Chapter 7- "Installation" the Way it Should Be

In 1989, my business partner worked many long hard hours with an engineering company who was designing a 50 ton chiller system and a 25 ton chiller system for a new training center building. In 1990, my business partner passed away having a bad bout with leukemia for which he lost the battle. Now this job was 100 % my baby. The job was sold and installed in 1990 and I had to be there for the start-up of the equipment and to aid the installing contractor. No, this is not an installer issue. But, it is a common installation issue.

During the start-up of the equipment, I noticed that the water flow rate through the equipment was changing. I commented to the installing contractor that something was screwed up in the water flow regulation of the system. We couldn't finish the start-up that day and had to come back the next day. A special company had been hired to set and regulate all the water circuits (proper flow rate per applied circuit) and to set the proper air flow of all applied air handlers and/or fan coils. When this man walked up to me and I introduced myself to him, he said, "Oh, you're the one who said the water flow rates are all screwed up". Yes, he did have an attitude. I said to him, "No, I'm the one who said that something was screwed up in the water flow regulation of the system. My equipment is seeing changes in its mandated flow rate when the system is operating". I explained the equipment's mandated requirements and he immediately said, "I know exactly what is wrong". It seems that all the designed 3-way by-pass valves had some how been changed to 2-way valves and when any given load zone was satisfied, the water flow rate through the equipment was reduced by that zone's flow rate.

The whole issue started when the general contractor and the building owner were seeing cost over-runs during the construction of the building. Corners had to be cut, and as is typical done, it was more important to have aesthetics, decorative trees and flowers, than it was to have a proper heating and cooling system. A 4 pipe designed system had been changed to a 2 pipe system. 2-way, Open-Closed valves were allowed in lieu of the required 3-way valves, and the list went on. I had to write a letter to the installing contractor notifying them, that if this water flow issue was not corrected, it would cause operational problems for the equipment and it was good cause for the manufacturer to void all warranties on the equipment. I should have been talking to a wall; I may have gotten more accomplished. Yes, problems occurred. The engineer was mad. The building owner was mad. Everyone was mad, but absolutely nothing was done to correct the issue.

Three years later, a new contractor was hire to fix all the problems. Change a 2 pipe system back to the originally designed 4 pipe system. Replace all the 2-way valves with 3-way valves, and on and on. But, it was too late for the equipment. It was already suffering with operational problems. Yes, the building owner pointed the fickle finger of fate at the manufacturer and blamed the equipment. Even after they read my letter again, which they said they had not seen before, the whole situation was not good. The big problem is, that this installation gone wrong story is not an isolated issue. This issue happens all too often.

During the writing and production of another book I wrote, I had the opportunity to talk to many manufacturers, seeking their permission to include information about their products and/or their name in my book. Many of them related this same scenario to me, telling me other horror stories about installations gone wrong. It seems that no matter how hard a manufacturer tries to produce a good quality product, some smart and learned individual will surely install it wrong, apply it wrong, or find some way to screw things up.

OOP's, there goes brand name reputation! Why is it, that the true culprit seldom gets the blame? Manufacturers have spent hours, upon hours, developing good and appropriate literature and manuals for the proper installation and application of their products. Now, they still have one big problem left.
"How to get people to read the instructions" ?

I must apologize for this some what long-winded introduction to this chapter. But, I have spent almost 25 years in the service/repair field before I entered the sales, engineering and design side of things. The stories I could tell are numerous, but the important item is, I truly believe I have a handle on this thing called proper installation. Now, I don't mean on everything, but chilled water cooling systems have been my life and the majority of them use hot water for heating too. I am some what limited in my knowledge of in-floor radiant systems, but my truly enjoyable membership in the Radiant Panel Association is changing this too.

A well rounded installation person, should know and understand many aspects of system designing and various equipment types. Or, they will just be following a design layout drawing and/or orders from a superior. The issue here is, are these factors right in themselves? Service/repair technicians have the same problem. Service/repair issues may not be an equipment problem; it could be a design or product/part choice problem.

7.1 Beginning an Installation

One word can basically define the beginning point for every installation;
<u>"READ"</u> **!**
Yes, get your hands on every piece of installation literature you can for all the equipment, air handlers, specialty valves and any other system items and read the installation requirements for all of them. Just because you have installed one company's chiller, air handler, 3-way valve, special flow control device, or any thing else, ***it does not mean that all chillers, air handlers, 3-way valves, etc, are the same or are identical.*** A boiler is not just a boiler, and a chiller is not just a chiller. Nuff Said !

7.2 Code Requirements

Every installation is going to be involved with many code requirements; Plumbing Codes, HVAC Codes, Electrical Codes and Gas Codes (gas-fired chillers). Every manufacturer typically tries their best in their installation literature, to provide as much information as they can, relating to typical code requirements as possible. But, as we all know, codes still vary from one city to another and from one inspector to another. This is getting much better in recent years, but it is still ***your responsibility to either know, or to find out what codes will govern your installation.*** Manufacturers provide information which their products mandate for proper operation. While these mandates may not necessarily violate any code, they could raise a question for an inspector. Having a manufacturer's installation manual to show and discuss with an inspector, is always a good idea.

7.3 Installation Prerequisites

There are many factors which must be considered for any chilled water cooling system, ***<u>before</u>*** it is ever installed. Yes, no different than any good hot water system too. System designers and engineers can not be expected to know every aspect of every chiller product on the market. Neither can an installer and/or service technician. But, it is always anticipated that they do. The poor service technician can really catch the majority of problem issues, because he/she is expected to keep a system in good repair and operation. But, a lot of these issues could have been avoided in the first place, simply by following some good prerequisites.

No matter how good a particular product may be for an application and installation, ***it will not operate properly if the installation (application) has not been designed and engineered properly in the first place*** . This is why system designing and engineering should always precede an installation and informational literature on installing. Then, having knowledge 1 in the first place, read installation literature in the second place and follow it. It is not un-common for an installer and/or service technician to run across a conflict between a system's designs verses a manufacturer's installation requirements. This is where a good installer and/ or technician can really shine. No engineer wants a designed system to be a failure and/or a black mark against their name. Contact the system's designer and discuss this conflict (Tip; never tell an engineer their wrong. Simply discuss the issue). If an installer just follows a design layout, knowing that something is wrong, he/she now becomes the problem. The end goal for everyone involved with a system's design and installation, should be, 100 % customer satisfaction. This of course equals a properly designed and installed system.

Special Note: *Many manufacturers, in their warranty polices, many times make a special note that, "IF" their product has not been installed per manufacturer recommendations, the manufacturer may reserve the right to constitute the installation as a mis-application of the product, and the product's warranty may be voided.*

I don't know about you, but I sure wouldn't want to be the designer and/or installer of a system for which this may have occurred.

7.4 Installation Location of Chiller

Small tonnage comfort cooling chillers come it two basic types; 1- Electric Operated Chillers, and 2- Gas-Fired Chillers. Gas-Fired Chillers are further defined as Air-Cooled Chillers, while Electric Chillers can be either Air-Cooled or Water Cooled (typically process cooling applications). Water cooled chillers require an outdoor cooling tower[1] as a heat rejection medium, while Air-Cooled Chillers, by definition, are strictly designed for outdoor installation. This book does not cover water cooled equipment, only Air-Cooled products.

1- Cooling tower applications will require a water pump and a designed and PD calculated piping system. Water tower pumping and piping are considered an Open Loop System. By following Open Loop piping logic, a cooling tower manufacturer's literature and a water cooled chiller manufacturer's literature, this application should be a breeze too.

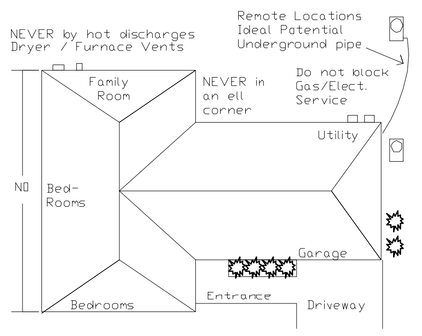


FIG 7.1 Typical Installation Locations

Figure 7.1 highlights several good choices for an installation location of a chiller, and several bad choices. Several factors enter into a choice for a proper location; 1- Is it an Electric Chiller? 2- Is it a Gas-Fired Chiller (3 times as much heat rejection). 3- Does the chiller reject heat (condenser air flow) upwards or sideways? 4- Is there only one chiller, or is there two or more? All these questions must be answered.

Bedroom window areas[2] should always be avoided due to the equipment's operational noise. Hot exhaust discharges must always be avoided to prevent heated air entering a chiller's air cooled coil section. Utility services must be open and accessible. Ell corners[3] should be avoided due to the limited ability of heated air dissipation.

