Modular Chiller Systems

APPLICATION GUIDE
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![ClimaCool Modular Chiller System with five UCW modules](image-url)
THE USE OF MODULAR CHILLER PRODUCTS HAS DISTINCT ADVANTAGES OVER A TYPICAL CHILLER/BOILER SYSTEM SUCH AS SPACE SAVINGS, BUILT IN REDUNDANCY, AND BETTER FLEXIBILITY TO LOAD MATCH.

Multiple independent modules and refrigeration circuits lessen the amount of down time during routine servicing and repairs. The modular chiller system can be designed with as many incremental steps in capacity as required. The system also has potential for expansion to match nearly any project requirement. It is important for the designer to understand not only the maximum BTUh requirement of the load, but also the minimum step of capacity during light loads to properly select the right tonnage of modules.

ClimaCool Modular Chiller System installed with three Air Source Simultaneous Heating & Cooling Heat Pump 20 ton modules
References/Nomenclature Conventions in this Manual

This manual describes the operation and provides illustrations of various system applications of ClimaCool modular chillers, both water source and air source. Model nomenclature used in this manual refers to ClimaCool Modular Chiller models. For simplicity and clarity, single line (intending to indicate both supply and return) water piping drawings are used to illustrate load (chilled or hot water) and condenser (source water).

Terms and Definitions

**Bank Controller** – The ClimaCool CoolLogic Bank Controller which controls the staging of the chiller modules and provides all operational data from the modules to a central location.

**BPHX** – Brazed Plate Heat Exchanger.

**Chiller Bank** – The entire chiller including all individual chiller modules.

**Chiller Module** – An individual chiller within the Bank.

**DP** – Delta Pressure or pressure difference.

**DPT** – Water Differential Pressure Transducer that monitors the water flow through each of the chiller headers. Its purpose is to provide a loss of flow shutdown of the chiller when the differential pressure across its headers falls below the trip point.

**DT** – Delta Temperature or temperature difference.

**Headers or Pipe** – The 6-inch or 8-inch steel headers that run through the chiller bank from one end to the other and are field connected between modules with grooved couplings.

**Load HX** – This terminology is used for Heat Pump modules instead of using of the term Evaporator for non-heat pump modules. In a heat pump module, the evaporator acts as the chilled water load or hot water load depending on the position of the unit’s reversing valve.

**Loads** – The devices being served with chilled or hot water system for heating or cooling the building zones.

**Refrigeration Circuit** – Each individual chiller module contains two independent refrigeration circuits. These two refrigeration circuits share the same water circuits within a module.

**Source HX** – The terminology used for Heat Pump modules instead of the use of the term Condenser for non-heat pump modules. In a heat pump module, the evaporating and condensing of refrigerant inside a heat exchanger changes with the usage of the heat exchanger depending on the mode the module is operating in. This is the heat exchanger within a chiller module that is used to reject heat to (Cooling mode), or absorb heat from (Heating mode) an external device such as a cooling tower, geothermal well field, dry cooler, etc.

**System** – The entire chilled and condenser water system outside of the chiller itself. This includes all external piping, pumps, tanks, building loads such as air handlers, fan coils, chilled beams, etc.
The UCW cooling only (4-pipe module) rejects heat to a geothermal well field or cooling tower (see Figure 1). The UCW model is typically applied as a retrofit to hard-to-install centrifugal chillers, or trim or pony chillers.

**Figure 1 UCW, Cooling Only**

* Simplified single line water circuit shown; V = motorized isolation and control valve

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The UCH heat recovery (4-pipe module), Figure 2, has three modes of operation: cooling, heating and heat recovery. The modes are NOT independent by module. The entire bank will operate in one of the three modes. In cooling mode, the cooling supply water setpoint is used to determine the stages of compressors required. In heating mode, the heating supply water setpoint is used to determine the stages of compressors required. In heat recovery mode, the cooling water and heating supply water setpoints are both used to determine the stages of compressors required. The first setpoint met will stage the system down or off as needed, sacrificing the opposite mode’s setpoint. The UCH HR model is typically used for building efficiency upgrades dedicated to the constant base cooling & heating loads.

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HEAT RECOVERY (4-PIPE) CONT’D.

