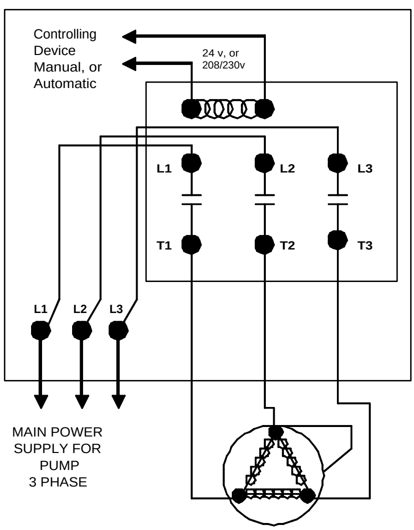
**Contactor applied for the operation of a single hot leg ( L1 )**




**Contactor applied for the operation of both hot legs ( L1 and L2 )**




**Starter applied for the operation of a 3 phase pump motor.**

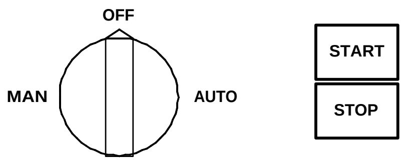



**CONTROLLING DEVICE OPTIONS:**
FOR CONTACTOR/STARTERS = C/S

1. One option is to use a simple manual On/Off Switch (typically used for a pump which will operate all the time).
2. For automatic operation, interlock a C/S's operating coil with the system's 24 volt controlling system (requires a 24v operating coil on C/S).
3. Depending upon the amp load of a C/S's coil, and the available power from the 24v source (transformer), use a small 24v operated relay and use the relay's contacts to close a high voltage circuit to operate the C/S (C/S must now have a 208/230v coil).
4. A manual switch can always be applied to a high voltage circuit too. This will help to reduce the 24v load on a transformer.

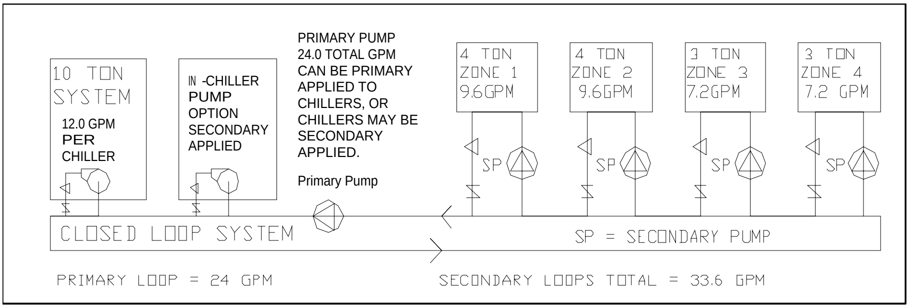
**Note: some installers have a way of adding several 24v controlling devices without ever considering the amp load on the transformer (it's just a 24v device right). Wrong ! Low voltage loads can add up fast too, and this can burn up a transformer and/or 24v coil fast, if an amp load gets to high.**

**Starters are available with Start/Stop Buttons, or a Manual Switch which can be set for a desired operation.**



## A-7.7 Chiller Capacity verses Load Demand

Many designed systems could have several pumps being applied to one system, especially for systems being designed around Primary/Secondary pumping. This means that every pumping circuit (every pump) must have its own means of being operated.