Note: any chiller operating in an ell corner, will create an increased percentage of discharged heat re-circulation.

For any given ambient of the day, an ell corner will be hotter than the ambient of the day. Chillers which have their heat rejection discharged sideways, should never discharge from one chiller right into another chiller setting along side of it. Side discharges are always best installed by having air flowing directly away from a building. Keep chillers a good distance away from a building for good heat rejection. Another neat aspect of chillers, which Freon systems cannot provide, is the remote location potential. Chilled water piping can easily be run under-ground from a chiller into a home or building. This may require increased pumping capabilities, but it sure could be a plus for many installations.

The last location issue is a real pain. Where a chiller should be located, verses where the customer wants it to be located.

2- Many cities and communities have code restrictions for side yard locations and for windows of the home. Gas-Fired, Air-Cooled Chillers, by code, may not be installed by a window. The minimum side clearance to a window has to be three feet. Always be sure to check local codes.

3- "IF" a gas-fired chiller is installed in an ell corner, it is destine to fail. Gas-fired chillers have three heat rejection operations; 1- is a gas-fired burner's combustion heat rejection. 2- is a condenser coil's heat rejection of the refrigerant. 3- is the absorber coil's heat rejection. By operation and design, the absorption process is critical to these chillers's performance. A gas-fired chiller must never be installed in an ell corner.

Chillers, by their nature and design, are much larger than traditional Freon units. This creates two issues for the customer; 1- where to locate this large ugly unit, and 2- what to place (build) around the chiller to hide it. Yes, where a chiller "should" be located and where a customer "thinks" it should be located can be a major battle. The bad side of this is, that too many installers have let the customer win the battle. Then, when chiller operating problems occur (and they will, sooner or later), now listen to what a customer has to say and who they are saying to. Yes, there are a lot of stories here too. "IF" this situation occurs, write up a Mis-Application Disclaimer Sheet and have the customer sign it, you sign it and have a third party sign it. Then make copies for all. This may even change the customer's mind as to where to locate the chiller. But, it will protect you and the manufacturer down the road.

What do Trees, Shrubs and Fences all have in common? They can all prevent a chiller from operating properly, if they are too close to a chiller. Customers love to hide air conditioning equipment, and I can certainly appreciate this. But, when doing so infringes on the equipment's ability to function properly, it now becomes a big issue. Yes, the customer will still blame the equipment when it breaks down and/or serious repair issues arise. A good installer must educate his customer regarding the equipment's operational requirements.

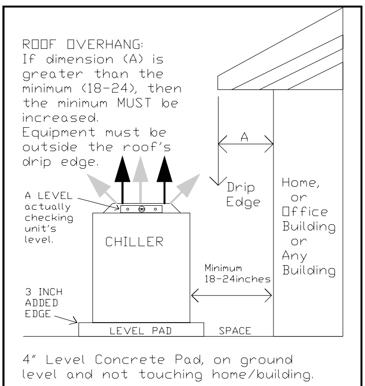


FIG 7.2 Clearances & Obstructions

Figure 7.2 highlights some more location issues and some clearance issues. The drawing shows a vertical air discharge chiller. Roof overhangs could infringe on heated air dissipation and can cause re-circulation. Stay outside the roof's drip edge. Chillers need room to breath and a good chiller to building clearance is 18 to 24 inches. Remember, more is better, less is trouble. Gas-Fired chillers must set level (shouldn't everything for good looks and saying another job well done?) Many manufacturers even ask that you use a level on top of the chiller to check the level.

Chillers weigh a lot more than a traditional Freon unit and they normally require a better/stronger supporting base (e.g. concrete pad). Be sure to check the chiller's weight factor and choose an appropriate base pad that will hold up and last. Many of these requirements are manufacturer mandated and that's why you should always consult installation literature.

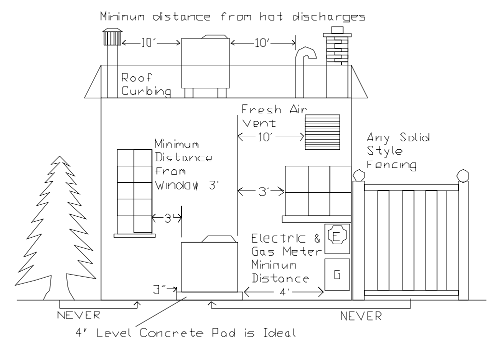


FIG 7.3 More Location Concerns

Few homes have a flat roof, but many small commercial businesses do, and this can be an ideal equipment location (very few trees and shrubs grow on roofs). Figure 7.3 highlights some more location concerns and a couple of code issues (more for gas-fired chillers). There's even a common sense[4] issue for heated discharges, keep chillers away from them.

Roofs can also create a unique operational issue just due to the prevailing winds. When wind currents travel over (across) a high peak or high flat roof, a lower pressure will be seen downstream (other side) of the peak. This will cause wind currents to "Fall" as they cross over the peak and if any operating equipment is too close to a peak or wall, this down current will infringe upon a chiller's ability to reject its operational heat properly. Figure 7.4 highlights some of these issues.

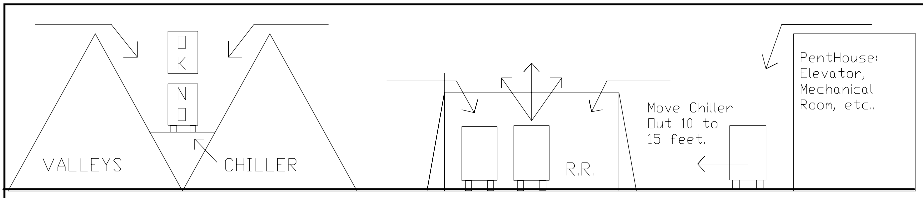


FIG 7.4 Dominant Wind Current – Valleys, Recessed Roofs & Penthouses

Every chiller manufacturer provides installation literature defining what a proper installation location is for their equipment. Success = following the instructions[5]. Roof top installations typically require special roof curbing, or a steel rail assembly may be provided for the equipment. As always, equipment weight is a concern, operational noise and/or vibration is a concern and the base frame design of the chiller can be a concern (some gas-fired chillers have u-channel rails under a base pan with sharp edges down).

4- Common sense for chiller installations, is the non-emotional and totally objective ability to know what is right, to know what is wrong, and then, to find the mental and physical capability to do that which is right.

5- READING, "Preparation is Everything !" **"PIE"**

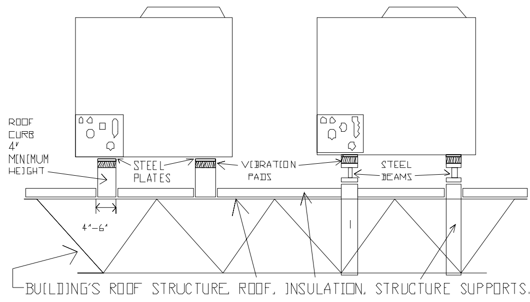


FIG 7.5 Roof Top Supporting

Figure 7.5 highlights some installation concerns for roof curb and steel rail structures. As with all chiller installations, the piping will soon be connected. Very important, chiller leveling starts with a level supporting mechanism (concrete pad, roof curb, etc.), then check a chillers level with a level (shim as needed, maximum 1/4" total) and then, start piping.

7.5 Chilled Water Piping

Special Note: More often than not, the main piping loop will be a larger pipe size than the connection point at a chiller and/or air handler (fan coil). The main piping loop <u>must never have any appreciable length of piping down sized</u>. When a main piping loop is larger than a connection point, use one reducing coupler and keep it as close to the connection point as possible. This rule applies to equipment, air handlers, fan coils, "And" water pumps which typically have smaller connections than the main piping.

Traditionally in past years, steel piping was commonly used for chilled water systems and I unfortunately worked on a lot of them. It was very common to have to clean strainer screens due to internal piping debris. That is, If I could access the strainer[6] to get to the screen. The initial logic was, that only the original filling water carries sediment and once it settles out, the system will be ok. Some one forgot about leaks and fresh water additions. Then came Open Loop chiller systems (water oxidation continually). Open loop chiller manufacturers, in their installation literature, emphatically stated, "No Ferrous Metal Piping". Then, PVC piping became the chilled water standard. Copper was always an option, but at a little added cost. Also, if any chilled water piping shared any part of its circuitry with hot water, that piping would definitely have to be copper piping. Some electric chiller manufacturers recommend the use of composite tubing for their systems. This is always a good option if a correct tubing size is available. Underground piping can be copper tubing, composite tubing and even poly tubing (minimum 100 PSI rating).

6- Be sure to purchase a strainer (if used) which has easy access to the screen for cleaning purposes.