The UCH heat pump (4-pipe module) operates in either cooling or heating (see Figure 3). The modes are NOT independent by module. All modules in a bank will operate in the same mode. The refrigerant reversing valve is used to index the module into cooling mode or heating mode. The load heat exchanger will provide chilled water to the load loop in cooling mode or hot water to the load loop in heating mode. The source heat exchanger will reject heat to the source in the cooling mode and absorb heat from the source in the heating mode.

HEAT PUMP (4-PIPE)

The UCH heat pump (4-pipe module) operates in either cooling or heating (see Figure 3). The modes are NOT independent by module. All modules in a bank will operate in the same mode. The refrigerant reversing valve is used to index the module into cooling mode or heating mode. The load heat exchanger will provide chilled water to the load loop in cooling mode or hot water to the load loop in heating mode. The source heat exchanger will reject heat to the source in the cooling mode and absorb heat from the source in the heating mode.
The UCH simultaneous heating and cooling, (SHC), heat pump (6-pipe module), has internal valves, see Figure 4. Each module has two modes of operation: heating or cooling. This is accomplished by using reversing valves to reverse the flow within the module refrigeration circuits. Both refrigerant circuits within each module must operate in the same mode, heating or cooling, since the heat exchangers both share a common water circuit. Each module may operate in either mode, heating or cooling, regardless of the position in the bank; provided header bypass kits are installed at the 3 chiller headers. In cooling mode, the chilled water is routed to the chilled water header cooling loop and the condenser water is routed to the source water header loop. In heating mode, the chilled water is rejected to the source water header loop and the condenser water is rejected to the hot water header loop. An added benefit is the heat that is rejected to the source water loop from modules operating in cooling mode can be reclaimed by modules operating in heating mode, taking advantage of the refrigeration process.

Figure 4 UCH SHC, Heat Pump

The SHC Heat Pump chiller is a six-header, five-valve unit that has two modes of operation: Cooling Only and Heating Only.

- The Cool Loop connects to the Load HX with one proportional valve and one ON/OFF valve.
- The Heat Loop connects to the Load HX with one proportional valve and one ON/OFF valve.
- The Source Loop connects to the Source HX with one proportional valve and one manual ball valve.
- The Source Loop proportional valve will modulate for refrigerant discharge pressure control in the Cooling mode and for suction pressure load limiting in Heating mode.

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SHC HEAT PUMP (6-PIPE) CONT’D.

Any module in a chiller bank will be automatically indexed into either of the available modes on a first come-first served basis based on the Heat and Cool PID count, which is derived from the building cooling and heating demand. Any module can also be manually fixed into either mode.

Figures 5 and 6 identify the modes of operation as they pertain to the water loop that the Load Heat Exchanger serves. The Load Heat Exchanger of each individual module in the bank can serve only one of the two load loops at a time. Having multiple modules in a chiller bank allows the two simultaneous modes of operation, Heat mode and Cool mode.

Since the Load Heat Exchanger can serve two water loops (Cooling and Heating); there will be mixing of water from one loop to the next loop over time. It is important when designing the piping system to confirm that the two loops will have the same fluid type, i.e. glycol type and percentage, and very similar fluid pressure at the chiller location within the piping system.

This mixing of loops does not take place while a module is in operation. The chiller module will first shut down the compressors, close the currently used valve pair, then open the new valve pair. The fluid (and pressure) inside the HX that is trapped by the closed valve pair will be transferred to the new water loop the HX will be serving.

It is also important to note that the fluid pump location must be defined as a Push Through or Draw Through application at the chiller. This helps to keep all the loops at similar pressures at the chiller location. ClimaCool recommends Push Through for the loop pumps. Failure to design the system in this manner will result in over-pressurization of the lowest pressure loop and a loss of pressure in the highest pressure loop.

Figure 5 Cooling Mode, SHC Simultaneous Heating and Cooling Heat Pump

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The UCH simultaneous heating and cooling, (SHC), heat recovery, (6-pipe module) (see Figure 7) operates as a bank of modules with three modes available: heating only, cooling only and heat recovery. These modes are accomplished by the using motorized valves between the heat exchangers and the appropriate headers.

In the heating only operation, the water that circulates through the condenser heat exchanger is routed to the heating water loop. At the same time, the chilled water from the evaporator heat exchanger is routed to the source loop and is used for no purpose other than to absorb heat for the refrigeration process.