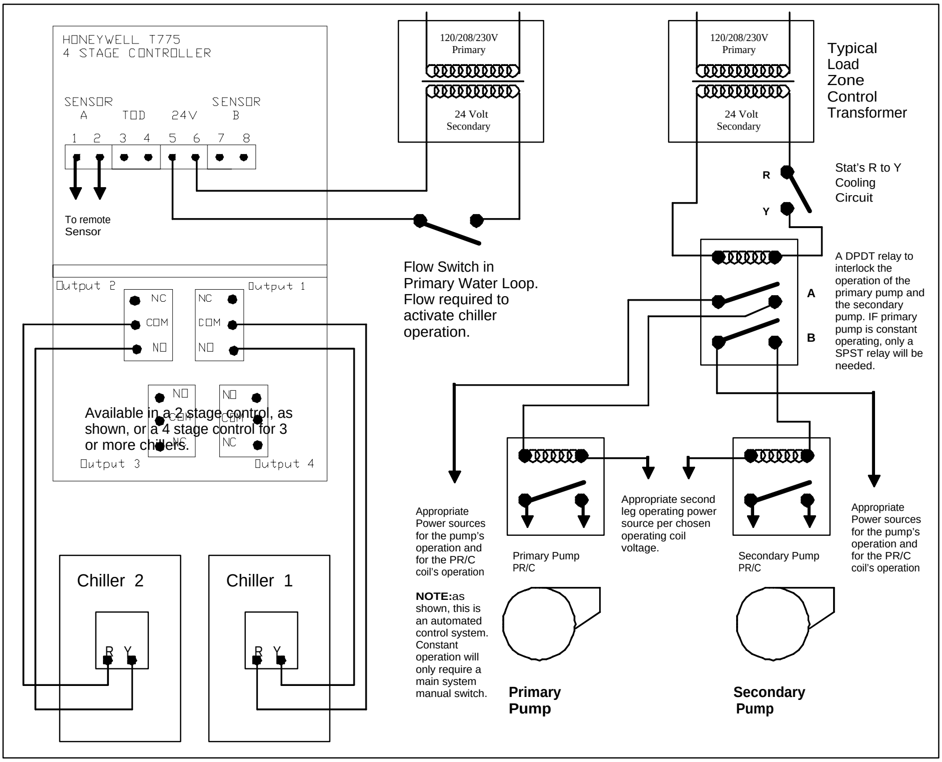

The above drawing shows a system with seven (7) pumps. One main primary pump and six secondary pumps. Because every chiller, main loop and four secondary loops all have their own water pump, the size of each pump will have a high potential for each one to be a relatively small pump with a small horse power rating. Only the main primary pump will have a potential for having a higher horse power motor.

**Chillers:** "If" the chillers have a manufacturer supplied pump, their controlling needs will be handled. A staging control, typically applied to multiple chillers, will control a chiller's R to Y operating circuit and the manufacturer's pump controlling circuit will control the pumps. "If" a water pump must be added, and a PR/C must be added (see A-7.3).

**Primary Pump:** A primary pump must be sized properly for the PD of the primary loop. The operation of the pump must be determined (On/Off Cycling or Constant) which for the above system will most likely be a constant operating pump. Primary pump controlling was discussed on A-7.6..

**Secondary Pumps:** Basically, all secondary applied water pumps will be controlled by the control system which operates the load zone (or chiller) to which the secondary pump is applied. The PR/C must be able to handle the amp load of the pump's motor and the PR/C's operating coil's voltage should match the voltage of the load's control circuit. Secondary loops do not normally require 3-way valves because no water will flow through the circuit unless the secondary pump is operating. The pumps can simply be interlocked with a thermostat's R to Y circuit (24 volt). But, there may be times when a control system needs to provide total system interlock, flow switch back-up to prove primary pump operation and to ensure some load for the chiller's operation (see A-7.7.1).

## A-7.7.1 Wiring Diagram for A-7.7




Please note contacts **A** and **B** on the interlock relay. "IF" the primary pump's operation is to be automated (Off unless a zone calls for cooling) one set of contacts (**A**) per relay must be parallel wired for all applied relays (zones). Contact **B** will only be used for the zone to which it is applied, for that zone's secondary pump. "IF" the primary pump is controlled to operate all the time, this need can be omitted and a single contact relay may be used for the secondary pump. The primary pump's flow switch is an option, but it is a good one. You really do not want chiller operation with no flow in the primary circuit. Each zone's stat will; 1- Energize the interlock relay ( R to Y) and 2- energize the blower relay ( R to G). The interlock relay will start the primary pump (**A**) and that zone's secondary pump (**B**). Provided water flow is established in the primary loop, the flow switch will energize the staging control and the chiller's operation will be started. Provided any zone is calling, the chillers will maintain a proper chilled water loop temperature through the staging control.

***Note:*** This is but one method of many which may be applied to this type of system.

## A-7.8 Process Cooling

Process cooling loads are almost always designed around primary/secondary pumping, "AND" the primary loop is almost always designed to operate all the time. This means that the primary pump will only require a properly sized relay, contactor or starter and some means of manually controlling that device will be needed. This need has been mentioned and discussed in the previous pages.

The secondary pump's operation will be controlled by the load zone's operational requirements. Some controlling item in the load's control system, must be used to energize the relay, contactor or starter chosen for the secondary pump. For process loads, the secondary pump could be operated constantly, or it may be automated. The logic which has been provided should be sufficient enough for you to determine your needs and to control them.

There are many, many controlling options for chilled water applied systems. The controlling designs I have shown are not the only way of doing things. Every body has an opinion on a good control system and that's great. I am always open to new and better ideas. BUT, no matter how your controlling system is designed, there are a few items which you must always remember about chilled water systems.

**1- Chillers should never operate without having water flowing through them.**

**2- Chillers have a specific flow rate requirement which must always be correct (minimum mandated flow rate).**

**3- Some chillers have a post operational cool down period which mandates flow.**

**4- "IF" item 3 exists for any chiller, and**
**"IF" an external pump is applied to any chiller, and**
**"IF" a chiller's time delay requirement can not be interlocked from the chiller,**

**A *FIELD ADDED* TIME DELAY RELAY MUST BE USED !**