Note: Be careful of any tubing which uses insert connections which penetrate inside the tubing. This will create a high PD potential. Always minimize poly barbed fittings and be sure to calculate a proper PD so the applied water pump works.

Basically, there are two good choices for a piping type for chilled water systems; PVC pipe and Copper pipe. Composite tubing and poly tubing, though useable, offer a high potential for a high PD piping system. This can be very critical when using a manufacturer's supplied water pump (limited Ft Hd). Also, I do not have, nor do I know of a PD chart which converts tubing insert fittings into an equivalent feet value or provides a Ft Hd value (PSI value). Some chiller manufacturers, who do recommend tubing, may provide some of this information for you (hopefully).

Note: Copper piping and PVC piping are available in different pipe wall thickness values. Each one is available with a very thin wall, called drainage/waste pipe. This should never be used. Copper has an assigned letter value which indicates a good (M), better (L) and best (K) wall thickness. PVC is rated by a schedule factor indicating a good (sch 40) and best (sch 80) wall thickness. The better the piping is, and the larger a pipe size is, will reduce the number of supports required to hold it up and/or to secure the piping.

7.6 Piping Insulation

All chilled water piping, including valves, fittings and all supporting mechanisms[7], must be insulated with a good quality insulation[8] to prevent condensation. All seams and wrappings must be sealed really good to ensure that no air can enter and come in contact with the piping. It is always a good practice to insulate all condensate drain piping for all air handlers (fan coils) too.

7- All piping styles will require some type and style of a supporting method. Some are connected directly to the piping which will require insulation OVER the support. Some are connected over the insulation and great care must be given to protect the integrity of the insulation.

8- There are many insulation types on the market. Be sure to choose one which is designed for chilled water applications and be sure to follow a manufacturer's use and application instructions. No insulation should be less than 1/2" in wall thickness.

7.7 Piping Connections

Every installed piping system will have many different styles and requirements for making a pipe connection; 1- Screwed connections which could be copper to copper, copper to PVC, copper to steel (manufacturer fitting on chiller), PVC to PVC, PVC to steel and maybe some brass fittings and/or flanges used with water pumps. 2- Sweat connections which could be copper to copper, or copper to brass/bronze. 3- Glued connections for PVC piping. 4- Special tubing connections. Every installed piping system will have some type of an antifreeze product being used in the circulating water system. ALL of these factors will create another ***very important factor***, choosing a good and proper pipe sealant, glue and/or soldering method. The goal of course is a leak proof connected system and to stay that way for a long time.

All pipe sealants are not created equal and one must be chosen which can be appropriately used with antifreeze products. PVC threaded connections, especially to metals, can be tricky too due to the different expansion factor of metal verses PVC. Pipe sealant used in conjunction with a good Teflon tape, can be a good option for this need. Copper to copper sweat connections may be a 50/50 or 95/5 soldered connection or a silflos soldered connection. Copper to brass/bronze sweat connections must be a silver-soldered connection.

Special Note: Every piping system must be leak checked which is typically done by an air pressure test, or by filling a system with water. NEVER add antifreeze to a system which has not been leak checked. Antifreeze leaves a residue on/in the piping, and this will make solder repairs a virtual nightmare. Also, never perform a final filling of the system, until the entire piping system has been flushed out good too.

PVC connections will require using a glue to make socket to socket connections. PVC glue is not just any PVC glue. Always use glue which the PVC manufacturer recommends and always follow a PVC manufacturer’s gluing recommendations. Some times, this may also require the use of a cleaning fluid. No matter what type of a connection you make, one word can define your anticipated success rate; “Cleanliness”.
Remember, “Preparation is Everything” (**PIE**).

Always, follow manufacturer recommendations and if problems occur, it’s their problem, not yours. And, be sure to follow the National Piping Code too.

7.8 Vibration Isolators

Some equipment (chillers and/or air handlers) may require the use of vibration isolators in the piping system, due to their installation location and/or to reduce the potential of mechanical noise transmission. When and if required, be sure to choose an appropriate product for a chilled water piping system. Also, be sure to consult a manufacturer's literature for a potential PD value for these isolators. It could affect your designed system's PD.

7.9 Piping Supports

Every installed piping system will require some supporting methods which can vary due to the item requiring support (piping, water pump, strainer, air separator, etc.).

Note: No supporting type should ever be installed or applied in any manner which could be detrimental to the piping and/or the piping's insulation.

Always refer to the National Piping Code for all supporting requirements. They do vary by piping type and piping size[9]. Some piping may require hanging supports, base hold down supports, raised leg supports, or some other support type based on a special need. Be sure to always use the best method for each requirement.

7.10 Load Zones

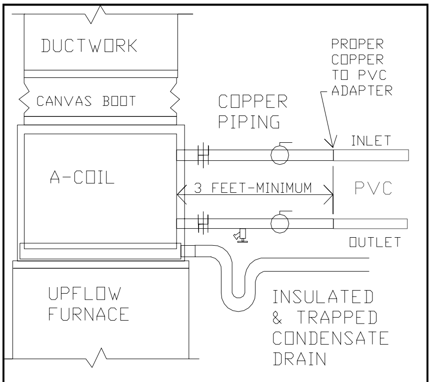


FIG 7.6 Typical Furnace Application

Just in case you ever do install a chiller system which has an a-coil (s) installed in a furnace (s), there is a special precaution which must be taken when PVC piping is being used for the main piping loop. Fluid in the a-coil will become heated during heating season operation. This could cause the PVC to soften and even break. To prevent this potential, always install 3 to 4 feet or more of copper piping right at the a-coil and then connect the PVC.

Note: Chilled water A-coil manufacturers state that, an a-coil applied in a counter-flow furnace, may see condensate blow off and they advise the use of a secondary drain pan in the duct work just below the a-coil.

9- The NPC lists piping support requirements based on; 1- a pipe type (copper, PVC, etc.). 2- piping hardness (copper harder than PVC). 3- a pipe's size (large size requires less supports). 4- pipe flexibility and much more.

7.11 Piping & Blower Systems

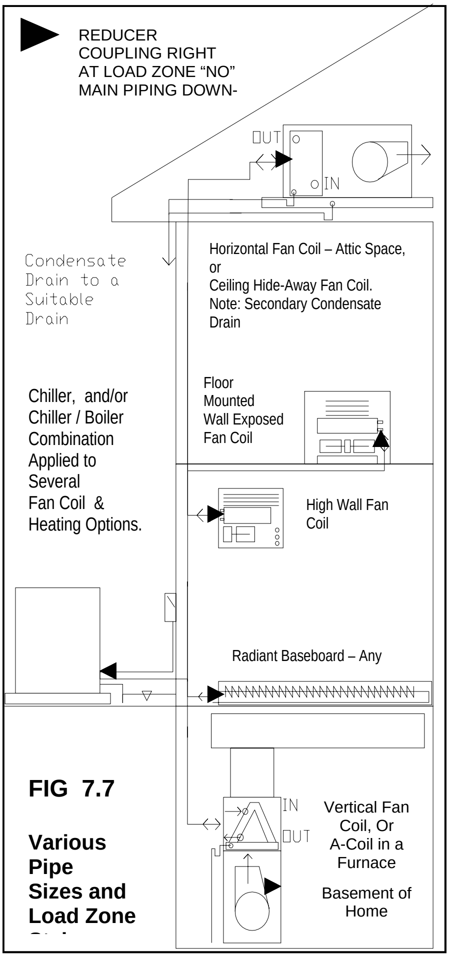


FIG 7.7

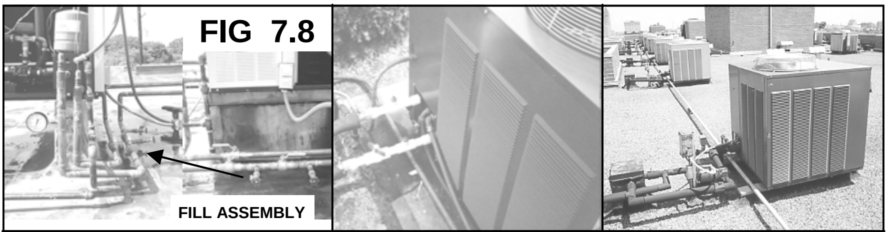
Various Pipe Sizes and Load Zone

Any installed piping system could have several different pipe sizes and several load zones which may also vary by size and/or manufacturer. The pipe size for each portion of a total system, must be sized properly for the GPM requirements of each circuit. The main piping loop may only be down sized after one zone has been fed (side outlet tee) and the continuing piping must be sized properly for the continuing GPM requirements. The connection at the chiller must be identical to the main loop piping, or a reducing coupler must be used right at the chiller. The reducing coupler must use a very short piece of connecting pipe (e.g. short nipple). As each properly sized water circuit is fed to an individual zone, that proper pipe size must be run to and be connected to each load zone. "IF" a load zone's connection point is smaller than the piping circuit, than another reducer coupling must be used right at the load zone. Again, using a very short piece of pipe.