In the cooling only operation, the water that circulates through the condenser heat exchanger is routed to the pair of headers labeled “Source.” This source loop water is sent to a geothermal well field or a cooling tower for the heat to be rejected and not utilized in any process. The chilled water from the evaporator heat exchanger will be directed to the cold header loop to be used for chilled water supply to the building.

In the heat recovery operation, the water that circulates through the condenser heat exchanger is routed to the pair of headers labeled “Heat.” This water is sent to the heating water loop of the building to be utilized for heating purposes instead of simply rejected and unused. Additionally, in the heat recovery mode, the chilled water from the evaporator heat exchanger will be directed to the cold header loop to be used for chilled water supply to the building. Just like the standard heat recovery module, the first setpoint met will stage the system down or off, regardless of the opposite mode’s set point.

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Each module in a chiller bank can be automatically or manually indexed into any of the available modes based on the model number.

Figures 8, 9 and 10 identify the modes of operation as it pertains to the water loop that each heat exchanger serves. Each heat exchanger can serve up to two separate loops to provide the various modes of operation.

Because there are two heat exchangers and three water loops, each heat exchanger can serve up to two water loops. This means there will be mixing of water from one loop to the next over time. This is important to note when designing the piping system to confirm that all three loops will have the same fluid type, i.e. glycol type and percentage; and very similar fluid pressure at the chiller location within the piping system.

This mixing of loops does not take place while a module is in operation. The chiller module will first shut down the compressors, close the currently used valve pair, then open the new valve pair. The fluid (and pressure) inside the heat exchanger that is trapped by the closed valve pair will be transferred to the new water loop the heat exchanger will be serving.

This is also important to note when selecting the fluid pump location as being a Push Through or Draw Through application at the chiller in an effort to keep all the loops at similar pressures at the chiller location. **ClimaCool recommends Push Through for all three loop pumps. Failure to design the system in this manner will result of over pressurization of the lowest pressure loop and a loss of pressure in the highest pressure loop.**

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Water Source Products Cont’d.

**SHC HEAT RECOVERY (6-PIPE) CONT’D.**

**Figure 8 Heat Recovery Mode, SHC Heat Recovery 6-Header Chiller Module**

**Figure 9 Cooling Mode, SHC Heat Recovery 6-Header Chiller Module**

**Figure 10 Heating Mode, SHC Heat Recovery 6-Header Chiller Module**
Air Source Products

COOLING ONLY (2-PIPE)

The UCA cooling only modules rejects heat to the air cooled condenser. The ambient air serves as the source for all UCA modules. (see Figure 11).

**Figure 11 UCA, Cooling Only**

![Diagram of UCA Cooling Only](image)

* Simplified single line water circuit shown; V = motorized isolation and control valve

HEAT PUMP (2-PIPE)

The UCA heat pump uses the load heat exchanger to produce chilled water in cooling mode and hot water in heating mode (see Figure 12). The whole bank is in heating mode OR the whole bank is in cooling mode.

**Figure 12 UCA, Heat Pump**

![Diagram of UCA Heat Pump](image)

* Simplified single line water circuit shown; V = motorized isolation and control valve
Air Source Products

SHC HEAT PUMP (4-PIPE)

The UCA simultaneous heating and cooling, (SHC) heat pump modules utilize four pipes, two for hot water and two for chilled water (see Figure 13). Any module can operate in either mode, heating or cooling, regardless of the position within the bank.

Figure 13 UCA SHC, Heat Pump, 4 pipe

Figure shows a bank of three modules:
Module 1 in Cooling
Module 2 in Standby
Module 3 in Heating

Load Cooling
Load Heating

* Simplified single line water circuit shown; V = motorized isolation and control valve

Figure 14 Cooling Mode, SHC Heat Pump 4-Header Chiller Module
MODULAR CHILLER SIZING
When selecting module chiller sizes, incremental capacity steps should be considered to match with building load profile.

Example: If the total load is equal to 210 tons the module sizes can be selected in one of the following ways:
1. Three 70-ton modules for a total of 6 capacity steps.
2. Seven 30-ton modules for a total of 14 capacity steps.