Special Piping & Load Zone Considerations:

Any load zone installed above a finished ceiling must have a secondary condensate drain pan. Condensate drain piping and connections must be absolutely leak proof above finished areas. Condensate piping must be insulated really well above finished areas. All piping must be insulated really well above finished areas. Many times, piping may be hidden in wall voids with little to no accessibility. If and when piping is installed and applied in this manner, it is always best to; 1- use a better and/or thicker walled insulation. 2- insuring an air tight insulating factor is a must. 3- choosing a proper supporting method which will last is also imperative. 4- make sure total system operation is checked and double check before closing up walls. **"PIE" !**

Figure 7.8 highlights some typical piping connections for closed loop chillers, open loop chillers and a roof top applied chiller.



TYPICAL CLOSED LOOP - COPPER PIPE PRESSURE GAUGE, LOW PRESS ZONE PETE'S PLUGS, FLOW CONTROL VALVE IN-CHILLER PUMP & EXP TANK	TYPICAL OPEN LOOP - PVC THERMOMETER WELLS, FLOW CONTROL VALVE, 1" MIP X 1 1/4" REDUCERS AT CHILLER	TYPICAL ROOF TOP CHILLER ON ROOF CURBING, CONSTANT CIRCULATOR APPLIED, IN-CHILLER WATER PUMP

7.12 Special Pipe Sizing Information

Some chiller manufacturers, who supply water pumps in their chillers or chiller/boiler combination units, also provide some easy to use pipe sizing charts. The following chart is for a gas-fired chiller.

Chiller Pipe Sizing Chart:

		Chiller Size & Flow Rate		
Type of Piping	Nominal Pipe Size	3 Ton 7.2 gpm	4 Ton 9.6 gpm	5 Ton 12.0 gpm
Copper	3/4"	115ft	****	****
Copper	1"	432ft	262ft	154ft
Copper	1 1/4"	1167ft	706ft	412ft
PVC	3/4"	162ft	98ft	****
PVC	1"	532ft	313ft	182ft
PVC	1 1/4"	1998ft	1159ft	668ft

**** Exceeds velocity limits of 6 FPS.

The logic is to add up the total length of straight piping to get one value. Then, add up the number of installed items in the piping circuit (90's, tees, 45's, valves, wells, etc.) and multiple the number of these items (e.g. 15 items) by 3 (3 feet per item).

15 times 3 = 45, or 45 straight feet of pipe. This is a manufacturer's answer to a conversion chart. Now, add the actual straight feet of pipe (e.g. 125 feet) to the 45 feet for a grand total of; 170 feet. Now, based on the chiller's size (e.g. a 5 ton chiller) look in the column under a 5 ton chiller and find a pipe length entry value which is equal to or larger than your calculated value of 170 ft. You will see in this chart that there are two potential choices; 1 1/4 Copper pipe (154ft is less than 170), or 1" PVC pipe (182ft is greater than 170). There is a slight chance that this may be an over-kill, but it definitely works. The manufacturer has taken into account the PD value of "One" standard water coil in their chart. This chart is only good for a single chiller and a single water coil.

Chiller / Boiler Combination Units with a manufacturer supplied water pump.

		Unit Size & Flow Rate		
Type of Piping	Nom. Pipe Size	3 Ton 7.2gpm	4 Ton 9.6gpm	5 Ton 12gpm
Copper	3/4"	0 to 82'	****	****
Copper	1"	83-300'	0 to 90'	0 to 60'
Copper	1 1/4"		91-225'	61-200'
Copper	1 1/2"			201-500

This chart uses the same logic as was used for the chiller. Only copper pipe may be used (hot water) and the useable figures are reduced due to the added piping in the manufacturer's unit (more piping = larger PD = less available pump Ft Hd). Never use a smaller pipe size, even if your total length is close (e.g. 5 T @ 62' = 1 1/4" pipe).

A Multiplication Factor: Some manufacturers (and others) may tell you that a good rule of thumb is to just multiply the total straight feet of pipe by 1.50 (50 % for piping items) and then calculate your PD from the friction chart. Then take that PD value, add in your slush factor and your all set. While this may work now and then, you really need to ask yourself, if you're willing to take that chance?

7.13 Gas Piping

Most small tonnage gas-fired chillers have a 1/2" or 3/4" gas pipe connection on the chillers. But, most gas supply lines will be 1" or larger. That's because, just like water piping, gas piping has a PD factor too. Gas supplies have a piping supply pressure and the chiller has a specific gas volume usage factor (btuh). All piping must be sized to deliver this usage volume, and pipe sizing is based on some specific variables (gas supply pressure, typically 0.5 psi or less and the distance the chiller is from the main supply source, gas meter). If you do not know and/or understand gas pipe sizing, always consult a professional and the National Fuel Gas Code.

All installed gas piping must be pressure tested to ensure that there are no leaks. This pressure testing could exceed 0.5 psi and if it does, it will certainly damage gas valves which are supplied in the chiller and boilers too. The equipment should always be isolated from the main gas piping when pressure testing exceeds 0.5 psi (typically a manual gas valve in the piping system and near the equipment). Most gas-fired chillers can also be operated by propane gas. If this need ever arises, be sure to consult a propane professional, because propane gas has some pipe sizing and supply issues all to it self.

7.14 Electrical Wiring

Let's get the almighty disclaimer out of the way first. ALL electrical wiring must conform to the latest edition of the National Electrical Code (**NEC**). Most manufacturers provide you with the electrical specifications and operating requirements of their products, but they provide very little regarding code requirements. It is your responsibility to either know the electrical codes, or to find out what is required. Disclaimer done.

There are several issues for electrical wiring; 1- gas-fired chillers typically have little electrical needs, a 15 to 20 amp maximum service. 2- electric operated chillers will have a much larger electrical service requirement, three to four times more than a gas-fired chiller. 3- each chiller type will have control wiring as well as a main electrical service. Control wiring choices for a wire's size is critical too. In our new age of electronics and solid stage ignition systems, many manufacturers are mandating a specific size for the control wiring (minimum acceptable size).

7.14.1 Service Disconnect

Almost every manufacturer's literature I have seen, indicates the necessity of having a fused disconnect for the equipment (chiller, boiler or combination). Most, if not all codes require one too. Most codes limit the distance a disconnect may be from the equipment. Many installers even mount disconnects right on equipment and this is a service person's nightmare[10]. When wiring is being run and supplied to a piece of equipment from a main fuse or breaker panel, its size will be based on the total operating amps of the equipment and the distance the equipment is from the main panel (**NEC**). IF, two or more pieces of equipment are being installed (maybe even a water pump or two), one supply, properly sized for the total amps of all applied equipment can typically be run, and then be split near the equipment for individual services and disconnects to each item. Even though it is typically a code requirement today, many manufacturers, especially gas-fired chiller manufacturers, will remind you that a common ground wire will also be required for the rectification process of the solid state ignition systems. Many manufacturers even provide electrical connection information and ideas in their literature (that is if you have read the literature).

10- Disconnects have a way of always being conveniently located right on a panel you have to access to service the equipment. Boy, have I use some good words for these guys in my servicing days.

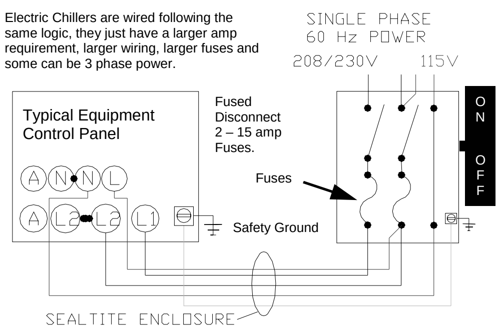


FIG 7.9 Typical Disconnect & Wiring

Figure 7.9 highlights a typical disconnect being connected to a piece of equipment. Gas-fired chillers can operate on 115 volts and 208/230 volts being a single phase service. Electric chillers having a higher amp load, typically operate on 208/230 volts which may be a single or three phase service. 115 volt panels are typically marked L (main power line) and N (the neutral line).

7.14.2 Wire & Disconnect Sizing

208/230 volt panels, having two (2) hot legs, are typically marked L1 (one hot line) and L2 (the second hot line, often referred to as the common line). Common typically means it is not used in the controlling circuit. This leg is commonly wired to all high voltage operating devices. Leg L1 will typically be used for the controlling circuit, for any normally open controlling devices. Sizing of wiring and disconnects are very important for proper equipment operation. As the total operating amps increases (single or multiple equipment) so will the supply wire size (e.g. 15 amps = # 14 wire, 20 amps = # 12 wire, 30 amps = # 10 wire, 40 amps = # 8 wire, etc.). The size requirement of a disconnect will increase to. As a disconnect increases in size, so will the type of fuse which is used in a particular disconnect (30 amp disconnect uses 15 to 30 amp fuses, 60 amp disconnect uses 35 to 60 amp fuses and with a different fuse design so they can only be used in this size disconnect).

7.14.3 Control Wiring

CAUTION: Many good electricians still do not necessarily understand good control wiring. This statement is not being made to condemn electricians. It is being stated because many control systems today, require special attention for their operational logic and application. Thermostat wiring ***is not necessarily the same as Control Wiring.*** Chiller systems can require an extensive control system due to the highly applicable variable of multiple zones. Also, chillers typically have a control transformer in them and this transformer is limited in its capacity to handle an extensive (long and/or multi-circuited) controlling system.

Many variables can enter into a chiller's controlling system; 1- By their nature, chillers typically have more controlling devices in them which creates a higher amp draw for the 24 volt control circuit. 2- Many manufacturers even set limits for a control circuit's wire size (e.g. minimum 24 volt wire size of 18 gauge). 3- Every installed and applied load zone will require a thermostat to operate the load zone's blower relay. 4- Every load zone will typically require a 3-way zone valve and this must be controlled by the load zone's thermostat. 5- Every load zone, when requiring cooling (or heating) must have a method of signaling the chiller (or boiler). 6- IF, there are multiple chillers (boilers), some means of staging must be provided for total effectiveness and efficiency of the system. 7- IF, there are any long runs of control wiring, the wires size may need to be increased (e.g. 50, 75 or 100 foot plus runs). 8- Having two or more load zones, typically means having a separate and independent control transformer for the zones. 9- Multiple chillers and multiple zones, equals multiple transformers and isolation relays must be used to isolate all applied transformers.

The following figures will highlight several controlling options for chilled water cooling systems.

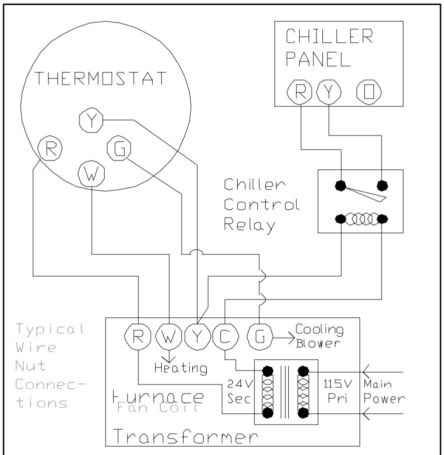


Fig 7.10 Isolation Relay

Figure 7.10 highlights a simple one on one system. Starting with a basic system and building from here, should make it easier to understand and follow the logic of larger applied systems. Typical control transformers, as provided in many chillers, are rated at 24 volts having a current rating of 40 VA (volt amps). This means that we can develop the following formula; (40 VA ÷ 24 V = 1.66 A). A 40 VA transformer can handle a 1.6 amp load, maximum. It is not a good idea to demand more than 75% of this total capability either (1.6 x .75 = 1.24).

So the maximum amp load for this transformer should really not exceed a 1.2 amp draw. Most chillers will use from 0.6 to 0.8 amps just to operate the chiller, so there is not a lot of power left for external use. Long wiring runs, the thermostat and a blower relay can really use up the excess amps fast. Very few systems will be a one on one system and it is easy to see why a second and independent control transformer will be needed.

To help keep the amp load resistance factor to a minimum, many manufacturers today are recommending a minimum wire size for any controlling circuit (18 gauge wire). Knowing that a two transformer system will most likely be used, it now becomes necessary to isolate these two power sources. This is done by adding a chiller control relay (isolation relay - Fig 7.10). To minimize the amp draw on the chiller's control circuit, use the thermostat's transformer to operate the relay and use the relay's contacts to operate the chiller's circuit. Also, knowing that we will most likely have a multi-zone system, means that we will have 3-way zone valves. This means that we now have an easier way to interlock a chiller's operation.

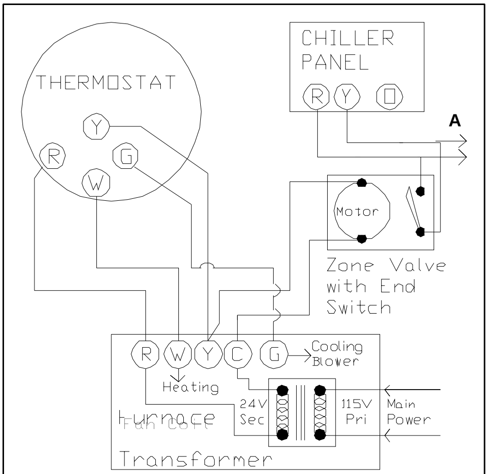


FIG 7.11 Zone Valve & End Switch

Figure 7.11 highlights the application and use of a 3-way valve. 3-way valves can be purchased with an end switch in them (set of normally open contacts). When a zone valve is powered to open, and at the end of its opening (motor operated arm), the end switch's trigger is pushed to close its contacts. The thermostat will energize the blower relay and the 3-way zone valve (one transformer) and the end switch contacts will signal the chiller to operate (second transformer). The end switch now isolates the two power sources.

The chiller's R to Y circuit may be parallel wired to all applied end switches (A). This is a common circuit and any one or all end switches will be closing the same circuit. "IF" a particular system had multiple chillers, the chillers would be operated by an applied staging control. Instead of the end switches signaling the chiller, they would now signal the staging control and the staging control would in-turn signal the chillers. If heating is going to be used with a cooling fan coil system, there is typically no means of controlling a blower's operation for heating. A typical heating system circuit, R to W, normally only signals the heating device itself to operate. There has to be another device added to the fan coil, to control the blower operation for heating (normally incorporated into a standard furnace system). There is a very easy answer for this need. A fan delay switch.

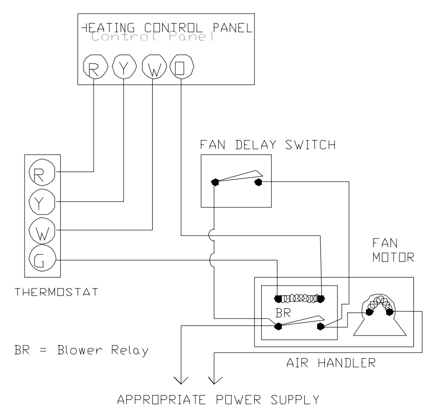


FIG 7.12 Fan Delay Relay

Figure 7.12 highlights the application and use of a fan delay relay. This is simply a pressure actuated switch which is parallel wired to the blower motor's control circuit. Figure 7.13 shows one such device which has been used for many years with gas-fired chiller systems. The blower relay in the fan coil is operated by the thermostat to close the blower relay's contacts on a demand for cooling. The fan delay relay's contacts are parallel wired to the BR's contacts which allows either device to turn on the blower motor (common circuit).

This fan delay relay is a remote bulb device (3/8" diameter by 6" long). The remote bulb is strapped to the face of the water coil (down stream air side). When hot water is circulated through the coil, the bulb is heated and the switch is energized (130° F On). When heating is done and hot water ceases to flow through the coil, continued air flow cools the bulb and the switch is de-energized (100° F Off). The switch is amp rated at 5.0 amps max. A very easy and effective method for automatically controlling the blower's operation.

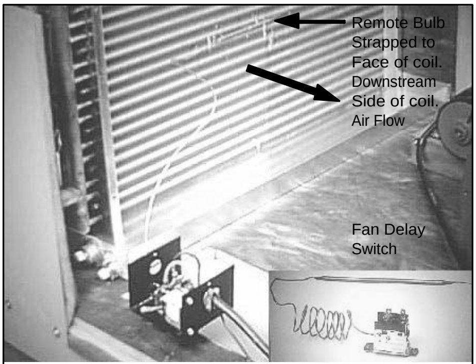


FIG 7.13 Remote Bulb Installation
Pictures Courtesy of Arkla Industries

Any remote bulb style switching device could be applied for this need, provided it meets similar specifications to that noted above. A couple of items do require special notes; 1- Many remote bulb controls have adjustable dials and the required operating temperature (e.g. 130° F), should be some where in the mid-range of the dial's total adjustability. 2- Many remote bulbs are shorter than 6 inches and this will take longer for them to heat up. Try to avoid short bulbs. 3- Be sure that you have the ability to set at least a 25 to 30 degree differential on the control. 4- Make sure the control has an appropriate amp rating for its contacts. Remote bulb controllers are very popular for hydronic systems. But, all too often they are installed and applied wrong and troubles can occur.