If space is an issue where seven 30-ton modules take up too much space, another consideration would be to utilize the three 70-ton modules and outfit a lead module with variable frequency drives (VFD) on the two compressors. This module can be set up as a Trim Chiller that will be first on, last off. Larger tonnage modules (50, 70 and 85-tons) are best applied with VFDs when smaller capacity steps are required. The minimum speed for compressor with VFD is 45 Hz (or 75% capacity).

Smaller tonnage modules (15 and 30-tons) that require additional capacity turn down can be applied with digital scroll compressors. The digital scroll compressor can provide a turn-down to about 30% capacity. Again, a lead module can be selected to apply the two digital compressors on as a Trim Chiller that will be first on, last off.

For the purpose of attaining incremental capacity steps between compressors using VFD or digital compressors, it is not necessary to outfit all modules with VFD-driven compressors unless equalized runtime is a concern. Contact ClimaCool Engineering for recommendations on the best application of variable capacity compressor for a specific project.

ClimaCool system with separated air cooled modules operating as one bank.
WATER SYSTEM DESIGN
All ClimaCool modular chillers will have two independent R-410A refrigeration circuits in each individual module. Both of these refrigeration circuits will be served by common water flow. In a typical water cooled application with nominal water flows of 2.4 gpm/ton through the evaporator BPHX and 3.0 gpm/ton through the condenser BPHX, the delta temperature entering and leaving both BPHX's will be 10°F with both compressors running, and 5°F with one compressor running. The operation limitations found in the respective product’s Installation, Operation & Maintenance manual (IOM) will list the minimum and maximum delta temperatures along with the minimum and maximum flow rates, of which, will correspond to approximately a minimum ΔT of 5°F and a maximum ΔT of 20°F for the evaporator and a minimum ΔT of 5°F and a maximum ΔT of 24°F for the condenser.

In addition to water flow rate in gallon per minute as detailed above, there is also a minimum requirement of total number of system gallons in each water loop for adequate thermal mass to prevent short cycling. This requirement is six gallons of fluid per ton of refrigeration. For example, a bank of three 50-ton modules will require a minimum loop volume in each water loop of 3 x 50 x 6 = 900 gallons of total system fluid.

Modular chillers use brazed plate heat exchangers. To ensure their longevity, 60-mesh minimum first pass water strainers must be installed and maintained on each water loop.

Water treatment should be appropriate for brazed plate heat exchangers. Please see equipment IOM for water parameter details.

Each module bank is provided with a proof-of-flow safety sensor to avoid heat exchanger freezing. This differential pressure sensor is field installed between the supply and return water pipe. This sensor is not to be used for pump control. The Building automation systems should use its own means of measuring flow to control system pumping.

SIMULTANEOUS HEATING AND COOLING BANK AND PUMP LAYOUT
A “push-through” water pump arrangement is recommended. Pump arrangement must be the same for all water loops. Both the cooling and heating water loops should have the same relative loop pressures during mode change as they share a common heat exchanger. Equalization circuits between heating and cooling loops may be needed.

Figure 15 Cooling Mode, SHC Simultaneous Heating and Cooling Heat Pump
Modular System Design Cont’d.

**CHILLER HEADER BYPASS VALVES**

The Header Bypass Valves are 2-position and are only open when all module’s water valves are closed to that respective loop.

Their two purposes are to prevent pump “dead-heading” when module water valves are closed and to provide a single module’s worth of water flow across the water temperature sensors for load monitoring.

The operation of each header bypass pertains only to the loop on which it is installed. Taken on a loop by loop basis, the Bank Controller monitors all the motorized valve end switches within each of the modules that connect to that loop for that mode of operation. **Example: The Load Cooling Loop has motorized valves connected to the load heat exchangers.** When no module has motorized valves open to the Load Cooling Loop, all those motorized end switches will be electrically ‘open’, showing a closed status in the BACview® interface. The Bank Controller recognizes this and signals the header bypass valve to open. Once the first module is indexed to cooling mode and both motorized valves mechanically open (end switches electrically ‘close’); the header bypass valve is signaled to mechanically close.

Modules can also be assigned fixed bypass for heating, cooling and source flow, however, this limits the number of modules remaining for that duty. For example, with an SHC OnDemand® heat pump system with four modules, if one module is designated for heating bypass and one module for cooling bypass, the system now only allows a maximum of three modules for heating or three modules for cooling.