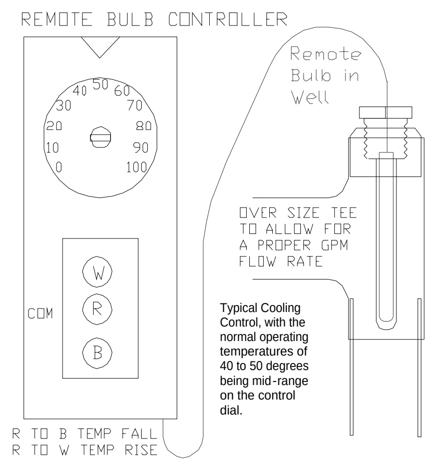


FIG 7.14 Installing a Remote Bulb

Figure 7.14 highlights the application requirements of a typical remote bulb. The remote bulb normally requires a bulb well which must be located in the piping's circulating water stream. The bulb can only perform properly, IF, the total bulb is submersed into the water stream. The bulb well is typically 1/2" O. D. to accept a 3/8" remote bulb (there are some larger remote bulbs too). When a bulb well is inserted into a piping circuit, the well itself will consume a good portion of the water's flowing area. IF, the pipe is not over-sized by one size, it could infringe upon the water's ability to flow properly (proper GPM).

This need is typically required for systems having a 1 1/2" pipe size or smaller. Every thing possible must be done to get the entire remote bulb totally submersed into the water stream. This means no side outlet tee adaptations.

7.14.4 Wiring Connections

One big issue which has really bothered me over the years, has been the method by which many people use to install and connect control wiring. Nothing is more frustrating than to have to trouble-shoot a system, only to find a poor wire connection due to laziness or what ever on the part of an installer. Figure 7.15 highlights some wiring connection issues.

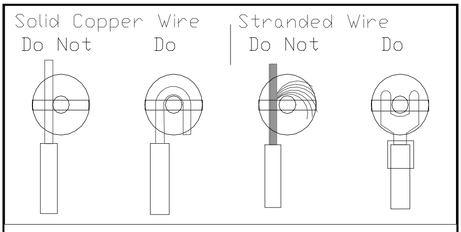


FIG 7.15 Proper Control Wiring Connections

Some other issues I have are; 1- wires nuts, when applied right, can be appropriate in a closed panel. But, exposed wiring, especially in equipment, should be connected by crimp on butt connectors and shrink wrapped when appropriate.

2- electrical tape is very handy and works great to add extra security over wire nut connections. But, when used by itself as the only securing means, I'd like to hang the jerk who does this. 3- use common sense. Choose proper wire types, proper sizes and when necessary, match a manufacturer's existing wiring for all repairs.

7.14.5 Staging Chillers & Multiple Zones

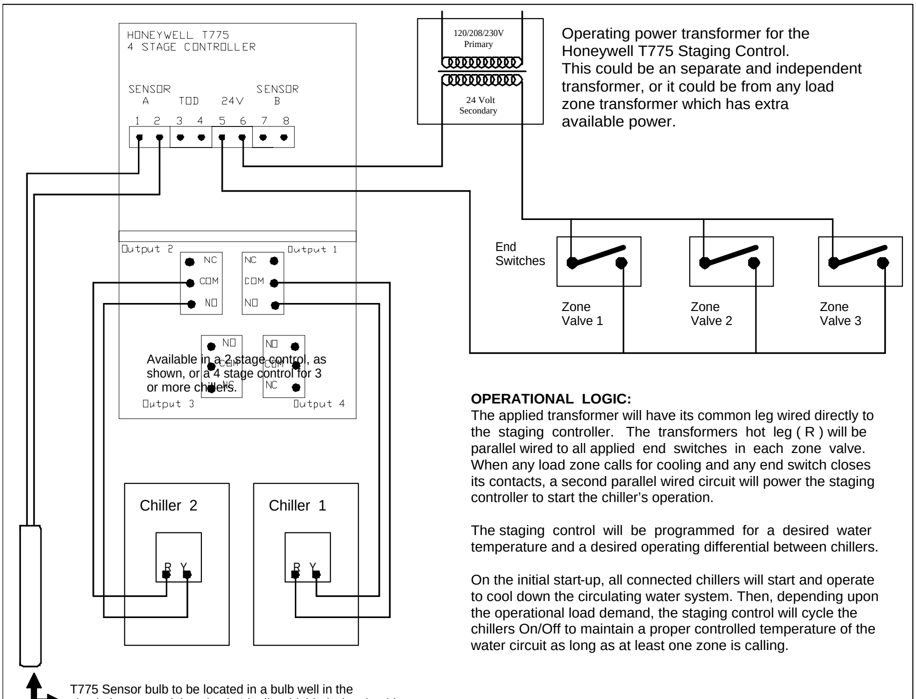


FIG 7.16 Staging Controls & Operational Logic

There are a few items to take note of regarding this Solid State Staging Controller[11];

1- It uses a remote bulb which must be installed in a bulb well (we know what that means).

2- Special shielded wire may be required for remote bulb connections (always consult manufacturer's literature). 3- It has many adaptive options which can be highly adaptable, even for heating systems too. 4- It has independent relay contacts which easily isolate a multi-transformer system. 5- It is available as a 2 stage or 4 stage device. 6- It can be operated by 110 volt and 220 volt power too.

11- This Solid State Staging Control is manufactured by the Honeywell Corporation. I have used many of their controls and have had great success in doing so. I would like to personally thank Honeywell International, Inc. for all their support.

Many, many pages could be written on controlling circuits, but that is another book all to itself. If and when the need occurs, and should you have any trouble in developing a good control system design, always consult a control specialist. When designing any control circuit for any system, always have every manufacturer's literature for every type of equipment which your system will be using (chiller, fan coils, 3-way valves, staging controls, etc.). The more information you have for everything, will only make your job easier and your control expert.

7.14.6 Controlling Water Pumps

There are numerous ways in which a water pump's operation may be controlled. Unfortunately, there is no typical method, save a manufacturer supplied pump right in the chiller. This too, is another reason for having a good control specialist to rely on. Water pumps will most likely be controlled through the normal 24 volt control system. As the number of items being controlled by a 24 volt circuit increases, so will the total amp draw of a given control circuit. Because you will be purchasing extra control transformers for added load zones, do not just settle for more 40 VA transformers. They are available in higher VA outputs. If you add up the amp draw of all devices for any given designed control circuit (you must consult a manufacturer's specifications per device), you can determine the VA requirement of a circuit (e.g. 65 VA) and you can now purchase an appropriate transformer (e.g. 100 VA). You may only need one larger transformer for one special circuit and all the others can be 40 VA (you should never use less than a 40 VA transformer per control circuit).

The important item to remember for all applied water pumps is, when should they be operating and when should they be off. Providing a control specialist with a good operating logic, will enable them to design a good and proper control system. Here are a few more items to consider; 1- An in-chiller pump will operate when the chiller's circuit tells it to. 2- If a booster pump has been added to an in-chiller pump, the chiller's circuit should tell the booster when to operate (e.g. use in-chiller pump's power circuit to energize booster). 3- A primary external pump can be controlled to operate all the time or it can be cycled On/Off through the designed system's main controlling device (be sure to consult a chiller manufacturer's literature regarding constant flow through their chillers). 4- If chiller's are to be secondary pumped, the chiller's circuit can control the secondary pump and the primary circuit is all to itself. 5- Any secondary applied pump must be controlled by the circuit it is feeding (load zone or chiller).

CAUTION: Many, many chillers have a post operational period (operational pump down and/or operational cool down) when the controlling R to Y circuit is opened. Most manufacturers mandate that water must be circulating through their chillers during this post operational period. This simply means one thing; ***Every water pump must have a time delayed shut off period when its controlling circuit opens, and this time delayed period must match or exceed the chiller's post operational period.*** Applications using in-chiller pumps will be covered by the manufacturer's designed chiller control package. All field applied pumps, must either interlock with a chiller's circuit, or a separate time delay relay must be added to a pump's control circuit. There is an appendix section at the end of this chapter. In this appendix, I will show some of the system design layouts which were shown in chapter 6, Designing and Engineering, and I will provide some controlling ideas for all applied water pumps.

7.15 Filling the System with Water & Antifreeze

With the system installed, piped, wired and controlled, it must now be made ready for the starting of the system. The first thing which must now be done, is the filling process of the water/antifreeze mixture.

> ***Special Note: During the wiring process of the system, many people like to operate electrical devices to ensure proper operation and proper rotation of these devices. NEVER, NEVER, OPERATE A WATER PUMP WITHOUT FLUID IN THE SYSTEM !***

Depending upon the chiller system type (Open or Closed, Gas or Electric), there may be some different requirements for the filling of the system. Always consult a manufacturer's literature. Also, before filling any system with a water/antifreeze mixture, you must be able to answer yes to these two questions; 1- Was the piping system leak checked good? 2- Was the piping system flushed and cleaned good ? If yes, proceed. If no, you know what to do.

In order to determine an appropriate amount of antifreeze for the system, you must; 1- Decide on an antifreeze percentage factor, and 2- You must calculate the total fluid volume for the entire system. These factors were outlined in chapter 6 - appendix. Most manufacturers mandate a minimum antifreeze percentage of 20% and many manufacturers also mandate purified water (distilled and/or de-ionized water). If you purchase your antifreeze as a pre-mixed percentage mixture, you will have both of these factors covered.

Most chiller systems today will be closed loop system. They will require some access point into the piping system for pumping the water/antifreeze mixture into the system. This was highlighted in Figure 7.8.


FIG 7.17 Filling Apparatus

Figure 7.17 shows a picture of a filling device which I have used for years to pump the fluid into a system. I just used a plastic holding tank and mounted it over a small pump. I can easily pour my mixture into the tank and I will connect a fill hose from the pump to a boiler drain in the piping system. With a main ball valve closed in the piping system, the fluid mixture I pump in can only flow in one direction into the system. I then open a second boiler drain on the other side of the ball valve to relieve air from the system. With a hose connected to this second drain, I hang it in my holding tank. At some point, fluid I am pumping in, will start coming out and I keep pumping until I have a steady stream.

The system now has enough water/antifreeze mixture to allow for normal water pump operation and for operating the system. Any air which may still be trapped in the system, will soon be removed by the air removing devices which are installed on the piping system. I will not remove the filling device yet, because when the chiller (s) are operated and as the water's temperature cools down, the pressure in the system will drop. It is very important to have a positive operating pressure (5 to 10 PSI) when the system is fully operational and the chilled water temperature is at least 50 degrees or lower. This is why a pressure gauge is needed at the suction side of the system's pump (or as close as possible).

As the system's water pump operates and as the air relief device (s) removes more air from the system, continue to add fluid maintaining a 10 psi system. When the chiller is ready to be operated, do so, and when the water's temperature reaches 50° F or lower, check the pressure gauge and add as needed. If you are still in doubt as to whether or not more air may still be removed, leave the filling device connected. There will surely be a little more work to do before you will leave and just before you leave for the day, you can make one more final system pressure check. If you really would like to save yourself some time and provide a little insurance factor for your customer, you could always install an auto-fill system.

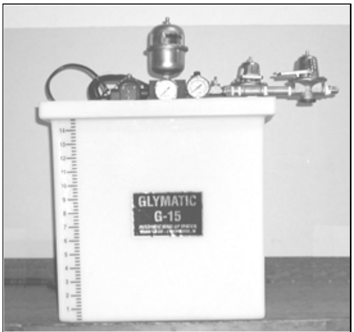


FIG 7.18 Auto-Fill System

There is finally, a small, in-expensive and really neat automatic filling system for water/antifreeze systems. It called the GLYMATIC® Glycol Make-Up Package and it is manufactured by the Wessels Company[12]. This neat little device can not only be a time saver for new installations, it's a great insurance package for systems which cannot have a city water make-up system. Once your main filling device has done the main filling (much faster than the auto-fill) the auto-fill system can easily handle all the rest.

7.16 Setting Water Flow Rates

Once the water system has been filled and the system's water pump (s) are able to operate, the flow rate settings may now be made. The method and or manner by which the flow rate (s) will be set, is totally dependent upon; 1- Whether it is an open or closed system. 2- The number of chillers being used. 3- The number of load zones for the designed system. 4- The flow control devices chosen for the system, and 5- If there are any special applied piping loops.

7.16.1 Open Loop Systems

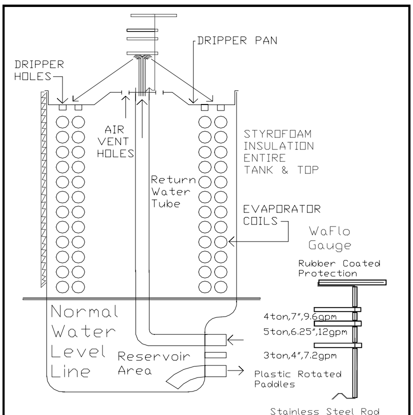


FIG 7.19 Open Chiller Flow Rates

Open loop chiller systems are a breed of their own and the manufacturer of these systems typically provides special requirements for flow rate settings. Figure 7.19 shows a cut-away drawing of a chiller assembly which has been around for over 30 years. A proper water flow rate is set by the height of a water column right inside the chiller (requires accessing the chiller's open tank assembly which is covered, but not pressurized). ***Be Sure*** to consult a manufacturer's literature if you come across an open loop system. This logic is for a single chiller, single coil application.

12- My sincere thanks to the Wessels Company. We have needed this system for a long time.

Very Important !
Most chiller manufacturers mandate a minimum acceptable flow rate through their chillers, when they are operating and cooling the water circuit. “And”, during the post operational pump down period (cool down period) should this exist. Chillers can typically operate with a “Larger” flow rate (25%), BUT, NEVER less than the mandated rate.

7.16.2 Closed Loop Systems

Closed loop systems must have their flow rates set by a pressure drop method. This can be accomplished by three basic methods; 1- A PD reading through a chiller. 2- A PD reading across a special flow control device. 3- A PD reading across a water pump.

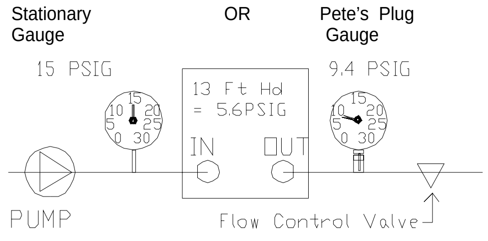


FIG 7.20 PD Reading Across a Chiller

Figure 7.20 highlights a PD reading being performed across a chiller. Using the manufacturer’s PD rating for the chiller (13 Ft Hd), it must be converted to a PSI value (13 ÷ 2.31 = 5.6). This means the difference between Pressure IN and P - OUT, must be 5.6 or more (higher flow rates = higher PD’s).

As shown, the P - In reads 15 psig. (15 - 5.6 = 9.4) The **.4** value will be hard to read on a typical pressure gauge. Therefore, the gauge needle **must** be closer to **9**, than it is to 10. 9 PSIG = a little higher PD (6.0) and it equals a little higher GPM. A 10 PSIG reading would = a 5 psig PD and a lower than mandated GPM. Last, the pressure in gauge reading is higher than the chiller’s PD rating, and this means the pump is providing sufficient Ft Hd for the system. If the P - IN reading was equal to or lower than the chiller’s PD rating, the pump is too small (either sized wrong, pipe sizing issues, or some other issue to be addressed).

This method only works for an external applied water pump. If you have a chiller with an in-chiller pump, you cannot take a PD reading across the chiller and the pump. You will have to use one of the other PD methods. The logic shown in figure 7.20 also works for fan coils (air handlers). Fan coil manufacturers do provide PD ratings for their water coils, based on a specific water flow rate through the coil. If P - In, minus P- Out, equals a manufacturer’s PD rating, the flow rate is correct.

Special Note: When the system is initially started, the initial pressure PD reading must be "Higher" than required. This means that there is a higher GPM flow rate than required (proper pump sizing) and that's why flow control valves are installed. To be closed down to set a correct and proper GPM flow rate.

FIG 7.21 Pete's Plug® & Adapter

Remember, you always have the option of installing physical stationary pressure gauges, or you can install Pete's Plugs® and then use a pressure gauge with an adapter for taking pressure readings. I prefer the Pete's Plugs® because my experience has shown that stationary gauges due not last a long time, and there is always a question of calibration between gauges. BUT, for every closed loop system, there should be at least one physical gauge installed at the lowest pressure zone to monitor system pressure.

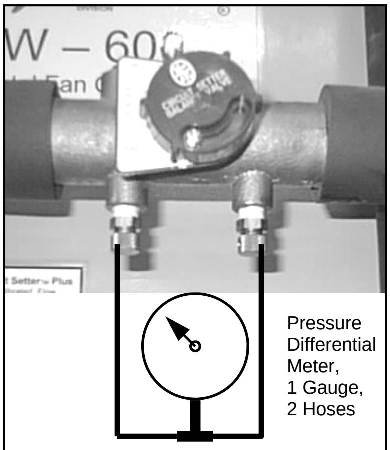


FIG 7.22 Special Flow Control Devices

Figure 7.22 highlights method two. Using a special flow control device which has pressure reading taps right on the device. While this method does require the purchasing of a pressure differential meter, it is by far the easiest and most universal method, and it can be used any where. This method is highly appropriate for multiple load zones, where every zone will require its own specific flow rate setting. Flow valve manufacturers provide and easy to use chart, for taking PD readings and for setting any specific flow rate.