**Figure 16 Bank Field Piping and Wiring Considerations**

**Notes:**
1. Locate DP sensor between the strainer and the entering side of the chiller as well as before the first water take off on the leaving side of the chiller.
2. Breaker panel represents field power supply and is to be installed by others. Power disconnects/fusing not included as part of ClimaCool modular chiller system.
3. All water piping and power and control wiring by others.
4. Field communication connections are simplified requiring only a two-conductor shielded cable daisy chain from the bank controller to the modules.
5. Water Pumps, isolation/shut-off valves, gauges and pressure taps, and any field piping insulation by others.
6. Temperature and pressure sensors to be installed at least 2 elbow lengths away from any turns to avoid turbulent flow.
7. DP sensors provided by BAS for control of VFDs on pumps shall be installed at same location as CCC DP sensors to avoid “Loss of Flow” alarms and provide adequate pump control for flow.
MODULAR SYSTEM DESIGN CONT’D.

BANK PIPING AND Wiring OVERVIEW
ClimaCool Supplied, Shipped Loose, and Field Installed by Others:

- CoolLogic Bank Control Panel (1 per bank)
- Phase Loss Monitor (PLM) on main incoming power, wired to CoolLogic Panel. (1 per bank)
- Pressure Differential (DP) Flow Proving Sensors, wired to CoolLogic Panel (1 per water loop). (Not for pump control.)
- Temperature Sensors, wired to CoolLogic Panel (1 set per water loop)
- Bank Header Bypass Valve Kit, wired to CoolLogic Panel (1 per water loop)
- 60 Mesh Strainer. (1 per water loop minimum)
- End Header Caps & Grooved Coupling (1 set per water loop)

ClimaCool four-module bank with a CoolLogic Bank controller
FREEZE PROTECTION – BANK LEVEL
The CoolLogic Bank Controller has temperature sensor inputs in each entering and leaving loop connected to the bank of modules. They are also used for high or low entering and leaving temperature safeties. The CoolLogic Controller also has differential pressure transducer (DPT) inputs for each water loop. The sole purpose of the DPT is for low water flow protection for each loop, and can also be used by the technician or operator to monitor the chiller header differential pressures viewable at the BACview interface.

FREEZE PROTECTION – MODULE LEVEL
Each chiller module has independent freeze protection in the form of a leaving water temperature sensor at the heat exchanger, refrigerant low-side pressure transducer and refrigerant suction temperature. Each of these trips points are defaulted at values for use with straight water. The default leaving water temperature trip point at the module heat exchanger is 40°F and for UCA Air Source units; below 36°F ambient.

GLYCOL USAGE
If glycol is used in a specific loop and these settings require adjustment, care must be taken to first confirm the type and percentage of glycol used in the loop. The ClimaCool Installation, Operation & Maintenance Manual (IO&M), containing the freeze chart for propylene and ethylene glycol, can be reviewed to determine the actual freeze point with the confirmed concentration. The IO&M manuals are available on the Literature page of www.climacoolcorp.com.

ClimaCool recommends the module freeze temperature setting be adjusted no less than 8°F above the actual freeze point of the solution. The coincidental refrigerant low pressure and temperature trip points will also require adjustment in accordance with this value using a 5°F to 6°F approach temperature. For example, 30% propylene glycol has been confirmed to be present in a chilled water loop. The freeze point of this solution is 9°F. So the module leaving water freeze point should be set to 17°F, (9°F + 8°F = 17°F). Using the approach of 5°F the refrigerant temperature at this leaving water temperature is 12°F. Using a pressure temperature chart, the coincidental refrigerant pressure is approximately 65 psig. The low suction temperature trip point should also be adjusted to the minimum superheat above the adjusted saturated suction temperature. In the example above, the saturated temperature was 12°F + 6°F minimum superheat is an 18°F low suction temperature trip point. These numerous safeties provide added layers of protection from freeze failures. Even with layers of protective alarms, repeated resetting of alarms without correcting the root cause can eventually result in equipment failure.