NOTE: *Any given size flow control valve (e.g. 3/4", 1", 1 1/4", etc.) can only handle a specific range of flow (e.g. A 1 1/4" B&G Circuit Setter® = 13 GPM maximum in a fully open condition). GPM flow ratings for a given valve size can vary by manufacturer*[13] *. Be sure to consult all valve types and styles for proper usage and application.*

13- Many thanks goes out to Bell & Gossett and ITT Fluid Technology Corporation.

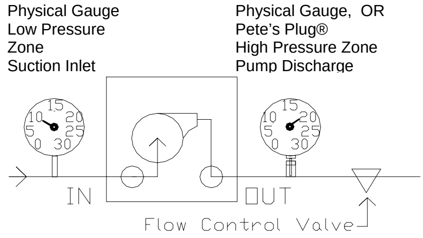


FIG 7.23 PD Across Operating

Figure 7.23 highlights a PD reading being made across an operational water pump (some pumps have pressure taps right on the pump). If, pressure taps do exist, they are typically plugged off. Remove plugs and add gauges and piping. The other option of course is, to have pressure gauges right in the piping system (the closer to the pump, the better and more accurate the reading will be).

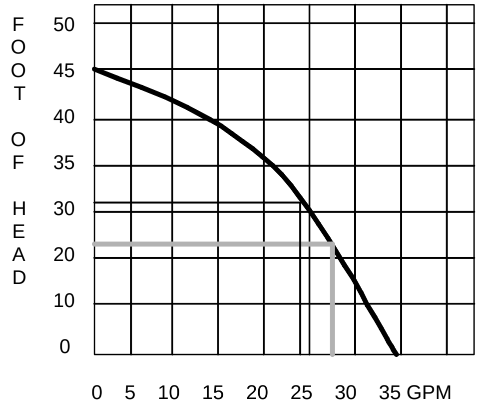


FIG 7.24 Typical Manufacturer Pump Curve

To perform this PD test and to set a proper flow rate, requires one to have a manufacturer's pump curve for the specific pump being used (manufacturers normally have a pump curve for every designed pump). Pressure IN = system static fill pressure being controlled by the filling process or an auto-fill system (e.g. 10 to 12 psig). Pressure OUT = the pump's capability + static. Pressure OUT minus Pressure IN = Pump's operational capacity.

Referring to figure 7.23, the differential between Pressure IN (10 psig suction inlet) and Pressure OUT (20 psig discharge outlet) is 10 psig (20 - 10 = 10). We must now convert this PSI reading into a Ft Hd value (1psi = 2.31 Ft Hd) (10 times 2.31 = 23.1 Ft Hd). Now, referring to figure 7.24, the manufacturer's pump curve, find the 23 Ft Hd on the left side of the chart. Draw a straight line (gray line) across to the manufacturer's operating curve (heavy dark line). Now, draw another line straight down to the GPM entry line. This pump is moving approximately 27 GPM. If your designed system has a GPM requirement of 27 GPM or less, this pump is fine. If your GPM flow rate is less, just close down the flow control until your pressure reading calculations match the GPM entry on the manufacturer's pumping curve for your designed GPM requirements (e.g. you want 24 GPM. This means the pressure reading calculations should provide an approximate 31 Ft Hd value).

7.16.3 Multiple Chiller / Load Zone Flow Settings

Any installed and applied system could have multiple chillers, multiple load zones and a combination of both. Every individual chiller and load zone must have a correct flow rate through it and it must be set properly at the time of starting the equipment. This means that the system's total flow rate will now be set at the chillers and/or load zones. The three basic potentials for this are; 1- Multiple chillers and one load zone. This will require flow control valves at the chillers and when each chiller's flow rate is set properly, the total system's flow rate is set. 2- Multiple load zones and one chiller. This will require a flow control valve at each load zone and when each load zone's flow rate is set properly, the total system's flow rate is set. 3- Multiple chillers and multiple load zones. This will require a flow control valve for all applied chillers and all applied load zones. Each item must have its particular flow rate requirement set properly for proper operation of each one. The above logic assumes that the total flow rate requirements of the chillers and the load zones are identical. Other flow controlling options were discussed in the design and engineering chapter.

7.16.4 Multiple Water Pumps & Special Needs

If any system is being applied by Primary/Secondary Pumping (multiple pumps), each pumping circuit will require its own flow control device. This is also mandatory for special pumping needs which are typically handled by secondary pumping (low to no flow circuits and/or special cooling loops which only operate when needed). No matter how many circuits require controlling of a given flow rate, one of the three flow controlling methods discussed in 7.16.2 will definitely work.

7.17 Low Ambient Operation

Many installed and applied chilled water cooling systems have the potential for operating in cold weather. Most manufacturers will note an acceptable outdoor temperature which their chillers can operate at (maximum and minimum). Many chillers can operate at lower ambient conditions, but only with some special items added (low ambient kits). Always consult a chiller manufacturer for this need, if you know that there is a potential for any chiller system to require low ambient operation. Many manufacturers will even set up the equipment for low ambient operation prior to shipment of the equipment. This is the easiest and best option. Order the equipment already pre-controlled for low ambient.

7.18 Basic Operational Start-Up Adjustments

Many manufacturers provide a list of basic adjustments and operational checks which need to be made at the time of start-up. This is not only for the chiller (s), it is also for the fan coils (air handlers). Because products can vary by manufacturer and style, it is always best to consult a manufacturer's literature for the specific adjustments for a given product (that is, if you can still find the manufacturer's literature). Here is a general list of some of these items which you may see for a given product type.

7.18.1 Electric Chillers

1- Check for a correct and accurate water flow rate through the chiller.
2- Check the operating amps for all high voltage operating devices.
3- Check all controls for operation and calibration.
4- Check condenser fan (s) operation and rotation.
5- Check system for any potential fluid leaks.
6- Check the refrigerant system for any potential leaks.
7- Check the refrigerant system for proper operating pressures.
8- Check all connected external controlling devices for proper operation.
9-Check the water circuit for a proper operating temperature.

7.18.2 Gas-Fired Chillers

1- Check for a correct and accurate water flow rate through the chiller.
2- Check the chiller to make sure it is setting perfectly level.
3- Check total chiller operating amps.
4- Check all controls for operation and calibration.
5- Check hydraulic pump for oil level and operational belt tension and condition.
6- Check gas input per manufacturer's operational chart.
7- Check condenser fan height, rotation and operation.
8- Check entire chiller for any potential fluid leaks.
9- Check water level in open fluid tank models.
10- Check operational temperature of the chilled water circuit.

7.18.3 Fan Coils & Air Handlers

1- Check blower motor operation and rotation.
2- Check blower speed and belt tension (when applicable).
3- Check 3-way valve operation and end switch (if applicable).
4- Check for a proper delivered air temperature (see note below).
5- Check for a proper water flow rate through the coil.
6- Check all supply and return air grilles, especially for any potential blockage of air flow.
7- Check for any potential fluid leaks at fan coil (s).
8- Check condensate drains for proper operation.

Special Note; Delivered Air Temperature

All chilled water cooling systems operate on a 10 degree temperature differential (Delta T or Δ **T**). A chiller, having a proper GPM flow rate and load, will cool the water down 10° F and when the water flows through the fan coil its temperature will rise 10° F. Proper air flow through any fan coil (air handler) may be checked by making a temperature test of the flowing air stream (return air into the fan coil verses supply air out of the fan coil). Two system operating factors are required for this test; 1- having a proper GPM flow rate through a fan coil, and 2- having a supply water temperature of at least 50° F or lower. As the air moves through a fan coil and across the chilled water coil, the air temperature should see a 15 to 20 degree temperature drop. If the temperature difference (Δ**T**) is less than 15° F, air is moving to fast across the coil and it cannot be cooled down properly. The blower motor's speed must be decreased. IF the Δ**T** is more than 20° F, air is moving to slow across the coil and it is being cooled down too much. The blower motor's speed must be increased.

7.19 Wrapping Thing Up

There are many other variables which can enter into the start-up and operation of any given system, but they will vary by system design and a chosen manufacturer's product. For this reason and purpose, there is ***ABSOLUTELY NO SUBSTITUTE*** for not having appropriate manufacturer literature. While there still may be many similarities between products, there is most likely, ***JUST AS MANY DIFFERENCES.***

Please, Please, do not make the fatal mistake which way too many people do, please read manufacturer's literature.

Goto Chapter 7 Appendix