AIR SOURCE INSTALLATION CONSIDERATIONS
Air source chillers require adequate air flow and air flow clearances to operate properly. Minimum air flow clearances should always be met and never shared between multiple banks. To minimize air recirculation, multiple banks should be staggered in lieu of a parallel configuration with the middle banks spread further than the minimum 84” required. If banks need to be installed near solid walls a 6’ minimum clearance should be met and the wall should not be taller than the top of the units. ClimaCool Air Source models are designed to be installed outdoors without any ductwork.

AIR SOURCE DEFROST CONSIDERATIONS
Outdoor packaged heat pump chillers will experience frost build-up on the coils at some point in most regions; requiring a defrost mode. When in defrost mode the unit is producing chilled water in lieu of the required load hot water. Therefore a de-rate in heating performance is experienced by the equipment. For a single unit; this de-rate is about 26%. This de-rate can be minimized or eliminated by adding redundant units to the bank. The quantity of redundant units is based on the building heating load and specific weather conditions.

COOLLOGIC BANK CONTROLLER
The CoolLogic Controller includes an enclosure, control transformer, surge protection, convenience outlet, three position selector switch, power and fault indication, microprocessor controller, and BACnet BAS interface. It is provided with all multiple unit banks to stage on or off units and compressors to match the required load in the building. It is shipped loose as a separate panel and field installed and wired to each unit in the bank.
MODULAR SYSTEM DESIGN CONT’D.

MODULE AND COMPRESSOR ROTATION
ClimaCool employs two methods of rotation operation: rotation of lead module and rotation of the lead compressor within a module. Rotation of the lead module method is done on a weekly basis. Each module’s lead compressor run hours is polled on a weekly basis to determine which compressor has the lowest run hours. That module is selected to operate first in line followed by the next module with the second lowest lead compressors run hours. The lead-lag rotation of the lead compressor within a module is done on a monthly basis. At the end of a run cycle at this interval, the next run cycle will start the opposite compressor first and will repeat for each additional module in the bank. As the module stages up, it will follow the method of starting the lead compressor in a module with the lowest run hours. As the module stages down, it will stage off the lead compressor with the highest run hours first, the second highest run hours next, and so on. The purpose is for compressor runtime equalization.

REMOTE SETPOINT ADJUST
The chiller bank systems can be configured to accept a hardwired 2-10 vdc or 4-20 mA signal that can proportionally change the water temperature setpoints based on any criteria determined by others providing the signal. When there are also associated building automation system (BAS) points, the voltage or current valves can be written to those points to accomplish the same result. The remote temperature reset menu must be configured using the CoolLogic BACview device before it will be available. Configure the option from “NONE” to “REMOTE (COOL OR HEAT) TARGET,” set the minimum and maximum temperature range and configure the signal type to be used.

DEMAND LIMIT
The chiller banks can be configured to accept a hardwired 2-10 vdc or 4-20 mA signal that can proportionally change the number of compressors available to operate to reduce energy consumption. There are also associated BAS points these voltage or current values can be written to for accomplishing the same result. The Demand Limit menu must be configured using the CoolLogic BACview device before it will be available. Configure the option from “NONE” to “DEMAND LIMIT MAX # OF COMPRESSORS.” Also, toggle “MANUAL SELECT (COOL OR HEAT) MODE DEMAND LIMITING” to “ON” and the “VOLTS IN” signal can be proportionally changed to set the number of available compressors. VDC of 2=NO Demand Limit; 10=Full Demand Limit.

% HEAT/COOL MODULES LIMITING CONTROL SCHEME, SIMULTANEOUS HEATING AND COOLING ONLY
This configuration provides a method of limiting the number of modules that are available for a given mode. The “SELECT % HEAT COOL MODS” menu must be configured using the CoolLogic BACview device before it will be available. Once configured ON, a fraction of heat mods and fraction of cool mods can be configured. “FRACTION OF COOL MODS + FRACTION HEAT MODS” must be less than or equal to 1.0. For example, if Heat is selected at 0.5 and Cool is selected at 0.5, then only one half of the modules in the bank are available for each mode.

TRIM CHILLER
Another advantage of the “cooling only” non-SHC modular chiller is to mix and match the tonnage sizes and apply a concept called Trim Chilling or Trim Heating. A module of a smaller size than the others in a bank can be designated as a Trim Module so that it is always the first on, last off. During light loads, this is an advantage to use a smaller tonnage compressor circuit which will promote longer run times and minimize short cycling. This concept should also be applied for modules with digital or VFD controlled compressors. All SHC banks require a minimum of 3 equally sized units for maximum flexibility.

FAIL TO RUN CONTROL (FtR)
Fail to Run allows the chiller to operate in the event that the Bank Controller has lost communication. FtR provides the ability to switch the chiller into manual mode, automatically keeping the chiller online until a replacement Bank Controller can be provided. FtR requires a power phase monitor and proof of flow per module.

CONSTANT FLOW CONSIDERATIONS
Constant flow banks are limited to a maximum of 3 units and a minimum of 42°F leaving chilled water without glycol.
VARIABLE FLOW LOAD SIDE BYPASS
A System Side (load side) Bypass Valve is required for the chilled, heat, and source loops with variable pumping and all load side 2-way valves. These bypasses are best sized to accommodate the minimum chiller flow at maximum chiller load of the entire chiller bank. There can be short durations when the building load diminishes quickly, closing 2-way valves, causing the variable speed pump to ramp down before the chiller senses the load change and has an opportunity to stage down. Without a system side bypass to monitor the chiller header DP and modulate open as the chiller header DP begins to fall below the submitted value, nuisance loss of flow and low temperature/pressure alarms can occur.

It is important to install 3-way valves or bypass valves at the load side of the system to keep flow above the minimum rate when these loads satisfy. Use of bypass valves at the far end of the system will also promote keeping the overall active loop volume high. The load side bypass valves are generally open when the load control valve is closed and could also operate in reverse proportion to the control valve. This is critical for maintaining proper flow at the load side of the system (See Figure 18).

Figure 17 Typical Load Bypass Valve Arrangement

![Typical Load Bypass Valve Arrangement Diagram]

STAGED VARIABLE PRIMARY PUMP SYSTEMS (PUMP CONTROL)
When using motorized valves on the chiller modules, the chiller bank requires a staged flow control scheme as the flow requirement changes based on the number of modules in operation. This can be accomplished by utilizing variable frequency drives to control pump speed and maintain the target differential pressure across the headers connected to the chiller bank. This target delta P will be the same regardless of the number of modules in operation. If the pump speed is controlled to a delta P at the load side of the system, as the load side valves begin to satisfy and modulate closed, the pumps respond by delivering a lesser flow to the chiller bank. When the chiller bank senses this drop in flow, the modules may have not yet staged down and could still be open in a temperature pull down situation. Loss of flow alarms, low or high water temp alarms and even low or high refrigerant pressure alarms can result.

When the system pump is controlled by the load side flow requirement, this single bypass valve can be controlled to maintain the proper differential pressure across the chiller bank. This will help ensure adequate flow at the chiller headers even as the loads stage down (internal chiller control valves close).

As the building system DP falls, the pump speed increases supplying more fluid flow to the building. As the building system DP rises, the pump speed decreases providing less fluid flow to the building. Meanwhile, the building system bypass valve toward the end of the loop monitors field supplied and installed DP sensors at the chiller. As the chiller DP falls (due to load side valves closing and the pump speed decreasing), this bypass valve will proportionally open maintaining the DP at the chiller. The act of the bypass valve opening proportionally, allows the pump speed to increase supporting the flow needs of the chiller (see Figure 19).
The pump speed will increase or decrease to maintain the submitted DP value across the chiller header. As chiller module internal valves open, the chiller header DP will fall. This will cause the pump speed to increase to maintain DP at the chiller header each time a new module opens its internal valves. Conversely, as the chiller modules satisfy and their internal valves close; the DP sensor will sense this increase in DP and the pump speed will decrease. Meanwhile, the building system DP set point will be maintained by the system bypass valve, proportionally opening when the system DP is high (when some load valves are closed) and proportionally closing when the System DP is low (as the load side valves are opening). When the load side valves are open (system bypass should be closed), this introduces additional load to the chiller, causing it to stage up to meet this increased load demand (see Figure 19).

Whichever method used, the system water flows must be controlled to keep a constant chiller header differential pressure and the DP to each active loop above the minimum flow trip point at all times or the above nuisance alarms will occur. The response time of the method used is also critical to prevent nuisance alarms.

Figure 18 Pump Control from Load Side (representative of one loop)

Figure 19 Pump Control from Chiller Header (representative of one loop)
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